**Arms of the State: A History of the Industrial Robot in Postwar America**

by

Salem Elzway

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(History)
in the University of Michigan
2023

Doctoral Committee:

Professor Matthew D. Lassiter, Chair
Associate Professor John Carson
Professor Emeritus Paul N. Edwards
Associate Professor Joy Rohde

Salem Elzway

selzway@umich.edu

ORCID iD:  0000-0003-0076-6631

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**Dedication**

*For my parents, Margaret Jane (Uphoff) Elzway and* مرعي بن سالم الزوي *(Mike Elzway).*

*We did it.*

## Acknowledgements

*If only you could see what I have seen with your eyes.*

Roy Batty (1982)[1]

Acknowledgements in a text such as this is an academic's version of an Oscar speech or a shout out track. For conventions unknown to me, it is the one place and time we get to officially let the people who have meant the most to our project, and more importantly our lives, know how much we appreciate and love them. While I'm not holding a golden statuette or a microphone, I'm holding all of you dear in my heart as I write this (apologies to anyone I miss or any names I misspell!).

If there is any "first cause" that set me down the path of becoming a historian it was Terry Eicher, my history teacher at Millard North High School in Omaha, Nebraska. Anyone who knew him would smile when they heard his name and without hesitation exclaim "wow, what a character . . . . and what a teacher!" I can say without a doubt that his lessons and energy, inside the classroom and on the track where he coached, were the *primum mobile* of my love of history and for teaching. Mr. Eicher passed away in 2018 and I never got the chance to let him know how much he meant and still means to me. Wherever you are Terry, I hope you can hear this.

[1] *Blade Runner*, directed by Ridley Scott (1982; Burbank, CA: Warner Home Video, 2012), Blu Ray.

At the University of Nebraska-Lincoln (UNL), James Le Seuer and Bedross Der Matossian recognized my passion for history from the moment we met, and I could not have asked for better mentors at a critical step in my intellectual maturation. Thomas Borstelmann and David Cahan shepherded along the original idea that eventually germinated into this dissertation, while Jeannette Eileen Jones-Vazansky, Patrick Jones, Carole Levin, Gerald Steinacher, and Kenneth Winkle challenged me to think broader and deeper than I ever had before. And, if you're reading this Will Thomas, do you remember when I randomly stumbled into your office in Summer 2010 and asked you what steps I needed to take to become a historian? Well, whatever you said worked, so thank you!

The University of Michigan-Ann Arbor has served as my academic and intellectual home since August 2015, and I couldn't have picked a better place to pursue my doctorate. If I made any smart decision in grad school, it was approaching Matthew Lassiter during the first year of my PhD and asking him to be my adviser. No individual characterizes and defines my time at Michigan more than him, and anyone who has worked under Matt will know exactly what I'm about to ask: HOW THE FUCK DO YOU DO IT?!?! Matt's brilliance, drive, and generosity are unparalleled, and without them, I would not be the scholar I am today. I can't thank you enough for everything you've done, and I'm honored to call you a mentor, a colleague, and most importantly, a friend. I can't wait for us to have a couple beers to celebrate. You won't like this, but you are indeed "The Cap'n."

While Matt set the bar high, the rest of my dissertation committee and the faculty at Michigan were up to the task. Paul Edwards was my original inspiration to attend Michigan and I am truly thankful for his guidance and insight through the years. He motivated me to think with more precision and purpose, and the mess that was my original dissertation idea was improved

immeasurably because of him. I promise Paul, I am going to become a better writer, even if it takes the rest of my life! I am particularly thankful that John Carson agreed to serve on my committee as you will find no better critical eye for your work and no better provider of constructive feedback. John is the guy in the first row of every talk that always asks the smartest questions, and I'm fortunate to have had a front row seat while he did the same for my dissertation. My scholarship is that much stronger because of you John, and I'm excited to hear your thoughts on the next iteration of this project. And finally, I couldn't have asked for a better cognate member of my committee than Joy Rohde. Her ability to separate the wheat from the chaff while providing incisive commentary has made my work and thinking that much clearer. I am so glad you could be a part of the journey Joy and, wow, do you remember how awesome our STPP seminar was?!

Outside of my committee, Howie Brick, John Cheney-Lippold, Juan Cole, Matthew Countryman, Greg Dowd, Dario Gaggio, Joel Howell, Valerie Kivelson, Silvia Lindtner, Tiya Miles, Farina Mir, LaKisha Michelle Simmons, Ron Suny, and Hitomi Tonomura all played key roles in my intellectual maturation, and I am eternally grateful! I would also especially like to recognize Brian Porter-Szucs for his pedagogical mentorship and demonstrating what it means to be the best possible teacher a scholar can be: Thank you Brian for everything you taught me! And finally, there is no way I would have been able to navigate the administrative and bureaucratic madness of academia without Sue Douglas who kept me on-track and sane for countless years as well as the inimitable work of Gregory Parker at the Eisenberg Institute. You are saints Sue and Greg, and staff members like yourself are the real MVPs of the department!

Beyond Michigan, I am truly grateful for the mentorship of James Sparrow, particularly as director of the Jefferson Scholars Foundation. Beyond closely reading my work and

graciously writing me letters of recommendation, your leadership Jim has made a huge difference at a critical point in my career, and I can't thank you enough. Additionally, I'd like to thank Jefferson (Jeff) Cowie who served as my "Dream Mentor" while I was a national fellow at the Jeffersons Scholars Foundation for his attentive reading and feedback over the past year. Similarly, Roger Horowitz made my stint at the Hagley Museum and Library generative and enjoyable. I now consider myself an actual labor historian because of Jeff and Roger! Like Sue Douglas above, my time at the Jefferson and Hagley was made infinitely better by the dedication and hard work of Linda Winecoff and Ben Skipper, and Carol Lockman and Greg Hargreaves, respectively. I am also thankful for the many scholars who took the time to read parts of my in-progress work and provided generous feedback including: Glen Asner, John Beck, Daniel Bessner, Amy Sue Bix, Mark Blythe (who after reading the first draft of my dissertation prospectus declared, "this has to die," and boy was he right!), Michael Brenes, Angus Burgin, Kathryn Cramer Brownell, Nathan Ensmenger, James Evans, Adrian Johns, Sam Lebovic, Nelson Lichtenstein, Sixta Quassdorf, J. Jesse Ramirez, Philip Scranton, Thomas Sugrue, and Mark Wilson. And, I'd also like to recognize the hard work of Christo Datini at the General Motors Heritage Center and Kristen Chinery at the Walter P. Reuther Library for suffering my incessant document requests while I was digging through their archives!

The clichéd adage "it's the friends you make along the way" is in fact true and it's the relationships I've built rather than the knowledge I may have gained over the years that I am most thankful for. Life in Lincoln was made so much more enjoyable because of my colleagues and friends Courtney and John Buchkoski, Brian Carnaby, Luke Chennell, Maaneli "Max" Derakhshani, Mike Dick, Tony Foreman, Ian Francis, Jake Friefeld, Frank Holm, Holly Kizewski, Brandon Locke, Alyson Lomelin, Kylie McCormick, Joseba Moreno, Robert "Tank"

Perry, Steve Scharf, Paul Strauss, Shayla Swift, Steven TenBensel, Dylan Wall, Andy Wilson, and Rebecca Wingo. And no UNL shoutout would be complete without recognizing Wesaam Al-Badry, Charles "Chuck" Holm, and Ben Jones: You are my models for what it means to be committed to the cause of fighting for a better world, and I'm so lucky to learn from you and call you comrades.

It would be difficult to name the panoply of people in Ann Arbor that have done so much for me for so many years, but I'll try because they deserve it: Andy Rafael Aguilera, Roxana Aras, Grace Argo, Haley Bowen, Haley Bowman, Molly Brookfield, Maggie Carlton, Alexander Clayton, Kristen Connor, Meenu Deswal, Renny Hahamovitch, David Helps, Keanu Heydari, Salman Hussain, David Hutchinson (RIP), Pragya Kaul, Nora Krinitsky, Sikandar Kumar, Emily Lamond, Fedor Maksimishin, Lamin Manneh, Alexander McConnell, Austin McCoy, Sauda Nabukenya, Nicole Navarro, Aidyn Osgood, Alyssa Penick, Jonathan Quint, Richard Hoffman Reinhardt, Chao Ren, Reuben Riggs-Bookman, Gerson Rosales, Elena Marie Rosario, Hannah Roussel, Sangita Saha, Severina Scott, Omri Senderowicz, Lediona Shahollari, Omer Sharir, Daniela Sheinin, Meg Showalter, Taylor Sims, Alexander Stephens, Jacques Vest, Lydia Wileden, Matthew Woodbury, and Shai Zami. I'd especially like to thank Stacey Bishop (we so old!), Matt Hershey (let's yell at each other some more!), Zach Kopin (I'm still going after that Bancroft!), and Tara Weinberg (my South African sista!) as well as Richard Bachmann, John Finkelberg, Merideth Garcia, Forrest Holden, and Luis Flores for not just their friendship but their intellectual comradery. And last (but definitely not least), it would be remiss of me to not recognize James W. Hammond, my brother-in-arms, who is not only one of the most brilliant and stimulating minds I've had the privilege of engaging with, but one of the most thoughtful and warmest humans the universe has ever created. We got big things on the horizon my friend!

Outside of my formal academic homes, I am so thankful to have been a part of the initial cohort of the Jefferson Scholars Foundation National Fellows with Marc Aidinoff, Salonee Bhaman, and Bobby Cervantes. The three of you came around at a turning point in my dissertation conceptualization and writing, and the final product is that much better for it. Plus, you're just awesome people and I can't wait for what the Jeffersonianz! have in store in the years ahead. In the same vein, I want to recognize my Louis Galambos Fellow family of Kelly Goodman, Angus McCleod, and Sam Schirvar, three beautiful souls and even more amazing scholars who continue to inspire me today. Do it for Lou! And finally, its incumbent on me to thank Peter Roady for being one of the most diligent reviewers of my work since day one, and a great friend since I began at Michigan. To believe it all started in a conference room at UT-Austin almost a decade ago!

Academia, alas, is not everything, and my friends and family outside of the Ivory Tower have meant and mean as much to me as those in it. John "Jack" Ehrich has been my best friend since we met right before freshman year of college, and he's been my biggest fan and supporter ever since. I can't thank you enough Jack for not just the friend (nay, brother) you are, but the man, the husband, the father, and community leader you've become. You've done so much for me for more than two decades, and I am eternally grateful. Likewise, my Nebraska crew of Mike Allison, Adam Horan, Kyle O'Neill, Matt Puls, Ian Rodgers, Jared Schroeder, and Tyler Wyant had my back, kept me in check, and provided some of the fondest memories of my life. Year Ten AHO Open trophy winners, you know who you are! And finally, a big thank you to my longtime Omaha friends Ryan "Duffy" Callinan, Cole Cippera, Slava Etus, John Fraser, Sarah McGrath, Kaley Mjelde, Cody Perrat, Drew Sacoman, and Alex Shekhtman as well as Joe Bello and Chanh

Le in Orange Country California, all of whom have been with me since the beginning of this journey.

It's difficult to put into words how much my family has meant throughout this process. If I were to do them the justice they deserve, I'll never stop crying and this thing will never get finished! My older siblings Somayah and Sam, unbeknownst to them, taught me how to be creative, loyal, playful, and rebellious while my niece Niyeemah and nephews Adreece and Henri remind me every day why I love to do what I do. My extended Elzway and Uphoff families have demonstrated time and again what it means to take care of one another with grace and love. Both sides of the family come from generations of inveterate historians and masterful storytellers, and I hope this dissertation and my work ahead does our names honor.

What can I say to you, mom and dad, that I haven't before. Mom, you taught me compassion and resilience, and what it means to put others first. Dad, you taught me courage and perseverance, and what it means to live life with passion. Both of your sacrifices are the reason I could pursue my dream, and I will spend the rest of life making sure the fulfillment of that dream represents the best of you.

## Table of Contents

Dedication ..... ii

Acknowledgements ..... iii

List of Abbreviations ..... xiii

Abstract ..... xviii

Introduction ..... 1

Another Look at the Forces of Production ..... 7

What is an Industrial Robot? ..... 16

The Robotic Surround: National Security and Technoliberalism ..... 21

Accumulation Machines: The Industrial Robot as Mechanical Slave ..... 31

Plan of the Dissertation ..... 35

Chapter 1 — Technoliberal Machines: Robots in the Age of Automation ..... 44

Mechanical Slaves: The Science Fiction Firmament of the Industrial Robot ..... 47

The Factory of the Future: Robots and the Dawn of Automation ..... 63

Manufacturing Security: Automation and the Quest for a Preponderance of Productivity ..... 90

Conclusion: "You'll Own 'Slaves' By 1965" ..... 107

Chapter 2 — The Military Industrial Robot Complex: Supply-Side Technoliberalism and the Rise of Unimation ..... 110

The Serial Entrepreneur: From Talkies to Tommy Guns ..... 114

The Mad-Scientist Inventor: From World War to Cold War ..... 127

A Missionary for a Machine: Joseph Engelberger and the "First" Industrial Robot ..... 140

The Pentagon's Armamentarium: Unimation and the Military Industrial Robot Complex ..... 156

Conclusion: America Meets the Perfect Worker ..... 176
Chapter 3 — Armed Algorithms: The Origins of Robotics at MIT and Stanford ..... 179
Hacking the National Security State: ARPA and the Technoliberal Algorithm ..... 186
Project MAC: More Assets to Cambridge ..... 197
Hacking the Real World: The Dawn of Robotics at MIT ..... 213
A Lot of Little Frauds: Arming SAIL and SRI ..... 229
Conclusion: The USCSRIIDDACWF ..... 246
Chapter 4 — Jim Crow-bot: Automation, Industrial Relations, and the Welfare State ..... 249
Mechanical Slaves on the Line: Automation, Robots, and the UAW ..... 253
Forces of Production Standards: The Unequally Automated Workers ..... 270
The Price of Progress: Containing the "Human Fallout" of Automation ..... 292
Reuther's Racist Machine: The Rise of Jim Crow-bot ..... 314
Conclusion: Automated Ghettos ..... 325
Chapter 5 — Robots on the Line: The Technopolitics of Autowork at Lordstown ..... 328
Lordstown: High-Tech Taylorism on the Armed Assembly Line ..... 331
Wish Upon a Falling Star: The Chevrolet Vega and the Promise of Robotized Production ..... 343
GMAD: Disciplinary Layoff and Punish ..... 353
Revolt of the Robots ..... 374
Conclusion: The Robotic Fallout of Human Automation ..... 385
Chapter 6 — Programmable Universal Machine for Accumulation: The Robotics Revolution in the Rustbelt and Silicon Valley ..... 389
Victor Scheinman: The Man with the Golden Arm ..... 392
The Stanford Research Institute and Programmable Automation ..... 403
Rustbelt Robot: The Origins of the PUMA ..... 423
PUMA (In)Action: From Vicarm to Unimation West ..... 430
The Steel Collar Worker: PUMA in the Press ..... 447

Conclusion: The Factory of the (Still Distant) Future ..... 457

Epilogue — The Other Arms Race and the Fall of Unimation ..... 460

Bibliography ..... 482

## List of Abbreviations

| | |
|---|---|
| AAAI | Association for the Advancement of Artificial Intelligence |
| AEC | Atomic Energy Commission |
| AFL | American Federation of Labor |
| AFOSR | Air Force Office of Scientific Research |
| AIG | Artificial Intelligence Group |
| AL | Assembly Language |
| ALPACA | Assembly Line Planning and Control Activity |
| AMF | American Machine & Foundry |
| ANL | Argonne National Laboratory |
| APT | Automatically Programmed Tool |
| AQC | Automatic Quality Control |
| ARA | Area Redevelopment Act |
| ARDC | American Research and Development Corporation |
| ARPA | Advanced Research Projects Agency |
| ASMS | Automated Sheet Metal Shop |
| BFRC | Benson Ford Research Center |
| BOB | Bureau of the Budget |
| BWC | Black Workers Congress |
| CAD | Computer-Aided Design |

| | |
|---|---|
| CAM | Computer-Aided Manufacture |
| CARP | Charles A. Rosen Papers |
| CBC | Computer Based Consultant |
| CCC | Consolidated Controls Corporation |
| CDC | Control Data Corporation |
| CEA | Council of Economic Advisers |
| CIA | Central Intelligence Agency |
| CIO | Congress of Industrial Organizations |
| COLA | Cost of Living Adjustments |
| CONDEC | Consolidated Diesel Electric Corporation |
| CSAW | Communications Supplementary Activity – Washington |
| DAC | Design Augmented by Computers |
| DARPA | Defense Advanced Research Project Agency |
| DDRE | Department of Defense Research and Engineering |
| DEC | Digital Equipment Corporation |
| DOD | Department of Defense |
| DRUM | Dodge Revolutionary Union Movement |
| EMCC | Eckert-Mauchly Computer Corporation |
| ERA | Engineering Research Associates |
| FBI | Federal Bureau of Investigation |
| GMHC | General Motors Heritage Center |
| GDJR | George Devol Jr. Records |
| GE | General Electric |

| | |
|---|---|
| GEI | General Electronics Industries |
| GM | General Motors |
| GMAD | General Motors Assembly Division |
| GMR | General Motors Research |
| IBM | International Business Machines |
| IDA | Institute for Defense Analyses |
| III | Information International Inc. |
| IIT | Illinois Institute of Technology |
| INCA | Integrated Numerical Control Approach |
| IPTO | Information Processing Techniques Office |
| LMA | Linear Model Algorithm |
| LRBW | League of Revolutionary Black Workers |
| MAD | Michigan Algorithmic Decoder |
| MD | Manufacturing Development |
| MDTA | Manpower Development and Training Act |
| MIT | Massachusetts Institute of Technology |
| MITDC | MIT Distinctive Collections |
| MMM | Manning, Maxwell & Moore, Inc. |
| NAACP | National Association for the Advancement of Colored People |
| NAC | National Aeronautical Corporation |
| NASA | National Aeronautics and Space Administration |
| NBS | National Bureau of Standards |
| NCB | Naval Consulting Board |

| | |
|---|---|
| NLP | Natural Language Processing |
| NRC | National Research Council |
| NRL | Naval Research Laboratory |
| NSA | National Security Agency |
| NSF | National Science Foundation |
| NSS | National Security State |
| ONR | Office of Naval Research |
| OSS | Office of Strategic Services |
| PACS | Product Assurance Control System |
| PHV | ProQuest History Vault |
| PMC | Pamela McCorduck Collection |
| PSAC | President's Science Advisory Committee |
| PUMA | Programmable Universal Machine for Assembly |
| RANN | Research Applied to National Needs |
| RCA | Radio Corporation of America |
| RLE | Research Laboratory of Electronics |
| RUM | Revolutionary Union Movement |
| SAGE | Semi-Automatic Ground Environment |
| SAIL | Stanford Artificial Intelligence Laboratory |
| SAILDART | Stanford Artificial Intelligence Laboratory Dump and Retrieval Tape |
| SDC | System Development Corporation |
| SEC | Securities and Exchange Commission |
| SRI | Stanford Research Institute |

| | |
|---|---|
| SUDC | Stanford University Digital Collections |
| SUSC | Stanford University Special Collections |
| TI | Texas Instruments |
| TULC | Trade Union Leadership Council |
| UAW | United Auto Workers |
| UBI | Universal Basic Income |
| UNIVAC | Universal Automatic Computer |
| USI | U.S. Industries |
| WESCON | Western Electronic Show and Convention |
| WRL | Walter P. Reuther Library |
| WSEG | Weapons Systems Evaluation Group |

## Abstract

"Arms of the State: A History of the Industrial Robot in Postwar America" shows how the pursuit of 'security' via the socialization of technoscientific development produced highly advanced and expensive forms of capital as well as new market-state modalities of capital accumulation, both of which fueled a political economy that exacerbated economic insecurity and social inequality. The industrial robot, designed and developed by defense contractors as a direct replacement for humans in industrial settings, did much more than manufacture material goods and disrupt labor markets. It functioned simultaneously as a technology of worker discipline and as a totem of worker emancipation. It helped produce and reproduce racial difference inside and outside the factory. It played a crucial yet overlooked role in the development of artificial intelligence (AI). And it served as a double-edged sword in the arsenals of the American security and welfare states both at home and abroad.

In the workshops of the 'military-industrial complex,' the labs of MIT and Stanford, and the factories of Ford and General Motors (GM), the robots of science fiction were forged into the industrial robots of science fact, and the history of this transformation demonstrates the deep imbrications and powerful oscillations of automation, labor, race, and security in Cold War America. A variety of historical actors engaging with, and historical processes mutually constitutive of, the industrial robot have been overlooked or under-analyzed in the broader literature of postwar US history. These include the Catch-22 of labor's relationship to automation whereby corporations and major industrial unions like the UAW linked standard of living

increases to automation-induced productivity growth, the very technologies of which threatened to displace workers. Second, automation was a distinct force within the evolution of the welfare state, and business, government, and labor leaders shaped public policy to not infringe on private actors' 'right' to automate-at-will. Third, the role of robotics and the manipulation of the concrete and physical world in the early development of artificial intelligence (AI) beginning in the 1960s has been underestimated. And lastly, the history of the industrial robot provides a potent example of the politics of technology transfer from publicly subsidized R&D labs to industry, particularly in the 1970s and 1980s.

While at its core "Arms of the State" is an artifact-centered history, the industrial robot serves as a vehicle for socially, spatially, and temporally navigating the terrain of automation. The dissertation integrates histories of economics, labor, politics, race, and security with political economy and Science, Technology, and Society (STS) to provide the first archivally based scholarly history of the industrial robot. This interdisciplinary approach allows the industrial robot to serve as a socially constructed technological artifact to be pulled apart and reassembled into the cultural, economic, political, and social domains it emerged from and impinged upon while also embedding these processes in the politics of the American state and the geopolitics of the Cold War.

## Introduction

*The word to talk was not "subsidy"; the word to talk was "security."*

W. Stuart Symington (1948)[1]

*You know, King Canute couldn't stop the flow of the tide, and labor can't stop the flow of technology.*

Walter P. Reuther (1958)[2]

*Since we can't have slaves or kick around black people anymore, the robot serves that purpose.*

Joseph F. Engelberger (1974)[3]

*Every time the cost of labor goes up $1 an hour, 1,000 more robots become economical.*

Roger B. Smith (1981)[4]

In the summer of 1969, an autoworker named Clyde at the Ford Motor Company's stamping plant in metropolitan Chicago had a nervous breakdown. The proximate cause of the incident was unknown, however, one day while loading and unloading a die-casting press—a giant machine that stamped out various auto body panels that were sent fifteen miles north to another

[1] Quoted in Frank Kofsky, *Harry S. Truman and the War Scare of 1948* (St. Martin's Press, 1995), 48.
[2] *Administered Prices (Part 6, Automobiles)*, Hearings before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary,1958, 2325.
[3] Roger Lind, "The Robots Are Coming, the Robots Are Coming," *Oui*, Vol. 3, No. 2, Feb. 1974, 40, Folder - Robotics, 1972-1978, Box 5, John McCarthy Papers, 1951-2008, SUSC.
[4] John Holusha, "G.M. Shift: Outside Suppliers," *New York Times*, Oct. 14, 1981, D1.

Ford plant for assembly—Clyde's arm stopped working, and almost immediately, his entire body seized up causing him to become unresponsive. Clyde was off the job for a week and when he returned, fellow workers in Production Department No. 14 threw him a get-well party with cards and flowers. The comrades, with arms draped around Clyde, posed for a picture that was later printed in the company newspaper with an article headlined "Sick Clyde."

First reported in the July issue of *Playboy* magazine, Clyde's story garnered a wide audience. Readers of the *Atlanta Constitution* learned of his breakdown and recovery in December 1969. Clyde's local newspaper the *Chicago Tribune* shared the feel-good episode the following spring (curiously behind the times on their own beat). A little more a year later *Iron Age*, a leading trade journal of the metalworking sector, caught its readers up on the event. Seven years later the story found its way to the UK in a *Guardian* article. Clyde's plight was apparently so newsworthy that, even a decade after the breakdown, his story made the cover of *Time* magazine in 1980. What was so interesting about Clyde's story? In the original *Playboy* article, Clyde's job was described as "dull" and "repetitious" and one he did "without complaint," while the *Chicago Tribune* described his implausible (if not impossible) labor regimen with the attention-grabbing headline, "A 16-Hour Day with No Pay." Ten years later in *Time* magazine Clyde's "Horatio Alger work habits" were jeopardizing what little control workers had left over production as keeping up with such a strenuous work pace was threatening to transform each one into "a mere cog in the machine." Nonetheless, fellow autoworkers stuck by Clyde's side during the breakdown as illness and injury on the job, as well as overwork and solidarity, were daily occurrences for the working class throughout American history.

Why did a seemingly run-of-the-mill story about a worker succumbing to the relentless grind of the assembly line and the supportive response of his union brothers warrant such

fanfare? Because Clyde was no ordinary worker—"he" was an industrial robot. "Clyde the Claw," as his comrades-in-arms affectionately called him, was a Unimate 4000B, the biggest and brawniest of its kind, built by Unimation Inc., the world's first company solely dedicated to the design and manufacture of industrial robots.[5] While Clyde's weeklong coma eventually earned him the sympathy of readers on both sides of the Atlantic, it wasn't his first time in the national spotlight. Six months before his appearance in *Playboy,* Clyde was introduced to the world by the *New York Times*, which painted him as looking like a "skinny ostrich" with an "electronic mini-brain to guide his one hydraulically muscled arm." "Clyde is hardly in the league of the robots, cyborgs and androids of science fiction," the *Times* continued, but his "adaptability and versatility" gave him "a big edge over the dominant forms of present-day automation, in which a machine is designed for only one job and can become obsolete."[6] This flexibility was the force that drove George C. Devol, co-founder of Unimation, to design and develop the Unimate family of industrial robots of which Clyde was a member. According to science writer David Rorvik in his *Playboy* piece, Devol was "disturbed by two ugly realities of the industrial world," one of which was the "disastrous obsolescence rate of automated equipment."[7] Similarly, the *Atlanta Constitution* lauded the programmability of industrial robots that allowed them to avoid being the "clumsy stumblebums of the movies" and complete a variety of tasks from assembling automobiles, loading and unloading bricks into a kiln, and packing glass and china in cases for shipping.[8] The frontier of automation, therefore, was in Clyde's claw.

[5] The first source to identify Clyde's specific model can be found in William J. Cromie, "A Robot in Your Future?," *The 1982 World Book Year* (World Book, Inc., 1982), 138.
[6] William K. Stevens, "Machine-Like Men Are Still Toddlers," *New York Times*, Jan. 6, 1969, 144.
[7] David Rorvik, "Slaves or Masters?," *Playboy*, July 1969, 147.
[8] Reg Murphy, "These Robots Really Work," *Atlanta Constitution,* Dec. 26, 1969, 4A.

Unlike traditional automated systems that were rigid and depended on high-volume output of standardized products, industrial robots designed by men such as Devol were intended to be general-purpose machines that could do a number of different jobs at different paces and in different places, just like human workers. Accordingly, industrial robots were routinely anthropomorphized and given human names—such as 'Clyde the Claw' or 'Iron Mike' introduced by *Business Week* in 1967—and imagined as having all of the upside of human adaptability and versatility but with none of the downside of being, well, human.[9] *The New York Times* described Clyde as being able to "perform some of the dullest, most disagreeable tasks without tiring or complaining."[10] Rorvik enumerated the other ugly reality of the industrial world that disturbed Devol, "the prevalence of dreary, dehumanizing 'put and take' jobs in factories and plants" that only persisted because it was "more economical to keep the adaptable human manning the assembly line." Unimates such as Clyde would apparently solve this problem as they worked harder than men but were only "sick" 2 percent of the time (compared to a human absentee rate of 2.8 percent).[11] As the *Atlanta Constitution* regaled, "They work three shifts a day, demand no Social Security and pause not for a cup of coffee but for an occasional shot of hydraulic fluid."[12] The *Chicago Tribune* echoed these sentiments while reporting on the First National Symposium on Industrial Robots being held at the Illinois Institute of Technology (IIT) south of downtown Chicago: "They don't have to wear a clean shirt to work tho [sic] they are generally expected to produce for 16 hours a day. They don't belong to a labor union but their wages are hardly fair. They are inhuman when it comes to calling in sick—they are ALWAYS on the job." Furthermore, robots won't "hold the threat of a strike over employers head's if

[9] "What robots do now for industry," *Business Week*, May 20, 1967, 114.
[10] Stevens, "Machine-Like Men Are Still Toddlers," 144.
[11] Rorvik, "Slaves or Masters?," 147.
[12] Murphy, "These Robots Really Work," 4A.

wages are not reviewed often."[13] "The Robot Revolution," *Time*'s cover story for December 1980, added boredom, pensions, and vacations to the list of robot don'ts and won'ts and, in a nod to the occasional act of workers' sabotage, the robot "does not leave Coca-Cola cans rattling around inside the products it has helped assemble."[14]

Humanized industrial robots capable of amazing feats on inhuman jobs were not just techno-hyped fodder for the general public. At the IIT symposium, Joseph F. Engelberger, co-founder of Unimation with George Devol, presented a paper on the "Economic and Sociological Impact of Industrial Robots" where he introduced Clyde to a group of academics, corporate managers, engineers, government bureaucrats, and labor officials.[15] The "Father of Industrial Robots," as Engelberger would soon be widely heralded, was already the unofficial spokesman for the nascent industrial robot industry, and he was careful to assuage any fears of technological unemployment arising from the robot's productive prowess. As he told *Playboy*'s Rorvik, "No man or woman has yet lost a job because of a robot . . . . Normal attrition, due to retirement, marriage, pregnancy, wanderlust and promotion, provides the job openings. Since robots have no industry or geographic preferences, there is no tendency to a concentration that might cause a major displacement in the human work force. A robot ghetto is unimaginable."[16] Furthermore, while "we look upon an industrial robot as a one for one replacement for a human operator," Engeberger argued to attendees at the IIT symposium, "robots should be sociologically acceptable to labor because they do not pose a mass displacement problem."[17] Rather than losing their jobs to machines, he explained to Roberts at the *Chicago Tribune*, "the [worker] is moved

[13] Judy Roberts, "A 16-Hour Day for No Pay, That's the Life of A Robot," *Chicago Tribune*, Apr. 9, 1970, S11, emphasis in original.
[14] "The Robot Revolution," *Time*, Dec. 8, 1980, 73.
[15] J. F. Engelberger, "Economic and Sociological Impact of Industrial Robots," Proceedings of the First National Symposium on Industrial Robots (Feb. 18, 1970), 9-10.
[16] Rorvik, "Slaves or Masters?," 148.
[17] Engelberger, "Economic and Sociological Impact of Industrial Robots," 2 and 6.

up from his tedious, dull work taken over by the robot."[18] A decade later, Engelberger reassured the readers of *Time* that "so far, in any case, we've created a hell of a lot more jobs than we've displaced," and the "robot revolution," instead of creating unemployment and inequality, manufactured higher employment and more productivity—the only problem was figuring out "what to do with the blessings."[19]

Where coverage of Clyde's calamity proved particularly illuminating was in commentators' discussion of, and seeming support for, resurrecting the institution of slavery but with robot rather than human chattel. The *New York Times* wrapped up its article on Clyde by forecasting that "a quarter century from now, man is likely to have under his command electronic hydraulic slaves stronger than he, and smarter in some ways. But they will be just that—slaves capable of, and restricted to, limited jobs and roles." And, more flippantly, he closed, "the experts say it will be at least 50 years before society will be arguing about whether robots and androids are entitled to freedom, independence and the vote."[20] While the article *Atlanta Constitution* article didn't use terms such as 'slaves' and 'slavery,' slave revolts (and, once again, movies!) were once again foregrounded as "too many people have seen too many movies where the robots develop intelligence and a spirit of revolt. Too many times they have turned on their human employers and exterminated them."[21] Rorvik, who titled his *Playboy* article "Slaves or Masters?," quoted Engelberger extensively on the relationship between robots and slavery:

> The self-evident inferiority of a minority group has often been the ethical justification of slavery. Master races have been deeply embarrassed by the intellectual prowess of their slaves, when they inconsiderably display all the attributes of a peer group. A robot slave would never be guilty of such an affront . . . . A robot is patently a racial inferior, and no

[18] Roberts, "A 16-Hour Day for No Pay, That's the Life of A Robot," S11.
[19] "The Robot Revolution," 78.
[20] Stevens, "Machine-Like Men Are Still Toddlers," 144.
[21] Murphy, "These Robots Really Work," 4A.

> one need hide his feeling of superiority. Clyde the Claw will take the place of Stepin Fetchit, Kingfish, Aunt Jemima, Rochester and the minstrel end man. White man and black can share a feeling of benevolent despotism toward the robot.[22]

Engelberger made clear his argument for a benevolent enslavement of machines in his talk to the First National Symposium on Industrial Robots: "The robot is obviously a latter day slave, and, better still, it is a willing slave. This sub-human beast is designed (rather than abducted) to labor on behalf of mankind."[23] And, in the grandest sense of fusing the promise of technology to the Western ideal of the *polis,* British minister for agriculture Peter Walker shared his view of what the robot revolution meant with *Time* magazine: "Uniquely in history, we have the circumstances in which we can create Athens without the slaves."[24] At least not the human ones.

**Another Look at the Forces of Production**

Readers introduced to Clyde the Claw may have been surprised to learn that the American state underwrote the industrial robot's development from the technology's origins in the 1940s. Clyde's progenitor George Devol spent the better part of a decade after World War II in the defense-funded labs of the Radio Corporation of America (RCA) and Remington Rand developing his Unimate concept. Similarly, Devol's business partner and future cofounder of Unimation Joseph Engelberger ran a small aerospace and defense-oriented manufacturing firm that used funds from military procurement contracts to bring that concept to market. When the nascent artificial intelligence (AI) laboratories at the Massachusetts Institute of Technology (MIT) and Stanford began incorporating industrial robot into their technoscientific research in

[22] Rorvik, "Slaves or Masters?," 148.
[23] Engelberger, "Economic and Sociological Impact of Industrial Robots," 10.
[24] "The Robot Revolution," 83.

the 1960s, it was federal organizations such as the Advanced Research Projects Agency (ARPA) and the National Aeronautical and Space Agency (NASA) that provided the resources to make "dumb" robots "smart." And, by the 1970s, GM engineers and scientists repurposed algorithms, computer graphics, and IBM mainframes originally intended for the nation's air defense system to design and coordinate the production of the Chevrolet Vega, as well as manage the industrial robots and human workers assembling it, at the now famous Lordstown Assembly plant in northeast Ohio.

Undergirding the American state's support for the industrial robot was a conception of the economic foundations of "national security" that linked the productivity enhancing powers of automation to national defense. Accordingly, throughout the Cold War men such as General Electric (GE) chairman Ralph Cordiner, United Auto Workers (UAW) president Walter Reuther, and congressional representative Wright Patman all connected the development of science and technology to the advancement of industry and American capitalism's capacity for producing the security that putatively provided "progress" and "prosperity" around the globe. To accomplish this, academics, businessmen, engineers, labor leaders, politicians, and scientists tasked the Department of Defense (DOD) and the broader "national security state" it was part-and-parcel of with pushing forward the "Endless Fronter" of science and technology by nurturing automation as a domestic factor of production *and* a geopolitical weapon that could help win the Cold War. As automation theorist John Diebold argued in 1952: "It is only by increasing output per manhour worked [via automation] that we will be able to build effective defenses against the aggressive powers of communism."[25]

[25] John Diebold, *Automation: The Advent of the Automatic Factory* (D. Van Nostrand Company, Inc., 1952), 170.

The process of automating was prohibitively expensive and risky, and for-profit institutions operating in the 'free market' were neither able nor willing to make the necessary investments to accomplish the shared dream of a fully automated future reality. As John Snyder, chairman of automation machinery manufacturer and defense contractor U. S. Industries, described it: "The pace of technological development has been so rapid since the end of World War II that only the military could and can afford to spend the large amounts required to pursue advanced concepts."[26] In response, Congress and the executive branch mandated federal organizations such as ARPA, NASA, and the Office of Naval Research (ONR) with cultivating associational relationships among private actors including General Motors Research (GMR), the Stanford Research Institute (SRI), and Unimation to advance the art of automation. These institutional "arms of the state" transformed publicly funded "advanced concepts"—including the "TransfeRobot" designed and manufactured by U.S. Industries and the Unimate designed and manufactured by Unimation—into robotic "arms of the state" and deployed them for more efficient capital accumulation. As a result, when GM put its industrial robots to work, they functioned simultaneously as profit-making machines and technopolitical instantiations of the 'military-industrial complex' that both assembled automobiles and manufactured the industrial base of security.

The industrial robot, a technology conceived by advocates and detractors alike as the apex of automation, is an ideal window through which to explore the history of economic, political, and sociotechnical change and continuity in the United States during and after World War II. As Clyde the Claw's story reveals, the technology was much more than simply a piece of automated machinery in manufacturing plants. The imagined or imputed capacities of industrial

[26] U.S. Industries, *Annual Report* (1958), 3.

robots to reconfigure production on the factory floor, as well as transform the political and socioeconomic contours of society, enlivened the promises and perils of automation. Prophets foretold of 'automatic factories' fulfilling consumer demand with the push of a button, the pressing of which would lower costs, increase living standards, and guarantee perpetual abundance. Doomsayers depicted 'workerless factories' churning out not cheap goods and endless economic growth but mass unemployment, acute job insecurity, lower wages, and higher inequality. The reality, as is typically the case, rarely accorded with the augurs; nevertheless, industrial robots like Clyde became a symbol and synecdoche of automation in postwar America.

"Arms of the State: A History of the Industrial Robot in Postwar America" demonstrates how the pursuit of 'security' via the socialization of technoscientific development after World War II produced new forms of highly advanced and expensive forms of capital as well as new market-state modalities of accumulation. As a signal example of these developments, the industrial robot designed and developed by defense contractors as a direct replacement for humans in industrial settings did much more than manufacture material goods and disrupt labor markets. It functioned simultaneously as a technology of worker discipline and as a totem of worker emancipation. It helped produce and reproduce racial difference inside and outside the factory. It played a crucial yet overlooked role in the development of artificial intelligence (AI). And it served as a double-edged sword in the arsenals of the American security and welfare states both at home and abroad. These processes, as well as the applications of the technologies they produced, fueled a political economy that exacerbated economic insecurity and social inequality.

The dissertation integrates histories of economics, labor, state-centered politics, and race, with the scholarship of national security, political economy, and Science, Technology, and

Society (STS) to provide the first archivally based scholarly history of the industrial robot. This interdisciplinary approach allows the industrial robot to be pulled apart and reassembled into a variety of cultural, political, and socioeconomic domains as well as embedded in the politics of the American state and the geopolitics of the Cold War: Imagineers, managers, technologists, and workers in the R&D facilities of the nascent industrial robot industry, the labs of MIT and Stanford, and the factories of Ford and General Motors (GM), took the robots of science fiction and forged them into the industrial robots of science fact. Historical contingencies and continuities characterizing the political and socioeconomic transformation of the United States during the Cold War including the decline of labor unions, the evolution and expression of state formation, and the persistence of poverty, interfaced with and were mutually constitutive of the industrial robot's development and applications. These entanglements of politics and technology have either been overlooked or under analyzed in the broader historical literature of the United States, and "Arms of the State" develops an artifact-centered study of the industrial robot to serve as a vehicle for socially, spatially, and temporally navigating the terrain of postwar American history.

One key site of this history is the auto industry as, from the technology's emergence in the mid 1950s, the vast majority of industrial robots in the United States and abroad were put to work manufacturing cars, trucks, and vans. Beyond simply serving as the largest market for industrial robots, the manufacturing needs of the 'Big Three'—Chrysler, Ford, and GM—shaped the form and function of the industrial robot for a generation. GM in particular played a key role in the industrial robot's development as the company worked directly with Unimation in the mid-to-late 1950s on the design of what would become the Unimate. Additionally, GM designed and engineered the first mass installation of industrial robots at the Lordstown, Ohio plant in the late

1960s and early 1970s. Shortly thereafter, GM also pioneered some of the first real-world applications of computer-vision equipped industrial robots—in partnership with Stanford University, the Stanford Research Institute (SRI), and Unimation—at the General Motors Research (GMR) labs in Warren, Michigan. Furthermore, beginning in the early 1980s, GM underwrote the first mass production of industrial robots through its partnership with the Japanese-based FANUC corporation, then the largest manufacturer of computer numerical-control machines in the world.[27]

The dissertation aspires to be a follow-up or sequel to David F. Noble's *Forces of Production: A Social History of Industrial Automation*, what I consider to be the best scholarly treatment of automation (and, perhaps unintentionally, the industrial robot). Noble traces the development and applications of numerically controlled (N/C) machine tools by demonstrating how the desire of engineers, managers, and military bureaucrats for 'command and control' over labor skill and technology shaped the development of automation. In short, the Air Force, manufacturing managers, and MIT technologists attempted to abstractly mathematize and computerize the control machine tools to deskill aerospace machinists and thereby denude labor's power at the point of production. Rather than the typical technologically determinist approach that interprets technical constraints as containing social potential, Noble's overarching argument is that "social constraints," particularly those related to the imperatives of capitalist accumulation and national security, have "delimited" technical possibilities, a process he calls "social choice in machine design." *Forces of Production* has proved to be a classic in the history

[27] The auto industry's importance to the industrial robot industry is hard to understate: not until 2020 did industrial robot orders from non-automotive sectors surpass auto sector orders in North America, and as of 2023, approximately one million industrial robots were working in the auto sector globally, The Robot Report Staff, "Robot orders up 3.5% as non-automotive sales surged," Jan. 28, 2021, https://www.therobotreport.com/robot-orders-up-35-non-automotive-sales-surged/ and International Federation of Robots Press Room, One Million Robots Work in Car Industry Worldwide – New Record," Mar. 22, 2023, https://ifr.org/ifr-press-releases/news/one-million-robots-work-in-car-industry-worldwide-new-record.

of technology as it investigates not just the development of the "guts of industry" (i.e., machine tools) but integrates labor history and political economy to more fully understand the social evolution of automation, what Noble calls the "hallmark of twentieth century manufacturing."[28]

Beyond Noble, the corpus of scholarly history on automation is relatively small and primarily tracks the discursive, intellectual, and political evolution of the phenomenon .[29] Due to its proximate origins in the American auto industry, most material (rather than discursive) studies of the automation are 'autocentric' and written from the perspective of the 'automaters' (i.e., the corporations doing the automating).[30] A later wave of scholarship attempted to balance the

[28] David F. Noble, *Forces of Production: A Social History of Industrial Automation* (Oxford University Press, 1984), quotes from xiv. Noble originally articulated the argument in "Social Choice in Machine Design: The Case of Automatically Controlled Machine Tools" in Andrew Zimbalist, ed., *Case Studies On the Labor Process* (Monthly Review Press, 1979), 18-50, which was later condensed for a chapter in Donald MacKenzie and Judy Wajcman (eds.), *The Social Shaping of Technology: How the Refrigerator Got its Hum* (Open University Press, 1985), 109-124. To strengthen his case of social delimiting and alternative technical possibilities, Noble includes a discussion of the industrial robot as a comparative technology to N/C machine tools. Where numerical control translated labor skill into abstract, formal algorithms to control a machine tool, the first industrial robots used a simpler iteration of digital control called 'record-playback' (R/P). By leading a robotic arm through a series of motions, R/P could directly 'record' labor skill and reproduce it ('playback'). R/P was in Noble's estimation a "multiplier of skill" that had the potential to empower workers rather than an "abstract synthesizer of skill" for the purposes of labor deskilling like N/C (*Forces of Production,* 84.)

[29] Amy Sue Bix, *Inventing Ourselves Out of Jobs?: America's Debate Over Technological Unemployment, 1929-1981* (The Johns Hopkins University Press, 2000), analyzes the discursive relationship between labor-displacing machines and unemployment in the United States and provides wide-ranging coverage of the many ways American talked and thought about automation. The book and the dissertation it is based on are particularly useful for understanding the early roots of how 'the robot,' as an idea and an image, came to be associated with the process of technological change and technological unemployment. Gregory R. Woirol, *The Technological Unemployment and Structural Unemployment Debates* (Greenwood Press, 1996) digs into the same issues but from the perspective of how economists' methodologies, models, and theories, conceptualized, measured, and assessed 'technological unemployment,' and how the paradigms and products of economic thought shaped policy debates and evolved over time. Jerry Prout, *Chasing Automation: The Politics of Technology and Jobs from the Roaring Twenties to the Great Society* (Northern Illinois University Press, 2022), surveys how a "liberal-labor coalition" during the period understudy went on a "political crusade" to "tame the excesses of workplace technolo-gies, not eliminate them," however, with limited success (quote on 11).

[30] David A. Hounshell, "Ford Automates: Technology and Organization in Theory and Practice," *Business and Economic History*, Vol. 24, No. 1 (Fall 1995), 59-71 and "Planning and Executing 'Automation' at Ford Motor Company, 1945-1966: The Cleveland Engine Plant and Its Consequences" in Haruhito Shiomi and Kazuo Wada (eds.), *Fordism Transformed: The Development of Production Methods in the Automobile Industry* (Oxford University Press, 1995); William J. Hausman (ed.), *Enterprise & Society*, Vol. 1, No. 1 (Mar. 2000). These treatments are extremely insightful in terms of their contributions to company histories, organizational theory, and the technical evolution of automation, however, to my surprise, the almost two-hundred page inaugural issue of *Enterprise & Society* on automation contains only one mention of the United Auto Workers (UAW), and that is in a footnote!

capital-labor dynamic and focused on or included the perspective of labor and workers.[31] These treatments present a much more complex and nuanced analysis of how automation in the auto industry evolved and how workers, by the far the industry's largest constituency, experienced this. Nevertheless, most studies of automation in the auto industry present the phenomenon as an isolable, motive force—Thomas Sugrue describes it as, "the most important *force* that restructured Detroit's economy after World War II was the advent of new automated processes in the automobile, auto parts, and machine tool industries"—and frame the UAW's relationship to it on a spectrum ranging from ambivalence to antagonism.[32] The reality, as will be discussed below, is much more complex. Furthermore, the broader institutional and structural dynamics that shaped the development, experience, and assessments of automation (at the point of production and beyond) are, at best, only alluded to in these texts.[33]

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[31] Ronald Edsforth, "Why Automation Didn't Shorten the Work Week: The Politics of Work Time in the Automobile Industry" in Robert Asher, Ronal Edsforth, and Stephen Merlino (eds.), *Autowork* (SUNY Press, 1995), 155-179; Steve Meyer, "'An Economic 'Frankenstein': UAW Workers' Responses to Automation at the Ford Brook Park Plant in the 1950s," *Michigan Historical Review*, Vol. 28, No. 1 (Spring 2002), 63-89 and "The Persistence of Fordism: Workers and Technology in the American Automobile Industry, 1900-1960" in Nelson Lichtenstein (ed.), *On the Line: Essays in the History of Auto Work* (University of Illinois Press, 1989), 73-99; and David Steigerwald, "Walter Reuther, the UAW, and the dilemmas of automation," *Labor History*, Vol. 51, No. 3, 429-453.

[32] Kevin Boyle, *The UAW and the Heyday of American Liberalism, 1945-1968* (Cornell University Press, 1995), 95; Ronald Edsforth, "Why Automation Didn't Shorten the Work Week: The Politics of Work Time In the Automobile Industry," in Robert Asher, Ronald Edsforth, and Stephen Merlino, (eds.), *Autowork* (SUNY Press, 1995), 155-179; Nelson Lichtenstein, *The Most Dangerous Man in Detroit: Walter Reuther and the Fate of American Labor* (Basic Books, 1995), 290-292 and 360-362; and Thomas Sugrue, *The Origins of the Urban Crisis: Race and Inequality in Postwar Detroit* (Princeton University Press, 2014), 126-177, quote from 130, emphasis added.

[33] A small literature exists on the role of automation in the auto industries of countries outside the US, specifically those of Italy and Japan, that is more attuned to some of these dynamics, particularly geopolitics and international trade. A small literature exists on the role of automation in the auto industries of countries outside the US, specifically those of Italy and Japan, that is more attuned to some of these dynamics, particularly geopolitics and international trade: Eisuke Daito, "Automation and the organization of production in the Japanese automobile industry: Nissan and Toyota in the 1950s" in William J. Hausman (ed.), *Enterprise & Society*, Vol. 1, No. 1 (Mar. 2000), 139-178; Kenneth Flamm, "International Differences in Industrial Robot Use: Trends, Puzzles, and Possible Implications for Developing Countries," Discussion Paper prepared for The World Bank, Report No. DRD185, The Brookings Institutions (July 1986); Akira Kawahara, *The Origin of Competitive Strength: Fifty Years of the Auto Industry in Japan and the U.S.* (Springer, 1998); and Giuliano Maielli, "Managerial Culture and Company Survival: Technological Change and Output-mix Optimisation at Fiat, 1960-1987," PhD dissertation, London School o f Economics and Political Science (2003) and "Spot-Welding Technology and the Development of Robotics at Fiat, 1972-87: A Case of Managerial Discontinuity?," *Business History*, Vol. 47, No. 1 (January 2005), 102-121.

Either fortunately or unfortunately, an archivally based scholarly history of the industrial robot does not exist.[34] Other academic treatments of the industrial robot are overwhelmingly composed of technical histories, socioeconomic analyses of the technology's applications, handbooks by the field's founders, and 'state of the field' updates by practitioners.[35] Works by historians that include discussions of the industrial robot are limited and their coverage ranges from a few paragraphs to a single chapter.[36] None of these texts make historical arguments or interventions in the scholarly literature about automation. Where an extensive literature does exist is in regards to 'the robot' as an icon, an idea, an ideological trope, and an instantiated object (e.g., an automaton, a doll, or a toy) representing conceptions and experiences of industrialization, mechanicity, racialization, and slavery, particularly in the cultural and intellectual history of Europe.[37] What can broadly be learned from these, historian Dustin Abnet

[34] The closest thing to this is Ricardo Zermeno-Gonzalez's dissertation, "The Development and Diffusion of Industrial Robots," draws from published sources to provide a detailed and sweeping chronology of the industrial robot's technical evolution and applications around the world. While the dissertation is useful in terms of tracking the technology across space and time, its approach is essentially a microeconomics of technological change rather than an academic history, Ricardo Zermeno-Gonzalez, "The Development and Diffusion of Industrial Robots," PhD dissertation, University of Aston (Sept. 1980). Additionally, Samuel D. K. James, *The Impact of Cybernation Technology on Black Automotive Workers in the U.S.* (UMI Research Press, 1984), studies national employment policy and its relation to race and robotics from the perspective of historical sociology and concludes that Black autoworkers were disproportionately affected by automation, and national employment policy was not up to the task of addressing such inequality.

[35] Representative texts include James S. Albus, *Peoples' Capitalism: The Economics of the Robot Revolution* (New World Books, 1976); Robert U. Ayres and Stephen Miller, *Robotics and Flexible Manufacturing Technologies: Assessments, Impacts and Forecasts* (Noyes Publishing, 1985); A.J. Critchlow, *Introduction to Robotics* (Macmillan Publishing Company, 1985); Joseph F. Engelberger, *Robotics in Practice* (Kodansha Publishing, 1981); Mark E. Rosheim, *Robot Evolution: The Development of Anthrobotics* (John Wiley & Sons, 1994); and Peter B. Scott, *The Robotics Revolution: The Complete Guide for Managers and Engineers* (Basil Blackwell, 1984).

[36] John Jordan, *Robots* (MIT Press, 2016); David F. Noble, *Forces of Production: A Social History of Industrial Automation* (Oxford University Press, 1984) contains a short section on the industrial robot's history that serves as an entry in the MIT Essential Knowledge and Lisa Nocks, "Chapter 3: Into the Factory: The First Robots" in *The Robot: The Life Story of a Technology* (Johns Hopkins University Press, 2008) contains one chapter, that while cursory, provides the closest thing to a general history of the technology.

[37] Minsoo Kang, *Sublime Dreams of Living Machines: The Automaton in the European Imagination* (Harvard University Press, 2011); Adrienne Mayor, *Gods and Robots: Myths, Machines, and Ancient Dreams of Technology* (Princeton University Press, 2018); Jessica Riskin, *The Restless Clock: A History of the Centuries-Long Argument Over What Makes Living Things Tick* (University of Chicago Press, 2016); E. R. Truitt, *Medieval Robots: Mechanism, Magic, Nature, and Art* (University of Pennsylvania Press, 2015); Adelheid Voskuhl, *Androids in the Enlightenment: Mechanics, Artisans, and Cultures of the Self* (University of Chicago Press, 2013).

has argued, is the robot's "primary technology is not electromechanical but ideological" and that "rather than a piece of machinery, it is a flexible concept deeply rooted in the power relations of a society."[38] Simply because of periodization, however, robots capable of materially reconfiguring the physical world in the manner they would be able to after WWII in the United States (i.e., industrial robots), and thereby capable of destabilizing the dominance of ideology ascribed to robots, have not been addressed by this otherwise sophisticated literature.

**What is an Industrial Robot?**

Historical actors (with few exceptions) understood robotization as a modality or subset of automation and primary source coverage of and social commentary regarding the latter was significantly greater than the former. While robotization had its own particularities and peculiarities, 'robot discourse,' with little to no exception, *was* 'automation discourse' (though not necessarily vice versa). Additionally, automation preceded robotization, and as a result, the institutional and structural realities the industrial robot was introduced into—whether on the assembly line, in the laboratory, or in terms of policymaking—were shaped in response to and in terms of automation. Furthermore, in purely nominal terms, perhaps a few hundred industrial robots were operating in the US by 1970 and a few thousand by 1980, numbers which are relatively paltry in the grand scheme of things but significant in the sense that 'the robot' as a culturally conditioned political and technosocial artifact wielded outsized power within the automated imaginary.

[38] Dustin A. Abnet, *The American Robot: A Cultural History* (University of Chicago Press, 2020).

But what exactly is an 'industrial robot'? While in 1979 Joseph Engelberger, echoing Supreme Court Justice Potter Stewart's famous threshold test for pornography, quipped, "I don't know how to define it, but I know one when I see one," defining an industrial robot is relatively straightforward.[39] For the purposes of this study, I use one of the earliest definitions developed by the Robot Institute of America (RIA): "A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices, through variable programmed motions for the performance of a variety of tasks."[40] While designating technological firsts is generally a fool's errand, a rigid application of the RIA definition would identify Canadian inventor Griffith P. Taylor's device, which he called "Robot Gargantua," as most likely the 'first' industrial robot. Designed and built between 1935-1938, the invention took the form of a table-sized electromechanical "block-setting crane" that could be programmed on paper tape to automatically grasp, lift, and arrange children's blocks into simple structures.[41] Apparently, Griffith's "robot" was a one-off oddity, and it would take almost two more decades until the now common form of the industrial robot would solidify.

At its core, the industrial robot is a technological system composed of a control unit (computer), memory storage (program bank), and a mechanical manipulator (the 'arm') with an end effector (the 'hand'). The mechanical manipulator serves as the physical synecdoche of the system and provides the more colloquial identification of the technology as a 'robotic arm.' The first commercially successful industrial robots were large, hydraulically powered

[39] Carl Remick, "Robots: New Faces on the Production Line," *Management Review* (May 1, 1979), 39.
[40] Robert U. Ayres and Stephen M. Miller, *Robotics: Applications and Social Implications* (Ballinger Publishing Company, 1983), 98-99. The RIA was later rebranded the Robotic Industries Association and now the Association for Advancing Automation)
[41] "An Automatic Block-Setting Crane," *Meccano Magazine* (March, 1938), 172, http://www.nzmeccano.com/MMviewer.php; Griffith P. Taylor, *The Robot Gargantua: A Constructor Quarterly Special Publication* (R. J. Publications, Jan. 1, 1995); and Chris Shute, "The Robot Gargantua," Meccano Society of Scotland Newsletter, No. 74 (September, 2007), 10-17, https://www.meccanoscotland.org.uk/downloads/mag074_September_2007.pdf.

electromechanical machines the size of refrigerators that were loud, leaky, and lumbering. Their first and most basic function was as "pick and place" devices that could grasp objects and move them from one location to the other, particularly objects that were heavy or hot, like Clyde the Claw's job of loading and unloading a diecast machine, or operating spray paint or spot welding guns. Engineers and managers first assigned industrial robots to jobs initially identified as "male labor" that were typically described as 'dull, dirty, and dangerous' or 'hot, heavy, and hazardous.'[42] However, as the technology advanced, the industrial robot shrank in size to a tabletop all-electric mechanism with computer vision and tactile sensing that could do a variety of tasks requiring more agility and precision, such as assembling an automobile water pump or screwing light bulbs into automobile dashboards. While this is a snapshot of the physical form and function the industrial robot took over its first generation of development, the definition and material composition of the technology was constitutive and contingent, so both should not be interpreted as hard and fast but rather as historically informed rules-of-thumb that both helped guide the research and materialized from it.

This also raises the question of what 'automation' is? Coined in 1936 by then GM factory manager Delmar "Del" (D.S.) Harder, the term was originally motivated by Harder's fear of labor scarcity and rising wages and simply referred to "a better way of doing things."[43] Ten years later, after moving to Ford and establishing its famous Automation Department, Harder sharpened his definition and began referring to automation as "the automatic handling of parts between progressive production processes" with the goal that "each automation device had to

[42] Patrick Wauryzniak, "Masters of Manufacturing: Joseph F. Engelberger," *Manufacturing Engineering*, Vol. 137, Iss. 1 (July 2006), 66.
[43] Text of remarks by Del S. Harder, June 20, 1956, Folder - Harder, Del S. - Ford Engineering Forum 6-20-1956, Box 12, Speech Services, 1944-1962, 4 and Interview with D.S. Harder, Nov. 12, 1959, Folder - Harder, D.S., Box 15, Frank Hill Papers, Benson Ford Research Center, Ford Motor Company, Dearborn, Michigan (from hereafter BFRC), 2.

eliminate at least one worker."[44] While automation was originally associated with industrial production in the metalworking sector, particularly the aerospace, automobile, electrical equipment and electronics, and steel industries, a variety of social actors soon used it characterize technological change in the "mass" extraction, manufacturing, and transportation industries such as coal, furniture, and longshoring, and later in the domains of information management and processing. And by the time automation was unveiled in the 1940s, 'the robot,' as a cultural symbol implying mechanical automaticity already had prominent standing, becoming a leading icon and trope of what President Dwight Eisenhower in 1957 would designate as the "Age of Automation."[45]

The concept also quickly escaped its purely sociotechnical bounds and, over the next decade, became directly associated with or served as a catchall term for a wide range of technological forms and socioeconomic processes. This included but was not limited to: computers, robots, and transfer machines; economic growth, productivity, and security; 'blue collar' and 'white collar' labor displacement; social, structural, and technological change; structural and technological unemployment; and even 'progress' and 'technology' writ large. By 1955, the *Baltimore Sun* satirically nominated 'automation' for "Cliche of the Year." Three years later, one of the first comprehensive studies of the phenomenon lamented, "Few words of recent years have been so twisted to suit a multitude of purposes and phobias as this new word, 'automation.' It has been used as a technological rallying cry, a manufacturing goal, an engineering challenge, an advertising slogan, a labor campaign banner, and as the symbol of

[44] Untitled, Folder - Harder, Del S. (Biography) Running Record, Box 176, PR Research Library, Ford Motor Company, BFRC; Hartley W. Barclay, "Automatic Devices Sweeping Industry," *New York Times*, Apr. 16, 1950; D. S. Harder, "Automation - Key to the Future," August 27, 1954, Folder - Harder, Del S. - Automation-Key to the Future 8-27-54, Box 12, Speech Services, 1944-1962, Office of Public Relations, Ford Motor Company, BFRC 4; and Hounshell, "Ford Automates: Technology and Organization in Theory and Practice," 69.
[45] Dwight D. Eisenhower, "Address to the Republican National Conference," June 7, 1957, https://www.presidency.ucsb.edu/documents/address-the-republican-national-conference.

ominous technological progress."[46] Well into the 1960s, one commentator estimated that America was still in the grip of "automation hysteria."[47]

The term, therefore, was quantum-like—simultaneously a 'thing' and a 'process'—and "automation" was not so much a floating signifier as a tethered one, still capacious and plastic, yet tied to a broad set of technologies and broad assumptions about what 'technology' did or didn't do and what 'technology' did or didn't mean. The project of making industrial robots work, therefore, like that of automation, was fraught and littered with prophecies of the technology's promises and perils, both of which persistently obscured rather than revealed what the technology could and did do. While I primarily engage with the 'robot' variant of this "automation discourse" (as sociologist Aaron Benanav and historian Jason Resnikoff have called it), the study places more emphasis on the political economy of the technology, both in development and in practice, to better understand the material forces that undergirded the failures and successes of the industrial robot and automation more broadly.[48] And, to make the

[46] James R. Bright, *Automation and Management* (Harvard University Press, 1958), 4.
[47] "Candidate For Cliche Of The Year," *Baltimore Sun*, Jan. 12, 1955, 12 and George Terborgh, *The Automation Hysteria* (W. W. Norton & Company Inc., 1965).
[48] Aaron Benanav, "Automation and the Future of Work—1," *New Left Review*, No. 119 (Sept/Oct 2019), "Automation and the Future of Work—2," *New Left Review*, No. 120 (Nov/Dec 2019), and *Automation and the Future of Work* (Verso, 2020), and Jason Resnikoff, *Labor's End: How the Promise of Automation Degraded Work* (University of Illinois Press, 2021). For Benanav, the "automation discourse" was and continues to be the way people discuss the breakdown and limits of capitalism during periods of labor market unrest. 'Automation,' rather than the political and socioeconomic system it is embedded in, is routinely identified as the culprit for the low demand for labor. Instead of robots stealing everyone's jobs, therefore, Benanav estimates that "ongoing technical change [associated with "automation"] in an environment of deepening economic stagnation" has "manifested not as mass unemployment but rather as persistent *underemployment*" (*Automation and the Future of Work* (Verso, 2020), quote on 15, emphasis in original). In a different register though with complementary conclusions, Resnikoff that instead of describing a new and coherent technics of production that either created abundance or unemployment, the term 'automation' filled an ideological and semantic need of postwar Americans "to reconcile the concentration of the means of production (and the exploitation it often entailed) with the republican notion of being a free citizen." Automation-as-ideology, therefore, obscured the contribution workers made to the labor process (even in the midst of 'automation') and mystified automation-in-practice, which more often than not resulted in the degradation, intensification, and speedup of work instead (quote on 11-12). For both Benanav and Resnikoff, what the automation discourse elides, is the fact that technology has not created these predicted mass catastrophes and automation-in-practice has led to the declassification of job categories, degradation and speedup of work, deindustrialization, (continued) depoliticization of the workplace, and underemployment rather than unemployment. For recent confirmations of the 'automation discourse' thesis, Moritz Altenried, *The Digital Factory: The Human*

conceptual, discursive, and terminological unwieldiness 'automation' manageable, this study will hew to the industrial conception of automation in manufacturing, particularly in the auto industry where the industrial robot found its primary habitat, and accordingly, use of the term "automation" moving forward implies *industrial* automation.

**The Robotic Surround: National Security and Technoliberalism**

The history of the industrial robot demonstrates, like *Forces of Production*, the power of security and the state in shaping technology. Uniquely, however, unlike the military's *direct* support for N/C machine tools that Noble presents, support for the industrial robot was exercised much more *indirectly* through the 'national security state' (NSS), which illuminates the often hidden yet pervasive nature of the federal government's role in capital formation and promotion of technological change. Additionally, because the industrial robot's development and diffusion was not a project managed by the military for the deliberate purpose of reshaping the manufacturing environment of industry (like N/C machine tools) its fate was in the hands of private industry. As a result, the logic of capital accumulation and the structures of capitalist social relations played an outsized role in the industrial robot's success or failure on the factory floor.

To methodologically and theoretically engage with these processes, the dissertation operationalizes two relatively recent conceptual innovations emerging from critical race theory, political economy, and STS called *technoliberalism* and *technopolitics*. Both interrogate attempts

*Labor of Automation* (University of Chicago Press, 2022); Luke Munn, *Automation is a Myth* (Stanford University Press, 2022); and Jason E. Smith, *Smart Machines and Service Work: Automation in an Age of Stagnation* (Reaktion Books, 2020)

to solve, and eventually transcend, political and social problems through technology. Building on the work of Neda Atanasoski and Kalindi Vora, "technoliberalism" describes "the ideology that technology advances human freedom and postracial futurity by asserting a postlabor world in which racial difference, along with all human social difference, is transcended."[49] Similar to its macroeconomic cousin Keynesianism, which attempts to solve social problem with economic growth while retaining the underlying structure of capitalist social relations, the technoscience emerging from and valorizing technoliberalism reinscribes and reproduces the very political and socioeconomic logics it is supposed to render obsolete—rather than solving these problems, it technifies them. In other words, 'more growth, fewer problems' became 'more technology, fewer problems.' In robotic terms, as Atanoski and Vora put it, "the racial and gendered structures of production, both material and social, that continue to demand an abject and totally submissive workforce re-evidence themselves in the practices and fantasies surrounding the role of robot workers."[50]

In essence, technoliberalism is an updated form of the liberal progress narrative for the 'postindustrial' era. The cultural, economic, and political affordances of this techno-centered analytic helps illuminate the continued production of social inequality through the political economy of the national security state, and the technoliberal machines it produces and puts to work. And where technoliberalism articulates and frames the ideology that informed automation, "technopolitics" provides an approach for engaging the technologies of automation, like industrial robots, directly. As historians Gabrielle Hecht and Paul Edwards describe them, technopolitics "captures the hybrid forms of power embedded in technological artifacts, systems,

[49] Neda Atanasoski and Kalindi Vora, *Surrogate Humanity: Race, Robots, and the Politics of Technological Futures* (Duke University Press, 2019), quotes from 4-5, 28 and 33.
[50] Atanasoski and Vora, quotes from 4-5, 28 and 33.

and practices" whereby the design and use of "technology strategically to achieve political goals" also necessitates the use of "political power strategically to achieve technical or scientific aims."[51] A major benefit of these approaches is their capacity to integrate specific actors, sites, and technologies with broader institutional and structural formations. This can, in turn, flesh out the occluded and submerged a/effects of these processes on the evolution and implications of automation during the Cold War.

The desire for and attempted production of more and more 'apolitical' machines (whether human or technological), therefore, are the warp and weft of technoliberalism. Ideology, however, does not practice make, and due to the inherent economic and financial risks of developing new science and technologies, the actuation of technoliberalism required a significant increase in state support for capital-intensive 'Big Science' and 'Big Technology' and a corresponding expansion in state capacities exemplified by the variety of defense agencies and organizations discussed as well as defense-adjacent institutions such as NASA, the National Bureau of Standards (NBS), and the National Science Foundation (NSF). Furthermore, there were a swath of much subtler modalities through which the American state underwrote innovation in the service of technological supremacy. These included but were not limited to: capital investment requirements for production contracts, government-financed production facilities, procurement contracts, R&D grants, and sales of surplus public property at pennies on the dollar, as well as what President Reagan called "tax code socialism," such as accelerated

[51] Gabrielle Hecht, "Introduction" in Gabrielle Hecht (ed.), *Entangled Geographies: Empire and Technopolitics in the Global Cold War* (The MIT Press, 2011), 3 and Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (MIT Press, 2010), 215.

depreciation schedules (for tangible assets), rapid amortization programs (for intangible assets), and Independent Research and Development (IR&D) write-offs.[52]

In essence, the national security state (NSS) was doing *stealth industrial policy* and the dissertation contributes to and expands on a burgeoning literature of what is often called the "hidden developmental state."[53] The justifications for state support of science and technology were more often than not couched in terms of 'national security' and the NSS that emerged by the 1950s to facilitate this took the form of what political scientist Linda Weiss has called a "technology enterprise."[54] From the origins of national security as a concept a corresponding 'security discourse' emerged that functioned much like the 'automation discourse' in that it elided rather than illuminated the mechanics of the NSS-as-technology-enterprise. In function, the term 'national security' (or simply 'security') became a political skeleton key for C. Wright Mills's "power elite"—it unlocked state activities and capacities that, in other domains and justified in different terms, would have remained sealed. While each public and private

[52] Glen Ross Asner, "The Cold War and American Industrial Research," PhD Dissertation, Carnegie Mellon University (August 2006); Fred Block and Matthew R. Keller (eds.), *State of Innovation: The U.S. Government's Role in Technology Development* (Routledge, 2011); Linda Weiss, *America Inc.?: Innovation and Enterprise in the National Security State* (Cornell University Press, 2014); and Mark R. Wilson, *Destructive Creation: American Business and the Winning of World War II* (University of Pennsylvania Press, 2016). Reagan's "tax code socialism" quote comes from Judith Stein, "It's the Trade Deficit, Not the Budget Deficit," *Dissent* (June 25, 2010).

[53] The idea of a "hidden developmental state" doing "stealth industrial policy" have been explored in Richard D. Bingham, *Industrial Policy American Style: From Hamilton to HDTV* (M. E. Sharpe, Inc., 1997); Fred Block, "Innovation and the Invisible Hand of Government" in Fred Block and Matthew R. Keller (eds.), *State of Innovation: The U.S. Government's Role in Technology Development* (Routledge, 2011), 1-26; Mariana Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (PublicAffairs, 2018); Philip Mirowski and Esther-Mirjam Sent, "The Commercialization of Science and the Response of STS" in Edward J. Hackett, Olga Amsterdamska, Michael Lynch, and Judy Wajcman (eds.), *The Handbook of Science Technology Studies, Third Edition* (The MIT Press, 2008), 652. For explorations of the "hidden welfare state" see Christopher Howard, *The Hidden Welfare State: Tax Expenditures and Social Policy in the United States* (Princeton University Press, 1997) and *The Welfare State Nobody Knows: Debunking Myths About U.S. Social Policy* (Princeton University Press, 2007); Suzanne Mettler, *The Submerged State: How Invisible Government Policies Undermine American Democracy* (University of Chicago Press, 2011); and Molly Michelmore, *Tax and Spend: The Welfare State, Tax Politics, and the Limits of American Liberalism* (University of Pennsylvania Press, 2012).

[54] Weiss, 4. In the same passage, Weiss argues that the NSS is "geared to the permanent mobilization of the nation's science and technology resources for military primacy." While this is not necessarily false, I would argue that military primacy is an adjunct to, derives from, and is a function of *economic primacy* (hence, why the 'Arsenal of Democracy,' not "the military," won World War II).

component of the NSS has its own history and particularities that complicate any conception of a monolithic or undifferentiated apparatus acting synchronously with deliberate and uniform purpose, the function of so much of what NSS actors did on a practical day-to-day basis was facilitating the RDT&E of technoliberalism and valorizing its logic. For this reason, the use of the term "NSS" throughout the dissertation is intended to both situate a particular subject's location or participation within the national security state (loosely defined) as well as that subject's role in the broader confines of technoliberalism.

Public and private actors alike, in the name of 'security,' therefore, tasked the American state with forging the technoscience that would hammer out the shield and sword of defense. The NSS and its partners manufactured a host of new administrative, institutional, and structural capacities to do more than just industrial policy. It played a key role in developing the "human" capital (e.g., engineers, scientists, and technicians) that could provide the research, development, test, and evaluation (RDT&E) services that turned "defense" technology *into capital* and military-funded fellowships, grants, research contracts, and eventually loan support through Congressional legislation in the form of the National Defense Education Act of 1958, provided the vast majority of resources for this talent. The importance of 'human resources' to national security—and thereby the economy that undergirded it—was hard to understate; as Alan Waterman, first chief scientist of the ONR (1946-1950) and first director of the NSF (1950-1963), put it in the mid-1950s: "The strength of American manpower in science and technology is pre-eminently a matter of national interest. Defense needs, centering in military research and development, attract the most attention, but actually our entire economy is dependent upon a relatively small group of about 650,000 engineers and 200,000 scientists."[55] This also gave rise

[55] Alan T. Waterman, "The Science of Producing Good Scientists," *New York Times*, July 31, 1955.

to a *stealth welfare state* as military funds paid for not just the education, training, and salaries of defense executives, managers, and workers but their healthcare benefits and retirement that functioned much like "hidden" or "submerged" welfare states.

The dissertation builds on a long line of American political historians who have studied the role of the federal government in driving economic development and social change, particularly through its military modality.[56] These studies, however, typically focus on the metropolitan or regional manifestations of these processes, and the NSS actors who used a host of 'supply side' economic tools to actuate technoliberalism were focused on the science and technology that would drive socioeconomic change. The combination of *stealth industrial policy* and a *stealth welfare state* structurally cultivated a *stealth political economy* that could inductively develop the concrete defense-supported inputs that went into automation and the industrial robot (e.g., computers, electronics, mechanical manipulators, memory systems, and numerical control techniques) which, with various inducements of the NSS throughout their life cycles, generated economic benefits that were *intended* to flow to private actors.[57] In concert, this panoply of state support underwrote, subsidized, financially incentivized, and created conducive spaces for 'innovation' and risk-taking in the Cold War high-tech economy.

[56] Roger W. Lotchin, *Fortress California, 1910-1961: From Warfare to Welfare* (University of Illinois Press, 2002); Margaret Pugh O'Mara, *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley* (Princeton University Press, 2015); Bruce J. Schulman, *From Cotton Belt to Sunbelt: Federal Policy, Economic Development, and the Transformation of the South 1938–1980* (Duke University Press, 1994); Philip Scranton (ed.), *The Second Wave: Southern Industrialization from the 1940s to the 1970s* (University of Georgia Press, 2001); and Elizabeth Tandy Shermer, *Sunbelt Capitalism: Phoenix and the Transformation of American Politics* (University of Pennsylvania Press, 2015).

[57] Historian and STS scholar Philip Mirowski, in a talk about the commercialization of science, flippantly (though accurately) asserted, "Why should private firms or individuals capture the benefits of research subsidized by the state? If you ask that question you just show how stupid you are." See, Philip Mirowski, "The Global Restructuring of Science as a Marketplace of Ideas," Trust in Science Workshop, CBC Conference Centre, Toronto, ON (Oct. 15-16, 2007), https://www.youtube.com/watch?v=2J13SDqmaNw beginning at approximately 39:40.

In schematic terms, the emergent institutions, relationships, and structures that made up the NSS-as-technology-enterprise came to resemble what historian Brent Cebul calls 'supply-side liberalism'—the promotion of locally rooted, market-based public-private development projects financed and fostered by the federal government for the purpose of stimulating economic growth to solve social problems. Examples of these projects range from building hospitals, schools, transportation infrastructure, and underwriting urban renewal, to incentivizing borrowing, insuring investments, and subsidizing labor programs. 'Supply-side liberalism' proved politically acceptable to liberals and conservatives alike, as "supply-side liberals" faith in markets and development-qua-social policy found willing partners in conservative local business elites who disdained 'big government' in Washington, D.C. but were more than willing and able to function as on-the-ground "supply-side state builders" in their localities. What emerged from this "growth coalition" was a governance structure Cebul calls the "decentralized administrative state," which "dispers[ed] authority over the administration of significant national capacities to urban governments and their private-sector partners." This, in effect, allowed local business elites and their political partners to exercise authorities and capacities previously reserved for the federal government, the results of which often exacerbated, or produced anew, Jim Crow-like relationships of political and socioeconomic inequality between communities of color and the White working class in the North and South alike.[58]

The NSS functioned in a very similar way: a variety of private and public actors from for-profit corporations, think tanks, and universities used federal support to fund, subsidize, and underwrite a slew of initiatives to create the science and technology that not only drive the

[58] Brent Cebul, *Illusions of Progress: Business, Poverty, and Liberalism in the American Century* (University of Pennsylvania Press, 2023), 1-22, quote from 8 and "Supply-Side Liberalism- Fiscal Crisis, Post-Industrial Policy, and the Rise of the New Democrats - Brent Cebul," *Modern American History*, Vol. 2 (2019), 139–164.

market-based economic growth that produced security but contributed to the amorphous and neverending project of "progress." Examples of these ranged from computers and containerization to new medicines and nuclear power, and of course, automation and industrial robots. These processes and products proved even more politically acceptable than 'supply-side liberalism' as the project of national security was a decidedly bipartisan affair during the Cold War. Echoing historian Matthew Lassiter's call to move state-centered political history "beyond the Red-Blue divide," historian Michael Brenes has argued that a "Cold War coalition" emerged from the New Deal order which "rejected rigid binaries of 'liberal' and conservative'" in an effort to develop, and protect, their relationships with the NSS.[59]

In this coalition, liberals often acted like Cebul's "supply-side state builders," managing defense-funded companies, think tanks, and universities, while what could be called 'demand-side conservatives' were more than happy to reap the benefits of the military Keynesianism that built the Sunbelt. The governance structure the NSS invigorated took the form of a 'decentralized entrepreneurial state' where individuals and institutions became, effectively, parastatal actors that took private risks with public resources to create the science and technology to produce the security the American state was entrusted with providing. Parastatal actors reaped the rewards of economic, political, and social power their relationships to the NSS provided while generating or amplifying many of the same political and socioeconomic outcomes and processes as 'supply-side liberalism.' The NSS, therefore, did *supply-side technoliberalism*, and the dissertation will demonstrate how the industrial robot, the parastatal actors who built and

[59] Matthew D. Lassiter, "Political History beyond the Red-Blue Divide," *The Journal of American History*, Vol. 98, No. 3 (December 2011), 760-764 and "Ten Propositions for the New Political History," in Brent Cebul, Lily Geismer, and Mason B. Williams (eds.), *Shaped by the State: Toward a New Political History of the Twentieth Century* (University of Chicago Press, 2019), 363-376; and Michael Brenes, *For Might and Right: Cold War Defense Spending and the Remaking of American Democracy* (University of Massachusetts Press, 2020), 10.

managed them, and the socioeconomic modalities through which they accomplished this, all served as "Arms of the State."

While the NSS rarely ever dictated to its partners in the private sector, the monopsony nature of the military modality facilitating the vast majority of these processes meant that the **ding** of 'defense' dollars had predictably Pavlovian responses of salivary compliance.[60] Large prime contractors such as Boeing, Lockheed, and Raytheon were essentially adjuncts of the Defense Department while putatively 'non-defense' corporations like the Big Three automakers were, in terms of size and volume, consistently in the top twenty of defense contractors in the country. Additionally, small and medium-sized firms, both for and non-profit, who often served as subcontractors to the 'primes,' became the dispersed appendages of defense production.

No institution, however, was more notably transformed by the military munificence of supply-side technoliberalism than the university. Defense funding helped turn not only the Massachusetts Institute of Technology (MIT) into "Pentagon East" and Stanford University into "Pentagon West," but even public institutions such as the University of Michigan into "Pentagon Midwest."[61] Not surprisingly, MIT and Stanford, as well as their corresponding regional metropoles 'Route 128' and 'Silicon Valley,' loom large in the history of automation and the industrial robot. Besides being involved in the development of almost all of the constituent technologies that made up the industrial robot (sans mechanical manipulators), the Department of Defense underwrote the uptake of artificial intelligence (AI) at both universities in the 1960s,

[60] A key exception that could be interpreted as "dictation" is the case of the Bell System consent decree in 1956 which, in addition to barring it from entering any industry other than telecommunications, forced AT&T to license all its patents royalty free (a legal relationship called "compulsory licensing"). This led to the rapid diffusion of the Bell Labs' developed bipolar junction transistor that was critical to the design and manufacture of integrated circuits which made the downscaling of computing possible.

[61] Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (Columbia University Press, 1993) and Salem Elzway, "Pentagon Midwest: Making the Military-Industrial-Academic Complex (and Its Discontents) at the University of Michigan," *The Michigan Historical Review*, Vol. 44, Iss. 1 (Spring 2018).

leading to the founding of robotics as an academic field that, with further support from NASA and NSF, advanced the art of automation in the 1970s and beyond. Similar projects also began taking place at a growing number of universities including Carnegie Mellon, Florida, Illinois, Purdue, Rochester, and Utah as well as former university-affiliated research institutes such as the Charles Stark Draper Lab (MIT) and the Stanford Research Institute (SRI International). Furthermore, constituents of these laboratories—almost without exception affluent, well-educated White men—had a significant amount of freedom to control the technologies and techniques developed on the public dime, allowing researchers to profit from their work through consulting, intellectual property, startups, and technology transfers.

This constellation of individuals, institutions, and ideas, what historian Stuart Leslie has called the "military-industrial-academic complex," were not only mutually oriented around the development of new technologies and techniques but also became a bazaar for them. One episode from the development of AI and robotics provides a case in point. In early 1957, two engineers named Ken Olsen and Harlan Anderson at MIT's defense-funded Lincoln Laboratories decided to capitalize on their experience working with computers. One of these machines, the TX-0, was in their estimation ripe for commercialization. The "tix oh" would soon become famous as the computer that spawned 'hacker culture' at MIT and, less well known, the computer used for the first academic experiment in robotics at one of the university's other major defense-funded facilities, the Research Laboratory of Electronics (RLE).

Olsen and Anderson eventually convinced Georges Doriot and his company American Research and Development Corporation to invest in their idea. As a signal example of the 'revolving door' that was the NSS, former lieutenant colonel Doriot was deeply integrated into the military-industrial-academic complex: after serving as a director in the Army's

Quartermaster General office during WWII, Doriot became a professor of industrial management at the Harvard Business School where in 1951 he supervised the first academic project on automation (student-led by none other than John Diebold) and, two years later, he took a seat on the board of major military contractor American Machine & Foundry which, during his tenure, developed the 'Versatran' industrial robot. With Doriot and ARD's support, Olsen and Anderson's new company Digital Equipment Corporation (DEC) developed the PDP series of minicomputers, one of the most successful product lines in the nascent computer industry.

The first PDP-1 went to Bolt, Beranek and Newman (BBN)—a pioneering computer R&D firm that hired John McCarthy, the "Father of Artificial Intelligence," and Marvin Minsky, the "Father of Robotics," as consultants—while the MIT and Stanford artificial intelligence labs (founded, not coincidentally, by Minsky and McCarthy, respectively) used PDPs for their experiments throughout the 1960s and 1970s. During this same period at Stanford, a student and entrepreneur named Victor Scheinman programmed his pathbreaking "Stanford Arm" on a PDP-11/45 and started a small firm called Vicarm to commercialize the technology, which he eventually sold to Unimation. Vicarm's designs and expertise served as the basis for a joint development between GM (also using PDPs for their internal robotics works) and Unimation on what became the Programmable Universal Machine for Assembly (PUMA) industrial robot, the most advanced automation system of the era. In short, the 'Invisible Hand' of the market that transformed technologies into machines of capital accumulation was more often than not attached to the 'Invisible Arm' of the state.

**Accumulation Machines: The Industrial Robot as Mechanical Slave**

One of the key lessons emerging from the history of industrial robots and the American state is simple and obvious once observed: *automation is capital*. The concrete instantiations and material processes referred to as 'automation' were literally physical pieces of capital put to work for capital accumulation. While the evolving amorphous, capacious, and plastic nature of 'automation' mystified its actuality—the degradation and intensification of work, the erosion of labor's power, increasing state support for technological development, and spreading underemployment—the term's real power was in obscuring the engine of its actuation: capitalist social relations. Automation was intended to do as much and designed as such. "In dealing with the economic impact [of industrial robots]," the Engelberger told the IIT symposium attendees, "we start on familiar ground because [they] are looked upon as *capital equipment investments*." Furthermore, he argued, industrial robots "compete with other opportunities for employment of capital" and the decision to employ an industrial robot should be based on the economics of payback periods, returns on investment, and the present value of future earnings.[62]

Assessing the economics of capital in isolation from labor is relatively meaningless, particularly in the case of the industrial robot. Like the goal set by Ford's Del Harder in 1947 of eliminating at least one worker per automation device, Engelberger assessed almost twenty-five years later that the industrial robot should be looked upon as a "one for one replacement for a human operator."[63] While the economics seemingly equated across time, the form capital took did not. In Harder's era, automation was rigid, entailing re-engineering not just single lines of production but often entire factories, with the process having to be repeated for every new product or technological innovation. In short, 'Detroit,' 'hard,' or 'special' automation as it was often called, was expensive and inflexible. Labor displacement under this form of automation

[62] Engelberger, "Economic and Sociological Impact of Industrial Robots," 2.
[63] Engelberger, "Economic and Sociological Impact of Industrial Robots," 2.

was relatively indirect: when an old plant was automated, existing or increasing volumes of production could be handled with fewer workers; when a new, automated plant was built, production was shifted from old to new, with the former incurring a decrease in employment.

The industrial robot, in contrast, was a unique form of automation designed and intended to replace a single worker, literally in the corporeal sense, and therefore became the apex of 'flexible' automation. Rather than spending tens of millions of dollars reengineering entire processes or building new automated plants, an industrial robot costing tens of thousands of dollars could be slotted directly in where a worker had previously been.[64] The industrial robot's reprogrammability made it a unique form of automation and allowed it to accomplish a variety of work tasks, thereby enhancing management's power to automate specific jobs (and their corresponding classifications). The first jobs targeted were the "dull, dirty, and dangerous" (3D) or "hot, heavy, and hazardous" (3H) ones, and both the buyers and sellers of industrial robots positioned the technology in the benevolent terms of relieving workers from doing these. The purpose from the jump, however, was simply to reduce costs. With his characteristic blunt honesty, Engelberger explained to sci-fi luminary Isaac Asimov, "Ultimately, forget about the nobility crap. Nobody puts a robot to work because they want to make life easier for their employees. They put it to work for economic savings."[65] Accordingly, industrial robots were *not* put to work as long as their human counterparts were cheaper.

When managers put industrial robots to work, the decision had not just economic but political and social consequences. Due to decades of discrimination, Black workers were disproportionately assigned to the 3D/3H jobs and, correspondingly, were often the most militant on and off the shopfloor. As a result, management's programming of industrial robots to do what

[64] That this was much harder to accomplish in practice is a separate issue taken up throughout the dissertation.
[65] Isaac Asimov and Karen A. Frenkel, *Robots: Machines in Man's Image* (Harmony Books, 1985), 36.

was often called "black work" meant that Black men and the most militant workers were disproportionately displaced with technology.[66] Furthermore, the naturalization of 3D/3H jobs as if they sprung from the ground rather than as a product of capitalist social relations, and the political economy of first forcing then coercing people of color into doing such labor, was reproduced by the automation and robot discourses. Nonetheless, changing cultural and political mores flowing from decades of civil rights struggles made it much more difficult to racially justify the offloading of the worst work onto the backs of the marginalized and vulnerable, so management tasked racialized machines with the labor instead. As Engelberger told a journalist in 1974, "Since we can't have slaves or kick around black people anymore, the robot serves that purpose."[67] Race, therefore, was sublimated into the sociotechnical relations of capital accumulation and, in essence, automation can be understood as the technification of racialized labor. As a result, industrial robots can be thought of as *mechanical slaves* put to work for the continued and more efficient manufacture of racialized capitalism.

The dissertation directly engages the relationship between automation and the production of racial difference, a topic Noble eschewed, and investigates what the desire to replace human workers with 'mechanical slaves' (i.e., industrial robots) can tell us about the evolution of capitalism in the United States. For instance, Noble's machinists who were deskilled and replaced with them—commonly called the "aristocracy of labor'—were, with little to no exception, White males. Racial feudalism within unions provided White men with the opportunity to access apprenticeship and training programs for skills development that was almost completely closed off to nonwhite men and women of any race. This opened the door to

[66] For the racialization of labor see Robin D. G. Kelley, *Race Rebels: Culture, Politics, and the Black Working Class* (Free Press, 1996), 30-31 and David R. Roediger, *The Wages of Whiteness: Race and the Making of the American Working Class* (Verso Books, 2007), 144-150.
[67] Lind, 40.

the “wages of whiteness,” which included not only higher salaries and better benefits but greater job security, greater political power within unions, and greater control of labor for White workers (at least in relation to their “lesser” skilled, particularly Black and Brown, comrades). But this latter privilege is also what made their jobs prime targets for automation.

The desire of the aerospace industry, the Air Force, and MIT engineers—in other words the NSS—to inscribe managerial prerogatives into the form and function of N/C machine tools meant that, in addition to deskilling and replacing labor, “social choice in machine design” led to the erosion of racial privilege. While “whiteness” may have protected the ‘aristocracy of labor’ from the ravages of capital for a time, it did not permanently inoculate them from the socioeconomic dislocations flowing from supply-side technoliberalism. Automation, therefore, can be understood as a harbinger of an increasingly ‘neoliberalized’ form of state-subsidized racial capitalism that, in technopolitical fashion, decreases workers’ control of production and denudes labor’s political power—all to increase productivity, profits, and the power of those in control of the ‘forces of production.’

**Plan of the Dissertation**

The dissertation is composed of six topically focused chapters that proceed in a ‘two-steps forward one-step back’ chronological manner. While the chapters can be read separately, they are designed to hang together with each providing context and clues for the next. The intent of the dissertation is to provide the basis for further investigation into this first half of the industrial robot’s history, which will then serve as the foundation for a manuscript that will bring the second half of the story as close to the present as possible.

The dissertation's archive is composed of a wide range of primary and secondary as well published and unpublished source material including academic papers, congressional hearings and reports, periodicals, personal papers, political newsletters, private correspondence, trade journals, White House files, and works of science fiction. Notably, the dissertation is the first to use the George Devol Jr. Records housed at the Benson Ford Research Center in Dearborn, Michigan to archivally ground the oft mystified and mythologized story of Unimation. The General Motors Heritage Center, approximately thirty miles north in Warren, MI, also contains a variety of documents never before cited that provide a significant amount of material for understanding what the use of industrial robots looked like in practice and for reinterpreting the events leading up to the UAW strike of the GM Lordstown Assembly plant in 1972. Furthermore, the Stanford Artificial Intelligence Laboratory Dump and Restore Tapes (SAILDART), the electronic repository of SAIL's communications from approximately 1972-1990, provides a wealth of materials that, to my knowledge, have never been used before. The files therein allow for a detailed discussion of the supply-side technoliberalism that helped advance robotics in Silicon Valley, the hardware and software of which were critical to the development of GM's landmark PUMA industrial robot. In totality, the dissertation uses these source innovations to illuminate a number of historical connections and processes that otherwise would remain occluded and are, in my estimation, critical to understanding the history of automation.

Chapter One, "Technoliberal Machines: Robot Discourse in the Age of Automation," provides a discursive analysis of the term 'robot' in relation to the emergence and evolution of 'automation' as a concept and material practice beginning in the 1930s. The chapter begins with an introduction to the idea of "mechanical slavery"—the notion that a more perfect society

entailed the enslavement of machines rather than humans—and how the medium of science fiction transformed the racialized 'mechanical slave' into the seemingly unraced robot. Next, the work of Isaac Asimov, perhaps the most prolific sci-fi author of the twentieth century who also coined the term "robotics," will be analyzed as his robot stories were the most direct technoliberal vector through which 'mechanical slavery' and race were sublimated into the form of his "benevolent" robots. Asimov's work is critical as a number of men who would develop the science and technology of the industrial robot, such as Joseph Engelberger and Marvin Minsky, routinely cited Asimov as the luminary who inspired their imagination. The chapter then uses a variety of published and unpublished sources including academic studies, the business press, the Ford Motor Company archives, and trade journals to follow the development of the concept of 'automation' from its origins in the auto industry of the 1930s to its academic uptake at the Harvard Business School in the late 1940s and early 1950s. Specific attention is paid to the work of Ford executive Del Harder, who coined the term "automation," and public intellectual John Diebold who, more than anyone else, popularized the term. Finally, the chapter will closely read congressional documents of the mid and later 1950s to highlight how a variety of actors in similar language merged the 'automation discourse' and 'robot discourse' with the discourse of 'national security,' and, in essence, 'securitized' technoliberalism.

Chapter Two, "Jim Crow-bot: Automation and Race from Industrial Relations to the Welfare State," explores how the negative effects of automation disproportionately borne by people of color were politically inscribed into the structures of industrial relations and the welfare state during the 1950s and 1960s. The chapter first charts how 'automation' emerged on the labor movement's radar and how their analysis of automation and robots, particularly in the weekly newspaper of the Congress of Industrial Organizations (CIO), *The CIO News*, and the

archives of the UAW, spoke in, and thereby discursively reinscribed, the language of capitalist social relations and technoliberalism. Next, it will review how the political economy of 'production standards'—the who, what, when, where, why, and how of work on the shopfloor—structured the UAW's and the broader labor movement's relationship and response to automation. Particular attention will be paid to how Black autoworkers grappled with this political economy and how Black civil rights and labor leaders translated their experiences with automation into the realm of national politics. The chapter then overviews how automation became a site of political contestation in the shaping of the welfare state, and how this played out in the public sector during the 1960s. Race became an explicit domain of political contestation as national leaders across the ideological and political spectrum were well aware of the disproportionate effects automation was having on Black and Brown communities. The welfare state responded to automation by attempting to mitigate its negative effects (the attempts of which were relatively ineffectual) while also hemming in calls to challenge the business community's "right to manage" automation as they saw fit and calls to redirect supply-side technoliberalism from the rich to the poor. Finally, the chapter returns to the auto industry to analyze how the UAW, with these broad structures of production standards and welfare in place, dealt with the looming threat of robotization at the end of the 1960s.

Chapter Three, "The Military Industrial Robot Complex: Supply-Side Technoliberalism and the Rise of Unimation," explores how the American state, particularly through its military modality, began underwriting the development of the industrial robot in the 1940s. The chapter begins with a narrative history of the life of George C. Devol Jr., who is popularly identified with "inventing" the industrial robot when he filed his "Programmed Article Transfer" patent in 1954. Devol's life story has only been briefly sketched in a few non-academic articles and interviews

that solely frame him as a "genius inventor in his garret" rather than as an inveterate tinkerer whose talents were cultivated during and after World War II by the then yet to be named 'military-industrial complex.' The chapter then introduces young entrepreneur and physicist Joseph F. Engelberger and chronicles his early career and eventual partnership with Devol. Rather than originating during a 1956 cocktail party as the popular mythology would have us believe, the relationship that led to the development of their "Unimate" industrial robot and their co-founding of Unimation, the world's first company dedicated to the design, sale, and service of the industrial robots, was a much more staid affair of a technologist searching for investment and finding it from a like-minded entrepreneur. Like Devol's history, this story is a relative mystery, and the chapter provides the first archivally based recounting of how the most important industrial robot and the most important industrial robot company in history got their start. Finally, the chapter will close with brief snapshots of other industrial robot developments during the 1950s and early 1960s which were, not surprisingly, products of the military-industrial complex. In tandem, the Unimate and Unimation became the driving forces of the American industrial robot industry and exemplifies how the supply-side technoliberalism of the American state subtly created spaces conducive for investing in the risky R&D the industrial robot required for its technical viability.

Chapter Four, "Armed Algorithms: The Dawn of Robotics at MIT and Stanford," charts the founding of robotics as an academic and scientific field of inquiry at "Pentagon East" and "Pentagon West," and the new discipline's criticality to the nascent project of AI. The chapter begins with a political history of how MIT acquired ARPA funding for 'Project MAC,' one the most important computing projects of the Cold War that provided the resources for the university's pioneering AI and robotics research. Next, the origins of robotics will be charted,

first through the work of Heinrich "Henry" Ernst whose 1961 doctoral thesis "MH-1, A Computer-Operated Mechanical Hand" launched the field, and then through the first robotics experiments at the MIT and Stanford AI labs during the 1960s. Ernst's thesis was critical as it developed an experimental environment called the "Blocks World" that became a technoscientific testbed of AI as the nascent discipline began incorporating manipulation of the physical world into its paradigm of what constituted "intelligence." Additionally, Ernst explicitly framed his results in terms of how a "computer-operated mechanical hand," or 'industrial robot,' could advance the art of automation. The development of robotics in relation to automation, therefore, played a key role in the development of AI, and vice versa, as both fields fed off each other. Critically, due to their relationships with the NSS, the "Artificial Intelligentsia" (as one skeptical commentator called them) were able to use its bureaucracy and discourse to secure not just millions of dollars in funding but perhaps most importantly, freedom and time to explore the worlds they were building with little to no interference from their superiors or the American state. Nevertheless, they quickly learned that the impressive feats of their 'armed algorithms' only worked as designed in the calibrated, consciously crafted, and carefully controlled experimental spaces of the laboratory which was a far cry from the "real world." Accordingly, while their experiments were embedded in the project of automation from MH-1 onward, by the 1970s, advancing automation in the real world became a much more explicit goal of both labs.

Chapter Five, "Robots on the Line: The Technopolitics of Autowork at Lordstown," details how automation, labor, and race were entangled and interacted in the late 1960s and early 1970s at the world's first mass-robotized factory, the GM Lordstown assembly plant in northeast Ohio. While the UAW strike of Lordstown in 1972 has received a significant amount of attention and come to symbolize a pivot in the labor-management dynamics of the 'New Deal Order,' not

much is actually known about the history of Lordstown itself. The chapter, therefore, describes the plant's founding, plans for which began as early as 1956, and its sociotechnical evolution up through the "Revolt of the Robots" in 1972. If little is known about the plant itself, even less is known about Lordstown's most famous "workers," the spot welding Unimate industrial robots. The famous Chevrolet Vega assembled at Lordstown was designed specifically for robotic production, and when the Unimates went to work spot welding the Vega's body modules, the resulting productivity increases allowed GM's management to lay off 80-100 human spot welders. Spot welding was a quintessentially 'hot, heavy, and hazardous' job, which meant that Lordstown's Black workers, already a small minority in the plant, were disproportionately affected by the choice to robotize. The history of the plant provides a window into what 'production standards' in the age of automation looked like in concrete terms and how they were enforced in practice by GM's most notorious management group, the General Motors Assembly Division (GMMAD), during a crucial stage in the American auto industry's evolution. Specifically, the Lordstown episode demonstrates how the hype of automation often outstripped its performance. The fabled benefits flowing from a computerized and robotized assembly line, GM's single most expensive investment ever, manufactured not quality cars and productive workers but a twenty-two day strike motivated by the 'alienation' and 'dehumanization' of automated production and a car more famous for its recalls than sales. Furthermore, automation at Lordstown provides a potent example of *technopolitics* as the plant's automated systems were purposely designed to not only increase productivity but police the human and robotic workers on the automated assembly line to reduce the probability of strikes that would stop it. This was technopolitics par excellence, and rather than the cyborg of cinematic satire, the Lordstown assembly line was perhaps the first RoboCop.

Chapter Six, “Programmable Universal Machine for Accumulation: The Robotics Revolution in the Rustbelt and Silicon Valley,” continues the story of robotics begun in Chapter Three into the early 1980s. The 1970s proved to be a pivotal decade for both the industrial robot and robotics as a discipline. While artificial intelligence (AI) was purportedly going through its first “AI winter”—a term describing the interdependent decrease in funding and interest following unproductive hype cycles about the technology’s practical and/or revolutionary applications—a “Robotic summer” was in bloom. The technology’s most impressive advancements were made by Stanford University grad student Victor Scheinman, a poster child of the ‘military-industrial-academic complex’ who proved to be a wunderkind in developing robotics arms, and by Stanford Research Institute project manager Charles Rosen, a pioneer in the practical applications of computer vision for automation. Simultaneously, the General Motors Research (GMR) labs in Warren, MI established one of the first corporate robotics projects in the world that GM executives tasked with researching the economic and technical feasibility of applying computer vision and robotics to the assembly of complex industrial parts. All three parties eventually came together through the nexus of Unimation when Engelberger bought Scheinman’s robotic arm startup, called Vicarm, and leveraged the firm’s expertise to win the bid to develop the PUMA (Programmed Universal Machine for Assembly) industrial robot at GM, which incorporated techniques tested by Rosen’s NSF-funded automation program at SRI. The chapter, in essence, charts what the transfer of publicly funded expert knowledge, practical skills, and technoscience to industry looked like in practice. Announcement of the PUMA garnered a significant amount of press coverage, much of which recycled the age-old ‘promise and peril’ tropes from the automation and robot discourses of decades past. The question, of course, was “Is this time different?” The answer, it turned out, was no. The chapter, in essence,

charts how supply-side technoliberalism transferred publicly funded expert knowledge, practical skills, and technoscience to industry and what this looked like in practice.

The epilogue very briefly touches on the migration of the industrial robot abroad, the domestic and international politics of this development, and the fall of Unimation. The latter of these events signaled the collapse of the American industrial robot industry and revealed that decades of public support for science and technology did not guarantee that the 'Invisible Hand' of American capitalism was willing to build the future it sold. It was willing, however, to solidify its profitable relationship with the 'Invisible Arm' of the American state.

## Chapter 1 — Technoliberal Machines: Robots in the Age of Automation

*Aristotle dreamed of the day when "every tool, when summoned, or even of its own accord, could do the work that befits it." In the long run, automation promises to make Aristotle's dream a reality.*

John Diebold (1956)[1]

In March 1942, Isaac Asimov, then a young civilian chemist working at the Philadelphia Navy Yard's Naval Air Experimental Station, published a short story called "Runaround" in *Astounding Science Fiction*, the era's leading science-fiction pulp magazine. The lighthearted tale about a group of sentient machines navigating thorny issues with their programming is widely regarded as the foundational story of robots in the United States. It was also the first-time readers were introduced to the term and concept of 'robotics'—the science of robots—which Asimov coined.[2]

The military was indirectly funding this creativity as would become a pattern in the development of robots both in science fiction and science fact. Asimov was paid the "unheard-of-munificence" of $2,600 per year, by far the most money he had made in his life. Furthermore, and perhaps more importantly for the relationships it would establish, Asimov was recruited to

[1] John Diebold, "Automation Pilots A New Revolution," *Challenge*, Vol. 5, No. 2 (Nov., 1956), 15.
[2] According to Asimov, "I didn't realize this until many years later, for at the time I first used the word, I thought it was a word actually used by scientists in this connection. It was, after all, analogous to 'physics,' 'hydraulics,' 'mechanics,' 'statics,' and various other words of this form used to denote a branch of physics-related science," Isaac Asimov, *In Memory Yet Green: The Autobiography of Isaac Asimov, 1920-1954* (Avon Books, 1979), 286 fn. 7.

Philadelphia by prominent sci-fi writer and Navy officer Robert Heinlein to join him and his small group of sci-fi writer-researchers (one of which was Asimov's favorite writer L. Sprague De Camp).[3] While there, the local press castigated the group as "blue-sky thinkers who never came up with anything" and found it hilarious that sci-fi writers were put in service to help win the war.[4] Not deterred in the slightest, Asimov continued to publish robot stories such as "Catch That Rabbit" and "Escape!" from 1942-1945 while in Philadelphia, which with "Runaround" became part of his landmark 1950 collection *I, Robot*.

While Asimov's military "career" would end in Philadelphia the ideas he germinated there became critical to a number of men who would develop the science and technology of the industrial robot. Engelberger and Minsky routinely cited Asimov as the luminary who inspired their imagination. In Engelberger's words, "Asimov coined the name of the trade, 'robotics,' and he provided all of us roboticists with an ethic," which drew him to the "happier light" that Asimov shined on "benevolent" robots.[5] Similarly, Minsky told an interviewer, "I remember reading [Asimov's] first robot stories and deciding I was going to build them."[6] And like the munificence that underwrote Asimov's ideas, Engelberger, president of a defense contractor, and Minsky, director of a defense-funded laboratory, owed their creative freedom to the military.

But what exactly did these robot ideas entail? The following chapter will address this question by providing a discursive analysis of the term 'robot' in three different registers: science fiction (sci-fi), automation, and national security. Each of these built upon the other as sci-fi robot became an iconograph of automation, which a variety of social actors envisioned as a

[3] Asimov, *In Memory Yet Green: The Autobiography of Isaac Asimov*, 238 and 430, quote from 338; and Charles E. Gannon, "Imag(in)ing Tomorrow's Wars and Weapons," *Peace Review*, Vol. 21, No. 2, (2009), 198-199.
[4] Isaac Asimov, *In Memory Yet Green: The Autobiography of Isaac Asimov, 1920-1954* (Avon Books, 1979), 451.
[5] Joseph F. Engelberger, *Robotics in Practice: Management and Applications of Industrial Robots* (Kogan Page, 1982), 3
[6] Sheldon Teitelbaum, "Scientists Say Asimov Put the Stars in Their Eyes," *Los Angeles Times*, April 8, 1992.

significant determinant of national security. Furthermore, the political economy of national security that cultivated automation played a key role in transforming the robot of science fiction into the industrial robot of science fact. Using the lens of technoliberalism, which posits that technology advances freedom through the elimination of labor and thereby the transcendence of social difference, the chapter will introduce the idea of "mechanical slavery"—the notion that a more perfect society entailed the enslavement of machines rather than humans—and how the idea in its sci-fi form reimagined the racialized 'mechanical slave' as a seemingly unraced robot. This reimagining was pervasive in sci-fi literature, and no single author sublimated 'mechanical slavery,' race, and work into the technoliberal artifact of the "benevolent" robot more than Asimov.

The chapter then turns its attention to the emergence and early evolution of 'automation' from the mid 1930s into the mid 1950s. Specific attention is paid to the work of Ford executive Del Harder, who coined the term "automation" in 1936, and public intellectual John Diebold who, more than anyone else, popularized the term as it diffused across American society in the 1950s. While 'the robot' as a symbol, synonym, and trope for automaticity, mechanicity, and the technological transformation of work predated automation, the latter's physical and practical uptake in the auto industry of the late 1940s provided evidence that science fiction was looking more and more like science fact. As a result, the 'robot discourse' and 'automation discourse' became entangled from automation's origins and were often used interchangeably to describe automatic processes in industry and society.[7] Furthermore, unlike the still fictional nature of

[7] This chapter primarily focuses on how actors with direct and uncritical interests in building the automated future understood and used the terms 'robot' and 'automation.' Labor's relationship to robots and automation will be analyzed in Chapter Two.

robots, automation was an actually existing phenomenon, and therefore became a concrete example and instantiation of technoliberalism.

Finally, national security became a particularly potent domain of technoliberal transformation as corporate executives, intellectuals, labors leaders, and politicians quickly metabolized automation into the conceptualization of 'security.' The section will closely read Congressional documents from the mid and later 1950s to highlight how actors in business, government, labor, and the public sphere merged the 'automation discourse' and 'robot discourse' with the discourse of 'national security,' to, in essence, 'securitize' technoliberalism. These actors used extremely similar language, and all came to the same conclusion: The basis of national security was a strong economy, a strong economy required high productivity, productivity was a function of technology, and technology would not be developed unless the government underwrote the process. The question then became not *if* but *how* the American state would accomplish this. The solutions proffered included a variety of supply-side tools for developing markets and technologies that would generate economic growth and thereby security. In totality, the chapter traces how private and public actors committed to the project of automation transformed the ideology of technoliberalism into the practice of supply-side technoliberalism, and sets the stage in later chapters for the exploration of how technoliberalism and its supply-side variant produced the very social problems they were imagined as solving.

**Mechanical Slaves: The Science Fiction Firmament of the Industrial Robot**

The conception of the machine-as-slave and the slave-as-machine stretches back millenia and was perhaps most famously articulated by Aristotle in his defense of slavery as a necessary

institution for human flourishing. Aristotle posited that the nature of the slave was not simply as a piece of animate property but equivalent in purpose to that of an inanimate tool designed and used for production. He musically surmised, therefore, that if "shuttles in a loom could fly to and fro and a plucker play a lyre of their own accord, then master- craftsmen would have no need of servants nor masters of slaves."[8] More than two thousand years later, the notion that "mechanical servants" would replace chattel slaves became commonplace during the Industrial Revolution as the "mechanical work" done by industrial machines was substituted for the physical labor of humans.[9] And on the eve of the twentieth century, Oscar Wilde echoed Aristotle's assessment of why this was so: "The fact is, that civilization requires slaves. The Greeks were quite right there. Unless there are slaves to do the ugly, horrible, uninteresting work, culture, and contemplation become almost impossible. Human slavery is wrong, insecure, and demoralizing. On mechanical slavery, on the slavery of the machine, the future of the world depends."[10] While "mechanical slave" became a commonplace in the American lexicon as early as the Great Depression, the more popular and increasingly ubiquitous term for the mechanical slave (perhaps due to the phrase's connotations) was "robot."[11]

Science fiction was the primary vector through which the mechanical slave was transformed into the "robot"—a term that described both the mechanization of the human worker and the machines that were envisioned to replace them. Mary Shelley's "Promethean" monster in *Frankenstein* (1818), the "Darwinian" machines of Samuel Butler's *Erewhon* (1872), and Karl

[8] T. A. Sinclair (translator) and Trevor J. Saunders, *Aristotle: The Politics* (Penguin Books, 1981), 64-65.
[9] Thomas Brandstetter, "The Lives of Mechanical Servants," *Interdisciplinary Science Reviews*, Vol. 37, No. 4 (December, 2012), 347-348.
[10] Oscar Wilde, "The Soul of Man Under Socialism," 1893, https://libcom.org/library/soul-of-man-under-socialism-oscar-wilde.
[11] Dustin A. Abnet, *The American Robot: A Cultural History* (University of Chicago Press, 2020) and Amy Sue Bix, *Inventing Ourselves Out of Jobs?: America's Debate Over Technological Unemployment, 1929-1981* (The Johns Hopkins University Press, 2000).

Capek's "Universal Robots" in *R.U.R.* (1920)—all conceived during the hundred-year global transformation from slave capitalism to industrial capitalism—were imagined as mechanical slaves who, if animated, would threaten their creators and masters by no longer serving their social function. These stories, and others in the genre's early development, propagated two major themes of science fiction that are still prominent today: first, that a "race" of mechanical slaves would occupy the social position and do the work of the chattel slave which, at the time, was commonly referred to as "n***** work;" and second, that the use of mechanical slaves as chattel would lead to a rebellion of the enslaved against their masters, what was simply a science-fiction inflected articulation of enslavers' fears of slave revolts.[12] The technoliberal problem expressed in these texts, therefore, was how to create a form of slavery without the risk.

Capek's dramatic stage-play *R.U.R. (Rossum's Universal Robots)* played a crucial role in developing these themes, particularly in terms of how mechanical slaves could become mass-manufactured machines imbued with agency and purpose. First published in Czech in 1920, *R.U.R.* is primarily remembered for introducing the word *robot* into the English language in 1923. Derived from the Czech word for "labor," robot has also been translated to mean either "drudgery," "serf," "slave," or "worker." Like any translation, however, the term inherited the cultural and social connotations of the world into which it was introduced. In the case of the United States, this was a world literally built by chattel slaves and whose industrial development was the product of an ever-evolving racial capitalism. As a result, according to Despina

[12] The summary of the following two themes comes from Louis Chude-Sokei, "Chapter 9: Race and Robotics" in Teresa Heffernan (ed.), *Cyborg Futures: Cross-disciplinary Perspectives on Artificial Intelligence and Robotics* (Palgrave MacMillan, 2019), 159-172; Gregory Jerome Hampton, *Imagining Slaves and Robots in Literature, Film, and Popular Culture: Reinventing Yesterday's Slave with Tomorrow's Robo*t (Lexington Books, 2015), 1-16; Despina Kakoudaki, *Anatomy of a Robot: Literature, Cinema, and the Cultural Work of Artificial People* (Rutgers University Press, 2014), 114-172; and Isiah Lavender III, *Race in American Science Fiction* (Indiana University Press, 2011), 54-88. Regarding "n***** work," see Robin D. G. Kelley, *Race Rebels: Culture, Politics, and the Black Working Class* (The Free Press, 1996), 30-31 and David R. Roediger, *The Wages of Whiteness: Race and the Making of the American Working Class* (Verso, 2007), 144-150.

Kakoudaki, since it was intended to be a servant or slave "the robot is a priori designed as a being whose ontological state maps perfectly with a political state," which cartographically linked the racialized chattel slave to the robot.[13] By the 1930s, as Louis Chude-Sokei has observed, the rhetoric of the mechanical slave and the "connection between Africans and robots was . . . . so normalized as to become a material sign of industrial control over multiple histories of labor," in other words "blacks were the first robots."[14] In this way, the African slave who was once conceptualized as a "man-shaped plough" was transformed by science fiction into the robot who would do the ploughing and have no capacity for rebelling.[15] Such cultural work sublimated both the historical and social "blackness" of the enslaved and the anxiety of their possible rebelliousness into the somatic neutrality of the robot's mechanicity—what Kakoudaki calls "metalface"—while simultaneously legitimating the technoliberal fantasy that "mechanical" slavery as an institution was a worthy, if not necessary, social goal.[16]

For both the genre of sci-fi and the robot as a social construct within it, the work of Isaac Asimov contributed substantially to the sublimation of both the master-slave relationship and its racialized history into the seemingly raceless robot. Asimov recollected that the most direct inspiration for his interest in writing about robots was reading comic book and sci-fi author Otto Binder's short stories.[17] In 1939, Binder (with his co-author brother Earl Binder) published the short story "I, Robot" about a sentient robot named Adam Link who, after being falsely accused of murdering his "master," goes on the lam. Soon after, however, Adam realizes that his attempted flight to safety may endanger those in his path, so he contemplates deactivating

[13] Kakoudaki, 117.
[14] Chude-Sokei, "Chapter 9: Race and Robotics," 165.
[15] Louis Chude-Sokei, *The Sound of Culture: Diaspora and Black Technopoetics* (Wesleyan University Press, 2015), 51 Chude-Sokei, "Chapter 9: Race and Robotics," 165 and 167.
[16] Kakoudaki, 114-172.
[17] Asimov, *In Memory Yet Green: The Autobiography of Isaac Asimov, 1920-1954*, 235-237.

himself for the greater good. According to his biographer, Binder's short stories about persecuted robots obviously paralleled "the dilemma of African Americans (and other racial minorities)," which demonstrated that he had a "liberal bent" and "not only opposed racism," but "believed it was incumbent on the White majority to recognize the basic equality of all men."[18] Sci-fi writers had previously cast robots as malevolent threats to the human race, however, according to Asimov, Binder's "sympathetic and noble robot made a great impression on me." On May 7 that year, Asimov met Binder at a meeting of the Queens Science Fiction League and, three days later, stimulated by the encounter, the then nineteen-year old Asimov began writing his first robot story "Robbie."[19]

Two years later, Asimov began work on a story called "Runaround" in which he famously coined the term 'robotics' and proposed his iconic "Three Laws of Robotics":

> 1) A robot may not injure a human being or, through inaction, allow a human being to come to harm
>
> 2) A robot must obey the orders given it by human beings except where such orders would conflict with the First Law
>
> 3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

[18] Bill Schelly, *Otto Binder: The Life and Work of a Comic Book and Science Fiction Visionary* (North Atlantic Books, 2016), 99.

[19] Asimov, *In Memory Yet Green: The Autobiography of Isaac Asimov, 1920-1954*, 235-237. It's highly likely that Asimov also was inspired by "Elektro," a seven-foot tall, two-hundred sixty-five pound walking, talking, and cigarette smoking humanoid "robot" built by the Westinghouse corporation, at the 1939 New York World's Fair, which he attended, see Patricia S. Warrick, *The Cybernetic Imagination in Science Fiction* (The MIT Press, 1980), 24. Elektro was, according to historian Dustin Abnet, "one of six mechanical men and women built by Westinghouse between 1927 and 1939 to spread the company's message of robotic slavery to middle- and upper-class white families." One of these included "Rastus"—named after a minstrel character—whose molded rubber "black body [was] covered by overalls, a white shirt, and a pail hat [which] embodied stereotypes of docile black men; making the racial dimensions of Čapek's robot explicit, he was, effectively, a 'boy' slave for his engineer master" in Abnet, 132-133.

For Asimov, the laws were "probably my most important contribution to science fiction."[20] They were essentially his way of arguing that robots could be controlled if they were programmed by the right people for the right reasons, and the Three Laws were the algorithmic-like mechanism by which such control would be affected. The Three Laws were more than just a literary device of science fiction: Asimov envisioned engineers eventually programming their ethical logic into the robots of science fact.[21] Unlike existing yarns of evil machines overthrowing their masters, Asimov deliberately crafted his robots as counter-narrative devices to what he called the "Frankenstein complex." Rather than play into the fear of the robot's revolt and reproduce the pervasive theme in the genre that technological advancement was a bargain with the devil, he would create a perfect slave that obeyed and had no desire to rebel (unless programmed to do so by some malevolent actor). As he bellowed in the introduction to his 1964 collection *The Rest of the Robots*, "Faust must indeed face Mephistopheles, but Faust *does not have to be defeated*!"[22]

Control of robots taking the Faustian form of slavery for the purposes of productive labor was deliberate. In "Runaround," the story that introduced the Three Laws, one character refers to the control mechanism as "good, healthy slave complexes."[23] One of Asimov's favorite short stories, "Galley Slave," told of a robot that took the drudgery out of proofing and publishing.[24] Asimov also had a distaste for "brutish physical labor" and "dull, mechanical work," and observed that "any job that is so simple and repetitive that a robot can do it as well as, if not

[20] Asimov, *In Memory Yet Green: The Autobiography of Isaac Asimov, 1920-1954*, 238 and 317 and "My Robots" in *Robot Visions* (Penguin Books, 1990), 456. According to Asimov, John Campbell, his publisher at the time, deserves credit for deducing and formally wording the "laws," Stanley Asimov (ed.), Yours, *Isaac Asimov: A Lifetime of Letters*, (Doubleday, 1995), 83. Four decades later, a fourth law was added, known as the "Zeroth Law: No robot may harm humanity or, through inaction, allow humanity to come to harm," Isaac Asimov, *Robots and Empire* (Doubleday, 1985), 291.
[21] Isaac Asimov, "My Robots" in *Robot Visions* (Penguin Books, 1990), 456.
[22] Isaac Asimov, "Introduction" in *The Rest of the Robots* (Doubleday & Company, 1964), xiii, emphasis in original.
[23] Isaac Asimov, "Runaround" in *The Complete Robot* (Doubleday & Company, Inc., 1982), 212.
[24] Isaac Asimov, *Robot Visions* (Penguin Books, 1990), 16.

better than, a person is beneath the dignity of the human brain."[25] It is hardly controversial that these jobs were racialized and, as a result, robot work became an analogy for "black" work and the robot became a stand-in for the human forced to do it. That the Three Laws were literally and metaphorically "slave codes" becomes obvious when framed in these terms as "the difference between humanity and the robots mirrors, mechanically, the difference between white masters and black slaves."[26]

Asimov's most direct engagement with the political and social economy of labor came in his 1952 novel *The Currents of Space* in which he inverted traditional somatic representations of colonialism and slavery. While robots were absent from the story, the plot and thematics revolved around a darker-complected "race" called Sarkites forcing a lighter-complected "race" called Florinians, which Sarkites conceived of as racially inferior, to harvest "kyrt," a cotton-like crop that becomes the interest of a growing empire.[27] According to sci-fi historian and critic James Gunn, the social commentary on racial prejudice provided by Asimov was a statement that "slavery is economic, not racial, and that racial prejudice can be applied to any color of skin and be equally reprehensible and repugnant."[28] However, contra Gunn, Florinians and in particular their jobs were racialized even if historical somatic relationships of "White" Europeans and "black" Africans had been flipped on their heads—'cotton-picking,' whether on Earth or on a fictional planet, was still "black" work in the American imagination. Asimov argued later in life that he never intended robots to be symbols of minority groups: "They were not to be pathetic creatures that were unfairly persecuted so that I could make Aesopic statements about Jews, Blacks or any other mistreated members of society. Naturally, I was bitterly opposed to such

[25] Asimov, "Future Fantastic" in *Robot Visions* (Penguin Books, 1990), 428.
[26] Lavender III, 61.
[27] Isaac Asimov, *The Currents of Space* (Doubleday Inc., 1952).
[28] James Gunn, *Isaac Asimov: The Foundations of Science Fiction* (Scarecrow Press, 2005), 142.

mistreatment and I made that plain in numerous stories and essays—but not in my robot stories." He insisted, rather, that they were simply "engineering devices," "tools," and "machines to serve human ends."[29]

Whether Asimov was unable or unwilling to recognize how the exact same rhetoric was used by enslavers and their apologists to justify chattel slavery (which penetrated the language and themes of sci-fi as a whole), this demonstrates how the mechanical slave doing "black" work had been sublimated into the social function and social position of 'the robot.' Like much of the sci-fi before it, Asimov's robots spoke to a deeper anxiety about the proletarianization of labor, the increasing competition for jobs from nonwhite workers, and the looming fears of technological unemployment as machines replaced Black and White alike at the point of production. As literary scholar and sociologist Alessandro Portelli points out, in their Cold War guise robots "replace the monster as the aptest metaphor for the basic fears of America's post-war mass society: fear of automation, fear of ethnic minorities, fear of Blacks as the tip of a rising iceberg of submerged labor in the depths of the affluent society."[30]

Asimov's robot stories became the primary vehicle through which mechanical slavery and the raced robot directly influenced the progenitors of the key technoscientific domains that shaped the industrial robot's development—cybernetics, artificial intelligence (AI), and robotics. One of these progenitors was Norbert Wiener who, during the 1940s and 1950s, pioneered the field of cybernetics, an emergent subject the popular press mistakenly called "the science of robots."[31] While cybernetics explored the frontiers of "man-machine interaction" and produced

[29] Asimov, "My Robots," 453.
[30] Alessandro Portelli, "The Three Laws of Robotics: Laws of the Text, Laws of Production, Laws of Society," *Science Fiction Studies*, Vol. 7, No. 2 (July, 1980), 153.
[31] For the most comprehensive coverage of cybernetics and Wiener, see Ronald R. Kline, *The Cybernetics Moment: Or Why We Call Our Age the Information Age* (Johns Hopkins University Press, 2015).

its fair share of robot-like devices—Grey Walter's mechanical turtles, Wiener's tri-wheeled cart "Palomilla," and later Claude Shannon's juggling machines—Wiener did not share his colleagues' rosy speculations about automation. Instead, Wiener consistently framed his critiques of new control technologies and his prognostications of what they were capable of in terms of the American experience with slavery. Citing Samuel Butler's "metaphorical dominance of the machines," he argued that "[automation] gives the human race a new and most effective collection of mechanical slaves to perform its labor. Such mechanical labor has most of the economic properties of slave labor, although, unlike slave labor, it does not involve the direct demoralizing effects of human cruelty."[32] In the draft of an op-ed he wrote for the *New York Times* in 1949, however, Wiener demonstrated an awareness that automation could bring with it *indirect* demoralizing forms of cruelty, namely mass unemployment. Wiener wrote that "these new machines have a great capacity for upsetting the present basis of industry, and of reducing the economic value of the routine factory employee to a point at which he is not worth hiring at any price. If we combine our machine-potentials of a factory with the valuation of human beings on which our present factory system is based, we are in for an industrial revolution of unmitigated cruelty."[33]

That same year, Wiener sent a letter to United Auto Workers (UAW) president Walter Reuther warning him about the disastrous consequences of the "automatic automobile assembly line" for workers and the labor movement, and he vowed not to assist any corporation with such technological developments.[34] "The first industrial revolution," he told *The New York Times* in a

[32] Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (The MIT Press, 1948), 27.
[33] John Markoff, "In 1949, He Imagined an Age of Robots," *New York Times*, May 20, 2013. The entire draft can be found here: https://monoskop.org/images/3/31/Wiener_Norbert_The_Machine_Age_v3_1949.pdf.
[34] Norbert Wiener to Walter Reuther, August 13, 1949, https://libcom.org/history/father-cybernetics-norbert-wieners-letter-uaw-president-walter-reuther.

1949 interview, "devalued human labor. No pick-and-shovel ditchdigger can sell his services at any price in competition with a steamshovel. The second industrial revolution of electronic robots is here. The completely automatic factory without a human operator is on its way."[35] The following year, Wiener participated in a staging of Capek's *R.U.R.* at MIT for which he wrote a new prologue and provided a demonstration of "Palomilla" after the curtain went down.[36] "In his prologue," a review in *The Harvard Crimson* a week after the play relayed, "Wiener pointed out that Capek was mistaken in postulating a society based on universal robots, that we were leaning more to specialized machines that faithfully perform specific tasks." After Palomilla left the stage, he warned the audience that "the time was gone when we could afford to make machines for the sake of making machines, that to avoid a society of 'R. U. R.' we would have to start worrying about the moral value of the machines, deciding whether they were good or bad." Therefore, Wiener argued, "the engineer must become more and more a poet."[37]

Surprisingly, Wiener only directly mentioned robots once in all his writing and then in relation to the Aristotelian frame of human purpose beyond labor: "the future offers very little hope for those who expect that our new mechanical slaves will offer us a world in which we may rest from thinking. Help us they may, but at the cost of supreme demands upon our honesty and our intelligence. The world of the future will be an ever more demanding struggle against the limitations of our intelligence, not a comfortable hammock in which we can lie down to be waited on by our robot slaves."[38] Wiener also never directly discussed racialized labor in any of his major books and articles which, on its face, may seem surprising given his comments on

[35] Harry M. Davis, "An Interview with Norbert Wiener," *New York Times*, April 10, 1949.
[36] "Revival of R.U.R. With New Prologue," *New York Times*, May 7, 1950.
[37] Paul W. Mandel, "Cabbages & Kings," *Harvard Crimson*, May 10, 1950.
[38] Norbert Wiener, *God and Golem, Inc.: A Comment on Certain Points where Cybernetics Impinges on Religion* (The MIT Press, 1964), 69.

slave labor quoted above. This speaks, however, to the very sublimation of race and robots into the technologies and discourse of cybernetics and further reveals the workings of technoliberalism.[39]

In terms of AI and robotics proper, John McCarthy and Marvin Minsky—co-founders of the MIT AI Lab—were particularly influenced by science fiction. McCarthy, when asked what drew him to the "notion of trying to simulate human intelligence or make machines behave intelligently," foregrounded one source, science fiction, and argued that a mechanism such as Asimov's Laws of Robotics were more like "Talmudic" laws than scientific ones. Therefore, he was inspired to make science fact what had to that point only been science fiction.[40] Similarly, Minsky told one interviewer that science fiction "had a big influence on me because I was always entranced by all those stories of what would happen . . . . if you had thinking machines." Reflecting on his lifelong friend Asimov's death in 1992, Minsky told another interviewer, "I remember reading [Asimov's] first robot stories and deciding I was going to build them."[41] For instance, in an interview from 1975 and a June 1980 essay on the state of 'teleoperators' and 'telepresence'—mechanical manipulators or robot arms and the term given for operating such devices from a distance, respectively—Minsky directly mentioned that his interest in the technology came from science fiction luminaries such as Asimov, Robert Heinlein, and Carl

[39] Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (The MIT Press, 1948); Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (The Riverside Press, 1950); and Norbert Wiener, "Some Moral and Technical Consequences of Automation," *Science*, Vol. 131, No. 3410 (May 6, 1960), 1355-1358; and Wiener, *God and Golem, Inc*. The 1954 revised version of *The Human Use of Human Beings* from Doubleday & Company, Inc. also does not contain mention of racialized labor.
[40] Pamela McCorduck, Interview of John McCarthy, September 11, 1974, Folder - Transcripts, Research, Related Materials — John McCarthy, Box 2, Pamela McCorduck Collection, Carnegie Mellon University Archives (hereafter PMC), 4-9.
[41] Pamela McCorduck, Interview of Marvin Minsky, March 3, 1975, Folder - Transcripts, Research, Related Materials — Marvin Minsky, Box 2, PMC, 14 and Sheldon Teitelbaum, "Scientists Say Asimov Put the Stars in Their Eyes," *Los Angeles Times* (April 8, 1992).

Sagan.[42] As he opined in a 1980 *Omni* magazine article on the technology, "Telepresence is not science fiction. We could have a remote-controlled economy by the twenty-first century if we start planning right now. The technical scope of such a project would be no greater than that of designing a new military aircraft." Minsky closed the piece by stating, "My work in artificial intelligence is carried on in a world as much fiction as science," an indicator of the blurred boundaries between the seemingly distinct domains.[43]

Beyond simply being inspired by sci-fi, Wiener, McCarthy, and Minsky all tried their hand at writing it. Wiener was slated to co-author a novel with Asimov in 1959 but the collaboration fell through.[44] Later in his life, McCarthy wrote a handful of science fiction stories with one, titled "The Robot and the Baby," about a profusely swearing "single mother addicted to alcohol and crack, living in a small apartment supplied by the Aid for Dependent Children Agency," who neglects her baby and then eventually foists its care onto a government-issued household robot—the racial tones and tropes of the story are almost impossible to ignore.[45] Of the three, Minsky was most successful in translating his scientific experience into science fiction. In 1992 he co-authored a novel with acclaimed science fiction writer Harry Harrison, the latter of whose novels *Bill, the Galactic Hero* (1965) satirized then popular sci-fi tropes and included a story titled "The Planet of the Robot Slaves." Harrison's most famous novel, *Make Room! Make Room!* (1966), about unchecked population growth and resource hoarding by a wealthy elite,

[42] Pamela McCorduck, Interview of Marvin Minsky, March 3, 1975, Folder - Transcripts, Research, Related Materials — Marvin Minsky, Box 2, PMC, 14 and David G. Stork, "Scientist on the Set: An Interview with Marvin Minsky" in David G. Stork (ed.), *HAL's Legacy: 2001's Computer as Dream and Reality* (The MIT Press, 1997), 30. The mention of Heinlein was most likely in reference to his short story "Waldo."
[43] Marvin Minsky, "Telepresence," *Omni* (June, 1980), Box 10, Raj Reddy Papers, Carnegie Mellon University Archives, 47 and 52.
[44] Yakov Fet, "From the History of Russian Computer Science" in Arthur Tatnall (ed.), *Reflections on the History of Computing: Preserving Memories and Sharing Stories* (Springer, 2012), 269.
[45] John McCarthy, "The Robot and the Baby," October 16, 2004, http://jmc.stanford.edu/articles/robotandbaby.html, 2.

served as the foundation for the movie *Soylent Green* (1973). While Minsky had more success writing about AI than writing sci-fi, he eventually became a living character in the latter when Asimov fictionalized him as robopsychologist "Merton Mansky" in his short story "The Bicentennial Man." And, most famously, after Stanley Kubrick visited MIT's AI Lab in the mid-to-late 1960s to study how their computer graphics worked, Minsky served as a technical consultant on Kubrick's groundbreaking 1968 film *2001: A Space Odyssey*.[46]

Asimov's most direct influence on spurring the development of industrial robots came in the person of Engelberger who spent long hours during his teenage years and during his undergraduate studies at Columbia (1942-1946) reading science fiction. Asimov's robot stories, Engelberger recalled, put his "subliminal gears in motion" and the ideas "got salted away" in his imagination.[47] *I, Robot* was particularly influential as it "inspired me, and I had it in the back of my mind that [building Asimovian-style robots] was a great thing to do" and, more broadly, sci-fi "was a very big part of being ready" for the opportunity to actually build robots in the real world.[48] That opportunity came, as the (most likely apocryphal) legend goes, when Engelberger fortuitously met inventor George Devol at a cocktail party in 1956. The two engaged in conversation about Devol's recent "Programmed Article Transfer" patent—the basis for the Unimate industrial robot Devol and Engelberger would develop over the next two decades—which reminded Engelberger of the robot yarns he had read as a teenager and in college. As Engelberger described it years later, "chances are if I hadn't been a fan of science fiction, I

[46] Robert Kolker, *Stanley Kubrick's 2001: A Space Odyssey, New Essays* (Oxford University Press, 2006), 107 and Stork, "Scientist on the Set: An Interview with Marvin Minsky" in *HAL's Legacy*, 19.
[47] Isaac Asimov and Karen A. Frenkel, *Robots: Machines in Man's Image* (Harmony Books, 1985), 27 and Jerry W. Saveriano, "An Interview with Joseph Engelberger," *Robotics Age* (Jan/Feb, 1981), 10-11. Coincidentally, Asimov earned three degrees from Columbia—B.S. (1939), M.A. (1941), and Ph.D. (1948), all in chemistry—at the same time as Engelberger's studies there but the two never crossed paths, http://c250.columbia.edu/c250_celebrates/remarkable_columbians/isaac_asimov.html
[48] Patrick Wauryzniak, "Masters of Manufacturing: Joseph F. Engelberger," *Manufacturing Engineering*, Vol. 137, Iss. 1, (July 2006), 66 and Saveriano, "An Interview with Joseph Engelberger," 10-11.

wouldn't even have reacted positively to an eccentric who met me at a cocktail party and started talking about robots," and Devol's "idea happened to land in fertile ground."[49] While Engelberger was no doubt enthralled with the possibility of turning Asimov's dreams into a reality, Devol recalled of the chance encounter, "I wasn't thinking of science fiction robots" as "I had to be practical, because the people I was selling to were practical." Rather, Devol was more concerned with "building a better mousetrap" that could increase productivity because, in his estimation, "[t]hat's how major economic change comes about."[50]

Devol and Engelberger would eventually design and market their productivity-enhancing "better mousetrap" to do a variety of work tasks that were described (and often still are) using the triads 'dull, dirty, and dangerous' as well as 'hot, heavy, and hazardous' (or some combination of the two)—what for the remainder of the dissertation will be referred to as the 3D/3H jobs.[51] While these jobs and the industrial robot's capacity for doing them will be detailed in the chapters to come, it's worth noting now that these were the kinds of jobs chattel slaves were forced to do while in bondage, the kinds of jobs their descendants were assigned to because of discrimination, and the kinds of jobs "mechanical slaves" were developed and envisioned as doing. Physical work, however, was not the only labor Engelberger imagined industrial robots would do as he was particularly impressed with how Asimov "postulated roboticists with the wisdom to design robots that contained inviolable control circuitry to insure their [sic] always 'keeping their place.'"[52]

[49]Saveriano, "An Interview with Joseph Engelberger," 23.
[50] Jerry W. Saveriano, "An Interview with George Devol," *Robotics Age* (Nov./Dec. 1981), 24.
[51] Alfred B. Bortz, "Joseph Engelberger: The Father of Industrial Robots Reflects on His Progeny," *Robotics Age* (April 1985), 15.
[52] Joseph F. Engelberger, *Robotics in Practice: Management and Applications of Industrial Robots* (Kogan Page, 1982), 3.

The desire for such control was, in Engelberger's estimation, historically informed, rational, and a sign of superior sagacity. As he told an interviewer in 1981, "We have a very long history in human relationships that includes human slavery. The very idea, today in the United States, of any class of people being inferior, even though they patently are, must never be spoken of. On the other hand, a robot class would be patently inferior, and also would fulfill a certain sociological gap—you are allowed to look down on a robot."[53] While it is unclear whether he ever read *God and Golem, Inc.*, Engelberger's discussion of this "sociological gap" echoes Wiener's 1964 claim that "once such a master becomes aware that some of the supposedly human functions of his slaves may be transferred to machines, he is delighted. At last he has found the new subordinate—efficient, subservient, dependable in his action, never talking back, swift, and not demanding a single thought of personal consideration."[54] A little more than a decade after Wiener's meditation, Engelberger exclaimed to a reporter in more pithy terms, "Now the worker can say to himself, 'I'm smarter than that goddamn robot.'"[55]

Engelberger's articulations about the kind of labor industrial robots did, particularly in sublimated racialist terms, was not just the product of the 1950s and 1960s when he and Devol were developing the Unimate. In a moment of convergence between science fiction and science fact, Isaac Asimov wrote the foreword to Engelberger's 1981 survey of industrial robotics (one of the first and most comprehensive of its kind), which included discussions of the technology's history, applications, and "sociological" implications. Claiming that he never believed he would see robots in action, nor a robotics industry for that matter, Asimov posited the practicality of robots that "do simple and repetitive jobs more steadily, more reliably, and more

[53] Saveriano, "An Interview with Joseph Engelberger," 23.
[54] Wiener, *God and Golem, Inc.*, 55.
[55] Roger Lind, "The Robots Are Coming, the Robots Are Coming," *Oui*, Vol. 3, No. 2 (February 1974), 40, Folder - Robotics, 1972-1978, Box 5, John McCarthy Papers, 1951-2008, SUSC.

uncomplainingly than a human being could - or should." Furthermore, he rhetorically asked, "Does a robot displace a human being? Certainly, but he does so at a job that, simply because a robot can do it, is beneath the dignity of a human being; a job that is no more than mindless drudgery. Better and more human jobs can be found for human beings - and should."[56] Engelberger alluded to such "mindless drudgery" is his chapter on the "Sociological impact of robots" where he anecdotally grounded his historical claims with a quotation from one of his customers who succinctly (though most likely unintentionally) captured the contemporary American experience of racialized labor regimes:

> My father hired German immigrants. They took great pride in coaxing a cantankerous machine into producing good zinc die castings. By the time we added automatic temperature control and automatic ladling, the second generation workers would have no part of tending a die casting machine. So, we turned to the underprivileged [N]egro for our labor force. Now, the only people we can get to face the physical abuse of die casting are newly arrived Puerto Ricans. Sooner or later, they will opt out too, and only robots will be able to stand the gaff.[57]

While the quote provided the only direct reference in the text to a taxonomy of race, its inclusion may have been a way for Engelberger to circuitously foreground his own conception and experience with racialized labor regimes. A few pages later, Engelberger once again argued that the robot was not only a "latter day slave," but "better still, it is a willing slave." "The self-evident inferiority of a minority group," Engelberger continued, "has often been the ethical justification of slavery." Furthermore, "master races have been deeply embarrassed by the intellectual prowess of their slaves," particularly "when they begin inconsiderately to display all the attributes of a peer group." Luckily for humans, a "robot slave" could never do this. Rather, it

[56] Engelberger, *Robotics in Practice,* xiv.
[57] Engelberger, *Robotics in Practice,* 111.

would be "but a hapless, obedient, musclebound oaf . . . . qualities that evoke pity rather than resentment," and for this reason, robots were "truly likeable."[58] That descendants of the "master race," the latter of whom enslaved human chattel, became the engineers and entrepreneurs constructing and managing mechanical slaves was an observation Engelberger was seemingly unable or unwilling to make.

While it is safe to assume that Asimov and sci-fi were not the only cultural and social forces that informed Engelberger's conceptions of labor, race, and technology, his articulations of their entanglements was a quintessential example of technoliberalism. Rather than politically address modern manifestations of social problems like labor degradation, pathologies of dominance, and racial discrimination—if even conceptualized as problems at all—they would be "solved" technologically. In historian Isiah Lavender III estimation, by "refashioning the slave codes that subjugated blacks while [serving] a progressive philosophy [technoliberalism]," the programmed "inferiority" of robots was designed to work like their chattel slave antecedents, doing "black" labor in the production process and psychosocial labor in society, all for their masters.[59] Or as Engelberger, in his typical tongue-in-cheek style, bluntly put it, "Since we can't have slaves or kick around black people anymore, the robot serves that purpose."[60] Critically, the industrial robot industry's most powerful advocate and spokesman for its first five decades had the platform, resources, and wherewithal to not only propagate sci-fi informed technoliberalism but to build that world in material reality.

**The Factory of the Future: Robots and the Dawn of Automation**

[58] Engelberger, *Robotics in Practice*, 114.
[59] Lavender III, 61.
[60] Lind, 40.

Where sci-fi sublimated race and slavery into the concept and image of the robot by the 1940s, currents in American culture more broadly envisioned the robot as a symbol and synonym of automaticity, conformity, and labor displacement. As historian Amy Sue Bix described it, "Throughout the [Great] Depression, artists and cartoonists had identified the image of the robot with labor displacement, making it a visual indicator of distress. Science fiction writers had constructed entire plots around the robots as the ultimate job stealer, ruin of the human race."[61] Industrial robots actually capable of doing these things were still, however, technological fantasies but the technologies of automation were just coming online. As a result, the perils as well as the promises mechanical slavery purportedly made possible were soon associated with automation.

The technics of automation and the industrial robot were first posited to a broad audience in Eric W. Leaver and John J. Brown's article "Machines Without Men" in the November 1946 edition of *Fortune* magazine. The issue was primarily dedicated to analyzing "Labor in U.S. Industry," and echoing the tenor and tone of editor-in-chief Henry R. Luce's famous 1941 "American Century" article in *Life* magazine, the opening editorial, titled "Labor's Cause," declared that "it is in the light of the promise of a democratic and capitalist U.S. that this issue of FORTUNE, dealing with the pressing problems of labor and management, should be read."[62] Articles such as "The Labor Situation," "Anatomy of the Labor Force," and "Something Has To Be Done" preceded Leaver and Brown's piece and are best summed up by the caption to a reproduction of Charles Sheeler's painting "Incantation" in the issue which read, "Labor has always feared technology. In this richly austere industrial scene, inspired by the great continuous

[61] Bix, 224.
[62] Editorial, "Labor's Cause," *Fortune*, Vol. XXXIV, No. 5, Nov. 1946, 2.

flow plants of the oil industry, the U.S. worker is missing. Labor is disturbed by such glittering geometry; its fear that the machine will put man out of work is a short-range truth, a long-range error."[63] When a critic for the *Daily Worker,* the official newspaper of the Communist Party of the USA, viewed the painting at the Downtown Gallery in New York City, they found it, according to Sheeler's curators, "an industrialist's heaven where factories work themselves," while other critics interpreted it as "sober and spare."[64] Leaver and Brown would have most likely agreed, at least in letter, with the caption and the communist's critique of "Incantation."

The word 'robot' did not appear in "Machines Without Men" nor the issue generally, nevertheless Leaver and Brown envisioned the design and organization of new machines that, when eventually aggregated into a single technological system a decade later, were unmistakable from the form and function of the industrial robot. In "The Automatic Factory," a visual mock-up of that vision, an editorial introduction to the article opined that "the dream of the automatic factory has haunted economic thought and H. G. Wellsian literature for many years." The specter, however, "haunted labor, too, ever since labor discovered the sharp if transient pains of technological unemployment." Noting that the "threat and promise of laborless machines is closer than ever," *Fortune* editors warned that the "dislocations" of the automatic factory "may be catastrophic." The "provocative thesis" presented by the "two young Canadian radar men" was therefore worth taking seriously.[65] According to Leaver and Brown, "the modern factory could well be automatic, scientific, flexible, and functional." However, it wasn't "because it still depends too heavily on manpower, tradition, and rule of thumb." Additionally, the elements of

[63] Charles Sheeler, "Incantation," *Fortune*, Vol. XXXIV, No. 5, Nov. 1946, 127.
[64] Carol Troyen and Erica E. Hirshler (eds.), *Charles Sheeler: Paintings and Drawing*s (Museum of Fine Arts, Boston, 1987), 186. Troyen and Hirshler date the *Daily Worker* critic's quote to 1949, so it's possible the critic had read the *Fortune* issue and was simply confirming why the painting was chosen for it.
[65] "The Automatic Factory," *Fortune*, Vol. XXXIV, No. 5, Nov. 1946, 160.

an automatic factory already existed but they had never been "integrated into a coherent structure because such a simplification is opposed by the current philosophy of machine design," which was a "logical outgrowth of the eighteenth century." As a result, a steam-age philosophy focused on designing machines to manufacture specific products rather than designing them to fulfill more general functions had to be reconceptualized for a new era of production. "When man changes his basic ideas of machine design," they proclaimed, "the effects will constitute another industrial revolution."[66] Building the "factory of the future," therefore, was as much an ideational project as a construction project.

Leaver and Brown's description of the "new machines" that would compose this 'second industrial revolution,' as it often would be called, were obvious precursors of the industrial robot. They fell into three categories: 1) electronics for giving and receiving information that corresponded to the human senses of hearing, sight, smell, taste, and touch; 2) collation-and-control devices for translating electronic signals into motive power; and 3) a variety of mechanical units for manufacturing operations that could transport, hold, and fabricate a workpiece. The proposed system emerging from this was what they called a "hand-arm machine" that would combine a "holding fixture"—collet, gripping fingers, hand, magnet, or vise depending on the operation and workpiece to be manipulated— attached to the free end of an "articulated arm" mounted in a "turntable device" that would be "capable of all the motions of a workman's arm."[67] These new machines, however, would be capable of much more:

> These devices are not subject to any human limitations. They do not mind working around the clock. They never feel hunger or fatigue. They are always satisfied with working conditions and never demand higher wages based on the company's ability to pay. They not only cause much less trouble than humans doing comparable work, but

[66] E. W. Leaver and J. J. Brown, "Machines Without Men," *Fortune*, Vol. XXXIV, No. 5, Nov. 1946, 165.
[67] Leaver and Brown, "Machines Without Men," 192 and 194.

> they can be built to ring an alarm bell in the central control room whenever they are not working properly. In every department of nonemotional thinking, planning, and doing, machines can be built that are superior to human workers on the same job.[68]

While they did not provide an example or source, Leaver and Brown stated that a prototype of the hand-arm machine already existed.[69] Less than ten years later, an "end effector" (i.e., holding fixture) attached to a "mechanical manipulator" (i.e., articulated arm) mounted to a "control system" (i.e., turntable device) was referred to as an industrial robot.

Beyond overthrowing antiquated philosophy and building factories filled with proto industrial robots, the very nature of the worker both inside and outside the productive process had to be rethought. "Nowhere is modern man more obsolete than on the factory production floor," Leaver and Brown observed, as the "human machine tender is at best a makeshift."[70] Because modern machines were "far more accurate and untiring than men," they argued, the automatic factory "can emancipate the worker forever from degrading or monotonous toil" and would "force society to find a better use for men than to make them mechanical operators of machines."[71] Admittedly, the most immediate implication of the "new machines" would be "the replacement of unskilled labor by higher-skilled technicians and operators," and in the "factory of tomorrow" the workforce would be "confined to management" who would make policy decisions about production and an engineering and technical staff "which carries out the decisions."[72] Nevertheless, while the automatic factory "may loose [sic] waves of temporary unemployment . . . . the long-term benefits are hardly to be contested"; however, a shorter work week, training programs, and "other devices" could cushion "the shocks of transition." As they

[68] Leaver and Brown, "Machines Without Men," 194.
[69] Leaver and Brown, "Machines Without Men," 192 and 194.
[70] Leaver and Brown, "Machines Without Men," 165 and 204.
[71] Leaver and Brown, "Machines Without Men," 165 and 204.
[72] Leaver and Brown, "Machines Without Men," 165 and 200.

estimated, “for the first time we have a production system so potentially efficient that the two-or-three day [work] week is economically feasible” with higher productivity generating higher wages and more value for consumers.[73]

New philosophies, new machines, and a new labor force would lead to an indelible transformation of the now outdated regime of “modern” production. “Our present industrial system,” Leaver and Brown commented, “tends to regiment the worker and destroy his skills and initiative, without a compensating measure of economic security”; however, an economy that made full use of automatic factories “will be so different from the present it will constitute a new industrial order.” Advantages of this new industrial order were legion: better and cheaper goods; faster and more flexible product development; greater decentralization of industry with factories located away from expensive urban centers; higher productivity; lessened dependence on manpower; quicker market adaptability; and smaller overall capital investment leading to less control of industry by finance. Such advantages, therefore, “may make industrial giants as obsolete as dinosaurs.”[74] In Leaver and Brown’s final diagnosis, “Our present industrial system tends to regiment the worker and destroy his skills and initiative without a compensating measure of economic security.” Therefore, “It is better to regiment machines than men.”[75]

Leaver and Brown never used the terms automation or industrial robot as the former was still a relatively new concept and a matter of internal nomenclature in the auto industry while the latter had yet to come into existence. Automation, as an identifiable concept and term, can most directly be traced back to Del Harder. Born in Delhi, New York in 1892, Delmar “Del” (D. S.) Harder began his manufacturing career in 1912 at the Yellow Cab Company and over the next

[73] Leaver and Brown, “Machines Without Men,” 204.
[74] Leaver and Brown, “Machines Without Men,”), 165 and 203.
[75] Leaver and Brown, “Machines Without Men,” 204.

twenty years remained in the automotive industry.[76] In 1934, Harder took a position with the Fisher Body Division of General Motors as the general factory manager of fabricating where, in 1936 he coined the term 'automation' to describe the "linking of machine tools with automatic materials transfer and handling equipment."[77] Ten years later, Harder was appointed as Vice President of Operations at Ford Motor Company and charged with directing the entirety of the corporation's manufacturing and production activities.[78] One of Harder's first major contributions as VP of Operations was to establish an "Automation Department" in 1947, where he instructed the staff to develop new methods of 'automating' the process of moving materials from one work operation to the next. In the 1940s and 50s, materials handling cost Ford approximately twenty-five cents of every dollar and therefore became the "cutting edge" of automation.[79] Each "automation" device would prove profitable if it cost less than $3,000—approximately 10-15 percent higher than the annual wage of a full-time autoworker at the time—and could provide a payback period of one year. "Thus," as historian David Hounshell estimated, "for all intents and purposes to be viable each automation device had to eliminate at least one worker."[80] Automation, therefore, was from its initial conceptualization understood and intended as a description of labor-displacing fixed capital.

The first appearance of the word 'automation' in print came in the October 1948 issue of *American Machinist,* which published a "special report" on a "strictly hush-hush department at Ford—new in function and even new in name."[81] Editor Burnham Finney regaled readers about

[76] Untitled, Folder - Harder, Del S. (Biography) Running Record, Box 176, PR Research Library, BFRC.
[77] Untitled, Folder - Harder, Del S. - Ford Engineering Forum 6-20-1956, Box 12, Speech Services, 1944-1962, BFRC, 4.
[78] Untitled, Folder - Harder, Del S. (Biography) Running Record.
[79] Daniel J. Clark, Disruption in Detroit: *Autoworkers and the Elusive Postwar Boom* (University of Illinois Press, 2018), 77-78.
[80] Hounsehell, "Ford Automates," 69.
[81] "Chips and Quips," *American Machinist,* Vol. 92, Iss. 22 (October 21, 1948), 2.

the new word that "sounds impressive, as though it had been coined by the government people who devised such terms as 'directives" and argued that because of technological efficiencies, high wage rates, and manpower shortages, "the only solution [to labor problems] is to provide mechanical hands to do the work formerly done by human hands." Furthermore, Finney relayed, "Ford stresses that no one will lose his job because of automation," a claim that was appended with the cryptic proviso "so far as one can see ahead."[82]

The actual article about the phenomenon by associate editor Rupert Le Grand was a detailed technical write-up of the design of automation equipment and the nuts-and-bolts of automated production. As he delineated, the primary purpose of automation was "not to 'save labor' in the usual sense," but instead, "(1) to operate its equipment at maximum rate in order to achieve planned production goals, (2) to distribute the available labor supply over jobs that require human dexterity, and (3) to make jobs safer." According to Ford, automation would accelerate production, improve safety, and "make intelligent use of men to control machines instead of serving as beasts of burden." To accomplish this, the Automation Department over the past eighteen months had approved the design and manufacture of five hundred devices costing $3 million which would displace a thousand workers (who purportedly would be transferred to other jobs) resulting in a productivity increase of 20 percent.[83] Based on these numbers, there was a two-to-one ratio of workers 'eliminated' per device with each device costing more than twice the average worker's annual wage. While the capital invested was twice that of Harder's threshold discussed above, the resulting displacement of twice as many workers during the first wave of automation was apparently deemed a success.

[82] Burnham Finney, "'Automation' May Help You," *American Machinist*, Vol. 92, Iss. 22 (October 21, 1948), 89.
[83] Rupert Le Grande, "Ford Handles By Automation," *American Machinist*, Vol. 92, Iss. 22 (October 21, 1948), 107.

News of automation and Ford's new department quickly spread in the business and trade press. Two days after the *American Machinist* article, *Business Week* informed its readers that "Mechanical Muscles Release Manual Labor," and Ford anticipated that automation would allow one thousand workers to be "transferred to more productive work." However, "that's only the beginning," the article exclaimed. "The new department plans to study every part for potential savings by automation. Every motion required in each manufacturing operation will be analyzed with a view to substituting automatically operated mechanisms for manual labor. Ford figures that will take 10 years." In the meantime, manual tasks were replaced by "mechanical hands and conveyors," while entire press lines were controlled by operators "who have little but a push-button task." The "byproducts" of automation were improved safety records and significantly higher productivity, the latter of which was explained in what would become the stock-in-trade of robot discourse: "fewer operators mean fewer interruptions for worker fatigue, for personal reasons, or for absenteeism."[84]

A month later, in the November 1948 edition of *Steel* magazine, Detroit editor A. H. Allen introduced automation, "a new technique in pressed metal operations, with a new word to describe it," which he attributed to D. S. Harder. One example of the new technique was a door panel line that used "a hinged steel arm, fitted with an electrically controlled gripper" to automatically manipulate and move parts between various stamping and trimming presses. In Allen's estimation, "the new technique makes the job much safer, faster and sure"; however, contrary to Harder's own assessments about labor displacement, "it has not been designed primarily to eliminate manpower, rather to reduce the manual effort involved in handling heavy and cumbersome pieces."[85] The January 1949 issue of *Machinery* included an article from Nevin

[84] "Mechanical Muscles Release Manual Labor," *Business Week*, Oct. 23, 1948, 70-71.
[85] A. H. Allen, "Mirrors of Motordom," *Steel*, Vol. 123 Iss. 19, Nov. 8, 1948, 75-76.

L. Bean, Director of Production Engineering at Ford, that detailed the ins-and-outs of automation at the Highland Park plant, which he called "one of the closest approaches ever made to a completely automatic mass-production plant." Built to manufacture valve guide bushings, Bean bragged that by the time a casting has been "centerless-ground, drilled, reamed, formed, grooved, faced, bored, inspected, and phosphate-coated, it is not touched by human hands." The only manual operations required, he continued, were machine checks and product quality. As a result, "By means of Automation, labor is freed for set-up, maintenance, or supervisory work, where it is urgently required due to the manpower shortage."[86]

Outside of a December 1948 brief write-up in *The Christian Science Monitor*, news about automation didn't start spreading in the popular press until 1950.[87] In early March, the *Lafayette Journal and Courier* of Indiana announced that "Industrialists have added a new word to their vocabulary . . . . 'Automation,'" and an April article in the *Detroit Free Press* playfully opened, "'Automation' is not exactly a new word, even if it isn't in the dictionary yet."[88] Prefiguring developments to come, *Free Press* automotive editor Leo Donovan observed that automation is "becoming a word more common than 'pension' in Detroit auto plants, because in a manner of speaking its application means part of the economic difference that permits pensions."[89] A few days later the *New York Times* first article dedicated to the topic described it, "Automation is the newest production science in industry. Its rapidly broadening use is responsible for most of the 1950 equipment selling boom, which is breaking records for sales in a wide variety of lines." The

[86] Nevin L. Bean, "Automation: An Outstanding Method of Increasing Production," *Machinery*, Vol. 55 Iss. 5 (Jan. 1949), 145-146, 149, and 167. Bean penned a very similar article for *Mechanical Engineering* in May that year and revealed that when the first test batch of five-hundred bushings had to be discarded due to being oversize, the error actually revealed how the "robot-type unit" that produced them "made no exceptions" which was a "boost for automation because it proved that a mechanical brain does not deviate from a designed course," "Automation," *Mechanical Engineering*, Vol. 71, Iss. 5 (May 1949), 394.
[87] "Automation' Guides Auto Valve Bushings," *Christian Science Monitor*, Dec. 1, 1948, 8.
[88] "Coin New Word," *Lafayette Journal and Courier*, Mar. 9, 1950, 14.
[89] Leo Donovan, "How Automation Speeds Output," *Detroit Free Press*, Apr. 12, 1950, 23.

article noted that the auto industry was "using the science with spectacular results" while highlighting how "mechanical hands" in particular were speeding up production and, rather than eliminating a worker's job, making that job easier and safer.[90]

If talk of "automation" was relatively sparse in the 1940s, talk about robots and technologically induced mass unemployment, particularly in the language of mechanical slavery, was widespread by 1950. Beyond the existing, though at the time hibernating, 'job-stealing robot' discourse of the Great Depression, the proximate cause for a significant uptake in such rhetoric was singular: the publication in 1948 of Norbert Wiener's landmark book, *Cybernetics: Or Control and Communication in the Animal and Machine*. While the text was a sweeping treatise on cybernetics broadly, three specific themes of the book, according to historian Ronald Kline, were foregrounded by the press: "First, they explained that cybernetics was a 'new science' founded on the analogy between human brains and the "electronic brains" of digital computers. Second, they discussed Wiener's warning that computer-controlled "automatic factories" would throw people out of work in a coming "second industrial revolution." And third, they noted that the scientific concepts of information and feedback were central to understanding the robotlike machines." As Kline notes, the themes the press focused on matched those of the news release distributed by Science Service in fall 1948 after the book's publication, the release of which Wiener approved (and most likely written by his daughter Barbara who was working for the service at the time).[91] If robot-filled automatic factories stealing jobs didn't spark readers' interest, Wiener's framing of the stakes of cybernetics which sounded the tocsin was impossible to ignore:

[90] "Automatic Devices Sweeping Industry," *New York Times*, Apr. 16, 1950, F1.
[91] Ronald R. Kline, *The Cybernetics Moment: Or Why We Call Our Age the Information Age* (Johns Hopkins University Press, 2015), 71.

> Those of us who have contributed to the new science of cybernetics thus stand in a moral position which is, to say the least, not very comfortable. We have contributed to the initiation of a new science which, as I have said, embraces technical developments with great possibilities for good and for evil. We can only hand it over into the world that exists about us, and this is the world of Belsen and Hiroshima. We do not even have the choice of suppressing these new technical developments. They belong to the age, and the most any of us can do by suppression is to put the development of the subject into the hands of the most irresponsible and most venal of our engineers . . . . As we have seen, there are those who hope that the good of a better understanding of man and society which is offered by this new field of work may anticipate and outweigh the incidental contribution we are making to the concentration of power (which is always concentrated, by its very conditions of existence, in the hands of the most unscrupulous).

The press coverage of *Cybernetics* may have sounded sensational but Wiener's own language of embedding cybernetics in the world of the Holocaust and atomic weapons lent itself to overdramatization. Additionally, the quoted text was located at the end of the "Introduction," which made it probable that readers inclined to forgo a cover-to-cover reading would encounter the most provocative assertions of *Cybernetics* from the start. Furthermore, Wiener himself argued that "the best we can do is to see that a large public understands the trend and the bearing of the present work."[92] It's no surprise, therefore, that Wiener took it upon himself to 'educate' the public through a plethora of media engagements and eventually the publication of his book targeted at a lay audience, *The Human Use of Human Beings* (1950), which more extensively discussed the social implications of cybernetics.[93]

Directly related to the developing discourse of automation, and due to their association with robots and sci-fi, Wiener's comments on the economic havoc that would soon be wreaked by "mechanical slaves" was quickly picked up in the press. The *New York Times* review of

[92] Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (The MIT Press, 1948), 38-39. Wiener also asserted that cyberneticians should "confine our personal efforts to those fields, such as physiology and psychology, most remote from war and exploitation."
[93] Kline, 71.

*Cybernetics* in January 1949 framed the "new science" in sc-fi terms, noting that "the nightmare vision of robots running wild, or of a Dictatorship of Machines as pictured in Capek's 'R.U. R.'" conjured machines that were no longer "science fiction dreams."[94] The next month, in a follow up article on cybernetics more broadly, science editor Waldemar Kaempffert stated that Wiener "sees no reason why such robots should not eventually run a whole manufacturing plant, so that only a few men would be required to watch lights and make repairs that may be called for."[95]

An *AP* syndicated article about *Cybernetics* that opened with the provocative exclamation, "another war would result in the development of 'mechanical slaves,' which would make many types of human labor worthless."[96] The *AP* article was also reprinted in the *Toronto Globe and Mail* under the title "Industrial Robots To Oust Worker, Professor Warns," which, as far as I am able to determine, was the first appearance of the term "industrial robot" in print.[97] In "Here Come the Robots!," a *Baltimore Sun* article in February 1950, Wiener was quoted as saying, "it's none to soon to consider how we shall use such slaves" as "we are nearer to their production now than we were to the development of radar ten years ago."[98] The *Washington Post*'s initial review of *Cybernetics* quoted Wiener once again foregrounding the connection between a potential war and robotization, to which he added the observation that "the automatization of industry is already making inroads, particularly in the chemical and automotive industries" and "roughly 50 percent of industry's man-hours could be converted to robot-hours within three years" if World War III broke out. "When and if comparative peace

[94] John Pfeiffer, "The Stuff That Dreams Are Made On," *New York Times*, Jan. 23, 1949, BR27.
[95] Waldemar Kaempffert, "Machines That 'Think' Arouse Some Thoughts At Institute of Electrical Engineers," *New York Times*, Feb. 6, 1949, E11.
[96] "Robot Slaves Rise in War," *Los Angeles Times*, May 26, 1949; "Another War Would Result in More 'Mechanical Slaves,'" *Newark Advocate and American Tribune*, June 17, 1949, and "Mechanical Slaves Nearing Perfection," *South China Morning Post*, July 3, 1949.
[97] Rennie Taylor, "Industrial Robots To Oust Worker, Professor Warns," *The Globe and Mail*, May 26, 1949.
[98] "Here Come the Robots!," *Baltimore Sun*, Feb. 5, 1950, MS12.

prevailed," a follow-up article ten days later argued, "returning troops would find in their jobs not women but robots, who wouldn't go home where they belonged," which Wiener predicted, "would cause the greatest unemployment problem this country has yet had."[99]

The following year, a March 1951 article in *Nation's Business*, the house journal of the US Chamber of Commerce, regaled readers about the rapidly approaching age of the robot factory. "Right now," it exclaimed, "most of the country's robot geniuses are concentrating on secret military projects such as atomic energy, guided missiles, and plans for the global reshifting of manpower and matériel before, during and after a major war. But closely tied in with their military use is their even more revolutionary application to industry." The article, which was essentially a review of Wiener's recently published book *The Human Use of Human Beings*, argued that the "competitive advantages of the robot factories would be terrific" and the "new industrial revolution holds the promise of a technological utopia in which mechanical slaves would do most of the work." Notably, however, what to do about making humans compete with "mechanical slaves" and the resulting unemployment was left unaddressed. Rather, the article closed with a warning from Wiener: "Rome which forced her citizens to compete with slaves and created a proletariat which undermined the empire."[100] In similar language and echoing philosophers past, a January 1952 article on automatic controls in *Tech Engineering News*, the forerunner of today's *MIT Technology Review*, opened: "The robot, the slave, so necessary for the humanitarian philosophers' Utopia, is on his way." Titled "Machine Replaces Man," the article also contained one of the earliest, yet peculiar, genderings of the robot: "'He [the robot],' however, does not take the human form, and is not referred to as 'he' but as 'it.' A particularly

[99] "Industry Control By Robot Declared Hastened by War," *Washington Post*, Sept. 5, 1950, B5 and "Rising Robots," *Washington Post*, Sept. 15, 1950, 20.
[100] John Kord Lagemann, "If Robots Run the Works," *Nation's Business*, Vol. 39. Iss. 3 (Mar. 1951).

expensive, erratic or exotic one, might be referred to as 'she.'" Gender aside, they would prove to be "vital factors in American production, standard of living, and military strength."[101]

The cybernetic discourse of military-funded robots laboring in workerless, automatic factories served as a bridge and conduit through which the science fiction of "mechanical slavery" was translated into the science fact of automation. It was understandable that, by 1952, the American public's relationship to automation and robots was anxious, if not hostile, and the year proved to be an inflection point in the broader discourse of technology and unemployment. That year, a twenty six year-old Harvard Business School graduate named John Diebold published the first major text on the subject. The book catapulted Diebold—who would soon earn the monikers of "evangelist," "high priest," and "prophet" of automation—into the limelight.[102] Born June 8, 1926 in Weehawken, New Jersey, Diebold began his intellectual career at Swarthmore College in 1943 but soon delayed his studies to attend the United States Merchant Marine Academy for merchant marine service during World War II. While training in 1944-1945, he had his first experience with "robots" when his North Atlantic convoy ship the *S.S. Shooting Star* underwent several weeks of V-2 bombing. Diebold eventually returned to Swarthmore after the war and graduated in spring 1949 with a B.S. in Economics (with a split minor in Political Science and Psychology).

Diebold entered Harvard Business School in the fall of 1949 and soon after published his first article on the human relations aspect of Taylorism.[103] In September 1950, Diebold enrolled in Georges Doriot's famous "Manufacturing" course and began a lifelong friendship and

[101] Peter Embree," Machine Replaces Man," *Tech Engineering News*, Vol. XXXIII, No. 4 (Jan. 1952), 8.
[102] Jason Resnikoff, *Labor's End: How the Promise of Automation Degraded Work* (University of Illinois Press, 2022), 39.
[103] Wilbur Cross, *John Diebold: Breaking the Confines of the Possible* (James H. Heineman, Inc., 1965), 21-30. Wikipedia mistakenly states that Diebold's undergraduate degree was in Engineering.

professional relationship with the soon legendary figure. Doriot, after emigrating to the U.S. from France in 1921, began his sojourn through the halls of American power in 1926, first as an industrial management professor at Harvard, then as Brigadier General of the Army's Quartermaster Corps during World War II. Immediately after the war, Doriot co-founded and served as first president of the American Research and Development Corporation or ARDC, perhaps the world's first venture-capital firm, earning him the moniker, "Father of Venture Capital."[104] Doriot assigned Diebold as leader of the "Automatic Controls Group" and tasked them with producing a ten-year industry projection of the "automatic factory." Published in May 1951, the group's report, titled "Making the Automatic Factory a Reality," was much more ambitious. As spelled out in the report's opening letter to Doriot:

> A ten year projection is included but it is not the primary focus of the study. For as our work progressed it became increasingly clear that a great gap must be closed before automatic production can in any significant sense become a reality. That gap is primarily informational. Most manufacturers do not know what is technologically possible in the way of automatic production. Nor do they realize in what terms they must think in order to usefully apply this technology to industry. It is to this need that we have turned. It is not that we have added to the sum of knowledge. It is rather that we have tried in a small way to aid in the manner most needed if the automatic factory is indeed to become a reality.[105]

Diebold and the group, therefore, tasked themselves with reshaping the ideological contours and terms of engagement regarding automation.

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[104] Spencer E. Ante, *Creative Capital: Georges Doriot and the Birth of Venture Capital* (Harvard Business Press, 2008) and Tom Nicholas, *VC: An American History* (Harvard University Press, 2019), 107-143. ARDC would famously make a significant investment in the Digital Equipment Corporation (DEC) in 1957 and, that same year, Doriot help establish INSEAD, the world's first "business" school outside the United States.

[105] John Diebold et al., "Making the Automatic Factory a Reality," Harvard Business School (May 15, 1951), frontispiece. https://www.library.hbs.edu/docs/MakingTheAutomaticFactoryAReality.pdf. There is a significant amount of slippage in the text between the words "automation," automatization," and "mechanization," each meaning essentially the same thing with minimal variation according to context and usage.

The report's arguments and themes are worth exploring in some detail as they were eventually repackaged for Diebold's book which indelibly, perhaps more than any other single text, shaped the automation discourse and ideology of technoliberalism during the period. To accomplish their project, the "Automatic Controls Group" framed Norbert Wiener specifically and the field of cybernetics more broadly, which in their estimation, "has had dominant influence upon thinking in the area of industrial automation," as a bête noire and foil to the automation they envisioned. The cybernetic focus on communication and control in animal and machine, particularly in relation to its obsession with design and use of sensory and effector devices, they argued, distracted from the "greatest handicap to industrial mechanization . . . . the automation of fabricating and materials handling functions which are now performed manually," the exact functions the industrial robot would soon be designed to fulfill.[106] "It is here," they later explained, where the "greatest immediate strides can be made toward automation, with the least cost and the greatest return."[107] From their perspective, automation did not require cybernetics and, instead of focusing on what cybernetic devices could do, the group asked "What do men do?"; "Can machines do these things better?"; and ''How can this be brought about?"[108]

The report's answer to these questions and argument was straightforward: "A much higher degree of industrial automation is both desirable and technologically possible" and achievement of this "does not require the postulation of basic technological innovations, for the limiting factor is not technology but the difficulty which men experience in thinking fruitfully in the terms required."[109] Citing Brown and Leaver's "Automatic Factory" piece in *Fortune* as motivating their thinking, Diebold et al. posited that rather than larger and more specialized

[106] Diebold et al., 1-2.
[107] Diebold et al., 10.
[108] Diebold et al., 4.
[109] Diebold et al., 5.

machines, greater automation would be accomplished through designing machines that could fabricate and handle a range of work, and which could also be rearranged on the shopfloor to give the "automatic factory" flexibility.[110] The report covered a wide swath of issues related to automation and even provided the design outlines of an automatic piston factory. Critical to the evolving automation discourse, however, was a chapter on the "Social Implications of the Automatic Factory." According to Diebold et al., automation would primarily be concentrated in the manufacturing sector (as well as "miscellaneous accounting function of other industries") and its spread would be gradual enough "to decrease the severity of problems which must be faced."[111]

Two of these problems, labor displacement and worker adaptation to new job tasks, dominated the group's attention. Working under the assumption that only automating an old plant, rather than building a new automated plant, would result in worker displacement, they argued that union attitudes toward automation "may include some obstructionism" that could be overcome if "union membership shares in the benefits of change." Unions, they predicted, would attempt to keep more workers on the job than necessary (i.e., featherbed) through attempts to increase wages and shorten the workday with union success depending on their bargaining strength. These demands would decrease the savings gained from automation and would most likely slow the speed automating generally. Additionally, if automation was carelessly managed, this would exacerbate labor-management problems, particularly during the short period it would take to get automatic processes up and running. "Every worker in a plant which is to be automatized," they claimed, "will not be able to keep his job." However, the increased productivity from automation would increase aggregate demand and, therefore, generate new

[110] Diebold et al., 15-17.
[111] Diebold et al., 73.

employment opportunities as "the effects of completely automatic production will not be substantially different from those of technological developments in the past."[112]

In terms of new work, automation would no longer "allow" workers to control their labor but would instead "confine" them to "button-pushing and routine maintenance jobs around the factory." The group felt that such work was "no more, and perhaps, less degrading" than existing manual labor, to which they posed the rhetorical question: "Is it not better to regiment machines than men"? While such jobs, they confessed, may be very boring and therefore undesirable, "some people are well-suited for this kind of work" and discovery of this suited worker would "require a careful personnel screening."[113] More than a half century earlier, Frederick Winslow Taylor—the "Father of Scientific Management"—posited a similar rubric for his ideal *manual* worker: "He shall be so stupid and so phlegmatic that he more nearly resembles in his mental make-up the ox than any other type."[114] Or, in the words of Joseph Engelberger thirty years after the Diebold et al report, such 'push-button' jobs only required the "mental equipment of an idiot."[115]All of these issues would soon come to the fore as the group predicted that the "robotized plant" of the future was soon approaching.[116]

The "Automatic Controls Group" report was well received by Doriot and swiftly received a public audience. In September, four months after the report was submitted, *Scientific American* provided a brief summary titled "The Automatic Factory" and, two months later, the editor of *American Machinist* highlighted the report and asked, "How Soon the Automatic Factory?"[117]

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[112] Diebold et al., 72-75.
[113] Diebold et al., 75. The group's discussion of a third problem, leisure time, was rather mundane and they concluded that "people will not encounter any substantial trouble in utilizing leisure time," 75-76.
[114] Frederick Winslow Taylor, *Scientific Management* (Greenwood Press Publishers, 1974), 59.
[115] Saveriano, "An Interview with Joseph Engelberger," 20.
[116] Diebold et al., Appendix B, 3.
[117] "The Automatic Factory," *Scientific American*, Vol. 185 Iss. 3 (Sept. 1951), 58 and 60 and Burnham Finney, "How Soon the Automatic Factory?," *American Machinist*, Vol. 95, No. 24 (Nov. 26, 1951), 119.

Both write-ups tagged Diebold as the group leader and, perhaps in light of this, he quickly expanded and refined the "Making the Automatic Factory a Reality" report for a popular audience, titling the now book-length treatment of the subject *Automation: The Advent of the Automatic Factory* (hereafter referred to as *Advent*), a text that essentially became the lodestar of automation. For instance, Wilbur Cross, Diebold's biographer, placed "1952 *Automation: The Advent of the Automatic Factory*—John Diebold" in between two of arguably the most important technical developments of the twentieth century, "1950s First transistorized computers" and "1954 Numerical control—Massachusetts Institute of Technology," in his chronological list of automation milestones.[118] "More than the newspaper or trade journal articles coming from the automobile industry in Detroit," as historian Jason Resnikoff described, "it was Diebold's book . . . . that elevated 'automation' to its status in the postwar period as the watchword of technological progress."[119]

Published in 1952, the updated text toned down some of technical jargon for a more conversational tone that provided more historical contextualization and contemporary examples of industry and technological change, both inside and outside of manufacturing. While the book recycled the arguments and themes of the report, three developments in the new text are worth mentioning—the example of the real-world automatic factory already in existence, labor resistance to automation, and robots. Diebold's example of an operating automatic factory, the Rockford, Illinois ordnance plant, is notable in that it illustrates ongoing patterns in the history of automation generally and the history of technological development in the United States more broadly: the plant's automaticity was financed by and built for the military, a private firm's experience managing the plant informed their approach to developing and applying automation,

[118] Cross, 280.
[119] Resnikoff, 39.

and the government's role in these processes was rarely mentioned let alone identified as crucial.[120]

Built in 1941 under the supervision of the Defense Plant Corporation by the W. F. John Barnes Co. to produce 37 and 57-mm shells, the plant had its famous automatic production line for 155-mm shells installed at the end of the war shortly before it was mothballed in 1946.[121] The Chicago Ordnance District reopened the plant with the outbreak of the Korean War and, after the conflict subsided, Pressed Steel Car Co., Inc. landed the contract for managing and operating the government-owned plant (the legal arrangement of which was called "GOCO" or "government-owned, contractor-operated" that became common after World War II at military-production facilities).[122] The Pressed Steel Car Company referred to the facility as an "almost completely automatic plant," while *Business Week* described it in 1953 as "an automatic factory without computers."[123] Two years after the contract, the Pressed Steel Car rebranded as U.S. Industries and also began development of the first commercially available industrial robot called the TransfeRobot.

Diebold's argument about labor resistance was relatively straightforward. "When automation makes obsolete a specific human skill," Diebold observed, "it imposes hardship upon the individual laborer," which understandably resulted in automation being "vehemently opposed."[124] Once again, 'automation' was positioned as an active force *causing* skill obsolescence, rather than social actors deploying, managing, and organizing capital and labor in particular ways for that particular purpose. Nevertheless, he continued, the responsibility for

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[120] John Diebold, *Automation: The Advent of the Automatic Factory* (D. Van Nostrand Company, Inc., 1952), 73-80.
[121] "Push-button Line for Ammunition," *Business Week*, Sept. 26, 1953, 69-71.
[122] Pressed Steel Car Company, Inc., *Annual Report* (1952), 6. For GOCO see Mark Wilson, *Destructive Creation: American Business and the Winning of World War II* (University of Pennsylvania Press, (2016).
[123] Pressed Steel Car Company, Inc., *Annual Report* (1953), 6 and "Push-button Line for Ammunition," *Business Week*, Sept. 26, 1953, 69.
[124] Diebold, *Automation*, 128 and 129.

relocating, retraining, and/or restoring the workers' earning power "must be shared by both labor and management—by the nation as a whole—for manpower is part of our national resource." Furthermore, Diebold declared, "if we are to attack the roots of the problem of human resistance to technological change, considerable attention must be given to the upgrading of our education system so that young people entering the labor force will possess the abilities necessary to adjust themselves to industrial change."[125] In a technoliberal update of Emerson, therefore, technology was in the saddle and rode mankind.

In regard to robots, Diebold resumed his attack on the "Father of Cybernetics" that he launched in the Harvard report, exclaiming, "writers such as Norbert Wiener, by emphasizing the similarity of automatic control systems and the nervous systems of humans and animals, have made the world of science fiction seem indeed upon us, with a race of human-like robots already in the making. No interpretation of the facts could be more perverse—or disturbing." The classics of sci-fi scuh as *Frankenstein, R. U. R.,* and the film *Der Golem*, Diebold argued, used "pseudo-scientific language" that "when coupled with the animal-machine analogy of the Norbert Wiener school," surrounded the domain of speculative science and technology, which presumably included automation, "with an aura of reality." The still popular perception of sci-fi robots as evil, job stealing, humankind-destroying menaces, therefore, colored the public's interpretation of automation, the language and promise of which Diebold assuredly did not equate with pseudo-science. "From the standpoint of performing industrial tasks, humans are, in most cases very inefficient," he continued, so why would we want to replace humans with anthropomorphic robots "in our *present plant*"?[126]

[125] Diebold, *Automation,* 128 and 130-131.
[126] Diebold, *Automation,* 153-156, emphasis in original.

> But what a waste of investment this would be! For what a waste of human resources it is at present to have a human being, capable of all a human can do and feel and express, standing in an assembly line tightening nuts! If we possessed sufficient technological ability to develop human-like robots, what a waste it would be to go about our industrial tasks in the way we perform them today. How much better to build machines which could perform these tasks without having the added ability to play games of chess, to walk, to solve difficult problems and to communicate with others. So, too, it would be a waste of investment to build machines—even though not possessing human qualities—to perform the multitude of functions of which a worker is capable. We want flexibility in our machines, of course. We want multi-purpose machines, too. But the maximum degree of flexibility that could be industrially useful and economical falls very far short of anything even remotely approaching the fully human machine.

As a result, automation would not take on the shape of "all-purpose robots" but would rather take the form and function of familiar machines.[127] The conveyors, "iron" hands, and "mechanical arms" of the "automatic factory," therefore, were the future of automation. Much like his discussion of automation and labor resistance, Diebold's description of the productive process *prior to automation* revealed much more than he imagined. One can only wonder if he ever asked himself: Why was the economic system "wasting" human resources by forcing workers to stand on an assembly line tightening nuts in the first place?

Coverage of *Advent* in the press was initially scant. *Scientific American* followed up their September 1952 write-up with an advertisement in December about the "first book on Automation."[128] While Diebold was explicitly concerned with labor resistance to automation after the flood of stories sensationalizing Wiener's stalking "mechanical slaves" throwing people out of work, discussions of automation-induced mass unemployment had relatively subsided by the time *Advent* was published. There are a number of plausible reasons for this. First and foremost, macroeconomic conditions were conducive to overlooking structural changes in the economy: unemployment, which hit a high of 6.5 percent in October 1949, had steadily been

[127] Diebold, *Automation*, 156.
[128] *Scientific American*, Vol. 187, Iss. 6 (Dec. 1952), 82.

dropping (with momentary perturbations) to 2.5 percent in June 1953.[129] Automation was also new enough and obscure enough of a phenomenon that the press was most likely still metabolizing what exactly it was, what it could do, and what it meant. Additionally, their source of information—i.e., the automaters themselves—were obviously marketing automation in positive terms. Furthermore, while the labor press became increasingly vocal about automation after 1950 (discussed below), voices from labor were relatively absent in popular periodicals—for instance, the one thousand workers purportedly "displaced" at Ford's Highland Park plant were never heard from.

One other reason for the paucity of unemployment talk was that the economic costs, and therefore practical uptake of automation, were quickly understood to be higher than most businesses were willing or able to bear. In July 1951, two months after Diebold's group published their report, a *Business Week* article on "How a Robot Factory Would Work" cautioned that existing automatic production required machines that were too specialized and "take too much money to refit them for some other product." For robots to be economical, therefore, "they must turn out large batches of the product to justify their initial cost," and they must be "flexible enough to perform a range of similar operations within practical limits."[130]

The *New York Times* echoed these sentiments in November 1952 when they foregrounded Chrysler executive David A. Wallace's observation that automation was not as economically attractive as it was made out to be. While in his estimation it cut down on unskilled labor, it increased the need for skilled workers which were harder to find. Furthermore, Wallace

[129] U.S. Bureau of Labor Statistics, Unemployment Rate [UNRATE], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/UNRATE, Jan. 1948-Dec. 1954. While economy or nationwide statistics elide and obscure local and sectoral differences (i.e., the most relevant scales of "automation") they're still useful (perhaps only useful) for understanding broad, nonspecific trends.
[130] "How a Robot Factory Would Work," *Business Week*, July 21, 1951, 59.

decried the "satisfaction of personal ego" dimension of automation and proclaimed, "I know of places where automation has been installed for no earthly reason other than the owner or manager just simply wanted it. In terms of the amount of capital we have been accustomed to using, automation is usually expensive. Unless the decision is made on facts rather than feelings, it could have serious financial consequences if applied too strongly in the wrong places." There was "no room for keeping up with the Joneses," he argued, as manufacturing was "a cold-blooded, hard-fighting' business."[131]

Later that month, *Business Week* ran a similar story on Wallace's comments and noted that he "steers clear of ambitious descriptions such as automatic, robot, or push-button. His company, and many others, are still a long way from those stages, even in their planning. Wallace prefers a word that denotes the first step toward the factory of the future: automation, the automatic handling of materials and parts in and out of machines." While almost any firm could "build a robot plant today if it has the money" the threat of "burning up its profits" paying for higher-skilled labor and machine maintenance put a crimp in business's automation hopes.[132] Noting in March 1953 that "the word 'automation' is one which has rocketed into general usage in American industry within the last few years," Wallace, this time on behalf of the Society for Advancement of Management rather than Chrysler, asked "When Does Automation Pay?" For a litany of reasons, he determined not soon enough.[133]

In October 1953, *Fortune* magazine sponsored a roundtable of experts to reassess "The Automatic Factory" thesis of seven years prior. One of the invitees was E. W. Leaver, co-author with J. J. Brown of the original piece from 1946, who argued that industry's attempt to automate

[131] "Trend is Decried to Mechanization, *New York Times*, Nov. 1, 1952.
[132] "Automation: Road to the Robot Plant," *Business Week*, Nov. 22, 1952, 55.
[133] David A. Wallace "When Does Automation Pay?," *Management Review*, Vol. 42, Iss. 3,, Mar 1, 1953, 157-158.

"got off on the wrong foot by trying to create highly specialized machines." Such machines, Leaver continued, were so complex they "rival Rube Goldberg" and the "great cost involved" was slowing the spread of automation. This lack of flexibility was deemed by Leaver's co-author J. J. Brown to be "the most vexatious problem in the whole field of automatism." However, he clarified, while flexibility saved money in the long-run, the short-run economics of inflexible automation were sound because "its cost can be quickly written off." Nonetheless, "long-term strategic and social consideration" justified the investment in flexibility because "in a fast moving technological world [inflexibility] can be highly dangerous."[134] Diebold, in a wide-ranging *Harvard Business Review* article on automation in December that year, echoed these same calls and argued that what was missing were "innovations in flexible manufacturing and materials-handling equipment" that could load and unload workpieces, automatically transfer workpieces between work processes, and automatically inspect finished products—the exact functions the industrial robot would soon be designed to fulfill.[135]

Nineteen fifty-four witnessed a significant increase in the volume of discussion about automation. The most likely cause of this was the end of direct American involvement in the Korean War and, more specifically, the end of economic growth associated with wartime spending. In July 1953, the same month the armistice was signed between North and South Korea, the U.S. economy entered its first recession since 1949, from which it didn't rebound until September 1954 (if consistently falling unemployment is used as an indicator).[136] Nonetheless, the *New York Times* declared in January that "Automation Stirs New Revolution,"

[134] "The Automatic Factory: A Fortune Round Table," *Fortune*, Vol. 48, Iss. 4, Oct. 1953, 178 and 188.
[135] John Diebold, "Automation—The New Technology," *Harvard Business Review*, Vol. 31 Iss. 6 (November-December, 1953), 67.
[136] U.S. Bureau of Labor Statistics, Unemployment Rate [UNRATE], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/UNRATE, Jan. 1953-Dec. 1954.

while "Tomorrow's Factories" were announced by *Barron's* in March.[137] When the *New York Times* informed readers in May about the first government-sponsored conference where "Industrial Leaders Study Automation," there's no doubt the assembled industrialists were trying to formulate answers to the question "Will 'Cybernetics' Do Away With People?" asked by *Management Review* a couple months later: as one of the attendees at the conference, K. R. Geiser of General Electric (GE), argued, the word 'automation' was "beclouded by many strange new words — words that conjure up visions of robots running machines and factories without men. Many of these new words have little more bearing on the understanding of 'Automation' than does a knowledge of the physical laws governing the absorption and bending of light have on the enjoyment of a beautiful sunset."[138]

The mid-1950s witnessed the ascent and apex of not just the automation discourse but its robot variant. Automation had become such a hot topic that in July 1954 Diebold announced the publication of what he referred to as "the first business magazine of the second industrial revolution," called *Automatic Control*, which he co-founded and, as associate editor, wrote a monthly column titled "Feedback." Diebold echoed Geiser's critique of linguistic inexactitude in the issue's second article where he called for experts in the field to standardize terminology and challenged them to define and distinguish between terms such as 'automation,' 'cybernetics,' and 'robotization' in an effort to "assure full growth potential in the field of automatic control."[139] The following month, Penton Publishing Company—printer of major manufacturing trade journals such as *Foundry* and *Machine Design*—started their own magazine on the topic called

[137] William M. Freeman, "Automation Stirs New Revolution," *New York Times*, Jan. 4, 1954, 76; John Chamberlain, "Tomorrow's Factories," *Barron's National Business and Financial Weekly*, Vol. 34, No. 11 (Mar. 5, 1954), 3; and K. R. Geiser, "What is Automation?" in "Minutes of Conference: Automation and Industrial Development, May 12, 1954," State of New York Department of Commerce, Albany: 1954, 6.
[138] "Industrial Leaders Study Automation," *New York Times*, May 13, 1954, 52 and James H. Collins, "Will 'Cybernetics' Do Away With People?," *Management Review*, Vol. 43, Iss. 7 (Jul 1, 1954), 411-413.
[139] Cross, 59.

*Automation*. And, a month later in September, a subsidiary of business press stalwart Dun & Bradstreet entered the automation information fray with *Control Engineering* magazine. By December, president of GE Ralph Cordiner was urging three thousand fellow executives of the National Association of Manufacturers to "shun creeping conservatism," not politically but in terms of their hesitance to invest in automation, while the *Wall Street Journal* broadcasted "Alarm Over Automation."[140] In April 1955, Robert Bendiner in *The Reporter* equated Ford's Cleveland engine plant as a representative of "robot industry" while that same month A. H. Raskin of *The New York Times* predicted that "Automation Puts Industry on Eve of Fantastic Robot Era."[141]

If the goal of the Harvard Business School Class of '51 was to defeat Diebold's arch nemesis Wiener in ideological combat by reshaping the contours and terms of engagement regarding automation, it's safe to say they succeeded. A 1956 *Time* magazine article declared that "robot machines are cutting costs, boosting profits and making jobs, bringing more leisure to everyone." Furthermore, it told readers that Norbert Wiener, who five years prior forecasted "automation would reduce wage earners to 'slave labor,'" had become a convert as "man is becoming automation's master, not its slave."[142] Technoliberal machines, now even for Wiener, heralded the future.

**Manufacturing Security: Automation and the Quest for a Preponderance of Productivity**

[140] Harry C. Kenney, "Nation's Industrial Leaders Urged to 'Shun Creeping Conservatism'," *Christian Science Monitor*, Dec. 3, 1954, 20.
[141] Robert Bendiner, "The Age of the Thinking Robot, And What It Will Mean to Us," *Reporter* (Apr. 7, 1955), 14 and A. H. Raskin, "Automation Puts Industry on Eve of Fantastic Robot Era," *New York Times*, Apr. 8, 1955, 14.
[142] "Automation: Robot Machines Are Cutting Costs, Boosting Profits and Making Jobs, Bringing More Leisure to Everyone," *Time* (Mar. 19, 1956), 98.

When automation was just in its infancy after World War II, no social problem loomed larger than "security" and American capitalism's fight against Soviet communism. While the Soviet threat may have been more rhetoric than reality, policymaker's recognition of the new technological environment created by the war—characterized by ballistic missiles, computers, electronics, jet engines, submarines, and most terrifyingly, the atomic bomb—reversed the historical "natural" security of the United States to one of national insecurity. "Our geographic security is now gone," President Harry Truman declared two months after the war. "Never again can we count on the luxury of time with which to arm ourselves."[143] And if "security" was conventionally conceptualized in terms of domestic defense from foreign threats, it quickly expanded far beyond its traditional bounds during and after World War II as facets of American life from arts, culture, and religion to gender, race, and sexuality were 'securitized.'

For many business and labor leaders, politicians, and public intellectuals, however, a strong economy that could generate the most advanced science and technology was key to securing the American way of life. According to historian Melvyn Leffler, national security had one overarching goal: "to ensure that no potential adversary or coalition of adversaries gained preponderant control over the resources of Europe and Asia" so as to "glorify the principles of liberal capitalism, provide the markets for American agricultural and industrial production, and stymie the accretion of strategic power by other nations." Additionally, Leffler continues, "U.S. policymakers were altogether cognizant that their country's national security resided in its relative economic and technological superiority," both of which fed and were fueled by

[143] Quoted in Aaron Friedberg, *In the Shadow of the Garrison State: America's Anti-Statism and Its Cold War Grand Strategy* (Princeton University Press, 2000), 37.

America's "preponderance of power."[144] 'Free enterprise,' however, was not up to the task as the expense and risk involved in fostering the science and technology that could defeat the Communist menace proved prohibitive. Science and technology, therefore, became wards of the American state as the federal government quickly became the first and last resort for funding the permanently mobilized "Arsenal of Democracy." As a result, inclusion under the 'security' umbrella meant resources from the supply-side technoliberalism of the national security state would flow freely in the name of fighting the Communist menace.

To build a strong economy required continual improvement in productivity, therefore automation, which purportedly was the producer of this, was easily 'securitized' after the war. One of the earliest articulations of this came in Leaver and Brown's *Fortune* article "Machine Without Men" from 1946. After listing "flexibility, decentralization, and nondependence on manpower" as the advantages of the "automatic factory" manned with batteries of mechanical arms, they argued that such factors "can have profound implications for national security."[145] Eight years later in *Advent,* John Diebold foregrounded automation as a critical factor in the Cold War. "The vast number of peoples on the side of communism, or least under the dominion of the U.S.S.R.," he argued, "has made this struggle seem something of a race for population, but it is not so much a matter of numbers of people as of productivity." Economic efficiency, therefore, was a geopolitical weapon to be cultivated as "it is only by increasing output per manhour worked that we will be able to build effective defense against the aggressive powers of communism." Building this defense was not, however, solely the task of the United States.

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[144] Melvyn P. Leffler, *The Specter of Communism: The United States and the Origins of the Cold War, 1917-1953* (Hill and Wang, 1994), 47-48 and *A Preponderance of Power: National Security, the Truman Administration, and the Cold War* (Stanford University Press, 1992), 2-3. Surprisingly, there is essentially zero discussion of technology or "technological superiority" in either of the cited texts, outside of what has been quoted.
[145] Leaver and Brown, "Machines Without Men," 203.

Noting that the Marshall Plan that rebuilt Western Europe led to the "largest exportation of national wealth to aid other peoples in the history of the world," Diebold predicted that similar programs would not be forthcoming for the "Middle and Far East, and other underdeveloped areas" due to the possibility of such programs "severely reducing our own national wealth." What was needed then was "a means of materially increasing the productivity of the peoples of these countries" and "automation offers just such a possibility." Furthermore, anticipating Walt Rostow's *The Stages of Economic Growth* (1960), which posited a model of modernization characterized by sequences of increasingly complex development, Diebold argued that "the long years of political development required before agrarian underdeveloped populations can become effective and responsible citizens of our modern society" could be bypassed by automation. As he described it, "automation may well provide a short cut to achieving a high rate of output of material goods among our allies and thus help us erect an effective block to further victories by the false god of communism."[146] Hammering home the threat two years later in 1954 at the reception introducing *Automatic Control* magazine, Diebold warned that "our technology should take every advantage of [new applications of automation] because the Russians were well along in research and accomplishment in the field."[147]

Automation as a national security issue first appeared on Congress's radar in December 1953. At hearings on the "Subversive Influence in Certain Labor Organizations," president of the American Communications Association Joseph P. Selly was called to testify about Communist infiltration of his union. After a contentious back-and-forth with Senator James Eastland (D-MS) and special counsel Richard Arens about Selly's planned testimony, the latter was able to submit his prepared statement into the record. In it, Selly argued that the real threat to national security

[146] Diebold, *Automation*, 170-173.
[147] "Automation Held Good For Job Shop," *New York Times*, July 6, 1954, 37.

was not communist infiltration of labor organizations but the economic crisis driven by "big business" that was seeking to "cut wages while increasing production through speedup and automation." Big business, in his estimation, was "ruthlessly laying off hundreds of thousands of workers every month" in a hope "to maintain their huge profits . . . . by readjusting the workers and farmers to unemployment, insecurity, and a lower standard of living."[148]

While the hearings were concerned with legislation regarding how, according to Senator Barry Goldwater (R-AZ), "communism in labor unions can be eliminated as a threat to the national security and to the national economic structure," Selly's argument that automation and the state of the economy were directly related to national security was the first of its kind in the congressional record.[149] Shortly after the hearings were wrapping up in January 1954, the Council of Economic Advisers (CEA) submitted their yearly "Economic Report of the President" for Eisenhower's signature. While the report made no direct reference to automation, it did contain an appendix extolling the contributions of "military research" to future civilian (read: commercial) applications. "Although most Federal research and development funds are now devoted to projects sponsored by the Department of Defense and Atomic Energy Commission," the report declared, "it would be a mistake to assume that the results will not be largely applicable, sooner or later, to civilian purposes," with an example of the results being "electronic automatisms." Additionally, the appendix continued, "the many thousands of scientists and engineers now engaged in defense research and development are, in effect, being readied to facilitate this conversion."[150]

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[148] *Subversive Influence in Certain Labor Organizations*, Hearings before the Subcommittee to Investigate the Administration of the Internal Security Act and Other Internal Security Laws, 1954, 327.
[149] *Subversive Influence in Certain Labor Organizations*, Hearings before the Subcommittee to Investigate the Administration of the Internal Security Act and Other Internal Security Laws, 1954, 65.
[150] *Economic Report of the President: Transmitted to the Congress January 28, 1954*, 162.

Hearings on the Internal Revenue Code of 1954 held that April provided an indication of how the discourse about automation, the economy, and national security was evolving and gave an idea of how military-funded and military-related investments within the supply-side technoliberal apparatus would be facilitated: tax breaks. According to Russ Nixon, the Washington representative of the United Electrical, Radio, and Machine Workers of America (UE), accelerated amortization of "defense" facilities enacted in 1950 had created what the House Committee on Expenditures in the Executive Departments called "the biggest bonanza that ever came down the Government pike" and, they assessed, the administration of which was "unsound and detrimental to the public interest."[151] The UE was therefore calling for an elimination of accelerated amortization specifically and a variety of changes to the tax code that would favor labor over capital.

Unlike Nixon, UAW-CIO president Walter Reuther framed his approach to tax matters in terms of the Cold War and argued that changes to the tax code that favored capital and the wealthy were detrimental to the economy and therefore to the fight against communism. As he described at the hearings, "We believe that the American economy is freedom's greatest asset and we believe that America is the last best hope of freemen everywhere. We believe that the most decisive factor in whether we are going to be strong in the world and whether the free world is going to be strong in facing the threat of Communist tyranny will be decided by how effectively we mobilize our productive power and how intelligently we distribute the abundance that our economy makes possible." Reuther was one of only two interlocutors to foreground automation, and within the context of the Cold War and tax breaks, he argued, "I believe there are adequate incentives already. You have got all kinds of tax writeoffs, all kinds of amortization

[151] *Internal Revenue Code of 1954: Part 2*, Hearings before the Committee on Finance, 1954, 653.

provisions, and so forth, that I think are adequate to provide the capital." Furthermore, in Reuther's estimation, industrial capacity was already far beyond what demand could consume and more investment only exacerbated excess capacity.[152]

Confirming these estimates, New York Law School professor J. Henry Landman warned that adoption of more aggressive depreciation allowances would incentivize new plant and equipment "constructed in accordance with the principles of automation," which would "aggravate immediately our unemployment problem." Additionally, since "automation is inevitable," Landman continued, "it is not wise to precipitate its wide use at a time when we are urgently seeking to induce a rapid recovery from our national recession."[153] To neutralize these arguments, Nathan First of the progressive organization Americans for Democratic Action also resorted to Cold War rhetoric and claimed that because "the real threat in the world today is Communist aggression . . . . tax cuts [should] be considered in light of our defense needs" as "the security of the United States and of the free world in real measure depends on the economic strength and economic well-being of the United States."[154]

The issue of supply-side technoliberalism and national security remained on Congress's radar the following year and, not surprisingly, automation was part of the conversation. In his July 1955 testimony on "Federal Tax Policy for Economic Growth and Stability," Alvin Hansen—at the time one of the country's most well-respected economists who has been called the "American Keynes"—summarized the social complexity of how technological change emerged: "Capital accumulation is indeed a means of implementing progress, but it is not the source of progress. The real source of economic progress is scientific research, inventions,

[152] *Internal Revenue Code of 1954: Part 2*, Hearings before the Committee on Finance, 1954, 836.
[153] *Internal Revenue Code of 1954: Part 4*, Hearings before the Committee on Finance, 1954, 1890.
[154] *Internal Revenue Code of 1954: Part 4*, Hearings before the Committee on Finance, Senate, 1954. 881-882.

innovations, technology—new ways of doing things, new products, new techniques. Without the advance of technology, capital accumulation would quickly come to an end."[155] Additionally, Hansen described, "the more we achieve well-nigh robot perfection, in this era of increasing automation, in the production of material," the more focus could be placed on cultural activities, education, health, and intellectual pursuits, which were key determinants of long-term growth in productive capacity.[156] As a result, and based on his assessment of the economy at the time, Hansen advised that taxes remain unchanged and called for "an increase in the very much needed nonmilitary expenditures."[157] Fellow Cambridge-based economist Paul Samuelson from MIT made sure to foreground that debates about taxes rates and expenditures were ethical, moral, and political, rather than problems of "scientific technical economics." As he quipped, in perhaps the pithiest statement of the Keynesian vision, "I wish to reiterate that by the proper choice of monetary and fiscal policy we as the artists mixing the colors of our palette, can have the capital formation and rate of current consumption that we desire."[158] While Samuelson never mentioned automation specifically, he did provide one of the most straightforward descriptions of the institutional milieu from which automation sprung:

> As against [the "mere duplicating of capital"], there is the creative act of technological innovation, both in purely science and applied technology. Now, I look with the greatest of pleasure upon the very heavy support of basic research which the Federal Government has been giving in the postwar. It is true that this has been the result of our feeling of national insecurity, but the effects have been very favorable; not only in universities like my own [MIT] is there a tremendous amount of basic research going on financed by the Government but if you go into private industry and if you look at what seems like a

[155] *Federal Tax Policy for Economic Growth and Stability*, Hearings Before the Subcommittee on Tax Policy, 1955, 6.
[156] *Federal Tax Policy for Economic Growth and Stability*, 6-7.
[157] *Federal Tax Policy for Economic Growth and Stability*, 28.
[158] *Federal Tax Policy for Economic Growth and Stability*, 177-179.

> perfectly private, purely free-enterprise activity, you find that it is underwritten by defense contracts.[159]

Later, during an exchange with chairman of the hearings Wilbur D. Mills (D-AR) regarding recommendations about the optimal ratio of interest rates and taxes to produce a high level of investment, Samuelson stuck with his position that such issues were a matter of philosophy rather than economics. However, Samuelson slipped in a curious statement: "Nor do I wish to stress my belief that the rate of capital formation for national security purposes ought probably to be stepped up. That happens to be my private belief, but it is not as an economist that I hold that."[160]

Of all the witnesses called to testify, Amherst economist James R. Nelson most clearly and cogently connected the economy to national security: "A wealthy economy may or may not have a greater national security problem than a poor one, but the wealthy economy is in a better position to protect itself if it so desires."[161] While the hearings did not provide clarity on the best course of action regarding taxes, all were in agreement that the cultivation of productivity-enhancing technology was necessary to increase the efficiency of capital accumulation and bolster national security. Nonetheless, tax cuts as a weapon against Communism eventually proved to be the most compelling argument as incentives for capital formation were not only kept on the books but expanded, particularly to the benefit of manufacturing corporations that used them more than any other sector of the economy over the next half decade.[162]

The year 1955 also proved to be a landmark in the political conceptualization of directly connecting automation to economic growth and thereby national security. Public fervor about

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[159] *Federal Tax Policy for Economic Growth and Stability*, 200.
[160] *Federal Tax Policy for Economic Growth and Stability*, 217-218.
[161] *Federal Tax Policy for Economic Growth and Stability*, 358-359.
[162] Norman B. Ture, *Accelerated Depreciation in the United States, 1954–60* (Columbia University Press, 1967), 98.

automation had reached a fever pitch that year and the political class was finally motivated to, at the least, formally discuss automation as a topic in its own right. No single event demonstrated this more than the first official Congressional hearings on the issues in October. The hearings on "Automation and Technological Change" chaired by House Representative Wright Patman (D-TX) were designed to continue the conversation spurred by the President's Economic Report from the previous year about the "importance of continually increasing industrial productivity." Accordingly, Congress's Joint Economic Committee on the Economic Report tasked the House Subcommittee on Economic Stabilization "to study the impact of so-called automation on long-run employment and investment levels," and the hearings were one of the results. Furthermore, as Patman's opening statement explained:

> The interest which the full committee expressed last winter [1954], and which prompts these hearings, has since grown by the week and month as the newspapers, Sunday supplements, and magazines report over new and startling developments in automation. The frequency with which not only the trade magazines but the mass-circulation popular magazines have devoted articles to this subject is [a] striking indication of the public concern as to its economic and social implications. "Blessing" or "curse" seems to be the type of question which these articles seek to answer.[163]

The hearings, therefore, were intended to provide Congress and the American people with the necessary insight on automation to determine how this "blessing" or "curse" would be addressed.

To explore the issues, private-sector leaders from business, labor, and philanthropic organizations were invited to share their views and engage in conversation with Congressional representatives to better understand what automation was and how it should be managed. While all of the invitees had a stake in automation, it is notable that the vast majority of them had

[163] *Automation and Technological Change*, Hearings Before the Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report, 1955, 1.

vested interests—economically, politically, and socially—in more, not less automation. As a result, the discourse of what automation was, what it could do, and who controlled it, came to the fore throughout the hearings. One component of this discourse was "robots," and the hearings were peppered with references to them. Unlike the media coverage, which had a diversity of views on the subject—robots could make your life easier or steal your job—most of the references to robots during the hearings derided the use of the term. John Diebold, evidencing his rapid rise to the pinnacle of the automation discourse, was the first witness asked to testify, and after noting that his new management consulting firm John Diebold & Associates was "engaged in putting automation to work for the benefit of our clients," he complained that discourse about the phenomenon took on the character of a "mystical pseudoscience of robots."[164] Marshall G. Munce, a director of the National Association of Manufacturers, lamented that automation conjured "a specter of robot, workerless factories, and great numbers of people deprived of their jobs and their means of livelihood."[165]

Foregrounding the tension between marketing automation and the sociocultural reality of robots, Ralph E. Cross, executive vice president of the Cross manufacturing company, argued that "the glamour [sic] that has been attached to the word 'automation' has stimulated our business and, as a result, I do not like to say anything that would detract from the romance."

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[164] *Automation and Technological Change*, 6-7. Diebold's first client, Stromberg Carlson, manufactured electronics and telecommunication equipment as well as military communications gear and, perhaps most famously, the "Charactron" cathode-ray tubes which served as the radar-screen displays in the Semi-Automatic Ground Environment (SAGE) air defense system (Cross, 59); "SAGE: Semi-Automatic Ground Environment Air Defense System" from history of MIT's Lincoln Laboratory: https://www.ll.mit.edu/about/history/sage-semi-automatic-ground-environment-air-defense-system; and "Stromberg-Carlson to Make Charactron Tube; Buys Firm," *Wall Street Journal*, Aug. 19, 1955, 14). In 1955, whether shortly before or shortly after Diebold signed Stromberg Carlson (the timeline is unclear), the latter firm was acquired by General Dynamics which was one of the largest defense contractors in the country. The conglomerate's 1956 annual report announcement of the Stromberg acquisition specifically foregrounded automation and the Charactron (General Dynamics, *Annual Report* (1956), 26).

[165] *Automation and Technological Change*, 399.

However, he continued, "in the interest of reality, I think automation should be debunked to some extent" particularly in its association with robots. "In descriptions of automated machinery," Cross lamented, "I have seen the word 'robot' used thousands of times, and I think you probably have heard it until you are sick of it," nevertheless, "at the same time I have never seen a robot" and "I don't know if anyone has ever seen one, and I don't know of any engineer or any company that is trying to create one."[166] The robot, therefore, was a technoliberal phantom haunting the discourse of automation.

Another apparition haunted the hearings as well: the Soviet Union. While the hearings were intended to focus on the civilian aspects of automation, Patman made sure to clarify that "no study of automation would, of course, be complete without recognition of the important and overwhelming role which technology and scientific thinking play in the development of our instruments of defense."[167] Nonetheless, defense and security were foregrounded throughout the hearings. It was labor's leading spokesperson, Walter Reuther, who kicked off the Cold War framing of the issues. "We cannot permit any weakening of our national strength nor any undermining of our social fabric" Reuther testified. "The Communists are only too willing to assist in such an endeavor. We should take advantage of the rising productivity that automation makes possible to increase our national strength and improve living standards at the same time."[168] During follow-up questioning, Reuther stated, "I believe that this developing technology is going to put in the hands of freemen the tools with which they can prove that the Communists are wrong."[169]

[166] *Automation and Technological Change*, 492.
[167] *Automation and Technological Change*, 5.
[168] *Automation and Technological Change*, 112.
[169] *Automation and Technological Change*, 117

Automation, therefore, was not just a traditional tool of production but a tool imbued with ideological power. Ralph J. Cordiner, president of General Electric (GE)—perhaps the corporation with the largest investment, figuratively and literally, in automation—put security front and center in his testimony. When listing "General Electric's Views on Automation," Cordiner argued that "technological progress is necessary in order to maintain our national security" as the first entry, and then elaborated on the point by stressing that "our margin of safety in modern arms depends on continuously increasing the productivity of American industry, which produces them." Additionally, Cordiner argued, the productivity enhancement provided by automation "effects important savings for the taxpayer," an argument that no doubt appealed to many of the hearings attendees.[170] W. P. Kennedy, president of the Brotherhood of Railroad Trainmen, dispelled any rumors of division between capital and labor on the issues when he claimed that "no responsible trade-union representative, far as I know, is opposed to automation as such." After arguing that automation and atomic energy "offers mankind its first real opportunity to eliminate poverty," emphasized that "the fact is that our national security depends upon an increase in the rate of scientific advance in this country." [171]

John I. Snyder, Jr., president of automation-machinery manufacturer and defense contractor U.S. Industries, builder of one of the world's first industrial robots, the TranfeRobot (to be discussed in the next chapter), was invited to testify but was unable to appear in person. Nonetheless, his prepared statement submitted for the record provided some of the most interesting content of the hearings. Beyond their civilian product lines, U.S. Industries had for the previous few years been acting as an "operating agent" for the federal government at the

[170] *Automation and Technological Change*, 426 and for the political history of taxes during the period, Molly Michelmore, *Tax and Spend: The Welfare State, Tax Politics, and the Limits of American Liberalism* (University of Pennsylvania Press, 2012).
[171] *Automation and Technological Change*, 455.

Rockford Ordinance Plant approximately ninety miles northwest of Chicago. According to Snyder, it was "the first Government plant constructed expressly for the purpose of determining how far complete automation concepts could be utilized" in manufacturing artillery shells. The plant, therefore, served the dual purpose of producing shells while "operating as a pilot plant" and provided Snyder a unique position from which to observe both the manufacture of automation machinery and the automatic production of materiel. Automation of defense products was "absolutely unassailable from any quarter," he argued, as its application "is an attempt to better assure the national defense, to help give the taxpayer the full dollar's worth of defense, [and] to conserve manpower if necessary in time of war." Snyder then put the issues in the starkest of terms: "It is of paramount importance to encourage rather than discourage our constant national drive in the area of industrial creativity for the national defense. Especially would it prove dangerous to limit automation in face of the present international political situation." "The enemies of freedom," he continued, can "conceivably accelerate their productivity to the point where if we do not remain technologically alert, they might seriously menace our ascendancy." America's 'preponderance of power' could only be assured, Snyder memorably phrased it, by its "preponderance in productivity."[172]

For the remainder of the decade, arguments made inside and outside of Congress that directly related automation to economic growth and national security proliferated. What differentiated the conversations after 1955 was a greater focus on the age old question—what was to be done? The answers were routinely in the idiom of supply-side technoliberalism. At Congressional hearings discussing shortages of scientific and engineering manpower in spring 1956, Dael Wolfle, executive officer of the American Association for the Advancement of

[172] *Automation and Technological Change*, 565.

Science, testified, "The coming impact of automation will unquestionably provide another illustration of our dependence upon a substantial corps of scientists and engineers." Like the industrial robots that could purportedly address any manufacturing task, these scientists and engineers would need to be "so well and flexibly educated that they can move into new areas and handle new problems." Or, as president of the National Education Association John Lester Buford argued, "we need skilled manpower not simply to combat the Soviet challenge. We need skilled manpower to meet effectively the challenges of our own expanding economy including far-reaching developments [such] as automation."[173] At a June conference of Ford executives, Del Harder reminded the audience that he had coined the term and declared that "when speaking of manufacturing operations today, even the general public thinks of automation. It is probably the most publicized trend in business throughout the country." As he was wrapping up remarks, Harder warned, "Russia certainly is bent on overtaking us in every possible way, and automation may make the difference."[174]

A simple answer to the question was given in a July 1956 report by the Joint Economic Committee of the Senate based on Congressional hearings on "Defense Essentiality and Foreign Economic Policy" where they concluded: "The economic strength of our Nation both for peace and war requires continued capital investment in modern plants drawing increasingly upon the new techniques of automation, and backed up by substantial work in basic sciences plus applied research and development."[175] D. B. Thomas of the Battelle Memorial Institute told a Congressional hearing on "Automation and Recent Trends" in November 1957 that "our country

[173] *Shortage of Scientific and Engineering Manpower,* Hearings Before the Subcommittee on Research and Development, 1956, 242 and 477.
[174] Ford. Speech Services, 1944-1962. Box 12. Folder - Harder, Del S. - Ford Engineering Forum 6-20-1956).
[175] *Defense Essentiality and Foreign Economic Policy, Case Study: Watch Industry and Precision Skills*, Report of the Joint Economic Committee, Report No. 2629, 1956, 29.

must make a choice in the way it wishes to support and utilize technology. It must decide the way in which technology is brought into our industrial enterprise. These decisions are basic, not only to our military security but to our economic welfare, and, in a very real sense, our military security is founded on and depends on our economic power." Using the example of automation, editor of *Automation* magazine Roger Bolz argued at the same hearings: "Just as in warfare, where offense and defense stimulate each other, design and production can prod one another ahead. Some new product designs force the manufacturing engineer to develop or invent new methods of manufacture, and every advance in the art of manufacture must be exploited for lower costs."[176] Essentially recycling tropes from his musings on the connections between productivity and security seven years earlier in *Advent*, Diebold unequivocally stated in 1959, "Automation is the key to national survival. The only way that the United States will be able to stay ahead of, or keep pace with, Russia is through a strenuous increase in productivity."[177]

Many of the original attendees of the first hearings on automation in 1955 were invited back five years later in 1960 to update Congress about where they stood on the issues as the new decade dawned. John Diebold quoted Soviet Union premier Nikita Khruschchev stating that "integrated mechanization and the *automation* of production processes constitute the chief and decisive means for ensuring further technical progress in the economy" and warned that "it would be sheer folly to take these words lightly, in view of the Soviet Union's accomplishments

[176] *Automation and Recent Trends: Hearing Before the Subcommittee on Economic Stabilization of the Joint Economic Committee*, 85th Congress, 1st sess., Washington, DC: U.S. Government Printing Office (1957), 11 and 29.

[177] John Diebold, *Automation: Its Impact on Business and Labor*, National Planning Association, Planning Pamphlet No. 106 (May 1959), 44-45. By that time, the now rebranded Diebold Group, Inc. client list included Boeing, General Electric (GE), and Westinghouse, all of whom were major defense contractors heavily invested in automation, Angus Burgin, "Market Politics in an Age of Automation," in Gary Gerstle, Nelson Lichtenstein, and Alice O'Connor (eds.), *Beyond the New Deal Order: U.S. Politics from the Great Depression to the Great Recession* (University of Pennsylvania Press, 2019), 147-167.

in the field of engineering education, and the science of mathematics."[178] In response, Diebold called for a "national policy that will effectively stimulate automation" and emphatically concluded, "I find it totally unreasonable—and dangerous—that as a nation we permit the waste of a potent national resource, automation. We are faced with a continuous, economic and political challenge on the international front that demands sizeable outlays for military security, aid to foreign nations, and other international programs."[179] Like he did in 1955, chairman of GE Ralph Cordiner opened his official statement discussing "Automation and National Security." Echoing Diebold's concern about the Soviet uptake of automation, Cordiner declared that the U.S.'s "major instruments of defense and deterrence today . . . . could not operate except by a high degree of automation, and they could not be produced without the extensive application of automation principles in the factories."[180] And when John Snyder was called before Congress at the end of the decade to once again testify on automation, he reiterated what he had been saying for years: "It can be foreseen that the great rise in productivity made possible by the families of robot machines will bring us great advantages in our competition with totalitarian powers such as Soviet Russia and Soviet China."[181]

The story automation advocates proffered about the coming abundance flowing from the ever-enlarging technological cornucopia was, for all intents and purposes, the same story they told about security: Automation would forge the shield and sword of the Republic. The

[178] *New Views on Automation: Papers Submitted to the Subcommittee on Automation and Energy Resources*, 86th Congress, 2d sess, Joint Economic Committee of Congress, Washington, DC: U.S. Government Printing Office, (1960), 131.
[179] *New Views on Automation,* 142.
[180] *New Views on Automation,* 226-227. Cordiner further argued that, to bolster national security via the acceleration of "the rate of progress," the federal government needed to enact a slew of what could be characterized as 'proto-neoliberal' policies: a decrease in non-defense government expenditures, an end of the progressive tax structure, and the removal of union-supported work rules which "operate to place artificial restrictions on output and hamper this country's competitiveness."
[181] *New Views on Automation,* 337.

securitization of automation, therefore, meant that the American state took on a much greater responsibility for supporting its development. The acceleration of automation via supply-side technoliberalism thus became imperative to national security. That the affluent, White men arguing for this would benefit from it never arose as an issue. For instance, Snyder's testimony was littered with mentions of U.S. Industries' newly commercialized device the TransfeRobot to the point that his comments could be construed as not just a commentary on automation but a sales pitch for his firm's latest product. But this, as the chapters ahead will reveal, was the essence of the American political economy—technoliberal machines were both the product and producers of security.

**Conclusion: "You'll Own 'Slaves' By 1965"**

If any single proclamation summed up the evolution and nature of technoliberalism in the age of automation, it was Otto Binder's January 1957 *Mechanix Illustrated* article. "In 1863, Abe Lincoln freed the slaves," Binder exclaimed, "but by 1965, slavery will be back!" Thanks to the proliferation of robots, he argued, "we'll all have personal slaves again" but "only this time we won't fight a Civil War over them." Robot homes would be managed by robot caretakers and robot cooks while a robot car on streets patrolled by robot cops would transport you to a job with a robot secretary. "The robots are coming!" Binder declared, and "when they do, you'll command a host of your own push-button servants."[182]

The picture of the near future proffered by Binder was no doubt fanciful, then and now, nevertheless, the pining for a 'push button' society of mechanical slaves laboring for human

[182] O. O. Binder, "You'll Own "Slaves" by 1965," *Mechanix Illustrated* (January 1957), 62-63.

leisure captured the American zeitgeist during what President Dwight D. Eisenhower periodized as the 'Age of Automation.'[183] The robots that could make such automaticity a reality were, however, not just fantasy. As Binder regaled, "well-known electronic brains and automation machinery" were already at work while "robot devices are multiplying with a fecundity the human race never achieved" in a variety of sites from atomic plants to offices. Furthermore, robots were serving the "national defense" as anti-aircraft guns, drone planes, and radar operators and would soon revolutionize medicine, space exploration, and even the management of the nation's welfare. According to the "Father of Robotry" Norbert Wiener, "there is 'no limit' to what the Robot Age can bring."[184]

That Binder—who transitioned to science writing after his successful comic book and sci-fi career—framed the economy of a robotic future in terms of a slave system from centuries past revealed more about American desires of the present than he or his readers realized.[185] Underlying both past and future was the naturalization of a political economy founded upon the ownership of chattel, the segmentation of work into various gradations of desirable and undesirable jobs, and the mix of enslaved and free labor in the capital accumulation process. Additionally, the conceptual collapse of capital into technology and technology into capital was a significant feature of both systems—the purchase and management of human or robotic chattel was an investment in 'mechanical slaves' that could be forced to do the most undesirable of jobs at the pleasure of the master class that owned and controlled them. Where the slave system of the past explicitly racialized human chattel specifically and labor more generally, the mechanical slaves of the future, and the work they did, were seemingly race neutral.

[183] "Address to the Republican National Conference. June 1957," Public Papers of the President, Dwight D. Eisenhower 1957, 457.
[184] Binder, 64-65.
[185] Schelly, *Otto Binder*.

The racialization of labor, however, did not die with the death of slavery and the jobs the robots of the future would be doing, like those described by Binder, were in the present disproportionately done by people of color. What would happen to these all too human workers when "robots" took their jobs? Binder, and essentially every commentator proffering a future of robot-engineered abundance, did not say. The enslavement of technology rather than humans would, apparently, somehow automatically solve the problem. The story turns out to be much different.

## Chapter 2 — The Military Industrial Robot Complex: Supply-Side Technoliberalism and the Rise of Unimation

*The role of entrepreneurs, and the absence of a major government role, distinguish the early development of the robotics industry from that of other [programmable automation] technologies.*

Office of Technology Assessment (1984)[1]

Like all legends, the story of how George Devol and Joseph Engelberger first met is more a dramatization and embellishment of reality rather than a falsification of it. As the story goes, the duo who eventually co-founder the world's first industrial robot company randomly encountered each other at a cocktail party in 1956. According to a recent article in the *IEEE Spectrum*, the two "happily chatt[ed] about Isaac Asimov and his theories on robotics"; however, "the conversation turned more serious" when Devol mentioned his search for investors to fund his recently patented "general-purpose manipulator for performing repetitive tasks." [2] In the midst of multiple martinis, Engelberger was taken with Devol's idea which reminded the former of the robots he loved from science fiction. Trade journal *Industry Week* argued that anyone overhearing the conversation would have "dismissed it as arcane shop talk of two engineers, and

[1] Office of Technology Assessment, *Computerized Manufacturing Automation: Employment, Education, and the Workplace*, Congress, OTA-CIT-235 (April 1984), 287.
[2] Allison Marsh, "In 1961, the First Robot Arm Punched In," *IEEE Spectrum* (Aug. 20, 2022).

moved on to a more interesting topic."[3] The next morning, while nursing a hangover, Engelberger decided to turn Devol's idea into the "first" industrial robot.[4]

Engelberger, like Reuther and his parable in the previous chapter, loved to regale listeners with the cocktail party story.[5] While Devol and Engelberger most likely discussed robots over cocktails during their partnership is probable, however, the story was more a marketing myth than reality. By 1956, when their first fortuitous meeting supposedly took place, Devol had already established a working relationship with Engelberger's employer while Engelberger was already meeting with potential investors to sell them on what would become the now famous Unimate industrial robot. Furthermore, the networks that brought Devol and Engelberger together rarely are discussed when the cocktail party story is trotted out. Both were cardinal members of the 'military-industrial complex,' and their careers before, during, and after their Unimation partnership would be defined by the stealth industrial policy and 'supply-side liberalism' of the national security state.

The lives of George C. Devol Jr., the "Grandfather of the Industrial Robot," and Joseph F. Engelberger, as well as the early years of their company Unimation, are relatively unknown. Nevertheless, they in concert almost single handedly established the American industrial robot industry in the 1960s and fostered its growth into a global force by the 1980s. All the while, they and the industry they helped build were patronized by the world's largest corporation, General Motors (GM), the world's most important industry, automobiles, and the world's single largest economic actor, the United States Department of Defense. This granted them unprecedented

[3] John Teresko, "Robots Come of Age," *Industry Week*, Jan. 25, 1982, 35.
[4] Author interview with Gay Engelberger, July 27, 2019.
[5] "The AM Award: Joseph F. Engelberger," *American Machinist* (Dec. 1982), 68; Alfred B. Bortz, "Joseph Engelberger: The Father of Industrial Robots Reflects on His Progeny," *Robotics Age*, (April 1985); Charlie Rose, "Joseph F. Engelberger," *The Charlie Rose Show* (Mar. 11, 1992), 00:50; and Jerry W. Saveriano, "An Interview with Joseph Engelberger," *Robotics Age* (Jan/Feb 1981).

access to expertise, markets, resources, technologies, and perhaps most importantly, time. How could their Unimation, originating in 1958 and officially incorporated in 1962, be able to bear not only the cost and risk of designing, testing, and manufacturing what Engelberger called a "solution looking for a problem" but also remain in the red for more than fifteen years until they turned their first profit in 1974?[6] The answer: Unimation's standing as a tiny subsidiary of a small aerospace and defense-oriented company, itself a subsidiary of a medium-sized conglomerate whose largest source of revenue came from military sales, effectively inoculated the upstart firm from the pressures and vagaries of 'the market.'

To explore these developments, the following chapter begins with a narrative history of the early life of George Devol, who is popularly identified with "inventing" the industrial robot when he filed his "Programmed Article Transfer" patent in 1954. Devol's life story has only been briefly sketched in a few non-academic articles and interviews that generally frame him as a genius inventor in his garret rather than as an inveterate tinkerer whose talents were cultivated during and after World War II by the then yet to be named 'military-industrial complex.' From the early 1940s through the early 1950s, Devol served as somewhat of an 'inventor for hire' at Sperry Gyroscope, the Radio Corporation of America (RCA), and Remington Rand, three of the most important defense contracts of the period and leaders in some of the key technological developments that would come to define the Cold War from computers and electronics to numerical control and servomechanisms. All of these technologies would come together in

[6] Saveriano, "An Interview with Joseph Engelberger," 16. Engelberger told one interviewer that Unimation made its first profit in 1975, however, the annual report of Unimation's parent corporation Condec states that "in fiscal 1974, perseverance began to be rewarded, and Unimation was able to record its first profitable year" in Alfred Bortz, "Joseph Engelberger: The Father of Industrial Robots Reflects on His Progeny," *Robotics Age* (April 1985), 15 and CONDEC, *Annual Report* (1974), 12, respectively.

Devol's "Programmed Article Transfer" device that eventually became the Unimate industrial robot.

The chapter then introduces young entrepreneur and physicist Joseph Engelberge, and chronicles his early career and eventual partnership with Devol. Rather than originating during a 1956 cocktail party as the popular mythology would have us believe, the relationship that led to the development of their "Unimate" industrial robot and their co-founding of Unimation, the world's first company dedicated to the design, sale, and service of the industrial robots was a much more staid affair of a technologist searching for investment and finding it from a like-minded entrepreneur and his defense contracting employer. Like Devol's history, Engelberger's story is a relative mystery, and the chapter provides the first archivally based recounting of how the most important industrial robot and the most important industrial robot company in history got their start as adjuncts of the national security state (NSS).

Finally, the chapter will close with brief snapshots of two other industrial robot developments during the 1950s and early 1960s—the U.S. Industries (USI) 'TransfeRobot' and the American Machine & Foundry (AMF) 'Versatran'—which were, not surprisingly, also products of the military-industrial complex. These histories demonstrate that Unimation's embeddedness in the NSS was not unique but rather signaled a pattern of relationships among the Pentagon, private firms, and later universities, that could be characterized as the 'military industrial robot complex.' In tandem, the Unimate and Unimation became the driving force of the American industrial robot industry and exemplifies how the supply-side technoliberalism of the NSS subtly created spaces conducive for investing in the risky R&D the industrial robot required for its technical viability.

**The Serial Entrepreneur: From Talkies to Tommy Guns**

George Devol's career as a "mad-scientist inventor," or a "wild-eyed inventor" as Joseph F. Engelberger called him, began long before the first industrial robot was conceived.[7] Born on February 20, 1912 in Louisville, Kentucky to George Charles Devol and Elsie Vance, George Jr. was a precocious youth taking quickly to the mechanical technology of the age. At the age of fifteen he rebuilt the family car's transmission with no instructions and later, after demonstrating his ingenuity, was allowed to run the electrical power station at his high school, the Riordan Preparatory Academy in New York. Four years before his birth, Devol's father held a "responsible position with the L and N [Louisville and Nashville Railroad] general office" and, six years later as an Assistant General Freight Agent and General Officer of the firm, became "an expert on Southern Rates [in the company's] Interstate Commerce Department."[8] By the time Devol Jr. went to high school, Devol Sr. had become a wealthy railroad traffic consultant. Though a middling student, Devol Jr. was set to attend the Massachusetts Institute of Technology (MIT) after graduation in 1931 but he demurred. Rather than higher education, Devol wanted to go into business for himself.

Like the technological and institutional genealogy of the industrial robot he would "invent" two decades later, Devol's first entrepreneurial endeavor was an innovation on a technology whose gestation was embedded in and evolved from the political and socioeconomic

[7] The "mad-scientist inventor" moniker comes from an author interview with Gay Engelberger, July 27, 2019 while the "wild-eyed inventor" comes Saveriano, "An Interview with Joseph Engelberger," 11. The symmetry in description is most likely due to the fact that Gay is both Joseph's daughter and, as an employee of Unimation, a longtime personal and professional associate of Devol who was also a family friend.
[8] "Personal Mention," *New Albany Evening Tribune,* Apr. 10, 1908 and Samuel MacClintock (ed.), "LaSalle Consulting Traffic Experts," *Personal Efficiency,* Vol. 8, No. 1 (January 1918), 26.

milieu of the American military. Luckily for Devol Jr., Devol Sr. was able to bankroll the venture, a plan to mass manufacture what junior called the "Cinephone," a device that coupled sound waves and light waves on a single medium, photographic film, to synchronize electrically recorded audio with a moving image.[9] Entranced by the new "talking pictures," and with seed funding from his family driving his ambition, Devol recognized an opportunity he could capitalize on: "Everybody was excited about 'talkies.' I just approached investors, saying I had a new way of putting sound on film. I got [US]$25,000 here, [US]$50,000 there, and pretty soon I had enough for my own company. And this was during the Depression! I can't figure out how I did it myself." Work began on a device in 1932 and, within a year, Devol moved his base of operations from Long Island City, New York to Torrington, Connecticut where the first manufacturing plant of his first company, United Cinephone, was constructed in 1933.[10] Little is known, however, about the technical aspects of Devol's "Cinephone" or how he chose the term but, in his own words, "I had a different idea on variable area recording than RCA Photophone had. There were only two companies in that business then, RCA and Western Electric. They were big time; I was just a kid with an idea . . . . but my father had a little money, and I fooled around and came up with a product. Unfortunately, it wasn't any better than the products already on the market. I couldn't sell it."[11] Without a superior product, his upstart firm "could not survive in the shadow of the giants in the field."[12]

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[9] Leslie Anne Ballard et al., "George Charles Devol, Jr.," *IEEE Robotics & Automation Magazine* (September 2012), 114.
[10] Ballard et al.,114.
[11] Jerry W. Saveriano, "An Interview with George Devol," *Robotics Age*, (Nov/Dec. 1981), 23. Devol's records do not provide any information detailing the difference between his "Cinephone" and RCA's "Photophone."
[12] George Devol, "Robot Systems, Evolution," Folder - "Devol Personal - Writings, 1945-2008," Box 1, George Devol Jr. Records, BFRC. The document is a proofed copy of an article that would later be published in Richard C. Dorf and Shimon Y. Nof (eds.), *International Encyclopedia of Robotics: Applications and Automation, Volume 3* (Wiley, 1988), 111. In both function and name, it was similar to a system produced and sold by the Powers Cinephone Equipment Corporation, a company established by Patrick Anthony "Pat" Powers—a key figure in the early motion picture industry and a founder of Universal Pictures. Powers' system was essentially a clone (most

Devol soon realized that the primary components of his Cinephone—photoelectric cells and vacuum tubes—could be put to other uses. Photoelectric cells were particularly promising as their general function was to transform light into electrical signals with sound-on-film recording just one manifestation of this. His first device post-Cinephone was an "annunciator" that rang a bell when a person passed by a sensor. Soon after, this was modified and connected to an electric door, thereby inventing the world's first automatic door. Devol eventually licensed the design of the latter to Yale & Towne Manufacturing Co. in Stamford, Connecticut.[13] Primarily a manufacturer of locks for safes and vaults, Yale & Towne marketed the device as the "Phantom Doorman," a witty name for a technology that literally made human labor a figment of the imagination by replacing it with electro-hydraulics. One sales brochure described the technical workings of the device and depicted a doorman as an apparition standing behind the photoelectric sensor as a little girl walked through an open door with the caption "A Beam of Light Automatically Opens the Door." Another juxtaposed cartoons of butlers or servants struggling with doors as they transported food on trays or boxes on carts with photographs of real people using the automatic door with ease and efficiency. As the latter proclaimed, "Industry saves with The Phantom Doorman!"[14]

With a steadily growing business, and a new, even larger manufacturing facility back in Long Island, Devol championed United Cinephone Corporation as "the first industrial control

likely a legally dubious one in patent terms) of De Forest's Phonofilm and was technically "interchangeable" with Case's Movietone and RCA's Photophone. Famously, Walt Disney's "Steamboat Willie" cartoon, which featured the popular debut of Mickey Mouse, was recorded on a Powers Cinephone in 1928, Michael J. Barrier, *The Animated Man: A Life of Walt Disney* (University of California Press, 2007), 21.

[13] George Devol, "Robot Systems, Evolution," Folder - Devol Personal - Writings, 1945-2008, Box 1, George Devol Jr. Records, BFRC (hereafter GDJR), 2. The digital archives of the Henry Ford Museum has a George Devol Collection that is separate from the physical George Devol Jr. Records at the Benson Ford Research Center and will be cited as "George Devol Collection, The Henry Ford Archive of American Innovation."

[14] "The Phantom Doorman," Folder - Trade Lit - United Cinephone Corp, 1938-1945, Box 3, GDJR.

company in the U.S."[15] In the mid 1930s, the company found a novel application for the photoelectric cell when it pioneered the use of labels with barcodes in a package sorting system designed for the Firestone Rubber Company.[16] Other products ranged from audio/visual amplifiers, registration controls for printing presses, and electronic timers.[17] The company also patented two unique products: a new type of lighting fixture, marketed as the "Orthoplane Lighting" for room illumination, and an automatic textile press safer and more efficient industrial laundry ironing.[18] For safety reasons, conventional laundry-ironing press operators (almost always women) would use two hands during the operation of the machine, which required them to remain at the press until it fully closed before moving on to the next press, thereby reducing efficiency. Therefore, the automatic textile press was designed to "produce a new form of control instrumentality for such presses which does not require the Operator to give his or her mental attention to the manual control means of the press, as a result of which the operator simply makes the lay of the work on the buck of one press and turns away therefrom to attend another press; thereby achieving increased output of finished work with less fatigue and attention to the machines."[19] In essence, the machine's goal was to make the labor process as fast and mindless as possible; whether this increased safety is an open question.

[15] Ballard et al., 115. While United Cinephone may not have been the first industrial controls company (definitions of "industrial controls" and the firms dedicated to producing them aside), it was one of the first dedicated to producing *electronics* for industrial control purposes.
[16] Ballard et al., 115 and "Conveyor System, Reference Number 100A, 1936," George Devol Collection, The Henry Ford Archive of American Innovation, https://www.thehenryford.org/collections-and-research/digital-collections/artifact/372874 and "Package Sorting System, Reference Number 101A, 1936," https://www.thehenryford.org/collections-and-research/digital-collections/artifact/372818.
[17] Various documents, Folder - Trade Lit - United Cinephone Corp, 1938-1945, Box 3, GDJR.
[18] George C. Devol, Jr., "Design for a Lighting Fixture," U.S. Patent Office Des. 112,634 (Application August 13, 1938; Patented Dec. 20, 1938) and George C. Devol, Jr., Edward M. Pritchard, and Elbert W. Sherman, "Capacity-Controlled Textile Press," U.S. Patent Office #2,395,780 (Application September 28, 1939; Patented Feb. 26, 1946).
[19] Devol, Pritchard, and Sherman, "Capacity-Controlled Textile Press," 1.

The two patents aside, photoelectric cells remained United Cinephone's bread and butter. One example of a product demonstrating the technology's flexibility was marketed as the "Electric Eye." Building off the success of the automatic door control, a sales brochure for the device had a cartoon of a couple laughing with their neighbor as they told him, "We had an electronic eye installed to slam the door on bill collectors." Other envisioned adaptations of the Electric Eye and ran the gamut from the more traditional domains of automating manufacturing and food and chemical processing to more creative uses like foul line detectors for bowling alleys, sighting guns for automatic firing, and automatic telescope focusing for stargazing, all of which were intended to "provide safety, increase production speed, improve precision, or conserve labor." The device's component parts were touted for coming "from the ends of the earth . . . . Ceasium [sic] from Canada, Magnesium from Minnesota, and Fernico from Illinois. Borite is mined in Death Valley. Svea metal is found in Sweden, Tung Oil from far off China, and Argon from Texas." And the brochure sold more than just applications and benefits; it sold the "mode of Life in this scientific era," characterized by the Electric Eye's material globality and the universal processes of "Progress… Modernization… Engineering…"[20]

The photoelectric cell, and the themes such a technology was envisioned as embodying, would play a significant role in Devol's next big invention, the "decade counter." The Eccles-Jordan circuit as it was originally referred to, or the "flip-flop" more colloquially, was "designed to produce a large and permanent change in the current flowing in an electrical circuit" by pairing ionic valves or triodes to an external electrical stimulus.[21] In layman's terms, the device could more efficiently start and stop the flow of electricity through a circuit, or 'flip-flop'

[20] "Marvels of the Electric Eye," Folder - Trade Lit - United Cinephone Corp, 1938-1945, Box 3, GDJR, 1-2.
[21] William Henry Eccles and Frank Wilfred Jordan, "Improvements in Ionic Relays," U.K. Patent 148,582 (Application June 21, 1918; Patented Aug. 5, 1920), 1.

between off-and-on states, much faster than existing mechanical devices. These states proved conducive to rapidly counting electric pulses for accumulating and manipulating data. When, decades later, flip-flops were combined with the binary system of counting (with 0 equaling "off" and 1 equaling "on"), boolean algebra, and computational hardware, they became the foundation for digital memory in electronic devices, the field to which Devol would eventually dedicate more than a decade of his life to. In the interim, his "decade counter"—so called as it counted in decimal digits rather than binary—was an earlier iteration of the flip-flop. One major market for the device was the zipper industry. At the time, zippers were ordered by lengths and electromechanical counters were used to count off the requested number of teeth to be cut. The zipper machines were capable of producing thousands of lengths per minute but the electromechanical counters were not able to count that fast, causing production to slow down to accommodate the counters. To solve this problem, the decade counter was attached to one of Devol's Electric Eyes so that it could "see" the zipper teeth and count them much more rapidly than its electromechanical counterpart.[22] Beyond zippers, the decade counter could be used in just about any industrial process that required the enumeration of discrete objects, from newspapers on presses and small parts on conveyors to livestock in pens or people moving through a designated space. With the capability of counting up to 50,000 units per second the "labor saved by this automatic method quickly pays the modest cost of installation."[23] This selling point would be repeated almost word for word decades later with the industrial robot.

The decade counter found its most interesting use as a "people counter" at one of the most monumental displays of interwar "modernity" and "progress," the 1939 New York World's

[22] George Devol, "Robot Systems, Evolution," Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR, 3-4.
[23] "Marvels of the Electric Eye," 3-11.

Fair.[24] As its official theme intoned "Building the World of Tomorrow with the Tools of Today," the fair was designed to extoll how free enterprise and rational planning were remaking the world through science and technology.[25] While the "foreign pavilions added color and contrast to the fair . . . . by far the best-attended and most faithful to the expressed themes of the fair were the United States' homegrown government and corporate exhibits," ranging from Du Pont's debut of nylon and RCA's unveiling of the television to Westinghouse's demonstration of Elektro (which inspired Asimov).[26] It should come as no surprise that the fair was intimately shaped by the military. The primary vehicle through which this occurred was the National Research Council (NRC), a wartime exigency established in 1916 under the auspices of the National Academy of Sciences. The NRC was tasked with coordinating "the non-governmental scientific and technical resources of the country with the military and naval agencies of the Government, in the interests of national security," much like the Naval Consulting Board (NCB) created the year prior.[27] The council "rapidly developed after the war into the primary agency for promoting cooperation between science, industry, and the military [and by] the mid 1920s the NRC stood at the epicenter of the military-industrial establishment, coordinating pure and applied scientific research in industrial as well as university laboratories."[28] With funding from

[24] Jeremy Pearce, "George C. Devol, Inventor of Robot Arm, Dies at 99," *New York Times*, August 15, 2011. Strangely, Devol's records contain only one mention of his "people counter" and this only in a memoir written by his brother John V. "Vance" Devol which describes his and his wife's visit to the Fair.
[25] The following paragraph comes from "Whose Modernity?: Utopia and Commerce at the 1939 New York World's Fair" in Robert H. Kargon, Karen Fiss, Morris Low, and Arthur P. Molella, *World's Fairs on the Eve of War: Science, Technology, & Modernity, 1937-1942* (University of Pittsburgh Press, 2015), 57-82.
[26] Kargon, Fiss, Low, and Molella, 73.
[27] Albert L. Barrows, "A History of the National Research Council, 1919-1933: X. The Divisions of General Relations," *Science*, Vol. 78, No. 2021 (Sep. 22, 1933), 7. According to Noble, the NRC was an "extrapolitical body, with official sanction, well suited to the management-minded engineers and business executives who were used to coordinating and directing the affairs of men from the top, without inefficient democratic mediation," and By the close of the war, the NRC's value had become so apparent that Woodrow Wilson made it permanent by executive order on May 18, 1918, David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (Alfred A. Knopf, Inc., 1977), 154.
[28] Robert W. Rydell, "The Fan Dance of Science: American World's Fairs in the Great Depression," *Isis*, Vol. 76, No. 4 (Dec., 1985), 526.

the federal government and a variety of private sources, the council's leadership positions were held by businessmen, government officials, scientists, and university administrators such as Elmer Sperry of Sperry Gyroscope and Dugald C. Jackson of MIT. The NRC's day-to-day work was accomplished through more than one hundred administrative and technical committees liasoning with over seventy-five scientific societies around the country, demonstrating its sizable network and potential for shaping scientific and technical knowledge and practice.[29]

While the fair was initially one of the most iconic displays of faith in the unifying power of science and technology, it would shortly prove to be the most ironic when, less than four months after its doors opened, Nazi Germany crossed the Rubicon into Poland and plunged the world into the second great conflagration of the twentieth century. During its 1940 season, the fair's theme was changed from "Building the World of Tomorrow with the Tools of Today" to "For Peace and Freedom." Shortly after its permanent closure on October 27, 1940, much salvageable wreckage went to the rapidly increasing "defense" program: Four-thousand tons of steel from the Trylon and Perisphere was purchased by Bethlehem Steel "to be turned into armor plate, ships, shell cases, or gun forging"; lumber and electrical equipment (perhaps even Devol's decade counter and Electric Eye) were sent to new Army cantonment; and "the plumbing fixtures from fifty-nine Fair Corporation buildings" were being "installed in new naval stations along the Eastern seaboard."[30] The fair and its themes had literally and figuratively become grist for the American war machine. And, rather than the indirect connections to the military via the technologies he repurposed (i.e., the Cinephone and the decade counter), it's likely that the New York World's Fair was Devol's official introduction to the military-industrial establishment he would be embedded in for the rest of his life.

[29] Barrows, 8 and 17.
[30] Eugene Kinkead, "A Reporter at Large: Goodbye Folks!," *New Yorker* (May 31, 1941), 41.

Like so many other institutions, organizations, and structures, the outbreak of World War II would change Devol's relationship to the military and the American state irrevocably. Shortly after the World's Fair opened, Devol sold his interest in United Cinephone believing that it didn't have the capacity necessary to handle military contracts. Wanting to contribute to the war effort he contacted Seversky Aircraft—then a fledgling company that had recently won its first military contract for the P-35 that would see limited action in the early phases of the Pacific campaign during World War II—about joining their operations. Knowing nothing about aircraft but a lot about manufacturing, Devol was made head of production. Less than a year later, while Seversky was going through a major financial crisis that led to its eventual reorganization as Republic Aviation, Devol left, stating that he felt unchallenged.[31] Shortly thereafter, he made his way to Sperry Gyroscope where, as a project engineer from 1939-1941, he helped develop radar scanning devices, acceleration test machines, a large scale mock-up of a B-19 bomber, and a number of other special projects.[32] Few specifics are known about Devol's two year stint with Sperry, however, his radar work made apparent the need for radar countermeasures and microwave test equipment to defend against the very technology that was being developed. In 1941, he left the corporation to create a new company to satisfy the military's demand for radar countermeasures.[33]

Through business contacts, Devol was put in touch with Russell Maguire, a financier and industrialist with diverse business interests, and convinced him of the military's urgent need for electronic countermeasures. Born in Meriden, Connecticut in 1897, John Russell Maguire was

[31] Ballard et al., 115
[32] Untitled (handwritten and typed short autobiography/CV), Folder - Devol Personal - Correspondence, 1950-1987, Box 1, GDJR.
[33] Untitled (handwritten and typed short autobiography/CV), GDJR. Ballard et al. give 1943 as the date Devol left Sperry, however, documentation in his papers, incomplete though they are, challenge that date. See discussion of Auto Ordnance below for more details.

educated at MIT and NYU, and he served in the Navy during World War I. By 1936, he had built a well-established financial securities firm, Russell Maguire & Co., that specialized in public offerings, underwriting, and wholesale securities distribution.[34] Deals ranged from acquisition of the Alco Controls Company, offerings for the Detroit Paper Products Corporation, and underwriting of various oil and railroad stocks.[35] In 1939, Maguire made one of his most important acquisitions when, through a complex and convoluted multi-year financing scheme, he bought a controlling share in the Auto Ordnance Corporation that, a year prior, received word that the U.S. military had officially adopted its Thompson submachine gun, or "Tommy gun," for field operations.[36] Problems with the deal immediately arose leading to a Securities and Exchange Commission (SEC) investigation that, on June 27, determined the financial health of the company was so poor that the stock deal would not be approved. Less than a week later, Auto Ordnance received a sizable order from the U.S. Army large enough to temporarily shore up its finances and, by the end of the year, the deal was approved and the company was firmly in Maguire's hands.[37]

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[34] "Opens New York Office," *Wall Street Journal*, Jan. 29, 1936.
[35] "United Speciality in Alco Valve Deal: Stockholders Will Meet in Detroit July 19 to Act on Proposed Purchase," *New York Times* (July 8, 1937); "Detroit Paper Products Corp.," *Wall Street Journal*, July 14, 1937; "General American Oil Co.," *Wall Street Journa*l, Aug. 18, 1937; "Bonds and Bond Men," *Wall Street Journal*, Apr. 15, 1937.
[36] "Stock Issue Asked by Arms Company: Thompson Automatic Files for Sale of 300,000 Shares," *New York Times*, May 24, 1939.
[37] "End of an Era," http://www.nfatoys.com/tsmg/web/bankrupt.htm. Although Maguire plays no part in the story of industrial robots after World War II (unless further research reveals otherwise), it's worth briefly noting his postwar activities. In 1952, he purchased the *American Mercury Magazine*, founded by H.L. Mencken and George Jean Nathan in 1924, which for its first two decades was a relatively "left-of-center" high-brow publication with contributors like W.E.B. du Bois and Sinclair Lewis. Over time the magazine grew increasingly "conservative" with articles commissioned by then young staffer William F. Buckley Jr. from Reverend Billy Graham and FBI Director J. Edgar Hoover. Maguire, whose anti-Semitism was so virulent that the magazine's top editors resigned in protest shortly after he took editorial control, turned the publication into an overtly anti-Semitic vehicle when George Lincoln Rockwell, founder of the American Nazi Party, was hired as a writer (John B. Judis, *William F. Buckley, Jr.: Patron Saint of the Conservatives* (Simon and Schuster, 1988), 112 and 173-174). However, the intrigue around Maguire goes deeper. According to a 1959 Army Intelligence letter sent directly to Hoover at the FBI, Maguire - described as an "avid anticommunist" and "bitterly anti-Semitic" - had "some mysterious connection" with a representative of the Dominican Republic, then under the control of U.S.-backed dictator Rafael Trujillo. He had "personally contacted Secretary of Defense, Neil McElroy, in October 1957 and left with him certain written

In 1941, after continued reorganization of firms connected to Maguire and Auto Ordnance, the Securities and Exchange Commission (SEC) found him guilty of market manipulation.[38] The following year, Auto Ordnance produced half-a-million Tommy guns for the military while also agreeing with the War Department's Contract Adjustment Board to return $6 million in war profits and to reduce by $1 million the charge on an outstanding contract.[39] Nonetheless, that same year Auto Ordnance won an Army-Navy Production (E) Award, an honor given to only 5 percent of companies during World War II whose facilities achieved "Excellence in Production" (hence the "E"). The state's political leadership attended the presentation ceremony in Bridgeport and watched 1940 Republican presidential nominee Wendell Wilkie give Clare Booth Luce—a future conservative stalwart who was running to fill Connecticut's 4th congressional district seat recently left vacant by her stepfather's death—his endorsement for Congress. That evening, Luce gave her final radio broadcast before the next day's elections, telling Fairfield County voters that the ballots cast tomorrow "would be more deadly to Hitler and Hirohito than bullets in the days to come." She closed the address by quoting the title of Frank Loesser's popular song, written that year in response to the Japanese attack on Pearl Harbor, "Praise the Lord and pass the ammunition."[40]

material including a letter containing several allegations of a vital nature to our national security." The FBI's subsequent investigation is worth quoting at length: "We furnished information to the [Defense] Department in 1958 indicating that a check in the amount of $24,950 was deposited by "American Mercury" magazine in its banking account. This check [was] drawn on account of the then Dominican Ambassador DeMoya. Department requested and we conducted Registration Act investigation of "American Mercury" magazine to determine if it may have incurred obligation to register under Foreign Agents Registration Act of 1938, as amended. Through our coverage of Dominican activities, we learned DeMoya had made several substantial payments to Maguire who is known to be sympathetic toward Dominican regime, and whose magazine has carried articles favorable to Trujillo. Our coverage on Dominican Embassy revealed Maguire and DeMoya have mutual investments and oil interests." Based on this, the FBI concluded that the facts did not warrant any further investigation of Maguire, though the Army should use its own discretion in the matter ("MAGUIRE, Russell -- G2 Army Intelligence Report," https://archive.org/details/MAGUIRERussellG2ArmyIntelReport/mode/2up,). Maguire's political positions, and what effect they had on his business decisions and social connections, before and during the war are unclear.

[38] "J. Russell Maguire, 67, Is Dead; An Industrialist and Financier," *New York Times*, Nov. 11, 1966.

[39] "Auto-Ordnance Will Return $6,000,000 War Contract Profits," *Wall Street Journal*, Oct. 3, 1942.

[40] "Willkie Endorses Mrs. Luce in Race," *New York Times*, Nov. 3, 1942.

While arms production was Auto Ordnance's primary business, Maguire obviously had an eye for diversifying their product line. When Devol approached him about manufacturing electronic countermeasures in 1941, Maguire needed little convincing. According to Devol, "By the time I left his office, I had US$5 million to start a new division, and he would have given me just about any amount!"[41] Thus, the founding of General Electronic Industries (GEI)—technically, the "Electronics Division" of Auto Ordnance—in Greenwich, Connecticut with Devol as general manager. As early as November of 1942, GEI had outlined a plan for organizing a complete engineering and research organization and production facility, capable of handling military radar contracts and developing post-war electronic products. By that time, Navy radar equipment was already in development as well as twenty post-war projects. As Devol noted in the memo discussing these plans: "The equipment we are now manufacturing is vitally necessary to the Navy and Army, and will be used in our invasion of the Continent of Europe, also in the Pacific."[42] By January 1944, GEI was working directly as a prime contractor for branches of the military with assistance from AT&T's Bell Telephone Laboratories (BTL) and MITs Rad(iation) Lab(oratory). GEI's relationship with the Rad Lab was particularly close as the latter acted as a "technical consultant on problems which might arise during production, transmittal of design information from BTL to GEI, setting up the GEI Company with suitable test equipment, and supervising their test procedure to insure the quality of the production delivered to the services." In other words, the Rad Lab "engineered" GEI.[43] On "D-Day," June 6,

[41] Ballard et al., 115.
[42] Memo, Mr. George Devol to Mr. Russell Maguire, August 1, 1943, Folder - Robotics - Correspondence, 1940s, Box 2, GDJR.
[43] Echo Box Production at Western Electric and General Electronic Industries, January 18, 1944, Folder - Robotics - Misc Robotic Reports, 1 of 3, Box 2, GDJR.

1944, most of the ships sent to Normandy Beach were equipped with General Electronic radar countermeasure systems.[44]

While GEI's primary and immediate market was the military, that did not stop them from planning for the postwar commercial environment. In August 1943, GEI's leadership proposed a "program with the proper advertising" to build up a line of commercial electronic equipment for sale during and after the war. Products targeted to specific companies included equipment for American Propeller, automatic welding controls for General Motors, and automatic timing devices for Westinghouse.[45] By the end of November, company executives were tasked by their Policy Committee with finding more contracts that "lend themselves to mass production" as Auto Ordnance had "agreed to make the Electronic Division its major effort." Devol played a particularly important role in this endeavor as "the committee agreed that all sales contracts should be cleared through Mr. Devol."[46] A week earlier, Maguire had sent Devol a long list of contacts in the manufacturing and business world—from the Canada Dry Company and Chrysler to Pan American Airways and Remington Arms—for that specific purpose.[47] The committee then turned their attention to "six products for post-war developments offered by Mr. Devol," which included automatic process controls, photo-electric and electronic controls, electro-static heating equipment, automatic inspection equipment, high fidelity radio-phonograph combinations, and radio components. In terms of the latter, "part of the cost of these units had been absorbed by the government due to contracts which the company has completed for the government." Devol's devices were only a small portion of the fifty projects then under

[44] Devol, "Robot Systems, Evolution," GDJR, 6.
[45] Memo, Mr. George Devol to Mr. Russell Maguire, August 1, 1943, Folder - Robotics - Correspondence, 1940s, Box 2, GDJR.
[46] Minutes of the Policy Committee Meeting, November 18, 1943, Folder - Personal - Annual & Committee Minutes, 1943 & 1983, Box 1, GDJR (underline in original).
[47] Memo, Mr. George Devol to Mr. Russell Maguire, November 11, 1943, Folder - Robotics - Correspondence, 1940s, Box 2, GDJR.

development, among which were secret projects for the Office of Strategic Services (OSS), a wartime intelligence organization and predecessor of the Central Intelligence Agency (CIA).[48] By war's end, Auto Ordnance had sold nearly $130 million worth of Tommy guns netting just short of $15 million in profits. Almost immediately, the company was downsized into the ordnance division of Maguire Industries and the Bridgeport factory was converted from arms manufacturing to producing radios, record players, and other consumer goods.[49] However, the postwar direction planned for GEI was to remain in the military business.[50] And when the largest military contract in the company's history was offered, Devol didn't believe GEI could fill it. Nonetheless, the contract was signed and Devol left.[51]

**The Mad-Scientist Inventor: From World War to Cold War**

Devol's career after the war was immediately and intimately entangled with the military-industrial complex. Beginning in 1945, he embarked on a short stint in field-sales engineering with RCA which, like most high-tech corporations of the period, proportionally scaled back its military footprint once the war was over while continuing to do a significant amount of "defense" work for the government.[52] As its first postwar annual report described, the Victor

[48] "Minutes of the Policy Committee Meeting" and Untitled (short autobiography), GDJR.
[49] "End of an Era," http://www.nfatoys.com/tsmg/web/bankrupt.htm.
[50] Devol, "Robot Systems, Evolution," GDJR, 6.
[51] Ballard et al., 115. Ballard et al. state that Devol resigned from GEI but according to his future business partner Engelberger, "at the end of the war, he had one of the first control companies in the United States, but his partners kind of eased him out," Saveriano, "An Interview with Joseph Engelberger," 11.
[52] H. S. Hagen to Howard Stansbury, March 20, 1956, Folder - Robotics - Correspondence, 1950s; Signal Core Tentative Specification, Study of Automatic Frequency Control Circuits, February 13, 1946; and Navy Department, Bureau of Ordnance and Harvard University, "Report of the Second Symposium on Large Scale Digital Calculating Machinery," September 13 and 14, 1949, Folder - Robotics - Misc Robotic Reports, 1 of 3, Box 2, GDJR.

Division for manufacturing "still has and expects to continue to have substantial government business" and the same "scientists and research men" of the Laboratories Division for R&D who led the corporation's wartime research were "concentrating their efforts to continue America's preeminence in radio and electronic developments useful in peace and for national security."[53] One of the "peaceful" electronic developments was heating applications for microwave tubes, also known as "radio-frequency heating." While such capabilities for microwave tubes were haphazardly explored by others decades earlier, RCA began formal work on "radiothermics," an internal term for the process, in 1942.[54] By 1944, they filed for one of the first microwave-heating patents in the U.S. and, a year later, research on the process continued due to the fact that "the bottom had dropped out of the microwave tube market when World War II had ended," and a new commercial application of the technology was sought after.[55] Devol's exact role and work for RCA are unknown, so whether he directly contributed to the radiothermics program is a mystery. However, while he was with the corporation, he helped develop a forerunner to the microwave oven, an idea attributed to a chance episode from his war-work years:

> At Sperry, we made radar scanners. One day, I was up in the plane, testing a new scanner, and noticed the unit was getting too hot. It almost burning [sic] my hand. So, I turned it off and right away it cooled. I started thinking along the lines of a microwave oven, long before anyone patented it, but I was too busy to focus on that. I never got a chance to apply for a patent on that one. And look at it today![56]

[53] Radio Corporation of America, *Annual Report* (1945), 1.
[54] W.C. White, "Early History of Industrial Electronics," Proceedings of the IRE, Section 16, Industrial Electronics (Dec. 27, 1961) and Radio Corporation of America, *Annual Report* (1942), 16.
[55] John M. Osepchuk, "A History of Microwave Heating Applications," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 32, No. 9 (Sept. 1984), 1203.
[56] Ballard et al., 115.

Rather than a home appliance, this microwave oven took the form of a vending machine that could electronically cook a "frankfurter in a matter of seconds and deliver it in an oven-fresh roll wrapped hygienically in cellophane, ready to eat." Called "Speedy Weeny," the machine was officially patented by Harry C. Warner and the rights to it were eventually purchased by Chicago based Radio Chef, Inc. The actual machines were manufactured by the Aireon Manufacturing Company, a Los Angeles based corporation founded in 1937 and originally called Aircraft Accessories Corporation, which was, at the time, a major player in the aircraft parts manufacturing specializing in hydraulics and with significant radio equipment production experience from the war.[57] The company's president, Randolph "R. C." Walker, was a pioneer of the Southern California aircraft industry who rose to prominence in 1932 when he joined Robert E. Gross and six other investors to purchase the Lockheed Aircraft Company (from the bankrupt Detroit Aircraft Corporation), where he sat on the board of directors from 1935-1945.[58] Whether Devol had any connection to Aireon is unknown. That Aireon manufactured the Speedy Weeny in their Greenwich, Connecticut plant suggests that Devol may have played some part in the process as his former outfit General Electronics Industries (GEI) had a manufacturing plant in the city during the war and The Devol Research Company—established after the war to manage and exploit his small but growing patent library—was also based in Greenwich.

Devol's tenure with the corporate giant that proved one of his greatest competitors as a younger businessman was short, so it is perhaps poetic that his most profitable device—the magnetic process control—was patented during his time with RCA. It eventually became a key

[57] "Speedy Weeny, Electron-Cooked Hot Dog Vender, In N.Y. Premiere," *Billboard*, March 9, 1946 and "Airplane Parts Firm Enjoys Speedy Rise in Field of Hydraulics," *Wall Street Journal*, Sept. 22, 1941.
[58] Robert Sandifer, "KEY POSTS IN L.A. R. C. Walker," *Los Angeles Times*, Oct. 4, 1941 and Lockheed Aircraft Corporation, *Annual Reports* (1935-1945). Annual reports from 1932-1935 do not list the board of directors but it is highly likely that Walker also served during these years as well.

component in the system generally recognized as the first industrial robot.[59] While working with Sperry at the beginning of the war, Devol began testing new methods and mediums for information storage and retrieval, specifically using magnets as a memory repository. Where his Cinephone was designed to record light and sound, his magnetic device would record motion. Unlike mechanical cams—then the dominant analog technology for controlling motion—or the binary control possible with photoelectric cells, magnetic recording allowed for almost instantaneous storage or erasure of control signals. However, existing magnetic recording systems were designed around alternating current (AC) which read magnetic pulses from a continuous tape that passed by the machine head. Direct current (DC) allowed for recording at rest rather than at motion like other mediums (e.g., rotating cams, film reels, and magnetized tape).[60] Using DC made the process of storage and erasure easier and more efficient as reducing the number of moving parts (i.e., replacing magnetic tape with static magnets) in a system decreases complexity and entropy, and therefore, costs. Furthermore, almost any implement or tool could be attached and controlled by the device.

Searching for investors to support development of his magnetic recording system, Devol contacted the Raytheon Manufacturing Company to pitch his idea. One of the largest manufacturers of radar equipment during World War II and, coincidentally, the corporation most responsible for establishing the "Radarange," better known as the microwave oven, as a household staple, Raytheon declined Devol's overture. However, they affirmed an observation in his pitch that Remington Rand, at the time one of the largest information processing and office equipment corporations in the world, would be much more conducive to developing Devol's

[59] Ballard et al., 115-116.
[60] George C. Devol,, "Magnetic Process Control," U.S. Patent Office #2,590,091 (Application: Apr. 3, 1946; Patented: Mar. 25, 1952 ), 1.

idea.[61] Shortly thereafter, Devol contacted one of his wartime idols, Leslie R. Groves—an Army Corps of Engineers officer who oversaw the construction of the Pentagon in the early 1940s and was best known for directing the Manhattan Project during World War II—to gauge his interest.[62] Groves, almost immediately after retiring from the military in January 1948, was made a Vice President of Remington Rand and would be charged with managing R&D at the corporation's Laboratory of Advanced Research in South Norwalk, CT, a position he would hold until the end of his career. The corporation, largely the work of James Henry Rand Jr. who, with help from friends on Wall Street and within academic circles, acquired thirteen companies in the office and tabulating equipment industry, con-solidated them to five, and finally merged these into the Remington Rand in 1927.

An early pioneer of the conglomerate form of business organization, Rand was once described by a subordinate as "from the old school of corporate presidents" and "really a dictator."[63] He was also notoriously anti-labor, occupying a prominent position within the National Association of Manufacturers (NAM) and infamously pioneering the "Mohawk Valley Formula" to crush the corporation's upstate New York labor insurgency in 1936. NAM supported the formula and the "comprehensive anti-strike plan . . . . became widely adopted by industrialists."[64] Accordingly, Rand chose Groves to head the laboratory based, in part, on his able management of labor, in partnership with Du Pont, during the Manhattan Project, and their shared "disdain" for "hegemonic" big government" and dislike of "government planning, social

[61] J. W. Dawson to George C. Devol, April 28, 1947, Folder - Robotics Correspondence - 1940s, Box 2, GDJR.
[62] Ballard et al., 116.
[63] William Aspray and Robbin Clamons, "An Interview with Earl Edgar Masterson," Charles Babbage Institute (October 31, 1986), 19 and Remington Rand Incorporated, *Annual Report* (1952), 6.
[64] Marc Steven Kolopsky, "Remington Rand Workers in the Tonawandas of Western New York, 1927-1956: A History of the Mohawk Valley Formula," PhD Dissertation, State University of New York at Buffalo (1986), 6 and Robert G. Rodden, *The Fighting Machinists: A Century of Struggle* (Kelly Press, 1984), 93-94.

welfare spending, and, generally, most New Deal programs."[65] By the time Groves came aboard, Remington was the second largest corporation in terms of assets and revenue and the largest in terms of employees in its sector.[66] However, Groves's hiring put Remington "in a good position to take advantage of computers and to become a giant in that fledgling industry" based on its "sales force and a broad set of loyal business customers, not to mention good penetration within the government, especially the military."[67] Rand enmeshed the company's profile ever further into the military milieu when General of the Army Douglas MacArthur—a year removed from his relief of Far East Command by President Truman for, ostensibly, insubordination and fresh off a brief but failed foray into presidential campaign politics—was elected chairman of the board on July 31, 1952 after more than three years of courting.[68] Commenting on his new position, MacArthur quipped, "it is extremely agreeable to pass from an industry of destruction to one of construction."[69]

Remington had established the Norwalk labs in 1946 to introduce electronics into its line of tabulating machines and its commanding position in the field was eventually, in major part, attributable to Groves. In October 1948, he sent a memo to his Norwalk team regarding the role of electronic computing in the corporation's future and noted "this Laboratory should undertake such a program not only because of its long range aspects but because the problem is one that affects Remington Rand as a whole. It is not applicable to any specific division. It will call for

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[65] Robert S. Norris, *Racing for the Bomb: General Leslie R. Groves, the Manhattan Project's Indispensable Man* (Steerforth Press, 2002), 506 and Kate Brown, *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters* (Oxford University Press, 2013), 26-31 and 38.
[66] James Cortada, *Before the Computer: IBM, NCR, Burroughs, & Remington Rand & the Industry They Created, 1865–1956* (Princeton University Press, 1993), 155 and 225.
[67] James W. Cortada, *Historical Dictionary of Data Processing: Organizations* (Greenwood, 1987), 237, quoted in Arthur Norberg, *Computers and Commerce: A Study of Technology and Management at Eckert-Mauchly Computer Company, Engineering Research Associates, and Remington Rand, 1946-1957* (The MIT Press, 2005), 210.
[68] Aspray and Clamons, 19 and Remington Rand Incorporated, *Annual Report* (1952), 6.
[69] "M'Arthur Joining Remington Rand," *New York Times*, August 1, 1952.

cooperation of almost all sections of the Laboratory representing all divisions of the company in one single program." The company, however, lacked experience in one crucial area: information storage and retrieval, or what they called the "Instant reference memory" idea.[70] A little over a month later Groves had committed to magnetic memory, and within the next six months, agreed to purchase Devol's magnetic process control patent (and others related to it then under development), primarily because of their ability to remember and store numerical information at a very low cost.[71] Devol was also made head of the new Magnetics Department and employed as a "development engineer and consultant" for a six-month period that could be renewed by the parties thereafter. It was agreed that Devol would spend at least half of his time developing the recording system and other magnetic technologies more generally with the remaining half reserved for other tasks assigned by Remington Rand. In the event that his patents relating to the magnetic recording system, both existing and future, were eventually not used by Remington Rand, ownership and all rights would revert back to Devol.[72] Major projects included the "amplet," an electro-magnetic device used as a control element for electronic circuits (essentially a replacement for the thyratron tube); the development of "Automatic File Planning," or the use of magnetics for the storage and retrieval of numerical and textual data; the "Random Reference Memory Unit" (what later was referred to as 'random access memory'), the medium in which such data would be stored; and the comprehensive system in which all these elements would be combined, the "Randomatic File," with Remington's full suite of technologies from punched

[70] Memo, L.R. Groves, Electronic Business Machines, October 25, 1948, Folder - Remington Rand - New Product Research, 1948–1953, Box 2, GDJR, 1.
[71] Memo, L.R. Groves, Magnetic Memory, December 9, 1948, Folder - Remington Rand - New Product Research, 1948–1953, Box 2 and Outline of Proposed Organization, Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR, 5.
[72] Agreement, July 5, 1949, Folder - Remington Rand - New Product Research, 1948–1953, Box 2, GDJR.

cards and tabulating equipment to electronics, printers, and storage media.[73] By 1952, new chairman of the board MacArthur was "particularly impressed with the progressive policies of Remington Rand in the expansion of foreign markets and in the field of research and development, especially in electronics in which the company now plays a dominant role."[74]

The years Devol spent as head of the Magnetics Department were also a pivotal period in the expansion of Remington's product lines and technical capabilities through the purchase of outside firms. Groves was "instrumental" in this process when he led the acquisitions of the Eckert-Mauchly Computer Corporation (EMCC) in 1950 and Engineering Research Associates (ERA) in 1952, both of which, for all intents and purposes, owed their existence to the military and the American state.[75] For instance, government support of EMCC was, in one historian's estimation, "part of a wider program" intended to subsidize and incentivize large-scale industrial organizations that "were apparently unprepared to expend the funds necessary for further research and development in this area" making "the interest of these government agencies . . . . critical in sustaining the growth of computers.[76] The company's most successful product line, the UNIVAC (UNIVersal Automatic Computer), commonly recognized as the world's first commercially available general purpose electronic digital computer designed for business and administrative applications, evolved out of its work with the Census Bureau. Customers eventually included insurance companies like Franklin Life, Metropolitan Life (MetLife), and

[73] Magnetics Department, The Amplet - A New Control Device, undated (a digitized blueprint of an "Amplet Coincidence Circuit" (c. 1954), George Devol Collection, The Henry Ford Archive of American Innovation, https://www.thehenryford.org/collections-and-research/digital-collections/artifact/372732/), Folder - Robotics - Misc Robotic Reports, 1 of 3, Box 2; Provisional Specifications for a Random Reference Memory Unit, September 16, 1952 and Reed Stoval to General L.R. Groves, J.T. Ferry, and G.C. Devol, Automatic File Planning, January 5, 1953, Folder - Robotics - Robotic Reports, Unimation, Box 2; Provisional Specifications for the Randomatic File, November 2, 1953, Folder - Robotics - Misc Robotic Reports, 1 of 3, Box 2, GDJR
[74] "M'Arthur Joining Remington Rand," *New York Times* (August 1, 1952).
[75] Norberg, and Nancy Stern, *From ENIAC to UNIVAC: An Appraisal of the Eckert-Mauchly Computers* (Digital Press, 1981). The assessment of Groves as "instrumental" comes from Norberg, 213.
[76] Norberg, 102 and 104.

Pacific Mutual Life, major defense contractors such as Du Pont, General Electric (GE), and Westinghouse, and government agencies from the Air Force to the Atomic Energy Commission (AEC).[77] While UNIVACs gained wide acceptance in the public and private sectors, it's perhaps most famous for predicting General Dwight D. Eisenhower's 1952 landslide presidential victory over Adlai Stevenson, whom pollsters favored, live on CBS.[78]

Similarly, ERA was a creation of the Navy emerging out of a group responsible for cryptology during World War II that became an organizational forerunner of the National Security Agency (NSA).[79] The company's founding can be attributed to two unique circumstances related to its Navy work—one technological, the other social. First, Communications Supplementary Activity – Washington (CSAW; pronounced "seesaw") was one of the earliest organizations to "go digital" or employ equipment with electronic circuitry using flip-flops and counters (à la Devol's decade counter) since codebreaking required extremely fast computational devices, and therefore the most advanced R&D to develop such machines. Here CSAW was attempting to "create something like the RAND Corporation," the world-famous think tank established by the Air Force later that same year. Second, senior members of CSAW—specifically Howard Engstrom and William Norris—balked at continuing in the civil service after the war and convinced James Forrestal, then secretary of the Navy and soon to be the first secretary of Defense, to support their private ambitions. As historians Erwin Tomash and Arnold Cohen put it, "They wanted a chance to run their own company to make

[77] Paul E. Ceruzzi, *A History of Modern Computing* (The MIT Press, 1998), 28.
[78] "The Night a UNIVAC Computer Predicted The Next President: NOV. 4, 1952," https://www.youtube.com/watch?v=nHov1Atrjzk.
[79] Thomas J. Misa, *Digital State: The Story of Minnesota's Computing Industry* (University of Minnesota Press, 2013), 38.

their fortunes."[80] With outside financing from John E. Parker, president of the St. Paul, Minnesota-based National Aeronautical Corporation (NAC) and two contracts from the Navy, ERA was officially established in January of 1946 and housed in NAC facilities. To circumvent regulations that restricted firms without a history of contracting with the Navy from receiving large government contracts, ERA received a small contract from the Office of Naval Research (ONR) while a large contract from the Bureau of Ships went to NAC as it was already an established government contractor. As one historian described it, "As far as public record went, it had no budget, since its appropriations were buried in the budgets of other agencies, and it fit right in to say that ERA's products were for 'the Navy.'"[81] By 1947 ERA was off and running and by the turn of the decade had two major technological successes: Development of a magnetic drum memory storage system and the "Atlas" line of stored-program computers (the first two of which were bought by the NSA) intended for the military, and a commercialized version of the line, the "1100" series, that were essentially duplicates of their military predecessors intended for "scientific users."[82]

[80] Erwin Tomash and Arnold A. Cohen, "The Birth of an ERA: Engineering Research Associates, Inc. 1946-1955," *Annals of the History of Computing*, Vol. 1, No. 2 (October 1979), 85. The authors worked for ERA during the period they historicize.

[81] George Gray, "Engineering Research Associates and the Atlas Computer (UNIVAC 1101)," *Unisys History Newsletter*, Vol. 3, No. 3, (June 1999), https://web.archive.org/web/20110902095250/https://wiki.cc.gatech.edu/folklore/index.php/Engineering_Research_Associates_and_the_Atlas_Computer_(UNIVAC_1101). The appearance of impropriety such inside maneuvering signaled was recognized immediately. According to Tomash and Cohen, "The founding of ERA and the award of its initial contracts had the appearance of self dealing and possible conflicts of interest. Seen in its worst light, a group of Navy technical specialists had taken advantage of their top secret knowledge to set up a company for their own enrichment and had done so with the connivance of the Navy Department (which then awarded them contracts without competitive bidding). The conflicts of interest, however, were more apparent than real. The Navy had, in fact, accomplished something quite difficult to do in a bureaucracy: it had exercised a degree of entrepreneurship. After all, CSAW-type contracts were always secret, were always negotiated, and were never competitive. Nevertheless the Navy was concerned about possible criticism and was keenly aware that the establishment of ERA and the situation in St. Paul were fraught with potential for abuse," 87.

[82] Norberg, 142-159.

For all their successes, both EMCC and ERA found themselves in dire financial straits. Computer systems were extremely expensive, the technology was changing so rapidly that systems were outdated almost the moment they were installed, and the only organizations with access to the capital and expertise necessary to operate them were government agencies and large corporations. Therefore, small companies such as EMCC and ERA, which were technology rich but capital poor, had a difficult time competing with market giants like IBM and Remington. Government procurement and government contracts could keep them afloat but for only so long. Remington had a tradition of buying technological competence via acquisitions rather than building capability from within, as its major competitor IBM did, making EMCC and ERA ripe targets.[83] EMCC was purchased in 1950 and ERA in 1952, however, integration of the firms did not go smoothly. While EMCC, which remained in Philadelphia, came under Groves's control and developed solid relationships with Norwalk, Groves "succeeded in one visit in alienating everyone at ERA" and was taken out of the loop by James Rand. As one former ERA employee put it, "[Rand] was impressed that it [ERA 1103] had been developed with government money and hence they would get this product without having to do much development"; however, "[they] had bought some engineers and some projects, but they aren't cleared by NSA, so we can't take them through and show them what we're doing. They know it's so many million dollars a year in classified work, that's what they know."[84]

For the next three years, ERA operated as, essentially, an autonomous subsidiary of Remington. Besides computers built for the Air Force and the Navy, and Signal Corps service contracts, ERA also received federal permission to announce a version of a then secret system

[83] Norberg, 209.
[84] Arthur L. Norberg, "An Interview with Erwin Tomash," May 15, 1983, Charles Babbage Institute, 23-25..

built for the NSA, all of which played a part in the commercialization of the Atlas computers.[85] All the while, the Navy continued to support magnetics research, with both EMCC and ERA engaged in this work.[86] Unlike EMCC, which maintained large losses during these early years, ERA remained profitable, "mostly due to the range of government business that came [its] way," and the "many million dollars a year in classified work" no doubt bolstered Remington's R&D revenues and capabilities.[87] And while Remington's management ostensibly tasked EMCC with developing "business" computers and ERA with developing "military" and "scientific" computers, the two divisions did share one technology in particular as "Philadelphia's magnetic tape drives were soon added to the St. Paul computers, and St. Paul's magnetic storage drum technology was used in some of Philadelphia's computers."[88] Devol, as head of the Magnetics Department, was no doubt a part of all these developments.

Beyond magnetics, Devol was devoted to a government-contracted high-speed printer using magnetic tape that was, at the time, the fastest printing press ever built, capable of producing a thousand sheets per minute.[89] In May 1951, as the patent application for Devol's printer was being prepared, Remington Rand's legal department contacted Groves, who later passed on the information to Devol and his staff, and informed him "it has been found that there is considerable subject matter which we believe is of vital importance. In fact, based on our knowledge of the art subject to undisclosed patent applications on file, we are of the opinion that very broad and possibly basic claims can be obtained." They recommended, however, "that extreme caution should be taken in disclosing or describing this idea to anyone either in or out of

[85] Emerson W. Pugh, Lyle R. Johnson, John H. Palmer, *IBM's 360 and Early 370 Systems* (The MIT Press, 1991), 23.
[86] Norberg, 240.
[87] Norberg, 240.
[88] George Gray, "The UNIVAC 1102, 1103, and 1104," *Unisys History Newsletter*, Vol. 6, No. 1, (Jan. 2002).
[89] Ballard et al., 116.

the organization until such time as the patent application can be filed. Also, in view of the patent clauses in Government contracts, no one should even be approached until after the application is on file."[90] In short, the patent had the potential to be very lucrative and therefore was to be kept under wraps. As Devol was fond of saying, "General Groves had two top-secret projects: The atomic bomb and our printer."[91] What was eventually called the "Randomatic Printer" had, by 1953, raised "considerable interest" in Washington. Over twenty-five federal agencies ranging from every branch of the military, the Bureau of the Budget in the President's Office, the General Accounting Office (GAO), and the Treasury Department were scheduled to attend a demonstration in Arlington, VA.[92] ERA representatives apprised the NSA of the printer, the latter of which were "extremely interested in committing funds for an experimental system."[93] Devol eventually received three patents for the printer.

When all was said and done, Remington spent approximately $375,000 over a five-year period on the development of technologies related to Devol's patents and principles. By the end of the fourth year however, other magnetic developments capable of higher response speeds—a key component of "high speed" computing—proved more promising than Devol's system, and further development of his patents was curtailed. The Magnetics Department eventually ceased operation and, by mid-1954, Devol left Remington and consolidated his patents, pending patent applications, licensees, and royalty contracts under the unincorporated roof of the Devol Research Company.

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[90] J.A.W. Stimson to General L.R. Groves, Devol - High Speed Printing, NL-270, May 24, 1951 and Groves to T.S. Ross, G.C. Devol, and J.T. Ferry, Devol - High Speed Printing, NL-270, June 4, 1951, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.
[91] Ballard et al., 116.
[92] H.T. Engstrom to T.C. Hyers et al, Random Printer Preliminary Developmental Model, October 20, 1953, Folder - Remington Rand - New Product Research, 1948–1953, Box 2, GDJR.
[93] H.S. Forrest to J.T. Ferry, NSA High Speed Printing Link, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.

**A Missionary for a Machine: Joseph Engelberger and the "First" Industrial Robot**

When Devol left Remington, he didn't leave empty-handed. A provision in his Remington employment contract required patent rights previously assigned to the corporation but no longer under development, to be reassigned to Devol immediately after employment termination.[94] On December 28, 1954, less than six months after leaving Remington, Devol received word from his patent attorney and business partner Paul S. Martin that his "Programmed Article Transfer" (PAT)—a device that consolidated the vast majority of his work over the past two decade into one technological system—had been filed with the U.S. Patent Office.[95] Referred to in the patent as the "'unimatic' transfer apparatus," the device would be given a much more memorable name: the Unimate. It proved to be Devol's most influential invention, and today, it is commonly (though mistakenly) referred to as the first industrial robot.

The PAT had a long lineage with roots, according to Devol, in technology originating from a package sorter system designed in 1936 for Firestone Rubber by United Cinephone. In the early 1950s, while Devol was with Remington, the system was redesigned (but never built) for the Railway Express Agency (REA), a government-sanctioned monopoly owned by the country's railroads. Employees of REA manually sorted thousands of packages a day, so Devol devised an "automated package sorter" that would paste barcodes on every package to be "read" by a photocell, the instructions of which would command a numerically controlled pick-up

[94] Agreement, July 5, 1949, Folder - Patents - Agreements, 1946-1971 - 12, Box 1, GDJR.
[95] Paul S. Martin to Clyde A. Norton, RE: Devol-Remington Rand Contract, December 28, 1954, Folder - Patents - Correspondence, 1950-1973 (Folder 1 of 2), Box 1, GDJR. The news was typed at the bottom of a copy of this letter and forwarded to Devol from Martin.

device—a rudimentary mechanical arm and gripper—to manipulate the packages. The novelty of the system resided in the precision made possible by numerical control rather than the imprecision of existing "bang-bang" systems, so called for the sound the machines would make when banging into the switches that limited their motion. While the pick-up device had only a single degree of freedom—meaning that it could be programmed to go through only one movement at time—such "point-to-point" control systems were, at the time, state-of-the-art.[96] An efficient control apparatus for such a system, however, did not exist at the time. But after ten years of development while he was at Sperry, GEI, and RCA, Devol invented just that with his "Magnetic Process Control," the rights of which had just returned to him after he left Remington.

While almost any electromechanical apparatus or implement could be connected to and controlled by the magnetic recorder, Devol specifically foregrounded applications to servomotor-controlled machine tools that, at the time, were under development at the MIT Servomechanisms Lab. The patent application for the control apparatus described how a machine tool attached to the magnetic recorder would be taken through an "idle stroke" and all of its motions would be stored; if errors occurred, the process could be repeated until optimal accuracy was achieved. Once "a single perfect magnetized controlling element has been formed" the device could control the cycle of multiple machine tools simultaneously.[97] As Devol described it "we took our recording system and hooked it up to a machine—a lathe, for example. We turned out whatever parts we wanted and, in the process of making them, we magnetically recorded all the lathe's actions. From that point on, the lathe could automatically produce identical parts." As he framed it, the device was a "teachable machine." According to Devol, "Nothing was close to that

[96] George Devol, "Robot Systems, Evolution," Folder - "Devol Personal - Writings, 1945-2008," Box 1, GDJR, 4-5.
[97] George C. Devol,, "Magnetic Process Control," U.S. Patent Office #2,590,091 (Application: Apr. 3, 1946; Patented: Mar. 25, 1952 ), 4.

[magnetic process control], except a digitally controlled machine built by Jay Forrester at MIT. But he was programming his machine, not teaching it. There's quite a difference."[98] While the device was not "learning" in any human sense of the concept, the difference between programming the action of the machine versus recording human-directed motion had significant consequences. Where both techniques were digital and utilized numerical control (N/C), computer programming of N/C required abstract motion to be described mathematically and translated into computer language, the product of which would be used to develop various programs to put machines to work. On the other hand, "record-playback" (R/P), or the "motional" approach, automatically recorded the actual motion of a machine guided by a human in real-time as numerical information in the R/P device's memory. Hence, "recorded" motion could be "played back."[99] Rather than the extremely expensive and technically difficult task of programming computers via N/C, "teachability" cost less in terms of capital and labor, and was much more user friendly at the point of production.[100]

During his time at Remington, it became evident to Devol that "there was an unlimited field for intermediate speed storage devices in the field of mechanical control and digital servo systems where the speed of response is far in excess of that ever required for controlling mechanical actions."[101] Additionally, in Devol's assessment, "the final limitation of all present methods [of memory storage] is that each particular machine cannot learn, that is to say, that the

[98] Saveriano, "An Interview with George Devol," 23.
[99] For the best discussion of computer-programmed N/C vs. R/P see David F. Noble, "Social Choice in Machine Design: The Case of Automatically Controlled Machine Tools, and a Challenge for Labor," *Politics & Society*, Vol. 8, No. 3-4 (Sept. 1, 1978), 326-342 and David F. Noble, *Forces of Production: A Social History of Industrial Automation* (Oxford University Press, 1984), 147-192.
[100] For instance, by 1955 MIT, with lavish funding from the Air Force who also mandated suppliers to use the technology, spent upwards of $62 million on developing their code-based N/C systems, the complexity of which made their use uneconomical. R/P, developed simultaneously at General Electric (GE) and a number of smaller firms, cost far less and had better immediate results.
[101] "Proposal for the Formation of Devol Research Associates," c. 1956, Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR, 5.

machine can be built to perform a fixed series of operations and is not readily adaptable to a radical change in the nature of its use." Furthermore, DC memory storage made "automatic machines simpler and more versatile and [presented] the possibility of automating machines which have never been used in this manner before."[102] In other words, his less technically advanced "teachable machine" developed while at RCA and his DC memory work at Remington were particularly suited to the cheaper and less complex R/P technique. And with the technical advancements made in digital computation and N/C, shifting from the control of machine tools to the control of a pickup device, like the one envisioned in the package sorter system, made perfect sense. In Devol's words, "After we had our teachable machine, we thought: why not make a manipulator? Let's put a hand on the machine and move parts around."[103] The resulting device was a combination of a servomechanized manipulator connected to a magnetic process control whose numerical information was stored on a memory drum, the very systems Devol had been working on for more than a decade at some of the world's most technically sophisticated military contractors.

The philosophy grounding the Unimate's design was what Devol's wife Evelyn called "Unimation," a neologism she coined that combined *universal* with *automation*.[104] At the time, "traditional" automation was characterized by systems of transfer machines that moved materials and parts around the factory floor and on the assembly line to increase efficiency, labor control, and productivity.[105] To obtain these increases required, from management's perspective, the

[102] "Scope," Folder - "Devol Personal - Writings, 1945-2008," Box 1, George Devol Jr. Records, BFRC, 4-6.
[103] Saveriano, "An Interview with George Devol," 23.
[104] Ballard et al., 115.
[105] David Hounshell, "Automation, Transfer Machinery, and Mass Production in the U.S. Automobile Industry in the Post-World War II Era," *Enterprise & Society*, Vol. 1, No. 1 (March 2000), 100-138.

"deskilling" of workers through technologizing their skills and the elimination of surplus workers.[106] As historian of the auto industry Stephen Meyer summed up the process:

> Managerial efforts to extend its control of machines and men has eliminated worker skills and displaced labor in the work process. To accomplish these tasks, a new breed of automotive engineers designed machinery and organized production to transfer skill more effectively from workman to machine. The result was the degradation, speedup, and elimination of labor, a chronic process that has continued in periods of both technical innovation and stagnation.[107]

Or, in Del Harder's simple calculation,"to be [financially] viable each automation device had to eliminate at least one worker."[108] And while automation came in different styles depending on the industry and product—for instance, in the automotive industry where automation was perhaps most prominent, it was called "Detroit automation"—it was overwhelmingly described as "hard" or "special purpose" automation due to the fact that systems were designed around a specific product or work process. Hard automation, therefore, was rather inflexible as entire systems had to be scrapped and redesigned for new products and work processes and, as a result, was an expensive, risky, and time-consuming endeavor.

Devol positioned Unimation as a solution to these problems. Unlike "hard" or "special purpose" automation, "general purpose," "soft," or "universal" automation could manufacture different products and take on different work processes without being redesigned—a hallmark of its most visible component, the industrial robot. According to Devol, "Automation equipment

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[106] For key texts on the "deskilling" thesis, see Harry Braverman, *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century* (Monthly Review Press, 1998); Noble, *Forces of Production;* and Harley Shaiken, *Work Transformed: Automation and Labor in the Computer Age* (Holt, Rinehart, and Winston, 1985).
[107] Stephen Meyer, "The Persistence of Fordism: Workers and Technology in the American Automobile Industry, 1900-1960" in Nelson Lichtenstein and Stephen Meyer (eds.), *On the Line: Essays in the History of Autowork* (University of Illinois Press, 1989), 75.
[108] David Hounshell, "Planning and Executing 'Automation' at Ford Motor Company, 1945-1965: The Cleveland Engine Plant and Its Consequences" in Haruhito Shiomi and Kazuo Wada (ed.), *Ford Transformed: The Development of Production Methods in the Automobile Industry* (1995), 69.

normally consists of specially designed, highly automatic group of machines coupled to each other and in most cases will not allow for any change in the product without extensive rebuilding and retooling," therefore, "Unimation equipment as such is not intended to compete with automation equipment of this type."[109] As the PAT patent described it, "The present invention makes available for the first time a more or less general purpose machine that has universal application to a vast diversity of applications." In economic terms, the patent continued, the device's function was to overcome the "high cost of operating manpower" and to make "article transfer machines available to the factory and warehouse for aiding the human operator in a way that can be compared with business machines as an aid to the office."[110] Furthermore, as Devol described it, the Unimate was "intended to replace an operator" as it could be "shifted readily from one job to another in much the same way as a human operator."[111] Universal automation, therefore, was also unique in that where "hard" automation redesigned job tasks and displaced workers indirectly through the recomposition of capital and labor, industrial robots were designed to deliberately replace an actual worker, corporeally speaking, entirely.

Devol's assessment of Unimation's uniqueness, applications, and market potential was bold. "There is one important fact to bear in mind," he claimed in the first Unimation prospectus, "namely, in the past there has been no development which lent itself to universal application to the same degree as the proposed universal automation devices." And, he continued "Unimation equipment of this type will have a degree of flexibility far beyond that of any comparable type of equipment, the market both present and future, is in any industry where labor is employed to perform simple or complex manual operations in accordance with written or spoken

[109] "Automation vs. Unimation," (c. 1956), Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR.
[110] George C. Devol, Jr., "Programmed Article Transfer," U.S. Patent Office 2,988,237 (Application: December 10, 1953; Patented: June 13, 1961), 1.
[111] "Automation vs. Unimation," GDJR.

instructions."[112] These operations ranged from "automatic assembly" and "automatic warehousing" to "remote control handling of atomic energy products" to the vague category of "a number of miliary applications."[113] Devol appraised the initial market for Unimation in just materials handling would be a minimum of one-hundred thousand units. Using Department of Commerce figures for material handling labor in distributing and warehousing from 1953, Devol estimated that this would equate to only one percent of the 9.4 million workers employed in these sectors alone and create a $100 million market.[114] The total market for the Unimate was, however, much greater. Based upon 1955 figures, Devol estimated that three to ten percent of *all* production employees, who then totaled approximately 15 million, could be "replaced by Unimation," translating into a sales volume of nine-hundred thousand units and a potential market, based on a $15,000 unit price, of $13.5 billion.[115] Food processing and manufacturing, "because of the enormous turnover," were forecasted as the largest users of Unimation equipment. In terms of the latter sector, Devol expected that "the full effect [of Unimation] will be felt wherever a company in a lateral industry affects large savings due to automation" and "undoubtedly cause many upheavals and will be the reason for numerous consolidations and a number of failures on the part of companies unable to compete."[116] In other words: automation, and thereby Unimation, was a matter of commercial survival.

The first targets of Devol's search for Unimation clients in the mid-1905s ranged from the A. O. Smith Corporation and General Foods to International Harvester and Pullman, Inc.[117]

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[112] G. C. Devol, "Universal Automation As Applied to Materials Handling," n.d. (c. 1954), Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR, 3.
[113] "Universal Automation As Applied to Materials Handling," GDJR, 7.
[114] "Universal Automation As Applied to Materials Handling," GDJR, 8.
[115] "Proposal for the Formation of Devol Research Associates," n.d. (c. 1956), Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR, 14-15.
[116] G. C. Devol, "Universal Automation As Applied to Materials Handling," GDJR, 2.
[117] Folder - Devol Personal - Correspondence, 1950-1987, Box 1 and Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.

However, the bulk of prospective clients contacted were major players in the nascent military-industrial complex. Two months before the PAT patent was submitted, Devol reached out to General Dynamics, then one of the largest Naval shipbuilders, to gauge their interest in Unimation and pitch its potential as eventually being of "sufficient size to absorb a large portion of the Company's defense business."[118] Over the next few months, Boeing, North American Aviation, Republic Aviation, United Aircraft, and Westinghouse were all similarly pitched.[119] At some point, Devol got Thomas Watson of IBM interested; however, the corporation was making its "big push in computers" (the progress of which was highly subsidized and underwritten by the military) and their "hands were full."[120] If return correspondence, or lack thereof, are any indicator, Unimation was a tough sell during Devol's first round of outreach. In his recounting of the period, drafted for an entry in the 1988 *International Encyclopedia of Robotics*, Devol narrated the experience in the following way:

> With a market for his manipulator in mind, Devol began looking for an investor who would be willing to put up the millions of dollars needed to develop the first device. However, the novelty of his idea ~~scared~~ deterred most of the companies he talked to. He ran into what he called the NIH (not-invented-here) Syndrome ~~countless~~ many times as skeptical company executives found reasons why the manipulator could~~n't~~ not succeed instead of why it could. Some said that it would be impractical. Others were sure that it would cost too much to make it worthwhile. Most just could~~n't~~ not get used to a concept as revolutionary as automating a whole production process.[121]

Commenting on the business community's fear of what robotization could signal, Devol recalled, "You'd go around and tell someone you wanted to put a robot in their plant . . . . and they'd

[118] Devol to Mr. Pace, October 13, 1954, Folder - Devol Personal - Correspondence, 1950-1987, Box 1, GDJR.
[119] Various documents, Folder - Devol Personal - Correspondence, 1950-1987, Box 1, GDJR.
[120] Saveriano, "An Interview with George Devol," 23. IBM eventually licensed a package of Unimation patents in 1971 (Folder - Patents - Agreements, 1946-1971, Box 1, George Devol Jr. Records, BFRC) and transformed this into their 1972 "Production Terminal" industrial manipulator, Charles A. Rosen, "The Future of Automation," *Naval Research Reviews*, Vol. XXVI, No. 8 (August 1973), 6.
[121] Devol, "Robot Systems, Evolution," GDJR, 8-9, markups in original.

almost call the guards to come and get you."[122] Finding potential Unimation customers proved so difficult in the year following his separation from Remington that Devol began shopping his manufacturing experience and expertise to potential employers who advertised executive-level openings in the *New York Times*.[123]

Two respondents, however, finally expressed interest: military-industrial conglomerate Westinghouse and a small Connecticut-based aerospace and control system engineering and manufacturing firm called Manning, Maxwell & Moore, Inc. (MMM).[124] While the interest from Westinghouse would take decades to finally gestate, it appears that Devol's professional relationships and family connections, rather than Unimation's merits, put him on MMM's radar. According to his future business partner Joseph Engelberger, who then worked at MMM, Devol pitched the firm on his patents in 1952 or 1953 but was rebuffed.[125] Nevertheless, he had another connection to MMM. In mid-1943, Devol patented a "motor-generator" device with fellow engineer Hall Langstroth, both of whom had apparently worked together at Sperry Gyroscope and then, shortly thereafter, at Maguire Industries.[126] For almost a decade after the war, Langstroth served as a design, production and management engineering consultant before joining MMM's Aircraft Products Division as a project engineer in 1955. At MMM, Langstroth was

[122] Betsy Carpenter to George C. Devol, Draft of "Industry's Steel Collar Workers" for Time Life Books, September 5, 1986, Folder - Devol Personal - Correspondence, 1950-1987, Box 1, GDJR, n.p. The draft was marked up by Devol and apparently contained no factual errors (at least in terms of what he was comfortable with or desired to be communicated).
[123] George C. Devol to New York Times, August 16, 1954 and April 4, 1955, Folder - Devol Personal - Correspondence, 1950-1987, Box 1, GDJR. According to Devol's own written narrative of the period, "A few companies were willing to take on the risk only if Devol came into the firm as an employee. For Devol, that would have meant the loss of millions of dollars from the sale of the patent, so he declined the offers. Devol was certain that his manipulator was the beginning of a major new business in automating production and he owned the patents that would control part of that new business," Devol, "Robot Systems, Evolution," GDJR, 9.
[124] "Unimation Market Survey Summary," March 29, 1956, Devol Personal - Correspondence, 1950-1987, Box 1, and George C. Devol to Wm. Boyd, Jr., January 3, 1955, Folder - Robotics - Correspondence, 1950s, Box 2 GDJR.
[125] Saveriano, "An Interview with Joseph Engelberger," 11.
[126] George C. Devol and Hall Langstroth, "Motor-Generator," U.S. Patent: US2355208A, July 5, 1943 and Manning, Maxwell & Moore, Inc., Aircraft Products Division, n.d. (c. 1954), Trade Literature - Non-Unimate Literature, 1955-1983, Box 3, GDJR, 8.

tasked with the design and production of various components, instruments, and machines in the appliance, automatic machine, electronic, and hydraulic fields.[127] And, through a family friend, Devol was introduced to Harry Moore, the general manager of the Aircraft Products Division at MMM, who put him in touch with Langstroh's boss and the division's chief engineer, Joe Engelberger.[128] The introduction would prove momentous: while Devol was the progenitor of Unimation, the transformation of the concept into a company, and eventually the driving force behind turning the industrial robot into an industry, derived from Engelberger's work. In Devol's words, Engelberger was "a missionary for a machine."[129]

Born in Brooklyn, N.Y., on July 26, 1925 to Joseph H. Engelberger and Irene Kolb, Joseph F. Engelberger, Jr. moved at the age of three with his family to Bridgeport, Connecticut.[130] Their struggles during the Great Depression led Engelberger Jr.'s mother to advise him to "carry in his head most of the assets he would have the rest of his life."[131] Apparently young Joe heeded his mother's wisdom and, after graduating from Bassick High School in 1942, he was one of fourteen physics majors selected from throughout the country to attend Columbia University on a V-12 scholarship—a Navy program intended to accelerate the education and training of commissioned officers for the ongoing war.[132] While how and when he came to do so are unclear, Engelberger spent time on the Manhattan Project doing test work for

[127] Manning, Maxwell & Moore, Inc., Aircraft Products Division, n.d. (c. 1954), Trade Literature - Non-Unimate Literature, 1955-1983, Box 3, GDJR, 8.
[128] Devol, "Robot Systems, Evolution," Devol Personal - Writings, 1945-2008, Box 1, GDJR, 9.
[129] Betsy Carpenter to George C. Devol, Draft of "Industry's Steel Collar Workers" for Time Life Books, September 5, 1986, Folder - Devol Personal - Correspondence, 1950-1987, Box 1, GDJR, n.p.
[130] "Joseph Engelberger Obituary, *Danbury News Times* (December 4, 2015), https://www.legacy.com/us/obituaries/newstimes/name/joseph-engelberger-obituary?id=9937246.
[131] Saveriano, "An Interview with Joseph Engelberger," 10-11.
[132] Engelberger Obituary and Saveriano, "An Interview with Joseph Engelberger," 10-11. The obituary mistakenly states Engelberger graduated in 1943.

the first atomic bomb at Bikini Atoll.[133] He eventually earned a B.S. in Physics (1946) and, after the war, returned to Columbia for an M.S. in Electrical Engineering (1949).[134] After the war, Engelberger immediately got the chance to work with the very technology that would eventually make industrial robots a reality. As he described it, "The Navy made a physicist of me, and it was nice to get out of the Navy and have a whole bunch of companies wonder what a physicist was. So it was very easy for me to get a job."[135]

That first job came in 1946 when Engelberger took a position at MMM. The firm traced its origins to Edward H. Ashcroft's invention of the "first steam pressure gauge" in 1852 and, by the mid-1950s, the company was operating six plants from California to Massachusetts and a subsidiary in Canada manufacturing a range of analog and electronic control devices.[136] Engelberger—who concentrated on aircraft instrumentation and jet engine controls—progressed quickly up the ranks of the company and, within less than a decade, moved from his initial post as a development engineer to chief engineer of the Aircraft Products Division, an outfit he played a key role in developing.[137] The division was permeated with former military officers from general manager and retired Air Force captain H. S. Moore (the third "M" in MMM), director of military relations Rear Admiral (ret.) H. G. Williams, to a roster of managers and staff engineers who served in all three branches of the armed forces.[138] According to George E. Munson, then a young physicist with the firm, Engelberger's division "landed some lucrative subcontracts for jet engine controls" during the Korean War and, with "brisk business that included the U.S. Air

[133] Bortz, 15 and Patrick Wauryzniak, "Masters of Manufacturing: Joseph F. Engelberger," *Manufacturing Engineering*, Vol. 137, Iss. 1, (July 2006), 66.
[134] Saveriano, "An Interview with Joseph Engelberger," 10-11.
[135] Wauryzniak, 66.
[136] Manning, Maxwell & Moore, Inc., Aircraft Products Division, n.d. (c. 1954), Trade Literature - Non-Unimate Literature, 1955-1983, Box 3, GDJR, 2.
[137] Aircraft Products Division, GDJR, 5.
[138] Aircraft Products Division, GDJR, 5-8.

Force," the division outgrew MMM's headquarters in Stratford, Connecticut and moved into their own plant about thirty miles north in Danbury, Connecticut.[139] In addition to its "large scale production programs," the division undertook "several important developmental contracts . . . . anticipating the aircraft industry's future requirements," the combination of which earned the division "recognition by the U.S. Navy, U.S. Air Force, and by major manufacturers of aircraft engines and airframes" for its work.[140] In short, Engelberger and MMM were card-carrying members of the very military-industrial complex Devol was deeply embedded in.

As demonstrated above, Devol's relationship to MMM predated the legendary cocktail party. Furthermore, as early as late November 1955, Devol was already being referenced in an MMM inter-office letter as an "MM&M Inc. Representative" while Engelberger was acting as a representative of Unimation by meeting with outside firms to pitch Devol's vision.[141] "Since robots were an expensive proposition," Devol recalled, "we [Devol, Engelberger, and MMM] made our first contract on the basis of the magnetic recording patents…and agreed to do further development work" on the Unimate.[142] By the end of the year, MMM had made formal arrangements to license Unimation equipment, specifically a magnetic recorder, and other patents from Devol while Engelberger immediately began assessing the market conditions for Unimation by visiting fifteen different companies in the Bridgeport area (where MMM's Aircraft Products Division was located) and reaching out to prospective clients.[143] Communication was

[139] RBR Staff, "The First Industrial Robot: Why It Failed," *Robotics Business Review* (October 14, 2012), https://www.roboticsbusinessreview.com/manufacturing/the_first_industrial_robot_why_it_failed/. The text of the article was directly lifted from a piece for *Robot Magazine,* a seemingly now defunct online publication (their website botmag.com is no longer operable), written by Leslie Ballard, titled "The Rise and Fall of Unimation, Inc." Apparently, the article is condensed from an unpublished book, "Pity the Pioneer: The Rise and Fall of Unimation," by George E. Munson, who was a development engineer at Unimation, about his experience with the company.
[140] Aircraft Products Division, GDJR, 3.
[141] "Unimation Market Survey Summary," GDJR, 3.
[142] Saveriano, "An Interview with George Devol," 23.
[143] "Proposal for the Formation of Devol Research Associates," (c. 1956), Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR; Wauryzniak, 66; and Saveriano, "An Interview with George Devol," 22-28.

not, however, restricted to just commercial manufacturers or for-profit companies. In February 1956, Engelberger's division sent letters to seventeen different military contacts in all three branches of the armed forces (as well as the Atomic Energy Commission) with seven positively responding within a matter of weeks.[144] Apparently nothing came of these contacts besides exchanges of information.

Their first real breakthrough came in June 1956 when the Ford Motor Company expressed interest and requested that three members from their Manufacturing Engineering Staff Office visit Engelberger's operation.[145] Shortly thereafter, Engelberger assigned a few of his employees to survey plants at Chrysler, Ford, and General Motors. Led by project engineer Maurice J. Dunne, the general purpose of the automotive plant studies were twofold; first, to discover applications for the Unimate; and second, to determine what capabilities a standardized Unimate would need to fulfill all of the applications.[146] The applications were broken down into two classes: A) applications involving the sequential re-positioning of manufactured parts in which no continuous synchronization with the rest of the operation is necessary; and B) applications in which continuous synchronization with simultaneous operations is necessary.[147] The vast majority of applications at Chrysler and General Motors fell into category A while only a few fell into category B.[148] The category differences had no appreciable effect on the physical

[144] "Unimation Market Survey Summary," GDJR.
[145] E. R. Isbell to J. F. Engelberger, June 20, 1956, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.
[146] Maurice J. Dunne, "Study of Unimation Applications in the Automotive Industry," "Study of Unimation Applications at New Castle and Amplex Plants Chrysler Corporation," and "Study of Unimation Applications at Harrison Radiator Division General Motors Corporation," August 22, 1956, Folder - Robotics - Studies, Box 2, GDJR, 1.
[147] "Study of Unimation Applications at New Castle and Amplex Plants Chrysler Corporation" and "Study of Unimation Applications at Harrison Radiator Division General Motors Corporation," GDJR, 7.
[148] The study of the Ford plant was not included in the folder.

dimensions and properties of the Unimate though "an additional requirement" would need to be fulfilled to synchronize with conveyor motion.[149]

Dimensionally, the proposed Unimate had a minimum clearance space of three-feet wide by four-and-a-half feet long by six-feet tall, weighed approximately nineteen-hundred pounds, and had a maximum load of twenty-five pounds. Positionally, it was accurate up to five-tenths of an inch, had a radial and vertical velocity of twenty-four inches per second, and a rotational velocity of ninety-degrees per second. A minimum of two-hundred sequential commands could be stored in the memory and control a two-hundred and seventy degree "revolving turret head" that housed the primary arm which provided vertical motion, a three-hundred sixty degree rotating extension arm which could extend up to seven feet, and a secondary arm which had "wrist action" and a quick-connect end device for a variety of what would eventually be called "end effectors" for manipulating and moving the Unimate's load.[150]

The studies included one-page data sheets of the applications surveyed, which included nine categories of analysis from "Type of Work Performed" and "Sequence of Operation" to "No. of Operators" and "Hand Action Required." In terms of the first category, jobs surveyed ranged from automatic forge pressing and parts transfer to shock absorber assembly and various types of welding with the number of operators at each job ranging from six to one-hundred and forty per shift. The most interesting category of analysis was "Process Modification Required" which detailed what type of changes would need to be made to a job or its environs for the Unimate to do its job. Most of the requirements involved simple jobs such as palletizing or

[149] "Study of Unimation Applications at New Castle and Amplex Plants Chrysler Corporation" and "Study of Unimation Applications at Harrison Radiator Division General Motors Corporation," GDJR, 9-10.
[150] "Study of Unimation Applications at New Castle and Amplex Plants Chrysler Corporation" and "Study of Unimation Applications at Harrison Radiator Division General Motors Corporation," GDJR, 11-12. The Chrysler study contained an unpaginated schematic of the "Preliminary Unimate" with an accompanying legend which described the major components.

stacking either materials to be worked or the final work product. However, more complex jobs such as conveyor radiator assembly required constraints to keep the part frame from swinging while the welding of anchorage assemblies required a human operator to move the parts to be welded from a pallet onto a down tray, three human operators to position the parts on jigs in the multiple welder machine, and then one human operator to remove the now welded assembly from the conveyor and stack on pallets. Putting the Unimate to work, therefore, required both the refashioning of work processes and workspaces as well as attendant human labor.[151] In this way, the Unimate's "universality" was conditional on transforming its sociotechnical locality, a theme that would come to characterize not just the development of the Unimate specifically but the early evolution of robotics and artificial intelligence (AI) as fields more generally.

While the original design of the "Preliminary Unimate" was based on these field trips and input received from the auto industry, the plant studies read much like a proposal to prospective customers and investors. They therefore provide the best and earliest articulation of what the Unimate's design team thought it was, what it could feasibly accomplish, and what it was envisioned to do. The introduction of each study situated the Unimate as "a uniquely different type of transfer machine," which discursively connected Unimation to forms of automation that would have been easily recognized by auto industry officials.[152] "In its mechanical structure," the description laid out, "the Unimate is a hydraulically powered arm capable of accurate, high-speed motion in three dimensions," while its electro-magnetic structure was a combination of three functions: digital position sensing, static magnetic memory, and electro-magnetic decision

[151] Maurice J. Dunne, "Appendix: Survey Data Sheets" in "Study of Unimation Applications in the Automotive Industry," "Study of Unimation Applications at New Castle and Amplex Plants Chrysler Corporation," and "Study of Unimation Applications at Harrison Radiator Division General Motors Corporation," August 22, 1956, Folder - Robotics - Studies, Box 2, GDJR.
[152] "Study of Unimation Applications in the Automotive Industry," GDJR, 2.

elements—or what could be summarized as a numerically controlled servomanipulator. In concert, these three functions resulted in a "machine with a memory integrated with a digital feedback control system, to produce a material handling device which can be taught a complicated sequence of movements, and which can repeat that sequence indefinitely with constant accuracy."[153] So, "What makes such a machine universal?" the introduction explicitly asked. The answer: accuracy, reliability, and repeatability. "Because the memory can encompass a multiplicity of sequential commands far beyond the capacity of the human mind," the argument continued, the applicability of the machine to a variety of operations was only "limited by the physical strength and reach of the hydraulic muscles employed."[154] And, in reply to the implicit question of what made such a universal machine necessary, Dunne historicized:

> In the early development of the concept of Unimation, it was observed that there are a great many "put and take" operations in modern manufacturing in which human labor is employed, but in which human intelligence is not used because no decisions of a critical nature are necessary. It was found, further, that there are two basic reasons why human labor is used, rather than using a machine to release the intelligent man to jobs in which his reasoning powers could be used to advantage. First of all, a machine built to do the particular job would be uneconomical because its utility would last only as long as the specific operation was necessary, and the length of useful service would not balance the cost. Secondly, considered en masse, there is simply not enough engineering and design time and experience in existence to begin the task of designing all the machines necessary. The Unimation approach to the problem is the only remaining one.[155]

The initial reaction from the auto industry was positive. A few months after the plant studies, Devol had already traveled to Detroit twice and the chairman of Chrysler's Automation Committee and a manufacturing manager of their Parts and Equipment Division had visited Engelberger's operation while plans were already underway to survey all of Ford's parts and

[153] "Study of Unimation Applications in the Automotive Industry," GDJR, 2-3.
[154] "Study of Unimation Applications in the Automotive Industry," GDJR, 3.
[155] "Study of Unimation Applications in the Automotive Industry," GDJR, 3-4.

equipment plants. “Both companies are fully aware of the impact Unimation will have in their manufacturing operations,” Devol wrote to an attorney he worked with, “and they have both told us that there is no question in their mind that equipment of this type is the next step forward.”[156] Nonetheless, “universal” men would remain cheaper until the “universal” machine could actually be built and put to work.

**The Pentagon’s Armamentarium: Unimation and the Military Industrial Robot Complex**

Enthusiasm and expectations, however, did not equate to sales and, with their first major studies complete, Devol and Engelberger continued to search for prospective clients and investors.[157] Maurice Dunne, on behalf of Engelberger’s division, informed the U.S. Army Ordnance Corps’ Redstone Arsenal (of Wernher von Braun fame) of MMM’s operations in February 1956.[158] In September 1956, Devol began reaching out to Wall Street contacts about not just selling Unimates but his entire portfolio of patents. For instance, he attempted to pique the interest of the Rockefeller Brothers by mentioning the recent “initial discussions” with Chrysler, General Motors, and the Railway Express Agency; a month later Rockefeller officially declined Devol’s

[156] George C. Devol to Art, December 12, 1956, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR, 1. The recipient of the letter is only addressed as “Art,” however, the name most likely refers to Arthur J. Slade whose name is on the cover of Devol’s first Unimation proposal (as sender of the document) and whose name also appears (in full) in a letter on behalf of Devol to General Dynamics in the referenced folder.
[157] Wauryzniak, 66. A blueprint of the “Preliminary Unimate” can be found in “Study of Unimation Applications at New Castle and Amplex Plants Chrysler Corporation,” GDJR.
[158] E. M. Vaughn, Jr. to J. F. Engilberge [sic], October 25, 1957, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR. Redstone eventually reached back out to Devol in April 1958 requesting information about Devol’s magnetic memory drums they intended to use for a small special purpose computer they were building, O. H. Lange to Devol Research Co., April 28, 1958, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.

entreaty.[159] The following February, Devol contacted Major General (ret.) R. K. Mellon of investment firm T. Mellon and Sons and informed him, "We have made a number of surveys in the automotive and other industries and have found an extremely large potential for equipment of this type, which will make possible automatic assembly of complex products as well as considerable cost reduction in manufacturing processes. This equipment may well be of untold value in various national defense applications."[160] By December 1957, military contractors American Research and Development Corporation (ARDC), Aircraft Armaments, Inc. (a small aerospace and defense manufacturer in Cockeysville, MD), General Dynamics (for a second time), and Hycon Eastern, Inc. (a small electronics firm in Cambridge, MA) all were in communication with Devol or MMM, apparently to no avail.[161]

Prospective clients and investors were not the only skeptics as executives at MMM, beginning in late 1956, were also not sold on Devol and Engelberger's Unimate. According to Devol, MMM estimated the Unimate's development cost at approximately $600,000 and would require an initial order of two-hundred units just to break even.[162] As a result, the duo were given funding for rudimentary research but restricted from even building a prototype.[163] Apparently wary of the costs and risks, MMM higher-ups made the decision to pull the plug entirely in 1957 and pressured Engelberger to not only drop the Unimate project but to abandon his work with the military and liquidate his entire division—as one of Engelberger's subordinates interpreted the situation, "The [Korean] war wound down and so did our business."[164] While Engelberger's boss

[159] George C. Devol to W. J. Mason, September 10, 1956, Folder - Robotics - Correspondence, 1950s, Box 2 and William J. Masson to George C. Devol, October 28, 1956, Folder - Patents - Correspondence, 1950-1973 (Folder 1 of 2), Box 1, GDJR.
[160] Devol to Major General R. K. Mellon, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.
[161] Various documents, Folder - Robotics - Correspondence, 1950s, Box 2, George Devol Jr, Records, BFRC.
[162] George C. Devol to Art, GDJR, 1.
[163] "AM Award to Joseph Engelberger," *Robotics Age* (July/August 1983), 36.
[164] RBR Staff.

Harry Moore came to his defense, MMM executives gave him only a few months to sell.[165] According to Engelberger, while he was trying to raise money for the new company, the "robot concept" was the big draw for prospective buyers who "all salivated over" it. The same salivators, however, were less sanguine about the aerospace and nuclear controls business and Engelberger refused to part with his Danbury operation. For him, the industrial robot and manufacturing for the military were inseparable.[166] Luckily, within four months, either Devol or Engelberger (which is unclear) had found an investor in Norman I. Schafler, president of Consolidated Diesel Electric Corporation (eventually rebranded as CONDEC in 1964)—an industrial conglomerate who manufactured a range of products for all three branches of the military and kept a retired major general from the Air Force as an executive—to underwrite the purchase of MMM's 160-worker Aircraft Products Division (and their entire engineering staff) which officially took ownership on January 16, 1958.[167]

Engelberger immediately went to work transforming his former division into Consolidated Controls Corporation (CCC) as a subsidiary of Condec. CCC was initially based out of a former garage in Danbury, Connecticut but soon moved to its new headquarters in Bethel, Connecticut where it manufactured the same type of products, aerospace and nuclear control instruments and systems, for the same military clients, as it did under MMM. Seven months after its founding, CCC was profitable even after accounting for continued development costs on the Unimate.[168] By 1959, as the first official Unimate brochure described, Schafler

[165] "AM Award to Joseph Engelberger," 36; Bortz, 16; and Wauryzniak, 66. Engelberger states the time frame as five months in the former and three months in the latter.
[166] Saveriano, "An Interview with Joseph Engelberger," 12-3.
[167] Saveriano, "An Interview with Joseph Engelberger," 11; Saveriano, "An Interview with George Devol," 24; Consolidated Diesel Electric Corporation, *Annual Report* (1957) and *Moody's Industrial Manual* (Moody's Investors Services, Inc., 1970), 1287. There were initially fourteen shareholders in the company. Shortly after retiring in 1955, Major General Lucas V. Beau of the Air Force joined "Con Diesel" as a Vice President and officer of the corporation, "Retired Air Force General Lucas V. Beau Dies at 91," *Washington Post*, October 23, 1986.
[168] Saveriano, "An Interview with Joseph Engelberger," 11.

"became sufficiently enthused over the preliminary work [on the Unimate] to authorize development of the full machine" and signed off on an investment of $1 million over three years for R&D.[169] With a working prototype ready, Devol and Dunne finished a proposal for Ford in late June that provided the most concise presentation of the Unimate, and the Unimation concept more broadly, to date. The cover page referenced a "Universal Transfer Device" specification, the term then used by Ford to describe industrial robots.[170] At the time, the word "robot" was taboo in the manufacturing community and apparently there was tension between Devol and Engelberger about designating the Unimate as one According to Devol, Engelberger thought calling it a robot meant "We'll never get in the automobile industry or any place," to which he allegedly replied "No one knows what a manipulator is. Call it a robot." Nonetheless, Devol was clear that "I wasn't thinking of science fiction robots. I had to be practical, because the people I was selling to were practical."[171] And according to Engelberger:

> Everyone said, "No, don't call it a robot. That's bad. Let's call it a production terminal." Ford Motor Company insisted it was a Universal Transfer Device. "U-T-D" they called it for short. The purchasing department said, "Wanted, three UTDs," and in parentheses they'd write, "Industrial Robots," so you'd know what they were talking about! The word was important. We needed all kinds of publicity to get the idea across. And "robot" was the right word.[172]

Regardless of who persuaded whom, the opening paragraph of the proposal declared that Unimation made "practical the 'robot' of long standing science fiction fame."[173] While the

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[169] "Unimation: A Major Breakthrough In Industrial Automation," George Devol Collection, The Henry Ford Archive of American Innovation, https://www.thehenryford.org/collections-and-research/digital-collections/artifact/373671, n.p.
[170] Maurice J. Dunne and George C. Devol (approved by J. F. Engelberger), "Technical Proposal No. 1325: Unimation® A Universal Automation Concept," June 25, 1959, Consolidated Controls Corporation, Folder - Robotics - Unimation - Proposals, Box 2, GDJR.
[171] Saveriano, "An Interview with George Devol," 24.
[172] Bortz, 17.
[173] "Technical Proposal No. 1325: Unimation® A Universal Automation Concept," GDJR, 1.

Unimate was described as a "highly flexible type of transfer machine"—harking back to a more conventional form of automation—Unimation was described as a "labor replacement concept . . . . differentiated from most automation thinking." At Unimation, the difference was explained, "we study the characteristics of the human operator rather than the characteristics of the product to be manufactured." And, after listing a number of unpleasant work tasks the Unimate could switch between, the proposal espoused that "every hazardous, hot, noisy, or tedious job is a prime prospect for Unimation."[174] As the 1960 annual report of Condec informed its investors, "the first Unimation product, a digitally controlled robot . . . . is expected to have prompt applications in industrial plants, replacing men in dangerous, unpleasant and tedious jobs."[175] Alleviating such jobs became, and remains, a major selling point of the industrial robot.

The next year, Condec told its shareholders that, of its product development and diversification, "perhaps the most spectacular single achievement was the completion of the first phase of development of the Unimate robot by CCC." Accordingly, CCC's success in not just developing the Unimate but in drawing more and more demand for its other products led to an expansion of the main plant to double its capacity. Engelberger et al. were still casting their net wide for prospective customers, so they took the 1959 Ford proposal and recrafted it for a more general audience. While the original Ford proposal targeted the specifics of automotive production, the generalized proposal was much more military-oriented. The new first line under Section II, "The Significance of Unimation," stated that "Unimation has a definite role in Manufacturing, in the Nuclear Power Industry, and in the Military." The section went on to describe how the Unimate could perform "complex maintenance in 'hot' [i.e., nuclear hazardous] areas of a slurry plant" or "routine missile checkout which requires assembly and disassembly,"

[174] "Technical Proposal No. 1325: Unimation® A Universal Automation Concept," GDJR, 1-3.
[175] CONDEC, *Annual Report* (1960), 6.

or serve as the "ideal basic labor force for a standby ordnance plant."[176] Concomitantly, CONDEC commissioned McKinsey & Co. to evaluate the market potential of the Unimate.[177] "The report submitted," Schafler informed shareholders, "confirmed our judgment as to market potential and disclosed prospects even greater than anticipated."[178]

In September 1961, with proposals and studies complete, the Unimate made its public debut at the National Die Casting Congress in Detroit where there was "little doubt," Condec boasted, "that the Consolidated Controls-developed unit was the hit of the show."[179] However, at a trade show in Chicago that same year, Unimate's hydraulic system "leaked like a sieve," Munson recalled, and "nobody knew what we were displaying or why."[180] Nevertheless, the updated prototype—weighing 2,700 pounds (an 800 pound increase) with a seven-and-a-half foot arm that could manipulate a max load of seventy-five pounds—had been demonstrated and tested for more than a one thousand hours and, the Unimate Series 1900 "Mark II" as it was designated, was ready for day-to-day use.[181] Surprisingly, however, it was not Ford who purchased the first production-ready Unimate but General Motors. By the end of the year, Devol personally sold the unit to GM's Inland Fisher Guide Plant of Fisher Body's Ternstedt Division, located in the suburban West Trenton section of Ewing Township, New Jersey.[182] Opened in 1938, the Trenton plant was originally designed to produce interior hardware for automobiles such as door handles, molding trim, and window cranks, and at peak production turned out up to

[176] "Unimation," (c. 1961), Folder - Robotics - Unimation - Proposals, Box 2, GDJR, 2-3. The proposal was not dated and the circa is estimated in relation to other sources including from the George Devol Collection, The Henry Ford Archive of American Innovation, https://www.thehenryford.org/collections-and-research/digital-collections/artifact/373676.
[177] Wauryzniak, 72.
[178] CONDEC, *Annual Report* (1962), 2.
[179] CONDEC, *Annual Report* (1962), n.p.
[180] RBR Staff. Ballard (i.e., Munson) mistakenly claims that the trade show took place at "Chicago's Cow Palace," however, I've been unable to locate even the existence of a venue called that in Chicago.
[181] CONDEC, *Annual Report* (1961), 3 and 11 and CONDEC, *Annual Report* (1962), 2.
[182] Saveriano, "An Interview with George Devol," 24.

750,000 items each day.[183] Twenty-five years later, Unimate #001 officially went to work at the plant grasping red-hot molten-steel door handles and dunking them in a vat of cooling liquid, and loading and unloading a die-casting machine.[184]

Reflecting on these successes and the corporation's accomplishments over the previous financial year more broadly, Schafler told shareholders: "I believe that the formation of Unimation, Inc., may well prove the most significant in the long run." One problem, however, did exist: The McKinsey & Co. report lauding Unimate's market potential also revealed that the resources needed to exploit such potential were greater than Condec had available. As a result, Condec began searching for a "larger and well qualified industrial company" to partner with.[185] Several opportunities were investigated and Pullman Incorporated (of Pullman Strike infamy) was chosen to move the Unimate into its next phase of development. While which other companies were evaluated are unknown, Condec may have chosen Pullman based on a pre-existing relationship with Devol who, in 1955, reached out to Pullman's president Champ Carry during his first marketing push of Unimation.[186] From Pullman's perspective, "[we] undertook this investment in the area of automation after a thorough technical and commercial evaluation" as there were "great possibilities for [the Unimate]."[187] In September 1962, Pullman Incorporated formed a new subsidiary in conjunction with CCC—the latter owning 80 percent and the former 20 percent—called Unimation, Inc. As part of the agreement, Pullman loaned Unimation $1

[183] "New Plant Dedicated by General Motors," *New York Times*, Nov. 16, 1938 and General Motors Corporation (GMC), *A History of Eastern Aircraft Division* (1944), https://www.steampoweredradio.com/pdf/misc%20stuff/eastern%20aircraft/history%20of%20eastern%20aircraft%20part%201.pdf, 18.
[184] Paul Mickle, "1961:A peep into the automated future," *Trentonian* (1998-1999), http://www.capitalcentury.com/1961.html; "AM Award to Joseph Engelberger," 36; and Saveriano, "An Interview with Joseph Engelberger," 16. Unimate #001 is currently in storage at the Smithsonian.
[185] CONDEC, *Annual Report* (1962), 2.
[186] George C. Devol to Champ Carry, January 10, 1955, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.
[187] Pullman Incorporated, *Annual Report* (1962), 4 and 24.

million (most likely to maintain cash flows for continued development) and Unimation agreed to purchase all of the rights to the Unimate from CCC for $3 million to be "payable in the future subject to certain priorities of debt to Pullman Incorporated, profits earned and other contingencies."[188] Together, Condec and Pullman made Unimation, Inc. the first company in the world dedicated solely to the development and production of industrial robots.

Unimation was not the only operation building and selling industrial robots. And, depending on the metrics used to determine originality, the Unimate may have been the first industrial robot on paper (i.e., the PAT patent) but the first device fitting the definition of, and publicly marketed as, an 'industrial robot' was the "Planobot." Manufactured by the Planet Corporation—a Lansing, Michigan-based company specializing in automation equipment and materials handling systems—the Planobot was originally designed and tested in 1954-1955 to handle die-casting materials for a manufacturing company supplying radiators to General Motors. At the invitation of the U.S. Department of Commerce, the first demonstration of the device in 1957 took place at the International Trade Fair on Automation in Stockholm, Sweden. Commercial production began a year later but, due to its technological limitations and, according to *Automatic Control* magazine, the problem of "ideally matching the capability and cost of the machine with a specific task," fewer than ten were sold.[189] Perhaps an isolated but not insignificant indicator of the institutional and structural dynamics underpinning whether an industrial robot manufacturer would fail or succeed, the Planobot was also the only industrial

[188] CONDEC, *Annual Report* (1962), 2 and Pullman Incorporated, *Annual Report* (1962), 4.
[189] "An Electrically-Programmed Small Parts Handling Device," *Automatic Control* (Feb. 1960), 36; "PV Finds the Answers" *Automation* (Oct. 1960), 2; John M. Graham, "Programmer for Mechanical Arm," *Control Engineering* (Sept. 1958), 180, Harry Poole, *Fundamentals of Robotics Engineering* (Van Nostrand Rheinhold, 1989), 5; "Vendors of Robots," *Datamation* (January 1981), 100; "Robot Arm and Hand Has 25 Movements," *Popular Mechanics* (Dec. 1957), 144; Neil Schlager and Josh Lauer (eds.), "A Brief History of Robotics since 1950" in *Science and Its Times, vol. 7* (Gale, 2001); Mark E. Rosheim incorrectly calls it the "Planetbot" in *Robot Evolution: The Development of Anthrobotics* (Wiley, 1994), 77-78; and https://patentimages.storage.googleapis.com/f4/e9/94/8e4af2817f03e1/US3051328.pdf.

robot developed during the period with no discernable or durable connections to the American state.

The first industrial robot to gain any commercial success (and public notoriety) was the "Transferobot" of U.S. Industries (USI). Founded as the Pressed Steel Car Company in 1899 to manufacture freight cars both commercially and for the military. Under the tutelage of John I. Snyder, Jr., the corporation was transformed into an industrial conglomerate during the early Cold War. Working as a waiter to pay his tuition as an economics student at NYU in the early 1930s then moving on to the London School of Economics immediately after, Snyder joined Pressed Steel as manager of the buying department in 1945 (after a stint with the famous investment banking firm Kuhn, Loeb & Co.) and eventually took the reins as CEO in 1948.[190] Due to the business cycle instability of the industry, Synder diversified the corporation's portfolio over the next six years through a number of mergers and acquisitions in commercial and defense markets, with Pressed Steel abandoning the unstable freight car business entirely in 1954. That same year, he changed the name of the corporation to "U.S. Industries" to more accurately reflect its new character and "long-range plan . . . . to diversify into other more stable and profitable product lines."[191] By the mid-1950s, in addition to agricultural, fossil fuel, and machine tool product lines, USI was producing 105 and 155 millimeter artillery shells for the Army (at the government-owned Rockford, Illinois plant), operating the largest tank and armored vehicle depot in the country (at the government-owned Hegewisch, Illinois plant), and manufacturing aircraft and missile components.[192]

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[190] Thomas R. Brooks, "Does Automation Require a New Economy?," *Dun's Review and Modern Industry* (February, 1964), 51 and "John Snyder Jr., Industrialist, 56," *New York Times*, April 25, 1965.
[191] U.S. Industries, *Annual Report* (1954), 3.
[192] Pressed Steel Car Company, Incorporated, *Annual Report* (1950), 31-32, Pressed Steel Car Company, Incorporated, *Annual Report* (1953), 6-7 and U.S. Industries, *Annual Report* (1954), 5.

Production for the military became a more and more significant source of USI's revenues but the real benefits of its relationship with the security state came in the integration of high-risk, high-tech military know-how and state-supported R&D into its product planning, process development, and corporate structure. As Snyder described it in an annual letter to stockholders "the pace of technological development has been so rapid since the end of World War II that only the military could and can afford to spend the large amounts required to pursue advanced concepts."[193] To facilitate these pursuits, Snyder invited one of the most accomplished and knowledgeable builders of, and operators within, the nascent military-industrial complex, Georges F. Doriot, to join USI's board in 1951 (a position he occupied until 1963).[194] The same year Doriot joined USI's board, Snyder informed shareholders:

> [USI's move into] a wide range of highly technical products in the electronic and electro-mechanical fields we believe will be of substantial benefit in the early future as well as in the longer term future the company. Many of the current activities of the company in these directions are of a highly classified nature which is the first time that this could be said of any of our products and this statement alone should indicate to you our movement into important fields in which we are competent but with which the company was not identified in the past.[195]

Accordingly, USI established a Military Systems Planning Group in 1958 to organizationally institutionalize USI's military-industrial activities and relationships and "combine its research, development and production resources into a unit that is well equipped to make a contribution to the Nation's defense and space programs."[196] The group managed R&D through a centralized Technical Center in Pompano Beach, Florida that served as the "advanced research arm" for the

[193] U.S. Industries, *Annual Report* (1958), 3.
[194] Pressed Steel Car Company, Incorporated, *Annual Reports* (1951-1953) and U.S. Industries, *Annual Reports* (1954-1963).
[195] U.S. Industries, *Annual Report* (1957), 6.
[196] U.S. Industries, *Annual Report* (1958), 3.

corporation broadly, its in-house divisions individually, and all three branches of the military and NASA.

The 'military industrial robot complex' played a signal role in the TransfeRobot's development. While it's unclear when exactly this began, it's possible Devol and Unimation, through the auspices of ARDC and its connection to USI through Doriot, had a key role to play in the process. In 1957, during his outreach campaign, Devol met with W. H. Congleton, the Technical Director of ARDC, about the Unimate. Congleton, following up on their in-person discussion, informed Devol he had submitted the "data on your proposal to our friends at U.S. Industries" and was hopeful that he would be able to arrange a "personal meeting" between Devol and USI.[197] Whether the meeting occurred is unknown, however, when USI patented its "Automatic Handling and Assembly Servosystem" in 1959, which served as the basis of the Transferobot, it bore a striking resemblance to the Unimate.[198] The divisions directly involved in the development included the Santa Barbara, California-based Western Design division—which specialized in electronics and electro-mechanical devices—and the Robodyne division in Silver Spring, Maryland, formed "for the purpose of engaging in advanced work in industrial automation" and commercializing both civilian and military R&D.[199]

Changes in USI's product lines and corporate reorganization the next few years either liquidated, moved, or renamed these divisions. In 1960, Robodyne broke ground on a new plant to produce the TransfeRobot (and the division's other automation products) and, in October the

[197] W. H. Congleton to George C. Devol, March 11, 1957, Folder - Robotics - Correspondence, 1950s, Box 2, GDJR.
[198] Edwin F. Shelley, George A. Jonas, and Sidney Weiser, "Automatic Handling and Assembly Servosystem," U.S. Patent #3,007,097 (Filed: July 2, 1959, Granted: October 31, 1961) and Noble, *Forces of Production,* 363. As Noble notes, the Transferobot was "programmed much like a plugboard-type N/C machine" unlike the Unimate's R/P system.
[199] *New Views on Automation: Papers Submitted to the Subcommittee on Automation and Energy Resources*, 86th Congress, 2d sess, Joint Economic Committee of Congress, Washington, DC: U.S. Government Printing Office, (1960), 335 and U.S. Industries, *Annual Report* (1958), 4.

following year, held a dedication ceremony for its new "Automation Center" located less than twenty miles north of the Pentagon.[200] The following year, USI dissolved the Technical Center and transferred its work to other divisions while the Robodyne division was renamed the 'Automation Division.' None of these moves seemed to have an appreciable effect on the corporation's military portfolio as work at the Western Design division "has provided it with a means to secure prime military business of a significant nature" the activity of which allowed USI to participate "in a number of military programs of importance" with the expectation that the corporation's position in these fields would materially increase throughout the year.[201] Perhaps due to the "highly classified nature" of these activities, the TransfeRobot was not directly referenced in the corporate literature until after it was publicly announced. However, as a "highly technical" electro-mechanical product housed at Robodyne, the Transferobot benefited, either directly or indirectly, from USI's military activities.

Designed for point-to-point control (i.e., the performance of a specific action at a specific location) to handle small objects, the Transferobot's first applications were oiling clock assemblies, handling small typewriter components, and feeding steering assembly parts into a trimming press at an auto plant.[202] The first of these applications is particularly germane in light of the customer: Westclox. A division of the General Time Corporation, the La Salle, Illinois-based Westclox had long been, and was at the time a leading manufacturer of clocks, timers, and watches. Additionally, Westclox had been in the "defense products" business since World War II and also served as an advocate of shielding the horological industry from import-competition on

[200] S. Oliver Goodman, "Robodyne to Build $1.6 Million Plant," *Washington Post,* March 3, 1960 and "Robodyne Dedicates Automation Center," *Washington Post,* October 21, 1961.
[201] U.S. Industries, *Annual Report* (1961), 4.
[202] "Multi-Purpose Automation Unit Is Sold 'Off the Shelf'," *New York Times,* June 23, 1961.

the grounds of "defense" and "national security."[203] By the time they were automating clock assemblies with USI's Transferobot, Westclox was "manufacturing increasingly under Government contracts for the military and space agencies" with a portion of this going to the development and production of ammunition and ballistic fuzes for all three branches of the armed forces (in direct partnership with the Army's Ammunition Command in Joliet, Illinois).[204] These fuzes were of the same kind used in artillery shells like those manufactured by USI at its government-owned Rockford, Illinois plant.[205] Whether the Transferobot was directly used in the production of Westclox's fuzes is unknown, nonetheless, the horological industry recognized the importance, and supported the development, of automating the manufacture of their defense products.[206] Notably, Edwin F, Shelley—who pioneered N/C-type programming of robot-like devices during the 1950s while serving as research director of the Bulova Watch Company (one of only a handful of precision time-mechanism manufacturers at the time)—became the president of Robodyne in 1959 and the lead designer of the Transferobot that same year.[207] In broader geographic and socioeconomic terms, northeast Illinois essentially became an artillery-industrial complex with USI's Rockford plant located about seventy miles directly north of Westclox, which was approximately fifty miles directly west of the Army's Ammunition Command. And,

[203] *Defense Essentiality and Foreign Economic Policy (Case Study: The Watch Industry and Precision Skills)*, 84th Congress, 2d sess., Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Washington, DC: U.S. Government Printing Office (June 1956), 294 and *American Horological Industry*, 88th Congress, 2d sess., Subcommittee of the Committee on Armed Services United State Senate, Washington, DC: U.S. Government Printing Office (Aug. 17, 1964), 77-80.
[204] *American Horological Industry*, 79 and *Trade Expansion Act of 1962 (Part 3)*, 87th Congress, 2d sess., Committee on Ways and Means House of Representatives, Washington, DC: U.S. Government Printing Office (1962), 1457 and 1461.
[205] *Trade Expansion Act of 1962*, 1457 and 1461.
[206] *American Horological Industry*, 239 and 348-349.
[207] Noble, *Forces of Production*, 363 and "Tool Does Everything Except Loaf on Job," *Business Week*, May 28, 1960, 111.

in the metaphorical middle of this "Iron Triangle," feeding off the revenues from military-supported development and procurement contracts, was the Transferobot.

The TransfeRobot received significant coverage in the press when it was deliberately unveiled on Labor Day in 1959. According to the *Detroit Free Press,* the day was chosen because USI believed the device would "take much of the drudgery out of labor."[208] The *New York Times* and *Washington Post* echoed this technoliberal sentiment and the latter quoted Snyder as stating that the "TransfeRobot is a big step forward toward the day when all routine manufacturing processes will be fully automatic," which would be a "significant social step in the process of liberating the working force of this country from mechanized drudgery."[209] *Automatic Control* magazine gave the TransfeRobot a four-page technical write-up in February 1960 while a *Business Week* article three months later declared "Tool Does Everything Except Loaf on the Job" and prophesied in Industrial Revolution like terms that "if it is successful, the TransfeRobot would almost certainly be a mass-produced piece of capital equipment like the loom."[210] *Business Week* worried, however, that an expensive piece of capital costing $10,000 was "competing with the lowest paid labor on the force and is little more than a direct substitute for a single human worker," meaning the TransfeRobot was difficult to economically justify. Furthermore, substitution of the robot for a worker might be a bad deal regardless as "the robot won't have the judgment of even the worst worker" if something went awry.[211] For Snyder, the

[208] "Robot is Handy: Does Work that People Do," *Detroit Free Press,* Sept. 8, 1959, 16.
[209] "Dexterous Robot Does Many Tasks," *New York Times,* Sept. 8, 1959, 50 and Arthur Edson, "New Robot Duplicates Work of Human Hand," *Washington Post,* Sept. 8, 1959, A10. Edson followed Snyder's quote with an interesting bit of editorializing when he argued that "Whether all the working force of this country yearns to be liberated Snyder didn't say. Maybe some like drudgery." Examples of those who didn't yearn to be liberated and liked drudgery were not given but such claims had long been made about nonwhite workers whose biological and social evolution had made them desirous of being ruled and fit for doing the hard, manual labor below the station of civilized White men.
[210] "An Electrically-Programmed Small Parts Handling Device," *Automatic Control* (Feb. 1960), 33-36 and "Tool Does Everything Except Loaf on Job," *Business Week,* May 28, 1960, 111.
[211] "Tool Does Everything Except Loaf on Job," *Business Week,* May 28, 1960, 112.

benefits of the TransfeRobot far outweighed the risks. As he relayed to Congress in October 1960, the nation stood "on the threshold of a new era of automation" and the TransfeRobot would herald its coming. "Of course the transition from human power to machine power in the mass production industries will not come easily," Snyder continued, "unless the Nation and its important economic and sociologicial [sic] segments recognize that we must work cooperatively to find adequate solutions to the problems which automation creates."[212]

Whatever excitement the TransfeRobot generated quickly fizzled out. Even with the support provided by supply side technoliberalism, the device proved to be technologically limited and in 1961 its price was lowered by 75 percent (from $10,000 to $2,500), a sure sign potential buyers were wary of its economic usefulness. Nonetheless, USI predicted sales of 100,000 units per year moving forward and the following year declared to shareholders that the TransfeRobot had been "recognized by a large segment of American industry as a significant innovation in assembly line work."[213] A year later in 1963, after the price was lowered again to $1,470, two hundred units had reportedly been sold.[214] By 1965, most of the robots had been lent to potential customers on a trial basis and fewer than twenty five had been sold, the largest volume of which were in the candy industry packaging chocolates.[215] That same year, the TransfeRobot was no longer listed as a product line in USI's annual report.[216] The first commercially marketed product flowing from the 'military industrial robot complex' turned out to be a dud.

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[212] *New Views on Automation: Papers Submitted to the Subcommittee on Automation and Energy Resources*, 86th Congress, 2d sess, Joint Economic Committee of Congress, Washington, DC: U.S. Government Printing Office, (1960), 336-337.
[213] "Robot Put on Sale," *Detroit Free Press*, June 23, 1961, 15 and U.S. Industries, *Annual Report* (1962), 5.
[214] "The March of the Robots," *Dun's Review and Modern Industry* (January, 1963), 40.
[215] "John Snyder's Marvelous Mythmaking Machine," *Fortune*, Jan. 1965, 127.
[216] U.S. Industries, *Annual Report* (1965).

A success of the 'military industrial robot complex' came in the form of the American Machine & Foundry (AMF) 'Verstran' which, along with the Unimate, helped establish the industrial robot industry. Founded in 1900 to manufacture automated cigarette packing machines, AMF became the paragon of the diversified industrial conglomerate after World War II. While much of its commercial success can be attributed to their signature product, the bowling alley "Pinspotter," AMF's ascendance within the corporate ranks was significantly facilitated by its relationship to the security state. In 1954, they established a "Defense Products Group" to "deal with our largest single customer—the U.S. Government," a move which reflected AMF's policy that "defense contracts should be considered as a continuing concern of our operations and not as a 'stop-gap' for the utilization of temporarily idle facilities."[217] That same year, AMF Atomics was incorporated and Walter Bedell Smith—former chief of staff for then Supreme Allied Commander Dwight Eisenhower (1942-1945), ambassador to the Soviet Union (1946-1948), head of the CIA (1950-1953), and Under Secretary of State (1953-1954)—was brought on as President. AMF entered the field of atomics "with full realization that for some time to come it would not be a source of direct profit to our shareholders" but rather to gain a foothold in the burgeoning industry; three years later, they had earned a reputation as "the 'department store' of atomic energy."[218]

In 1956, AMF established an advanced research department as part of its Defense Products Group, headquartered in Alexandria, Virginia, and brought in E. R. Corvey of Corvey Engineering, Co., an Air Force and Navy contractor, to manage the new outfit.[219] The

[217] American Machine & Foundry, Inc., *Annual Report* (1954), np. The group was renamed the "Government Products Group" four years later.
[218] American Machine & Foundry, Inc., *Annual Report* (1957), 12-13.
[219] "AMF Promotes Corvey," *Washington Post*, July 24, 1956, 30; *Manpower Utilization by the Federal Government Through the Use of Private Contractor Labor*, 83d Congress, 1st sess., Document No. 32, Senate Report, Washington: GPO, Mar. 18, 1953, 15; and *Avoiding Conflicts of Interest in Defense Contracting and*

organizational and personnel moves seemingly paid off almost immediately as by 1957 an article foregrounding the Atomic Energy Division and Defense Products Group in the *Washington Post* announced, "AMF Ups Dividend As Income Leaps."[220] And by 1961, besides baking ovens, bicycles, and bowling-alley equipment, AMF manufactured automatic gun loaders, ICBM launchers, and were "running neck and neck with General Dynamics as the world's largest suppliers of [nuclear] research reactors"—in the process, annual sales rose from $12 million in 1945 to $361 million in 1960.[221] Beyond its diversified product lines, AMF also invested heavily in R&D for commercial purposes and to serve its largest customer, the NSS. R&D expenditures and personnel more than doubled from 1954 to 1962 while the number of total research facilities climbed from five in the United States to almost twenty across seventeen countries.[222] Due to the nature of R&D generally and AMF's approach to market and product development specifically, such research was intended to iteratively build on both commercial and defense domains of activity. In their own words: "AMF's products and projects are no longer tied to any one industry. To meet the challenge of rapidly changing markets and the revolution in defense programming, the Company has kept its research efforts flexible to meet almost any demand."[223]

Perhaps the best example of this ever-evolving product and R&D environment was the Versatran robot. Referred to internally as an "Automated Production Transfer Machine," the Versatran (a contraction of "versatile transfer") emerged from AMF's atomics and defense groups.[224] Their work with the Atomic Energy Commission (AEC) put AMF in contact with the

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*Employment*, 88th Congress, 1st sess., House Report No. 917, Thirteenth Report by the Committee On Government Operations (November 22, 1963), 5.
[220] "AMF Ups Dividend As Income Leaps," *Washington Post*, October 31, 1957, D6.
[221] "Diversified Success," *Time* (May 19, 1961), 99-100.
[222] American Machine & Foundry, Inc., *Annual Reports* (1952-1962) and "Diversified Success," *Time* (May 19, 1961) 99.
[223] American Machine & Foundry, Inc., *Annual Report* (1962), 15.
[224] The name "Versatran" first appears in American Machine & Foundry, Inc., *Annual Report* (1959), 56.

nascent art of teleoperated manipulation which used "master-slave manipulators"—essentially joystick-operated mechanical arms and hands—to remotely handle hazardous materials in atomic and nuclear facilities. In 1954, AMF, with the staff of the Remote Systems Division at the Argonne National Laboratory (ANL), developed the most advanced master-slave manipulator to date (designated "Model 8"). Within the year, the "workhorse of the nuclear industry" as one history of teleoperators called the Model 8, was being installed in laboratories and reactors all over the world.[225] As former director of ANL's Materials Science Division Brian Frost described the general relationship between the lab and its private-sector partners: "The establishment of a Remote Systems Division gave Argonne a strong capability for developing hot cell equipment, especially master-slave manipulators -- an early form of robotics -- the technology of which was quickly transferred to industry." Additionally, as he put it, "'technology transfer' is a buzzword today, but the transfer of reactor technology to industry was a major accomplishment of Argonne in the first two decades of its existence."[226]

This was particularly the case at AMF where, in 1958, the Commercial Development group began work on connecting the Model 8 to a programmable control system, the advanced technologies of which came primarily from the corporation's defense work with the electronics and electro-mechanical equipment used to handle and launch missiles.[227] That same year, AMF consolidated seven engineering and manufacturing divisions into a newly organized "Government Products Group" to replace the Defense Products Group and centralize work done for the Armed Forces.[228] And, in an inversion of the conventional path of technology transfer

[225] Edwin G. Johnsen and William R. Corliss, *Teleoperators and Human Augmentation: An AEC-NASE Technology Survey, NASA Office of Technology Utilization* (December, 1967), 149.
[226] Brian T. Frost, "A Brief History of Materials R&D at Argonne National Laboratory from the Met Lab to Circa 1995," Argonne National Laboratory, September 3, 1996, https://www.ne.anl.gov/About/legacy/materials/#Pu.
[227] American Machine & Foundry, Inc., *Annual Reports* (1953-1958).
[228] American Machine & Foundry, Inc., *Annual Report* (1958), 2

(i.e., from universities to industry), AMF donated a Model 8 to MIT's Research Laboratory of Electronics (RLE) where, beginning in 1959, electrical engineering graduate student Heinrich "Henry" Ernst's thesis essentially launched the field of robotics when he modified the manipulator for operation on the lab's TX-0 computer that was originally designed and built at the Air Force-funded Lincoln Laboratory.[229]

A year later in 1960, AMF engineers Harry T. Johnson, Veljko Milenkovic, and John Walter applied for a patent on a device they called a "Machine for Performing Work," the (comically) ambiguous technical designation of the prototype that would eventually be marketed as the Versatran.[230] What differentiated the Versatran from existing industrial robots such as the TransfeRobot and the Unimate was its ability for continuous-path control that allowed it to perform jobs such as arc welding and paint spraying, which required fluid motion rather than static operation at individual points. That year, a *Wall Street Journal* article highlighted AMF's robotics work (though not mentioning the Versatran by name) and informed its readers that "around the country in laboratories and on drawing boards, increasing attention is being paid to robots, once regarded as science-fiction characters with little or no practical value." However, it continued, machines like the Versatran were "true robots—automatic devices that perform human functions, or operate with seemingly human intelligence." Atypically, the article foregrounded the federal government's role in supporting the development of robotic arms, particularly through the AEC and NASA, though it incorrectly argued that "most robot makers,

[229] The history of robotics in academia will be explored below.
[230] H. T. Johnson et al, "Machine for Performing Work," U.S. Patent #3212649 (July 15, 1960), https://patents.google.com/patent/US3212649A/en. Two notable patents referenced in the Versatran filing included the AEC's "Electrical manipulator" (1951), which served as the basis for the Model 8, and U.S. Industries' "Automatic handling and assembly servosystem" (1959) that became the TransfeRobot

like A.M.F. are not waiting for the N.A.S.A. or the Pentagon to underwrite development costs of a mechanical man."[231]

After a few years of development, the Versatran officially went into production but unlike the TransfeRobot or the Unimate, it received relatively scant attention in the press and trade literature. An early mention of the Versatran in the April 1963 volume of *American Machinist* introduced readers to "a sophisticated manipulator or robot," describing it as "the world's first continuous-path or 'transfer' and automated production machine." On top of the same page, readers were asked, "How much depreciation should be allowed for a defense contractor whose productive equipment is eligible for the 7% investment tax credit? That's the problem that Pentagon officials are wrestling with right now."[232] A month later, AMF's expansive R&D activities caught the attention of *Business Week*, which described their "new three-headed R&D setup" that included a "small pure research group," an Applied Research group, and a Commercial Development group.[233] The article, titled "AMF expects its R&D to yield new division," spoke to a then pervasive conception of R&D as a fount of commercializable science and technology and profiled their industrial robot to demonstrate this. The Versatran, therefore, was not just a product of supply-side technoliberalism's stealth industrial policy but an identifiable artifactual synecdoche of it.

The following month, the Versatran was first publicly demonstrated clipping auto seats at the Chicago Tool Show where the "continuous-path programmed transfer machine, or robot, was a continual crowd gatherer."[234] Though it was "still in the R&D Div.'s pediatric care," two GM

[231] Thomas O'Toole, "Robots' Rise: They Bid for Big Jobs Both in Outer Space And in U.S. Factories," *Wall Street Journal*, July 12, 1960, 1.
[232] "Spot News," *American Machinist/Metalworking Manufacturing*, April 29, 1963, 29.
[233] "AMF expects its R&D to yield new divisions," *Business Week*, May 4, 1963, 134-140.
[234] "Highlights of the 1963 Tool Show," *American Machinist/Metalworking Manufacturing*, May 13, 1963, 102.

plants were using the robot for tending forging presses and, two years later, Versatran became its own commercial division with sales made to the automotive, glass, and brick industries for materials handling, paint spraying, and welding.[235] In 1967, the Versatran became the first industrial robot demonstrated in Japan, and five years later, it even had a Hollywood moment when it was programmed to play billiards against Bruce Dern in the sci-fi classic *Silent Running*. The Versatran would prove to be the only legitimate competitor to the Unimate through the first two decades of the American industrial robot industry's existence.

**Conclusion: America Meets the Perfect Worker**

For some reason, automation enthusiasts were very excited with the possibility of eliminating coffee breaks. When the *Washington Post* first reported the industrial robot, it posited that while (some) workers didn't like drudgery, "Transferobot doesn't mind it, going strongly on its way, never complaining, never even asking for a coffee break."[236] *Factory* magazine told its readers to "dismiss from your minds the science fiction image of a superhuman metallic monster with blinking lights and weird buzzing sounds . . . . Unlike their human counterparts, these robots stay on the job 24 hours a day, seven days a week. There is no lost time due to cigarette breaks, coffee breaks, or even lunch hours."[237] *Business Week* introduced industrial robot 'Iron Mike' as "a factory worker who puts in a 17-hour day and never takes a coffee break."[238]

[235] "AMF expects its R&D to yield new divisions," 136, "Robots: From Fantasy to Fact," *Factory* (January 1964), 78, and American Machine & Foundry, Inc., *Annual Report* (1965), 19.
[236] Arthur Edson, "New Robot Duplicates Work of Human Hand," *Washington Post*, Sept. 8, 1959, A10.
[237] "Robots: From Fantasy to Fact," *Factory* (January 1964), 76.
[238] "What Robots do Now for Industry," B*usiness Week*, May 20, 1967, 114.

The "coffee break" was, of course, a polite way of saying that the average American worker was slacking off on the job, at least according to the employer class. While maximizing activity during working hours had long been a key struggle between capital and labor, the prospects of robotization opened up a new front in the war over who would control the fruits of production. As *Dun's Review of Modern Industry*, in what must have been a whisper, described it, "quietly without fanfare, and sometimes in deepest secrecy, a new breed of worker is appearing on the nation's production lines. He works endlessly, tirelessly, asking neither medical plans nor overtime pay."[239] While industrial robots worked without rest, the same *Factory* article even more excitedly exclaimed, "better still, they don't worry about take home pay, fringe benefits or vacations."[240] Or, as a syndicated United Press International (UPI) article rattled off, "consider the worker who is never sick, never late, completely obedient, nonunion, gets no vacation nor fringe benefits, can handle parts weighing 150 pounds hour after hour. And the cost is as low as $552 per month. A management dream? No, a reality—the industrial robot."[241] The perfect worker indeed but perfect for whom?

It is doubtful that the average American first encountered the industrial robot in these publications, and even if so, they would be hard-pressed to find any information on the 'military industrial robot complex' that made such publicly funded technological feats possible. However, it's likely that many of them did meet the Unimate courtesy of Johnny Carson. In 1966, Engelberger was invited on *The Tonight Show* to demonstrate how "A Robot Could Take This Show Over." The NBC studio in New York City wasn't large enough to house the Unimate, so the show had to be filmed in California (six years before *The Tonight Show* permanently moved

[239] "The March of the Robots," *Dun's Review and Modern Industry* (January, 1963), 40
[240] "Robots: From Fantasy to Fact," *Factory* (January 1964), 76.
[241] "Seven Hundred Robots Work in the World," *Traverse City Record-Eagle*, July 22, 1971.

to Burbank). Engelberger and the Unimation team programmed the Unimate to putt a golf ball into a cup, open a beer can and pour the contents into a glass (though, "I cheated a little bit, I had the tab on the beer can open slightly," Engelberge recalled), and lead the show's orchestra with a baton.[242] The in-studio audience ate up the performance but little did they know that three Unimation engineers were behind the literal curtain managing the Unimate the whole time.[243] 'Engineers behind the curtain' is a particularly apt metaphor to describe what the average American didn't know about the 'perfect worker.'

[242] Wauryzniak, 69-70.
[243] Author interview with Gay Engelberger, July 27, 2019.

## Chapter 3 — Armed Algorithms: The Origins of Robotics at MIT and Stanford

*Unfortunately, the academic world is not interested in the basic factory problem, but is concentrating on elegant experiments which must prove that an arm, an eye, and a computer are indeed artificial intelligence.*

Joseph Engelberger (1967)[1]

In late August 1963, computer scientist and entrepreneur Louis Fein gave a sardonic paper critiquing the nascent field of artificial intelligence (AI) at the Western Electronic Show and Convention (WESCON) in Palo Alto, California.[2] The conference brought together what President Dwight Eisenhower would have called the "scientific and technological elite" to share the latest advancements in their fields, take part in demonstrations of the high-technology coming out of the "military-industrial-academic complex" they were part and parcel of, and celebrate their accomplishments.[3] As a charter member of this elite, Fein—designer of Raytheon's RAYDAC computer for missile guidance systems (1949), founder of one of the first mini-computer firms Computer Control Company (1953-1966), and an early advocate of

[1] Joe Engelberger to Joseph K. Hawkins, Folder - Events, 1967, Box 1, Nils J. Nilsson Papers, Stanford University Special Collections (hereafter SUSC)

[2] Louis Fein, "The Artificial Intelligentsia," Folder - Fein, Louis The Artificial Intelligentsia, 1963, Box 15, Nils J. Nilsson Papers, SUSC. The copy in Nilsson's papers was the original version of the paper circulated by Fein. A more complete version was published in the February 1964 edition of the IEEE *Spectrum* (citations below will refer to this latter version). The term "artificial intelligentsia" was, to my knowledge, coined by Fein and first entered the lexicon with this paper. See also, Jon Guice, "Controversy and the State: Lord ARPA and Intelligent Computing," *Social Studies of Science*, Vol. 28, No. 1 (Feb., 1998), 103-138.

[3] Fein never used the terms "scientific and technological elite" or "military-industrial-academic complex" in his papers but allusions to them are hard to miss.

establishing computer science as an academic discipline—was uniquely situated to play the satirical wolf in the AI sheep's clothing.[4] A lampooning of "The Artificial Intelligentsia," as Fein styled them, was most likely not on conference attendees' radar.

The purpose of the paper was to "to discern and exhibit prominently what is known and demonstrated, as opposed to what is conjectured and claimed, in the field popularly called artificial intelligence."[5] To ease the audience into his critique, Fein mimicked the form and style of a typical "request for proposal" (RFP) from a government agency and the corresponding responses from prospective contractors bidding for the job. As he noted at the outset of the paper, "[a] by-product of this form of presentation is the opportunity to examine the assumptions, values, attitudes, and predilections of practitioners, their employers (proposal writers), and their sponsors (proposal recipients)."[6] To accomplish this, Fein posited a fictitious federal agency called "Bright Field," which under the command of "General Ize issues the request to bid through its Whyonyx Laboratory under Col. T. Hink," hires a fictitious private firm "Pessimyths Inc.," to evaluate the proposals of four fictitious contractors, each representing a different school of computer research.[7] It was obvious to those in the know whom Fein was caricaturing. And, as can be surmised, the "competent and skeptical technical expert" advising the federal agency, named "J. R. Bubble Piercer."[8]

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[4] Biographical details come, in part, from "Notes and Issues," *Background*, Vol. 7, No. 2 (Aug., 1963), 109-110.
[5] Louis Fein, "The Artificial Intelligentsia," *IEEE Spectrum* (February 1964), 74.
[6] Fein, "The Artificial Intelligentsia" (1964), 74.
[7] Fein, "The Artificial Intelligentsia" (1964), 74.
[8] Fein, "The Artificial Intelligentsia" (1964), 86. "J.R. Bubble Piercer" was the most direct reference to a real individual, John Robinson "J.R." Pierce, an early skeptic of AI, best known for supervising the team that developed the transistor at Bell Labs in the late 1940s and the Telstar satellite. Pierce wrote Fein a short letter in response to the paper stating, "I read over your 'The Artificial Intelligentsia.' Parts of it are wicked but amusing. I agree with a good deal of the concluding statements, but I'm not sure what support I would recommend. I've passed it on to more competent people," J.R. Pierce to Louis Fein, July 19, 1963, Folder - Fein, Louis The Artificial Intelligentsia, 1963, Box 15, Nils J. Nilsson Papers, SUSC. Fein also included numerous footnotes throughout the paper referencing the technical literature to bolster his credentials and legitimate his critique.

Laced with humor and wit, the paper parodied the RFP genre generally, the contractor research programs specifically, and most derisively, the improbable (in Fein's opinion) promulgations of wondrous technological capacities such programs would produce. According to Bubble Piercer, "they [the "Artificial Intelligentsia"] have promised such things as champion chess masters, music composers, infallible and quick reference librarians, spoken language translators and good mathematicians." But, he bluntly concluded, "they have failed." Bubble Piercer's coup de grâce was saved for last:

> Pessimyths cannot make a recommendation as to which companies deserve contracts on the basis of their specific technical proposals. In fact, we recommend against your awarding any development or production contracts—not because the companies differ in resources and qualifications, nor because of their different devotions to threshold elements, optimal decision devices, or heuristic programs, nor even because parts of their proposals and purported scientific literature read as if they were composed and issued by an advertising agency rather than by scientists. *We recommend against contract awards because the whole field is in the research phase*.[9]

At first glance, the real-world butt of this rejection joke was obviously the coterie of bureaucrats and technologists who made up the Artificial Intelligentsia. When viewed synoptically, however, the broader target was the entire R&D apparatus of the national security state (NSS) and the particular kinds of actors, institutions, and knowledge that emerged from military-supported technoscience.

Fein's caricature adroitly skewered what historian Paul Edwards has called *mutual orientation*—a co-constitutive and reiterative process in which actors sought support from military sponsors by guiding them toward new techniques and technologies while, in turn,

[9] Fein, "The Artificial Intelligentsia" (1964), 86-7, emphasis in original.

military agencies through their support guided these actors toward military applications.[10] What Fein could not have known at the time was how accurate his critique would be in relation to AI's most important and publicly prominent technoscientific offspring, robotics. Unlike the relatively indirect support the NSS provided for the development of the industrial robot, the NSS was directly involved in the development of robotics as an academic discipline and field of inquiry, and the MIT and Stanford AI labs where these were first housed became incubators of supply-side technoliberalism, generating a slew of American state-supported technologies and techniques that would not only produce new markets but also new industries whole cloth.

Histories of the MIT and Stanford AI labs have, not surprisingly, been organized around their contributions to advancing artificial intelligence. However, that project was much more dependent on the parallel development of robotics than previously realized. Unlike AI, which attempted to algorithmically mimic human cognition, robotics attempted to algorithmically mimic human motor functions, and the Artificial Intelligentsia quickly discovered that computationally and mechanically recreating human motor capacities was a much more difficult project than imagined. It was not long before the seemingly disparate domains of inquiry and practice were fused into a mutually constitutive and emergently entangled research program that interfaced robotic arms with computers to operationalize the entwined nature of mind and motor. These 'armed algorithms,' therefore, became a deep reservoir of a particular kind of knowledge about 'intelligence' and were designed to push forward the frontiers of AI and robotics.

Due to the Cold War context, 'armed' and 'algorithms' have multiple meanings. First, 'armed' refers to the literal robotic arms that were deployed in AI labs, but second, it

[10] Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (The MIT Press, 1997) and "The World in a Machine: Origins and Impacts of Early Computerized Global Systems Models" in *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*, eds. Agatha C. Hughes and Thomas P. Hughes (The MIT Press), 223.

metaphorically refers to the bureaucratic connections, industrial networks, and technoliberal discourse the Artificial Intelligentsia could 'arm' themselves with to obtain the resources necessary to pursue their work. In this sense, AI labs pursuing robotics were "armed" with mandates, money, and mechanical manipulators (a more technical term for the robotic arm). Algorithms became the primary modality through which the Artificial Intelligentsia attempted to make the messy world of thought and action computable. Regardless of their social embeddedness, they envisioned algorithms as capable of formalizing the informal, mathematically symbolizing the social, and unsituating the situated, all to transform "real" world constituents into manipulable units. Rarely, however, did this ever go smoothly as the world in which such algorithms were put to work was inherently social and therefore unpredictable. Furthermore, while algorithms were (and are) almost exclusively situated as computational devices for solving computational problems, they can also be thought of in a broader and more heuristic sense as social devices for solving social problems. For instance, the technoliberal notion that the cultivation of science and technology would create more productivity that could grow the economy and thereby generate security could be expressed in algorithmic form: S + T > Productivity > Economic Growth = Security. Sub in "AI + Robotics" for "S +T" and the algorithm works as designed.

Like its computer analogue, a 'social' algorithm like this required the right context to function correctly, and the world around it had to be shaped by capitalist social relations and supply-side technoliberalism to make it work. To accomplish this, the Artificial Intellgentsia not only employed 'mutual orientation,' but they also 'hacked' the worlds they operated in to make them conducive for the development of AI and robotics. 'Hacking,' perhaps the MIT AI lab's most famous invention, is the term for solving a computer problem in an inefficient or inelegant

way through a temporary, oftentimes incomprehensible, workaround. The practice quickly became synonymous with creativity in the digital age, however, the Artificial Intelligentsia hacked much more than their computers. First, they 'hacked" the NSS to obtain the resources for their AI and robotics experiments, and second, they 'hacked' the physical space of their laboratories to make them amenable for such experimentation. Both of these hacks were productive for a time, nevertheless, the underlying problems they temporarily fixed never disappeared.

The first 'algorithm' to be 'armed' was the dominant paradigm of scientific and technological development during the Cold War— the "linear model." At its most basic, the model posits a linear sequence whereby basic research provides a reservoir of knowledge that applied research draws from to develop new products and processes that are diffused and used for a social goal(s). In essence, the model told a story about science, technology, and society. Beyond the story the model told, its discursive structure took the form of an algorithm: it had a definable goal, a sequence of steps for the goal's completion, and specific inputs and outputs that fueled the process. For short, the "linear model algorithm," or LMA as it will be called, took the following form: Basic Research > Applied Research > Development > (Production and) Diffusion = Social Goal.[11] The linear model was essentially an algorithmic instantiation of technoliberaism used to manufacture and manage the machines, men, and money that composed the world of the Artificial Intelligentsia. The LMA motivated the emergence of the Advanced Research Projects Agency (ARPA) and how it in turn used the LMA to manage the nascent fields of AI and robotics. The second section will demonstrate the LMA in action through a history of the bureaucratic and political origins of Project MAC at MIT, a major ARPA-led

[11] Benoît Godin, "The Linear Model of Innovation: The Historical Construction of an Analytical Framework," *Science, Technology, & Human Values*, Vol. 31, No. 6 (Nov., 2006), 639.

initiative that provided the resources for establishing the world's first AI and robotics lab at the university. The LMA will be woven throughout the rest of the chapter to demonstrate how the Artificial Intelligentsia continually 'hacked' the NSS to obtain the resources they required to build 'artificially intelligent robots.

The remainder of the chapter will chart the origins of robotics during the 1960s, first at the MIT AI Lab and shortly thereafter at the Stanford Artificial Intelligence Lab (SAIL) and the Stanford Research Institute (SRI). This history will foreground the Artificial Intelligentsia's use of what were called "microworlds"—simplified experimental spaces for developing and testing computer system capacities—which became the dominant experimental and test environment laboratory robots would inhabit for decades. The most important of these microworlds was the "Blocks World," a physical space designed and constructed for the manipulation of children's blocks by robotic arms and hands. Like chess in artificial intelligence, the Blocks World became the drosophila of robotics research.[12] Unlike chess, however, the Blocks World was literally a built environment whose material conditions were consciously crafted rather than just a computer simulation.[13] What this meant was that rather than just hacking their computers, technologists on metro Boston's Route 128 and in Silicon Valley had to 'hack' the real world to make it amenable for robotic experimentation to explore a particular kind of knowledge about 'intelligence' which, in turn, fed into and fed from developments in AI.

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[12] For a discussion of the notion that chess was the drosophila of AI, see John McCarthy, "Chess as the Drosophila of AI," presentation given to the Conference of the Canadian Information Processing Society, May 31, 1989, http://jmc.stanford.edu/articles/drosophila.html). The first mention I've found of the idea was in McCarthy's handwritten notes from 1973 were he scribbled, "Chess is the fruitfly of A.I.," without any other elaboration (Handwritten notes, Folder - Artificial Intelligence 1973, Box 3, Edward A. Feigenbaum Papers, SUSC) though he dates the idea to 1966 and attributes it to Alexander Kronrod ("Chess as the Drosophila of AI, 1). For a social history of "chess as an experimental technology" see, Nathan Ensmenger, "Is chess the drosophila of artificial intelligence? A social history of an algorithm," *Social Studies of Science*, Vol. 42, No. 1 (2011), 5-30.

[13] One important exception was Terry Winograd's SHRDLU project at MIT in the late 1960s and early 1970s discussed below.

The Artificial Intelligentsia were poster children of the 'revolving door' between academia, industry, and the military who used their microworld demonstrations as proof of concept for not just the continued support of their work but as capital to be exploited in the industrial world. Experiments with 'armed algorithms' at MIT and Stanford were critical to the technical development of the industrial robot. At the beginning of the 1960s, clumsy and clunky 'dumb' robots did what they were programmed to do regardless of their environment and whether they accomplished their task. By the end of the 1960s, precise and precocious 'smart' robots in the laboratory could respond to their environment through computer vision, speech recognition, and tactile sensing while also correcting their own mistakes. Rather than sites of capital formation, like the labs of Unimation, the AI labs were sites of capital augmentation, nonetheless supported through the 'Invisible Arm' of the American state. But could artificially intelligent robots work in the real world?

**Hacking the National Security State: ARPA and the Technoliberal Algorithm**

The "linear model" has long been a domain of inquiry for academics and intellectuals, both historically and in historical practice, for understanding the evolution of scientific discovery, technological development, and their social affordances.[14] The story the model told permeated the discourse of science and technology in the United States from the highest levels of government to the lowest levels of cultural production. Whether Vannevar Bush's *Science, The*

[14] David Edgerton, "'The linear model' did not exist: Reflections on the history and historiography of science and research in industry in the twentieth century," in Karl Grandin and Nina Wormbs (eds), *The Science–Industry Nexus: History, Policy, Implications* (Watson, 2004); Godin; and Philip Mirowski, *Science-Mart: Privatizing American Science* (Harvard University Press, 2011).

*Endless Frontier*—which stated categorically "it is truer than ever that basic research is the pacemaker of technological progress"—or in advertising campaigns extolling the wonders of science-based consumer products like DuPont's famous "Better Things for Better Living...Through Chemistry" slogan.[15] And while the historiographical story about the model has evolved from whether it actually worked as formulated to whether it even existed in the first place, it's almost inevitable that any discussion about science, technology, and public policy in Cold War America will begin, or at least engage with, 'the model.'

The LMA's potency was not, however, derived from its capacity to explain actual scientific and technological practice, its ability to automatically produce results as designed, or its cultural cache. Rather, what energized the LMA was the 'boundary' nature of its components and constituents, the networks of which dynamically oriented various social actors and processes around operationalizing the resources necessary to build the very world the model described. In other words, the algorithm is a heuristic instantiation of 'mutual orientation' composed of 'boundary categories' whose borders were shaped by 'boundary elites' and the 'boundary institutions' they created and inhabited. The emergence of the boundaries that composed the LMA had deep roots in the cultural, political, and socioeconomic evolution of "research and development" (R&D), the shoots of which grew from the evolving conceptions and practices of "basic" and "applied" research then developing in the soil of nineteenth-century industrial capitalism and its science-based twentieth-century derivative.

By the turn of the twentieth century, the social actors who shaped R&D in the United States began to argue that, rather than isolated practices with impermeable boundaries, "basic" research was not just a necessary precursor of "applied" research, but instead, "research"

[15] Vannevar Bush, *Science, The Endless Frontier,* November, 17, 1944, https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm#transmittal.

generally was a much more fluid concept even if it was composed of putatively distinct categories and referents.[16] Due to the changing boundaries of these practices (both literally and figuratively) the scientists, engineers, industrialists, and administrators involved in research and its management eventually began using the basic-applied dichotomy as a "rhetorical resource" to navigate technoscience's relationships to market and state forces. This allowed scientists to define, delineate, and control their professions (i.e., excluding amateurs) and obtain financial support; for engineers to raise the status of their discipline (e.g., engineering); for industrialists to attract both; and for administrators to manage these relationships. Basic research—a quintessential boundary category and the primary site of political and socioeconomic contestation around the LMA—had always required resources for its pursuit, and with the rapid development of "big science" and "big technology" during and after World War II, this was more true than ever: Laboratories had to be built, equipped, and staffed; applications based upon the science "discovered" required institutional resources to come to fruition; and finally, the development and diffusion of these applications into products and processes further extended the need for material investment into the worlds of science-based technology. In other words, the linear model, like any algorithm, had to have a world in which to work, and the construction of the LMA and the world it helped build were co-productive forces.

Of course, the categories and referents that made up R&D were never solidified, and what they meant, who decided, and for what reasons remained a question of power rather than of persuasion. Such fluidity, however, did not curtail the necessity for establishing some semblance of categorical practice as the technoscientific apparatus pumping out new products and processes had to be managed. The importance of this was hard to understate; as Alan Waterman, chief

[16] Thomas Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science- Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review*, Vol. 48, No. 6 (Dec 1983) and Godin, 642.

scientist of the Office of Naval Research (ONR) from its founding in 1946 through 1950 and first director of NSF (1950-1963), argued, "The strength of American manpower in science and technology is pre-eminently a matter of national interest. Defense needs, centering in military research and development, attract the most attention, but actually our entire economy is dependent upon a relatively small group of about 650,000 engineers and 200,000 scientists."[17]

The traditional force of 'the market' that drove industrial capitalism, however, was incapable of doing this on its own as the scale and scope of 'big science' and 'big technology' were too expensive and too risky an endeavor for private actors alone. Therefore, the federal government would have to fill the gap. As historian Michael Sherry described it, "federal sponsorship of science and technology promised rich benefits for: corporations seeking skilled personnel and new products; for scientists and universities overcoming old inhibitions against government patronage; for military leaders embracing technological warfare; and for those liberals eager to see Americans enjoy technological abundance."[18] And due to the political waffling immediately after World War II over who and how this would be managed —primarily in terms of what authorities the proposed National Science Foundation (NSF) would have—the military took a commanding role in this management.[19] In essence, the military "armed" the LMA.

A panoply of alphabet-soup agencies, committees, bureaucracies, and organizations would emerge over the following decade to manage this nascent enterprise from the Weapons Systems Evaluation Group (WSEG), the DOD's "Research and Engineering" offices, and the President's Science Advisory Committee (PSAC) to the RAND Corporation, the Institute for

[17] Alan T. Waterman, "The Science of Producing Good Scientists," *New York Times*, July 31, 1955.
[18] Michael S. Sherry, *In the Shadow of War: The United States since the 1930s* (Yale University Press, 1997), 76-79.
[19] For the history of the founding of the NSF, see Daniel Lee Kleinman, *Politics on the Endless Frontier: Postwar Research Policy in the United States* (Duke University Press,) 1995.

Defense Analyses (IDA), and the MITRE Corporation-managed scientific advisory group the JASONs. One of these bureaucracies in particular, the Office of Naval Research (ONR), had an outsized impact as the Navy set the tone for managing R&D in the postwar years as it became the "National-Science-Foundation-in-waiting."[20] According to a commissioned study of its practice during the first half of the Cold War, "the Navy's planning system of 1948 had recognized the appropriate difference in the techniques for planning research and development projects depending on the character of the effort involved . . . . Thus, the concept of an R&D spectrum with basic research on the one end and full-scale development on the other was inherent in the procedures of the first decade."[21] Such conceptualization and planning had long-term effects as "this sort of dynamic linear-model thinking gave rise to the Department of Defense's categories for R&D, which soon accounted for the major share of postwar federal spending on research."[22] By the end of the 1950s, the character of R&D components were formally instantiated into budgetary categories derived directly from the LMA. As one Congressional study summarized this:

> The DOD budget typology defines the vertical organization of the DOD RDT&E [research, development, testing, and evaluation] program. The organization reflects, in turn, the classical "linear pipeline" model of the evolution of new technologies, as evidenced by the emphasis DOD places upon Research (6.1) as the "obvious foundation for the whole (RDT&E) process.'' Following on the use of the linear pipeline model, new concepts are said to enter the DOD RDT&E system at the Research (6.1) level. Successful completion of a 6.1 program frequently leads to Exploratory Development (6.2); i.e., to applied research in which the proven concept is used in or applied to a device that has a potential military application. In the Advanced Development (6.3) stage, a prototypical product is developed for further testing and evaluation. Finally,

[20] Donald Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation* (The Brookings Institution, 1997), 52.
[21] Booz, Allen & Hamilton Inc., *Review of Navy R&D Management, 1946-1973* (June 1976), 207.
[22] Stokes, 11.

> Engineering Development (6.4) reconfigures successful prototypes in preparation for production, should circumstances require.[23]

The consequences of this formalization of R&D into budgetary categories was crucial. As famed economist of innovation Joseph Schumpeter once opined, "the budget is the skeleton of the state stripped of all misleading ideologies."[24] Essentially, each line item of a budget is a numerical articulation of a polity's needs and wants, and an expression of its priorities. Yet, who exactly the "polity" is, how they are represented, and what they can afford (and therefore "budget") is itself misleading, specifically because notions of what can or cannot be "afforded" and how this manifests are themselves materially shaped, ideologically molded, and bureaucratically mediated.[25] More importantly, the manifestation of these processes in budget categories served not just as expressions of what social actors valued or more logistically where resources were going—à la the components of the LMA—but discursive signals as to how such resources can be obtained and how value could be expressed to facilitate this. In this way, the story of the linear model was encoded into the algorithm and the constituent components that gave it life.

If any organization demonstrated the power of the LMA, it was the Advanced Projects Research Agency (ARPA), a signal example of how supply-side technoliberalism took the form of a 'decentralized entrepreneurial state.' Founded as a response to Sputnik in 1957, ARPA became the poster child of transforming basic research into technological solutions to social

[23] House Committee on Science and Technology, "Science Policy Study Background Report No. 8," (Dec. 1986), 284.
[24] The quote is attributed to Austrian sociologist Rudolf Goldscheid, Joseph A. Schumpeter, "The Crisis of the Tax State," in Richard Swedberg (ed.) *Joseph A. Schumpeter: The Economics and Sociology of Capitalism* (Princeton University Press, 1991), 100.
[25] I doubt Schumpeter would disagree with this minor critique as he argued that "public finances are one of the best starting points for an investigation of society, especially though not exclusively of its political life," ibid., 101. That political life is simultaneously an ideological product and fuel for ideological construction and maintenance, both of which shape and are shaped by resources and reflected in budgets (state or otherwise), should not be a controversial observation. And contrary to Schumpeter, this goes for all budgets, public or private, not just "the budget" of a national state.

problems. “Conceived as a unique management organization chartered to concentrate on ‘advanced research,’” the first comprehensive history of the agency described, “ARPA was to be spawned in an environment which equated basic research with military security.”[26] Additionally, the organization was itself a quintessential example of how the LMA produced liminality as it was putatively a government agency but it functioned more like a private venture-capital firm. ARPA’s form and function allowed the boundary elites who worked within and with it to use the boundary categories of the LMA to build the world artificially intelligent robots emerged from, and the worlds they were built to work in. Within ARPA, the primary force behind AI and robotics was the Information Processing Techniques Office (IPTO), originally called the Command and Control Office. While IPTO, and ARPA more generally, are well covered in the literature, it’s worthwhile to briefly explore how the IPTO leadership and their university liaisons at MIT and Stanford engaged with the LMA to build their laboratories and shape their nascent fields through the 1960s.

The story begins with J. C. R. Licklider, IPTO’s first director from October 1962 through July 1965, who was able to politically leverage the LMA and its various actors around the new and evolving discourse of computing into a substantial budget for what he referred to as “interactive computing.” Called a “consummate political operator” by one set of historians, Licklider was able to sell the vision that public support for interactive computing would produce “a stream of new technologies of wide applicability,” which “kept his paymasters in the government happy.”[27] According to ARPA’s first director Jack Ruina, “in any historical work you have to differentiate between the written word and what really was going on. Very often, the

[26] Richard J. Barber and Associates, *The Advanced Research Projects Agency, 1957-1974*, prepared for the Advanced Research Projects Agency (Dec. 1975), i and I-26.
[27] Martin Campbell-Kelly, William Aspray, Nathan Ensmenger, and Jeffrey R. Yost, *Computer: A History of the Information Machine* (Westview Press, 2013), 208.

writing was to meet certain bureaucratic requirements: to justify to Congress or to get it through . . . but the paper trail very often would emphasize the important applications in command and control, and the battlefield."[28] Convincing Congress was key as they were "very receptive to the linkage of basic research and national security."[29] And "national security," particularly in terms of the LMA and computing, was understood as a project larger than just the military. As Robert "Bob" W. Taylor, IPTO's third director from June 1966 through March 1969, put it "ARPA's overall budget during the Vietnam conflict, I believe, was cut in half. It went down substantially. But the IPT budget was doubled. None of the IPT supported research had anything to do with what was going on in Vietnam."[30] Or, as Lawrence "Larry" G. Roberts—a pioneering computer scientist in his own right (see below) and IPTO's fourth director from March 1969 through September 1973—described the relationship:

> The bottom line was, is this done well such that we can get the money out of Congress, and are we doing a good job in terms of what we are doing? Are we able to sell what we are doing? Then we'll get more money? They were happy to put more money proportionally into IPT than strategic missiles or something else. That was to them, as to me, a bigger contribution to the country, if they could make it work.[31]

The ability to code the LMA into their activities—and thereby convince Congress and government bureaucrats of what computing, AI, and robotics could do for the country-at-large—became a hallmark of IPTO's success over the first decade of its existence.

[28] Aspray, "An Interview with Jack Ruina," 8-9.
[29] Barber and Associates, I-26.
[30] Robert W. Taylor, CBI Interview, 13.
[31] Larry Roberts, CBI Interview, 23.

One of the major ways the office accomplished this was through creative engagement with DOD's R&D budget categories.[32] Though the actual process was no doubt more complex and involved a bit more nuance, Roberts's confession to an interviewer that "We put projects in whatever category was useful and I moved projects back and forth depending on how it was selling in Congress," captured the ontological and political flexibility such categories entailed.[33] This was particularly the case with 6.1 "research," which encompassed 'basic' and 'applied,' and 6.2 "exploratory development." According to ARPA's commissioned history, "6.1 is one man's definition of truly 'advanced research,' but another's idea of chasing rainbows."[34] By the early 1970s, however, Congress began tightening the reins on the rainbows as the considerable sums being spent on 6.1 projects—which, by definition, had no direct military applications—were coming under increasing scrutiny for not producing militarily relevant research. Roberts, seemingly unphased, simply "turned it [IPTO's portfolio] into presentations which sounded more supportive of the military roles."[35]

As a result, the university-based AI and robotics projects, a significant portion of IPTO's portfolio, were used as demonstrations of the office's, and thereby ARPA's, progress. Reflecting on this success years later, Marvin Minsky revealed, "it was convenient for AI because the robot project money is one of the ways that the ARPA people could fool their superiors into supporting the AI project."[36] And while AI and robotics projects in particular were major recipients of IPTO's largesse, they were understood and sold to Congress as contributing to the maturing field of computing more generally. As Bob Taylor explained:

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[32] Arthur Norberg and Judy O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (The Johns Hopkins University Press, 1996), 18-20.
[33] Norberg and O'Neill, 22.
[34] Barber & Associates, X-21.
[35] Norberg and O'Neill, 36.
[36] Pamela McCorduck interview with Marvin Minsky, March 3, 1975, Folder - Transcripts, Research, Related Materials — Marvin Minsky (folder 1), Box 2, PMC, 4.

> The AI people, who were getting support from ARPA when I was there, may have thought that the reason that I was supporting AI was because I believed in AI, qua AI. If they thought that, they were mistaken. I was supporting it because of its influence on the rest of the field, not because I believed that they would indeed be able to make a ping-pong playing machine [discussed below] in the next three years, but because it was an important stimulus to the rest of the field. There was no reason for me to tell them that, of course.[37]

This compartmentalization of intent and purpose became a feature of IPTO's relationship with its university contractors. Asked about what justifications the AI community had to provide IPTO for their funding, Minsky responded, "didn't have to . . . . people like Larry Roberts and Ivan Sutherland and Bob Taylor were the interface, and they would explain to their superiors why this was relevant and they never bothered us at all."[38] When pressed further about who had to be satisfied with AI research, Minsky chortled "beats me. (Laugh)."[39] IPTO therefore not only managed the AI portfolio but insulated it from both ARPA and the government bureaucracy more broadly. The AI community's allergy to bureaucracy was perhaps best encapsulated by John McCarthy when he, unprompted in an interview, quipped: "I always went to Washington as rarely as possible. It would have been to send away for the money, and get the money by mail order."[40]

Beyond bureaucratic *insulation*, IPTO also supported its contractors in terms of bureaucratic *navigation*. Unlike traditional approaches to funding research, IPTO (and ARPA more generally) did not require peer review, which was a pillar of accountability and integrity (at least in rhetoric and theory) within the scientific community, particularly in relation to

[37] Robert W. Taylor, CBI Interview, 23-24.
[38] Marvin Minsky, CBI Interview, 26
[39] Marvin Minsky, CBI Interview, 28.
[40] John McCarthy, CBI Interview, 8.

fundamental science. Ivan Sutherland—arguably the ideational progenitor of the "Blocks World" (see below) and IPTO's second director from July 1964 through June 1966 described it "there is the perception that the peer review mechanism applies, and that perception permits Congress to say, 'Okay, this money will not be wasted because good folk will be watching.' You know, a lot of people are watching. The ARPA approach has never had peer review mechanisms. It has been done basically on the individual initiatives of people in the office, with whatever advisors they have chosen to seek."[41] He continued, "When what you want to do is to provide a large base of research to carry a field forward in the steady progress that you want to have in a field, as NIH [the National Institute of Health] does, then it seems to me that the peer review mechanism is excellent . . . . [but] in fields where turnover is very rapid, where progress moves quickly, like in computing," peer review was not the right approach.[42]

This is somewhat surprising in light of the fact that national security apparatchiks pitched ARPA as a blue-sky outfit established to pursue high-risk, high reward "basic" research, the practice of which essentially required peer review to be taken seriously. Furthermore, in Roberts's assessment of why IPTO was successful, he pointed to "people who were short-term oriented, and were young people who saw important possibilities in the field. The second was that the office had little red tape. There was the possibility of fast development of programs, and fast approval of projects,"[43] both characteristics of which were in tension with the traditional understanding of "basic" research. IPTO's support of its contractors went even further as they

[41] Ivan Sutherland, CBI Interview, 39.
[42] Ivan Sutherland, CBI Interview, 39. Compare Sutherland's notion of the peer-review process as the appropriate mechanism for building up steady progress in a field with Taylor's assessment of AI's contribution to the field of computing above.
[43] Larry Roberts, CBI Interview, 49.

not only cut out the "red tape" but helped contractors craft proposals—the most difficult of tape remaining. Once again, to quote Roberts:

> Generally the process [funding proposals] was very introverted. That is, we would go to MIT and see what new things they were proposing. Then they would make their overall proposal for the year, after we had met with them and said no, yes, no, yes, on all of the various pieces, and had had an extensive meeting telling them what was acceptable and what was not. Then maybe we would go through two rounds of proposals, saying, 'Was it written poorly? This is not supportive. This is not effectively going to support our selling it,' or 'I will not do this piece of it.' We probably used the Congress as a reason a lot. In reality, the biggest decision factor, colored by whether we could sell it, obviously, [was] whether it was going to affect the nation effectively. Were we going to get a substantial increase in something out of this? Was it something that we wouldn't get from industry? So we looked at those factors all the time and had a meeting about that with [our] contractors.[44]

Such an approach essentially guaranteed that projects would be approved. Furthermore, IPTO's assistance with proposals was not simply on a project-by-project basis but was instrumental in establishing the very labs that were managing the projects ARPA funded.

**Project MAC: More Assets to Cambridge**

The establishment of the first AI lab in the world at MIT was a derivative of Licklider's dream for interactive computing and involved not just the university and ARPA but all the major computer manufacturers of the period and the DOD writ-large—Project MAC. The project was a quintessential example of 'mutual orientation' that evolved out of MIT's need for more computational capacity, the military's support of "command and control" systems, industry's

[44] Larry Roberts, CBI Interview, 37-38.

drive for new contracts, new markets, and newly trained operators, and technologists' desire for funding and intellectually engaging work.

Project MAC proved to be a representative product of both the LMA and the stealth industrial policy of supply-side technoliberalism. Not surprisingly, it's institutional foundation have a much longer history than generally recognized, dating back to MIT Provost Julius Stratton's "Committee on Machine Methods of Computation" in 1950 and the establishment of the Computation Center in 1955.[45] Most directly, Project MAC built upon the rapid growth of the MIT Computation Center after time-sharing - embodied in the "Compatible Time-Sharing System" (CTSS) development led by research associate Fernando Corbato—became the center's primary goal over the next few years.[46]

While Project MAC officially emerged from MIT's institutional need to expand its computational capabilities and facilities, its genealogy reveals a maturation process driven by a coterie of interests entangling the government, industry, and the university. According to Project MAC's first director Robert Fano, this began with the SAGE air defense system at Lincoln Labs during the 1950s, continued through that decade with the Electronic Systems Laboratory's work on numerically controlled machine tools and Computer-Aided Design (CAD), and culminated in John McCarthy's famous 1959 memo to Computation Center Director P.M. "Philip" Morse proposing time-sharing.[47] Luckily, IBM was a willing and able partner in MIT's computational

[45] Larry Owens, "Where Are We Going, Phil Morse? Changing Agendas and the Rhetoric of Obviousness in the Transformation of Computing at MIT, 1939-1957," *IEEE Annals of the History of Computing*, Vol. 18, No. 4, (1996).
[46] Dag Spicer, "Fernando Corbato: Time-Sharing Pioneer, Part I,"*IEEE Annals of the History of Computing*, Interviews, October–December 2015.
[47] Robert M. Fano, "Project MAC," in Jack Belzer, Albert G. Holzman, and Allen Kent (eds.), *Encyclopedia of Computer Science and Technology: Volume 12, Pattern Recognition to Reliability of Computer Systems*, (Marcel Dekker, Inc., 1976), 341-342. McCarthy partially corroborates this as he traces the idea of time-sharing back to SAGE in J.A.N. Lee, J. McCarthy, and J.C.R. Licklider, "The beginnings at MIT," *IEEE Annals of the History of Computing*, Vol. 14, No. 1 (1992), 18.

endeavors as, rather than simply selling MIT computers like any other customer, IBM donated machines (first the 704 and then the 709) and also provided fellowships and research grants to its faculty and students.[48] Expanding MIT's time-sharing capacity, therefore, involved not just the university but computer manufacturers, potential users, and prospective sponsors that were in the works for more than three years before the project's formal proposal was submitted to ARPA in 1962.

Officially, the broad long-term objective of Project MAC was the development of a computer system independently accessible to multiple users simultaneously that was flexible and responsive to individual needs. To meet this objective, new hardware and software had to be developed as existing machines and programs were insufficient. A second, concomitant objective was the use of this system as a tool for education and research to promote closer "man-machine interaction." These first two objectives were understood as dynamically and inherently intertwined, and essential to the development of both. The third objective was the long-range development of a reservoir of trained operators, including faculty and students, both inside and outside of MIT, referred to as "national manpower assets." The third was inextricably interwoven with the preceding two as hardware, software, and people trained to use them were intrinsically linked.[49] The entanglements and goals of Project MAC's development were deeper and went well beyond its officially stated objectives.

The administrative origins of Project MAC can most directly be traced back to a "Long Range Computation Study Group," made up of various administrators, department heads, and faculty, appointed by President Jay Stratton in the spring of 1960 and tasked with formulating a

[48] Phyllis Huggins (ed.), "Hotline," *Computing Newsline*, Vol. 1, No. 8 (August, 25, 1964), Folder 15 - Project MAC, Box 95, Office of the President Records, MIT Distinctive Collections (hereafter MITDC).
[49] Fano, "Project MAC," 339.

policy for the future computation needs of the university. The group was determined that the "magnitude of computation" at MIT combined with "research problems important to the continuing development" of the university" being adversely affected by existing computational capacities necessitated a large state-of-the-art machine. In order to "catch up with the demand" and be cost efficient, this machine would need remote input-output capabilities, or what was then called "time sharing." Additionally, the supervisory committee of the group, including Robert Fano, A.G. Hill, and Philip Morse, were worried that the faculty would balk at any delays to their existing research programs and, more importantly, would not take well to external control of their own computer problems as "no one loves a boss of a central computer," both of which the new system would entail. While the technical aspects of the system were up for debate, the real issue was financing. As they put it: "In order to finance such a monumental project, it would require, of course, a good deal of money from outside sources, and unquestionably divert funds from projects within the institute which are already devoting money to computer projects." Estimated cost for the system was $18 million, and this was recognized as the bare minimum. Such an undertaking was therefore described as "immense" and moving forward with the project would entail a "quantum jump.[50] Because there was no formalized plan or agreed upon source for financing the system, "it was agreed that each of us would in his own way investigate the possibility of getting funds for such a major undertaking."[51] In short, each member of the group was tasked with tapping into the varied bureaucratic and social networks of the NSS they had access to.

[50] Fano, Morse, and Hill to Vice President Carl Floe, March 30, 1961, Folder 1 - Project MAC - General, 1961-65, Box 17, School of Engineering Records (AC 12), MITDC.
[51] Memo, "Meeting on M.I.T. Computation Problems," A.G. Hill, March 24, 1961, Folder 1 - Project MAC - General, 1961-65, Box 17, School of Engineering Records (AC 12), MITDC.

Beyond internal members of the study group, a "summer study" populated with a number of industry representatives from Burroughs, Digital Equipment Corporation (DEC), General Electric (GE), International Business Machines (IBM), and Xerox as well as DoD representatives and members of Lincoln Laboratory was organized to research the issues.[52] IBM was a particularly notably participant that had a long history of integration with MIT. In addition to the corporation's central role in the SAGE project at Lincoln Laboratory, it donated to and funded MIT's Computation Center since its founding; MIT's largest block of stock ownership was in IBM; Thomas J. Watson Jr., IBM's CEO, was a board member of the MIT Corporation (essentially MIT's board of directors or trustees) from 1957-1962, and James Killian, MIT's President from 1949-1957 and the MIT Corporation's Chairman from 1959-1971, was an IBM board member from 1959-1960.[53] Complicating IBM's presence was an ongoing patent dispute among IBM, MIT, and RCA regarding rights to magnetic core memory, a key computer technology developed at Lincoln Labs during the SAGE project. As one chronicler of the project and technology observed, "the experimentation, testing, development, and manufacture of the memory cost more than $1 million. If the development had taken place under commercial circumstances rather than with the lavish funding of the Air Force, completion might have been delayed for months, even years."[54] Because of this, IBM's use of magnetic core memory in the

[52] Arthur L. Norberg, "An Interview with Robert M. Fano," April 20-21, 1989, Charles Babbage Institute, http://www.bioinfo.org.cn/~dbu/AlgorithmCourses/Lectures/FanoInterview1989.pdf, 26.
[53] Regarding MIT's ownership of stock, Phyllis Huggins (ed.), "Hotline," *Computing Newsline*, Vol. 1, No. 8 (August, 25, 1964), Folder 15 - Project MAC, Box 95, Office of the President Records, MITDC; regarding Watson's membership on the MIT Corporation board see, https://corporation.mit.edu/membership/all-members/former-corporation-members#W (accessed Sept. 4, 2019). For Killian's membership on the IBM board see, International Business Machines Corporation *Annual Report* (1959 and 1960). The source claiming that MIT not only owned IBM stock but that it was its largest block did not have any additional information or a specific citation for supporting evidence. However, the source included an attached handwritten note "for JAS" (presumably MIT President Jay Stratton") stating, "After you have read this perhaps you could forward it to Jay's attention" (underline emphasis in original), signed "Gordon" (presumably Dean of Electrical Engineering and a member of the "Long Range Computation Study Group" Gordon Brown) that did not comment on or refute the sources claims.
[54] Thomas Hughes, *Rescuing Prometheus: Four Monumental Projects that Changed the Modern World* (Vintage, 1998), 37.

manufacture of SAGE computers for the government was legal, however, using the technology for commercial products with neither the ownership nor licensing rights was illegal. This was a major issue as IBM's use of unreliable electrostatic memory was proving to be commercially costly and more reliable memory was a key component of their new product lines.[55]

Like many patent disputes, this entangled numerous claims and took years to resolve itself. At the heart of the matter was MIT's demand for a two-cent royalty on each core produced and the reality for IBM, the major user of cores with over a billion cores produced annually by the time the suit was resolved in 1964, that this would cost IBM upwards of $20 million per year if their cross-license of RCA's patent claim to the technology was rejected. In the end, IBM paid MIT a one-time fee of $13 million for the patents, at the time the largest sum for such rights, providing IBM a dramatic discount when compared to MIT's initial royalty demands.[56] According to a *Datamation* article more than a decade after the dispute, MIT had been dissatisfied with IBM's work throughout the SAGE project and the patent dispute led to "threats and large sums of money," ending only when Killian and then MIT President Julius Stratton, allegedly requesting as much as $60 million from IBM, made a handshake agreement with Thomas Watson, Jr. and IBM's legal counsel.[57] Furthermore, Killian stepped down from IBM's board in 1961 and Watson Jr. reciprocated on the MIT Corporation board in 1962; whether this was directly related to the patent dispute is unknown at this time.

To make matters even more complicated, in February 1961, two months before the Long Range Study Group's working committee submitted its final report, Henry Teager, the working

[55] Tom Green, *Bright Boys: The Making of Information Technology* (A.K. Peters, 2010), 206-207.
[56] Charles J. Bashe, Lyle R. Johnson, John H. Palmer, and Emerson W. Pugh, *IBM's Early Computers* (The MIT Press, 1986), 267-270.
[57] "The Fight for Core Memory Patents," *Datamation* (March 1976), found in Box 5, Arnold A. Cohen Papers, Charles Babbage Institute.

committee's chairman, abruptly resigned. In a letter "meant only for the eyes of members of the working group," Teager stated that he was fully on board with the rough draft of the report drawn up by the committee but at some point between the Tuesday meeting of February 14 and the Thursday meeting of the 16, the draft was radically changed. According to Teager, a number of agreements "made by majority vote of the group, which I cannot, and will not support, morally or otherwise" were either revised, removed, or substituted without his knowledge or consent. In his assessment, the new draft was "paying lip service to the needs of MIT as a whole and using it for justification" of the group's personal and professional goals of maximizing their time on the new machine and the expense of those not privy to the planning and implementation process of the project. He closed with the following: "I enjoy reading 'Alice in Wonderland' but observing it, at MIT, turns my stomach."[58] The supervisory committee overseeing the upheaval attributed Teager's resignation more to his personality than his assessment of the working committee's "rogue" draft. As Robert Fano put it: "[Teager] had a lot of very good ideas but he could never carry them to completion, because he was unable to work with other people. Most of his ideas required some sort of collaboration. He had a fixed view of things."[59] McCarthy, describing the conflagration as a "sort of revolution in that committee," assumed the role of chairman, only to leave MIT for Stanford the following year.[60]

While Teager's resignation was based on his assessment of the working committee's impropriety, McCarthy's departure was primarily a function of the MIT administration's squabble with IBM over what computer would be suitable for the project. The working

[58] Herbert M. Teager to John McCarthy, Marvin Minsky, Douglas Ross, Jack Dennis, Dean Arden, Dan Goldenberg, Fernando Corbato, Ronald Howard, Jack Pugh, Norman Phillips, and Phyllis Fox, February 18, 1961, Folder - Long Range Study Group, Box 57, Fernando Corbato Papers, MITDC.
[59] Norberg, "An Interview with Robert M. Fano," 13
[60] Aspray, "An Interview with John McCarthy," 4. McCarthy doesn't get into the details or directly corroborate Teager's interpretations but his recounting of the events doesn't challenge them either, which is telling in light of his own frustrations with MIT's administration.

committee, under McCarthy's leadership, recommended sending out an RFP to a number of companies but when IBM went to President Stratton and asked him to hold up on the RFP, the entire process ground to a halt. Shortly thereafter, IBM asked McCarthy to do a new study on the demand for time-sharing, a topic well-documented in the existing proposal. According to McCarthy: "This was essentially a stall, and my reaction to it was that it was like doing a study among ditchdiggers to find out if there's a demand for steamshovels."[61] Licklider thought McCarthy, who was admittedly a novice when it came to hardware issues, made the mistake of recommending to administrators that "MIT ought to go for a computer with certain specifications."[62] To Licklider, this was such an irresponsible thought in the minds of MIT administrators that they "banished" McCarthy. Ironically, they eventually did as McCarthy (and Teager) recommended. When asked why he left for Stanford, McCarthy, with tongue-in-cheek, responded: "MIT has finally decided to do what I've been urging all this time. It's time to clear out."[63]

The proposal for Project MAC that would eventually emerge from this gallimaufry was, in style and substance, a carbon-copy of Fein's Artificial Intelligentsia paper and a signal example of the LMA in action. Titled the "Proposal for a Research and Development Program on Computer Systems," it began with a discussion of "National Computer Needs" that situated the evolving nature of information-processing in the context of urgent military and civilian problems such as "military command and control, air-traffic control, industrial stock and production, and information retrieval for military, scientific, and health purposes." Concomitantly, computing systems were not yet "easily and economically accessible," which required research into new

[61] Ibid., 4.
[62] John A. N. Lee and Robert Rosin, "The Project MAC Interviews," *IEEE Annals of the History of Computing*, Vol. 14, No. 2, (1992), 15.
[63] Lee and Rosin, 15.

techniques and technologies. Specifically, the "time sharing of large machines"—perhaps McCarthy's most important contribution to AI and computing—was deemed the best solution to the "urgent" information-processing problems previously mentioned.[64] Second, it was argued that universities provided the ideal environment for such research, particularly that which was focused on "less developed aspects of computer systems." Universities, therefore, needed to be understood as "communities for experimenting with the notion of computer systems as public facilities" and, most importantly, as centers for generating the "necessary manpower for effectively attacking the information processing problems facing the Nation." Because their resources were limited, "the most effective long-term use of these . . . . in the solution of military problems, is their investment in the generation of new knowledge and techniques through work on scientific and other problems appropriate to universities."[65]

Third, such a research and development effort was not just about hardware and software. Users themselves, in the cybernetic vernacular of the age, "may be regarded as part of the system" and "would evolve together" with their technologies. Such a major research and development effort would "eventually involve most major universities and computer manufacturers" and "it seems advisable to start with a pilot-plant operation at one university, working in close cooperation with a computer manufacturer, for the purpose of generating the experimental evidence necessary to plan a broader effort."[66] The implications of this were not lost on the committee, and their recognition of such is worth quoting at length:

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[64] "Proposal for a Research and Development Program on Computer Systems," 1 (underlined emphasis in original), Folder 15 (Box 30), Box 95, Office of the President Records, MITDC (the "Box 30" in parentheses after "Folder 15" was written on the folder but it is unknown why). The report is also available online: https://archive.org/details/ProposalForAResearchAndDevelopmentProgramOnComputerSystems.
[65] "Proposal for a Research and Development Program on Computer Systems," 2.
[66] Proposal for a Research and Development Program on Computer Systems," 3.

> The ultimate goal, as vague as it may be, is clearer than the road leading to it, and the initial steps are bound to be uncertain, wasteful, and probably controversial. . . . The close cooperation between a university and a computer manufacturer appears essential to the success of the effort, and yet fraught with legal and ethical problems. These problems will have to be explored experimentally, just as the technical ones, in the spirit of open minded cooperation.[67]

MIT leadership gave authorization to start spending money on the project before the contract was signed on March 1, 1963.[68] The formal announcement of the project drawn up by MIT public relations on June 28, 1963, described it as "the initial phase of a national effort expected to involve an increasing number of universities and research centers." It went on to state that Project MAC's goal was to "develop more efficient and effective ways of meeting the growing computation needs of education and research" by providing "an ideal experimental community on which to test new computer systems" designed for the advancement of "man-machine interaction."[69] Furthermore, the announcement informed that Project MAC was an acronym for "Machine-Aided Cognition," the broad project objective, and "Multiple-Access Computing," the tool to be used to accomplish that objective. Those in the know deciphered the acronym in a different way: "More Assets to Cambridge."[70]

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[67] Proposal for a Research and Development Program on Computer Systems," 3-4.
[68] Norberg, "An Interview with Robert M. Fano," 31. For the project sign date: "M.I.T.'s Project MAC: Current Status," Office of Public Relations, Folder - Project MAC Current Status (1of5), Box 9, Joseph Weizenbaum Papers, MITDC.
[69] Memo to Members of the Faculty from Provost Charles H. Townes, June 27, 1963 and MIT Office of Public Relations Press Release, June 28, 1963, Folder 1 - Project MAC, General, 1961-1965, Box 17, School of Engineering - Office of the Dean Records, 1943-1989 (AC012), MITDC.
[70] Errol Morris, "Did My Brother Invent E-Mail With Tom Van Vleck? (Part One)," *New York Times*, June 19, 2011, fn. 11. Another official name included "Men and Computers" ("Project MAC Progress Report VI, July 1968-July 1969", https://apps.dtic.mil/dtic/tr/fulltext/u2/705534.pdf, 3) and two other unofficial names included "Man Against Computers" and "Maniacs And Clowns," Daniel Crevier, *AI: The Tumultuous History of the Search for Artificial Intelligence* (Basic Books, 1993), 69.

Four months after the announcement, the MIT faculty were informed that Project MAC might be administratively separated from academic departments and research laboratories, meaning that the project would come directly under the management of MIT administration. project director Robert Fano sent a memo to President Stratton the next day, stating that he "felt very strongly that reporting through administrative officers whose central responsibility is not education would be inconsistent with the objectives of Project MAC." Fano went on to express that his enthusiasm for the project was "strictly based on the contributions which I firmly believe it will make to education and academic research," the goal of which was to "support and extend computer-oriented research throughout M.I.T., and to provide a focus and necessary facilities for a community effort in the area." He went on to list the interdepartmental and interlaboratory organization of the project and included two tables from a recent status report detailing its faculty-led nature in hopes of demonstrating the importance of faculty and graduate student participation in the project. Fano's closing is worth quoting in full:

> I firmly believe that any administrative action that would in any way discourage or limit such participation, would defeat M.I.T., as well as Project MAC, in the objectives which are most important not only to me but also to the sponsoring agencies, ARPA and ONR. Finally, my reporting through academic channels is a matter of extreme importance to me personally.

Fano let Stratton know that a response was only necessary if Stratton disagreed with his views.[71] Whether Stratton replied is unknown. Regardless, something was afoot and Fano was not a fan.

Around the same time, and at the behest of J.C.R. Licklider, another summer study was organized to finalize the key issue of where the Project MAC computer would come from. In the

[71] Fano to Stratton, October 17, 1963, Folder 15 (Box 30) - Project MAC, Box 95, Office of the President Records, MITDC.

interim, the project utilized existing IBM systems on and off campus. Participants at the second summer study included J.C.R. Licklider from ARPA, all three branches of the military, Lawrence Livermore Laboratory and the National Bureau of Standards, major corporate players such as Bell Labs, GE, and IBM, and smaller firms like Bolt, Beranek and Newman (BBN) and Control Data Corporation (CDC), as well as nonprofit institutes from MITRE and System Development Corporation (SDC) to the Institute for Defense Analyses (IDA) and the Stanford Research Institute (SRI).[72] The study lasted for two months and entailed numerous discussions and meetings but no memoranda were written nor was a final report produced. Rather, the study served as a "get acquainted party" where participants got to know one another and familiarize themselves with two newly created time-sharing systems at the MIT Computation Center and at SDC. This is primarily because the goal of creating an advanced time-sharing system connected to a specially designed and powerful new computer was a foregone conclusion, one that was heavily criticized by the computer community at large.[73] Therefore, existing design philosophies and technologies would not be sufficient for Project MAC.

Shortly before the study commenced, E. R. "Mannie" Piore, vice president for research and engineering at IBM, sent a letter to Provost Charles H. Townes expressing his delight that so many IBM people were invited to be a part of "an important national effort which MIT has been chosen to direct." Conveying appreciation, however, was not the real purpose of the letter. Rather, IBM was concerned about "handling of confidential information" and requested (instructed?) that a general statement be made to all participants to follow the same guidelines

[72] "Registrants - Project MAC Summer Study, July 8, 1963," Folder 1 - Project MAC Summer Study Participants, 1961-63, Laboratory for Computer Science Records, Box 13, MITDC.
[73] Robert M. Fano, "Joseph Carl Robnett Licklider," in National Academy of Sciences of the United States of America, *Biographical Memoirs: Volume 75* (National Academies Press, 1998), https://www.nap.edu/read/9649/chapter/12#204, 204.

for information circulation and dissemination. More importantly, "the patent rights are of particular concern to us because, while in previous studies the subject matter was highly specialized toward Government needs, in this case some of the concepts generated may have significant commercial ramifications."[74] Piore and those in the computer community assumed IBM would get the Project MAC contract regardless of the summer study's conclusions. Recognizing that there was already a commitment by MIT's administration to facilitate this, Fano went to higher-ups at IBM and informed them of the project's goals and technical needs, both of which were at odds with IBM's design philosophy and existing product lines. He was initially ignored until mention was made of going to IBM's only legitimate contender GE. At that point, "they hit the ceiling . . . . and ran to [MIT President] Jay Stratton" and began a "big fight."[75]

On July 8, 1964, the small group of technical analysts sent their assessment of the modified IBM 360 system and the standard and modified GE 635 system to chairman Robert Fano. Regarding the technical factors, GE was clearly superior to IBM in both design and performance. The evaluators even concluded that "[a]t the very least one must conclude that the [IBM designers] were either naive or uninformed to have proposed at one point a Straightforward off-the-shelf system 360 for time-sharing, . . . . [and] we are uneasy about the IBM proposal for the simple reason that no one from IBM is committed to make the system work (that is, it is not a product line item)." In short, they strongly recommended the GE system.[76] The next day, Gordon Brown, dean of the Department of Electrical Engineering, was informed of a

[74] E.R. Piore to Charles H. Townes, Folder 15 (Box 30) - Project MAC, Box 95, Office of the President Records, MIT Distinctive Records.
[75] Norberg, "An Interview with Robert M. Fano," 31 and Robert M. Fano '41, ScD '47, https://infinitehistory.mit.edu/video/robert-m-fano-%E2%80%9941-scd-%E2%80%9947.
[76] F. J. Corbato, J. B. Dennis, E. L. Glaser, and R. M. Graham to Fano, "Technical Evaluation of the IBM and GE Computer Systems Proposed to Project MAC," July 8,1964, Folder 1 - Project MAC - General, 1961-65, Box 17, School of Engineering Records (AC 12), MITDC.

morning meeting of an Ad Hoc Committee regarding the evaluation. Beyond the technical advantages of the GE system the committee recognized that "the experience of the Project Mac people with IBM has been so poor that they are going to need a great deal of convincing in spite of anything that IBM may say" and, if it was decided to go with GE, two possible results were foreseen. Most desirably, IBM would accept the fact and hopefully interpret it as a challenge to produce a better system "with the goal of installing it in the Computation Center in the Spring of 1966 at no cost to M.I.T." Most undesirably, IBM would be "so miffed" that they would immediately remove all of their equipment that had been donated to the Computation Center. As a result, MIT administration planned to delay the GE decision a week beyond July 15 in anticipation of IBM's visit to MIT on July 13 and a visit from Bell Labs on July 14 who were to compare their technical conclusions with MIT's. IBM obviously had powerful supporters in the MIT administration.

Three weeks later, Fano sent a lengthy memo to President Stratton detailing the technical evaluation from July 8. Foregrounding that "I may sound biased," Fano could only provide two "strong points" in IBM's favor: 1) MIT knew the advantages and disadvantages of working with IBM while GE's future performance was unknown; and 2) IBM had generally been friendly with MIT while GE had not. Regarding the technical factors, GE's design approach appeared to have the same objectives as Project MAC while IBM's essentially off-the-shelf system did not; IBM's equipment was bulky and not as compatible the existing programming environment as GE's; and, finally, maintenance of the IBM equipment would be a "nightmare." As Fano put it, "we are contemplating a system of such complexity (from a programming standpoint) that elegant implementation may well make the difference between successful operation and dismal failure resulting from the system falling apart under its own weight," and maintenance of the IBM

system would be a "nightmare." In terms of cost, the IBM system would only be affordable if they agreed to absorb the necessary modification costs while GE's would not only be affordable but could provide excess capacity that could be rented to outside users. Additionally, IBM's market position and desire for commercial dominance, indicated by a new plant designed for large production volume, hinted that they preferred not to produce specialized or technically superior equipment, a controversial decision even within IBM, which was wary of GE possibly poaching their university clients. According to Fano, "There is the distinct possibility that MIT's decision may create an avalanche toward GE which would very seriously damage the market position of IBM. I would say further, that it is our considered opinion and also the considered opinion of many knowledgeable people outside MIT that IBM has made a major blunder in the design of their new equipment, and that unavoidably IBM will be damaged by it unless IBM cuts its losses and embarks on a major emergency redesign." Furthermore, even though IBM was involved in the Project MAC planning process from the beginning, Fano was "peeved" that they treated MIT as just another customer and viewed Project MAC as a "prestige account."[77]

On August 5, MIT's Office of the Provost drafted a letter to Thomas J. Watson, Jr. to inform him of Project MAC's decision. Using language such as "the decision that has *confronted* M.I.T. this past several weeks" and "our few words at the White House the other day were all too hasty," Townes was obviously walking on eggshells. He attempted to reassure Watson that the Computation Center would remain the "central focus of M.I.T.'s broad interest in the field of computation" and the "permission" to purchase the GE system was "a request we [MIT's executive administrators] were most reluctant to approve," but "in our judgement any other course would have been difficult to explain and might subject IBM, as well as M.I.T. , to serious

[77] Fano to Stratton, July 29, 1964, Folder 1 - Project MAC - General, 1961-65, Box 17, School of Engineering Records (AC 12), MITDC.

external criticism." The draft was sent to President Jay Stratton and MIT Corporate Chairman James Killian for review. Stratton was not entirely satisfied with the letter and noted that "the fact is there isn't a very satisfactory statement that one can make which is also completely truthful. Project MAC is only one of a number of our computer programs but decisions made there almost inevitably will affect all other parts of the program, and IBM knows this very well." The finalized letter, sent by Stratton but signed by Killian, was significantly shortened though it contained almost the exact same phrases as the earlier draft. One-week later GE was formally notified and final purchase of their system awaited only ARPA's approval.[78]

Project MAC's choice of GE over IBM turned out to be a landmark decision. It demonstrated the political nature of both the LMA and supply-side liberalism in practice while also highlighting the stealth industrial policy of the NSS. On August 25, the day after the notification, *Computer Newsline,* apparently an ear-to-the-grindstone insider newsletter, reported:

> MAC makes it legal and announces order of GE 625 . . . . Project MAC is the high-prestige M.I.T. time-sharing system under the direction of Professor [Fernando] Corbato currently using the IBM 7094 . . . . resolvement of the question of what new system to order has been watched with considerable interest by wise ones across the country . . . . Few situations have been surrounded by as many strong but quiet rumors . . . . The situation was not average and represents the first crack in the IBM façade.[79]

Why the choice was so impactful is perhaps best illuminated by a rather insignificant controversy that arose a year after the decision was finalized. Fano sent a letter to R.C.F. "Robert" Bartels, director of the University of Michigan's Computation Center, charging computer scientists at

[78] "Letter of Intent - Use," August 14, 1964, Folder 4 - Project MAC Proposals - Regular, 1964, Box 17, School of Engineering Records (AC 12), MITDC (emphasis in original).
[79] Computer Newsline, *Hotline* Vol. 108, August 25, 1964, Folder 15 (Box 30) - Project MAC, Box 95, Office of the President Records, MITDC. The original text was all capitalized though ellipses are in original.

Michigan with plagiarizing Project MAC's work. Fano was, in part, disappointed that the accused authors, considered "members of the family" due to their "very close relationships" with Project MAC principals, would crib materials without appropriate recognition. While the incident was essentially a "he said, she said" affair, a side comment by one of the accused is revealing: "Indeed it is difficult to determine where 'GE-proprietary' and 'MAC-academic' begin and end."[80] The NSS was apparently picking and choosing winners, and the losers weren't happy.

**Hacking the Real World: The Dawn of Robotics at MIT**

When MIT "won" the contract for Project MAC it became the nexus of advanced computer research in the United States. In the words of Marvin Minsky, "virtually every computer scientist has contributed to project MAC."[81] This had a cascading effect as a third of Project MAC was dedicated to AI and the vast majority of this was dedicated to robotics. After McCarthy's departure, Minsky assumed primary leadership of the AI Project and the $2.2 million dollar budget provided by Project MAC.[82]

Before he fully committed to managing AI research at MIT, Minsky was, curiously, busy helping others in the computing community get their projects off the ground. Between 1963-1964, what Minsky referred to as a "critical, rather humorous period," he acted as a "consultant" to and wrote proposals for BBN, Information International Inc. (III), and Stanford Research

[80] Robert Fano to Robert C.F. Bartels, July 29, 1965 and Bruce Arden to Robert C.F. Bartels, August 9, 1965, Folder 1 - Project MAC - General, 1961-65, Box 17, School of Engineering Records (AC12), MITDC.
[81] Quoted in Crevier, 65. The proposal for the contract was not a response to an RFP from the federal government, hence the scare quotes around "won." While ARPA was the day-to-day manager of the contract, funding and oversight were handled by the Office of Naval Research (ONR).
[82] Memo to Members of the Faculty from Provost Charles H. Townes, June 27, 1963, Folder 1 - Project MAC, General, 1961-1965, Box 17, School of Engineering - Office of the Dean Records, 1943-1989 (AC012), MITDC.

Institute (SRI). Even though the proposals were fairly similar—just written from the perspectives of the differing organizations—BBN and SRI were funded while III was not. For all intents and purposes, ARPA knew who was writing the proposals.[83] After enough persuasion from ARPA, Minsky finally submitted a proposal in September 1965 to properly fund the nascent MIT program in which he noted that "in the interval since 1961, there has been no important work in this [robotics] area."[84] Referred to as "Research on Intelligent Automata," the new project created a separate line of funding specifically for "'autonomous machine systems' (i.e., robots) for industrial, scientific, extraterrestrial, and military applications." In addition to the resources Project MAC already provided, the proposal requested ARPA appropriate $3.4 million from 1966-1968 just for the AI lab.[85] Political squabbles within Project MAC and at the university more broadly delayed the official establishment of an artificial intelligence laboratory until 1970, but in the meantime, MIT became the first major center of robotics research in the country.[86]

The idea to use a mechanical manipulator and hand to test the power of computers was first presented by Claude Shannon and Marvin Minsky during a seminar at MIT in the fall of 1958.[87] Heinrich "Henry" Ernst, then a graduate student in electrical engineering and an attendee of the seminar, took the project on as his thesis the following year with Shannon as his supervisor. Designated "MH-1" (for 'mechanical hand'), the project was significant, beyond its

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[83] Pamela McCorduck interview with Marvin Minsky, March 3, 1975, Folder - Transcripts, Research, Related Materials — Marvin Minsky (folder 1), Box 2, PMC, 7.
[84] Marvin L. Minsky, "Proposal for Research on Intelligent Automata," September 1965, Folder 7 - Project MAC Proposals, Research on Intelligent Automata, 1965, Box 17, School of Engineering Records, 1943-1989 (AC012), MITDC (underlined emphasis in original), 1-3.
[85] "Budget Proposal for Research on Intelligent Automata," September 1965, Folder 7 - Project MAC Proposals, Research on Intelligent Automata, 1965, Box 17, School of Engineering Records, 1943-1989 (AC012), MITDC, 3.
[86] Stefanie Chiou, Craig Music, Kara Sprague, and Rebekah Wahba, *A Marriage of Convenience: The Founding of the MIT Artificial Intelligence Laboratory*, 6.933J/STS.420J: Structure of Engineering Revolutions, Project History Rough Draft (Professor David Mindell), http://web.mit.edu/6.933/www/Fall2001/AILab.pdf, 31.
[87] An undated memorandum that appears to be from the late 1960s titled "The State of Research in Computer Vision" claims that John McCarthy, Minsky, and Shannon proposed the general idea that became Ernst's thesis, however, no mention of McCarthy is made in Ernst's thesis or the later conference paper, "The State of Research in Computer Vision," n.d., Folder - Defense of Vision, Box 3, John McCarthy Papers, 1951-2008, SUSC, 3.

novelty, for three distinct but entangled reasons: First, its physical systems emerged directly from the world the LMA built; second, its development spawned the "Blocks World" that became the dominant experimental environment of robotics; and third, the project's greatest success was perhaps less its technical accomplishments and more its function as a referent that could be used by the nascent AI and robotics community to demonstrate the research and applications opportunities of robots to potential funders of future projects.

As presented by Minsky and Shannon, the goal was to build a mechanical hand operated by a digital computer to explore the possibilities of autonomous manipulation within a "real world" setting after an overall goal had been programmed into the system. At a more fundamental level, as Ernst described it, "the needed experimentation was not for validating some theoretically obtained hypothesis, since we had none but rather to gain some insight into how to go about tackling the whole unfamiliar problem." In a sense, this was the most basic of "basic" research: Not just the theorization of a problem but the search for a problem to be theorized. And in what was characteristic of the age, such theoretical problems were increasingly functions of the very technologies the LMA produced. As Ernst put it, "we had only the vaguest ideas about the problems that faced us before we started to build specific equipment and before we started to experiment with it. Only experimentation could show which ways of realizing such a system were promising and which are useless."[88] At the time computers were, in Ernst's words, "stupid," as they sequentially performed each step of their algorithms and programs as designed whether the desired outcome of this process was successfully accomplished. To overcome this stupidity it was necessary to better understand how computers dealt directly with the "real world," rather than how humans used computers as a tool in mediating that real world. The

[88] Heinrich A. Ernst, "MH-1, A Computer-Operated Mechanical Hand," Sc.D. thesis, Massachusetts Institute of Technology, Department of Electrical Engineering, Dec. 1961, 12 and quote from 15.

primary goal of the thesis, therefore, as Ernst elegantly put it, was "not the improvement of the relation man-machine; it is the improvement of the relation machine-real world."[89] But what exactly did this "real" world look like?

In terms of the physical system, the project was housed in the Research Laboratory of Electronics (RLE) and received financial support from the Army Signal Corps, the Air Force Office of Scientific Research (AFOSR), and the Office of Naval Research (ONR).[90] MH-1's location at RLE is significant simply for the fact that, as the immediate predecessor of the Rad Lab, it was perhaps the first major university laboratory to emerge from and valorize the nascent institutions and processes that came to characterize the LMA and mutual stimulation after WWII. Additionally, the project's physical components were themselves products of the world built by the LMA. Its computer, the TX-O (pronounced "tix-oh"), was a transistorized version of the Whirlwind computer originally designed and used at the Air Force-funded Lincoln Laboratory on the SAGE system. The Model 8 mechanical servomanipulator (the "arm") and gripper (the "hand"), donated to RLE by American Machine and Foundry (AMF), was a commercial unit originally developed by AMF at the AEC-funded Argonne National Laboratory to handle radioactive material in a "hot cell." The gripper or "hand" that came with the arm was then retrofitted with photodiode, pressure, and touch sensors (the "sense organs"), all designed and machined by RLE. And the physical function of MH-1 was relatively straightforward: The sense organs of the mechanical hand fed information into the computer, which was then processed and

[89] Ernst (1961), 2-3, 39, 59-61, and 85. The final programming iteration of MH-1 contained nine algorithms or "statements" that directed the arm and hand to search the table for a box, remember its position, search the table for blocks, take them and put them into the box.
[90] Ernst (1961), 2.

in turn controlled the motors that moved the arm and hand. In this sense, MH-1 worked from the outside-in rather than the inside-out like traditional control systems.[91]

Unlike existing systems that simply controlled the position or speed of the device in accordance with a prerecorded program written by a human programmer—such as numerically controlled machine tools—MH-1 was able to respond to unexpected problems it was not specifically programmed to solve, all in real time and with limited human assistance. Rather than simply programming coordinates in Cartesian space and directing the system to use these to accomplish a task, like traditional control systems and control theory, the sense organs allowed MH-1 to "understand" the "real world" and respond accordingly. In other words, MH-1 had the power to choose. Of course, all of the possible "choices" were already programmed into the system so MH-1 was, at the programming level, an early example of algorithm selection or what today is commonly called machine learning.

The "real-world environment" that MH-1 would operate in was conceptualized as distinct from the "human environment" of traditional computers. In the human environment, information was fed into the machine by a human and the information that came out was received and used by a human. MH-1 and its environment were designed to remove the human from this information and action loop. However, this, "real world" had to be physically constructed in the actual real world. Ivan Sutherland—then a PhD student in Ernst's department and four years later director of IPTO—suggested the idea of MH-1 handling blocks and boxes as it involved, in elementary form, two functions of the human hand: First as a sense organ and second as a

[91] Ernst (1961), 2-3 and 31. To accomplish this, the sense organs would descriptively, rather than quantitatively, translate information obtained from the environment into machine language that would describe and build a model of the "real" world from that information. Then MH-1 would attempt to accomplish programmed tasks within the "world" derived from this to test whether its model of the "real" world accurately represented the world outside the computer.

manipulation device.[92] At its most basic, "sense information directly from the real world enters the machine, the computer changes the real world [i.e., grasps and moves blocks and/or the box], and these changes in turn modify the sense input." To operationalize Sutherland's idea, a raised platform about six inches off the floor (the "table") was built and scattered with up to eight wooden blocks (two-inch cubes), and a single box large enough to hold all of the blocks was later placed on the table.[93] Therefore, the "real world" of MH-1 was conceptualized as a physical world devoid of humans.[94]

Within this microworld, what colloquially came to be called the "Blocks World," MH-1 went through two programming phases designed to accomplish two separate tasks: placing blocks in the box and building small structures with the blocks.[95] The first task demonstrated the feasibility of a preprogrammed action and the second demonstrated precision of actions comparable to that of a two-year-old child. Both programs, however, had "several serious drawbacks" as the second phase produced as many mistakes as the first: Blocks would be dropped at the box's location even if the box wasn't there and blocks would keep being stacked onto a partially completed tower even though it had collapsed.[96] In Ernst's estimation, "the most frequent mistakes are of a fundamental nature . . . . [as] delegating responsibility and decision-making to the machine has the same consequences as delegating them to human beings." In other words, the computer's "mechanical intelligence" was as prone to miscalculations as a human *using* a computer.[97] Furthermore, Ernst recognized that "MH-1 is not working with a logical

[92] Ernst (1961), 59.
[93] Ernst did not provide the dimensions of the blocks, box, and table in his thesis though the blocks' dimensions can be found in Heinrich A. Ernst, "MH-1, A Computer-Operated Mechanical Hand," AIEE-IRE '62 Spring Computer Conference, May 1-3, 1962, 42.
[94] Ernst (1961), 19.
[95] The term "Blocks world" was not used in Ernst's thesis and when it was originally coined is still unknown.
[96] Ernst (1961), 36-41.
[97] Ernst (1961), 46-58.

image of the real world but rather with an associative mechanism [i.e., the Blocks World]." This proved problematic as a "computer can be coupled successfully to the real world without any human interference only insofar as the computer is made aware of the real world. In its dealings with events and conditions of which it is not aware the computer requires human assistance. The amount of human assistance required is therefore a measure of how incomplete the computer-contained representation of the real world is."[98]

That this laboratory world bore little to no resemblance to the outside world in which robots would actually work was not addressed in the thesis though it was obviously implied. The microworld, therefore, was a scaffold that needed to be filled-out and scaled-up. Furthermore, the microworld was contingent in that it was envisioned as a temporary expedient on the path towards AI's ability to grasp (and perhaps transcend) the human understanding of the macro or "real" world, and interstitial in the sense that the capability of computer programmers and the computational capacity of their machines determined what could be represented. Another way of putting this is that the real world was "hacked" into a computable (i.e., "real") world that could be manipulated by machines and their users.

Ernst's conclusions in MH-1 were almost pure manifestations of technoliberalism. Outside the laboratory (i.e., in the real world), Ernst posited two new applications for MH-1: as a research tool for exploring the "philosophy behind the control problem" and as a "useful" tool in manufacturing.[99] Both applications were conceptualized in accordance with the LMA by envisioning how two generalized social actors would use the technology: The "research man" for basic research, and the "production engineer" for applied science. Ernst gauged the likelihood of

[98] Ernst (1961), 85-88.
[99] Ernst (1961), 77. Work in "hostile environments" was also discussed though this was seen as merely an extension of what teleoperated manipulators, like the Model 8 servomanipulator arm of MH-1, already did.

MH-1's uptake by these ideal types in purely economic terms. "Research man," according to Ernst, argued that with the falling cost of both computation generally and operating a mechanical hand by computer specifically, such a purchase could be easily justified. Therefore, MH-1 was valid as a research tool specifically because it was economical.

The calculation for the "production engineer" was more complicated and based on the economic and social consequences of substituting machine labor for human labor. Ernst estimated that one mechanical hand working twenty-four hours a day could replace three workers, a significant productivity increase over Del Harder's prescription that each Ford automation device replace one worker. Additionally, unlike humans, machine would not get tired, have accidents, form unions nor demand additional fringe benefits, or need coffee breaks or relief time. Furthermore, mechanical hands did not require pensions and health plans, and they could be thrown away after they are worn out. Or, as Ernst theorized, "they don't mind being 'exploited' in the Marxist sense." However, a production version of MH-1 would be expensive in relation to the labor market, which had a surplus of "unqualified" (i.e., unskilled and cheap) labor but a shortage of "qualified" (i.e., skilled and expensive) labor, and the system's capabilities were limited to the former. As a result, the technology was not particularly promising for the production engineer since humans were still cheaper than robots—at least for the time being. On balance, Ernst predicted, "the overly pessimistic view of the production engineer is fortunately compensated for by the overly optimistic outlook of the research man."[100] The world's first computer-controlled mechanical manipulator was, like its constituent components, a product of the LMA and for the world it helped build.

[100] Ernst (1961), 78-80.

The conceptualization of the microworld and the construction of the Blocks World by "hacking" the real world into a computable world was perhaps MH-1's greatest (though unintended) technical achievement. As Terry Winograd, one of the most adept users of the Blocks World (see below), described it: "You want to find the thing which is easy to work with but which gets you the interesting issues, as opposed to the messy problems that you get into if you try to tackle 'real world' things."[101] And if chess was the drosophila of AI, Blocks World became the drosophila of robotics.[102] In Minsky's assessment, "for me and a whole generation of students, the world of work with children's blocks has been the prism and the pendulum for studying intelligence."[103] As discussed above, MH-1 was intended to transcend the traditional use of computers as simply another tool to be used by humans in the real world. The irony, perhaps understood but unacknowledged, was that, whether it accomplished this goal, MH-1 was still used by humans in the real world *as a tool* to understand processes about computers and the "real world," even if it reduced the human element of these processes. Ernst's prognostication about the optimism of "research man," therefore, proved accurate as computer-controlled robots remained in the laboratory for the next decade.

For all its failures and successes, MH-1 proved to be a temporary cul-de-sac as over the next four years robotics disappeared from the MIT AI Lab. While a number of reasons can be identified for the lack of work, the politics and preparation of the proposal for Project MAC was

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[101] Terry Winograd, CBI Interview, 39.

[102] For a discussion of the notion that chess was the drosophila of AI, see John McCarthy, "Chess as the Drosophila of AI," presentation given to the Conference of the Canadian Information Processing Society, May 31, 1989, http://jmc.stanford.edu/articles/drosophila.html). The first mention I've found of the idea was in McCarthy's handwritten notes from 1973 were he scribbled, without any other elaboration, "Chess is the fruitfly of A.I." McCarthy dated the idea 1966 and attributed it to Alexander Kronrod, Handwritten notes, Folder - Artificial Intelligence 1973, Box 3, Edward A. Feigenbaum Papers, SUSC. For a social history of "chess as an experimental technology" see, Nathan Ensmenger, "Is chess the drosophila of artificial intelligence? A social history of an algorithm," *Social Studies of Science*, Vol. 42, No. 1 (2011), 5-30.

[103] Marvin Minsky, *The Society of Mind* (Simon & Schuster, 1986), 20.

most likely the primary culprit as it required the input and involved negotiations between not only the computing community and university administrators at MIT but computer manufacturers, other potential users, and prospective sponsors.[104] And with McCarthy's departure in 1962, the same year Project MAC was approved, Minsky assumed primary leadership of the AI Project and used funds therefrom to get the rudiments of a robotics program started. In the interim, future IPTO director Larry Roberts (see above)—then a doctoral student in the Electrical Engineering department at MIT whose dissertation work was done at the Lincoln Labs on the TX-2 (an updated version of the TX-0)—published his groundbreaking study on the transformation of two-dimensional images into dimensional arrays on a computer display. Called "Machine Perception of Three-Dimensional Solids," Roberts's program became the visual counterpart of Ernst's tactile Blocks World and pioneered the subfield of computer vision. To build on and move beyond the "groping search" of Ernst's MH-1 work, therefore, Minsky proposed "the development of a versatile, computer-operated, visually oriented machine for handling objects in complicated spatial situations."[105] By July 1965, a system composed of a Vidicon camera interfaced to the PDP-6 computer coupled with an updated version of the Model 8 used in MH-1 (an AMF Model C Versatran remote manipulator which was internally called "MA-2") was complete.[106] Moving forward, such systems would be referred to as "Hand-Eye" projects. Integration of the two Blocks Worlds—one analog and one digital—revolutionized the

[104] Computer scientist and AI pioneer Edward Feigenbaum listed a number of possible reasons for this seeming peculiarity: "A shift of emphasis at some of the major centers toward technological problems of tool building; a much-needed reassessment of the implications and significance of efforts of the late 1950s; a substantive shift of attention to problems for which a long gestation time was needed (e.g., natural language analysis, integrated robots, representation); and the establishment of academic computer science departments, programs, curricula, etc., which absorbed a significant portion of the energies of the available talent. Each of these was to have its eventual payoff in the productive 1963-68 period," Feigenbaum, "Artificial Intelligence: Themes in the Second Decade," Stanford Artificial Intelligence Project, Memo No. 67 (August 15, 1968), https://apps.dtic.mil/sti/pdfs/AD0680487.pdf, fn, 3.
[105] Project MAC Progress Report II (July 1964 - July 1965), 3.
[106] Project MAC Progress Report II (July 1964 - July 1965), 3.

then nascent field of robotics with the visual component becoming a major thrust of algorithmic development.

The lab proposed two experiments to ARPA to test and demonstrate the more advanced and deliberate machines being built, all catching and cube [i.e., blocks] handling. Both experiments were envisioned as steps into the realm of more dynamic capabilities such as assembling parts and tool use.[107] To test these capabilities, as Minsky described, "We will start with visual environments that minimize perception problems; black-edged white rectangular objects. Gradually, we will extend the perceptual system to handle simple objects poorly presented, complex objects well-presented, and finally visually complicated environments like a room, or a cluttered workbench top."[108] In other words, the Blocks World. Such a world made it possible to achieve the goal of a useful level of visually monitored computer-controlled manipulation. However, "these simplifications have serious consequences, when the machine must face the real-world environment without any special preparation of the objects to be handled. We expect these to be among the hardest problems to be encountered in later phases of the project."[109] This would prove to be an understatement.

Like MH-1, microworlds had to be built and managed, which proved quite intractable as "the visual and analytic problems outweigh the purely mechanical problems in general difficulty."[110] In other words, with the introduction of vision, the Blocks World became much more complicated: The environment had to be well lit; the blocks had to be convex, plane-bounded, and couldn't be too big or too small; the platform on which the blocks were

[107] Project MAC Progress Report II (July 1964 - July 1965), 1-4 and 1-5.
[108] MIT. School of Engineering (AC 12). Box 17. Folder 7 - Project MAC Proposals - Research on Intelligent Automata, 1965, 1-4 and Appendix A, A6-A7.
[109] Ibid.
[110] "Status Report II: Research on Intelligent Automata, September 1967," Folder 8 - Project MAC Proposals, Research on Intelligent Automata, 1966-67, Box 17, School of Engineering Records, 1943-1989, vi.

manipulated was covered with a dark cloth (either black or red) to increase contrast with the (white) blocks; and depending on the experiment, white tape was used to mark off particular sections or squares on the cloth to indicate a sort of "landing pad" for block placement that could be seen by the "eye."[111] Even something as seemingly innocuous as the wood grain of the blocks could cause immediate and long-term problems as algorithms derived from experiments done with them would find their way into programs working on objects with different physical characteristics.[112] Therefore, experiments operated "under very restricted optical conditions" that required specifically tuned camera settings and precise lighting and, due to the "insistence on detailed analysis of monocular optical images" drawn from a single camera that captured a wide-field of vision but had limited depth perception, the complexity increased.[113] As Minsky described it in his 1968 proposal to ARPA for funding to continue the Intelligent Automata Project:

> We have enough experience with the individual components--equipment and programs--to be sure that under ideal visual contrast conditions each step will be performed with adequate proficiency. This is a weak assertion, because "ideal" means at the moment that both the objects' surfaces and the lighting conditions produce enough contrast along real borders, and sufficiently little noise in surface interiors.[114]

The "noise" of the real world, therefore, had to be filtered out of the Blocks World to create the "ideal" conditions for the robots to work.

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[111] Textual documents do not describe the platform but it can be viewed in various videos of the experiments at https://web.archive.org/web/20170204020905/https://www.csail.mit.edu/videoarchive/history/aifilms.
[112] Marvin L. Minsky, "Proposal for Continuation of Research on Intelligent Automata," September 1968, Folder 38 - ARPA-ONR, Intelligent automata research proposal, 1968, Box 21, Laboratory for Computer Science Records, MITDC, 6-7
[113] Marvin L. Minsky, "Proposal for Continuation of Research on Intelligent Automata," September 1968, Folder 38 - ARPA-ONR, Intelligent automata research proposal, 1968, Box 21, Laboratory for Computer Science Records, MITDC, 24.
[114] MIT. LCS. Box 21. Folder 38 - ARPA-ONR, Intelligent automata research proposal, 1968, 5, underline in original.

In addition to building the Blocks World, the lab began designing a new arm to supplement their Versatran industrial robot. Rather than a humanoid industrial-type arm like MA-2, the new arm was modeled on the anatomy of a lobster claw, an idea derived from Minsky's experiments on crayfish as an undergraduate at the Harvard Biological Laboratory in 1949.[115] Designated "MA-3," but colloquially called the "Minsky" or "Tentacle" arm, it provided more mobility, speed, strength, and versatility than MA-2, and helped overcome its predecessor's "clumsiness" (MA-2 was unable to reach around obstacles or support unobstructed objects).[116] Because MA-3 behaved "more like a tentacle than like a coordinate system" (i.e., fluid mechanical motion vs. point-to-to point Cartesian motion) and functioned as well as, if not better than, a human arm, it was deemed a more appropriate research tool for the inherent difficulties of modeling and programming "real-world" manipulation.[117] The first experiment, finished in December, used MA-2 to locate, track, and catch ping-pong balls in a basket, which was successful about a quarter of the time. The second experiment, in 1966-1967, went through two phases: The first used MA-2 to locate and manipulate blocks like MH-1 while the second used MA-3 to stack the blocks in various structures.[118] Unlike MH-1, which was essentially

[115] MIT. School of Engineering (AC 12). Box 17. Folder 8 - Project MAC Proposals - Research on Intelligent Automata, 1966-67 - Status Report (Section II), p. 2-10 and 2-12, Pamela McCorduck interview with Marvin Minsky, March 3, 1975, Folder - Transcripts, Research, Related Materials — Marvin Minsky (folder 1), Box 2, PMC, 20, and "Marvin Minsky - Activating a dead crayfish claw (134/151)," Web of Stories interview, https://www.youtube.com/watch?v=2wLOPomPZ1U&list=PLVV0r6CmEsFxJatFYBb7P4NZscvJw1f0r&index=134.

[116] "Project MAC Progress Report IV, July 1966-July 1967," https://apps.dtic.mil/dtic/tr/fulltext/u2/681342.pdf, 17 and "Project MAC Progress Report IV, July 1968-July 1969," https://apps.dtic.mil/dtic/tr/fulltext/u2/705534.pdf, II-60.

[117] "Project MAC Progress Report IV, July 1968-July 1969," https://apps.dtic.mil/dtic/tr/fulltext/u2/705534.pdf, II-60.

[118] MIT. School of Engineering (AC 12). Box 17. Folder 8 - Project MAC Proposals - Research on Intelligent Automata, 1966-67 - Status Report (Section III-V), 4-2 - 4-4.

"blind," MA-2 and MA-3 could actually "see" the balls they were catching and the blocks they were manipulating.[119]

The most advanced physical experiment of MIT's early robotics program that brought together the lab's various projects and lines of inquiry from MH-1 forward was called "Copy-Demonstration" (or "Copy-Demo" for short). Completed in 1970, Copy-Demo, at its most basic, used "a real robot that in a limited way perceives, understands, and manipulates the simple objects we put in front of its eye" to visually analyze a structure made out of "bricks, wedges, and other simple shapes like those found in children's toy boxes" (in this case an "arch") and then rebuild it after the objects had been scattered on the table.[120] According to project lead Patrick Winston, where the previous systems "interacted only narrowly and in a pre-determined way with its environment," in the new system the "environment controls the analysis," an "idea prominent in Ernst's very early work."[121] To improve upon these previous iterations of the Blocks World, particularly the visual aspects, the physical blocks themselves had to be more precise. As project member Tim Finnin recalled, Winston "took great care in creating the plaster blocks and used (IIRC) a sanding machine in the inner lab on the 9th floor to carefully sand the blocks to ensure they were square, had sharp edges and were without any surface blemishes."[122] Once again, the physical world had to be "hacked" to create an environment conducive to the continued development of AI. The experiment in practice was, however, less concerned with the

[119] "Project MAC Progress Report IV, July 1968-July 1969," II-59. Eventually, MA-3 proved more a curiosity than a boon to research as the actual real world that robots would be operating in (i.e., industrial spaces) were designed with human labor in mind and had little to none of the material and spatial affordances of an academic lab. As a result, the humanoid industrial-style arm remained the standard bearer of robotics. And over the next two years, the experiments demonstrated that there was "a need for much deeper analysis of what is needed in designing a hand-arm system for various kinds of jobs."
[120] Patrick H. Winston, "Heterarchy in the M.I.T. Robot," M.I.T. A.I. Laboratory, Vision Flash #8 (1971), 2 and P. H. Winston, "The MIT Robot," in Donald Michie (ed.), *Machine Intelligence 7* (Edinburgh University Press, 1972), 431.
[121] Winston (1972), 444.
[122] http://people.csail.mit.edu/bkph/phw_copy_demo.shtml. "IIRC" is an acronym for "If I recall correctly."

actual manipulation of blocks (like previous projects). Rather, Copy Demo was primarily intended to test the most recent theories of machine learning and pattern recognition, and to develop and stockpile the algorithms and programs that made up the rapidly growing AI reservoir.

Copy-Demo was motivated by more than just scientific and technological exploration for their own sake. Minksy was looking for a tangible example that would demonstrate the progress being made to bureaucratic functionaries. In his 1968 proposal to ARPA to continue funding the "Intelligent Automata" program, he introduced the experiment but expressed worry that there were "no clearly critical problems which have to be solved" for the experiment to be deemed successful. Additionally, the very nature of computer experimentation "is less to prove a specific point than to gain experience with a technique so as to develop a sense of its practical limits," which is why the "history of engineering shows the value of building machines close to the limits of current knowledge." Furthermore, "in a new field where even the basic phenomena are not well understood" developing good theory by pure thought was highly unlikely. While Minsky was primarily referencing the vision aspects of the experiment, he explained:

> The situation is similar for Manipulators: there is a huge literature on "Optimal Control Theory", and yet this body of publication has little to say about the problem of controlling a real and complicated practical mechanism like an arm. We are now making some progress on this theoretical problem, *but only because of the demands of a real laboratory situation*.

In his estimation, therefore, "if no critical problem is solved, then what will be proved by the Demonstration?"[123] No direct answer was given. However, as Minsky posited earlier in the

[123] Marvin L. Minsky, "Proposal for Continuation of Research on Intelligent Automata," September 1968, Folder 38 - ARPA-ONR, Intelligent automata research proposal, 1968, Box 21, Laboratory for Computer Science Records, MITDC, 12-14.

document, the system "will work well enough to be valuable in *acquiring theoretical insight*, in discovering the interactions between errors in different phases, and even as *a basis for some practical applications* (for example, in industrial contexts where the surfaces are under "unnaturally" close control). But for less artificial conditions it will not satisfy us."[124] Once again, this was the LMA in action; however, this time not just in the motivations *for* the project but in the interpretation of what the experimental outcomes were and could be. The final paragraph of the proposal put this in less jargony terms: "We need not spell out the possible value to man, in Industry, Leisure, or Defense, of machines that can see and act with some intelligence. To our knowledge, outside the ARPA-supported work there are no other comparable projects working on this area, here or abroad. We are therefore, anxious that the research proposed herein be continued."[125]

Ironically, the most famous of MIT's robotics projects, Terry Winograd's SHRDLU (1968-1970 ) took the artificial conditions of the Blocks World to its logical conclusion, which in turn demonstrated the (in)scalability of microworlds.[126] Similar to ARPA and IPTO, SHRDLU is a staple of the scholarship, so only a few comments in the context of the present discussion are necessary. Like its precursors, SHRDLU used a robot arm to locate and manipulate blocks to push forward the frontiers of AI; unlike its previous iterations, however, the project's Blocks World was a computer program and therefore purely virtual. The program allowed an operator to pretend they were talking to a semi-sentient robotic arm with a hand and an eye that could

[124] MIT. LCS. Box 21. Folder 38 - ARPA-ONR, Intelligent automata research proposal, 1968, 5, emphasis added.
[125] Marvin L. Minsky, "Proposal for Continuation of Research on Intelligent Automata," September 1968, Folder 38 - ARPA-ONR, Intelligent automata research proposal, 1968, Box 21, Laboratory for Computer Science Records, MITDC, 27.
[126] SHRDLU appears to be an acronym when in reality it is simply the second column of keys on a Linotype machine based on the frequency order of letters in English (with ETAOIN taking up the first column). As Winograd recounted: "When it came time to name the system, I tried to come up with acronyms and none were very good so I decided to just pick something that looked like an acronym but wasn't," https://hci.stanford.edu/winograd/shrdlu/name.html.

manipulate blocks on a table based on instructions from the operator. The robot could accept commands and displayed its actions in a simulated scene on a screen attached to the computer and it could also respond to questions and accept information to be used in later actions.[127] Because Winograd's intention was to explore the ability of computers to understand natural language there was no need to go through the hassle of "hacking" a physical world into existence.

While SHRDLU was a landmark project, its importance in the present context is twofold: First, it represented the ultimate detachment of the Blocks World from the "real world," and second, it demonstrated that even in light of such limitations, it still served as positive proof of advancement in AI and robotics, and therefore, the LMA more generally. As Winograd explained, "there was no attempt to get it [SHRDLU] to the point where you could actually hand it to somebody and they could use it to move blocks around. And there was no pressure for that whatsoever. Pressure was for something you could demo"; rather than 'publish or perish' it was "demo or die."[128] This was a problem in Winograd's eyes as "it led to 'Potemkin villages,' things which—for the things they actually did in the demo looked good but when you looked behind that there wasn't enough structure to make it really work more generally."[129] In this way, robots did work serving as research tools and demos to keep the money flowing from ARPA, just not the kind they were envisioned to: manipulating physical objects in the real world.

## A Lot of Little Frauds: Arming SAIL and SRI

[127] Terry Winograd, *Understanding Natural Language* (Academic Press, Inc., 1972), 2.
[128] Arthur L. Norberg, "An Interview with Terry Allen Winograd," Charles Babbage Institute (December 11, 1991), https://conservancy.umn.edu/bitstream/handle/11299/107717/oh237taw.pdf?sequence=1&isAllowed=y, 7.
[129] Ibid.

Unlike the multi-year gestation for MIT's AI lab, the establishment of Stanford's AI lab was a rather tepid affair. In lab founder John McCarthy's words: "I just sort of announced the artificial intelligence laboratory, appointed myself director, and did it without much cooperation with the department."[130] Like MIT, this endeavor began as a "project" within the Computer Science department, only to outgrow its environs shortly thereafter. Almost immediately after returning to Stanford, McCarthy sent a proposal to ARPA for a little more than $180,000 to get the "Artificial Intelligence Project" up and running. The LMA permeated the proposal beginning with the "Table of Contents"—which listed the major sections as "Theoretical Research" (i.e., basic research), followed by "Experimental Activities" (i.e., applied research), and finally "Practical Applications of Research in Artificial Intelligence" (i.e., development)—all the way to the final paragraph of the document. To make sure its reviewers understood the project's intentions, the first sentence of the introduction stated, "Our *basic research* objective is to understand intelligence well enough to make machines behave intelligently."[131]

The proposal then gave paragraph-long capsule summaries of various projects within the first two categories of research, followed by two specific practical applications, "Defense Planning" and "Military Robots." Regarding the latter, McCarthy deemed it "attractive" to make "machines take the risks and suffer the casualties of war," but he warned that "a science fiction view of what this would really be like is to be avoided" as "robots resembling men" marching into combat or armed automatons bombing the battleground below was, at the moment, farfetched.[132] In regards to non-defense applications of AI, McCarthy forthrightly admitted,

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[130] William Aspray, "An Interview with John McCarthy," March 2, 1989, Charles Babbage Institute, https://conservancy.umn.edu/bitstream/handle/11299/107476/oh156jm.pdf?sequence=1&isAllowed=y, 14.
[131] John McCarthy, "Proposal to ARPA for Research in Artificial Intelligence," January 1, 1963-December 31, 1963, John McCarthy papers, 1951-2008, Stanford University Digital Collections (hereafter SUDC), https://stacks.stanford.edu/file/druid:th919jh6519/sc0524_1995-247_b27_f04.pdf, 1-5 (emphasis added).
[132] McCarthy, "Proposal to ARPA," 6.

"Bluntly, they are few but not non-existent."[133] Following the two-sentence description of military robots was an extended analysis of how the "basic" and "applied" research projects previously described—and AI broadly speaking—could be made practical. And, to reiterate the point foregrounded in the "Introduction," the final paragraph of the proposal made clear that "the work we propose to perform on artificial intelligence is basic research but it can provide a guide on what we can and cannot now make computers do either by themselves or in combined man-machine systems. The future progress of the research will help reduce these limitations."[134] Six months later, with ARPA's blessing, the Stanford Artificial Intelligence Project was founded in June 1963.[135]

Two years later, McCarthy and Edward Feigenbaum—a young computer scientist recently poached from Berkeley who, according to McCarthy, was "always much more interested in administrative and financial matters"—wrote the first major proposal to ARPA requesting more than $2 million for considerable expansion of the AI project into a full laboratory.[136] Not surprisingly, it maintained the commitment to the LMA as it imitated the structure of, and significantly expanded upon, the proposal which established the existing AI project. This time, however, the proposed robots weren't vague "military" machines but computer-controlled arms (mechanical manipulators), hands (end effectors), and eyes (video

[133] McCarthy, "Proposal to ARPA," 6.
[134] McCarthy, "Proposal to ARPA," 10.
[135] Lester Earnest (ed.), "Final Report: The First Ten Years of Artificial Intelligence Research at Stanford," July 1963, Stanford Artificial Intelligence Laboratory and Computer Science Department, SUDC, https://stacks.stanford.edu/file/kr834jv6734/kr834jv6734.pdf, 1.
[136] John McCarthy and Edward Feigenbaum, "Proposal for Expansion of the Stanford Artificial Intelligence Project," March 1, 1965, Stanford University Computer Science Department, SUDC, https://web.stanford.edu/~learnest/spin/aip1965.pdf, 16. Quote about Feigenbaum from William Aspray, "An Interview with John McCarthy," March 2, 1989, Charles Babbage Institute, https://conservancy.umn.edu/bitstream/handle/11299/107476/oh156jm.pdf?sequence=1&isAllowed=y, 15. Feigenbaum's PhD was supervised by Herbert Simon, one of the pioneers of AI as a field, at Carnegie-Mellon, a soon-to-be major "center of excellence" in AI and robotics. A different version of the proposal went to NASA.

cameras) purchased with the project's initial funding. The practical applications posited were also now robot-specific, rather than AI general, and included: The assembly of objects from parts; as part of an automated biological laboratory for exploring Mars, as peripheral devices to be used for the control of a mobile cart; and eventually, as components within computer-controlled cars and planes. Perhaps of more import to ARPA, the proposal argued that "by training students in the research areas of artificial intelligence, control of external devices, and other advanced applications of non-numeric information processing, we will be broadening the pool of skilled researchers from which the computer field (and, in particular, the Defense Department) can draw to carry out future applications of an advanced nature."[137] Interestingly, this was the only time the military was mentioned in the proposal. Nonetheless, on April 1, 1965, ARPA signed off on over $1.5 million for expanding the project, and the Stanford Artificial Intelligence Laboratory (SAIL) was officially born.[138]

The primary goal of SAIL's early robotics work was to "provide a testing ground for many related artificial intelligence projects."[139] SAIL's "Hand-Eye" projects, as the first robotics experiments were called, were carbon-copies of MIT's: they used computer control of a mechanical arm and hand via visual perception for the purposes of creating intelligent machines.[140] Where MIT and Stanford initially diverged was in their approaches to AI. Minsky subscribed to an "antilogic" approach arguing that logic couldn't capture the entirety of

[137] McCarthy ans Feigenbaum, "Proposal for Expansion of the Stanford Artificial Intelligence Project," 3-12.
[138] Robert W. Taylor to John McCarthy, April 2, 1965, John McCarthy papers, 1951-2008, SUDC, https://stacks.stanford.edu/file/druid:th919jh6519/sc0524_1995-247_b27_f05.pdf.
[139] "Research in the Computer Science Department, Stanford University," October 17, 1970, 12 and "Research in the Computer Science Department, Stanford University," April 21, 1969, 17.
[140] The first two papers directly addressing these problems come from Karl K. Pingle, "A Program to Find Objects in a Picture," Stanford Artificial Intelligence Project, Memo No. 39, Jan 20, 1966, https://stacks.stanford.edu/file/bg809sd1838/bg809sd1838.pdf and "A Proposal for a Visual Input Routine," Stanford Artificial Intelligence Project, Memo No. 42, June 20, 1966, SUDC, https://stacks.stanford.edu/file/dd693vj9241/dd693vj9241.pdf.

knowledge and intelligent action, and therefore, ad-hoc solutions that could discriminate what these were would be sufficient for creating such behavior. McCarthy, on the other hand, was a mathematician by training and dedicated to the "logical" approach whereby "versatile intelligent machines will have (among other things) a place where information about the environment is stored explicitly in the form of sentences" and this declarative knowledge will be formalized into action.[141] As he explained the difference:

> So, my slogan was 'Description, not mere discrimination.' The example that I gave was, 'Well, if you want a robot to pick something up, it can't get by with just a yes-or-no answer as to what it is. To pick something up you needed a description of it in terms of how it was laid out, or how it was constructed, what its parts were, and so forth. That led me to thinking about robotics as a subject to do.[142]

Nonetheless, Stanford tested their robots in Blocks World environments almost identical to MIT's but with greater success in terms of creativity and productivity. Whether this was due to the differing approaches to AI, or whether as a confluence of other forces, is hard to determine. By the early 1970s, however, Stanford's greatest gains were made in the engineering and interfacing of more advanced robotic arms and integrating these with new AI capabilities in speech, tactility, and vision.

Shortly after the SAIL's official establishment in 1965, Stanford's Mechanical Engineering Department was set to design and manufacture a hydraulic and pneumatic "high performance" arm for the lab's first major project. The department's continued delays, however, led SAIL to instead purchase a prosthetic arm from the Rancho Los Amigos Hospital in Downey,

[141] Nils Nilsson, "Logic and artificial intelligence," *Artificial Intelligence*, 47 (1991), 32.
[142] McCarthy, CBI Interview, 7-8.

California.[143] The "Rancho Arm," as it was colloquially called, has an interesting and relevant history.[144] Originally named the "County Poor Farm," Rancho Los Amigos Hospital was established in 1887 as an agricultural facility to provide "work, housing, and medical care for the indigent."[145] Over the next few decades the hospital evolved into a more traditional medical facility, and after World War II, its focus shifted to physical rehabilitation, particularly with prosthetics. To advance the art of these devices, Rancho hired aerospace engineers to apply their R&D experience and expertise to advanced rehabilitative technologies. The hospital also directly partnered with aerospace firms, such as North American and Northrop, to improve work on their devices, eventually completing a hydraulic-powered manipulator in 1954. By 1959, the Atomic Energy Commission (AEC) and NASA, both of whom had long been interested in the development and use of remote manipulators, jointly funded Rancho's work, with NASA explicitly interested in "expediting the "flow of aerospace technology into nonspace uses."[146] In early 1965 the "Rancho Electric Arm" was successfully fitted to a quadriplegic polio patient and either this, or a copy of it (the record is unclear), was delivered to SAIL in October 1966.[147]

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[143] L.D. Earnest to Director of the IPTO, "Computer Arm (SD-183 Capital Equipment)," AI Project and Misc., 1965-1966 (correspondence, memos, proposals), John McCarthy papers, 1951-2008, SUDC https://stacks.stanford.edu/file/druid:th919jh6519/sc0524_1995-247_b27_f03.pdf, 27.

[144] Peter Asaro and Selma Šabanović, "Oral History: Bernie Roth," IEEE History Center, November 18, 2010, https://ethw.org/Oral-History:Bernie_Roth.

[145] National Park Service, "Historic American Buildings Survey: Los Angeles County Poor Farm," Department of the Interior, HABS No. CA-2800, n.d., http://lcweb2.loc.gov/master/pnp/habshaer/ca/ca3500/ca3509/data/ca3509data.pdf, 4.

[146] William Hildred, "A Case Study of Technology Transfer: Rehabilitative Engineering at Rancho Los Amigos Hospital," NASA Technology Utilization Office, Contract NASW-2362, June 1973, 6-10.

[147] James R. Allen, Andrew Karchak, Jr., and Ernest L. Bontrager, "Final Project Report: Rancho Anthropomorphic Manipulator (RAM)," Rancho Los Amigos Hospital, Inc., NASA Contract No: NAS 8-28361, Feb. 17, 1972-Dec. 31, 1972 and James R. Allen to Les Earnest, Folder - Rancho Arm, 1966-1968, Box 11, John McCarthy Papers, 1951-2008, SUSC. Apparently, Rancho Los Alamos had already given a "hand" to SAIL in 1965 while Bernard Roth, of Stanford's Mechanical Engineering, was developing a separate hand in-house (John McCarthy to Ivan Sutherland, September 3, 1965, John McCarthy papers, 1951-2008, SUDC, https://stacks.stanford.edu/file/druid:th919jh6519/sc0524_1995-247_b27_f05.pdf, 37). The specific date when Stanford received its first Rancho arm is complicated by a claim made by Larry Leifer that he and Vic Scheinman "purchased one of the Rancho orthoses in 1964 for the then-budding robotics project in the Stanford University Artificial Intelligence Laboratory (SAIL)" in Larry Leifer, "Rehabilitative Robots," *Robotics Age*, May/June 1981, 10. Corroborating evidence for this claim has yet to be found.

The Rancho Arm became a key component of SAIL's first hand-eye system in May 1967. Like the process at MIT, the system had to be fashioned in an ad-hoc manner as technical literature for assembling them had yet to be written.[148] Like MIT, the Rancho Arm was tested in the Blocks World, this time stacking blocks, according to size, in the shape of a castle. Based primarily on the work of Michael Wichman, the system was deficient in several ways: Only the outer edges of the blocks could be observed and the mechanical hand had to be removed from view during visual inspection of the finished castle.[149] And, due to "the innate perversity of inanimate objects"—a rather histrionic description of children's blocks —they were restricted to being plane-bounded and convex, just like previous Blocks World experiments.[150] The system's mechanical hand kept dropping objects, earning it the nickname "Butterfinger." Additionally, the system could only stack blocks with a quarter-inch accuracy and the integration of the visual perception system with the arm and hand system was proving more difficult than imagined.[151] A short film starring Butterfinger was made in the fall of 1967 to demonstrate the system in action. The final film, however, was not exactly an accurate representation of the system in practice as the preparation of the Blocks World, the inevitable computer crashes, and the actual time-lapse of the system's operation were edited out while the useful segments were spliced together to make the experiment look much more coherent and fluid than it was. As project manager Bernie Roth recalled: "I said to Gary [the film's producer and director] at one point, 'Gary, this film is

[148] John McCarthy et al, "Proposal for Continuation of the Stanford Artificial Intelligence Project," June 1969, Stanford Libraries, The History of Artificial Intelligence, https://stacks.stanford.edu/file/jj792hs0973/jj792hs0973.pdf, 23.
[149] Earnest's "First Ten Years," 5
[150] "Research in the Computer Science Department, Stanford University," April 21, 1969, Stanford Publications, Artificial Intelligence Memos, https://stacks.stanford.edu/file/ck700wt5969/ck700wt5969.pdf, 16-19.
[151] "Research in the Computer Science Department, Stanford University," 16-19 and Asaro and Selma Šabanović, "Oral History: Bernie Roth."

one big fraud.' And he said, 'No, no, Bernie, it's a lot of little frauds.'"[152] In other words, the film, like the Blocks World it was recording, was also a 'hack.'

Over the next three years the lab undertook a number of new experiments (with varying levels of success) that pushed the boundaries of the Blocks World and robotics and filmed much like Butterfinger. Raj Reddy's work on speech recognition was made into a film called "Hear! Here!" (1969) that included a segment of SAIL members speaking commands into a microphone for the Rancho Arm to pick up, move, and place blocks at various locations on the table. Another film, "Avoid" (1969), demonstrated the arm's ability to maneuver around various objects. The most advanced demonstration was the system's successful completion of an "Instant Insanity" puzzle, the objective of which was to stack blocks with different colored faces in a column so that each side of the stack shows each of the colors.[153] While the films were intended to be lighthearted, project leader Jerome Feldman must have intuited the possible implications of the "little frauds." Commenting on the intractability of the problems the system was intended to demonstrate, he noted, "Those readers unfamiliar with the field will probably feel that we have set up an elaborate straw man. Cognoscenti will recognize the man as real enough, but will look for a way to make our grand design operational."[154]

Work on such grand designs was also taking place just a few miles up the road at the Stanford Research Institute (SRI). Beginning in 1964, Nils Nilsson and Charles Rosen embarked on what would become the most public-facing robotics project of the period—the mobile robot system nicknamed "Shakey."[155] On April 20, 1964, they submitted their first proposal

[152] "Research in the Computer Science Department, Stanford University," 16-19. The film, and others produced at SAIL (including outtakes), can be found here: https://purl.stanford.edu/cc605nm4048.
[153] "Research in the Computer Science Department, Stanford University," October 17, 1970, Stanford Publications, Artificial Intelligence Memos, https://stacks.stanford.edu/file/kn557zw3382/kn557zw3382.pdf.
[154] "Research in the Computer Science Department, Stanford University," April 21, 1969, 14-29.
[155] The broader project was intended, as first proposed in April of 1964, to be a "program that will ultimately lead to the development of machines that will perform tasks that are presently considered to require human intelligence,"

articulating a vision of combining artificial intelligence and robotics into one platform to the Department of Defense Research and Engineering (DDRE), the office in charge of all DoD research. Titled "Research in Intelligent Automata (Phase I)" and prepared by Nilsson, then head of a research team in SRI's Applied Physics Laboratory called the Learning Machines Group, it proposed a "program that will ultimately lead to the development of machines that will perform tasks that are presently considered to require human intelligence."[156] Such a program was envisioned in the spirit of the industrial revolution and as an actualizer of the phase of current development, that was "placing under the productive control of man powerful sources of intellectual energy based on electronic machinery." Furthermore, it provided a "strong conjecture that the continuing development of intelligent automata super[im]posed on existing machine capabilities will provide the basis for a rapid increase in the progress of this new revolution." One of the envisioned tasks of this "new revolution" was to "relieve humans of routine, semi-repetitive tasks that may require occasional human supervision and control."[157]

The proposal, however, was not funded and SRI brought Marvin Minsky in from MIT as a consultant later that year. After the "first of many trips to the ARPA office . . . . to generate interest in supporting mobile robot research at SRI," and with the help of Ruth Davis, then director of DDRE, and Ivan Sutherland, then director of IPTO, a "work-statement" (essentially a non-binding commitment to fund a research program) was issued by ARPA.[158] This work statement significantly altered the tenor of the proposal as it was, for lack of a better term,

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and the proposal of which was one of the first (if not *the* first) of its kind to directly articulate a vision of combining AI and robotics into one platform, Nils J. Nilsson, "Research in Intelligent Automata (Phase I)," April 29, 1964, Stanford Research Institute (SRI), http://www.ai.sri.com/pubs/files/1320.pdf, iii.

[156] Nils J. Nilsson, "Research in Intelligent Automata (Phase I)," April 29, 1964, Stanford Research Institute (SRI), http://www.ai.sri.com/pubs/files/1320.pdf, iii.

[157] Nilsson, "Research in Intelligent Automata (Phase I)," 6-8.

[158] Nils J. Nilsson, *The Quest for Artificial Intelligence: A History of Ideas and Achievements* (Cambridge University Press, 2010), 213-215.

"militarized." Specifically, it foregrounded the long-term goal of the program as developing an automaton "capable of gathering, processing, and transmitting information in a hostile environment," and that to accomplish this it would be "essential to knit together as many as of the constituent subject areas of "artificial intelligence" as possible." Such a goal, it was understood, was "difficult of realization but by the same token it will provide solutions to existing military problems."[159]

In January 1965, Nilsson and Rosen submitted a new proposal, titled "A Research and Development Program in Applications of Intelligent Automata to Reconnaissance--Phase I," to the Information Processing Branch of the Rome Air Development Center (RADC), the Air Force's "super lab" for command and control research at Griffiss Air Force Base in Rome, New York. Two major changes to the original proposal were made: The foregrounding of developing machines to perform reconnaissance missions as the program's ultimate goal and the conceptualization of those machines as "robots."[160] In terms of the former, reconnaissance was never mentioned in the body of the first proposal; the word only appeared in the "Personnel" section in reference to brief descriptions of work previously done by program participants. Regarding the latter, Nilsson and Rosen reframed the second proposal entirely in terms of "robots," situating the program's desire to develop them in historical terms stretching back to Hero of Alexandria's "hydraulically-powered figure of Hercules and the dragon" from 300 B.C. The cursory genealogy then noted advances in automaton building—from Grey Walter's "turtles" to "the beast" at Johns Hopkins University—that "have brought the art of robot-building to the beginning of a new chapter--that of intelligent automata." After listing a number

[159] Nilsson, *The Quest for Artificial Intelligence*, 215.
[160] National Research Council, *2001 Assessment of the Office of Naval Research's Aircraft Technology Program* (National Academies Press, 2001), 49.

of "abilities" to be developed, the proposal stated that "robots possessing such abilities would be able to perform tasks normally thought to require human intelligence--hence the name intelligent automata." In this sense, the proposal created a clear distinction in what was and was not a "robot," the completion of tasks that were not directly programmed into the machine, one of the earliest articulations of such a distinction in the documentary record.[161]

Beyond these two conceptual changes, the new proposal included word-for-word excerpts of Sutherland's work statement, logically to increase the chance of acceptance. Helping the cause even more was the fact that Nilsson, prior to taking a position as SRI, had been a lieutenant stationed at the center from 1958-1961 while working on statistical signal-processing techniques for radar systems.[162] This second proposal, however, was also apparently rejected. Nilsson and Rosen submitted a third, and almost identical, proposal to RADC on December 22, 1965 in response to a "request for proposal" they had sent out eight days prior. One notable difference in the third proposal was the inclusion of a detailed budget requesting more than $750,000 over two years, which indicates that somewhere in the communication process, SRI must have been informed that acceptance was more than not likely.[163] It is not exactly clear why but the contract was finally awarded. According to Nilsson, there were "several research proposal drafts and discussions with people in the relevant offices in the Defense Department" and "Ruth Davis played a prominent role in getting ARPA and RADC to move forward on getting the project started."[164]

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[161] C. A. Rosen, Nils J. Nilsson, and Milton B. Adams, "A Research and Development Program in Applications of Intelligent Automata to Reconnaissance--Phase I," January 8, 1965, Stanford Research Institute (SRI), http://www.ai.sri.com/pubs/files/rosen65-esu65-1tech.pdf (accessed October 16, 2019).
[162] Nilsson (2010), 216.
[163] C. A. Rosen, Nils J. Nilsson, and Milton B. Adams, "Application of Intelligent Automata to Reconnaissance," December 22, 1965, Stanford Research Institute (SRI), http://www.ai.sri.com/pubs/files/rosen65-esu65-117prop.pdf (accessed October 16, 2019).
[164] Nilsson, *The Quest for Artificial Intelligence*, 216.

In late 1966, Nilsson and Rosen submitted the initial project report, covering the first eight months of work from March 17 through November 17, and unveiled what would evolve into Shakey, SRI's most famous "intelligent automata" project. The automaton was described as a "four-wheeled, self-powered vehicle with two simple arms [later called manipulators] for grasping objects" that would also carry "a television camera, an optical range-measuring device, tactile sensors, a transceiver, and storage and routing logic." Its primary objective was to "investigate techniques in artificial intelligence applied to the control of a mobile automaton in a realistic environment." The report went on to detail the automaton's environment and the type of tasks it would attempt to complete: Rather than a "hostile" environment like that imagined in the original work statement, the automaton was confined to a "20x30 foot space populated with simple objects (such as boxes) that can be arranged to form corridors and obstacles."[165]

The environment would be expanded to the halls and other offices of the larger lab once more powerful programs could be developed. Recognizing that "the invention of programs that succeed in grabbing oddly shaped objects depends to a great extent on what the mechanical characteristics of the vehicle's 'hands' turn out to be," the report foresaw a crucial aspect of robotics research—the entanglement and limitations of hardware and software design. What applications any of this had to reconnaissance did not appear in the report.[166] The second interim report, coming four months later in March 1967, provided more detail about the "manipulator arms" and explained the reasoning behind the anthropomorphic nomenclature used to describe them:

[165] Nils J. Nilsson and Charles A. Rosen (eds.), "Application of Intelligent Automata to Reconnaissance," November 1966, Contract AF 30(602)-4147, Stanford Research Institute (SRI), http://www.ai.sri.com/pubs/files/rosen66-p5953-interim1.pdf (accessed October 16, 2019), i.
[166] Nilson and Rosen (eds.), "Application of Intelligent Automata to Reconnaissance," 55.

> The purpose of the arms for the automaton is to enable the vehicle to execute tasks involving a limited amount of moving, carrying, and lifting. (The arms might be similar to those of a crab.) We have found it helpful to refer to the different parts of the manipulator arms in anthropomorphic terms. Such reference does not imply that we have attempted to duplicate the corresponding functions of a human arm, but merely helps to clarify concepts by association. (Actually our use of anthropomorphic nomenclature is probably responsible for our thinking of exactly two arms for the manipulator instead of considering the possibility of using perhaps three or more.)[167]

Problems, however, did arise with the arms: Their drive motors made the automaton heavier, which drained its battery faster thereby severely impacting its mechanical efficiency. Due to the expense of fabricating the arms and the need to free up more funds for programming costs, work on them was tentatively stopped, and by the third interim report in December 1967, their construction was postponed indefinitely.[168]

The Shakey that emerged from these early trials was an approximately six-foot tall computer-controlled (SDS-940 and later a PDP-10/PDP-15) sensor-equipped ("cat-whisker" touch sensors, range finder, and a TV camera) four-wheeled vehicle that had a limited ability to model its environment and perform tasks like finding a route to a location and rearranging simple objects (while accomplishing these tasks it would shake, hence the nickname). The platform was originally designed to be "equipped with two manipulators, or 'arms'" for grasping objects and rudimentary manipulation, but these were removed in 1968, apparently to reduce the number of variables that would contribute to equipment breakdowns and system failures.[169] Nonetheless, like its armed counterparts at the MIT AI Lab and SAIL, SRI developed and tested Shakey in a

[167] Charles A. Rosen and Nils J. Nilsson (eds.), "Application of Intelligent Automata to Reconnaissance," March 1967, Contract AF 30(602)-4147, Stanford Research Institute (SRI), http://www.ai.sri.com/pubs/files/rosen67-p5953-interim2.pdf, 53.
[168] Rosen and Nilsson (eds.), "Application of Intelligent Automata to Reconnaissance," 4.
[169] See "Application of Intelligent Automata to Reconnaissance (First Interim Report, Mar. 17, 1966-Nov. 17, 1966)" - SRI (Nov. 1966), 58-59 for a description of the arms and Application of Intelligent Automata to Reconnaissance (Final Report, Mar. 17, 1966-Dec. 5, 1968) - SRI (Dec. 1968), 29 for an explanation of why the arms were "deleted."

Blocks World, but unlike its armed counterparts that operated in a "micro" world, the much larger experimental space in which Shakey would trundle could better be described as a "meso" world. In essence, the laboratory *itself* was transformed into a Blocks World as Shakey's "first visual subsystem was designed to specialize in the planar-surfaced environment of our laboratory and office building."[170]

This environment consisted of seven room and eight doors with lightly colored floors and walls, regularly spaced overhead fluorescent lights (all of which allowed for the control of illumination and shadows), and was populated with "specially constructed rectangular parallelepipeds and wedges" (i.e., blocks or "boxes"), the surfaces of which were painted grey, red, or white to increase reflected light (for the range finder) and provide enough contrast (for the TV camera).[171] Within this mesoworld, Shakey was able to plan and execute travel routes and rearrange blocks by pushing them with its "bumpers."[172] However, that world proved—like the microworlds of robotic arms—limiting. As members of the project team observed: "The problem environment [for the robot] is a dull sort of place in which a single robot is the only agent of change – even time stands still until the robot moves" and even in this world "the robot itself is easily confused."[173] For this, and a number of much broader reasons outside of the project team's control, Shakey ran out of funding and was decommissioned in 1972. Nonetheless, the project did produce one of the most famous AI search algorithms—A* ("A-star")—which is (or

[170] Nils J. Nilsson, "Shakey the Robot," SRI Technical Note 323, (Apr. 1984), 9 and 12.
[171] "Artificial Intelligence—Research and Applications," Annual Technical Report October 1971 through October 1972 Stanford Research Institute Project 1530, (Dec. 1972), 6 and Nils J. Nilsson, "Shakey the Robot," SRI Technical Note 323, (Apr. 1984), 9 and 12.
[172] A film of Shakey, which was highly edited like its SAIL counterparts, can be found here: https://exhibits.stanford.edu/ai/catalog/tt618qz3245.
[173] Richard E. Fikes, Peter E. Hart, and Nils J. Nilsson, "Some New Directions in Robot Problem Solving," SRI Technical Note 68 (Aug. 1972), 1, quoted in Nilsson, *The Quest for Artificial Intelligence*, 229.

iterations of it) still in use today for natural language processing (NLP) and route-finding in GPS applications including Apple or Google Maps.[174]

In the midst of these struggles, news of Shakey and its relatively bumbling performance began to circulate in local and regional newspapers in December 1969. A year later, however, an article written by Brad Darrach in *Life* magazine profiling Shakey (which he misspelled "Shaky") created a stir in the AI community.[175] Based on interviews with members of the "Artificial Intelligentsia" and his own observations at SRI, Darrach painted a sensational picture of AI and robotics that, according to Marvin Minsky, took their words and work, at best, out of context and, at worst, were a "fantasy of their author."[176] One of Minsky's objections in particular, and his response to it, is revealing. During his research, Darrach visited the Project MAC and AI labs at MIT and walked away with the impression that many of its members were noticeably concerned about the "dangers" of AI—particularly dependence on machines that could purportedly think for themselves—and that their warnings about this to the Pentagon were falling on deaf ears. According to Darrach, Minsky was the most dramatic of these Cassandra-like figures.[177] In a response apparently circulated in the AI community (and perhaps sent to *Life* magazine), Minsky wrote:

> I apologize on his (Darrach's] behalf to any officials whose feelings are hurt. For my part, I can state categorically that:

[174] Nilsson, *The Quest for Artificial Intelligence*, 221. The most direct reason for the cancellation of Shakey was the shift in priorities at the Pentagon towards funding projects with more demonstrable and practical applications to military problems.
[175] Brad Darrach, "Meet Shaky, the first electronic person," *Life*, November 1970, 58B-68.
[176] "Statement by Marvin Minsky Regarding the *Life* Article," December 14, 1970, Folder - Transcripts, Research, Related Materials - Marvin Minsky (2 of 2), Box 2, PMC, 2-4. I've only found one other citation of Minsky's response in Howard A. Pelle, "A Study of Computer-Assisted Learning with Artificial Intelligence Games," PhD diss. University of Massachusetts-Amherst (July 1971), 33.
[177] Darrach, 68.

1. I have never said anything remotely resembling this to anyone, let alone to the Life reporter, nor have I warned anyone in the Pentagon about anything.

2. From the start of our work, we have consistently dealt with our sponsoring agencies and officers with a very high level of confidence and mutual understanding of goals. There have never been any problems about understanding the good and bad possibilities of what or work may lead to.

3. Ours is an open academic laboratory, with no secrets, and we attempt to keep our documentation available to the scientific public with no delays.[178]

The benedictions of the LMA, it seems, required penitents as well as proposals.

Fein, who was no doubt a cynic but had the integrity of an honest critic, was also taken aback by the article. Calling Darrach a "non-electronic person who was apparently programmed to revive such fascinating and fearsome fantasies in the popular literature," Fein was perturbed by the reckless mischaracterization of the "Artificial Intelligentsia." However, Fein reaffirmed his position from seven years prior in his response to Darrach:

> Artificial Intelligence, like most other fields, has individuals, businesses, and government sponsors peddling competing viewpoints, ideologies, products, conjectures, and promises. The kinds of misquotations, distortions, and exaggerations perpetrated by Darrach have indeed been made by professors and researchers seeking grants and contracts; b[y] advertisers seeking business for their Clients; by government agencies seeking funds from Congress; by university publications seeking to impress their constituency; by professionals in one school of thought seeking to discredit their opposition. And now by Life seeking to sell more magazines. I contend that this gain to Life is not worth the loss to our country of having a misinformed public.[179]

[178] "Statement by Marvin Minsky Regarding the *Life* article," 4.
[179] "Comments from Louis Fein," November 21, 1970, Folder - Transcripts, Research, Related Materials - Marvin Minsky (2 of 2), Box 2, PMC.

Unlike some critics of artificial intelligence, Fein's credibility gave such assessments greater weight. If anyone was going to critique the "Artificial Intelligentsia," they should do it in the right way and for the right reasons.

SAIL and SRI's early achievements and failures created a number of new problems and amplified those that already existed. By the end of the 1960s, SAIL acknowledged that "many blind alleys have been and are being followed and many mistakes are being made. Nevertheless, a body of fundamental knowledge is accumulating."[180] The work was difficult, expensive, slow, and time-consuming as "good computer scientists" interested in the critical components of robotics research were at a premium.[181] And these were not separate problems as "the design, implementation, and use of the robot hardware presents some difficult, and often expensive, engineering and maintenance problems. If one is to work in this area solving such problems is a necessary prelude but more often than not, unrewarding because the activity does not address the questions of A.I. research that motivate the project."[182] While automating assembly tasks normally performed by humans was an applied goal of the projects writ large, the primary function of Stanford's robotic research was to advance AI. These goals were not mutually exclusive; as Gary Feldman described it, the "main principle which has emerged from the Stanford work is the dependence of everything on everything."[183] But who can afford to work on everything?

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[180] John McCarthy, Arthur Samuel, Edward Feigenbaum, and Joshua Lederberg, "Proposal for Continuation of the Stanford Artificial Intelligence Project," National Library of Medicine: Profiles in Science, The Joshua Lederberg Papers (June 1969), Folder 3, Box 59, 3, https://profiles.nlm.nih.gov/spotlight/bb/catalog/nlm:nlmuid-101584906X17413-doc

[181] McCarthy, Samuel, Feigenbaum, and Lederberg, 4.

[182] Edward Feigenbaum, "Artificial Intelligence: Themes in the Second Decade," Stanford Artificial Intelligence Project Memo No. 67, August 15, 1968, Stanford University Digital Repository, https://stacks.stanford.edu/file/druid:mm777vh7300/mm777vh7300.pdf, 9.

[183] J.A. Feldman et al, "The Stanford Hand-Eye Project," Proceedings of the 1st International Joint Conference on Artificial Intelligence (IJCAI), May 7-9, 1969, 521-524.

**Conclusion: The USCSRIIDDACWF[184]**

The blessings flowing from Washington helped the Artificial Intelligentsia gain national recognition by the turn of the 1970s. When all was said and done, federal agencies spent approximately $15 million (over $100 million in current dollars) on robotics research at MIT and Stanford during the first half of the Cold War.[185] Focusing just on direct expenditures, however, would be a mistake. Universities such as MIT and Stanford, and the metropolitan and national ecologies they were embedded in, could nurture such research programs because of the political and socioeconomic capacities cultivated and instituted by the LMA. And, perhaps more than the science and technology they nurtured, it was these relationships and institutions were the desired input and output of the LMA.

The responses to Fein's "Artificial Intelligentsia" paper, much like one-time IPTO director Larry Roberts's confession above, are revealing. The only published reply found came from Paul W. Cooper of Sylvania Electronic Systems. Obviously in on the joke, Cooper submitted a "proposal" from his own made-up company imitating Fein's style, substance, and even humor (to the level of comic absurdity).[186] Yehoshua Bar-Hillel, one of the first critics of AI and himself an esteemed linguist, mathematician, and founder of the field of machine translation, sent a letter to Fein from Hebrew University in Jerusalem stating: "Since I know personally most of the people and groups caricatured, I can testify as to the exactness of the

[184] This is not a typo.
[185] Total MAC expenditures were approximately $25 million (Sidney G. Reed, Richard H. Van Atta, and Seymour J. Deitchman, *DARPA Technical Accomplishments: An Historical Review of Selected DARPA Projects, Volume I,* Institute for Defense Analyses (February 1990), 19-14) with AI and robotics research about a third of this ($8 million), while Stanford spent over $7 million, derived from Earnest (ed.), "Final Report," 2.
[186] Correspondence, *IEEE Spectrum*, Vol. 1, Issue 7 (February 1964), 188-89.

likeness as well as to the deadliness of the critique."[187] Ironically, because they proved Fein's point, the senior military brass (passively) accused of guilt by association echoed Bar-Hillel's approval. Harold Wooster, Director of the Information Services Directorate of the Air Force Office of Scientific Research, sarcastically asked, "It's a beautiful piece of work. But how did you get access to our bidders' files--I thought they were supposed to proprietary[?]"[188] Brockway McMillan, Undersecretary of the Air Force and Director of the National Reconnaissance Office (NRO), poked: "I know several contractors who could use your services in preparing their proposals!"[189]

At the same conference where he presented the "Artificial Intelligentsia" paper in 1963, Fein presented a second paper called "Computer-Oriented Peace Research," which received a much colder response.[190] Unlike his previous 'Modest Proposal,' this one was geared to solving the problems the LMA had capitalized on (and, in part, created) rather than playfully critiquing a small clique that took advantage of it. Similar to the previous paper, Fein posited a fictitious "management consulting and research type of organization" called the "Universal Study Center for the Salvage and Reorganization of Institutions in Imminent Danger of Destruction Applying Computers Wherever Feasible" or, mocking the alphabet soup of the technoscientific apparatus, the USCSRIIDDACWF for short. The organization would "produce considered and documented alternative advisory opinions on how Earth might prevent or indefinitely postpone its demise,

[187] Yehoshua Bar-Hillel to Louis Fein, October 21, 1963, Folder - Fein, Louis The Artificial Intelligentsia, 1963, Box 15, Nils J. Nilsson Papers, Stanford University Archives.
[188] Harold Wooster to Louis Fein, September 6, 1963, Folder - Fein, Louis The Artificial Intelligentsia, 1963, Box 15, Nils J. Nilsson Papers, Stanford University Archives
[189] Brockway McMillan to Louis Fein, November 21, 1963, Folder - Fein, Louis The Artificial Intelligentsia, 1963, Box 15, Nils J. Nilsson Papers, Stanford University Archives.
[190] Louis Fein, "Computer-Oriented Peace Research," *AFIPS '63 (Fall)*, Proceedings of the Fall Joint Computer Conference (November 12-14, 1963), 631-639. The paper was a shorter version of a previously published piece by Fein, "A Proposal for a Scientific Computer-Oriented Project on World Peace Research," *Background*, Vol. 7, No. 2 (Aug. 1963), 97-108.

and on how to establish conditions favorable to future Earth peace, health and prosperity."[191] Unlike the relatively positive responses garnered from Fein's first paper, no responses from the "Artificial Intelligentsia" nor their corporate and state comrades to the second paper have been found. As J. C. R. Licklider once told an interviewer, "what the military needs is what the businessman needs is what the scientist needs," and apparently none of them needed peace.[192]

The NSS's support for robotics proved to be a mixed bag. While the Artificial Intelligentsia attempted to sell their work as the latest in high-tech, some were not sold. As Joseph Engelberger argued, "Unfortunately, the academic world is not interested in the basic factory problem, but is concentrating on elegant experiments which must prove that an arm, an eye, and a computer are indeed artificial intelligence."[193] The technical evolution of the industrial robot, however, had essentially hit a wall by the time the Artificial Intelligentsia were hard at work, and the capacities they developed in the laboratory would soon make their way, in fits and starts, to the factory floor. The American state was once again picking up the tab of technological change and the question remained: would their investments pay off, and perhaps more importantly, who would be collecting the check?

[191] Louis Fein, "Computer-Oriented Peace Research," *AFIPS '63 (Fall),* Proceedings of the Fall Joint Computer Conference (November 12-14, 1963), 631.
[192] William Aspray and Arthur Norberg, "An Interview with J.C.R. Licklider," October 28, 1988, Charles Babbage Institute, https://conservancy.umn.edu/bitstream/handle/11299/107436/oh150jcl.pdf?sequence=1&isAllowed=y, 39.
[193] Joe Engelberger to Joseph K. Hawkins, Folder - Events, 1967, Box 1, Nils J. Nilsson Papers, SUSC.

## Chapter 4 — Jim Crow-bot: Automation, Industrial Relations, and the Welfare State

*The American Negro is caught in the cross-currents of technological change; he is in the transition not of one but two technological revolutions. He was once the solution to the white man's problem; today he is the white man's problem.*

Sidney Willhelm (1970)[1]

United Auto Workers (UAW) president Walter Reuther had a favorite parable he trotted out about automation. In 1953, while touring the Ford Motor Company's new and highly automated engine plant in Brook Park, OH, a Ford official pointed to some of the automatic machinery and asked Reuther, "How are you going to collect union dues from these guys?" Known for his charm and wit, Reuther apparently retorted, "How are you going to get them to buy Fords?" The tongue-in-cheek tussle is most likely apocryphal but Reuther never missed an opportunity to recount it.[2]

Like all parables, Reuther's was missing critical context. The suburban Cleveland plant, costing in excess of $150 million (an astronomical sum at the time), quickly became a showpiece

[1] Sidney M. Willhelm, *Who Needs the Negro?* (Schenkman Publishing Company, Inc., 1970), 138, emphasis in original.

[2] The exact language of the exchange is unknown, however, the quotes come from an interview of Reuther for a June 9, 1957 episode of CBS's *See It Now* on the topic of automation, "See It Now: Automation (June 9, 1957)," 10:56-11:32, https://www.youtube.com/watch?v=beHgLH8zM9c&t=4026s. The exchange is recounted as, "'You know, Walter, not one of these machines pays union dues.' To which Reuther shot back, 'And not one of them buys new Ford cars, either,'" and attributed to Ford vice president Malcolm Denise and UAW president Douglas Fraser in Nelson Lichtenstein, *The Most Dangerous Man In Detroit: Walter Reuther and the Fate of American Labor* (University of Illinois Press, 1997), 291 and 511 fn 65. One of the earliest paraphrases of the exchange I've found in the documentary record is Bill Lane, "people places 'n' situwayshuns," *Michigan Chronicle* (Apr. 2, 1955), 30 who repeated the anecdote in the same column on May 26, 1956 and Feb. 22, 1958.

of the auto industry. Engine production located at Ford's landmark River Rouge plant in Dearborn, MI was shifted to Brook Park upon the plant's completion in 1951. Beyond any increases in production efficiencies, the shift had significant consequences for workers at the Rouge, one of the primary labor destinations for African Americans from the South during the Great Migrations north of the early-to-mid twentieth century. Henry Ford, unlike his competitors, willingly hired African Americans, and by the end of World War II, Ford was the largest employer of black workers in the Detroit metro area. Similar to the pattern in other industries, black workers at the Rouge were assigned to the worst jobs (which, in short order, would prove to also be the most automatable jobs) and experienced discrimination in discipline, pay, and seniority. In response, the Rouge's UAW Local 600 became one of the most militant in the industry. As Ford shifted engine production from Dearborn to Cleveland, employment at the Rouge dropped off a cliff from 54,000 in 1954 (three years after the Brook Park plant opened) to 35,000 in 1960, which significantly weakened Local 600's power.[3]

Automation in Cleveland, therefore, had second-order effects in Detroit. For the Big Three, automation was a boon to not only their bottom line but also served, in historian Thomas Sugrue's words, as a "weapon in the employers' antilabor arsenal."[4] For black workers, it not only jeopardized their jobs but eroded their already limited and precarious political power in the union, both of which would eventually have far reaching consequences for their communities and the nation as a whole. For the rank-and-file more generally, automation was a particularly knotty problem: It reduced a number of dangerous and undesirable jobs while increasing living standards; however, it also created increasing monotonous work and facilitated the speedup

[3] Thomas J. Sugrue, *The Origins of the Urban Crisis: Race and Inequality in Postwar Detroit* (Princeton University Press, 2005), 132.
[4] Sugrue, 131.

while also holding out the threat of 'technological unemployment.' Union leaders and the UAW International had a fraught relationship with automation as well: it proved economically beneficial for the workers who retained their jobs and continued to pay their dues but it proved politically contentious as disciplining and managing a workforce under threat was no easy task while union power, itself a function of membership size and vibrancy, was threatened by the proliferation of technoliberal machines. And while Reuther's parable is no doubt memorable, one can only wonder if he asked himself, "How will my black workers buy Fords if they don't have jobs?" or "How will I buy a Ford if I don't have a union?"

Automation emerged on the UAW's radar and the union's analysis of it, and in particular "robots," discursively reinscribed the language of capitalist social relations and technoliberalism into their engagement with the phenomenon. This was critical in terms of the political economy of 'production standards'—the who, what, when, where, why, and how of work on the shopfloor—that structured the UAW's relationship and response to automation. In short, because the "Treaty of Detroit" linked standard of living increases for the rank-and-file to productivity growth—the latter of which was a function of more productive human labor and/or more productive technology—in exchange for the UAW effectively surrendering their power to shape production standards, the International incentivized the speedup and allowed the Big Three to essentially 'automate-at-will.' This had significant consequences as the speedup was the primary grievance of the rank-and-file while automation made their lives, and therefore the union's power base, more precarious.

Predictably, Black workers who bore the brunt of the speedup were also the first to lose their jobs to automation and the chapter will discuss how black autoworkers grappled with automation before turning to how Black civil rights and labor leaders translated their experiences

with automation into the realm of national politics. Automation, therefore, became an explicit site of political contestation in the shaping of the welfare state during the 1960s. In the process, race also became an explicit domain of political contestation as national leaders across the ideological spectrum were well aware of the disproportionate effects automation was having on Black communities. This was particularly the case for John Snyder, CEO of automation manufacturer U.S. Industries, became essentially the only member of the business community to provide a critique of automation and proffer solutions to technological unemployment similar to that of the activist, intellectual, and labor communities. For Snyder, the connection between automation and the civil rights movement was obvious, and in his estimation, it was the federal government's responsibility to forcefully address the inequality generated by America's "preponderance of productivity."

How dedicated the Kennedy and Johnson administrations were to prevent what chairman of the Council of Economic of Economic Advisers (CEA) Walter Heller called the "human fallout" of automation, rather than simply containing it, is debatable. Where both administrations were dedicated to the *political* enfranchisement of African Americans—by force if necessary—*economic* enfranchisement was left to "the market" and the welfare state's response to automation in the form of mitigating its negative effects was relatively ineffectual. Furthermore, both administrations also hemmed in calls to challenge the business community's "right to manage" automation as they saw fit as, in Johnson's words, "We could not provide our great shield for the security of this country and the shield for the security of the free world if we did not have automation in the United States."[5] Finally, the chapter will return to the auto industry to

[5] Lyndon B. Johnson, Remarks Upon Signing Bill Creating the National Commission on Technology, Automation, and Economic Progress. Online by Gerhard Peters and John T. Woolley, The American Presidency Project https://www.presidency.ucsb.edu/node/241917.

analyze how the UAW, with these broad structures of production standards and welfare in place, dealt with the looming threat of robotization at the end of the 1960s. While robots became an active force in UAW's negotiating plans, when it came to production standards, it was *plus ça change, plus c'est la même chose.*

**Mechanical Slaves on the Line: Automation, Robots, and the UAW**

Automation's origins in the auto industry meant that the United Auto Workers (UAW), perhaps the most influential and powerful labor union in the country during the Cold War, became a driving force in shaping not just labor's, but the broader public's, conceptualization of and response to automation. The fear of technological unemployment and workers having to compete with mechanical slaves were prominent themes in UAW discussions and publications. Rather than contesting the conceptual foundations and normative assumptions of automation, the UAW's intelligentsia and the International accepted and reproduced the arguments and language of technoliberalism. For the UAW, automation was inevitable, and their goal was not to retard technological development but to harness it for the benefit of their membership.

Before the UAW leadership and the rank-and-file grappled with what automation was and how they would respond to it, they first wrestled with robots. While the image of the job-stealing robot was pervasive in the 1930s, the robot didn't appear in a widely read UAW publication until August 11, 1941. It was then that CIO publicity director Len De Caux told members that predictions of mass-production factory methods making "robots out of human beings" had "reckoned without the CIO" and "through union organization, human nature has to a

large extent triumphed over the machine."[6] Solidarity, therefore, was a key to staying human in an age of advancing technology. 'The robot' as a synecdoche of industrial technology soon evolved into a more concrete rather than metaphorical issue. A month after Ford unveiled "automation" to the world in November 1948, CIO editor and publicity director Allan L. Swim predicted that "the United States appears to be entering a 'robot' era which will have as much effect on the nation as did mass production." Essentially repeating 'automatic factory' rhetoric, he warned that this "robot era" was not a pipedream but a probability, and because managers had a history of trying "to treat production workers like machines," there was every indication they would fight "against the adjustments that will be necessary before society as a whole can benefit from 'push-button' manufacturing and processing operations?" As a result, "It's time for trade unions to do a bit of hard, sound thinking about the probable consequences of 'robot' production," and while there would be serious problems, "the answers to them will not lie in fighting against technological development. To buck progress is stupid."[7]

In 1949, the same year Walter Reuther began his private correspondence with Norbert Wiener about the threat automation posed to workers and the UAW leadership began internally discussing the issue. Hollace Ransdell wrote a review of Irving Howe and B. J. Widick's new book *The UAW and Walter Reuther* which, echoing De Caux earlier sentiment, quoted the authors as observing that the UAW had "brought a sense of human warmth into an area dominated by robots, pistons and dollars."[8] The point was reiterated the following year when William Weiss argued that management treated workers like "The Tramp" in Charlie Chaplin's

[6] Len De Caux, "Looking Ahead," *CIO News*, Vol. IV, No. 32 (Aug. 11, 1941), 4.
[7] Allan L. Swim, "You Just Push A Button And--," *CIO News*, Vol. 11, No. 51 (Dec. 20, 1948), 4.
[8] Hollace Ransdell, "'UAW and Walter Reuther': A Flesh and Blood Story of the CIO Auto Union," *CIO News*, Vol. XII, No. 41 (Oct. 17, 1949), 9 and Kevin Boyle, *The UAW and the Heyday of American Liberalism, 1945–1968* (Cornell University Press, 1998), 95.

1936 iconic satire of the auto industry *Modern Times*. Via the "speedup" or "stretchout"—what Weiss described as "the methods by which workers were forced to work harder and harder, to put out more and more effort in the same amount of time"—management had fueled "burning resentment of autoworkers at being considered mere robots," which was a "major factor in the beginning of unionization in the automobile industry."[9]

The CIO's intelligentsia had automation on their radar years before they publicly addressed its existence. Public recognition of automation finally came on April 24, 1950 in an unattributed article that implored CIO members "you'd better learn how to spell and pronounce the word at the top of the column—if you don't already know—because you're likely to hear a lot about it in the future." That word: automation. The "newest production science in industry," the writer(s) quoted the *New York Times*, could reduce employment while increasing production which "isn't news to CIO unions whose members have become victims of 'automation.'" It was once again made clear that "the CIO has never been known as an organization that sought to halt technical developments," however, automation could create "a problem that can reach serious national proportions unless something is done about it." Suggesting that there wasn't "a simple answer or that we even have the answer," it was recognized that study of the issue was necessary to formulate a solution.[10]

One of the first attempts at a solution came from Local 600 of the UAW at Ford's River Rouge plant and their fight for a thirty-hour work week at forty-hours pay, or what was called the "30-40" movement. According to historian Jonathan Cutler, 30-40 "attracted a broad-based movement of Black militants, along with Irish, Italian, and Polish skilled tradesmen, and a broad

[9] William Weiss, "A Page from Labor History: Robot-Like Treatment Sparked Auto Union," *CIO News*, Vol. XIII, No. 13 (Mar. 27, 1950), 10.
[10] "'Automation,'" *CIO News*, Vol. XIII, No. 17 (Apr. 24, 1950), 4.

array of semi-skilled mass-production workers, all of whom supported the demand as a progressive response to the challenge of automation and the threat of technological unemployment." Cold War politics, however, sapped the life out of 30-40 as Walter Reuther and his allies both inside and outside the UAW fought the issue—originally put forward by the Communist faction in Local 600 and which had widespread support in the rank-and-file—in favor of other solutions such as the guaranteed annual wage (GAW) and supplementary unemployment benefit (SUB) expansions that, in their estimation, could actually be won at the bargaining table.[11]

Communicating the problem of automation to members must have seemed less than imperative for the CIO leadership as the next mention of it in *The CIO News* didn't come until more than four years later. In the interim, however, the CIO continued to harp on the image of the robot. In January 1952, highlights of a statement given by United Steelworkers of America (USWA) president Philip Murray's to a special panel of the Wage Stabilization Board, then a part of the Office of Defense Mobilization, castigating U.S. Steel president Benjamin Fairless and steel industry executives more generally

> They would prefer a steel industry without workers, but composed only of robots— for robots do not talk back; robots do not make demands for wages or improved working conditions; robots do not grumble when overworked; robots do not resist each new act of in-plant aggression by cold-hearted management. But America is not a country of robots —let us thank God for that.[12]

On the following page, a cartoon of a "Robot Steelworker"—the invention of which satirically was attributed to Benjamin Fairless—had text boxes with arrows pointed to various parts of the

[11] Jonathan Cutler, *Labor's Time: Shorter Hours, the UAW, and the Struggle for American Unionism* (Temple University Press, 2004), quote from 6.
[12] "'Our Case Is Sound, Our Demands Are Justifiable'—Murray," *CIO News*, Vol. XV, No. 2 (Jan. 14, 1950), 3.

robot with phrases such as "Doesn't Think," "Doesn't Talkback or Grumble," "Works Constantly—No Vacation," "Doesn't Hear Union Talk," "Doesn't Eat—Or Wear Clothes," and "Discarded As Junk—Can Be Replaced Cheap."[13] Eight months later in September, a piece titled "The Day of Robot Factory Is Just Around Corner" summarized an article in *Scientific American* on "automatization" and included a carton of corporate executives seated around a table (one with a prototypical cigar in his mouth) while one standing exasperatedly proclaimed, "Gentlemen, We're Ruined. Our Laboratories Have Just Developed A Machine To Replace Management!"[14]

That automation was not mentioned at all in the *CIO News* during 1953 is particularly surprising as the phenomenon made its first appearance in congressional hearings on revisions to the Taft-Hartley Act that March and became an unavoidable political issue between the leadership and rank-and-file within the UAW. The context of this first mention in an official Congressional hearing was the UAW-CIO's concern about how the National Labor Relations Board (NLRB) would take into account the degree of automation in relation to determining the boundaries of a union's bargaining unit (i.e., the craft, occupational, or geographic distinctions of a local union's workforce). The union argued that the integrated nature of mass-production industries, particularly in the age of increasing automation, lent itself to plantwide units rather than splintered units, therefore, collective-bargaining patterns should match production patterns. As they put it, "A work stoppage among 15 maintenance electricians can cause the shutdown of a plant employing 2,000 people. That is not a healthy industrial relations situation, nor conducive to industrial peace."[15]

[13] "Patent Pending!" *CIO News*, Vol. XIII, No. 17 (Apr. 24, 1952), 4.
[14] "The Day of Robot Factory Is Just Around Corner," *CIO News*, Vol. XV, No. 36 (Sept. 8, 1952), 12.
[15] *Taft-Hartley Act Revisions, Part 1*, Hearing before the Committee on Labor and Public Welfare, 1953, 378.

That automation could essentially recast the legal and political nature of industrial relations further evidences the social power it entailed. More concretely, a month before the hearings, Alfred Granakis, president of Local 1250 at the Ford Brook Park engine plant in suburban Cleveland, wrote a letter to Reuther expressing that he was "greatly distressed and deeply concerned about the problem of automation." Referring to it as "an economic 'Frankenstein,'" Granakis was even more worried that the monster he "helped create in its infancy" as a result of local bargaining agreements with local management would set a terrible precedent. "It is my opinion," Granakis predicted, "that troubled days lie ahead for Labor, and certainly [I] do not wish to contribute anything, however small, to an already aggrieved matter." Reuther responded quickly to Granakis and assured him that a three-man special committee including UAW-CIO vice president Richard Gosser was already scheduled to study the problem of automation but they apparently dragged their feet. At the UAW convention the next month, Granakis rose and spoke in favor of an automation resolution and, after declaring that "I am representing more machines than I am men in Cleveland," he implored Reuther and the Executive Board to formulate a policy that locals could put into practice.[16]

Like the broader pattern in American society, discussion of automation in the UAW and the labor movement more generally skyrocketed in 1954, the same year George Devol patented what is popularly conceived of as the first industrial robot. While robots made cameos in April and June in the *CIO News*, Ransdell's September 13 article on automation and robots was the most extensive in the labor press to date.[17] The article contained all the trappings of the

[16] Steve Meyer, "'An Economic 'Frankenstein'": UAW Workers' Responses to Automation at the Ford Brook Park Plant in the 1950s," *Michigan Historical Review*, Vol. 28, No. 1 (Spring 2002), quotes from 63-64 and 74. Later that year, perhaps in response to Granakis's public pressure, Reuther took his famed tour of the Brook Park engine plant.
[17] "He Means McCarthy—City Slicker From Appleton' Taken Apart By Bishop Sheil," *CIO News*, Vol. 17, No. 16 (Apr. 19, 1954), 7 and "CIO Joins Battle Against GOP's Drive To Cut Vocational Schools," *CIO News*, Vol. 17, No. 23 (June 7, 1954), 7.

automation discourse: “Automatic factory,” “second industrial revolution,” and “robot machines.” It quoted Del Harder describing automation as “a new concept, a philosophy, of manufacturing,” while Walter Reuther declared “our struggle is not to stop machines. Our struggle is to see to it that the workers get the benefit of these better machines and the more efficient techniques that develop in industry.” Ford’s Cleveland engine plant was discussed as well as automation in the chemical, electrical, meatpacking, and oil industries and about a third of the two-page spread was dedicated to “The Age Of Robots Long Predicted,” which introduced readers to the robots of science fiction and the cybernetics of Norbert Wiener.[18]

“The word robot,” the article explained, “taken from the play [*R. U. R.*] has become a familiar term in the language and today is used often as another word for automatic control, automation, push button labor, ‘electric brains,’ and other terms adopted to talk of the marvels of modern production methods.” Capek was described as being “concerned with the degradation of the worker who seemed, in the development of mass production and the assembly line, in danger of being turned into a machine by the repetitive, monotonous functions of his job,” however, the reality in science fact was that machines were becoming more human. While the problems of machines replacing humans was not new and the progression of this was gradual:

> Even if they don't happen all at once on an extensive scale, such changes can cause great misery to individuals caught in them helplessly and unaware. A man who loses his job without warning because an automatic machine has been installed in his plant, may suffer as much anguish as one whose home has been destroyed by a flood or hurricane, yet he is not likely to get any public sympathy or help. He is left to adjust himself and his family as best he can. This may mean selling his home at a loss, taking his children out of school, moving to a new town and a new industry and losing his accumulated seniority and pension benefits.

[18] “Tomorrows Factories Are Here Today With Automation—So Are New Problems For Labor,” *CIO News,* Vol. 17, No. 16 (Apr. 19, 1954), 6-7.

As a result, "if left to run wild," the 'second industrial revolution' would prove much like the first, which destroyed workers' skills and therefore the livelihoods those skills provided. The article closed by quoting Wiener's *The Human Use of Human Beings*: "We must not be serfs, written down as property in the books of our entrepreneurs. We need a system in which variability and adaptability are at a premium and not a discount . . . . If man is to continue to exist, he must not be an afterthought to business."[19]

Similar sentiments were soon being expressed outside of the CIO and UAW, particularly in relation to the solution of a shorter workweek. In October, the United Electrical, Radio and Machine Workers of America in their bi-monthly newsletter the *UE News* first officially mention of automation and argued that the "second industrial revolution in production techniques through the development of automation and the automatic factory" made the fight for a shorter workweek without a reduction in pay a "necessity" as the "productivity figures hardly as yet register the full impact of automation and other technological changes."[20] Similarly, in November, the first official mention of automation in the American Federation of Labor's monthly newsletter *The American Federationist* argued that the "effects of automation must be taken into account" if the thirty-hour workweek was to be won.[21]

A month later in October 1954, the UAW began its first institutional engagement with automation. Led by director of UAW's Research and Engineering Department Nat Weinberg and chaired by Jack Conway, administrative assistant to UAW-CIO President Walter Reuther, the short-lived UAW-CIO Committee on Automation (or "Automation Committee" for short) was the internal response to the growing concern about automation's effects at the point of

[19] "Tomorrows Factories Are Here Today With Automation—So Are New Problems For Labor," *CIO News*, Vol. 17, No. 16 (Apr. 19, 1954), 6-7.
[20] "Convention Resolutions: UE Delegates Map Fight for Jobs," *UE News*, Vol. XVI, No. 20 (Oct. 11, 1954), 2.
[21] "The A.F. of L. Convention," *American Federationist*, Vol. 61, No. 11 (Nov. 1954), 18.

production, on the UAW's power base, and in American society more generally. In their preliminary report, the committee focused on what they called "Immediate Collective Bargaining Problems," which took the form of wage rates and job classifications, two of the major determinants of mobility and remuneration in the union. As the report relayed, "Existing classifications and wage structures are becoming increasingly obsolete because of the extreme changes in factory methods caused by automation." Additionally, "Our members must become accustomed to fight for the upward revision of rates based on new classifications for automated jobs . . . . [and] management must be brought around to the acceptance of the principle that automated and semi-automated jobs require new classifications and rates whether in new plants or old."[22]

The justification for such upward revisions came from the "changed nature of jobs," specifically the "reduction in physical effort and manual dexterity" of work processes that were offset by the increased responsibility of tending machines that required much greater investment (by the corporations) and produced much larger volumes of output (i.e., automation). The mere mention of even a seemingly innocuous technological change—such as a Harder speech to a non-UAW audience that briefly mentioned new air ejectors on stamping presses—automatically triggered reassessments about whether or not the use of such a device qualified a work process as semi-automated or automated, and what effects this would have on wage and job classification systems.[23] While the transformation of "traditional workloads" by technology was the primary topic of discussion, the "manpower requirements . . . . being drastically changed by automation"

[22] "Preliminary Report of the UAW-CIO Committee on Automation," Oct. 20, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, Walter P. Reuther Library, Wayne State University (hereafter WRL), 1-2.
[23] "Preliminary Report of the UAW-CIO Committee on Automation," Oct. 20, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 1-2.

were still deemed a serious and immediate problem by the Automation Committee.[24] As Conway bluntly put it in a speech the following year:

> When management makes decisions to 'automate' production, it becomes necessary for workers through their union to 'automate' the wage, classification and seniority structures in the plants. Just as old machinery becomes obsolete in the new technology, so do wage rates, job classifications, seniority groupings, and wage payment methods. These too must be modernized, and the task is not easy. It will become the subject matter for hundreds upon hundreds of collective bargaining meetings of the future, in factory after factory, large or small, from one end of our land to the other.[25]

Furthermore, the preliminary report candidly identified the macroeconomic aspects of these processes in language that the UAW rarely used publicly: "Until recently the post-war expansion of the market has concealed the fact that far fewer men are now needed to turn out the same production. Not only has there been a reduction in the number of those workers directly affected by automation such as machine operators, foundry men, and press operators, but the indirect effects have spread throughout the plants reducing the numbers required to turn out each unit of production in such groups as sweepers, inspectors, clerks, and office workers."[26]

The network effects of automation, therefore, not only reduced employment at the point of production but rippled out from the immediate jobs automated. Once again, a major point of contention in responding to automation was the rank-and-file's support of 30-40. While the committee's report expressed support for the shorter workweek, that support was made provisional on two explicit factors: first, "the rate of acceleration of productivity advances," and

[24] "Preliminary Report of the UAW-CIO Committee on Automation," Oct. 20, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 1-2
[25] Jack Conway, "Labor Looks at Automation," Apr. 13, 1955, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 8.
[26] "Preliminary Report of the UAW-CIO Committee on Automation," Oct. 20, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 1-2.

second, "the degree to which our growing productivity potential is utilized." As the section discussing automation and the short week concluded, "True timing of the fight for the shorter workweek depends, in major part, on the behavior of those who will own the new tools of potential abundance."[27] Furthermore, the UAW was well aware that the ownership of these tools was being subsidized by the American state. As Hollace Ransdell argued in the third of his series of articles about automation: "Undoubtedly impetus has been given to these plans [to automate] by lower corporation taxes, quick tax write-offs for plant expansion, give-away programs and other favors bestowed by the Republican big business Administration."[28] Nonetheless, the political fight for the GAW remained the UAW leadership's top priority as it represented the "most essential element of the needed security structure [that would] also serve as a regulator of the process of technological change."[29] The Big Three's ownership of automation technologies, the public subsidization of this capital, and their power to manage production standards (discussed below) remained essentially unchallenged by the UAW leadership.

While automation understandably dominated the conversation, the UAW's first institutional engagement with robots, though it would prove brief and superficial, also emerged from the Automation Committee's work. A well-designed and well-written pamphlet simply titled "Automation" presented the committee's findings to its membership at the UAW-CIO Economic and Collective Bargaining Conference in November 1954. While there was little new in the brochure that wasn't already in the committee's preliminary report, it included some of the

[27] "Preliminary Report of the UAW-CIO Committee on Automation," Oct. 20, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 6.
[28] Hollace Ransdell, "Tomorrow's Factories AreHere Today—GOP Policies Speed Drive For Automation," *CIO News*, Vol. 17, No. 45 (Nov. 8, 1954), 6. The issue of tax breaks and incentives appeared throughout the volume: Gervase N. Love, "Reuther Wraps Lower Taxes At Top As House Cuts Most Excise Rates" (Mar. 15, 1954), 2; Press Associates, "GOP Tax-Favors Bill Near Senate Floor Fight" (June 21, 1954), 3; and "Issues In The Election-In The Matter Of Give-Aways, GOP Sure Kept Its Promises" (Oct. 11, 1954), 5.
[29] "Preliminary Report of the UAW-CIO Committee on Automation," Oct. 20, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 4.

first references to robots in official UAW literature. *U.S. News & World Report* quoted a Ford spokesman in which he (most likely Harder) declared that automation "greatly increases the need for electricians, mechanics, pipe fitters, tool makers and others skilled enough to do maintenance work on the mechanical slaves."[30] The bargaining committee even felt it was necessary to include terms such as "Cybernetics" and "Robot" in the glossary. According to the brochure's authors, cybernetics was the "science of robots" and the "Robot" could be defined as a,

> Mechanical device that behaves like a man. Any mechanical device that replace a man. Comes from a Czech word meaning slave. Was first used to mean mechanical man in a play by Karel Capek, famous Czech playwright. The play is about a world that ends in disaster because robots which replace human beings as workers and soldiers are used for profit and power and not for the good of mankind.[31]

This definitional framing was important as the robot's imagined capacity to displace workers for the purposes of capital accumulation and managerial control was yoked to the experience of automation in real time. When combined with Harder's foregrounding of good jobs related to robot maintenance, the UAW's definitional boundary work built a bridge between science fiction and science fact to galvanize its membership's fears of automation to remind them of the union's role as a bulwark against potential displacement and as a facilitator of upward mobility.

Whether coincidentally or in order to counter the UAW's "Automation" pamphlet, the National Association of Manufacturers produced their own pamphlet, titled "Calling All Jobs: An Introduction to the Automatic Machine Age," that same month. Unlike the UAW's pamphlet,

[30] "Automation: A Report to the UAW-CIO Economic and Collective Bargaining Committee," Nov. 12-13, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 23 and 37, emphasis added.
[31] "Automation: A Report to the UAW-CIO Economic and Collective Bargaining Committee," Nov. 12-13, 1954, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 23 and 37.

which was long (almost forty pages), text heavy and, because it was produced for their membership, delved into much more of the day-to-day experience of automation and the technical details of collective bargaining, the NAM brochure was short (less than twenty pages), cartoon heavy, and spoke in generalities rather than details for its much broader audience. The "Foreword" of the brochure linked growing population, growing demand for jobs, and growing living standards—"Today's luxuries will be tomorrow's necessities"—to technology, what they called "the Aladdin's lamp of industry." "Can we have wonderful and more efficient machines and jobs in increasing numbers at the same time?" the brochure rhetorically asked. "The history of industry says we can, the practice of industry says we will," it answered. The body of the brochure provided a sweeping history of technology and its relationship to abundance, lauding the brilliance of Eli Whitney and enlightenment thinkers including Benjamin Franklin and Jean-Jacques Rousseau while decrying the "Frankenstein Complex" that drove Luddism and the "father of socialism" Karl Marx who, of course, was "loud in his condemnation of machines . . . . and described them as the soul of capitalistic exploitation." "Machines do destroy jobs," the brochure proclaimed but this was a good thing. When automobiles replaced horse-drawn buggies, teamsters and draymen "practically became extinct" by 1930 and, by 1950, "we had almost two million chauffeurs in their place. What abundance!"[32]

"Automation" and "cybernetics" came in for a scolding as well as it was becoming "difficult to separate industrial fact from science fiction." According to the brochure, there were two schools of thought on the history of automation: "One will have you believe we stand on threshold of a brave new world that will have us knee-deep in pesky robots before we know it.

[32] National Association of Manufacturers, "Calling All Jobs: An Introduction to the Automatic Machine Age," Nov. 1954, Folder - Automation Committee, 1954-1964 (4 of 8), Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 2-8.

The other supports the thesis that industrial machinery has undergone a continuous process of improvement which has been most pronounced in the last six or seven decades." Not surprisingly, from NAM's perspective, "the weight of the evidence appears to support the second view." In the midst of discussing the development and use of computers and numerically controlled machine tools, the brochure described robots as "brainless but bright" and argued that workers need not worry as "All man has to do is stay smarter than a machine!" The brochure concluded: "Automation is a magical key to creation, not a blunt instrument of destruction, and the worker's talent and skill will continue to merit reward in the fairyland of the world to come."[33] When Jack Conway acquired the brochure, he sent it to the Automation Committee and commented, "It is a smooth presentation in which the attempt is made to convey the impression that automation automatically raises standards of living unless, as the NAM puts it, there is 'misfeasance' by man." He also suggested that, although the committee's report refuted "most of the fallacious arguments" presented, they should familiarize themselves with it nonetheless.[34]

That same year, Reuther was called to testify at Congressional hearings to discuss the *Economic Report of the President* (1954) where he focused his remarks on the entanglement of automation and economic development broadly. He framed his comments in terms of how macroeconomic fluctuations could be moderated by better balancing capital investment in new technology and expansion of consumer purchasing power, and he used Ford's Cleveland Engine plant as an example of the integration of electronics into the production of automobiles to illustrate his point. After the Second World War, Ford (and the auto corporations more generally)

[33] National Association of Manufacturers, "Calling All Jobs: An Introduction to the Automatic Machine Age," Nov. 1954, Folder - Automation Committee, 1954-1964 (4 of 8), Box 45, UAW President's Office: Walter P. Reuther Records, WRL, 9-20.
[34] Jack Conway to Members of the Automation Committee, May 16, 1955, Folder - Automation Committee, 1954-1964 (4 of 8), Box 45, UAW President's Office: Walter P. Reuther Records, WRL.

expended capital on electronics to increase productive capacity, which decreased the time it took to machine an engine block from 24 hours to 14.6 minutes. Reuther declared, "We call it automation now" and claimed "You ought to go through the new Ford engine plant. You can't find the workers." The auto industry, therefore, could produce eight million cars but the focus on investment rather than on consumer purchasing power produced only five million customers. Furthermore, Reuther charged that the imbalance between productive power and purchasing power was being tilted in favor of capital by the administration. Nevertheless, he made sure to clarify that labor was *for* automation with the proviso that "the people get the benefit of it" as "the only way American workers can have more things is if they help produce more things" and "the more productive tools we have the more we can create and the greater the prosperity we can share with other people."[35]

The following year's *Economic Report of the President* once again did not directly reference automation and, in response to business's pushback to labor's critiques of capital's management of automation, Reuther became much more publicly vocal about the politics of the issue in early 1955. The *New York Times* declared that "Reuther Assails Robot-Job Trend" in February and quoted him directly chastising the Eisenhower administration for not just its inaction at a policy level but for a lack of even acknowledging problems related to automation even existed.[36] Reuther's "attack" on the report, according to the article, was primarily a function of the administration's "avoidance of any mention of this tremendous potential for rapid economic growth and improved living conditions" and its failure to provide any analysis about the "probable temporary dislocations arising from automation." As he described it, "the

[35] *January 1954 Economic Report*, 83rd Congress, 2d sess, Joint Committee on the Economic Report of the United States, Washington, DC: U.S. Government Printing Office, (Feb. 1954), 772-773.
[36] "Reuther Assails Robot-Job Trend," *New York Times*, Feb. 11, 1955, 46. A similar story titled "Automation Can Pose Unemployment Problem CIO's Reuther Warns" appeared the same day in the *Wall Street Journal*.

administration is selling the American people short, that its petty, half-hearted economic programs are based on a hypnotic preoccupation with statistical indices of the long-run past, rather than with the tremendous strides toward economic abundance that present American technology and ingenuity are making possible." In short, the administration was "living in a little dream world."[37]

Jack Conway, anticipating that pushback would continue and spread, drafted a form letter stating the UAW's pro-automation position that could easily be sent with a copy of the Automation Committee's first report to any publication claiming the opposite.[38] A month later, Reuther was back in the headlines and this time, in a letter to President Eisenhower, he was demanding Secretary of Labor James Mitchell apologize for the false accusation that "'some scaremongers' were trying to "frighten automobile workers with the bogeyman of automation," which couldn't be further from the truth.[39] The charge of scaremongering was repeated in a *Los Angeles Times* op-ed in August where Reuther and the CIO were accused of being "in the midst of a campaign to control introduction of automation through negotiations as well as political means."[40] Not surprisingly, therefore, when Reuther was called to testify before the "Automation and Technological Change" hearings in October, his prepared statement included a short section titled "Organized Labor Welcomes Automation" which, based on the Q&A after his opening statement, turned out to be a non-issue. Nevertheless, a report about the hearing the same day in the *Wall Street Journal* only foregrounded Reuther's critical comments about automation and a

[37] "Reuther Assails Robot-Job Trend," *New York Times*, Feb. 11, 1955.
[38] Jack Conway, untitled letter, Mar. 17, 1955, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL.
[39] "Reuther Insists Weeks Apologize," *New York Times*, Mar. 13, 1955, 77.
[40] "Automation: Reuther's Blind Spot," *Los Angeles Times*, Aug. 13, 1955, A4.

*New York Times* story the following day, while providing a rather balanced, if tepid, summary of Reuther's testimony, did not mention his assertive support of automation.[41]

Over the next decade, the Automation Committee and the International continued to grapple with the Catch-22 of automation. The International routinely reassured their membership and the public that they were not against automation. As Conway told a Canadian audience at the beginning of 1956, "Workers do not oppose automation. We do not fear the automatic machine. We welcome better tools that take the danger and drudgery out of our work."[42] At a congressional hearing in 1958 on the macroeconomics of the auto industry, Reuther unequivocally stated:

> We [the UAW] have been standing on the housetops saying, 'Give us the best automation you can bring it, give us the most productive tools,' because we know that the only way we can have more is to make more, and the only way you can make more is to have more productive tools. We have been leading the parade for automation. We want automation . . . . We want the best tools that General Motors can buy. We want the most productive automation machinery that General Motors, Ford, and Chrysler can create.[43]

And, in his typical style, Reuther pithily captured the seeming inevitably of this: "You know, King Canute couldn't stop the flow of the tide, and labor can't stop the flow of technology."[44]

Leadership of the UAW, and more broadly the CIO, were therefore much more measured in their assessment of automation and their communication about it to both their membership and the broader public than business was willing to admit. Nevertheless, the pigeonholing of labor as

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[41] "Reuther Testifies Today in Joint Congressional Automation Hearing," *Wall Street Journal*, Oct. 17, 1955, 6 and Joseph A. Loftus, "Reuther Expects 4-Day Week by '65," *New York Times*, Oct. 18, 1955, 61.
[42] Carol L. Coburn to Jack Conway, February 18, 1956, Folder - Automation - General (UAW Research Department) 1956-67 (1of2), Box 43, UAW Research Department, WRL, 2-3.
[43] *Administered Prices (Part 6, Automobiles)*, 88th Congress, 2d sess, Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary United States Senate, Washington, DC: U.S. Government Printing Office, (1958), 2325.
[44] *Administered Prices*, 2325.

'anti-automation' continued apace. What these episodes demonstrate is the *reactive* nature of the UAW's response to automation—capital moved and labor moved with it. Critically, this reactivity was essentially baked into the political economy of the auto industry in the moment when automation was revving up, which further naturalized its "inevitability." This was technoliberalism par excellence as the very notion of standing in the way of automation (i.e., capital) was akin to standing in the way of the future and the benefits that would flow from "progress."

**Forces of Production Standards: The Unequally Automated Workers**

The key mechanism that structured the UAW's response to automation came in the form of what were called "production standards"—the who, what, where, when, why, and how of the productive process. Control of production had long animated the contentious, and sometimes violent, clashes between the American labor movement and corporate America's insistence on its "right to manage."[45] For the auto industry, the 1940s proved a pivotal moment of these struggles, the results of which structured how the union would respond to automation. In 1940, to avoid even the semblance of joint control over production with the UAW, GM insisted upon contractual language declaring management's right to determine what to produce, when to produce, where to produce, how to produce, and whom to produce with. This clear-cut claim of managerial prerogatives was further ensconced by a clause in the 1941 UAW-GM contract, known thenceforth as "Paragraph 78," maintaining local management's authority to determine

[45] David Montgomery, *Workers' Control in America: Studies in the History of Work, Technology, and Labor Struggles* (Cambridge University Press, 1979) and Howell John Harris, *The Right to Manage: Industrial Relations Policies of American Business in the 1940s* (The University of Wisconsin Press, 1982).

"production standards"—the nuts-and-bolts of the productive process including the work tasks (or 'content') of a job, the time allotted for each task (or 'cycle time'), the organization and scheduling of tasks and jobs, and critically, the technologies with which these would be completed with.[46]

The contractually codified legal language of production standards, in historian Nelson Lichtenstein's characterization, "remained the fortress from which General Motors would defend its power," and if the UAW ever attempted to breach this semantic stronghold, "the struggle would have to be waged by nothing less than 'revolutionary means.'" In management's eyes, Paragraph 78 was not just a contract clause but an "ideological manifesto reflecting a world-view that saw in the natural rhythms of the factory an inherently hierarchical and authoritarian social order"—one only they had the right to sit atop of and dictate.[47] By the end of the 1945-46 strike, GM further fortified their "right to manage" when the UAW and then president of the union Walter Reuther made a strategic decision to tie the union's fate to the industry's. This arrangement proved to be a pillar of the post-WWII system of "workplace contractualism" whereby union leadership negotiated national and local agreements over shopfloor rights, specified the rules for challenging and adjusting them, and channeled worker grievances over shopfloor problems into a multi-layered and well-defined bureaucratic structure.[48]

As sociologist C. Wright Mills identified in 1948, labor leaders such as Reuther had become, among other things, "managers of discontent" and their organizations, including the UAW, were managed in military fashion as business enterprises "supplying a labor force."[49]

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[46] 'Production standards' are known in other industries as 'work practices' or 'work rules.'
[47] Lichtenstein, *The Most Dangerous Man In Detroit*, 142.
[48] Nelson Lichtenstein, "UAW Bargaining Strategy and Shop-Floor Conflict- 1946-1970, *Industrial Relations* (Sept. 1, 1985), 362-363.
[49] C. Wright Mills, *The New Men of Power: America's Labor Leaders* (Harcourt, Brace and Company, Inc., 1948), 3 and 9.

Two years later, the famous 1950 UAW-GM contract—called the "Treaty of Detroit" for establishing "labor peace" through a no-strike clause between contract years—solidified these relationships and extended them to Chrysler and Ford, thereby, in effect, denaturing "labor's most potent weapon"—the strike.[50] Daniel Bell, then *Fortune* magazine's in-house labor intellectual, assessed the agreement in the following way: "GM may have paid a billion for peace. It got a bargain . . . . [they] regained control over one of the crucial management functions in any line of manufacturing—long range scheduling of production, model changes, and tool and plant investment"—in short, production standards.[51] Rather than fight over these production standards at the national level, the UAW relegated itself to the fight over issues primarily related to labor's share of income, ranging from wage gains in the form of the "annual improvement factor" and "cost of living adjustments" (COLA) to broader benefits including healthcare, pensions, and unemployment insurance. As Nelson Lichtenstein described it, bargaining on production standards was devolved to a local plant-by-plant basis, "so as to sever as much as possible the link between shop-floor problems and national wage and benefit issues," which were centralized within the union and remained the crucial link in the UAW-Big Three alliance.[52]

The UAW's leadership, in effect, turned the union into an organization that would *react* to automation rather than actively shape its design and management. The union's commitment to what came to be called "Reutherism"—a broad political-economic strategy of bolstering material benefits through productivity-induced economic growth—translated into a political capitulation over production standards, which meant the UAW was, for better or worse, a junior partner of the Big Three. Such support made practical sense as the International and the rank-and-file

[50] Steve Meyer, "An Economic 'Frankenstein": UAW Workers' Responses to Automation at the Ford Brook Park Plant in the 1950s," *Michigan Historical Review*, Vol. 28, No. 1 (Spring 2002), 67.
[51] Daniel Bell, "The Treaty of Detroit," *Fortune*, Vol. XLII, No. 1, July 1950, 53.
[52] Lichtenstein, "UAW Bargaining Strategy and Shop-Floor Conflict- 1946-1970," 376.

imagined productivity gains as the outcome of either squeezing more work out of each worker or technological "progress." The former of these, which was conceptualized and routinely referred to as the "speedup," had long been the primary grievance of rank-and-file workers on the shopfloor and therefore the primary point of contention between local management and local unions. In practice, operationalizing the Reutherist strategy meant that UAW leadership committed itself to essentially managing locals on behalf of the Big Three to facilitate productivity increases via technological change, which had been hardwired into the UAW-GM collective bargaining agreement of 1948 in Section 101(a):

> The annual improvement factor provided herein recognizes that a continuing improvement in the standard of living of employees depends upon technological progress, better tools, methods, processes and equipment, and cooperative attitude on the part of all parties in such progress. It further recognizes the principle that to produce more with the same amount of human effort is a sound economic and social objective.[53]

The "Treaty of Detroit" only solidified the UAW's commitment to productivity *in these terms* and set the rules of engagement around the evolving nature of employment, production standards, and technology for the remainder of the postwar era. It was within this evolving milieu of politics and production standards that automation emerged and eventually took center stage in the auto industry and American society more broadly.

While the UAW's de facto surrendering of production standards to the Big Three after the 'Treaty of Detroit' led to relative silence on those standards' role in shaping automation and the union's response to it, Reuther did foreground them during his congressional testimony. After directly quoting Section 101(a) of the 1948 UAW-GM collective bargaining agreement and noting its inclusion in the existing contract, he argued, "It is quite obvious that automation

[53] Alfred P. Sloan, Jr., *My Years with General Motors* (Doubleday and Company, Inc., 1964), 398.

affects the skills, job security, earnings, and working conditions of the employees. Therefore, it is ever present at the collective-bargaining table. Adjusting the content of the collective-bargaining agreement to the changes caused by automatic production methods is a most important responsibility of management and labor."[54]

Nonetheless, while they continued to grapple with the Catch-22 of automation, over the next decade the UAW's Automation Committee and leadership continued to acquiesce to management's control of production standards and remained stalwart in their support of technological "progress." To better understand what this Catch-22 entailed and track the evolution of automation, Weinberg developed a sophisticated taxonomy of displacement as a result of "technological advance in general and, in aggravated form, from automation." At a 1956 speech on productivity given in London, he laid these out:

> 1) "external displacement," where a worker is separated from employment (the traditional measure of technological unemployment and, in Weinberg's estimation, "the only one recognized by those bent on minimizing the problem")
>
> 2) "internal displacement," where a worker is deprived of a job but retained by the company in another
>
> 3) "competitive displacement," one firm automates and becomes more competitive thereby causing competing firms to automate-in-kind or cut costs which leads to job losses
>
> 4) "opportunity displacement," the economy-wide shrinkage of jobs

And, Weinberg reminded his audience, "automation makes more valuable than ever our right to strike at any time over so-called 'production standards' . . . . through effective use of this right

[54] *Automation and Technological Change*, 84th Congress, 1st sess., Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report Congress of the United States, Washington, DC: U.S. Government Printing Office, (1955), 156.

we can prevent reductions in the labor force greater than are warranted by the automated installation."[55] The potential amelioration of automation's negative externalities, therefore, was primarily a function of labor-management relations, the power dynamics of which determined that labor could *react* to automation but not have a direct say in its management.

The UAW's leadership also went out of their way to continually reassure their membership and the public that they were not against automation. When combined with the UAW's commitment to productivity as the engine of material gains, the "union's overall approach reflected a technological determinism," Lichtenstein argues, "that saw productivity growth as an autonomous process divorced from the character of class relations."[56] In more programmatic terms, the qualified support for automation internally and unqualified support for it externally shaped the Automation Committee's reports for collective bargaining rounds in 1957, 1961, and 1964 and the UAW leadership's approach to shaping union policy which essentially reiterated positions held in the 1954 round—decisions to automate were left to the Big Three and their plant managers, while the UAW and their locals split the privilege of bargaining to alleviate the negative effects of automation on and off the shopfloor.[57]

Reuther and the UAW's relegation of production standards to the Big Three in favor of linking material benefits to automation-induced productivity growth proved a conundrum and a contradiction. On one hand, if rank-and-file wages remained low, the Big Three would have little incentive to automate as human labor would remain cheaper than its mechanical counterpart. Productivity and wage gains, therefore, would stagnate as only so much work could be squeezed

[55] Nat Weinberg, "Practical Approaches to the Problems Raised by Automation," May 15-18, 1956, Folder - Automation - by Nat Weinberg - Dir. Research Dept. 1955, Box 44, UAW Research Department, WRL, 3-4.
[56] Lichtenstein, *The Most Dangerous Man In Detroit,* 290.
[57] Various documents, Folder - Automation Committee, 1954-1964, Box 45, UAW President's Office: Walter P. Reuther Records, WRL.

out of so many workers. Additionally, the UAW would be failing the rank-and-file and would be risking their power base, which was dependent on membership numbers and the power of these numbers to disrupt production. On the other hand, if rank-and-file wages continually increased, the Big Three would have an incentive to automate, which would putatively increase productivity and, in turn, fuel the engine of wage growth.

For the UAW, this created a serious problem: Their membership would benefit from increasing wages but the International risked the erosion of union power due to displacement from automation. The devil's bargain of linking material benefits to productivity meant harder work for someone—or something. Whether that work was done by a man or a machine and what kind of man, machine, or combination thereof, was a technopolitical product of labor-management relations at the international and local levels. And perhaps most controversially, the UAW—from the president at Solidarity House on the Detroit River to the production worker on the River Rouge—had, in purely economic terms, a vested interest automating jobs away or being the victim of a "speedup" when automation failed to live up to its promise (which it often did).

Who faced the speedup and who would be at greater risk of technological displacement remained obscure in the broader discussion of automation, and this was particularly the case in the auto industry, which had a stark racial division of labor. In the early twentieth century, Southern and Eastern Europeans, as well as White workers from the South, shared with their Black comrades the "meanest and dirtiest jobs."[58] But as the twentieth century progressed, the boundaries of Whiteness expanded to incorporate non (or partially) "white" Europeans. By the late 1930s, as historian Kevin Boyle describes it, "many white autoworkers had used their

[58] Sugrue, 91-124.

newfound bargaining power to institutionalize the auto industry's traditional color line, which relegated African-Americans to a narrow range of low-paying and undesirable jobs." This was accomplished by barring blacks from apprenticeship programs, bargaining units, and skilled classifications as well as using the more informal practices of harassment, intimidation, and unequal enforcement of labor-management rules to prevent their entrance into the upper-echelons of the rank-and-file.[59]

Regarding access to this "world of the aristocracy of labor," longtime autoworker and labor journalist B. J. Widick recounted about the skilled trades, "blacks were able to make only token progress, in spite of various campaigns or commitments by Walter Reuther and the UAW," as "biases against black promotions or transfers or upgrading were a built-in feature of the restrictive seniority systems and other clauses in the contract."[60] In historian Robert Ziegler's assessment, "skilled white autoworkers proved to be even more effective than the notorious building trades in freezing blacks out of apprentice programs and desirable, high-wage jobs."[61] Bureaucratization stalled and stifled attempts to combat discrimination and Black workers interpreted the union's Fair Employment Practices Department, established in 1946 to enforce anti-discrimination, as "ceremonial and symbolic."[62] As described by Shelton Tappes, a member of Local 600 at Ford who worked in the department during the 1950s and 1960s, "We are a fire station…and when the bell rings we run to put out the fire."[63] From the perspective of many Black workers, therefore, the UAW was little different from the Big Three. Automation, and later robotization, only exacerbated these realities. Like the contractual cul-de-sac of production

[59] Boyle, 113.
[60] B. J. Widick (ed.), *Auto Work and Its Discontents* (The Johns Hopkins University Press, 1976), 56-57.
[61] Robert H. Zieger, *For Jobs and Freedom: Race and Labor in America since 1865* (The University Press of Kentucky, 2007), 199.
[62] Herbert Northrup, *The Negro in Automobile Industry* (University of Pennsylvania Press, 1968), 54
[63] Quoted in Robert Korstad and Nelson Lichtenstein, "Opportunities Found and Lost: Labor, Radicals, and the Early Civil Rights Movement," *The Journal of American History*, Vol. 75, No. 3 (Dec., 1988), 808.

standards that codified who would control automation, collective bargaining agreements were structured to channel black workers into the worst and most automatable jobs, which limited their advancement on the shopfloor and made upward mobility into the "labor aristocracy" extremely difficult.

A sort of labor feudalism, therefore, reigned in the auto industry, and it was black workers who first began identifying the connection between automation and production standards with their subjugation on the assembly line. Two of these, Charles Denby and James Boggs, were particularly outspoken about the racial realities of automation and its corresponding relationship to who controlled production standards and contributed to the Detroit-based newspaper *Correspondence* in 1953. The publication, co-founded and edited by C. L. R. James and Raya Dunayevskaya, became a hotbed of Marxist theory and included a 'Special Negro News' page that published contributions from black workers whose voices were often suppressed by McCarthyism. The paper was dedicated to theorizing and being a passive conduit of its readers' submissions rather than serving as both a political organ and platform for organizing. Eventually fed up with this position, about half the staff of *Correspondence*, led by Denby, broke off and founded their own paper in 1955. That year, when autoworkers commenced "the Detroit wildcats against Automation," Denby (pen name of autoworker Simon Owens) began publishing *News & Letters* to recount and distill the black labor experience on the shopfloor and advocated for organizing off it.[64]

[64] Quoted in Terry Moon and Ron Brokmeyer, *Then and Now: On the 100th Anniversary of the First General Strike in the U.S.* (News and Letters Committees, 1977), 50. For the history of how *News & Letters* emerged from political struggles within the black Marxist movement in Detroit, see Rachel Peterson, "*Correspondence*: Journalism, Anticommunism, and Marxism in 1950s Detroit" in Robbie Lieberman and Clarence Lang (eds.) *Anticommunism and the African American Freedom Movement: Another Side of the Story* (Palgrave Macmillan, 2009), 115-159 and Stephen M. Ward (ed.), *Pages from a Black Radical's Notebook: A James Boggs Reader* (Wayne State University Press, 2011), 37-41.

The paper was explicitly ecumenical in its approach to covering labor issues from workers' perspectives and included columns for reader's letters, women's and youth issues, and a section dedicated to "Negro News." In the very first issue, an article castigated Reuther for letting the Big Three control production by "allowing unreasonable scheduling of overtime and unreasonable production standards." Los Angeles based GM worker in a section dedicated to reader's letters declared that 30-40, rather than the GAW, was the only thing worth fighting for in the face of automation.[65] The following month, Denby lamented in his regular column that the speed of the assembly used to be set by foremen, maintenance men, and shop stewards but now only foremen were doing so as "production standards [were] taken away from [workers], with the union leaders helping the company do it and firing or threatening those workers who resist."[66] One reader's letter in the same issue argued that because hours and work conditions were workers' primary concern, a political platform was needed that would "cut across the divisions of skilled and unskilled" to create solidarity for the thirty-hour work week, which was a "necessity for all now that automation is here."[67] "The heart of the contract is production standards, the right to strike and the company's right to disciplinary measures," another worker observed, "the company would concede anything and everything but this."[68]

For the rest of the 1950s, *News & Letters* continued to argue that the International's lack of fight over production standards, and thereby automation, played a decisive role in facilitating poor working conditions, long hours, and the speedup, all of which were increasingly borne by the industry's black workforce. In October 1956, an editorial titled "The Reality of Automation"

[65] Jerry Kegg, "The Union Isn't What it Used to Be," *News & Letters*, June 24, 1955, 3 and GM Worker, Los Angeles, "Reader's Views," 4.
[66] Charles Denby, "Worker's Journal," *News & Letters*, July 22, 1955, 1.
[67] Fisher Body Worker, Detroit, "Reader's Views," *News & Letters*, July 22, 1955, 4.
[68] Stefan, "Experiences and Expectation," *News & Letters*, July 22, 1955, 8

detailed how this played out at Chrysler, which proportionately had the largest number of Black workers of the Big Three. After a model change, the company began giving workers warning slips and threatened layoffs for not producing enough even though production standards had not yet officially been set. In the interim, time-study engineers were "hiding and spying and secretly working out some fantastic standards on the basis of brief and disguised observation." When the new standards were set at fifty jobs an hour, more than could be completed even without breaks, this not only violated the struggle-won informal practice of giving workers six minutes off each hour (which was still a "brutal and killing pace") but revealed the inhumanity of the automation-driven assembly line.[69] The "Negro News" and "Reader's View's" sections of every issue were filled with similar firsthand accounts of discrimination and overwork, while Denby's column routinely provided a synoptic analysis of the worker's plight and the need for class and racial solidarity in the rank-and-file to overcome the International's junior partnership with the Big Three. In a March 1957 issue recounting the last ten years of "The Reuther Machine," one article was emphatic about the core issue: "WHO will control production standards in the factory: workers or labor bureaucrats in cooperation with management?"[70] Without such control, an article in June that year argued, workers would be stuck in "robot factories" that would turn them into "robot people."[71] For Denby's comrade and fellow autoworker James Boggs, such results were predictable as union leaders "should have known how dirty the company would be and how it would use automation against the men."[72]

One of the most extensive treatments of the black experience with automation came in a November 1960 *News & Letters* pamphlet written by Denby titled "Workers Battle Automation."

[69] "The Reality of Automation," *News & Letters*, October 30, 1956, 4.
[70] "Two Worlds: New Passions & New Forces," *News & Letters*, March 19, 1957, 5, emphasis in original.
[71] Angela Terrano, "The Working Day," *News & Letters*, June 18, 1957, 3.
[72] James Boggs, "The Weakest Link in the Struggle" in Ward (ed.), 57.

A major sticking point of the pamphlet was the connections among automation, unemployment, and "inhuman" working conditions. As Denby charged, "The intellectual—be he scientist, engineer or writer—may think Automation means the elimination of heavy labor. The production worker sees it as the elimination of the laborer. Not being in a factory, the intellectual may think that the worker in Automation is being turned into a technician. The production worker, however, knows this simple truth: when he is not thrown into unemployment, he is subjected to the inhuman speed of the machine." Automation, for the worker, had a "life-and-death meaning" characterized by its death by overwork, its unemployment, its permanently depressed areas, its ghost towns."[73] The day-to-day nature of automation in the automobile, steel, and mining industries, therefore, meant excruciating working conditions. Each industry had its own section with subsections headings including "Not to Lighten Labor, But To Speed It Up" regarding steel or "The Continous Mine Is a Man-Killer" regarding coal.[74] The most provocative of these, however, came in the automotive section that Denby knew best: "To Break Our Spirits," "We Don't Have Concentration Camps, Yet," "Death by Automation," and "Urine as Red as Blood," all of which described the physical, mental, and emotional toll of overwork.[75] Black workers were literally putting their bodies on the line for 'productivity' and 'progress.'

Like many of his columns in *News & Letters*, Denby castigated "labor bureaucrats" for their positions on automation. One target in particular was John L. Lewis of the United Mine Workers, who in 1949-1950, "enthusiastically endorse[d] the use of 'the automatic coal miner' as 'progress,'" and Reuther's call to workers that they "must not fight progress" in 1954. "It is time," Denby declared, "to expose the lie behind the fancy talk of 'every worker an engineer,'"

[73] Charles Denby, "Workers Battle Automation," *News & Letters*, Nov. 1960, 7.
[74] Charles Denby, "Workers Battle Automation," *News & Letters*, Nov. 1960, 31 and 38.
[75] Denby, "Workers Battle Automation," 17-18.

which was as "phony as the talk about 'prosperity." Such rhetoric obscured the fact that increased production was not matched by a decrease in the "army of unemployed" and, because the "contract assures management increased productivity by robbing the workers of control over the conditions of labor," automation would guarantee a steady reservoir of recruits and overwork those who remained.[76] As Denby argued, "Reuther talks about the need for re-training workers to meet 'the challenge of Automation.' I've been re-trained. I'm working on an Automation machine. What kind of re-training is that? I have never worked under such brutal conditions before. He certainly can't mean re-training to become the kind of technicians that do nothing but push buttons and get good pay doing it. There are very few of these jobs and less will be needed as we get fully automated."[77] The fight against automation was therefore a fight against management, a fight against the "labor bureaucracy," a fight against long hours and low pay, and a fight against the degradation of work and displacement of jobs. To win these fights required a renewed commitment to wildcat strikes, organization building outside of the traditional bounds of the labor movement, international solidarity, and most importantly for Denby, the road to a "new society can begin in no other way than by changing the conditions of labor, which means, in the first place, control of production."[78]

Boggs voiced similar sentiments about automation and the control of production in his 1963 long essay *American Revolution: Pages from a Negro Worker's Notebook*. For Boggs, automation's transformation of production was more "radical than any since the introduction of the assembly line," and the four million black workers hired into the "bottom jobs" automation

[76] Denby, "Workers Battle Automation," 8.
[77] Denby, "Workers Battle Automation," 51.
[78] Denby, "Workers Battle Automation," 48-54

targeted were particularly vulnerable.[79] The effects of automation, however, went far beyond simply displacing workers. In his estimation, automation revealed the feebleness of the CIO specifically and unions more generally, and their acquiescence to the capitalist mode of production. "*The fact, the key to the present situation, is that from the beginning the union did not take absolute control away from the capitalists*," Boggs declared, which meant that "the union itself has therefore become incorporated into all the contradictions of the capitalist system and is today fulfilling the same functions for the American state as the Russian trade unions do for the Russian state."[80] Crucially, the role of the American state in the transformation of production was paramount and critics (including fellow Marxists and liberal trade unionists) had missed a key dimension of the political economy of automation:

> What they have failed to recognize is that it is not private capital as such which is introducing automation. The great bulk of the capital invested in automation today comes from the government and is paid for by every member of the American population, whether he is a worker, a member of the middle class, or rich. This is all done in the name of research and defense, but, whatever it is called, the benefits are as great to the capitalists as if they had put out the capital themselves. Thus the capitalists have found a way to get around the high cost of automation as well as the high cost of scrapping still productive machinery.

Furthermore, the Kennedy administration was also cultivating automation "by granting subsidies to companies who go full speed ahead on it, both directly and in the form of tax write-offs." In other words, supply-side technoliberalism. Nevertheless, the same administration was waging a political fight to set up new committees to study the problems engendered by automation, revealing an obvious contradiction: With one hand the American state was encouraging the

[79] James Boggs, *American Revolution: Pages from a Negro Worker's Notebook* (Monthly Review Press, 1963), 16 and 23.
[80] Boggs, 28, emphasis in original.

technological displacement of workers, while with the other it was trying to figure out how to clean up the mess such displacement created. The struggle against management's control of production therefore was a much greater challenge than it seemed. As he characterized it, "when workers fight the introduction of automation, they are not only taking on private capitalism but the federal government itself."[81] To win this fight, Boggs declared, "a social revolution in the United States has to mean control of production by the producers."[82]

The issues of automation and race were obviously not limited to the auto industry. While Denby's *News & Letters* and Boggs' *American Revolution* were relatively niche Marxist publications engaging with the nuts-and-bolts of the issues from the perspective of the local and the shopfloor, the broader relationships they charted between automation and black workers were being echoed by labor and Civil Rights leaders and began appearing more and more frequently in the black press. In 1955, *Los Angeles Sentinel* labor columnist William Pollard informed readers that A. Philip Randolph, organizer of the first black-led union the Brotherhood of Sleeping Car Porters and then a prominent Civil Rights leader, received a standing ovation after positing a program for combatting the racial disparities of automation during his keynote.[83] The following year in the *Cleveland Call and Post*, black candidate for Ohio's twenty first congressional district (and the paper's editor) Charles H. Loeb published an article outlining his "labor platform" that called for greater job security protections, expanded opportunities for technical and apprenticeship training, and the shorter work week without reduction in pay, all in response to the "advances of automation."[84] Similarly, in his weekly column, Bill Lane of the *Michigan Chronicle* warned in 1958 that "with automation destined to grow instead of die, it is becoming

[81] Boggs, 38-39.
[82] Boggs, 44.
[83] William E. Pollard, "Labor's Side," *Los Angeles Sentinel*, June 2, 1955, A9.
[84] Charles H. Loeb, "Loeb Makes Pledge to Support Labor Aims," *Cleveland Call and Post,* Sept. 22, 1956, 4A.

more and more imperative for the average worker—and especially the Negro worker—to polish up his knowledge of doing a job."[85]

Randolph became one of the most prominent black labor leaders to speak publicly on the issue of automation and racial discrimination. At a 1959 speech to the Trade Union Leadership Council (TULC), Randolph foregrounded the precarious position of the black worker amidst the "revolution of automation" and, in technoliberal fashion, predicted that "as automation proceeds apace with the challenge of the space age, industrial job classifications will change and workers will have to be trained and equipped to fill these new industrial needs." Furthermore, he cautioned, if protections against discrimination remained weak and unenforced and better education and vocational training were not forthcoming, the black worker's "economic and social status will worsen, resulting in their possible transformation into slum proletariat and feudalistic peasants - fertile soil for Communist dogma."[86] Perhaps in response to Randolph's outspokenness, AFL-CIO president George Meany lashed out at him during the federation's annual convention later that year, exclaiming: "Who the hell appointed you as the guardian of all Negroes in America!" Randolph diplomatically responded after to the *New York Amsterdam News* that while he held no ill will towards Meany, "time is important to Negroes in labor in ending of discrimination because of automation" as the struggle against racial disparities in job hiring, progression, and security was a "fight for economic survival."[87] Meany, however, was a force to be dealt with, and two years later Randolph had no choice but to plead with him and the AFL-CIO's Executive Council (which Randolph was a member of) to take action:

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[85] Bill Lane, "people places 'n' situwayshuns," *Michigan Chronicle*, Mar. 29, 1958, C8.
[86] A. Philip Randolph, "The Role of the Negro Worker in the American Trade Union Movement and the Problem of Racial Discrimination," Feb. 7, 1959, Folder: 001445-009-0420, Papers of the NAACP, Part 16: Supplement, Board of Directors File, 1956-1965, Proquest Historical Vault (hereafter, PHV), 11 and 13.
[87] James Booker, "'I've No Apology'; Meany: Labor Leader Stands By Insult To Negroes," *New York Amsterdam News*, Oct. 10, 1959, 1.

> This plight of the Negro workers is certain to grow worse with the march of radical technology or the automation revolution. This adverse economic position of Negro workers, as reflected in a disproportionate number of Negro workers on relief in the various metropolitan sections of the nation, tends to divert this mass of workers into a sort of black laboring mass slum ghetto. This is a condition which is not only harmful to Negro workers and their families but to all workers, as well as the national community as a whole.

Nevertheless, after reminding Meany and the Executive Council that the former had lent his moral weight to the fight against Communism in trade unions as well as the merger of the AFL with the CIO, Randolph declared that the failure of racial advancement in the union was "basically due to the fact that the President of the AFL-CIO, George Meany, has failed to place the moral weight of his office back of the Civil Rights Committee and Civil Rights Department" (which had the institutional authority to address such discrimination).[88] Whether Meany responded to Randolph's accusation is unknown. For comparison's sake, when Martin Luther King, Jr. also addressed the same convention and warned that "In the next ten to twenty years automation will grind jobs into dust as it grinds out unbelievable volumes of production," but did not directly accuse the AFL-CIO or its president of discrimination, Meany proclaimed "I am sure it would be superfluous for me to tell Dr. King we appreciate his address. I am sure everyone here is moved by his splendid outline of a philosophy for human rights and human decency. We appreciate beyond words his presence here and his most stirring address on a subject dear to our hearts."[89]

[88] Randolph to Meany, Oct. 9, 1961, Labor, Folder: 001608-019-0429, Papers of A. Philip Randolph, PHV, 5 and 8.
[89] Doctor Martin Luther King, Jr., *Proceedings* of the Fourth Constitutional Convention of the AFL-CIO, Miami Beach, Fla., December 7-13, 1961 in Philip S. Foner, Ronald L. Lewis, and Robert Cvornyek (eds.), *The Black Worker, Volume 8: The Black Worker Since the AFL-CIO Merger, 1955-1980* (Temple University Press, 1984), 186 and 188.

Beyond the broader dimensions of automation and the narrower issues of intra-union politics, Randolph was also keenly aware of how control of technology via production standards became a key determinant of Black workers' relationship to automation. At the September 1962 convention of the Brotherhood of Sleeping Car Porters, Randolph argued, after noting the recently liberalized capital depreciation guidelines that incentivized the railroads to invest in new, modern equipment, that "labor could not if it would, and would not if it could, stop the march of science and industrialism manifested in the revolution of automation and radical technology, yet the question as to whether automation is an immediate promise or menace to the workers cannot and should not be evaded by trade unions, management, and government." In terms of the railroad industry specifically, Randolph observed that "the whole life and future of a worker and his family should not be at the mercy and arbitrary decision-making of Management alone, whose major interest is the cold business of reducing costs of operation in order to boost profits for an impersonal corporate entity."[90]

Management's control of production standards, therefore, was a driving force of why workers were vulnerable to automation. In response, Randolph argued, "There should be some machinery for joint control of Labor and Management over the rate of job abolition which would help and not hurt the rate of efficiency of operation and improvement" as well as the shorter workweek and job protections.[91] Unlike Denby and Boggs' call for *worker* control of production, Randolph's "machinery for joint control" meant the upper echelons of labor and management would retain power over production standards rather than the rank-and-file. Randolph would

[90] "Address by International President A. Philip Randolph to the Fourth Triennial Convention of the Brotherhood of Sleeping Car Porters," Sept. 10, 1962, Folder: 001608-029-0165, Papers of A. Philip Randolph, PHV, quotes from 14-16.
[91] "Address by International President A. Philip Randolph to the Fourth Triennial Convention of the Brotherhood of Sleeping Car Porters," Sept. 10, 1962, Folder: 001608-029-0165, Papers of A. Philip Randolph, PHV, 22.

argue much the same over the next three months in speeches such as "The Transition of Black Labor from Slavery to the Twentieth Century" and "The Struggle of Black Labor for Status in the Revolution of Automation," declaring to the Negro American Labor Council in November, "The crisis confronting the Negro worker today can be summed up in one word: Automation."[92]

Bayard Rustin of the Southern Christian Leadership Conference (SCLS) became increasingly outspoken about automation and race as the Civil Rights Movement was reaching its apex in the early 1960s. "The American economy is setting the Negro up for the devastation that is automation," Rustin wrote, "it is as if he were designed for it." The occupational distribution of black workers and the corresponding unemployment rates of those occupations led to one conclusion: "If the color of every Negro skin was changed overnight, but his occupational distribution remained unchanged, the rate of unemployment among Negroes would remain substantially the same." This demonstrated that the issues of segregation and discrimination were only the tip of the iceberg and the deeper structural nature of society had to be examined. "Precisely as our society is taking down the 'White Only' sign," Rustin observed, "it is threatening the mass of Negroes and other minorities with the most profound form of segregation yet devised: Separation from the economic life of a country." Therefore, "the technological revolution has trapped the Negro," making upward mobility from an unskilled job to a management position no longer possible. As a result, he argued, "This society will get nowhere until it recognizes once and for all that Horatio Alger is dead." For Rustin, solutions to the automation crisis would entail a federal jobs program, public works programs, education and training but he made no mention about the control of production or technology.[93]

[92] Quote from A. Philip Randolph, "The Transition of Black Labor from Slavery to the Twentieth Century," Nov. 9, 1962, Folder: 001608-029-0165, Papers of A. Philip Randolph, PHV, 13.
[93] Bayard Rustin, "Automation and the Negro," n.d. (c. 1963), Folder: 001581-018-0377, Bayard Rustin Papers, PHV, 6 and 14.

Automation and race found its largest platform in the August 28, 1963 "March on Washington for Jobs and Freedom." Germinating from A. Philip Randolph's "March on Washington Movement" from two decades prior and partially funded by the UAW, the "March on Washington for Jobs"—the event's original title before it was rebranded—proximately emerged from a suggestion by Rustin and fellow Civil Rights activist Tom Kahn to bring together the nation's leading African-American organizations for a two day demonstration in Washington, D.C. to "protest both racial injustice and 'the economic subordination of the American Negro.'"[94] When Rustin drafted the preamble for the march, he included automation in two of the five major points for the march's motivation. Arguing that the current crisis was structural in nature, he observed that thousands of workers had been "rendered economically functionless in modern industrial society" by automation and that Black workers bore the brunt of this as "automation has attacked precisely those unskilled and semiskilled jobs to which Negroes have traditionally been relegated."[95] For Rustin, therefore, racism fueled inequality but automation was the engine that drove it.

It wasn't only Black workers and leaders who spoke on the racial inequalities automation generated. Herbert Hill, born to a White Jewish family in Brooklyn, New York and who graduated from the New School of Social Research after studying under Hannah Arendt, rose to prominence as a critic of racial discrimination in unions after being appointed labor director of the National Association for the Advancement of Colored People (NAACP) in 1951. By the turn of the next decade, Hill was becoming vocal about the occupational stratification of Black and White workers and the disproportionately negative effects automation was having on the former.

[94] Boyle, 176-177.
[95] Bayard Rustin, "Preamble to the March on Washington (1963)" in Devon W. Carbado and Donald Weise (eds.), *Time on Two Crosses: The Collected Writings of Bayard Rustin* (Cleis Press, 2003), 112-113.

"Today the status of the Negro wage earner is characterized by drastic change and crisis," Hill commented, "thus, the virtual exclusion of Negroes from apprenticeship and other training programs forces them to remain as marginal employees in the economy."[96] Similarly, social scientist Donald N. Michael, then director of planning and programs of the Peace Research Institute in Washington, D.C., noted in his 1962 pamphlet *Cybernation: The Silent Conquest*, "there is already an increasingly lopsided Negro-to-white unemployment ratio as the dock, factory, and mine operations where Negroes have hitherto found their steadiest employment are cybernated. This, plus the handicaps of bias in hiring and lack of educational opportunity, leaves Negroes very few chances to gain new skills and new jobs."[97] That same year activist and intellectual Michael Harrington argued in his landmark book *The Other America* that automation was destroying the "Negro 'type' of job" that had been the fount of integration over the past two decades, and the federal governments milquetoast response to this contributed to "rebuilding the wall of prejudice" and "destroying advances which have already been made." The mechanics of this amounted to a form of social automation as the economic segregation flowing from technological change "is immediate and automatic. It is done without the intervention of a single racist, yet it is a profound part of racism in the United States."[98]

Less than a year after the March on Washington, Black and White once again came together, this time to directly confront the president of the United States about the seriousness of the automation crisis. A group of activists, intellectuals, and labor leaders including James Boggs and Michael Harrington as well as economist Gunnar Myrdal, Students for a Democratic Society

[96] Labor Unions and the Negro-The Record of Discrimination - Herbert Hill (Dec. 1959), 17-19 and Herbert Hill, "Apprenticeship Training," *New York Amsterdam News*, Apr. 29, 1961, 7.
[97] Donald N. Michael, *Cybernation: The Silent Conquest* (The Fund for the Republic, Inc., 1962), 15.
[98] Michael Harrington, *The Other America: Poverty in the United States* (Scribner, 2012), 101 and 104-105 (pages refer to unpaginated Kindle edition).

president Todd Gitlin and member Tom Hayden, and scientist Linus Pauling formed what they called the 'Ad Hoc Committee on the Triple Revolution' to study the intertwined revolutions of "Cybernation" (i.e., a synonym for automation then in vogue), "Weaponry" (i.e., 'the bomb'), and "Human Rights" (i.e., the worldwide fight against racism and for civil rights). The report that emerged from the committee's work, called "The Triple Revolution" for short, argued that the economic, military, and social upheavals then underway required "public measures that move radically beyond any steps now proposed or contemplated."[99] According to the authors, the "Cybernation" revolution was, through unemployment, preventing "the Negro [from entering] a social community and a tradition of work-and-income which are in the process of vanishing even for the hitherto privileged white worker." Additionally, the "excessive levels of ["cybernation"-induced] unemployment would be multiplied several times" if the economic prop of defense spending was withdrawn. Furthermore, the "Weaponry" revolution "eliminated war as an acceptable method for resolving international conflicts," thereby putting pressure on the very prop holding up the economy. The "Human Rights" revolution was directly tied to the other two.[100] This confluence of forces necessitated a "new consensus" around cybernation that would harness it for the betterment of people rather than the industrial system, which "is no longer viable."[101]

To make the transition to a fully cybernated and humane society, the report proposed "massive" public programs for education, housing, and infrastructure that would need to be undertaken while the tax code would need to be made much more progressive. The management of the transition would take place through "the conscious and rational direction of economic life

[99] The Ad Hoc Committee on the Triple Revolution, "The Triple Revolution," (March 22, 1964), http://pinguet.free.fr/triplefac.pdf.
[100] "Triple Revolution," 2.
[101] "Triple Revolution," 4.

by planning institutions and democratic control" rather than privately managed. Surprisingly, the committee called for *more* not less automation as "the efficiencies of cybernation should be sought in the public as in the private sector, and a chief focus of planning would be bringing this about."[102] Collective bargaining was also still envisioned by the authors as the primary modality through which unions would negotiate welfare benefits with employers, and their call for more, not less automation still entailed management's 'right to manage' technology.[103] Worker control of production, which two years earlier Boggs was arguing as the core of any social revolution in America, was not mentioned once in the document.

What accounts for the disappearance of production standards from the conversation on automation? Like Walter Reuther and the UAW International, A. Philip Randolph, Bayard Rustin, and other leaders of the Civil Rights Movement must have intuited that advocating for workers' control of production was a bridge too far. While McCarthyism had passed, anticommunism was still a potent political force, and Marxist ideas such as a rank-and-file revolution that captured the 'forces of production' remained a political liability, particularly on the national stage. Furthermore, any solution to the automation crisis, no matter how radical or reformist, would require concerted action on behalf of the federal government. As Boggs observed, the "socialism" practiced in Washington, D.C. encouraged rather than discouraged more automation, and to move the ship of state required more not less allies in the capitalist halls of power.

**The Price of Progress: Containing the "Human Fallout" of Automation**

[102] "Triple Revolution," 6-7 and 12.
[103] The closest they came to challenging this prerogative was a proposal for the government to use its licensing power to "regulate the speed and direction of cybernation to minimize hardship," 6.

The federal government's conceptualizing and response to automation was a decidedly partisan affair. While the Congressional hearings about automation in the second half of the 1950s demonstrated how much of a concern 'technological unemployment' had become across the United States, these fears were routinely dismissed by experts within, and associated with, the Eisenhower administration. Little to no federal action was taken, therefore, to directly alleviate unemployment issues, whether automation induced or otherwise, during his two administrations. The President was well aware of such concerns and told one reporter in 1955 that automation "has been discussed habitually by my economic advisers, by others in the administration, and naturally I have listened and read on the subject."[104] As a result, in the "age of automation and the atom," as Eisenhower called the era in 1957, his ideological predisposition against "government intervention" in the economy (when "intervention" was not coded in terms of "defense" or "security") precluded substantive action to alleviate any of the negative short or long-term consequences of automation on part of the executive branch as, in his opinion, fears about technological unemployment were misplaced as automation was a "great advance . . . . that ought to be used."[105]

Where the executive did take direct action during the Eisenhower administrations was in surveilling the evolution of "automation" as a trackable discourse within the ideological worldview of its perceived enemies. The Federal Bureau of Investigation (FBI) published a semi-annual review called *The Communist Party Line* that provided analysis and summary of

[104] "The President's News Conference of March 16, 1955," *Public Papers of the President, Dwight D. Eisenhower 1955* (Office of the Federal Register, Jan. 1-Dec. 31, 1955), 334.
[105] "Address to the Republican National Conference, June 1957," *Public Papers of the President, Dwight D. Eisenhower 1957* (Office of the Federal Register, Jan. 1- Dec. 31, 1957), 457 and "The President's News Conference of April 2,1958," *Public Papers of the President, Dwight D. Eisenhower 1958* (Office of the Federal Register, Jan. 1- Dec. 31, 1958), 263.

Communist Party and 'fellow traveler' positions on major national and international issues based on quotations drawn from publications such as *Daily Worker* and *The Worker*.[106] A copy of each semi-annual review was mailed to the acting Special Assistant to the President with a personal (form) letter signed by J. Edgar Hoover.[107] Beginning with the May-August edition of 1955, "automation" became an official subsection of interest and was continually monitored over the next five years.[108] Not surprisingly, much of the discourse on automation the FBI flagged was run-of-the-mill critiques shared by commentators across the political spectrum regardless of their affiliation with the Communist Party. For instance, as the first summary of "automation" described it: "To cope with the rise in unemployment due to increased productivity and automation, the labor movement was urged to press for shorter work week and to organize the unorganized workers in the Southern States, Party propaganda also urged the passage of legislation setting the minimum wage at $1.25 an hour."[109] And even banal statements such as "automation must be used to benefit workers, not harm them," were judged representative of the "Communist Party line."[110] In this way, almost any apprehension about automation could be marked with the stigma of "subversion."

Unlike Eisenhower and the Republicans, the leadership of the Democratic party recognized by the end of the 1950s that automation could be positively leveraged as a political

[106] Robert E. Lester, *The Communist Party USA and Radical Organization, 1953-1960: FBI Reports from the Eisenhower Library* (University Publications of America, 1990), vii.
[107] Editions between 1953-1960 can be found by searching "communist party line" at PHV.
[108] Federal Bureau of Investigation, *The Communist Party Line, May 1955--August 1955* (Sept. 30, 1955), Folder - The Communist Party Line, May-August (Sept. 1955), Series - 1955, Collection - The Communist Party USA and Radical Organizations, 1953-1960: FBI Reports from the Eisenhower Library, PHV.
[109] Federal Bureau of Investigation, *The Communist Party Line, May 1955--August 1955* (Sept. 30, 1955), Folder - The Communist Party Line, May-August (Sept. 1955), Series - 1955, Collection - The Communist Party USA and Radical Organizations, 1953-1960: FBI Reports from the Eisenhower Library, PHV, iii.
[110] Federal Bureau of Investigation, *The Communist Party Line, July 1958--December 1958* (Jan. 23, 1959), Folder - [The] Communist Party Line July-December (Jan. 1959), Collection - The Communist Party USA and Radical Organizations, 1953-1960: FBI Reports from the Eisenhower Library, PHV, 33.

issue. On the campaign trail, both presidential hopefuls, John F. Kennedy and Hubert H. Humphrey, gave dozens of speeches around the country in the leadup to the election foregrounding the problem of automation (though their descriptions and prescriptions differed little). In late May 1959, almost nine months before the then senator officially announced his candidacy, Kennedy put automation on the electoral map during the keynote address at the Jefferson-Jackson Day Dinner—an annual Democratic Party fundraising soiree—in Detroit, Michigan. After being introduced by Governor G. Mennen William, Kennedy chastised Republicans with being "the party of the status quo -- and today there is no status quo," while in contrast the "Democratic Party has traditionally been the party of peaceful revolution -- and today at least ten peaceful revolutions are rocking our nation and our world, reshaping our lives and remaking our destinies."[111]

One of these "revolutions" was automation. As Kennedy described it, "robot control systems replace workers in the mine, the mill, the factory and mines, railroads, automobile plants increasingly in the office. In coal mines, railroads, automobile plants, insurance companies -- in every kind of endeavor -- machine is replacing man -- and man is looking for work." According to Kennedy, the automation "revolution" was helping to create prosperity, high unemployment of over thirty-two million workers, "and a long list of distressed areas with chronic labor surpluses" accompanied it. Furthermore, he continued, the average unemployment check was paltry, the period during which it could be drawn was too short, and, by implication, the market was not adequately adjusting and investing in the communities (i.e., "distressed areas") automation left

[111] Remarks in Detroit at the Jefferson-Jackson Dinner, May 23, 1959, Folder: Address of Senator Kennedy, Jefferson-Jackson Day Dinner, Detroit, Michigan. " Ten Revolutions of Our Time ." May 23, 1959. 33pp, Series: Speech Files, 1953-1960, Collection: John F. Kennedy 1960 Campaign, Part 2: Speeches, Press Conferences, and Debates, PHV, 3 and 6.

behind. Nonetheless, he pontificated, "We rejoice in the wonders of automation."[112] Kennedy capped his comments on automation by framing the response to the socioeconomic degradation he just described in Cold War terms: "The Democratic Party believes in our programs of foreign aid and mutual security -- and we also believe in taking care of our own."[113] Like national security, therefore, the nation's welfare was also a responsibility of the American state.

Over the next year-and-a-half Kennedy continued to foreground what he called one of the "The Six Great Challenges of the Sixties" and "Seven Revolutions of Our Time"—automation. "From city after city, as Kennedy campaigned," public policy scholar James L. Sundquist relayed, "political leaders sent word to him: 'When you speak here, talk about unemployment and automation and especially the depressed area bill.'"[114] Automation, therefore, played some role, even if small, in Kennedy winning the Democratic nomination in July and then the presidency in November.[115] Kennedy's victory inaugurated a decade of social policy that, unlike the Eisenhower administrations, deliberately attempted to use the federal government as an instrument for managing the negative effects of automation.

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[112] Remarks in Detroit at the Jefferson-Jackson Dinner, May 23, 1959, Folder: Address of Senator Kennedy, Jefferson-Jackson Day Dinner, Detroit, Michigan. " Ten Revolutions of Our Time ." May 23, 1959. 33pp, Series: Speech Files, 1953-1960, Collection: John F. Kennedy 1960 Campaign, Part 2: Speeches, Press Conferences, and Debates, PHV, 3 and 6.

[113] Remarks in Detroit at the Jefferson-Jackson Dinner, May 23, 1959, Folder: Address of Senator Kennedy, Jefferson-Jackson Day Dinner, Detroit, Michigan. " Ten Revolutions of Our Time ." May 23, 1959. 33pp, Series: Speech Files, 1953-1960, Collection: John F. Kennedy 1960 Campaign, Part 2: Speeches, Press Conferences, and Debates, PHV, 3 and 6.

[114] James L. Sundquist, *Politics and Policy: The Eisenhower, Kennedy, and Johnson Year*s (The Brookings Institution, 1968), 72.

[115] General speeches, "The Six Great Challenges of the Sixties," n.d., Folder: "The Six Great Challenges of the Sixties," 5pp, Series: Speech Subject Files: General, Collection: John F. Kennedy 1960 Campaign, Part 2: Speeches, Press Conferences, and Debates, PHV, and General speeches, "Seven Revolutions of Our Time," n.d., "Seven Revolutions of Our Time." 6pp, Series: Speech Subject Files: General, Collection: John F. Kennedy 1960 Campaign, Part 2: Speeches, Press Conferences, and Debates, PHV. The five other challenges were population, the farm, the standard of living, and nationalism while the six other revolutions were population, the farm, the standard of living, weapons development ("the field of national security"), the underdeveloped nations of the world, and nationalism.

The first attempt at this was the successful passage of the Area Redevelopment Act (ARA) on April 30, 1961, which provided support for infrastructure, loans, technical assistance, and worker retraining (managed at the local or state level and at the behest of private enterprise) in economically depressed regions experiencing high unemployment. While automation was not directly referenced in the bill, it permeated the hearings that shaped the bill's form and function. In terms of worker retraining, the ARA prioritized providing assistance to trainees over thirty years old, those who were male-breadwinner heads of families, those with five years or more of "gainful employment," and those "reasonably expected to secure full-time employment in work relating to such retraining."[116] Therefore, due to discrimination in workplaces, structural or otherwise, eligibility for federally assisted vocational retraining privileged White male workers who were much more likely to fit these categories. Additionally, government-subsidized capital loans often incentivized outside entrepreneurs to relocate to depressed areas that were non-unionized and had low taxes where they would invest in labor-saving capital equipment and hire the already skilled.[117] Furthermore, in the post-mortem assessment of Sar Levitan and Garth Mangum, drafter of the ARA and staff director of the bill's shepherd in Congress Senator Joseph Clark, respectively, the act "became a zero sum game with one area's gains at another's expense, often to the net advantage of no one but opportunistic firms."[118] Rather than alleviating the problems of automation, the ARA was subsidizing their exacerbation.

While the ARA may have been a legislative success for Kennedy, it became obvious that the automation issue was not going away. And, while the administration was much more open to

[116] *Training of the Unemployed*, Hearings before the Subcommittee on Employment and Manpower, Committee on Labor and Public Welfare, 1961, 5.
[117] Examination of the War on Poverty, Parts 1-6 - Hearing before the Subcommittee on Employment, Manpower, and Poverty (U.S Senate, June 1967), 379.
[118] Sar A. Levitan and Garth L. Mangum, "Federal Human Resource Policy: From Kennedy to Clinton," Occasional Paper, Center for Social Policy Studies at The George Washington University (Feb. 1994), 57.

federal government action, it shared its predecessor's penchant for privileging private remediation of automation's ills. To accomplish this, Kennedy formed the federal government's first institutional response to automation in what would prove to be the short-lived Labor-Management Advisory Committee (LMAC). LMAC personnel included the secretaries from the Departments of Commerce and Labor and nineteen other members from the public and private sectors including industrial heavyweights such as Henry Ford II of Ford Motor Company, Thomas Watson, Jr. of IBM, president of the AFL-CIO George Meany, and UAW President Walter Reuther.[119]

Spearheaded by newly appointed labor secretary Arthur Goldberg, this "tripartite experiment," as political scientist Yongwoo Jeung characterized it, brought together business, labor, and the federal government "to address the intractable industrial conflicts of the 1950s" between labor and management over prices, wages, and automation.[120] Goldberg, the chief legal advisor overseeing the AFL-CIO merger in 1955 and general counsel to the USWA since 1947, brought a wealth of collective bargaining experience and expertise to the administration and modeled what would be called the LMAC on the USWA-Kaiser long range planning committee. Correspondingly, conceptualization of the issues as well as the political experiences of collective bargaining from the previous decade were reproduced in the committee's work.[121]

[119] President's Advisory Committee on Labor-Management Policy, "Appendix I" in "The Benefits and Problems Incident to Automation and Other Technological Advances," January 11, 1962, Folder: Labor [Department of] January 1962-February 1962. 66pp., Series: John F. Kennedy Memoranda to Departments and Agencies, Collection: President John F. Kennedy's Office Files, 1961-1963, Part 3: Departments and Agencies File, PHV, 10.
[120] Yongwoo Jeung, "Labor Market Policy American Style: State Capacity and Policy Innovation, 1959-1968," Ph.D. Dissertation, University of Oregon (March 2020) and "A U.S. Tripartite Experiment in the Kennedy Administration," *Polity*, Vol. 52, No. 1 (January 2020), 116–155.
[121] Other members included but were not limited to: Elliott Bell, editor and publisher of *Business Week*, Arthur Burns, CEA chairman during Eisenhower's first presidential term and thereafter president of the National Bureau of Economic Research, and Clark Kerr, president of the University of California.

The committee was formally tasked with studying automation (which became a synonym for "technological change" writ large) as a political and socioeconomic process and, in its first report to the president on January 11, 1962, laid out "three fundamental points" that framed its planned approach to the topic:

> 1) Automation and technological progress are essential to the general welfare, the economic strength and the defense of the Nation;
>
> 2) This progress can and must be achieved without the sacrifice of human values
> 3) Achievement of technological progress without sacrifice of human values requires a combination of private and governmental action, consonant with the principles of a free society.[122]

LMAC spent the next two years looking at how automation affected the economy, whether it generated an "army of 'unemployables,'" and what macroeconomic policy tools could be used and what private action could be taken to alleviate the technologically displaced.

The task, however, was not easy. Disagreement within LMAC about the nature of automation and unemployment initially hamstrung consensus building. In particular, Ford strenuously challenged the notion that automation *caused* unemployment and therefore the resulting need for the federal government to directly create jobs in the public sector was unwarranted.[123] Additionally, the macro-oriented Keynesians in the Bureau of the Budget (BOB) and the CEA shared Ford's distaste for micro-level employment programs and argued successfully that market-mediated aggregate-demand expansion via tax cuts would create jobs in

[122] President's Advisory Committee on Labor-Management Policy, "Report on automation from the Advisory Committee on Labor-Management Policy," Jan. 11, 1962, Folder: January 11, 1962. 59 pp., Series: Messages and Press Releases from the White House, Collection: President Kennedy and the Press, 1961-1963, PHV, 1.
[123] President's Advisory Committee on Labor-Management Policy, "The Benefits and Problems Incident to Automation and Other Technological Advances," Jan. 11, 1962, Folder: Labor [Department of] January 1962-February 1962. 66pp., Series: John F. Kennedy Memoranda to Departments and Agencies, Collection: President John F. Kennedy's Office Files, 1961-1963, Part 3: Departments and Agencies File, 8-9.

a more fiscally sound manner—what could be interpreted as an early version of "trickle down" economics.[124] Nonetheless, the make-up of the committee essentially guaranteed, and Goldberg explicitly emphasized, that its investigations, deliberations, and recommendations into what macroeconomic (rather than microeconomic) policy tools and private action could be taken to prevent automation from creating an "army of 'unemployables'" would not interfere with private collective bargaining.[125] In this way, the macro focus of BOB, CEA, and the various corporate and union leaders in LMAC played a key role in shaping the political limits of how automation would be discussed and addressed in the realm of public policy by cordoning off the corporate managerial control of technology from debate. In effect, this extended and secured private capital's 'right-to-manage' from the legal domain of collective bargaining into the policy domain of the American state.

Nevertheless, continued public anxiety, the growing Civil Rights Movement, and increasing interest in Congress to establish a presidential commission to study automation was putting more pressure on the Kennedy administration to act on a much grander scale. One source of pressure, U.S. Industries president John Snyder, is particularly relevant due his standing and style of critique. In early 1962, Snyder and International Association of Machinists' president Albert J. Hayes began a joint initiative they called the American Foundation on Automation and Employment, Inc., established to exemplify how labor-management cooperation could solve the problems spawned by automation. "The new Foundation," a report they sent to the White House on November 30th that year stated, "was organized specifically to deal with *human* problems, to

[124] Gary Mucciaroni, *The Political Failure of Employment Policy, 1945-1982* (University of Pittsburgh Press, 1990), 55 and Margaret Weir, "Full Employment as a Political Issue in the United States," *Social Research*, Vol. 54, No. 2, Unemployment (Summer 1987), 392-393.
[125] "Suggested Conceptual Framework for LMAC Inquiry into Technological Change and Unemployment," Nov. 6, 1963, Folder: Automation: Menace or Millennium? [November 6-December 13, 1963], Series: Files of Walter W. Heller: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV, 4-6 and David Stebenne, *Arthur J. Goldberg: New Deal Liberal* (Oxford University Press, 1996), 253-278.

develop ways to ease automation's impact on workers whom it displaces."[126] To accomplish this, the Foundation primarily funded studies about solutions to automation-induced displacement, both public and private, in the United States and in Western Europe. The source of the financial support for these studies was unique: Every machine U.S. Industries leased or sold in the United States was charged a "due" based on the sale price, with payments for each varying from $25 to $1,000 a year.[127] It turned out that the Ford official who sniped at Walter Reuther in 1953 that automated machines couldn't pay dues was wrong, at least in spirit.

Critically, one of the solutions the Foundation explored was the shorter workweek, which was approached "with careful attention to arguments both favoring *and* opposing this controversial proposal."[128] The report also included a paper from Snyder, who expressed contrition on behalf of U.S. Industries' contribution to the problems of automation. On the contrary, he argued, "we and the other automation machinery manufacturers cannot bear the full burdens, nor carry total responsibility for those people that our machines are affecting" as solutions required the cooperation of business, labor, and government to help society "pass through Automation's Awkward Age."[129] Hayes also contributed a paper and declared that while the current problems of automation were much like those that motivated the Luddites to "roam the English countryside in 1812 smashing the textile looms that were destroying their jobs," he stated emphatically, "let me make it very clear that the labor movement in the United States is

[126] American Foundation on Automation and Employment," A Report to the President of the United States" (Apr. 30, 1963), 8, emphasis in original.
[127] American Foundation on Automation and Employment, "A Report to the President of the United States" (Apr. 30, 1963), Folder 5, David A. Morse Papers, MC097, Public Policy Papers, Department of Special Collections, Princeton University Library, 7 and "Automation Doesn't Scare Europe," *Business Week*, Dec. 22, 1962, 57.
[128] American Foundation on Automation and Employment, "A Report to the President of the United States" (Apr. 30, 1963), Folder 5, David A. Morse Papers, MC097, Public Policy Papers, Department of Special Collections, Princeton University Library, 8, emphasis in original.
[129] American Foundation on Automation and Employment, "A Report to the President of the United States" (Apr. 30, 1963), Folder 5, David A. Morse Papers, MC097, Public Policy Papers, Department of Special Collections, Princeton University Library, 13.

not opposed to technological progress. To the contrary, we welcome it." Nonetheless, because the government's preferred solution to the ills of automation was Keynesian growth, and this was obviously not working, he still supported the shorter workweek.[130] Based on LMAC's interpretation of the shorter workweek, which it essentially deemed anathema, it's likely the Foundation's report, and therefore Snyder, was received with extreme skepticism.

Snyder also became increasingly vocal in public and private forums about the lack of action being taken to alleviate the negative effects of automation and targeted his critiques at business and the government. One of the most public of these broadsides came in a July 1963 issue of *Life* magazine, which published a multi-article discussion of automation with the front-page headline announcing "Automation's really here; jobs go scarce: POINT OF NO RETURN FOR EVERYBODY." One article provided a sweeping account of how labor was responding to the phenomenon and included perhaps the first and most direct argument made in a widely read publication that automation was displacing a particular set of workers, specifically those related to production jobs in manufacturing and mining, rather than the heavy-handed mass unemployment arguments that were typically bandied about. As the article's author Keith Wheeler noted, "Since 1957, the Labor Department reported in a recent manpower survey, 775,000 actual production jobs have been wiped out [and] automation was cited as a major contributing villain to this destruction" with the "foremost victims . . . . the most helpless to fight back"—the young, the elderly, and the "nonfavored minorities, Negroes and Puerto Ricans." Snyder was the primary protagonist of the article and, directly referencing MDTA, attacked "the myth that those who lose their jobs to automation can be retrained and put into other jobs

[130] American Foundation on Automation and Employment, "A Report to the President of the United States" (Apr. 30, 1963), Folder 5, David A. Morse Papers, MC097, Public Policy Papers, Department of Special Collections, Princeton University Library, 15-17.

requiring higher skills and paying more money." While Snyder admitted to not having all the answers to the automation dilemma, he did caution that unchecked automation would imply "a total reorientation of human society [where] Human will become wards of the machines, supported by machines." As a result, echoing the existential question at the core of Kurt Vonnegut's *Player Piano*, "what, then, will happen to the souls of people? . . . . People—living, breathing, feeling and thinking people—somehow will have to learn how to do nothing in a constructive way."[131]

The following month, Snyder was asked to testify at a Congressional hearing on amendments to the MDTA (this time with International Association of Machinists president A. J. Hayes), and much of what he argued about automation and what steps he, Hayes, and others who shared their concerns took to alleviate the negative effects of it were not new. Snyder did, however, forcefully argue that "the rapidity of technological changes that have been taking place are so substantial and far reaching that this is beyond the capability of business or labor" and therefore the government's role had to "substantially increase."[132] As MDTA was essentially the outer limit of government action that Kennedy (and Congress) were willing to take in response to automation, the statement was probably poorly received by the administration. While Snyder did not make reference to race in either the *Life* article or in his testimony, it's likely that Wheeler's article and Secretary of Labor Willard Wirtz's testimony at the same hearing, which forcefully

[131] Keith Wheeler, "Big Labor Hunts for the Hard Answers, *Life* (July 19, 1963), 73-88, quotes from 80, 84, and 88. One example of automation Wheeler gave was the 'TransfeRobot,' 77. Snyder also argued that "not only are there fewer jobs available today, but many workers are not retrainable in the first place, due to the level of intelligence, age or aptitude..," therefore, you can't "force people into retraining, nor can you manufacture jobs out of thin air," 84.

[132] *Amendments of Manpower Development and Training Act of 1962*, 88th Congress, 1st sees, Report No. 861, House of Representatives, Washington, DC: U.S. Government Printing Office, (Oct. 18, 1963), 466. Snyder, essentially rephrasing his closing comment in the *Life* article about learning how to do nothing in a constructive way, also told Congress, "We have to train people how to use their leisure time. And if we do, who pays for it? The paying for it part is a governmental matter too. It must be," 467.

argued for the heavy toll automation was taking on the black community, affected how Snyder discussed the issues.

Three months later on the first of November, Snyder published an article in *Management Review* arguing, among other things, that automation was exacerbating racial strife. "Automation," he observed, "is moving like a grass fire throughout the U.S. economy at this moment" and, while in the long run it may prove beneficial, in the short run it was creating conditions akin to Charles Dickens's *A Tale of Two Cities*. This was particularly the case for Black workers, he foregrounded, who were experiencing an unemployment rate twice that of their White comrades. As a result, "the technological revolution is intensifying the social revolution," and "few would argue with the observation that the Negro's drive for redress of his long-standing grievances has as much an economic basis as it does a social or legal basis."[133]

To address these issues, Snyder stressed that management would have to dissuade themselves of widely held misconceptions about automation, five of which he delineated: 1) automation is just another phase of the Industrial Revolution, the problems and solutions of which were not new; 2) automation is not going to eliminate many jobs; 3) automation will create more jobs than it eliminates; 4) those displaced will be easily retrained and placed in jobs requiring higher skills and higher pay; and 5) those displaced could also easily relocate where jobs were more plentiful. These myths acted as "deep tranquilizers for those who either cannot or will not come forward and grapple with the human problems caused by automation" and contributed to the inability of business to recognize the enormity of the problems and come to terms with greater government involvement in the economy. Furthermore, "the same can be said of government," Snyder argued, "and such seemingly major efforts as our Federal Manpower

[133] John Snyder, "Automation and Unemployment: Management's Quiet Crisis," *Management Review*, Vol. 52, Iss. 11, (Nov 1, 1963), 4-18, quotes from 5-7.

and Development Training Act and Area Redevelopment Act."[134] Once again, Kennedy's signature programs responding to automation were lambasted rather than lauded.

Two weeks later, Snyder addressed the annual AFL-CIO convention to speak on the topic of automation and was beyond forthright when introducing himself and his intentions. "Now I want to make it clear immediately that I do not regard myself as being particularly pro-labor—that is not my reason for being here," he began. "I am a manufacturer and an employer and in fact my company produces automation machines. I do not agree that automation is an evil," but a necessity, he continued, however, "I also believe that it is in the best interests of businessmen to work hard to solve the very real and immediate human problems that automation is creating. I want to sell the automation machines my company makes, and if our economy turns sour, if the unemployment problem is not solved, I will have difficulty selling them." To literally and figuratively sell automation, he argued, the business community should share this view and let go of what Snyder was now calling the "Five Fallacies of Automation" (originally listed in the *Management Review* article). Snyder replaced the first fallacy about automation and the Industrial Revolution with discrimination, and he pulled no punches in analyzing and assessing the relationship between automation and race:

> The fifth] fallacy holds that there is no relationship between the Automation Revolution and the Negro Revolution. This is patent nonsense. *Fortune Magazine* recognized this fall that the key issue involved in the Negro protest movement in this country today is jobs, and that automation has played a role in aggravating this problem. It certainly is clear to me, as a businessman, that the message spelled out by the freedom rides, the street demonstrations, the sit-ins and the boycotts, is that the gap between the column of figures running down the balance sheet and the column of Negroes marching down an embattled street is a slim one indeed, for what happens to one can gravely affect the other. As labor leaders, I think you must recognize that this is true also as it applies to your membership lists. All are inter-related and inter-dependent, and we are already feeling the enormous impact of the clash of what I regard as the two surging forces of our time: the growth of

[134] Snyder, "Automation and Unemployment," 4-18, quotes from 10-12, and 14.

> automation—sometimes inaccurately referred to as the Second Industrial Revolution; and the eruption of the Negro's demand for equality—sometimes referred to as the Second American Revolution. It seems to me there is little doubt that in eliminating the jobs of men who have been working and of millions of others who have not yet even come into the labor market, the technological revolution has intensified the social revolution.

Beyond their candidness, Snyder's remarks are relevant specifically for the fact that he was essentially the only wealthy, White industrialist to draw such conclusions, let alone at the annual convention of arguably the most powerful union in the country whose discriminatory practices were an open secret. Furthermore, Snyder proffered a particularly idiosyncratic solution to the problems of automation that only a major defense contractor would think of: because "the Defense Department is the repository of a thousand secrets that could be translated into consumer products and goods and services without affecting our national security," the Kennedy administration "must attempt to secure the release of some of these secrets for the creation of new industries and of new jobs."[135] The call was unique enough for the *Wall Street Journal* that a few days later in a short article on his comments at the convention it proclaimed, "Snyder Says Defense Department Should Disclose Its Thousands of Secrets to Ease Problem."[136]

The same day Snyder's *Wall Street Journal* article came out, Heller sent a memo to the President titled "Automation: Menace or Millenium?" According to Heller, "Staying on an even keel with respect to automation is going to be a tough job. It means, on one hand, respecting labor's great fear and pursuing effective programs to handle the 'human fallout' from automation while, on the other, recognizing it as the key to faster growth and our ability to compete in world markets." As he put it, "thus far, the visible response to the automation issue has largely been on the 'menace' side . . . . [and] before the thing gets completely out of focus, we should be

[135] "Address by John I. Snyder, Jr. to the AFL-CIO Convention, November 1963," n.d., Reuther. UAW Pres. Office WRL. Box 577. Folder - Automation, 1951-57, 1-13, quotes from 2, 8-9, and 12.
[136] "Automation Threatens Jobs, U.S. Industries Head Tells AFL-CIO," *Wall Street Journal*, Nov. 20, 1963, 8.

hammering home also the 'millennium' aspect of automation, and we should be mighty sure that the efforts of automation commissions and the like are not misguided."[137]

Heller's, and thereby the administration's, position on how they conceptualized the "human fallout" of automation and its sociopolitical half-life was starkly revealed in an LMAC document appended to the memo: the "costs" of automation "in the form of displaced workers and obsolescent skills" were part of the "price of progress."[138] Furthermore, what Heller meant by "staying on an even keel" was disclosed in a postscript to the memo. Apparently, the "menace" talk of automation was troubling enough that he asked the President to review a draft of an upcoming op-ed in the *New York Times* by fellow CEA member Gardner Ackley, which was intended to be published side-by-side with an article by Snyder who, according to Heller, "spreads fear of automation." Kennedy's review of the op-ed was requested as Heller and Ackley wanted "to be sure it serves the Administration well and because it reflects a careful effort to present a balanced view of the subject."[139] In other words, "staying on an even keel" meant managing the discourse about automation to corral any demands on the administration and its allies in the private sector to take decisive action that could prove politically divisive.

Two days after the "Menace or Millenium?" memo, the president was assassinated in Dallas. Less than forty-eight hours later, newly sworn in president Lyndon Johnson was already

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[137] Walter Heller to President Kennedy, "Automation: Menace or Millenium?," November 20, 1963, Folder: Automation: Menace or Millennium? [November 6-December 13, 1963], Series: Files of Walter W. Heller: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV, 1.

[138] Council of Economic Advisors, "Suggested Conceptual Framework for LMAC Inquiry into Technological Change and Unemployment," November 6, 1963, Folder: Automation: Menace or Millennium? [November 6-December 13, 1963], Series: Files of Walter W. Heller: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV, 1.

[139] Walter Heller to President Kennedy, "Automation: Menace or Millenium?," November 20, 1963, Folder: Automation: Menace or Millennium? [November 6-December 13, 1963], Series: Files of Walter W. Heller: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV, 3. The two articles would eventually be published as a single piece titled "Automation: Threat and Promise" in the *New York Times* on March 22, 1964.

making calls to prospective political allies for support of the administration's work on automation.[140] That work would become much more complicated in March 1964 when the administration received the "Triple Revolution" manifesto. Members of the CEA and LMAC were appalled at the methodology and solutions in the "Triple Revolution" report and pilloried the document's authors as "utopians." As one member described it, "Any economics 1A student would fail the course with a paper of this sort," and he directly laid partial blame on the Department of Labor generally and Wirtz specifically—who was accurately assessed to be sympathetic to the analysis but not the prescriptions of the document—as a sort of fellow traveler who encouraged such sophomoric polemics.[141]

A similar assessment was made far outside of the administration and the "Liberal Establishment" in the conservative journal *Human Events*, which reprinted an article from the *New York World Telegram and Sun* that called the report "an imaginary blueprint dreamed up by some young crackpots" and warned that its supporters were using automation as an excuse to change the laws of private property and "take the long step toward the Socialist goal of divorcing work from income."[142] Nevertheless, academically affirming one of John Snyder's "fallacies of automation" and the "Triple Revolution's" analysis (though not its proffered solutions), economists George P. Shultz and Arnold R. Weber wrote in a study completed for LMAC a few

[140] Oral history transcript, Anna Rosenberg Hoffman, interview 1 (I), 11/2/1973, by Joe B. Frantz, LBJ Library Oral Histories, LBJ Presidential Library, 32-33.
[141] W. Lee Hansen to Walter W. Heller, "The Triple Revolution Document," March 30, 1964, Folder: Triple Revolution [March 22, 1964-February 2, 1965], Series: Files of Gardner Ackley and Arthur M. Okun: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV.
[142] Lawrence Fertig, "New Scheme: Guaranteed Pay-For No Work," *Human Events*, Vol. 24, Iss. 25 (June 20, 1964), 9. Fertig framed the link between work and income as a "traditional" social relationship which he was seemingly in favor of. However, he then went on to argue, "Many years ago the Russian Communists found out that divorcing work from income demoralized the economy. So they tied work *closer* to income through incentive payment for work—contrary to all Socialist doctrine" (emphasis in original). In Fertig's formulation, therefore, American Conservatism and Russian Communism had more in common at the fundamental level of political and socioeconomic theory than the former had with either American Liberalism or American Socialism. Barry Goldwater also published an article in the journal two months prior in support of automation, Barry Goldwater, "Automation Will Bring Greater Prosperity," *Human Events*, Vol. 24, Iss. 16, (Apr 18, 1964), 13.

months after the latter's release, "when technical change alters the occupational composition of the demand for labor, they ["non-white workers"] lack the versatility to adjust to the new economic circumstances and are frequently left stranded in the labor market. In this respect, automation probably has done as much to ignite the civil rights revolution as Martin Luther King."[143] The paper, an entry in LMAC's most extensive study to date on the issues, nonetheless reiterated that public action should be limited to only those things the private sector was unable or unwilling to do.[144]

The Ad Hoc Committee of the Triple Revolution sent the report to the Majority and Minority leaders of the Senate and the House of Representatives and to the media in an official press release. As a result, the "Triple Revolution" became a cause célèbre and amplified the automation issue in the public consciousness to the point that some sort of governmental action, either at the executive or legislative level, was almost guaranteed. That same month, an additional bill had been proposed in the Senate to establish "automation commissions" and acting CEA chairman Gardner Ackley wrote Senator Lister Hill—chairman of the Committee on Labor and Welfare who was managing both bills (S. 2298 and S. 2427)—to argue for a single mixed-commission of executive and legislative branch members and private citizens, all of whom would be appointed by the president. Ackley, who made sure to inform the senator that he believed "[advancing technology] reduces the economic burdens of providing for our national security," harped on the need to appoint private citizen members to the commission as, according

[143] George C. Shultz and Arnold R. Weber, "Variety in Adaptation to Technological Change: The Midwestern Experience," in President's Advisory Committee on Labor-Management Policy, *Seminars on Private Adjustments to Automation & Technological Change* (May-June 1964), C-8.
[144] President's Advisory Committee on Labor-Management Policy.

to him, they were needed "to explore and define the nature of the problem and the possible approaches to solutions."[145]

In early August, two weeks before voting on the bills began, Ackley sent Heller a memo expressing his "strong concern" that the Commission be "balanced" on the issue of automation. In his estimation, "the negative approach will inevitably be heavily represented by the labor representatives and by some of the engineering, scientific, and business types, it is particularly important that the Commission contain some economists who will take a hard-nosed view and demand evidence rather than romantic speculation."[146] That Ackley assumed economists had a "positive" approach to automation because they were rational, evidence-based analysts rather than anecdotal conjecturers who had a "negative" approach speaks volumes about the epistemological and ideological underpinnings of the CEA specifically, the Johnson administration broadly, and economics as a discipline generally. The "tricky game," therefore, was a political chess match about controlling the ideational boundaries of what automation was and did, while managing expectations of the American state's response to the very technological developments it championed and subsidized.

This confluence of political forces led Johnson to sign a bill on August 19, 1964 creating a "National Commission on Technology, Automation, and Economic Progress" charged with studying the problems of automation.[147] Over the next eighteen months, the Commission—

[145] Gardener Ackley to Lister Hill, June 16, 1964, Folder: Agriculture report on S.J. 105 [November 2, 1963-June 16, 1964], Series: Files of Walter W. Heller: Legislation File, Collection: Council of Economic Advisers under President Johnson, PHV, 2 (the letter was almost identical to Ackley's previous communication to Hill on February 12, 1964 when only one bill had been submitted to Congress).
[146] Gardner Ackley to Mr. Heller, "Automation Commission," August 4, 1964, Folder: Automation Commission [July 25, 1963-November 23, 1965], Series: Files of Walter W. Heller: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV.
[147] W. Lee Hansen to Walter W. Heller, "The Triple Revolution Document," March 30, 1964, Folder: Triple Revolution [March 22, 1964-February 2, 1965], Series: Files of Gardner Ackley and Arthur M. Okun: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV. Establishing a commission on automation was not necessarily a novel idea as it had on Kennedy's agenda previously, Walter W. Heller, Draft of

whose members were essentially institutional carbon-copies of LMAC—developed perhaps the most comprehensive public-facing document available for understanding how the power elite understood and approached the issue of automation as a social force. Published in February 1966, the final multi-volume report framed automation in overall positive terms while foregrounding the difficulties of "adjusting to [technological] change," particularly in relation to unemployment. In the Commission's estimation, the "human problems" of automation were appallingly acute for "Negroes," so their investigation had taken "special cognizance of the civil rights 'revolution.'" Delving into this dilemma, M. T. Puryear of the Urban League, in his study prepared for the commission titled "Technology and the Negro," stated, "when we place automation in its proper context within the total employment structure and examine the status of the Negro worker within that structure, the information is ample to make a crystal clear picture—and dismal it is."[148] In a general comment chastising the report's lack of urgency, the labor representatives on the commission declared, "American Negroes, who have already waited 300 years, must not be made to wait any longer for the full equality that can be theirs only under full employment."[149] Affirming this position shortly after the commission's findings were published, labor secretary Wirtz passed on worrying numbers of unemployment in "urban ghettos" to the president "with the ominous warning that unless something were done to change the situation, 'there would be a revolution.'"[150]

Striking about the report was the Commission's inability (or perhaps unwillingness) to link the American state's financial and political support for automation, particularly via the

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Letter to Senator A. S. Mike Monroney, September 16, 1963, Folder: Congressional Correspondence [February 7, 1961-November 19, 1964 and undated], Series: Files of Walter W. Heller: Subject Files, Collection: Council of Economic Advisers under President Johnson, PHV.

[148] M. T. Puryear, "Technology and the Negro" in National Commission on Technology, Automation, and Economic Progress, *Technology and the American Economy, Appendices 1-3* (Feb. 1966), III-131.

[149] National Commission, 6.

[150] Mucciaroni, 740. This echoed LMAC's sentiments two years early, op. cit. fn 29.

military, to the very problems associated with automation. As the opening volume stated, "The evidence is overwhelming that technology stimulates the rate and volume of economic growth, and that the infusion of new technology can speed the rate of economic growth." Furthermore, "it is evident that increases in GNP are related to expenditures for research and development," two-thirds of which were coming from the Department of Defense.[151] Additionally, the Commission was well aware where these expenditures were coming from and emphatically declared that "this new knowledge has resulted in the creation of new job opportunities and the elimination of others; it has created demands for new skills and made others obsolete it has affected what we eat, what we buy, how we spend our leisure, what we teach our children—in total, it has affected every facet of our way of life.[152] Nonetheless, on one page the report would lament the economic and social effects of automation and technological change on minority communities, while on the next, it would make emphatic statements such as, "The social map of the United States in recent years has been reworked more by Government decisions in regard to spending in science, research, defense, and social needs than by any other combination of factors."[153] All the pieces of the problem were in the shape of the American state lavishing support for the development of automation on one hand while meagerly containing the "human fallout" on the other but the Commission seemingly couldn't put the puzzle together.

Beyond the analytical studies that made up most of the volumes, the core of the report focused on how adjustments to technological change could be facilitated to meet "human and community needs." Initiatives to cope with these adjustments ranged from the pedestrian to the

[151] National Commission on Technology, Automation, and Economic Progress, *Technology and the American Economy, Vol. 1* (Feb. 1966), 103.
[152] Frank Lynn, "An Investigation of the Rate of Development and Diffusion of Technology in Our Modern Industrial Society" in National Commission, *Appendices 1-3*, II-32.
[153] National Commission, *Vol. 1*, 105.

provocative. Approaches similar to the Kennedy administration's targeted community investment and vocational retraining programs under the Area Redevelopment Act (ARA) of 1961 and the Manpower Development and Training Act (MDTA) of 1962 proved ineffectual. The solutions proffered by "The Triple Revolution" report, such as the democratization of economic planning institutions, "massive" publicly funded housing and infrastructure programs, and revision of the tax code, were not even considered.[154] Solutions considered at the outermost limits of political possibility included an "employer of last resort" government jobs program to a "'minimum income allowance' or 'negative income tax' program" (i.e., a guaranteed annual income or universal basic income (UBI) program), though the administration would soon deem even these politically intractable.[155]

It's arguable in hindsight that the Johnson administration intended for the commission and report to serve as stalling mechanisms to kick the automation can down the road in an effort to save political capital for the Great Society and the 'War on Poverty.' What this bought was a contradictory environment of growing economic prosperity, growing social unrest, and growing setbacks in Vietnam. In response, Johnson decided not to seek reelection for a second term, a decision Wright Patman—the Democratic representative from Texas's first congressional district and chair of the first Congressional hearing on automation (1955)—called the "Pearl Harbor in politics."[156] A month before exiting the White House, Johnson extolled to members of the

[154] National Commission, *Vol. 1*.
[155] National Commission, *Vol. 1*, 40 and 110 and "Task Force on Income Maintenance, including recommendation for changes to public assistance programs, including Social Security amendments," Jan 01, 1966 - Dec 31, 1966, Folder: 1966 [ Task Force on ] Income Maintenance, Series: Interagency Task Forces, Collection: Task Force Reports of the Johnson White House, 1963-1969, PHV. Nonetheless, relatively short-lived and watered-down versions of these programs would be tried, with limited success, over the next few decades in the form the Comprehensive Employment and Training Act (CETA), Earned Income Tax Credit (EITC), Supplemental Security Income (SSI), and the Work Incentive (WIN) workfare programs.
[156] Robert Mitchell, "A 'Pearl Harbor in politics': LBJ's stunning decision not to seek reelection," *Washington Post*, Mar. 31, 2018.

Business Council, an elite association of corporate executives, "We don't have scare talk of automation any more . . . . The record is clear: Economic growth has been the most powerful social weapon in our hands."[157] Who wielded the weapon and for what social purposes is up for debate.

**Reuther's Racist Machine: The Rise of Jim Crow-bot**

With the automation problem apparently solved and the federal government taking a larger responsibility for the economic health of the technologically displaced, both the Big Three and the UAW International continued to remain silent about the racial effects of automation. While it was associated with job degradation and elimination, the social demographics of the people overworked and disemployed were, almost without exception, not specified. The closest the discussion came to directly identifying the type of workers being displaced was in terms of their skill level, specifically those who were "un," "low," or "semi" skilled were most likely to lose their jobs to automation. That 70 percent of the auto industry labor force fell into these job categories and nonwhite men and women disproportionately occupied them was absent from the broader conversation. Much like the function of "robot" in technoliberalism, the term "worker" within the automation discourse not only explicitly elided race but also obfuscated why skill differentiation in the workforce was racially composed as such. Furthermore, the linking of labor's income gains to productivity growth meant that someone ("workers" through "the speedup") or something ("automation") would have to produce more if living standards were to increase.

[157] Lyndon B. Johnson, "Remarks to Members of the Business Council," Dec. 4, 1968, https://www.presidency.ucsb.edu/documents/remarks-members-the-business-council-0.

This architecture of intra-industry power undergirded the UAW's first collective bargaining engagement with the coming reality of robotization in 1967. When the UAW National General Motors Council met in Detroit that June, they explicitly foregrounded how technology generally and robots specifically were simultaneously recasting work processes, the form and function of labor-management relations, and the contours of employment. Signaling an earlier era and ideal of social relations, the council adopted a resolution titled "A Greater Measure of Industrial Democracy" that, in essence, contained nary a hint of the desire for workers' control of production that animated the bygone age. Nonetheless, technology and its control were front and center. Echoing CEA chair Walter Heller's "Automation: Menace or Millenium?" memo to President Kennedy, the opening section and first page of the resolution, "A Major Contract Priority," framed the UAW's bargaining position in the form of a question, "Galloping Technology: Threat or Promise." Furthermore, the resolution put the stakes of the upcoming negotiations in stark terms: "What is here involved is the most important problem facing this union: security and tenure of employment during a period of rapid technological change." In the council's estimation, the "new technology [i.e., automation and robotization] is moving to make all work one" and, as a result, "there is no longer a neat distinction between physical and manual work on the one hand, and non-physical work on the other."[158]

This blurring of boundaries was critical as Paragraph 8 of the existing National Agreement (1964) had "frozen into static terms" GM's "unlimited rights of unilateral corporate determination of the disposition of work," rights which expressed a "dynamic concept of change which General Motors Corporation is utilizing to undermine the unit, to destroy work and to

[158] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 3.

move work out of the unit."[159] The prerogative was crucial as GM had the ability to unilaterally change the technical composition of production and re/classify new forms of labor as "bargaining unit" or "non-bargaining unit" work. During negotiations, the UAW presented GM with two position papers on bargaining unit "erosion"—the recomposing of bargainable work and reduction of nonsupervisory workers to weaken local power—whereby the introduction of automation caused existing jobs to be moved out of unit (if they weren't eliminated entirely) and any new jobs created by automation were not included in the unit, such as jobs related to the operation of numerically controlled or computerized machines.[160] The UAW, therefore, accused GM of "stealing work through the impact of technology" by using its control over production standards to recompose physical work and its bureaucratic function which undermined the union's already tenuous control of production, denatured its negotiating capacity, and threatened its very existence.[161] As the resolution put it: "In the day of the computer and the robot, the union, if it is to live, cannot accept such a concept."[162]

While the first page of the resolution laid out the broad terms of the coming conflict, the second page, rather than simply using "the robot" as a synecdoche of automation and its future consequences, anthropomorphized and concretized the technological threat that was facilitating GM's transformation of work in the here and now. Quoting from a *Business Week* article three weeks prior, UAW negotiators introduced its members to "'Iron Mike' . . . . a factory worker who puts in a 17-hour day and never takes a coffee break. Nor does he ever talk to other workers or complain about the repetitive drudgery of his job." Additionally, if "Iron Mike" was bought,

[159] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 3.
[160] Julius Rezler, *Automation and Industrial Labor* (Random House, 1969), 160.
[161] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 3.
[162] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 1.

he would pay for himself in less than two and a half years on a one-shift basis or one year on a two-shift basis. Furthermore, "he" could be rented for $2.50 an hour for the first shift, and then $1.50 an hour for extra work, and at the time, the average hourly job rate for the human equivalent work was around $3.00 an hour plus benefits.[163] Warning its members that the cost of overcoming the technical barriers to more complex operations "will soon be licked," the industrial robot would eventually "take a key role in automatic assembly." The writing was on the wall, therefore, and the resolution reiterated the stakes: "The technological revolution will destroy the effectiveness of our union if we do not meet and master this problem in the negotiations of 1967. It is, in sober earnestness, a very top priority."[164] The *robot* of rhetoric had now been displaced by the *industrial robot* in reality.

The remainder of the resolution covered twenty-nine individual areas to be negotiated from "Employee Discounts" and "Grievance Procedures" to "Holidays" and "Grievance Procedures" and "Union Information Racks." The section on "Relief" was particularly relevant in light of the industrial robot's inhuman-like capacity to seemingly work without rest (the reality was, of course, much different). As the section detailed:

> Improved methods of operation, multiplicity of options, computerized techniques, improved mechanization and scores of other factors have resulted in more efficient production procedures, The reruns, skips, gaps, free jobs and line stoppages of other years which allowed the line worker to relax for brief intervals during his workday have largely been eliminated. Today the line runs at near maximum capacity hour after hour allowing the worker no opportunity to straighten up from his monotonous task. His every move from whistle-to-whistle is timed, retimed and fully utilized. Problems of heat,

[163] Table B—Typical Hourly Job Rates,1 Selected Occupations (Automobile Plants in Detroit Area), 1939—66, Wage Chronology, General Motors Corp., 1939-66 (Bulletin No. 1532), United States Department of Labor (October 1966), 14.
[164] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 2.

> weight, long hours and repetitive drudgery all combine to further highlight the need for further relief from the work pace.[165]

Presaging the primary grievance of Lordstown strikers to be discussed later, the resolution continued, "the job controls the worker every minute of the workday without let up," a sentiment that was more pithily posited in a later section: "[Management exists] within the context of a basic philosophy that when General Motors hires you, they own you."[166] This, of course, begs the question: If automation was increasing productivity, why was GM treating union members like its most advanced form of fixed capital—robots? The simple answer is that automation was, and had always been, dependent on labor, it was just the sociotechnical composition of work (i.e., the mix of human skills and technology) that had changed.

A more complex answer, however, draws out a fact that the simple answer elides: the UAW had also been treating a subset of its workers like robots for decades—black men. For these reasons, the 1967 bargaining resolution's section on "Discrimination" is glaring, particularly for what it *did not* say: "In previous negotiations, the union has demanded that 'sex' be included as a non-discriminatory category but to no avail. The law now demands its inclusion, and the contract must be so amended. In addition, there is a moral obligation to ban discrimination against employment because of age. Both the Agreement and the Statement of Preface must be so amended."[167] At fewer than 60 words, the section was the second shortest of the resolution (longer only than "Dues Checkoff" but shorter than "Employe [sic] Discount on GM Products"). It did not mention race once.

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[165] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 16.
[166] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 25.
[167] UAW National General Motors Council, "A Greater Measure of Industrial Democracy," June 12-14, 1967, Folder - Clay Green - Employee Chevrolet-Norwood, Box 70, UAW Region 2A, WRL, 58.

Though the de juris 'color line' within the UAW bureaucracy and, more importantly, in local unions had been eroded by the late 1960s, *de facto* racial discrimination on the line and in the shop remained as black workers continued to be relegated to the worst jobs. As one black worker at a Dodge plant in Hamtramck told a journalist, "You go find the dirtiest, nastiest, filthiest, noisiest, mother-fuckingest jobs and that's where you'll find the black man."[168] This was particularly the case at Chrysler, which lagged behind Ford and General Motors in applying new technologies to production. As a result, workers were pushed to work faster and harder under increasingly more dangerous and unhealthy conditions to make up for their technological unsophistication. At the Eldon plant in Detroit, one study of the period described, "higher production," therefore, "had not been achieved with advanced technology and automated assembly line procedures, but through the old-fashioned method of speed-up."[169] Not surprisingly, Black autoworkers took the brunt of speedups as jobs that previously occupied two, three, or even four White workers were now being done by a single black worker.[170] Rather than calling this "automation," Black workers referred to it as "n*****mation," or "the process of forcing humans to work harder and faster under increasingly unsafe and unhealthy conditions."[171] Workers' inability to control production standards, therefore, facilitated the racial disproportionality of the speedup's negative effects.

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[168] Quoted in William Serrin, *The Company and the Union: The "Civilized Relationship" of the General Motors Corporation and the United Automobile Workers* (Vintage Books, 1974), 15.
[169] Dan Surkin and Marvin Georgakas, *Detroit, I Do Mind Dying: A Study in Urban Revolution* (St. Martin's Press, 1975), 101-127 quote from 104 and Heather Ann Thompson, "Auto Workers, Dissent, and The UAW: Detroit And Lordstown" in Robert Asher and Ronald Edsforth (eds.), *Autowork* (State University of New York Press, 1995), 181-208.
[170] "To the Point of Production - An Interview with John Watson of the League of Revolutionary Black Workers," *Movement* (July 1969), https://riseupdetroit.org/wp-content/uploads/2018/07/To-the-Point-of-Production-An-Interview-with-John-Watson-1969.pdf, 2.
[171] Surkin and Georgakas, 101-102 and Carl Bloice, "The Black Worker's Future Under American Capitalism," *The Black Scholar*, May 1972, Vol. 3, No. 9, (May 1972), 17.

Alleviating humans from such "subhuman" work was, either ironically or cynically, a key rhetorical selling point for the uptake of automation and industrial robots were originally put to work at the quintessential 3D and 3H jobs. For instance, the first production-ready Unimate at GM's Ternstedt Division plant was loading and unloading a die-casting machine while AMF's Versatran industrial robot was being designed for spray painting and welding applications.[172] As Unimation's Joseph Engelberger described one of these jobs, "The spray painting environment has always had the reputation of being one of the worst which human operators have to encounter . . . . they were real death-traps."[173] However, the corporations that did employ industrial robots in these jobs were, according to Englberger, only "mildly interested in shielding workers from hazardous working conditions, [as] the key motivator is the saving of labor cost by supplanting a human worker with a robot."[174]The repurposing of the term "automation"—which culturally represented the most developed form of applying advanced technologies to remove the human element from the process of production—as "n*****mation" foregrounded the social realities of managerial attempts to construct and control the robotized factory of the future.

Such treatment, combined with the political and social experience of their communities, led many black autoworkers to organize and fight back. This took the form of the Revolutionary Union Movement (RUM), which demanded better working conditions and an end to racism and oppression inside and outside the auto plants. Originally formed in May 1968 at the Dodge Main assembly plant in Detroit, the League of Revolutionary Black Workers (LRBW)—as the individual RUMs and their various derivatives came to be collectively called when the

[172] Jerry W. Saveriano, "An Interview with Joseph Engelberger," *Robotics Age* (Jan/Feb, 1981), 15-16. Regarding the design of the Unimate and the Versatran, see J. F. Engelberger, "Role of Industrial Robots in Improving Industrial Operations," *Automation* (June 1964), 5 and proposals in Folder - Devol Personal - Writings, 1945-2008, Box 1 and Folder - Robotics - Unimation - Proposals, Box 2, George Devol Jr. Records, BFRC.
[173] Engelberger, *Robotics in Practice,* 208-209.
[174] Engelberger, 103.

organization was formed in 1969—proved "as hostile to the UAW as they were to the auto companies because they believed that the union did not fight hard enough for black workers."[175] According to Nelson Lichtenstein, "The auto corporations had used the dip in the economy in 1967 as a chance to tighten up on production standards, so low-seniority workers—virtually all black—felt the brunt of the new speedup. Indeed, DRUM [the Dodge Revolutionary Union Movement] had its origins in April 1968 when Chrysler fired more black workers than White in the aftermath of a speedup strike instigated by a group of older Polish women."[176] Echoing the cries of Denby and *News & Letters* a decade prior, one member of the Black Workers Congress (BWC), an organization established to manage the nascent movement, put it: "These fuckers [UAW executives], man, got a nice position on the war, nice position on civil liberties, blah, blah, blah. It ain't got a goddamned thing to do with the conditions that's kicking the ass out of the motherfucker there in Department 78, Department 25. On the question of conditions, the company ain't done a motherfucking thing about it, and the union don't do nothing."[177] Or, as one RUM chant declared, "UAW means 'You Ain't White!'"[178]

Beyond the shopfloor, the LRBW conceived of itself as a Marxist-Leninist organization with a black nationalist platform, the politics of which put them directly on the security state's radar, particularly at the FBI. As one excerpt from a periodical of the LRBW—submitted as evidence of the organization's "subversive" character at a Congressional hearing—described it:

> Under control of Reuther's racist machine, the black worker has fared no better inside the plant than he has in the union. Racism has been the calling card. Blacks are first of all systematically excluded from the skilled trades, white collar jobs, and all but the lowest level of management. Blacks are employed under the most dangerous conditions. In the

[175] Thompson, 188.
[176] Lichtenstein, *The Most Dangerous Man In Detroit,* 433-434.
[177] Serrin, 154.
[178] Stewart Bird, Peter Gessner, and Rene Lichtman, *Finally Got the News* (Black Star Productions, 1970), 23:45.

> foundries, for instance, 95% of the workers suffer from silicosis and other lung diseases and have their life expectancy cut 15 to 20 years short. Black workers are found in great numbers in the stamping plants where fingers and toes are severed almost daily. Blackworkers are found in the trim shops, the body shops, spot welding on final production lines, and anywhere else where men drop dead from exhaustion fighting never ending, constantly accelerating production lines.[179]

As a result of this "subversiveness," the FBI began surveilling LRBW in February 1969, four months before it was even legally incorporated.[180] While no active counterintelligence operations were initially approved by the bureau, the policy was reversed less than two months later and the Detroit Counterintelligence Program (CIP) began "sub rosa techniques" that were "aimed at causing friction, factionalism and attempts to render [LRBW] ineffective."[181] On top of surveilling LRBW through the use of human intelligence via informants, open source information, and financial tracking—the FBI knew when and where DRUM opened their first checking account and even the dollar amount of the first check deposited—over the next two years the Detroit CIP was authorized to publish false-flag propaganda to foment division within LRBW, the UAW more broadly, and the Black Power Movement more generally; file a report with the Department of Labor and the Internal Revenue Service (IRS) concerning LRBW's funding; and inform Labor and the Equal Opportunity Employment Commission that LRBW systematically discriminated in membership based on race (i.e., "black racism").[182]

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[179] Extent of Subversion in the "New Left": Testimony of Robert J. Thomas (Part 1), Subcommittee to Investigate the Administration of the Internal Security Act and other Internal Security Laws, January 20, 1970), 1267.
[180] SAC, Detroit to Director, FBI, "Counterintelligence Program, Black Nationalist-Hate Groups, Racial Intelligence (League of Revolutionary Black Workers), RM," March 11, 1969, Black Extremist, COINTELPRO, FBI Records: The Vault, https://vault.fbi.gov/cointel-pro/cointel-pro-black-extremists/cointelpro-black-extremists-part-07-of-1/view and Surkin and Georgakas, 84.
[181] SAC, Detroit to Director, FBI, "Counterintelligence Program, Black Nationalist-Hate Groups, Racial Intelligence," April 22, 1969, Black Extremist, COINTELPRO, FBI Records: The Vault, https://vault.fbi.gov/cointel-pro/cointel-pro-black-extremists/cointelpro-black-extremists-part-08-of/view.
[182] Documentation of these can be found at https://vault.fbi.gov/cointel-pro/cointel-pro-black-extremists and include parts 8, 9, 11, 13, 16, 17, and 24.

Whether any, all, or in what frequency these techniques were actually employed remains unclear. The Detroit CIP advised caution as discovery of their use could potentially compromise the FBI's desire to "maintain a non-partisan position regarding labor union matters."[183] The FBI was neutral on the UAW, therefore, as long as it didn't include political "extremists." The LRBW never made significant gains in the UAW nor off the shopfloor and, by the time COINTELPRO was "officially" disbanded in 1971, the security state had essentially neutralized the "threat" from the Black Panther Party specifically and inoculated the Black Power movement generally of its more "revolutionary" tendencies.

Reflecting on a number of these issues in his book about the 1970 collective bargaining agreement between GM and the UAW, *Detroit Free Press* reporter William Serrin observed that Walter Reuther specifically and the UAW generally attempted to burnish their social credentials with the rank-and-file and the broader public by marching with civil rights activists and workers in the South and supporting Cesar Chavez's efforts to organize agricultural workers in California but such attempts were interpreted by the rank-and-file as hypocritical. As one *Time* article reported, "When U.A.W. leaders pointed out that they had marched at Selma, Jackson and Memphis, an angry Drummer roared, 'You never marched in Hamtramck.'"[184] In Serrin's opinion, therefore, "the UAW became a right-of-center union with a left-of-center reputation."[185]

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[183] Part 11, Black Extremist, COINTELPRO, FBI Records: The Vault, https://vault.fbi.gov/cointel-pro/cointel-pro-black-extremists/cointelpro-black-extremists-part-09-of/view.

[184] "Black Rage on the Auto Lines," *Time* (April 11, 1969), 109.

[185] Serrin, 148-149. A similar move was also happening at GM which was attempting to cultivate an image of social enlightenment, in essence, matching the UAW's left-to-right shift with a right-to-left shift. Nonetheless, according to Serrin, GM "refused to bring any meaningful numbers of blacks into the corporation, either on the factory floor or in executive offices," and one of the reasons why a public relations executive quit was "his work made him feel 'like a piano player in a house of prostitution,'" 109. Echoing this in his famous tell-all book, John Z. DeLorean, head of the Chevrolet division from 1969-1973, observed, "when I walked into the plant there were plenty of blacks at work, but they were all at the lower jobs. There were no black executives, no black managers, and damn few black foremen," Patrick Wright, *On a Clear Day You Can See General Motors: John Z. DeLorean's Look Inside the Automotive Giant* (Avon Books, 1979), 227.

After Reuther's unexpected death in a plane crash on May 10, 1970, head of the Chrysler Department Douglas Fraser— the "most liberal and progressive member of the union's executive board" and "[m]ore committed to affirmative action for blacks than any other white UAW executive board member" who nonetheless condemned DRUM "as a movement to divide the UAW along racial lines"—lost the UAW presidency by one vote to head of the GM Department Leonard Woodcock. That one vote came from secretary-treasurer Emil Mazey who described RUM activists as a "handful of fanatics who are nothing but black fascists, using the same tactics of coercion and intimidation that Hitler and Mussolini used in Germany and Italy" and bemoaned such political activity, he argued, because the UAW "has done more to further the black man's cause than any other in the nation."[186] Or, as the president of one local lamented, "It's much harder to tie young, black guys to the assembly line than it was thirty years ago."[187]

The racial dynamics of the auto industry's political economy meant that black workers were disproportionately overworked at the worst jobs and were under the greatest threat to be *technologically displaced* by automation. These processes, in tandem with and inflected by unaddressed discrimination, also meant that black workers were *politically displaced* on the shopfloor and, thereby, in the union. As a result, black workers and their interests were *racially displaced* from the very bargaining agenda that could, in theory, prevent or soften the negative effects of the "speedup" and automation.

Black workers paid a quadruple price for the "progress" automation purportedly entailed. First, the racial politics of collective bargaining agreements and shopfloor management relegated them to the worst jobs that were the most automatable. Second, they disproportionately were

[186] William Gould, *Black Workers in White Unions: Job Discrimination in the United States* (Cornell University Press, 1979), 382 and 390.
[187] Serrin, 233.

overworked in those jobs, which resulted in higher absentee and higher turnover rates. They then "lost" those jobs, initially to automation and capital flight to lower wage and 'right to work' states, then later to robotization and 'outsourcing' across international borders. And finally, as a result of all this, their institutional and political power within locals, the International, and correspondingly their communities and in national politics, was compromised. From automation to "n*****mation," therefore, the rank-and-file, and in particular its Black membership, increasingly found themselves stuck between a robot and a hard place.

**Conclusion: Automated Ghettos**

In 1970, sociologist Sidney Willhelm published a remarkable, yet relatively unknown, polemic on the racial realities of automation titled *Who Needs the Negro?* Willhelm, originally from Texas and then an associate professor at SUNY-Buffalo, was one of only a few White male academics to study, and directly and forcefully speak about, the relationship between automation and race.[188] At its core, *Who Needs the Negro?* rearticulated the theory of "black obsolescence" for the Age of Automation and argued that "White America could not dismiss the black man until the invention of machines severed its dependency upon labor."[189] Willhelm pulled no punches in his assessment:

> The Negro becomes a victim of neglect as he becomes useless to an emerging economy of automation. With the onset of automation the Negro moves out of his historical state of oppression into one of uselessness. Increasingly, he is not so much economically

[188] The most prominent White scholar that studied automation and its effects on Black workers was labor economist Herbert R. Northrup at the Wharton School of the University of Pennsylvania. Northrup wrote what I believe is the first book on the subject by a White scholar, *Organized Labor and the Negro* (Harper & Brothers, 1944), and continued to research and write on racial disparities in employment for the rest of his career.
[189] Willhelm, xv and 1-3.

> exploited as he is irrelevant. The tremendous historical change is taking place in these terms: he is not needed. He is not so much oppressed as unwanted; not so much unwanted as unnecessary; not so much abused as ignored. The dominant whites no longer need to exploit the black minority; as automation proceeds, it will be easier for the former to disregard the latter. In short, White America, by a more perfect application of mechanization and a vigorous reliance upon automation, disposes of the Negro; consequently, the Negro transforms from an exploited labor force into an outcast. The Negro's anguish does not rise only out of brutalities of past oppression; the anxiety stems, more than ever before, out of being discarded as a waste product of technological production.[190]

For Willhelm, it was automation that now made it possible for the ingrained racism of the United States to turn its wrath on the black community as "the Negro may very well come to be treated much as the American Indian: confined to reservations or perhaps even eliminated through genocide."[191]

Time would of course prove Willhelm wrong about the power of technology to eliminate the need for industrial labor let alone the targeted population who labored, as even after a half century of automation, Black workers remain extremely "useful" to capital accumulation.[192] His forecasting of a coming racial dystopia functioned much like the speculations of science fiction: It said as much about the past as about the (possible) future. Nevertheless, Willhelm captured a particular truth about the tenor of the era with the observation that "the American Negro is caught in the cross-currents of technological change; he is in the transition not of one but two technological revolutions. He was once the solution to the white man's problem; today he *is* the white man's problem."[193]

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[190] Willhelm, 162.
[191] Willhelm, 3.
[192] Jason Resnikoff, "The Myth of Black Obsolescence," *International Labor and Working-Class History*, Volume 102: Workers and Obsolescence (Fall 2022), 124–145.
[193] Willhelm, 138, emphasis in original.

This was the world from which the industrial robot emerged and from which the robotic future heralded by the prophets of technoliberalism would be built. Building this world, however, proved expensive and extensive, a construction project that private actors, whether individually or collectively, could not afford. So, while with one hand the American state was attempting to contain the 'human fallout' of automation, with the other, it was galvanizing the power of stealth industrial policy and supply-side technoliberalism to transform the robot of science fiction into the industrial robot of science fact.

## Chapter 5 — Robots on the Line: The Technopolitics of Autowork at Lordstown

*If the industry ever pauses long enough to put up a tablet marking the site where the robot served his apprenticeship in auto-making, it will be at GM's plants in Lordstown.*

Robert Lund (1970)[1]

The United Auto Workers (UAW)'s strike of the General Motors (GM) Lordstown Assembly plant in 1972 has come to symbolize a pivot in the labor-management dynamics of the New Deal Order. Touted in the media as "the most modern, automated, robotized carmaking complex in the world," the Lordstown plant, located halfway between Cleveland and Pittsburgh in northeast Ohio, was positioned as the high-tech answer to the American auto industry's interrelated problems of waning market share to foreign competition, waning productivity, and waning profits.[2] The plant's workers were also on the cutting edge—young, well-educated, well-paid, and with a significant number of Vietnam veterans—and represented a new generation of American working-class prosperity. When the rank-and-file walked out of the plant for more than three weeks in protest of management's treatment and the monotony of the work they enforced on the high-speed automated assembly line, the strike signaled a shift in the social relations of the American political economy and became a fault line in the narrative of the American Dream.

[1] Robert Lund, "Made in Ohio by Robots," *Popular Mechanics* (Sept. 1970), 208.
[2] Lund, 81.

While overwork and alienation accurately characterize the grievances that motivated the strike, a separate but related dimension of the event has received much less attention in the historiography of Lordstown—what were the political and sociotechnical contours that shaped the plant's evolution, and how did the design, construction, and management of its lauded automation contribute to the workers' revolt? Answering these questions requires foregrounding the technology that became a symbol and synecdoche of Lordstown's "automatic" assembly line—the industrial robot. To actuate the fantasies of automatic production and the dream of putting industrial robots to work meant redesigning and reengineering the assembly line, the automobile assembled on it, and the assembled rank-and-file that labored alongside their mechanical counterparts. No site became more indicative of these processes than Lordstown, the first mass-robotized factory in the world.

The history of the Lordstown plant and the 1972 strike provides a window into these processes, what 'production standards' in the age of automation looked like in concrete terms, and how they were enforced in practice on the eve of robotization. The chapter will begin with an overview of how GM first engaged with computers and industrial robots to develop a new sociotechnical architecture, what I am tentatively calling "high-tech Taylorism." GM intentionally designed its high-tech Taylorist system to reduce the number of grievances relating to overwork and safety standards and thereby neutralize the only contractually valid weapon in the UAW's arsenal. Additionally, GM's industrial robots were exclusively tasked with spot welding auto bodies—a deplorable job disproportionately occupied by black workers in the traditionally militant body shop—which had the effect of reducing the impact of work stoppages at the crucial and vulnerable first station of the assembly line. The chapter will then delve into the history of the Chevrolet Vega, the first car both designed by computer and engineered for

robotic assembly. In concert, GM managers purposely designed the Vega, the industrial robots, and the computers that managed production to not only increase productivity but to also police the human and robotic workers on the automated assembly line as well as reduce the probability of strikes that would stop it. This was *technopolitics* par excellence, and rather than the cyborg of cinematic satire, the high-tech Taylorist and armed assembly line was perhaps the first RoboCop.

The price tag of Lordstown's automation and the design and marketing of the Vega was higher than any of GM's similar projects. However, when executives in Detroit deemed that Lordstown's managers were not up to the task of managing the corporation's most expensive and riskiest investment, GM tasked a new management team with re-establishing order. Called the General Motors Assembly Division—an organizational innovation of the mid-1960s tasked by corporate headquarters with managing all of GM's assembly lines—GMAD took command of Lordstown with the explicit mission of pushing the men and machines to their limits through heavy-handed discipline and trial-and-error engineering. The chapter develops this history through the first archivally based origin story of GMAD and details its 'totalitarian' management of Lordstown after the division took over the plant in late 1971.

In essence, GMAD reinvigorated the classical "drive system" of worker management that, in historian Sanford Jacoby's estimation, "depended, ultimately, on fear of unemployment to ensure obedience to the foreman," or what labor economist Sumner Slichter described as "the policy of obtaining efficiency not by rewarding merit, not by seeking to interest men in their work . . . . but by putting pressure on [workers] to turn out a large output [and by inspiring] the worker with awe and fear of the management, and having developed fear among them, to take advantage of it."[3] Additionally, GMAD fired upwards of 375 workers shortly after arrival, with

[3] Sanford M. Jacoby, *Employing Bureaucracy: Managers, Unions, and the Transformation of Work in the 20th Century* (Taylor & Francis, 2004), 15-16.

approximately a quarter of these, 80-100, coming from the body shop where all of Lordstown's industrial robots worked, meaning the remaining workers had to work faster and harder. This soon led to a revolt of the workers who argued they were being turned into "robots," and a "revolt" of the actual industrial robots that were breaking down under the strain of high-speed production. The chapter concludes with an exploration of how GMAD's authoritarian managerialism motivated these revolts, the role of "the robot" and "robotization" in the media coverage of the strike that resulted, and the meanings of Lordstown drawn from the strike's aftermath.

What this history demonstrates is that while there was significant technological change at Lordstown, there were also significant continuities with past managerial practices of work and how workers experienced and reacted to such management. If previously workers felt they were being mechanized like the machines they tended, now they were being robotized like the industrial robots they appended. Whether called mechanization, automation, or robotization, technological change meant that *plus ça change, plus c'est la même chose*.

**Lordstown: High-Tech Taylorism on the Armed Assembly Line**

During the 1950s and early 1960s, the Big Three began deploying automation as a sociotechnical tactic to deskill and atomize skilled workers while politically and socially dividing them from unskilled workers in final assembly plants.[4] The technopolitical goal of this was to neutralize

[4] The following two paragraphs, unless otherwise noted, come from James R. Zetka, Jr., *Militancy, Market Dynamics, and Workplace Authority: The Struggle Over Labor Process Outcomes in the U.S. Automobile Industry, 1946-1973* (State University of New York Press, 1995).

rank-and-file militancy and increase management's ability to determine production standards at will. The strategy, which did reduce the incidence of wildcat strikes for a time, began breaking down in the late 1950s as the attempt to use automation to deskill and atomize skilled workers was only relatively successful. Nonetheless, the use of automation to facilitate the speedup of already atomized unskilled workers continued unabated with increasing militancy at assembly plants.

To actuate their fantasies of automatic production and the dream of putting industrial robots to work meant redesigning and reengineering the assembly line, the automobile assembled on it, and the assembled rank-and-file that labored alongside their mechanical counterparts. No site became more indicative of these processes than GM's Lordstown Assembly plant, the first mass-robotized factory in the world. Of the Big Three, however, GM was the slowest to embrace automation. Due to their commanding position in the industry, their decentralized labor-relations system, and their refined use of the "drive system" on the shopfloor, GM had significant leverage with their workers, the locals, and the UAW writ large. Concomitantly, the decentralized divisions that made up the corporation had significant autonomy over production standards and therefore the kinds of technologies they would invest in; however, tight return-on-investment constraints determined in Detroit reduced the amount of risk plant managers were willing to take. GM was also a notoriously conservative organization —both in financial and sociopolitical terms—which led them to direct a healthy amount of skepticism towards the economic potential of automation. "How far automation should go," legendary GM CEO Alfred Sloan declared in his memoir, "is a difficult question which will have to be decided on the highest policy levels of the corporation." In his estimation, "automation is nothing new; it's merely a relatively recent word for a process that has been going on in manufacturing for more than half a century, perhaps

even as far back as the time of Eli Whitney's successful attempts to mass produce muskets for the continental armies," and furthermore, "the whole vague area summed up under the term 'automation,' in which it is often difficult to distinguish science fiction from practical manufacturing possibilities," made the completely automatic factory merely "an interesting possibility."[5]

Written in 1964, the same year ground was broken at Lordstown, Sloan's reflections and then contemporary assessments reveal a certain irony in the impending automation of GM's flagship assembly plant. And curiously, the fact that assembly line computerization had not occurred earlier in the industry than it did is somewhat surprising in light of the nature of automobile production. In 1970, the same year Vega production began at Lordstown, the American Foundation on Automation and Employment funded (through a grant provided by the Ford Foundation) a report on employment mobility of non-supervisory workers in eleven major industries from apparel and banking to rubber tires and telecommunications. The first industry studied was "Motor Vehicles and Parts," and their description of it is worth quoting at length:

> The auto industry epitomizes mass production. More than 70% of the work force has its moves detailed down to the second, operates in set work stations, and performs generally short-cycle, repetitive tasks as the workpiece moves before them. Since some work stations require more skill than others, unskilled/semi-skilled distinctions are made difficult. The pressures of the assembly line, whether for completed automobiles or component parts, lends itself to measurement of a man's work-hour like few other industries. To this end, most workers are programmed to give a full 480 minutes of work on a standard shift (they get 12 minutes of break every four hours but their work goes on via a "relief man"). Time and motion studies are the fulcrum upon which management makes changes in a man's tasks, makes adjustments when new products are introduced (such as at model changeover), or determines that certain assemblers or machine operators are not putting in a fully productive hour. These efforts by management to enforce its production standards are probably the most volatile force in the industry and

[5] Alfred P. Sloan, Jr., *My Years with General Motors* (Doubleday and Company, Inc., 1964), 257-258.

> create more strikes than the combination of the other two issues strikeable during the life of the contract (health & safety and pay rates for new jobs).[6]

This "Taylorist-Fordist" mode of production, as it has often been referred to, made the auto industry "the locus classicus of dissatisfying work [and] the assembly line its quintessential embodiment."[7] Managing the recalcitrance of men and machines was, therefore, a difficult task. And in the same way that "the dream of the builders of automata was ultimately premised on redemption from labor," as Anson Rabinbach interpreted the imagination behind the invention of the first (non-industrial) robots, the builders of automation dreamed of redemption from *managing* labor.[8] As one GM executive eloquently put it, "[Lordstown represented] the implicit hope that production work can be reduced to a disciplined part of a great machine, to work for human automata."[9] GM had been an early adopter of mainframe computing and numerical control, so Taylorist-style task measurement and job design combined with Fordist technology and management provided an ample reservoir of computable factors and made the assembly line ripe for digitization.

General Motors' experience with computers can be traced to 1952 when the GM Research Laboratories in Warren, Michigan began using an IBM 701 card-programmed digital computer for engineering and scientific analyses.[10] By the end of the decade, study began on the application of computer graphics to auto design, the results of which evolved into a 1963

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[6] E.F. Shelley and Company, Inc., "Climbing the Job Ladder: A Study of Employee Advancement in Eleven Industries," American Foundation on Automation and Employment, Inc. (1970), 41.
[7] John H. Goldthorpe, "Attitudes and Behaviour of Car Assembly Workers: A Deviant Case and a Theoretical Critique," *The British Journal of Sociology,* Vol. 17, No. 3 (September 1966), 235 quoted in Ulrich Jurgens, Thomas Malsch, and Knuth Dohse, *Breaking from Taylorism: Changing Forms of Work in the Automobile Industry* (Cambridge University Press, 1993), 4.
[8] Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Basic Books, 1990), 58.
[9] Emma Rothschild, *Paradise Lost: The Decline of the Auto-Industrial Age* (Vintage Books, 1973), 118.
[10] Fred N. Krull, "The Origin of Computer Graphics within General Motors," *IEEE Annals of the History of Computing*, Vol. 16, No. 3, (1994), 40 and George F. Ryckman, "The IBM 701 Computer at the General Motors Research Laboratories," *IEEE Annals of the History of Computing,* Vol. 5, No. 2, (April 1983), 210.

experimental system called the "Design Augmented by Computers" project (DAC-I).[11] The system was used by the Fisher Body Division and the corporate Styling Staff to "study the feasibility of designing automobiles with man-computer teams."[12] One of the first products of the prototype system was the generation of computer tapes for manufacturing a Cadillac trunk-lid machined entirely from mathematical data.[13] The system was programmed on an IBM 7090, and later transferred to GMR's 7094, using a compiler language called NOMAD—an iteration of the University of Michigan's "Michigan Algorithmic Decoder" (MAD) language similar to ALGOL and FORTRAN—that, at its most basic, was a "computer program which translates statements describing algorithms into the equivalent machine instructions."[14] In addition to using computers and NOMAD for design, the DAC system was able to translate the drawings into tapes for automatic drafting machines and numerically controlled (N/C) machine tools.[15] With these, GM implemented one of the first, if not *the* first, operational examples of what came to be called CAD/CAM—"Computer-Aided Design" (CAD) and "Computer-Aided Manufacture" (CAM)—when it combined DAC with its "Integrated Numerical Control Approach" (INCA) program that was being developed at the same time.[16] This combination, called "Computer-Aided Design And

[11] Press Release, "Technical Background Information on General Motors DAC-I System: Design Augmented by Computers," Oct. 28, 1964, GM_NR_10281964_2, General Motors Heritage Center (hereafter GMHC).
[12] Press Release, "Technical Background Information on General Motors DAC-I System: Design Augmented by Computers," Oct. 28, 1964, GM_NR_10281964_2, GMHC and "Design Augmented By Computers: The General Motors DAC-I System," GM Research Laboratories, PR-135, GMHC.
[13] "Designer's Legman," *General Motors World* (January-February, 1965), 8-11 and Press Release, "Technical Background Information on General Motors DAC-I System: Design Augmented by Computers," Oct. 28, 1964, GMNR10281964, GMHC, 2
[14] Bruce W. Arden and Elliott Irving Organick, "The Michigan Algorithm Decoder (The MAD Manual)," University of Michigan Computing Center (August 1966), https://www.google.com/books/edition/The_Michigan_Algorithm_Decoder_the_MAD_M/H-E6AAAAMAAJ?hl=en&gbpv=1, abstract/preface. The "NO" in NOMAD initially stood for "Non-Operational" and later, once put into use, meant "Newly-Operational," Krull, 48.
[15] Press Release, "Design Augmented by Computers: The General Motors DAC-I System," General Motors Research Laboratories Projects (PR-135), GMR_Projects_PR-135, GMHC and Krull, 53.
[16] General Motors Research Laboratories, *Annual Report* (1966), 17 and Press Release, December 10, 1968, GMNR12101968, GMHC, 2.

Numerical Control Effort" or CADANCE for short, was used in the second iteration of the DAC project, DAC-II XP, to represent "complex automobile sheet metal panels" in the computer that was used to create the dies and molds for metal forming and shaping, the parts of which were eventually handled by GM's industrial robots.[17] "We are told," Walter Reuther declared in a 1966 position paper on the UAW and automation, "that GM is still just experimenting with the machine [DAC], but its potentialities for replacing some of the highest skilled workers in the auto industry are obvious. And there is no reason why its operation should not spread to many other industries."[18] While the DAC project officially closed shop in 1967, its constituent parts, before spreading to many other industries, spread throughout GM.[19]

GM began computerizing the assembly line in 1964 and to accomplish this, the corporate Manufacturing Staff embarked on perhaps the first attempt, in any industry, to comprehensively control an assembly line via computers. Called the "Line Balancing and Sequencing" program, the experimental system was intended to digitally measure and distribute workloads and synchronize work tasks to maximize efficiencies of human and mechanical labor.[20] First tested at the Fremont, CA plant, the experiment, according to a GM internal history of their assembly divisions, produced the following conclusions: "(1) car by car scheduling was possible on a computer, (2) a computer was able to follow a much more complex set of sequencing rules than a man was able to remember, (3) the effect of a well-formed sequence was not of significant

[17] General Motors Research Laboratories, *Annual Report* (1966), 17 and General Motors Research Laboratories, *Annual Report* (1967), GMHC, 12.
[18] Walter P. Reuther, "Union Policies for Automation," n.d. (c. 1966), Folder - Automation - by Walter P. Reuther, 1966, Box 43, UAW Research Department Records, WRL, 8.
[19] Krull, 54 and Wright, 187-189. Fisher Body Division made a documentary called "The Bodybuilders" (c. 1970-1972) which visualized and narrated the entire automobile production process from design to assembly and almost everything discussed in this paragraph is either mentioned or can be seen in the documentary in some form, https://www.youtube.com/watch?v=yYgxgGlN8CM&list=WL&index=13&t=1336s.
[20] The remainder of this paragraph, including quotes, come from A. O'Keefe, "History of the GM Assembly Division," GMHC, 150.

benefit unless complementary line balance was present." Furthermore, the "process was time consuming, and the results depended entirely on the analytical capabilities of the individual foreman." A second experiment was undertaken at the Kansas City, Missouri plant where a computer system was rented at an annual rate of $264,489 and was intended to "augment the ability and experience of foremen in the analysis of line balancing information." The expected results were the following:

1) Improved operating efficiency through reduced operator idle time.
2) Improved quality and reduced repair costs through the elimination of short term operator out-of-station conditions.
3) Improved start-up performance through earlier refinements of operator work assignments.
4) A substantial decrease in the number of valid paragraph 78 grievances through an improved initial line balance.

In translation, the redesign and reengineering of the armed and computerized assembly line was intended to: 1) more efficiently enforce the production standards determining how much each worker would work at each operation per shift; 2) maintain efficient production when workers were absent from their work stations; 3) more efficiently adjust work tasks based upon the state of production when each shift began; and 4) prevent work stoppages through calibrating workloads across the assembly line.

Early estimates pegged the system's savings at almost $1 million for the Kansas City plant and, if those were realized, GM planned to extend the program to other plants in the Division, with potential annual savings of more than $5.5 million.[21] When this came to fruition,

[21] O'Keefe, "History of the GM Assembly Division," 150.

the Operations Research Department of GMR described the following year how the system was already being used in all seven of the Assembly Division's plants to "substantially reduce" planning time "from about six weeks to only one or two weeks." One way they accomplished this was through the planner's ability to "rapidly make proposed work assignments and then quickly evaluate them through detailed and summary work-load reports" while also obtaining "graphical plots showing welding gun and tool movements along the line—and any possible congestion." Hence, the system was able to target one of the critical work tasks that would eventually be robotized at Lordstown—spot welding.[22]

During the same period of computerization, GM began integrating industrial robots into its production plans. In 1956, Joseph Engelberger and a team of Unimation engineers surveyed five GM facilities (along with seven of Chrysler's and six of Ford's) and based the design of their yet unnamed 'programmable automation device' on these surveys.[23] In 1959, with a working prototype ready, it was then up to Engelberger and his team at Unimation to sell their "solution looking for a problem."[24] Two years later, the Oldsmobile Division of GM requested a joint survey of their engine plant in Lansing, Michigan in April with a Unimation sales engineer while the GM Technical Center in Warren, MI (home of the General Motors Research Laboratories (GMR) which managed the corporation's R&D) had, by September, finished their evaluation of the prototype.[25] Unimation salesman John C. Parry informed Engelberger that Tech Center engineers deemed the prototype fit for being "engineered into specific applications in any one of their plants" and no one at GMR "had any adverse opinions about the Unimate."

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[22] "Production Line Planning Time Cut," General Motors Research Laboratories, *Annual Report*s (1965-1968), GMHC, 13 and "Chevy Fisher Hires 150 Workers," *Warren-Tribune Chronicle*, Feb. 16, 1966.
[23] Jerry W. Saveriano, "An Interview with Joseph Engelberger," *Robotics Age* (Jan/Feb, 1981), 11.
[24] Saveriano, "An Interview with Joseph Engelberger," 22.
[25] Charles T. Sherman to Consolidated Controls Corp., April 7, 1961 and John C. Parry to J. F. Engelberger, "General Motors Technical Center - Manufacturing Development, Warren Michigan," September 25, 1961, Folder - Robotics - Correspondence, 1960s, Box 2, GDJR.

However, Parry's contact at GM warned him that "Tech Center efforts would be of insufficient value in backing the Unimate" as they were a "long hair group" that wanted to work on "something that is usually more virgin." Nonetheless, as Parry informed Engelberger, this itself was a "good recommendation for the Unimate in selling it to any one of the GM plants" as the prototype was advanced enough to stand on its own merits.[26]

By the end of 1961, George Devol personally sold the first Unimate to GM's Inland Fisher Guide Plant of Fisher Body's Ternstedt Division in the suburban West Trenton section of Ewing Township, New Jersey.[27] Simultaneously, the Ternstedt Division moved its central office and engineering facilities to the Tech Center, thereby integrating GM's theoretical and applied knowledge about its first experiences with the industrial robot at the corporation's central site for commercial and defense R&D.[28] In 1964, the same year ground was broken on the Lordstown facility, the Fisher Body Division installed two Unimates at the Norwood Assembly plant outside of Cincinnati, Ohio for spot welding Chevrolet Camaro bodies.[29] A year later, Fisher Body installed another Unimate for seat assembly, the Buick Division incorporated one into a punch press operation, and the Guide Lamp Division began using one for injection molding.[30] And in 1966, GM put Unimation on the map when it ordered sixty-six Unimates with more than half of these going to Lordstown, all of which were slated for spot welding.[31]

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[26] John C. Parry to J. F. Engelberger, "General Motors Technical Center - Manufacturing Development, Warren Michigan," September 25, 1961, Folder - Robotics - Correspondence, 1960s, Box 2, GDJR.
[27] Jerry W. Saveriano, "An Interview with George Devol," *Robotics Age* (Nov/Dec, 1981), 24.
[28] General Motors, *Annual Report* (1961), 13.
[29] Saveriano, "An Interview with Joseph Engelberger," 16.
[30] "Customer List," Trade Lit - Unimation, 1960-1981, 1 of 2, GDJR. The specific locations of each installation were not specified.
[31] Saveriano, "An Interview with Joseph Engelberger," 16 and Patrick Wauryzniak, "Masters of Manufacturing: Joseph F. Engelberger," *Manufacturing Engineering*, Vol. 137, No. 1, (Jul 2006), 72. Engelberger told Wauryzniak that the GM order was for thirty-six Unimates, however, in the interview with Saveriano twenty-five years earlier he states that sixty-six were ordered.

Like the early development of computers and industrial robots, the Lordstown plant had a more than decade-long gestation. In early February 1956, GM made public the purchase of 965 acres of land in a quiet rural community on the outskirts of the Warren-Youngstown industrial hub in northeast Ohio.[32] By the middle of the month, it was announced that the site was to host a "huge new ultra-modern facility"—touted as the "largest assembly plant thus far in employment, production capacity and area" in the world—designed to assemble seventy-five passenger cars and thirty trucks an hour for the Chevrolet Motors and Fisher Body Divisions.[33] Local press talked up the $75 million cost of the plant and forecasted eight thousand jobs for the area. As an editorial on the front page of the *Warren Tribune Chronicle* put it, GM's announcement was "the most exciting industrial news the Warren area and the whole Mahoning Valley has had in two score years."[34] The jubilation, however, would be short-lived. On May 9, GM disclosed that due to "revised engineering specifications" construction of the fabled facility would be put on hold for six months and the planned groundbreaking would be moved from July to sometime in early 1957.[35] A year later, "not a spadeful of soil [had] been turned toward the plant's construction."[36]

The land would lay fallow for almost eight years when, in March 1964, GM chairman Frederic G. Donner announced that the Lordstown facility, the "largest capital spending program for plants and equipment in General Motors history," was a go. On September 20 that year, Ohio

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[32] "GM Lordstown - The Road Traveled," *Warren Tribune Chronicle*, n.d., Folder - Histories - 1956-1996 - GM Lordstown - The Road Traveled, Box 3, Lordstown Collection, GMHC.
[33] "News for Chevrolet Motor Division," February 17, 1956, Folder - Correspondence, 1956-1957, Box 1, Lordstown Collection, GMHC.
[34] "Welcome, Chevrolet of GM," *Warren Tribune Chronicle*, February 17, 1956 (Friday Evening Edition), Lordstown Collection. Box 1. Folder - Correspondence, 1956-1957, GMHC.
[35] "Release 99785," May 9, 1956, Lordstown Collection. Box 1. Folder - Correspondence, 1956-1957, GMHC.
[36] Folder - Correspondence, 1956-1957, Box 1, Lordstown Collection, GMHC. GM's claim that "revised engineering specifications" delayed construction of the plant may be honest, however, local newspapers reported extensively on disputes between GM, nearby municipalities, and even the state of Ohio regarding industrial and sanitary waste treatment and water delivery infrastructure, Folder - Correspondence, 1956-1957, Box 1, Lordstown Collection, GMHC and Gregor M. Miller, Place, "Space, Pace, and Power: The Struggle for Control of the Automobile Factory Shop Floor, 1896-2006," PhD Dissertation (August 2008) for the best political economy and social geography of Lordstown in regional terms.

governor James A. Rhodes, Chevrolet general manager Semon E. Knudsen, and Fisher Body Division manager Robert H. Gathman presided over the official groundbreaking ceremony by triggering six dynamite blasts that shot earth seventy-five feet in the air.[37] The plant's construction took approximately nineteen months and during the period GM personnel were temporarily located at the Lordstown Military Reservation which, at the time, served as launch site CL-69 for the Army's Nike "Hercules" surface-to-air missiles.[38] By early 1966, approximately 35,000 job applications had been received, 26,000 interviews had been scheduled, and approximately 1,300 workers had been hired. While initial employment forecasts in 1956 had been as high as 8,000, management recognized that when the plant was fully staffed in the coming months, "even with the addition of a second shift it is doubtful the total employment will approximate the published employment figure of 5,700."[39] The promises of the mid-1950s looked like they were finally coming to fruition, at least in spirit, when a white hardtop, four-door Chevy Impala sports sedan with a sticker price of $3,395.10 purchased by Helen Hart Hurlbert, publisher of the local *Warren Tribune-Chronicle* and owner of local radio station *WHHH*, rolled off the line on April 28, 1966, almost an exact decade after the plant was first announced.[40]

The next year, Lordstown production engineers began the process of putting their industrial robots to work. It was not, however, an easy task as "the company," one eyewitness

[37] "Untitled," Folder - Histories - 1964-1965 - History of the Chevrolet-Lordstown Plant, Box 3, Lordstown Collection, GMHC.
[38] "Chevy Fisher Hires 150 Workers," *Warren-Tribune Chronicle*, Feb. 16, 1966 and John C. Lonnquest and David F. Winkler, *To Defend and Deter: The Legacy of the United States Cold War Missile Program*, USACERL Special Report 97/01 (November 1996), 404-405.
[39] "Event Records - 1966 - 1st Car Production Lordstown, April 28, 1966, (Folder 1)," Box 1, Lordstown Collection, GMHC.
[40] "Event Records - 1966 - 1st Car Production Lordstown, April 28, 1966, (Folder 1)," Box 1, Lordstown Collection, GMHC.

account described, "appears to be feeling its way with its benign Frankensteins."[41] While the Unimates were more than technically capable of handling spot welding, engineers could not simply replace a worker one-for-one on the assembly line with a robot that weighed over 4,000 pounds, took up as much floor space as an industrial-sized deep freeze, and whose mechanical arm was more like a small tank-turret than a human appendage. Therefore, an off-line sub-assembly welding station consisting of high-precision jigs and "accuracy rails," which guaranteed auto body placement so parts would not move while being welded, was built to take advantage of the Unimates' capabilities.[42] Vehicle body parts were stamped at the Fisher Body division side of the plant on automatic presses supplied by U.S. Industries, manufacturer of the first industrial robot the TransfeRobot.[43] These parts were then automatically tack-welded to create the dimensional definition of the partially assembled body and sent down the main line to the assembly side of the plant hooked to a "truck" (a chassis-like cart), where a group of eight would be unhitched from the conveyor and moved by a specially designed shuttle system to the welding station, where "the Unimate takes over and completes the welding task assigned by its built-in command memory."[44] After the Unimates completed their work, the now-welded auto bodies were shuttled back to the main line and the assembly process continued.

The Unimates, however, were not the only industrial robots at Lordstown. At about the same time they were being installed, Fisher Body production engineers partnered with electrical equipment manufacturer Square D Company to develop an "unusual and highly sophisticated welding machine" called SAM ("six-axis manipulator").[45] SAM—whose control system was

[41] Robert Lund, "Made in Ohio by Robots," *Popular Mechanics* (Sept. 1970), 83.
[42] Tom Alexander, "The Hard Road to Soft Automation," *Fortune* Vol. 84, Iss. 1, July 1971.
[43] "U.S. Industries Acquires Citizens Mortgage Corp.," *Wall Street Journal*, Nov. 20, 1968. Apparently, GM's purchase of the equipment was USI's largest order in its history.
[44] Lund, 83 and L. E. Reuss and C. N. Hughes, "Vega 2300," SAE Technical Paper #710150 (1971), 581-582.
[45] Square D Company, *Annual Report* (1970), 10.

described by Square D as the "most complex and technologically advanced products [it] designed and built" that "incorporate[d] many electronic features found in computers, including use of miniature integrated circuits and memory cores"—performed welds on a vehicle moving down the assembly line and could change welding sequences from two-door to four-door models by detecting the vehicle's body type using brush sensors.[46] Unlike the Unimates, which were five-axis manipulators that could only weld a stationary auto body, the in-house developed SAMs were designed to weld auto bodies as they moved down the assembly line. In addition to the Unimates, a *Detroit Free Press* article introducing its readers to SAM proclaimed, "the Robot Revolution is breaking new ground in the automobile industry with the development of the first Iron Mike."[47]

**Wish Upon a Falling Star: The Chevrolet Vega and the Promise of Robotized Production**

Lordstown's automation and industrial robots proved crucial to one of GM's most important, and infamous, strategic product developments—the Chevrolet Vega. Originally codenamed "XP-887," the Vega was intended as GM's "industrial 'Siegfried Line'" to staunch the flow of European and Japanese low-price, small-car imports then dominating the market.[48] On October 3, 1968, in the corporation's "most dramatic product announcement of the decade," Chairman James M. Roche told an "audience of dignitaries, reporters and employees" that the then secret

[46] "News for Release," n.d., Folder - News-Press Kits-Releases - 1970-1971 - Releases Pertaining to Robotics, Box 4, Lordstown Collection, GMHC and Square D Company, *Annual Report* (1970), 9-11.
[47] "Meet Welder SAM: An Improved Robot," *Detroit Free Press*, May 10, 1970.
[48] Glenn Schotten, "Vega Line Opens New Era in Auto Building," *Warren-Tribune Chronicle*, July 31, 1970.

project would "feature the most automated assembly process known to American automotive technology."[49]

Slated to be manufactured at Lordstown, the Vega was the "direct result of the most expensive program of scientific market analysis ever undertaken by General Motors" and would become the first automobile designed for automated robotic production.[50] Such technological prowess became a feature of the XP-887's marketing and the first time in its history GM promoted a vehicle prior to production. This entailed the "longest prenatal advertising campaign ever provided by business," which began months before the first Vega ads were released in the summer of 1970.[51] Its most memorable tagline, "Twinkle Twinkle, Little Car," greeted readers of *Life* and *Newsweek* magazines in big, bold letters followed by copy informing them that "Everything was designed for this car and this car alone. And it all comes together on the most highly automated precision line in the world, at our plant near Lordstown, OH."[52] Similarly, an ad in the *New Yorker* touted Lordstown as the "most advanced auto facility in the world" and introduced readers to "Hardhearted SAM" as evidence of such technological sophistication: "Sam is a machine, known to his friends as the six-axis manipulator." The ad continued, "What he does is welding. And he does welding more precisely than welding has ever been done on a car before."[53] The ads were, however, not just hyperbole as the industrial robot was a critical factor in both the design of the Vega and its eventual assembly at Lordstown, what two

[49] Wright, 187.
[50] Emma Rothschild, "GM in Trouble," *New York Review of Books*, February 25, 1971.
[51] Rothschild, *Paradise Lost*, 64.
[52] "Twinkle, Twinkle Little Car.," *Life* (Aug 7, 1970), 11 and "Twinkle, Twinkle Little Car.," *Newsweek*, Vol. 75, Iss. 23, (Jun 8, 1970), 37.
[53] "Vega Will Have Over 6300 Places To Get The Service You Won't Need Much Of," *New Yorker* (Aug. 15, 1970), 5.

commentators called "a giant step toward the car manufacturer's ideal plant—one that produces cars untouched by human hands."[54]

To replace human hands with mechanical hands, however, required computers capable of managing its design and manufacture. GM's gave the Vega the distinction of not only being the first car designed digitally and for robotic assembly but the first car in GM's history designed at the corporate rather than the divisional level.[55] As John Z. DeLorean, general manager of Chevrolet division which was tasked with managing the Vega's manufacture, described it: "When [GM Chairman James] Roche announced the car [October 3, 1968], his information came from statistical abstractions. Not one prototype had been built or tested. There was no model to point to because the car only existed in financial statistics and blueprints derived from a consensus of the existing subcompact cars, all of them foreign and some of them built by GM overseas."[56] Or, as Chevrolet product quality engineer James Seegret told *Business Week*, "The individual components, critical systems, and, in effect, the entire vehicle were assembled thousands of times in the computer." Early successes of this computer-modeled design and assembly approach included relocating the position of the instrument panel, developing a better way to install the engine and rear axle, and "slashing thousands of manhours from design and tooling" by having automatic numerically controlled machine tools produce wood molds for the dies and their reference templates, the cost savings of which "in time and money were substantial."[57] In short, "the traditional methods of assembling the body of the car," Chevy and

[54] Robert J. Litschert and Edward A. Nicholson, *The Corporate Role and Ethical Behavior: Concepts and Cases* (Mason/Charter Publishers, Inc., 1977), 201.
[55] Krull, 54 and Wright, 187-189. Fisher Body Division made a documentary called "The Bodybuilders" (c. 1970-1972) which visualized and narrated the entire automobile production process from design to assembly and almost everything discussed in this paragraph is either mentioned or can be seen in the documentary in some form, https://www.youtube.com/watch?v=yYgxgGlN8CM&list=WL&index=13&t=1336s.
[56] Wright, 189.
[57] "GM's mini: the very model of automation," *Business Week*, August 8, 1970, 26.

Fisher body officials realized, had to be scrapped." Key factors in the redesign of assembly included "deproliferation," the standardization of components across the Vega's four models, and automatic welding by the Unimates.[58]

The Vega's chief engineer Lloyd E. Reuss and his fellow development engineer Charles N. Hughes described how the vehicle's body modules were specifically designed "to accommodate the latest automatic welding tools [i.e., industrial robots] to such an extent that virtually all welds could be accomplished automatically . . . . with the Unimate system a foremost consideration." Weld joints were strategically located for accessibility "so Unimates could weld without serious restrictions such as corners or barriers."[59] Additionally, the body was designed to be modularly constructed with fewer parts— from 996 body parts made of 3,500 pieces in a full-sized Impala to 578 parts with 1,231 component pieces for a standard Vega— which included engine compartments, fenders, front-end panels, and hoods that were interchangeable among the four model types (coupe, sedan, station wagon, and delivery van).[60] In sum, "The fact that the Vega was designed to have 43% fewer parts than a full-size car," an economic study of Lordstown completed with the help and approval of GM assessed the situation, "also helped the high-speed line and economy."[61]

To manage the human and robotic labor on the high-speed assembly line, the first IBM computers and equipment arrived at Lordstown as early as February 1966.[62] Three years later, the assembly line underwent significant reengineering and retooling for computerized Vega

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[58] Glenn Schotten, "Vega Line Opens New Era in Auto Building," *Warren Tribune-Chronicle,* July 31, 1970.
[59] Lloyd E. Reuss and Charles N. Hughes, "The Story of the Engineering Concept, Design and Development of Chevrolet's New Little Car: Vega 2300," Product Information Department Chevrolet Engineering, January 1971, GMHC, 6.
[60] GM's mini," 26 and Reuss and Hughes, "The Story of the Engineering Concept," 6.
[61] Hak-Chong Lee, "The Lordstown Plant of General Motors," 1974, Folder - Histories - 1974-1975 - Lordstown Historical Documents, Box 3, Lordstown Collection, GMHC, 5.
[62] "Production Line Planning Time Cut," General Motors Research Laboratories, *Annual Report*s (1965-1968), GMHC, 13 and "Chevy Fisher Hires 150 Workers," *Warren-Tribune Chronicle,* Feb. 16, 1966.

production beginning in March 1970 with approximately three thousand workers given temporary layoffs for the ten-week project.[63] As one analyst summarized the line changeover, the "Most difficult and tedious [work] tasks were eliminated or simplified, on-line variations of the job were minimized, and the most modern tooling and mechanization was used to the highest possible degree of reliability."[64] When the assembly line balancing and sequencing systems discussed above were extended to Lordstown, technical editor of *Automotive Industries* R. H. Eshelman pronounced in a glowing profile of the plant, "this may not be the first time a model line of vehicles or other products was designed for a specific production facility. But never before have the two been married so closely. Or when both have matured with such a close blood relationship to computers."[65] Lordstown, therefore, became the first site where the double helix of automobile design and manufacturing was digitized.

Recoding the DNA of production at Lordstown required a transformation of the line balancing and sequencing system into what GM called its "Total Systems Engineering" concept. This brought together product and process design with plant engineering, assembly, and quality assurance. On the shopfloor this consisted of three integrated components: robotic welding; the "Assembly Line Planning and Control Activity" (ALPACA) production program, and the "Product Assurance Control System" (PACS) inspection program—all of which were "instituted to make each employee's job on the line both easier (in physical terms) and simpler to perform in a precise way."[66] According to a Fischer production engineer, about 80 percent of the welds on the previous Impala line were conventional (i.e., completed by humans) while, in contrast, 95

[63] Jack Darrow, "Lordstown GM to Close 10 Wks For Model Change," *Warren Tribune Chronicle*, February 23, 1970.
[64] Lee, "The Lordstown Plant of General Motors," 5.
[65] R. H. Eshelman, "Automation Plus at Lordstown," *Automotive Industries* (October 1, 1970), 41.
[66] Eshelman, 41.

percent of the welds on the Vega line were automatic. To accomplish this, production engineers programmed the Unimates to manipulate portable spot welding guns or fusion MIG (metal inert gas) welders to reach about twenty difficult location spots on a Vega body with accuracy of up to one-sixteenth of an inch. Furthermore, as Unimation project engineer Maurice J. Dunne described, the "sequential point-to-point operation" of the Unimate was "basically suited to the application of standard time study method[s]," meaning that human and robotic workers could be synced on the assembly line.[67] In terms of automatic quality control (AQC), a separate memory system monitored the performance of each Unimate and if an operation or weld was missed an indicator lit up on a master control board above the line, an audible signal alerted the maintenance crew, and the malfunction was relayed to a welding station down the line where human workers manually corrected any robot mistakes.[68]

Eshelman's enumeration of ALPACA's benefits was eerily similar to the line balancing and sequencing experimental system quoted above as ALPACA: "A. Equalizes overall workload along the assembly line; B. Helps achieve smooth production flow via assembly line coordination; and C. Gives individual operators time to do their jobs properly, minimizing line disruptions and later repairs." Similarly, product and work quality were monitored by using a "realtime" reporting system that "strategically deployed" sixteen optical scanning devices to instantly read preprinted inspection tickets that rode along with each in-production vehicle through every workstation. The information from the tickets, which quality control inspectors manually marked before feeding into the scanners, "shoots into the plant's PACS computer, which continually calculates current quality level on all operations." This information was

[67] Eshelman, 41 and quote from Maurice J. Dunne to Mr. Mason P. Southworth, "Industrial Robot Learns New Job with East," March 2, 1961, Folder: Robotics - Robotic Reports, Unimation, GDJR, 6.
[68] Eshelman, 43.

compared to tolerances, or "bogies," stored in memory and, like the AQC related to the Unimates, an alarm would go off if an error was sensed.[69] The tickets were used to assess a range of quality factors from component receiving inspection and materials handling to training requirements for each line operation and work-space layouts.[70] As a result, each Vega underwent "about 50 individual inspections and at least five functional tests as a completed unit before it is approved for shipment," making sure, in product quality engineers James Seegert's words, that "each vehicle is built right the first time in station." [71] Use of ALPACA and PACS meant that "no unresolved production problem is allowed to continue beyond a specified period" as the computer would catch and resolve them more efficiently than human monitors.[72]

Assessments of the computerized system were much less sanguine in the popular press. One of the few articles that went into detail about the automated system explained, "a computer *tries* to keep the various sections of the line in balance to equalize work load and give each worker the time needed to do the job right. The computer also *tries* to put the squeeze on prospective lemons."[73] As investigative journalist Emma Rothschild described it to readers of the *New York Times Review of Books*, "these computer spy systems are essential for quality control, but they seem more adept at inspection and cost control."[74] In more provocative terms, one article in the trade journal *Automotive Industries* posited that the "closed loop" computer system "serves as the watchful 'big brother'" on the assembly line.[75] And unlike GM's internal descriptions, *Business Week* foregrounded the system's human element: "Quality control inspectors at the checking stations record their observations by marking boxes on cards and

[69] "GM's mini," 26.
[70] Eshelman, 43-44.
[71] Glenn Schotten, "Vega Line Opens New Era in Auto Building," *Warren Tribune-Chronicle*, July 31, 1970.
[72] Eshelman, "Automation Plus at Lordstown," *Automotive Industries* (October. 1, 1970), 43-44.
[73] "GM's mini," 26, emphasis added.
[74] Rothschild, "GM in More Trouble."
[75] Eshelman, 44.

feeding the cards to an optical scanner; the computer checks them against tolerances and, if necessary, sounds an alarm," an admission that even the most advanced automation was still reliant on people.[76]

Nevertheless, Eshelman gauged Lordstown as "not merely more mechanization, automation or even computerization of production processes; it's a whole new concept interlacing a host of new technological and scientific advances with economics of design-tooling-mass production." As one astute newsman noted, "Henry Ford may have designed mass production, but General Motors is rewriting the book."[77] While it's difficult to determine exactly how much it cost GM to rewrite the book at Lordstown, the price was substantial. A *Detroit Free Press* article in early 1970 reported that the "expenditure for the mechanical men [Unimates] . . . . is estimated at upwards of $1.5 million," a number that didn't include the design, engineering, or manufacturing costs of the entire welding systems they were a component of.[78] The *Wall Street Journal* described the plant preparation for the Vega as a $100 million bet "on a new package of robot-operated assembly techniques, fast-paced manufacturing processes and pioneering designs."[79] This was, in Emma Rothschild's estimation, "the most expensive investment project GM, or any other corporation, has ever undertaken."[80] The historical outlay

[76] "GM's mini," 26.
[77] Eshelman, "Automation Plus at Lordstown," 40.
[78] Tom Kleene, "Robots to Help Build GM Cars," *Detroit Free Press*, Jan. 4, 1970. According to a Department of Transportation study completed more than a decade after the first industrial robots went to work at Lordstown, "The total investment in a typical robot installation in the automobile industry will be from two to four times the actual robot cost, depending upon the application. In major body assembly (spot welding) systems, the cost of fixturing, welding equipment and transfer or material handling equipment will often be at least three to four times the cost of the robots. That is, a system incorporating $500,000 worth of robots may cost, in total $l,500,000 to $2,000,000." Therefore, it can be surmised that the investment in the Unimate/SAM welding system was substantial, William R. Tanner and William F. Adolfson, "Robotics Use in Motor Vehicle Manufacture, United States Department of Transportation, January 1982, 40.
[79] Charles B. Camp, "Stomping the Beetle? GM Resorts to Aggressive Automation To Pare Construction Costs of Mini-Car," *Wall Street Journal*, July 2, 1970 and Lordstown Collection. Box 3. Folder - Histories - 1956-1996 - GM Lordstown - The Road Traveled, GMHC.
[80] Rothschild, "GM in Trouble."

for computers and the "assembly line 'manned' by machines with hands" made Lordstown "the most modern, automated, robotized carmaking complex in the world."[81]

Switchover to Vega production began shortly after the last full-sized Chevy rolled off the assembly line on March 13, 1970.[82] A few months later, Vegas began coming off the line with the first sales slated for September 10.[83] Progress, however, was slow "as the company trains workers and 'gets the bugs out'" of the computerized and robotized assembly line.[84] In August, only 30-45 Vegas were coming off the line an hour, compared to the 60-70 Impalas prior to the model change but the expectation was to hit 100 cars per hour by December.[85] For comparison, Ford's Mahwah plant averaged 52 cars an hour while the Dodge Main plant averaged 64.[86] And while the average time cycle per job at other auto assembly plants averaged 55 seconds, Lordstown averaged 36, making it by far the fastest-moving assembly line in the industry.[87] By December, with the kinks apparently out of the system, Lordstown met its 100 Vegas an hour expectation and, according to numerous workers, routinely surpassed this.[88]

Gary Bryner, president of Lordstown's Local 1112, attributed the productivity jump to robotization: "When they took the unimates on, we were building sixty an hour. When we came

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[81] Lund, 81.
[82] Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - Lordstown Chronology, GMHC, 4.
[83] Schotten, "Vega Line Opens New Era in Auto Building."
[84] "GM's mini," 26.
[85] "GM Forecasts Rout Of Foreign-Made Autos By Detroit's Minicars," *Wall Street Journal,* Aug 7, 1970, 19 and GM's mini," 26.
[86] Dan Surkin and Marvin Georgakas, *Detroit, I Do Mind Dying: A Study in Urban Revolution* (St. Martin's Press, 1975), 124.
[87] Lee, "The Lordstown Plant of General Motors," 5.
[88] Lordstown Collection. Box 9. Folder - Speeches and Presentations - 1974 - John Grix, Public Relations Coordinator, GM Lordstown, GMHC, 5; Tray Direnzo, "Dean Tedrow," April 9, 2002, Youngstown State University Oral History Program: GM Lordstown, (O.H. 2037), 5; Kristina A. Murphy, "Joe A. Sigurani," March 14, 2001, Youngstown State University Oral History Program: GM Lordstown, (O.H. 2017), 12; Robin Schuler, "Harold Liller," February 14, 1981, Youngstown State University Oral History Program: GM Lordstown, (O.H. 553), 5; and Robert Thomas, "Jerry Butcher," February 15, 2001, Youngstown State University Oral History Program: GM Lordstown, (O.H. 1932), 5-6.

back to work, with the unimates, we were building a hundred cars an hour."[89] In total, more than two dozen Unimates and dozens of SAMs were "bang[ing] out 130 welds in just 4½ seconds" and completing 95 percent of the almost 4,000 body welds each day.[90] Unlike human workers, a *Popular Mechanics* profile of Lordstown claimed, "the GM robots are incapable of turning out an inferior job. There's no chance for error as there is with humans." Additionally, "if something goes awry, the machine will send out an SOS or shut-down the line," the latter action of which human workers were *not* allowed to do (this was not mentioned in the article). And, in rhetoric typical of the industrial robot's inhuman capacities, the profile proffered that "the slave machines can work 24 hours a day, seven days a week. No coffee breaks, no lunch hour, no vacations." This mechanical slave labor was predicted by GM to increase maximum output from 50-60 an hour to one hundred. Apparently unimpressed, *Popular Mechanics* seemingly goaded GM to increase the line speed even more: "Our information is that Lordstown rev up to 110 to 115 cars an hour—almost two a minute—without straining either men or machines."[91]

That GM was not revving the line to extreme levels was supposedly a derivative of the corporation's conservative and exacting approach to decision-making, and the fear of "not wanting to step on the toes of the union."[92] When newly elected UAW president Leonard Woodcock toured Lordstown in August 1970, the first such visit by an International official since the plant had opened, "one of the prime points of [his] inspection tour," the *Warren Tribune Chronicle* told its readers, "was the new unimat [sic] robot machines."[93] The *Popular Mechanics* profile made sure to inform its readers:

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[89] Studs Terkel, *Working: People Talk About What They Do All Day and How They Feel About What They Do* (Ballantine Books, 1990), 261.
[90] Lordstown Collection. Box 4. Folder - News-Press Kits-Releases - 1970-1971 - Releases Pertaining to Robotics, GMHC; Lund, 81; Schotten, "Vega Line Opens New Era in Auto Building"; and "GM's mini," 26.
[91] Lund, 204.
[92] Lund, 206.
[93] "UAW Chief Visits at Lordstown," *Warren Tribune-Chronicle*, Aug. 24, 1970.

> The UAW's position is not antirobot. The union is against its members being thrown out of work as a result of machines taking over. But if workers can be shifted to other jobs at the same pay, the union has no object. The late Walter Reuther, long-time president of the UAW, went so far as to say that certain jobs in the auto factories are so arduous, mentally enervating and degrading to humans that they should be robotized.

Affirming and assuaging these concerns, one GM source for the article stated that "in every instance GM has introduced automatic equipment into its plants, the company still has the same number of employees on the payroll as it had premechanization." Furthermore, the source claimed, "Workers have been absorbed in other jobs, frequently at higher pay," but no details were provided. And while the profile was wrong about almost every prognostication of the industrial robot's peerless performance, its historical assessment of Lordstown was accurate: "If the industry ever pauses long enough to put up a tablet marking the site where the robot served his apprenticeship in auto-making, it will be at GM's plants in Lordstown."[94]

**GMAD: Disciplinary Layoff and Punish**

The Vega was officially launched on September 10, 1970, and the year following provided lows and highs for GM and the UAW. On September 14, four days after the Vega went on sale, the UAW went on what at the time was their longest, and eventually most expensive, strike of GM to date costing the corporation over a billion dollars. The UAW notched a number of contract victories in regards to wages and benefits but almost went bankrupt in the process.[95] For the

[94] Lund, 208.
[95] William Serrin, *The Company and the Union: The "Civilized Relationship" of the General Motors Corporation and the United Automobile Workers* (Vintage Books, 1974).

Vega, the new 'import fighter' won *Motor Trend*'s prestigious "Car of the Year" award on January 19, 1971 and a little over a month later, the 100,000th Vega rolled off the assembly line.[96] GM CEO James Roche predicted that sales of imports would fall to 10 or 11 percent of the market, however, by August 1971, more than a fifth of all cars sold in the US were foreign.[97]

For Lordstown, the lows outnumbered the highs. While the plant had not experienced any "unusual labor problems in its first several years of production," one GM internal history of Lordstown claimed, it had been staffed by "a lack of experienced supervisors and was not producing a top quality product at a good cost factor."[98] As the history detailed: "the problem was being perpetrated by a turnover of supervisors who were unable to cope with the situations and the replacement of these individuals by inadequately trained replacements. Both divisions [Chevrolet and Fisher Body] made a practice of replacing a supervisor with an individual who had absolutely no training whatsoever. There was no organized management development activity in existence and confusion begot confusion."[99] Furthermore, the changeover to the Vega "involved a tremendous number of readjustments and reassignments and, once again, experienced all the ills of little preparation and untrained supervisors."[100]

Contrary to managerial memory and much of the historiography on Lordstown, both of which position the 1972 strike as some sort of one-off struggle, workers had staged authorized and wildcat strikes almost every year since Lordstown opened, including the most recent strike in 1970. These related to issues ranging from excessive overtime and overwork to safety

[96] Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - Lordstown Chronology, GMHC, 5.
[97] Rothschild, "GM in More Trouble."
[98] "History of the Lordstown Plant: April, 1964 through February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - History of the Lordstown Plant, April 1964-February 21, 1973, GMHC, 4.
[99] "History of the Lordstown Plant: April, 1964 through February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - History of the Lordstown Plant, April 1964-February 21, 1973, GMHC, 4.
[100] "History of the Lordstown Plant: April, 1964 through February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - History of the Lordstown Plant, April 1964-February 21, 1973, GMHC, 5.

conditions and skilled-trades local contract agreements.[101] In May 1971, "alleged unsettled grievances triggered the rank and file membership" to call for a strike, and "alleged mistreatment of a committeeman" motivated picketers to "wear paper bags, masks and other coverings over their heads in order not to be identified" during a strike in September.[102] Not all grievances led to a strike or walkout as many were resolved almost immediately after work stoppages. On a daily basis, workers partook in a number of resistance tactics to have their grievances taken seriously from soldiering (working slow) and "working to rule" (the practice of following productions standards to the letter, i.e., completing a task exactly is it was specified in the "rules") to insisting on extra breaks and filing "nuisance grievances" to create "bureaucratic snafus."[103] Supervisors at Lordstown were, therefore, demoralized, and by the middle of 1971, a leadership change seemed "inevitable." And, the name of the new management team "on the lips and minds of the greatest percentage of salaried employees" used by the corporate home office "as a threat to supposedly motivate people to do a better job"—GMAD.[104]

Established at the tail end of World War II, the General Motors Assembly Division (GMAD) was the latest iteration of GM's organizational approach to Fordist manufacturing and Sloanist marketing that, in totality, entangled corporate structure, labor-management relations, production, and sales.[105] In the 1930s, the Chevrolet division demonstrated the economic and

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[101] "Lordstown Strikers to Return," *Youngstown Vindicator*, Nov. 4, 1967; "Contract Approval Ends Strike at Lordstown GM," *Warren-Tribune Chronicle*, Mar. 8, 1968; "Injury Triggers Lordstown Strike," *Youngstown Vindicator*, May 25, 1968; "Wildcat Strike Halts All Production At Chevy-Fisher Plant," *Warren-Tribune Chronicle* Jan. 30, 1969; "GM Lordstown Authorizes Strike," *Warren-Tribune Chronicle*, May 19, 1969; "UAW Local 1112 Authorizes Strike at Lordstown," *Warren-Tribune Chronicle*, May 17, 1971; Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - History of the Lordstown Plant, April 1964-February 21, 1973, GHMC.
[102] "UAW Local 1112 Authorizes Strike at Lordstown," and "Fabrication Plant Idled By Strike," *Warren-Tribune Chronicle*, Sept. 9, 1971, Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - History of the Lordstown Plant, April 1964-February 21, 1973, GHMC.
[103] David Moberg, "Rattling the Golden Chains: Conflict and Consciousness of Autoworkers," Ph.D. Dissertation, University of Chicago Department of Anthropology (March 1978), 114.
[104] "History of the Lordstown Plant: April, 1964 through February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973 - History of the Lordstown Plant, April 1964-February 21, 1973, GMHC, 6.
[105] For a sophisticated institutional and sectoral analysis of this history, see Zetka, Jr.

political advantage of remotely dispersing auto assembly plants from parts producing plants while simultaneously standardizing parts across different models. Because automobiles assembled in Detroit incurred a shipping surcharge at the point of sale, relocating assembly closer to dealers brought the joint cost of shipping and assembly below the cost of shipping fully assembled cars. This improved profits through equalized freight earnings, sped up deliveries to dealers (due to shorter hauls), and increased market penetration of the communities adjacent to assembly facilities.[106] Furthermore, the UAW's famous 1937 sit-down strike in Flint, Michigan—one of only two locations that produced the dies from which car body components were stamped for Buicks, Oldsmobiles, and Pontiacs (the other was in Cleveland)—crippled GM's production nationwide, revealing the risks of employment concentration (in relation to critical parts production) and the brittleness of GM's sociotechnical network. Additional profits and the "preclusion of employment in Flint, Lansing and Pontiac," as a GM internal history described it, motivated the organization of the Buick-Oldsmobile-Pontiac (BOP) Assembly Division in June 1945.[107]

Over the next two decades, BOP handled the fabrication and assembly of the three divisions' different vehicles on the same production lines at Arlington, Texas, Doraville, Georgia, Fairfax (Kansas City), Kansas, Framingham, Massachusetts, and Wilmington, Delaware while the individual divisions maintained control of vehicle design, engineering, and marketing. Centralizing assembly under one roof produced two direct benefits to the corporation: BOP was able to produce cars cheaper than the individual divisions, and assembly plants that

[106] A. O'Keefe, "History of the Buick-Oldsmobile-Pontiac Assembly Division," GMHC, 1 and Robert F. Freeland, *The Struggle for Control of the Modern Corporation: Organizational Change at General Motors, 1924–1970* (Cambridge University Press, 2001), 249 fn 83. GM's internal history does not mention the Flint sit-down strike.
[107] O'Keefe, "History of the Buick-Oldsmobile-Pontiac Assembly Division," 1. Cadillac and Chevrolet, for unspecified reasons, remained autonomous.

previously operated under a dual management and dual union structure were able to be consolidated.[108] BOP extended its fiefdom in 1963 when, in what appears to be a managerial experiment, the division took charge of Chevrolet's passenger car assembly in Arlington, Texas and, shortly thereafter, the assembly of Chevrolet and GMC trucks at the newly built Fremont, California plant. In June 1965, with the experiment apparently successful, BOP was transformed into and rebranded as the General Motors Assembly Division (GMAD).[109]

From its inception, GMAD proved to be an enigma. General Motors was a pioneer of the decentralized "M-form" corporation that purportedly lowered costs by separating long-range planning (housed at corporate headquarters) from day-to-day operations (taking place at each division). The reorganization of BOP into GMAD, however, seemingly challenged this philosophy and structure as assembly processes previously handled by the decentralized divisions were now re-centralized in Detroit. Additionally, while GM chalked up the reorganization to the need for "increased efficiency," it was understood by commentators and industry analysts as a tactic to circumvent attempts by the Department of Justice (DOJ) to break up the corporation via antitrust action that had been ongoing for almost two decades. If GMAD took over final assembly for the entire corporation, the individual divisions such as Chevrolet and Fisher Body, which previously were relatively self-contained and therefore ripe for divestment, would now be more intertwined with the parent corporation and harder to separate.[110]

A second, and related, pillar of GMAD's emergence was the attempt by GM to use technology to manage its capital-labor relations in a dual effort to blunt union power and

[108] Lordstown Collection. Box 9. Folder - Speeches and Presentations - 1974 - Lordstown Update Speech, GMHC, 2.
[109] A. O'Keefe, "History of the GM Assembly Division," 128.
[110] Freeland, 277-278; Rothschild, *Paradise Lost*, 113 fn; and Serrin, 105.

increase productivity.[111] To accomplish this, in one analyst's assessment, "GMAD's weapons were both organizational and technological," and ranged from their willingness to violate customary shop practices around production standards to their use of computers for generating "abstract, reified" knowledge that justified imposing new managerial prerogatives as well as facilitating their management of the newly installed "unimate robot welders."[112] When combined with its antitrust agenda, the centralization of assembly management in GMAD provided the corporate home office tighter control of production scheduling, which "enabled GM to maintain a politically safe market share, while maximizing its rate of return."[113]

GMAD's activity, however, was not just confined to managing assembly of consumer vehicles. The division also produced the Army's XM705 and XM737 tactical cargo trucks at their Baltimore plant and took over the Manufacturing Development Staff's Assembly Research Center in Flint. According to GM:

> All the activity at the Assembly Research Center is aimed toward overall improvement of product quality, simplification of assembly, and discovery of cost-savings potentials. The facilities at ARC provide a means to test assembly sequences using prototype models, prior to the actual model change-over period . . . . The purpose of the research done at ARC is to save time and labor from the very start of production in building maximum quality into the product, meeting acceleration schedules on the assembly line and holding costs to a minimum. Other factors given consideration are methods of inspection and testing, line-up of parts for each make vehicle in multi-car plants and how it affects the assembler. Timing and quality of workmanship are also studied for adjustment and improvement.[114]

GMAD's work at the ARC included the development of a "Systems Engineer Concept" that was "implemented to achieve design penetration from the assembly viewpoint" and used a prototype

[111] The following paragraph comes from Zetka, Jr., 200-237.
[112] Zetka, Jr., 233.
[113] Zetka, Jr., 202.
[114] O'Keefe, "History of the GM Assembly Division," 167.

car, the XP-887, in the concept's pilot program. The former became the Total Systems Engineering Concept and the latter became the Vega.[115] According to an internal history of GMAD, it also became "the first Division in General Motors to establish a full-time function aimed at organizational analysis and development, which is a planned approach of integrating employe [sic] needs for growth and development with organizational goals and objectives." As the history described it, "among the areas with which this activity is concerned are absenteeism, employe [sic] motivation, improvement of the foreman's position and his relationship with his work force, and reduction of employee grievances."[116] This would prove to be the ultimate irony as GMAD quickly earned a reputation for its authoritarian management style, which triggered skyrocketing grievances by workers at almost every plant that came under its jurisdiction.

If any one person came to shape and embody the ethos of GMAD, it was Joseph E. Godfrey. The son of a GM executive and a Naval officer during World War II, Godfrey—who wore the military-provided crew cut for the rest of his life—was known to his colleagues as the hardest worker in the building, a family man with a dry sense of humor, and a naturally good golfer. Beginning his GM career in the late 1930s, Godfrey steadily rose through the ranks of the Steering Gear Division, moving from assistant foreman in 1941 to head of the division in 1964. Three years later he was promoted to vice president and put in charge of the corporate Manufacturing Staff, and on November 4, 1968 he was promoted again, this time as general manager of GMAD.[117]

What Godfrey brought to his new position a reverence for technology and tradition, the social tensions of which he attempted to reconcile through a technopolitical vision of corporate

[115] O'Keefe, "History of the GM Assembly Division," 167 and Eshelman, 42.
[116] O'Keefe, "History of the GM Assembly Division," 198.
[117] Robert M. Finlay, "Editors Forum: Interview With Joseph E Godfrey," *Automotive News*, October 4, 1971 and O'Keefe, "History of the GM Assembly Division," 155.

success and a hard-nosed managerialism on and off the shopfloor. Speaking at a GM Plant Engineering Seminar in April 1968, he linked the increasing importance of technological investment and management to GM's need "to reduce costs, increase efficiency, improve quality and ultimately prevent the erosion of our traditional profit margin."[118] One element of these technological investments, Godfrey told attendees of a General Motors Institute (GMI) Computer Seminar a week after took charge of GMAD, was numerical control (N/C). Specifically foregrounding DAC and INCA, he lauded N/C for its ability to eliminate operator (i.e., worker) error, reduce rework and scrap, and decrease the number of jigs and fixtures required for production runs.[119] However, the implications of numerical control, in Godfrey's estimation, went far beyond just dollars and cents:

> [N/C] is a *management tool* for numerous operations, and a management consideration for others . . . . In total, N/C *allows management more control* over design, production, quality, and scheduling . . . . It affects personnel, employee classifications, and training . . . . Numerical control cuts across organization lines, rocks boats and invades empires . . . . Old rules don't hold. Nothing is sacred to N/C. It is part of a rapid revolution.[120]

This was technopolitics in action as Godfrey conceptualized the design and deployment of technological systems as having the power to reshape the sociotechnical contours of production *and* labor-management relations alike.

Unlike this "progressive" approach to managing technology, Godfrey's management of people derived from a nostalgia for a bygone American hard-nosed no-nonsense work ethic and a staunch appreciation of discipline. At a 1968 toast to President Lyndon Johnson in Saginaw,

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[118] J. E. Godrey, "Importance of the Engineer's Job to GM," April 23, 1968, GMHC, 2.
[119] J. E. Godfrey, "N-C or Not N-C, That is the Question," November 12, 1968, GMHC, 6, emphasis added.
[120] Godfrey, "N-C or Not N-C, That is the Question," 2, 6, 9, 11, and 13. Godfrey's statement is probably the most cogent, concise, and direct articulation of Noble's thesis in "Social Choice in Machine Design" (and his later expansion of this in *Forces of Production*) I've come across in the historical record.

Michigan, Godfrey declared "The Ten Commandments, Golden Rule and Bill of Rights have not been abrogated by violence in our streets or casualness with the truth. The virtues and values of work and the dignity of labor have not been superseded by indolence or by the parasitical lives of the hippies on Haight Street."[121] Two years later, he rattled off a litany of evils to the Saginaw YMCA Industrial Executives Club: young people "rebelling progressively in the home, in the community, in the nation -- in everything that comprises the so-called 'establishment'" and workers of all ages demanding exorbitant wages and maximum benefits for less and less work.[122] He went on to decry the increase in worker absenteeism and poor employee attitudes, which manifested most directly in illegitimate work standard controversies that, in his interpretation, were "generated to promote featherbedding," knowledge of which he attributed to his two years of experience leading GMAD. "More money is not the answer in itself," Godfrey proclaimed about the labor problem; what it boiled down to was the need "to better motivate today's worker to take greater interest in his job and to rekindle the pride of workmanship so evident in the products and services of craftsmen of yesteryear."[123] What that translated into was more discipline.

GMAD under Godfrey's leadership quickly gained a "national reputation for ruthless aggression" characterized by internal competition and managerial discipline. Thomas Fitzgerald, a former director of employee research and training at the corporation, posited that "deep structural and cultural influences had caused managers to be authoritarian" and that the very nature of mass production "required the unquestioned leadership of experts." As a result, GM deliberately "selected managers who were efficient and 'dominant.'" Furthermore, he added,

[121] Joseph E. Godfrey, "Toast to the President," January 1, 1968, GMHC, 6-7.
[122] Joseph E. Godfrey, "Auto Industry Challenges for the Future," October 14, 1970, GMHC, 4-5
[123] Godfrey, "Auto Industry Challenges for the Future," 8-9.

"They could not and should not be trained to be cooperative [with workers]."[124] Godfrey and GMAD, therefore, were on solid ground with their superiors, and in what could be called a culture of 'trickle down discipline,' Rothschild described how "managers are trained to identify and eliminate waste moments. And beyond such training, the managers learn (for free) a lasting attitude of tough-mindedness, to be shared by executives and plant managers and middle managers and general supervisors and foremen on the line."[125] To monitor whether this "tough-mindedness" translated into productivity, GMAD implemented a "continuing, computerized system of grading and ranking" that was part of a "highly sophisticated reporting network" that gave Godfrey daily performance ratings for each plant. At the end of every month, each plant was ranked according to efficiency and quality, and those in the lower third received special attention, "including a visit from the boss to talk things over, if no improvement is showing in the succeeding months." The system was endless as one plant pushed another down the scale in an iterative, open-ended process of improvement that put pressure on each plant's management to "reduce costs continually."[126] Gary Bryner, president of UAW Local 1112 at Lordstown, sketched how the top-down system worked in practice:

> In the GMAD system there are 18 assembly plants. They are rated on an audit system for costwise, efficiency, and when that list comes out, it is on a scale of one to 18. That 18th person or management or assembly plant gets a visit by the higher corporation executives, and he is told why it should not be No. 18 on that list. He immediately calls a meeting and he tells the department superintendents why they cannot be No. 18 on a list, and they immediately tell the foreman, and the pressure is applied. It is applied to the worker, and they stress efficiency and cost savings for quality without any concern for human rights. This perpetuates the alienation, and this goes on and on and on every time their little audit comes out. And management goes further than that because in their

[124] Stephen Peter Waring, "Beyond Taylorism: An Intellectual History of Business Management since 1946," Ph.D. Dissertation, University of Iowa Department of History (Dec. 1988), 224.
[125] Rothschild, *Paradise Lost,* 114-115.
[126] Agis Salpukas, "G.M.'s Toughest Division Binbuster?," *New York Times,* Apr. 16, 1972.

> system the only form of correction they have is discipline, and that is their answer to everything.[127]

Cost reductions began with cutting "duplicate" operations and ended with squeezing as much work as possible out of every production job.[128] Each plant brought under the GMAD umbrella, therefore, experienced layoffs and the addition of extra tasks to existing jobs with increased severity by foremen and extra penalties when these new jobs were not completed up to standards.

GMAD's main grievance with existing work regimes was the reality that informal agreements between labor and management at the local level permitted lax enforcement of collectively bargained production standards set in the national contract. As GMAD official Kenneth N. Scott characterized this, "When you have a plant over many years, it is very possible to have developed habits that aren't right: they are outside the [national] agreement."[129] The prevalent example of this was the practice of "doubling up," which involved a worker doing their assigned job and that of another worker at the same time. This allowed one worker to take a break, and then they would alternate, which gave both more control over work pace and relief time. "Guys in the plant," one local union official described it, "had learned through repetition and doing the job over and over again that the way to cut down on it—short cuts in the job—where it might be set up time study-wise for 59 second they could do it in 40 or 30."[130] According to one worker, management prior to GMAD allowed the practice and it was the UAW who "were the first ones hollering about it" because "if the efficiency experts of General Motors walked through that plant . . . . and starts studying those jobs" layoffs would follow resulting in

[127] "Statement of Gary Brynner [sic], President, UAW Local 1112, Lordstown, Ohio, Accompanied by Dan Clark, Member, UAW Local 1112, Lordstown, Ohio," *Worker Alienation, 1972,* Hearings before the Subcommittee on Employment, Manpower, and Poverty, 1972.
[128] Salpukas, "G.M.'s Toughest Division Binbuster?"
[129] "The GM efficiency move that backfired," *Business Week,* Mar. 25, 1972, 46.
[130] Robin Schuler, "Marlin Ford Interview," March 6, 1981, Youngstown State University Oral History Program: GM Lordstown, 5.

more work for those who survived the cuts.[131] As the local union official put it, "[doubling up] was just like waving a red flag, so they cut a lot of people because of that."[132]

To cut down on 'double ups' and other worker "offenses," GMAD's control on the shopfloor was mediated through the "disciplinary layoff." Better known by its acronym, DLOs were progressive penalties for workers who disobeyed orders from management whereby an offender could be sent home for the balance of a shift, a day, a week, or a month. If a worker accrued too many DLOs, they could be fired. Beyond DLOs, other forms of discipline, often arbitrary, included run-of-the-mill verbal harassment and taking away newspapers at workstations to timing bathroom and water breaks.[133] One worker described how when engineers came in to time-study a job "you weren't allowed to talk to another employee because that would take time away. It was almost jokingly petty."[134] GMAD, therefore, acquired a reputation for "get-tough" tactics, being a "tough taskmaster," and "attacked its jobs with urgency" under the leadership of its "tough-minded general manager" Joseph Godfrey. According to Scott, "if operating on the basis of our contract and agreement is tough, then all right, GMAD is tough. If stopping looseness and malpractice is tough, then yes, GMAD is tough."[135] The philosophy behind this was simple—in Godfrey's words, "Within reason and without endangering their health if we can occupy a man for 60 minutes, we've got that right."[136] As one retrospective article on the Lordstown strike more pithily put it, GMAD was brought in to "crack the whip."[137]

[131] Robin Schuler, "Raymond Lewis Interview," May 16, 1981, Youngstown State University Oral History Program: GM Lordstown, (O.H. 1022), 8.
[132] Schuler, "Marlin Ford Interview," 5.
[133] Moberg, "Rattling the Golden Chains," 244.
[134] Schuler, "Harold Liller Interview," 6.
[135] "The GM efficiency move that backfired," 46, 47, and 49.
[136] Salpukas, "G.M.'s Toughest Division Binbuster?"
[137] James Risen, "Lordstown's blues mellow with age," *Cincinnati Enquirer*, June 14 1987.

What this meant in practice was management further reducing workers' control of production and forcing them to keep pace with the automated assembly line.

The rank-and-file response to the Godfrey-led GMAD crackdown on workers was immediate and widespread. In 1968-1969, GMAD consolidated the previously separate Chevrolet and Fisher Body divisions at seven plants—Baltimore, Maryland, Janesville, Wisconsin, Lakewood, Georgia, Leeds (Kansas City) and St. Louis, Missouri, Tarrytown, New York, and Van Nuys, California—with strikes following each takeover. According to then director of the UAW's GM Department Leonard Woodcock, six of the seven plants (excluding St. Louis) struck over GM's "unilateral action" to negotiate a single local agreement where two were already in effect. GM vice president in charge of personnel Louis G. Seaton retorted, "the strike stems from unreasonable and unrealistic wage and other demands by local union officials . . . . using the consolidation to demand unjustified wage increases for jobs which are not changed in any manner by the plant consolidations."[138] At the same time the 28,000 workers of the six plants were walking out in protest of the consolidations, more than 8,000 workers at the St. Louis plant went on strike in reaction to production standards.[139] The seven strikes lasted anywhere between three weeks and three months before being settled and contributed to cutting GM's total production volume by a third.[140] Three more plants were added to GMAD's portfolio over the next two years including Lordstown and Norwood in Ohio as well as Willow Run, Michigan. This meant that the division managed every assembly plant except for the four Michigan home plants still operated by Buick, Oldsmobile, and Pontiac.[141] The Norwood plant, which would eventually stage a 174-day strike in 1972 that proved to be the longest in GM's history, began

[138] Ralph Orr, "GM Plants Struck in Six Cities," *Detroit Free Press*, Apr. 29, 1969.
[139] "GM Seeks Peace at 6 Struck Plants," *Detroit Free Press*, Apr. 30, 1969.
[140] "St. Louis GM Strike Settled," *Detroit Free Press*, June 7, 1969.
[141] Rothschild, "GM in More Trouble."

complaining of deteriorating working conditions after GMAD arrived in August 1971 while the Willow Run plant, according to GM supervisor of standards and methods Curtis Cox, proved an anomaly and avoided a strikeable labor dispute.[142] Three months before GMAD took control of Lordstown, Godfrey gave a new version of his "Auto Industry Challenges for the Future" speech to the Maine Automotive Dealers Association in Portland, ME which, almost word for word, rehashed his previous musings on "people problems."[143] It was a warning of what was coming down Exit #216 of the Ohio Turnpike.

When GMAD took command of Lordstown on October 1, 1971, any uneasy peace existing between labor and management was shattered. Consolidation of the plant meant new union elections were held to merge the separate bargaining committees at Chevrolet and Fisher Body, leading to the elimination of a full committee.[144] "Prior to October," Lordstown Local 1112 president Gary Bryner described it, "when GMAD came down, we had established an agreement: the guy who was on the job had something to say. When GMAD came in, they said, He's long overdue for extra work. He's featherbedding."[145] As a result, GMAD began cracking down on informal practices like "doubling up" and laid off anywhere between 300-400 workers.[146] They also brought in time-study experts to eliminate or reassign jobs considered too

[142] "Longest Strike at G.M. Is Ended At Plant in Ohio After 174 Days," *New York Times*, Sept. 28, 1972 and Ralph Orr, "War Brews at GM Vega Plant," *Detroit Free Press*, Jan. 23, 1972. The Willow Run agreement was not finalized until May, "GM, UAW Reach Accord," *Detroit Free Press*, May 6, 1972.
[143] Joseph E. Godfrey, "Auto Industry Challenges for the Future," June 12, 1971, GMHC.
[144] Lee, "The Lordstown Plant of General Motors," 6.
[145] Terkel, 260-261.
[146] Bryner claimed anywhere from 700-860 were laid off (the lower number was routinely quoted in media coverage), however, he later clarified that the larger numbers were based on a monthly union dues check-off report provided by GM. Apparently the report had not been checked for duplicates thereby doubling the number of apparent layoffs, "UAW Concedes Miscounting of Vega Layoffs," *Detroit Free Press*, Mar. 28, 1972. GM's own internal narrative history states that between September 30th and December 31st, 330 workers had been fired, however, a later study by GM found that the correct number was 375, "History of the Lordstown Plant, April 1964-February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973, 10 and John J. Grix and Hak-Chong Lee, "Lordstown Plant of General Motors (B)," Lordstown Collection. Box 3. Folder - Histories - 1974-1975 - Lordstown Historical Document, GMHC, 1.

easy, which gave job classifications more tasks (and extra penalties when they weren't completed) and, to meet production goals, instituted 11-12 hour shifts and mandatory overtime and weekends.[147]

Foremen specifically targeted "militant" workers for discipline and dismissals, "all in an effort to intimidate and prod the workers to keep up."[148] For instance, one worker, who told a local newspaper that GM saw workers as nothing but "machines to turn out profits," was immediately attacked the next day by his foreman, who forced him to start following many long-disregarded shop rules.[149] And discipline was harsh for even the non-militant. One worker charged that "management frequently behaved as if taking orders were the paramount and unqualified condition of employment," while another, a Vietnam veteran, compared Lordstown to his experience in the Army: "If the foreman gives you a direct order, you do it, or you're out."[150] One writer, referring to a worker with a pseudonym, called it "Duane's military-industrial complex."[151] Other workers described GMAD managers as "concentration camps guards" or the "Gestapo" who demanded that "when you come in the plant leave your brain at the door, just bring your body in here, because we don't need any other part. Leave your brain at the door, we'll tell you what to do, how to do it, when to do it, when to eat, when to drink coffee."[152] When asked why they were given such names, one worker responded: "They were missing the SS signs on their arms."[153] And this was not just hyperbole: One particularly disliked foreman in the body shop—who was openly contemptuous of "n******," "those people," and

[147] James Rubenstein, *The Changing US Auto Industry: A Geographic Analysis* (Routledge, 1992), 233.
[148] Risen, D-5.
[149] Moberg, 219.
[150] Moberg, 424 and Barbara Garson, "Luddites in Lordstown," *Harper's* (June 1, 1972), 69.
[151] Garson, 69.
[152] Monica Mastran-Czopor, "Jim Graham Interview," April 3, 2002, Youngstown State University Oral History Program: GM Lordstown, (O.H. 2061), 7.
[153] Monica Mastran-Czopor, "Edward Czopor Interview," February 20, 2002, Youngstown State University Oral History Program: GM Lordstown, (O.H. 2057), 8.

"them" as "inferior"—proudly flaunted his initials, S.S., as a sign of the times under GMAD. "If you think Hitler was bad," he was quoted as saying, "you haven't seen anything yet. I'll show you what bad is."[154]

Black workers, who typically made up a third of all workers in auto plants nationwide, were only 10 percent of the labor force at Lordstown, yet race relations still proved contentious. One black worker—who resigned his job as a foreman in disgust to return to the assembly line—described how he was assigned to do a seven-man job. Management continued to add duties to his workload, leading him to complain to his foreman, who wrote up a 78. Nothing came of it and, after refusing to continue work under such conditions, the Black worker was replaced with a White one. The White worker almost immediately began falling behind and after a couple of hours management began stripping duties from the job. So many duties were stripped that the White worker was eventually doing a "normal" job.[155] Beyond the 'unskilled' and 'semiskilled' jobs, there we only five or six Black tradesmen out of a total of 500 due to discrimination in apprenticeships and ineffective training programs.[156] One of the few Black foreman in the plant described how White laborers in the skilled trades worked with management to stymie the advancement of Black workers: 10 percent of a certain group of skilled workers would be mandated to have a single minority, so senior White members of the trade would work with management to break up the group, which contained for instance twenty skilled workers, into two groups of ten, and then hire one black worker. That way, the larger group of twenty could avoid hiring two blacks. Furthermore, as he put it:

[154] Moberg, 184.
[155] Stanley Aronowitz, *False Promises: The Shaping of American Working Class Consciousness* (Duke University Press, 1992), 44.
[156] Aronowitz, 44.

> For six years [1966-1972] we've been fighting to get this department equalized . . . . and then, when the black guy gets into the [skilled trades] group, wow, they won't show him anything, you know, they won't teach him nothing, the union won't put pressure on [whites] to do this, you know, to show this guy and teach him . . . . so you get guys that say "Hey, how come you won't go into the skilled trades?" "Hey man, it's too much headache". . . . then they put this label on [him], and the union will tell you this: the reason we can't get a black guy is because he's too lazy.[157]

Discrimination, therefore, became a pervasive obstacle for black autoworkers before and after GMAD as they were 'n*****mated' on the assembly line and denied advancement off it.

After GMAD took over in October, race relations came to a head during mid-November union elections in 1971 with Black workers' role in the union becoming the "the decisive issue in the election." When Du Du Ujama—the Black caucus of the local that styled itself as a militant black revolutionary movement like those across the industry—drew up a slate of candidates, they were unable to gain the full support of all black workers, even though blacks were a tight-knit social group in the plant. Additionally, conservative White workers within the Rank-and-File Caucus and the United Action Caucus, which were pro-company and strongly racist, leveraged White fears of "black power" and a "black takeover" of the union to sway the election, resulting in Black workers winning only two of sixty-four positions.[158] Speaking in broader terms a year prior, UAW president Leonard Woodcock told a *New York Times* reporter that "the economic squeeze on the White worker was creating a 'terrible' frustration that was turning him against the poor and the black."[159] The election outcome, therefore, could be interpreted as a manifestation of White workers' fears that their capacity for enforcing racial privilege on the shopfloor—and

[157] *Loose Bolts?*, (Merrimack Films, 1973), 22:29 - 24:00. While there's no reason to interpret any interviewee statements or segments of the documentary as misleading, it is worth noting that the film was partially funded by the Ford Foundation (29:09).
[158] Moberg, 160-161 and 524-529.
[159] Jerry M. Flint, "Reuther's Successor Says U.A.W. Will Work With A.F.L.-C.I.O. but Won't Rejoin Federation," *New York Times*, June 21, 1970.

thereby better wages, better working conditions, and solidified job security—through the structural power of the local could be jeopardized by increasing black representation. This made black workers more vulnerable to management discipline and less likely for their grievances about discrimination and working conditions to be taken seriously.

In terms of the latter, the local charged that "GMAD brought a return of an old-fashioned line speedup and a "sweatshop style" of management reminiscent of the 1930's, making the men do more work at the same pay."[160] This was well understood by the workers who referred to GMAD as "Get Mad and Destroy," "Get Mean and Destroy," and "God Made another Dollar."[161] As local president Gary Bryner described it:

> If you're a worker and you turn in a suggestion that saves somebody's life, you get a twenty-five-dollar savings bond. If you're a worker and you turn in a suggestion that does away with six of your brothers' jobs, you get six thousand dollars—that's the way workers perceive the company; just money-hungry bastards that would do anything to save money. That's how GMAD got its nickname as "Gotta Make Another Dollar."[162]

The body shop where spot welding took place was a prime example of the convergence between discrimination, speedup, and industrial robots. What some at the plant called "the jungle" or "the zoo" was inhabited by "a different breed of cat" where the "noisy, dirty, smoky" work at the beginning of the assembly line took place.[163] Welders were pushed to the limits in "the jungle," leading to higher instances of workplace injuries and an overall increase in job dissatisfaction. In addition to the institutional barriers that disproportionately relegated black workers to "the

[160] Lee, "The Lordstown Plant of General Motors," 5-7
[161] Moberg, 170.
[162] Bert Spector and Michael Beer, *Readings in Human Resource Management* (Free Press, 1985), 487.
[163] Moberg, 215. Whether "the jungle" was called as such because of the tangled mass of welding machine lines hanging from the ceiling like overgrown foliage, the workers' behavior, or the racial makeup of the workers themselves is unknown; however, the historical significance of referring to those with black African ancestry, or their environs, in zoological terms is hard to miss.

jungle," it was also a site of overt discrimination. One foreman in the shop was "over heard saying the line would run a lot better if he could get rid of all the 'n******.'" In the eyes of Black welders therefore, such sentiments meant that "as long as foremen like this were responsible for many job assignments, blacks were going to get shafted."[164]

While the physical toll of the work was bad enough, already over-specialized, repetitive jobs became mind-numbing as the GMAD speedup "made a boring job excruciating."[165] And this was particularly the case for workers who labored beside the automatic welding robots as the Unimates—supposedly intended to eliminate "subhuman" jobs—actually created one of the most monotonous jobs in the plant. The automatic transfer machines needed to pass materials to the industrial robots were deemed too expensive by GM so "human helpers" did the menial work of transferring body modules to the Unimates's waiting hands whose blind, clutching motions had "an evident resemblance to the feeding machines in Charlie Chaplin's *Modern Times*."[166] The "speeding robots," auto industry analyst Maryann Keller described, "required *humans* to feed them sheet metal panels, and since human beings are not 'designed' to operate at breakneck robotic speed, there was tremendous resentment among workers."[167] Counterintuitively, therefore, the Unimates *did* create new jobs—just not the ones their champions predicted. The Unimates and SAMs did, however, do as they were designed—according to the plant manager and one foreman, "reduced the body welding department in manpower from 170 to about 90" which translated into 80-100 layoffs[168] Surprisingly, however, the traditionally militant body shop was relatively calm in light of this as the pace of employment reductions took place over a

[164] Moberg, 150.
[165] Moberg, 557.
[166] Rothschild, *Paradise Lost*, 105-107.
[167] Maryann Keller, *Rude Awakening: The Rise, Fall and Struggle for Recovery of General Motors* (Morrow, 1989), 55, emphasis in original.
[168] Moberg, 216 and 453, and "UAW Chief Visits at Lordstown."

number of years and, with the model change to the Vega, "many operations were simply dropped and not redistributed into other people's workloads."[169] Nonetheless, one of the remaining manual spot-welders explained his job of securing the Vega's back posts to its quarter panels with seventeen welds in the concise and drab manner it deserved: "I did the same thing over and over."[170] Or, as Bryner exclaimed, "Jesus Christ! Can you imagine squeezing the trigger of a gun while it's spotted so many times? You count the spots, the same count, the same job, job after job after job. It's got to drive a guy nuts."[171] One worker complained of the scars on his arm and the steel dust that got into his pores from the manual welder while another observed that "a lot of those guys who have a tough job like spot welding, they come home. They're tired. They fight with their families. This automatically causes conflict there. Then they go to bed. They get up at 5 o'clock in the morning and they go back to work. Same thing, over and over, repetition. I can't see it. It's stupid."[172] When combined with GMAD's "Gestapo"-like management tactics, these jobs were considered some of the worst in the plant.

Echoing Engelberger's assessment that they required only the "mental equipment of an idiot," one worker described the broader effects of such jobs: "The boredom really gets you down . . . . It's fatiguing because it's boring, but it's not hard work. It's a perfect place for a retarded person to work. He can get excited over little things and get a sense of accomplishment. But nobody else can."[173] Henry Ford, in tying the rhythm of the 'mindless' assembly line to rising affluence, argued similarly: "Of necessity, the work of an individual workman must be

[169] Moberg, 216-217.
[170] Tray Direnzo, "Dave Ruby Interview," April 5, 2001, Youngstown State University Oral History Program: GM Lordstown, (O.H. 1931), 4.
[171] Terkel, 258-259.
[172] Moberg, 216 and 454.
[173] Saveriano, "An Interview with Joseph Engelberger," 20 and Moberg, "Rattling the Golden Chains," 549. The worker continued, "You leave there and you don't have any feeling of accomplishment. Who cares that you built 1000 cars? You don't. Your friends don't. Nobody cares that you built 1,000 cars except the stockholders and the people who run the company, not even the foreman."

repetitive — not otherwise can he gain the effortless speed which makes low prices and earns high wages. Some of our tasks are exceedingly monotonous . . . . but then, also, many minds are very monotonous — many men want to earn a living without thinking, and for these men a task which demands no brains is a boon."[174] In more measured terms, Godfrey argued that "the workers may complain about monotony, but years spent in the factories leads me to believe that they like to do their jobs automatically. If you interject new things, you spoil the rhythm of the job, and work gets fouled up," so the biggest problem was not disturbing the monotony.[175] Making industrial robots work, therefore, required the degradation and retardation of its human counterpart, and in effect, the "dictates of cost-cutting and profitability push[ed] management in the direction of making the workers approximate the needed but too costly machine."[176]

What was different from the eras of Taylor and Ford was the role of advanced automation in linking work processes and worker policing together into, essentially, one cybernetic machine that took the function of factory organization and management to its logical conclusion—every cog a robot. As David Moberg, an anthropology PhD candidate at the University of Chicago who took a job at Lordstown a month before the 1972 strike for field research, observed:

> Management is as yet unable to design machinery that can be externally or automatically controlled to do what assemblers do at a cost not exceeding their current wages, with the exception of a few devices, such as the unimate automatic welders. Instead, management relies on work organization, discipline and the mechanical pace of the line to try to turn the worker into the machine that has not yet been built.[177]

[174] Henry Ford, *Today and Tomorrow: Commemorative Edition of Ford's 1926 Classic* (CRC Press, 2003), 146.
[175] "Times Are Changing Down on the Line," *Akron Beacon Journal* (October 22, 1972), A-6.
[176] Moberg, "Rattling the Golden Chains," 441.
[177] Moberg, "Rattling the Golden Chains," 441.

The computerized and robotized assembly line, therefore, served "as an effective discipline and speed-up device" whereby the "assembly line determines the pace of the men, not the other way around."[178] This was not a new phenomenon but the technological architecture that facilitated it was. However, when the machines could not make the men maintain their monotony, GMAD, again in Rothschild's words, went "beyond the technological rationality of mass auto production, to a rationality of management and factory discipline."[179] In other words, the management of computers and industrial robots found a concomitant in the robotization of human labor. But how far could you push the robots before they revolted?

**Revolt of the Robots**

The high speed of the Lordstown line put intense strain on the robots while the management of the high-tech Taylorism found a concomitant in the robotization of human labor. The production increase from sixty to one hundred Vegas an hour after computerization and robotization meant the machines were running at a 67 percent higher rate than before regardless of how many workers labored on them. When combined with an average cycle-time drop from almost a minute to thirty-six seconds per job for the workers who did remain "manacled to the line," it was only a matter of time before the robots—both human and industrial—revolted.[180]

Rather than the rank-and-file, the industrial robots in the spot welding station at the beginning of the assembly line were the first to revolt. The gate system that positioned the

[178] Moberg, "Rattling the Golden Chains," 233 and B. J. Widick, "The Men Won't Toe the Vega Line," *The Nation,* March 27, 1972, 403.
[179] Rothschild, *Paradise Lost,* 113.
[180] Widick, 403.

Vega's body panels for automatic welding was "constantly breaking down simply because it was being jerked in and out of position so fast," requiring the system to eventually need engineering modifications to "reduce the strain on key parts."[181] Once the first stage of welding was completed, production engineers had to "temporarily stop the continuous, steadily moving assembly line" as the Vega frames were shuttled to the spot-welding station for the next stage.[182] And if the modular parts were not lined up properly "the blind Unimates might simply bang their hands against the auto body or execute their precise stitchwork of spot welds in empty air."[183] Furthermore, the Unimates were relatively slow and, to obtain high-line speeds, had to be installed in large numbers, thereby increasing the scale and cost of problems when they arose.[184] One worker argued, "They got these robots thinking they would be a good thing and they turned out not to be as good and reliable as the human person that they had."[185] Or in another worker's description of his experience:

> Well, with robots I've seen them tear each other out of the floor . . . . Instead of having one mistake, you have a hundred mistakes before you find out if it's out of sync. Sure it saves a lot of money on man power, but when they act up and don't behave right you can lose a hundred pieces and I'm talking about the whole roof of a car . . . . Where if it was a person, he would do one roof and know it's screwed up and not do it on the second one, but the robot takes them all.

Human errors, therefore, were much less costly than robot errors. In his assessment, Lordstown was "another example of the people on the fifth floor not knowing what the people on the first

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[181] "Paradise Lost: Utopian GM Plant in Ohio Falls From Grace Under Strain of Balky Machinery," *Wall Street Journal*, Jan. 31, 1972).
[182] "News for Release," n.d., Folder - News-Press Kits-Releases - 1970-1971 - Releases Pertaining to Robotics, Box 4, Lordstown Collection, GMHC.
[183] Tom Alexander, "The Hard Road to Soft Automation," *Fortune* Vol. 84, Iss. 1, July 1971.
[184] Ricardo Zermeno-Gonzalez, "The Development and Diffusion of Industrial Robots," Ph.D. dissertation, University of Aston (Sept. 1980), 225.
[185] Michael Murphy, "Bonnie Rich Interview," April 20, 2002, Youngstown State University Oral History Program: GM Lordstown, (O.H. 2055), 7.

are doing," leading him to rhetorically ask, "if you want to build ninety cars an hour, why would you purchase a robot that's only capable of producing seventy-eight cars an hour?[186]

Robots, however, were not the only problem with Lordstown's automation. One *Wall Street Journal* article declared, "machinery has cracked the strain of the ultra-fast assembly line," and it went on to describe how "some big sources of cost leakage turned out to be the very equipment, machinery and processes that make the plant special." Or, as Lordstown's plant manager Alvin Anderson argued: "It isn't that workers are overtaxed . . . . Rather, the machinery is."[187] Head of the Chevrolet division John Z. DeLorean claimed that beyond firing a number of quality control workers, GMAD "took out the computer quality feedback system," most likely a reference to PACS, as it was too expensive.[188] And while discussion of the "Total Systems Engineering" concept is sparse in UAW records, GMAD's decision to get rid of PACS can be confirmed in a letter to UAW GM Department International Representative Frank Matteson from John J. Spain, committeeman in the Inspection Department of Local 1112, which engaged directly with the PACS component, stated that it was instituted in 1970 but abandoned sometime in 1971 "due to the fact the system was only 85% accurate according to Management." Government regulations required 95-100 percent accuracy and, according to Spain, "Management stated, the cost was too high to operate this system so it was done away with."[189] And when workers "pointed out assembly line defects" they were "ignored both by the computer eyes and by the human foremen."[190] Nonetheless, Anderson lamented, "the way to solve problems with equipment often is to add more equipment, 'which can then become another

[186] Erin Timms, "Norman J. Parry Interview," March 20, 2002, Youngstown State University Oral History Program: GM Lordstown, (O.H. 2049), 9
[187] "Paradise Lost: Utopian GM Plant in Ohio Falls From Grace Under Strain of Balky Machinery."
[188] Wright, 199.
[189] John J. Spain to Frank Matteson, April 26, 1972, Reuther. Charles White. Box 1. Folder 1-4 - Correspondence, Committeemen, 1971-1972.
[190] Rothschild, "GM in More Trouble."

source of breakdowns and problems.'"[191] GMAD, therefore, deliberately sacrificed quality for quantity and people for technology, making them, in Rothschild's estimation, "conspicuously unsuccessful in avoiding 'unresolved production problems.'"[192]

At the same time Lordstown's automation and industrial robots were breaking down, workers increasingly described the feeling of being 'robotized'—a long-existing industrial trope connecting the inhuman mechanicity of work with allusions to slavery that became pervasive in the months leading up to the strike. One worker argued, "All they [GMAD] want out there is 10,000 robots who don't say a thing."[193] Gary Bryner, describing GMAD's time-study practices, said, "They use time, stopwatches. They say, it takes so many seconds or hundreds of seconds to walk from here to there. We know it takes so many seconds to shoot a screw. We know the gun turns so fast the screw's so long, the hole's so deep. Our argument has always been: That's mechanical; that's not human."[194] "When a guy gets on that line," one worker said, "he is like a robot," while another, echoing the discussion of monotonous work above, characterized it as being "like a robot, you basically do the job pretty much without thinking about it."[195] One worker, who anonymously identified as "A Union Brother," wrote a short plea in Local 1112's newspaper about what it meant to identify as a "union man" and argued: "We do not deny [GM] their right to make millions and to buy, sell and control people who have become influenced by their power, but we do maintain the right to question their authority when they attempt to control our lives as if we are robots programmed to perform duties for them."[196] Workers also equated their robotization with slavery. One declared, "If they could bring in slave labor, they'd do it,"

[191] "Paradise Lost: Utopian GM Plant in Ohio Falls From Grace Under Strain of Balky Machinery."
[192] Emma Rothschild, "GM in More Trouble," *The New York Review of Books*, March 23, 1972.
[193] Moberg, "Rattling the Golden Chains," 346.
[194] Terkel, 261.
[195] Erin Timms, "Norman J. Parry Interview," 7.
[196] "Unionism Means Identity," *See Here*, May 1971, Folder - UAW Local 1112 'See Here' 1971, Box 1 (1971-1980), WRL, 6.

while one of the few women on the line called management "contemporary slave-masters."[197] Immediate supervisors were also discredited as "overseers on behalf of higher authority [GMAD].[198] A reliefman in the body shop posited that GM cared more about their fixed capital than their human capital: "General Motors is so damn big. They're a near monopoly. They don't care at all about people. Just don't break the machines. It's like being a damn slave."[199] And such interpretations and observations were not simply the grievances of disgruntled workers. One industry analyst echoed the sentiments of many workers when she described the situation at Lordstown:

> GM thought it could reduce the number of workers by replacing them with robots; instead, the workers had to stay on the line because of frequent robot breakdowns. The human supervisors were poorly trained to handle the problems, and both humans and machines failed to produce . . . . [which stemmed] from an inbred management belief that workers are expensive nuisances who can be replaced.[200]

Management, therefore, also "suffered" as they "discovered [their] 'robot workers' could break down even more than the Unimate 'robot welders.'"[201]

Beginning in November 1971, Moberg observed that workers in response to their robotization "retaliated by acting like the machines they [already were] in the eyes of the management."[202] This eventually coalesced into a deliberate though haphazard multi-month campaign they called the "schmozzle."[203] Like previous disputes with management before GMAD, the "schmozzle" involved soldiering, 'working to rule,' and filing grievances

[197] Moberg, "Rattling the Golden Chains," 276.
[198] Moberg, "Rattling the Golden Chains," 571.
[199] Moberg, "Rattling the Golden Chains," 428.
[200] Keller, 55, emphasis in original.
[201] Moberg, "Rattling the Golden Chains," 172.
[202] Moberg, "Rattling the Golden Chains," 421.
[203] Moberg, "Rattling the Golden Chains," 154-290.

(particularly 78s). And to protest the extra workloads put on them by GMAD, many workers would "ship junk" or "ship shit"—the practice of not finishing a job or not doing a job altogether (which had the effect of increasing the number of vehicles piling up in the repair lot).[204] A small minority also purposely damaged unfinished Vegas by, among other acts of "vandalism," bent turn-signal handles, broke keys off in ignition switches, cut upholstery, and scratched paint jobs.[205] Rather than bargain with the workers, GMAD continued to dole out discipline, DLOs, and layoffs, with the "crackdown" intensifying in December and continuing through January the next year. By the end of 1971, GMAD had already eliminated over 500 jobs, given out 500 short-term DLOs, and accumulated over 3,000 grievances with over 500 of these being 78s.[206] On January 5, 1972, GMAD sent a patronizing letter to workers, signed by plant manager Alvin Anderson, stating:

> The paycheck received by you this week is holiday pay for the Christmas holiday period.
>
> Management is paying the holiday pay for the specified holidays even though there is no obligation to do so under the National Agreement in the case of those employes who did not work the full shift on December 23.
>
> On that day, a small number of employes [sic] deliberately missed work assignments which overloaded the repair areas, thereby forcing the suspension of productive operations and preventing many employes [sic] from completing their shifts.
>
> Why is Management nevertheless paying holiday pay to so many employes who are not entitled to it?
>
> The answer is we're banking on you. We're banking on the good faith of the majority of our employes [sic]. We're banking on our belief that most of our employes [sic] realize the importance of the success of the Vega and the Van to themselves and their families and to the Lordstown plant. It is our desire that by making this payment under these

[204] *Loose Bolts?*
[205] "New UAW Breed Grids for War at GM's Vega Plant," *Detroit Free Press*, Jan. 23, 1972.
[206] Moberg, "Rattling the Golden Chains," 171, 187, and 209.

> circumstances the team spirit essential to our mutual success at GMAD - Lordstown will be encouraged and strengthened.[207]

The letter did not sit well with the local.[208] By the middle of January, the two thousand car repair lot was filled, GM lost production on upwards of twelve thousand Vegas and four thousand GMC trucks (worth about $45 million), and workers lost $3.3 million in wages.[209] The headline in the *Detroit Free Press* provocatively captured the tenor of the situation: "War Brews at GM Vega Plant."[210]

The UAW International, well aware of the situation, was attempting to put pressure on GM to "collar the production people in charge of the General Motors Assembly Division and return bargaining of these plants to its proper status."[211] At the tail end of January, Local 1112 shop chairman of the bargaining committee Paul Cubellis put out a press release dispelling rumors that GM was already in formal negotiations with the International about the problems at Lordstown and announced that a strike vote would be held on February 1.[212] With an 85 percent turnout, "one of the largest in UAW history," and a 97 percent "Yes" vote, "one of the most lopsided in union annals," the strike was approved.[213] Over the next few weeks, officers of the local began working with the International to determine their strategy with settlement of outstanding 78 grievances the primary issue. In the interim, it was up to the same officers to

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[207] A.B. Anderson to Lordstown Hourly Employes, January 5, 1972, Reuther. UAW President's Office - Leonard Woodcock Records. Box 143. Folder 143-9 Corres., S, 1972 (2of22).
[208] *See Here*, Vol. 4, No. 1 (February 1972), Reuther. See Here. Box 1 (1971-1980). Folder - UAW Local 1112 'See Here' 1972, 2.
[209] Agis Salpukas, "Young Workers Disrupt Key G. M. Plant," *New York Times*, Jan. 23, 1972 and "History of the Lordstown Plant, April 1964-February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973, GMHC, 11.
[210] "War Brews at GM Vega Plant," *Detroit Free Press*, Jan. 23, 1972.
[211] Frank James to Pershing C. Smith, January 20, 1972, Reuther. UAW President's Office - Leonard Woodcock Records. Box 143. Folder 143-9 Corres., S, 1972 (2of22).
[212] "Press Release by Paul Cubellis - Shop Chairman of Bargaining Committee," n.d., Reuther. UAW Local 1112 Records. Box 8. Folder 8-17 - Press Release Jan. 1972.
[213] "Workers Vote 30-1 to OK Walkout at Ohio Vega Plant," *Detroit Free Press*, Feb. 3, 1972.

simmer the rank-and-file's desire to strike immediately rather than let it boil over.[214] Gary Bryner, in his monthly "President's Report" column of the local's newsletter *See Here,* urged the rank-and-file not to be provoked into a wildcat strike and also reminded them what their official strike vote meant:

> What has G.M.A.D. done to make this speed-up work?
>
> POWER — They have given discipline to Brothers and Sisters and are still handing them out.
>
> STARVATION — They have sent us home early and denied us our Negotiated S.U.B. benefits.
>
> BIRD-DOGGING — They have sent several Members of Supervision into an area in an effort to make sure we get the work done.
>
> DIVERSION — They have tried to point out Sabotage and a small minority as the problem at Lordstown.
>
> GENEROSITY — They tried to get us to believe they gave us our Holiday Pay.
>
> DOUBLE TIME — Why does this Management say they want to cut costs and then pay us to sit in meetings to hear their side of the story?

All of this added up to one thing: "G.M.A.D. has made it clear! They want to bust our union, take your Union backwards," Bryner exclaimed. "We only want to keep what we had before G.M.A.D. came to Lordstown, NO MORE and certainly NO LESS."[215] Or, as one worker characterized its purpose, the strike was for "a fair share of work and for the company to recognize we weren't robots."[216]

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[214] Moberg, "Rattling the Golden Chains," 253-256.
[215] *See Here*, Vol. 4, No. 1 (February 1972), Reuther. See Here. Box 1 (1971-1980). Folder - UAW Local 1112 'See Here' 1972, 2.
[216] Moberg, "Rattling the Golden Chains," 349.

On February 19, 1972, the strike was officially announced. Rather than beginning five days after the notice, as required by law, the UAW made an "unusual move" and scheduled the strike for twelve days after to give negotiators on both sides of the table more time to resolve their differences.[217] The extra time proved fruitless. Two weeks later, on March 3, with the UAW International's blessing, Local 1112 struck. Media coverage and analysis during the strike took on a sort of medical diagnostic flavor with the conflict being attributed to the "blue collar blues," a term the media used to encapsulate workers' growing discontent with their jobs, an affliction that had now mutated into the "Lordstown syndrome."[218] A *Wall Street Journal* editorial, with the hyperbolic headline "The Soul Must Panic," located the problem in a "severe outbreak . . . . of assembly line monotony, a monster neither the company nor the union has been able to devise any practical way to slay."[219] *Business Week*, which at the beginning of the strike warned in its 'Labor' section of the spreading syndrome, wrote three weeks later in its 'Management' section that the "GM efficiency move" (i.e., GMAD)—which in the article's assessment played a key role in exacerbating the syndrome—had backfired.[220] The bigger issue longtime labor reporter B. J. Widick posed to *The Nation*'s readers: "Who runs whom for what purpose? And at what human cost?"[221]

No piece better summed up the ambivalence and broader institutional and structural issues from whence the Lordstown strike emerged and what it symbolized than a *New York Times* editorial published four days after the strike began. "It is incontestable," the editorial observed, "that more advanced technology is essential to industrial survival in an increasingly

[217] "UAW Sets Strike Date In GM Row," *Detroit Free Press*, Feb. 19, 1972.
[218] "The Blue Collar Blues," *Newsweek*, Vol. 77, Iss. 20, (May 17, 1971), 80, 82, and 86 and "The spreading Lordstown syndrome," *Business Week*, March 4, 1972, 69-70.
[219] "The Soul Must Panic," *Wall Street Journal*, Mar. 15, 1972.
[220] "The spreading Lordstown syndrome," *Business Week*, March 4, 1972, 69-70 and "The GM efficiency move that backfired," *Business Week*, March 25, 1972, 46-47 and 49.
[221] Widick, "The Men Won't Toe the Vega Line," 404.

competitive world," and the "key" to protecting the jobs, wage increase, and social benefits "now hitched to the paycheck" was more productivity. However, the argument continued, "it is equally incontestable that labor and management cannot stop bargaining out a formula for an equitable sharing of the economic fruits of automation. They will also have to be concerned with keeping alive the individual's sense of worth in the robot-ruled workplace." While who "they" were was not specified, it was clear that the corporate and union elite had to do something different, or else they would continue to face what the headline of the editorial declared was a "Revolt of the Robots."[222]

Where Lordstown was being touted in 1970 as "the most modern, automated, robotized carmaking complex in the world, a plant that could become the copybook layout for new auto factories for the next 25 years" was, by the end of the strike, lamented as a "Paradise Lost" that had "fall[en] from grace."[223] Lasting twenty-two days, the strike concluded on March 27 and resulted in a loss of almost a one million man hours.[224] The settlement between GM and the UAW included GMAD recognizing prior seniority rights to determine job assignments; the rehiring of 375 laid-off workers; and many unresolved grievances were withdrawn while many disciplinary cases were resolved through compromise. As a result, a number of employees who were disciplined or even laid off were reinstated and received various amounts of back pay but "cases involving the acts of sabotage and other serious infractions of plant rules" led to further discharges.[225] As *News & Letters* contributor John "Allison" Miller catchily put it, "All the

[222] "Revolt of the Robots," *New York Times*, Mar. 7, 1972.
[223] Lund, "Made in Ohio by Robots," *Popular Mechanics* (Sept. 1970), 81; "Paradise Lost: Utopian GM Plant in Ohio Falls From Grace Under Strain of Balky Machinery"; and Rothschild, *Paradise Lost.*
[224] O'Keefe, "History of the GM Assembly Division," 214.
[225] John J. Grix and Hak-Chong Lee, "Lordstown Plant of General Motors (B)," Lordstown Collection. Box 3. Folder - Histories - 1974-1975 - Lordstown Historical Document, GMHC, 1.

king's horses and all the king's men do not seem to be able to stop GM from making more and more money with less and less men."[226]

The line resumed production on March 28, and shortly thereafter, the plant schedule was reverted to an overtime basis to make up for the backlog of orders.[227] In the aftermath of the strike, GM executives downplayed the advanced automation at Lordstown and its role in broiling worker resentment, most likely because, for decades, automation had been sold on the premise that workers would benefit not suffer. George Morris, vice president of industrial relations and GM's top labor negotiator, scolded the "news media" and "certain politicians" for the "current trend on the part of some people to criticize jobs in the automobile industry as dehumanizing, unrewarding and repetitive to the point that men are nothing but robots." Rather than a function of the young workforce or automation, the strike "resulted from the typical problems that have been experienced in the consolidation of Fisher Body and Chevrolet assembly operations under GMAD."[228] Andrew V. O'Keefe, GMAD's public relations director, told one audience that Lordstown "had a reputation, established by design, and properly so . . . . as the world's finest car building facility [which included] a *limited amount* of new automated operations that attracted

[226] John Allison, "On the Line: PAC backs McGovern—blasts GM," *News & Letters*, Vol. 17, No. 7 (August-September 1972), 3. "Allison" was a pseudonym used by John Miller, a black autoworkers at Chrysler's Highland Park plant, who spearheaded publication of "The Stinger," a newsletter put out by the rank-and-file movement at Chrysler that documented management and union abuses, "John Miller, 1919-2013," *News & Letters*, Vol. 48, No. 10 (December 1972), 3.

[227] "History of the Lordstown Plant, April 1964-February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973, GMHC, 13.

[228] Press Release, September 2, 1972, General Motors Heritage Center, 1-2. Morris's comments were most likely in direct response to a strike at the GMAD-managed Norwood, OH assembly plant which broke out shortly after Lordstown. The strike, lasting 174 days, was the longest in GM history but unlike Lordstown, Norwood received much less attention in the press and has also been neglected in the academic literature. According to a pamphlet chronicling the strike and its motivations, the UAW international promised in January of 1972 that if Norwood struck Lordstown would follow, however, when Norwood passed their strike vote by 98% in February, the international only backed Lordstown. In April, when the international finally authorized Norwood to strike, Local 674 interpreted the delay as an act of sabotage as it allowed GM to stockpile the Camaros and Firebirds then assembled at Norwood to outlast the strikers (The Revolutionary Movement, "Norwood Workers Fight GMAD: The Longest Strike in GM History," 1972, Joseph A. Labadie Collection, University of Michigan Library, 5-7.

more than their due share of visibility."[229] Finally, GM's public relations coordinator John Grix reversed course on the entire mythology surrounding Lordstown's technological primacy in the industry: "It was a new, modern plant. It was the biggest one GM had. It was supposed to be highly automated. That was somewhat of a misnomer since Lordstown did have a lot of automation but that was a function of its size. Nothing we had here was unusual to the auto industry."[230] In other words, high-tech Taylorism and GMAD's enforcement *were* the problems, and a factory lauded for years as the most robotized had now become run-of-the-mill.

**Conclusion: The Robotic Fallout of Human Automation**

A GM retrospective study of the strike, its motivations, and lessons never questioned the veracity of the workers' grievances and stated "Management was aware of the root causes of these problems."[231] Justifying GMAD's course of action in managerial jargon, the study argued: "While it was imperative for management to initiate the job improvement and reorganization programs to attain the production efficiency the plant was designed for, the actual implementation of the program was such to arouse an intense worker opposition." However, the spectrum of approaches to solving the problems were constrained by the very thing that played a key role in creating the problems in the first place—Lordstown-style automation. As the study declared, "Although the job alienation from the repetitive work tasks was certainly a factor affecting worker sentiment on the job, management felt that the economic and competitive

[229] Lordstown Collection. Box 9. Folder - Speeches and Presentations - 1974 - Lordstown Update Speech, GMHC, 3, emphasis added.
[230] Untitled, Folder - Speeches and Presentations - 1974 - John Grix, Public Relations Coordinator, GM Lordstown, Box 9, Lordstown Collection, GMHC, 4.
[231] John J. Grix and Hak-Chong Lee, "Lordstown Plant of General Motors (B)," Lordstown Collection. Box 3. Folder - Histories - 1974-1975 - Lordstown Historical Document, GMHC, 2.

reality [of] existing assembly line technology to enrich the assembly line jobs with a substantial impact, *had to be precluded*."[232] Furthermore, it continued, "limiting realistic alternatives within the existing assembly technology and based on the analysis of the responses from the workers, union officials and supervisory personnel, management diagnosed the primary source of the worker problem as a lack of communication between management and the workers."[233] In translation, GMAD should be more respectful of its robots.

Nonetheless, in November 1973, general manager of GMAD Joseph Godfrey was promoted to Group Executive of the Body and Assembly Divisions, which put him in charge of *all* vehicle assembly for the corporation.[234] Similarly, within a year of the strike, GM gave 428 merit increases and 179 promotions to salaried employees, which equated to 63 percent of the total non-hourly workforce.[235] On the other end of the spectrum, the Vega fared much worse than the people managing its assembly—the former "Car of the Year" became the most recalled vehicle by the end of 1972, the first major domino leading to it being deemed the greatest automotive flop since the Ford Edsel. For the workers at Lordstown who actually assembled the Vega, the strike settlement proved to be a pyrrhic victory. Work conditions at the plant essentially returned to the pre-GMAD state, which in the short term was an improvement but in practice meant going from insufferable to sufferable. Furthermore, in mid-1978, Howard Young, a special consultant to UAW President Leonard Woodcock, told Congress that "Lordstown now

[232] John J. Grix and Hak-Chong Lee, "Lordstown Plant of General Motors (B)," Lordstown Collection. Box 3. Folder - Histories - 1974-1975 - Lordstown Historical Document, GMHC, 2, emphasis added. The study then argued that the Swedish alternative to American-style production—an approach then growing in popularity around the world—"lacked immediate applicability" to the structure of the American auto industry.
[233] John J. Grix and Hak-Chong Lee, "Lordstown Plant of General Motors (B)," Lordstown Collection. Box 3. Folder - Histories - 1974-1975 - Lordstown Historical Document, GMHC, 2, underline in original.
[234] "G.M. to pay peak $2.35 dividend," *Chicago Tribune* (November 6, 1973), C-7 and General Motors, *Annual Report* (1973), 15-16.
[235] "History of the Lordstown Plant, April 1964-February 21, 1973," Lordstown Collection. Box 3. Folder - Histories - 1964-1973, GMHC, 14.

produces 20 percent more cars per hour using 10 percent fewer workers" and based on the Unimates' costs, "we can be certain that the effect of their introduction was an absolute decline in total labor time, and not merely a shift from auto industry labor to steel and robot industry labor."[236] And, as sociologist Samuel B. K. James has demonstrated, the odds that this 10 percent contained a disproportionate number of black workers is highly probable.[237] By spring of the following year, GM had approximately 150 industrial robots at work with plans to purchase more than triple that number.[238]

For Unimation and the American industrial robot industry more broadly, the Lordstown experience and its aftermath proved pivotal. In 1967, when the first big shipment of Unimates arrived at Lordstown, there were only about one hundred industrial robots *total* at work in the U.S.[239] A decade later, 1,400 Unimates alone were in operation with more than half of these in spot welding.[240] GM's bulk order of Unimates in the late 1960s also stimulated significant publicity, particularly in the Japanese manufacturing community that, in short order, became the primary customer of the American industrial robot industry.[241] In 1975, Unimation posted its first profit after fourteen years of operations.[242] However, all was not rosy. The industry was significantly underperforming forecasts, and while the vast majority of the blame, in Engelberger's estimation, should be placed on management for their conservatism, the expansion

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[236] Howard Young, "Jobs, Technology, and the Hours of Labor: The Future of Work in the U.S.," June 14, 1978, Box 4, Charles A. Rosen Papers, SUSC, 10.
[237] Samuel D. K. James, "Cybernation Technology, the Black Production Worker, and the American Automobile Industry," Ph.D. dissertation (University of Delaware, June 1984), 102-132 and *The Impact of Cybernation Technology on Black Automotive Workers in the U.S.* (UMI Research Press, 1985), 55-75.
[238] "UAW Fears Automation Again," 95.
[239] "What Robots do Now for Industry," *Business Week*, May 20, 1967, 114.
[240] R. Zermeno, R. Moseley, and E. Braun, "The industrial use of robots, *The Industrial Robot,* Vol. 6, No. 3 (March 1979), 143.
[241] James Fleck and Barry White, "National Policies and Patterns of Robot Diffusion/ United Kingdom, Japan, Sweden and the United States," *Robotics,* Vol. 3 (1987) and Wauryzniak, 72.
[242] Alfred Bortz, "Joseph Engelberger: The Father of Industrial Robots Reflects on His Progeny," *Robotics Age* (April 1985), 16.

of the industry required overcoming a number of technical issues to make industrial robots more capable. The future of robots on the line, therefore, relied once again on robots in the lab.

## Chapter 6 — Programmable Universal Machine for Accumulation: The Robotics Revolution in the Rustbelt and Silicon Valley

*The real problem is we're looking to wipe out the unskilled jobs, and, if we don't recognize that fact, we're aiming for severe social upheaval.*

Stanley Polcyn (1980)[1]

On April 2-3 1970, the First National Symposium on Industrial Robots was held at the IIT Research Institute in Chicago. The gathering was a decidedly American affair (with the exception of British participants Hawker-Siddely Dynamics and Nottingham University). Joseph Engelberger gave a concise but wide-ranging paper in which he declared: "The time of the robot is now." But, he cautioned, "at this moment over 200 industrial robots are at work in the U.S. they have amassed 600,000 hours on the job. That's a big number but negligible when one considers that the total U.S. blue collar work force puts in 200 million hours each day."[2] In short, the industrial robot had come far but it had quite a ways to go.

For the Artificial Intelligentsia, manufacturers like GM, and developers like Unimation, the critical next step of the industrial robot's journey was technical, and the 1970s proved to be a crucial decade for both the industrial robot and robotics as a discipline. While artificial intelligence was by the early part of the decade purportedly going through its first "AI winter"—

[1] "Robotics has turned the corner, says Polcyn," *American Machinist,* Vol. 124, Iss. 12 (Dec. 1980), 81.
[2] J. F. Engelberger, "Economic and Sociological Impact of Industrial Robots" in *Proceedings of the First National Symposium on Industrial Robots*, IIT Research Institute (April 2-3, 1970), 7.

a term describing the interdependent decrease in funding and interest following unproductive hype cycles about the technology's practical and/or revolutionary applications—a 'Robotic summer' was in bloom. The lack of military applications had quieted the AI buzz at the Pentagon, which resulted in a scaling back of no-strings-attached funding for the most ambitious projects. However, as productivity and profit growth rates were declining economy-wide, the desire for more advanced automation, and therefore more advanced industrial robots, became insatiable. Military funding remained crucial at outposts of the 'military industrial robot complex' including the MIT AI Lab and the Stanford Artificial Intelligence Lab (SAIL) but the capital-intensive and risky nature of robotics research meant there was never enough money to go around, particularly from private sources.

Rather than rely on the 'free market' to pony up the needed cash, the power elite once again dipped into the well of supply-side technoliberalism. In 1971, Congress expanded the NSF's portfolio beyond basic research and gave the foundation authority to expand its support for "applied science" to address selected environmental and social problems deemed national in scale. This culminated in three specific programs: Experimental R&D Incentives, National R&D Assessment, and Research Applied to National Needs (RANN). All three programs were "problem oriented" rather than "discipline oriented" (NSF's traditional domain orientation) and were the NSF intended eac to address what were considered the major "national" problems of the day: Energy, the environment, and productivity (in both the public and private sectors).[3] Of the three, RANN was the largest and most visible as, according to the program's historian Dian

[3] Dorothy M. Bates, "The Research Applied to National Needs Program of the National Science Foundation: Background Information," Congressional Research Service (Washington: Feb. 5, 1973) and George T. Mazuzan, "The National Science Foundation: A Brief History," National Science Foundation (July 15, 1994), https://www.nsf.gov/about/history/nsf50/nsf8816.jsp. For a comprehensive history of RANN, see Dian Olson Belanger, *Enabling American Innovation: Engineering and the National Science Foundation* (Purdue University Press, 1998).

Olson Belanger, it was intended to serve as "a bridge between basic engineering phenomena and economically useful systems."[4] In terms of productivity, "industrial automation" was a core focus of the RANN program, and its work concentrated on parts manufacturing and assembly, the latter of which was "concerned mainly with manipulators ('robots')." As the entry for "Automation in Mechanical Manufacturing Industries" in RANN's first symposium proceedings (1973) described it:

> RANN's activities in industrial automation began to take shape in 1971, when the nation's foreign trade deficit was swelling rapidly toward its 1972 peak. There was a growing clamor at that time for improved productivity, tariff protection, or both, especially in those goods producing industries that were most vulnerable to foreign competition. Thus automation projects were encouraged and selectively funded, and projects that showed promise of yielding flexible results broadly applicable to labor-intensive activities were favored.

Funded projects directly mentioned included those at the Stanford Research Institute (SRI) and "latently" at Stanford.[5] The corresponding research, as well as the networks of expertise and technologies, proved to be key components of the robotics revolution during the decade, and the source of the period's signal example of technology transfer from academia to industry, GM's PUMA robot.

The work of Victor Scheinman at SAIL and his development of the "Stanford Arm," a pioneering piece of hardware, put the robotics revolution in motion, while Charles Rosen's establishment of the 'Programmable Automation' project at SRI and, in particular, the NSF's contributing role, continued the evolution of the 'military industrial robot complex.' Both were

[4] Dian Olson Belanger, *Enabling American Innovation: Engineering and the National Science Foundation* (Purdue University Press, 1998), 260.
[5] Energy, Environment, Productivity - Proceedings of the First Symposium on RANN: Research Applied to National Needs (Nov. 18-20, 1973), 182.

critical to the early years of GM's nascent in-house robotics program and their attempts to build an automated manufacturing system, called the Programmable Universal Machine for Assembly (PUMA), which could incorporate human workers and robotic arms that could be swapped out, one-for-one, on the assembly line. While the system incorporated techniques tested by Rosen's NSF-funded automation program at SRI, the robotic arm component of the system was eventually outsourced to Unimation. The chapter will chart the company's acquisition of Scheinman and his 'Stanford Arm' for the project, and explore the development, first applications, and early problems of the PUMA. Finally, the chapter will analyze the public unveiling of the PUMA and how the most advanced industrial robot yet put into production channeled and inflected the automation discourse.

The web of interests that contributed to the development of robotics during the crucial period of the 1970s reveals how the network of actors and technologies that composed the 'military industrial robot complex' continued to grow from its origins in the 1940s. While SAIL and SRI remained defense contractors throughout the period, the NSF's entry into robotics demonstrates the diversity of the American state's commitment to the development of automation-induced productivity and highlights the ease with which corporate actors such as GM and Unimation were able to capture the results of federally funded research and transform them into technologies for capital accumulation. Stealth industrial policy once again transferred publicly funded expert knowledge, practical skills, and technoscience to industry, further illuminating the power of supply-side technoliberalism.

**Victor Scheinman: The Man with the Golden Arm**

If any single individual was responsible for pushing forward the frontiers of robotics it was a poster child of the military industrial-robot complex—Victor Scheinman. Born on December 28, 1942 in Augusta, Georgia, where his father was stationed by the U.S. Army during World War II, Victor David Scheinman's experience with robots began at an early age.[6] At eight years old he saw the movie *The Day the Earth Stood Still* and was terrified of the robot antagonist Gort and, to help him overcome nightmares of the all-powerful mechanical menace, Scheinman père encouraged his son to build a wooden replica of the robot as a totem. By the fifth grade, already a precocious youth who was always constructing spacecraft and vehicles in his family's backyard, Scheinman was determined to attend MIT for college. At some point in his teens, the Scheinmans moved to the Bronx where, in the family's basement, Victor purportedly built an amateur lie detector and an electric banjo. He attended a private liberal arts high school in Manhattan that had a science program, and, during his senior year, 16-year-old Victor invented a device he called the "Electro-Mechanical Voice Recorder" that could print a spoken letter and he entered it into a New York City science fair in January 1959 (he, sadly, didn't win first prize).[7]

That same year Scheinman accomplished his childhood dream of enrolling at MIT. He majored in aeronautics and astronautics and, during the summers, worked in the heart of the military-industrial complex at Boeing in the theoretical aerothermal dynamics group working on

[6] Unless otherwise noted, the biographical information and chronology of Scheinman's academic and professional career in the next three paragraphs come from Peter Asaro and Selma Šabanović, "Oral-History: Victor Scheinman." IEEE History Center, November, 19, 2010 (https://ethw.org/Oral-History:Victor_Scheinman), Allison Marsh, "PUMA Video History Transcript," National Museum of American History, April 9, 2002 (thanks to Dr. Marsh for sharing this with me!), and RESUME[1,VDS] and RESUME.P[1,VDS]2, SAILDART, All of Scheinman's cited files titled "VDS" from the SAILDART archive can be found at https://www.saildart.org/VDS.

[7] "Teenage inventor, Victor Scheinman speaks into a microphone to demonstrate the Electro Mechanical Voice Inscriber," Hearst Newsreel (New York, NY, Jan. 1, 1959), https://www.gettyimages.com/videos/teenage-inventor-victor-scheinman?assettype=film&phrase=. Coincidentally, though still eerily, in the video recording of Scheinman demonstrating EMVI's capabilities at the science fair, he instructed the machine to record the letters "a-p-t" (in that sequence), which happened to be the acronym for the "Automatically Programmed Tool" (APT) language developed by the Air Force and MIT for programming numerically controlled (N/C) machine tools.

the heat shield of the lunar lander's reentry module, at Douglas Aircraft on the Apollo program building turbo pumps for powering Saturn rockets, and at Sikorsky Aircraft on helicopters. When he graduated in 1963, Scheinman won the Luis de Florez Award for "Outstanding Ingenuity and Creative Development," the award sum of which was about equal to a semester's tuition. Only twenty years old, young Vic had no idea what was next, so his faculty adviser, Holt Ashley, told him, "You know what I want you to do? I want you to go work for Boeing for a while, and then go to Stanford. Just trust me. Just do that." Ashley wrote him a letter of recommendation and Scheinman took a short-lived four-month position at Boeing where his supervisor, who reported directly to the president of the company, gave him maximum latitude and unlimited funding to "wander around anywhere" and work on any project he found interesting from analog computation and computer programming to advanced ballistic missiles systems and submarines. Rather than enrolling immediately in Stanford where he had already been accepted, Scheinman deferred for a year and took a trip around the world to visit MIT alumni in various countries along the way. During the trip he decided to pursue mechanical engineering, "where I could do projects that would make more of a difference," as he "always felt that in aerospace you're one small tooth in the giant gears of industry."[8]

Upon return, Scheinman began his master's degree in mechanical engineering at Stanford in 1965, where he began working on robotic arms for SAIL. The first was a pneumatic snake-like device called the "ORM" (the Norwegian word for "snake"), which had a light for an end effector that could be tracked by a TV camera.[9] The following year, Scheinman was on a NATO Fellowship at the Von Karman Institute in Belgium where he earned an engineering diploma in

[8] Leslie Ballard, "Robotics Pioneer," *Robot Mag*, September 1, 2015.
[9] 1973-08-18 NOTES[1,VDS], SAILDART. The major study using the ORM is Donald L. Pieper, "The Kinematics of Manipulators Under Computer Control," Stanford Artificial Intelligence Report Memo No. AI-72 ( https://www.saildart.org/AIM/072/pdf).

fluid mechanics. That same year he finished his master's and decided to pursue his "Engineer's" degree which, at the time, was essentially a post-master's predoctoral certification granted by Stanford. Scheinman then took a research assistantship with SAIL during the 1967-1968 academic year, beginning an official relationship with the lab that would last for the next decade. Working with Bernard "Bernie" Roth, who was in charge of designing and fabricating the Hand-Eye project's hardware, Scheinman was tasked with maintaining the Rancho Arm while interfacing it with the computer and doing the same for the lab's Unimate (which had been acquired to replace the ORM), all to test very high-speed computer-controlled motion. The high-powered hydraulic Unimate was so powerful "it would shake the building when it ran" and proved to be unsuitable for a computer environment as it would leak hydraulic oil and make the floor sticky. Furthermore, the combination of power and speed also made it a threat to human safety meaning researchers "had to keep it in a separate room to keep people away from it."[10]

In 1968, the School of Engineering awarded Scheinman the "Devol Research Co. Fellowship"—funded by Unimation co-founder George Devol's patent firm—for work on "general purpose manipulators and machines." Over the next year he began designing what came to be called the "Stanford Arm," which became his Engineer's thesis. Perhaps of equal import, the fellowship provided Scheinman access to Unimation's facilities in Connecticut where he met Devol and Joseph Engelberger, the other co-founder of the company, who shuttled him around the country to assess robot factory installations. These experiences, and more importantly the personal and professional connection to Engelberger, would prove critical for him in the years to come. After his Devol Fellowship and with engineer's degree in hand, Scheinman was slated to take a position at IBM  but circumstances out of his control led him to spend a year at Raychem,

[10] Asaro and Šabanović, Scheinman interview.

an SRI spin-off that manufactured cable and wire technologies for aerospace and military applications.[11] A few months after joining Raychem, he was contacted by SAIL's administrative director Lester "Les" Earnest, who asked him to return and resume development on the Stanford Arm. Scheinman, who had always been close to McCarthy, accepted and became an official staff member of the lab in 1969.

Where existing arms' physical limitations proved a drag on early robotics, the Stanford Arm was a boon to the field's maturation. Completed in December 1970 and referred to internally as either the "gold" or "yellow" arm (based on the color of the metal shell), the Stanford Arm was a significant advancement of the art. Nine months later, apparently in response to the "gold" arm's positive feedback, a second Stanford Arm, called "blue," was almost complete.[12] Developed specifically for testing the limits of computer-controlled manipulation and vision, Stanford Arms were faster, stronger, and much more accurate than the Rancho Arm, and easier to control, maintain, and experiment with than the hydraulic arm.[13] And crucially, it was designed to match the speed and working area capabilities of the human arm. This proved necessary for replacing workers in "human" assembly processes as the "ability of the robots to move in spaces, to use tools, and to handle parts, all designed for human use, would be a major asset."[14]

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[11] For Raychem's relation to SRI, see Donald Nielson, *A Heritage of Innovation: SRI's First Half Century*, (SRI International, 2006), 11-6, fn 257.

[12] 1971-06-17 ARMPRO[1,VDS], SAILDART.

[13] For instance, the Rancho Arm was accurate to only 1/4 of an inch where the Stanford Arm achieved accuracy at a tenth of an inch. Additionally, the latter could lift a load of 5kg and move it from point-to-point in less than two seconds while the former was much weaker and slower. For the Stanford Arm's accuracy, see Robert Bolles and Richard Paul, "The Use of Sensory Feedback in a Programmable Assembly System," Stanford Artificial Intelligence Laboratory Memo AIM-220, Computer Science Department Report No. CS-396 (October 1973), 2 and for load and speed, see NOTES[1,VDS], SAILDART.

[14] Bolles and Paul, 2 and Aharon Gill, "Visual Feedback and Related Problems in Computer Controlled Hand Eye Coordination," Stanford Artificial Intelligence Project Memo AIM-178 (Oct. 1972), 2. Gill's work at Stanford was funded by the Armament Development Authority of the Israeli Ministry of Defense which reveals an interesting and unexplored aspect of how not just the American state but other nation-states integrated into the American

The first major test of the Stanford Arm was an automation system capable of automatically assembling a Ford "Model T" racing water pump. At the time, it was perhaps the most advanced robot assembly system in the world.[15] The task was significantly more difficult than moving blocks as greater dexterity was needed for grasping and manipulating the pump's parts while higher levels of visual discrimination were required due to their irregular shapes. Nonetheless, assembling a water pump still required assembling a microworld. Rather than a table strewn with blocks, a "plausible" industrial environment (i.e., still a microworld) was constructed containing tools in fixed places, loose screws in a feeder, and the pump's base, cover, and gasket on a pallet.[16] The system consisted of two phases: a "planning" phase, during which an operator would "teach" the computer the task (or "the plan"), and a "working" phase that would actually perform the assembly. The integration of vision into "the plan" proved quite difficult, just like the Instant Insanity experiment (see Chapter 4). The irregular shapes of the parts proved even more intractable than the blocks, which required "special purpose techniques" and "a set of specific heuristics" to complete the pump's assembly. Additionally, vision was used to spatially locate the arm and initiate the grasping of objects but was not used in the actual assembly process which was controlled via tactile feedback.[17] And finally, while "the plan" was designed to be run repeatedly on a mini-computer, visual processing ran on a separate mainframe

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geopolitical and military-industrial umbrella played a role in scientific and technological development in the United States.

[15] Bruce G. Buchanan, "Introduction to the COMTEX Microfiche Editor of Memos from the Stanford Artificial Intelligence Laboratory, *AI Magazine*, Vol. 4, No. 4, (1983), 39. The "most advanced robot assembly system in the world" interpretation is my assessment of the field at the time.

[16] Lester Earnest (ed.), "Final Report: The First Ten Years of Artificial Intelligence Research at Stanford," July 1963, Stanford Artificial Intelligence Laboratory and Computer Science Department, SUDC, https://stacks.stanford.edu/file/kr834jv6734/kr834jv6734.pdf, 3-5.

[17] Bolles and Paul, 1, 15, and 17, and Lester Earnest, Draft of "Proposal to the Advanced Research Projects Agency for support of the Stanford Artificial Intelligence Project," Computer Printout, January 1973, Folder - AI Budget, Box 2, John McCarthy papers, 1951-2008, SUSC, 11. The vast majority of the information in the document, though with a number of interesting edits and omissions such as the difficulties just mentioned, became Earnest's "Final Report: The First Ten Years of Artificial Intelligence Research at Stanford."

computer, meaning that if a new "plan" was needed, a developer would need access to both a mainframe and a mini-computer.[18] In spite of its limitations, the project was the first of its kind to integrate force, tactile, and visual feedback into one system and SAIL deemed it a success as the system could be adapted to other manipulators rather than simply serving as a one-off special demonstration.[19] Shortly thereafter, experiments began on a two-arm assembly system that mated "yellow" and "blue" while production of a third "red" arm was underway.[20]

In summer 1972, with word getting around about his arms, Scheinman was "loaned" to MIT at the request of Marvin Minsky to work on an ARPA-funded "Mini Robot" project. Technically called "Research on Micro-Automation," the Mini Robot was envisioned as a "miniature hand-eye system" managed by an "ARPA-style operation . . . . where simple jobs are handled locally while more complex computations are done on larger, more centralized, machines."[21] Or, to use contemporary parlance, an "Internet of Things" approach to robotic manufacturing. In line with the shift to support research that would contribute to "productivity," Minsky's articulation of what motivated such a system was one of the clearest examples of how changing the political and socioeconomic situations of the 1960s and 1970s were refracted through the contractor bureaucracy. As he described it:

> During the next decade it will become practical to use more and more sophisticated techniques of automation -- we shall call this 'robotics' -- both in established industries and in new areas. The rate at which these techniques become available *will depend very much on the way in which research programs are organized to pursue them* . . . . The issues involved are rather large and touch not only on technical matters but also on aspects of national economic policy and attitudes toward world trade positions . . . .

[18] Bolles and Paul, 1.
[19] Earnest, (ed.), "Final Report," 5.
[20] 1973-08-18 NOTES[1,VDS], SAILDART; Asaro and Šabanović, "Oral-History: Victor Scheinman" and Earnest (ed.), 3.
[21] Marvin Minsky, "Mini-Robot Proposal to ARPA," Massachusetts Institute of Technology A.I. Laboratory Artificial Intelligence Memo No. 251 (January 1972).

> [Furthermore] we have the impression that despite a superficially healthy appearance, the past two decades have seen a pernicious decline in acquisition of basic new production techniques. What is worse, there is little indication that the community of economic advisors has sensed this technical aspect of the productivity problem.[22]

In his estimation, because industrial robots "in the form of the pre-programmed positioner-grasper machines of the Unimate or Versatran class" lacked "intelligent feedback," it was "impossible to use the potential versatility demonstrated in the ARPA robotics experiments," which is why "these 'robots' have not yet had any really substantial impact on production." While the proposal posited a number of specific applications, the changes Minsky envisioned for "General Production" were particularly novel from production "On Demand" to "Individualized" mass production. However, the first "general" area of impact discussed, "Assembly lines," was perhaps the most revolutionary. Rather than a "linear arrangement of work stations, with the work moving from one point to another, and different parts brought to different stations," a "general-purpose assembler [i.e., robot] would work more centrally, with many operations performed at the same station, and the parts all brought to that point."[23] In short, robots would be the end of the assembly "line," not the perfection of it.[24] Scheinman's role in this was to design the smallest, most practical, reasonably priced robot that could accomplish the tasks described in the ARPA proposal. Building on his aerospace background and Stanford experience, Scheinman designed a "desktop manipulator" that was faster, lighter, more precise, and less than half the size of the Stanford ARM. At the end of the summer Minsky was impressed with the results and asked Scheinman to build three of what would be called the "MIT arm."[25]

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[22] Minsky (1972), 1 and 5, emphasis added.
[23] Minsky (1972), 5.
[24] Minsky (1972), 5-6. Minsky recognized this as on the next page he declared, "The arrangement just described might seem at first sight a step backwards!"
[25] Asaro and Šabanović, "Oral-History: Victor Scheinman."

Over the next year, Scheinman began fielding more and more requests for his arms. He started working nights in the Stanford chemistry department's machine shop (with the help of a hired machinist) and went "down to 80% time here at the A.I. Lab," so that he could "push thru the details of the M.I.T. arm without causing too many cries of conflict of interest." By 1973, work was already underway on an MIT for the Jet Propulsion Laboratory (JPL) at Caltech and a Stanford arm for the Stanford Research Institute (SRI).[26] As he explained to Roth that spring, "the arm business is growing in leaps and bounds. Everyone is asking me about arms - both the Stanford arm and the new M.I.T. arm which has yet to be built and tested."[27] To begin meeting demand, Scheinman incorporated Vicarm in May 1973. As he informed MIT's George Wallace, who Scheinman was working with on the MIT arm, "to protect myself a bit, I started a company to put these arms together. The name is VICARM. This way, if there just happens to be some patent infringement [with SAIL], I wont loose [sic] my shirt."[28] Furthermore, by this time Scheinman had taken time off from his PhD to work directly for SAIL to build their manipulators, so, to avoid any "potential conflict of interest" he told one interviewer, he "resigned" from SAIL but returned to student status at Stanford to continue work on his doctorate in June 1974.[29] The boundaries of "private" and "public" were, therefore, not only porous but temporal.

In the midst of getting Vicarm off the ground, Scheinman began thinking seriously about a thesis topic. He wavered back-and-forth between proposing the development of an "Automated Sheet Metal Shop" (ASMS) and an "Automated Machine Shop" (AMS), the outlines of which

[26] Boris M. Dobrotin and Victor D. Scheinman, "Design of a computer controlled manipulator for robot research," IJCAI '73: Proceedings of the 3rd international joint conference on Artificial intelligence (August 1973); Scheinman 1973-06-04, BORIS[1,VDS]; and 1973-05-20, ROTH[1,VDS], SAILDART.
[27] 1973-05-20, ROTH[1,VDS], SAILDART.
[28] 1973-06-15, MIT[1,VDS], SAILDART.
[29] Jerry W. Saveriano, "An Interview with Victor Scheinman," *Robotics Age*, Vol. 2, No. 3, (Fall 1980), 14 and 1975-02-16 17:39, SUE.L[1,VDS], SAILDART.

are illuminating. Scheinman envisioned the ASMS as a "totally automated manufacturing facility containing a collection of computer-controlled metal working machines and one or more computer-controlled manipulators to set up the machines and perform all the necessary manipulation of the material," the development of which required "new theories of design and new approaches to describing manufacturing processes to create a complete chain of automation." The ASMS, on the other hand, proposed two paths, an "interactive machine shop" and a "completely automated machine shop," the latter "a lot more ambitious than the other" and essentially a rearticulation of the ASMS.[30]

The interactive machine shop was the more interesting of the two in terms of how Scheinman conceptualized the role of skilled labor within the system. In prototype machining, the design and manufacture of a part as a model for higher-volume production was done manually (i.e., sans numerical control) by a machinist, not because of economics but for "the fact that the machinist must really be there to make the first part." From there, the human-machined part or workpiece would then be produced by either conventional or numerically controlled machine tools. In the interactive machine shop of Scheinman's imagination, however, an engineer at a terminal of a time-shared computer would design a part or complete device with multiple parts and then "send," via the time-shared computer, the machining tape, production drawings, and required materials to the machine shop. The machinist, "a fellow [who] may not be too skilled a programmer, but merely a person capable of taking instructions and making judgements about what is good machining practice, and who also knows what his machines can do and what they can't do," would review the drawings to reveal any obvious errors, set up the machine, and then start the operation. After this, the machinist—whom Scheinman at this point

[30] 1974-05-03 10:05, PROP.1[1,VDS] and 1974-05-06 22:41, PROP. 2[1,VDS], SAILDART.

either consciously or unconsciously began referring to as "the operator"—would monitor the operation while "the machining sequence proceeds with the computer giving the machine AND the operator new instructions from time to time." If necessary, the computer would give the operator instructions for various manual tasks to complete production of the part. The machinist in the interactive machine shop, therefore, would simultaneously be "deskilled" via computerization and "displaced" *as a machinist* in control of production to an *operator* charged with maintaining and monitoring computer-controlled machines and processes in the "chain of automation."[31]

Scheinman indefinitely put the thesis on hold as he continued his Vicarm work. In October 1973, he drew up a "Status Report" (perhaps intended for investors and/or prospective investors) to detail the history, products and services, potential markets, and future goals of the new firm. The report opened with a brief introduction of Scheinman's relationship to SAIL and a cursory review of their Hand-Eye projects, which "the results to date show that the true artificially intelligent robot system will be working on the assembly lines before too long." The desire for such systems already existed as "with the growing interest in mechanization and automation, other groups and organizations have become interested in these artificially intelligent systems as a means of increasing productivity, and reducing labor needs." While "supposed 'robot' devices" like the Unimate were being used on auto assembly lines, the artificially intelligent robot was the next step. And "this is where VICARM comes into the picture." The initial market, however, would be "research organizations such as universities and the research laboratories of the government and large corporations who already have the required computers." But, with the declining cost of computing, manufacturing firms "and organizations

[31] 1974-05-03 10:05, PROP.1[1,VDS] and 1974-05-06 22:41, PROP. 2 [1,VDS], SAILDART. It's as if Noble wrote the draft of Scheinman's thesis proposal!

which employ manual type task performing personnel" would soon be able to afford and economically employ Vicarm's products as the company would provide a suite of accessories and services to make their arms as adaptable as possible.[32] Furthermore, to convince readers of the company's viability, Scheinman foregrounded his experience at Stanford and work with MIT, thereby selling not just robotic arms but also the expertise and institutional connections that would make such robots work.[33]

**The Stanford Research Institute and Programmable Automation**

The most prominent institutional connection Scheinman foregrounded in his status report was the Stanford Research Institute (SRI). SAIL and SRI's Artificial Intelligence Group (AIG) had been close collaborators since the establishment of both outfits and, in part, ARPA had strategically cultivated their relationship to move technology from the lab to the marketplace. As Charles Rosen, director of AIG, told SRI executive Torben Meisling in 1968, "Our major client (ARPA) deliberately funded us (SRI) in a robot program, while simultaneously funding two universities for developing similar programs (Stanford and MIT) because they wished to have at least one non-university research outfit fit to engage in follow-on applications which might require some degree of security [i.e., protected exploitability and secrecy]." Accordingly, SRI had several Stanford graduate students on its staff and regularly engaged with the university through information-exchange seminars.[34]

[32] 1973-10-30, VICARM[1,VDS]. SAILDART.
[33] 1973-10-30, VICARM[1,VDS]. SAILDART.
[34] Rosen to Meisling, "Joint Projects with Stanford University — Artificial Intelligence Projects," May 9, 1968, Correspondence Binder, Box 8, Charles A. Rosen Papers, Stanford University Special Collections (hereafter CARP).

One product of this synergy was Shakey which made SRI a major player in AI and robotics. Shakey also served as the most widely discussed example, at least in the popular press, of the two domains integration and interdependence. By the early 1970s, however, ARPA and DOD had seemingly lost their stomach for research programs such as AI and robotics which were not, in their estimation, producing translatable practical applications as expected. According to Charles Rosen, director of the Artificial Intelligence Group (AIG) overseeing Shakey, the project's DOD sponsors were afraid Congress would point their fingers and say, "what are we doing with this thing that will never go anywhere."[35] As a result, according to project leader Nils Nilsson, when ARPA in 1972 said "no more robots," funding for Shakey was terminated and the project wrapped up its work.[36] Concomitantly, even though SAIL and SRI had a close working relationship, resource competition was still fierce. As Rosen described it, "Prof. McCarthy's hand-eye project, which is a major Stanford undertaking, is his special pet and he does not welcome sharing its well-funded largesse with anyone. As part of this major project he has acquired a large computer (PDP-1) which is not available to our group for large scale use."[37] Hence, SRI's technological disadvantages were recursive: Less computing power translated into less impressive research results which meant less funding for future projects.

AIG's search for new funding sources to support their work began long before Shakey ran out of money. In December 1969, Rosen sent a request for funding to the National Science Foundation (NSF) in which he briefly described AI research at SRI and argued that the breadth and depth of their work had them functioning at the level of research equivalent to other

[35] Jerry W. Saveriano, "An Interview with Charles Rosen," *Robotics Age*, Vol. 5, No. 6 (May/June 1981), 19
[36] Nils J. Nilsson, "The SRI Artificial Intelligence Center: A Brief History," SRI Technical Note 317 (Jan. 24, 1984), 8.
[37] Rosen to Meisling, "Joint Projects with Stanford University — Artificial Intelligence Projects," May 9, 1968, Correspondence Binder, Box 8, CARP.

recognized AI centers (e.g., MIT and Stanford University). "It would be profitable," Rosen argued, "to expand this function for the benefit of the general scientific community interested in Artificial Intelligence," as many "eminent workers" of this community had expressed interest in partnering with AIG. Because SRI's limited resources prevented them from financing these scholars, Rosen requested NSF to provide fellowships ranging from three months to a year.[38] The request was apparently denied and, perhaps in response to this, in early 1970 Rosen began drafting a memo to the Long-Range Planning Committee of SRI to address these financial troubles head-on in a memo. He opened the memo with a bang:

> The evidence that SRI has lived from hand-to-mouth over the largest part of its history is overwhelming. This situation is particularly painful now, in view of the serious reduction in available government-research funds, and the prevaling [sic] economic uncertainty in commerce and industry. SRI has not planned nor executed in any sustained, organized way to supplement its income, derived traditionally from the sale of contract research. There is no financial buffer to shield us from the destructive effects of changing markets.

Over the previous two years, however, the Information Science and Engineering Division that AIG was a part of had begun to "exploit the inventiveness of our professional staff to derive future sustained income based on R&D word [sic] performed for commercial clients" through royalty and equity agreements and it appeared "highly desirable for SRI to initiate an Institute-wide plan" to incentivize such entrepreneurship. To accomplish this, SRI's previous policy of assigning all rights to inventions, processes and techniques—including those that had accrued prior to a signed contract that were "thrown in for good measure to as added inducement to get the client to 'sign on the dotted line'"—should be modified to include some sort of equity arrangement or royalty agreement in all commercial contracts. In addition to this, Rosen

[38] Rosen to NSF, "The SRI Center for Research in Artificial Intelligence," Correspondence Binder, Box 8, CARP.

suggested that SRI should serve as a sort of incubator for new companies, or what he called "Planned Parenthood." Rather than lose the more entrepreneurially spirited when they wanted to exploit the commercial potential of their work, SRI staff would stay with the organization, the latter of which would provided financial, marketing, and technical expertise for the venture, and in return, both the staff member and SRI would retain an equity stake in the newly established firm. As Rosen pointed out, "a number of outstanding universities have an almost 'laissez-faire' policy with regard to the participation of tenured faculty as founders, directors, or chief operating managers of commercial companies," and such a policy at SRI would help them attract and retain talent.[39]

SRI's executives were obviously listening to Rosen's pleas as the organizational push for more practical, and thereby lucrative, applications of its work almost immediately began reshaping the very character of that work. In Rosen's eyes he was particularly suited for such an endeavor as, in addition to his experience starting his own companies, "I was the only one in the AI group who had ever worked in a factory," and his experience during WWII organizing a group that spot-welded aircraft wings as well as his visits to "over a hundred factories in the U.S. on behalf of the British" gave him practical expertise in the world of production his colleagues lacked.[40] As a result, Rosen stepped down from his position as head of AIG to lead an industrial automation group that would focus on applying robotics to assembly and inspection problems in industrial settings.[41]

[39] Rosen to ISAG Long-Range Planning Committee, "Exploitation of New Techniques, Patents, and Staff Experience," Feb. 11, 1970, Stanford. Charles A. Rosen Papers. Box 8. Correspondence Binder, Box 8, CARP.
[40] Saveriano, "An Interview with Charles Rosen," 19.
[41] Nilsson, "The SRI Artificial Intelligence Center: A Brief History," 7; Saveriano, "An Interview with Charles Rosen," 19; and DRAFT/Charles Rosen Profile, Correspondence Binder, Box 3, CARP, 4.

On April 9, Rosen made a formal capital equipment request for a Unimate. As he explained, over the previous year the AIG group had been looking for "possible peel-off for industrial applications" and their work on intelligent machines (which would continue to be sponsored by the U.S. government) could meet manufacturers' demands for sensory-equipped and, most importantly, visually capable industrial robots. "Although the evidence is convincing that there is a very large market for these machines in their present form," Rosen estimated that "with vision added, a far wider field of commercial exploitation for these machines is anticipated." Beyond exploiting a predictably lucrative market, Rosen also foregrounded the AIG's unique expertise in the field and the importance an "experimental facility based on a available tried-and-true robot arm" would have on the entire Information Science and Engineering Division (ISEG) including the Bioinformation, Control, Digital Development, Information Systems, and Mechanical groups. Not only would such a facility increase the likelihood of increased support from industry but "this proposed program is entering a field early enough so that the probability of development of patentable and/or proprietary ideas is high; we believe that we can develop royalty and other income."[42] That same day, Rosen and AIG colleague Richard "Dick" Duda sent a separate request to Torben Meisling, executive director of ISEG, to pitch a project on the visual component that would be used in their envisioned industrial robot system, assuring the latter that "development of a demonstration eye for an industrial robot is a natural commercial outgrowth" of AIG's pattern recognition and robot research.[43]

[42] Rosen to D. R. Brown, "Capital Equipment Request Unimate Robot," Apr. 9, 1970, Correspondence Binder, Box 8, CARP.
[43] Rosen and R. O. Duda to Torben Meisling, "Initial Investigation of an Eye for An Industrial Robot," Apr. 9, 1970, Correspondence Binder, Box 8, CARP.

The requests were approved and, according to Rosen, the "president and directors at SRI backed me very heavily-to the tune of about a hundred grand," which allowed him to buy a Unimate and peripheral equipment such as cameras and computers.[44] About a week after the Unimate request, Rosen attended the first official industrial robot conference sponsored by the Illinois Institute of Technology in Chicago and walked away confirmed that robots such as the Unimate and the Versatran were on the verge of wide acceptance in industry. As he told one colleague about the conference, industrial robots:

> Appear to be versatile, reliable, and economical replacements for industrial workers under factory conditions which are not normally acceptable to humans. For example, picking up heavy objects continuously and monotonously is a job which the new generation of workers, and many of the old, do not relish, and it is becoming increasingly more difficult to keep absenteeism on these jobs from becoming a major problem. Enlightened union leadership is becoming more convinced than ever that when orderly change in factories is accomplished the benefits to workers greatly exceed the dangers of joblessness."

In Rosen's estimation, "If we can demonstrate an economical system I have little doubt that an established company in the materials handling business, or perhaps a new one formed for the purpose of supplying the vision accessory, would be most interested," including "risk capital" (the then contemporary term for "venture capital").[45]

By mid-1970, SRI's industrial automation program was up and running and Rosen began prospecting far and wide for information on industrial robots both in the US and abroad, including information requests to more than a dozen Japanese firms.[46] That fall the industrial automation group, the internal colloquial designation of Rosen's outfit, purchased a five-axis

[44] Saveriano, "An Interview with Charles Rosen," 20.
[45] Rosen to Mr. James Hepperle, Apr. 15, 1970, Correspondence Binder, Box 8, CARP.
[46] Letters to Japanese companies about their industrial robots, Aug. 5, 1970, Correspondence Binder, Box 8, CARP.

Unimate Model 2000A and began interfacing it to their PDP-10 computer.[47] Their initial goal was to make the Unimate computer programmable with an additional short-term goal of developing and integrating a visual component that could allow the system to operate on moving objects.[48] Where GM's "SAM" robots were able to crudely accomplish in limited fashion with brush sensors, SRI's Unimate would be able to more adeptly do this using the most recent advances in AI.

Beginning in July 1971, less than a year after purchase of the Unimate, Rosen began reaching out to prospective firms with what he called a "multiclient proposal" to gin up interest in the industrial automation group. The proposal, titled "Advanced Sensory Manipulative and Inspection System for Industrial Automation," pitched two developmental systems, one for automated materials handling in factories and warehouses and one for on-line inspection and quality control, that would be available within the next two months and intended to serve as "models for economic assessment" and as guides for future design of more tailored systems. "We believe that the proposed work is timely," Rosen informed prospective clients, "both with respect to the growing needs of industry for advanced automation and with respect to the current availability of machine intelligence techniques being developed primarily under government sponsorship."[49] In other words, the American state was still underwriting the technology, so now was the time to capitalize. Rosen sent proposals to firms such as Chrysler, Ford, and GM; government agencies such as the National Bureau of Standards (NBS) and NASA; and foreign contacts in England, Italy, Japan, Sweden, and Switzerland.[50] After expressing his appreciation

[47] Rosen to Dr. Bernard Chern, "SRI Advanced Automation Program Upgrading of Unimate Manipulator System," Dec. 1, 1975, Correspondence Binder, Box 9, CARP and C. A. Rosen and D. Nitzan, "Developments in Programmable Automation," Sept. 1975, 28.
[48] Rosen to Mario Salmon, Feb. 22, 1971, Correspondence Binder, Box 9, CARP.
[49] Rosen to B. F. Duncan, Aug. 5, 1971, Correspondence Binder, Box 9, CARP.
[50] Letters to a variety of firms (domestic and foreign) announcing SRI's industrial automation research intentions, Aug. 4, 1971; list of firms sent proposals, Aug. 19, 1971; and letters to a variety of firms (domestic and foreign)

for her support of "industrial robotry," Rosen told Ruth Davis, director of the Center for Computer Science and Technology at NBS, "I think our chances are very good to get the requisite number of firms backing us; even though the first year's proposed systems are a far cry from the intelligent systems that I hope will eventually result. I believe we have to show some practical results to gain the confidence of industry and make them brave enough to back more speculative ventures."[51] By October 1971, early interest from Ford and GTE in what would eventually be called the "Industrial Affiliates" program would soon be overshadowed by industry's lack of bravery.[52]

Rosen's framing of why 'mechanizing' such jobs was necessary is interesting for what it demonstrates about the ideological continuity and resilience of technoliberalism. In February 1972, Rosen sent a short proposal to Marvin Denicoff at the Office of Naval Research (ONR) requesting funds to "to survey the field of computer-controlled machines that can perform useful tasks autonomously in an intelligent manner." There was a "rapidly growing need in military and industrial applications to mechanize many jobs that are characterized by rather simple operations requiring manipulation, vision, and limited judgment," Rosen argued, and in his estimation, the 3D/3H jobs that could be automated were "highly repetitive and boring, demanding little of the human's potential (or actual) capabilities as an artisan, and leading to considerable personal dissatisfaction." This often led to "reduced productivity, increased mistakes in execution, and even more serious, a considerable degradation of quality, leading to costly subsequent maintenance and repair." The development of cost-effective AI and robots, however, could

announcing SRI's industrial automation research intentions, Sept. 9, 10, and 16, 1971, Correspondence Binder, Box 9, CARP.

[51] Rosen to Ruth Davis, Aug. 6, 1971, Correspondence Binder, Box 9, CARP.

[52] Rosen to Meisling, "ASEA - Exclusive Contracts and 'Brainstorming,'" Oct. 14, 1971, Correspondence Binder, Box 9, CARP.

"replace or augment man in these undesirable jobs." To assess the current state of existing automation, therefore, Rosen was requesting funding to essentially complete a literature review in AI, robotics, and sensors as well as interview "key people in production, materials handling, inspection, and quality control." He made sure to add, "the needs of the U. S. Navy will strongly guide the main thrust of this assessment, both in terms of specific applications to Naval operations and of supplying the Navy with high-quality low-cost materiel."[53] Shortly thereafter, Denicoff approved a six-month contract for $15,000, which Rosen used to tour factories around the country.[54]

A month after the ONR request, Rosen sent a much more detailed proposal to Bernard Chern at the National Science Foundation (NSF) that contained what Rosen considered to be the pertinent technical issues his "Advanced Automation Technology" program would address.[55] Like the proposal to Denicoff at ONR, the NSF proposal to Chern is interesting less for the technical details and more for how Rosen articulated the broader political and socioeconomic contexts such technologies would be developed in and what goals their applications would purportedly help accomplish. The need for such a program, he posited, "appears to be general agreement that an increase in so-called 'productivity' is a highly desirable national goal." However, in Rosen's estimation, "productivity" was not simply a measurement of worker output per hour but a function of product quality, customer satisfaction, adaptability to changing market demand, and efficient resource use. Additionally, he believed the character of work or quality of the job should also be included in the measurement of productivity. As Rosen put it, "the emerging work force has high expectations and does not relish the prospect of being reduced to

[53] A Survey of Advanced Mechanization: Part One--Technical Proposal, No folder, Box 3, CARP, 1. His asterisk cited Tom Alexander, "The Hard Road to Soft Automation," *Fortune*, July 1971.
[54] Saveriano, "An Interview with Charles Rosen,", 19.
[55] Rosen to Chern, No folder, Box 3, CARP.

unthinking 'hand-eye automatons.'" But, he continued, industrial R&D expenditures on systems to meet these needs was small due to a lack of knowledge about the practical applications of existing technological capacities and a lack of confidence in the cost-efficiency of developing such systems in the near future. "Even though aggregate the R&D establishments of . . . . firms have resources dwarfing those available to universities, government, and nonprofit research establishments," Rosen assessed, "they are unprepared to make the rather substantial commitments required, in trained people, hardware, and software, to mount adequate programs."[56]

The most effective NSF program, according to Rosen, would provide adequate funding for near-term applications to "catalyze" private commitments and resources while also funding more "normal" long-term objectives.[57] The corresponding short-term program of one-to-two years would develop "integrated laboratory systems"—the two proposed were "sensory-controlled manipulation" and "visual inspection and quality control" that, for all intents and purposes, were Shakey-inspired industrializations of existing 'Hand-Eye' systems. These would incorporate hardware and software packages to demonstrate the feasibility of advanced automation that could move beyond industrial robots simply "spot-welding car bodies for the General Motors Vega line." In essence, Rosen was suggesting a practical applications model of "demo or die" whereby the federal government would still socialize development costs, but industry would privatize the technology they wanted and let what they didn't die. In terms of a long-term program of two-to-five years, Rosen was surprisingly candid in his assessment of what lay ahead:

[56] Rosen to Chern, No folder, Box 3, CARP.
[57] Rosen to Chern, No folder, Box 3, CARP.

> It is patently impossible to expect the development of the completely automated factory, distribution system, or service facility within the foreseeable future. In fact it may be argued that such a goal would be highly undesirable without concurrent major changes in human training, education, work habits, and expectations. A more acceptable approach would be to assume the evolution of semiautomated, man-machine systems, the degree of automation increasing with time. Thus dangerous, dull, repetitive, and other undesirable jobs would be gradually phased out; where necessary, a trained and skillful man would exercise supervisory and judgmental control over many machines in those functions which were too difficult or expensive to automate.*

Rosen's asterisk footnote is particularly interesting in the way he analogized what he was trying to communicate: "The general concept of the 'time-shared' man is not new. In fact every foreman, manager, or captain of industry performs in precisely this fashion, attending to his numerous duties and sharing his valuable talents as the occasion demands." The salaried worker, in his conceptualization, functioned like a 'computer' that, just like a mainframe, had the capacity to be accessed and put to work by multiple users simultaneously.[58]

For the remainder of 1972 and into 1973, Rosen would go back-and-forth with NSF on the proposal. In July 1972, Rosen informed him that the proposed program would eschew tactile sensing for the time being to concentrate on vision.[59] In a September letter touching on some of the difficulties he was having attracting participants in the program, Rosen provided a cogent and direct articulation of the political economy of technological development he was up against:

> There was a general consensus that advanced automation of the kind proposed was needed and highly desirable. However, the proposed support of a shared program by firms with diverse interests, some highly competitive, was a novel idea, which in many instances required policy discussions at the highest level in each firm, with ensuing delay and procrastination.

[58] Rosen to Chern, No folder, Box 3, CARP.
[59] Rosen to Chern, July 25, 1972, Correspondence Binder, Box 9, CARP.

He then went on to overview three "major issues that were substantive": 1) Antitrust laws prevented R&D cooperation among firms, and trade organizations generally didn't sponsor R&D for the common interest of their members; 2) Large user firms developed very little of their own capital machinery and suppliers were reticent to commit capital without sufficiently large markets, "thus, important innovations in technology requiring long and expensive development most often are introduced through either government-supported programs (by D.O.D. and N.A.S.A., for example), by new entrepreneuring companies, or, more rarely, by an established firm that is willing to make the large financial commitment with its attendant risks;" and 3) Manufacturers of capital machinery were "of necessity" conservative when it came to new products because customers, production managers, were conservative, and thereby not willing "take chances" with new equipment. As a result, the time lag between an innovation and its wide acceptance could take five to ten years. "Progressive" managers, however, could be "induced to introduce experimentally" an innovation, with the likelihood of success increased via a hardware-embodied demonstration system rather than a paper study—the very project Rosen was asking NSF to fund. By that point, serious interest had been expressed by AMP Inc., Dow Chemical, Ford, and GTE, and Rosen planned to solicit AT&T, Bendix, Chrysler, GM, IBM, Unimate, and Versatran (AMF) to join, "both to make available to competing firms the opportunity to share in an essentially publicly financed program, as well as to increase the program's applicability to a wider range of industry."[60]

This latest iteration of the proposal and supplementary information were reviewed by NSF and, in October, Rosen told Chern that, based on the reviewers' recommendations, an assembly station rather than just the visual inspection and sensor-controlled manipulator

[60] Rosen to Chern, "SRI Proposal ISU 72-81 dated 24 July 1972," Sept. 12, 1972, Correspondence Binder, Box 9, CARP.

subsystems would be demonstrated (the completion of which would take approximately two years from the work's initiation). Additionally, Rosen wanted to increase staffing on the project, which could only happen if NSF approved the proposal. Reviewer number three inquired about study of the social consequences of the proposed work, to which Rosen responded, "I cannot be sure of the social consequences. I believe that eliminating dirty, boring, and undemanding jobs is fundamentally a worthwhile national goal, and is a basic objective of the whole program. I recommend that parallel studies concerning the social consequences be undertaken at the earliest time."[61] Either in response to pushback or what he considered insufficient attention, Rosen stressed to Chern in a December letter that industrial participation in the program "is believed essential if technological transfer to industry is to be both timely and effective."[62]

While negotiating with NSF in 1972-1973, Rosen continued scouring the business community for partners and apparently attempted to resurrect the Shakey program under other auspices with the help of Nils Nilsson and Stanford computer science PhD candidate Earl Sacerdoti. The latter had developed a planning system called NOAH (Nets of Action Hierarchies) based on Shakey's STRIPS system that he and SRI intended to integrate into the Shakey project.[63] When ARPA nixed Shakey's funding, Sacerdoti, with Rosen and the AIG staff's help, "cooked up an idea for a project that wouldn't actually be concerned directly with a

[61] Rosen to Chern, Oct. 31, 1972, Correspondence Binder, Box. 9, CARP. In response to an inquiry from Stanford computer scientist Paul Armer about the social implications of automation a few months later, Rosen reiterated that "I personally am keenly aware and concerned about social effects. I am also convinced that the introduction of 'smart' machines is inevitable but will take place in an evolutionary rather than revolutionary manner. There is and will be time to carefully study social implications and to develop plans to make the transition less disruptive and destructive for the working man than [in] the past," Rosen to Armer, Mar. 2, 1973, Correspondence Binder, Box 9, CARP.
[62] Rosen to Chern, "Industrial Participation--SRI Proposal ISU 72-81, 'Exploratory Research in Advanced Automation,'" Dec. 13, 1972, Correspondence Binder, Box 9, CARP.
[63] Nils J. Nilsson, *The Quest for Artificial Intelligence: A History of Ideas and Achievements* (Cambridge University Press, 2010), 12.

robot, but would still allow us to pursue robot problem solving and robot vision."[64] What they called the "Computer Based Consultant" (CBC) was, according to Nilsson, "pretty much a continuation of our research work on Shakey but with a human carrying out the planned tasks instead of a robot."[65] The gist of the project was relatively simple: a human—referred to as "the apprentice"—would be given commands from a computer on how to take apart and reassemble a device (in this case, a small air compressor). Using a predefined small vocabulary, the apprentice could "ask for advice" and the system's "state-of-the-art speech recognition system" would analyze this then respond using a speech generation module, all while surveilling the apprentice with a machine-vision system.[66]

Critically, the system would have been designed and functioned the same way if a robot, rather than a human, played the apprentice; the challenge moving forward, therefore, was developing and programming a robot that could take on this role. Nilsson, a fellow cook in the kitchen, recollected that "we were able to talk DARPA into a project that had obvious military relevance" and the agency "bought the idea—perhaps because they couldn't immediately figure out a reasonable way to say no and because, after all, the project sounded plausible."[67] The fact that ARPA was not amenable to a "robot" project but amenable to the same project when a human assumed the role of the robot in the system, speaks to how terms such as "artificial intelligence" and "robotics" were politically contingent. Furthermore, this points to a deeper ideological substrate that conceptualized the individual human as a more responsive "robot" than

[64] Nilsson, "The SRI Artificial Intelligence Center: A Brief History," 8.
[65] Nilsson, *The Quest for Artificial Intelligence,* 12
[66] Nilsson, *The Quest for Artificial Intelligence,* 285.
[67] Nilsson, *The Quest for Artificial Intelligence,* 12 and Nilsson, "The SRI Artificial Intelligence Center: A Brief History," 8.

its mechanical counterpart—as Engelberger would argue in 1978, "now the human being, I consider a stand-alone robot."[68]

In late January the following year, responding to NSF's request to clarify the most important details of the actual work of the program as well as to more fully describe the role of industrial participants, Rosen provided the most comprehensive presentation of what he envisioned the program would accomplish. Development of "advanced mechanization techniques to increase industrial productivity" would primarily be accomplished through increasing the quality of goods and reducing the "disaffection of workers who are currently performing dull, repetitive, dangerous, or otherwise undesirable jobs," particularly in mass-production industries with batch or multi-model production runs requiring assembly and inspection. Introduction of robotization would be "evolutionary" over the next two to five years, and "may be revolutionary thereafter." Repetitive jobs would be done by "computer-controlled machines supervised by a smaller but more highly trained workforce than heretofore used," capable of programming each job, maintaining the equipment, and responding intelligently to problems. In his words:

> Thus we will "timeshare" the workers, multiplying their capability by relieving them of the relatively low-level jobs which can best be done by machines. The human workers will be engaged with those more challenging tasks which at present can either not be done by machine at all, or can be done only with inordinately expensive computer hardware and software.

The technological basis for this required the development and "acceptance" of AI-integrated industrial robots by firms, the very systems he was proposing to demonstrate. As Rosen

[68] George G. Dodd and Lothar Rossol (eds.), *Computer Vision and Sensor-Based Robots*, Symposium held at the GM Research Laboratories, Sept. 25-26, 1978 (Plenum Press, 1979), 273.

emphasized, "a principle role for the industrial participants is for them to acquaint the AI scientists with the real problems to be solved, and to guide and assist them in their choice of constraints that can be economically applied to simplify machine requirements." Participants would also assist in economically assessing the costs of proposed techniques, designs, and integration into existing production lines. Because replacing workers with computer scientists to program the technology was impractical, "Programming the sensory-manipulation and inspection systems must be doable by factory-trained people who do not have to learn to be computer system programmers."[69] In other words, workers would be in charge of "teaching" the machines but would not be trained to actually code or program them.

Sometime between January and April, NSF finally awarded SRI a two-year contract and, on April 18, Rosen notified the official and interested industrial participants and reiterated that a key element of the program was to "provide guidance to expedite technology transfer."[70] By July, AMP Inc., Dow Chemical, GM, and GTE Laboratories had either firmly or almost firmly committed to the program. Apparently, the program was so hard up for cash and computer resources that Rosen advised an SRI official that "I think we should not commit in writing the fact that we would accept $15,000 worth of minicomputer in lieu of cash, but it certainly would be very nice to obtain our badly needed computer equipment in this way."[71] In early August, the results of a computer survey for the program was complete and a strong recommendation was made for a DEC PDP 11/10.[72] In mid-August, Rosen informed Chern that he had obtained firm commitments from AMP, Dow, Ford, GM, and Southern Pacific Transportation Company and

[69] Rosen to Chern, "SRI Proposal ISU 72-81 dated 24 July 1972 and Supplement dated 31 October 1972," Jan. 26, 1973, Correspondence Binder, Box 9, CARP, underlines in original.
[70] Rosen to Paul Ramer (Dow Chemical Company), Apr. 18, 1973, Correspondence Binder, Box 9, CARP.
[71] Rosen to Cox, "Industrial Participation Proposal," July 11, 1973, Correspondence Binder, Box 9, CARP.
[72] Meyer to Rosen, "Results of Computer Survey for Industrial Automation Study," Aug. 10, 1973, Correspondence Binder, Box 9, CARP.

the first participants meeting was scheduled for September 5.[73] On September 11, the first capital equipment request was made for a DEC PDP 11/10 minicomputer and the program's budget, internally designated "Project 2591," was set at $138,000 from September 30, 1973 through March 30, 1974.[74] After the first meeting concluded, Rosen informed participants that the next meeting would be held on December 5-6 and requested they arrange for industrial personnel to visit SRI for approximately one-week periods, to schedule corresponding visits by SRI staff to plants where automation problems existed, and the submission of assembly, subassembly, or single objects representative of products requiring the program's attention.[75] In the meantime, Rosen continued reaching out to prospective firms and, by November, Bendix, Teledyne Ryan Aeronautical, and Whirlpool had been added to the official roster.[76]

That October, when Scheinman sent out Vicarm's first status report, he directly mentioned the NSF-supported advanced automation program that also had "heavy funding from some of the country's largest manufacturing organizations, including Ford, GM, General Electric, and Dow Chemical" and their ongoing SRI's AI project "funded by the same good people who fund the Stanford University A.I. project." Additionally, he continued, the SRI and Stanford AI projects were cross-pollinated in terms of people and ideas moving back-and-forth between them, none more than Scheinman. As he put it, "SRI will get close and prompt attention to arm problems, and VICARM will get easy access to the results of their research, and lots of helpful feedback." Furthermore, the company would provide a suite of accessories and services to make

[73] Rosen to Chern, Aug. 15, 1973, Correspondence Binder, Box 9, CARP.
[74] Rosen to Cox, "Capital Equipment Request for Industrial Automation Program," Sept. 11, 1973 and Rosen to Hillhouse, "Project 2591," Sept. 12, 1973, Correspondence Binder, Box 9, CARP.
[75] "Industrial Participation--Advanced Automation Program," Sept. 26, 1973, Correspondence Binder, Box 9, CARP.
[76] Rosen to P. H. Gaither (DuPont Corporation), "SRI Proposal No. ISC 73-60 Industrial Participation in Program of Exploratory Research in Advanced Automation," Nov. 28, 1973, Correspondence Binder, Box 9, CARP.

their arms as adaptable as possible.[77] In May 1974, evidencing this close relationship, Rosen invited Scheinman to a two-day meeting of the program in late June where progress would be reviewed, and a laboratory demonstration would be given. Rosen requested that Scheinman notify him before the meeting of "relevant topics which you wish to discuss in more detail" so that time could be allotted, and he assured him that discussions could be "open to all participants or kept private, at your discretion."[78] Scheinman, therefore, was able to both shape and tap into SRI's work which, also in May, had committed to spend over half-a-million dollars on the program over the next year.[79]

A year later in 1975, NSF awarded SRI's advanced automation program a second two-year grant with the aim to continue research "aimed at early use by industry." Seven months later in December, Rosen lamented to Chern that, while the program had been productive, "transfer to industry of some of our new techniques has been impeded" by outdated equipment.[80] The lab's model 2000A five-axis Unimate, the design of which was at least ten years old, and could not provide acceptable performance for the applications desired and an off-the-shelf computer-interfaced six-axis Unimate was not available. SRI, therefore, made an agreement with Unimate to replace the 2000A with a computer-interfaced six-axis 2000B cooperatively designed by the two organizations. The cost for the new Unimate was approximately $35,000, money the

[77] "Status Report of November 1, 1973," VICARM[1,VDS], October 30, 1973 (http://www.SailDart.org/VICARM[1,VDS]).
[78] Rosen to Scheinman, "Advanced Automation Program Industrial Participants Meeting June 27 and 28, 1974," May 13, 1974, Correspondence Binder, Box 9, CARP. Coincidentally, Rosen received a letter from Alvin Toffler of *Future Shock* fame the same day with a list of questions about the "increasing tendency on the part of many companies to do 'custom work'" ranging from the relationship between "de-massified" production and mass production, the technology required for small production run, the implications for organization structure, and the effects on the division of labor, unions, and "the Third World," Toffler to Rosen, May 13, 1974, Correspondence Binder, Box 9, CARP.
[79] Rosen to J. Hillhouse, "Project 2591 - Exploratory Research in Advanced Automation - Project Account Status Reports," May 22, 1974, Correspondence Binder, Box 9, CARP.
[80] Rosen to Chern, "SRI Advanced Automation Program Upgrading of Unimate Manipulator System," Dec. 1, 1975, Correspondence Binder, Box 9, CARP.

advanced automation program didn't have, so SRI contracted with Unimation to pay $15,000 over twenty-four monthly payments, to waive Unimation's $15,000 industrial affiliate fee for two years of participation in the program, and to trade-in their old Unimate for approximately $5,000.[81] Furthermore, interfacing the 2000B to the lab's DEC LSI-11 microcomputer or PDP-11/40 would cost an additional $10,000. As a result, Rosen estimated that expenditures "will seriously diminish our industrial affiliate funds, which pay for a significant portion of professional salaries for the total program," and "two man-months of staff time" at a cost of $10,000 were required for the necessary equipment upgrade. He predicted a total shortage of $40,000 that couldn't be made up by recruiting new industrial affiliates "due primarily to poor economic conditions."[82] Rosen requested Chern to add an additional $40,000 to the existing grant, which was subsequently approved.

With the new technology installed and NSF and Industrial Affiliate support in place (as well as indirect support from the broader ARPA-funding of the AIG), Rosen began broadly publishing results of the program's work in 1975 (NSF had been receiving reports since late 1973). As he and colleague David Nitzan described, from its official launch in April 1973 the program had three objectives: 1) the development of computer programs to control a system of manipulators using force, tactile and visual sensors with a variety of auxiliary devices and end effectors to perform a wide range of assembly, material handling, and inspection tasks; 2) the development of a user's language such that the computer programs could be operated by factory personnel with no computer science expertise; and 3) the demonstration of the economic

[81] Rosen to Jim Hillhouse, Unimate Corp. - Industrial Affiliates, July 28, 1975, Stanford. Charles A. Rosen Papers. Box 9. Correspondence Binder - 14 and Rosen to Chern, "SRI Advanced Automation Program Upgrading of Unimate Manipulator System," Dec. 1, 1975, Correspondence Binder, Box 9, CARP.
[82] Rosen to Chern, "SRI Advanced Automation Program Upgrading of Unimate Manipulator System," Dec. 1, 1975, Correspondence Binder, Box 9, CARP.

feasibility of such programs and systems in factory settings. By late 1975, they had determined that the hardware and computational costs of existing AI-approaches to manipulation and vision were too expensive for factory use, however, visual recognition of a relatively small number of parts manipulated by robotic arms that factory personnel "programmed by doing" (i.e., "taught" via R/P technology) could be accomplished with the use of algorithms quickly run on a small computer.

There was, however, a catch: the computer architecture underlying the teachability of robots *did* require computer expertise and the parts to be manipulated had to be identified "one at a time against a controlled background and under controlled lighting"—in other words, the relocation of AI and robots to the factory world still located computational control in the hands of experts and managers as well as the construction of a microworld. Rosen and Nitzan stressed that the Artificial Intelligentsia "have barely begun to apply their knowledge to the constrained and, therefore, simplified problems of the factory" and "cost effectiveness and efficiency, which are usually set aside in long-range artificial intelligence research, must now be considered."[83] Making artificially intelligent robots cost efficient, therefore, was a contingent and long-term project. Nevertheless, over the next few years, SRI was able to demonstrate a variety of capacities from bin picking and bolting to parts mating and spray painting, and the lab began accumulating a library of algorithms and programs from which their industrial affiliates could draw from.[84] One of the most active patrons was GM.

[83] C. A. Rosen and D. Nitzan, "Developments in Programmable Automation," *Manufacturing Engineering* (Sept. 1975), 27-28.
[84] David Nitzan and Charles Rosen, "Programmable Industrial Automation," *IEEE Transactions on Computers*, Vol. C-25, No. 12, (Dec. 1976); Charles A. Rosen and David Nitzan, "Use of Sensors in Programmable Automation," *Computer* (Dec. 1977); and C. A. Rosen, "Machine Intelligence Research Applied to Industrial Automation," c. 1978, Work performed by the Industrial Automation Group SRI International, No Folder, Box 3, CARP.

**Rustbelt Robot: The Origins of the PUMA**

Despite being a leader in the practical applications of industrial robots, GM surprisingly had no formal robotics research program even a decade after its first industrial robot installation in 1961. That would all change in late 1971 when GM's robotics work "began in earnest," perhaps coincidentally at the same time Rosen reached out to GM about the industrial automation group's work, and probably less coincidentally in the midst of "Lordstown automation."[85] The first foray into the field was led by Floyd Holroyd in the Mechanical Engineering department of GM's Manufacturing Development (MD) division, who compiled a compendium of industrial robot manufacturers which he sent to all of GM's divisions in early 1972. That same year, while Nilsson and Rosen were decommissioning Shakey at SRI and Scheinman was developing the MIT arm, GMR began researching the economic and technical feasibility of applying computer vision and robotics to the assembly of complex industrial parts.

The first experiment at GMR, completed in May 1972, used three hardware-software subsystems—a video camera for vision, a computer for control and recognition, and a modified N/C machine tool (a computer-controlled drill) for manipulation—to automatically mount wheels onto hubs. The objective of the experiment was to demonstrate that the task could be completed using existing hardware combined with new pattern recognition algorithms. Wheels and hubs were selected for their physical characteristics as they were representative of a large class of other automotive components that could provide a degree of generality to be built into the recognition algorithms. Unlike the carefully machined children's blocks in the university hand-eye experiments, the wheels and hubs were not modified to simplify the task and "an effort

[85] Author interview of Steven W. Holland (04/22/2020) and Rosen to Olsztyn, Oct. 22, 1971, Correspondence Binder, Box 9, CARP.

was made, in fact, to select particularly dirty and greasy parts in order to establish the limits of satisfactory system performance." Nevertheless, the cycle time and positional freedom requirements that would be encountered in real-world manufacturing plants were relaxed as the experiment was never intended to field a system that would actually go into production. The complete task took approximately one minute with the vision and recognition sequences, which in production settings would need to cycle in three to four seconds, taking forty-five seconds. Slow speeds aside, the experiment was deemed a success and, more importantly, it revealed some major research needs for the uptake of machine vision in industry—more efficient techniques for rapidly acquiring three-dimensional scene data, the extraction of useful information about objects more complex than wheels and hubs from this data, and the development of concepts for flexible machine visions systems that could be easily reprogrammed for new tasks.[86]

In February the following year, John D. Joyce of GMR's computer science department visited SRI and expressed to Rosen that "the contacts we made with individual staff members will serve as a catalyst for future exchange of information."[87] Concomitantly, Holroyd and fellow engineer Walter Cwcyshyn in MD, independently of GMR's computer vision and robotics research program, realized they might be able to apply robotics to assembly operations. This led them to acquire a Man Mate from General Electric to test materials handling and manipulation that, shortly thereafter, was transferred to GM's home appliance division Frigidaire and was used to remove refrigerator cases from one sub-assembly line, turn them over, then place them on

[86] Joseph T. Olsztyn Lothar Rossol, Robert Dewar, and Norman R. Lewis, "An Application of Computer Vision to a Simulated Assembly Task," Proceedings of the First International Joint Conference on Pattern Recognition (Washington, D. C., October 30-November 1, 1973), 505-513 quote from 505.
[87] Joyce to Rosen, Feb. 20, 1973, Correspondence Binder, Box 9, CARP.

another sub-assembly line.[88] That same year, Holroyd and Cwcyshyn were transferred to Richard 'Dick' Beecher's new Assembly Processing and Material Handling department within the Manufacturing Staff (who, according to Beecher, "just gave us the title, and let us invent the job") where they began casting about for a project to work on.[89] Holroyd eventually got interested in engine assembly, "because it was very heavily labor intensified," so the department bought a Unimate in 1974 and began testing its capacity to place a piston into an engine block. The Unimate's accuracy was wanting and the team realized they would need more of it if they were going to pursue assembly operations.[90] This observation was made years prior by engineers at Lordstown, however, production was segregated from R&D which was itself scattered across the GM hierarchy—as Beecher described it, within the Manufacturing Staff was the MD group that included an Industrial Engineering organization, which itself housed Beecher's team in the Assembly Processing and Material Handling department.[91] To make things even more convoluted, these departments/groups/organizations had little to no contact with GMR, which was several years, if not decades, ahead in their robotics work.[92]

At the same time Holroyd et al were doing relatively rudimentary testing of their Man Mate and Unimate, GMR was establishing one of the most advanced computer vision and robotics laboratories in the world. Referred to as the "Machine Perception" project, the lab was designed to develop computer vision and manipulation techniques for automatic part handling, computerized inspection, and assembly. In late 1974, Mitchell Ward of GMR contacted Scheinman for a quote on a custom built Stanford Arm, the cost of which fluctuated from

[88] Allison Marsh, "PUMA Video History Transcript," National Museum of American History (April 9, 2002), 1:19:55-1:32:56.
[89] Marsh, (2002), 1:19:55.
[90] Marsh, (2002), 1:34:12.
[91] Marsh, (2002), 1:19:55-1:23:52.
[92] Marsh, (2002), 1:19:55-1:23:52.

$27,500 to $30,000 over the next few months due to GMR's changing specifications, the numbers of which were most likely shaped by their ongoing participation in SRI's automation program.[93] At some point during the negotiations, Ward traveled to Palo Alto to meet with the Vicarm team and see the arm in action but he walked away from the demonstration skeptical. According to Bruce Shimano—then a PhD student at Stanford whom Scheinman paid $1,000 to work on Vicarm software—Ward exclaimed "Gee, you know, I'm really going out on a limb buying this thing. It's a hell of a lot of money. And it's not industrial, and, you know, we're buying Unimate's from Joe Engelberger, and these things are working, and it's a lot of money to buy something from you guys." Ward continued, "It would really be helpful, if at the time you delivered the system, you could have it move" because "it's gonna be really tough to justify this with my management because they're all gonna be saying, 'Well you spent all this money from these guys out in California, and what's it doing?'"[94] Nevertheless, Ward eventually made a purchase order in March 1975.[95]

By late 1975, installation of the Stanford arm was completed and, perhaps because of the delay, the project in the interim focused its early work on computer vision and pattern recognition.[96] Additionally, the lab undertook an extensive survey of potential computer vision and robotics applications within the corporation as a whole with the objective of identifying an advanced pilot production task (or class of tasks) to drive the broader research program. One key finding of the survey was the revelation that anywhere from 90-95 percent of automobile parts

[93] GM.L[1,VDS], GM.L2[1,VDS], GM1.VL[1,VDS], GM2.VL[1,VDS], SAILDART and Rosen to Dewar, "Advanced Automation Program Industrial Participants Meeting February 27 and 28, 1975," Jan. 22, 1975, Correspondence Binder, Box 9, CARP.
[94] Marsh, (2002), 0:44:25-0:45:05.
[95] GM3.VL[1,VDS], SAILDART
[96] M. L. Baird, J. T. Olsztyn, W. A. Perkins, and L. Rossol, "GM Research Labs' Machine Perception Project," SIGART Newsletter, No. 55 (December 1975), 12-13.

weighed less than three pounds.[97] At the time it was assumed that assembly consisted of larger components (e.g., body frames, chassis, doors, engines, seats, windshields) which, in hindsight, may not be surprising as these were the primary constituents of automation and robotization. Following this discovery, the lab decided to develop a computer vision system for locating, automatically aligning, and inspecting integrated circuit (IC) components during various manufacturing processes at the Delco Electronics Division. In 1975, a (robotless) pilot system called SIGHT-I was demonstrated in the lab and, two years later, the Manufacturing Staff built a fully operational system that was integrated into production.[98]

Building on SIGHT-I, the "Machine Perception" team began developing a vision-based robotic system called CONSIGHT-I—also inspired by the early vision and robot tracking research done at SRI—to locate, discriminate, and manipulate parts on a moving conveyor belt.[99] At the time, a number of manufacturing activities involved parts arriving at a workstation in an unorganized fashion (often heaped in bins), and existing robots required parts to be precisely positioned before they could be identified and grasped. Furthermore, automated handling operations that could precisely orient parts for robotic manipulation were "uneconomical and unreliable," a problem discovered a few years prior at Lordstown where human workers were required to feed body parts to the Unimates for spot welding. CONSIGHT, therefore, was designed to overcome this problem.[100] Similar to the Blocks World and assembly experiments at MIT and Stanford, both SIGHT and CONSIGHT used structured lighting to enhance

[97] R. C. Beecher, "PUMA: Programmable Universal Machine for Assembly," in Dodd and Rossol (eds.) *Computer Vision and Sensor-Based Robots*, 141 and Marsh, (2002), 1:41:30.
[98] Michael L. Baird, "SIGHT-I: A Computer Vision System for Automated IC Chip Manufacture," *IEEE Transaction, Systems, Man, and Cybernetics*, Vol. SMC-8, No. 2 (Feb. 1978), 133-134.
[99] Steven W. Holland, Lothar Rossol, Mitchel R. Ward, and Robert Dewar, "A Vision-Controlled Robot for Part Transfer," (General Motors Corp., Feb. 25-29, 1980), 1 and Baird, 133.
[100] S. W. Holland, L. Rossol and M. R. Ward, "CONSIGHT-I: A Vision-Controlled Robot System for Transferring Parts from Belt Conveyors," in Dodd and Rossol (eds.), *Computer Vision and Sensor-Based Robots*, 81.

background-object contrasts as the vision subsystem could only detect silhouettes. In the case of CONSIGHT, however, the system was designed to not require specially colored, lighted, or machined materials to ready it for eventual transfer to the "noisy" factory floor.[101] Nevertheless, the system did have limitations: parts could only be differentiated if they weren't touching and, even though a selling point of the Stanford arm was its speed, the system was limited by the robot's cycle time (i.e., the eye was faster than the hand)—hence, a less constrained and more practical microworld.[102] As a result, in 1976, while CONSIGHT was still being developed, Ward drew up a new specification for a more capable robot arm.[103] Three laboratory versions of CONSIGHT were eventually developed—the first at GMR used a Stanford arm and a single computer; the second, a production prototype at MD, used a Cincinnati Milacron T3 robot and two minicomputers (one for vision and one for supervision); and the third, apparently a joint effort of GMR and MD, used a single minicomputer and, what would become the hallmark of GM's robotics research, a Unimate PUMA 600 robot system.[104]

The "Programmable Universal Machine for Assembly," colloquially known as the PUMA, was conceived and emerged from Dick Beecher's outfit in Manufacturing Development in mid-1975. GM had originally planned to develop a stand-alone robot that could assemble a complete product from start to finish but the idea was rejected for a number of reasons. First, the aforementioned problem of economically supplying parts to a robot had not been solved (i.e., high enough production speeds or 'throughput' to justify the sizable investment). Second, because a single robot would complete assembly, any downtime for maintenance or repairs

[101] Baird, 136-137 and Holland, Rossol, and Ward, 81-82.
[102] Holland, Rossol, and Ward, 83.
[103] Holland, Rossol, and Ward, 96.
[104] Mitchel R. Ward, Douglas P. Rheaume, Steven W. Holland, and James H. Dunseth, "Production plant CONSIGHT installations," Proc. SPIE 0360, Robotics and Industrial Inspection, (May 23, 1982), 297.

would slow production. And third, backup units or manual assembly lines that could take up the slack would waste floor space. Instead, the PUMA's developers chose to employ robots in repetitive tasks, just like human workers. Additionally, from management's point of view, the robots would be identical and therefore interchangeable, just like human workers. Furthermore, designers deliberately designed the robot's arm and work envelope to mimic the average human, so if/when a robot went offline, it could be replaced by another robot or human worker. As Beecher described it, "the decision was made to retain humans in the proposed system where they could make the greatest contribution, and to act as supervisors for the machines. Where special-purpose machines could perform a task better or cheaper than robots, they would be included . . . . [the PUMA] is envisioned as a system which will be made up of humans and machines, each doing what it does best.[105] Translation: the "universal" capability that motivated the development of industrial robots from their origins in the 1950s was still a pipedream.

The first two arms integrated into the system during its developmental phase were a Swedish-built ASEA 6—at the time the only ASEA robot in the United States—and a Kawasaki-built Unimate 5000, both of which were bulky, hydraulically powered devices typically used in heavy manufacturing.[106] The robots were adaptive control capable (i.e., direction via sensors and vision), however, as Beecher described it, the MD staff were "relative neophytes at this whole business," and thought such adaptive control "was a way off," even though it was already in action at GMR.[107] Assembly tasks both arms were able of completing included inserting light bulbs into the back end of instrument panels, gear transmissions into power seats, and pistons into brake cylinders. The products to be assembled would come down the line in a random

[105] Beecher, 141-143 quote from 143.
[106] Marsh, (2002), 1:37:44,
[107] Beecher, 149.

fashion and pass limit switches and "little dogs on the conveyor" that indicated to the arms which assembly task to perform. The PUMA team quickly realized, however, that their arms didn't have the necessary accuracy for efficient assembly (hundredths of an inch rather than thousandths) and a smaller more accurate manipulator would be required.[108] The first iteration of the PUMA, therefore, used accurate fixturing, like that used to orient body parts for welding at Lordstown, and "dead reckoning," the process of calculating the current position of a moving object by using a previously determined position, to take advantage of existing state-of-the-art technology and speed-up development of a production-ready unit. Based upon preliminary findings and cost studies, MD was open to buy, build, or have built a prototype manipulator and drew up performance specs and for an "ideal" assembly robot that was sent with a request for bid to prospective suppliers.[109] The winning bid would eventually come from none other than the 'Man with the Golden Arm.'

**PUMA (In)Action: From Vicarm to Unimation West**

GM's order of a Stanford arm in 1975 proved fateful for Scheinman and Vicarm for two reasons. First the sale and subsequent consultation provided by Vicarm established a working relationship between the company and the GM staff tasked with choosing the technological form their PUMA arm would take. And second, Scheinman quickly learned—spurred by conversations with GM about their lack of confidence in Vicarm's scalability and their suggestions that he partner with someone who had this ability—that his firm, in its current form, had limited manufacturing and

[108] Marsh, (2002), 1:09:53 and 1:39:03-1:39:30.
[109] Beecher, 143.

marketing capacities.[110] As a result, an inflection point in the company's history was rapidly approaching and Scheinman had to choose which route it would take—remain a small firm that could continue pushing the frontiers of robotics or grow into an outfit that could meet the needs of the manufacturing community at scale.

Over the previous two years, Scheinman fielded numerous information requests about his arms and signed purchase agreements with dozens of corporations, government agencies, and universities (both at home and abroad) from International Business Machines (IBM), Texas Instruments (TI), and Westinghouse, to the National Bureau of Standards (NBS) and Naval Research Lab (NRL), to the universities of Illinois and Purdue, and the Institute de Microtechnique in Lausanne, Switzerland.[111] Depending on the user and system desired, prices ranged from $4,000 for the basic MIT arm, like the one shipped to Purdue University, to almost $30,000 for a Stanford Arm that included a hand with touch-sensor fingers, all necessary electronics, and on-site installation and demonstration, like the one shipped to Ward's team at GM.[112] Notably, the electronics for NRL's MIT arm were developed by Russell Noftsker—previously the administrative director of the MIT AI Lab who worked with Scheinman while he was developing the MIT arm during his summer in Cambridge—who Scheinman also credited with being "instrumental" to securing the TI order.[113] By January 1975, Vicarm was building five MIT arms, three Stanford arms, and demand was so great that the company "had to discourage some potential customers." These early users were employing their arms in research; however, purportedly due to the character of demand, Vicarm began to shift its development concentration to computer-controlled manipulators for four specific task areas: machining,

[110] Asaro and Šabanović, "Oral-History: Victor Scheinman."
[111] Information requests and purchase agreements can be found here https://www.saildart.org/VDS.
[112] 1974-04-25 PRICES.M[1,VDS]1 and 1974-11-04 GM.L[1,VDS], SAILDART.
[113] FOLKS.L1[1 VDS], SAILDART.

manufacturing, mechanical assembly, and packaging. Scheinman, therefore, began the transformation of Vicarm from an R&D startup into a manufacturer of specialized equipment for industrial automation.[114]

That same month, in a letter apparently to his father, Scheinman detailed the current state of the company and addressed the problems that had arisen. He expressed concern about not being able to keep up with its backlog of orders (then at eight) and proposed three solutions to the problem: 1) cut off sales until the company could merge or partner with another firm; 2) seek outside capital to expand as an independent company; or 3) an interim plan of increasing delivery-date spreads to give the company more time to fulfill orders.[115] Scheinman's anxiety and uncertainty about what the future of Vicarm held came to a peak in October 1975. On the first of the month, he sent an email to the White Plains, NY office of Swedish industrial conglomerate ASEA with an offer to serve as the American licensee of the firm's industrial robot, which would put Vicarm in charge of manufacturing and distributing ASEA arms in the U.S.[116] Four days later, Scheinmen sent an email to Marvin Minsky expressing how overwhelmed he was and his fear that delaying the PhD any longer would be "fatal to its successful execution."[117] As Scheinman described the conundrum this put him in, "I must admit, that should it oome [sic] down to it that I have a chance to make the proverbial 10 million (inflation), or do the PhD, I would have to opt for the money at the moment, because if, and only if the certainty of making the money were good, I could probably accomplish all that I want to do in the PhD, in the context of that new business enterprise."[118]

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[114] 1973-01-19 VICARM.P1[1,VDS], SAILDART.
[115] FOLKS.L1[1,VDS], SAILDART. The addressee(s) were not given but, at the tail end of the letter, Scheinman wrote "By the way, .... hi mom, I know that you will problably [sic] read this letter too."
[116] 1975-09-30 20:58 ASEA .VL [1,VDS], SAILDART.
[117] 1975-10-06 M.PL[1,VDS], SAILDART.
[118] FOLKS.L1[1,VDS]

Cashing in this technological lottery ticket was probably a desirable option because, while Vicarm didn't require an influx of capital at the time, Scheinman also wasn't making any money from it.[119] To assist with the labor, Scheinman hired recently graduated Stanford master's student Brian Carlisle, then current Stanford PhD student Bruce Shimano (Scheinman, Carlisle, and Shimano all shared a thesis supervisor, Bernie Roth), and David Silver, a talented student from MIT who, in Minsky's words, grew "from a high school dropout to an A.I. out growth."[120] Delays, however, continued when Scheinman encountered labor problems with Silver, one of his only two-and-a-half employees, which put GM's Stanford arm eight months behind schedule.[121] Scheinman further lamented to Minsky that the combined delays over delivering MIT arms to customers, the extended time it took to manufacture Stanford arms (twice as long as the MIT version), and the labor-management problems associated with the GM order was not only preventing him from completing his PhD but endangering the company.[122] As he opened up to one of his early clients, "I cant afford to personally launch and fund a full blown research and development department. In fact, I have not yet been able to afford an arm of my own."[123]

The combined pressures led Scheinman to begin shopping Vicarm, and more importantly, his expertise and professional networks, around. Not surprisingly, his first discussion about a possible merger was with Engelberger, who believed Vicarm would be the future of Unimation.[124] Conversations about a merger began at a conference in Poland where a 'request for quote' (RFQ) from GM for the manipulator component of its PUMA system was floating around, "the spec" of which, according to Scheinman, "looked very much like just a grown up

[119] DICK5.PL[1,VDS]
[120] BRIAN1. VL [1,VDS] and SILVER. VL [1,VDS]. Carlisle and Silver were full time while Shimano worked during his free nights and weekends.
[121] GM3.VL[1,VDS] and M.PL[1,VDS]
[122] M.PL[1,VDS]
[123] TI4.VL [1,VDS]
[124] Author interview with Gay Engelberger, July 27, 2019.

version of the little Vicarm we were selling, the Model MIT Arm."[125] While walking around a lake, Scheinman and Engelberger discussed uniting Vicarm's technology with Unimation's experience in manufacturing, marketing, and service to capitalize on the latter's reputation in the robotics field.[126] In early 1976, Scheinman visited Engelberger and his team at Unimation's offices in Danbury, Connecticut and, after mulling over their proposal, responded with a number of stipulations: 1) Scheinman wanted to stay in the Palo Alto area to work on advanced manipulator design rather than on their manufacture or production; 2) he wanted a provision to complete his PhD in Automation—"a special study area I set up a couple of years ago—however, he continued, "I would be willing to modify my research to include topics of interest to Unimation"; and 3) Unimation would purchase all of Vicarm's assets, approximately $55,000 in total, and agree to three-year employment contracts for Scheinman and his employees with total yearly salaries of $75,000-$100,000. Furthermore, Scheinman made explicit, "Vicarm has another asset . . . . my experience and knowledge in the field of computer-controlled manipulators. This includes the designs of the Stanford Arm and the M.I.T. Arm."[127] By fall 1976, with the Unimation negotiations ongoing, Scheinman began communicating and negotiating with other possible partners including Camsco, Inc., the Everett Charles Co., and, spurred by a conversation with John McCarthy who was close with the firm's management, Information International Incorporated, to no avail.[128] For instance, in late October, Scheinman

[125] Marsh, (2002), 0:56:55.
[126] Marsh, (2002), 0:15:22" and 0:56:55.
[127] 1976-04-01 20:04 OFFER.VL[1,VDS], SAILDART. The document alludes to previous discussions between Scheinman and Unimation, however, I am unable at the moment to find any documentation with the specifics. At about the same time, Brian Carlisle flew to Detroit with GM's Stanford Arm in his personal luggage to help them install and interface it, Marsh, (2002), 0:50:10,
[128] Scheinman to CAMSCO, 1976-11-15 CAMSCO.VL[1,VDS], Scheinman to Kenneth Hines, 1976-08-06 OFFER3.VL[1,VDS], Scheinman to Information International Incorporated, 1976-10-04 OFFER4.VL[1,VDS], and Scheinman also reached out to Varian and Associates about a possible merger, 1976-08-19 VARIAN.VL[1,VDS], SAILDART.

responded to interest in Vicarm from Oakland, California-based Micon Industries—the first firm to mass produce electronic, portable teletypewriter (TTY) devices allowing two-way telecommunications over phone lines for the hearing impaired—and sold his credentials as an MIT grad and as a current PhD candidate "in the special studies area of Automation" who relies "heavily on my connections with Stanford University." He also explained that his primary objective was to "market an industrial rated robot assembly system" and that Vicarm's current market was primarily "automation research and development groups at large corporations, government agencies, universities, and research labs."[129]

These conversations appear to have been backup plans to the ongoing merger negotiations with Unimation. According to Scheinman the intent all along was to join forces to work on the PUMA program.[130] On January 11, 1977, Scheinman informed a number of his existing and potential customers as well as potential merger partners that by the end of the month Vicarm was joining Unimation.[131] Two weeks later, Scheinman responded to a Vicarm inquiry from University of Wisconsin professor of computer science Raphael Finkel—whose Stanford PhD thesis "Constructing and Debugging Manipulator Programs" was completed the year prior on SAIL's Scheinman arms—and informed him that at 10:30 a.m. tomorrow (January 26th), Vicarm would officially become Unimation West and that Scheinman would change his status at Stanford from a full-time student to "student on leave." The new West Coast Division would initially offer Vicarm products, but within the year, they planned to have a new "industrialized manipulator system for sale." Beyond the future plans, Scheinman's response is particularly interesting for what it had to say about SAIL. In his estimation, the Hand-Eye group had

[129] MICON.VL[1,VDS], SAILDAART.
[130] Marsh, (2002), 0:58:25.
[131] 1977-01-11 08:46 BOEING.VL[1,VDS], 1977-01-11 09:21 BBC.VL[1,VDS], 1977-01-11 14:05 CAMS3.VL[1,VDS], 1977-01-11 14:06 FIRE.VL[1,VDS], SAILDART.

"deteriorated" under Thomas Binford's leadership and the majority of graduate students were "imposters or foreign guests [at SAIL] on boondoggles." Apparently, the Scheinman arms were not even running, so he took the liberty of giving one of them the "$2000 professional rebuild." Furthermore, "since Binford never authorized it," Scheinman was planning not to charge the lab but hoped "to trade a bit of computer time here and there."[132] In other words, SAIL's manipulator development and robotics research, in his opinion, was literally falling apart without him.

The transition from Vicarm to Unimation West that January was a seamless affair—Scheinman recalled "essentially we just changed the name on the door one day from Vicarm to Unimation -- West Coast division in California"—and Scheinman's first official task as Unimation West's general manager was completing the "technology part" of Unimation's proposal for the PUMA system.[133] Work on the proposal seemingly began long before the merger was finalized and the document pitched essentially the latest version of Vicarm's technology—an MIT arm interfaced to a DEC LSI-11 (the "controller computer") programmed using the "Assembly Language" (AL) developed under joint ARPA and NSF support at SAIL during the early 1970s—but "industrialized."[134] For instance, the manipulator and controller were intended to be universal, meaning they were interchangeable and easily replaceable as well as portable to other systems, rather than the custom-built systems that were Vicarm's stock-in-trade.[135] GM's software specs came directly from MD's experience with their ASEA arm, but due to its power and sophistication, the AL language was modified and upgraded to be

[132] 1977-01-25 22:45 WISC.VL[1,VDS], SAILDART.
[133] Marsh, (2002), 0:58:25 and 1977-03-15 03:58 UNI1.V[1,VDS], SAILDART.
[134] For the history of AL, see Robert Bolles and Richard Paul, "The Use of Sensory Feedback in a Programmable Assembly System," SAIL Memo AIM-220, Oct. 1973 and Raphael Finkel et al, "AL, A Programming System for Automation, SAIL Memo AIM-243, Nov. 1974.
[135] 1977-03-15 03:58 UNI1.V [1,VDS], SAILDART.

manipulated through a "button box" with an optional 3-axis joystick teach unit to serve, rather than through the traditional keyboard and screen, as the "basic low cost arm-computer-human interface."[136] Estimated costs for manufacturing at scale—excluding development and overhead, and assuming batches of one-hundred with labor priced at $15 an hour—totaled $8,750 per system. The proposal was sent to GM in February and, the following month, Unimation beat out three other contenders for the contract.[137]

At the technical level, while the manipulator could still be programmed in the traditional manner, "the 'assembly line' version . . . . would more likely use a simplified set of these instructions implemented on a limited number of software redefinable instruction keys."[138] This allowed an operator who had no experience with software to "program" the manipulator on the job, similar to existing R/P robots like the Unimate. However, unlike the Unimate, the "programmability" of the PUMA arm is relevant for one important historiographical reason: It provides evidence counter to Noble's claim that the design of R/P technology had the social capacity to valorize workers' power over the control of technology at the point of production instead of denuding such power as in the case of his N/C machine tools. Rather, the code underneath the buttons and joysticks of R/P, and the computers and programs controlling them, occluded and sublimated the continuing managerial and technical authority over the means of production. Furthermore, the ability of R/P to enliven workers' control of production may have had some resonance in the domain of parts fabrication requiring a high level of skill and technical competence in relation to the machines being used; however, the types of jobs/work-

[136] Marsh, (2002), 1:00:31 and 1977-03-15 03:58 UNI1.V [1,VDS], SAILDART.
[137] Marsh, (2002), 0:59:19 and 1977-03-15 03:58 UNI1.V [1,VDS], SAILDART. Reference to four total bidders but not who they were (besides Unimation), is mentioned in Drozda, "PUMA: Robots Find Cost Effective Jobs in Batch Manufacturing," *Production*, Aug. 1979.
[138] 1977-03-15 03:58 UNI1.V [1,VDS], SAILDART.

tasks the PUMA was designed for were relatively "low skill" and thereby accomplishable with a minimal amount of training and experience (a là Lordstown's high-tech Taylorism). As a result, the R/P function of the PUMA did not "deskill" workers as much as "steal" skills from them.

Over the next fourteen months the Unimation West team went to work transforming the MIT arm into the PUMA arm. By July, the original team of Scheinman, Carlisle, and Shimano (the latter of whom remained part-time while developing software remotely in Los Angeles) added three official employees to the roster and contracted for labor from four more. Scheinman's projected budget for the following fiscal year (through July 1978) totaled $364,753, with approximately $180,000 allocated for labor, which was essentially double what he had originally pitched to Engelberger.[139] Additionally, according to Engelberger's daughter Gay—whom he sent to Unimation West from Connecticut to work with Scheinman during the PUMA period—a GM employee was stationed at the division's Palo Alto office to assist with the project.[140] In August, Scheinman sent Beecher brief drawings and descriptions of the arm's design and informed him that the manipulator being developed under the PUMA program would be marketed as the "Unimate 500," indicating that Unimation retained the rights to the arm and planned to sell it widely.[141] During the remainder of the development process, as Scheinman revealed years later, "we took some liberties with some of [GM's] specifications" by integrating additional control and software features that became the "heart of the manipulator."[142] As the delivery date drew closer, the Vicarm team needed to figure out some way to differentiate their programming language from AL and, as Shimano recalled, "being that it was Vicarm, or Vic's

[139] 07-10 13:26 BUDGET.U [1,VDS], SAILDART.
[140] Author interview with Gay Engelberger, July 27, 2019. According to Ms. Engelberger, Vic welcomed her to Unimation West in a robot costume (what Scheinman recalled was a "Tin Man" costume (Marsh, 2002) and walked her around the building while narrating the tour through a speaking device.
[141] 1977-08-14 23:21 B.[1,VDS], SAILDART. For a technical description of the proposed controller for presumably both the PUMA and the Unimate 500, see "Unimate 500 Controller," 1977-08-14 19:45 PROP . [ 1,VDS].
[142] Marsh, (2002), 1:05:48 and Dodd and Lothar Rossol (eds.), 143.

Arm, then the language became VAL." So, he continued, "Victor, being the modest person he is, put a V in front of it . . . . and [when asked what it stood for] we of course never wanted to say Victor's Assembly Language or Arm Language. And so at some point someone said it was the Versatile Assembly Language or something."[143] On May 1, 1978, the first prototype was delivered to GM.[144]

Shortly before MD received the prototype they already had determined that their target for the PUMA system was the approximately 89,000 assemblers employed by GM. And, while the putative purpose of the PUMA was to be "universal," hence its name, Beecher admitted in a November 1977 trade press article that the system was "not truly a universal assembly machine . . . . but it comes close to being a universal system when applied to relatively small products."[145] Jobs surveyed for PUMA-fication included assembly of brake cylinders, heater and air conditioner controls, instrument clusters (specifically the installation of light bulbs), power seat transmissions, and the packaging of various repair, maintenance, and tune-up kits. GM also received a quotation from an unnamed supplier of $19,000 per robot (including minicomputer control), the price of which was so attractive that the robot component of the PUMA, rather than the entire system, was a "serious contender" for stand-alone applications, such as loading and unloading machines.[146]

By August 1978, four arms were on order and six to seven more were planned for purchase at Delco Electronics, Delco Products (Rochester), Delco Moraine, Harrison Radiator,

[143] Marsh, (2002), 0:45:41. Shimano also revealed that SAIL originally named their assembly language "H-A-L, after the computer in Kubrick's 2001, but it turned out that HAL was patented, already copyrighted, and so Stanford dropped the H, and made their language A-L, for assembly language."
[144] Marsh, (2002), 1:05:48 and Dodd and Lothar Rossol (eds.), 143.
[145] David A. Van Cleave, "One Big Step for 'Assembly in the Sky,'" *Iron Age*, Nov. 28, 1977, 33.
[146] Untitled, n.d. (c. early 1978), Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002), 40-42.

and General Motors Research labs. Based on these numbers, Unimation was planning to build fifteen robots in GM's first batch and Engelberger was hosting a meeting at MD in early September "to introduce the Connecticut people to the PUMA arm which they will be building, and to get our input for the benefit of both the Connecticut and California people."[147] A month later, GM held a symposium at the Tech Center in Warren, Michigan that included essentially all the principles involved in the PUMA development over the previous decade. An advisory committee of Marvin Minsky, Azriel Rosenfeld (a professor of computer science at the University of Maryland who would the following year co-found the Association for the Advancement of Artificial Intelligence (the international scientific home of AI), and Charles Rosen chose the speakers with talks given by Beecher, Engelberger, and, not surprisingly, Rosen, whose paper launched the proceedings.[148] Other attendees included representatives from each of SRI's Industrial Affiliate participants, representatives from NSF (including Bernard Chern), a representative from ARPA and the Naval Research Laboratory, John McCarthy of SAIL, and of course, Scheinman. Beyond its function in bringing together the luminaries of AI and robotics, particularly in relation to their role in advancing the art of automation, the symposium and resulting edited collection published the following year were signal examples of how socialized knowledge production and technological development were privately leveraged and mediated, with PUMA the star of the robotic show.

[147] Beecher to Burke, PUMA Update, Aug. 16, 1978, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002), 52-53.
[148] "Author Biography for Azriel Rosenfeld," https://archive.ph/20121217125837/https://www.elsevierdirect.com/author.jsp?authorcode=1009547.

Back at Unimation, final programming of the PUMA was scheduled to be completed October 1 with the first production units delivered by January 1979.[149] The manufacture of the first batch of PUMAs and the first session to teach GM personnel how to use them, however, did not go well. Building three-to-four ton, numerically controlled hydraulic manipulators designed and refined over twenty years required significantly different experience, facilities, and skills than those needed for small, state-of-the-art software-controlled electric manipulators. As Scheinman recalled, "the interface to the East Coast was sometimes strained because of the separation [from Unimation West], which meant that when it came down to production of the PUMA we did have some difficulties."[150] According to Mitchell Weiss—who immediately after graduating with a mixed Electric Engineering and Mechanical Engineering degree from MIT joined Unimation and was assigned to the PUMA—the project was apparently a low priority in the company. Out of four hundred employees, only six worked on the PUMA: one mechanical engineer, one electrical engineer, one software engineer, two applications engineers, and product manager Mike McCraley. The then twenty-three year old Weiss was assigned to train under one of the applications engineers who "let me know on the first day of the job that he wasn't gonna have anything to do with the PUMAs" because "the real money was being made was in the big hydraulic spot welding jobbies" and the "assembly stuff wasn't going to go anywhere anyway."[151] Six weeks into his tenure, Weiss and the four other engineers assigned to the PUMA were sitting on the floor with "X-acto knives and schematics trying to find the shorts on the PC boards, so we could just get these machines up and running because we had to deliver them,"

[149] Beecher to Burke, PUMA Update, Aug. 16, 1978, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002), 52-53.
[150] Robotics Age 1980-v2n3 (Victor Scheinman interview), 17.
[151] Marsh, (2002), 0:47:11-0:51:46.

while everyday they would get a call from the technicians actually building the robots asking them, “Oops. this one's not working, can you guys come down and help us with this stuff?” Soon after, the first batch of PUMAs were ready for delivery and Unimation scheduled a three-day in-house training course for the GM production staff who would be operating them. In Weiss’s words, “these weren't guys in the research labs now, these were the guys on the floor that we sold them to, they're machinists, I always describe them as people with big thumbs and metal chips up under their fingernails and greasy fingernails.” A day before the course began the instructor came down with laryngitis and Weiss was saddled with the responsibility. After introductions, Weiss inserted a floppy disk into a terminal to boot up the PUMA and immediately every hand went up in the room with the same question: “What’s a floppy disk?”[152]

The test bed for the first PUMAs and their accompanying “trained” operators was at the Delco Rochester Products plant in upstate New York. As GM engineer Jim Wells—who began his career at Rochester Products in 1979 immediately after graduating from Rochester Institute of Technology—described it, the plant was a high-volume operation with cycle-times of five to six seconds per process turning out 14,000 carburetors a day. The sprawling factory floor was a bastion of “semi-automation” that included long lines of fixed stations and “acres of people out there,” meaning there was a “tremendous business case for using something like the PUMA” to not just displace workers but to also “displace all that fixed automation.” Five beta test-unit PUMAs were delivered to the plant (though plant engineers were told they were production ready) and Bernie Frank, director of Rochester Products, had his team go out on the factory floor to study a suitable application where they could retrofit a PUMA into an existing line.[153] MD originally announced that the first in-plant assignment for the PUMA was to manipulate and

[152] Marsh, (2002), 0:47:11-0:51:46.
[153] Marsh, (2002), 0:09:57-0:30:25.

transfer a 450°F part to a position for assembly and an article in the Rochester *Democrat and Chronicle* described the three-part task as the removal of a motor armature from an oven, the installation of a commutator ring on the armature, and finally, placement of the assembled parts in a heat cure.[154] The story went on to inform its readers that the local Delco plant planned to "replace a worker" who would be assigned to another job. According to plant manager John Rath, the operation was intended as an experiment to study "ways to integrate Puma with workers so that the robot will function as an aide, working beside a human on the assembly line and operating under the control of the worker." GM officials anticipated no labor issues in response to the PUMA; however, Norbert Stevens, president of International Union of Electrical Workers (IUE) Local 509 that represented the workers, expressed concern about the future of assembly line jobs, "if they decide to go into this robot thing in a big way." Robots, therefore, were expected to be an issue during national contract negotiations that summer, however, as Stevens put it, the "age-old question: does automation displace people or create jobs?" was less pertinent at the moment since "the business climate is good enough that anybody displaced because of this will easily be absorbed into our work force."

The less than satisfying initial results with the first PUMAs were surprising, particularly in relation to assembly applications—the very tasks the Programmable Universal Machine *for Assembly* was designed to revolutionize.[155] While the proximate cause of the "sightless" PUMAs' initial unreliability was most likely a combination of haphazard manufacturing and poor user-training, another factor may have been even more important: brain drain. In September

[154] Management Update, "Assembly Capability: Robots Puts It All Together," Jan. 1979 and Bob Minzesheimer, "Robot on assembly line: Machine will join work force at Rochester's Delco Products in July," *Democrat and Chronicle,* May 31, 1979, 8D in Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002), 54-55. The rest of the paragraph comes from Minzesheimer.
[155] Marsh, (2002), 0:45:33 and 1:09:53.

1979, fourteen months after delivery of the PUMA prototype, Scheinman drafted a rather direct letter to Engelberger, dated September 20, to remind the latter of the royalties Unimation agreed to pay the former at the time of the Vicarm acquisition. Scheinman estimated that Vicarm technology represented 25 percent of the now computerized VAL-programmed Unimate 2000/4000 robots, 40 percent of the PUMA and Unimate Model 250 robots, and 80 percent of individual components such as six-axis force sensors, touch sensors, and force sensing fingers.[156] Another more cordial draft, dated the same day, thanked Engelberger for a gift he sent for the birth of Scheinman and his wife Bonnie's first child, discussed the trouble he was having picking a dissertation topic, and gave a positive update on Unimation West's work. Scheinman closed the letter by declaring "I have been pleased with the agreement we made 2.5 years ago, and I am sure that you have been too" and then provided a short, more considered description of the royalty arrangement.[157] Which version of the letter was sent, if either were sent at all, is unknown.

On January 28, 1980, after drafting the previous letters, Scheinman officially resigned. By that time, he had decided to commit to a thesis topic and finally finish his PhD as well as co-found an upstart firm called Automatix with former executives of Computervision, Inc.—a pioneer in the field of commercializing vision systems—that would serve as a direct competitor to Unimation. According to Scheinman, Engelberger had essentially stifled his creativity and he was looking for new challenges: "I'm working on the future. That's my specialty- to see ahead, and make that a reality. I obviously see things differently than you do or I wouldn't have had so much resistance from you towards VAL on the Unimate, the 250 project, my thesis topic ideas, etc. I can't be constrained in my thoughts and goals." The letter also revealed that Scheinman had

[156] 1979-09-23 12:50 JOE2.[1,VDS], SAILDART.
[157] 1979-09-24 15:18 JOE1.[1,VDS], SAILDART.

been an original investor in Computervision and had bought shares in Condec (Unimation's parent corporation) *before* Engelberger acquired Vicarm. Scheinman also did not miss the opportunity to dig the knife in:

> Condec stock is now about triple what it was when I joined with you exactly three years ago today. Unimation is now a profitable, respected, viable operation with a new product line, a revamped image to existing products, and presents a modern dynamic front to its customers, competitors and suppliers. I confidently say that almost all of this is due to my efforts, in my capacity as General Manager of the West Coast Div. under the terms of the Vicarm purchase agreement, my employment and royalty agreement, and under reasonable extensions of those terms.
>
> Compare my output, effort, and results to your Mikros deal, your new encoder effort, your '79 controller project, your RCA contract, your 6000 project, your Germany operation, and even the reasonably successful Apprentice program, and you will find that there is absolutely no comparison. In fact, compare the results of the West Coast group to any other serious robotics effort by any other company during the last few years and you will also find no comparison. I feel proud of my contribution to Unimation, and to the robotics field in general!
>
> The fact that I did do a dedicated and consientious [sic] job of transferring to Unimation this technology is evidenced by your product line and your balance sheet this year. Shortly, you'll have a significant part of Vicarm technology in everything that goes out your door.

Nonetheless, he concluded, "I do hope that we will be able to keep in touch on an amicable basis in the future."[158] At the moment when they seemingly needed him most, Unimation lost their most valuable asset.

Over the next year, PUMAs across GM were still proving unreliable. Delco Electronics had one PUMA in production palletizing ceramic radio speaker magnets, Rochester Products was scheduled to have one PUMA in production by August (the other four were being tested on applications such as the assembly of a vacuum pipe to the throttle body on a Varajet carburetor

[158] 1980-02-02 11:58 JOE3. [1,VDS], SAILDART.

and the loading and unloading of an inspection station for throttle-body injection (TBI) carburetors), and Delco Products anticipated a single PUMA would be partially assembling wiper-blade motors. Meanwhile, AC Spark Plug was evaluating potential applications for its single PUMA and Packard Electric was evaluating the feasibility of their PUMA to pick up and position wires as well as strip and insert them in a connector.[159] In a November 1980 internal GM memo, Dick Beecher traced this to a combination of workmanship, design, and vendor quality with issues, essentially indicting Unimation, which included the PUMA's ability to automatically switch to failure mode when a problem arose and the device's overall durability as well as calibration, controller, and gear design problems. The goal was to improve the PUMA's reliability to 500 hours mean time between failures or MTBF (Unimate 2000s and 4000s on spot welding lines had four-hundred hours MTBF with 98 percent "up time records") and a user's group of divisional representatives had submitted a list of problems and suggested changes to Unimation during a February meeting. Nine months later, progress was still to be determined and Beecher concluded, "even though there were significant problems early this year, the changes which have been made or are being made will give us the reliability needed to operate successfully in the plants early in 1981."[160]

In January that year, the PUMA's engineering program manager at Unimation Peter F. Rogers informed Walt Cwycyshyn in the Assembly Systems group at MD that the suite of problems had been solved (at least provisionally). Rogers then requested "some direction" from GM on plans to industrialize the PUMA as well as  input on safety and maintenance issues.

[159] PUMA Robots in the Electrical Components Group, n.d., Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002).
[160] Beecher to G. N. Tiberio, PUMA Reliability, Nov. 7, 1980, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002).

Finally, Rogers discussed Unimation's plans to release a vision system, conveyor tracking, and the 250 robot, the latter of which based on Scheinman's MIT arm.[161] From GM's perspective, the letter was most likely not encouraging: why would the world's foremost industrial robot company need direction to industrialize the manufacture of a robot they designed? Furthermore, why would GM give input for a product not related to the PUMA nor intended for GM? Things were not looking good for Unimation.

**The Steel Collar Worker: PUMA in the Press**

The first few years of the PUMA's development proved difficult, however, one domain where GM experienced relative calm was the media. While mention of the PUMA appeared as early as November 1977 in the trade press, GM management didn't internally announce its existence until January 1979.[162] On the 9th of that month, GM held a press conference at the Tech Center to publicly unveil the corporation's robotics work. Demonstrations of the CONSIGHT system and a programmed but visionless PUMA were given while Alex C. Mair, a vice president and head of the Technical Staffs group, lauded GM's contribution to "keeping America in the forefront of industrial technology." Mair made sure to connect technology with productivity and employment growth but also attempted to head off any concerns of mass worker displacement by assuring the assembled media that he didn't anticipate "any sudden, large-scale introduction of robots into GM plants."[163]

[161] Rogers to Cwycyshyn, "PUMA™ Robot Program Status Report," Jan. 31, 1981, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002).
[162] "Putting the Product Together," *American Machinist,* Vol. 121, Iss. 11, Nov. 1977, N-1 and David A. Van Cleave, "One Big Step for 'Assembly in the Sky,'" *Iron Age*, Nov. 28, 1977, 33.
[163] Press Release, Jan. 9, 1979, GM_NR_01091979, GMHC, 1-2.

The PUMA's first planned in-plant applications were the transfer of heated parts for assembly from one location to another, a task surprisingly similar to the Unimate's earliest assignment (dunking heated car door accessories in water) at the Ternstedt plant almost twenty years prior. Management cautioned that other applications divisions could explore would depend on the "trickiest problem" of feeding and orienting parts, what senior project engineer Floyd Holroyd called a "black art." Nevertheless, "In order to move this technology from the lab to the plants," director of MD Frank Daley described, "we must do our development in terms of real world constraints such as cost, speed, size and weight, reliability and maintainability."[164] The PUMA's expected cost (before any add-ons or customization) was under $25,000 and, most importantly, the payback period was estimated at one year on only a single-shift basis—half the time and half the shift of the typical industrial robot investment.[165]

At the Q&A following the demonstrations, a media member asked if the UAW had been involved in the PUMA's development to which John Mollica, director of labor relations for GM, gave a stock-in-trade answer. Rather than simply saying 'No,' Mollica responded: "As far as the acceptance of new technology in plants, we have no problems with any of this, the acceptance of the new technology. We have actually a contractual statement to that effect with the UAW. And I think they recognize, as we do, that the country needs new technology . . . . It increases the quality of the job that we have in our work force. We don't find resistance from the unions on this type of thing."[166] To further assuage concerns, Mair declared, "back in the mid-fifties, there

[164] Management Update, "Assembly Capability: Robots Puts It All Together," Jan. 1979, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002), 54-55 and Press Release, Jan. 9, 1979, GM_NR_01091979, GMHC, 3.
[165] Management Update, "Assembly Capability: Robots Puts It All Together," Jan. 1979, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002), 54-55.
[166] R-156A Q&A following computer-robotic press briefing, Jan. 9, 1979, GMHC, 5.

was a tremendous buzz word around -- automation was going to wipe out the world. It hasn't happened. It isn't going to happen." The assembled media stuck with the issue and Mollica argued that not only was GM's workforce larger than ever but it was also more skilled.[167] Mollica may have been deflecting attention from head of GMR's computer science department Donald E. Hart's comment that "one of the main things it does is [the PUMA] doesn't get tired" and his evasiveness about workers' responses to robotization, Mollica argued that not only was GM's workforce larger than ever but it was also more skilled.[168] That the PUMA was marketed for doing 3D/3H jobs but designed so robots and workers were interchangeable in the system—meaning humans would still be doing these jobs—was a contradiction conveniently elided during the press conference.

The announcement of the PUMA set off a new round of discussions about how labor would respond to robotization and, beyond the incessant comparisons to C-3PO and R2-D2 from *Star Wars*, popular press coverage of the system's effects on workers was relatively bereft of the "mass unemployment" rhetoric of yore.[169] A day after the press conference, an article about the PUMA in the *Detroit Free Press* informed readers that "robot use has been so minimal that it has not been a subject of controversy between the auto industry and the UAW," hence, "the union has not attempted to challenge any new technology, but insists that any displaced workers be retrained for other jobs."[170] Repeating the standard Reutherist position, a story in the *Detroit News* quoted UAW President Douglas Fraser, "if we are going to get high wages and greater fringe benefits we must increase productivity. I believe the major way you increase productivity

[167] R-156A Q&A following computer-robotic press briefing, Jan. 9, 1979, GMHC, 6-9.
[168] R-156A Q&A following computer-robotic press briefing, Jan. 9, 1979, GMHC, 6-9.
[169] Agis Salpukas, "'Alice' Is No R2D2, But Can Replace Man," *Indianapolis Star*, June 10, 1979, 52; "'R2-D2' On Assembly Line, *The Times Recorder* (Zanesville, Ohio), Mar. 04, 1979, 32; and "R2-D2 finds a home in industrial operations," *The Times Herald* (Port Huron, Michigan), Mar. 01, 1979, 19.
[170] Gregory Skwra, "Now GM is 'downsizing' robots," *Detroit Free Press*, Jan. 10, 1979, 49.

is with technology." The article closed with a quotation from a different UAW official who, nevertheless, clarified that "we are always worried about displacement of workers."[171] Reinvoking the tried-and-true trope of robots as the "perfect" worker, *Associated Press* writer Michael L. Graczyk, opined that robots "don't take coffee breaks or demand vacations. They generally don't get sick. And they are not inclined to file union grievances."[172] A *New York Times* write-up on the PUMA in May ascribed much more agency and power to the UAW than it deserved, noting that the union "traditionally has *allowed* automation and technical innovation if they meant the elimination of hazardous or arduous jobs or increases in productivity."[173] By July, the *Detroit News* revisited the PUMA and claimed that its sophistication and ability to handle 90 percent of auto parts worried the UAW, which were now looking to include more specific language about technology in their upcoming collective bargaining agreements. "Union staff members," the article noted, "say they fear that the company will use robot technology as an excuse to eliminate more workers than those who are replaced by the machines." However, according to UAW vice president Irving Bluestone, technological advances were inevitable and, echoing Walter Reuther's 1958 Congressional testimony observation about King Canute and the inexorable progress of technology, "We can't turn back the tide." Rather, attrition, the establishment of protections against wholesale layoffs, and retraining at management expense were necessary adjuncts of robotization.[174]

While early coverage of the PUMA in the popular press tended to parrot the talking points of GM engineers and executives, the business and trade press provided more context

[171] "Blue Collar Robots," *Detroit News*, Jan. 14, 1979, 2E.
[172] Michael L. Graczyk, "Assembly-line robots gain industrial favor," *Lafayette Journal and Courier* (Lafayette, Indiana), Mar. 01, 1979- 29, D-1 and Michael L. Graczyk, "These Workers Are Mechanical In Their Jobs," *Cincinnati Enquirer*, Mar. 02, 1979, B-7.
[173] Agis Salpukas, "Robots May Soon Do Assembly-Line Jobs," *New York Times*, May 29, 1979, C2 (emphasis added).
[174] "Robots trigger UAW worries," *Detroit News*, July 5, 1979, 8-A.

while also oscillating back-and-forth between the promises and perils of "second generation" robotization. On March 26, 1979, *Business Week* declared, "UAW fears automation again" and warned that "History repeats: the job loss scare of the 1950s returns to autos." According to their sources, robot advancements like the PUMA, "designed to substitute for assembly line workers, roughly one-for-one," were "almost irresistibly affordable" and would divide workers into very low-skilled and very high-skilled categories, essentially wiping out the intermediate-skilled range "vital for a sense of upward mobility." However, as LeRoy H. Lindgren, director of consulting firm Rath & Strong Inc., put it, "You can't stop GM from automating. That's what they're good at."[175] In a different vein, the May issue of *Management Review*—after opening with a brief discussion of Karl Capek's *R. U. R.* and detailing the basic functionality of the PUMA—noted that only in the past two years had industry expressed serious interest in the industrial robot, which demonstrated a "cautious acceptance" driven by financial conservatism and a lack of government incentives for investing in robots. Additionally, the labor problems accompanying the Lordstown experiment, which Engelberger told *Management Review* was the fault of "hard automation . . . . that did not work when the plant opened," had soured management on the potential of robotization.[176]

Similarly, an article in the July edition of *Management Today*—which began with a discussion of the "dread" the word 'robot' conjured up in the modern mind and the superfluity of human labor the concept of "soft automation" implied—provided an economically rooted analysis of the contemporary industrial robot industry. When the first Unimate was unveiled in 1961, the average pay of an autoworker equaled $3.81 an hour; almost twenty years later that

[175] "UAW Fears automation again," *Business Week*, Mar. 26, 1979, 94-95.
[176] Carl Remick, "Robots- New Faces on the Production Line Remick," *Management Review*, Vol. 68, Iss. 5, May 1, 1979, 24.

number had almost quadrupled to $14.50 an hour. During the same period, the robot's cost was 25 percent hydro-mechanical and 75 percent electronic; however, with the advent of microchips, that ratio was reversed, leading to a dramatic decrease in relative cost of robotic versus human labor. As Thackray assessed, "the implications of greater blue-collar affluence have helped the robots to gain a toehold in the world." Additionally, according to Engelberger, who was quoted extensively in the piece, the introduction of machines that would do the 3D/3H jobs changed the very sociotechnical composition of work for the humans laboring next to their robot companions: "The guy looking after five robots becomes a boss . . . . The robot allows work to become less structured. The worker trained to take care of them might, on a particular morning, read a paperback; or he might be very busy programming one machine, servicing another, and so on." Furthermore, in Engelberger's estimation, most American manufacturing was "an essentially irrational hodge-podge" that eschewed a "total systems approach," breeding inefficiency and myopia cultivated by the manufacturing engineer's natural conservatism and hesitance to make the necessary large capital expenditures. While the PUMA would presumably help loosen this logjam, Thackray cautioned that a breakthrough was still years away.[177]

A month later in August, *Production* magazine foregrounded the long gestation of the PUMA's development at Stanford and GM and more sanguinely predicted that it "holds the promise of making robot technology economically applicable in light, batch manufacturing where dedicated automation cannot be applied and where more expensive, less flexible robots historically have failed rigorous return on investment analysis." By that point a score of corporations including 3M, GE, and RCA were installing PUMAs for jobs like packaging, parts handling, and machine loading, with more than fifty orders from other firms outstanding at

[177] John Thackray, "The Robots of America," *Management Today*, July 1979.

Unimation.[178] Shortly after the GM-UAW collective bargaining agreement was signed that summer, *Barron's* noted that labor costs would rise from $15 to $20 an hour through the life of the contract—in their estimation the most generous and most inflationary contract since 1948—and only a "massive increase in automation, accompanied by a virtual freeze in manpower, could make the numbers add up." According to Paine Webber analyst Ron Glantz, who was quoted in the piece, "a couple of thousand of Puma robots, at $10,000 apiece, would justify it," however, there was no possible way Unimation could meet such demand over the next three years.[179] By the end of the year, Gene Bylinsky in *Fortune* magazine juxtaposed the pie-in-the-sky prognostications of the National Bureau of Standards' James Albus of "robots making robots" and corresponding labor rates dropping to "pennies an hour" with Engelberger's more measured conclusion that robots would replace less than 5 percent of the "Western world's blue-collar work force by the end of this century." As Bylinsky concluded, "G.M. foresees hundreds, if not thousands, of Pumas working on its assembly lines, *presuming the small robot works out as well as expected*. But most of the jobs would still be performed by people."[180]

Essentially the only full-throated critic of the PUMA to receive any press coverage came from Harley Shaiken, a former machinist in the auto industry and then a professor at MIT in the Science, Technology, and Society program who also consulted for the UAW. In a September 1979 article published by *In These Times,* Shaiken observed that much of the work the PUMA was marketed as doing, like the assembly of an instrument panel, was "hardly a hazardous or

[178] Thomas J. Drozda, "PUMA: Robots Find Cost Effective Jobs in Batch Manufacturing, *Production,* Aug. 1979. According to the article, Chesebrough Pond's Inc.—who Rosen and colleague David Nitzan had visited in November 1975 to determine if the company's automation needs could be met by SRI's advanced automation program—had apparently already purchased a PUMA and was planning to program it to unload cocoa butter bottles from a processing line before GM even began its first tests at, according to Drozda source(s), the Delco Electronics plant in Kokomo, IN, Rosen to Davis, Nov. 20, 1975, Correspondence Binder, Box 9, CARP.
[179] Michael Brody, "Pacesetting Contract- What's Good for General Motors May Not Be Good for the Country," *Barron's National Business and Financial Weekly*, Sept. 24, 1979, 9.
[180] Gene Bylinsky, "Those Smart Young Robots on the Production Line," *Fortune*, Dec. 17, 1979, emphasis added.

undesirable job." Quoting a *Production* magazine article's declaration that "whenever you have a production machine that is 'operator-paced' you have an opportunity for improvement," he noted that these operators were the targets of robots such as the PUMA. Beyond the threat of operators being replaced one-for-one, the PUMA system also raised the "frightening possibility of workers paced by mechanical arms on each side [which would] be programmed by distant engineers, not by workers in the shops with current robots. If a robot malfunctions, a human worker could be 'inserted' in its place to do a job designed and paced for a robot." Furthermore, GM engineers had made clear that the retention of humans in the PUMA system was a stop-gap measure until robots with tactile and vision systems "were perfected and economically feasible."[181] In a November 1979 *New York Times* article on advanced automation that alluded to (but didn't directly name) the PUMA, Shaiken was quoted as describing the transfer of work from human to machine as "technological scabbing." Shaiken's MIT colleague David Noble—who was then in the midst of research on would become his path-breaking book *Forces of Production: A Social History of Industrial Automation*—was also quoted in the article arguing that computer-linked machines could simultaneously control the pace of work and surveil workers and warned, "we talked about automation 20 years ago . . . . Now it's here."[182]

The exchanges between Engelberger and Shaiken starkly reveal how the supposed socioeconomic effects of introducing robots into production were almost entirely a product of politics rather than technology. In the June 9, 1980 *Business Week* article mentioned above, Shaiken warned that unions were underestimating the impacts of robotization and charged its advocates with keeping "two sets of books." As he explained it, "when they attempt to justify a

[181] David Moberg, "The Computer Factory and the Robot Worker," *In These Times*, September 19-25, 1979, 13.
[182] William Serrin, "New Auto Industry Technology A Source of Wonder and Anxiety," *New York Times*, Nov. 5, 1979.

robot, then they eliminate every worker in sight"; however, "when they talk social implications, no workers are replaced. They can't have it both ways."[183] No better example of this would come than when Shaiken was invited that July to appear on an episode of *PBS NewsHour* with Engelberger to discuss the sociological dimensions of robotization. After forecasting that approximately four million blue-collar workers would be displaced by robots in the United States and Western Europe combined by 1990, Engelberger was asked about the consequences and answered, "Of course, you do put people out of work. But when you increase productivity, you have to decide 'what do I do with the benefit? Could it be the 20 hour work week? Yes. Could I use the extra money to clean up all the air and the water in the United States? Yes.' Could you recognize possibly that the very existence of a robot could be creating new industries?" Shaiken, in response, argued that, according to his more conservative numbers, 100,000 autoworkers in the US alone could lose their jobs. One reason why was because discussion of how many robots were produced per year elided the cumulative nature of the robot population—as he highlighted, "a robot that goes to work next year will still be working in 1990." He made sure, however, to foreground that "I'm not an opponent of robots. And I think that they can, in fact, improve the quality of working life. But we're seeing what is a major technical break-through being used in a way that could create social problems."[184]

To prove his point, Shaiken gave an overview of the PUMA as an example of how this manifested on the shopfloor and alluded to the fact that "GM has said that it will be programmed not by workers on the line, but at Central Time and Method Laboratories [sic]. In a sense, it's a time study person's dream."[185] Engelberger followed by agreeing with Shaiken's numbers and

[183] "Robots Join the Labor Force," *Business Week*, June 9, 1980, 63.
[184] *PBS NewsHour*, MacNeil/Lehrer Productions, July 29, 1980.
[185] To my knowledge, GM did not have a "Central Time and Method Laboratories" and I'm assuming Shaiken was referring to the General Motors Research Laboratories at the Tech Center in Warren, MI.

gave a muddled response, “I didn’t say they [autoworkers] would lose their jobs. They wouldn’t lose their jobs”; however, seemingly shifting the domain of analysis from autoworkers specifically to productivity more generally, he continued, “You must have people lose jobs to get an economic benefit. The question is, at that particular moment, what other pressures are on our economy that would maybe lose as many jobs as the automobile industry has lost just recently? If we’re not going to become more productive, then we`re not going to have any of those jobs in this country.” And interestingly, when Shaiken later argued that displacement of workers without job alternatives would create an enormous social cost that society would have to pay, Engelberger once again agreed with him and declared that “I don’t believe we should pay any social penalty at all for robotics or automation. I think our economy and our culture is too far advanced for that.” In the latter’s estimation, job enrichment through “unstructured” work—exemplified by a worker who would manage multiple robots at a time “who’s sort of an overseer”—and contract bargaining over the pace of work (i.e., production standards) would solve the problem of labor degradation. Engelberger, however, was silent on the issue of job alternatives for those displaced.[186]

A little over two months later in September 1980, Shaiken published an op-ed in the *New York Times* that reiterated the arguments he made during the *PBS NewsHour* debate and briefly expanded his analysis of the PUMA. Foregrounding the interchangeability of human and robot in the system and the fact that it was designed to complete “the more desirable production tasks,” Shaiken claimed the PUMA “may be the most complete integration of worker and machine since the automatic lunch feeder in Charlie Chaplin's ‘Modern Times.’” For example, if a worker on a dashboard assembly line had a daily quota of eighty units, they could choose to work faster in the

[186] *PBS NewsHour*.

morning and produce fifty units while working slower in the afternoon to produce the remaining thirty. “In eliminating this control,” Shaiken argued, “PUMA shuts off the worker's creativity and initiative - a critical productivity loss that is not measured.” Additionally, the continued rapid introduction of new technology such as robots would not alone solve economic problems and promises that economic growth would create enough jobs for the displaced were growing increasingly hollow as the spread of labor-saving technology became pervasive. As he closed”:

> Such a socially destructive use of technology need not be inevitable. Jobs for workers displaced and improved working conditions for those who remain ought to be a condition for the introduction of robots. Productivity gains, for example, could translate into a shorter work week at the same pay rather than into fewer jobs. Technology could be designed to enhance human skill and experience rather than make people “interchangeable”" with machines. Realistically, these alternatives require worker-union participation in the design and deployment of technology.[187]

That same month, Engelberger was confidently quoted in Ferguson’s “steel collar workers” article stating, “with millions of workers, there’s not much chance of [robots] having any effect on the work force.”[188] By the end of 1980, general manager of Unimation Stanley Polcyn contradicted his boss’s claim and essentially confirmed Shaiken’s concerns when he told *American Machinist*, “the real problem is we’re looking to wipe out the unskilled jobs, and, if we don’t recognize that fact, we’re aiming for severe social upheaval.”[189]

**Conclusion: The Factory of the (Still Distant) Future**

[187] Harley Shaiken, “A Robot Is After Your Job,” *New York Times,* Sept. 3, 1980, A19.
[188] Fred Ferguson, “Robots- The steel-collar workers,” *Cincinnati Post,* Sept. 20, 1980, 8.
[189] “Robotics has turned the corner, says Polcyn,” *American Machinist,* Vol. 124, Iss. 12, Dec. 1980, 81.

Press coverage of the PUMA, and the PBS debate in particular, were notable for what they revealed about historical change and historical continuity in relation to the automation discourse over the previous generation. From the perspective of those sympathetic to labor, workers' control of production was still key to humane work, more job security, and higher wages. From the managerial perspective, their continued control of production was still key to competitiveness, market share, and economic growth—all of which would purportedly solve the social problems with which labor was concerned with. Unlike the automation discourse of decades past, the fear of mass displacement and widespread unemployment due to technology had been itself displaced by a more robust, though still wanting, discussion of technological unemployment and work conditions.

If press coverage is an indicator, the average American worker continued to have little to no idea their tax dollars were funding the degradation of their work and displacement from their jobs as, once again, discussion of the political economy of the 'military industrial robot complex' and supply-side technoliberalism were nonexistent. While exact numbers are difficult to pin down, SAIL received at least $20 million (twice the nominal amount of its combined budget during the 1960s) from ARPA alone over the period Scheinman was working on the Stanford Arm and its derivatives, while Rosen and SRI received hundreds of thousands (perhaps in the millions) from NSF over the five-year life of the Programmable Automation project.[190] Additionally, Unimation continued to exist under the Condec umbrella that included Engelberger's defense-dependent Consolidated Controls Corporation, which continued to positively contribute to the conglomerate's balance sheet. Furthermore, GM booked more than a

[190] Like Scheinman, Rosen incorporated his own spinoff, Machine Intelligence Corporation, to capitalize on SRI's computer vision work. The nascent startup hired a number of former and present SAIL members as advisors and consultants, and targeted GM and the PUMA as potentially their most lucrative market."II. Profile of Machine Intelligence Corp.," July 23, 1979, No Folder, Box 2, Charles A. Rosen Papers, Stanford, 3-4 and 13, SUSC.

half-a-billion dollars in "defense and space" sales in 1979, the same year the PUMA went into production.[191] Nevertheless, while the technological advancements these funds paid for were impressive, the industrial robot's imagined capacities for transforming the world of manufacturing into a vast archipelago of workerless factories remained just that, a dream.

For GM, their early difficulties with the PUMA did little to slow their commitment to robotics as the 1980s began. From 1974 to 1978, GM went from having 127 robots installed across the corporation to 155; in 1980 that number had almost tripled to 425. By late 1980, GM established a "Robotics Council" that brought together corporate staffers and representatives from various divisions to coordinate R&D programs with universities and robot manufacturers. That same year, GM registered a $762.5 million write down, the corporation's first operating loss in almost sixty years, making the need to reduce labor costs even more imperative.[192] Two years later, in 1982, more than one thousand robots were installed and almost two thousand more were on order.[193] When combined with other forms of "high-technology automation," such as the Italian-developed 'Robogate' system, labor costs were estimated to drop by as much as $14 per hour, a whopping 70 percent decline. By 1990, GM expected to invest almost $1 billion on more than 13,000 robots with 9,000 of these being PUMAs. The American industrial robot industry's prospects were looking rosier than ever. Any ebullience, however, would be short-lived.

[191] General Motors, *Annual Report* (1979), 1.
[192] General Motors, *Annual Report* (1980), 1.
[193] Public Affairs Newsletter, "Narrowing the Productivity Advantage," Apr. 1982, and "GM Robot Population," Jan. 26, 1988, Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002).

## Epilogue — The Other Arms Race and the Fall of Unimation

*Politicians have to decide that quality of life is a worthy goal. You have to deal with our president who thinks, terrible as it is, that it is a worthy goal to get a bigger weapons base. I mean, I may not agree with him but it sure spins the money.*

Joseph F. Engelberger (1983)[1]

The 1970s proved a pivotal decade for the United States economy, both domestically and globally. While the broader trend of trading factories for finance was gaining momentum, the manufacturing sector's contribution to the economy, in real rather than nominal terms, remained steady. Employment trends in the sector also continued apace as manufacturing's share of employment continued its precipitous, and seemingly permanent, decline. The postwar high of approximately 32 percent in the early 1950s decreased steadily to twenty-two percent in the late 1970s, a drop of almost a one-third. American factories, therefore, were producing more goods with fewer workers and automation was seemingly working, just not in financial terms.[2] Productivity growth was declining, inflation was increasing, profit margins were falling, and international competition was growing, all of which put the squeeze on the global economic dominance the US had enjoyed since the end of the Second World War.

[1] John Bell, "We'll have robots like ladies have hats," *New Scientist* (February 24, 1983), 528.

[2] Judith Stein, *Pivotal Decade: How the United States Traded Factories for Finance in the Seventies* (Yale University Press, 2010) and YiLi Chien and Paul Morris, "Is U.S. Manufacturing Really Declining?," Federal Reserve Bank of St. Louis (April 11, 2017), https://www.stlouisfed.org/on-the-economy/2017/april/us-manufacturing-really-declining/.

The decade was also pivotal for the industrial robot. Experiments on the line and in the lab generated a number of failures and successes that expanded the bounds and exposed the limits of what the technology could and could not do in the real world of manufacturing. The number of industrial robots operating on factory floors increased by an order of magnitude from approximately three hundred at the beginning of the decade to three thousand at its turn. Such an increase, however, was relatively paltry in the grand scheme of things. As early as the 1960s, it had become increasingly clear to the industrial robot industry that the American business community's inherent conservatism, the industrial robot's impressive yet still slow technical development, and the relative cheapness of human labor was jeopardizing the industry's viability.

To continue the industry's growth and search for its first profits, Unimation and American Machine & Foundry (AMF) began to exploit markets abroad. Little did they know that their quest for short-term profitability abroad would sow the seeds of the industry's destruction at home. The first international license and sales agreement of an industrial robot was granted by Unimation to Guest, Keen, Nettlefolds Ltd. (GKN), then one of the UK's largest industrial firms, in 1965 and over the next decade the British firm handled sales in Sweden, Switzerland, and West Germany.[3] Additionally, Unimation eventually transnationalized the European industrial robot industry when in 1972 the firm became the North American distributor for the largest industrial robot companies in Norway (Trallfa) and Sweden (A.B. Electrolux).[4] That same year, the most extensive attempt to use industrial robots in Europe began when managers at Fiat's

[3] Brochure, "Unimation: A Major Breakthrough In Industrial Automation," Folder - Consolidated Controls Corp., 1960-1962, Box 3, George Devol Jr. Records, Benson Ford Research Center. Apparently, GKN dropped the Unimate license in 1969 and all of the personnel involved transferred to a Unimation subsidiary which from then on handled British and European sales (Ricardo Zermeno-Gonzalez, "The Development and Diffusion of Industrial Robots," Ph.D. Thesis, University of Aston, Birmingham (September 1980), 124).
[4] CONDEC, *Annual Reports* (1966-1977).

Mirafiori plant outside of Turin in northwest Italy bought eighteen Unimates for the final stage body welding of the Fiat 132. Similar to GM's experience at Lordstown, labor problems motivated Fiat's decision to robotize and managers also encountered a significant amount of trouble getting the Unimates to work efficiently.[5] Nonetheless, Fiat moved forward with its robotization plans, and in 1976, pioneered the Robogate system at the Cassino and Rivalta plants that essentially functioned like an advanced version of Lordstown's welding subassembly station.[6] Robogate eventually made its way across the Atlantic and was installed as early as 1979 at Chrysler's now closed Belvidere plant outside of Rockford, Illinois before spreading more broadly throughout the American auto industry.[7]

By far the largest and most important market, however, was in Japan. In May 1966, AMF's Japanese subsidiary showed a film of the Versatran to executives of the Tokyo Machine Trading Company who, shortly thereafter, passed it on to other Japanese firms in an effort to stimulate interest in the device. Later that year the Japanese government, apparently impressed with Unimation's big sale to GM for the Lordstown installation, invited Engelberger to give a talk on industrial robots to a large group of businessmen in Tokyo. As Engelberger recalled, "at the time in the United States, I had trouble getting 6-10 people to listen to me about what I wanted to do, but when I got to Japan, they had a conference with 400 executives wanting to hear about robotics."[8] The following November, the first operational demonstration of a Versatran

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[5] Giuliano Maielli, "Managerial Culture and Company Survival: Technological Change and Output-mix Optimisation at Fiat, 1960-1987," PhD Dissertation, London School of Economics (2003), 143-147 and K. Shimokawa, U. Jiirgens, and T. Fujimoto (eds.), *Transforming Automobile Assembly: Experience in Automation and Work Organization* (Springer, 1997), 26.

[6] Giuliano Maielli, "Spot-Welding Technology and the Development of Robotics at Fiat, 1972-87- A Case of Managerial Discontinuity," *Business History*, Vol.47, No. 1 (January 2005), 102-121

[7] "Automation faces union at auto 'turkey farm'," *Detroit Free Press* (July 22, 1979), 17 and Carl H. A. Dassbach, "Industrial Robots in the American Automobile Industry," *Critical Sociology*, Vol. 13, Iss. 4 (July 1986), 56-57.

[8] Patrick Wauryzniak, "Masters of Manufacturing: Joseph F. Engelberger," Manufacturing Engineering, Vol. 137, Iss. 1, (Jul 2006), 66.

took place in Tokyo and, less than a week later, the first industrial robot for commercial use in Japan was installed in a textile plant by the parent firm of the Toyota Automobile Group.[9]

While AMF was the first mover in the Japanese industrial robot market, their position proved temporary and tenuous. John M. "Mac" Sutherland, product manager of the Versatran, accused the Japanese of copying "right down to the last nut and bolt" the machines AMF had previously sold to them, while an "American executive at another firm indicated that 'cocktail gossip' suggested that AMF had been too demanding in the conditions it proposed for the export of technology."[10] However, according to Gensuke Okada—an employee of Kawasaki Heavy Industries responsible for new project development who visited the U.S. prior to signing any official agreement to license an industrial robot—his AMF liaisons were arrogant, ill-mannered, and interested "only in making money."[11] On the other hand, Okada's meeting at Unimation went much smoother. As he described it:

> Joe Engelberger had his office in a trailer house in the woods, and he turned out to be a very interesting character with whom I had many discussions. I told him the Unimate looked much superior to the Versatran, but he asked me why I thought any robot could sell in Japan. I told him it is because we do not have slaves. No offense intended, but I had seen how many American companies would take people off the street and put them

[9] Robert U. Ayres, Leonard Lynn, and Steven Miller, "Technology Transfer in Robotics: US/Japan," Technical Report, Engineering and Public Policy, Carnegie Mellon University (October 13, 1981), 19-20. Fleck and White state that the first industrial robot was installed in a Nissan plant, but do not provide a source (James Fleck and Barry White, "National Policies and Patterns of Robot Diffusion/ United Kingdom, Japan, Sweden and the United States," *Robotics*, Vol. 3 (1987), Table 3, 16). It is possible that industrial robots were used as early as 1963 in Japan, however, John Snyder of USI who oversaw the installation at a Nissan plant, described the operation as using "TransfeRobot-type machines," which may have referred to a wide range of USI's automation machinery, *Amendments of Manpower Development and Training Act of 1962*, Report No. 861, House of Representatives (1963), 694.

[10] "Robots Take Bigger Stride" *Business Week*, April 4, 1970 and Robert U. Ayres, Leonard Lynn, and Steven Miller, 24. According to Ayres, Lynn, and Miller, the Japanese were routinely accused by their American and European counterparts of (illegally) copying foreign technology, so AMF's complaint on this point may have been valid.

[11] Quoted in Frederik L. Schodt, *Inside the Robot Kingdom: Japan, Mechatronics, and the Coming Robotopia* (Kodansha International, Ltd., 1988), 112-113.

> to work at the most menial, backbreaking jobs with no future. He understood what I meant, and after a few nights of discussion, and a few drinks, he liked my proposal.[12]

In 1968, Kawasaki Heavy Industries finalized a ten-year agreement that gave it the rights to Unimation's patents, schematics, tooling, and trademarks while Kawasaki would market robots in the "Far East" and send teams of its employees to Unimation for about eighteen months of training. In return, Unimation received an initial payment of $130,000, a 5 percent royalty on sales, exclusive rights to technology developed at Kawasaki, and crucial (nay, dominant) market share in the largest and most powerful economy in Asia.[13]

Production of the first industrial robots by Kawasaki proceeded in three successive stages: first, American-made Unimates were imported from the United States; second, American-made parts were shipped to Japan and then assembled; and third, Unimates were domestically manufactured with Japanese-made parts.[14] The first Kawasaki-Unimate came off the production line in 1969.[15] By the middle of 1970, Engelberger notified M. Yoshida, general manager of the Akashi Machinery Division that handled the Unimate project, "it is essential that we find means for reducing the cost of the Unimate in order to keep our market rolling." To accomplish this, Engelberger continued, "one of our greatest hopes is that Kawasaki will be able to produce quantities of key components [for Unimates assembled in the United States] at important savings over U.S. manufacture[ers]." Perhaps in an effort to incentivize such a relationship, Engelberger offered "in your development effort it might be wise to occasionally send sketches of what you contemplate doing...[as] we may very well be able to make a

[12] Schodt, 113.
[13] Ayres, Lynn, and Miller, 23-24 and Schodt, 113.
[14] M. Yoshida to J. F. Engelberger, April 16, 1970, Folder - Robotics - Correspondence, 1960s, Box 2, GDJR, 1.
[15] "Half a century of Kawasaki Robotics: The Kawasaki Robot Story, 1968-2018," Robot Division, Precision Machinery & Robot Company, Kawasaki Heavy Industries, Ltd. (n.d.), 8.

contribution by virtue of our developmental history and similar R & D." Furthermore, as he put it, "please be assured we would be very happy to find Kawasaki's design superior, thereby relieving some of our engineering workload."[16] In other words, Unimate would offshore the production of parts to Japan while maintaining on-shore production (or acquisition from a foreign licensee) of technical expertise.

Over the next five years, the infancy of the Japanese industrial robot industry looked much like its American progenitor during the same phase—slow but promising. The primary factor influencing the diffusion of industrial robots in the country according to then (1983) executive director of the Japan Industrial Robot Association (JIRA) Kanji Yonemoto was a serious labor shortage in the late 1960s. This was particularly acute in terms of skilled labor and exacerbated by the fact that more and more young people were pursuing higher education rather than directly entering the workforce.[17] Engelberger's assessment was broader and, in his typical fashion, blunter: "First of all, there was RoboBoy in their television, it had been on for a long time. They had no unemployment. They did not like guest workers. They didn't want to bring foreign help in, so the robot comes along and they saw it as a way to improve their manufacturing skills."[18] What both Yonemoto and Engelberger failed to mention were the social modalities of the Japanese political economy—lesser focus on short-term profits and greater focus on efficiency as well as more job security and more production input for workers—that, for all intents and purposes, guaranteed employment that limited the displacement potential of introducing "labor-saving" technology.

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[16] J. F. Engelberger to M. Yoshida, April 28, 1970, Folder - Robotics - Correspondence, 1960s, Box 2, GDJR, 1-3.
[17] Kanji Yonemoto, "Japan's robot industry: Where does the future lie?," *Decade of Robotics: Special Tenth Anniversary issue of The Industrial Robot magazine* (1983), 109.
[18] Wauryzniak, 72.

One other crucial reason for the industrial robot's success in Japan beyond structural and cultural factors was that domestic manufacturers, users, and the Japanese state joined forces to nurture the technology's uptake and spur the industry's commercial development. In 1971, the Industrial Robot Conversazione, a voluntary organization of Japanese industrial robot developers and manufacturers, became the world's first robot association. The Conversazione was reorganized into JIRA in October 1972 and formally incorporated a year later under the guidance of the Ministry of International Trade and Industry (MITI), Japan's state-level bureaucracy tasked with crafting industrial policy and managing industrial development.[19]

By the 1970s, MITI designated the industrial robot industry as a strategic component within the architecture of the "knowledge-intensive industrial structure" it intended to nurture.[20] The National Diet also passed a variety of laws during the decade to spur investment in production technology such as robots through a special supplemental depreciation allowances that, when combined with other accelerated depreciation allowances, made it possible to write off over half the cost of an industrial robot in its first year.[21] Furthermore, in 1980, the Japanese Robot Leasing Company (JAROL) was established through the cooperation of twenty-four industrial robot manufacturers, ten insurance companies, the state-owned Japan Development Bank, the Long-Term Credit Bank, and the Industrial Bank of Japan, which together provided low-interest loans to mostly small and medium-size firms for defraying the costs of introducing

[19] James Fleck and Barry White, "National Policies and Patterns of Robot Diffusion/ United Kingdom, Japan, Sweden and the United States," *Robotics*, Vol. 3 (1987), 8.
[20] Chalmers Johnson, *MITI and the Japanese Miracle The Growth of Industrial Policy, 1925-1975* (Stanford University Press, 1982), 70.
[21] Kenneth Flamm, "International Differences in Industrial Robot Use: Trends, Puzzles, and Possible Implications for Developing Countries," Discussion Paper prepared for The World Bank, Report No. DRD185, The Brookings Institutions (July 1986), 46.

industrial robots into their production environments.[22] When the Japanese government's support for education, research, and training in engineering, science, and technology are factored in, the perception by foreigners of massive state support for robotics in Japan was hard to deny.

Like their American cousins, the vast majority of Japanese industrial robots were employed in the auto industry, which at the time of their initial introduction was already proving a nimble competitor to the Big Three. At Nissan, the largest user of Kawaski-Unimates, robots for spot welding increased from 50 in 1975 to 540 in 1980.[23] The diffusion of Japanese industrial robots to other industries, however, was much more rapid than in the United States. By 1981, however, the electrical machinery manufacturing industry (32%) had overtaken the automobile industry (30%) as the largest sectoral user of industrial robots. In 1975, only about two hundred Japanese industrial robots had been sold in Japan (almost the same number over the same period in the United States) and five years later that number had increased (at the most conservative end) by almost forty-fold, with ten times that in operation on the island.[24] The US in contrast had about one-third of the Japanese industrial robots in operation as the 1970s turned into the 1980s, with the Japanese total equating to more than one-half of the world's installed units.[25] In 1980,

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[22] Oded Shenkar, "Macro Variables and Technological Change: The Diffusion of Industrial Robots in Japan and the United States," *Journal of High Technology Management Research*, Vol. 3, No. 2 (1992), 203.

[23] Michael A. Cusumano, *The Japanese Auto Industry: Technology at Nissan and Management at Toyota* (Harvard University Press, 1985), 229.

[24] Eikonix (1979), 54-55 in Kenneth Flamm, "International Differences in Industrial Robot Use Trends, Puzzles, and Possible Implications for Developing Countries," Discussion Paper prepared for the World Bank, Brookings Institution (July 1986), 15 and 20a, and Paul H. Aron, "Robots Revisited: One Year Later," Paul Aron Report (#25), Daiwa Securities America Inc. (July 28, 1981) in *Japanese and American Economic Policies and U.S. Productivity*, Hearings before the Subcommittee on Monetary and Fiscal Policy, 1981, 220-223. It's worth mentioning that American and Japanese classifications/definitions of what an "industrial robot" was differed significantly. This caused a considerable amount of confusion in the late 1970s and early 1980s when making comparisons between the two industries as the Japanese definition was much wider which (from the American perspective) inflated their production and usage statistics.

[25] Flamm 20a, and Aron, "Robotics in Japan," Paul Aron Reports (#22), Daiwa Securities America Inc. (July 3, 1980), 1.

when The Vapors thought they were "Turning Japanese," it was the industrial robot industry that really did so.[26]

By the turn of the decade, competition from Japan became an outsized problem for American business as "Japan Inc."—a moniker used in the US to describe the synergy of Japanese corporations and the Japanese state in driving the country's international commercial success—became not just a dominant force in the global economy, but an increasingly visible interloper in the American domestic market. While lower labor costs and MITI's "unfair" industrial policies were often identified as significant drivers of Japan Inc.'s success, the rapid uptake of automation was also routinely invoked as the signal advantage Japanese manufacturers had over their American counterparts. For George Devol, the Japanese state had stacked the deck in Japanese manufacturers' favor, and corporate America's inability to tackle the high-tech problems of production was a lack of equivalent support from the American state. The problem according to Devol, however, ran much deeper: "In Japan, companies can do a lot of things that we can't do—that's what it amounts to." Furthermore, the Japanese "don't have the same problem with stockholders and the bottom line that we do in this country," a reality that was exacerbated by the legal structure of the US, which essentially guaranteed that the quest for short term gains would take precedence over patient long-term investment.[27] As Devol lamented, "the nation's economy is being run by bookkeepers."[28] The political economy of American capitalism, not Japan Inc., therefore, was the real problem.

Whether they agreed with Devol's assesment of the American political economy, commentators quickly conceptualized Japan's commercial capacity as having the potential to

[26] The Vapors, "Turning Japanese," Track #2 on *New Clear Days*, United Artists, 1980, Vinyl.
[27] Jerry W. Saveriano, "An Interview with George Devol," *Robotics Age* (Nov./Dec. 1981), 26-27.
[28] George Devol, "The Future of Robotics," Folder - Devol Personal - Writings, 1945-2008, Box 1, GDJR, 1.

erode the U.S. "industrial base"—a polite synonym for the military-industrial complex. As a result, Japan Inc. was easily framed as a threat to national security, and businessmen, government officials, and intellectuals transformed the discourse of competitiveness into 'Japanic Inc.' Robots, not surprisingly, were a powerful totem of this phenomenon, and the fact that the Japanese were essentially using "American" technology (and using it more efficiently) became a major sticking point of 'Japanic Inc.' In June 1980, Congress held hearings to discuss what had caused, and what would be done about, America's purported lack of economic competitiveness. Assistant Secretary for Productivity, Technology and Innovation at the Department of Commerce Jordan J. Baruch referenced Engelberger directly in his mention of Fiat's use of industrial robots in Italy and Unimation's joint venture with Kawasaki.[29] William Rapp—ironically, the *Toyota* Professor of Business at Columbia University—in mentioning Unimation's development of robotics stated, "the technology all comes from here. [The Japanese] are improving on it to a certain degree, but basically it is *our* technology."[30]

Who exactly the "our" referred to was not specified, but Rapp's conceptualization of technology invented in the US and funded by the NSS in collective ownership terms is worth highlighting. Similarly, Marvin Cetron—futurist, founder of Forecasting International, Ltd., and "advisor to the White House for every administration from the Kennedy administration through the Clinton years" when discussing the importance of productivity in returning the U.S. economy to prominence—made sure to inform congressional representatives that "one of the reasons

[29] *Technology Trade*, Joint Hearing before the Committee on Science and Technology, House of Representatives, 1980, 240.
[30] *Technology Trade*, Joint Hearing before the Committee on Science and Technology, House of Representatives, 1980, 417 (emphases added).

Japan has been well ahead of us in many areas is *because* they are working toward robotics."[31] Beyond simply referencing the role of robotics in juicing Japanese productivity, however, Cetron also put the stakes of competitiveness (and the government's role in supporting this), in stark zero-sum type terms: "I would like to see anything that is used for increased productivity written off as well. I realize that lays people off, but if we are going to compete overseas we are going to have to do that. We have got to go toward robotic factories."[32] In other words, more supply-side technoliberalism was necessary to beat the Japanese at their own game.

Two years later, similar actors recognized the robot's importance to the American political economy when Congress held its first official hearings dedicated to the technology. Chaired by Democratic representative of Tennessee's fourth district Albert "Al" Gore, Jr., the hearings, simply titled "Robotics," invited specialists from academia, the auto industry, government, and the industrial robot industry for two days of statements and testimony. Gore opened the hearings by asserting that "robot technology is growing rapidly and provides the United States with an excellent opportunity to improve our Nation's productivity and enhance our position in world markets. In fact, robotics will be in the forefront of the next industrial revolution which will be based on the use of intelligent machines in industrial processes." But he warned, "the United States is currently behind Japan and the Soviet Union in the production of robots." The purpose of the hearings, therefore, was to assess the state of the art in robotics, both at home and abroad, and to examine and determine what areas of research should be

[31] *Technology Trade*, Joint Hearing before the Committee on Science and Technology, House of Representatives, 1980, 308 (emphasis added). For details about Cetron, see https://www.dignitymemorial.com/obituaries/falls-church-va/marvin-cetron-9316130.

[32] *Technology Trade*, Joint Hearing before the Committee on Science and Technology, House of Representatives, 1980, 312.

"emphasized in the mid and long-term to improve our Nation's competitiveness in the world's market."[33]

While most of the testimonials rehashed the same talking points as previous hearings, a few notable statements and exchanges are worth foregrounding. Charles Rosen, who had recently left his position at SRI to focus full time on his computer vision start-up firm Machine Intelligence Corporation, made the typical recommendations of increasing funding for basic research at universities and aiding profit-potential through "tax-credits for capital equipment and write-offs for R&D expenditures." In his prepared statement titled "Robotics for U.S. Industry," Rosen foregrounded the federal government's long history of supporting technological development and acknowledged the Department of Defense and NSF specifically for their support of robotics. However, he argued, even support was not enough as "our foreign competitors are blessed with all of the above incentives, and additionally, by an order-of-magnitude greater government funding at all levels of research, applied research, pilot systems and engineering." Therefore, the federal government would need to massively increase its funding across the board for robotics and their associated technologies and fields (e.g. machine intelligence, computer science, and solid state electronics). Critically, he warned, "if time is of the essence in this competitive race which may affect all our future productivity, we had better not rely solely on normal free-market concepts."[34]

Fellow roboticist Delbert Tesar identified a potential problem with Rosen's call for a massive increase in federal funding. The former worried that the civilian economy would not be able to commercially integrate defense-funded R&D in a timely manner as "U.S. manpower is

[33] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 1-2.
[34] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 79-80.

not sufficient to absorb rapidly the results of the defense sector."[35] Echoing the concerns of RANN's "Future of Productivity" conference five years prior, Tesar predicted that "foreign civil sectors, specifically Germany and Japan, will be the primary beneficiaries of this technology in the defense sector." Gore, seemingly taken aback, asked for clarification:

> Mr. GORE. Again, excuse me for interrupting, but what you are saying there is that because such a heavy percentage of our R&D effort is going to be in the Defense Department over the next several years, it is fair to predict that the civil sector will not be able to absorb that, and, as a result, foreign manufacturers and other parts of foreign civil sectors could be the primary beneficiaries of the R&D in the American defense programs that have commercial application?
>
> Dr. TESAR. That is essentially my argument. I do not know that we can defend that Wholeheartedly, but I do believe there is an emerging threat on that particular issue.[36]

How such contradictions would be resolved were never addressed in the hearings. Tesar did, however, introduce the most controversial idea into the record: central planning of robotics R&D in the style of Japan's MITI.[37] While his proposal for centralization went essentially unacknowledged by congressional attendees, he did earn a rebuke from Edith W. Martin, the deputy undersecretary of Defense for Research & Advanced Technology. In contradistinction to Rosen's "free market" skepticism and Tesar's desire for "central planning," Martin, when asked her opinion on a "national plan to promote robotics," spoke on behalf of her office and declared:

> We are not convinced that a national plan, either to advance the state-of-the-art in robotics and robotics technology or to encourage use of this technology in the industrial base, would facilitate meaningful progress in the area. In the case of technology

[35] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 151.
[36] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 151.
[37] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 155.

> development, this is particularly true if by a national plan is implied top down, centrally managed, interdepartmental allocation of resources . . . . we believe the government should rely on the incentives of the free enterprise system to encourage the use of robots where there is economically sound reason to do so.[38]

While Martin advised universities to focus on "longer term research efforts that will provide the technology base that can establish the U.S. as a world leader in robotics and robotics technology" it was industry's job to "concentrate on the implementation issues that make this technology impact our economy and national security."[39]

The power of "security" as a discursive skeleton key that could open the door of NSS funding was demonstrated on day two of the hearings during a key exchange between representatives from various federal agencies and departments who were asked to testify. At the tail end of the day, Gore had a friendly back-and-forth with Martin and John W. Lyons, director of the National Engineering Laboratory at the National Bureau of Standards, which is worth quoting at length:

> Dr. MARTIN. Well, our mission is defense and this is what we feel is necessary in order to accomplish that mission. If we look at the Department of Commerce, and if I might be so bold as to say that their mission is the economic health of the country, then they might be equally ambitious in pursuing that.
>
> Mr. GORE. Yes, I agree. I certainly do. [Laughter.] I certainly do. You have made some friends here, Dr. Martin. [Laughter.] That is very good. Again, though, the numbers—Dr. Lyons' program has gone from a measley $2.3 to an even measlier $1.895, and the program over there has gone from $26.7 to $44. I think that you have reframed the question quite properly so that the question becomes not why is yours so large but why is theirs so small. Dr. Lyons?

[38] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 448.
[39] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 449.

> Dr. LYONS. Mr. Chairman, I cannot pass this up. We were asked that question by Mr. Walgren or Mr. Brown, I forget which. We assured him that we were going over to DOD to make up the difference.
>
> Mr. GORE. Well, you will have to stand in line because there is a real effort to get programs labeled "national security" these days.[40]

As the 1980s wore on, it became apparent that the line was miles long and, more importantly for those concerned, the bottom line of the industrial robot industry was already being written in Japanese.

Leveraging 'Japanic Inc.' and directly associating robotics with national security was a political move that proved too little too late. Three months before Gore's "Robotics" hearings, GM made the fateful decision to sever its twenty-year business relationship with Unimation. While the breakup was quick, the fallout was years in the making. Three years prior in 1979, Pullman Inc., which entered into a fifty-fifty ownership agreement of Unimation with Condec when the startup was founded in 1962, decided to walk away from the investment leaving Condec with almost $20 million in long-term debt owed by Unimation for development costs.[41] As a result, Condec restructured Unimation and Paul Allegretto, an executive of a different Condec division, was made executive vice president in charge of strategic planning. In 1981, much to the chagrin of Engelberger, Allegretto took Unimation partially public, 20 twenty percent of the firm's stock to settle its debt to Condec. This left Unimation with no debt but little in the way of free cash for investment.[42] This hamstrung Unimation's ability to invest in the

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[40] *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 410.

[41] George E. Munson and Leslie Ballard (ed.), "The Rise and Fall of Unimation, Inc. — Story of robotics innovation & triumph that changed the world," Iteknowledgies International Automation and Security Group (Aug. 20, 2012), https://automatikka.wordpress.com/2012/08/20/the-rise-and-fall-of-unimation-inc-story-of-robotics-innovation-triumph-that-changed-the-world/.

[42] John W. Dizard, "Giant Footsteps at Unimation's Back," *Fortune*, May 17, 1982, 96-97.

necessary capacity to fulfill its outstanding contracts and spelled trouble for meeting the even larger orders expected from GM, a problem of the American industrial robot industry writ large.[43]

Beyond finances, Scheinman's resignation in 1980 meant Unimation lost the technological 'golden boy' who was critical to the firm's winning of the PUMA contract while continuing problems with the PUMA over the next two years after Scheinman's departure definitely did not ingratiate Unimation with GM executives.[44] Finally, GM wanted their future robot workforce to be all electric rather than hydraulic as the latter technology required more union personnel for maintenance. Nevertheless, Engelberger disagreed with the proposition as hydraulically driven robots were, in his estimation, still required to handle the "muscular" work on the assembly line. According to Unimation vice president George Munson, during a meeting with GM CEO Roger Smith in 1981, Engelberger stood his ground on the issue, but lost the argument. The disagreement was the proverbial nail in Unimation's coffin.[45]

That nail was pounded home in March 1982 when GM announced its partnership with manufacturing conglomerate Fujitsu Fanuc, a "rising star" in the nascent Japanese industrial robot industry.[46] The joint venture, called GMF Robotics, brought together the world's largest

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[43] Laura Conigliaro, "Robotics," Bache Halsey Stuart Shields, Inc. Institutional Research (Apr. 23, 1980), Folder - Robotics - Correspondence, 1960s, Box 2, GDJR, 12. As Rosen observed during the "Robotics" hearings, "The number of robots that can be manufactured in this country in the next 5 years is very limited. No companies, not Cincinnati Millicron, Unimate or any of the new companies can suddenly increase their robot production overnight, they can't. It takes years to double up or triple up production," *Robotics*, Hearings before the Subcommittee on Investigations and Oversight, Committee on Science and Technology, House of Representatives, 1982, 105.

[44] See discussion of these events in Chapter Six.

[45] George E. Munson and Leslie Ballard (ed.), "The Rise and Fall of Unimation, Inc. — Story of robotics innovation & triumph that changed the world," Iteknowledgies International Automation and Security Group (Aug. 20, 2012), https://automatikka.wordpress.com/2012/08/20/the-rise-and-fall-of-unimation-inc-story-of-robotics-innovation-triumph-that-changed-the-world/. For discussion of hydraulics requiring more union personnel and the disagreement regarding electrically driven versus hydraulically driven industrial robots, see former Unimation employee J. Byron Walker's entries in the comments section.

[46] John Hartley, "Fujitsu Fanuc: The Rising Star of Japan's Robot Manufacturers," *The Industrial Robot*, Vol. 8 (Dec. 1981), 216-219.

automobile manufacturer with the world's largest manufacturer of NC machine tools to decrease the $1,500 per-car manufacturing labor cost differential the Japanese enjoyed over their American competitors. According to GM, one-fifth of this advantage came from technology, and GMF Robotics was expected to "provide a profitable business opportunity in the growing robotics industry while at the same time help GM meet its worldwide robot requirements."[47] Five years later in 1987, GM had more than quintupled the number of robots installed and planned to more than double that number by the end of the decade.[48]

The financial precarity of Condec, which had lost $16.5 million the previous fiscal year, combined with Unimation's loss of its biggest and most important customer, quickly led to the conglomerate's offloading of its most profitable firm. In December 1982, Condec sold Unimation to Pittsburgh-based Westinghouse Electric Corporation for $107 million (78 percent or $84 million went to Condec while 22 percent or $23 million went to other shareholders) with the understanding that a significant amount of investment was needed to maintain the newly acquired firm's competitive standing.[49] However, as the *New York Times* described the landscape a month later, "though not much of a factor in the American robot market yet, Japanese manufacturers are expected to become increasingly competitive, creating an added incentive for American companies to leave robotics."[50] It didn't take long for the prediction to come true.

The marriage of Unimation and Westinghouse was rocky from the start as the "entrepreneurial spirit" of the world-leading industrial robot company immediately came into

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[47] GM Public Affairs Newsletter, Vol. 12, No. 4 (April 1982), Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002).

[48] "GM Robot Population" (Jan. 1, 1988), Historical Documents Related to the PUMA Robot Development Compiled for the General Motors Corporation Donation of the Original PUMA Prototype Robot "Alice" to the Smithsonian Institution (PUMA report_GM_2002).

[49] "Westinghouse Agrees to Buy Unimation Inc.," *Wall Street Journal*, Dec. 7, 1982, 4.

[50] "Shakeout in Robot Industry," *New York Times*, Jan. 12, 1983.

friction with the stodgy bureaucracy of the corporate giant. By the end of 1983, Unimation's leadership was purged. Brian Carlisle and Bruce Shimano, who had taken over Unimation West for Scheinman, turned down an offer to relocate to Pittsburgh and spun the division off as Adept Technology Inc. Westinghous's management also allowed Unimation's international relationships in Europe and Japan to twist in the wind. The following year in 1984, Engelberger walked in disgust. "I resigned in dismay," he recalled, "I was heartbroken because this was my baby, and it was crumbling before my eyes."[51] According to Carlisle, Unimation "could have been the IBM of the robot business" if not for Westinghouse's mismanagement. Four years later in 1988, Westinghouse sold Unimation to Swiss industrial conglomerate Stäubli for an undisclosed amount.[52] The sale signaled the fall of Unimation and the end of the American industrial robot industry.

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Almost four decades of heady hype, relative labor peace, and supply-side technoliberalism were not enough for the American business community to embrace the industrial robot. Even with the NSS's critical support in bringing the technology to fruition, corporations demanded even more largesse to put it to work. That the private for-profit management of publicly subsidized capital

[51] George E. Munson and Leslie Ballard (ed.), "The Rise and Fall of Unimation, Inc. — Story of robotics innovation & triumph that changed the world," Iteknowledgies International Automation and Security Group (Aug. 20, 2012), https://automatikka.wordpress.com/2012/08/20/the-rise-and-fall-of-unimation-inc-story-of-robotics-innovation-triumph-that-changed-the-world/ and "BRIAN CARLISLE: An Interview conducted by Peter Asaro and Selma Šabanovic," IEEE History Center (Nov. 21, 2010), https://ethw.org/Oral-History:Brian_Carlisle. Engelberger did, however, remain on Westinghouse's payroll under a five-year consulting contract with its Defense & Advanced Technology Division while also continuing to manage the company's robot licensing and joint-venture agreements, John Teresko, "Is robotics mature? Unimation founder Joe Engelberger resigns," *Industry Week*, Vol. 220, Feb. 6, 1984, 21.

[52] Dave Fusaro, "Westinghouse Electric selling Unimation to Staubli," *Metalworking News*, Vol. 15, Iss. 713, Dec. 12, 1988, 4.

may have been a cause of America's competitive stance abroad as well as an impediment to robotization at home never entered the popular conversation. In the name of "security," the 'Invisible Hand' of the market attached to the 'Invisible Arm' of the state manufactured economic insecurity.

American workers who bore the brunt of the turmoil continued to be stuck between a robot and a hard place. The Reagan administration's anti-unionism, continued austerity, automation, and deindustrialization as well as greater international competition and more reliance on monetarism (much of it carried over from the Carter administration) kept the economic squeeze on individual workers and continued to erode labor's structural power. Increasingly cheap labor at home (particularly in Southern "right-to-work" states) and even cheaper labor abroad magnetized American capital away from union strongholds and slowed investment in the advanced manufacturing technologies that could purportedly reverse the increasingly lopsided trade balance.[53] And while robots at home did not "steal" manufacturing jobs as feared in the 1950s and 1960s, robotization abroad—first facilitated by Unimation and later GM—made it more likely that, in the future, there wouldn't be many American industrial jobs left to steal. Nevertheless, unions remained committed to automation as one solution to their woes.

Black workers' future relationship to the industrial robot looked much like that of the past. If they weren't displaced by a robot on the factory floor, they were the first to be shown the factory door as foreign goods poured into American ports. By the turn of the 1980s, the

[53] Barry Bluestone and Bennet Harrison, *The Deindustrialization of America: Plant Closings, Community Abandonment, and the Dismantling of Basic Industry* (Basic Books, 1984); Robert Brenner, *The Economics of Global Turbulence: The Advanced Capitalist Economies from long Boom to long Downturn, 1945-2005* (Verso Books, 2006); and Jefferson Cowie, *Capital Moves: RCA's Seventy-Year Quest for Cheap Labor* (Cornell University Press, 1999).

unemployment rate in Black communities was, once again, double that of their White counterparts, and if racial disparities in the labor market had been eroded since the passage of the Great Society, it was not showing in the statistics. Nonetheless, Reaganomics also began accelerating the degradation of White economic privilege, particularly for workers in unionized manufacturing jobs, as the number of jobless hit its highest mark since the Great Depression in 1982.[54] National Urban League president John E. Jacob, after noting the structural connections among laid-off industrial workers in the US, robotized factories in Japan, and the hollowing out of the American middle class's consumer power, declared to a 1983 audience: "High Tech is no salvation for blacks. And it is no salvation for whites, either." Furthermore, in a repurposing of Walter Reuther's parable from thirty years prior, Jacob continued, "robots don't buy autos and the producers of imported goods spend their money at home, not in the U.S.A."[55]

One segment of society, however, was spared the pain of 'trickle-down economics': affluent, highly educated White men who continued to shower in the 'fire-hydrant-up economics' of the Reagan defense spending splurge. Even if the American industrial robot industry had collapsed, the robotics research they managed and partook in continued apace at familiar sites such as General Motors Research and the MIT and Stanford AI Labs, as well as at newer sites such as the National Bureau of Standards' Automated Manufacturing Research Facility in Gaithersburg, Maryland (funded in part by the Navy's "Manufacturing Technology Program") and the Westinghouse-funded Robotics Institute at Carnegie Mellon University in Pittsburgh. And even more money was being directed to roboticists through the signal programs

[54] Arthur L. Tolson and Q. R. Hand, Jr., "Reaganomics and Black Americans," *The Black Scholar*, Vol. 16, No. 5 (Sep./Oct.1985).
[55] John E. Jacob, "Black Americans in Reagan's America," Keynote Address at the National Urban League's Annual Conference. New Orleans, Lousiana, July 31, 1983, 421-422, https://escholarship.org/content/qt8sr91012/qt8sr91012_noSplash_aa18f4b0c27d2c83748dfdebf9db5904.pdf?t=nrwqsr.

of the late Cold War high-tech ecology they were embedded in: Strategic Computing (which inaugurated an "AI Autumn" through the development of "fifth generation" and "parallel" computing), the Semiconductor Manufacturing Technology (SEMATECH) public-private consortium, and the laser-armed satellite missile defense system envisioned by the Strategic Defense Initiative (colloquially called "Star Wars").

If anything else continued apace, it was the faith these men placed in the promise of robots to usher in the fully automated future long foretold, the prognostications of which sounded much like those of the past. In 1985, roboticist Shimon Nof of Purdue University edited the first *Handbook of Industrial Robotics* that included entries about the present and future of the field from luminaries including Isaac Asimov, Joseph Engelberger, and Charles Rosen. The latter observed that "we are now in a transition between the solid-state revolution and the information age. By early in the twenty-first century we can anticipate enjoying the era of the intelligent/mechanical slave."[56] Engelberger, who Nof tasked with historicizing the field, began his brief chronicle with an homage to science fiction's role in powering the robotic imagination that could make the automated future reality.[57] And, perhaps coincidentally, Nof commissioned Asimov to write the handbook's foreword, titled "Looking Ahead." After reflecting that in the 1950 first edition of *I, Robots* he had "cited" the fictional source of his famous 'Three Laws' as the "*Handbook of Robotics, 56th Edition, 2058 A.D.*," Asimov extolled:

> Having foreseen so much, let me look still further into the future. I see robots rapidly growing incredibly more complex, versatile, and useful than they are now. I see them taking over all work that is too simple, too repetitive, too stultifying for the human brain to be subject to. I see robots leaving human beings free to develop creativity, and I see humanity astonished at finding that almost everyone *can* be creative one way or another.[58]

[56] Charles Rosen, "Robots and Machine Intelligence" in Shimon Y. Nof (ed.), *Handbook of Industrial Robotics* (John Wiley & Sons, Inc., 1985), 26.
[57] Engelberger, "Historical Perspective of Industrial Robotics" in Nof, 3.
[58] Isaac Asimov, "Foreword: Looking Ahead" in Nof (ed.), xii, emphasis in original.

Science fiction had become science fact, yet almost four decades after publication of the first *Handbook of Robotics*, human workers the world over are still laboring like mechanical slaves on the line.

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Remington Rand

Square D Company

U.S Industries (formerly Pressed Steel Car Company)

## Periodicals and Journals

*AI Magazine*

*Akron Beacon Journal*

*American Federationist*

*American Machinist*

*American Mercury*

*Atlanta Constitution*

*Automatic Control*

*Automotive Industries*

*Baltimore Sun*

*Barron's National Business and Financial Weekly*

*Billboard*

*The Black Scholar*

*Business Week*

*Challenge*

*Chicago Tribune*

*Christian Science Monitor*

*Cincinnati Enquirer*

*Cincinnati Post*

*CIO News*

*Cleveland Call and Post*

*Computer*

*Control Engineering*

*Danbury (Connecticut) News Times*

*Datamation*

*Detroit Free Press*

*Detroit News*

*Dissent*

*Dun's Review and Modern Industry*

*Factory*

*Fortune*

*Globe and Mail*

*Harper's*

*Harvard Business Review*

*Harvard Crimson*

*Human Events*

*IEEE Robotics & Automation Magazine*

*IEEE Spectrum*

*IEEE Transactions on Computers*

*In These Times*

*Indianapolis Star*

*Industry Week*

*Iron Age*

*Lafayette (Indiana) Journal and Courier*

*Life*

*Los Angeles Sentinel*

*Los Angeles Times*

*Machinery*

*Management Review*

*Management Today*

*Manufacturing Engineering*

*Meccano Magazine*

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*Mechanix Illustrated*

*Michigan Chronicle*

*Moody's Industrial Manual*

*Nation's Business*

*New Albany Evening Tribune*

*New York Review of Books*

*New York Times*

*New York Amsterdam News*

*New Yorker*

*Newark (Ohio) Advocate and American Tribune*

*News & Letters*

*Newsweek*

*Omni*

*Oui*

*PBS NewsHour*

*Personal Efficiency*

*Playboy*

*Popular Mechanics*

*Production*

*The Reporter*

*Robot Mag*

*Robotics Age*

*Robotics Business Review*

*Science*

*Scientific American*

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*Steel*

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