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THE FLOW OF SATURATED WATER AND OF COLD WATER THROUGH A VALVE

by

Donald BOWDEN Mackay

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THE FLOW OF SATURATED WATER AND OF COLD WATER THROUGH A VALVE

by Donald B. Mackay

The object of this investigation was to determine and compare the flow characteristics of both saturated water and of cold water while passing through a valve. The importance of this problem may be judged by the difficulties that have been encountered in the proper sizing of valves and orifices in processes where saturated liquids must be handled.

A simple though effective apparatus was constructed in which a certain quantity of water was heated to the saturation point and then caused to flow through a test valve. The flow rate was determined by the volume of fluid passing through the valve in a given period of time. The valve had an orifice diameter of 0.707 inch and was especially designed so that pressure and temperature measurements could be taken at the inlet section and at several stations in the discharge end. The valve body and plug were designed so that the valve lift could be changed, yet accurately positioned and measured for each test. Tests were conducted at several valve inlet pressures ranging up to 132 psia (348 F). Special thermocouples with an outside diameter of only 0.034 inch were developed and inserted into the water stream to measure its temperature.

The water was found to be in a metastable state while passing through the restruction of the valve and, as a result, the flow was retarded by an amount which in turn

depended upon the extent to which the change of phase had been completed in the critical section. If little change had taken place, the flow rate approached that of cold water. In this investigation the flow of saturated water was found to be from 2 to 35 percent less than that of cold water for identical pressures. The reduction depended upon the valve lift and the head. The volume rate for the fluid passing through the valve was found to be independent of the initial pressure. It varied only with the pressure drop effected in the valve when this pressure drop was expressed in an equivalent head measured in feet of inlet fluid. An appreciable recovery of the pressure drop across the valve restriction was observed for cold water but a negligible amount was found for saturated water.

As a result of this investigation the performance of actual valves can now be more accurately predicted. However it is expected that the flow characteristics of saturated water through a given valve is influenced both by the size of the valve and by its configuration, and future work should be done to determine the magnitude of these effects.

Gratefully Dedicated

to Jean

PREFACE

The object of this investigation was to establish a procedure by which the flow characteristics of liquids passing through valve components in combination could be studied. Also, the analysis as applied to the data suggests an approach to a theoretical explanation of the characteristics of flow through valves.

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SUMMARY

The volume of saturated water passing through the test valve, per unit of time, was found to be 2 to 35 percent less than that of cold water when compared under similar conditions of pressure head and valve opening. Initially saturated water flowing through the restriction in the valve was found to be in an unstable state in that the computed value of the density and its measured temperature were higher than the equilibrium values determined from the steam table. An equation was derived from the test data for determining the effective state of the mixture flowing through the valve. Temperature measurements were made by using specially developed thermocouples which were extremely small and unique in construction, as shown in Fig. 34, page 68. (All figures are grouped together starting at page 35.) The volume rate of fluid flowing through the valve was found to be independent of the initial pressure. It varied only with the pressure drop across the valve when this pressure drop was expressed in an equivalent head measured in feet of inlet fluid. An appreciable recovery of the pressure drop across the valve restriction was observed for cold water; but it was found to be negligible for initially saturated water.

The data obtained in this investigation were apparently consistent and reliable. As a result of this study it is believed that the performance of actual valves can now be more accurately predicted. The technique developed for conducting

these tests should be of great help in continuing research in this field.

INTRODUCTION

Little research has been done on the flow of saturated water through valves, in spite of the fact that considerable difficulty has been encountered in predetermining suitable valve sizes for power plant applications and for processes where hot liquids must flow through valves. Information available on flow through nozzles is likewise limited. In fact, at the beginning of this work, it was impossible to predict the quantity of liquid that would flow through the newly designed valve. The lack of data prompted the Industrial Instruments and Regulators Division Applications Committee of the ASME to sponsor at this University a research project to determine the flow characteristics of saturated water. Since this investigation was expected to be carried on over a period of years, the apparatus was designed to be as flexible as possible, in order that investigations could be continued with a variety of orifice configurations and plug designs. The problem could be extended to the study of any liquid which undergoes some change of phase while passing through a valve or orifice. The valve was designed to be used at pressures considerably higher than those currently available in the laboratory.

When laying out the valve it was considered important to construct the inlet and exit sections so that accurate pressure and temperature measurements could be taken. It was therefore important that the water immediately up stream and immediately down stream from the pressure taps be made to flow through

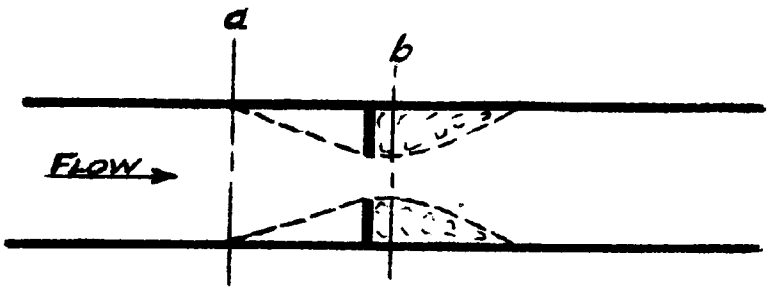
sections of pipe without bends or obstructions. The valve was elongated so as to conform with the afore-mentioned requirements and it was constructed so that the valve's plug could be accurately positioned.

The measurement of the water temperature presented a difficult problem. It was anticipated that the water would not be in a state of equilibrium. For that reason care had to be taken that the water temperature and flow were not disturbed by inserting a large thermocouple well. This necessitated the development of an extremely small thermocouple. To obtain accurate measurements the thermocouple wires had to be electrically insulated from each other, except at the junction, from the walls of the thermocouple well and from the water. This phase presented difficulties, since the temperatures involved in this investigation were to be in excess of 300°F., at which point most commercial enamel coatings were known to break down and become conductors of electricity.

The test data were substituted into basic flow equations, thus permitting the evaluation of the constant terms of these equations. In this way subsequent flow data were predicted with a minimum of testing. The data were finally analyzed and equations determined for predicting the volume flow rate and the density of the mixture flowing through the valve.

FLOW THEORY

The flow of liquids through an orifice can be analyzed by using the general energy equation applied to the flow between the section a, upstream, and the section b, downstream, from the re-



striction (as shown above). The mechanical-energy balance between the two sections (neglecting friction losses) appears in a simplified theoretical form as,

$$\frac{U_b^2}{2g} = \Delta h + \frac{U_a^2}{2g} \qquad (1)$$

where U_a is the root-mean-square velocity of the fluid, ft./sec., in section a, the upstream section at the point where the pressure and other properties of the fluid are determined,

U_b is the ideal velocity of the fluid, ft./sec., in the central part, i.e., the jet portion of section b.

Δh is the static pressure drop between sections a and b expressed in feet of fluid determined from the properties of the fluid in the jet in section b.

By a similar reasoning velocity U_a can be converted to an equivalent head, h_{ua}, known as inlet velocity head, or

$$h_{ua} = \frac{U_a^2}{2g} \qquad (2)$$

This substitution in equation (1) yields

$$U_b^2/2g = \Delta h + h_{ua}$$

or

$$\frac{U_b^2}{2g} = \Delta h_t' \qquad (3)$$

where $\Delta h_t'$ is the sum of $\Delta h + h_{ua}$ which is the total head available to cause flow.

The ideal velocity of fluid at the down stream section then becomes:

$$U_b = \sqrt{2g \Delta h_t'} \quad (ft/sec) \qquad (4)$$

The volume of fluid Q (cu.ft./min.) that would theoretically pass through down stream section may be expressed as

$$Q = 60\ U_b A \qquad (5)$$

where A is the area in sq. ft. through which the fluid is flowing with the velocity U_b.

The above equations can also be used for analyzing the flow through venturi meters, valves and other obstructions. In the case of well designed venturi meters it is theoretically possible for the area A to be equal to the cross-sectional area at the down stream location. In general the cross-sectional area A of this jet is considered to be a fraction of the size of the smallest area, A_r, of the restriction through which the water must pass. In the case of the valves illustrated in Fig. 25 to 30, the area A_r can be either the area of the orifice or the minimum annulus area between the plug and the seat, depending

upon which is smaller. In the valve configuration used in these tests the minimum area under the plug is $\pi xz/144$, where x indicates the diameter of the orifice measured in inches and z is the valve lift in inches.

The actual rate of flow of liquid through the valve is obtained by (1) substituting A_r for the value of A in Equation (5) and (2) multiplying the right hand side of Equation (5) by a factor C' which takes into account the difference between A and A_r and also takes into account the effect of fluid friction. Equation (5) may then be rewritten as follows,

$$Q = 60\ C'\ U_b\ A_r = 60\ C'\ A_r \sqrt{2g\Delta h_t'}\ . \qquad (6)$$

The temperature of water passing through the valve remains constant provided the pressure at state b is not lowered to the extent of causing a change of phase. Cold water normally does not undergo such a change since the pressure at section b is usually not sufficiently low to produce the vapor phase. The effect of pressure on density without phase change is negligible, so that a given head measured in feet of fluid at section b is the same as that head measured in feet of fluid at section a. Equation (6) is thus altered to read,

$$Q = 60\ C'\ A_r \sqrt{2g\Delta h_t}\ \text{(cu. ft./min.)}\ . \qquad (7)$$

Δh_t is the sum $\Delta h + h_{ua}$, i.e., the head measured in feet of inlet fluid at station a. This equation can be used to study the flow of fluids in a valve since all the variables except C' can be measured.

Equation (7) can be written in an alternate form in which

$$Q = e^{b} (\Delta h_t)^{m} \quad \text{(cu.ft./min.)} \tag{8}$$

where the values of b and m will be determined after further consideration of the problem. By taking the log of each side of Equation (8), the following is obtained:

$$\log Q = (m \log \Delta h_t + b) \quad \text{(cu.ft./min.)}. \tag{9}$$

It is evident from this equation that if the volume flow Q is plotted against Δh_t on logarithmic coordinates a straight line with slope m will result, providing m and b are constant. Test data demonstrates that this is essentially true over a considerable range of values of Δh_t. However, the actual value of m is not 0.5 as one might expect from comparing Equations (7) and (8). This means that the value of C' is also a function of Δh_t. The value of C' can be obtained if Q is eliminated by substituting its value obtained from Equation (7) into Equation (8) or

$$60\ C'\ A_r\ \sqrt{2g\ \Delta h_t} = e^{b}\ \Delta h_t^{m}$$

from which

$$C' = \frac{e^{b}\ \Delta h_t^{(m - 0.5)}}{60\ A_r \sqrt{2g}} \quad . \tag{10}$$

The actual value of C' can then be computed after the values of b and m have been experimentally determined. The values of C' computed from this equation are more reliable than they would be had they been determined using Equation (7), since this method uses values of m and b which are mean values obtained from a

number of tests.

The flow of saturated liquids presents problems which are not found in a study of the flow of cold liquids. The pressure drop across a restriction creates a low pressure region in which part of the fluid might flash into vapor. The change of phase, theoretically accomplished in a short period of time, is in reality retarded by surface tension.* This results in suppressing the formation of vapor cavities. But the effects of this tension are eventually overcome by the thermodynamic forces of the superheated liquid.

An analysis of flow data reveals that during the flow of saturated liquid through the restriction, the separation of vapor from the liquid is only partially completed by the time the fluid reaches the throat section. The exact extent of this transformation is little understood, but it has been found to vary with the shape of the orifice, the inlet conditions, the head, and probably with other factors such as turbulence. Once the formation of vapor sets in the specific volume of the mixture increases and, if unobstructed, the jet would expand laterally. If the jet is confined in a passageway so that it cannot expand laterally it would have to expand in the direction of flow. In doing this the flow in the upstream section is retarded because it is necessary to accelerate the mixture which has a greatly increased specific volume in its transformed state. The exact state of the mixture can only be approximated after making some assumptions

*See reference 6 pp 615 to 617 and reference 7 pp 433 to 440 for supplementary reading on superheated vapor and supersaturated liquid.

regarding the flow and then by analyzing the test data. In other words, the state of the mixture is predicted by the effect which is observed in the flow and may be somewhat in error.

The condition of the fluid in the throat can be analyzed by referring to Equation (6). The weight rate of flow of fluid passing through the valve is constant for any section of the valve or,

$$W = Q_s d_s = Qd \tag{11}$$

also $$\Delta h_t' = \frac{144\ \Delta P_t}{d} \tag{12}$$

and $$\Delta h_t = \frac{144\ \Delta P_t}{d_s} \tag{13}$$

where $$\Delta P_t = P_a - P_b + \frac{h_{ua}\ d_s}{144} \tag{14}$$

where W = the flow rate in pounds per minute

Q = the volume rate of flow at the point of minimum cross-section - cu.ft./min.

d = the fluid density at the corresponding section in pounds per cubic feet

ΔP_t = total pressure drop from point a to point b, and includes a pressure drop equivalent to the inlet velocity - PSI.

Subscript s refers to the inlet section a where the water is saturated.

Substituting values from Equations (11) and (12) into Equation (6),

$$W = 60\ C'\ A_r\ \sqrt{288\ g\ d\ \Delta P_t} \tag{15}$$

In this investigation there was no precise way of determining the value of C' for the flow of initially saturated water as considered in Equation (15) and it was necessary to approximate its value. This was done by computing a value of Δh_t in Equation (13) for the desired total pressure drop ΔP_t, then the value of C' from Equation (10) for cold water was determined at this head and used for the value of C' in Equation (15). The value of d can then be computed since all the other items in Equation (15) can be either measured or computed. The value of d computed in this manner must be regarded as an effective value and may differ somewhat from the actual value.

Due to the number of variables involved in evaluating the density (d), it appeared impossible to establish the relationship existing between the variables when test results were used directly in Equation (15). It was therefore decided to analyze the flow data using the general equations applicable for cold water conditions. For this analysis, the properties of the saturated water at the inlet section were used and the appropriate flow coefficients determined. After analyzing the data it was found that the flow rate of saturated water when plotted as a function of Δh_t on logarithmic coordinates produced a straight line similar to that of cold water. Since this proved to be the case, it was possible to write equations for the flow rate of saturated water which were the same as Equations (7), (8), and (10), except, of course, for the numerical value of the constants.

Thus, Equation (8) can be rewritten as,

$$Q_s = e^{b_s} (\Delta h_t)^{m_s} \quad \text{cu.ft./min.} \qquad (16)$$

and Equation (10) as,

$$C' = \frac{e^{b_c} (\Delta h_t)^{(m_c - 0.5)}}{60 A_r \sqrt{2g}} \tag{17}$$

where the subscripts c and s refer to cold and saturated liquid respectively.

If the value of W from Equation (11) is substituted into Equation (15) one obtains,

$$d_s Q_s = 60 C' A_r \sqrt{288g\, d \Delta P_t} \tag{18}$$

Substituting the values given in Equations (16) and (17) into (18), and simplifying, the following equation is obtained:

$$d_s e^{b_s} (\Delta h_t)^{m_s} = e^{b_c} (\Delta h_t)^{(m_c-0.5)} \sqrt{144\, d \Delta P_t} \tag{19}$$

Substituting the value of Δh_t from Equation (13),

$$d_s e^{(b_s-b_c)} \left[\frac{144 \Delta P_t}{d_s}\right]^{(m_s-m_c + 0.5)} = \sqrt{144\, d \Delta P_t}$$

After squaring each side of this equation and simplying, the effective density d is found to be equal to

$$d = \frac{e^{2(b_s - b_c)}}{(144)^{2(m_c-m_s)}} \cdot \frac{d_s^{[1+2(m_c-m_s)]}}{\Delta P_t^{2(m_c-m_s)}}$$

or

$$d = K \frac{d_s^{\,n}}{(\Delta P_t)^f} \tag{20}$$

where

$$K = \frac{e^{2(b_s - b_c)}}{(144)^{2(m_c - m_s)}} \tag{21}$$

$$n = 1 + 2 (m_c - m_s) \tag{22}$$

$$f = 2(m_c - m_s). \qquad (23)$$

Equation (20) can be used to study the nature of the metastable mixture passing through the valve.

A mathematical relationship can be derived which compares the flow of saturated water to that of cold water. Equation (8) can be written as follows:

$$Q_c = e^{b_c} (\Delta h_t)_c^{m_c} \quad \text{cu.ft./min.} \qquad (24)$$

or

$$Q_s = e^{b_s} (\Delta h_t)_s^{m_s} \quad \text{cu.ft./min.} \qquad (25)$$

Dividing Equation (25) by (24)

$$\frac{Q_s}{Q_c} = e^{(b_s - b_c)} \frac{(\Delta h_t)_s^{m_s}}{(\Delta h_t)_c^{m_c}}$$

If the flow rates are compared at the same head (Δh_t) then

$$Q_s = Q_c \, e^{(b_s - b_c)} \Big/ (\Delta h_t)^{(m_c - m_s)} \qquad (26)$$

which is the desired equation and can be used to determine the volume flow rate of saturated water as compared to the flow rate of cold water.

APPARATUS

It appeared at the outset of this investigation that it would be impossible to set up test equipment to maintain steady flow of hot water through the test valve, since the high rate of flow would necessitate a large supply pump. Instead an intermittent process was selected in which a certain quantity of water was heated to saturated conditions at a rate possible with the existing pumping equipment in the laboratory. This supply of water was then used in the relatively short time as required by the test.

The apparatus was constructed as shown in Fig. 35 to 40, and plates 1, 2, and 3, pages 75 to 77.

Saturated water was formed by spraying relatively cold water into a tank in which high pressure was maintained by admitting live steam. A nozzle shown in Fig. 33 was developed to produce a fine spray so as to form a maximum of water surface area. The liquid was injected radially near the top of the tank to utilize effectively the space available for intimate contact between steam and water. The style of nozzle shown has large passageways for the water and was selected because it was less apt to clog with pieces of loose scale than other available nozzles. After trying several configurations it was found that four holes, as shown, made a pattern in which the spray from each hole covered a sector of approximately 90^{o}.

Due to the high pressures applied during the test work, the tank into which the water was sprayed had to be checked for

safety because of explosion possibilities. A hydrostatic pressure test was made up to 275 psi in order to insure a margin of safety. The tank was also hammered at the seams while the pressure was at its maximum. After this test the tank was calibrated as explained on page 79 of Appendix I.

The discharge line from the tank to the test valve was made as short as possible to reduce the line pressure drop to a minimum. While tests were being conducted with a valve lift of 0.035 inches, it was necessary to install a fine mesh screen into the line in front of the valve to prevent scale from clogging the narrow passageway.

The design of the valve tested is shown in Fig. 35 to 40. The discharge section was split as shown, in order to facilitate instrumentation, and was sealed during assembly with Copaltite Plastic Sealing Compound. This section was purposely made very long since it was not known how the flashing liquid would behave, and a study of the characteristics of the liquids was necessary. The inlet section was made as streamlined as possible in order to reduce the turbulence to a minimum and to facilitate accurate measurements. Adjustments on the valve plug were made by using spacers of different thicknesses. It was necessary to unscrew the union in the line ahead of the valve in order to reach the retainer which held the valve plug in position. While this method of changing the valve lift would not be convenient on a commercial valve, it was a desirable feature for test work since the plug could be accurately set at a desired position and maintained in place while under test. The valve lift was also free

from thermal expansion problems as both the plug and the wall were at practically the same temperature regardless of conditions existing either on the outside or inside the valve as indicated by the wall temperature measurements.

The thermocouples shown in the valve on Fig. 39, and Plate 3, page 77, were constructed as shown in Fig. 34. It must be emphasized that extreme care was used in their construction. In spite of the fact that the wires of each thermocouple were very flexible, it was essential that while being handled they be kept in as straight a position as possible, since it was difficult to force them into shape after they were bent. While the glass insulated pair of thermocouple wires were being filed to a half round section as indicated on Fig. 34, they were carefully placed on a board with one wire above the other and held with thumb tacks so that their mating surfaces were kept in proper orientation with respect to each other. The upper wire was lifted and the lower wire was filed by stroking it toward its end with a dead flat file, until the desired amount of metal was removed. The upper wire was straightened, the assembly turned over and the process repeated. After this operation the two flat sides of the wires were easily arranged opposite each other to form a virtually round section of the thermocouple cable. The silicone rubber insulation was applied and cured as indicated on Fig. 34. The wires were then carefully inserted into a tube similar to A-2-2*, Fig. 34, except that both ends of the tube were left open.

* Hereafter, parts will be designated by drawing number first and then the item number; for example, the part referred to here is found on drawing number A-2 item number 2.

Then the wires were adjusted to extend about 3/16" beyond the end of the tube. An ohmmeter was subsequently used to determine whether or not there was a short circuit between the wires, or between the wires and the tube. If no short circuit was evident the rubber was removed from a section extending back approximately 1/16" from the end of each wire. The bare ends were welded together in a carbon arc and the welding bead was filed down so that it completely cleared the inner walls of the tube when withdrawn. The end of the couple was then coated with silicone, cured and inserted either into tube A-2-1 or A-2-2 in Fig. 34. After the wires were inserted the assembly was rechecked for possible short-circuits between the wires and the wall of the thermocouple well. If any were indicated on the ohmmeter, their respective positions were ascertained by carefully removing and examining the wires. The coating was then patched, cured, and the process repeated.

After the welded ends of the wires had been successfully inserted into the thermocouple wells A-2-1 or A-2-2, the 1/8" O.D. copper tubes A-2-3 or A-2-4 were slipped into position from the opposite ends. The final assembly and curing were then completed as called for on Fig. 34. After this final assembly a further short-circuit check was made.

The thermocouple assembly being still very delicate had to be carefully installed into the valve as shown in Fig. 39, and protected with the box shown in Fig. 40 and Plate 1. Whenever the position of the valve plug was changed the box had to be removed and on those occasions also, extreme care had to be taken not to strike the thermocouples. In order to make sure that no

damage had been done the thermocouples were checked for short-circuits after each time the plug position was changed.

The pressure gauges were calibrated before installation as explained in Appendix I. After making eleven tests on saturated water, gauges 1 and 6 were replaced by more accurate gauges. Following test 204 on cold water, gauge 7 was installed and gauge 8 was replaced.

The other parts of the apparatus are illustrated in Fig. 40.

METHOD OF TEST

The testing process for the flow of saturated water was as follows:

1. The calibrated tank was emptied, the discharge valves were closed, the vent valve opened and steam slowly admitted into the tank until the pressure was considerably in excess of test requirements.
2. The pump was started and the water contained in the full lower tank was pumped into the upper tank at such a rate that the pressure in the upper tank did not fall below test pressure. The lower tank was emptied, the pump stopped, and the discharge valve on the pump was closed.
3. The pressure in the upper tank was allowed to fall until the test pressure was reached. Temperatures of the water in the tank were taken at the four positions indicated on Fig. 40, and tests were not conducted if a variation of more than $2^{\circ}F.$ was observed.
4. The pressure at station 1 was held constant throughout the test by manually regulating the by-pass valve on the steam line. The gate valve upstream from the test valve was opened, the discharge control valve adjusted to produce the particular discharge pressure sought, and the time for a desired change in the water level was determined by means of a stop watch. While the water was flowing, water and valve temperatures were recorded by the Speedomax millivolt recorder and the gauge pressures were read. Since the

Speedomax was limited to 8 thermocouples, it was necessary to change the thermocouple switches during the test in order to obtain all of the temperature readings.

5. The test results were computed according to the method presented in Appendix I.

The testing process for the flow of cold water was as follows:

1. The calibrated tank and the storage tank were filled with city water. Compressed air was admitted into the tank until the desired pressure was reached; for most tests a pressure of 70 psig was used.
2. The pressure at station 1 was held constant throughout the test by manually controlling the by-pass valve on the air line. The gate valve upstream from the test valve was opened, the discharge control valve adjusted to produce the particular discharge pressure sought, and the time for the desired change in water level was determined by use of a stop watch. While the water was flowing the temperature and gauge pressures were read.
3. The computations of test results were made as explained in Appendix I.

The water temperature readings were examined after each test to make sure that no apparent discrepancy had arisen. If any irregularities were noted the couples were checked with the ohmmeter to see if a short-circuit had developed. In a number of cases the readings were obviously incorrect and were omitted from the data sheets. Tests which for obvious reasons yielded

incorrect flow data were re-run.

Curves were plotted on both cartesian and logarithmic coordinates with volume flow rates as ordinate and total head Δh_t as abscissa. From the curves plotted on logarithmic coordinates the values of m and e^b for Equation (8) were determined for each valve lift. Curves showing the value of these constants were plotted as a function of valve lift. The coefficient C' in Equation (10) was determined for each valve lift and for both saturated and cold water. These were plotted and presented on graphs. Values of (m_c-m_s), $e^{(b_s-b_c)}$, n and f were likewise determined and plotted as a function of valve lift.

TEST RESULTS

Test data for saturated and cold water are shown in Appendix II. In addition, the results which appeared to be most important are presented in the following enumerated Figures:

Fig. 1 shows the weight rate of flow of cold water and saturated water at different inlet pressures for a valve lift of 0.1465".

Fig. 2 to 8 compare the volume rate of flow of saturated and cold water. Each Figure shows the results for a particular valve setting.

Fig. 9 illustrates how the flow rate of saturated water changes with different valve lifts.

Fig. 10 illustrates how the flow rate of cold water changes with different valve lifts.

Fig. 11 shows a comparison of the data, Fig. 9 and 10.

Fig. 12 indicates the volume flow rate of saturated water plotted against valve opening area in percent of orifice area.

Fig. 13 shows the volume flow rate of cold water plotted against the valve opening area in percent of orifice area.

Fig. 14 compares the data of Fig. 12 and 13.

Fig. 15 compares the flow rate of saturated and cold water when the test data are plotted on logarithmic coordinates.

Fig. 16 gives the values of m for saturated and cold water.

Fig. 17 presents the flow coefficient e^b for saturated and cold water.

Fig. 18 supplies the value of the coefficient C' for saturated water.

Fig. 19 furnishes the value of the coefficient C' for cold water.

Fig. 20 gives the value of the exponent $(m_c - m_s)$ used in Equation (26).

Fig. 21 shows the value of $e^{(b_s - b_c)}$ used in Equation (26).

Fig. 22 illustrates how the flow of saturated water is reduced in comparison with the flow of cold water, which is used as a standard.

Fig. 23 gives the values of the exponents n and f, used in Equation (20).

Fig. 24 presents the value of K for Equation (20).

Fig. 25 to 31 show the comparison between flow characteristics under the test conditions of maximum pressure drop for each valve lift for saturated water and for cold water with as nearly identical pressure drop conditions as possible. In addition the temperatures of the water as measured are compared to saturation temperatures.

Fig. 32 correlates data obtained for the flow of initially saturated water when the plug was removed, with the results obtained by other authors.

DISCUSSION AND CONCLUSIONS

It was observed from Fig. 1, that the weight rate of flow of initially saturated water varied with inlet pressure. The near identity of these curves suggested that a flow comparison should be made on a volume basis. This proved to be the case in all tests made in this investigation. In addition, the data by Benjamin and Miller (reference 1) were likewise re-checked on a volume basis and excellent agreement was found for most of their data and for the test data obtained in this investigation. As can be seen in Fig. 32, the correlation is excellent in spite of the fact that the conditions of the tests were widely different and the orifice used in this investigation was not a standard thin plate orifice. The data of Benjamin and Miller for the inlet conditions of 103 psia seem to be in error, considering the rest of their data.

In all cases presented here, the flow of cold water was greater than that of the saturated water. This was expected except in the case where the plug was removed. Under the latter conditions the valve would behave as an orifice and other authors had predicted that equal flows would be obtained. However, for this condition the deviation between the two curves was not large. For the other cases the difference between the flow rates of hot and cold water was found to increase as the valve lift decreased. The results of this investigation proved very definitely that the flow agreement could only be expected when the analysis was made on a volume basis.

The most important finding in this investigation is pre-

sented in Fig. 15. This graph shows clearly that the volume rate of flow of saturated and cold water is a straight line function of the total head, when the two are plotted on logarithmic coordinates. From this information it is possible to write Equation (8) which expresses an important mathematical relationship existing between the flow and the pressure head. From Equation (8) it is possible to write Equation (10) which evaluates the flow coefficient C'. After further investigation into the flow theory it was found that Equation (20), for the effective density, could be derived. Without these equations it would have been difficult -- if not impossible -- to determine the nature of the flow. If a similar relationship should be found for fluids other than water, it may be possible to determine the properties which govern their behavior. If a correlation based on fluid properties such as surface tension or viscosity can be made it should be possible to predict their behavior in a valve without the necessity of performing elaborate tests on each individual liquid. In other words, from the test results of a few liquids it would be possible to predict the behavior of all liquids.

The flow characteristics for cold water did not seem regular in the region extending from approximately 30 to 80 percent as shown in Fig. 13. The discrepancy is apparent in two forms when the flow equations are further analyzed. Fig. 16 shows the value of m or the slope of the lines presented in Fig. 15. At a valve lift of 0.1465 inches, which corresponds to 82.8 percent valve opening, the slope was found to be only 0.467, whereas a smooth

curve through the remaining points indicates that the value should be 0.511. This is a discrepancy of 8.6 percent in the slope but it amounts to a discrepancy of only 3 percent of the flow (calculated at 70' head). The other irregularity appears in Fig. 17. At a valve lift of 0.0675 inches, which corresponds to a valve opening of 42 percent, it can be seen that the test point falls below the smooth curve. The difference amounts to only 3.3 percent in the volume of flow. There are two possible reasons for these differences. At the valve lift of 0.0675 inches considerable trouble due to scale was encountered. It is possible that small pieces lodged between the plug and the seat, thus reducing the flow. At the valve opening of 82.8 percent it is possible that there was a change in the flow pattern of the water as it passed around the end of the plug and out the orifice. The flow should be controlled by the annular space between the plug and seat, since this area is the smaller. Actually, it is possible that the orifice area may have been the controlling factor at the higher heads, since at this condition of high velocity flow the jet formed in the center of the orifice would be smaller than the orifice itself. It seems possible, then, that the annular area under the plug may have controlled the flow at low heads and the orifice controlled the flow at high heads. The saturated water, however, seemed uneffected by this condition. This can be accounted for by the fact that the vapor liberated is less dense than the water and it is able to change direction much better than water when it is passing around the plug and out through the orifice. A change of flow pattern could only

take place over a limited range of valve lifts. For this reason the values read from the smooth curves were used in computing the values of C' and e^b.

The values of m for saturated water are scattered but the scale used for plotting the points is highly magnified. The tested range of pressure head Δh_t was not large and the measurements of small pressure differentials by the use of Bourden gauges is somewhat uncertain, in spite of the fact that very accurate gauges were used on this investigation. These two facts could easily account for the small discrepancies obtained.

Several methods were tried for deriving an equation for the effective density before the method presented under flow theory was evolved. The first attempt was to determine the coefficient C' from test data and to plot curves showing the result. From these curves and the original test data, the value of the density was computed by using Equation (15). All attempts to correlate the variation of density failed. Using a new approach the observed flow rates were adjusted so that the flow would agree with the values obtained from the smooth curve plotted through the test data. Still the results were inconsistent and showed no general trend. It later became evident that Equation (10) could be written for the evaluation of C'. Using this data it was found that the computed values of the density were consistent but it appeared that the density was a rather complex function of both inlet conditions and pressure drop. It was anticipated that the change in density would be some function of the theoretical equilibrium change in density. Rather consistent results

were obtained from this approach but no simple mathematical relationship could be expressed for determining the density. It finally became evident that the density could be determined from the fairly simple procedure explained under flow theory and presented in Equation (20).

After determining the density from Equation (20), it was possible to analyze the temperature measurements taken from the test data. The temperatures taken from the test data are illustrated in Fig. 25 to 31. It can be seen that the measured temperatures indicate that the metastable state of the hot liquid existed below the orifice but the temperatures corresponding to the effective density are much higher than those measured. This indicates that the point where the effective density was determined was upstream from station 3. It is unfortunate that thermocouples were not located in the region immediately under the plug and in the throat of the orifice. The metastable state exists for a distance below the valve seat. However, the exact distance depends upon the plug opening or lift. When the plug was close to the seat, equilibrium was practically complete at station 3, as shown in Fig. 25, by the fact that the saturation temperatures and the measured temperatures coincide from stations 3 to 8 inclusive. As the lift increased the difference between the temperature as measured and that determined for the saturation pressure increased progressively and extended to station 4 at a plug lift of 0.1465 inches. For some reason at a valve lift of 0.307 inches and when the plug was removed the instability at station 4 vanished, possibly due to an increase in turbulence associated with the

higher rates of flow at these conditions. Beyond station 4 no instability was detected in any of the tests.

The pressure characteristics for saturated and cold water were found to be quite different in the discharge tube, and can be studied by referring to Fig. 25 to 31. In the case of cold water a recovery of part of the pressure drop was made by a conversion of the kinetic energy of the jet into pressure. Practically no recovery was found for saturated water under any conditions. The specific volume of the metastable mixture at the throat section was increasing rapidly and the results indicate that by the time the mixture reached section 3, the flow was quite uniformly distributed over the cross-section of the tube and not confined to a high velocity central jet, as was true for cold water. Therefore, when studying the results of valve tests or for predicting the behavior in a given installation, it will be necessary to make an allowance for this fact.

A regular and systematic change in the value of C' was observed for both saturated and cold water. However, it can be seen (Fig. 18 and 19) that the value of C' from valve lifts 0.035 to 0.1825 inches became smaller as the valve lifts increased, but beyond 0.185 inches the value of C' became larger. The reduction in C' with increasing valve opening for the lower values of lift is probably due to the increase in turbulence brought about by the flow increase. With large valve openings the value of C' approaches that of the orifice coefficient indicating a straightening of the lines of flow.

From the test results the flow rate of saturated or cold

water through the test valve can be calculated for any desired valve lift and for any assumed inlet and exit pressure, providing the assumed conditions are reasonably close to the tested range. Extending the data to predict the flow in pressure regions beyond the tested range appears reasonably safe since no evidence has been observed either during the test work or from analyzing the test data which would indicate a change in the behavior of the flow. The volume rate of flow of cold water can be determined in two ways.

1. The flow can be computed by using Equation (7), wherein the value of C' can be obtained from Fig. 19.
2. The flow can be computed from Equation (8), in which the values of m and e^b can be obtained for cold water from Fig. 16 and 17.

The flow rate of saturated water can be computed in three ways.

1. The volume rate of flow measured at inlet conditions can be obtained from Equation (7) in which the value C' can be taken for saturated water from Fig. 18.
2. The volume rate of flow measured at inlet conditions can be obtained from Equation (8). The value of m and e^b can be obtained for saturated water from Fig. 16 and 17.
3. The weight rate of flow of saturated water can be computed from Equation (15). In this equation the value of C' from Fig. 19, for cold water must be used. The effective density d can be computed from Equation (20) wherein the values of f and n are obtained from Fig. 23,

and the value of K is obtained from Fig. 24. The weight rate computed by this method can readily be converted to an inlet volume rate by multiplying the weight rate by the specific volume of the water at the inlet.

The flow rates for saturated water compared to that of cold water can be made by referring to Equation (26), where the proper values of $(m_c - m_s)$ and $e^{(b_s - b_c)}$ are selected from Fig. 20 and 21. An easier method of comparison pertaining to the test data can be obtained from Fig. 22. From this graph it is evident that the observed volume rate of flow of saturated water is from 2 to 33 percent less than that of cold water, depending upon the valve lift and the head. In general, it appears that the reduction depends upon the shape of the passageway through which the saturated liquid is flowing. If the passageway is such that the pressure drop is progressive for a considerable distance and, at the same time, the flow is completely confined by the walls of the passageway, the reduction in flow will be appreciable. On the other hand, if the formation of vapor takes place in a jet of flowing fluid and can expand laterally into a liquid region which would normally surround the jet, the flow is only moderately reduced. Applying this reasoning to the flow behavior in other types of plugs and valve seats, tapered plugs fitting into tapered valve seats should be effected more drastically than the other types. The exact extent of the variation will have to be determined by further test work. In this investigation a single valve with only one configuration has been tested and it is ex-

pected that other sizes of valves and other configurations will behave differently.

It appeared from the performance of the apparatus used in this study that the discharge line from a valve should be given particular attention. The discharge line shown in Fig. 40 was one and one-half inches in diameter, had an over-all length of 135 inches, contained one angle valve, three tees, one 90° elbow and two 45° elbows. The vent line from the storage tank which allowed the steam to escape was only 23 inches long. Under the conditions shown in test 89, in which the plug was removed, the inlet pressure was 132.5 psia and the pressure at station 8 was 113.9 psia. This shows that the pressure drop across the orifice was only 18.6 psi. All of the remaining pressure head was consumed either in the discharge line or in the vent line. It thus appears that in a given installation the pressure drop in the discharge line may easily be greater than that of the valve unless the discharge line is exceptionally large and free from bends or obstructions.

RECOMMENDATIONS

Future test work should be directed toward a study of the behavior of saturated water in different configurations and different types of plugs and valve seats. For example, data on conical plugs and seats with varying angles of taper would be extremely valuable. The investigation of the exact nature of the flow in the metastable state should be more carefully analyzed. This study could be made by installing a number of thermocouples, similar to those described above, but located as close to the restriction as possible. These thermocouples are recommended because their thermal capacity is small and the time lag in establishing equilibrium is short. In addition they create little disturbance in the flow. The expansion of saturated water through an orifice or tube could also be investigated in this manner.

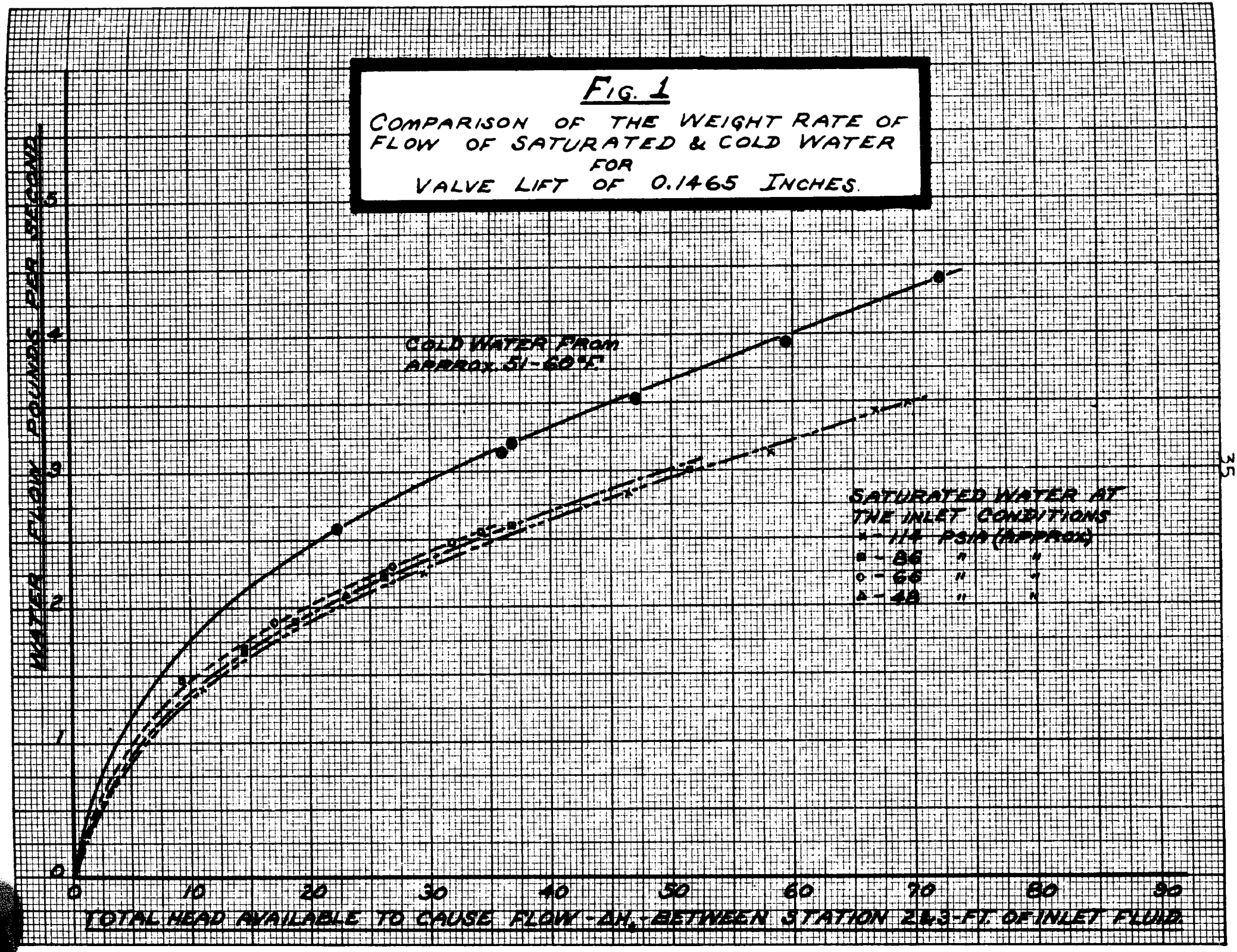
The behavior of liquids other than water should be tested and the work correlated to determine, if possible, the role which the normal fluid properties play in causing the variation in flow rate.

The type of apparatus used in this research for producing hot water is recommended for future use. It was found that a large quantity of saturated water could be quickly and easily produced. The apparatus is simple to construct and efficient to operate.

Minor changes should be made in the construction of the testing equipment. The size of the discharge line from the test

valve should be increased in order to cut down on the pressure drop in the line and thus provide for more pressure drop in the valve. This alteration will increase the range of study and yield a more complete set of data. If more pressure drop is effected the flow will increase and a tank as large as the one calibrated should be provided for storage purposes. In the tests discussed in this report the length of a run was governed to a large extent by the capacity of the storage tank since the established pressure conditions on the valve changed abruptly as soon as the tank was full.

Since loose scale lodged in the test valve during operation and necessitated a re-run of a number of tests, it is recommended that a device be installed to prevent the scale from reaching the valve.


FIG. 1
COMPARISON OF THE WEIGHT RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.1465 INCHES.
WATER FLOW - POUNDS PER SECOND
0
1
2
3
4
5
0
10
20
30
40
50
60
70
80
90
TOTAL HEAD AVAILABLE TO CAUSE FLOW - ΔH_t - BETWEEN STATION 2 & 3 - FT. OF INLET FLUID
COLD WATER FROM APPROX. 51 - 60 °F.
SATURATED WATER AT THE INLET CONDITIONS
× - 114 PSIA (APPROX)
■ - 86 " "
○ - 66 " "
△ - 48 " "

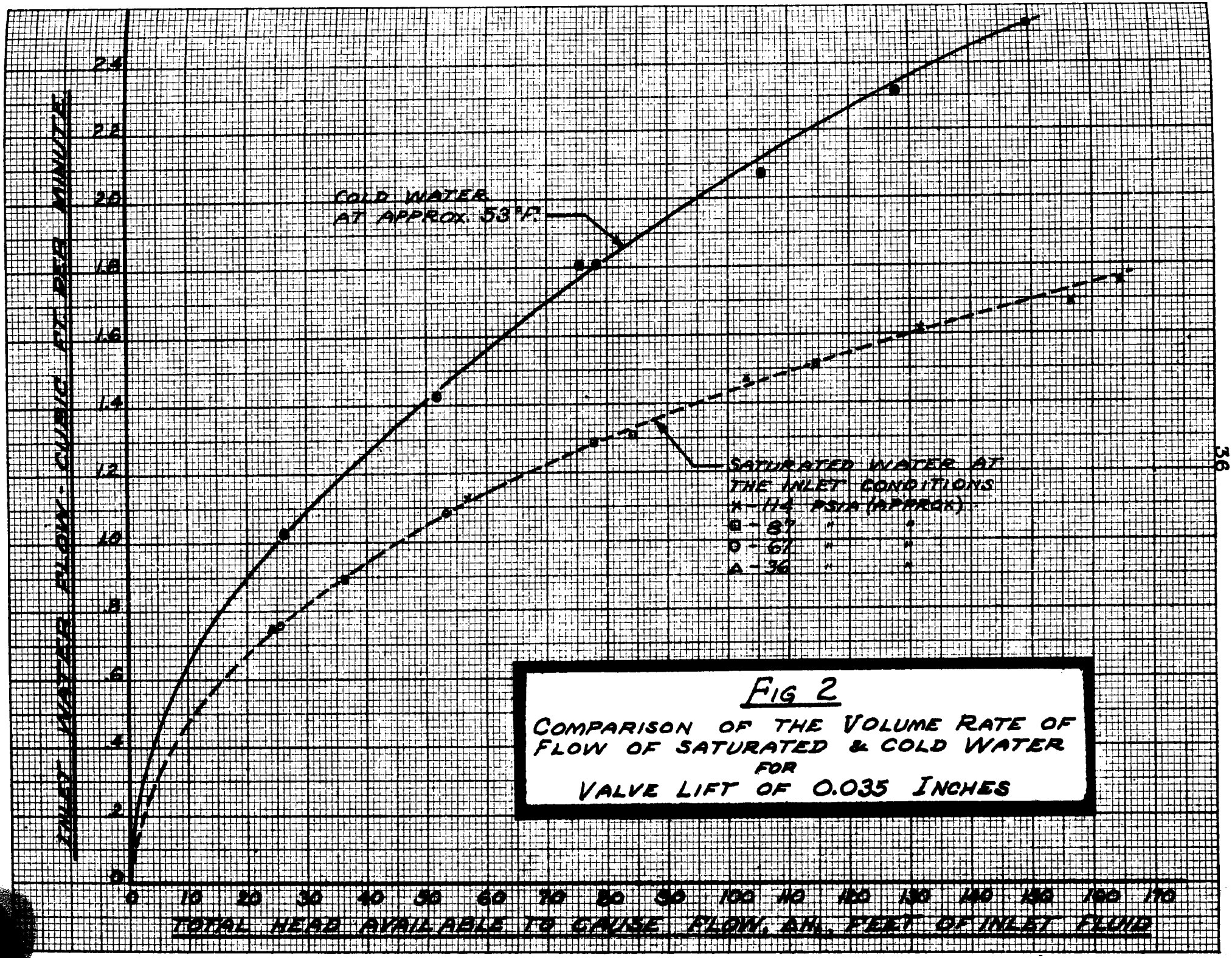
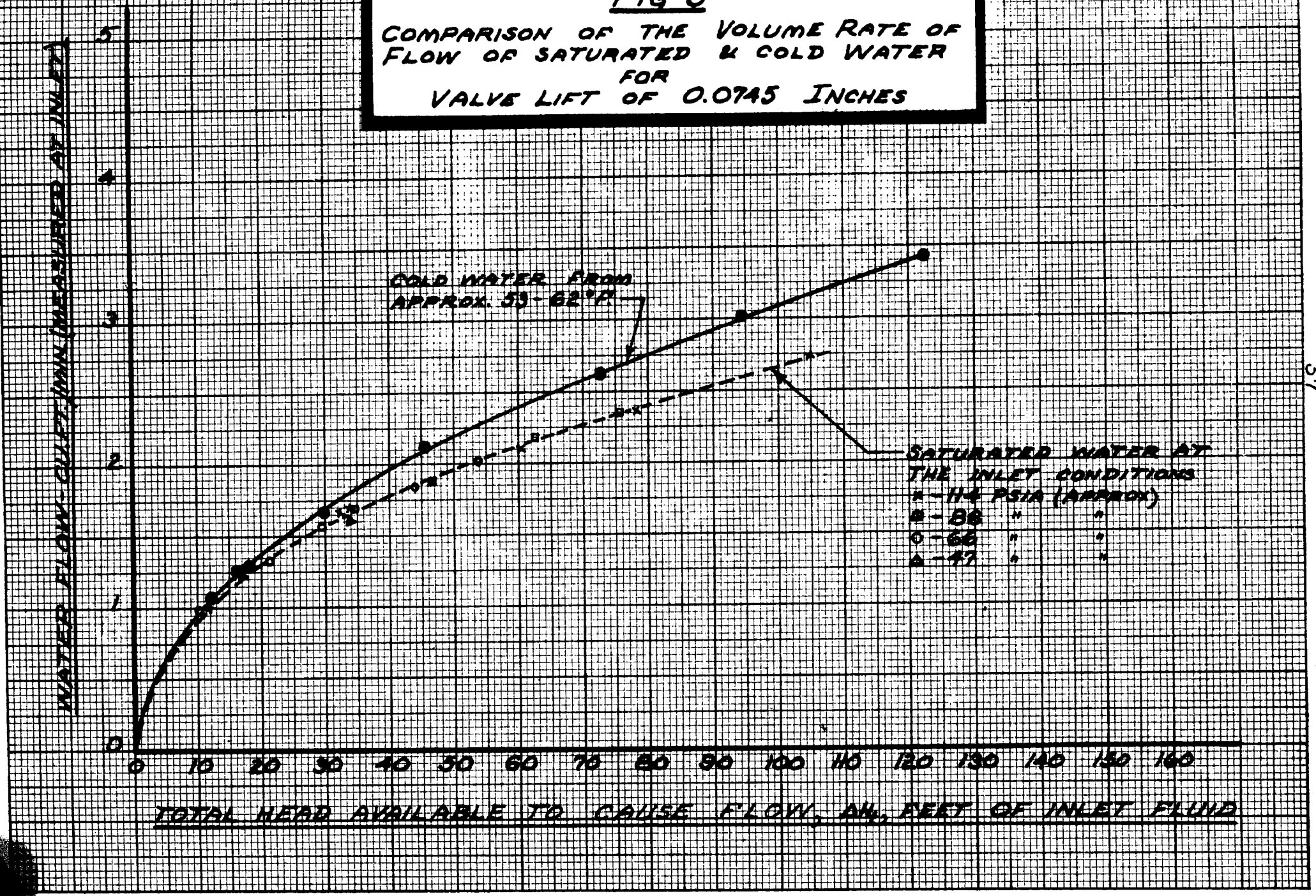


FIG 2

COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.035 INCHES

FIG 3

COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.0745 INCHES



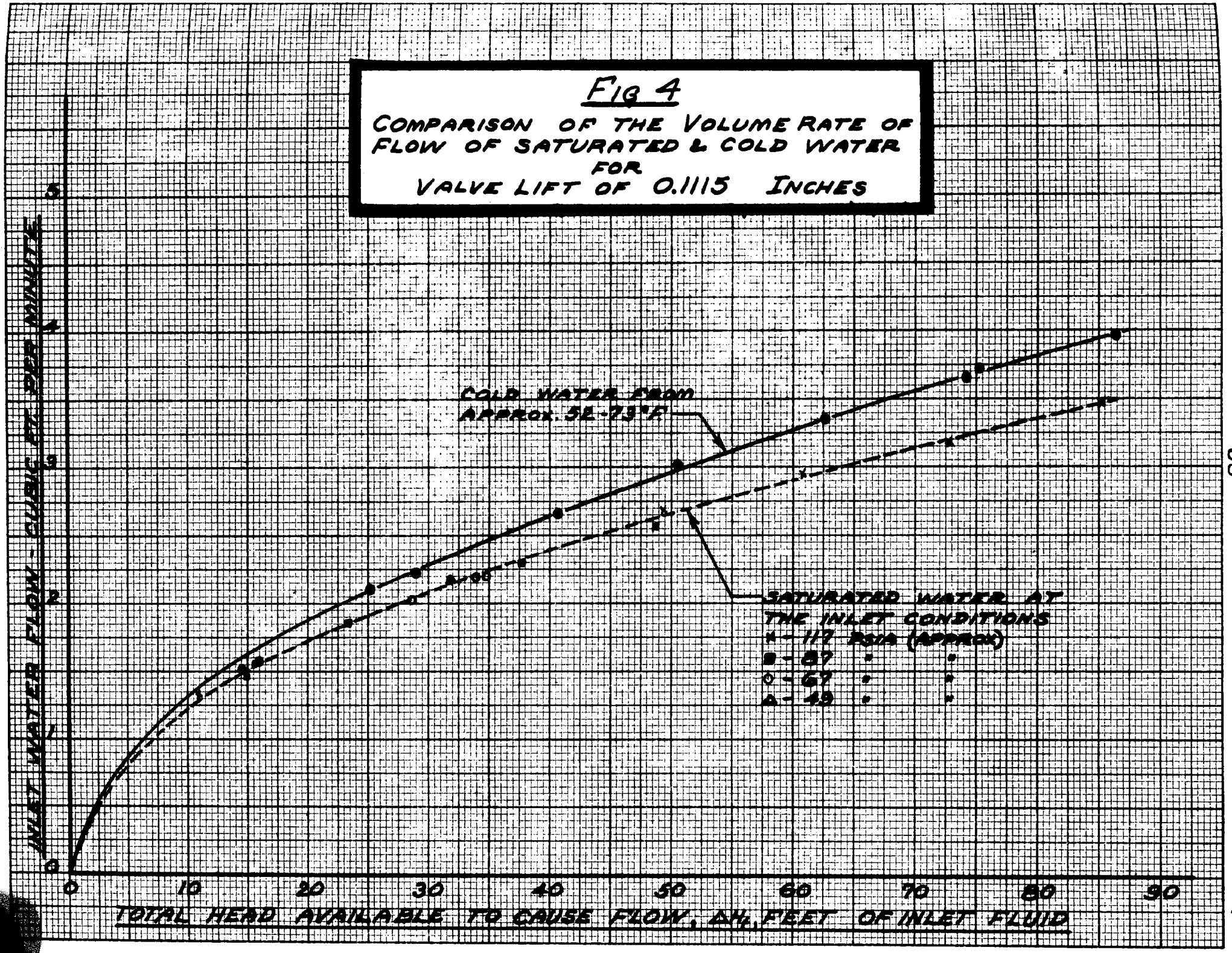
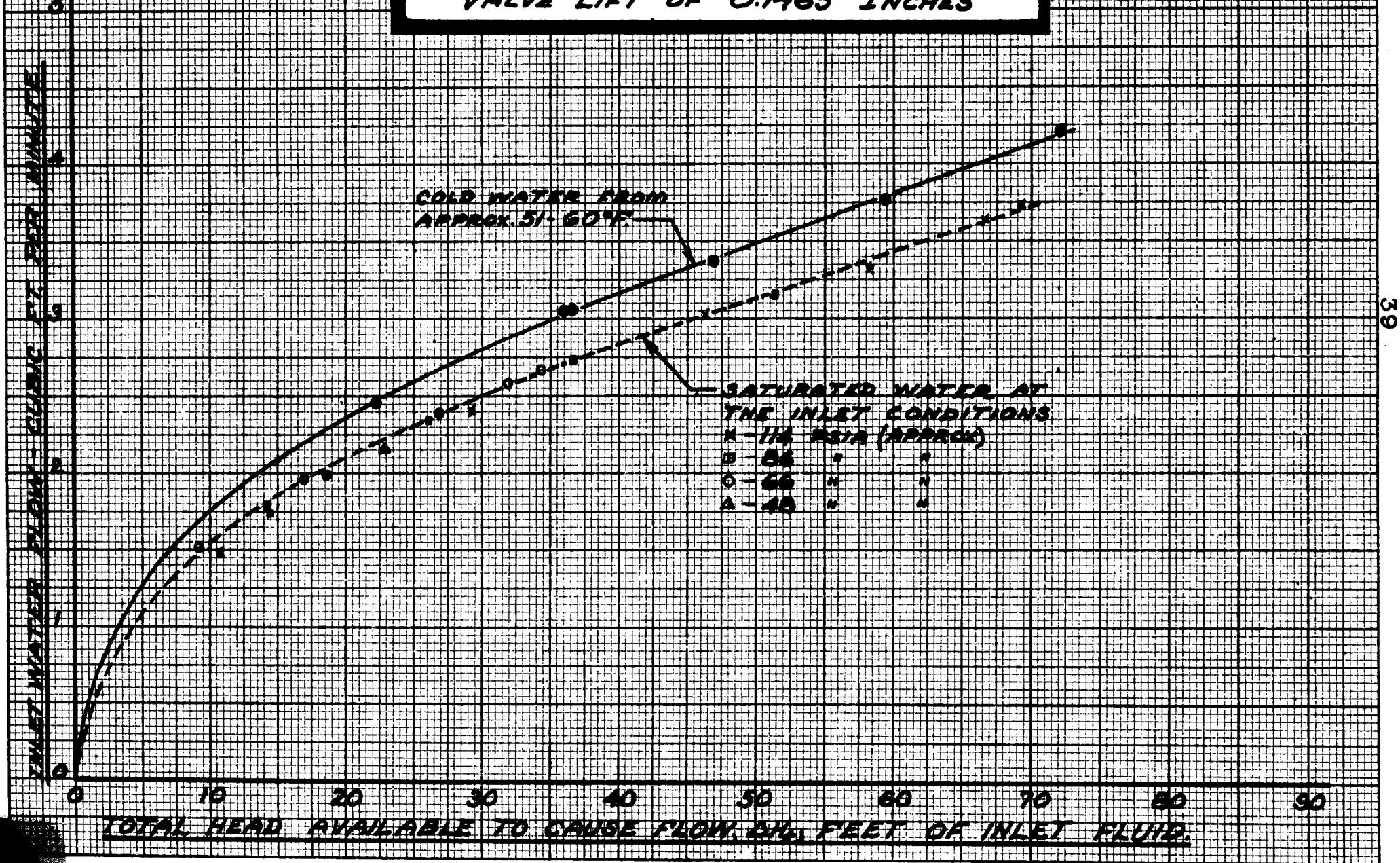
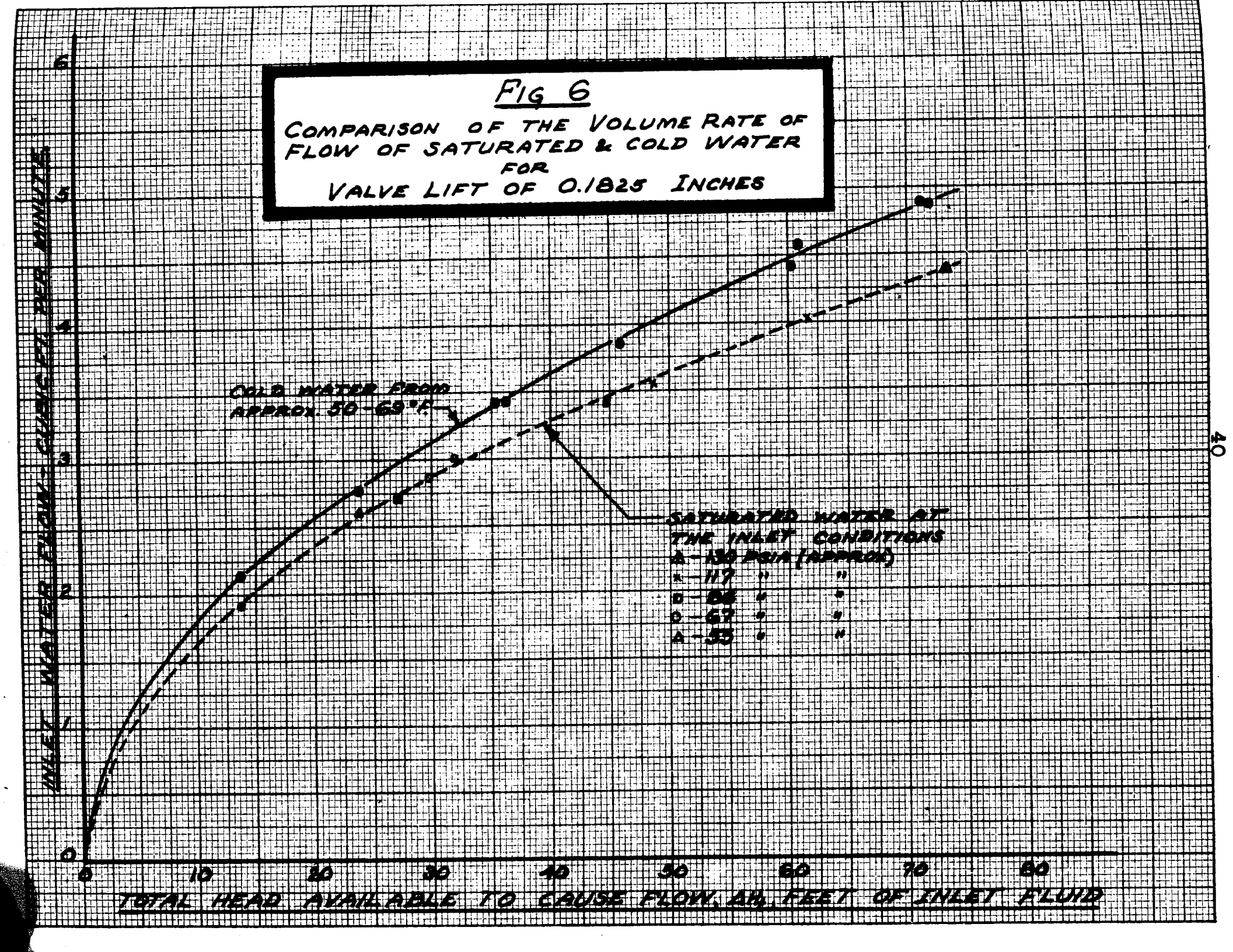
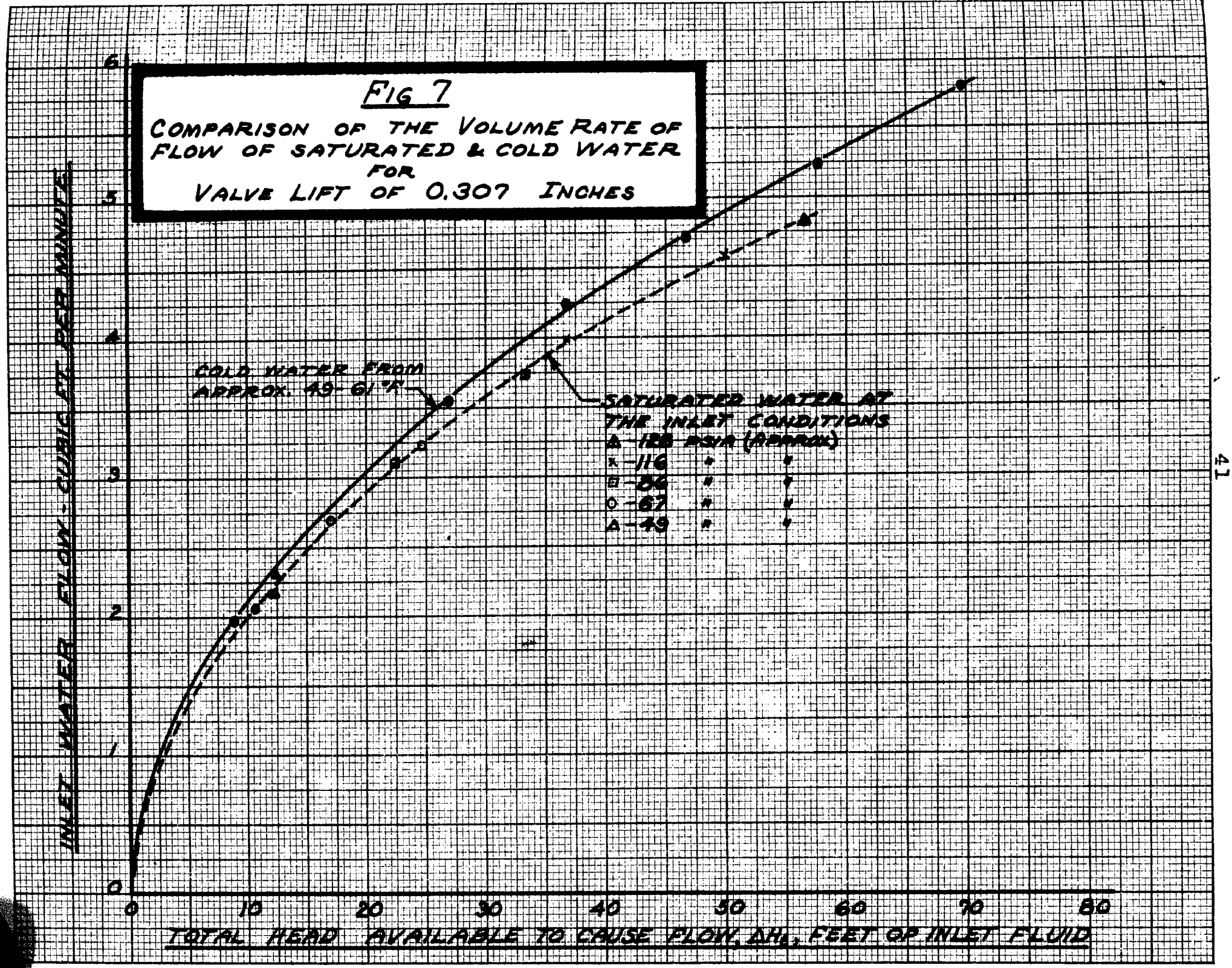

FIG 4
COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.1115 INCHES
COLD WATER FROM APPROX. 52-73°F
SATURATED WATER AT THE INLET CONDITIONS
x - 117 PSIA (APPROX)
■ - 87 " "
○ - 67 " "
△ - 49 " "
INLET WATER FLOW - CUBIC FT PER MINUTE
0
1
2
3
4
5
0
10
20
30
40
50
60
70
80
90
TOTAL HEAD AVAILABLE TO CAUSE FLOW, ΔH, FEET OF INLET FLUID

FIG 5

COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.1465 INCHES




FIG 6
COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.1825 INCHES
COLD WATER FROM APPROX. 50-69°F.
SATURATED WATER AT THE INLET CONDITIONS
A - 130 PSIA (APPROX)
x - 117 "
B - 88 "
D - 67 "
A - 55 "
INLET VOLUME FLOW, CUBIC FEET PER MINUTE
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
TOTAL HEAD AVAILABLE TO CAUSE FLOW, Δh, FEET OF INLET FLUID


FIG 7
COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER FOR VALVE LIFT OF 0.307 INCHES
INLET WATER FLOW - CUBIC FT. PER MINUTE
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
TOTAL HEAD AVAILABLE TO CAUSE FLOW, ΔH, FEET OF INLET FLUID
COLD WATER FROM APPROX. 49-61°F
SATURATED WATER AT THE INLET CONDITIONS
△ - 128 PSIA (APPROX)
X - 116 "
□ - 86 "
○ - 67 "
△ - 49 "

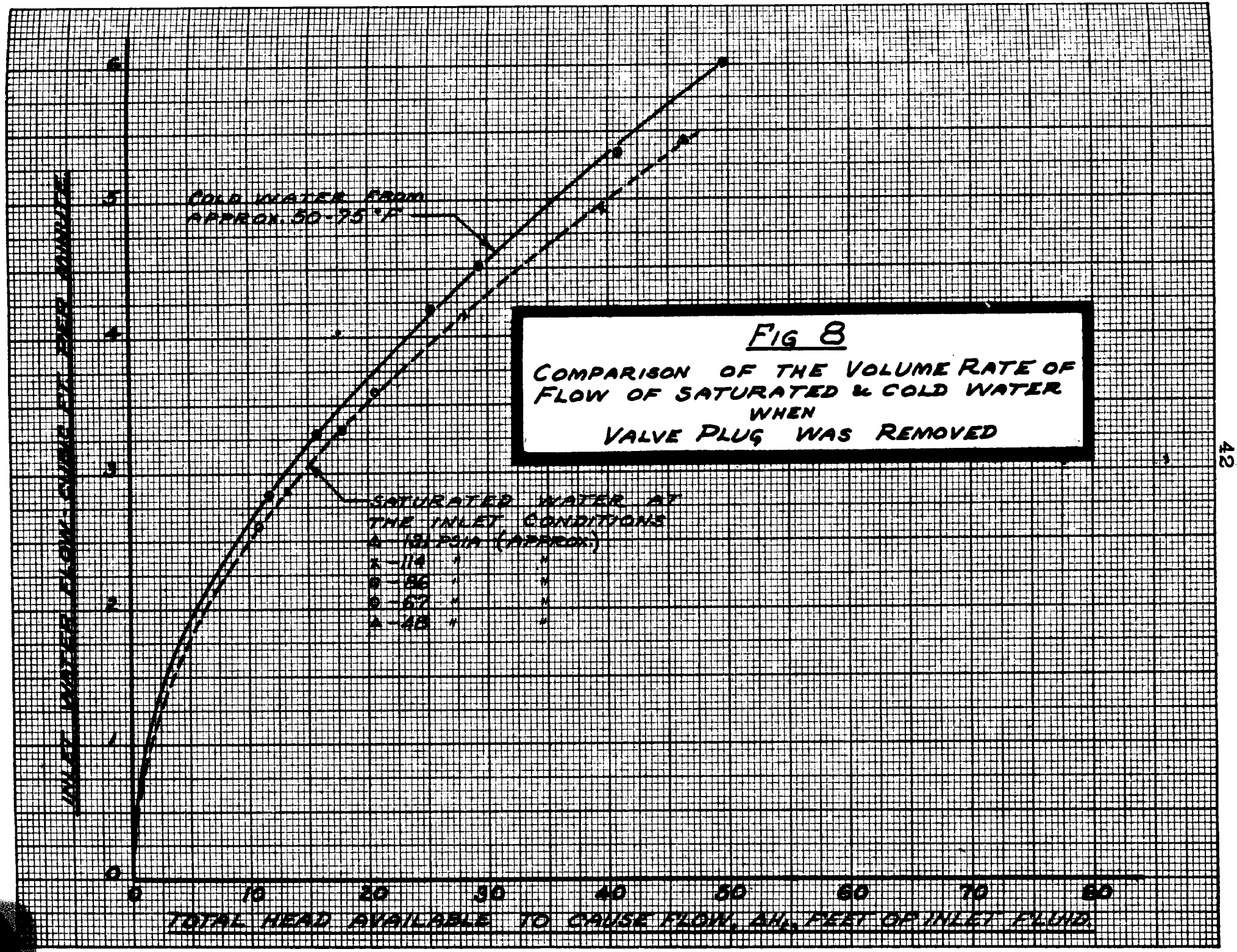
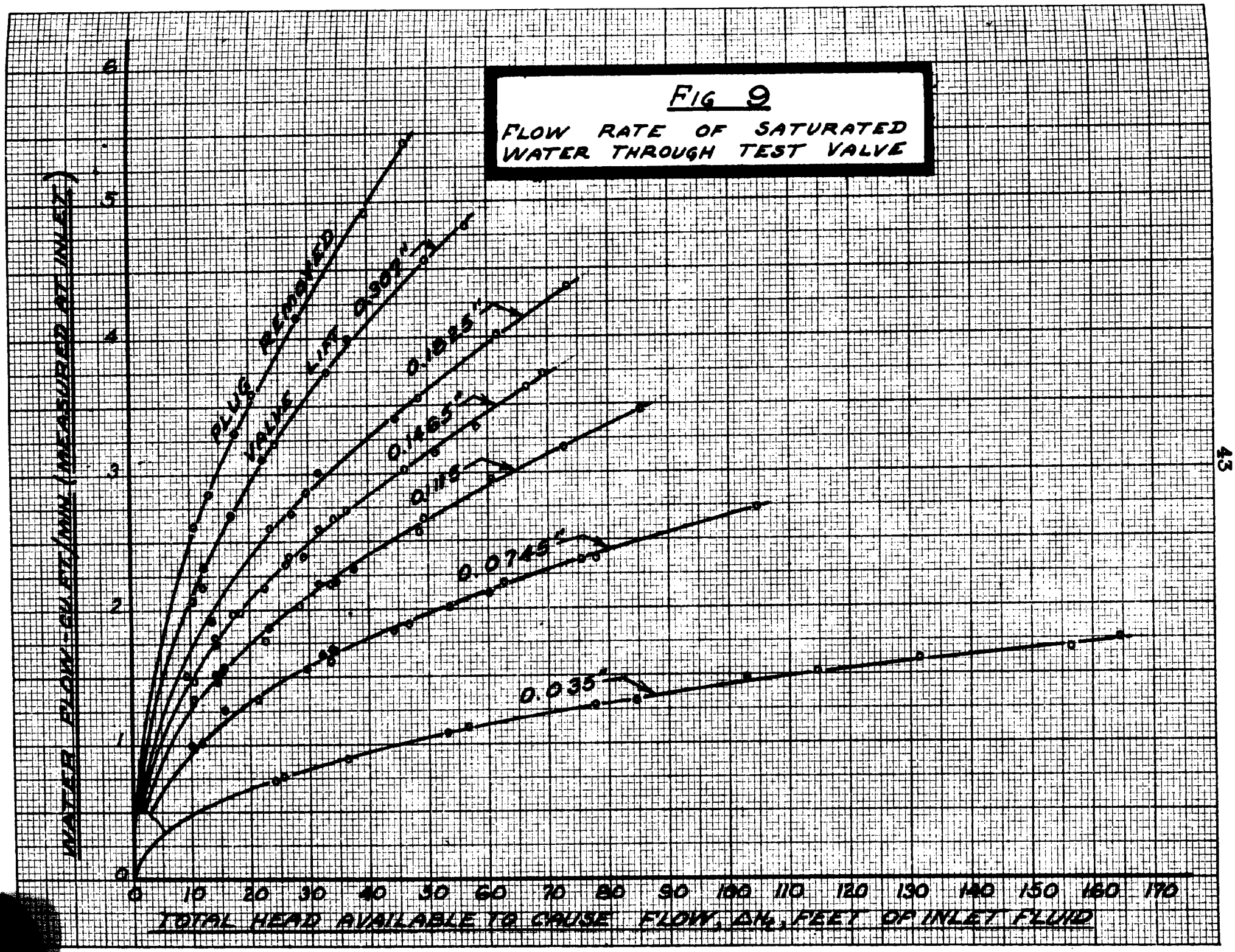
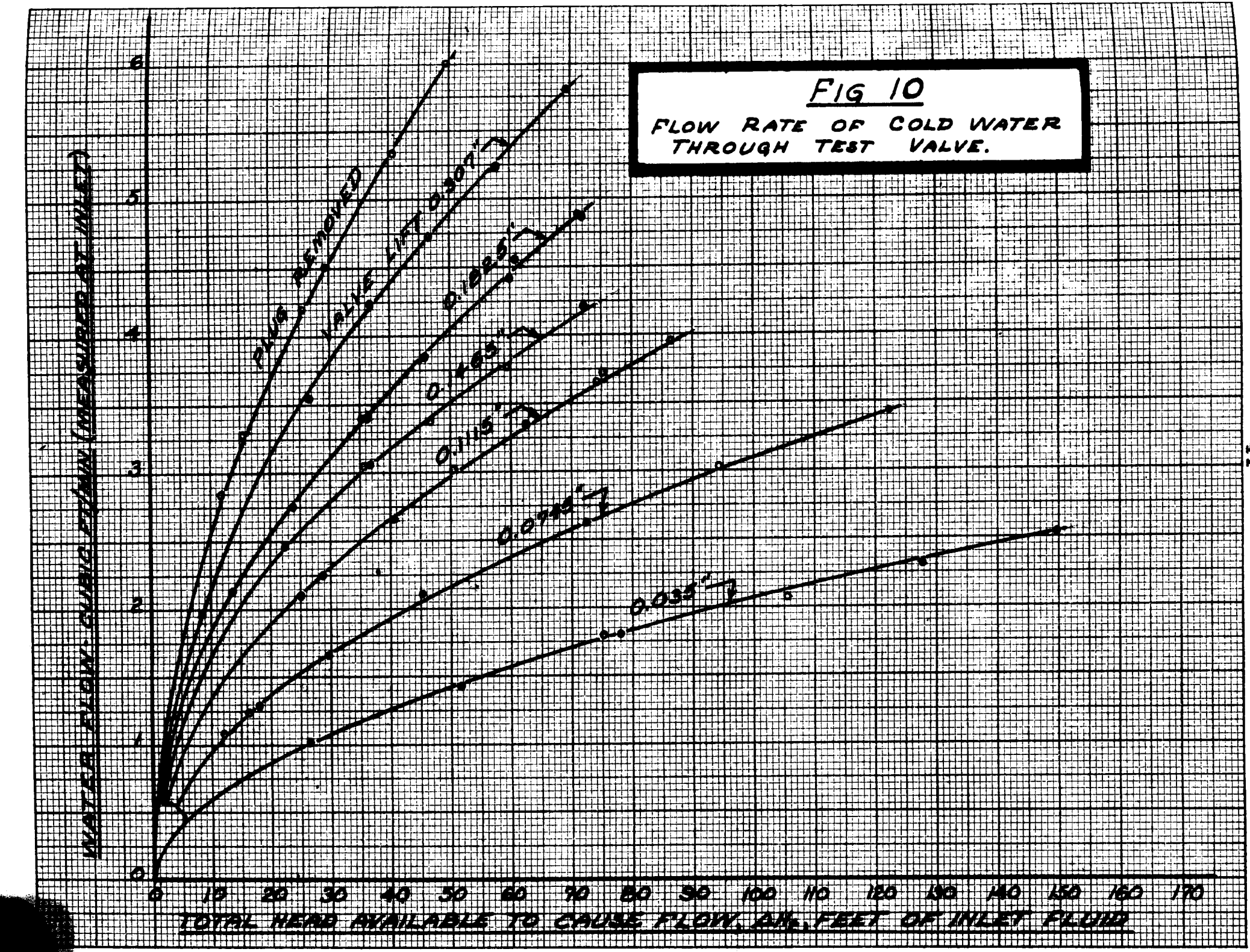
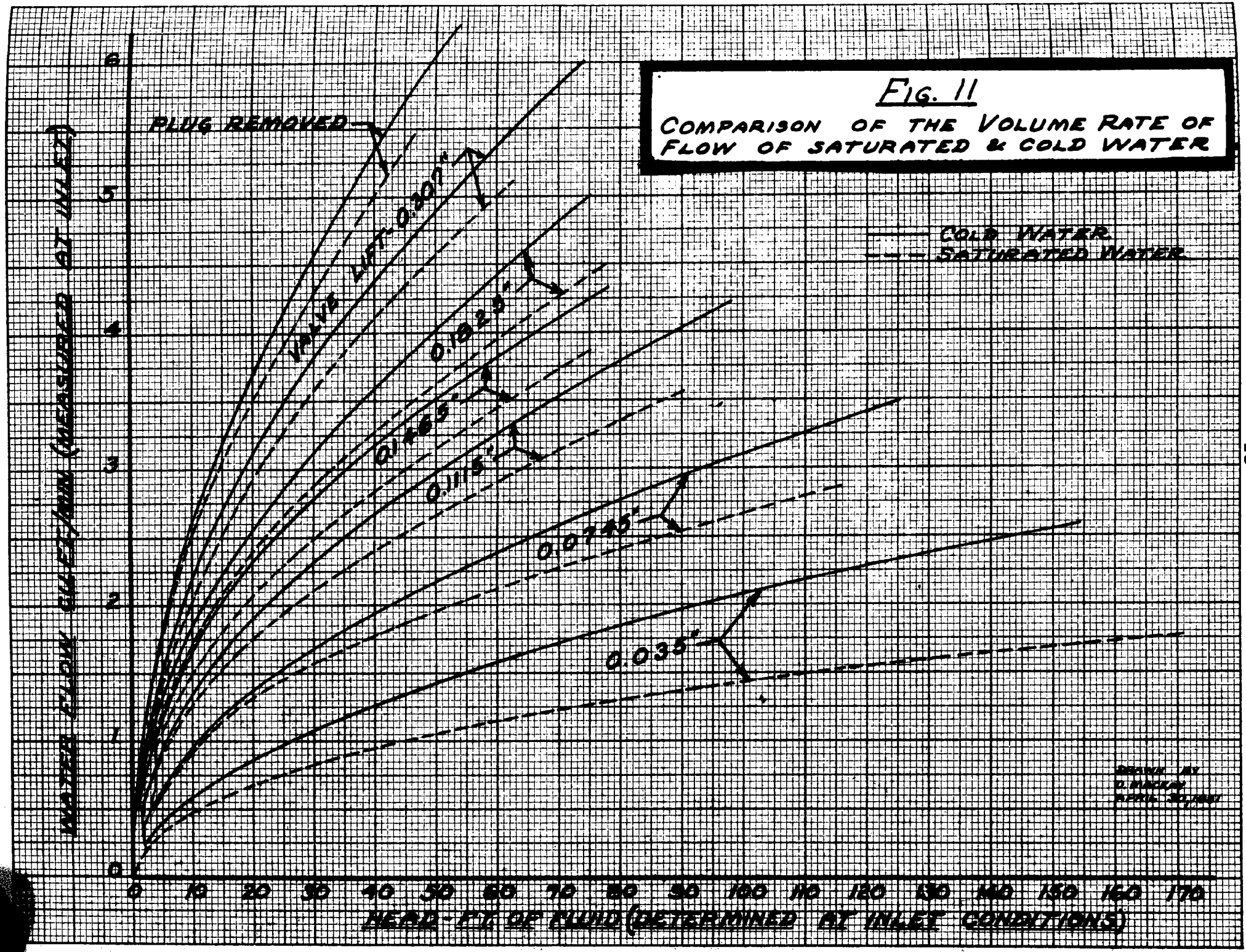


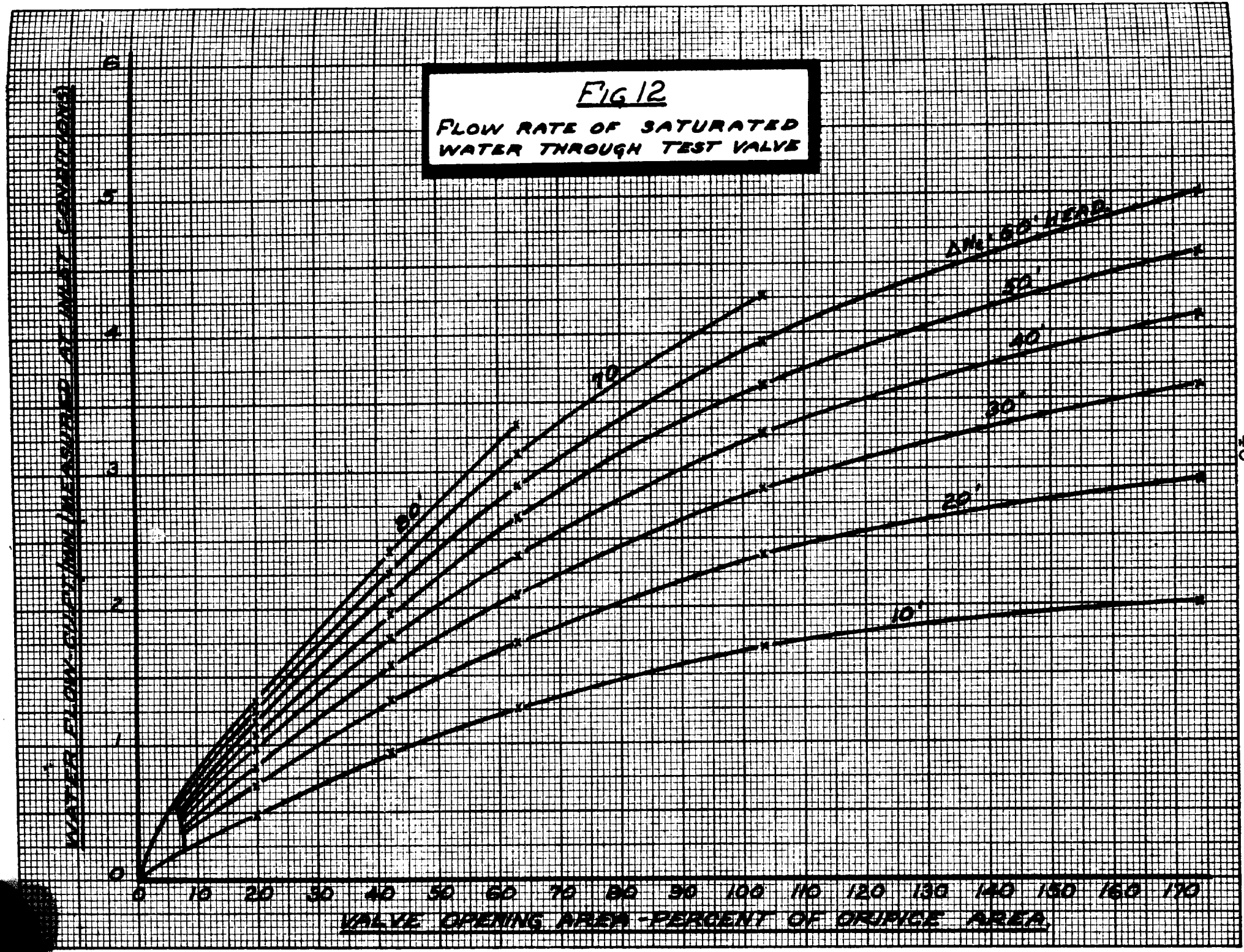
FIG 8

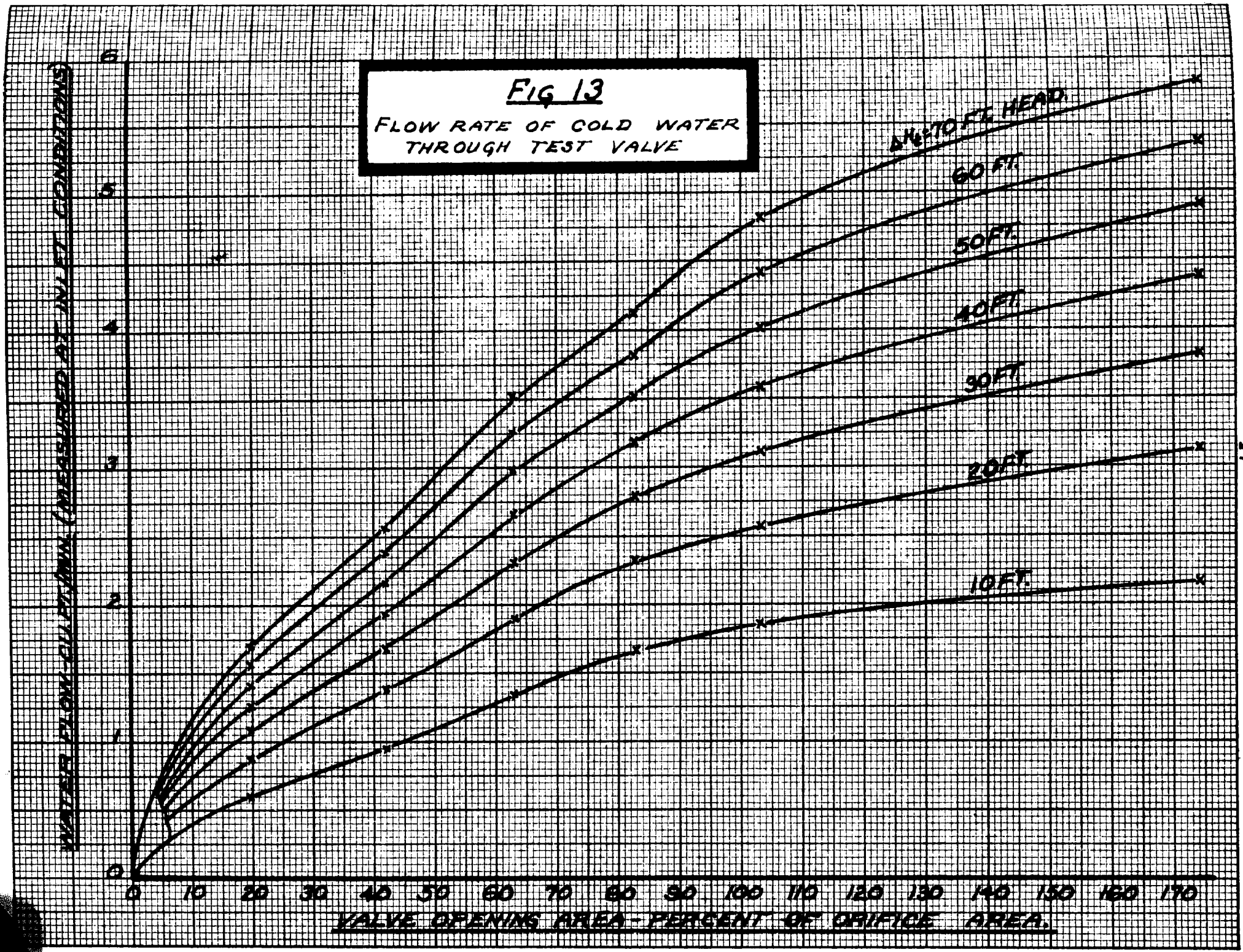
COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER WHEN VALVE PLUG WAS REMOVED

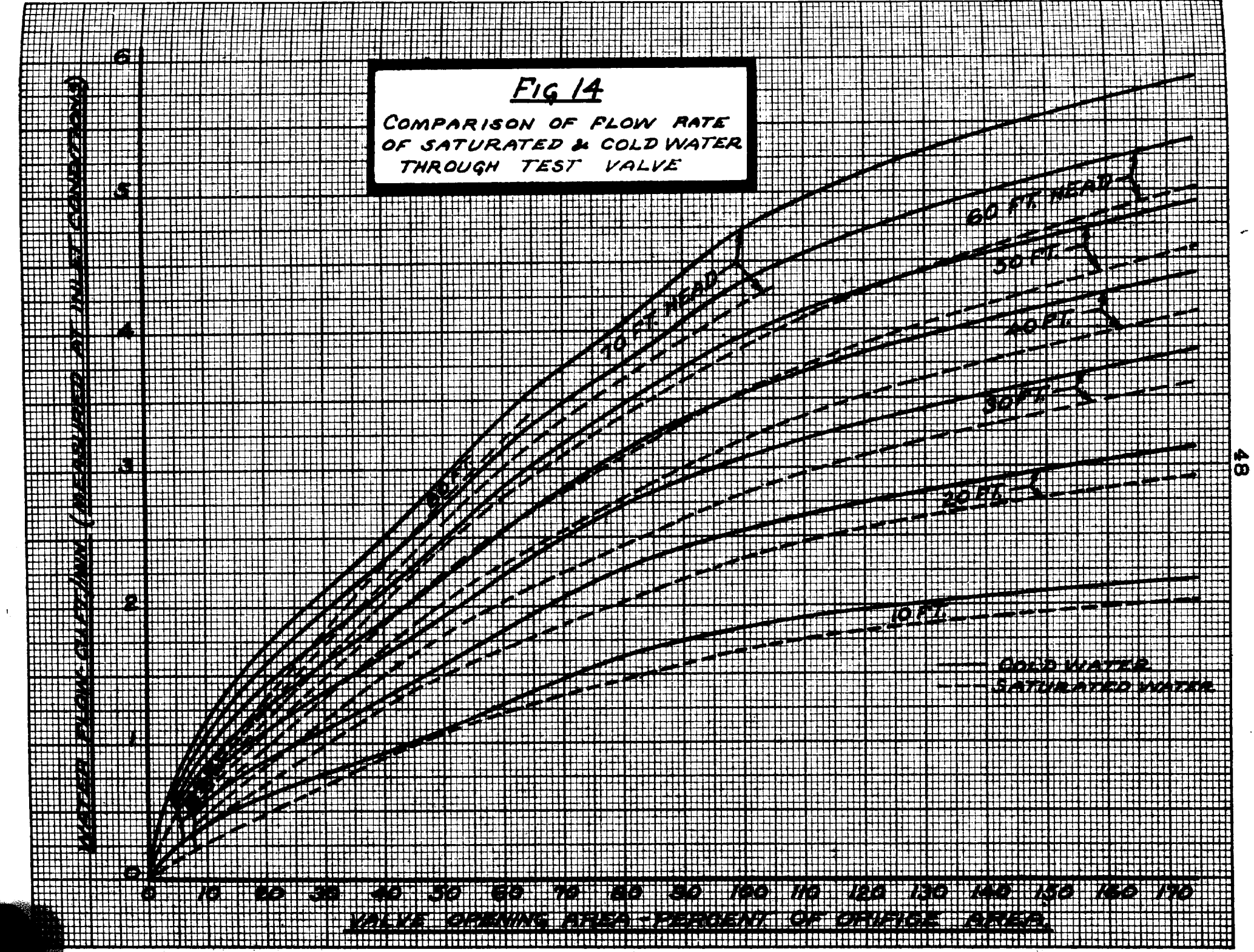

FIG 9
FLOW RATE OF SATURATED WATER THROUGH TEST VALVE
PLUG
VALVE
LIFT
0.302"
0.1825"
0.1465"
0.118"
0.0745"
0.035"
WATER FLOW, GAL/FT² (MIN.) (MEASURED AT INLET)
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
TOTAL HEAD AVAILABLE TO CAUSE FLOW, ΔH, FEET OF INLET FLUID


FIG 10
FLOW RATE OF COLD WATER THROUGH TEST VALVE.
WATER FLOW, GUMS PER MIN. (MEASURED AT INLET)
TOTAL HEAD AVAILABLE TO CAUSE FLOW, IN FEET OF INLET FLUID
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
1
2
3
4
5
6
DISK REMOVED
0.206"
0.166"
0.146"
0.1115"
0.0745"
0.035"


FIG. 11
COMPARISON OF THE VOLUME RATE OF FLOW OF SATURATED & COLD WATER
COLD WATER
SATURATED WATER
PLUG REMOVED
1/8" VLV
0.30"
0.10"
0.05"
0.115"
0.0745"
0.035"
WATER DELIVERED (MEASURED) IN GALLONS PER MINUTE
HEAD - FT. OF FLUID (DETERMINED AT INLET CONDITIONS)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
0 1 2 3 4 5 6


FIG 12
FLOW RATE OF SATURATED WATER THROUGH TEST VALVE
WATER FLOW-GALLONS PER MINUTE
0
1
2
3
4
5
6
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
VALVE OPENING AREA - PERCENT OF ORIFICE AREA
ΔH = 60' HEAD
50'
40'
30'
20'
10'


FIG 13
FLOW RATE OF COLD WATER THROUGH TEST VALVE
WATER FLOW-GALLONS PER MIN. (MEASURED AT INLET CONDITIONS)
VALVE OPENING AREA - PERCENT OF ORIFICE AREA.
ΔH = 70 FT. HEAD
60 FT.
50 FT.
40 FT.
30 FT.
20 FT.
10 FT.
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170


FIG 14
COMPARISON OF FLOW RATE OF SATURATED & COLD WATER THROUGH TEST VALVE
60 FT. HEAD
50 FT.
40 FT.
30 FT.
20 FT.
10 FT.
COLD WATER
SATURATED WATER
VALVE OPENING AREA - PERCENT OF ORIFICE AREA
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
0 1 2 3 4 5 6

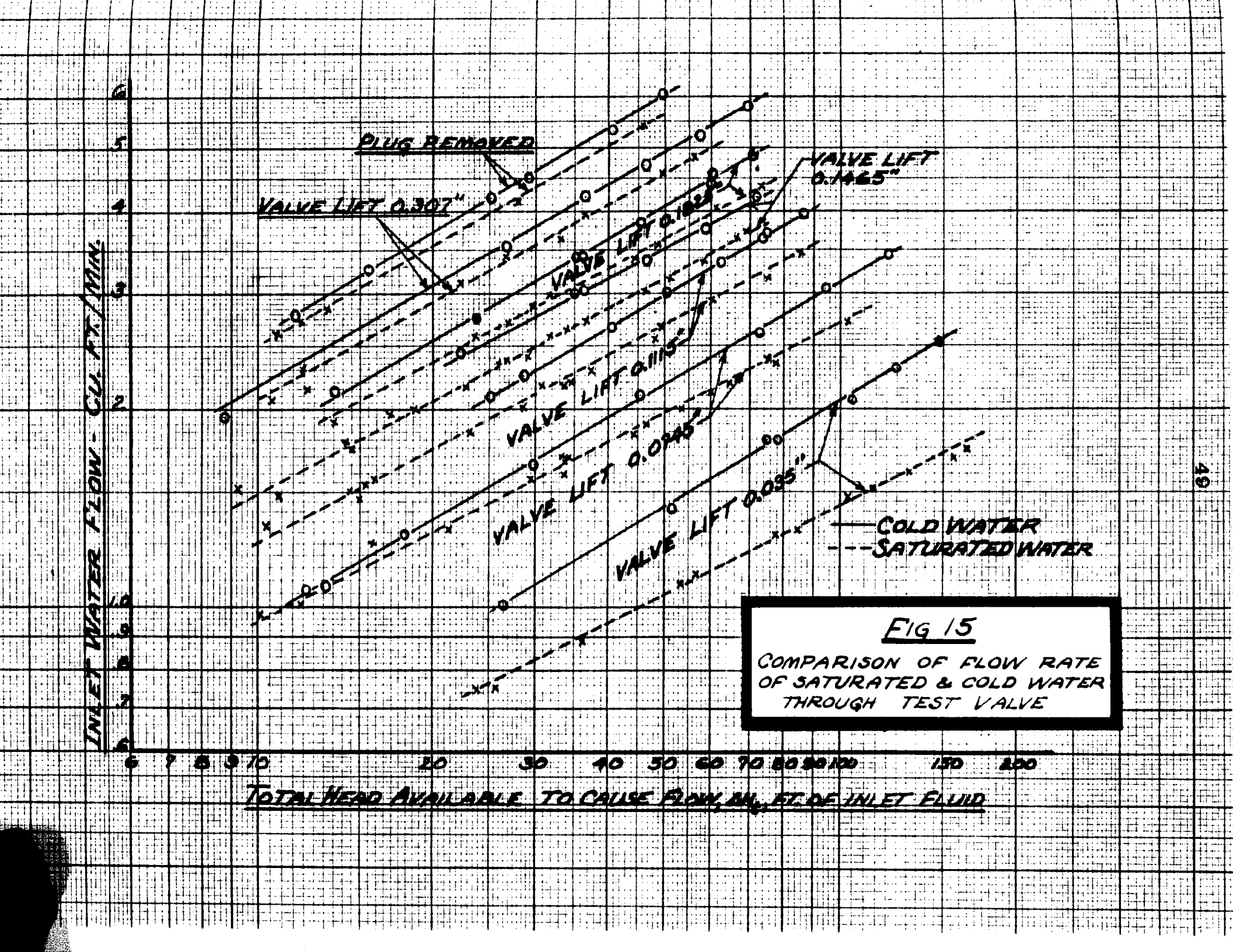
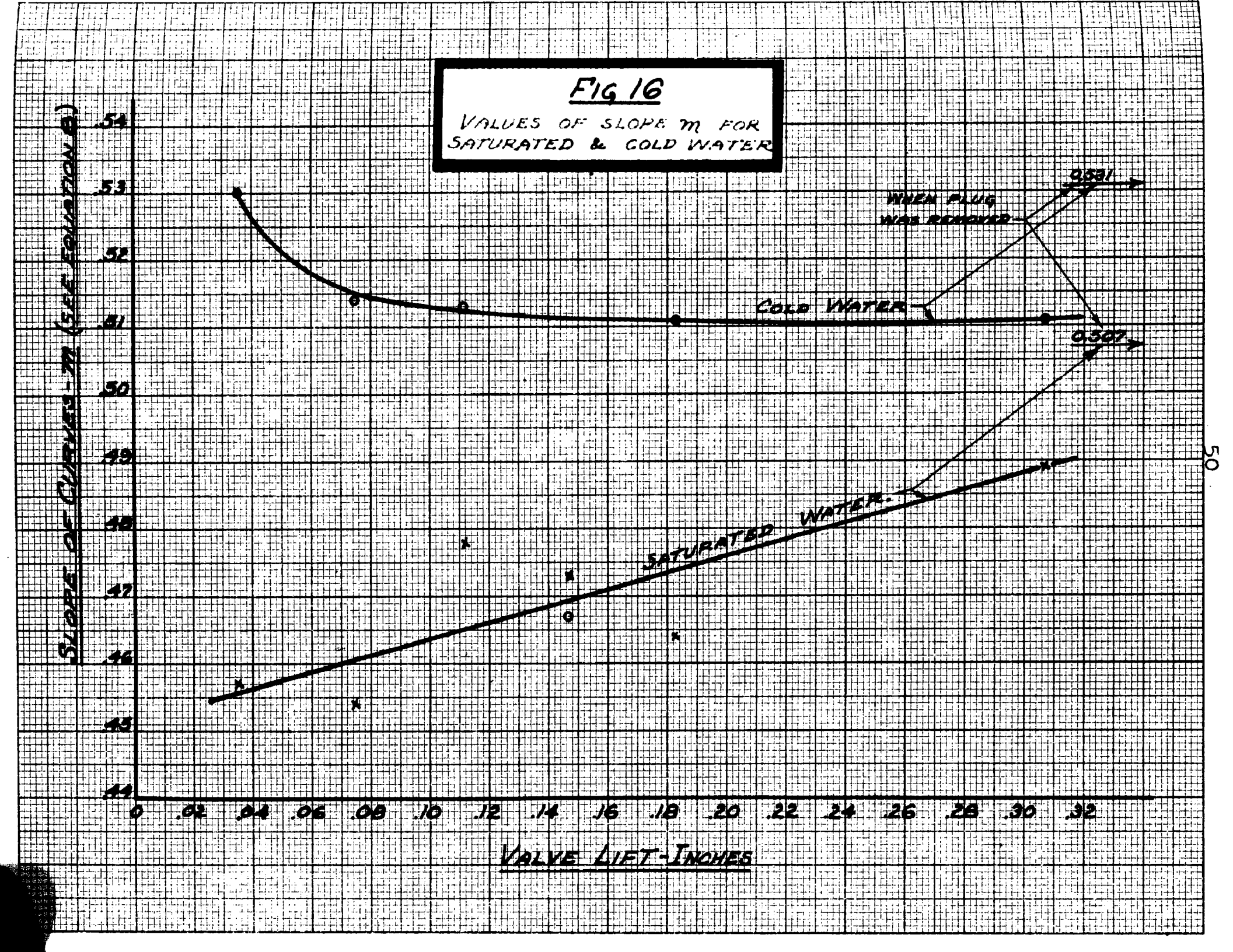
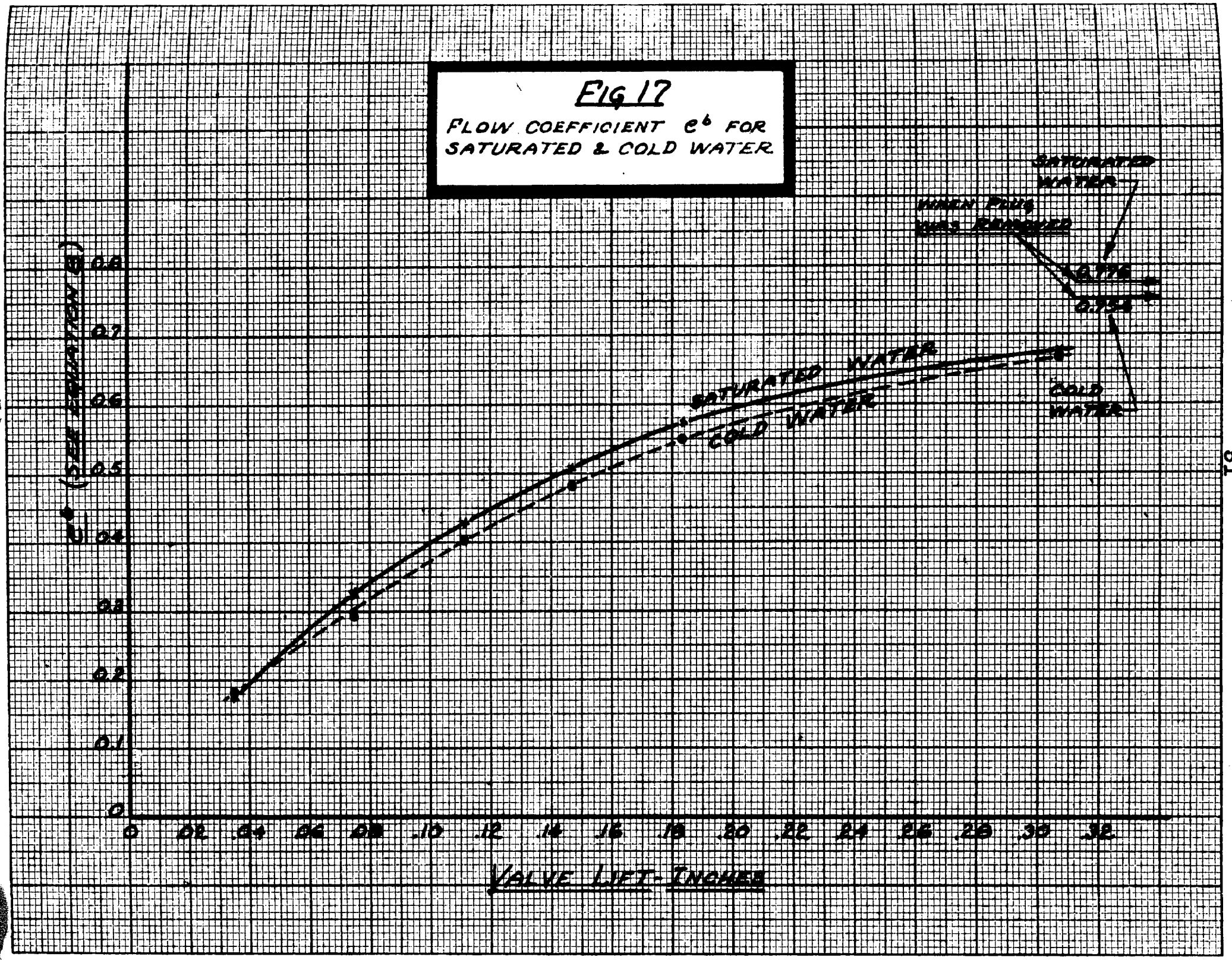
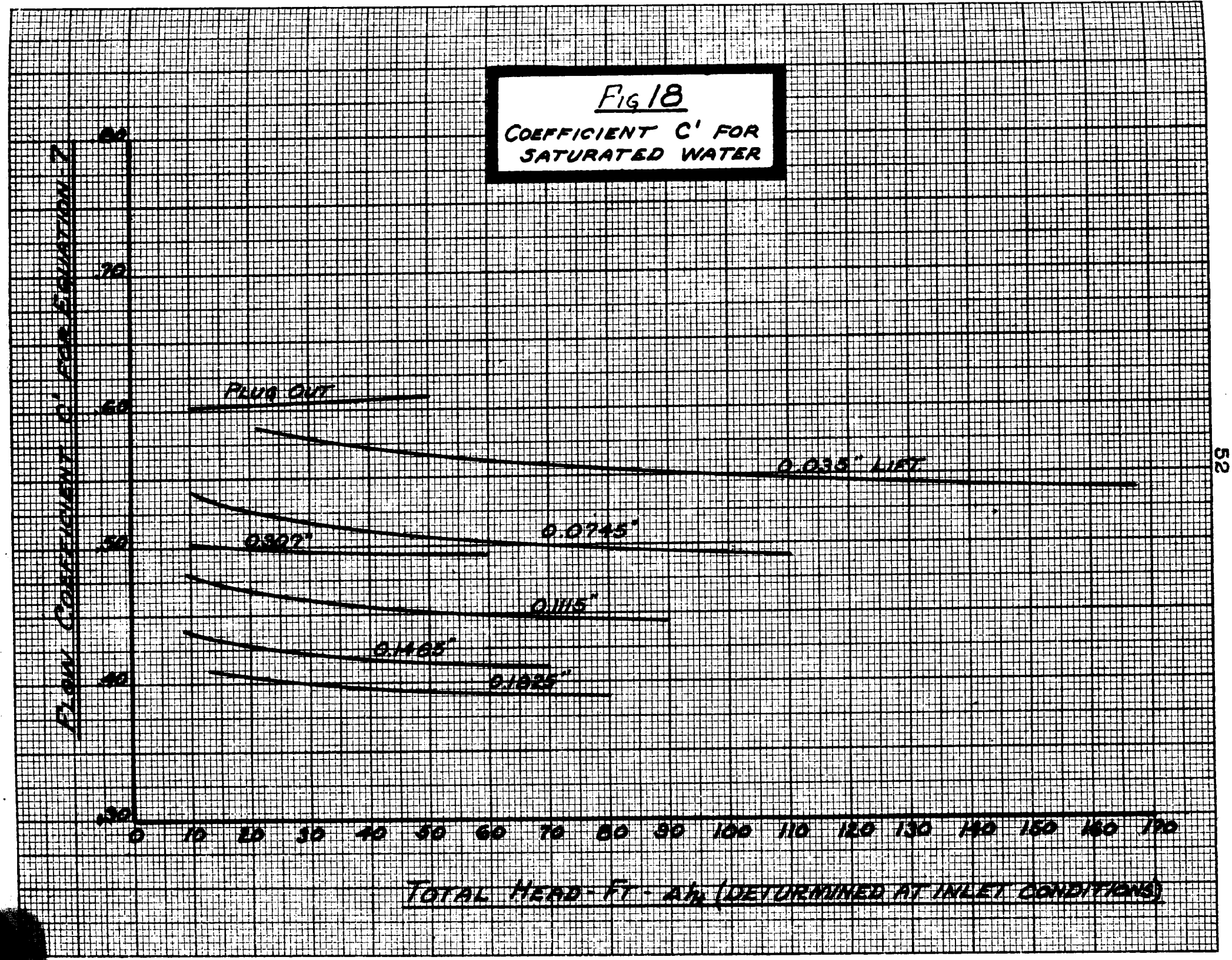


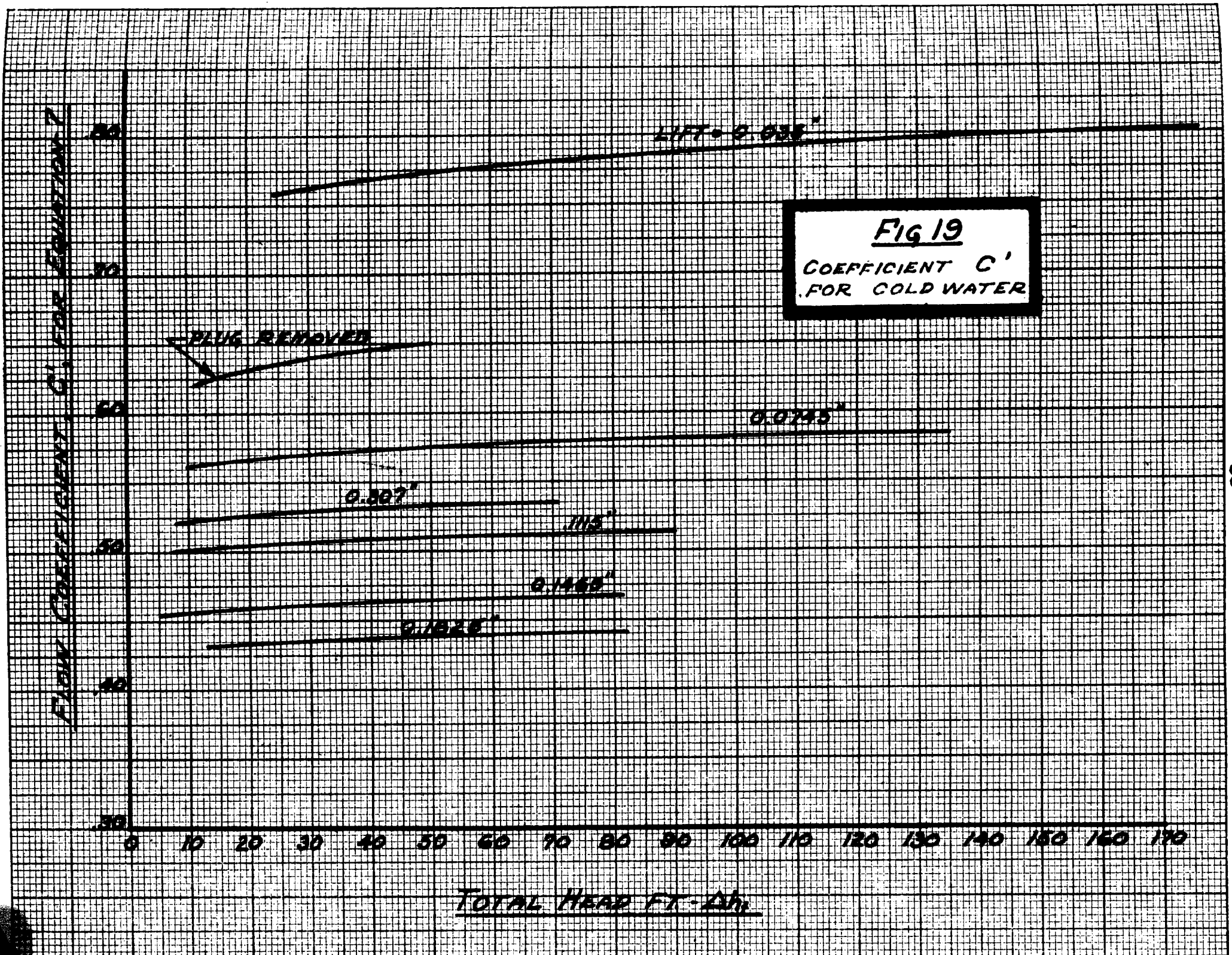
FIG 15

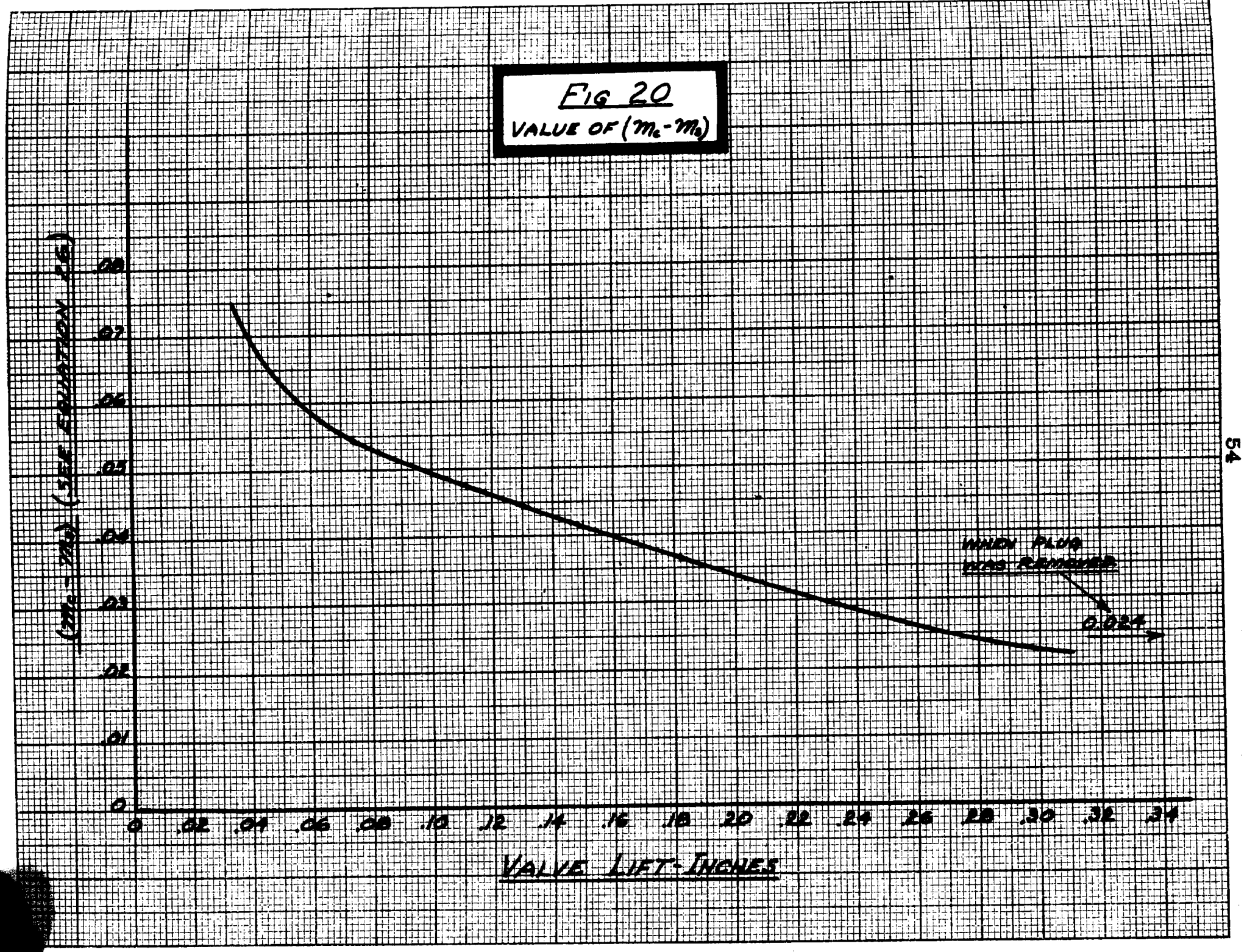
COMPARISON OF FLOW RATE OF SATURATED & COLD WATER THROUGH TEST VALVE

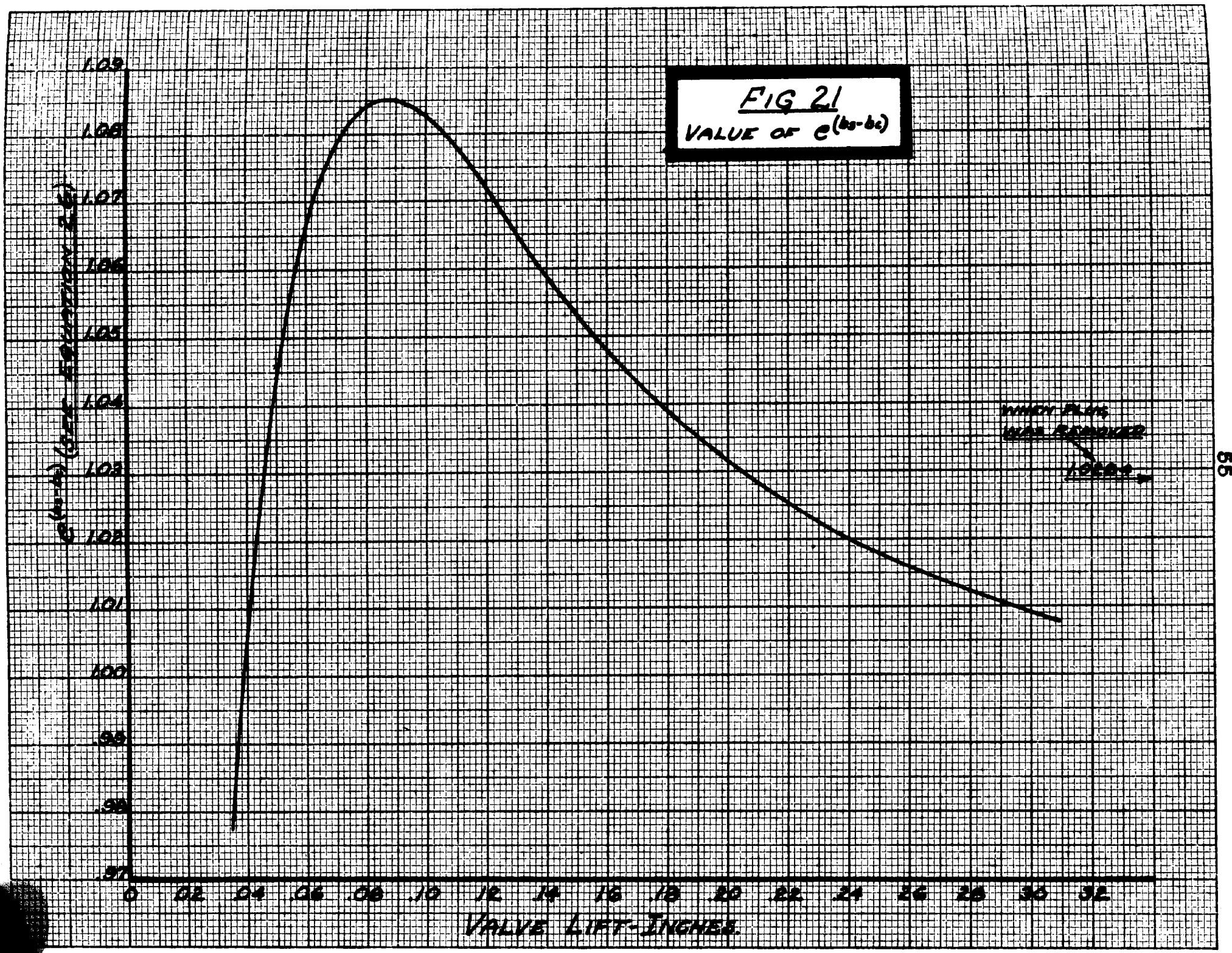

FIG 16
VALUES OF SLOPE m FOR SATURATED & COLD WATER
SLOPES OF CURVES - m (IN EQUATION P = C/V^m)
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
.32
VALVE LIFT - INCHES
0531
WHEN PLUG WAS REMOVED
COLD WATER
0502
SATURATED WATER.

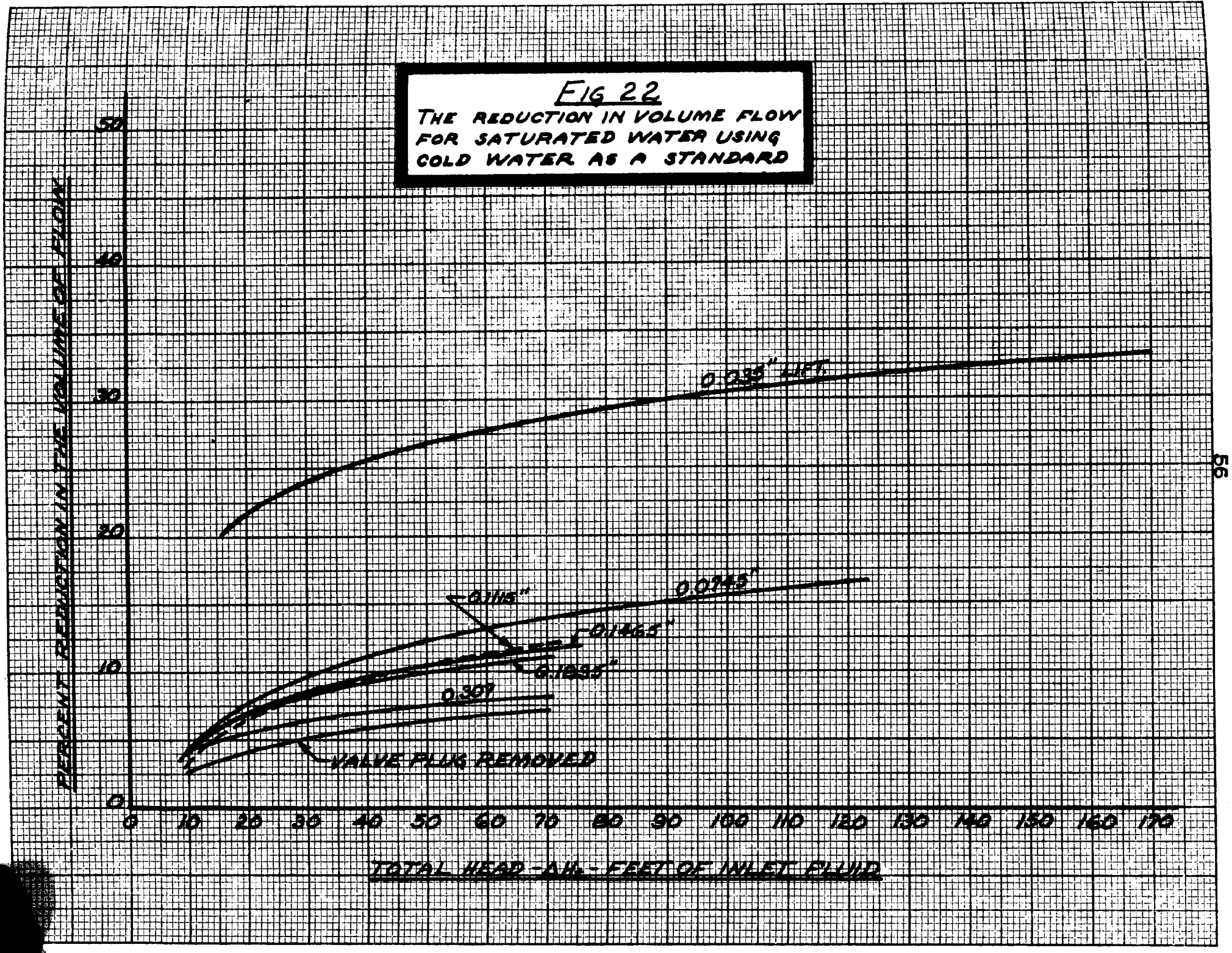

FIG 17
FLOW COEFFICIENT C_b FOR SATURATED & COLD WATER
SATURATED WATER
WHEN FLOW WAS REVERSED
0.775
0.758
SATURATED WATER
COLD WATER
COLD WATER
0.6
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
.32
VALVE LIFT - INCHES

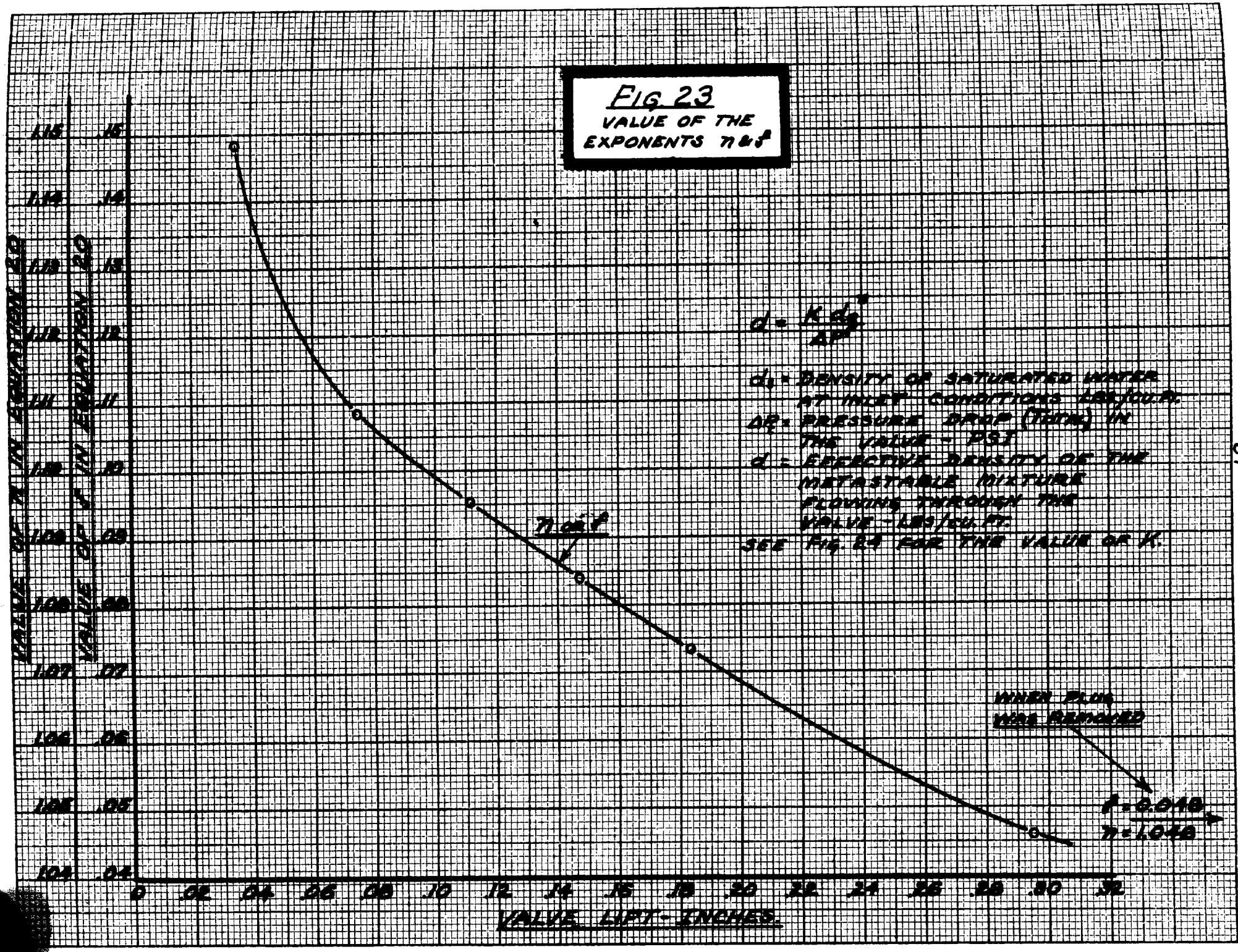

Fig 18
Coefficient C' for saturated water
Flow Coefficient C' = Q/A√2gh
80
70
60
50
40
30
Plug Out
0.035" Lift
0.0745"
0.0302"
0.1115"
0.1485"
0.1925"
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Total Head - Ft - Δh (Determined at inlet conditions)


Fig 19
Coefficient C'
for Cold Water
Plug Removed
Lift - 0.635"
0.0745"
0.307"
.1115"
0.1465"
0.1826"
Coefficient C'
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Total Head Ft. - Δh


FIG 20
VALUE OF ($m_c - m_s$)
($m_c - m_s$) (SEE EQUATION 25)
.08
.07
.06
.05
.04
.03
.02
.01
0
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
.32
.34
VALVE LIFT-INCHES
WHEN PLUG WAS REMOVED
0.024


FIG 21
VALUE OF e(bo-bc)
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
.99
.98
.97
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
.32
VALVE LIFT-INCHES.
INTAKE PORT WAS REMOVED


FIG 22
THE REDUCTION IN VOLUME FLOW FOR SATURATED WATER USING COLD WATER AS A STANDARD
PERCENT REDUCTION IN THE VOLUME OF FLOW
50
40
30
20
10
0
0.235" LIFT
0.0742"
0.1115"
0.1465"
0.1935"
0.307"
VALVE PLUG REMOVED
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
TOTAL HEAD - ΔHa - FEET OF INLET FLUID


FIG. 23
VALUE OF THE EXPONENTS n & β
$d = \frac{K d_f^{\beta}}{\Delta P^{n}}$
d_f = DENSITY OF SATURATED WATER AT INLET CONDITIONS - LBS/CU. FT.
ΔP = PRESSURE DROP (THRU) IN THE VALVE - PSI
d = EFFECTIVE DENSITY OF THE METASTABLE MIXTURE FLOWING THROUGH THE VALVE - LBS/CU. FT.
SEE FIG. 24 FOR THE VALUE OF K.
n and β
WHEN FLOW WAS REMOVED
β = 0.018
n = 1.048
1.15 .15
1.14 .14
1.13 .13
1.12 .12
1.11 .11
1.10 .10
1.09 .09
1.08 .08
1.07 .07
1.06 .06
1.05 .05
1.04 .04
0 .02 .04 .06 .08 .10 .12 .14 .16 .18 .20 .22 .24 .26 .28 .30 .32
VALVE LIFT - INCHES.

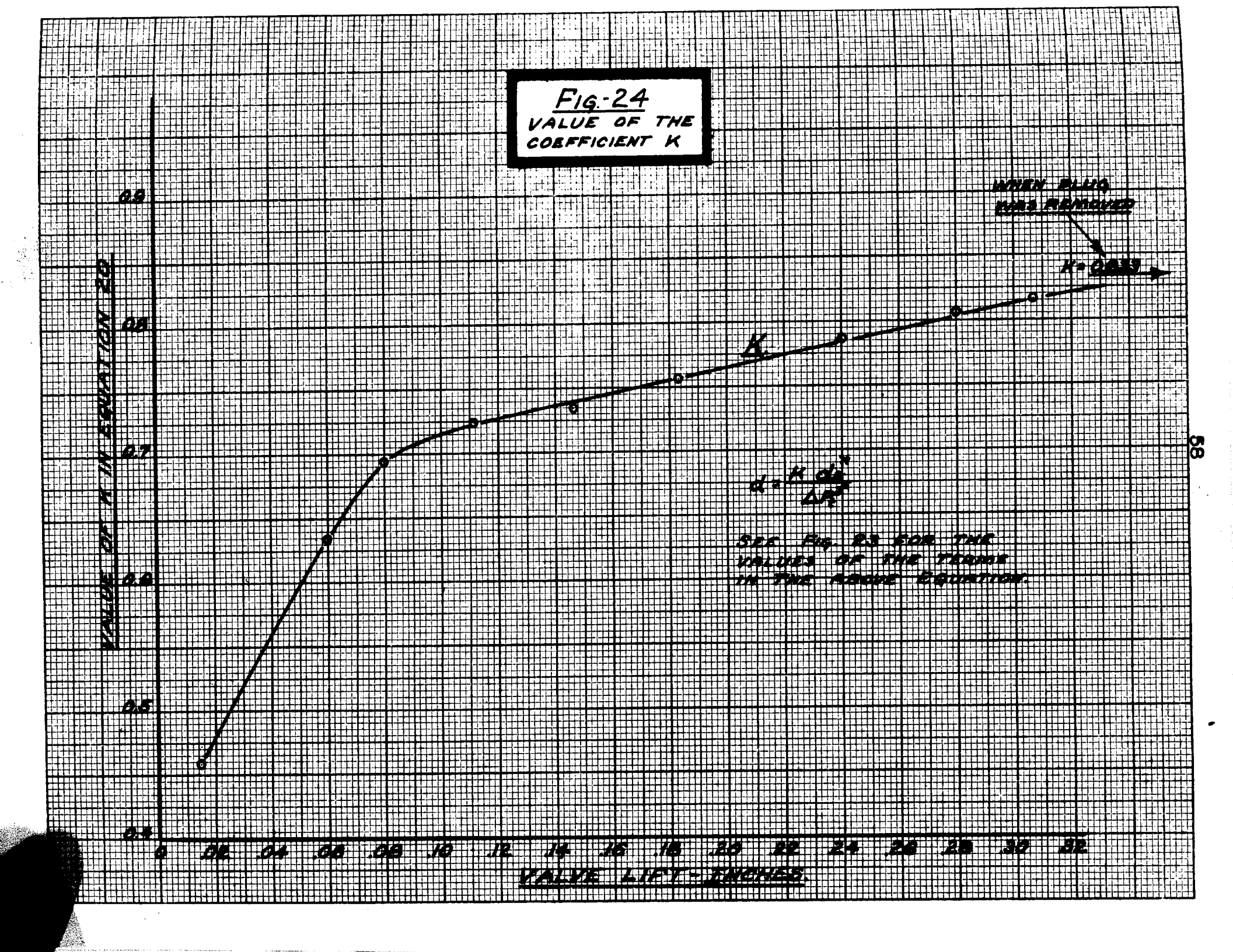

FIG.-24
VALUE OF THE COEFFICIENT K
WHEN PLATE WAS REMOVED
K = 0.633
K
$d = K \frac{d\phi}{\Delta P}$
SEE Fig. 23 FOR THE VALUES OF THE TERMS IN THE ABOVE EQUATION.
VALUE OF K IN EQUATION 22
0.9
0.8
0.7
0.6
0.5
0.4
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
.32
VALVE LIFT - INCHES.

FIG-25 COMPARISON OF TESTS NUMBERS 62 & 227

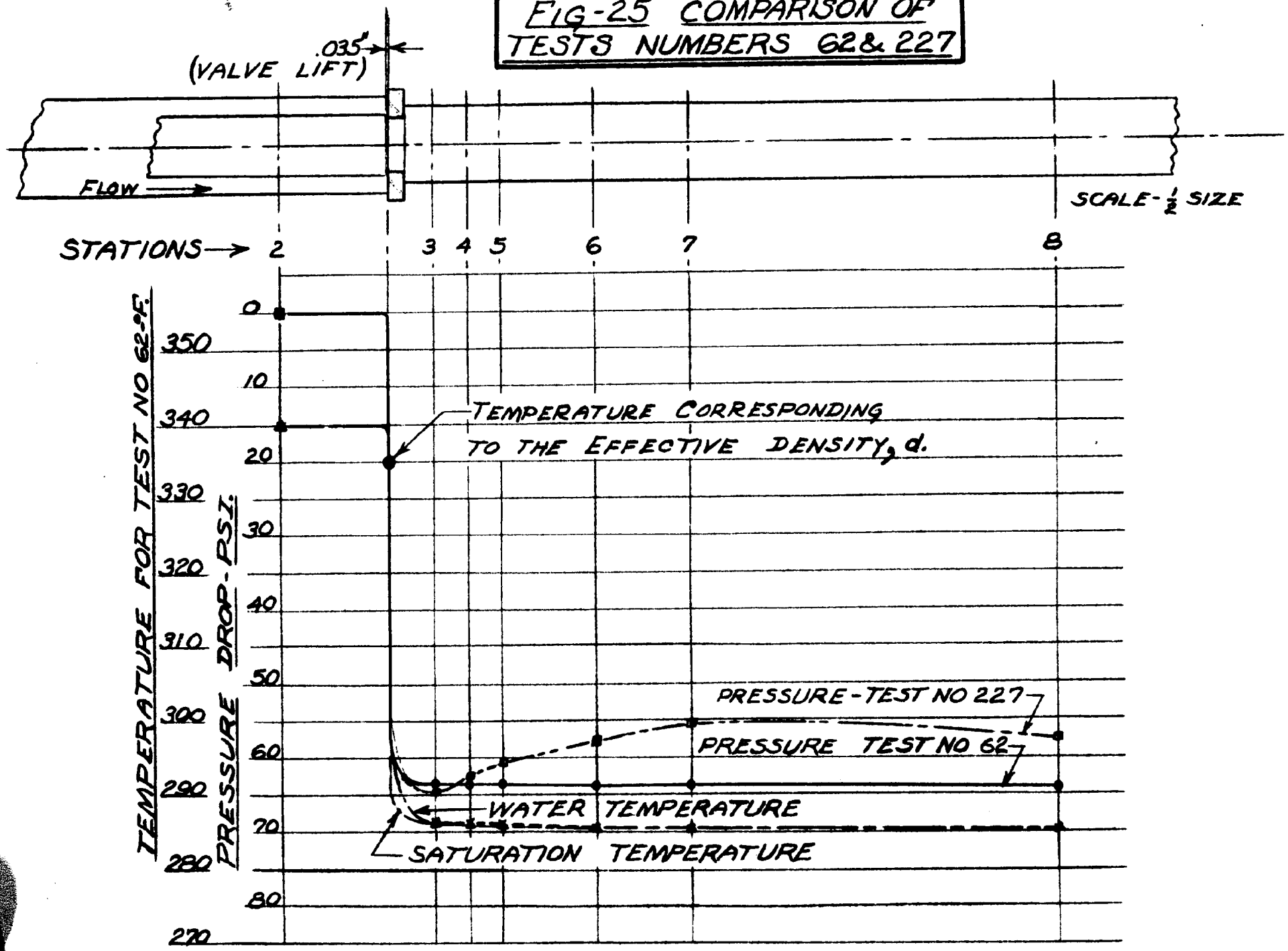
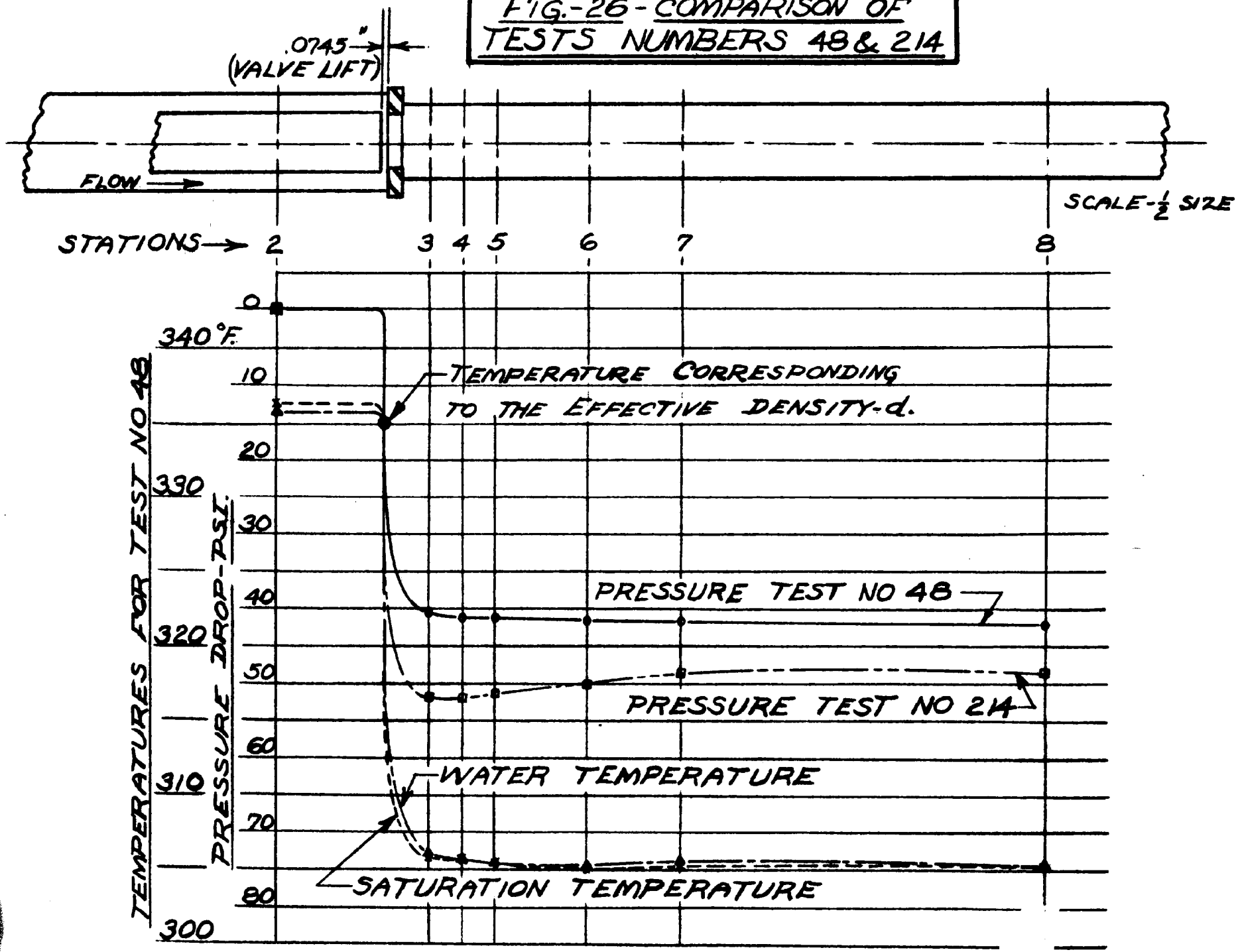
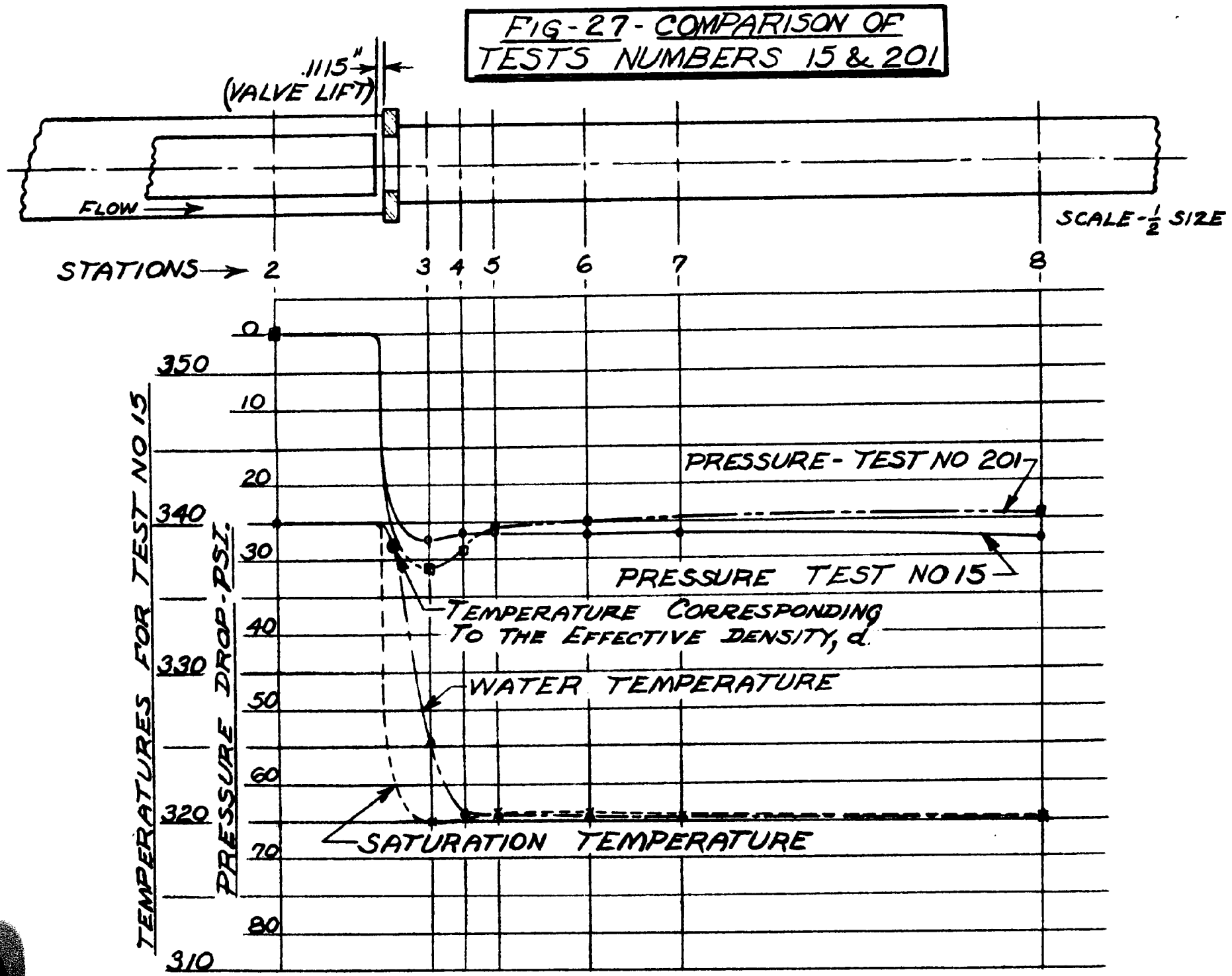


FIG.-26 - COMPARISON OF TESTS NUMBERS 48 & 214




FIG-27 - COMPARISON OF TESTS NUMBERS 15 & 201
.1115" (VALVE LIFT)
FLOW
SCALE - 1/2 SIZE
STATIONS → 2 3 4 5 6 7 8
0
10
20
30
40
50
60
70
80
350
340
330
320
310
TEMPERATURES FOR TEST NO 15
PRESSURE DROP - PSI.
PRESSURE - TEST NO 201
PRESSURE TEST NO 15
TEMPERATURE CORRESPONDING TO THE EFFECTIVE DENSITY, d.
WATER TEMPERATURE
SATURATION TEMPERATURE

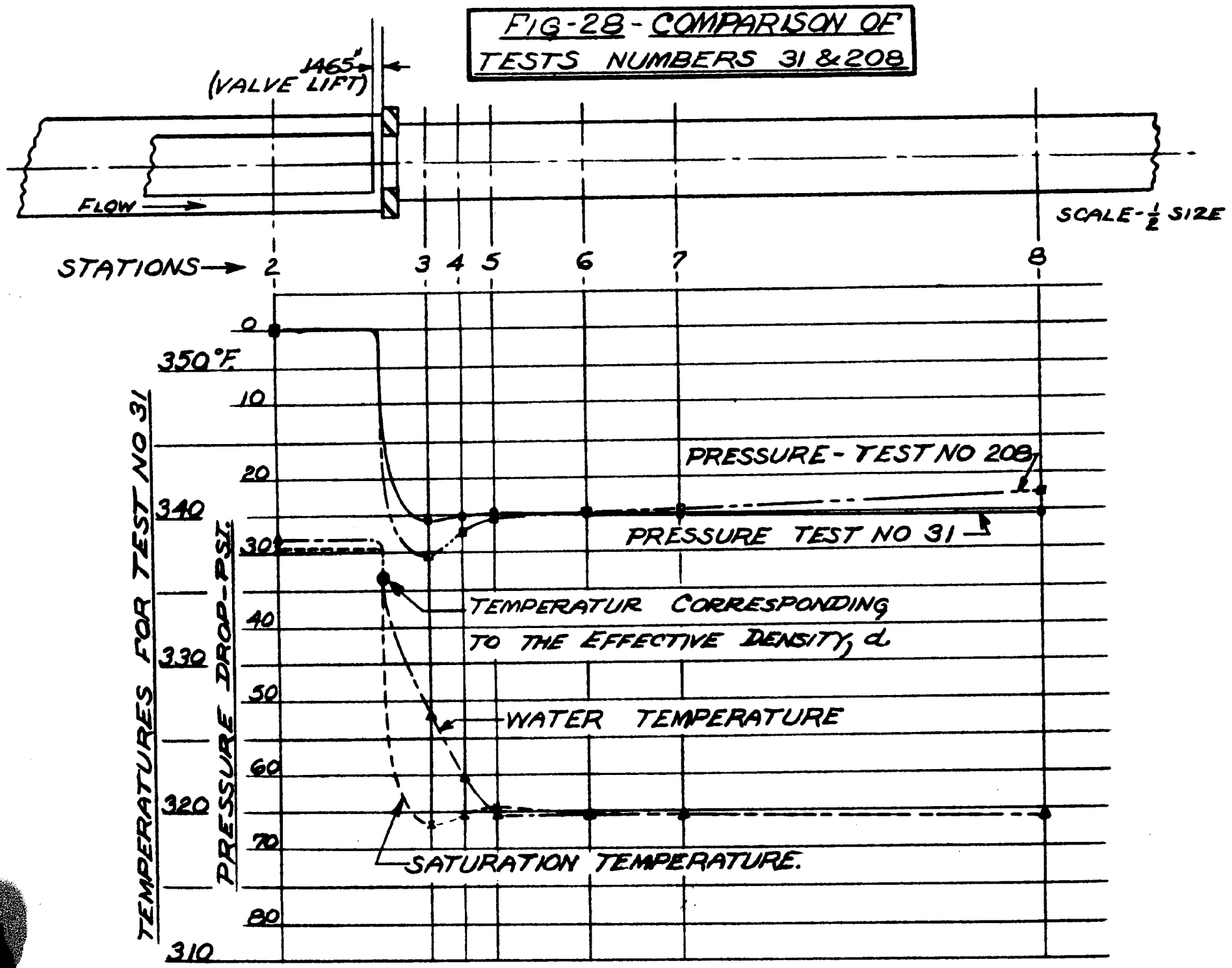
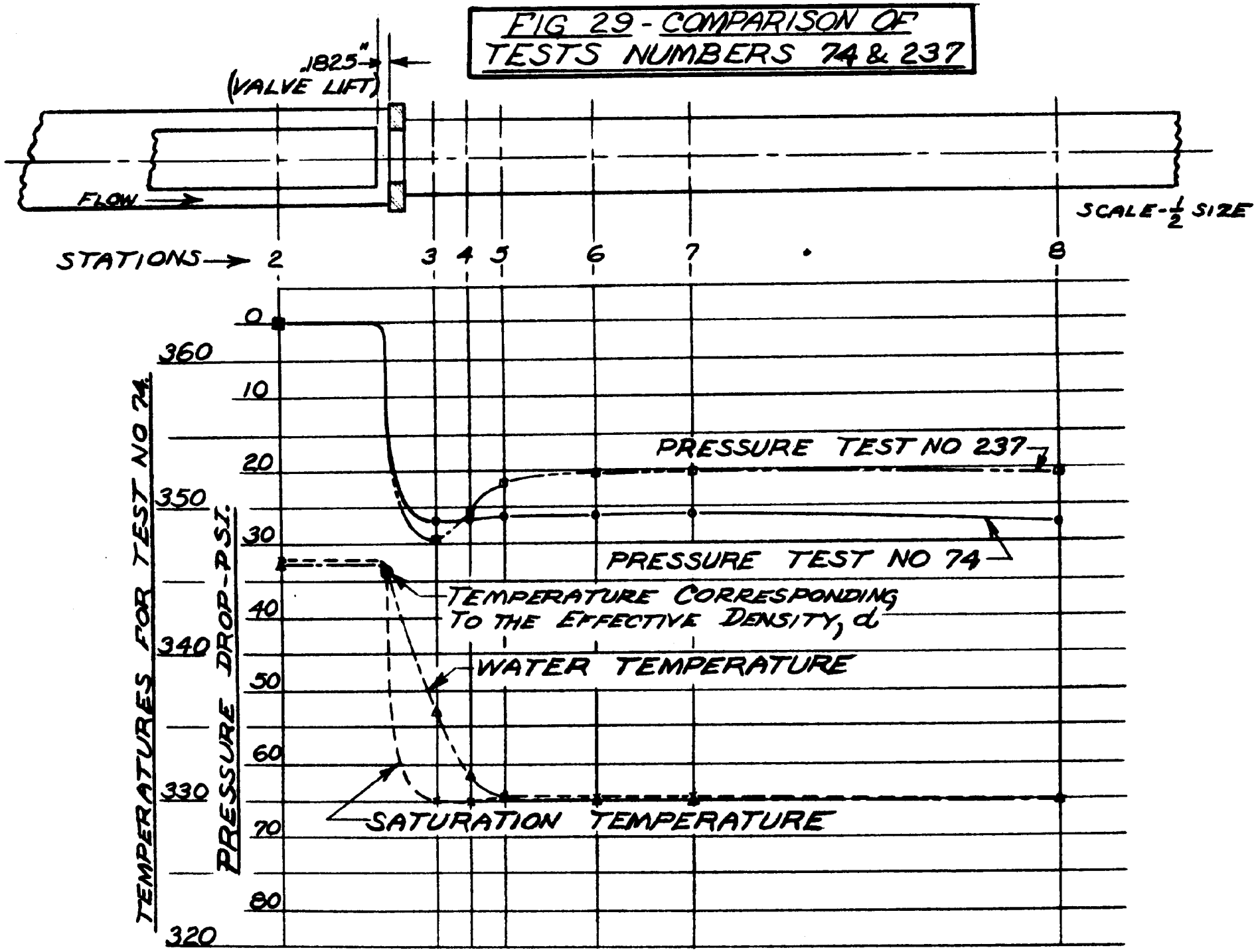

FIG-28 - COMPARISON OF TESTS NUMBERS 31 & 208
1465" (VALVE LIFT)
FLOW
SCALE - 1/2 SIZE
STATIONS → 2 3 4 5 6 7 8
0
10
20
30
40
50
60
70
80
350°F
340
330
320
310
TEMPERATURES FOR TEST NO 31
PRESSURE DROP - PSI.
PRESSURE - TEST NO 208
PRESSURE TEST NO 31
TEMPERATUR CORRESPONDING TO THE EFFECTIVE DENSITY, d
WATER TEMPERATURE
SATURATION TEMPERATURE.

FIG 29 - COMPARISON OF TESTS NUMBERS 74 & 237



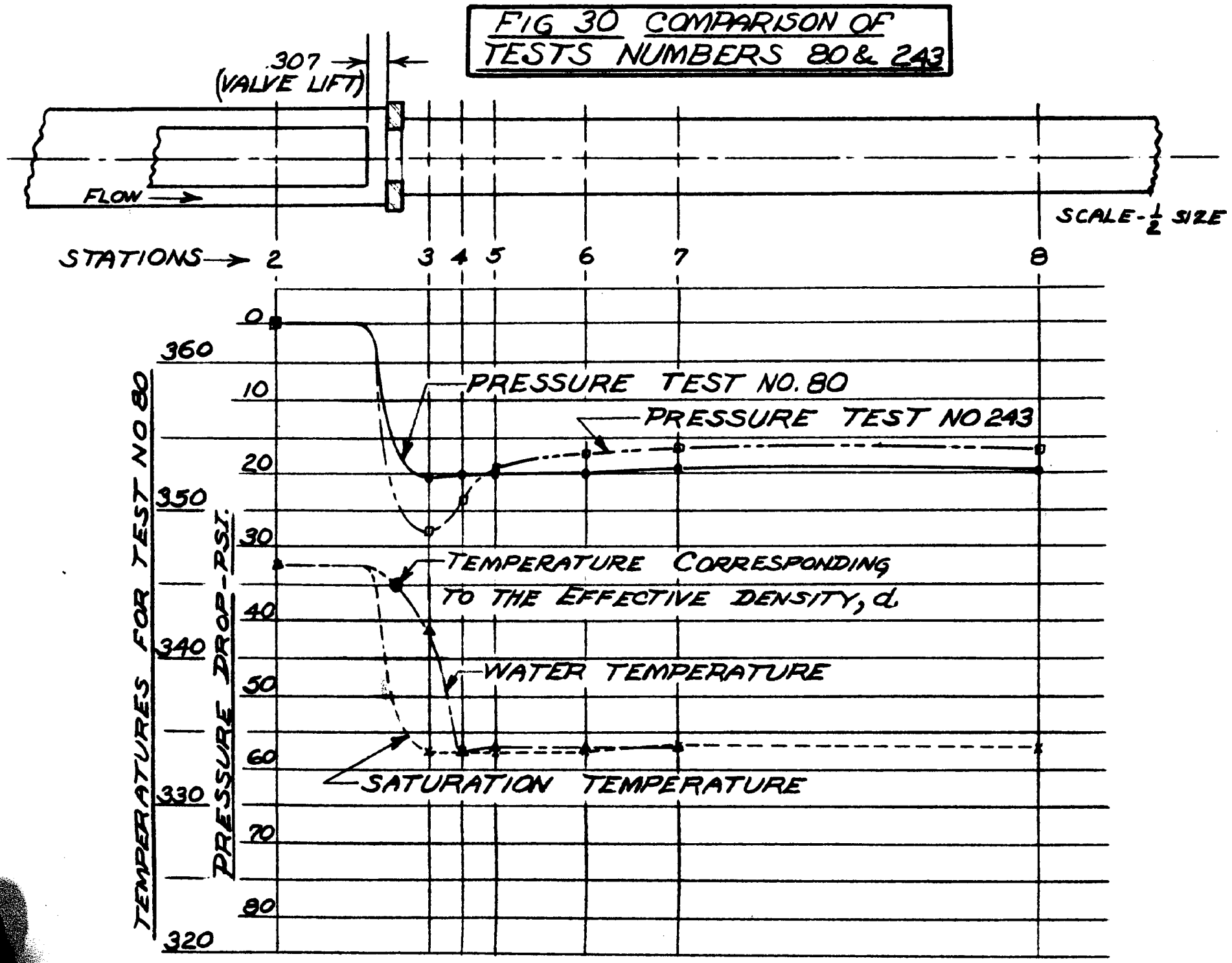
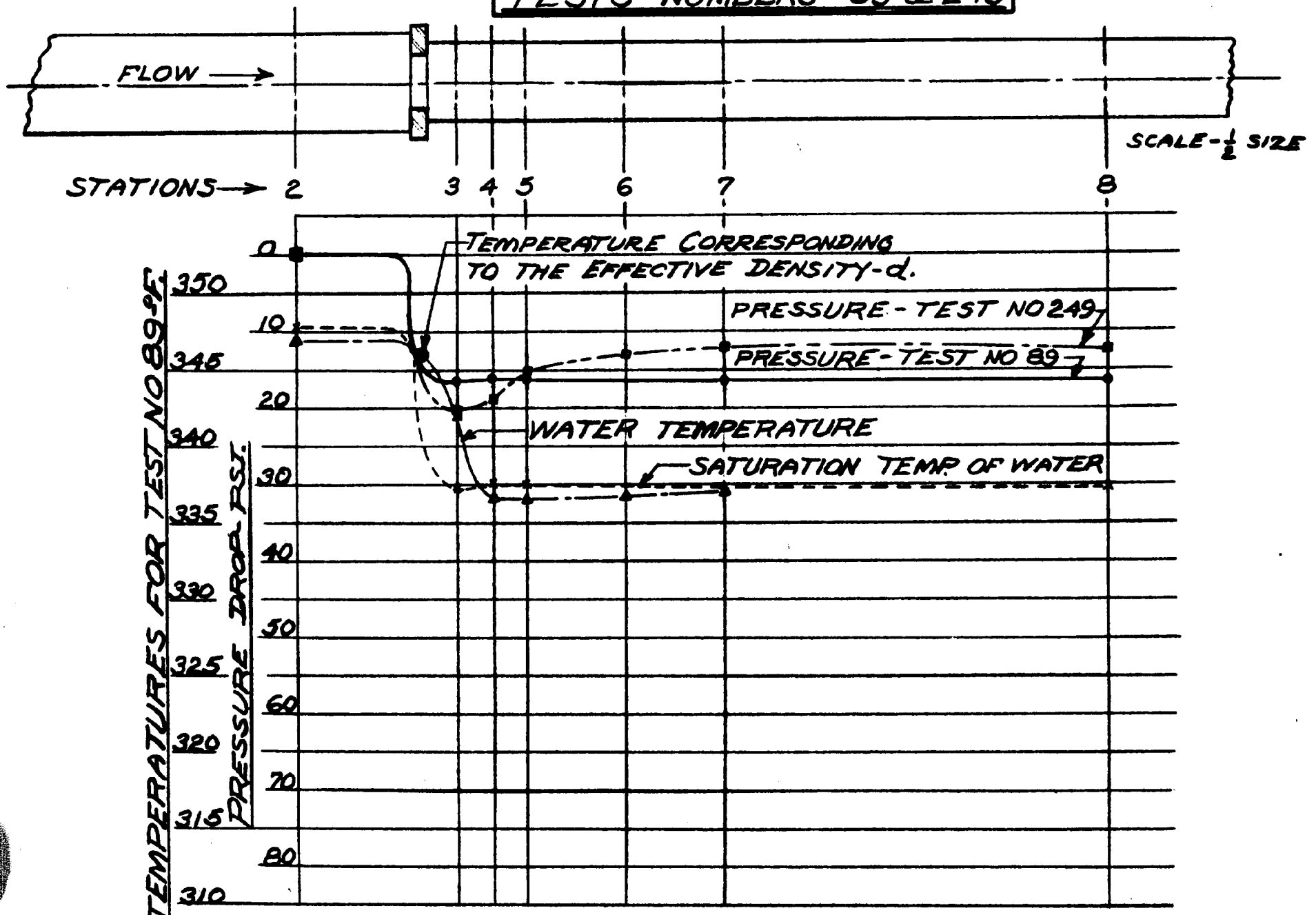
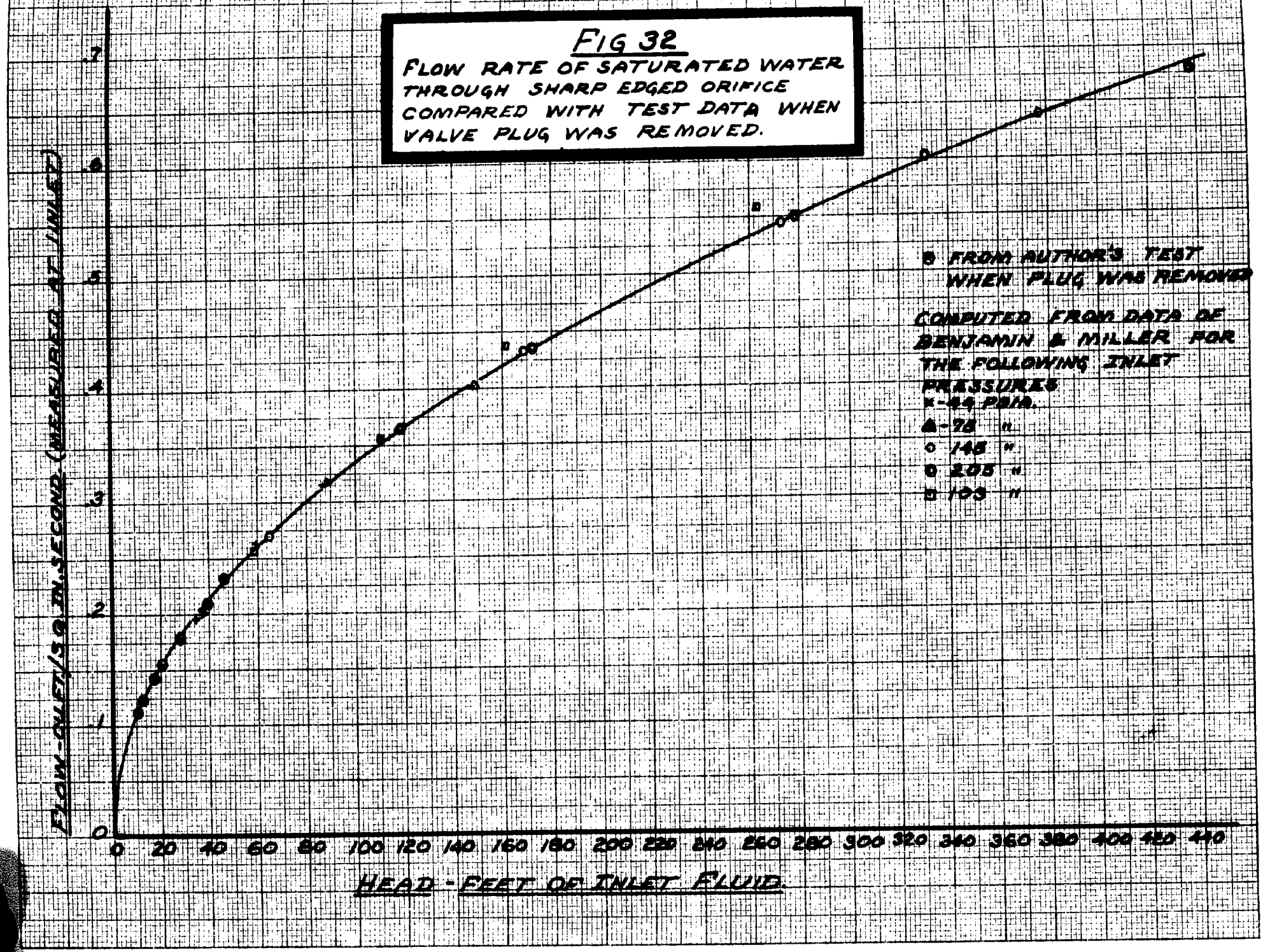
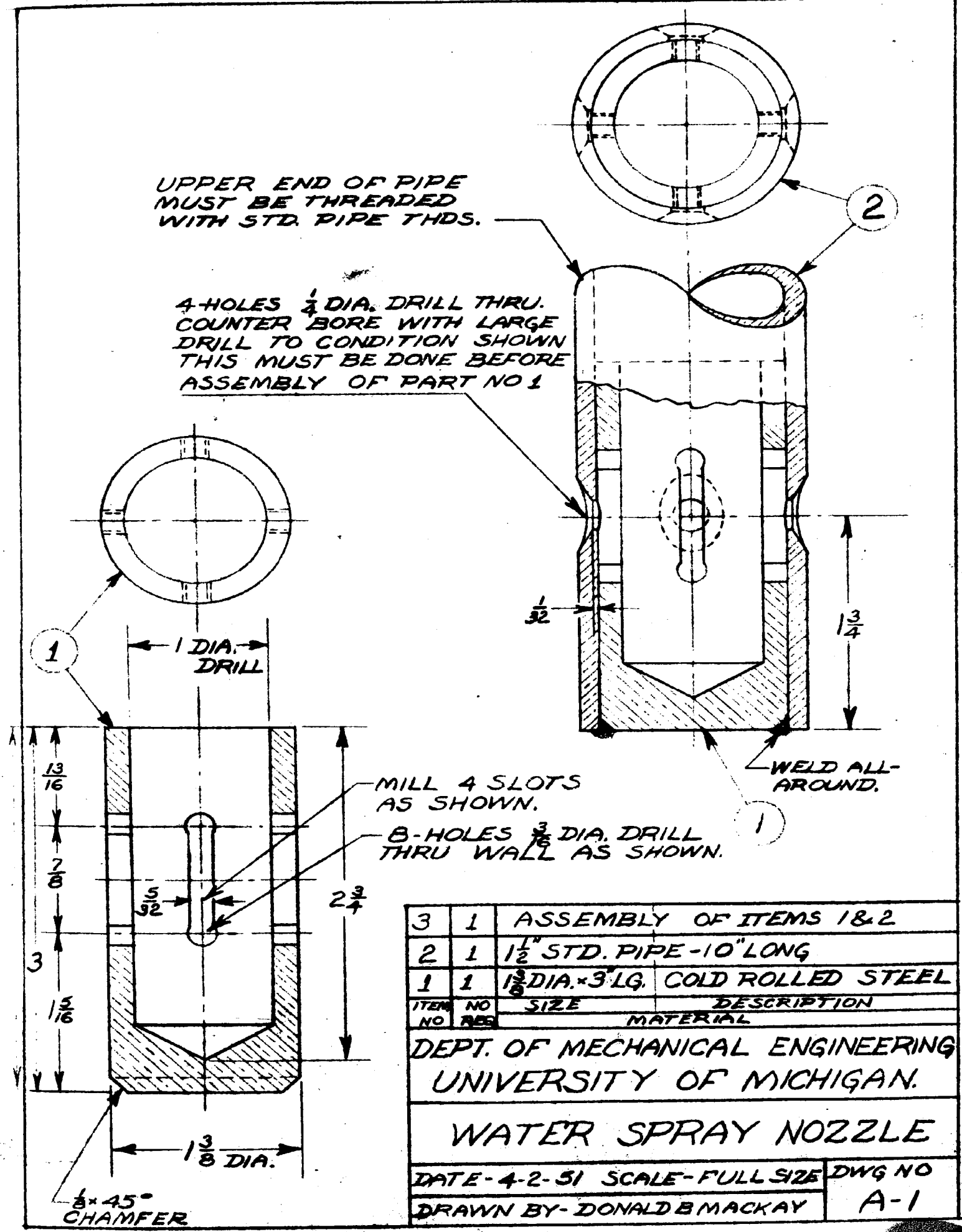

FIG 30 COMPARISON OF TESTS NUMBERS 80 & 243
.307 (VALVE LIFT)
FLOW
SCALE - 1/2 SIZE
STATIONS → 2 3 4 5 6 7 8
PRESSURE TEST NO. 80
PRESSURE TEST NO 243
TEMPERATURE CORRESPONDING TO THE EFFECTIVE DENSITY, d.
WATER TEMPERATURE
SATURATION TEMPERATURE
TEMPERATURES FOR TEST NO 80
PRESSURE DROP - PSI.
0
10
20
30
40
50
60
70
80
360
350
340
330
320

FIG. 31 - COMPARISON OF TESTS NUMBERS 89 & 249




FIG 32
FLOW RATE OF SATURATED WATER THROUGH SHARP EDGED ORIFICE COMPARED WITH TEST DATA WHEN VALVE PLUG WAS REMOVED.
FLOW-CUFT/SEC. IN SECOND (MEASURED AT INLET)
0
1
2
3
4
5
6
7
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440
HEAD - FEET OF INLET FLUID.
FROM AUTHOR'S TEST WHEN PLUG WAS REMOVED
COMPUTED FROM DATA OF BENJAMIN & MILLER FOR THE FOLLOWING INLET PRESSURES
x - 44 PSIA.
▲ - 78 "
○ 148 "
● 205 "
□ 103 "



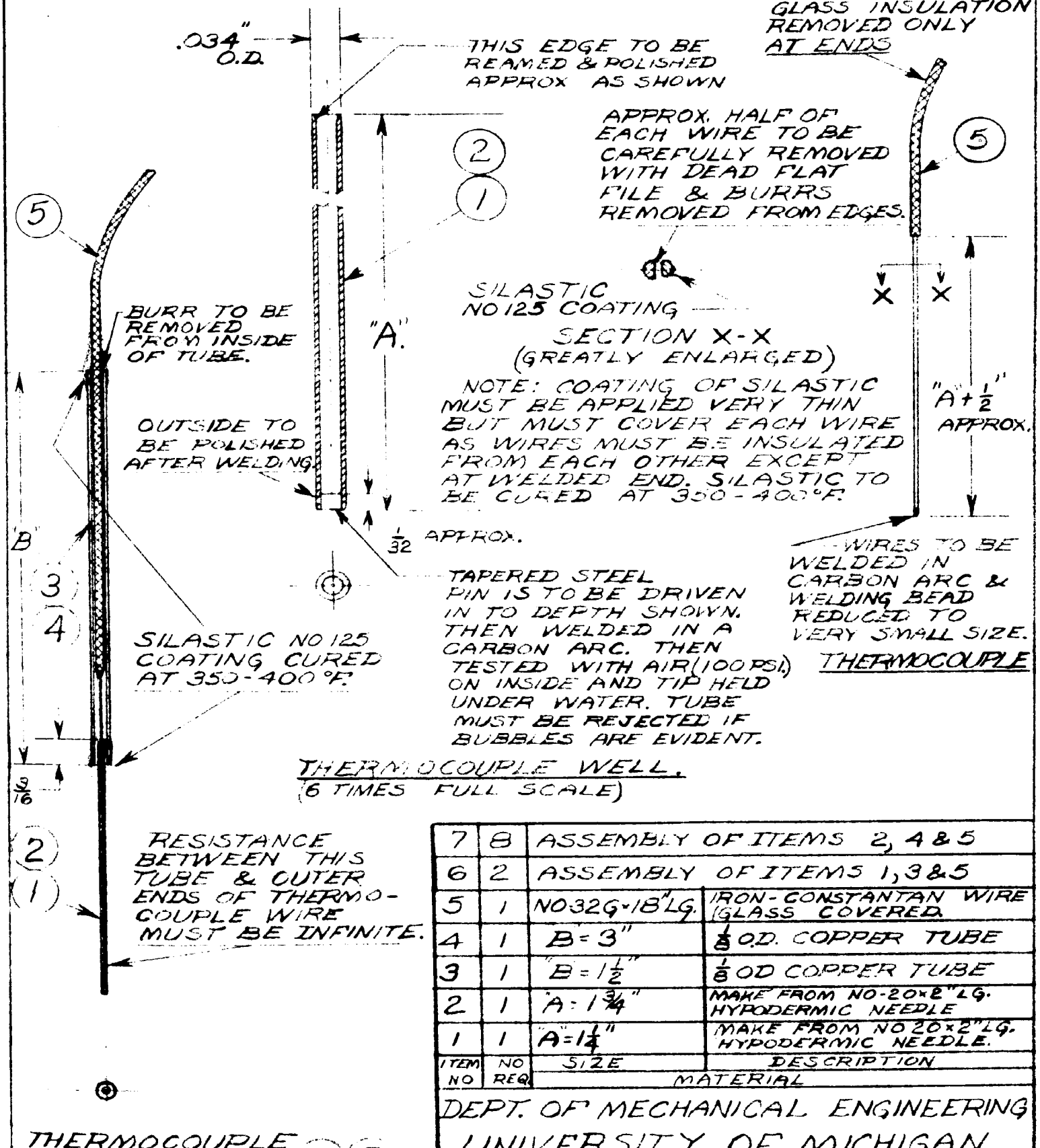
ITEM NO	NO REQ	SIZE / MATERIAL	DESCRIPTION
3	1		ASSEMBLY OF ITEMS 1 & 2
2	1		1 1/2" STD. PIPE - 10" LONG
1	1	1 3/8 DIA. x 3" LG.	COLD ROLLED STEEL

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WATER SPRAY NOZZLE

DATE - 4-2-51 SCALE - FULL SIZE
DRAWN BY - DONALD B MACKAY
DWG NO A-1

FIG 33



THERMOCOUPLE WELL.
(6 TIMES FULL SCALE)

THERMOCOUPLE ASSEMBLY (6) (7)
(FULL SIZE)

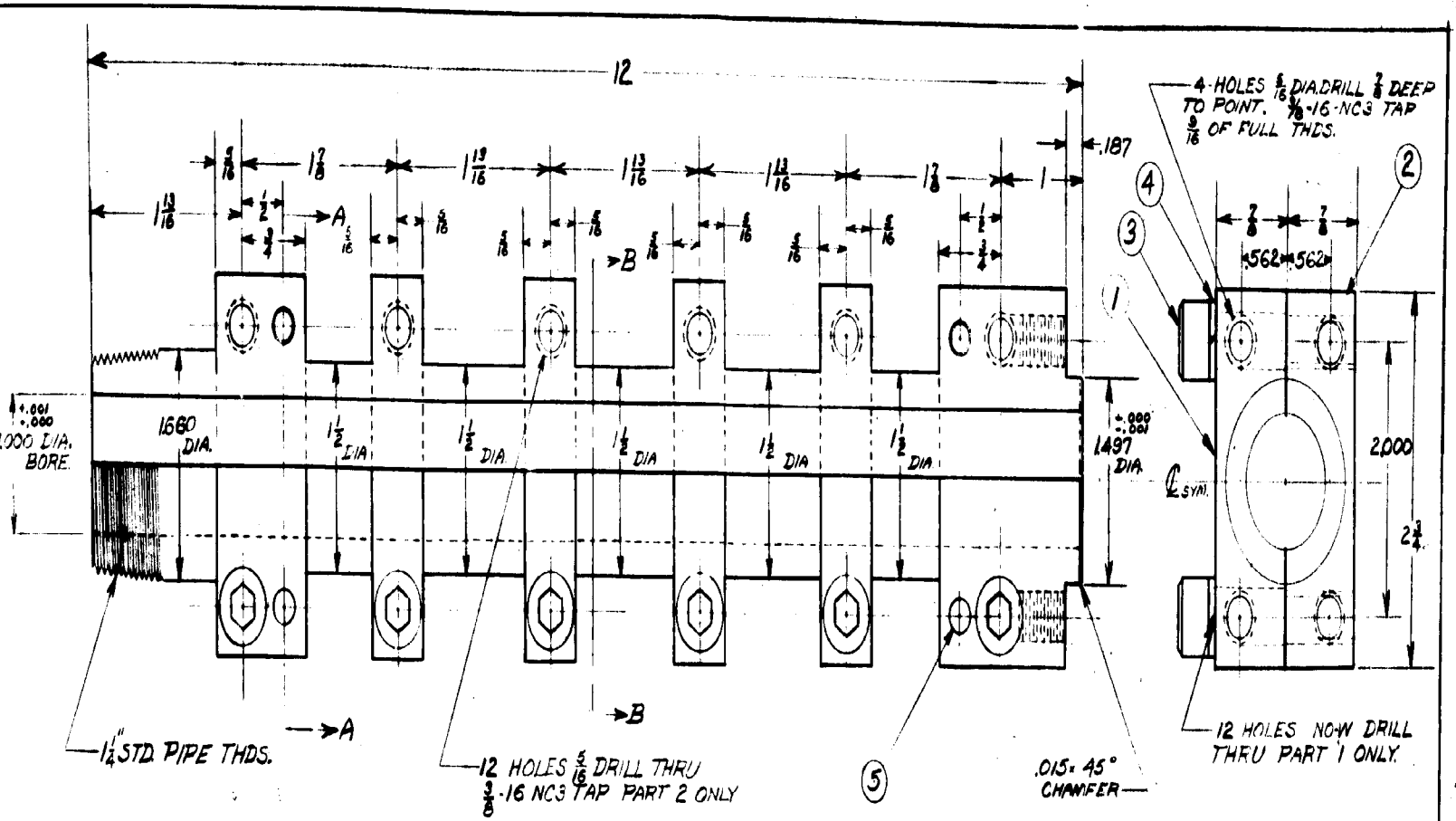
ITEM NO	NO REQ	SIZE	DESCRIPTION / MATERIAL
7	8		ASSEMBLY OF ITEMS 2, 4 & 5
6	2		ASSEMBLY OF ITEMS 1, 3 & 5
5	1	NO 32 G - 18" LG.	IRON-CONSTANTAN WIRE (GLASS COVERED)
4	1	B = 3"	1/8 O.D. COPPER TUBE
3	1	"B" = 1 1/2"	1/8 OD COPPER TUBE
2	1	"A" = 1 3/4"	MAKE FROM NO-20 x 2" LG. HYPODERMIC NEEDLE
1	1	"A" = 1 1/4"	MAKE FROM NO 20 x 2" LG. HYPODERMIC NEEDLE.

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THERMOCOUPLE ASSEMBLY

DATE - 4-2-51	SCALE - NOTED	DWG. NO
DRAWN BY - DONALD B MACKAY		A-2

FIG 34



ITEM NO	NO REQ.	SIZE	DESCRIPTION / MATERIAL
5	4	NO 4 - 1 1/2 LG.	STANDARD TAPER PIN
4	12	3/8	LOCKWASHER (REGULAR)
3	12	3/8-16 NC3 x 1 1/4 LG.	SOCKET HED CAP SCREW (ST'L)
2	1	1 x 2 3/4 x 12 1/8	BRASS - SAE
1	1	1 x 2 3/4 x 12 1/8	BRASS - SAE

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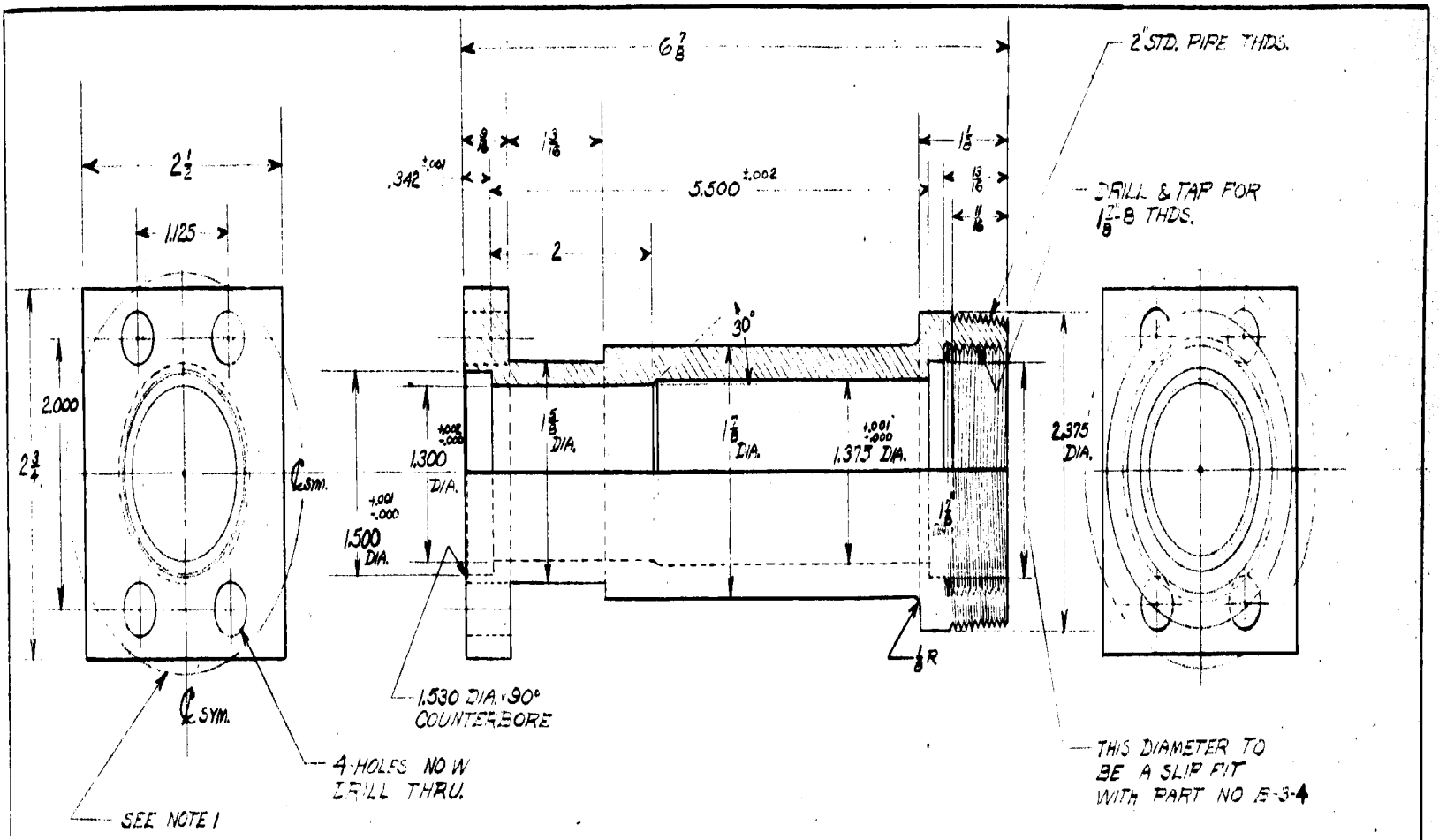
DISCHARGE TUBE ASS'Y

DATE - 11-17-50

DRAWN BY - DONALD B MACKAY

DRAWING NUMBER B-1

Fig. 35



NOTE
1. 3" DIA. BARSTOCK MAY BE SUBSTITUTED FOR THE 2 1/2 × 2 3/4 MATERIAL.

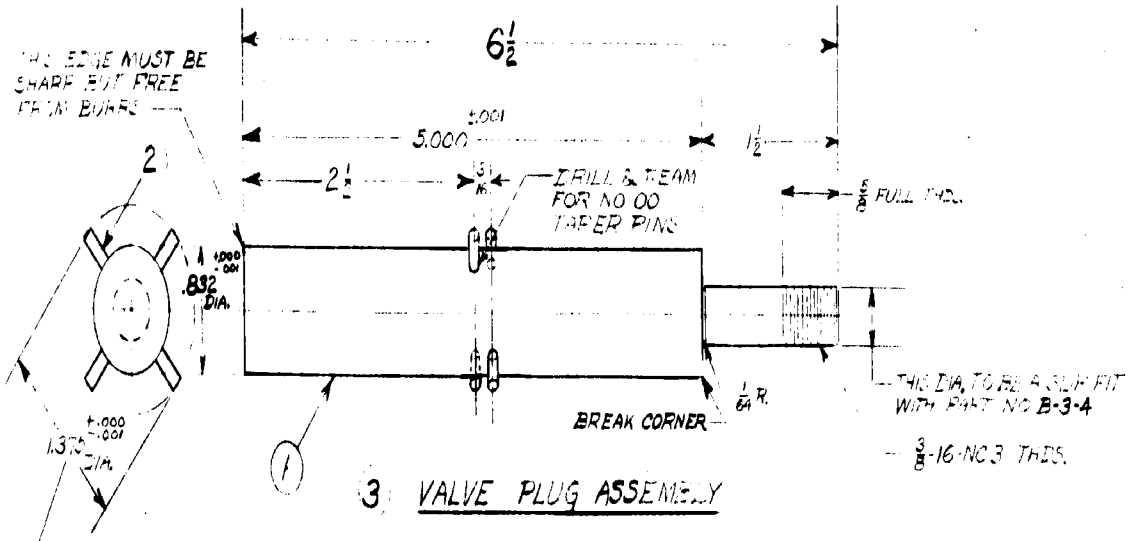
ITEM NO	NO REQ	SIZE	DESCRIPTION / MATERIAL
1	1	2 1/2 × 2 3/4 × 7LG	BRASS STAY

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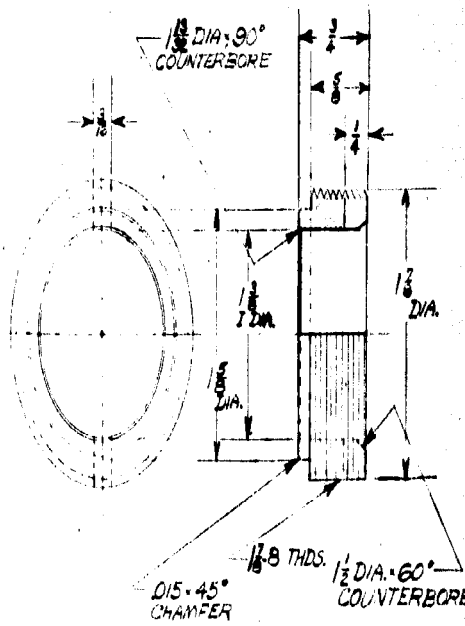
INLET TUBE

DATE 11-16-50
DRAWN BY DONALD B MACKAY
DRAWING NUMBER B-2

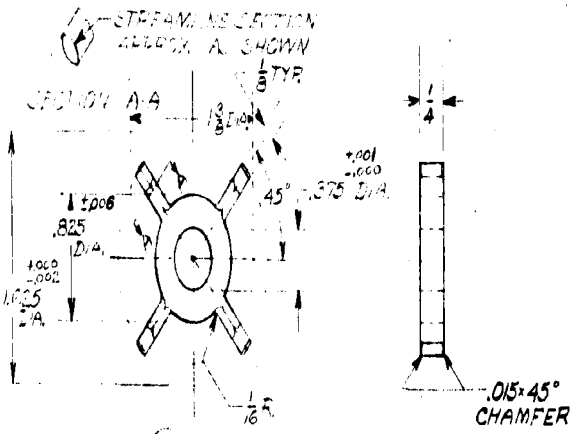
Fig. 36



3 VALVE PLUG ASSEMBLY

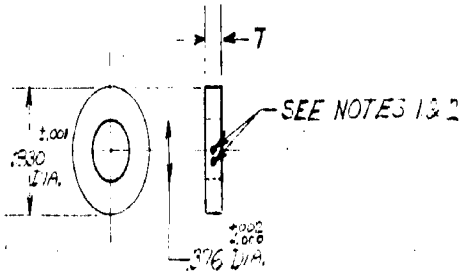


13 RETAINER



4 PLUG SUPPORT

NOTE- BREAK ALL SHARP EDGES



5 TO 12 SPACER

NOTE. BREAK ALL SHARP EDGES

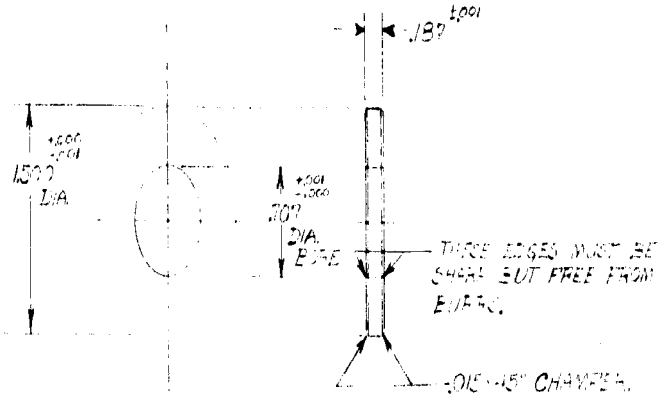
TABULATION OF VALUES FOR "T" ARE:

ITEM NO	T
5	.2505
6	.1875
7	.1325
8	.1245
9	.0625
10	.0200
11	.0100
12	.0050

NOTES

1- ITEM 7 TO BE CENTER PUNCHED TWICE AS SHOWN

2- ITEM 8 TO BE CENTER PUNCHED ONCE.



14 VALVE SEAT

ITEM NO	NO REQ	SIZE	DESCRIPTION / MATERIAL
14	1	⅛ DIA × ¼ TK.	STAINLESS STEEL
13	1	2⅛ DIA. × ⅜ LG.	BRASS
12	2	1" × 1"	BRASS SHIM STOCK.
11	2	1" × 1"	BRASS SHIM STOCK
10	1	1" × 1"	BRASS SHIM STOCK
9	1	1 DIA × ⅛ LG.	BRASS
8	1	1 DIA × ½ LG.	BRASS
7	1	1 DIA × ¼ LG.	BRASS
6	1	1 DIA × ⅜ LG.	BRASS
5	1	1 DIA × ⅜ LG.	BRASS
4	1	¾ DIA × ⅜ LG.	BRASS
3			VALVE PLUG ASSEMBLY
2	4	NO-00 × ⅝ LG.	BRASS TAPER PIN
1	1	1" DIA × 6⅝ LG.	BRASS-SAE

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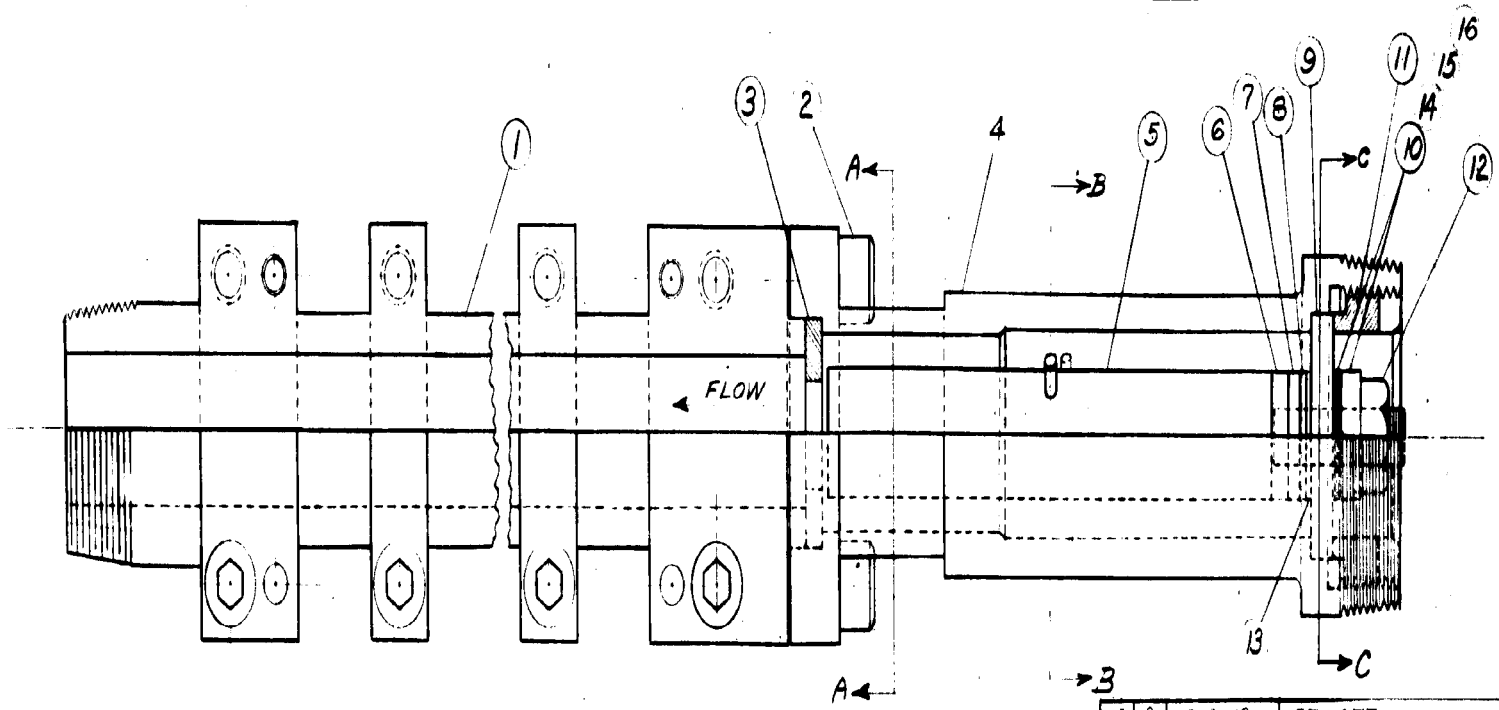
DETAILS-MISC. PARTS

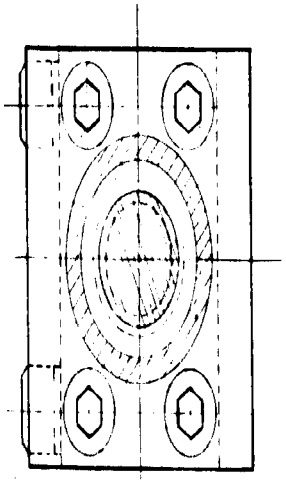
DATE 11-10-50

DRAWN BY- DONALD B MACKAY

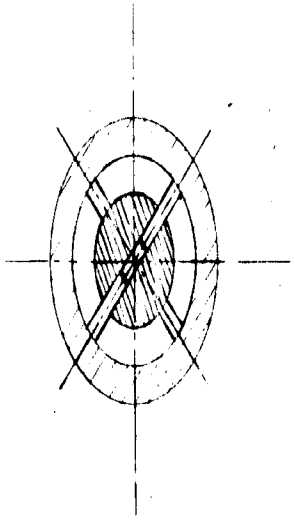
DRAWING NUMBER B-3

Fig. 37

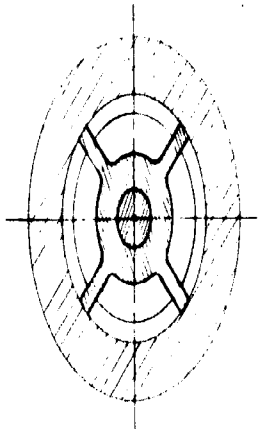




SECTION A-A.



SECTION B-B



SECTION C-C.

ITEM NO	NO REQ	SIZE	DESCRIPTION / MATERIAL
16	2	B-3-12	SPACER
15	2	B-3-11	SPACER
14	1	B-3-10	SPACER
13	1	B-3-9	SPACER
12	1	3/8-16-NC3	HEX NUT (BRASS)
11	1	B-3-9	RETAINER
10	1	B-3-5	SPACER
9	1	B-3-4	PLUG SUPPORT
8	1	B-3-8	SPACER
7	1	B-3-7	SPACER
6	1	B-3-6	SPACER
5	1	B-3-3	VALVE PLUG ASSEMBLY
4	1	B-2	INLET TUBE
3	1	B-3-10	VALVE SEAT
2	4	3/8-16 NC3 x 1 1/2 LG	SOCKET HED CAP SCREW (ST'L)
1	1	B-1	DISCHARGE TUBE ASS'Y.

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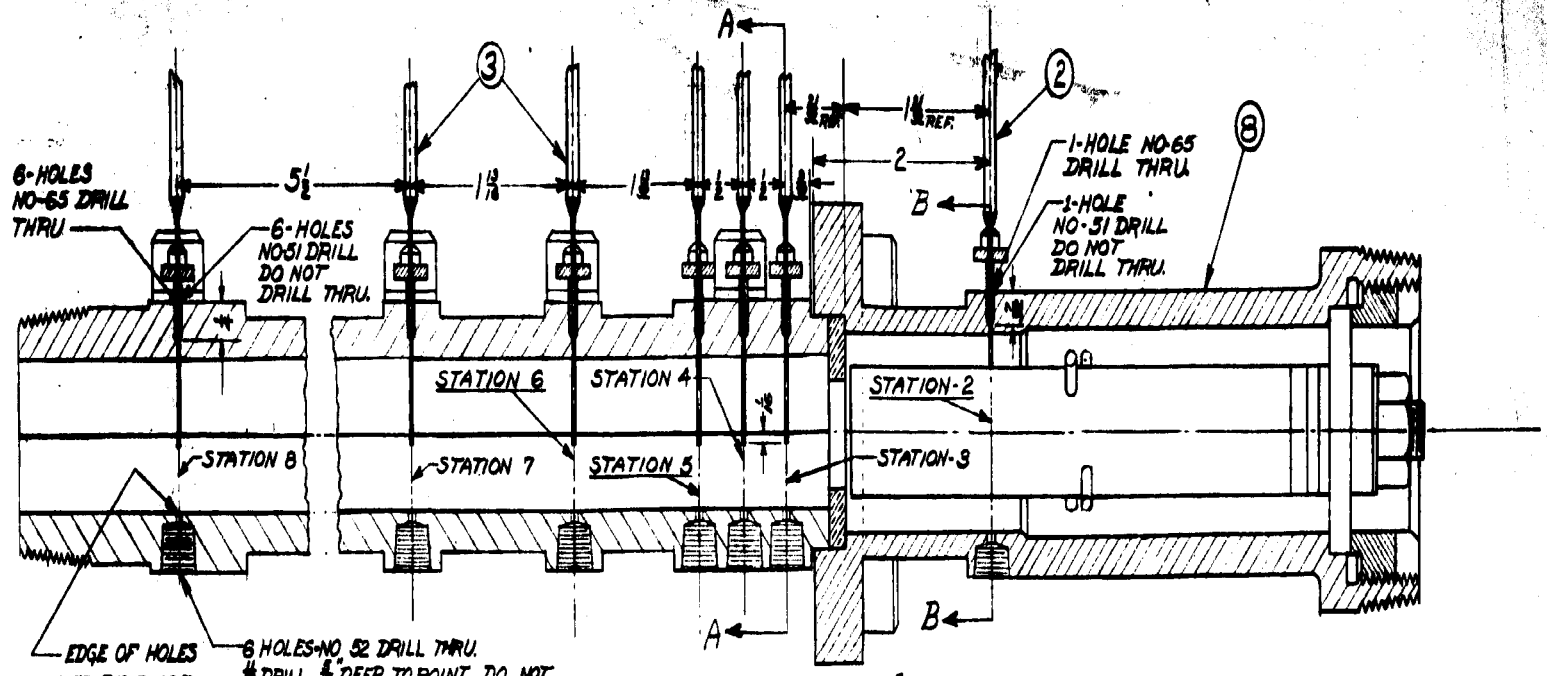
TEST VALVE - ASSEMBLY

DATE 1-14-50

DRAWN BY DONALD B MACKAY

DRAWING NUMBER B-4

Fig. 38

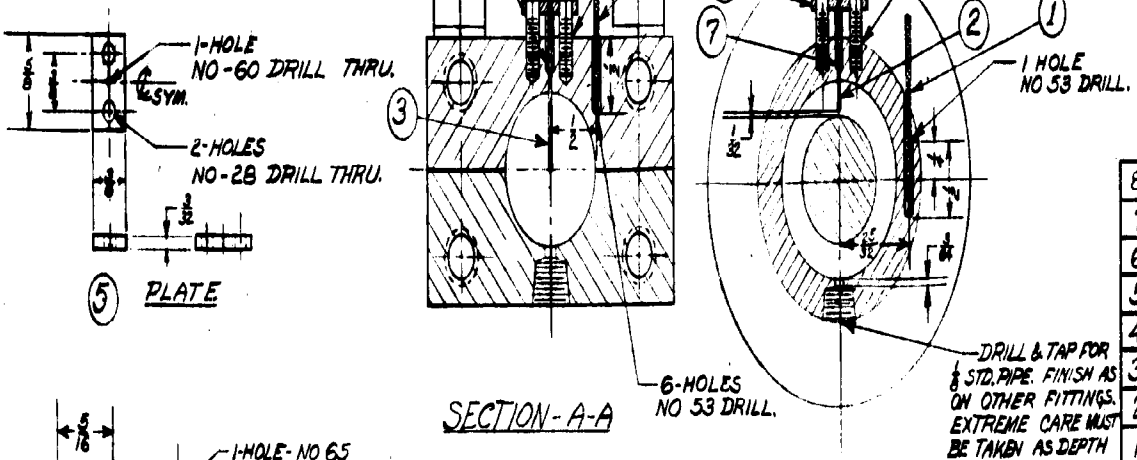


EDGE OF HOLES MUST BE SHARP BUT FREE FROM BURRS.

6 HOLES-NO. 52 DRILL THRU. 11/32 DRILL 7/16 DEEP TO POINT DO NOT DRILL THRU. FINISH WITH VERY BLUNT END DRILL. 1/8 STD. PIPE TAP. FINISH WITH BOTTOMING TAP.

12-HOLES NO36 DRILL 7/16 DEEP TO POINT. DO NOT DRILL THRU. 5-36 TAP-USE BOTTOMING TAP.

2-HOLES NO-38 DRILL 7/16 DEEP TO POINT. DO NOT DRILL THRU. 5-36 TAP USE BOTTOMING TAP.



(5) PLATE

SECTION-A-A

SECTION B-B

(4) PACKING GLAND.
SCALE TWICE FULL SIZE (APPROX)

ITEM NO	NO REQ	SIZE	DESCRIPTION / MATERIAL
8	1	B-4	TEST VALVE - ASSEMBLY
7		STRING PACKING	(ASBESTOS & GRAPHITE)
6	14	5-36 - 3/16 LG.	BRASS SCREWS
5	7	3/8 x 3/4 x 3/32 TK.	BRASS
4	7	.065 DIA. - 1/2 LG.	COPPER WIRE.
3	6	A-2-2	THERMOCOUPLE ASSEMBLY.
2	1	A-2-1	THERMOCOUPLE ASSEMBLY
1	7	NO 32 G - NBLG	IRON CONSTANTAN THERMOCOUPLE (GLASS COVERED)

DEP'T OF MECHANICAL ENGINEERING

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INSTRUMENTATION - VALVE

DATE-1-6-51

DRAWN BY- DONALD B MACKAY

DRAWING NUMBER B-5

Fig. 39

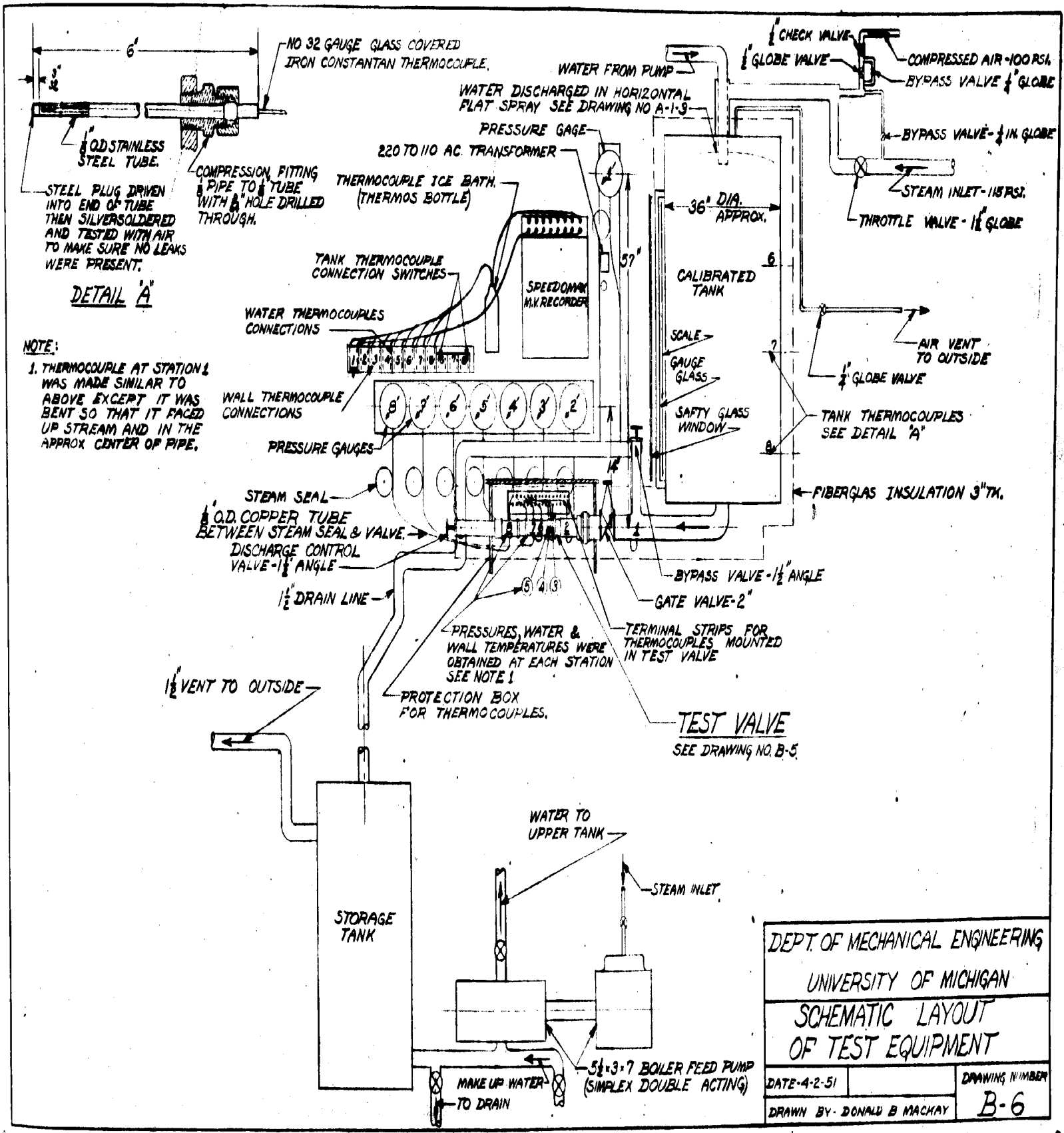

6'
NO 32 GAUGE GLASS COVERED IRON CONSTANTAN THERMOCOUPLE.
1/4" O.D. STAINLESS STEEL TUBE.
COMPRESSION FITTING 1/8" PIPE TO 1/4" TUBE WITH 1/8" HOLE DRILLED THROUGH.
STEEL PLUG DRIVEN INTO END OF TUBE THEN SILVERSOLDERED AND TESTED WITH AIR TO MAKE SURE NO LEAKS WERE PRESENT.
DETAIL 'A'
NOTE:
1. THERMOCOUPLE AT STATION 1 WAS MADE SIMILAR TO ABOVE EXCEPT IT WAS BENT SO THAT IT FACED UP STREAM AND IN THE APPROX CENTER OF PIPE.
WATER FROM PUMP
1" CHECK VALVE
1" GLOBE VALVE
COMPRESSED AIR - 100 PSI.
BYPASS VALVE 1/4" GLOBE
WATER DISCHARGED IN HORIZONTAL FLAT SPRAY SEE DRAWING NO A-1-9
PRESSURE GAGE
220 TO 110 AC. TRANSFORMER
BYPASS VALVE - 1/4 IN. GLOBE
THERMOCOUPLE ICE BATH. (THERMOS BOTTLE)
36" DIA. APPROX.
STEAM INLET - 115 PSI.
THROTTLE VALVE - 1 1/2" GLOBE
57"
TANK THERMOCOUPLE CONNECTION SWITCHES
SPEEDOMAX M.K RECORDER
CALIBRATED TANK
WATER THERMOCOUPLES CONNECTIONS
SCALE
GAUGE GLASS
AIR VENT TO OUTSIDE
1/4" GLOBE VALVE
WALL THERMOCOUPLE CONNECTIONS
SAFTY GLASS WINDOW
TANK THERMOCOUPLES SEE DETAIL 'A'
PRESSURE GAUGES
STEAM SEAL
FIBERGLAS INSULATION 3" TK.
1/4" O.D. COPPER TUBE BETWEEN STEAM SEAL & VALVE.
DISCHARGE CONTROL VALVE - 1 1/2" ANGLE
BYPASS VALVE - 1 1/2" ANGLE
1 1/2" DRAIN LINE
GATE VALVE - 2"
PRESSURES, WATER & WALL TEMPERATURES WERE OBTAINED AT EACH STATION SEE NOTE 1
TERMINAL STRIPS FOR THERMOCOUPLES MOUNTED IN TEST VALVE
1 1/2" VENT TO OUTSIDE
PROTECTION BOX FOR THERMOCOUPLES.
TEST VALVE
SEE DRAWING NO. B-5.
WATER TO UPPER TANK
STEAM INLET
STORAGE TANK
5 1/2 x 3 x 7 BOILER FEED PUMP (SIMPLEX DOUBLE ACTING)
MAKE UP WATER
TO DRAIN
DEPT. OF MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN
SCHEMATIC LAYOUT OF TEST EQUIPMENT
DATE-4-2-51
DRAWING NUMBER
B-6
DRAWN BY - DONALD B MACKAY

Fig. 40

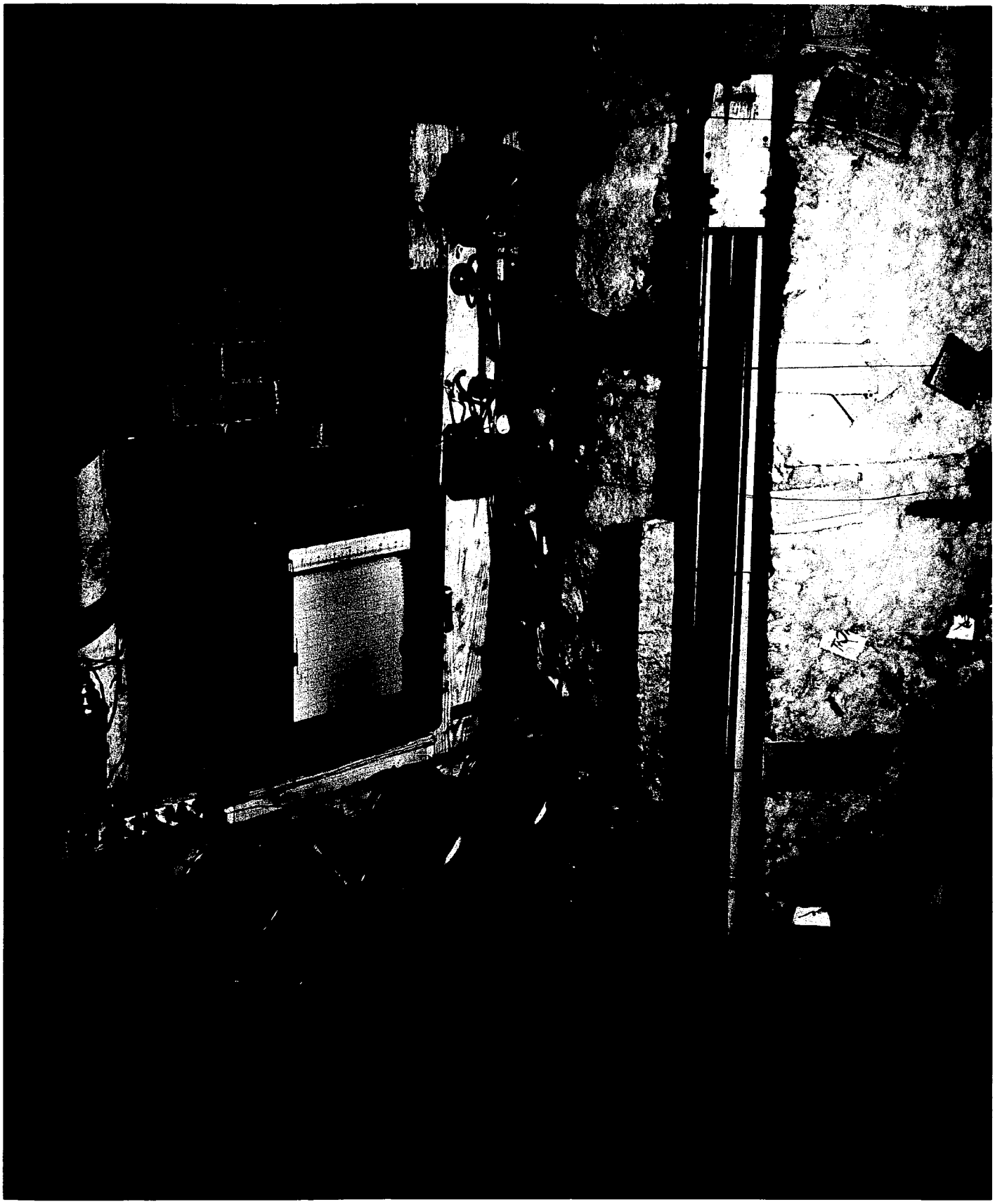


Plate 1
Major Part of Test Equipment

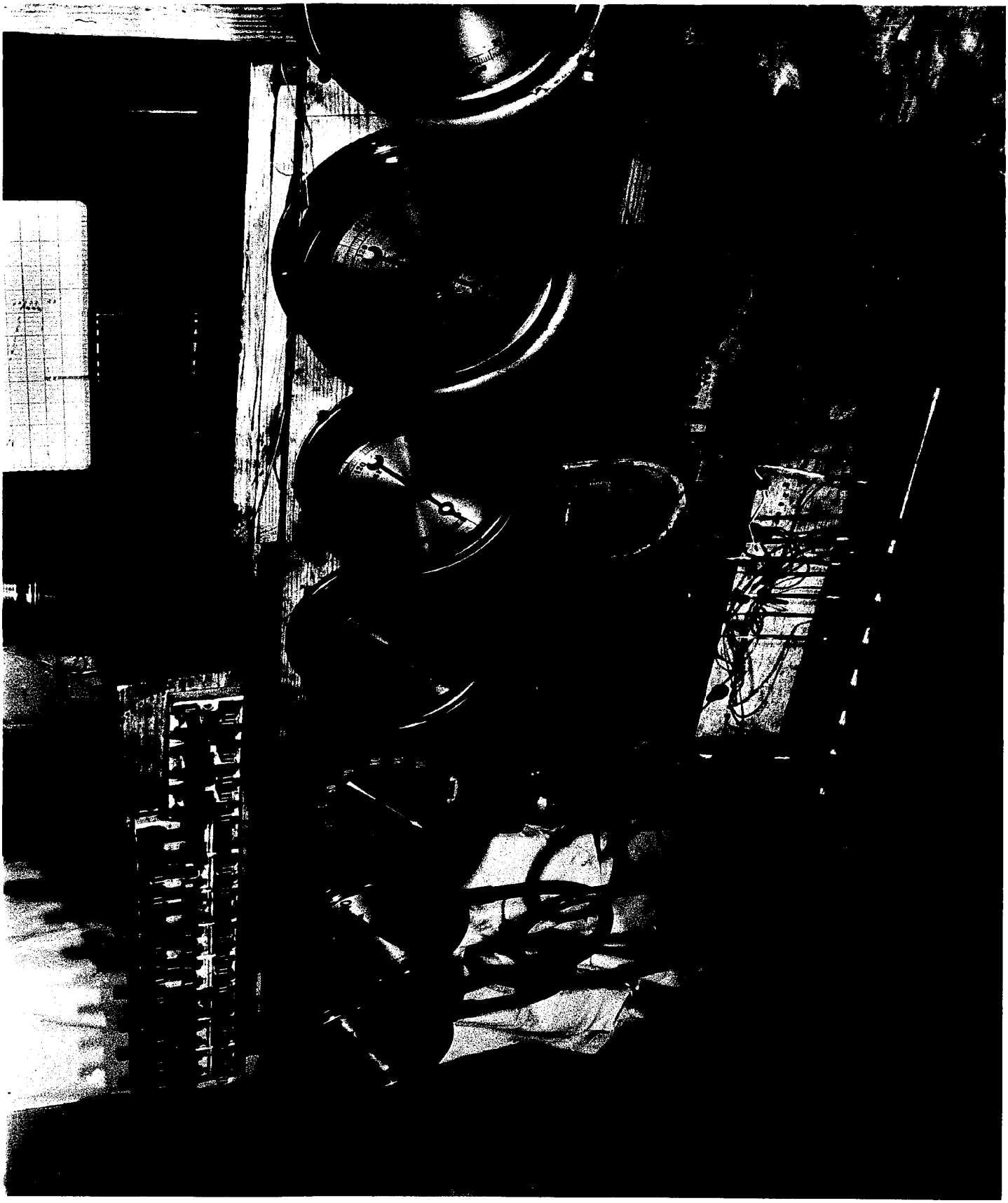


Plate 2
Instrumentation Details

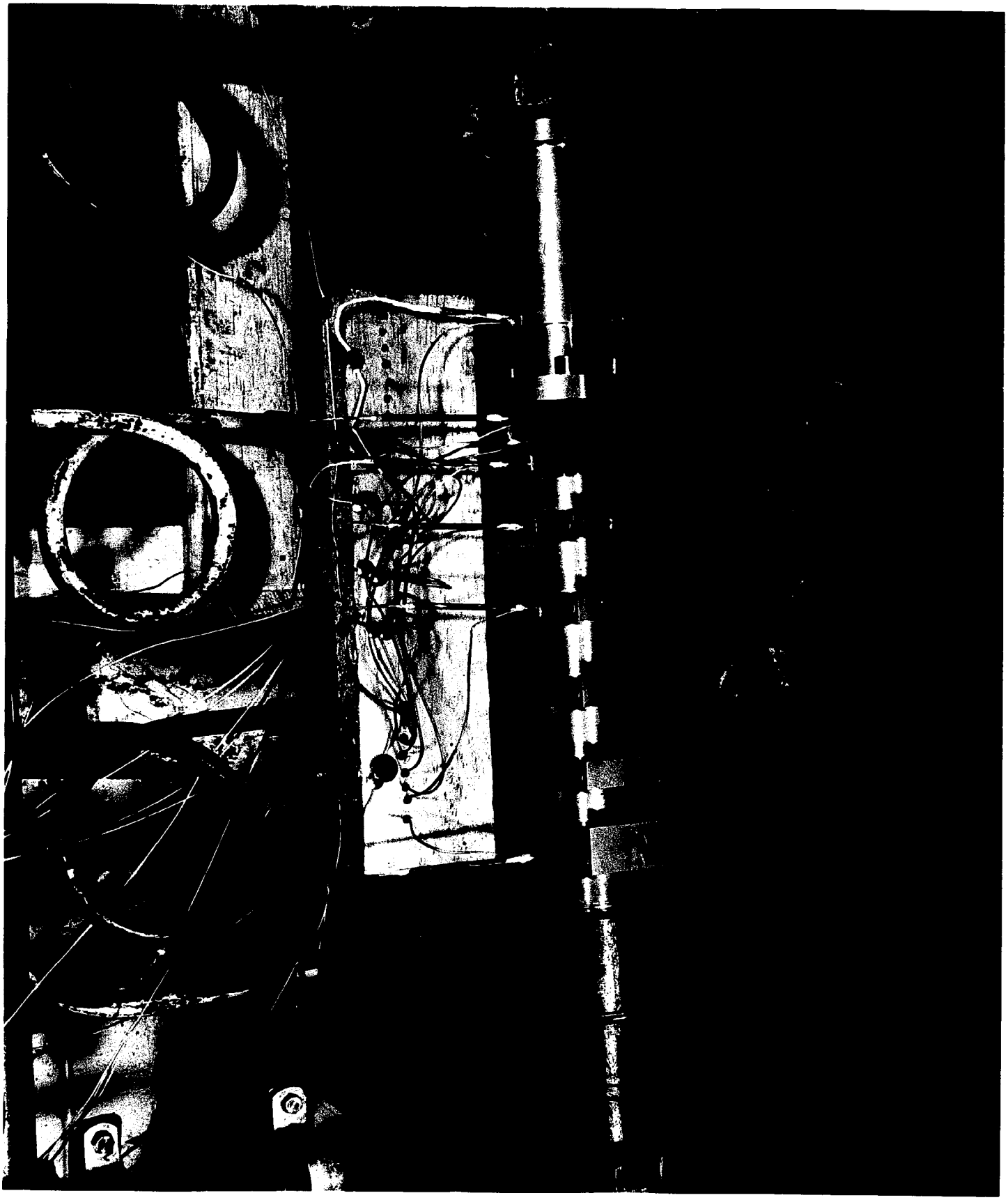


Plate 3

Close-up of Test Valve

APPENDIX I

The absolute pressures as shown on the data sheets in Appendix II were computed by adding to, or subtracting from, the observed gauge readings the following items:

1. Corrections shown in Fig. 41 to 46, which were obtained from a calibration of the gauges by means of a dead weight tester. (Figures 41 to 52 are grouped together at the end of this Appendix, beginning on page 83.)

2. Atmospheric pressure as determined with a mercury barometer and corrected as indicated by Shoop and Tuve (reference 12, pp 19 to 21).

3. A water column correction which assumed the column to be water at 80°F. and to extend vertically from the center line of the test valve to the center line of the gauges.

The computations of the areas through which the water passed were made by referring to the dimensions given in Fig. 35 to 40. However, since there were a number of dimensions to be taken into account in order to obtain the valve lift, spacers B-3-6, B-3-7 and B-3-8 were placed on the plug and the plug assembled into the valve. The space between the end of the plug and the valve seat was measured with a micrometer and found to be 0.050". The other valve lifts were then computed on the basis of the latter figure and the measured thicknesses of the spacers added or subtracted.

The properties of the inlet fluid were taken from the steam tables in reference 8. In order to reduce the work of interpolating the steam tables, a chart was drawn, Fig. 52, showing

the pressure-temperature relationship for saturated water.

The temperatures given on the data sheets were computed by taking the millivolts recorded on the Speedomax potentiometer and converting them to temperature by using conversion tables, of Leeds and Northrup Company (reference 14). The tank was calibrated by filling it with water at 55°F. and reading the level before and after a quantity of water was removed. The amount drawn off was weighed. This process was repeated several times and it was found that lowering the level of the tank by one foot removed an average of 296.3 lbs. of water. This value was corrected to test conditions by multiplying it by a factor F which was derived and applied as follows:

1. The specific volume of water varies with temperature, and an approximate factor F' taking this fact into account would be,

$$F' = \frac{v_{f55}}{v_{f2}}$$

where v_{f2} is the specific volume of saturated water at station 2 and v_{f55} is the specific volume at 55°F.

2. Due to pressure the diameter of the tank increases. Using the thickness of metal as 1/4" and 30,000,000 as the modulus of the elasticity of steel, the increase in diameter for the condition of 115 psi was found to be equal to 0.0176 percent. For other pressures the factor F'' would be,

$$F'' = 0.000176 \frac{P_2'}{115}$$

where P_2' is the gauge pressure psi in the tank under test conditions.

3. The thermal expansion of the metal would increase the diameter of the tank. Using a coefficient of expansion of 6.3×10^{-6} and a temperature increase of $300^{\circ}F$. the weight increase was found to be 0.378 percent. A factor F''' due to thermal expansion would be

$$F''' = 0.00378 \frac{(t-55)}{300}$$

where t is the temperature of the tank during test.

The above factors were computed independently of each other and their combined effects would simply be the sum of the factors. Calling the over-all factor F, its value may be written,

$$F = F' + F'' + F'''$$

Since the factor F''' is small it was concluded that a factor to account for the expansion of the scale used to determine the water level would also be small and was, therefore, neglected. For cold water the change in flow due to Factor F was small and no correction was applied.

The computation of the water flow, W, through the valve in lbs./sec. would therefore be,

$$W = \frac{296.3 \times F \times \text{difference in water level}}{12 \times 60 \times \text{duration of test in minutes}}$$

or

$$W = 0.412\ F \times \frac{\text{difference in water level}}{\text{duration of test in minutes}}$$

The volume flow was computed by converting the weight flow to a volume flow.

The static head between the stations 2 and 3 in feet of inlet fluid was computed by using the following formula:

$$\Delta h = (P_2 - P_3) \times v_2 \times 144$$

where P_2 is the absolute pressure at station 2, psia.

P_3 is the absolute pressure at station 3, psia.

v_2 is the specific volume of water at station 2, cu.ft./lb.

The inlet velocity head was determined by the use of Fig. 47. This figure was plotted by using Equation (2), page 5. The inlet velocity was computed from the physical dimensions of the valve at station 2 and the volume of the fluid flowing past this point.

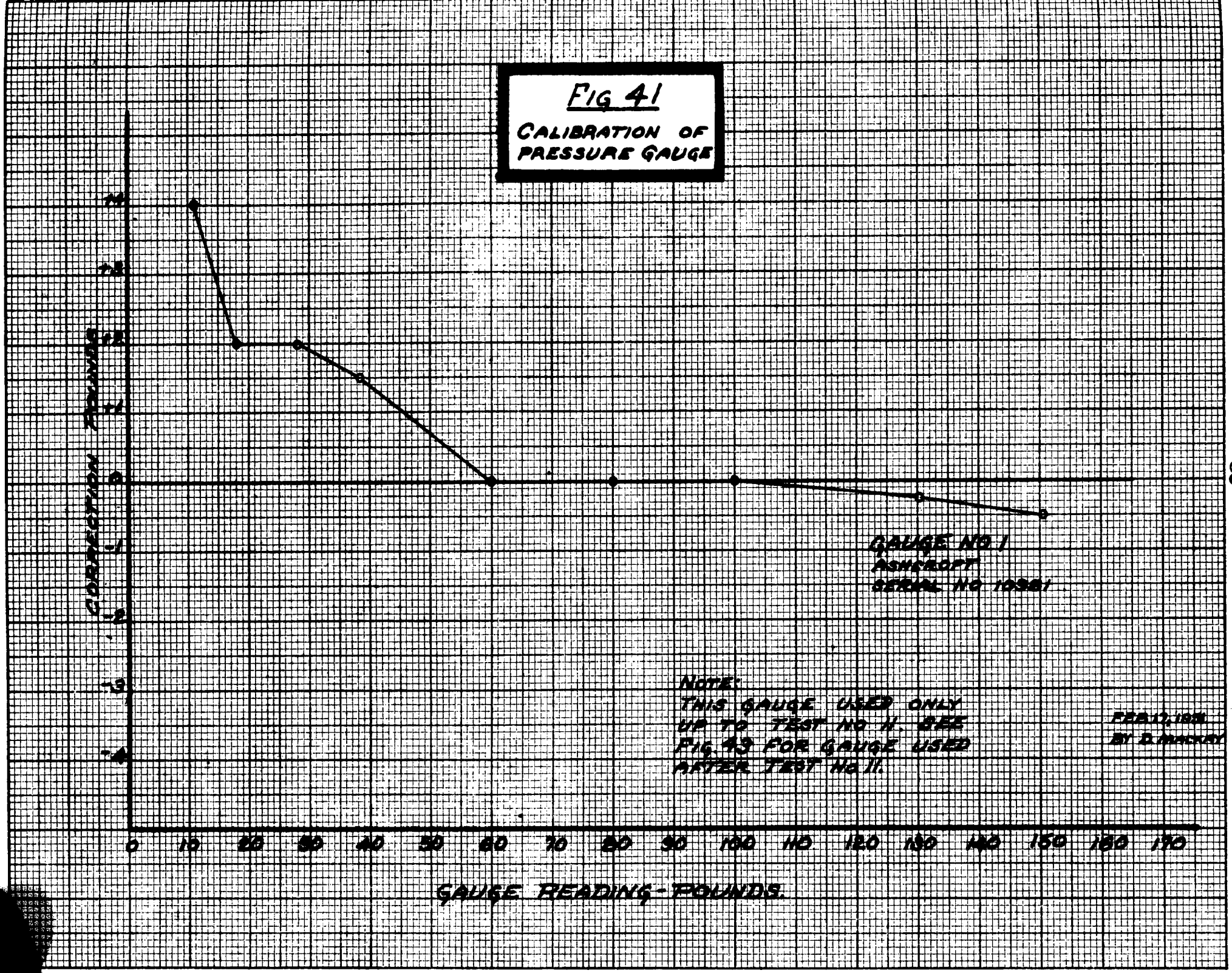
The slope m for Equations (8) and (9) were determined for each line shown Fig. 15, by arbitrarily selecting two points near the ends of each line. The measured vertical distance between these two points divided by the measured horizontal distance between the same two points gave the value of m.

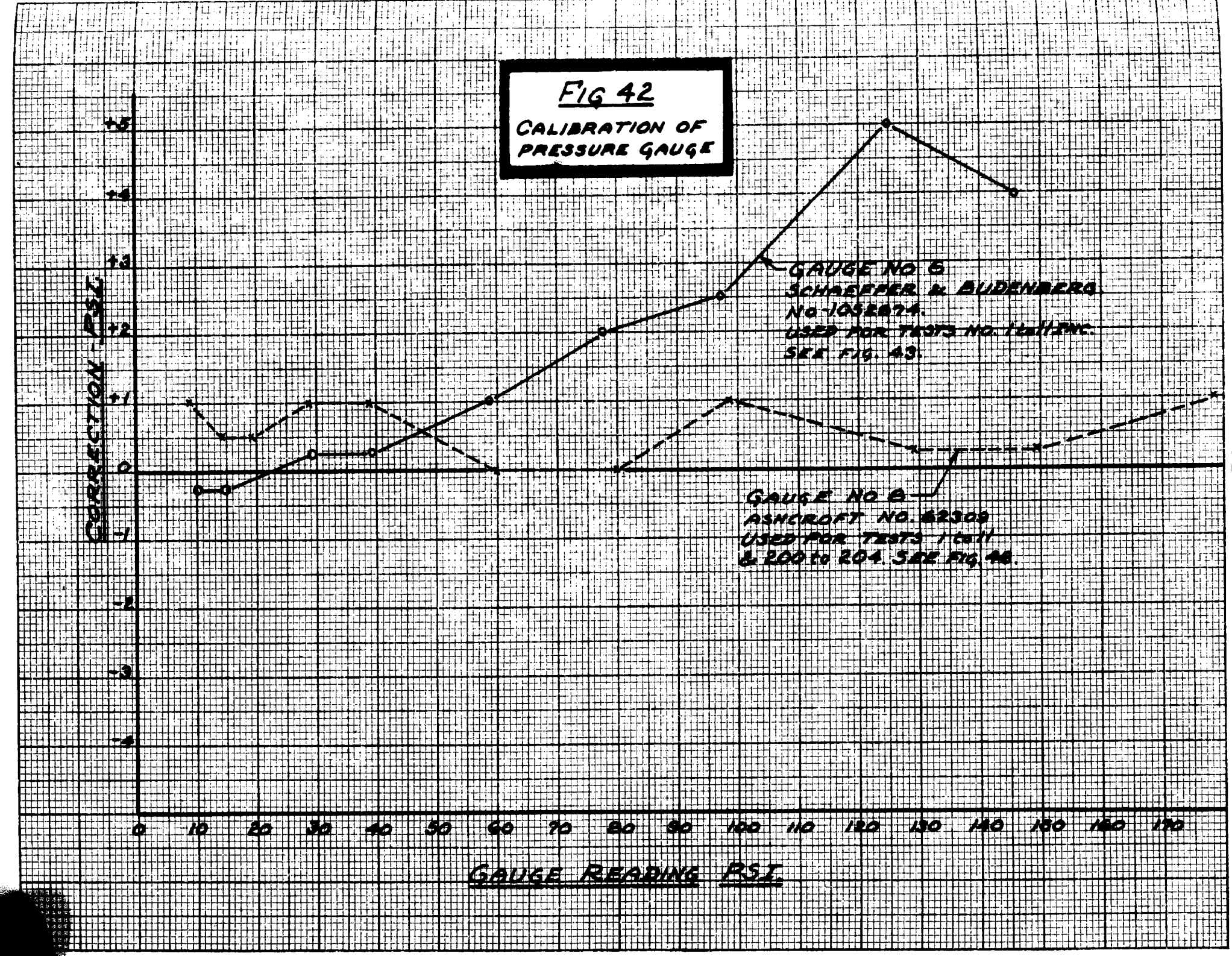
The flow coefficient e^b was determined for each set of data by first selecting an approximate mid-point on each of the lines shown Fig. 15. At this point the values of Q and Δh_t were read on the graph. These values along with the value of m obtained above were substituted into Equation (8) and the value of e^b calculated.

The values for the discharge coefficient C' as shown Fig. 18 and 19 were computed using Equation (10). Values of m and e^b were taken from Fig. 16 and 17 respectively and the value of A_r was computed as explained under flow theory.

The ideal density for saturated water, i.e., considering

equilibrium conditions, was determined in most cases by using Fig. 48 to 51. In using these graphs the flow through the valve restriction was considered to be isentropic. The inlet condition was located on the saturated liquid line and then by following down the line of constant entropy to the discharge pressure, the ideal density was read directly from the graph. By a somewhat similar process the temperature corresponding to the effective density was determined. The effective density for any given test was determined from Equation (20). By starting from the inlet condition located on the saturated liquid line and following down a line of constant entropy to the value of the effective density, a point was located which represented the state of the mixture which corresponds to the effective density. By moving horizontally from this point over to the saturation curve the temperature of the mixture was read. These temperatures were plotted on Fig. 25 to 31 for the indicated tests.


FIG 41
CALIBRATION OF PRESSURE GAUGE
CORRECTION - POUNDS
+2
+1
0
-1
-2
-3
-4
GAUGE NO 1
ASHCROFT
SERIAL NO 109861
NOTE:
THIS GAUGE USED ONLY
UP TO TEST NO 11. SEE
FIG 43 FOR GAUGE USED
AFTER TEST NO 11.
FEB 17, 1938
BY D. MACKAY
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
GAUGE READING - POUNDS.


FIG 42
CALIBRATION OF PRESSURE GAUGE
CORRECTION - PSI.
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
GAUGE READING PSI.
GAUGE NO 6
SCHAEFFER & BUDENBERG.
No-10528?4.
USED FOR TESTS NO. 1 to 11 INC.
SEE FIG. 43.
GAUGE NO 8
ASHCROFT NO. 62309
USED FOR TESTS 1 to 11
& 200 to 204. SEE FIG. 46.

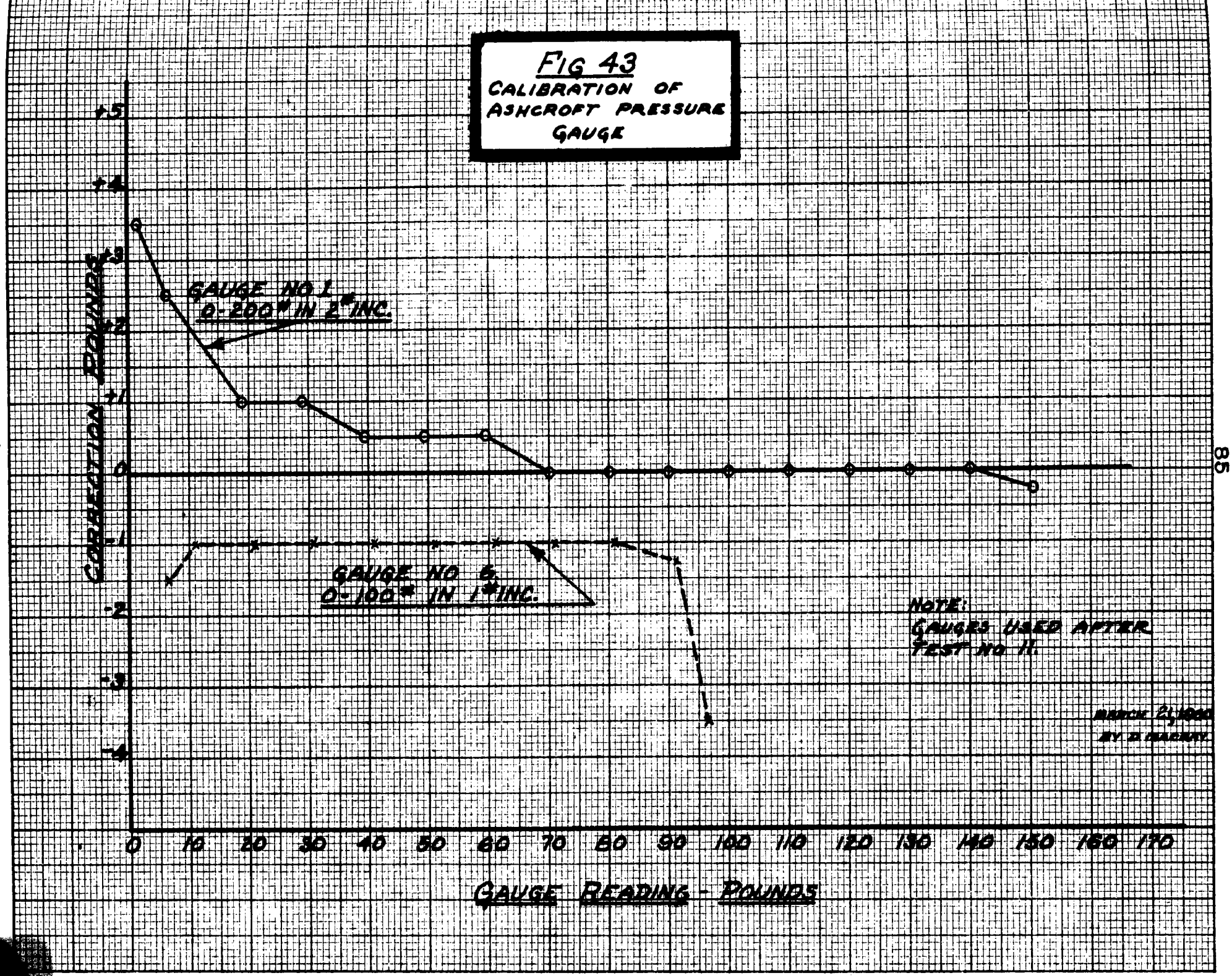

FIG 43
CALIBRATION OF ASHCROFT PRESSURE GAUGE
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
CORRECTION POUNDS
GAUGE NO 1
0-200# IN 2# INC.
GAUGE NO 6
0-100# IN 1# INC.
NOTE:
GAUGES USED AFTER TEST NO 11.
MARCH 23, 1933
BY D MACKAY
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
GAUGE READING - POUNDS

FIG 44
CALIBRATION OF AMERICAN TEST GAUGES (6¾" DIA., 0-200#)

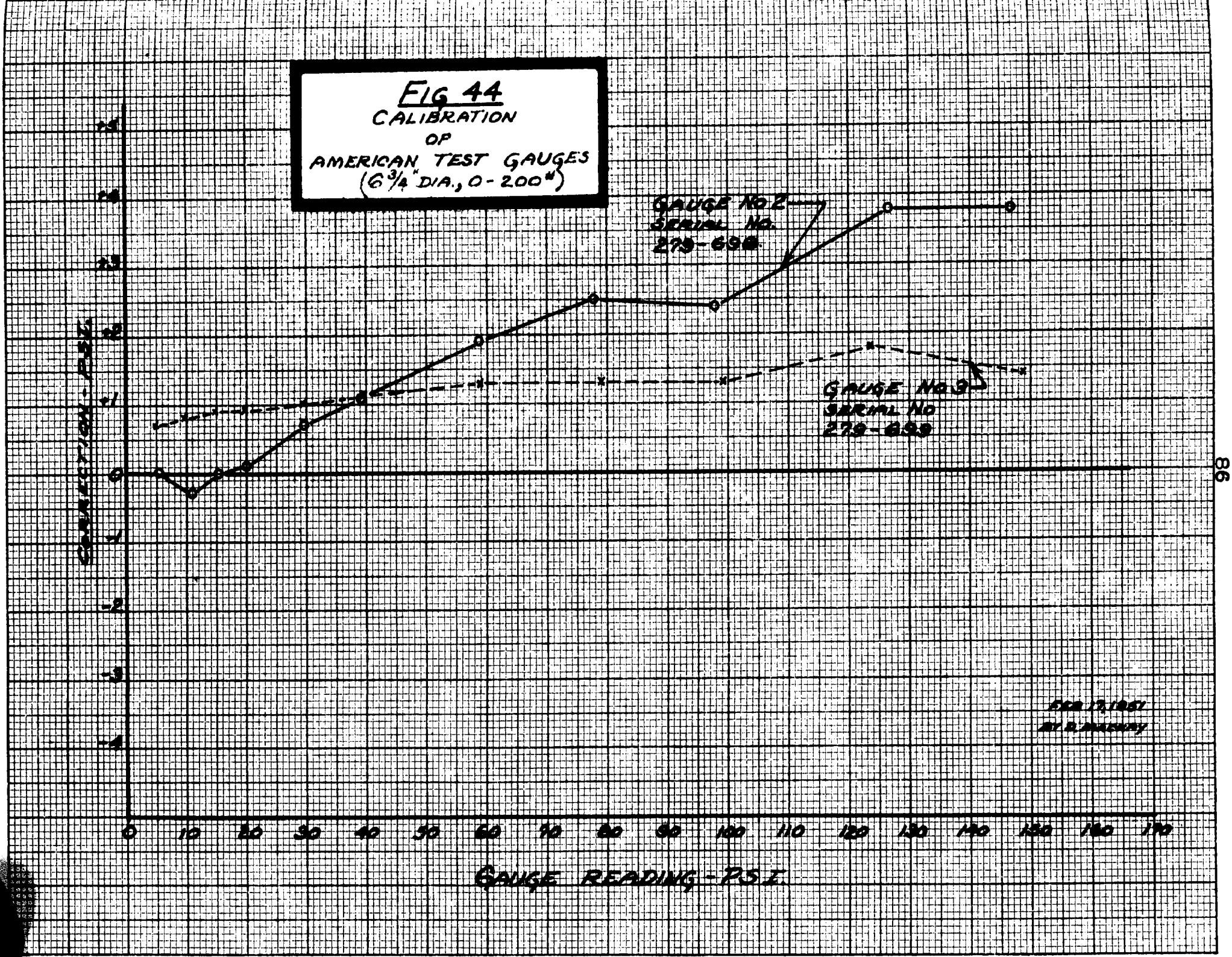


FIG 45
CALIBRATION OF AMERICAN TEST GAUGE (6" DIA., 0-200#)

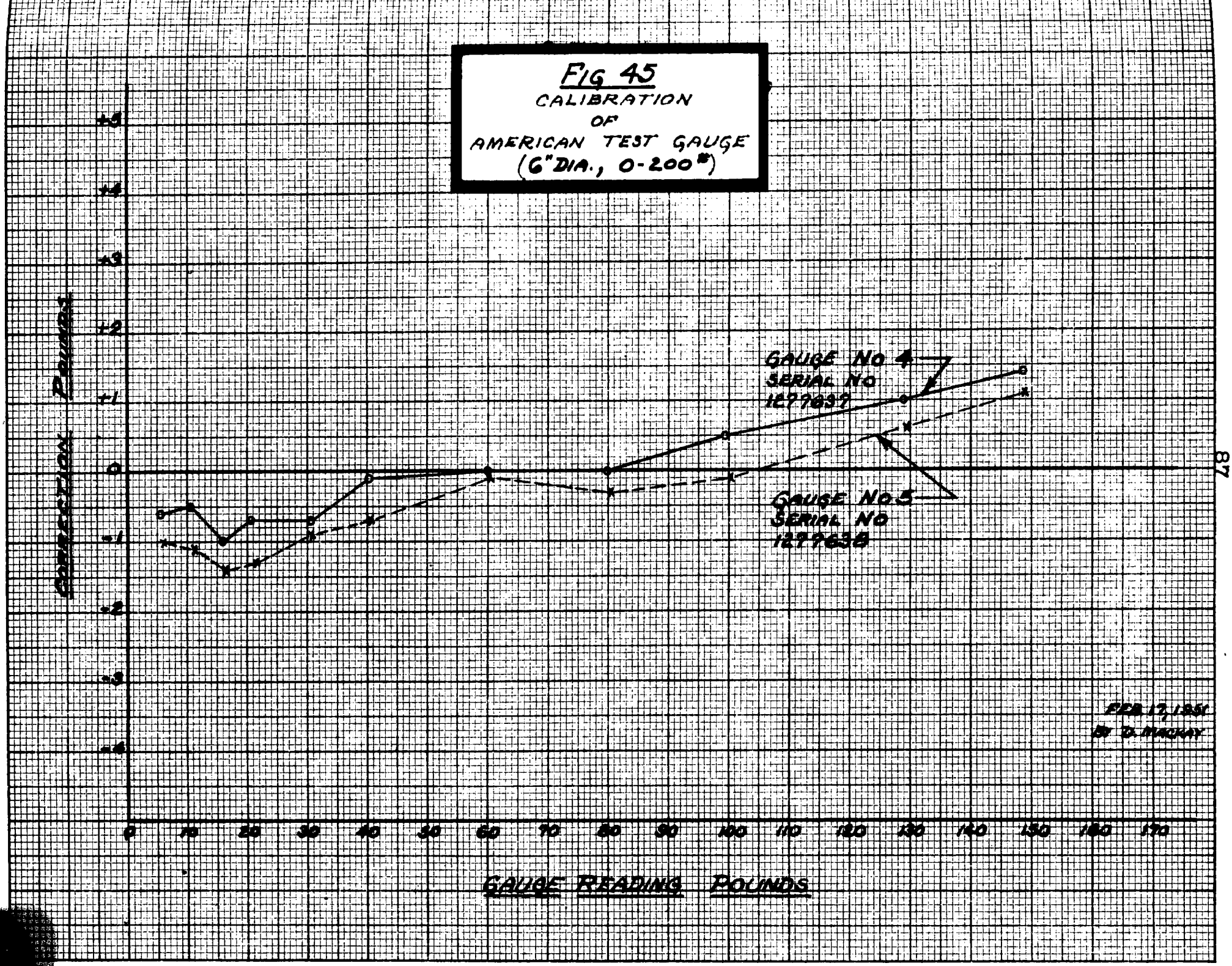
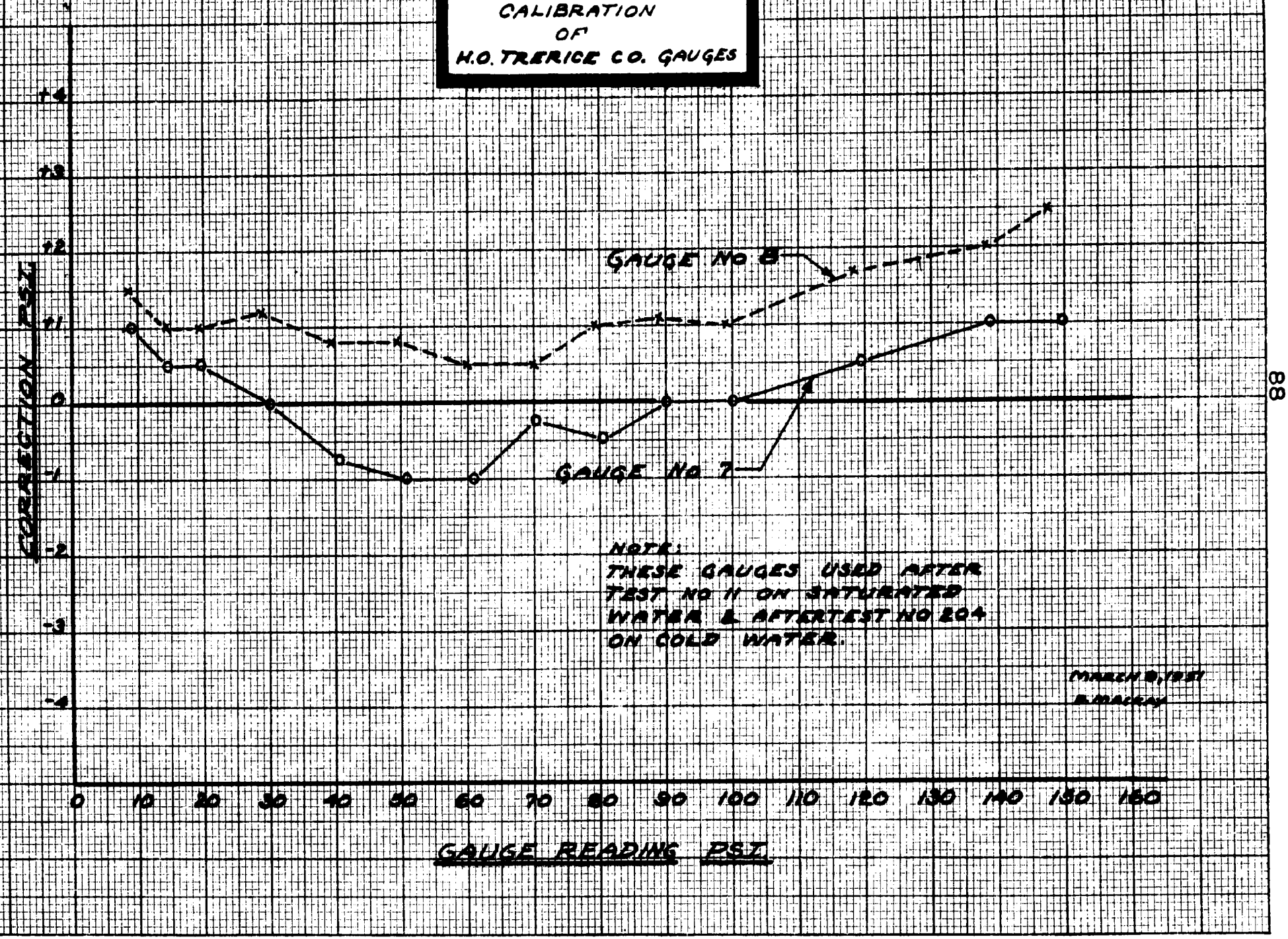


FIG 46
CALIBRATION OF H.O. TRERICE CO. GAUGES



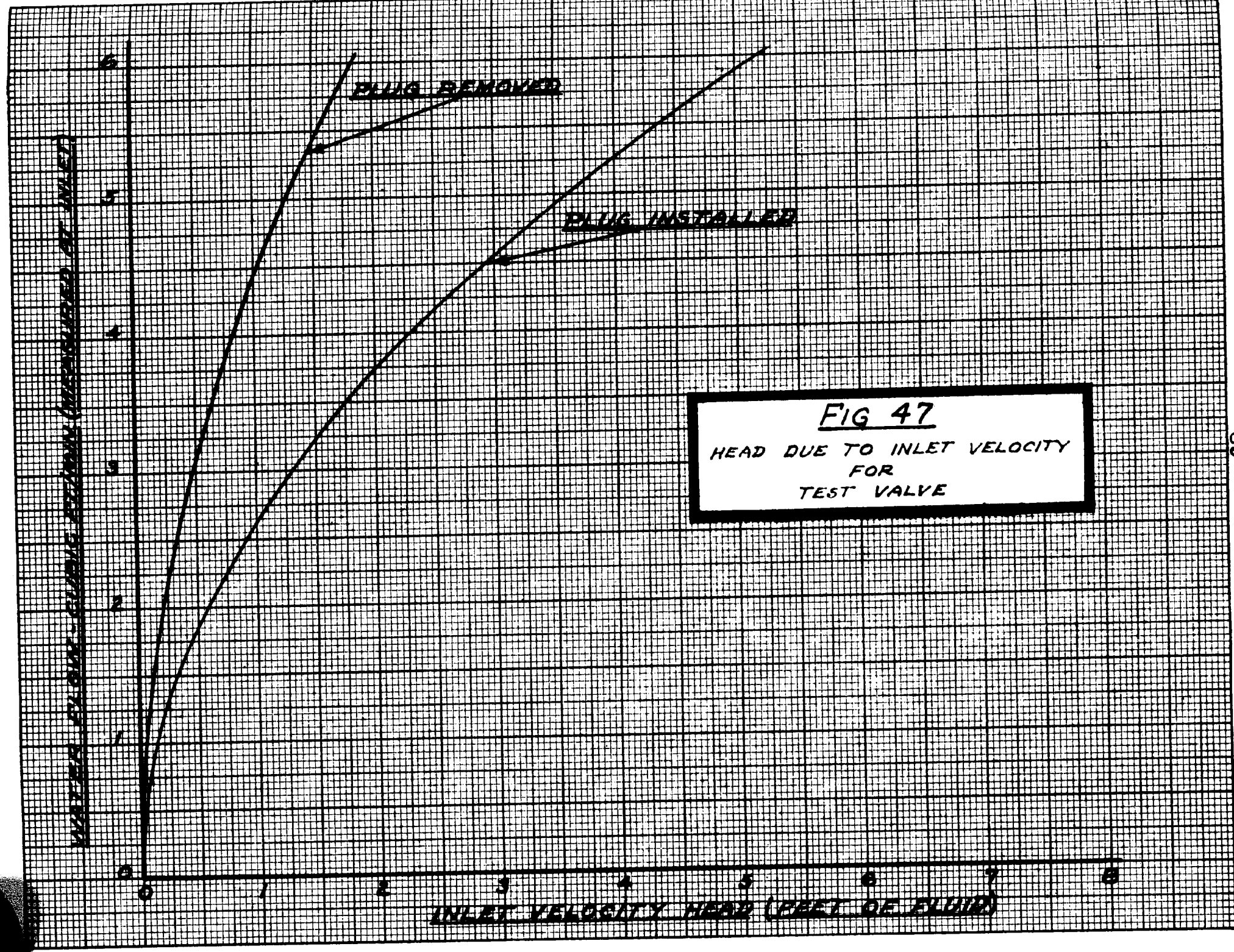
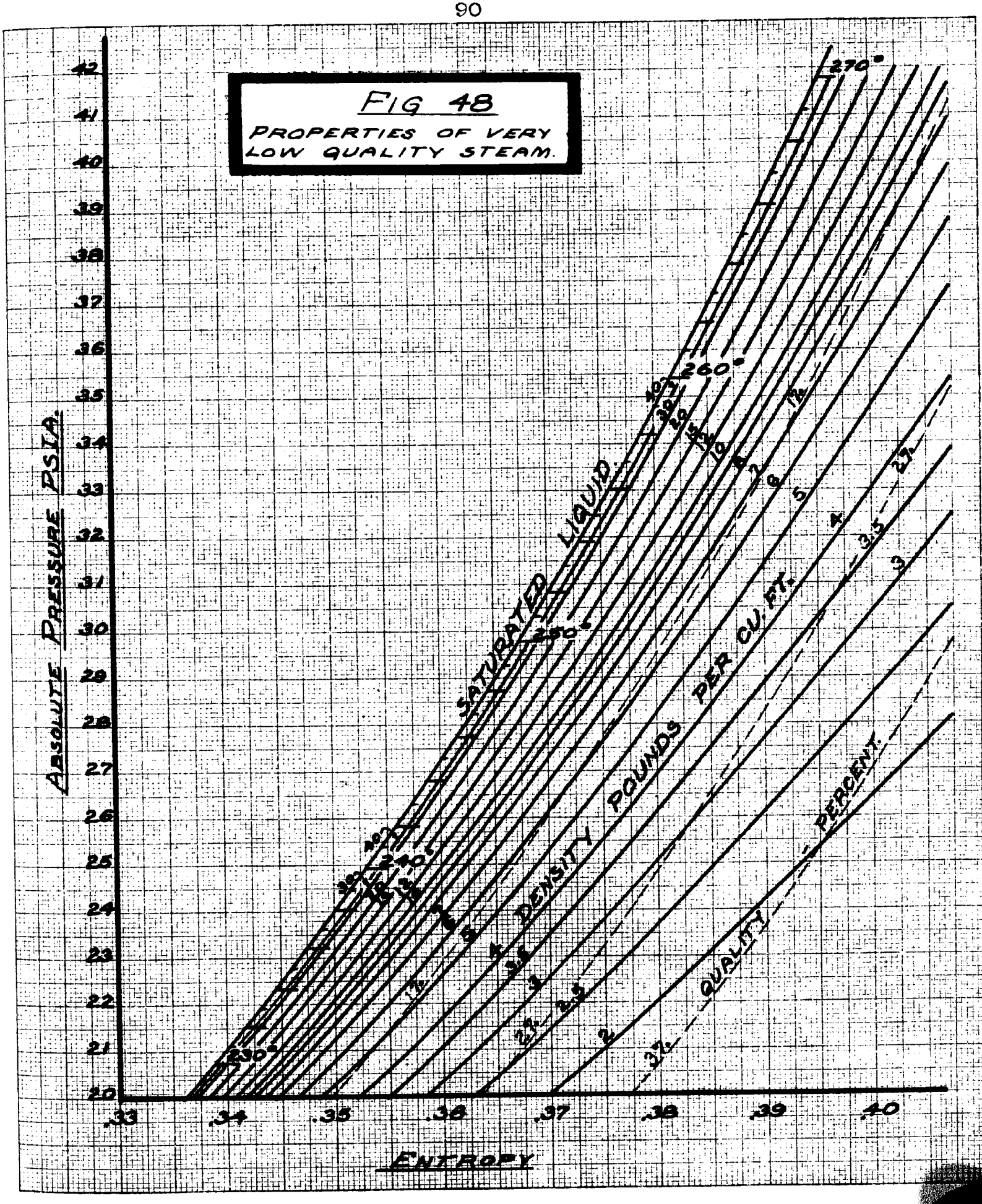
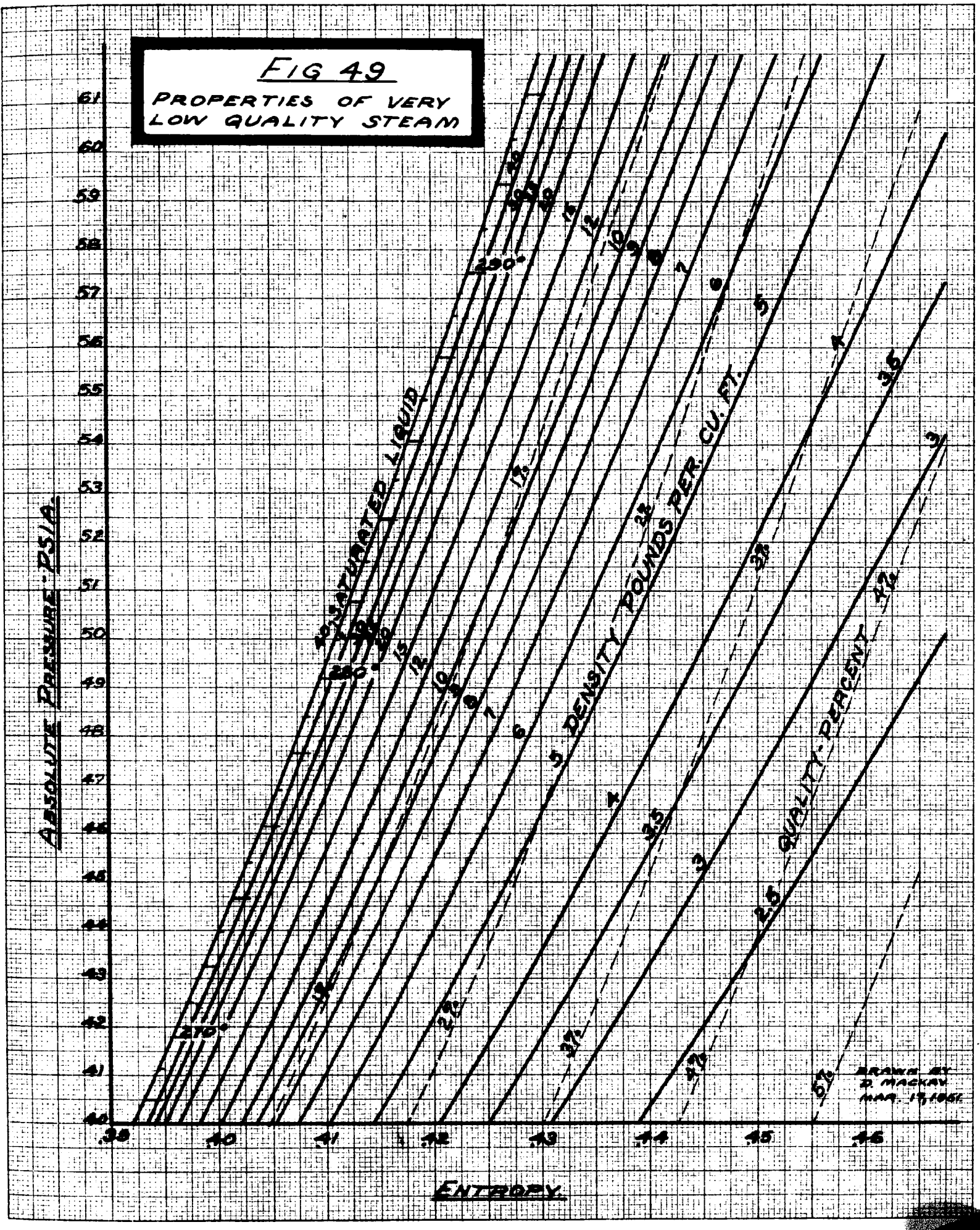
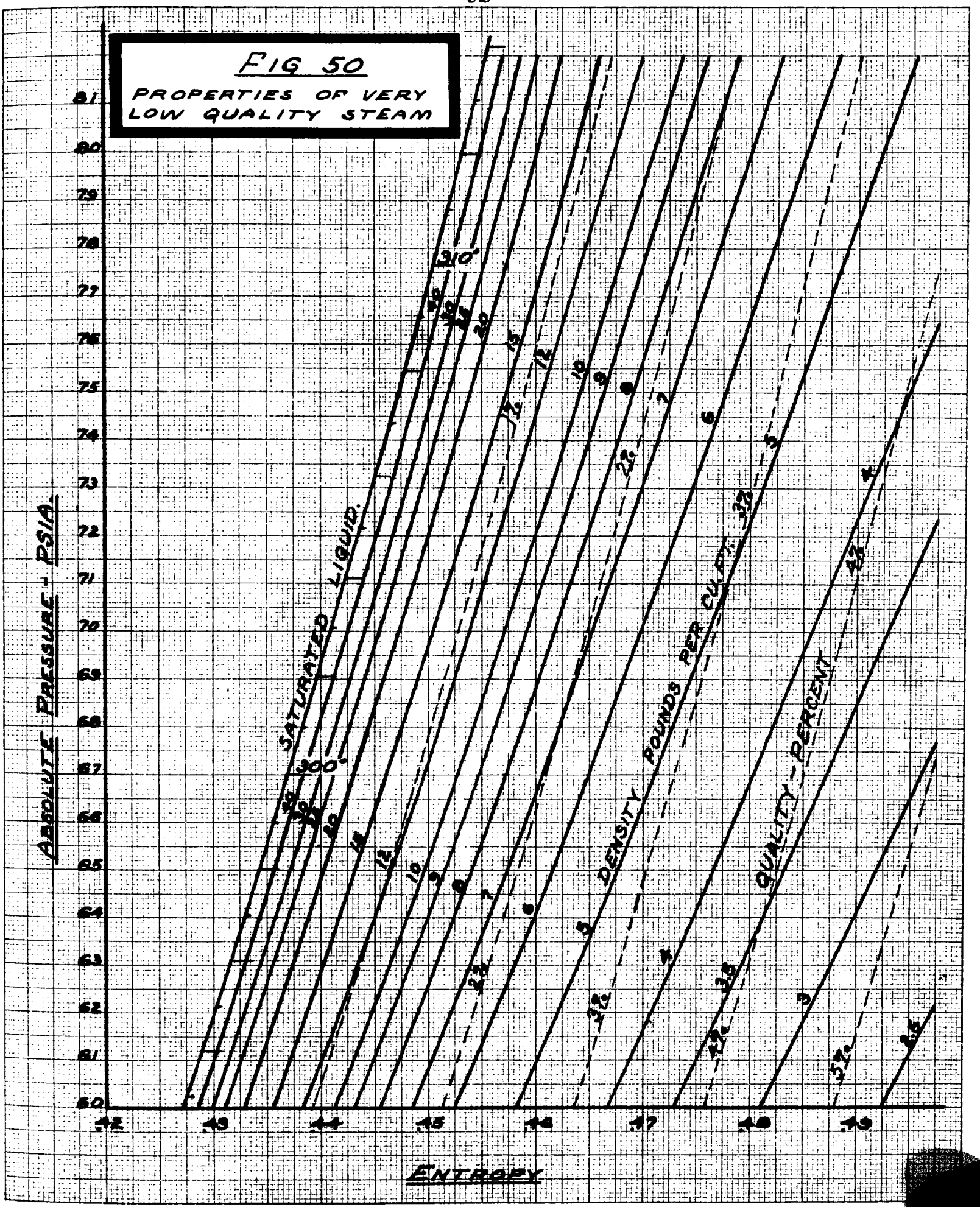


FIG 47

HEAD DUE TO INLET VELOCITY FOR TEST VALVE


FIG 48
PROPERTIES OF VERY LOW QUALITY STEAM.
ABSOLUTE PRESSURE PSIA.
ENTROPY
SATURATED LIQUID
DENSITY POUNDS PER CU. FT.
QUALITY PERCENT.
270°
260°
250°
240°
230°
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
.33
.34
.35
.36
.37
.38
.39
.40


FIG 49
PROPERTIES OF VERY LOW QUALITY STEAM
ABSOLUTE PRESSURE - PSIA
ENTROPY
SATURATED LIQUID
DENSITY - POUNDS PER CU. FT.
QUALITY - PERCENT
290°
270°
61
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
41
40
.39
.40
.41
.42
.43
.44
.45
.46
DRAWN BY D MACKAY MAR. 17, 1961


FIG 50
PROPERTIES OF VERY LOW QUALITY STEAM
ABSOLUTE PRESSURE - PSIA.
ENTROPY
SATURATED LIQUID
310°
300°
DENSITY POUNDS PER CU. FT.
QUALITY - PERCENT
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
.42
.43
.44
.45
.46
.47
.48
.49

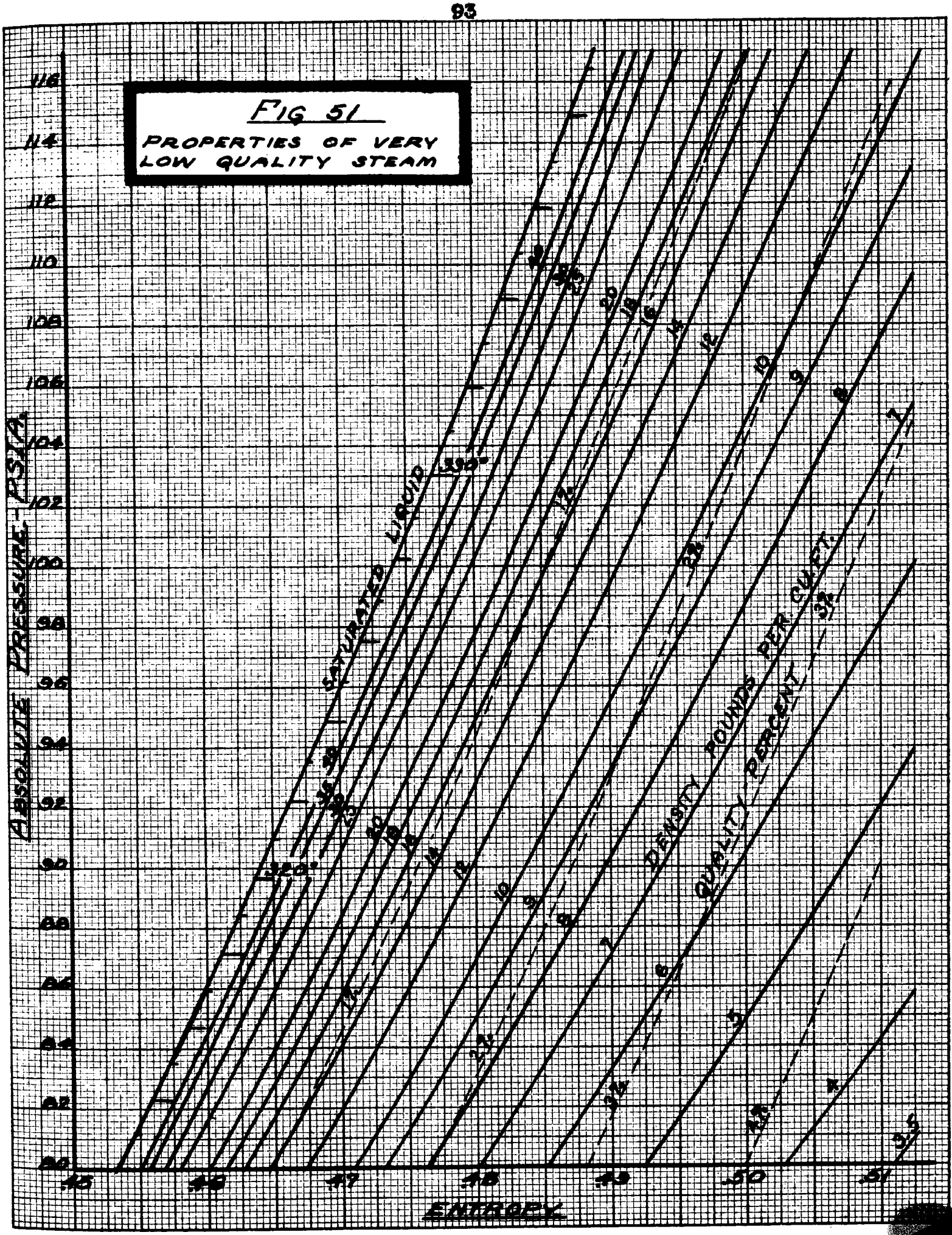
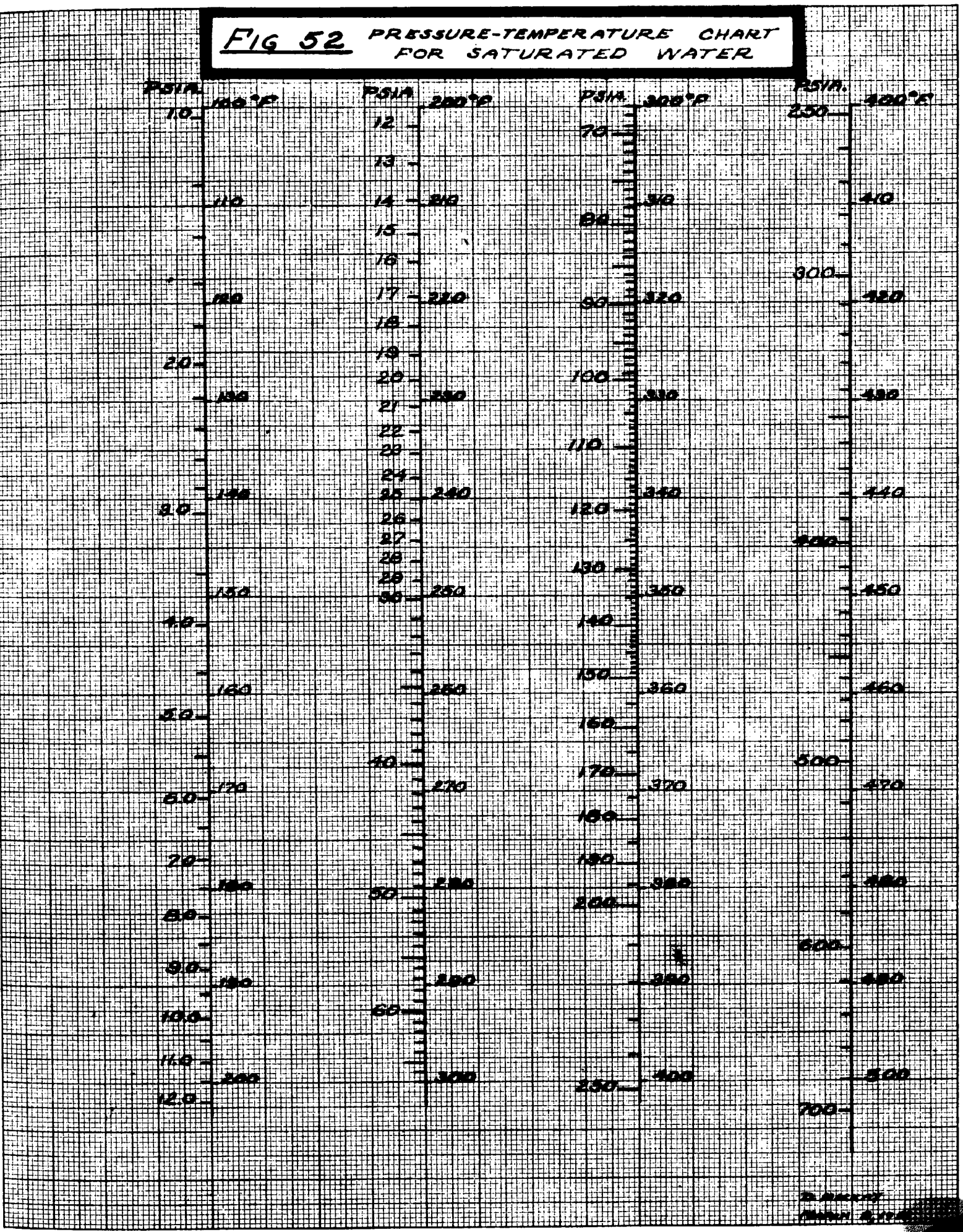

FIG 51
PROPERTIES OF VERY LOW QUALITY STEAM
ABSOLUTE PRESSURE - PSIA
ENTROPY
SATURATED LIQUID
320°
330°
DENSITY POUNDS PER CUBIC FOOT
QUALITY PERCENT
116
114
112
110
108
106
104
102
100
98
96
94
92
90
88
86
84
82
80
.45
.46
.47
.48
.49
.50
.51

FIG 52 PRESSURE-TEMPERATURE CHART FOR SATURATED WATER



APPENDIX II

The data taken during the tests as well as the major part of computed results are summarized and presented in this appendix. The test data for saturated water are numbered from 1 to 89 inclusive, and are shown on pages 96 to 140. The test data for cold water are presented in a different form, as shown on pages 141 to 147, and are numbered from 200 to 249.

Test Number 1 Date 3-6-51

Valve Opening (lift)-- 0.307 Inches.
Duration of Test ----- 4.592 Minutes.
Water Level Difference 25 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	50.1	48.6	43.9	45.0	44.8	44.7		42.9
Saturation Temperature °F.	282.0	279.4	273.7	274.5	270.4	274.0		271.5
Water Temp. Measured °F.	281.8	281.8	280.1	278.5	277.0	277.0	277.0	277.0
Wall Temperature °F.	280.0	281.8	278.5	278.5	278.5	277.8	277.8	277.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.932
Specific volume of inlet water cu.ft./lb. -------	0.01728
Water flow lbs./sec. ----------	2.085
Water flow cu.ft./min.(measured at inlet) -------	2.16
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	4.7
Static head between sta. 2 & 3, ft. of inlet fluid	11.6
Head due to inlet velocity (ft. of inlet fluid) -	0.7
Total head available (sta. 2 to 3), ft. of fluid	12.3

Test Number 2 Date 3-6-51

Valve Opening (lift)-- 0.307 Inches.
Duration of test ----- 4.749 Minutes.
Water Level Difference 28 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.		48.9	44.2	44.5	45.3	44.7		42.9
Saturation Temperature °F.		279.5	273.5	274.8	275.0	274.0		271.5
Water Temp. Measured °F.	281.7	281.7	280.0	278.5	277.0	277.0	277.0	277.0
Wall Temperature °F.	280.2	281.7	278.5	278.5	280.2	280.2	278.5	278.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.916
Specific volume of inlet water cu.ft./lb. -------	0.01728
Water flow lbs./sec. ----------	2.22
Water flow cu.ft./min. (measured at inlet) ------	2.31
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	4.7
Static head between sta. 2 & 3, ft. of inlet fluid	11.6
Head due to inlet velocity (ft. of inlet fluid)--	0.8
Total head available (sta. 2 to 3), ft. of fluid	12.4

Test Number 3 Date 3-9-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 3.572 Minutes.
Water Level Difference 23 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	85.4	85.0	66.2	67.6	67.5	67.5		67.7
Saturation Temperature °F.	316.8	316.5	299.3	300.5	300.5	300.5		300.6
Water Temp. Measured °F.	315.8	315.8	305.2	300.3	300.3	300.3	300.6	300.6
Wall Temperature °F.	315.1	315.5	302.5	302.0	302.2	302.2	300.3	300.3

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.915
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	2.426
Water flow cu.ft./min.(measured at inlet) -------	2.565
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	18.8
Static head between sta. 2 & 3, ft. of inlet fluid	47.7
Head due to inlet velocity (ft. of inlet fluid) -	1.0
Total head available (sta. 2 to 3), ft. of fluid	48.7

Test Number 4 Date 3-9-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 3.248 Minutes.
Water Level Difference 18 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	68.0	66.9	53.4	53.1		52.1		52.8
Saturation Temperature °F.	300.7	299.8	285.2	283.5		283.5		284.5
Water Temp. Measured °F.	300.3	300.0	290.3	285.0	285.0	285.3	285.0	285.0
Wall Temperature °F.	296.0	298.8	286.5	286.5	286.8	286.5	286.4	285.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.922
Specific volume of inlet water cu.ft./lb. -------	0.01745
Water flow lbs./sec. ----------	2.10
Water flow cu.ft./min. (measured at inlet) ------	2.20
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	13.6
Static head between sta. 2 & 3, ft. of inlet fluid	34.1
Head due to inlet velocity (ft. of inlet fluid)--	0.7
Total head available (sta. 2 to 3), ft. of fluid	34.8

Test Number 5 Date 3-10-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.425 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	85.6	86.3	71.8	72.5	73.2	71.9		71.7
Saturation Temperature °F.	316.7	317.5	304.5	305.3	306.0	304.5		304.6
Water Temp. Measured °F.	317.7	317.7	311.6	306.8	305.3	305.5	305.2	305.2
Wall Temperature °F.		316	307	307	307	307	307	306

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.912
Specific volume of inlet water cu.ft./lb. -------	0.01768
Water flow lbs./sec. ----------	2.165
Water flow cu.ft./min.(measured at inlet) -------	2.295
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	14.5
Static head between sta. 2 & 3, ft. of inlet fluid	36.9
Head due to inlet velocity (ft. of inlet fluid) -	0.8
Total head available (sta. 2 to 3), ft. of fluid	37.7

Test Number 6 Date 3-10-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 2.928 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	68.2	68.0	56.8	57.6	58.2	57.3		56.9
Saturation Temperature °F.	301.2	300.8	289.0	290.0	290.8	289.7		289.2
Water Temp. Measured °F.	300.3	301.5	295.8	291.3	290.5	290.5	290.0	290.0
Wall Temperature °F.		300.3	290.0	291.0	290.5	291.3	290.0	

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01747
Water flow lbs./sec. ----------	1.933
Water flow cu.ft./min. (measured at inlet) ------	2.026
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	11.2
Static head between sta. 2 & 3, ft. of inlet fluid	28.1
Head due to inlet velocity (ft. of inlet fluid)--	0.6
Total head available (sta. 2 to 3), ft. of fluid	28.7

Test Number 7 Date 3-9-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.573 Minutes.
Water Level Difference 12 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	85.5	86.2	77.2	77.4	78.3	78.1		76.9
Saturation Temperature °F.	316.7	317.5	309.7	309.8	310.6	310.5		309.2
Water Temp. Measured °F.	315.0	315.3	312.0	310.0	309.3	309.0	309.5	309.0
Wall Temperature °F.	312.0	315.0	310.0	310.0	310.0	310.5	310.0	309.2

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.915
Specific volume of inlet water cu.ft./lb. -------	0.01760
Water flow lbs./sec. ----------	1.756
Water flow cu.ft./min.(measured at inlet) -------	1.855
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	9.0
Static head between sta. 2 & 3, ft. of inlet fluid	22.7
Head due to inlet velocity (ft. of inlet fluid) -	0.5
Total head available (sta. 2 to 3), ft. of fluid	23.2

Test Number 8 Date 3-9-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 2.728 Minutes.
Water Level Difference 10 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	85.5	87.2	81.4	81.4	82.8	82.3		81.4
Saturation Temperature °F.	316.7	318.2	213.4	313.4	314.4	314.0		313.4
Water Temp. Measured °F.	314.8	314.8	314.0	313.5	313.2	313.0	313.0	313.0
Wall Temperature °F.	313.4	314.8	314.4	314.4	314.4	314.4	314.4	314.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.915
Specific volume of inlet water cu.ft./lb. -------	0.01760
Water flow lbs./sec. ----------	1.381
Water flow cu.ft./min. (measured at inlet) ------	1.456
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	5.8
Static head between sta. 2 & 3, ft. of inlet fluid	14.7
Head due to inlet velocity (ft. of inlet fluid)--	0.3
Total head available (sta. 2 to 3), ft. of fluid	15.0

Test Number 9 Date 3-9-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.890 Minutes.
Water Level Difference 11 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	68.1	67.5	61.9	63.0	64.3	62.5		62.4
Saturation Temperature °F.	301.3	300.6	294.6	295.7	297.3	295.3		295.3
Water Temp. Measured °F.	302.0	302.0	300.3	296.5	296.5	296.5	296.5	296.5
Wall Temperature °F.	300.3	301.5	296.8	296.8	298.0	298.6	298.0	296.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01747
Water flow lbs./sec. ----------	1.442
Water flow cu.ft./min.(measured at inlet) -------	1.512
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	5.6
Static head between sta. 2 & 3, ft. of inlet fluid	14.1
Head due to inlet velocity (ft. of inlet fluid) -	0.3
Total head available (sta. 2 to 3), ft. of fluid	14.4

Test Number 10 Date 3-10-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 3.804 Minutes.
Water Level Difference 21 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	68.2	68.1	54.9	55.4	56.6	55.3		54.5
Saturation Temperature °F.	317.4	317.3	287.0	287.7	289.0	287.5		286.5
Water Temp. Measured °F.	301.5	301.8	293.0	288.5	287.8	287.0	286.8	285.8
Wall Temperature °F.		300.3	288.8	288.8	288.8	288.4	288.4	

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01747
Water flow lbs./sec. ----------	2.085
Water flow cu.ft./min. (measured at inlet) ------	2.185
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	13.2
Static head between sta. 2 & 3, ft. of inlet fluid	33.2
Head due to inlet velocity (ft. of inlet fluid)--	0.7
Total head available (sta. 2 to 3), ft. of fluid	33.9

Test Number 11 Date 3-9-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.576 Minutes.
Water Level Difference 10 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	85.5	87.2	81.2	81.4	83.3	82.3		81.4
Saturation Temperature °F.	316.8	318.2	313.3	314.3	314.8	314.1		313.4
Water Temp. Measured °F.	313	313	313	313	313	313	313	313
Wall Temperature °F.		312.0	311.7	311.7	311.7	311.7	311.7	311.9

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01758
Water flow lbs./sec. ----------	1.463
Water flow cu.ft./min.(measured at inlet) -------	1.543
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	6.0
Static head between sta. 2 & 3, ft. of inlet fluid	15.2
Head due to inlet velocity (ft. of inlet fluid) -	0.3
Total head available (sta. 2 to 3), ft. of fluid	15.5

Test Number 12 Date 4-21-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 4.296 Minutes.
Water Level Difference 17 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.9	66.8	60.6	61.1	61.4	60.6	60.9	61.6
Saturation Temperature °F.	299.8	299.7	299.0	294.0	294.3	293.5	293.8	294.3
Water Temp. Measured °F.	299.3	299.3	295.8	294.3	293.3	293.3	293.3	293.3
Wall Temperature °F.	296.5	297.5	293.3	293.3	293.8	294.1	294.1	

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01744
Water flow lbs./sec. ----------	1.501
Water flow cu.ft./min. (measured at inlet) ------	1.570
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	6.2
Static head between sta. 2 & 3, ft. of inlet fluid	15.5
Head due to inlet velocity (ft. of inlet fluid)--	0.4
Total head available (sta. 2 to 3), ft. of fluid	15.9

Test Number 13 Date 4-20-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.193 Minutes.
Water Level Difference 19 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.5	117.4	84.9	85.9	85.7	84.9	84.8	84.4
Saturation Temperature °F.	340.4	339.6	316.3	317.1	317.0	316.3	316.0	315.4
Water Temp. Measured °F.	339.3	339.3	320.5	317.8	317.8	317.0	316.9	316.4
Wall Temperature °F.	337.0	339.2	319.7	319.7	319.0	317.4	316.6	315.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01786
Water flow lbs./sec. ----------	3.22
Water flow cu.ft./min.(measured at inlet) -------	3.455
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	32.5
Static head between sta. 2 & 3, ft. of inlet fluid	83.6
Head due to inlet velocity (ft. of inlet fluid) -	1.7
Total head available (sta. 2 to 3), ft. of fluid	85.3

Test Number 14 Date 4-21-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 3.825 Minutes.
Water Level Difference 21 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	49.2	48.7	36.1	36.9	36.6	36.6	37.2	37.6
Saturation Temperature °F.	280.3	279.2	261.4	262.5	262.0	261.6	263.0	263.5
Water Temp. Measured °F.	276.2	276.2	269.0	263.8	263.6	263.0	263.0	263.0
Wall Temperature °F.	273.0	275.5	264.0	264.0	264.5	264.2	263.0	262.3

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.935
Specific volume of inlet water cu.ft./lb. -------	0.01722
Water flow lbs./sec. ----------	2.11
Water flow cu.ft./min. (measured at inlet) ------	2.18
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	12.5
Static head between sta. 2 & 3, ft. of inlet fluid	31.1
Head due to inlet velocity (ft. of inlet fluid)--	0.7
Total head available (sta. 2 to 3), ft. of fluid	31.8

Test Number 15 Date 4-21-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.255 Minutes.
Water Level Difference 18 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.4	117.3	89.6	90.4	90.6	90.0	90.4	89.5
Saturation Temperature °F.	340.2	339.6	319.8	320.7	320.6	320.3	320.5	319.8
Water Temp. Measured °F.	341.0	341.0	326.2	321.8	321.5	321.3	321.3	321.3
Wall Temperature °F.	337.8	341.0	324.0	324.0	324.5	322.3	321.3	319.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01787
Water flow lbs./sec. ----------	2.97
Water flow cu.ft./min.(measured at inlet) -------	3.185
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	27.7
Static head between sta. 2 & 3, ft. of inlet fluid	71.3
Head due to inlet velocity (ft. of inlet fluid) -	1.5
Total head available (sta. 2 to 3), ft. of fluid	72.8

Test Number 16 Date 4-21-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 2.698 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.4	117.3	94.2	94.5	95.0	94.6	95.4	94.8
Saturation Temperature °F.	340.2	339.6	323.6	323.7	324.2	323.8	324.5	324.0
Water Temp. Measured °F.	341.0	341.0	330.0	325.5	325.5	325.5	325.5	325.5
Wall Temperature °F.	337.8	340.1	326.5	325.5	326.5	326.0	325.5	324.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01787
Water flow lbs./sec. ----------	2.757
Water flow cu.ft./min. (measured at inlet) ------	2.95
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	23.1
Static head between sta. 2 & 3, ft. of inlet fluid	59.5
Head due to inlet velocity (ft. of inlet fluid)--	1.3
Total head available (sta. 2 to 3), ft. of fluid	60.8

Test Number 17 Date 4-21-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of Test ----- 2.449 Minutes.
Water Level Difference 16.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.3	113.8	95.0	95.2	95.5	95.7	96.0	95.7
Saturation Temperature °F.	337.6	337.2	324.2	324.4	324.5	324.6	324.7	324.6
Water Temp. Measured °F.	336.3	336.3	328.7	324.8	324.8	324.8	324.8	324.8
Wall Temperature °F.	332.8	336.3	324.8	324.0	324.0	326.7	323.2	324.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01782
Water flow lbs./sec. ----------	2.50
Water flow cu.ft./min.(measured at inlet) -------	2.67
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	18.8
Static head between sta. 2 & 3, ft. of inlet fluid	48.3
Head due to inlet velocity (ft. of inlet fluid) -	1.0
Total head available (sta. 2 to 3), ft. of fluid	49.3

Test Number 18 Date 4-21-51

Valve Opening (lift)-- 0.1115 Inches.
Duration of test ----- 4.171 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.3	118.3	114.1	114.8	115.6		114.7	114.7
Saturation Temperature °F.	340.2	340.2	337.5	337.8	338.6		337.8	337.8
Water Temp. Measured °F.	339.5	339.5	338.8	338.2	338.2	338.2	338.2	338.2
Wall Temperature °F.	339.5	339.5	338.5	338.5	338.5	338.5	338.5	338.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01786
Water flow lbs./sec. ----------	1.249
Water flow cu.ft./min. (measured at inlet) ------	1.337
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	4.1
Static head between sta. 2 & 3, ft. of inlet fluid	10.6
Head due to inlet velocity (ft. of inlet fluid)--	0.3
Total head available (sta. 2 to 3), ft. of fluid	10.9

Test Number 19 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.970 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.5	66.1	52.9	52.9	53.0	52.8	53.1	53.3
Saturation Temperature °F.	299.6	299.2	284.4	284.4	284.7	284.5	284.8	284.9
Water Temp. Measured °F.	299.4	299.0	292.8	286.8	286.0	286.0	286.0	285.4
Wall Temperature °F.	295.0	295.5	287.5	288.0	288.5	293.5	292.8	290.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01744
Water flow lbs./sec. ----------	2.55
Water flow cu.ft./min.(measured at inlet) -------	2.665
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	13.2
Static head between sta. 2 & 3, ft. of inlet fluid	33.2
Head due to inlet velocity (ft. of inlet fluid) -	1.0
Total head available (sta. 2 to 3), ft. of fluid	34.2

Test Number 20 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 3.471 Minutes.
Water Level Difference 21 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.5	66.1	55.7	55.8	56.0	55.8	56.7	56.8
Saturation Temperature °F.	299.6	299.2	287.7	287.8	288.3	287.8	288.8	288.8
Water Temp. Measured °F.	300.2	294.8	291.0	289.9	289.9	289.9	289.9	289.9
Wall Temperature °F.	293.5	300.9	286.3	286.3	291.0	291.5	291.0	289.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01738
Water flow lbs./sec. ----------	2.295
Water flow cu.ft./min. (measured at inlet) ------	2.39
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	10.4
Static head between sta. 2 & 3, ft. of inlet fluid	26.1
Head due to inlet velocity (ft. of inlet fluid)--	0.8
Total head available (sta. 2 to 3), ft. of fluid	26.9

Test Number 21 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.825 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.0	66.1	59.5	60.1	60.1	59.7	60.1	60.7
Saturation Temperature °F.	299.0	299.2	292.3	292.9	292.9	292.4	292.9	293.4
Water Temp. Measured °F.	300.2	300.5	296.0	294.4	293.9	293.9	293.9	293.9
Wall Temperature °F.	298.5	300.2	294.4	294.4	295.0	295.3	295.5	

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01744
Water flow lbs./sec. ----------	1.88
Water flow cu.ft./min.(measured at inlet) -------	1.967
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	6.6
Static head between sta. 2 & 3, ft. of inlet fluid	16.5
Head due to inlet velocity (ft. of inlet fluid) -	0.6
Total head available (sta. 2 to 3), ft. of fluid	17.1

Test Number 22 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 3.912 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.5	66.2	62.7	62.9	63.2	62.5	62.7	63.8
Saturation Temperature °F.	299.6	299.2	295.5	295.8	296.0	295.4	295.5	296.5
Water Temp. Measured °F.	298.0	298.0	296.8	296.0	296.0	296.0	296.0	296.0
Wall Temperature °F.	296.0	298.5	295.7	295.7	295.7	296.0	295.7	295.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01742
Water flow lbs./sec. ----------	1.453
Water flow cu.ft./min. (measured at inlet) ------	1.518
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	3.6
Static head between sta. 2 & 3, ft. of inlet fluid	8.9
Head due to inlet velocity (ft. of inlet fluid)--	0.3
Total head available (sta. 2 to 3), ft. of fluid	9.2

Test Number 23 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 3.835 Minutes.
Water Level Difference 28 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.5	66.2	53.9	54.2	54.4	53.9	54.2	54.5
Saturation Temperature °F.	299.6	299.2	285.7	286.3	286.4	285.7	286.3	286.5
Water Temp. Measured °F.	298.6	299.0	292.0	286.4	285.5	285.5	285.5	285.5
Wall Temperature °F.	297.6	297.6	287.3	286.8	287.5	286.8	286.0	286.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	2.47
Water flow cu.ft./min.(measured at inlet) -------	2.585
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	12.3
Static head between sta. 2 & 3, ft. of inlet fluid	30.9
Head due to inlet velocity (ft. of inlet fluid) -	1.0
Total head available (sta. 2 to 3), ft. of fluid	31.9

Test Number 24 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 2.657 Minutes.
Water Level Difference 21 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.0	85.7	66.1	67.4	68.4	67.2	67.5	67.7
Saturation Temperature °F.	317.4	316.8	299.0	300.5	301.3	300.2	300.5	300.5
Water Temp. Measured °F.	316.6	316.6	306.5	301.3	300.2	300.2	300.2	300.2
Wall Temperature °F.	315.0	316.6	301.2	302.5	303.5	301.3	299.5	298.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	2.985
Water flow cu.ft./min. (measured at inlet) ------	3.15
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	19.6
Static head between sta. 2 & 3, ft. of inlet fluid	49.8
Head due to inlet velocity (ft. of inlet fluid)--	1.4
Total head available (sta. 2 to 3), ft. of fluid	51.2

Test Number 25 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.281 Minutes.
Water Level Difference 10 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.0	85.8	80.3	80.7	81.4	80.6	81.5	81.5
Saturation Temperature °F.	317.4	316.8	312.4	312.6	313.5	312.6	313.5	313.5
Water Temp. Measured °F.	316.6	316.6	315.0	313.8	313.8	313.8	313.8	313.8
Wall Temperature °F.	312.6	315.8	312.6	312.6	313.2	312.6	312.3	312.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	1.651
Water flow cu.ft./min.(measured at inlet) -------	1.745
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	5.5
Static head between sta. 2 & 3, ft. of inlet fluid	14.0
Head due to inlet velocity (ft. of inlet fluid) -	0.4
Total head available (sta. 2 to 3), ft. of fluid	14.4

Test Number 26 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 3.198 Minutes.
Water Level Difference 22 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.0	85.9	71.9	72.5	72.3	72.7	73.0	73.0
Saturation Temperature °F.	317.4	317.0	304.6	305.3	305.2	305.4	305.6	305.8
Water Temp. Measured °F.	316.6	316.6	311.0	307.0	306.3	306.3	306.3	306.3
Wall Temperature °F.	315.0	315.8	307.0	307.0	307.2	307.6	306.0	305.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	2.595
Water flow cu.ft./min. (measured at inlet) ------	2.735
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	14.0
Static head between sta. 2 & 3, ft. of inlet fluid	35.5
Head due to inlet velocity (ft. of inlet fluid)--	1.1
Total head available (sta. 2 to 3), ft. of fluid	36.6

Test Number 27 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.442 Minutes.
Water Level Difference 11 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.0	85.9	80.5	80.6	81.1	80.7	82.0	82.5
Saturation Temperature °F.	317.4	317.0	312.5	312.5	313.0	312.5	313.7	314.3
Water Temp. Measured °F.	316.6	316.6	315.0	314.0	313.3	313.3	313.3	312.6
Wall Temperature °F.	311.5	315.8	313.3	313.3	313.7	314.5	313.7	313.7

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	1.697
Water flow cu.ft./min.(measured at inlet) -------	1.794
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	5.4
Static head between sta. 2 & 3, ft. of inlet fluid	13.7
Head due to inlet velocity (ft. of inlet fluid) -	0.5
Total head available (sta. 2 to 3), ft. of fluid	14.2

Test Number 28 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 2.554 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.0	85.9	76.0	76.3	76.5	76.5	76.9	77.0
Saturation Temperature °F.	317.4	317.0	308.3	308.7	309.0	309.1	309.1	309.2
Water Temp. Measured °F.	316.6	316.6	313.4	310.2	309.4	309.4	309.4	309.4
Wall Temperature °F.	315.0	316.6	309.4	309.4	310.0	311.0	310.2	308.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	2.215
Water flow cu.ft./min. (measured at inlet) ------	2.34
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	9.9
Static head between sta. 2 & 3, ft. of inlet fluid	25.3
Head due to inlet velocity (ft. of inlet fluid)--	0.8
Total head available (sta. 2 to 3), ft. of fluid	26.1

Test Number 29 Date 4-12-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 3.210 Minutes.
Water Level Difference 16 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.0	85.9	78.8	78.5	79.3	79.0	79.9	80.5
Saturation Temperature °F.	317.4	317.0	310.8	310.8	311.5	311.0	311.8	312.4
Water Temp. Measured °F.	316.6	316.6	314.0	312.0	311.5	311.5	311.5	311.5
Wall Temperature °F.	311.0	311.5	311.0	311.0	312.0	312.0	312.0	310.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	1.88
Water flow cu.ft./min.(measured at inlet) -------	1.985
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	7.1
Static head between sta. 2 & 3, ft. of inlet fluid	18.1
Head due to inlet velocity (ft. of inlet fluid) -	0.6
Total head available (sta. 2 to 3), ft. of fluid	18.7

Test Number 30 Date 4-13-51

Valve Opening (lift)-- 0.1416 Inches.
Duration of test ----- 4.611 Minutes.
Water Level Difference 25 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	46.9	46.3	37.3	37.7	37.4	37.9	38.2	38.5
Saturation Temperature °F.	277.1	276.2	263.3	263.6	263.4	264.0	264.5	264.9
Water Temp. Measured °F.	276.2	276.2	270.3	265.5	264.5	264.2	263.9	263.5
Wall Temperature °F.	274.7	275.8	265.5	265.5	266.8	267.2	266.3	264.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.935
Specific volume of inlet water cu.ft./lb. -------	0.01722
Water flow lbs./sec. ----------	2.091
Water flow cu.ft./min. (measured at inlet) ------	2.16
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	9.0
Static head between sta. 2 & 3, ft. of inlet fluid	22.2
Head due to inlet velocity (ft. of inlet fluid)--	0.7
Total head available (sta. 2 to 3), ft. of fluid	22.9

Test Number 31 Date 4-13-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.450 Minutes.
Water Level Difference 23 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	116.0	114.9	88.7	89.3	90.4	89.4	89.5	88.6
Saturation Temperature °F.	338.7	337.9	319.2	319.7	320.5	319.7	319.7	319.1
Water Temp. Measured °F.	338.6	338.6	326.7	322.6	319.7	319.7	319.7	319.7
Wall Temperature °F.	332.8	338.5	320.4	320.4	323.0	319.7	319.0	317.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01785
Water flow lbs./sec. ----------	3.49
Water flow cu.ft./min.(measured at inlet) -------	3.73
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	26.2
Static head between sta. 2 & 3, ft. of inlet fluid	67.3
Head due to inlet velocity (ft. of inlet fluid) -	2.0
Total head available (sta. 2 to 3), ft. of fluid	69.3

Test Number 32 Date 4-13-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 2.619 Minutes.
Water Level Difference 22 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	116.0	114.8	92.8	93.0	92.6	92.5	93.0	90.2
Saturation Temperature °F.	338.7	337.8	322.5	322.7	322.4	322.4	322.6	321.8
Water Temp. Measured °F.	338.0	337.5	329.5	323.4	323.4	323.4	323.4	323.4
Wall Temperature °F.	334.5	337.0	323.7	323.4	323.7	323.4	322.3	321.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01784
Water flow lbs./sec. ----------	3.12
Water flow cu.ft./min. (measured at inlet) ------	3.34
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	22.0
Static head between sta. 2 & 3, ft. of inlet fluid	56.5
Head due to inlet velocity (ft. of inlet fluid)--	1.6
Total head available (sta. 2 to 3), ft. of fluid	58.1

Test Number 33 Date 4-13-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.623 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	116.0	115.0	97.5	97.5	97.8	97.4	98.1	97.9
Saturation Temperature °F.	338.7	338.0	326.0	326.0	326.2	326.0	326.4	326.2
Water Temp. Measured °F.	337.8	337.8	331.0	326.5	326.0	326.5	326.0	326.5
Wall Temperature °F.	334.5	337.0	326.5	325.5	326.5	327.8	326.5	325.0

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01784
Water flow lbs./sec.	2.83
Water flow cu.ft./min.(measured at inlet)	3.03
Pressure drop (P_2 - P_3). lbs./sq.in.	17.5
Static head between sta. 2 & 3, ft. of inlet fluid	44.9
Head due to inlet velocity (ft. of inlet fluid) -	1.4
Total head available (sta. 2 to 3), ft. of fluid	46.3

Test Number 34 Date 4-13-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 2.485 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.0	113.8	102.7	102.4	102.1	102.2	102.8	103.0
Saturation Temperature °F.	337.2	337.2	329.8	329.5	329.3	329.5	329.7	330.0
Water Temp. Measured °F.	336.8	336.8	333.5	330.0	329.7	330.0	330.0	330.0
Wall Temperature °F.	334.5	336.8	329.5	329.5	329.5	329.7	329.5	328.7

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01783
Water flow lbs./sec.	2.24
Water flow cu.ft./min. (measured at inlet)	2.40
Pressure drop (P_2 - P_3). lbs./sq. in.	11.1
Static head between sta. 2 & 3, ft. of inlet fluid	28.5
Head due to inlet velocity (ft. of inlet fluid)--	0.8
Total head available (sta. 2 to 3), ft. of fluid	29.3

Test Number 35 Date 4-13-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of Test ----- 2.695 Minutes.
Water Level Difference 10 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.0	113.8	109.7	110.3	110.2		110.9	110.4
Saturation Temperature °F.	337.2	337.2	334.7	335.0	335.0		335.3	335.2
Water Temp. Measured °F.	336.2	335.7	334.5	333.5	333.0	333.0	333.0	333.0
Wall Temperature °F.	332.0	335.3	333.5	333.5	333.5	333.5	333.5	333.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01781
Water flow lbs./sec. ----------	1.38
Water flow cu.ft./min.(measured at inlet) -------	1.476
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	4.1
Static head between sta. 2 & 3, ft. of inlet fluid	10.5
Head due to inlet velocity (ft. of inlet fluid) -	0.3
Total head available (sta. 2 to 3), ft. of fluid	10.8

Test Number 36 Date 4-14-51

Valve Opening (lift)-- 0.1465 Inches.
Duration of test ----- 2.615 Minutes.
Water Level Difference 24 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	110.1	108.9	83.6	82.3	82.5	81.5	82.6	81.5
Saturation Temperature °F.	335.1	334.0	315.2	314.2	314.3	313.3	314.3	313.3
Water Temp. Measured °F.	330.0	330.0	322.3		315.0	315.0	315.0	315.0
Wall Temperature °F.	327.5	329.5	315.8	315.0	315.5	315.0	315.0	314.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01776
Water flow lbs./sec. ----------	3.42
Water flow cu.ft./min. (measured at inlet) ------	3.64
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	25.3
Static head between sta. 2 & 3, ft. of inlet fluid	64.7
Head due to inlet velocity (ft. of inlet fluid)--	1.9
Total head available (sta. 2 to 3), ft. of fluid	66.6

Test Number 37 Date 4-16-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 2.960 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.7	66.4	45.3	44.9	44.8	44.4	45.3	44.8
Saturation Temperature °F.	299.7	299.3	275.0	274.3	274.2	273.8	274.8	274.2
Water Temp. Measured °F.	301.3	301.3	277.8	276.2	275.5	275.5	275.5	274.8
Wall Temperature °F.	299.4	301.3	277.8	277.0	276.6	276.2	275.3	274.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01745
Water flow lbs./sec. ----------	1.92
Water flow cu.ft./min.(measured at inlet) -------	2.01
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	21.1
Static head between sta. 2 & 3, ft. of inlet fluid	52.9
Head due to inlet velocity (ft. of inlet fluid) -	0.6
Total head available (sta. 2 to 3), ft. of fluid	53.5

Test Number 38 Date 4-16-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 3.018 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.7	66.4	49.1	49.4	48.9	48.5	49.3	49.6
Saturation Temperature °F.	299.7	299.3	280.0	280.2	279.8	279.3	280.1	280.5
Water Temp. Measured °F.	302.0	302.0	285.3	281.8	281.8	282.0	281.8	281.8
Wall Temperature °F.	298.5	301.3	282.0	282.0	281.8	281.2	281.2	280.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01745
Water flow lbs./sec. ----------	1.76
Water flow cu.ft./min. (measured at inlet) ------	1.846
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	17.3
Static head between sta. 2 & 3, ft. of inlet fluid	43.6
Head due to inlet velocity (ft. of inlet fluid)--	0.5
Total head available (sta. 2 to 3), ft. of fluid	44.1

Test Number 39 Date 4-16-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 3.317 Minutes.
Water Level Difference 13 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.7	66.4	54.7	55.0	54.8	55.7	55.3	55.9
Saturation Temperature °F.	299.7	299.3	287.7	287.3	287.7	288.0	287.9	288.2
Water Temp. Measured °F.	301.8	301.3	292.8	288.5	288.5	288.5	288.5	288.5
Wall Temperature °F.	289.0	301.3	289.5	289.5	289.5	290.3	289.5	289.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01745
Water flow lbs./sec. ----------	1.487
Water flow cu.ft./min.(measured at inlet) -------	1.558
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	11.7
Static head between sta. 2 & 3, ft. of inlet fluid	29.3
Head due to inlet velocity (ft. of inlet fluid) -	0.4
Total head available (sta. 2 to 3), ft. of fluid	27.7

Test Number 40 Date 4-18-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 4.156 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.7	66.7	58.3	59.1	59.2	58.8	58.8	59.5
Saturation Temperature °F.	299.7	299.8	290.9	291.7	291.8	291.3	291.3	292.3
Water Temp. Measured °F.	300.2	300.2	296.0	292.8	291.6	291.6	291.6	291.0
Wall Temperature °F.	297.6	298.5	292.0	291.6	291.0	292.0	291.6	290.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01744
Water flow lbs./sec. ----------	1.278
Water flow cu.ft./min. (measured at inlet) ------	1.338
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	8.4
Static head between sta. 2 & 3, ft. of inlet fluid	21.2
Head due to inlet velocity (ft. of inlet fluid)--	0.3
Total head available (sta. 2 to 3), ft. of fluid	21.5

Test Number 41 Date 4-16-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 6.427 Minutes.
Water Level Difference 16 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.7	66.4	62.4	63.2	63.7	63.1	63.6	63.9
Saturation Temperature °F.	299.7	299.3	295.3	296.3	296.5	296.2	296.5	296.7
Water Temp. Measured °F.	296.0	296.0	295.0	294.0	295.5	295.5	295.5	295.5
Wall Temperature °F.	294.3	295.0	294.3	294.3	294.3	294.3	294.3	294.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01740
Water flow lbs./sec. ----------	0.945
Water flow cu.ft./min.(measured at inlet) -------	0.987
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	4.0
Static head between sta. 2 & 3, ft. of inlet fluid	10.0
Head due to inlet velocity (ft. of inlet fluid) -	0.1
Total head available (sta. 2 to 3), ft. of fluid	10.1

Test Number 42 Date 4-18-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 3.471 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	47.2	46.7	33.2	33.5	33.0	32.5	33.2	32.7
Saturation Temperature °F.	277.5	276.7	256.1	256.7	255.9	255.2	256.1	255.3
Water Temp. Measured °F.	276.2	276.2	257.3	254.5	253.8	254.2	254.5	253.8
Wall Temperature °F.	274.7	276.2	257.3	256.5	256.0	254.5	253.8	253.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.935
Specific volume of inlet water cu.ft./lb. -------	0.01722
Water flow lbs./sec. ----------	1.554
Water flow cu.ft./min. (measured at inlet) ------	1.605
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	13.5
Static head between sta. 2 & 3, ft. of inlet fluid	33.5
Head due to inlet velocity (ft. of inlet fluid)--	0.4
Total head available (sta. 2 to 3), ft. of fluid	33.9

Test Number 43 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 2.627 Minutes.
Water Level Difference 15.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.2	56.7	56.0	56.3	56.1	56.5	56.6
Saturation Temperature °F.	317.4	317.4	288.8	288.3	288.7	288.5	288.0	288.1
Water Temp. Measured °F.	316.7	316.7	291.0	289.5	289.0	289.0	287.5	287.2
Wall Temperature °F.	308.6	315.8	291.0	289.5	288.0	287.5	287.5	286.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	2.222
Water flow cu.ft./min.(measured at inlet) -------	2.35
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	29.5
Static head between sta. 2 & 3, ft. of inlet fluid	74.8
Head due to inlet velocity (ft. of inlet fluid) -	0.8
Total head available (sta. 2 to 3), ft. of fluid	75.6

Test Number 44 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 2.367 Minutes.
Water Level Difference 13 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.2	61.7	62.7	63.1	62.0	61.9	62.6
Saturation Temperature °F.	317.4	317.4	294.5	295.4	296.0	294.4	294.4	295.4
Water Temp. Measured °F.	314.0	314.0	298.5	296.0	295.6	295.2	295.2	294.7
Wall Temperature °F.	312.0	312.6	304.8	305.5	306.2	309.5	308.7	307.7

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01758
Water flow lbs./sec. ----------	2.075
Water flow cu.ft./min. (measured at inlet) ------	2.188
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	24.5
Static head between sta. 2 & 3, ft. of inlet fluid	61.9
Head due to inlet velocity (ft. of inlet fluid)--	0.7
Total head available (sta. 2 to 3), ft. of fluid	62.6

Test Number 45 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 3.790 Minutes.
Water Level Difference 18 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.6	68.4	68.8	69.9	68.8	69.3	69.4
Saturation Temperature °F.	317.4	317.6	301.3	301.8	302.8	301.8	302.2	302.3
Water Temp. Measured °F.	316.7	316.7	305.5	302.5	302.0	301.5	301.3	301.3
Wall Temperature °F.	311.0	315.0	302.0	301.3	302.0	302.0	301.3	299.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01761
Water flow lbs./sec. ----------	1.79
Water flow cu.ft./min.(measured at inlet) -------	1.89
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	18.2
Static head between sta. 2 & 3, ft. of inlet fluid	46.3
Head due to inlet velocity (ft. of inlet fluid) -	0.5
Total head available (sta. 2 to 3), ft. of fluid	46.8

Test Number 46 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 3.740 Minutes.
Water Level Difference 15.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.2	73.0	73.0	73.4	73.4	74.3	74.1
Saturation Temperature °F.	317.4	317.4	305.9	305.7	306.3	306.3	307.0	306.8
Water Temp. Measured °F.	315.8	315.8	310.2	307.0	306.0	306.0	306.0	306.0
Wall Temperature °F.	314.0	315.5	307.0	306.5	306.5	306.5	306.5	306.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01798
Water flow lbs./sec. ----------	1.562
Water flow cu.ft./min. (measured at inlet) ------	1.685
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	13.2
Static head between sta. 2 & 3, ft. of inlet fluid	34.1
Head due to inlet velocity (ft. of inlet fluid)--	0.4
Total head available (sta. 2 to 3), ft. of fluid	34.5

Test Number 47 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 4.883 Minutes.
Water Level Difference 15.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.8	80.7	80.7	81.9	81.6	82.3	81.3
Saturation Temperature °F.	317.4	317.7	312.5	312.5	313.6	312.4	314.2	313.2
Water Temp. Measured °F.	313.5	313.5	312.7	313.0	313.0	313.0	313.0	313.0
Wall Temperature °F.	310.3	312.6	312.0	311.0	311.0	310.3	311.0	310.3

Computed Results.

Tank Calibration Correction Factor - F.	0.917
Specific volume of inlet water cu.ft./lb.	0.017575
Water flow lbs./sec.	1.197
Water flow cu.ft./min.(measured at inlet)	1.263
Pressure drop (P_2 - P_3). lbs./sq.in.	6.2
Static head between sta. 2 & 3, ft. of inlet fluid	15.5
Head due to inlet velocity (ft. of inlet fluid) -	0.2
Total head available (sta. 2 to 3), ft. of fluid	15.7

Test Number 48 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 2.682 Minutes.
Water Level Difference 18.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.3	114.2	73.9	72.9	72.9	72.3	72.6	72.3
Saturation Temperature °F.	337.6	337.5	306.5	305.5	305.5	305.0	305.3	305.1
Water Temp. Measured °F.	336.5	336.5	307.0	306.2	305.5	305.2	306.1	305.2
Wall Temperature °F.	333.6	336.2	307.8	306.2	306.2	305.5	304.0	303.0

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01783
Water flow lbs./sec.	2.56
Water flow cu.ft./min. (measured at inlet)	2.735
Pressure drop (P_2 - P_3). lbs./sq. in.	40.3
Static head between sta. 2 & 3, ft. of inlet fluid	103.7
Head due to inlet velocity (ft. of inlet fluid)--	1.1
Total head available (sta. 2 to 3), ft. of fluid	104.8

Test Number 49 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 6.233 Minutes.
Water Level Difference 16 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.3	114.2	109.6	110.2	110.1		110.3	109.8
Saturation Temperature °F.	337.6	337.5	334.5	334.9	335.3		336.4	334.6
Water Temp. Measured °F.	335.8	335.8	334.5	335.4	335.3	335.3	335.3	335.0
Wall Temperature °F.	332.0	334.5	333.5	333.5	332.8	332.8	332.8	332.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01782
Water flow lbs./sec. ----------	0.953
Water flow cu.ft./min.(measured at inlet) -------	1.019
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	4.6
Static head between sta. 2 & 3, ft. of inlet fluid	11.8
Head due to inlet velocity (ft. of inlet fluid) -	0.2
Total head available (sta. 2 to 3), ft. of fluid	12.0

Test Number 50 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 2.941 Minutes.
Water Level Difference 17.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.3	114.2	84.1	84.2	84.6	84.2	85.0	84.3
Saturation Temperature °F.	337.6	337.5	315.5	315.5	313.8	315.5	316.1	315.6
Water Temp. Measured °F.	335.8	335.8	319.0	317.0	316.7	316.6	315.4	315.0
Wall Temperature °F.	331.0	334.5	315.8	315.4	315.6	314.4	314.0	313.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01782
Water flow lbs./sec. ----------	2.21
Water flow cu.ft./min. (measured at inlet) ------	2.362
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	30.1
Static head between sta. 2 & 3, ft. of inlet fluid	77.2
Head due to inlet velocity (ft. of inlet fluid)--	0.8
Total head available (sta. 2 to 3), ft. of fluid	78.0

Test Number 51 Date 4-17-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 3.524 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.3	114.2	101.1	100.5	101.3	101.6	102.1	102.3
Saturation Temperature °F.	337.6	337.5	328.8	328.3	328.7	329.1	329.3	329.6
Water Temp. Measured °F.	335.3	335.3	331.0	328.4	328.4	328.4	328.4	328.4
Wall Temperature °F.	331.0	335.3	328.4	328.0	328.0	328.4	328.4	328.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01781
Water flow lbs./sec. ----------	1.58
Water flow cu.ft./min.(measured at inlet) -------	1.70
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	13.1
Static head between sta. 2 & 3, ft. of inlet fluid	33.4
Head due to inlet velocity (ft. of inlet fluid) -	0.4
Total head available (sta. 2 to 3), ft. of fluid	33.8

Test Number 52 Date 4-18-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of test ----- 3.263 Minutes.
Water Level Difference 13.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	112.2	112.4	100.0	99.5	100.2	100.7	101.4	101.2
Saturation Temperature °F.	336.4	336.4	227.8	227.5	228.2	228.3	228.8	228.8
Water Temp. Measured °F.	334.0	334.0	331.0	329.5	329.5	329.5	329.5	329.5
Wall Temperature °F.	332.0	333.2	329.3	328.7	328.7	328.7	328.7	328.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01781
Water flow lbs./sec. ----------	1.558
Water flow cu.ft./min. (measured at inlet) ------	1.665
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	12.4
Static head between sta. 2 & 3, ft. of inlet fluid	31.8
Head due to inlet velocity (ft. of inlet fluid)--	0.4
Total head available (sta. 2 to 3), ft. of fluid	32.2

Test Number 53 Date 4-18-51

Valve Opening (lift)-- 0.0745 Inches.
Duration of Test ----- 3.244 Minutes.
Water Level Difference 17 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	112.2	112.1	88.9	89.2	89.8	89.5	89.8	89.4
Saturation Temperature °F.	336.4	336.3	319.3	319.5	320.0	319.8	320.0	319.8
Water Temp. Measured °F.	334.5	334.5	325.2	321.5	321.5	321.5	321.5	321.5
Wall Temperature °F.	331.5	333.5	322.3	321.5	321.5	322.0	321.5	320.3

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01781
Water flow lbs./sec. ----------	1.975
Water flow cu.ft./min.(measured at inlet) -------	2.11
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	23.2
Static head between sta. 2 & 3, ft. of inlet fluid	59.5
Head due to inlet velocity (ft. of inlet fluid) -	0.6
Total head available (sta. 2 to 3), ft. of fluid	60.1

Test Number 54 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of test ----- 7.467 Minutes.
Water Level Difference 14 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	37.3	36.4	26.6	26.6	27.7	27.7	28.3	28.3
Saturation Temperature °F.	263.2	261.8	243.5	243.5	245.5	245.6	247.0	247.0
Water Temp. Measured °F.	258.0	257.3	249.1	246.5	245.8	245.8	245.8	245.8
Wall Temperature °F.	256.5	257.3	246.5	245.8	245.8	245.8	245.8	240.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.946
Specific volume of inlet water cu.ft./lb. -------	0.01705
Water flow lbs./sec. ----------	0.729
Water flow cu.ft./min. (measured at inlet) ------	0.746
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	9.8
Static head between sta. 2 & 3, ft. of inlet fluid	24.1
Head due to inlet velocity (ft. of inlet fluid)--	0.1
Total head available (sta. 2 to 3), ft. of fluid	24.2

Test Number 55 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of Test ----- 4.557 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.8	66.8	33.2	33.9	33.9	33.5	34.2	33.7
Saturation Temperature °F.	299.7	299.7	256.3	257.2	257.5	256.9	258.1	257.2
Water Temp. Measured °F.	299.0	299.0	259.0	257.3	257.3	257.0	256.5	255.5
Wall Temperature °F.	296.0	297.6	259.7	258.0	257.3	256.5	256.5	255.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	1.249
Water flow cu.ft./min.(measured at inlet) -------	1.305
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	33.6
Static head between sta. 2 & 3, ft. of inlet fluid	84.2
Head due to inlet velocity (ft. of inlet fluid) -	0.2
Total head available (sta. 2 to 3), ft. of fluid	84.4

Test Number 56 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of test ----- 4.763 Minutes.
Water Level Difference 13 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.8	66.8	45.7	45.9	46.0	45.8	46.6	46.3
Saturation Temperature °F.	299.7	299.7	275.3	275.5	275.6	275.5	276.6	276.5
Water Temp. Measured °F.	298.5	298.5	277.8	276.6	276.2	275.8	275.8	275.6
Wall Temperature °F.	297.3	298.5	277.0	276.2	275.8	275.6	275.6	275.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	1.035
Water flow cu.ft./min. (measured at inlet) ------	1.082
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	21.1
Static head between sta. 2 & 3, ft. of inlet fluid	53.1
Head due to inlet velocity (ft. of inlet fluid)--	0.2
Total head available (sta. 2 to 3), ft. of fluid	53.3

Test Number 57 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of Test ----- 6.018 Minutes.
Water Level Difference 11.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.8	66.9	56.6	57.0	57.2	56.7	57.4	57.5
Saturation Temperature °F.	299.7	299.7	288.8	289.3	289.6	288.9	289.9	290.0
Water Temp. Measured °F.	299.0	298.5	293.3	291.0	289.8	289.4	289.0	288.5
Wall Temperature °F.	296.0	296.8	290.3	289.4	290.3	290.7	290.3	289.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	0.726
Water flow cu.ft./min.(measured at inlet) -------	0.758
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	10.3
Static head between sta. 2 & 3, ft. of inlet fluid	25.7
Head due to inlet velocity (ft. of inlet fluid) -	0.1
Total head available (sta. 2 to 3), ft. of fluid	25.8

Test Number 58 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of test ----- 3.152 Minutes.
Water Level Difference 12 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.4	41.3	41.5	41.1	40.9	41.4	41.3
Saturation Temperature °F.	317.4	317.5	264.3	269.5	269.0	268.7	269.5	269.4
Water Temp. Measured °F.	317.4	317.4	271.2	269.6	269.0	269.0	269.0	268.0
Wall Temperature °F.	315.0	315.8	271.0	269.6	269.4	268.0	268.0	267.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01768
Water flow lbs./sec. ----------	1.434
Water flow cu.ft./min. (measured at inlet) ------	1.518
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	45.0
Static head between sta. 2 & 3, ft. of inlet fluid	114.3
Head due to inlet velocity (ft. of inlet fluid)--	0.3
Total head available (sta. 2 to 3), ft. of fluid	114.6

Test Number 59 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of Test ----- 4.497 Minutes.
Water Level Difference 14.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.7	56.0	56.6	56.6	56.1	56.9	57.0
Saturation Temperature °F.	317.3	317.8	288.2	288.8	288.8	288.3	289.2	289.3
Water Temp. Measured °F.	315.8	315.8	290.3	289.4	289.0	288.5	288.5	288.5
Wall Temperature °F.	313.3	315.0	289.4	287.5	287.5	287.5	287.5	286.5

Computed Results.

Tank Calibration Correction Factor - F. ----------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.017597
Water flow lbs./sec. ----------	1.216
Water flow cu.ft./min.(measured at inlet) -------	1.282
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	30.7
Static head between sta. 2 & 3, ft. of inlet fluid	77.7
Head due to inlet velocity (ft. of inlet fluid) -	0.2
Total head available (sta. 2 to 3), ft. of fluid	77.9

Test Number 60 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of test ----- 5.533 Minutes.
Water Level Difference 12.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.6	72.3	72.8	72.8	72.5	72.7	73.1
Saturation Temperature °F.	317.3	317.6	305.2	305.2	305.4	305.2	305.4	305.6
Water Temp. Measured °F.	315.0	315.0	307.7	306.3	305.5	305.5	305.5	305.5
Wall Temperature °F.	313.3	314.0	306.3	305.5	305.5	304.8	305.5	304.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01759
Water flow lbs./sec. ----------	0.852
Water flow cu.ft./min. (measured at inlet) ------	0.898
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	14.3
Static head between sta. 2 & 3, ft. of inlet fluid	36.2
Head due to inlet velocity (ft. of inlet fluid)--	0.1
Total head available (sta. 2 to 3), ft. of fluid	36.3

Test Number 61 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of Test ----- 3.795 Minutes.
Water Level Difference 16 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.4	113.7	52.9	52.1	52.2	51.3	52.7	52.2
Saturation Temperature °F.	337.7	337.1	284.5	283.6	283.7	282.7	284.3	283.7
Water Temp. Measured °F.	335.3	335.3	283.5	283.5	282.8	282.0	282.0	281.7
Wall Temperature °F.	331.5	334.4	285.3	283.5	282.8	282.0	282.0	281.2

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01781
Water flow lbs./sec.	1.57
Water flow cu.ft./min.(measured at inlet)	1.68
Pressure drop (P_2 - P_3). lbs./sq.in.	60.8
Static head between sta. 2 & 3, ft. of inlet fluid	156.1
Head due to inlet velocity (ft. of inlet fluid) -	0.4
Total head available (sta. 2 to 3), ft. of fluid	156.5

Test Number 62 Date 4-20-51

Valve Opening (lift)-- 0.035 Inches.
Duration of test ----- 4.326 Minutes.
Water Level Difference 19 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.5	118.0	54.2	54.1	54.2	53.5	53.7	53.3
Saturation Temperature °F.	340.4	340.0	286.3	286.3	286.3	285.3	285.6	285.2
Water Temp. Measured °F.	340.1	340.0	286.8	286.0	285.7	285.3	285.3	284.5
Wall Temperature °F.	337.0	339.4	287.5	286.0	285.7	285.3	284.5	284.2

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01787
Water flow lbs./sec.	1.633
Water flow cu.ft./min. (measured at inlet)	1.75
Pressure drop (P_2 - P_3). lbs./sq. in.	63.8
Static head between sta. 2 & 3, ft. of inlet fluid	164.2
Head due to inlet velocity (ft. of inlet fluid)--	0.4
Total head available (sta. 2 to 3), ft. of fluid	164.6

Test Number 63 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of Test ----- 4.569 Minutes.
Water Level Difference 17 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.4	114.2	74.1	74.2	74.3	74.0	74.8	74.3
Saturation Temperature °F.	337.7	337.5	306.8	307.0	307.0	306.7	307.4	307.1
Water Temp. Measured °F.	336.3	335.7	308.5	306.7	306.3	306.3	306.3	306.3
Wall Temperature °F.	334.5	335.3	339.4	307.0	307.0	306.3	306.3	305.5

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01781
Water flow lbs./sec.	1.382
Water flow cu.ft./min. (measured at inlet)	1.477
Pressure drop (P_2 - P_3). lbs./sq.in.	40.1
Static head between sta. 2 & 3, ft. of inlet fluid	102.7
Head due to inlet velocity (ft. of inlet fluid) -	0.3
Total head available (sta. 2 to 3), ft. of fluid	103.0

Test Number 64 Date 4-19-51

Valve Opening (lift)-- 0.035 Inches.
Duration of test ----- 5.315 Minutes.
Water Level Difference 15 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.4	114.2	92.1	92.2	92.6	92.6	93.3	92.1
Saturation Temperature °F.	337.7	337.5	322.0	322.1	322.3	322.3	322.8	322.0
Water Temp. Measured °F.	335.3	335.3	334.9	321.9	321.5	321.5	321.5	321.5
Wall Temperature °F.	332.8	334.5	322.8	322.3	322.3	322.3	322.3	321.5

Computed Results.

Tank Calibration Correction Factor - F.	0.903
Specific volume of inlet water cu.ft./lb.	0.01781
Water flow lbs./sec.	1.05
Water flow cu.ft./min. (measured at inlet)	1.123
Pressure drop (P_2 - P_3). lbs./sq. in.	21.1
Static head between sta. 2 & 3, ft. of inlet fluid	56.7
Head due to inlet velocity (ft. of inlet fluid)--	0.2
Total head available (sta. 2 to 3), ft. of fluid	56.9

Test Number 65 Date 4-20-51

Valve Opening (lift)-- 0.035 Inches.
Duration of Test ----- 4.199 Minutes.
Water Level Difference 17 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.5	118.2	67.1	67.4	68.1	67.1	67.4	67.6
Saturation Temperature °F.	340.4	340.2	300.1	300.3	301.0	300.1	300.4	300.5
Water Temp. Measured °F.	341.0	341.0	302.2	301.3	300.8	300.3	300.3	299.8
Wall Temperature °F.	337.0	341.0	303.0	301.3	300.8	300.3	299.8	299.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01788
Water flow lbs./sec. ----------	1.507
Water flow cu.ft./min.(measured at inlet) -------	1.615
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	51.1
Static head between sta. 2 & 3, ft. of inlet fluid	131.5
Head due to inlet velocity (ft. of inlet fluid) -	0.4
Total head available (sta. 2 to 3), ft. of fluid	131.9

Test Number 66 Date 4-21-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of test ----- 3.188 Minutes.
Water Level Difference 23 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.8	66.3	54.8	55.1	55.3	54.7	55.1	55.0
Saturation Temperature °F.	299.7	299.2	287.0	287.3	287.5	287.0	287.3	287.1
Water Temp. Measured °F.	298.5	298.5	292.8	287.2	286.8	286.8	286.8	286.8
Wall Temperature °F.	297.6	298.5	288.6	288.6	290.3	290.3	288.0	287.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01742
Water flow lbs./sec. ----------	2.732
Water flow cu.ft./min. (measured at inlet) ------	2.855
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	11.5
Static head between sta. 2 & 3, ft. of inlet fluid	28.7
Head due to inlet velocity (ft. of inlet fluid)--	1.2
Total head available (sta. 2 to 3), ft. of fluid	29.9

Test Number 67 Date 4-21-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of Test ----- 3.547 Minutes.
Water Level Difference 17 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.8	66.8	61.5	62.3	62.6	61.5	61.8	62.5
Saturation Temperature °F.	299.7	299.7	294.4	295.2	295.4	294.4	294.5	295.3
Water Temp. Measured °F.	299.4	299.4	297.0	294.3	294.3	294.3	294.3	294.3
Wall Temperature °F.	297.5	298.6	295.2	295.2	296.0	297.0	295.2	295.2

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	1.822
Water flow cu.ft./min.(measured at inlet) -------	1.908
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	5.3
Static head between sta. 2 & 3, ft. of inlet fluid	13.3
Head due to inlet velocity (ft. of inlet fluid) -	0.5
Total head available (sta. 2 to 3), ft. of fluid	13.8

Test Number 68 Date 4-21-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of test ----- 2.591 Minutes.
Water Level Difference 17 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	54.9	54.7	45.6	45.9	45.7	45.2	45.9	45.4
Saturation Temperature °F.	286.8	286.7	275.3	275.5	275.4	274.9	275.8	275.0
Water Temp. Measured °F.	285.3	285.3	280.4	275.4	275.2	274.7	274.7	274.7
Wall Temperature °F.	284.5	285.3	276.3	276.3	277.8	278.6	276.7	274.7

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.9275
Specific volume of inlet water cu.ft./lb. -------	0.01730
Water flow lbs./sec. ----------	2.505
Water flow cu.ft./min. (measured at inlet) ------	2.6
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	9.1
Static head between sta. 2 & 3, ft. of inlet fluid	22.7
Head due to inlet velocity (ft. of inlet fluid)--	1.0
Total head available (sta. 2 to 3), ft. of fluid	23.7

Test Number 69 Date 4-22-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of Test ----- 3.506 Minutes.
Water Level Difference 30 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.0	68.9	69.7	69.7	69.1	69.7	69.7
Saturation Temperature °F.	317.4	317.0	301.8	302.5	302.5	302.2	302.5	302.5
Water Temp. Measured °F.	314.0	314.0	307.7	302.2	301.3	301.3	301.3	301.3
Wall Temperature °F.	312.6	314.0	311.0	311.0	304.8	304.0	302.2	311.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01758
Water flow lbs./sec. ----------	3.23
Water flow cu.ft./min.(measured at inlet) -------	3.405
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	17.0
Static head between sta. 2 & 3, ft. of inlet fluid	43.1
Head due to inlet velocity (ft. of inlet fluid) -	1.7
Total head available (sta. 2 to 3), ft. of fluid	44.8

Test Number 70 Date 4-22-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of test ----- 2.965 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.5	76.2	76.2	76.4	76.0	76.3	76.7
Saturation Temperature °F.	317.3	317.5	308.8	308.8	308.9	308.4	308.7	309.1
Water Temp. Measured °F.	324.0	324.0	320.0	307.7	307.2	307.0	307.0	307.0
Wall Temperature °F.	313.5	315.0	308.5	308.5	309.4	310.3	309.4	307.7

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01769
Water flow lbs./sec. ----------	2.545
Water flow cu.ft./min. (measured at inlet) ------	2.70
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	10.3
Static head between sta. 2 & 3, ft. of inlet fluid	26.1
Head due to inlet velocity (ft. of inlet fluid)--	1.1
Total head available (sta. 2 to 3), ft. of fluid	27.2

Test Number 71 Date 4-22-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of Test ----- 1.979 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.5	117.2	94.1	94.7	95.1	94.5	94.7	93.6
Saturation Temperature °F.	340.2	339.4	323.4	323.8	324.3	323.7	323.8	323.0
Water Temp. Measured °F.	337.4	337.7	327.5	322.3	321.8	321.5	321.5	320.4
Wall Temperature °F.	335.3	337.0	323.3	323.3	324.9	323.3	322.3	322.3

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01784
Water flow lbs./sec. ----------	3.76
Water flow cu.ft./min.(measured at inlet) -------	4.02
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	23.1
Static head between sta. 2 & 3, ft. of inlet fluid	59.3
Head due to inlet velocity (ft. of inlet fluid) -	2.3
Total head available (sta. 2 to 3), ft. of fluid	61.6

Test Number 72 Date 4-22-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of test ----- 2.009 Minutes.
Water Level Difference 18 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.3	117.2	99.0	98.8	99.9	102.3	100.5	99.7
Saturation Temperature °F.	340.3	339.5	327.2	327.0	327.8	328.2	328.5	327.6
Water Temp. Measured °F.	337.8	337.8	331.0	326.7	326.7	326.7	326.7	326.0
Wall Temperature °F.	337.0	338.6	328.2	327.4	328.7	328.7	327.4	325.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01784
Water flow lbs./sec. ----------	3.318
Water flow cu.ft./min. (measured at inlet) ------	3.55
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	18.2
Static head between sta. 2 & 3, ft. of inlet fluid	46.8
Head due to inlet velocity (ft. of inlet fluid)--	1.8
Total head available (sta. 2 to 3), ft. of fluid	48.6

Test Number 73 Date 4-22-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of Test ----- 2.526 Minutes.
Water Level Difference 19 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.3	86.0	73.9	73.9	74.1	73.1	74.7	74.2
Saturation Temperature °F.	317.3	317.0	306.5	306.5	306.8	306.8	307.3	307.0
Water Temp. Measured °F.	318.0	318.0	312.0	307.0	307.0	307.0	307.0	307.0
Wall Temperature °F.	314.0	315.8	307.7	307.0	308.6	309.4	308.6	305.7

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01762
Water flow lbs./sec. ----------	2.84
Water flow cu.ft./min.(measured at inlet) -------	3.005
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	12.0
Static head between sta. 2 & 3, ft. of inlet fluid	30.5
Head due to inlet velocity (ft. of inlet fluid) -	1.3
Total head available (sta. 2 to 3), ft. of fluid	31.8

Test Number 74 Date 4-22-51

Valve Opening (lift)-- 0.1825 Inches.
Duration of test ----- 1.823 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	132.3	130.3	103.0	102.9	103.8	103.5	103.6	102.8
Saturation Temperature °F.	348.8	347.5	330.0	329.8	330.5	330.4	330.4	329.8
Water Temp. Measured °F.	347.0	347.0	336.7	331.0	330.4	330.0	330.0	330.0
Wall Temperature °F.	336.3	347.0	332.8	332.0	332.8	332.0	331.5	329.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.900
Specific volume of inlet water cu.ft./lb. -------	0.01794
Water flow lbs./sec. ----------	4.07
Water flow cu.ft./min. (measured at inlet) ------	4.37
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	27.3
Static head between sta. 2 & 3, ft. of inlet fluid	70.5
Head due to inlet velocity (ft. of inlet fluid)--	2.8
Total head available (sta. 2 to 3), ft. of fluid	73.3

Test Number 75 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of Test ----- 3.508 Minutes.
Water Level Difference 28.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.9	66.1	56.9	57.5	57.6	57.3	57.5	58.1
Saturation Temperature °F.	299.8	299.2	289.2	290.0	290.1	289.9	290.0	290.7
Water Temp. Measured °F.	299.4	299.4	295.2	289.4	290.3	290.3	289.8	290.3
Wall Temperature °F.	297.7	299.4	291.0	291.0	292.4	293.5	292.0	289.4

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01744
Water flow lbs./sec. ----------	3.075
Water flow cu.ft./min.(measured at inlet) -------	3.22
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	9.2
Static head between sta. 2 & 3, ft. of inlet fluid	23.1
Head due to inlet velocity (ft. of inlet fluid) -	1.5
Total head available (sta. 2 to 3), ft. of fluid	24.6

Test Number 76 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of test ----- 3.091 Minutes.
Water Level Difference 29 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.4	85.7	73.4	73.5	73.4	73.8	74.3	74.0
Saturation Temperature °F.	317.5	317.0	306.2	306.3	306.2	306.5	307.0	306.8
Water Temp. Measured °F.	317.4	317.4	313.3	306.5	307.0	307.3	307.3	307.6
Wall Temperature °F.	315.8	317.4	308.6	308.6	310.0	310.3	309.4	306.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01762
Water flow lbs./sec. ----------	3.54
Water flow cu.ft./min. (measured at inlet) ------	3.74
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	12.3
Static head between sta. 2 & 3, ft. of inlet fluid	31.2
Head due to inlet velocity (ft. of inlet fluid)--	2.0
Total head available (sta. 2 to 3), ft. of fluid	33.2

Test Number 77 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of Test ----- 2.569 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.4	85.8	77.6	77.4	77.7	77.8	78.1	78.3
Saturation Temperature °F.	317.4	317.0	309.9	309.8	310.0	310.0	310.3	310.6
Water Temp. Measured °F.	317.4	317.4	314.0	310.3	310.3	310.3	310.3	311.0
Wall Temperature °F.	315.0	317.4	311.0	311.0	312.7	314.0	313.4	310.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01762
Water flow lbs./sec. ----------	2.94
Water flow cu.ft./min.(measured at inlet) -------	3.11
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	8.2
Static head between sta. 2 & 3, ft. of inlet fluid	20.9
Head due to inlet velocity (ft. of inlet fluid) -	1.4
Total head available (sta. 2 to 3), ft. of fluid	22.3

Test Number 78 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of test ----- 2.524 Minutes.
Water Level Difference 29 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.4	116.3	98.1	98.3	99.1	99.3	99.0	98.3
Saturation Temperature °F.	340.3	339.0	326.5	326.7	328.3	327.5	327.2	326.7
Water Temp. Measured °F.	339.0	339.5	333.5	326.6	326.6	327.5	327.0	327.7
Wall Temperature °F.	336.2	339.5	327.5	327.5	328.4	328.9	325.1	327.7

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01786
Water flow lbs./sec. ----------	4.27
Water flow cu.ft./min. (measured at inlet) ------	4.57
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	18.2
Static head between sta. 2 & 3, ft. of inlet fluid	46.8
Head due to inlet velocity (ft. of inlet fluid)--	3.0
Total head available (sta. 2 to 3), ft. of fluid	49.8

Test Number 79 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of Test ----- 2.255 Minutes.
Water Level Difference 22.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	118.4	116.5	103.1	102.5	102.4	103.6	103.2	103.4
Saturation Temperature °F.	340.3	339.0	330.1	329.6	329.6	330.4	330.2	330.3
Water Temp. Measured °F.	339.7	340.0	336.3	329.4	329.8	330.0	330.0	330.5
Wall Temperature °F.	337.8	341.0	331.0	331.0	332.8	332.5	331.8	330.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01787
Water flow lbs./sec. ----------	3.71
Water flow cu.ft./min.(measured at inlet) -------	3.98
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	13.4
Static head between sta. 2 & 3, ft. of inlet fluid	34.4
Head due to inlet velocity (ft. of inlet fluid) -	2.3
Total head available (sta. 2 to 3), ft. of fluid	36.7

Test Number 80 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of test ----- 1.822 Minutes.
Water Level Difference 22 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	130.4	128.3	107.7	108.1	108.1	107.8	108.8	108.4
Saturation Temperature °F.	349.4	346.4	333.6	333.5	333.5	333.6	333.9	333.6
Water Temp. Measured °F.	346.1	346.5	342.1	333.5	334.0	334.0	334.0	335.3
Wall Temperature °F.	335.4	346.1						

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.900
Specific volume of inlet water cu.ft./lb. -------	0.1794
Water flow lbs./sec. ----------	4.47
Water flow cu.ft./min. (measured at inlet) ------	4.82
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	20.6
Static head between sta. 2 & 3, ft. of inlet fluid	53.2
Head due to inlet velocity (ft. of inlet fluid)--	3.4
Total head available (sta. 2 to 3), ft. of fluid	56.6

Test Number 81 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of Test ----- 6.737 Minutes.
Water Level Difference 35 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.9	66.9	62.9	63.5	64.0	63.2	63.3	64.1
Saturation Temperature °F.	299.7	299.7	295.8	296.5	296.8	296.3	296.2	297.0
Water Temp. Measured °F.	298.5	298.5	297.7	296.0	296.5	296.5	296.5	296.0
Wall Temperature °F.	297.6	298.5	295.7	296.0	296.5	296.0	297.3	297.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.920
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	1.97
Water flow cu.ft./min.(measured at inlet) -------	2.06
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	4.0
Static head between sta. 2 & 3, ft. of inlet fluid	10.0
Head due to inlet velocity (ft. of inlet fluid) -	0.6
Total head available (sta. 2 to 3), ft. of fluid	10.6

Test Number 82 Date 4-24-51

Valve Opening (lift)-- 0.307 Inches.
Duration of test ----- 3.696 Minutes.
Water Level Difference 25 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	66.9	66.5	60.2	60.8	61.1	60.5	60.9	61.6
Saturation Temperature °F.	299.7	299.5	293.0	293.5	294.0	293.3	293.7	294.3
Water Temp. Measured °F.	299.4	299.4	297.0	293.6	293.6	293.6	293.2	294.0
Wall Temperature °F.	297.0	299.4	292.8	293.6	294.3	296.0	295.2	293.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.920
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	2.57
Water flow cu.ft./min. (measured at inlet) ------	2.69
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	6.4
Static head between sta. 2 & 3, ft. of inlet fluid	16.0
Head due to inlet velocity (ft. of inlet fluid)--	1.0
Total head available (sta. 2 to 3), ft. of fluid	17.0

Test Number 83 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of Test ----- 3.193 Minutes.
Water Level Difference 26.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	86.5	86.4	79.6	79.4	80.0	79.7	80.3	79.9
Saturation Temperature °F.	317.5	317.5	311.7	311.6	311.9	311.8	312.2	311.9
Water Temp. Measured °F.	317.4	317.4	315.8	312.6	312.6	312.6	312.6	314.0
Wall Temperature °F.	315.8	317.5	312.0	312.6	314.0	315.4	315.0	313.3

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.917
Specific volume of inlet water cu.ft./lb. -------	0.01762
Water flow lbs./sec. ----------	3.13
Water flow cu.ft./min.(measured at inlet) -------	3.31
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	6.8
Static head between sta. 2 & 3, ft. of inlet fluid	17.4
Head due to inlet velocity (ft. of inlet fluid) -	0.5
Total head available (sta. 2 to 3), ft. of fluid	17.9

Test Number 84 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of test ----- 3.208 Minutes.
Water Level Difference 29 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	67.0	67.0	59.0	59.7	59.9	59.3	60.0	59.7
Saturation Temperature °F.	299.9	299.9	291.6	292.3	292.6	292.0	292.8	292.3
Water Temp. Measured °F.	300.2	300.2	296.8	292.0	292.0	292.0	292.0	294.3
Wall Temperature °F.	299.4	300.2	293.5	294.3	295.3	296.0	295.2	292.8

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. --------	0.01744
Water flow lbs./sec. ----------	3.43
Water flow cu.ft./min. (measured at inlet) ------	3.59
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	7.9
Static head between sta. 2 & 3, ft. of inlet fluid	19.9
Head due to inlet velocity (ft. of inlet fluid)--	0.7
Total head available (sta. 2 to 3), ft. of fluid	20.6

Test Number 85 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of Test ----- 3.184 Minutes.
Water Level Difference 21 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	67.0	67.0	62.8	63.3	63.7	62.6	62.9	63.7
Saturation Temperature °F.	299.9	299.9	295.6	296.3	296.4	295.3	295.8	295.6
Water Temp. Measured °F.	297.6	298.5	297.3	296.0	296.0	296.0	296.0	296.5
Wall Temperature °F.	296.0	297.0	295.2	295.2	296.0	296.5	297.0	296.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.921
Specific volume of inlet water cu.ft./lb. -------	0.01743
Water flow lbs./sec. ----------	2.495
Water flow cu.ft./min.(measured at inlet) -------	2.61
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	4.2
Static head between sta. 2 & 3, ft. of inlet fluid	10.5
Head due to inlet velocity (ft. of inlet fluid) -	0.3
Total head available (sta. 2 to 3), ft. of fluid	10.8

Test Number 86 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of test ----- 2.633 Minutes.
Water Level Difference 19 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	49.3	48.1	42.9	43.9	43.8	43.9	44.9	44.6
Saturation Temperature °F.	280.3	278.6	271.6	272.9	272.6	272.9	274.3	274.0
Water Temp. Measured °F.	278.7	279.0	276.6	272.0	272.0	272.0	272.0	
Wall Temperature °F.	278.2	278.7	273.9	273.9	274.7	277.0	277.0	275.6

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.935
Specific volume of inlet water cu.ft./lb. -------	0.01725
Water flow lbs./sec. ----------	2.775
Water flow cu.ft./min. (measured at inlet) ------	2.87
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	5.2
Static head between sta. 2 & 3, ft. of inlet fluid	12.8
Head due to inlet velocity (ft. of inlet fluid)--	0.4
Total head available (sta. 2 to 3), ft. of fluid	13.2

Test Number 87 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of Test ----- 1.748 Minutes.
Water Level Difference 21.5 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.5	114.3	99.4	99.0	99.4	100.2	100.2	99.4
Saturation Temperature °F.	337.7	337.6	327.7	327.2	327.7	328.2	328.2	327.7
Water Temp. Measured °F.	337.0	337.4	332.0	327.5	327.5	327.5	327.8	328.7
Wall Temperature °F.	333.5	337.0	327.5	330.4	329.5	329.2	323.4	325.5

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01786
Water flow lbs./sec. ----------	4.58
Water flow cu.ft./min.(measured at inlet) -------	4.92
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	14.9
Static head between sta. 2 & 3, ft. of inlet fluid	38.4
Head due to inlet velocity (ft. of inlet fluid) -	1.2
Total head available (sta. 2 to 3), ft. of fluid	39.6

Test Number 88 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of test ----- 2.585 Minutes.
Water Level Difference 27 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	114.5	113.8	103.2	102.5	102.7	103.7	103.8	103.5
Saturation Temperature °F.	337.7	337.2	330.3	329.6	329.8	330.4	330.5	330.3
Water Temp. Measured °F.	337.0	337.0	334.5	329.5	329.5	329.5	329.7	331.0
Wall Temperature °F.	335.8	337.0	330.0	331.0	332.8	333.1	332.0	330.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.903
Specific volume of inlet water cu.ft./lb. -------	0.01783
Water flow lbs./sec. ----------	3.88
Water flow cu.ft./min. (measured at inlet) ------	4.15
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	10.6
Static head between sta. 2 & 3, ft. of inlet fluid	27.2
Head due to inlet velocity (ft. of inlet fluid)--	0.9
Total head available (sta. 2 to 3), ft. of fluid	28.1

Test Number 89 Date 4-26-51

Valve Opening (lift)-- Plug Removed Inches.
Duration of Test ----- 1.469 Minutes.
Water Level Difference 20 Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.	132.5	131.2	113.9	114.4	114.2		113.9	113.9
Saturation Temperature °F.	348.7	348.0	337.2	337.6	337.5		337.2	337.2
Water Temp. Measured °F.	347.0	347.0	342.0	336.6	336.6	336.6	337.0	
Wall Temperature °F.	346.0	347.8		338.6	342.0	341.0	337.8	337.0

Computed Results.

Tank Calibration Correction Factor - F. ---------	0.900
Specific volume of inlet water cu.ft./lb. -------	0.01794
Water flow lbs./sec. ----------	5.04
Water flow cu.ft./min.(measured at inlet) -------	5.43
Pressure drop (P_2 - P_3). lbs./sq.in. ----------	17.3
Static head between sta. 2 & 3, ft. of inlet fluid	44.8
Head due to inlet velocity (ft. of inlet fluid) -	1.5
Total head available (sta. 2 to 3), ft. of fluid	46.3

Test Number _____ Date _____

Valve Opening (lift)-- _____ Inches.
Duration of test ----- _____ Minutes.
Water Level Difference _____ Inches.

Data at Stations	1	2	3	4	5	6	7	8
Absolute Pressure, psia.								
Saturation Temperature °F.								
Water Temp. Measured °F.								
Wall Temperature °F.								

Computed Results.

Tank Calibration Correction Factor - F. ---------	
Specific volume of inlet water cu.ft./lb. -------	
Water flow lbs./sec. ----------	
Water flow cu.ft./min. (measured at inlet) ------	
Pressure drop (P_2 - P_3). lbs./sq. in. ----------	
Static head between sta. 2 & 3, ft. of inlet fluid	
Head due to inlet velocity (ft. of inlet fluid)--	
Total head available (sta. 2 to 3), ft. of fluid	

COLD WATER FLOW TESTS

Date	4-7-51	4-8-51	4-8-51	4-8-51	4-8-51	4-9-51	4-9-51	4-10-51
Test Number	200	201	202	203	204	205	206	207
Valve Opening (Lift), Inches	.1115	.1115	.1115	.1115	.1115	.1115	.1115	.1115
Duration of Test, Minutes	3.315	2.560	2.640	1.971	1.900	2.685	4.319	3.375
Tank Water Level Difference, In.	28	24	14	15	19	15	29	31
Gauge Pressure, psi., Sta. 1	72.1	62.5	62.5	62.5	62.5	62.5	62.5	62.5
Gauge Pressure, psi., Sta. 2	72.5	62.5	63.5	62.8	62.3	62.7	63.1	62.3
Gauge Pressure, psi., Sta. 3	46.1	30.7	52.9	41.6	25.9	50.5	45.9	31.1
Gauge Pressure, psi., Sta. 4	49.1	34.3	54.5	44.0	29.7	52.1	48.2	34.5
Gauge Pressure, psi., Sta. 5	50.9	36.3	55.2	45.2	32.0	54.0	49.6	36.2
Gauge Pressure, psi., Sta. 6	51.5	37.4	54.8	45.7	33.7	53.0	49.6	37.5
Gauge Pressure, psi., Sta. 7						53.2	49.7	38.1
Gauge Pressure, psi., Sta. 8	51.2	38.2	54.8	46.2	33.8	54.0	50.4	38.5
Water Temperature °F.	58.9	72.8	52.0	63.2	61.6	66.6	65.0	60.8
Specific Volume Of Water	.01604	.01606	.01605	.01604	.01604	.01605	.01605	.01604
Water Flow Lbs. per Second	3.48	3.86	2.18	3.13	4.12	2.30	2.77	3.79
Water Flow Cu. Ft./ Minute	3.35	3.72	2.10	3.02	3.96	2.23	2.67	3.65
Press. Drop $P_2 - P_3$, psi.	26.4	31.8	10.6	21.2	36.5	12.2	17.2	31.2
Head Feet of Fluid, ($P_2 - P_3$)	61.0	73.3	24.5	49.1	84.2	28.1	39.7	72.2
Head Due to Inlet Velocity - Ft.	1.6	2.0	.6	1.3	2.3	.7	1.0	1.9
Total Head Available	62.6	75.3	25.1	50.4	86.5	28.8	40.7	74.1

Notes: _____

COLD WATER FLOW TESTS

Date	4-13	4-13	4-13	4-13	4-13	4-13	4-14	4-14
Test Number	208	209	210	211	212	213	214	215
Valve Opening (Lift), Inches	.1465	.1465	.1465	.1465	.1465	.1465	.0745	.0745
Duration of Test, Minutes	3.747	1.680	1.978	2.465	1.925	2.455	2.425	2.495
Tank Water Level Difference, In.	40	16	15	21	12	19	21	19
Gauge Pressure, psi., Sta. 1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1
Gauge Pressure, psi., Sta. 2	70.7	71.7	72.7	71.7	71.7	71.7	71.8	71.7
Gauge Pressure, psi., Sta. 3	40.6	46.9	56.8	52.1	62.5	56.5	19.6	31.4
Gauge Pressure, psi., Sta. 4	43.3	49.0	58.1	53.8	62.5	57.9	19.3	30.3
Gauge Pressure, psi., Sta. 5	44.9	51.1	58.8	55.3	63.0	58.9	20.3	31.4
Gauge Pressure, psi., Sta. 6	45.6	51.3	59.5	55.5	63.5	59.5	21.6	32.7
Gauge Pressure, psi., Sta. 7	46.6	52.5	60.0	56.5	64.3	60.3	22.9	33.3
Gauge Pressure, psi., Sta. 8	47.8	52.3	60.0	56.1	64.0	60.0	23.1	33.6
Water Temperature °F.	60.3	60.3	51.5	51.0	51.0	51.0	57.0	57.0
Specific Volume Of Water	.0160	.0160	.0160	.0160	.0160	.0160	.0160	.0160
Water Flow Lbs. per Second	4.39	3.92	3.13	3.51	2.57	3.19	3.57	3.14
Water Flow Cu. Ft./ Minute	4.22	3.77	3.05	3.38	2.47	3.06	3.43	3.02
Press. Drop $P_2 - P_3$, psi.	30.1	24.9	15.0	19.6	9.3	15.2	25.2	40.3
Head Feet of Fluid, ($P_2 - P_3$)	69.5	57.3	34.5	45.3	21.4	35.2	120.7	93.0
Head Due to Inlet Velocity - Ft.	2.6	2.1	1.3	1.7	.9	1.4	1.7	1.3
Total Head Available	72.1	59.4	35.8	47.0	22.3	36.5	122.4	94.3

Notes: _____

COLD WATER FLOW TESTS

Date	4-14	4-14	4-14	4-14	4-16	4-16	4-19	4-19
Test Number	216	217	218	219	220	221	222	223
Valve Opening (Lift), Inches	.0745	.0745	.0745	.0745	.0745	.0745	.035	.035
Duration of Test, Minutes	2.713	3.595	4.052	5.405	4.590	6.244	4.637	3.605
Tank Water Level Difference, In.	18	19.13	17	17	15	17	12	13
Gauge Pressure, psi., Sta. 1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1
Gauge Pressure, psi., Sta. 2	72.0	72.2	72.8	72.8	72.8	72.8	72.2	72.2
Gauge Pressure, psi., Sta. 3	41.0	52.9	60.0	65.8	65.1	67.6	60.7	49.8
Gauge Pressure, psi., Sta. 4	40.9	52.2	60.0	65.5	65.0	67.0	61.0	50.4
Gauge Pressure, psi., Sta. 5	41.2	53.3	60.0	65.8	65.2	67.8	61.1	51.9
Gauge Pressure, psi., Sta. 6	41.8	53.1	60.0	65.5	65.3	67.4	61.5	51.8
Gauge Pressure, psi., Sta. 7	42.7	54.0	60.5	66.4	66.1	68.6	62.1	52.7
Gauge Pressure, psi., Sta. 8	43.3	53.7	61.0	66.0	66.0	68.0	62.5	52.8
Water Temperature °F.	53.3	53.3	53.3	53.3	62.0	62.0	52.3	52.3
Specific Volume of Water	.0160	.0160	.0160	.0160	.0160	.0160	.0160	.0160
Water Flow Lbs. per Second	2.73	2.19	1.724	1.295	1.345	1.12	1.066	1.485
Water Flow Cu. Ft./ Minute	2.625	2.105	1.657	1.245	1.293	1.078	1.026	1.429
Press. Drop $P_2 - P_3$, psi.	31.0	19.4	12.8	7.0	7.7	5.2	11.5	22.4
Head Feet of Fluid, $(P_2 - P_3)$	71.7	44.7	29.5	16.1	17.8	11.9	26.5	51.6
Head Due to Inlet Velocity - Ft.	1.0	0.6	0.4	0.2	0.2	0.2	0.2	0.3
Total Head Available	72.7	45.3	29.9	16.3	18.0	12.1	26.6	51.9

Notes: _____

COLD WATER FLOW TESTS

Date	4-19	4-20	4-20	4-20	4-20	4-22	4-22	4-22
Test Number	224	225	226	227	228	229	230	231
Valve Opening (Lift), Inches	0.035	0.035	0.035	0.035	0.035	.1825	.1825	.1825
Duration of Test, Minutes	2.413	3.067	4.186	3.135	3.964	3.249	2.446	2.320
Tank Water Level Difference, In.	11	16	24.5	20	18	17.5	17	20
Gauge Pressure, psi., Sta. 1	72.1	72.1	72.1	84.1	84.1	72.1	72.1	72.1
Gauge Pressure, psi., Sta. 2	72.2	70.8	70.7	83.5	84.1	72.3	72.2	71.7
Gauge Pressure, psi., Sta. 3	38.5	27.3	15.6	19.2	51.8	66.6	62.5	56.8
Gauge Pressure, psi., Sta. 4	38.5	28.1	17.9	21.0	52.7	66.6	63.4	58.9
Gauge Pressure, psi., Sta. 5	39.8	29.0	19.2	22.5	54.8	67.3	64.0	59.5
Gauge Pressure, psi., Sta. 6	40.8	30.4	20.8	25.5	55.1	67.5	64.4	60.0
Gauge Pressure, psi., Sta. 7	41.7	31.9	22.4	26.7	55.3	67.5	64.8	61.5
Gauge Pressure, psi., Sta. 8	41.8	31.6	22.5	26.6	55.6	67.0	64.0	60.5
Water Temperature °F.	52.3	52.3	52.8	66.9	66.9	68.5	68.5	53.5
Specific Volume of Water	.0160	.0160	.0160	.0160	.0160	.0160	.0160	.0160
Water Flow Lbs. per Second	1.876	2.150	2.410	2.625	1.867	2.220	2.865	3.550
Water Flow Cu. Ft./ Minute	1.805	2.070	2.315	2.530	1.800	2.140	2.760	3.415
Press. Drop $P_2 - P_z$, psi.	33.7	43.5	55.1	64.3	32.3	5.7	9.7	15.0
Head Feet of Fluid, $(P_2 - P_z)$	77.7	105.0	127.1	148.8	74.7	13.1	22.3	34.6
Head Due to Inlet Velocity - Ft.	0.5	0.6	0.8	0.9	0.5	0.7	1.5	1.7
Total Head Available	78.2	105.6	127.9	149.7	75.2	13.8	23.8	36.3

Notes: _____

COLD WATER FLOW TESTS

Date	4-22	4-22	4-25	4-25	4-22	4-25	4-23	4-23
Test Number	232	233	234	235	236	237	238	239
Valve Opening (Lift), Inches	.1825	.1825	.1825	.1825	.1825	.1825	.307	.307
Duration of Test, Minutes	2.893	1.825	2.881	2.515	1.789	3.182	3.432	2.349
Tank Water Level Difference, In.	25	21.06	28	28	22	39	17	21
Gauge Pressure, psi., Sta. 1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1
Gauge Pressure, psi., Sta. 2	71.7	70.7	71.2	71.2	70.7	70.9	72.8	71.7
Gauge Pressure, psi., Sta. 3	57.2	45.7	52.3	46.5	41.4	41.3	69.2	60.9
Gauge Pressure, psi., Sta. 4	59.2	47.4	55.0	49.8	45.2	44.9	69.5	62.5
Gauge Pressure, psi., Sta. 5	59.7	49.1	57.3	52.6	47.1	49.1		63.9
Gauge Pressure, psi., Sta. 6	60.1	49.9	58.8	53.9	47.7	50.3	70.1	64.7
Gauge Pressure, psi., Sta. 7	60.7	50.5	59.1	54.5	48.2	50.5	71.2	65.4
Gauge Pressure, psi., Sta. 8	61.0	50.8	58.6	54.2	48.3	50.5	70.2	65.0
Water Temperature °F.	50.0	51.0	55.0	51.5	49.5	53.0	51.0	49.5
Specific Volume of Water	.0160	.0160	.0160	.0160	.0160	.0160	.0160	.0160
Water Flow Lbs. per Second	3.560	4.750	4.000	4.580	5.070	5.060	2.040	3.690
Water Flow Cu. Ft./ Minute	3.425	4.570	3.850	4.420	4.880	4.870	1.963	3.550
Press. Drop $P_2 - P_3$, psi.	14.6	25.0	18.9	24.7	29.3	29.6	3.6	10.8
Head Feet of Fluid, ($P_2 - P_3$)	33.6	57.8	43.7	57.2	67.6	68.4	8.3	25.1
Head Due to Inlet Velocity - Ft.	1.7	3.0	2.1	2.8	3.4	3.4	0.6	1.8
Total Head Available	35.3	60.8	45.8	60.0	71.0	71.8	8.9	26.9

Notes: _____

COLD WATER FLOW TESTS

Date	4-23	4-23	4-23	4-25	4-26	4-26	4-26	4-26
Test Number	240	241	242	243	244	245	246	247
Valve Opening (Lift), Inches	.307	.307	.307	.307	plug out	plug out	plug out	plug out
Duration of Test, Minutes	2.012	2.779	2.652	2.323	2.647	2.175	2.822	3.429
Tank Water Level Difference, In.	21.5	33	35	34	19	18	30	39
Gauge Pressure, psi., Sta. 1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1
Gauge Pressure, psi., Sta. 2	71.3	70.8	70.4	69.7	72.8	72.9	72.6	72.4
Gauge Pressure, psi., Sta. 3	56.5	52.0	47.1	41.7	67.9	66.4	62.0	60.1
Gauge Pressure, psi., Sta. 4	58.7	44.3	50.5	46.0	68.2	66.7	63.6	61.9
Gauge Pressure, psi., Sta. 5	60.5	47.1	54.4	50.1	69.8	68.3	65.2	63.8
Gauge Pressure, psi., Sta. 6	61.9	59.1	56.0	52.1	69.5	68.6	66.3	64.8
Gauge Pressure, psi., Sta. 7	62.4	60.0	56.5	52.8	70.4	69.2	66.4	65.4
Gauge Pressure, psi., Sta. 8	62.2	59.5	56.6	52.7	69.5	68.7	66.0	65.0
Water Temperature °F.	49.5	49.5	49.5	61.5	75.5	75.5	54.0	51.0
Specific Volume of Water	.0160	.0160	.0160	.0160	.0160	.0160	.0160	.0160
Water Flow Lbs. per Second	4.410	4.900	5.440	6.020	2.955	3.410	4.370	4.680
Water Flow Cu. Ft./ Minute	4.240	4.720	5.230	5.800	2.845	3.285	4.20	4.510
Press. Drop $P_2 - P_3$, psi.	14.8	18.8	23.3	28.0	4.9	6.5	10.6	12.3
Head Feet of Fluid, $(P_2 - P_3)$	34.1	43.4	53.8	64.6	11.3	15.0	24.4	28.3
Head Due to Inlet Velocity - Ft.	2.6	3.2	4.0	4.9	0.4	0.5	0.9	1.0
Total Head Available	36.7	46.6	57.8	69.5	11.7	15.5	25.3	29.3

Notes: _____

COLD WATER FLOW TESTS

Date	4-26	4-26						
Test Number	248	249						
Valve Opening (Lift), Inches	Plug out	Plug out						
Duration of Test, Minutes	2.815	2.578						
Tank Water Level Difference, In.	38	39						
Gauge Pressure, psi., Sta. 1	72.1	72.1						
Gauge Pressure, psi., Sta. 2	72.4	72.2						
Gauge Pressure, psi., Sta. 3	55.2	51.5						
Gauge Pressure, psi., Sta. 4	57.1	53.7						
Gauge Pressure, psi., Sta. 5	60.2	56.5						
Gauge Pressure, psi., Sta. 6	61.9	58.8						
Gauge Pressure, psi., Sta. 7	62.1	59.5						
Gauge Pressure, psi., Sta. 8	62.2	59.2						
Water Temperature °F.	50.0	50.0						
Specific Volume of Water	.0160	.0160						
Water Flow Lbs. per Second	5.560	6.240						
Water Flow Cu. Ft./ Minute	5.340	6.010						
Press. Drop $P_2 - P_3$, psi.	17.1	20.7						
Head Feet of Fluid, $(P_2 - P_3)$	39.5	47.7						
Head Due to Inlet Velocity - Ft.	1.4	1.8						
Total Head Available	40.9	49.5						

Notes: _____

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