UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

INVESTIGATIONS OF THE HYDRAULIC PROPERTIES OF THE REVISED HOWELL-BUNGER VALVE - CITY OF SEATTLE, WASHINGTON

Hydraulic Laboratory Report No. 168

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

April 24, 1945

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Engineering and Geological Control
and Research Division
Denver, Colorado
April 24, 1945

Laboratory Report No. 168
Hydraulic Laboratory
Compiled by: Fred Locher

Reviewed by: J. E. Warnock

Subject: Investigations of the hydraulic properties of the revised Howell-Bunger valve, City of Seattle, Washington.

1. Introduction. On June 23, 1944, the Bureau of Reclamation received a letter from S. Morgan Smith Company transmitting a design of a 72-inch Howell-Bunger valve fitted with a hood to confine the jet. A 6-inch hydraulic model was constructed according to this design and tested in the hydraulic laboratory. The results of those tests were presented in Hydraulic Laboratory Report No. 156, a copy of which was sent to S. Morgan Smith Company on November 30, 1944.

In a letter of January 2, 1945, to the Bureau of Reclamation from S. Morgan Smith Company, it was stated that "A thorough check-up by our Engineering Department shows that a regrettable error had occurred on our part when we furnished Mr. Warnock with details of the hood for a 72-inch valve on June 23, 1944. About the only excuse we can offer for this mistake is the rush of wartime contracts and the shortage of manpower in our Design Department. The dimension of 104-inches for the inside diameter of the hood which we furnished Mr. Warnock should have been 117-inches, which would change the 6-inch model hood from 8.667 inches as shown to 9.75-inches."

The letter stated further "We realize these changed dimensions would greatly affect the coefficient of discharge, pressure factor curves and unbalanced thrust chart shown on figures 5, 6 and 7 in the Bureau's report and we believe that a new valve hood and seal plate should be made and tests reconducted so that the record can be cleared up. We would be willing and expect to pay for these additional tests."

Based on the correspondence between the City of Seattle, the S. Morgan Smith Company, and the Bureau of Reclamation, all of which is included in appendix A, the tests have been reconducted with the valve altered to conform to the new dimensions furnished by the manufacturer and the costs charged to the City of Seattle's account suitably earmarked so that the City of Seattle can be reimbursed by the S. Morgan Smith Company.

2. The model. The 6-inch bronze model valve of the previous tests was revamped, figure 1, to conform with the dimensions furnished by letter from S. Morgan Smith Company dated March 2, 1945 (appendix A). The changes involved loosening the ribs and moving the cone forward to provide more clearance between the valve body and the seat, remachining the downstream face of the cone, decreasing the base diameter of the cone, changing the angle, diameter, and thickness of the seat ring, and making a completely new hood. The alterations on the valve, with the exception of the hood, were minor, being of the magnitude of a few hundredths of an inch.

3. Results of tests discharging into the atmosphere with hood. The valve was assembled as shown in figure 1 and placed on the test line with suitable piezometer connections, as indicated in the figure by

numbers, to a manifold and mercury gage and then tested with the valve set at various openings between zero and full-open position. The results are shown in figure 1C where the pressure factor F and the coefficient of discharge C have been plotted against percent of full-valve opening.

The pressure factor F has been defined in figure 1 as the ratio of the measured piezometer pressure to the total head (static head plus velocity head) one inlet diameter upstream from the valve. This reduces F to a dimensionless number, making it possible to obtain the pressure at a point on the valve by selecting from the curves the value of F and multiplying it by the total head one inlet diameter upstream. As an example, to find the pressure at piezometer 8 when the total head is 200 feet of water and the gate 60 percent open, follow the 60 percent line until it intersects curve P8, figure 1, and read the value of the pressure factor at the left which in this case is 0.165. Multiply 200 times 0.165 and the resulting pressure is 33.0 feet of water. Likewise the pressure at piezometer 4 is -41.0 feet of water. As this pressure is unattainable, the result indicates that vapor pressure of water or the maximum negative pressure corresponding to the existing atmospheric conditions will exist in the prototype and pitting due to cavitation may be expected with heads of this magnitude. Actually, the pressure factor curves show that the vapor pressure of water will exist at much lower heads than 200 feet of water. Curves P1, P2, P3, and P6 show pressure factors below -0.40 which indicate that the vapor pressure of water will exist at these points with heads as low as 75 feet of water and gate openings between

60 and 90 percent of full-valve opening.

It has been found that if the scaled value of the pressure at any point in the valve extends below the vapor pressure of water, it is not possible to predict with accuracy the correct pressure at any point in the prototype for the particular head and valve position in question. However, this does not preclude the use of the data at any other valve position or head where none of the scaled results exceeds the vapor pressure of water.

The coefficient of discharge, C, reaches a maximum value of 0.895 at 92 percent of full gate and falls back to 0.850 at maximum opening. The high coefficient obtained at partial openings was due to the negative pressures which prevailed at the valve seat and on the hood. Since the scaled negative pressures are beyond the vapor pressure of water under reasonably high heads, the coefficient of 0.895 will not occur in the prototype and the value of 0.85 is probably more nearly the correct value for the prototype.

The use of the hood on this valve creates an unbalanced thrust on the valve which acts opposite to the direction of flow. The magnitude of the force has been computed by integrating the results of the pressure measurements in the valve and hood (see appendix A). These values have been reduced to the force on a 12-inch valve, under a 1-foot head to simplify the computation of the thrust on a valve of any diameter, figure 2. The prototype thrust can then be obtained from the formula,

$T = n^2Ht$, where n = valve diameter in feet, H = total head in feet of water one diameter upstream from the valve, t = a thrust value selected from figure 2 for a particular valve position.

The maximum unbalanced thrust for a 72-inch valve amounts to 55,800 pounds per 100 feet of head. This does not include the balancing effect of the friction drag of the water on the boundaries. However, this is small and is estimated to be no more than four percent of the maximum thrust.

The thrust obtained with this hood is considerably less, 55,800 pounds as compared to 94,250 pounds for the hood used in the tests described in HYD-156. The decrease is due partly to the increased negative pressures and partly to the fact that the jet was not turned through the entire 45 degrees but left the valve diverging at a central angle of approximately 20 degrees. Had the jet emitted parallel with the valve axis as it did with the smaller hood of the previous design, the thrust would have been larger and the severity of the negative pressures somewhat decreased.

4. Results of tests with discharge into the atmosphere without hood. As in the previous tests without the hood all pressures on the valve were positive. A satisfactory hydraulic performance of the valve may be expected under any head.

The jet emitting from the valve spreads at an angle of approximately 45 degrees, causing a considerable amount of spray and fog to form. This would be a disadvantage if the installation were near electrical installations or in cold climates where severe icing conditions would be a hazard.

The maximum coefficient of discharge obtained when tested under these conditions was 0.840 at the full-gate position. This was practically the same value obtained before the valve was altered to the dimensions furnished by the S. Morgan Smith Company on March 2, 1945.

5. Operation of the valve submerged. These tests were not repeated with the altered valve because the main features of the valve were essentially the same as in the previous tests reported in Hydraulic Laboratory Report No. 156 and similar performance could be expected. For completeness in this report the results of the previous tests are included here.

The tests were made with the valve submerged sufficiently to keep the jet from breaking the water surface. The coefficient of discharge curve for this type of operation without the hood very nearly coincides with the one for free discharge into the atmosphere.

The pressures obtained with the arrangement indicate negative pressure on the valve gate and seat of such a magnitude that cavitation erosion may be expected unless the operation is limited to very low heads or the gate be operated only between 50 and 70 percent of full-gate opening, in which case the head limitation is 200 feet of water. The pressure inside the jet and downstream from the valve is extremely low and considerable noise and disturbance in the jet can be expected from this source.

It appears that 20 feet of submergence would be required at Ross Dam to keep the jet from breaking through the water surface. When submerged, the jet, after it left the valve, was not stable. Eddies forming on either side of the jet caused it to fluctuate from side to side creating a condition which would cause considerable scour of erosible material. The jet can be stabilized by admitting air to the inner portion; however, this aeration will not relieve the negative pressures on the valve. The fact that the aeration stabilized the jet indicates that the negative pressure existing in the jet interior was the major factor contributing to its instability.

Some tests were made with the valve discharging submerged with the hood in place, as a matter of record. When operated in this manner, the coefficient of discharge was increased due to the increase in severity of the negative pressures. The results of this operation have no value except as a matter of record. Any prototype installation of this kind is not recommended.

6. Conclusions. As far as could be determined from the model, it appears that positive pressures will exist on all parts of the valve for free discharge without the hood attached. It was not possible to obtain pressures on the 0.667-inch radius at the downstream end of the valve body, figure 1B. It cannot be stated that positive pressures will exist on this part of the valve.

The severity of the negative pressures and the instability of the jet when the valve is discharging submerged without the hood makes its use in this manner questionable. Operation in the same manner with the hood in place is not recommended.

The use of the valve with the hood in place discharging into the atmosphere is very limited. Between 35 and 95 percent of full-gate travel, severe negative pressures and the resulting pitting can be expected with total heads exceeding 70 feet of water. Between 0 and 32 percent of full gate and at full gate it appears that the valve can be operated continuously at any head without cavitation. If the valves at Ross Dam must be operated between 35 and 95 percent of full gate, their use with the hood is not recommended.

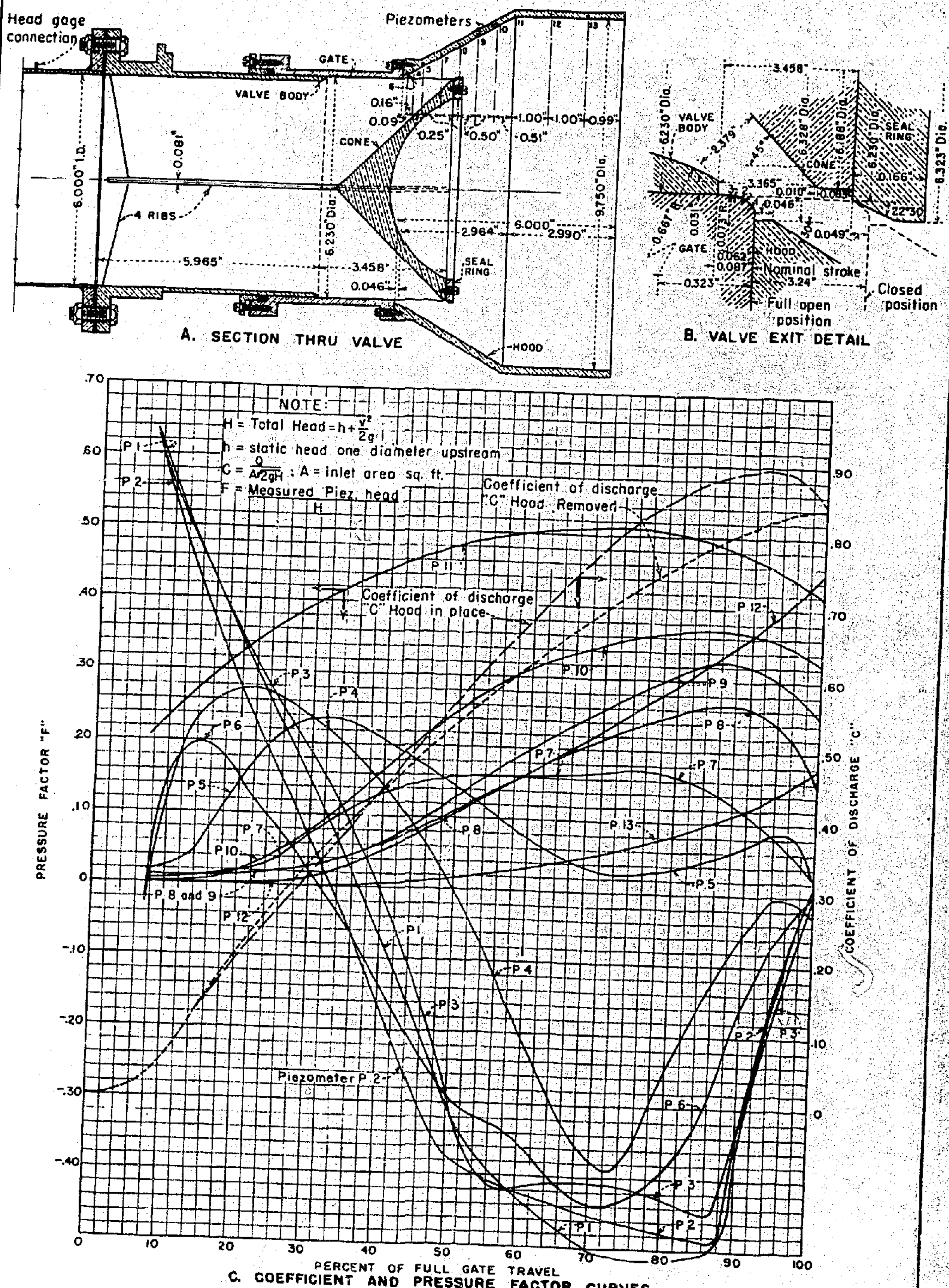
The maximum coefficient of discharge obtained on the model is 0.895 with the hood in place. This coefficient was the result of negative pressures in the hood and when the prototype head exceeds 70 feet of water it is not indicative of the prototype. The coefficient of 0.850 obtained at full-valve opening where the negative pressures were nearly completely relieved, is a more representative value for the prototype.

The maximum unbalanced thrust for a 72-inch valve is 55,800 pounds per 100 feet of head. Ample provisions for this thrust should be embodied in the prototype.

The jet issuing from the valve without the hood spreads at an angle between 40 and 45 degrees with the center line of the valve and causes a considerable amount of spray and fog which would be objectionable if the valve were near transformers or other equipment which must be kept reasonably dry. Icing conditions in cold climates might also be a hazard.

The use of the hood confines the jet to spreading at a central angle of approximately 20 degrees.

FIGURE 1



A. SECTION THRU VALVE

B. VALVE EXIT DETAIL

C. COEFFICIENT AND PRESSURE FACTOR CURVES

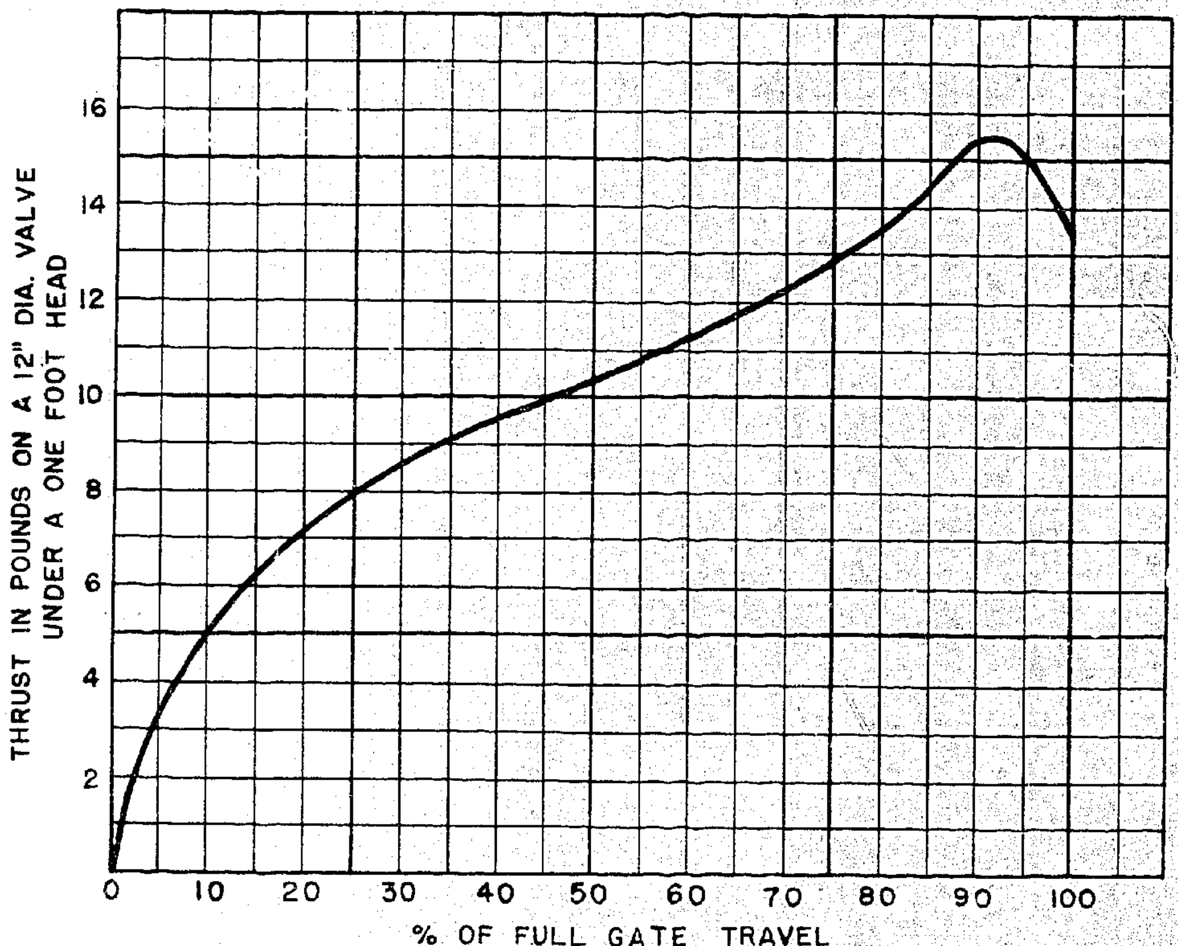
HOWELL-BUNGER VALVE STUDIES

DETAILS AND CHARACTERISTICS DETERMINED FROM 6-INCH HYDRAULIC MODEL

REVISED DESIGN

E 7

FIGURE 2



HOWELL-BUNGER VALVE WITH REVISED HOOD

UNBALANCED THRUST DETERMINED FROM

A 6-INCH HYDRAULIC MODEL

APPENDIX A

S. MORGAN SMITH COMPANY

MANUFACTURERS OF

HYDRAULIC TURBINES
VALVES
YORK, PA.

June 23, 1944.

Mr. J. E. Warnock,
Hydraulic Engineer,
Bureau of Reclamation,
Customhouse,
Denver, 2, Colorado.

Dear Sir:

Mr. C. H. Howell wrote us, June 17th, that the Bureau's hydraulic laboratory has been requested by the City of Seattle to make a scale model test for a 72" and a 96" Howell-Bunger valve. Enclosed is a photostat, with marked dimensions, showing the water passages, valve port openings, thickness of ribs, and other details and dimensions taken from the City of Seattle valve, for the 72" valve, and from Mud Mountain, U. S. Engineers valve for the 96" valve. We have also shown a sketch of the valve hood for these two sizes of valve, similar to the hood arrangement furnished City of Tacoma for Alder and LaGrande Dams, where they thought best to confine and restrict the normal expanding jet to keep spray away from the walls of the powerhouse. The photostat mentioned is supplemented by sketch marked "No. 1", which shows a full size detail of the sliding gate in maximum open position on the valve body, and also the detail of the valve hood flange which bolts directly to the downstream face of the sliding gate.

Sketches Nos. 2 and 3 show hand operating mechanism which we have used for testing model valves in our laboratory. We thought these might be of some help to you.

In order to keep the rib, or vane, sections in proportion, on the model, to the prototype, we suggest brazing sheet brass rib to the inside of the valve body and to the conical section. If this method is used, the conical section can be turned to true dimensions before assembling. We mention this because of difficulty we had with a small bronze cast model valve which had a slightly irregular water passage and heavier vanes than were required.

S. MORGAN SMITH CO.

NAME	PAGE NO.	DATE
Mr. J. E. Warnock.	2	6-23-'44.

We are very much interested in these tests and will certainly appreciate a copy of your reports.

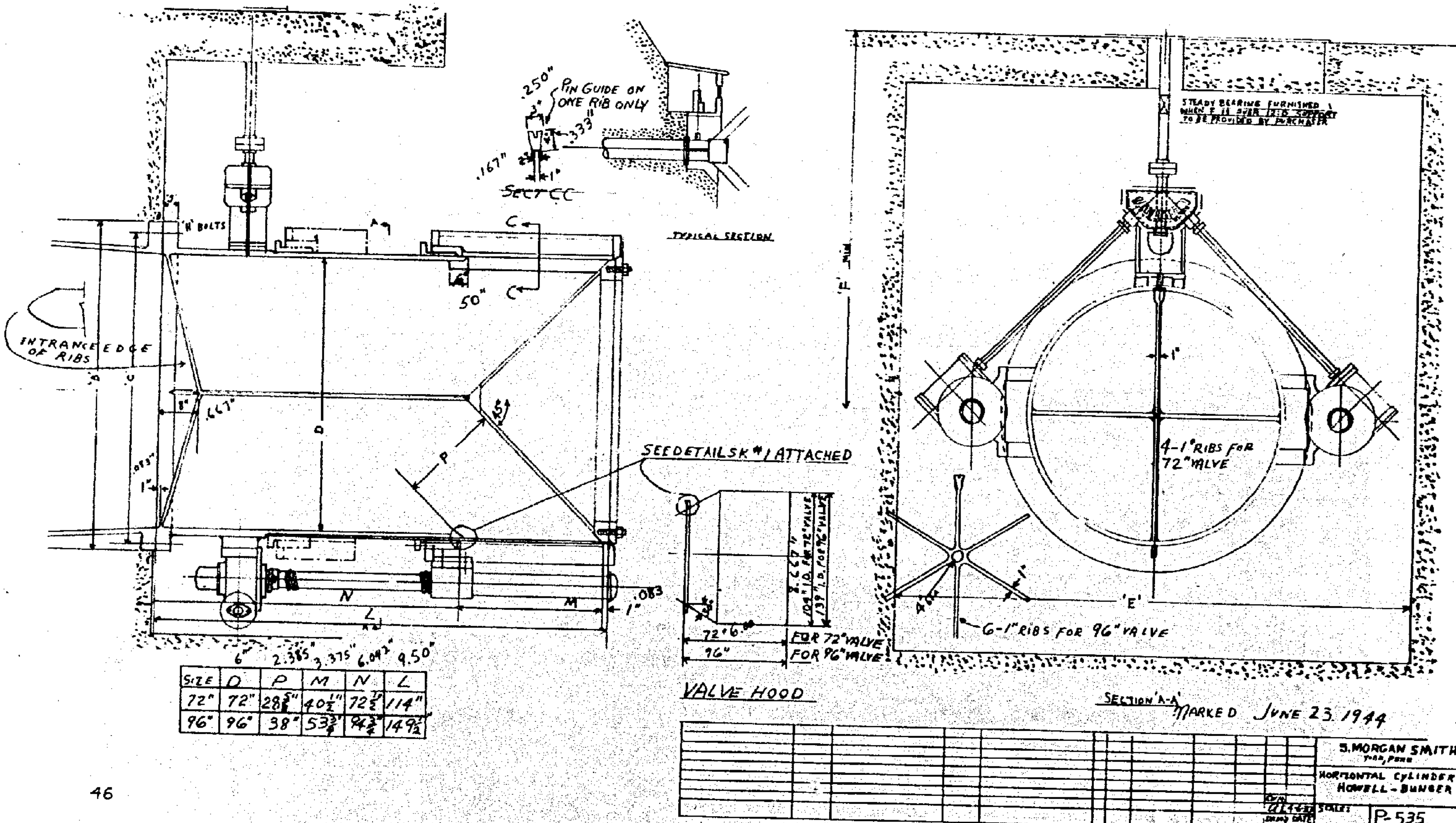
Please feel free to call on us for whatever additional information you may require.

Very truly yours,

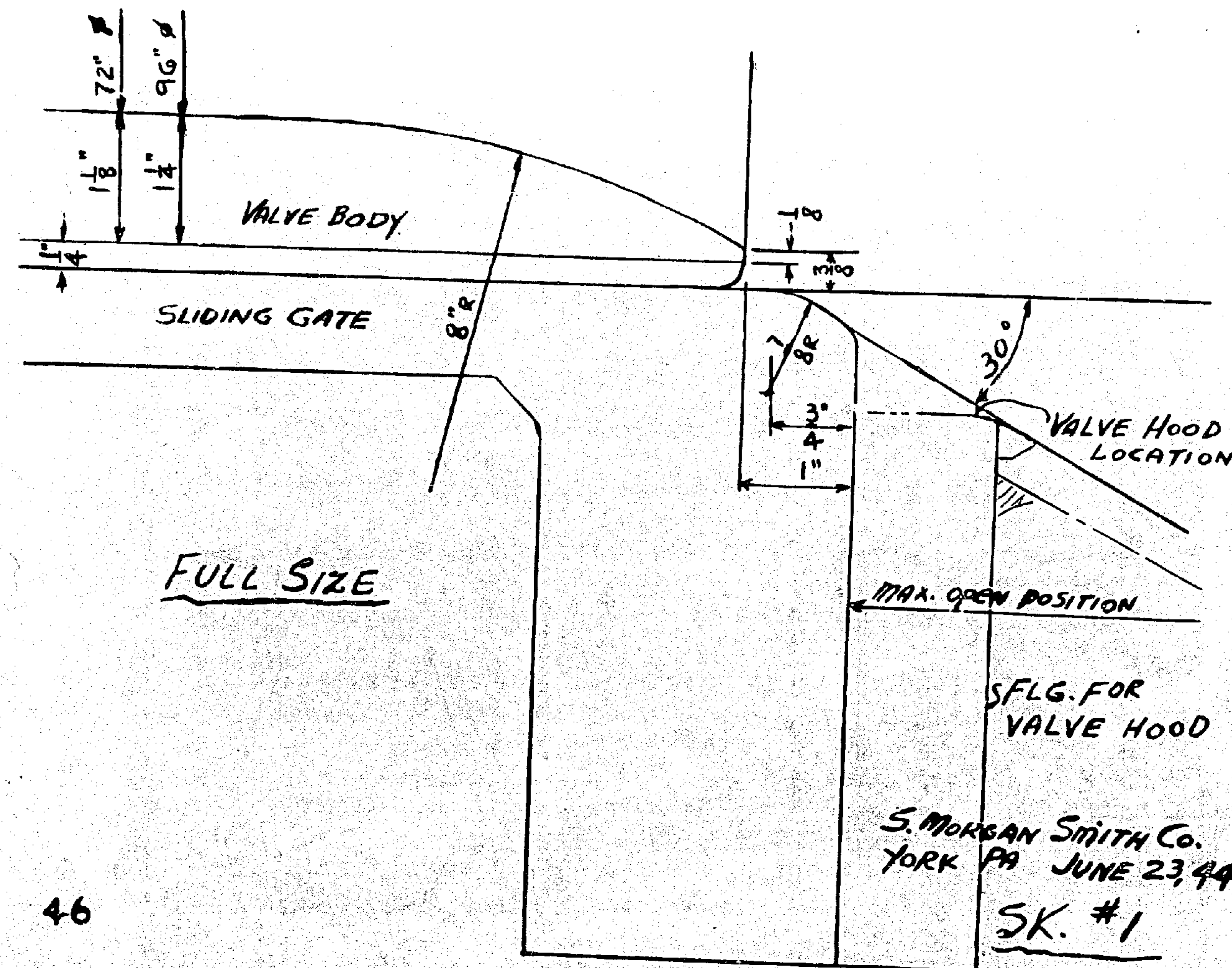
S. MORGAN SMITH CO.,

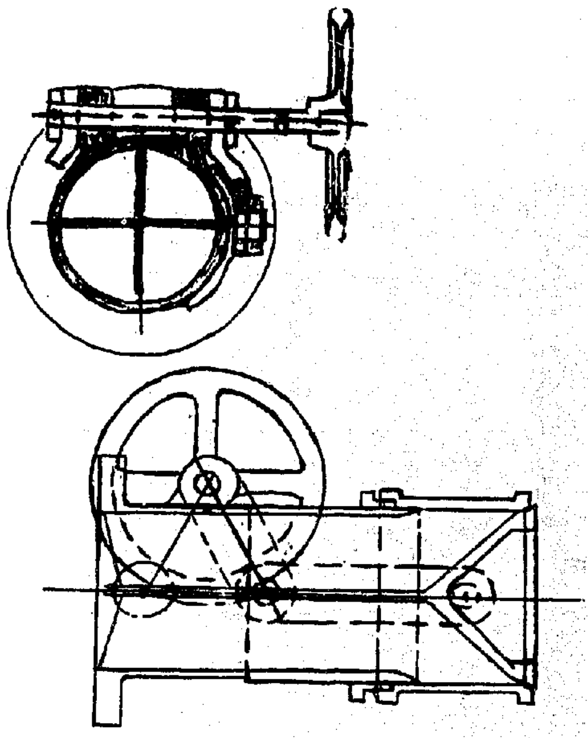
By W. E. Hollingshead.

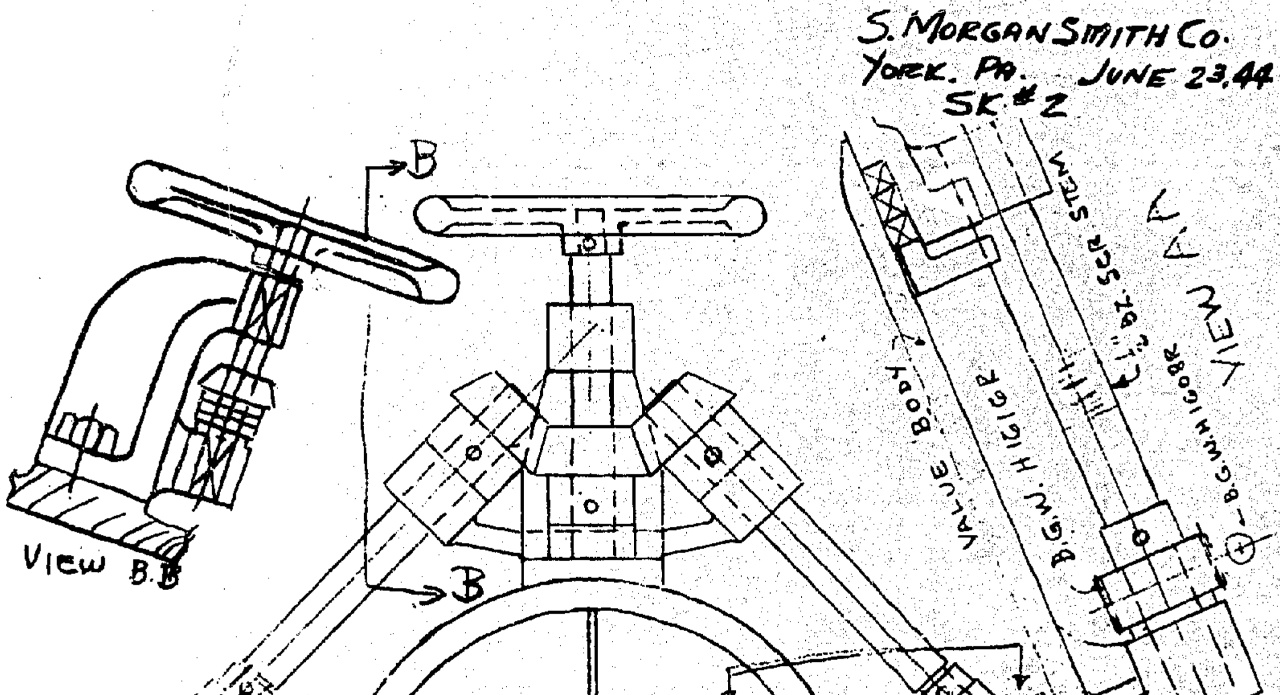
WEH-AB
Encs.



SIZE	D	P	M	N	L
	6"	2.385"	3.375"	6.043"	9.50"
72"	72"	28 5/8"	40 1/2"	72 1/2"	114"
96"	96"	38"	53 3/4"	94 3/4"	149 1/2"


72" ø
96" ø
1 1/8"
1 1/4"
1/4"
VALVE BODY
SLIDING GATE
8" R
1/8
3/8
7/8 R
3/4"
1"
30°
VALVE HOOD LOCATION
MAX. OPEN POSITION
SFLG. FOR VALVE HOOD
FULL SIZE
S. MORGAN SMITH CO.
YORK PA JUNE 23, 44
SK. #1




S. MORGAN SMITH CO.
YORK. PA. JUNE 23,44
SK #2
VIEW B.B
VALVE BODY
VIEW A-A
S. MORGAN SMITH CO
YORK, PA. JUNE 22, 1944

COPY

S. MORGAN SMITH COMPANY

York, Pa.

January 2, 1945

Bureau of Reclamation,
Customhouse,
Denver 2, Colorado

Attention: Mr. S. O. Harper,
Chief Engineer,
by W. H. Nalder, Acting

Subject: Laboratory Study of a 6" Howell-Bunger Valve, Hydraulic Laboratory Report No. 156.

Dear Sirs:

Receipt is acknowledged, with thanks, of your letter of November 30, 1944, together with a copy of the above mentioned report. We think you have done a very fine job and wish to congratulate you on the thoroughness of the test and report.

A thorough check-up by our Engineering Department shows that a regrettable error had occurred on our part when we furnished Mr. Warnock with details of the hood for a 72" valve on June 23, 1944. About the only excuse we can offer for this mistake is the rush of wartime contracts and the shortage of manpower in our Design Department. The dimension of 104" for the inside diameter of the hood which we furnished Mr. Warnock should have been 117", which would change the 6" model hood from 8.667" as shown to 9.75". These correct dimensions are proportioned from the 6½" inside diameter of the hood for the 4" model valve designated Hood for Test No. 3, our "Report on Tests of Various Discharge Hoods for Restricting the Spray on the Howell-Bunger Valves", a copy of which is enclosed. We also note that insufficient information in regard to the end seal plate and downstream end of the valve caused some inconvenience. We would have been glad to furnish this information upon notification. There is a slight variation from the 6" model parts used, from the prototype, which would change the outside diameter of the model seat ring from 6.380" diameter to 6.325" and the thickness from .188" to .366", with the angle on the seat changed from 30 degrees to 22½ degrees. Two (2) blue prints showing the seat assembly, full size, for the 72" Howell-Bunger valve, dated December 14, 1944, are enclosed. Also enclosed are two revised prints from Sketch No. 1, dated June 23, 1944, showing, full size, the sliding gate in full open position, for a 72" valve.

We realize these changed dimensions would greatly affect the coefficient of discharge, pressure factor curves and unbalanced thrust chart shown on Figs. 5, 6 and 7 in the Bureau's report and we believe that a new valve hood and seal plate should be made and tests reconducted so that the record can be cleared up. We would be willing and expect to pay for these additional tests.

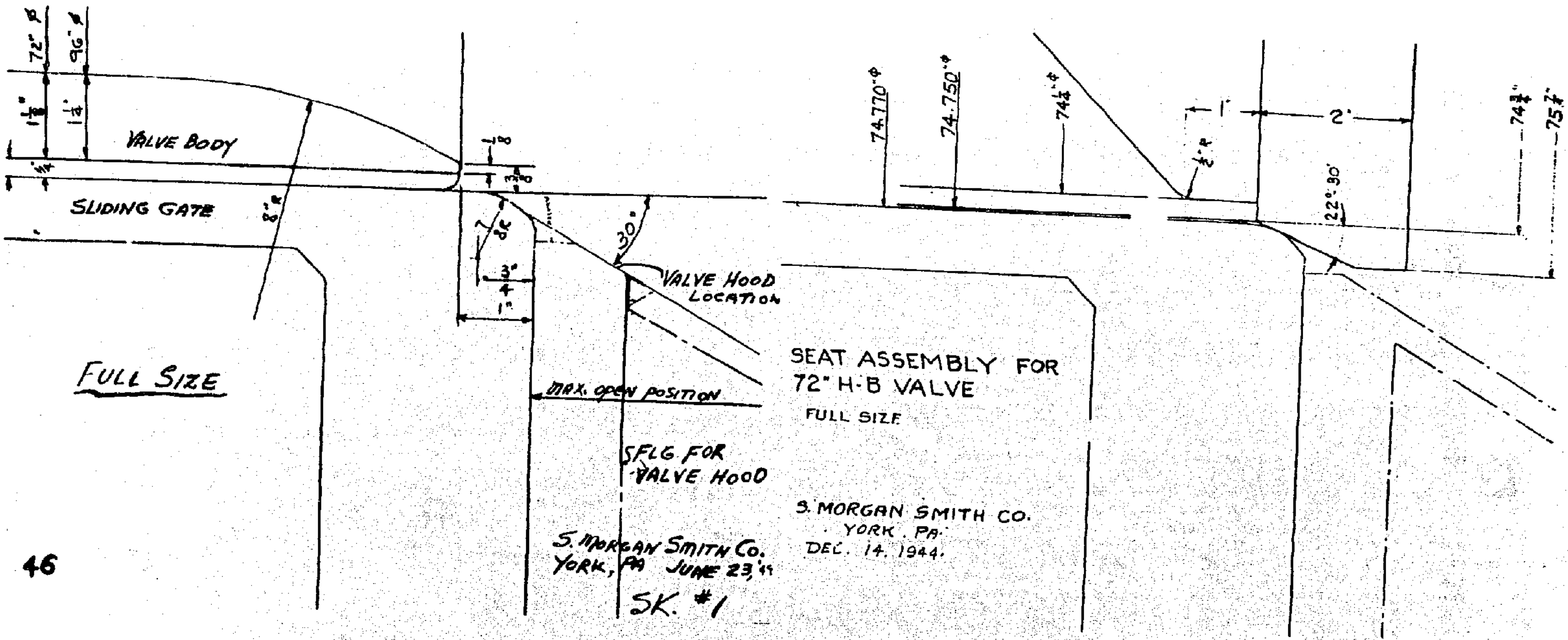
Also enclosed are two copies of curve sheets dated 1/4/44, showing the comparison of Howell-Bunger valve discharge coefficients with and without the hood arrangement, from tests made in our laboratory. You will note that the maximum coefficient of discharge without the hood is 0.85 as compared to the Bureau's figure of 0.848, which is very close. We are very much interested to see what the new tests with the hood to correct dimensions will show in comparison with the curve shown in dotted lines, with the hood, on curve sheet dated 1/4/44. For the purpose of comparison, we are also sending with this letter two copies of our test No. 1748 dated 3/15/44, showing pressures at the various piezometer locations on the 4" model hood, with heads from 15 ft. to 51 ft. and at different gate openings.

We have the following comments to make in regard to the Conclusions shown on the Bureau's report:

In the second paragraph, tests made in our laboratory with the valve without the hood, partially submerged and submerged, did not show instability of the jet mentioned, and while it is true that negative pressures will occur at piezometer locations A, B, C, E, S and J, we are not at all sure that pitting will take place on the valve gates, body or seal plates or whether cavitation action will occur in the water after these surfaces have been passed, as in the case of the edges of runner buckets, and, in any event, the seal plates could be repaired or replaced at little cost.

The third paragraph under Conclusions should be disregarded pending new tests with properly dimensioned hood.

The fourth paragraph under Conclusions is not at all clear to us. We are greatly interested in the details concerning the method of computing the thrust contained in your report No. 148, "Model Studies for Development of Hollow Jet Valve - Anderson Ranch Dam" and as indicated in Fig. 8 and, if possible, would appreciate very much receiving a copy of this report and knowing how the figures shown were arrived at. We are wondering, in particular, whether or not the friction of the water against the hood was taken into account in determining the amount of unbalanced thrust on the valve hood, as this friction tends to balance the force in the upstream direction. We intend to conduct tests to actually determine the amount of unbalance with the hood, in our laboratory. From previous tests of the model valve with the hood, in our laboratory, no unbalance was apparent and less effort was required to move the operating hand-wheel at all gate openings when under discharge than when not discharging.


72" Ø
96" Ø
VALVE BODY
SLIDING GATE
FULL SIZE
VALVE HOOD LOCATION
MAX. OPEN POSITION
SFLG FOR VALVE HOOD
S. MORGAN SMITH CO. YORK, PA JUNE 23, '44
SK. #1
74.770" Ø
74.750" Ø
22° 30'
SEAT ASSEMBLY FOR
72" H-B VALVE
FULL SIZE
S. MORGAN SMITH CO.
YORK, PA.
DEC. 14. 1944.

The sales literature showing a discharge coefficient of 90% was published from information supplied to us at the time we started manufacturing the Howell-Bunger valve under patent license agreement and subsequent laboratory tests made by us with the 4" model valve under free discharge showed a discharge coefficient of approximately 85%, as noted above.

We thank you for your cooperation in sending us a copy of your report and will appreciate your comments on the information outlined above.

Very truly yours,

S. MORGAN SMITH CO.

By: (Sgd.) W. E. Hollingshead
Welding Engineer

WEH-AB
Encs.

CC-Mr. E. R. Hoffman,
Supt. of Lighting,
Dept. of Lighting,
City of Seattle,
Seattle 4, Wash.

JEW:MLS

January 17, 1945

Mr. W. E. Hollingshead,
Welding Engineer,
S. Morgan Smith Co.,
York, Pa.

Dear Sir:

Reference is made to your letter of January 2, 1945, acknowledging receipt of our letter of November 30, 1944, by which we transmitted a copy of Hydraulic Laboratory Report No. 156, "Laboratory Study of a 6-inch Howell-Bunger Valve - Ross Dam - City of Seattle, Washington," and outlining certain errors on drawings of details of the hood for a 72-inch valve furnished Mr. Warnock by letter of June 23, 1944. You expressed the realization that the changes in the design of the hood for the 6-inch model would affect greatly the coefficient of discharge, pressure-factor curves, and unbalanced thrust chart shown on figures 5, 6, and 7 of Report 156. You also indicated the desirability of the construction of a new hood and the reconduct of the tests so that the records may be cleared. You also expressed a willingness to pay for these additional tests.

Based on the information and the dimensions contained in your letter and in a letter from Mr. E. R. Hoffman, Seattle, Washington, of January 8, 1945, transmitting a copy of your letter of December 29, 1944, to them, we will proceed with the reconduct of the tests involving the hood. The costs of these additional tests will be charged to the City of Seattle, suitably earmarked so that adjustment of these costs can be made between the City of Seattle and the S. Morgan Smith Co.

A print of figure 3 of Report No. 156 is enclosed, showing our interpretation of the dimensions as shown on drawings submitted June 23, 1944, as amended by drawings submitted by your letter of January 2, 1945.

In interpreting your recent drawings some inconsistencies have been found which need clarification before we can proceed with the modification of the 6-inch valve. The dimension "L" as shown on the marked photostat (June 23, 1944) of drawing P-6866-87-1 is 114 inches. The same dimension shown as "D" on the blueprint of drawing P-6866-87-1 is 126 inches, or 12 inches greater. In the design of the 6-inch model the 114-inch dimension was used, it apparently being of the most recent date.

The print of the "Comparison of Howell-Bunger Valve Discharge Coefficients Based on Laboratory Tests" dated January 4, 1944, contained in your letter of January 2, 1945, shows the full valve stroke as 0.55 x nominal diameter. With a nominal diameter of 72 inches - dimension "D" on the marked photostatic copy of P-6566-BP-1 - the full stroke of the 72-inch valve would be 0.55 x 72, or 39.60 inches as shown on the accompanying sketch, "Details of the Seat of the 72-inch Howell-Bunger Valve," January 18, 1945. From that value the distance from the downstream end of the valve body to the upstream face of the seal ring is 39.94 inches. From the value of "M" shown on the photostat as 40-1/2 inches, and adding the 1 inch at the downstream end, a value of 41.50 inches is obtained for the distance from the downstream end of the valve body to the upstream face of the seal ring, instead of 39.94 inches. Using the 41.50 inches, the full stroke, or gate travel, becomes 41.16 inches instead of 39.6 inches.

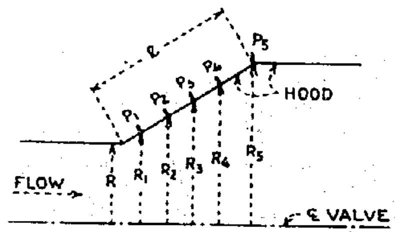
The sketches submitted by you to date have not included a complete detail of the seating area on the gate. Sketch S.K. No. 1, copies of which were included in your June 23, 1944, and January 2, 1945, letters, shows a different design from that on "Seat Assembly for 72-inch Howell-Bunger Valve" dated December 14, 1944.

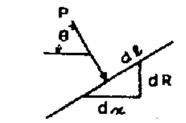
The drawing, "Seat Assembly for 72-inch Howell-Bunger Valve," dated December 14, 1944, shows a diameter of 74-1/4 inches for the base of the conical section, whereas all other drawings indicate this dimension to be approximately 74-3/4 inches.

According to the drawing of "Hood for Test No. 3" on page 4 of your June 22, 1943, report, which presumably was the accepted design, the angle of divergence of the hood is "30 degrees app." By using the dimensions of this sketch and making the diameter of the upstream end of the hood as indicated by the revised line on the print of S.K. No. 1 in your January 2, 1945, letter, the diverging angle of the hood is approximately 37 degrees, 45 minutes. A complete detailed drawing of valve hood has not been received from you. The design as shown on figure 3, Report 156, was prepared by utilizing material from the sketches you furnished.

In the third section of your comments on the "Conclusions in Report 156," you indicated a desire for an amplification of the method of computing the thrust as contained in Report 148. Because of the slight difference in application, the method of computation for the hooded Howell-Bunger valve is discussed in the following paragraphs.

The thrust on the valve hood was computed as follows:





ELEMENT OF HOOD

p = measured piezometric pressure,

ℓ = length along surface of hood,

R = radius from center line of valve,

$2\pi Rp\,d\ell$ = total thrust on the increment $d\ell$,

$2\pi Rp\,d\ell \cos\theta$ = horizontal thrust.

Then the total thrust in the horizontal direction is

$$2\pi\int_0^{\ell} Rp\cos\theta\,d\ell$$

but as $d\ell = \frac{dR}{\cos\theta}$, the total horizontal thrust reduces to

$$2\pi\int_R^{R_5} Rp\,dR.$$

In evaluating the integral it is necessary to know p as a function of R, but as this was difficult to define in a mathematical equation, the integration was performed graphically by plotting the value pR against the corresponding R for each piezometric pressure. The area under the curve was measured by a planimeter to obtain the $\int_{R}^{R_b} Rp\,dR$. The result was multiplied by 2π to obtain the thrust on the valve for a particular head.

As the value of the radius used in the computations was in inches, the value obtained in the preceding computation was multiplied by 0.434 to reduce the results to pounds for a particular head. This was reduced to the thrust for a 1-foot head on the 6-inch model by dividing the result by the head. This result was multiplied by 4 to convert it to the thrust on a 12-inch valve under a 1-foot head, for simplicity in computing the thrust on a valve of any diameter. Since the thrust is proportional to the head and the square of the ratio of the valve diameters, the formula

$$T = n^2 Ht$$

where

T = thrust in pounds,

n = valve diameter in feet,

H = total head 1 diameter upstream from the valve, and

t = a value obtained from figure 6, Report 156,

contains all the variables necessary to compute the thrust on a valve of any diameter. In this computation the balancing force due to the drag of the water on the hood has been neglected.

During the course of the tests it was necessary to reduce the head of the valve a considerable amount when starting it closed from a full-open position, which indicated the magnitude of the thrust. When the valve was removed from the conduit and placed in a vertical position, a static load of 160 pounds could be lifted by the operating mechanism without undue difficulty.

The balancing force due to the friction drag, or shear, along the walls of the hood has been evaluated in accordance with your suggestion and has been found to be approximately 2 per cent of the computed maximum thrust at the point of maximum thrust (figure 6, Report 156).

As soon as we receive a clarification from you of the dimensions of the hood for the 72-inch Howell-Bunger valve, we will modify the valve and proceed with the tests.

Very truly yours,

Walker R. Young,
Acting Chief Engineer

Encls.

CC-Mr. E. R. Hoffman,
Superintendent of Lighting,
Department of Lighting,
Seattle 4, Washington.

ADDRESS ALL COMMUNICATIONS TO
THE CHIEF ENGINEER

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

OFFICE OF THE CHIEF ENGINEER

CUSTOMHOUSE
DENVER, COLORADO

JAN 18 1945

Mr. E. R. [illegible],
Superintendent of Lighting,
Department of Lighting,
City of Seattle,
Seattle 4, Washington.

Attention: Mr. W. B. Wolfendale.

Dear Sir:

Reference is made to your letter of January 3, 1945, enclosing, for our information and files, a copy of a letter from the S. Morgan Smith Company dated December 29, 1944; and to Mr. Wolfendale's telephone conversation with Mr. Warnock on January 5, 1945, concerning Hydraulic Laboratory Report No. [illegible] on the laboratory study on the 6-inch Howell-Bunger valve. The S. Morgan Smith Company letter described an inadvertent error of dimension on drawings of the hood for the 72-inch valve which had been furnished Mr. Warnock on June 23, 1944. The inside diameter of 104 inches should have been 117 inches which would change the 6-inch model hood inside diameter from 8.667 inches, as used, to 9.75 inches. Additional information was also supplied relative to the dimensions of the end seal plate and the downstream end of the valve gate, whereby the outside diameter of the model seat ring should be changed from 6.[illegible] inches to 6.[illegible] inches and the thickness from 0.[illegible] to 0.[illegible] inches, with an angle on the seat of 22½ degrees instead of 30 degrees.

In a letter of January 4, 1945, to the Bureau, the S. Morgan Smith Company outlined the same information and expressed the belief that these changed dimensions would affect greatly the coefficient of discharge, pressure factor curves, and unbalanced thrust chart shown on figures 5, 6, and 7 in Report No. [illegible]. It further expressed the belief that a new valve hood and seal plate should be made and tests reconducted so that the record could be cleared. It expressed a willingness to pay for these additional tests. A copy of the company's letter is enclosed for your information and files.

On the basis of your letter of January 3, 1945, and your telephone conversation with Mr. Warnock, we will proceed with the conduct of additional tests based on the new dimensions supplied by S. Morgan Smith Company as soon as it has clarified certain dimensions. A print of figure 3, Report No. [illegible], and of "Details of Seat of 72-inch Howell-Bunger Valve," January 16, 1945, showing our interpretation of the new data are being sent to the company for approval before proceeding with the revisions of the model. A copy of the letter of transmittal and the drawing is enclosed.

The costs of these additional tests will be charged to funds of the City of Seattle now on hand for hydraulic laboratory studies and adjustments of these costs can be made between the S. Morgan Smith Company and the City of Seattle.

Very truly yours,

[illegible] Young,
Acting Chief Engineer.

Encls.

CC-Mr. [illegible] Hollingshead,
Welding Engineer,
S. Morgan Smith Co.,
York, Pa.

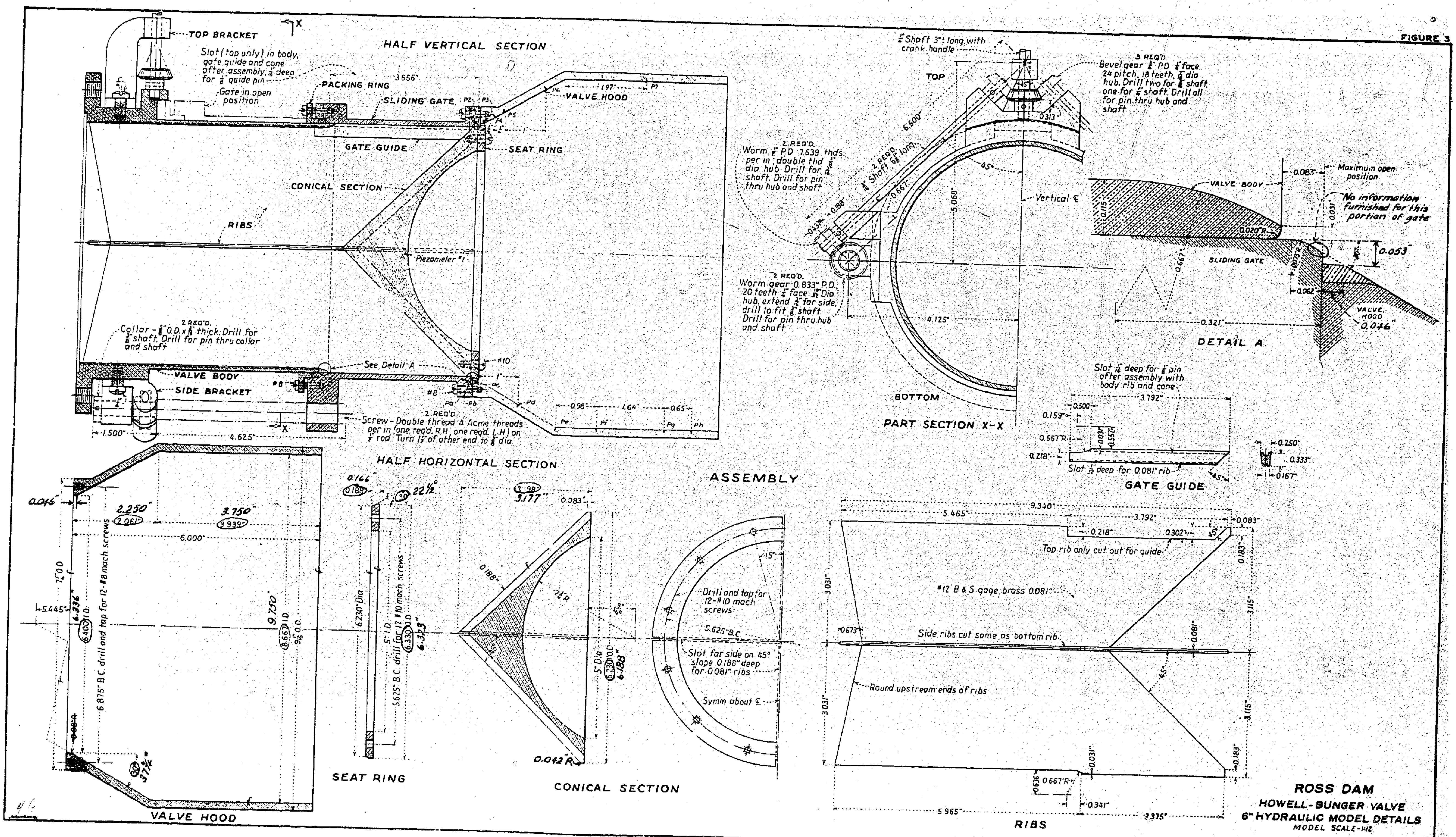
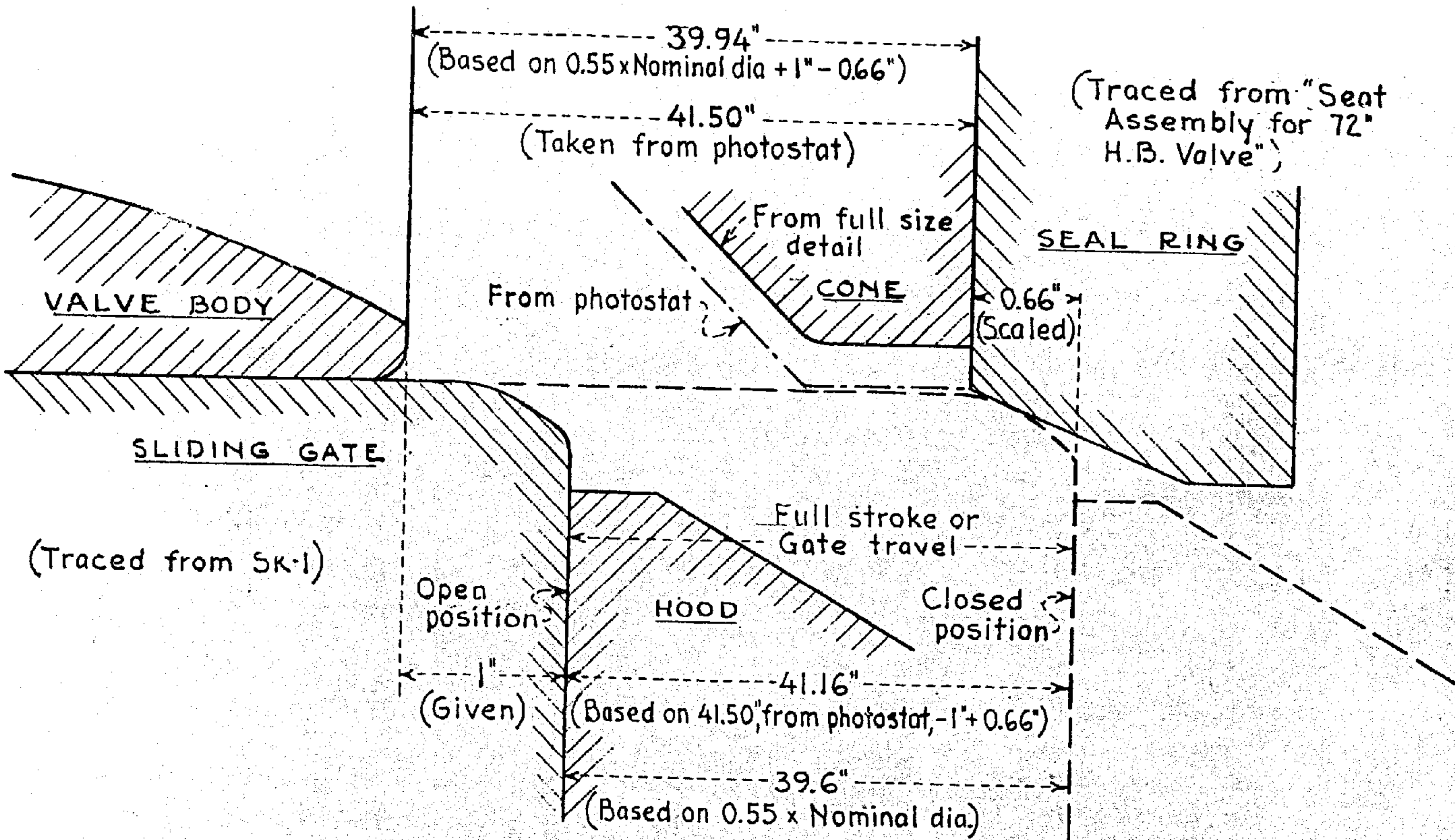


FIGURE 3
HALF VERTICAL SECTION
HALF HORIZONTAL SECTION
TOP BRACKET
PACKING RING
SLIDING GATE
VALVE HOOD
GATE GUIDE
SEAT RING
CONICAL SECTION
RIBS
VALVE BODY
SIDE BRACKET
See Detail A
PART SECTION X-X
TOP
BOTTOM
DETAIL A
No information furnished for this portion of gate
GATE GUIDE
ASSEMBLY
VALVE HOOD
SEAT RING
CONICAL SECTION
RIBS
ROSS DAM
HOWELL-BUNGER VALVE
6" HYDRAULIC MODEL DETAILS
MODEL SCALE-1:12



DETAILS OF SEAT OF 72" HOWELL-BUNGER VALVE

S. MORGAN SMITH COMPANY

MANUFACTURERS OF

HYDRAULIC TURBINES

VALVES

YORK, PA.

January 23, 1945.

Bureau of Reclamation,
Customhouse,
Denver 2, Colorado.

Attention: Mr. Walker R. Young, Acting Chief Engineer,
By Mr. W. H. Nalder.

Subject: Laboratory Study of a 6" Howell-Bunger Valve,
Hydraulic Laboratory Report No. 156.

Dear Sirs:

Receipt is acknowledged of your letter of January 17, copy of letter to Mr. E. R. Hoffman, City of Seattle, of January 18, sketch of details of seat for 72" Howell-Bunger valve dated January 16, 1945, and marked print of drawing Fig. 3, 6" hydraulic model details for Howell-Bunger valve for Ross Dam.

It is noted that clarification is required of the details and dimensions furnished by us for the hood of the 72" Howell-Bunger valve, also seat assembly, stroke and valve body, and that you will proceed to reconduct the tests after this clarification. Your letter is being turned over to our Design Department immediately for checking the discrepancies outlined therein in regard to dimensions and also for checking the sketch and drawing mentioned above, and this information will be sent to you as quickly as possible.

It is agreeable to us that the costs of these additional tests will be suitably earmarked when charged to the City of Seattle, so that adjustment of these costs can be made between the City of Seattle and the S. Morgan Smith Co.

We appreciate your cooperation very much and will check carefully to see that full and proper information will be furnished promptly for the modification of the model details.

Very truly yours,

S. MORGAN SMITH CO.,

By W. E. Hollingshead,
Welding Engineer.

WEH-AB

S. MORGAN SMITH COMPANY

MANUFACTURERS OF

HYDRAULIC TURBINES

VALVES

YORK, PA.

February 16, 1945

Bureau of Reclamation
Customhouse
Denver 2, Colorado

Attention: Mr. Walker R. Young,
Acting Chief Engineer

SUBJECT: Laboratory Study of a 6" Howell-Bunger Valve
Hydraulic Laboratory Report No. 156.

Gentlemen:

We have checked the data contained in your letter of January 17 and are enclosing one print of our sketch dated February 13 as well as photostat of your drawing, Figure 3, on the 6" Howell-Bunger model valve. In order to clarify the dimensions that are to apply to the model valve for the new test, we have made the sketch above referred to to scale ten-to-one, and you will note that in order to obtain the throat opening between cone and body sleeve, it will be necessary to trim back the body sleeve to the dimensions shown. We found that on the model valve the throat was not in accordance with the prototype due to the fact that allowance was not made for the depth of the rib slots in the cone. You will note that the throat opening should be 2.364" which, based on the master layout is the nominal opening to which is added a tolerance on fabricated valves to allow for assembly variations. We believe that the body can be cut back without much difficulty and the slots in the ribs could be built up again by soldering.

Referring to your drawing, Figure 3, you will note that we have checked your figures in red and made several corrections. On the cone, we believe it unnecessary to reduce the diameter to [illegible].6188" for the new test, as it will not affect the discharge with a larger hood of proper dimensions, as occurred before with the incorrect hood diameter. The radius of the gate as per detail A of .073" should be drawn to intersect with the end of the gate and should not be tangent to the 30° line. The center of the radius is correctly shown.

The cone angle of the valve hood should be 30° as corrected.

Referring again to our sketch you will note that the distance from the face of the cone to the end of the body sleeve is 3.458", which is not homologous to our master lay-out but includes the additional length of the cone due to the face that the outside length of .083" should be on a diameter of 6.188" instead of 6.230". This corresponds to a diameter of 73-3/4" on the 72" valve to which diameter the body is machined before the bronze liner is added. The bronze tips on the vanes are carried across the base of the cone and machined to 74-1/4" in diameter in line with the outside of the liner. This extra length again will not affect your further tests and we have, therefore, made allowance in the figure given above.

The end of the gate for full open should be positioned .087" from the end of the body sleeve and the nominal stroke is 3.42". Again the actual stroke on your model valve will be longer for the same reason as explained above, but for your tests we think the indicator should be calibrated for the nominal stroke. The strokes for the prototype will be determined on the same basis, namely, the location of the gate in full open position and the seat ring, the location of which may not always be truly homologous due to fabrication and machining considerations. Therefore, the strokes of various valve sizes may not be strictly proportional.

Figure 5 of Test Report 156 shows the discharge curve of the valve with hood removed, flattening off at about 95% gate opening indicating that the valve is choked. With the correct throat dimension we believe that the curve will continue upward to the full gate opening.

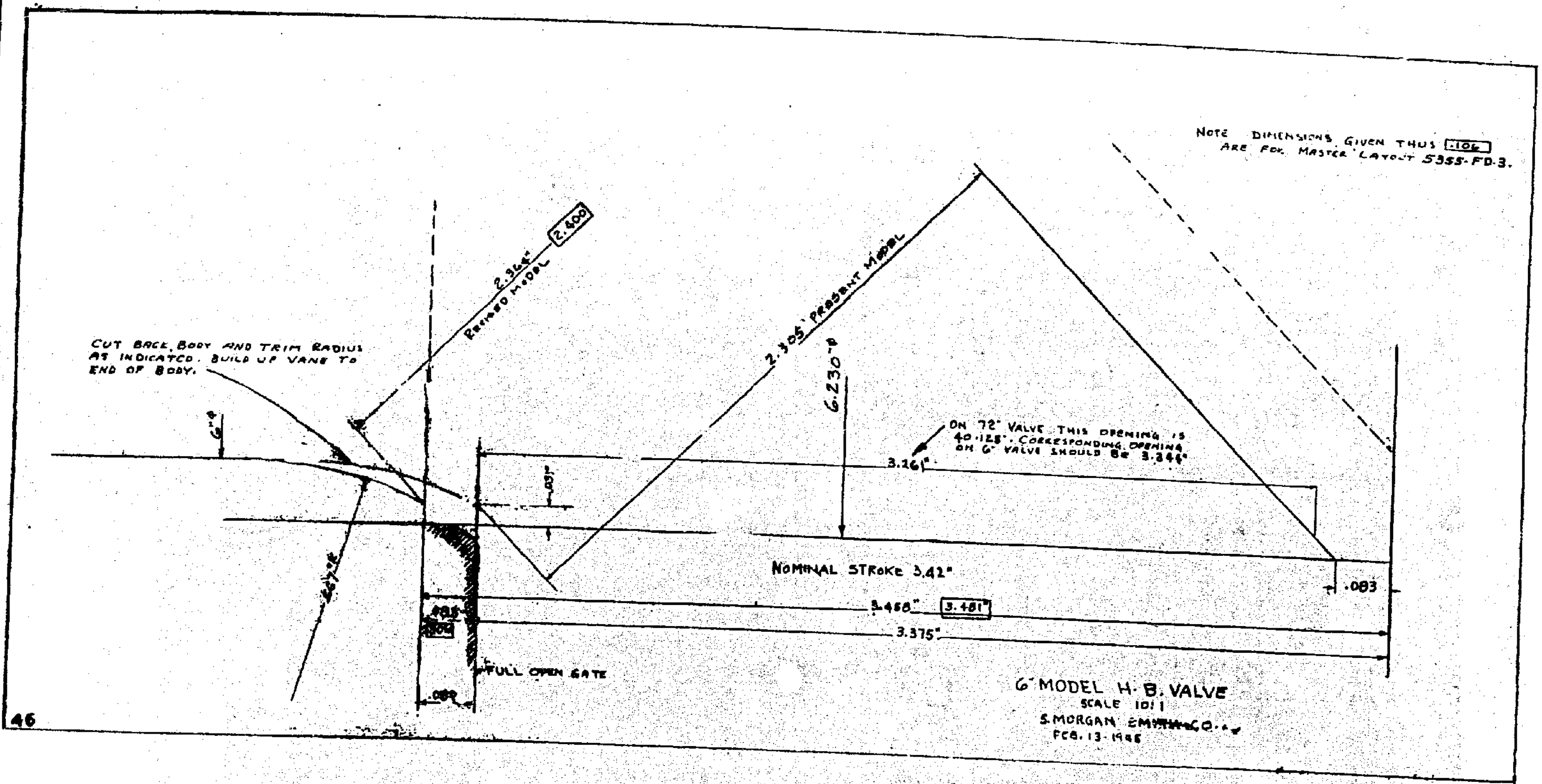
We trust the above will give you sufficient information to permit you to change your model and undertake the new test. We shall, however, be glad to answer further inquiries if you find it necessary to ask for additional information.

Yours very truly,

S. MORGAN SMITH COMPANY

J. Finch
Chief Design Engineer

JF/PH
cc-Mr. C. H. Howell
Box 447, Estes Park, Colorado
cc-G.A.J.
T.S.R.



NOTE DIMENSIONS GIVEN THUS .106 ARE FOR MASTER LAYOUT 5355-FD-3.
CUT BACK BODY AND TRIM RADIUS AS INDICATED. BUILD UP VANE TO END OF BODY.
2.364" REVISED MODEL
2.400
2.305" PRESENT MODEL
6.230"
ON 72" VALVE THIS OPENING IS 40.125". CORRESPONDING OPENING ON 6" VALVE SHOULD BE 3.344"
3.261"
NOMINAL STROKE 3.42"
.083
3.458"
3.481"
3.375"
FULL OPEN GATE
6" MODEL H. B. VALVE
SCALE 10:1
S. MORGAN SMITH CO.
FEB. 13. 1945

JMR:DDW

'IR MAIL

FEB 22 1945

S. Morgan Smith Company,

York, Pennsylvania.

Attention: J. Fisch,
Chief Design Engineer.

Gentlemen:

The data contained in your letter of February 16, 1945, in connection ith the laboratory study of a 6-inch Howell-Bunger valve, shows that the valve seating arrangement has been dimensioned for a diameter at the base of the cone of 6.230 inches instead of the correct diameter of 6.188 inches. While it is probably true that this will not appreciably effect the discharge of the valve, the laboratory prefers that the valve be constructed such that all of the water passages are homologous so far as this is possible. The construction of the model valve is such that this alteration can be accomplished without removing the cone from the vanes and will require a very small amount of time.

A drawing of the valve seat and the downstream part of the valve body is enclosed showing the dimensions A, B, C, etc., based on a diameter at the base of the cone of 6.188 inches which are needed to make the model valve conform with the prototype. For our purposes it will be preferable for the missing dimensions to be placed on the drawing and to return to this office either the original or a photostat copy.

Very truly yours,

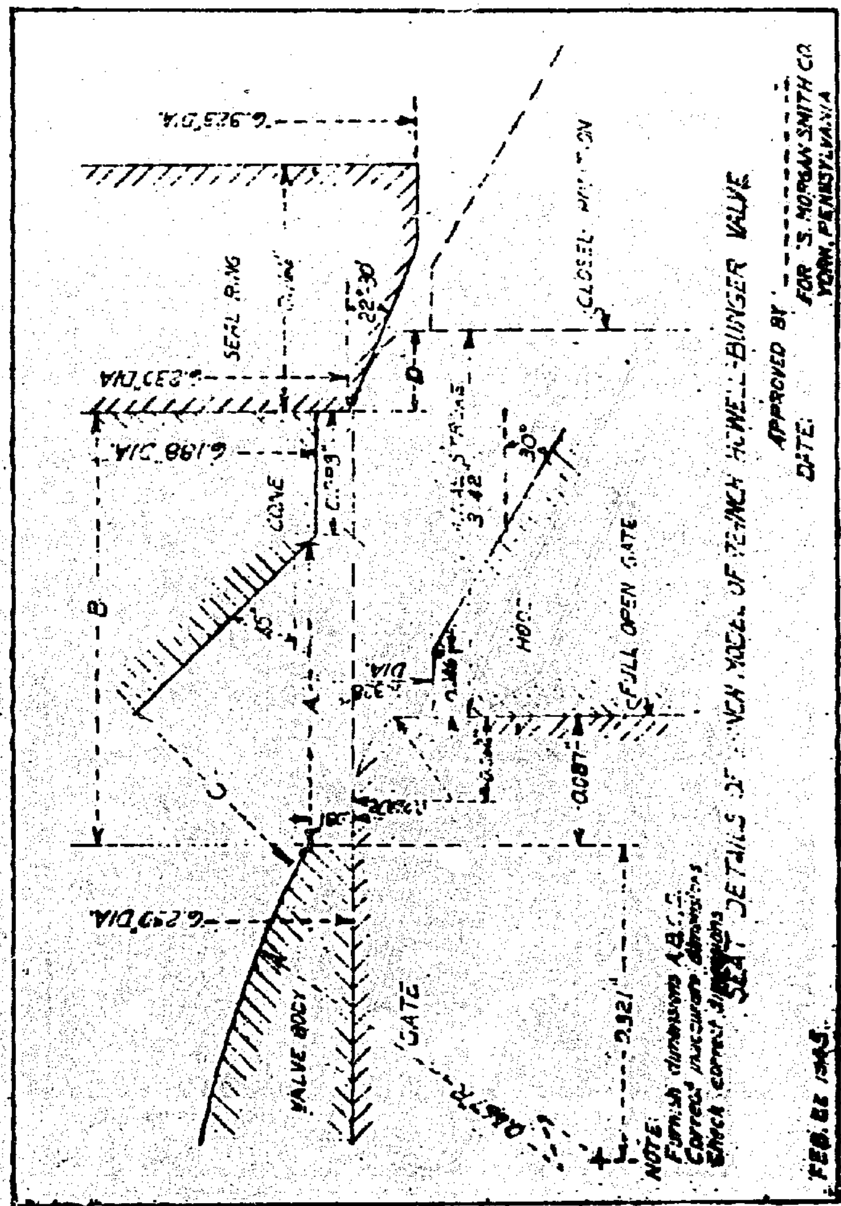
Bureau of Reclamation,

By:

L. N. McClellan,
Chief Electrical and
Mechanical Engineer.

Encl.

CC-J.E.Warnock



S. MORGAN SMITH COMPANY

MANUFACTURERS OF

HYDRAULIC TURBINES
VALVES
YORK, PA.

March 2, 1945

U. S. Department of Interior
Bureau of Reclamation
Customhouse
Denver, Colorado

Attention: Mr. L. N. McClellan
Chief Electrical and
Mechanical Engineer.

SUBJECT: Howell-Bunger Valve - Laboratory Tests.

Gentlemen:

Reference is made to your letter of February 22 and enclosed print of Seat Details for the subject project.

We note your laboratory's desire to make the model as nearly homologous as possible to the full size valve, which is satisfactory to us.

Enclosed we are returning to you sketch dated February 22 on which we have indicated the desired dimensions. All other dimensions originally shown on the print were checked and found to be correct.

Since you are machining the cone part of the valve, we wish to call to your attention that not only the diameter must be reduced to 6.188", but the face must be machined off to a dimension of .053", from the intersection of the cylinder with the 45° cone.

Yours very truly,

S. MORGAN SMITH COMPANY

J. Fisch
Chief Design Engineer

JF/PH
Enc.