UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

OPERATING INSTRUCTIONS FOR MOORING, SINKING, AND REFLOATING THE GRAND COULEE FACE CAISSON AS DETERMINED FROM HYDRAULIC MODEL STUDIES--COLUMBIA BASIN PROJECT

Hydraulic Laboratory Report No. Hyd.-264

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

DECEMBER 2, 1949

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Research and Geology Division
Denver, Colorado
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Laboratory Report No. Hyd-264
Hydraulic Laboratory
Compiled by: W. C. Case and
W. P. Simmons
Reviewed by: J. W. Ball

Subject: Operating instructions for mooring, sinking, and refloating the Grand Coulee face caisson as determined from hydraulic model studies--Columbia Basin Project.

PURPOSE

To describe the operating procedure for mooring, sinking, and refloating the caisson for making repairs to the spillway face of Grand Coulee Dam.

CONCLUSIONS

Instructions for mooring and sinking the caisson:

1. Tow the floating caisson by tug or workbarge into approximate position at the face of the spillway.

2. Attach the peaking line and lateral control lines to anchors on the spillway face (Figure 1).

3. By using Figure 2(C), fill the upper tank to an amount not more than that shown by the dashed Curve (a) in Figure 2(A) for the existing riverwater elevation at the caisson location.

Note: The upper tank must be filled to an amount near that given by the dashed curve to maintain sufficient wheel load needed for lateral stability of the upper end of the caisson. Small negative tilt angles may be encountered during this operation at the higher riverwater surface elevations.

Example: If the riverwater elevation at the caisson location is 941 feet, the maximum water to be placed in the upper tank during mooring, based on dashed Curve (a) of Figure 2(A), is 40 percent. Water is pumped into the upper ballast tank and, simultaneously, readings of the head, H, in the tank and angle of tilt are taken. By using Figure 2(C), the amount of water in the upper tank is determined and no more than 40 percent is pumped into this tank for a riverwater elevation of 941 feet at the caisson location.

4. By using the curves from Figure 2(D) or Figure 3, fill lower tank to an amount shown by curve in Figure 2(B) for the existing riverwater elevation.

Note: If there is appreciable leakage of water between the three compartments of the lower ballast tank, the three compartments will have to be filled simultaneously and Figure 3 used to determine the amount of water in the lower ballast tank.

Caution: After the angle of tilt has reached 10°, further filling should be done very slowly as small additional amounts of water rapidly increase the angle of tilt (Figure 4).

Example: If the riverwater elevation is 941 feet at the caisson location, the amount of water to be placed in the lower ballast tank, based on Figure 2(B), is 79 percent. Water is pumped into the lower ballast tank and, simultaneously, readings of the head, H, in the tank and angle of tilt are taken. By using Figure 2(D) or Figure 3, the amount of water in the lower tank is determined; and no more than 79 percent is pumped into this tank for a riverwater elevation of 941 feet.

5. Lower A-frame until guide shoe rests on connecting guide; slack off peaking lines.

6. Attach cable from a hoist on the roadway across the dam or a barge in the river below the dam, whichever is used, to A-frame after running the cable through a block on the mooring post. Pull caisson to mooring post with slight tension on lateral control lines.

7. Or in lieu of 6, lift the caisson with workbarge cranes.

8. Pin guide shoe to mooring post on spillway face.

9. Partially deflate tires to prevent overloading wheels when caisson is sunk.

10. By using Figure 2(C), fill upper tank to an amount shown by the minimum Curve (b) in Figure 2(A).

Example: If the riverwater elevation is 941 feet at the caisson location, the amount of water to be placed in the upper ballast tank, based on Curve (b) of Figure 2(A), is 56 percent. Water is pumped into the upper ballast tank and, simultaneously, readings of the head, H, in the tank and angle of tilt are taken. By using Figure 2(C), the amount of water in the upper tank is determined.

11. Continue to fill upper tank slowly until caisson seats against the spillway face, but do not fill upper tank beyond that amount shown by the maximum Curve (c) of Figure 2(A) in order to avoid excessive mooring post loads. For example, for a riverwater elevation of 941, the maximum amount the upper ballast tank is to be filled is 68 percent.

12. If the caisson fails to seat completely around the seal, fill the lower ballast tank a maximum of 2 percent more.

13. Pump out working chamber.

Instructions for refloating the caisson:

1. Flood working chamber to riverwater elevation at the caisson location.

2. Pump out upper tank to an amount slightly less than dashed Curve (a) in Figure 2(A) for the existing riverwater elevation. This operation should break the caisson seal.

3. Reinflate tires.

4. Release A-frame from mooring post and lower caisson until floated by cable from hoist on the roadway or barge--Slight tension on lateral control lines. Release cable from A-frame.

5. Or in lieu of 4, lower the caisson with workbarge cranes.

6. Raise A-frame from connecting guide using the peaking line.

7. Unwater lower tank until desired attitude of caisson is obtained.

8. Remove lateral control cables.

9. Caisson is now ready for moving to a new location or, if caisson is to be stored, pump out the remaining water from both ballast tanks.

RECOMMENDATIONS

1. Determine by field tests the relation of tilt angle to the amount of water in the upper and lower ballast tanks before the mooring operations are begun, and make any necessary corrections to Figures 2(C), 2(D), and 3.

2. Do not use the lateral control lines for tilting the caisson.

3. Do not pull the caisson up the spillway face too fast as the pulling force on the mooring post may increase as much as 100 percent and, after the caisson is moored, it may rock about the wheels and cause considerable fluctuation of force on the mooring post.

4. After Recommendation No. 1 is completed, duplicate Figure 2 for permanent attachment to the caisson.

INTRODUCTION

This report is a derivative of Hydraulic Report No. 238, "Hydraulic Model Studies of the Operation of the Face Caisson for Inspection and Maintenance of the Submerged Portion of the Spillway Face at Grand Coulee Dam--Columbia Basin Project." This report is intended to give concise instructions for operating the spillway face caisson for making repairs on Grand Coulee Dam. All material herein is based on model tests described in the reference report.

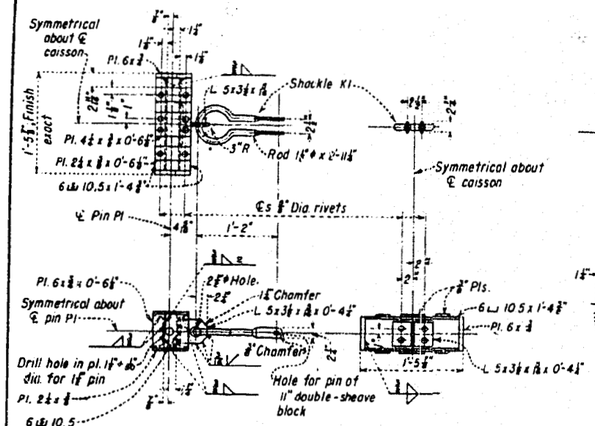
DISCUSSION

Proper operation of the Grand Coulee Spillway face caisson during the mooring, sinking, and refloating operations depends primarily upon placing the correct quantities of water in the upper and lower ballast tanks in the proper sequence. There must be enough water in the tanks to provide adequate wheel loads on the spillway to resist the force of sidewise currents on the caisson and to keep the caisson under control on the spillway face. However, the quantity of water must not be so great that the A-frame and mooring post are overloaded. In addition, the water must be properly distributed between the upper and lower tanks to obtain the desired tilt of the caisson. Particular care must be used in filling the lower tank when the tilt angle of the caisson exceeds 10°. At greater angles, the addition of only a small quantity of water will result in a large change in tilt. Overtilting the caisson may result in the lower seals dragging on the spillway face with serious damage to the seals. A trim tank is provided in the upper right-hand corner of the caisson to correct any tendency of the caisson to list sidewise when floating. Lateral control lines are also provided to keep the caisson's longitudinal axis perpendicular to the spillway face.

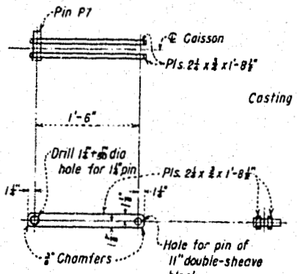
To measure the quantity of water in the ballast tanks, liquid level gages are provided on the operating platform of the caisson. In addition, an instrument for measuring the angle of tilt of the caisson within plus or minus one-half a degree is required. As shown by the sketches in Figures 2(C), 2(D), and 3, the liquid level gages measure the head, H, above the lower corner of the rectangular-shaped ballast tanks. To use the gages, air is simply pumped into the line slowly. The pressure gage will indicate the head when all water is removed from the line.

The head, H, will depend not only upon the quantity of water in the tank, but also upon the angle of tilt of the caisson. Three sets of curves are presented, one set for the upper ballast tank, Figure 2(C), and two sets for the lower ballast tank, Figures 2(D) and 3. The tilt angle, α, is the ordinate; H, the head above the lower corner of the tank is the abscissa, and the curves represent the different amounts of water in the tanks. Thus, by measuring the tilt angle and the head, the amount of water in the ballast tanks may be found. Figure 3 is where all compartments of the lower ballast tank are filled simultaneously with the same amount of water, and Figure 2(D) is where both side compartments of the lower ballast tank are filled 95 percent first, and then the center compartment filled. Note that the percentage curves for Figure 2(D) refer to the total percentage of water in the lower tank and not to the percent of water only in the center compartment. Figure 2 was arranged with the view in mind that it will ultimately be duplicated for attachment to the caisson.

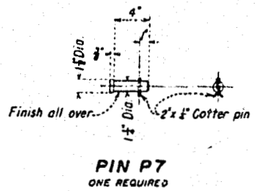
Undoubtedly, there will be a difference between the caisson weight and center of gravity and the computed caisson weight and center of gravity based on the model which will alter the relation of tilt angle to the amount of water in the ballast tanks. Hence, the Recommendation No. 1, Page 3.



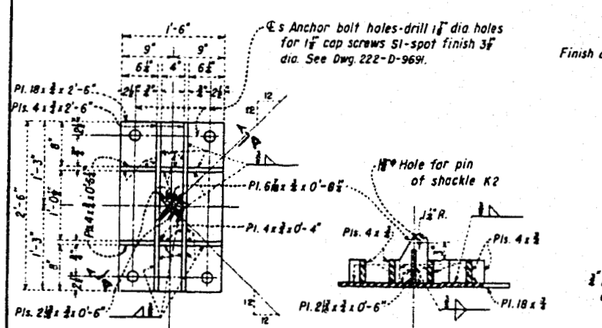
BLOCK HITCH FOR PULLING-IN LINE
ONE REQUIRED



BLOCK HITCH FOR PEAKING LINE
ONE REQUIRED

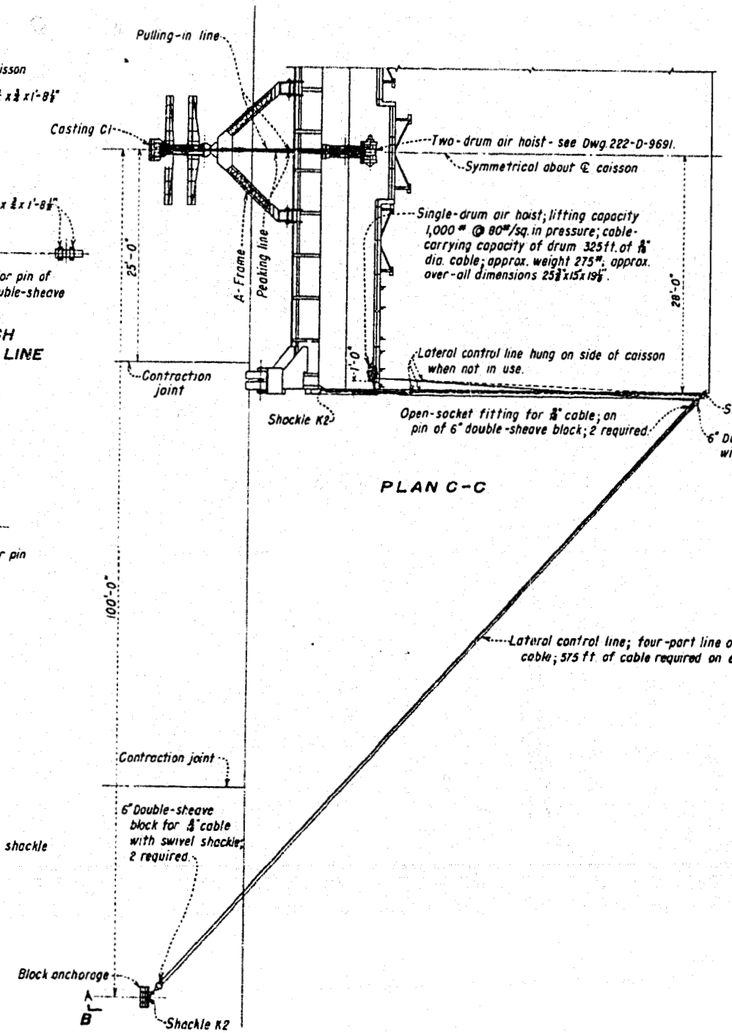


PIN P7
ONE REQUIRED

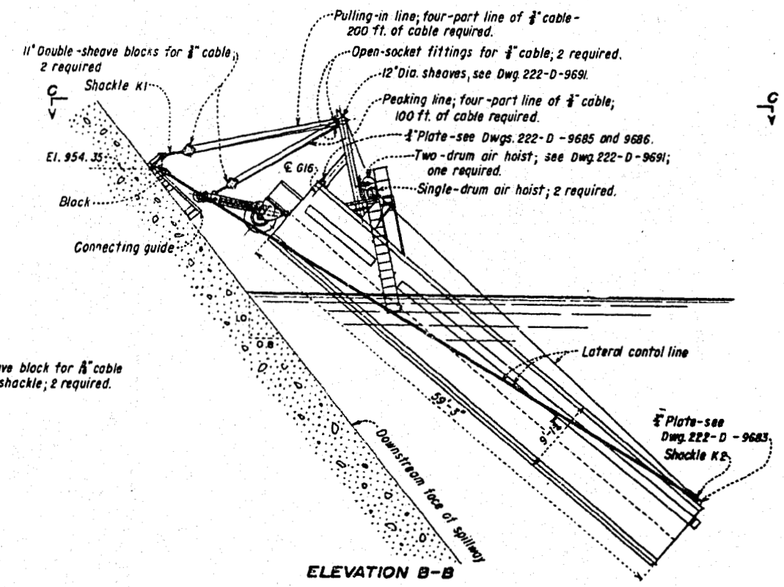


ANCHORAGE FOR LATERAL CONTROL LINE BLOCK
ONE REQUIRED AS SHOWN
ONE REQUIRED OPPOSITE HAND

SHACKLE K2
SIX REQUIRED



PLAN C-C



ELEVATION B-B

NOTES

All sheaves are to be furnished with self-lubricating bushings.

REFERENCE DRAWINGS

FACE CAISSON-GENERAL ASSEMBLY	222-D-9653
FLOATING CAISSON-A-FRAME-ANCHOR BOLTS	222-D-9634
FUSION WELDING SYMBOLS	X-D-2509

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT-WASHINGTON

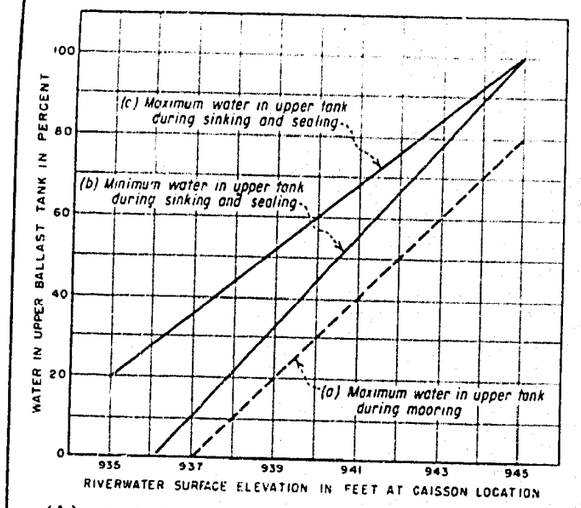
GRAND COULEE DAM
MAINTENANCE OF SPILLWAY

FACE CAISSON RIGGING ARRANGEMENT

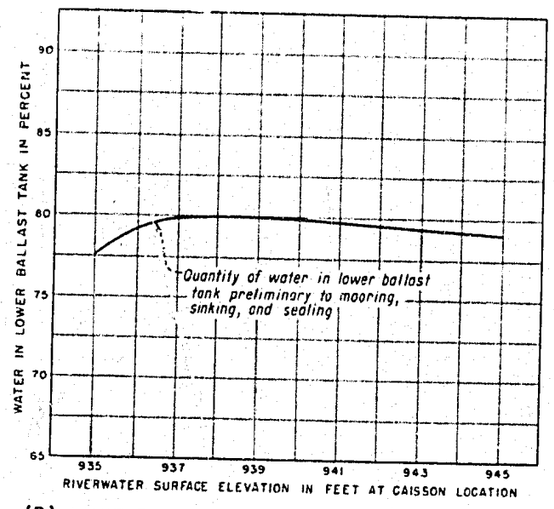
DRAWN H.R.O. SUBMITTED
TRACED O.L.P.-E.M.W. RECOMMENDED
CHECKED J.P.K.K. APPROVED
CHIEF ENGINEER

DENVER, COLORADO, JUNE 13 1946

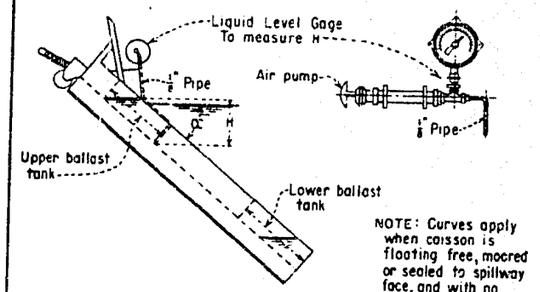
222-D-9712



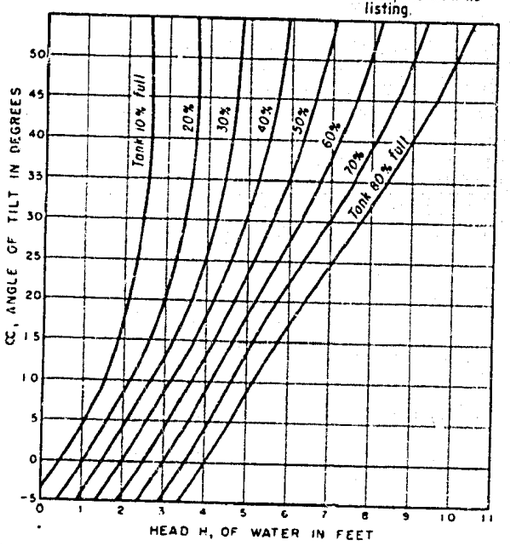
(A) LIMITATIONS OF WATER IN UPPER BALLAST TANK



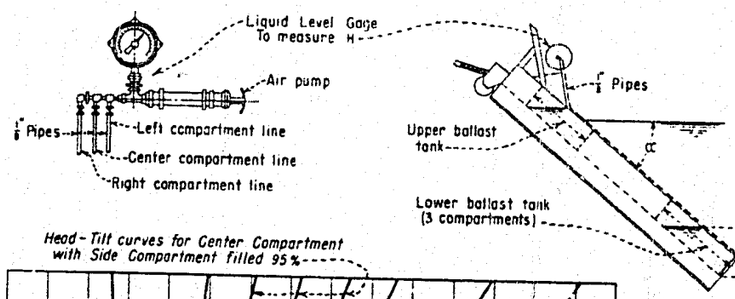
(B) LIMITATIONS OF WATER IN LOWER BALLAST TANK

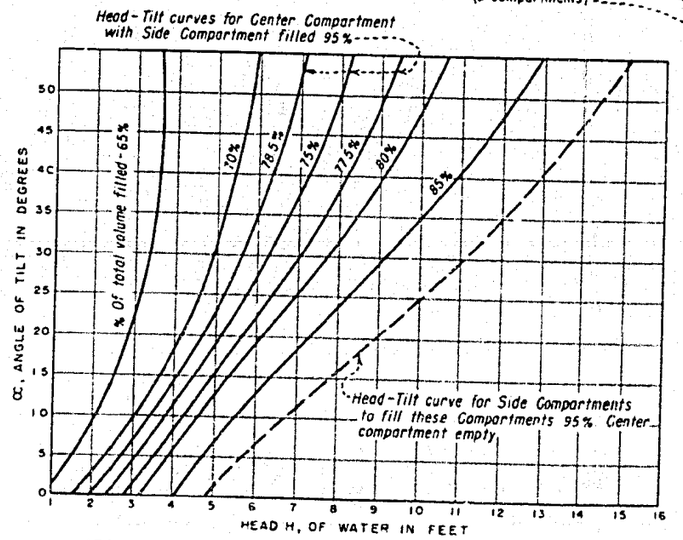


NOTE: Curves apply when caisson is floating free, moored or sealed to spillway face, and with no listing.



(C) DETERMINATION OF AMOUNT OF WATER IN UPPER BALLAST TANK





(D) DETERMINATION OF AMOUNT OF WATER IN LOWER BALLAST TANK WITH SIDE COMPARTMENTS 95% FULL, ADJUSTMENTS BY CENTER COMPARTMENT

NOTE: Curves apply when caisson is floating free, moored, or sealed to spillway face, and with no listing.

INSTRUCTIONS FOR MOORING AND SINKING THE CAISSON

1. Tow the floating caisson by tug or workbarge into approximate position at the face of the spillway.
2. Attach the peaking line and lateral control lines to anchors on the spillway face.
3. By using Figure (C), fill the upper tank to an amount not more than that shown by the dashed Curve (a) in Figure (A) for the existing riverwater elevation at the caisson location.

*NOTE: The upper tank must be filled to an amount near that given by the dashed curve to maintain sufficient wheel load needed for lateral stability of the upper end of the caisson.

EXAMPLE: If the riverwater elevation at the caisson location is 941 feet, the maximum water to be placed in the upper tank during mooring, based on dashed Curve (a) of Figure (A), is 40 percent. Water is pumped into the upper ballast tank and, simultaneously, readings of the head, H, in the tank and angle of tilt are taken. By using Figure (C), the amount of water in the upper tank is determined and no more than 40 percent is pumped into this tank for a riverwater elevation of 941 feet at the caisson location.

4. By using the curves from Figure (D), fill lower tank to an amount shown by curve in Figure (B) for the existing riverwater elevation.

CAUTION: After the angle of tilt has reached 10° further filling should be done very slowly as small additional amounts of water rapidly increase the angle of tilt.

EXAMPLE: If the riverwater elevation is 941 feet at the caisson location, the amount of water to be placed in the lower ballast tank, based on Figure (B), is 79 percent. Water is pumped into the lower ballast tank and, simultaneously, readings of the head, H, in the tank and angle of tilt are taken. By using Figure (D), the amount of water in the lower tank is determined; and no more than 79 percent is pumped into this tank for a riverwater elevation of 941 feet.

5. Lower A-frame until guide shoe rests on connecting guide; slack off peaking lines.
6. Attach cable from a hoist on the roadway across the dam or a barge in the river below the dam, whichever is used, to A-frame after running the cable through a block on the mooring post. Pull caisson to mooring post with slight tension on lateral control lines.
7. Or in lieu of 6, lift the caisson with workbarge cranes.
8. Pin guide shoe to mooring post on spillway face.
9. Partially deflate tires to prevent overloading wheels when caisson is sunk.
10. By using Figure (C), fill upper tank to an amount shown by the minimum Curve (b) in Figure (A).

EXAMPLE: If the riverwater elevation is 941 feet at the caisson location, the amount of water to be placed in the upper ballast tank, based on Curve (b) of Figure (A), is 56 percent. Water is pumped into the upper ballast tank and, simultaneously, readings of the head, H, in the tank and angle of tilt are taken. By using Figure (C), the amount of water in the upper tank is determined.

11. Continue to fill upper tank slowly until caisson seats against the spillway face, but do not fill upper tank beyond that amount shown by the maximum Curve (c) of Figure (A) in order to avoid excessive mooring post loads. For example, for a riverwater elevation of 941, the maximum amount the upper ballast tank is to be filled is 68 percent.
12. If the caisson fails to seat completely around the seal, fill the lower ballast tank a maximum of 2 percent more.
13. Pump out working chamber.

INSTRUCTIONS FOR REFLOATING THE CAISSON

1. Flood working chamber to riverwater elevation at the caisson location.
2. Pump out upper tank to an amount slightly less than dashed Curve (a) in Figure (A) for the existing riverwater elevation. This operation should break the caisson seal.
3. Reinflate tires.
4. Release A-frame from mooring post and lower caisson until floated by cable from hoist on the roadway or barge. Slight tension on lateral control lines. Release cable from A-frame.
5. Or in lieu of 4, lower the caisson with workbarge cranes.
6. Raise A-frame from connecting guide using the peaking line.
7. Unwater lower tank until desired attitude of caisson is obtained.
8. Remove lateral control cables.
9. Caisson is now ready for moving to a new location or, if caisson is to be stored, pump out the remaining water from both ballast tanks.

NOTE

For additional information on face caisson operation, see Hydraulic Laboratory Report No. 264.

* Small negative tilt angles may be encountered during this operation at the higher riverwater surface elevations.

THIS DRAWING SUPERSEDES DWG. 222-D-9722

UNITED STATES
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COLUMBIA BASIN PROJECT—WASHINGTON

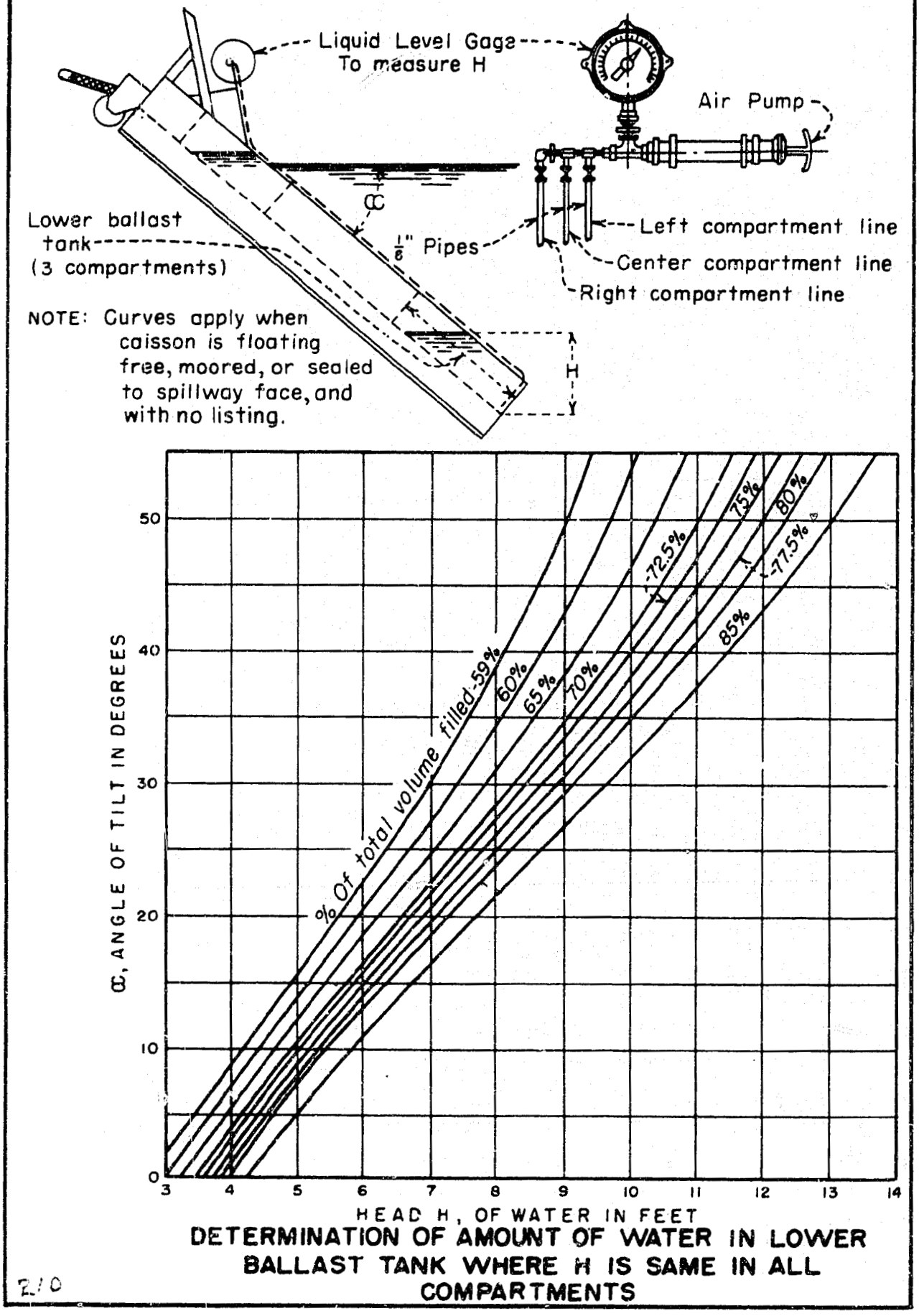
GRAND COULEE DAM
MAINTENANCE OF SPILLWAY

FACE CAISSON OPERATING INSTRUCTIONS

DRAWN	F.C.L.	SUBMITTED	J.E. Warnick
TRACED	E.P.S.	RECOMMENDED	W.E. Stanley
CHECKED	L.W.D.C.	APPROVED	S.O. Ripley, Assistant Chief Designing Engineer

DENVER, COLORADO, SEPT. 30, 1948 — 222-D-1445B

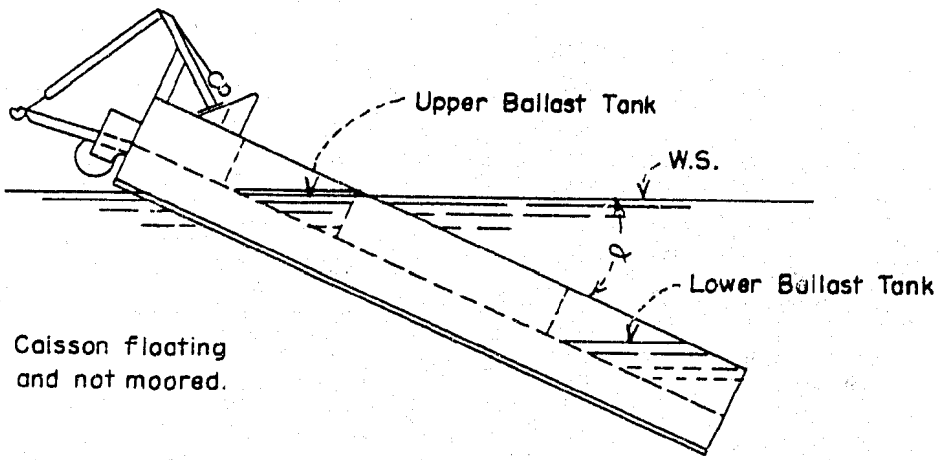
FIGURE 3

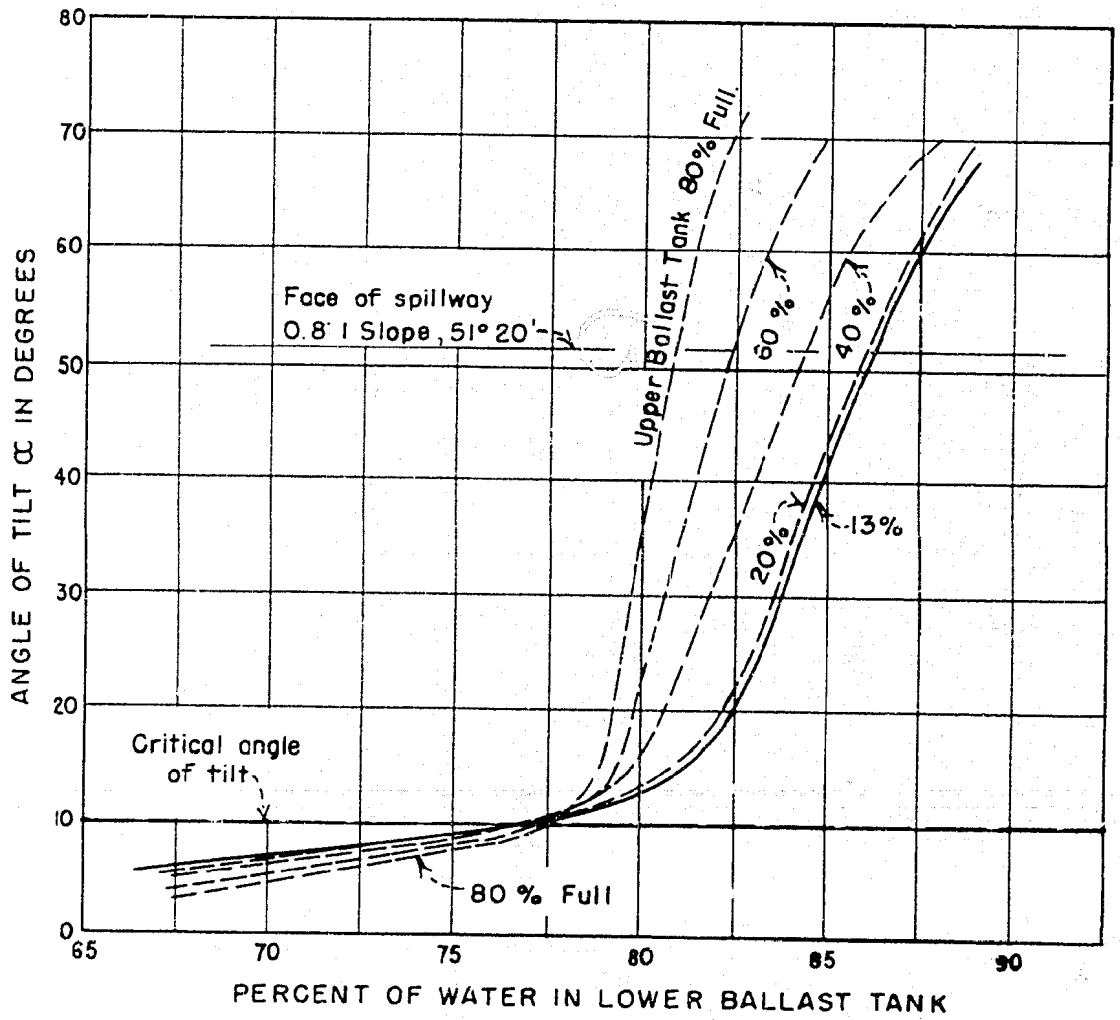


DETERMINATION OF AMOUNT OF WATER IN LOWER BALLAST TANK WHERE H IS SAME IN ALL COMPARTMENTS

Z-10

FIGURE 4





COLUMBIA BASIN PROJECT—WASHINGTON

GRAND COULEE DAM

HYDRAULIC STUDIES ON 1:20 MODEL
OF SPILLWAY FACE CAISSON
RELATION OF TILT TO WATER IN UPPER
AND LOWER BALLAST TANKS

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