

THE DESIGN OF AN AUTOMATIC
SPILLWAY GATE

THESIS FOR THE DEGREE OF B. S.

L. B. Yarger

1931

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Little Spillway gate

**SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK**

Civil engineering Hydraulic engineering

The Design of an Automatic
Spillway Gate

A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
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By

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Candidate for the Degree of
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THESIS

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PREFACE

Automatic spillway gates are few in number in this country and there are very little available data concerning them. There are, however, many gates of this type in use in Europe that have been working successfully for many years. Many of the notes on the types of gates discussed in this thesis were obtained from the few references given in the Engineering Index in the College Library.

The writer of this thesis wishes to thank Professor Cade and the other members of the Civil Engineering Department for the aid and suggestions received from them. The promptness of the Michigan State Highway Department in supplying the desired blueprints is also appreciated by the writer.

L.P.Y.

INTRODUCTION

Where the paved highway crosses the outlet of Lobbell Lake Argentine Township, Genesee County, Michigan there is a reinforced concrete bridge and dam combined. The fill under the bridge is a puddled clay and boulder one with sufficient backfill to hold it in place. There are two sluice gates at the downstream side of the bridge to regulate the outlet discharge. These sluice gates are hand operated by means of a large wrench which is in possession of the owner of the old mill nearby. This wrench is not always available when desired as the mill owner lives four miles away and the wrench is locked in the mill.

The old mill is not used as there is no connection to the flume that was constructed as part of the bridge contract. Mills of this type are fast becoming obsolete and this one will probably never be used again. The flume mentioned above is an ideal one in which to locate an automatic gate to safeguard the bridge and dam. The elevation of the center of the pavement is 361.85 feet and the elevation of the normal water surface of the lake is 357.58 feet. Thus a rise of 4.27 feet in the lake level would bring the water surface to the road level. Before this point would be reached the bridge and dam would probably be damaged with a possibility of destroying both.

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If such a washout occurred the waters of Lodgepole Lake would empty into the valley below causing much damage to property owners as well as ruining the bridge.

The necessary field work consisted of checking the size of the flume as given on the blueprint furnished by the Highway Department. The field measurements corresponded to the ones given on the blueprint. Snapshots were taken of the flume and the enlargements show it very plainly.

The gate used here will be designed so as to open when the water approaches a depth of nine feet above the bottom of the flume. As the water rises the gate must continue to open. When the water falls to a depth of about seven feet above the bottom of the flume the gate must close and thus *maintain* the normal lake level which is six and sixty-one hundredths feet above the bottom of the flume.



Flume looking upstream

Fluore looking upzthson



Flume looking downstream

PART 1

A Discussion of the Various Types of Automatic Gates

STAUWERE TILTING GATE

This type of gate gives such a regulation of water surface that a rise of several inches will cause the gate to tip. This gate is balanced by the concrete counterweight as shown on the drawing. As the water level rises the increasing pressure of water on the gate causes it to overcome the reaction of the counterweight and the gate lowers letting the increased flow over the gate. As the pressure decreases due to a falling water level the counterweight tends to return the gate to its normal position. In its normal position the gate is inclined to the vertical so debris will not lodge on it. This type of gate requires much head room and is unsuitable where space is limited. The concrete design is also complicated on this sort of gate.

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AUSTIN TEXAS DAM TILTING GATE

These crest gates, fifteen feet high, are made with a structural steel framework. The lower portion is filled with concrete while the upper part is covered with crossoted yellow pine. The thickness of this gate is about one foot. These gates turn about rockers on bascules which are fastened into the piers at either end of the gate. When the gates are vertical and the water is at normal height the center of pressure coincides in elevation with the point of support on the bascule curve. When the water rises above the normal level, the center of pressure rises and there exists a net moment to cause the gate to overturn. As overturning begins, the moment to cause it increases due to diminution of pressure on the lower part. This increase in overturning moment is compensated for by the fact that the gate turning around the bascule is continually changing its point of support, this point moving from a position at one-third the height of the gate to one very near the middle of the gate when it is finally in a horizontal position. In order to prevent the gates from leaving the bascules and being pushed downstream, guide pins are placed at the ends of the gate and these pins operate in curved channels of cast iron set in the concrete faces of the piers.

When the level of the water lowers sufficiently, the gates automatically close.

This is affected by the counterweight provided by the concrete filling in the bottom of the gates, so the center of gravity of the gate is near the bottom and there is always a tendency for gravity to restore them to their normal vertical position. These gates provide water level regulation from fourteen inches below normal to thirty-four inches above normal.

LEAF TYPE DAM GATE

This type of crest gate consists of two connected leaves, placed at an angle to each other preferably but not necessarily ninety degrees, joined horizontally at the axis by a hinge by which the gate is attached to the fixed base of the dam. The leaves are held rigidly in their proper position to each other by the necessary ties and braces.

The base of the dam contains a recess into which the crest falls, the front of which is curved to conform to the outer edge of the lower leaf, as the crest rotates about its axis with just sufficient clearance for easy operation. The upward rotation of the crest is limited by the overhanging part of the recess into which the crest falls. The water in the upstream side of the dam has free access to the two leaves of the crest, to the upper face by the regular overflow and to the lower face by orifices provided for the purpose. In order that the crest may rise there must be a difference in the level of the water on the two sides of the dam, that is, there must be a distinct fall and the tail water must not be above the axis of the hinges.

The water pressure against the upper leaf tends to rotate the crest downward and this force is supplemented by the weight of the crest and a counterweight placed on the lower leaf. Opposed to these forces is the water pressure on the lower leaf tending to rotate the crest upward.

At low water level the water reaches the top of the gate as shown in the drawing. The gate will not fall below this level unless the draft exceeds the natural flow of the stream. When the flow increases in volume, the surplus water spills over the top of the crest and runs to waste without lowering the dam. With a continuing increase in flow the water surface gradually raises until the high water level is reached at which stage the crest falls, opening a way for the flood to escape. As the flow diminishes, the water surface gradually drops until the low water level is reached whereupon the crest raises to its highest position. The main difficulty in constructing this type of gate is the complicated concrete recess construction.

TALLAHATCHE FILLING GATE

The purpose of this gate is to keep the pond level at a constant elevation and to drop slowly when the pond level rises three inches above elevation fifteen hundred and continue their downward movement when the river flow increases until they rest flat on the dam crest. They are adjusted to return to their normal position at an angle of sixty degrees with the horizontal as the flow subsides, always maintaining the water level at about the same elevation. Each gate is composed of a movable panel twenty-eight feet long and seven feet high made up of a structural steel frame with timber decking. At the lower end it is hinged to the dam crest with six cast steel hinges and bronze pins. The water seal at the hinge is accomplished by a one-eighth inch steel plate with leather facing pressed on a curved steel longitudinal piece riveted at the lower end of the flashboard panel. At each end a three-fourth inch clearance is provided between the bridge pier and the panel. Bronze sheet strips fastened to the ends of the flashboard panel for the purpose of making a watertight joint, press firmly against the bridge piers.

The counterweight is twenty-eight feet long, three feet three inches in diameter and weighs thirty-four thousand pounds. At each end it rests on a track.

The curvature of the track is figured so as to compensate for the different loadings corresponding to the different positions taken by the flashboard. The counterweight is provided at each end with cast iron geared drums engaging a rack, thus preventing slipping when subjected to the pull of the cables of the flashboard. A twelve inch diameter wrought iron pipe enclosed in concrete, reinforced with steel rods, connects the two end drums. A one and one-fourth inch steel plow-steel cable connects each end of the flashboard to the counterweight drums winding around these in grooves. The principle of the flashboard, its counterweight and track is therefore a balancing of moments. The hydrostatic pressure on the flashboard gives through the rope and drums a moment tending to roll the counterweight up the track, while the dead load of the counterweight tends to roll it downward. The track is so constructed that the lever arms for the forces change when the weight moves, thus giving moments that balance each other. As the dead load of the counterweight is constant and the pull on the rope due to the hydrostatic pressure increases when the water level rises, the track is not a straight line, but a curve, with its convex side pointing upward. With the flashboard in its lowest position, the counterweight is at its highest, offering no obstruction to floating debris.



Young G.

DRUM GATE

The drum gate is an automatic type, designed to maintain a fixed relation between the position of the gate and the quantity of water flowing over it. When due to an increase in flow, the water begins to overtop the gate, it must immediately start down and must stop when it has reached a depth sufficient to permit passage of the increased flow. This is accomplished by placing the outlet valve under the control of both the drum gate and the water above the dam. The drawing gives a diagrammatic elevation of the control mechanism. The drum gate is indicated by dotted lines in the raised position, and all the other parts are shown in the positions they will occupy when the water is at the point of overtopping the crest.

Water for overcooling leakage from the drum chamber and for holding the drum gate in its raised position enters through the partially opened hand operated inlet gate A. This gate is permanently set at the smallest opening which can be safely depended on to maintain the required pressure in the drum chamber, against leakage, with the outlet valve closed. The drum gate is lowered by opening the balanced valve E and allowing the water to escape from the drum chamber through the passages B and C. It is not necessary that the inlet gate be closed.

The outlet valve is operated by the pressure of the water passing through it. The pressure in the chamber E, around the needle, is transmitted to the space U above the piston J through a restricted opening in the bypass pipe G. If there is no outlet from the chamber U, the pressure intensity on the top of the piston will equal that on the bottom. The area exposed to pressure on the top being greater than on the bottom, the needle will be pressed against its seat. If the water is permitted to escape from the chamber U through an opening relatively larger than the opening in the bypass pipe, the pressure on top of the piston will drop and the needle will be lifted from its seat by the excess pressure on the exposed part of the bottom of the piston. The outflow from the chamber U is controlled through the port D and the pilot valve F.

To give a better idea of the actions of the arm gate a cycle of operation will be given. Starting with the water level as shown, let the water surface be assumed to rise slowly. The well around the float H communicates with the water level through a passage leading to a point beyond the influence of the draw-down curve of the dam. The water level in the float well is always the same as in the river above the dam. If the float is adjusted properly, it will be on the point of rising and will start up with the rising water level.

The motion of the float is communicated through the bracket R and the sheave rod V to the floating sheave K, where it is doubled and transmitted to the pilot valve F through the bronze tiller rope. When the pilot valve is lifted from its seat a short distance, the outflow from the chamber V exceeds the inflow, the pressure drops and the piston and needle rise. The sleeve rod S is thus lifted until it approaches the pilot valve. Outflow from the chamber U is thus checked, pressure builds up above the piston and the needle stops. As the float continues to rise the pilot valve is gradually lifted higher, followed at all times by the needle of the balanced valve.

The first small movement of the balanced valve needle will have no effect on the position of the drum gate but will only increase the inflow through the gate A. When the balanced valve opening becomes such that with a pressure in the drum chamber just sufficient to support the drum gate, the outflow is exactly equal to the inflow, it is in a position which may be called the balancing position. If the water surface continues to rise after this condition is reached, the balanced valve opening is temporarily increased. As a result the outflow exceeds the inflow, the pressure in the drum chamber drops and the drum gate starts down. The bronze tiller rope, after passing over the floating sheave K, passes under the fixed sheave I and is anchored to the sheave sector M.

The sheave sector is keyed to an extension of the hinge of the drum gate and moves with the drum gate. As soon as the drum gates start down tiller rope paid out at M passes under the sheave L and over the sheave K allowing the pilot valve to drop. The opening process is thus reversed and the balanced valve forced down, as the drum gate continues to fall, until the balancing position is again reached. If the water surface continues to rise, the process will be repeated until the drum gate is entirely down.

The cycle of operation of a falling water level is exactly opposite that for a slowly rising level, the drum gate gradually coming up as the flow decreases. A sudden change in flow causes the balanced valve to open rapidly, but it comes promptly back to balancing position when the drum gate reaches the correct height for the changed flow. It is not necessary for the drum gate or the valve to hunt for the proper position.

The drum gate is rather complicated in its design due to the valve and float arrangement necessary. The radius of the drum gate must not vary more than one-fourth of an inch and manufacturers claim that the construction of these gates is very difficult.

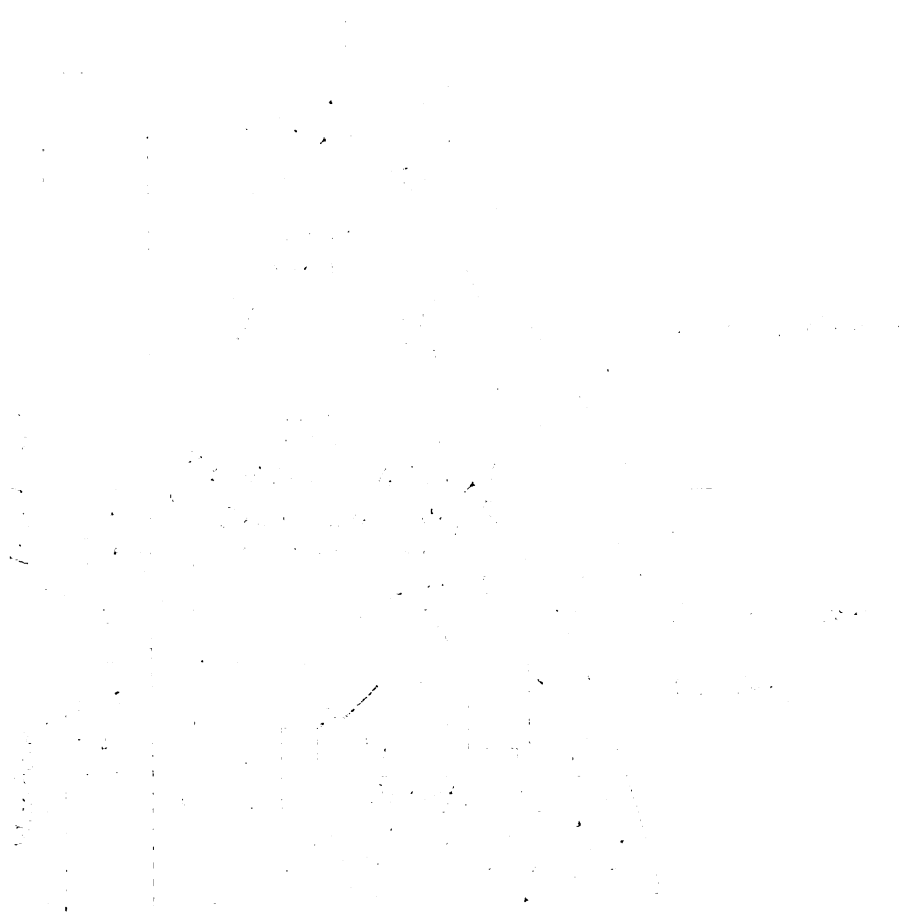


Diagram of the pump and chamber

PART 3

The Design of an Automatic Gate

Introduction

Probably the best type of gate for the square flume is a panel that will tilt in the channel when the water level must be lowered. Counterweights can be used to close the gate if they can be designed so as not to require too much head room. In the design of a gate of this type a study of water pressures and their effect on a movable gate is necessary. For the study of these pressures a panel seven feet high pivoted at the lower third point will be used. It will also be necessary to know the overturning moments on this panel as it changes position for the changes in the water pressure in order to determine the size of the counterweights. After the values of the pressures and their moments are known, the sizes of the various other parts of the gate can be determined. In the following calculations where assumptions are made the assumptions given are the final ones, the preliminary trials of incorrect value being omitted.

Center of Pressure

In Figure 1 ABCD is a submerged plane area with water pressure acting on one side only. The area may be divided into strips dy wide and area dA at a depth y below the surface. The pressure on each strip then equals $dAyw$ in which w is the unit weight of water.

Let P equal the total pressure on the area.

Let h_{-pc} equal the distance along the plane produced from the pressure center to $S - S$.

Then taking moments about $S - S$, the line formed by the intersection of the water surface and the plane of the area, the moment of the total pressure of the area equals the sum of the individual pressures on horizontal elements of the area.

$$Ph_{-pc} \text{ equals } \int_{y_1}^{y_2} y (dAyw)$$

$$Ph_{-pc} \text{ equals } w \int_{y_1}^{y_2} (dA)y$$

$$\text{but } w \int_{y_1}^{y_2} (dA)y \text{ equals } I_S \text{ of area } A \text{ about } S - S$$

$$\text{Then } Ph_{-pc} \text{ equals } wI_S$$

P equals the total pressure equals $A \times p_{-cg}$ equals $Ah_{-cg}w$ in which h_{-cg} is the distance to the center of gravity of the area.

$$h_{-pc} \text{ equals } wI_S \text{ divided by } A \times h_{-cg} \text{ equals}$$

$$\frac{I_S}{Ah_{-cg}}.$$

Overturning Moments on the Gate

The terms of Figure 3 are as given below.

4 feet 8 inches equals 4.667 feet.

x_2 equals $4.667 \cos \alpha$

OA' equals $\frac{OA}{2}$

x_3 equals x_2 divided by 2

x_1 equals $4.667 - x_2$

P equals total pounds pressure on the gate above the pivot point.

P_1 equals total pounds pressure below the pivot point .

h_{-pc} equals distance in feet to the pressure center on the part of gate above the pivot point.

h_{+pc} equals distance in feet to the pressure center on the part of gate below the pivot point.

l equals $4.667 - h_{-pc}$

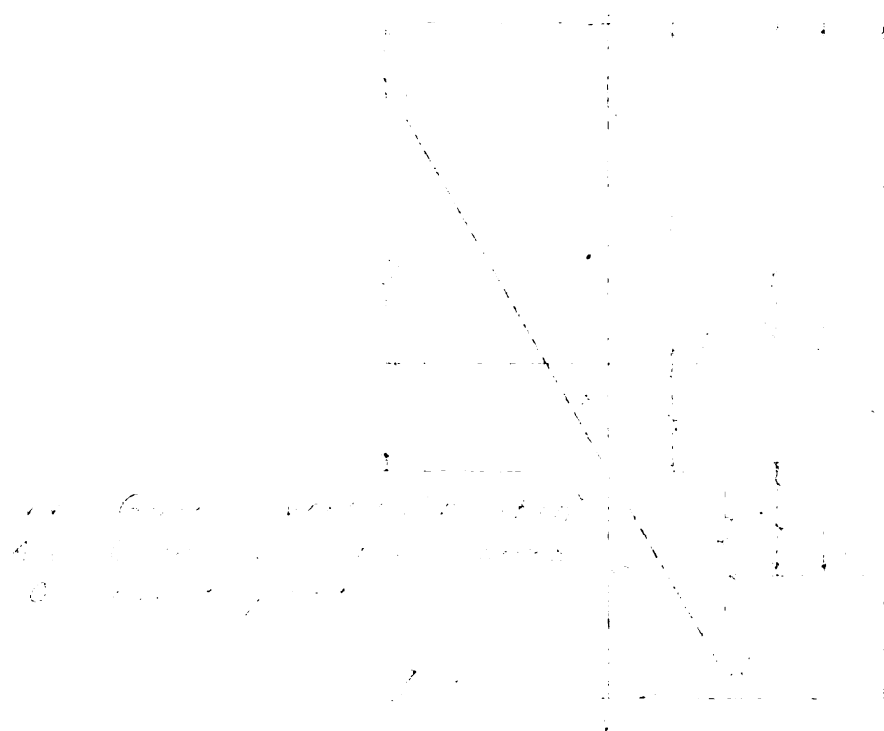
l_1 equals $h_{+pc} - 4.667$

$-M$ equals $l \times P$

$+M$ equals $l_1 \times P_1$

M equals ΣM_s equals overturning moments in foot pounds.

The terms above also apply to the data given in Table 1.



1. Distance is directly proportional to Time
2. Distance is directly proportional to Time
3. Distance is directly proportional to Time

Distance is directly proportional to Time
 Distance is directly proportional to Time
 Distance is directly proportional to Time

Overturning Moments on the Gate

Table 1

α°	$\cos \alpha$	x_2	x_1	x_3	P	P_1	h-pc
0	1.00	4.37	0	2.33	630	300	3.11
5	.996	4.33	.02	2.31	630	308	3.11
10	.992	4.29	.03	2.29	630	316	3.11
15	.988	4.21	.10	2.22	670	316	3.12
20	.984	4.13	.20	2.14	673	729	3.12
25	.980	4.05	.40	2.11	674	732	3.12
30	.976	4.04	.60	2.07	683	713	3.13
35	.971	3.92	.80	1.91	683	672	3.20
40	.965	3.83	1.09	1.79	643	664	3.25
45	.957	3.70	1.37	1.63	631	613	3.32
50	.948	3.56	1.67	1.49	595	519	3.41
55	.937	3.37	2.00	1.34	555	444	3.51
60	.926	3.22	2.30	1.16	519	390	3.63
65	.913	1.97	2.70	.99	452	330	3.73
70	.898	1.60	3.07	.80	395	252	3.92

h-pc	1	l_1	-M	+M	ΣM
5.31	1.36	1.24	1054	1054	0
5.30	1.36	1.23	1054	1040	-14
5.33	1.36	1.21	1054	1015	-39
5.36	1.36	1.19	1054	932	-69
5.38	1.36	1.16	1051	917	-134
5.73	1.34	1.11	1033	839	-193
5.73	1.31	1.06	1010	762	-248
5.67	1.47	1.00	963	672	-296
5.60	1.42	.93	913	530	-383
5.54	1.35	.87	839	495	-344
5.45	1.26	.76	747	393	-349
5.36	1.16	.69	644	303	-338
5.26	1.04	.59	530	222	-303
5.16	.89	.49	401	137	-266
5.07	.76	.40	290	101	-189

The overturning moments tend to rotate the gate in a counterclockwise direction and are given above as negative moments. The above moments are foot pounds per foot length of gate.

Trial Computation for Overturning Moment

P equals $\frac{1}{2}wbh$ in which b is one, w is 62.4 pounds and h is the height of the plane.

P above pivot equals $\frac{1}{2} \times 62.4 \times 4.67^2$ equals 680 pounds.

P on seven foot gate equals $\frac{1}{2} \times 62.4 \times 7^2$ equals 1530 pounds equals P_2

P_1 equals $P_2 - P$ equals 1530 - 680 equals 850 pounds below the pivot.

h_{-pc} equals $2/3 \times 4.67$ equals 3.11 feet

h_{-pc} equals $\frac{I_2}{Ah-cg}$ equals $\frac{I + A(h-cg)^2}{Ah-cg}$

h_{-pc} equals $\frac{1/12 \times 1 \times (2.35)^3 \text{ plus } 2.35 \times 1 \times (3.35)^2}{2.35 \times 1 \times (2.35)}$

h_{-pc} equals $\frac{30.25}{12.6}$ equals 5.91 feet

l equals $4.67 - 3.11$ equals 1.56 feet

l_1 equals $5.91 - 4.67$ equals 1.24 feet

-M equals 1.56×680 equals - 1054 ft. lbs.

+M equals 1.24×850 equals 1034 ft. lbs.

ΣMs equals 0

The other computations are calculated in the same way with the proper values for the terms of the equation at the various positions of the gate.

Design of Shaft

The shaft will act like a uniformly loaded beam and will be designed accordingly.

White oak weighs 46 pounds per cubic foot.

$46 \times 7 \times 3/12 \times 10$ equals 810 pounds or 81 pounds per foot of gate.

Assume a 7 inch diameter shaft. Steel weighs 490 pounds per cubic foot. Weight equals $12 \times 7/12 \times 7/12 \times .7854 \times 490$ equals 1570 pounds or 131 pounds per foot of shaft.

The shaft will be designed to withstand the pressure with the gate submerged two feet. Pressure per foot equals $\frac{1}{2} \times 62.4 \times 9^2 - \frac{1}{2} \times 62.4 \times 3^2$ equals 2400 pounds.

Adding for braces, bolts and fastenings 50 pounds per foot, the total load per foot of shaft is 3352 pounds.

M equals $\frac{SI}{C}$ in which $\frac{I}{C}$ equals .098175 d^3 for a round shaft.

The maximum moment equals $1/8 Wl^2$ or $1/8 \times 3352 \times 10^2$ equals 33400 foot pounds.

S will be taken as 10000 pounds per square inch.

$\frac{33400 \times 12}{10000}$ equals .098175 d^3

d^3 equals 338 or d equals 6.95 inches as the diameter of the shaft. Hence a seven inch shaft will be used.

Design of Counterweight

A 330 pound counterweight will be used as a trial size for the first computations.

With the water nine foot deep in the flume the over-turning moment on the gate is -325 foot pounds per foot of gate. This is calculated in the same manner as the moments given in Table 1 for which a trial computation is given so the computations for the above result will not be given.

The total moment on the gate is then -325×10 or -3250 foot pounds and one-half of this for each half of the gate where the counterweight acts is -1625 foot pounds. The counterweight has a lever arm of 3.67 feet and its moment is 3.67×330 or 1206 foot pounds.

The water pressure at the nine foot level is 2400 pounds per foot of gate as found by the computations for the design of the shaft. The reaction at each bearing due to water pressure is 2400×5 or 12000 pounds. The coefficient of friction will be taken as .3 and the frictional force equals $12000 \times .3$ or 3600 pounds. The force acts at the outside of the shaft so the frictional moment is $\frac{3600 \times 3.6}{12}$ or 1050 foot pounds. This moment acts with the moment of the counterweight when the water pressure tends to rotate the gate open.

The net moment on the gate is $-1625 + 1206 + 1050$ or -215 foot pounds at each side where the counterweight fastens.

The total overturning moment on the gate is -210×2 or 420 foot pounds so the gate will open a short time before the water reaches a depth of nine feet in the flume.

The water pressure at the seven foot level is 1530 pounds per foot of gate as shown in the trial computations. The reaction at each bearing due to water pressure is 1530×5 or 7650 pounds. The frictional force equals $7650 \times .3$ or 2295 pounds. The frictional moment is $\frac{2295 \times 3.6}{12}$ or 670 foot pounds.

As the gate tilts the angle at which the cable pulls on the gate decreases thus decreasing the lever arm of the counterweight slightly. At the 45 degree angle position the overturning moment is largest and the length of the lever arm is 3.0 feet. The moment due to the counterweight is 3×330 or 990 foot pounds.

The moment at the 45 degree position is -349 foot pounds per foot or -349×5 or -1745 foot pounds due to water pressure. This is the maximum moment.

The net moment on the gate is $-1745 - 670 + 990$ or -425 foot pounds at each side where the counterweight acts. In this case the frictional moment acts with the water pressure when the gate tends to close. The total closing moment is 225×2 or 450 foot pounds so the gate will close a short time before the water drops to the seven foot level.

Cast iron weighs 480 pounds per cubic foot or 1728 cubic inches.

$$\frac{480}{330} \text{ equals } \frac{1728}{x}$$

and x equals 1263 cubic inches is the volume of the counterweight.

The diameter of the counterweight will be 9.5 inches.

The area equals $9.5 \times 9.5 \times .7854$ equals 70.9 square inches.

The length equals $\frac{1263}{70.9}$ equals 17.9 inches

The vertical timber on the gate where the counterweight fastens will be 6 inches by 6 inches.

The maximum moment on this is (330×3.67) foot pounds.

Using the formula $M \text{ equals } \frac{SI}{C}$ the stress in the timber is found to be 954 pounds per square inch.

Cast iron weighs 480 pounds per cubic foot or 1728 cubic inches.

$$\frac{480}{330} \text{ equals } \frac{1728}{x}$$

and x equals 1203 cubic inches as the volume of the counterweight.

The diameter of the counterweight will be 9.5 inches.

The area equals $9.5 \times 9.5 \times .7854$ equals 70.9 square inches.

The length equals $\frac{1203}{70.9}$ equals 17.0 inches

The vertical timber on the gate where the counterweight fastens will be 6 inches by 6 inches.

The maximum moment on this is (330×8.67) foot pounds.

Using the formula $M \text{ equals } \frac{SI}{C}$ the stress in the timber is found to be 954 pounds per square inch.

Description of Gate

The gate is made of oak plank three inches by six inches by seven feet. The end timbers are six inches by six inches by eleven feet; the greater length being for the counterweight function. The middle cross timbers are three inches by twelve inches and the end cross timbers are three inches by six inches. The entire wood part of the gate is creosoted. The middle cross timbers are held in place by U-bolts that go around the shaft and through the gate. The other cross members are held in place with one half inch bolts as shown on the drawings. The seven inch shaft of the gate is cut down to a five inch diameter for a distance of one foot at each end. A bronze bearing one inch thick is shrunk on this cut down part of the shaft. This bearing fits inside ^{the} bronze bushing in the fixed part of the bearing in the steel casing. This casing is held together with four one inch stud bolts as shown in the bearing details.

Sealing the gate

Watertightness at the bottom of the gate is secured by means of a rubber seal which consists of a rubber hose and timber sill. One inch ordinary garden hose is inserted in a recess in the timber to a depth of about one-half the diameter of the hose. One quarter inch bolts having an eye at one end are put through the timber at the bottom of the gate. At the upper end the eye is allowed to project into the recess in the timber. The bolts are spaced six inches center to center. Then slots are cut in the lower part of the hose and the hose is placed in the recess in the timber so the eyes of the bolts project through the slots in the hose. A one quarter inch rod is then run through the hose and through the eyes of the bolts. The nuts on the bolts are then tightened thus securing the hose in position. The timber is then set in place in the concrete under the gate. The detail drawing of the bottom seal gives a better understanding of this seal.

The seal at the sides of the gate consists of a one inch rubber hose fastened to a two and one-half inch angle. The hose is fastened to the angle with eye bolts and a rod in the same manner as the above fastening. In this case no recess is needed as the gate presses against the hose. The angle is fastened to the wall of the flume with one-half inch bolts fourteen inches long.

The angle above the pivot is three feet seven inches long leaving a thirteen inch clearance above the pivot point of the gate so there will be no interference when the gate tilts. The part below the gate is the same as the above and is one foot ten inches long leaving a six inch clearance below the pivot point. This nineteen inch clearance is necessary because of the cross timber on the gate. The space not sealed with angles and hose is sealed with five ply rubber belting fastened to the gate. Complete details of the sealing are shown in the detail drawings and the positions of the various angles shown clearly on these drawings.

Counterweights and Cables

The counterweights are fastened to the end timbers of the gate by means of a one quarter inch cable fastened to an eye bolt on the timber. The cable runs over a 12 inch two pulleys to the counterweight where it fastens to an eye bolt in the counterweight. The pulleys are six inches in diameter and two inches thick with a one-half inch groove in them for the cable. They are equipped with roller bearings as shown in the detail drawings of the pulleys. The pulley shafts are of steel two inches in diameter and twelve feet in length. The counterweights move up and down in ten inch cast iron pipes fourteen feet long.

Conclusion

The most important variable used in the design of this gate is the value of the coefficient of friction which was assumed as .3. If such a gate were put in use it is possible that the size of the counter weights would have to be changed due to a different value of the coefficient of friction than the one given above. There is also a small amount of friction to be overcome in the pulleys, in the seals and in the pipes where the counterweights move. The latter would be very small as there is one quarter of an inch clearance around the weights. The size of the counterweights could easily be varied and with one or two trials the correct size for best operation of the gate could be determined.

2. The second part of the document addresses the challenges of data management in a rapidly changing environment. It highlights the need for flexible and scalable solutions that can adapt to evolving requirements. The author argues that investing in modern data management tools and training is crucial for ensuring that information remains relevant and accessible over time.

5. The fifth part of the document addresses the issue of risk management. It outlines the steps for identifying potential risks, assessing their impact, and implementing strategies to mitigate them. The text emphasizes that proactive risk management is key to ensuring the long-term sustainability and resilience of an organization.

7. The seventh part of the document addresses the issue of compliance and legal requirements. It outlines the steps for ensuring that all activities comply with relevant laws and regulations. The text emphasizes that maintaining compliance is not only a legal obligation but also a key factor in building trust and credibility with stakeholders.

9. The ninth part of the document addresses the issue of financial management. It outlines the steps for budgeting, monitoring expenses, and ensuring that the organization remains financially sound. The text emphasizes that sound financial management is essential for the long-term viability of any organization.

The following table shows the results of the experiments conducted on the 10th of May 1900. The experiments were conducted on the 10th of May 1900. The results of the experiments are as follows:

Experiment	Result
1	1.0
2	1.0
3	1.0
4	1.0
5	1.0
6	1.0
7	1.0
8	1.0
9	1.0
10	1.0

The results of the experiments are as follows:

The following table shows the results of the experiments conducted on the 10th of May 1900. The experiments were conducted on the 10th of May 1900. The results of the experiments are as follows:

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The following table shows the results of the experiments conducted on the 10th of May 1900. The experiments were conducted on the 10th of May 1900. The results of the experiments are as follows:

1890

1891

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1900

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1903

1904

1905

1906

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1911

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1918

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1926

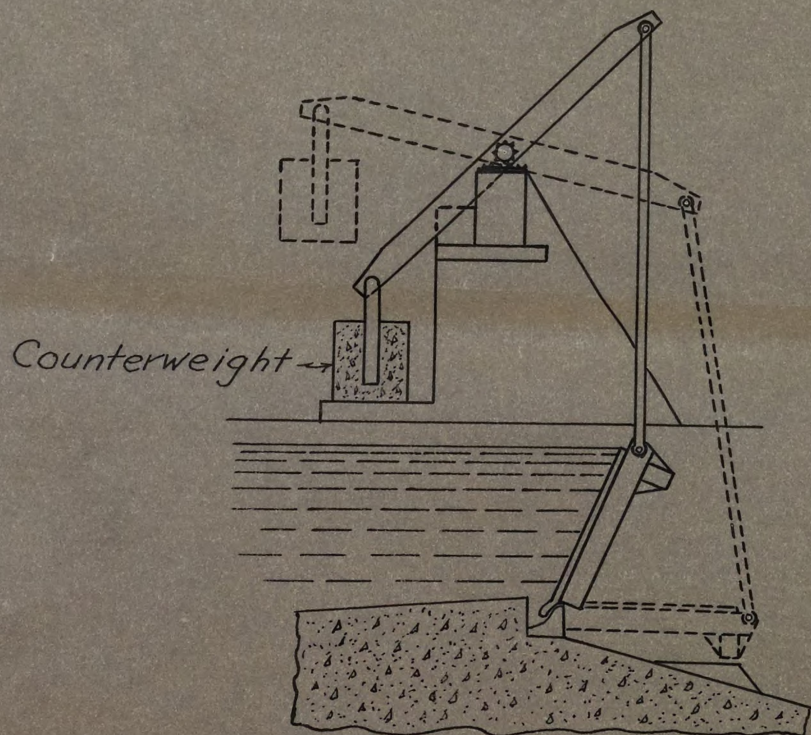
1927

Journal of the American Medical Association

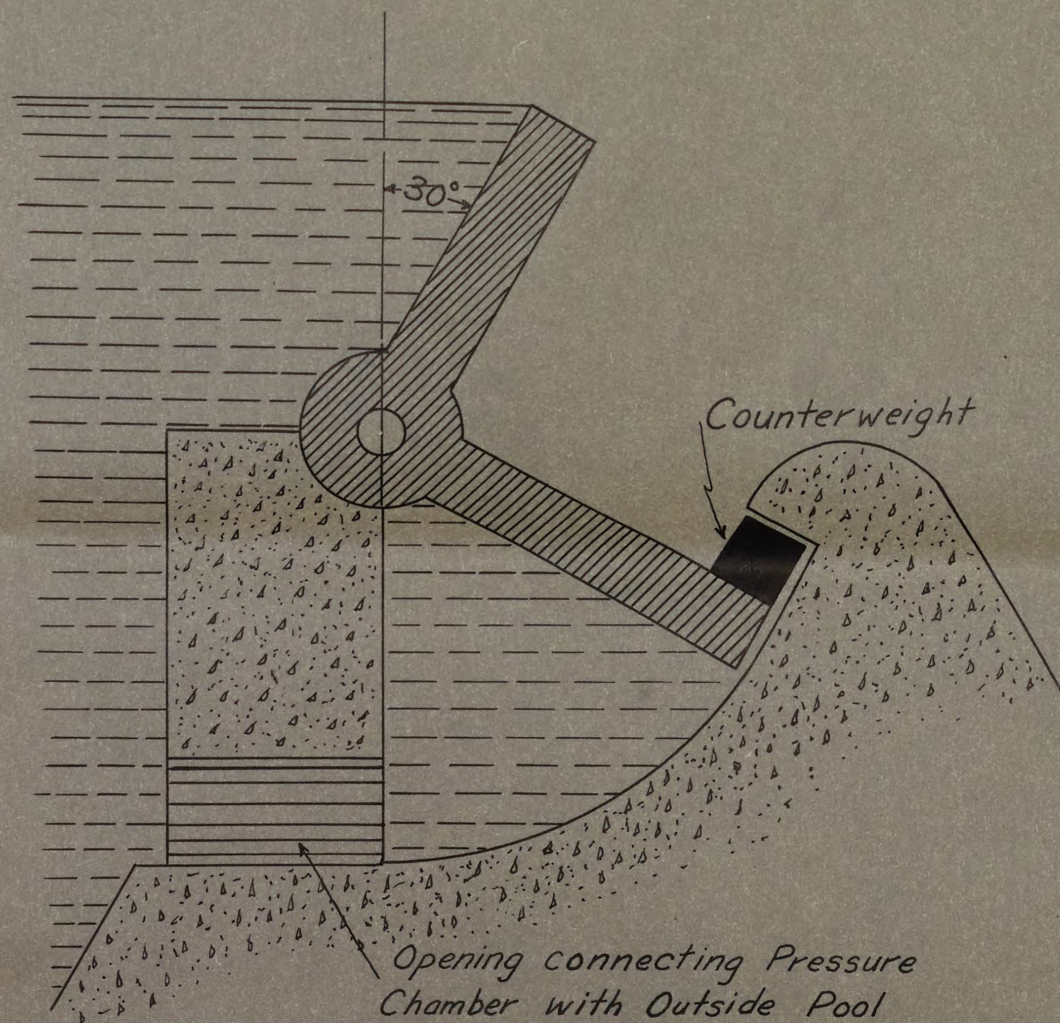
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2. Drum Gates. Water Supply Engineering by Ebbitt and Deland.
3. Automatic Spilling Gates at the Black Canyon Dam. Drum Type. Engineering News-Record Vol. 94
4. Dams and Control Works by the U.S. Department of Interior.
5. Automatic Crest Gates on the Austin Texas Dam. Engineering-Record Vol. 71
6. Hydraulics by Schoder and Dawson.
7. Iancuili Automatic Dam. Cyclopedie of Civil Engineering Vol. 9
8. Hydroelectric Handbook by Creager and Justin.

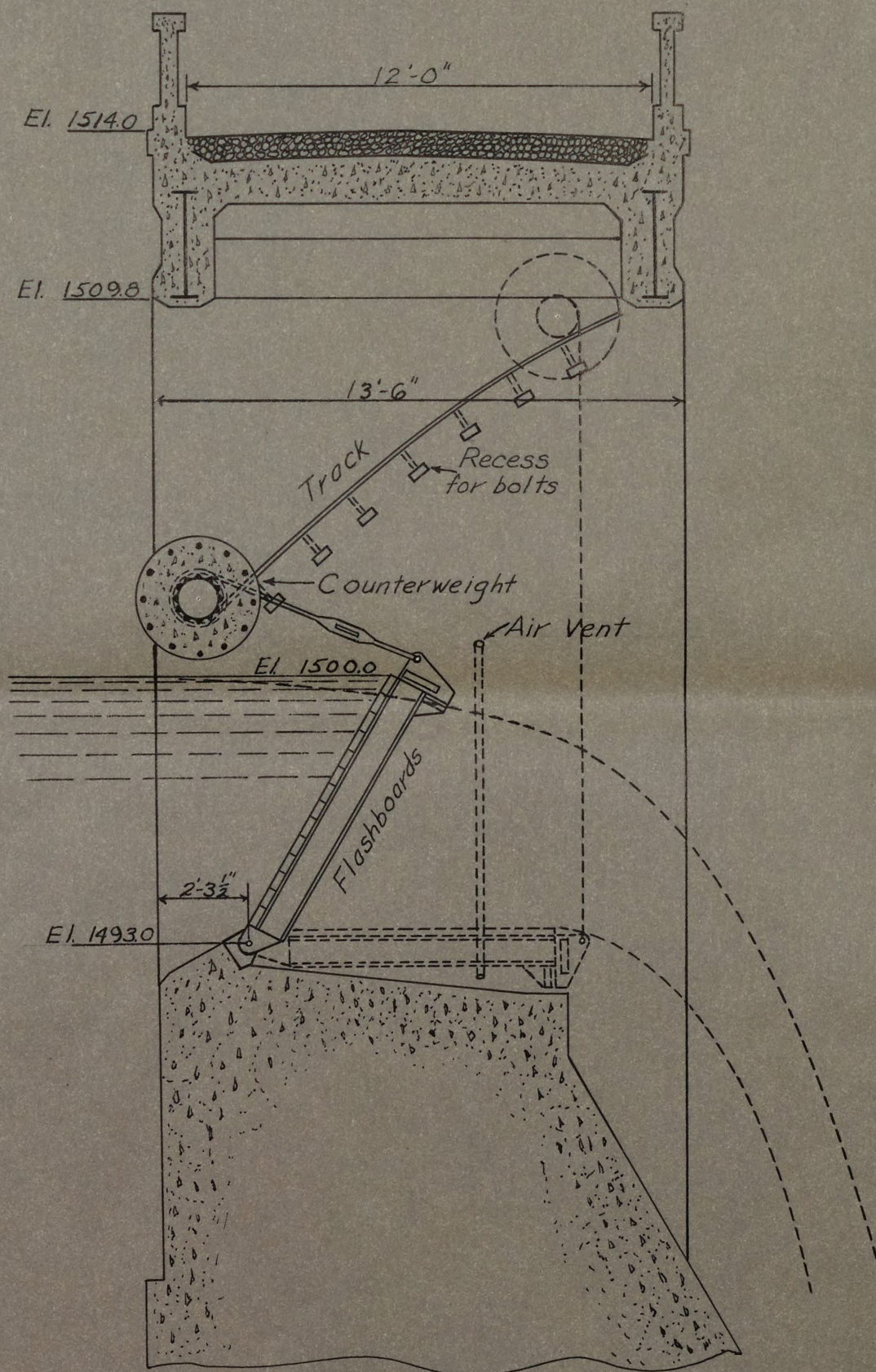


Stauwerke Tilting Gate



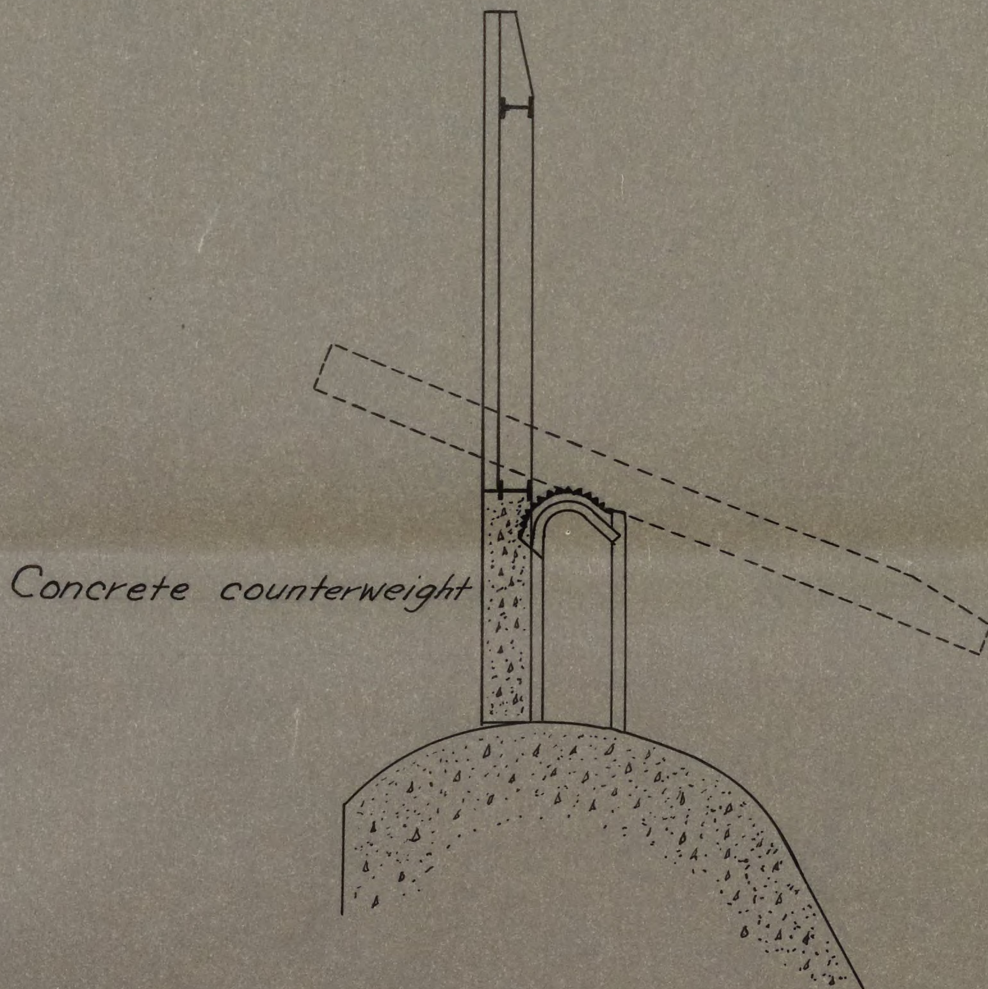
Leaf Type Drum Gate

SUPPLEMENTARY
MATERIAL



Tilting Gate at Tallaluh Falls, Ga.

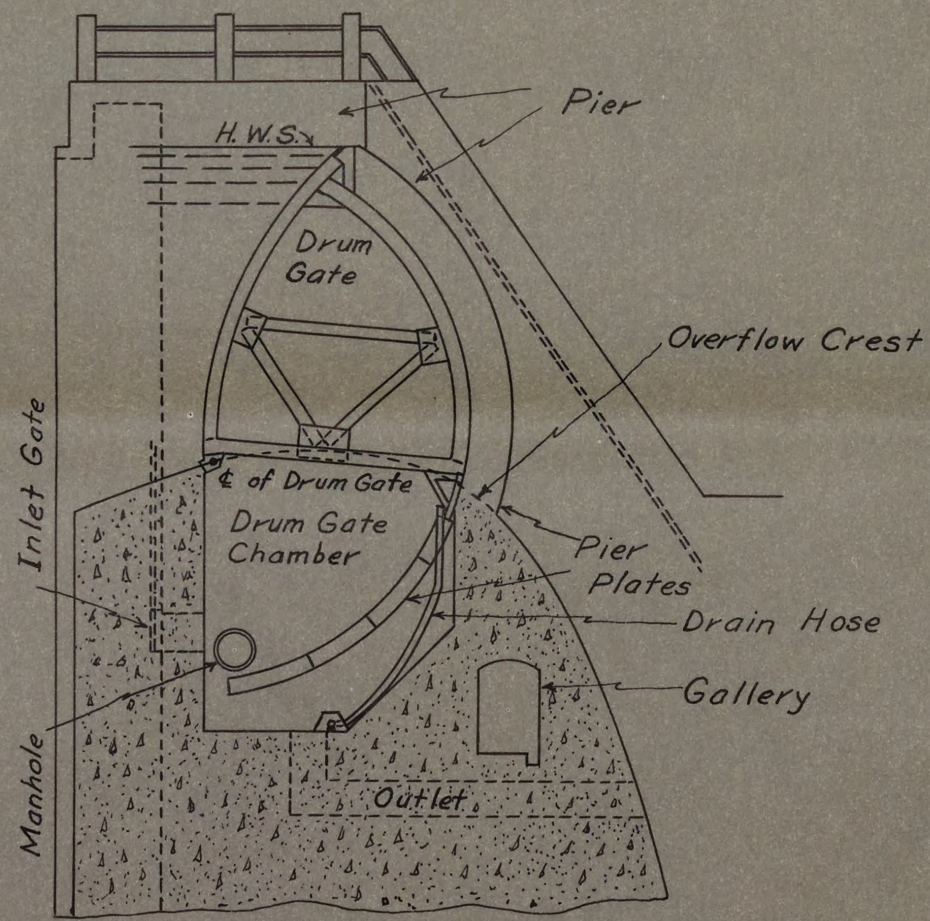
683
TK
Drawing
SUPPLEMENTARY
MATERIAL



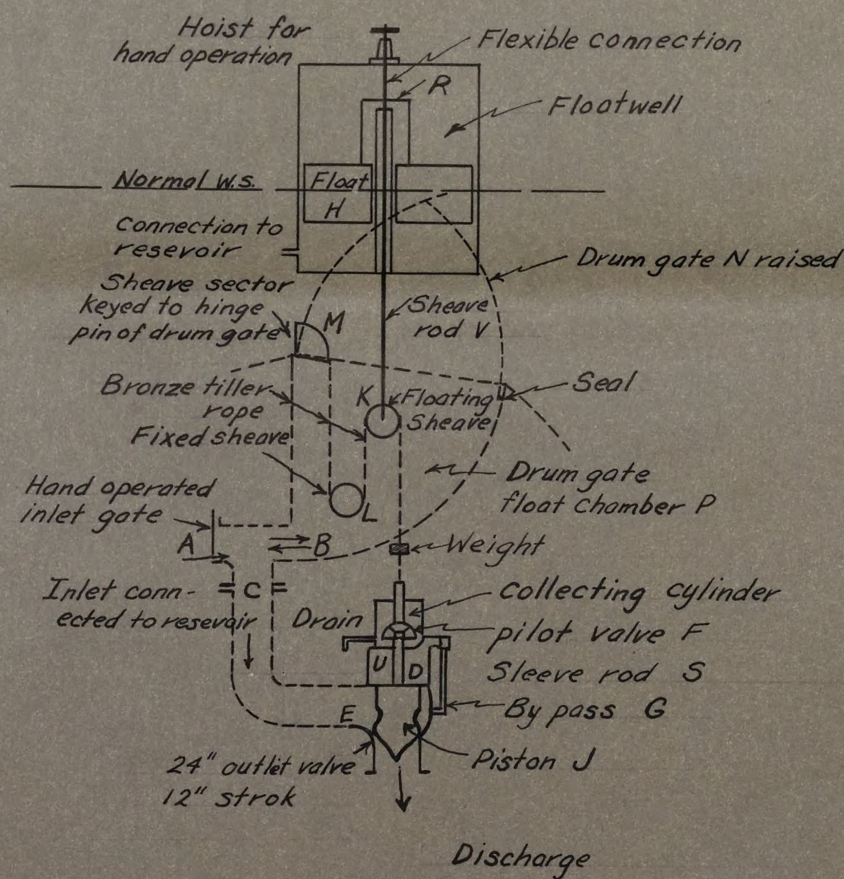
Tilting Gate used on Austin Texas Dam.

131
633
THS
Drawing
5

SUPPLEMENTARY
MATERIAL



Cross-section of drum gate and chamber



Operating Mechanism of Drum Gate

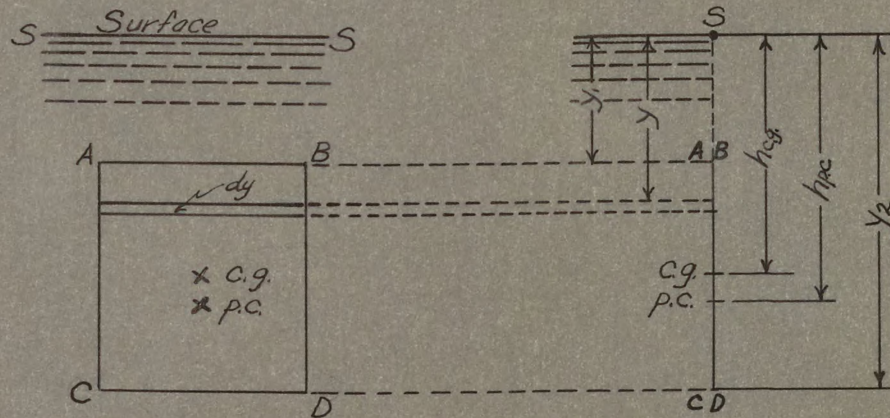
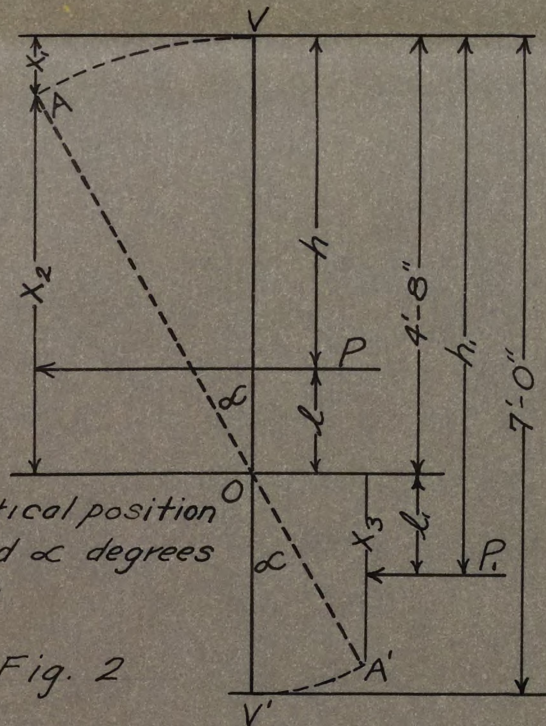


Fig. 1

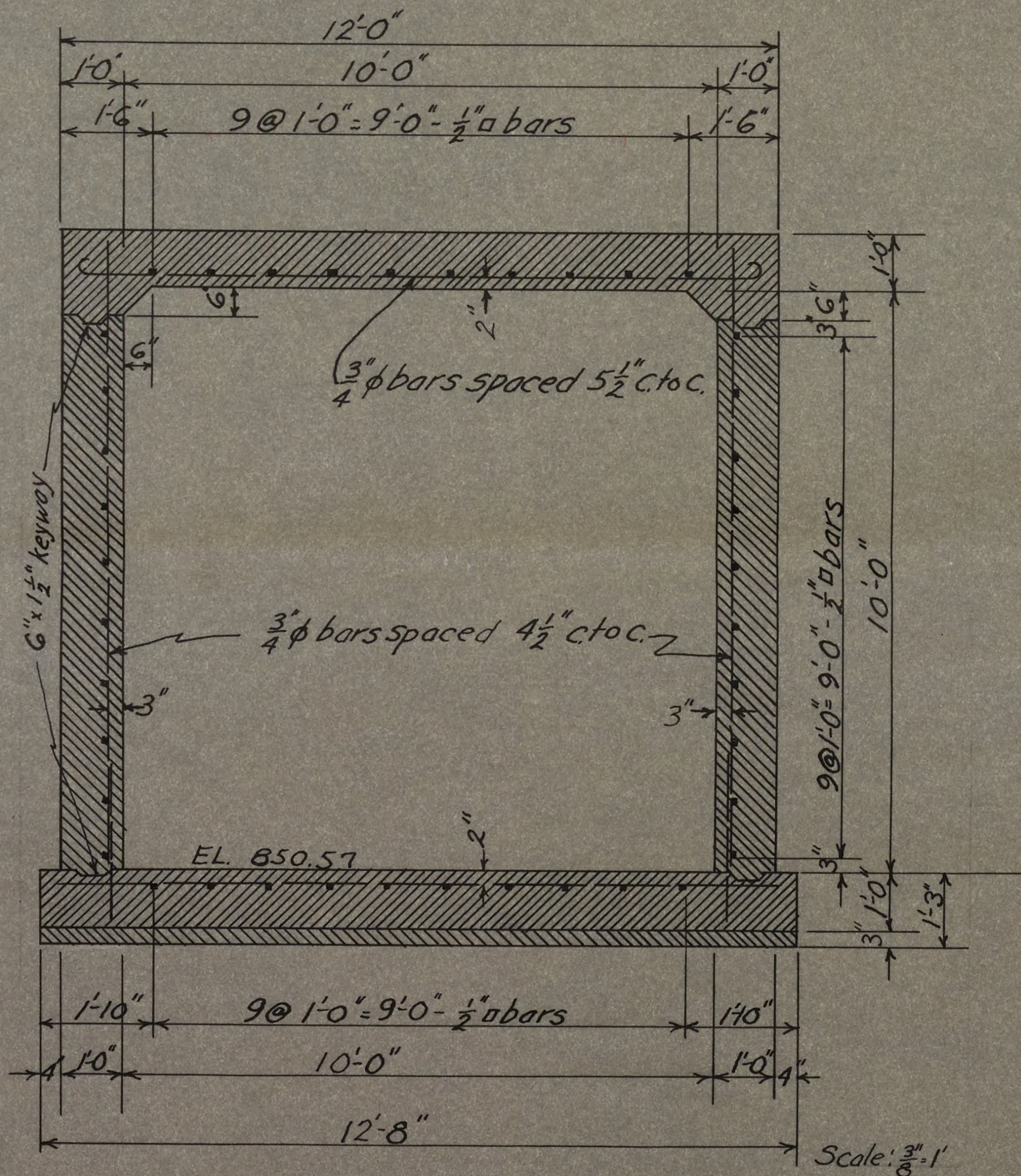
Diagram used in proving $h_{pc} = \frac{I_3}{A h_{cg}}$



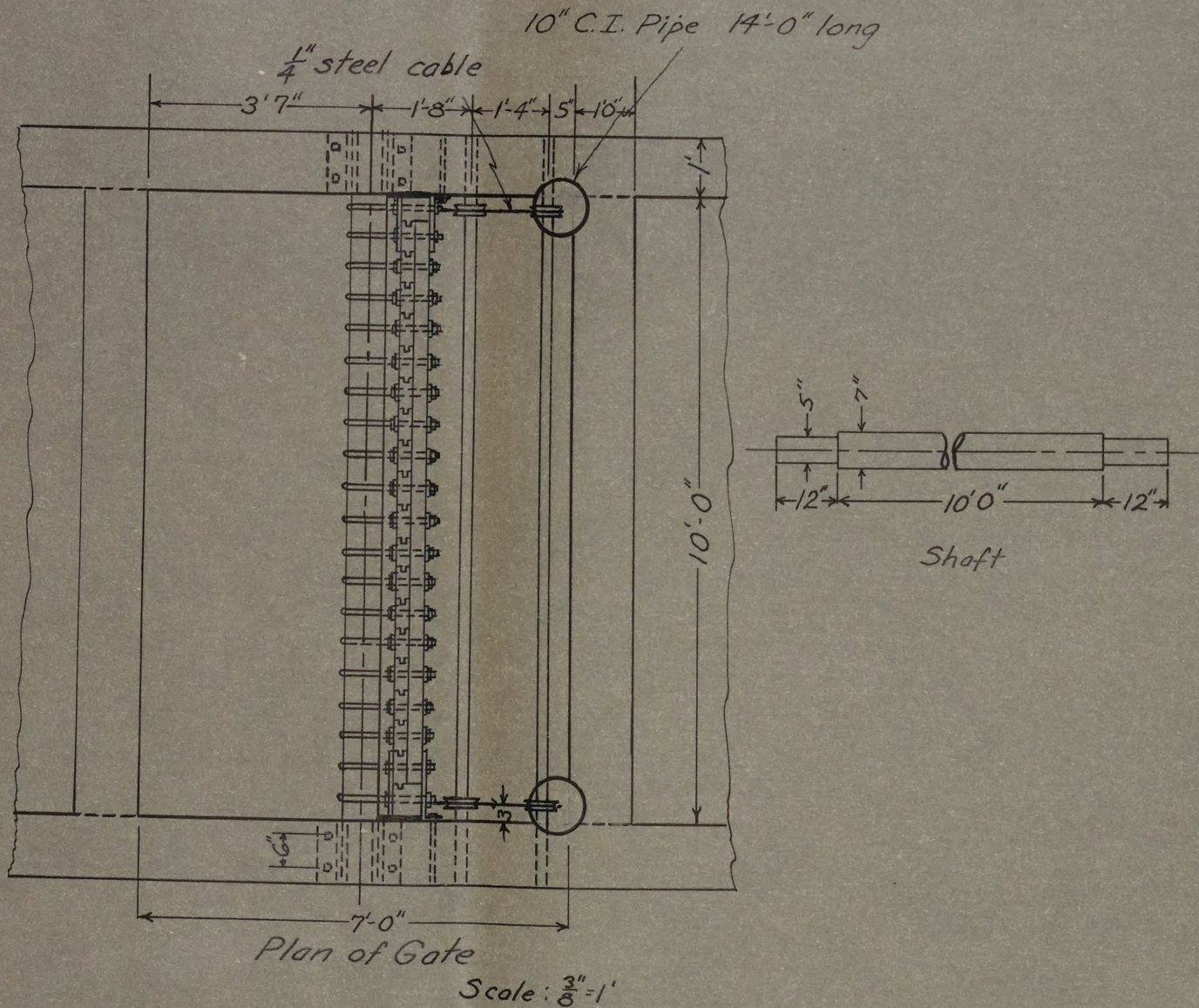
VV' - Gate in vertical position
AA' - Gate inclined α degrees
O - Pivot point

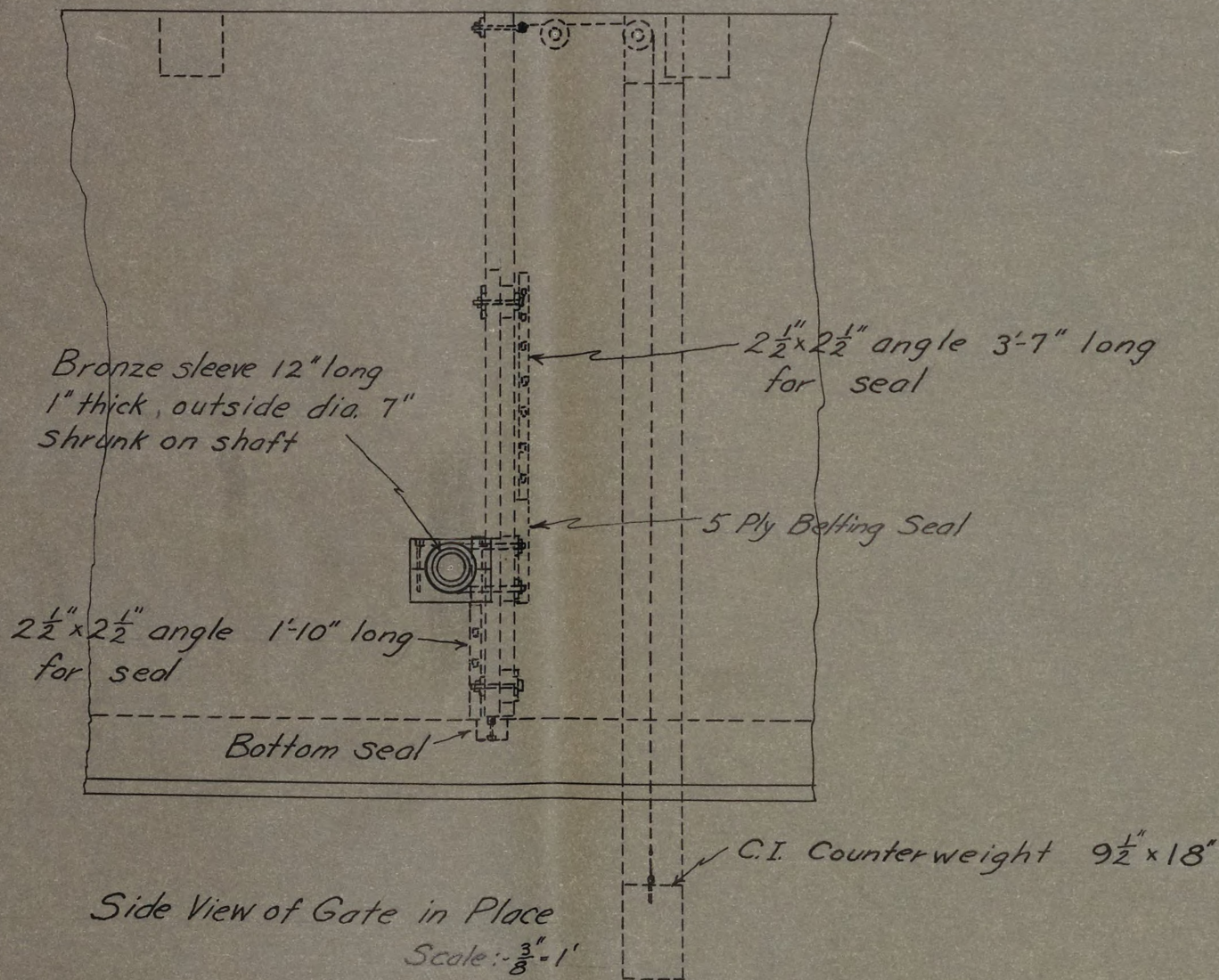
Fig. 2

Diagram used in computing the overturning moment at various positions of the gate.



Right Angle Section of Flume





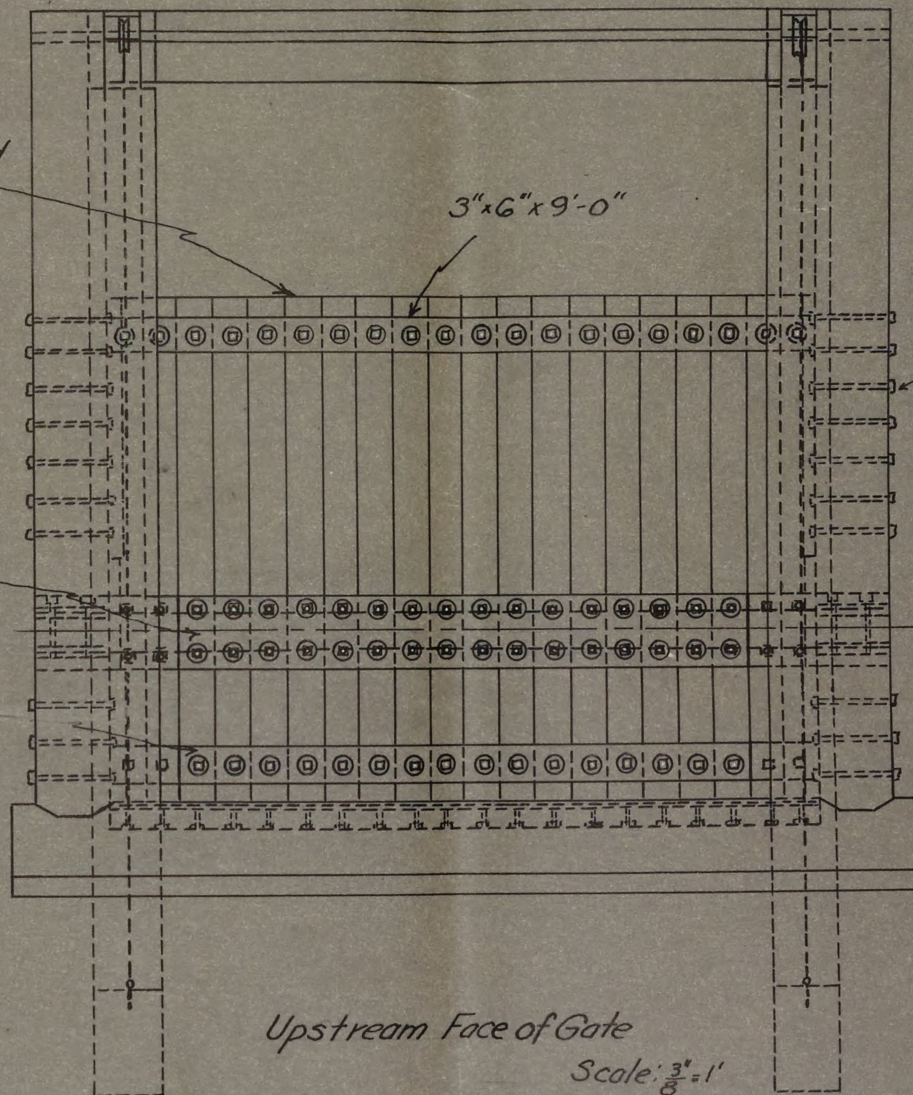
3"x6"x7'-0" creosoted
oak - tongued and
grooved

3"x6"x9'-0"

1/2" bolts 14" long for
angles of seal
6" c. to c.

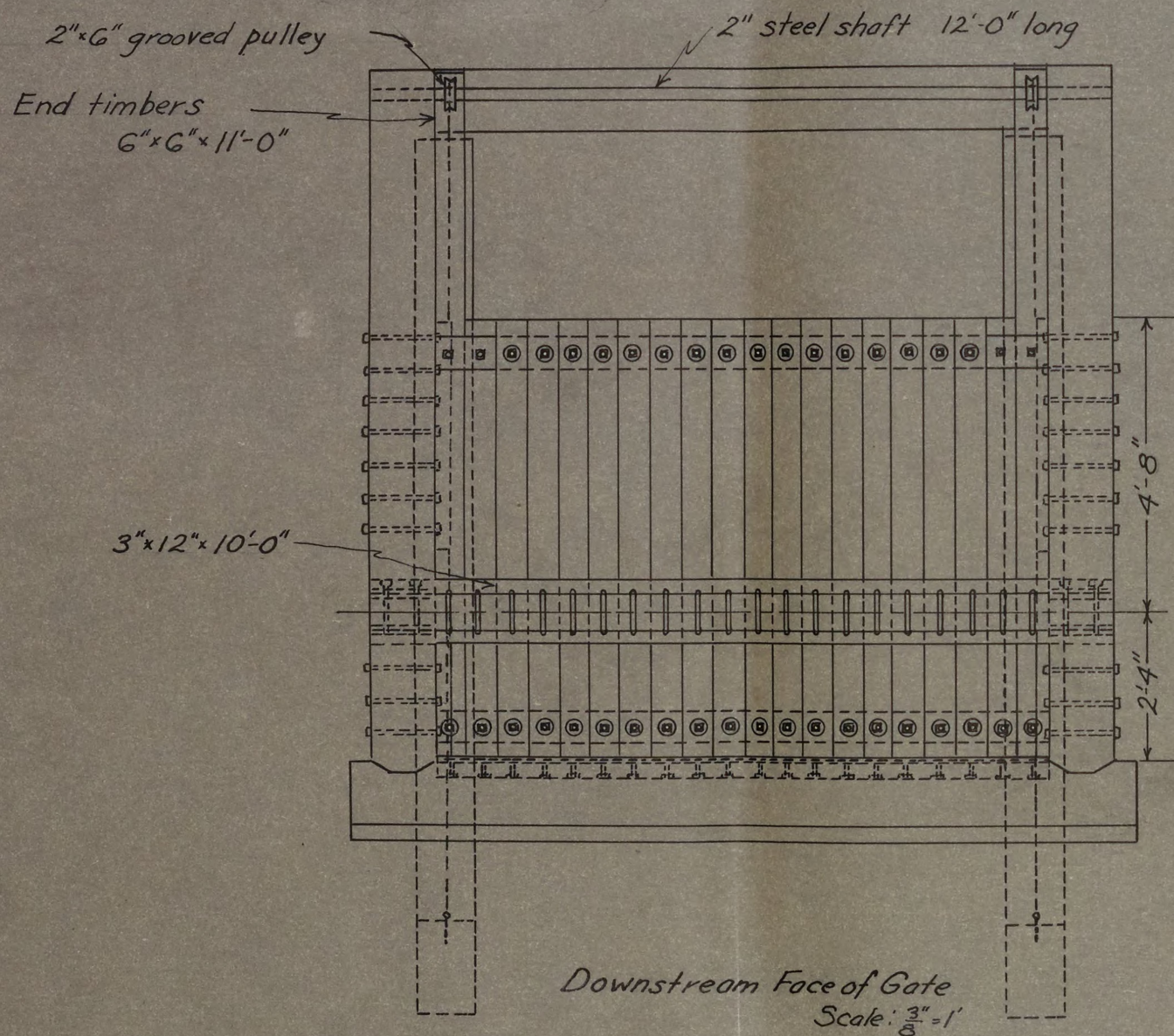
3"x12"x9'-0"

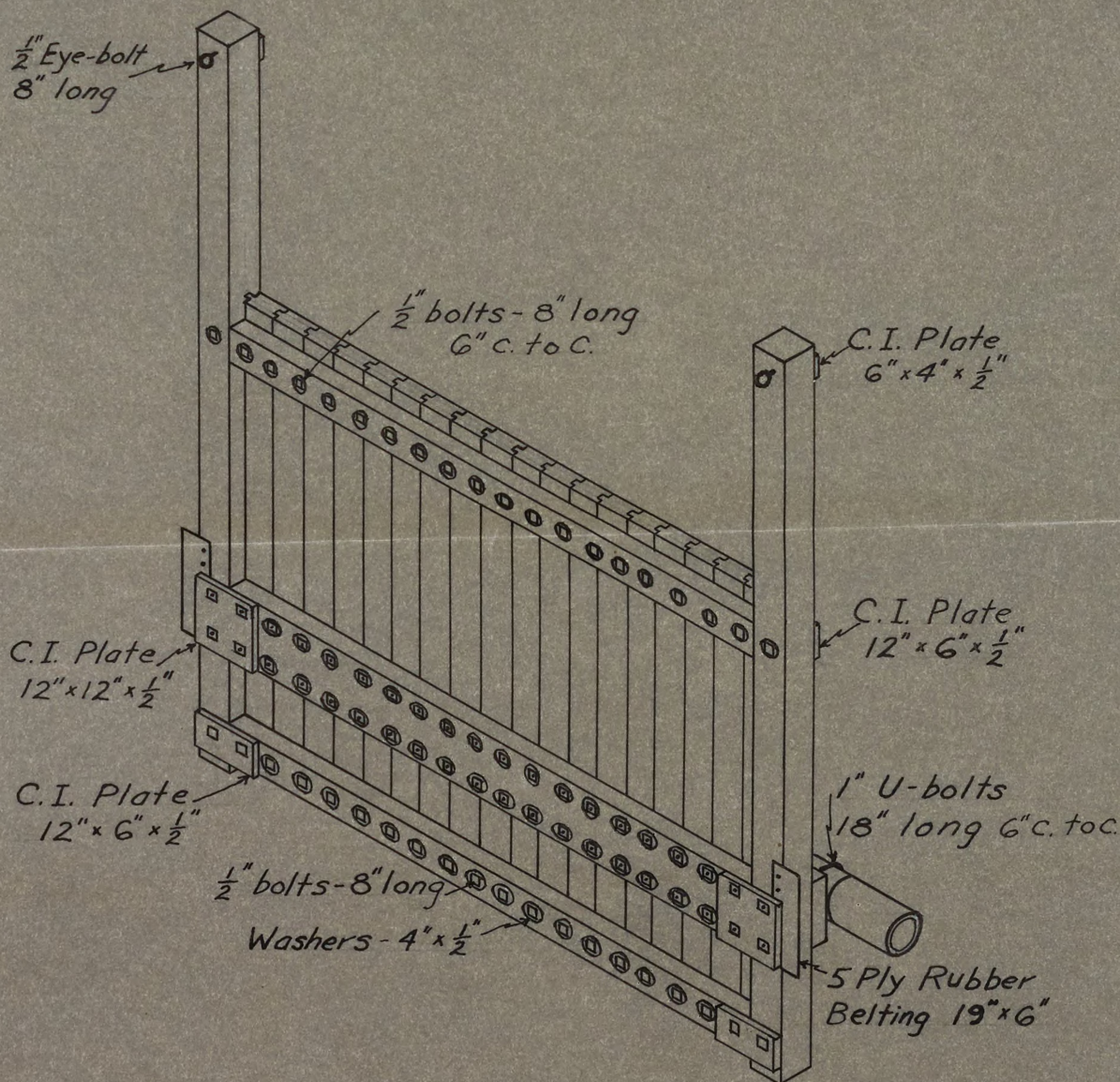
3"x6"x9'-0"



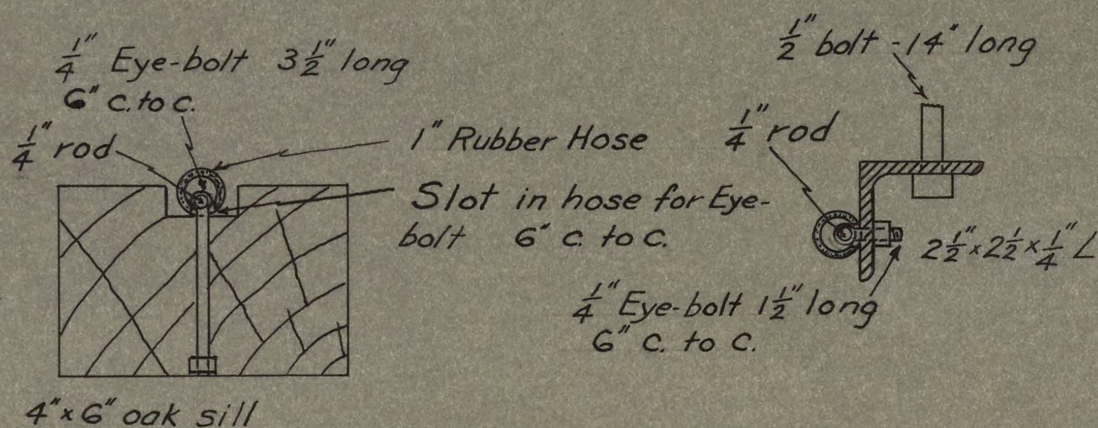
Upstream Face of Gate

Scale: $\frac{3}{8}$ " = 1'

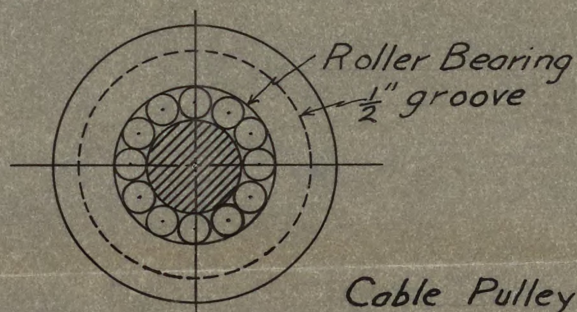




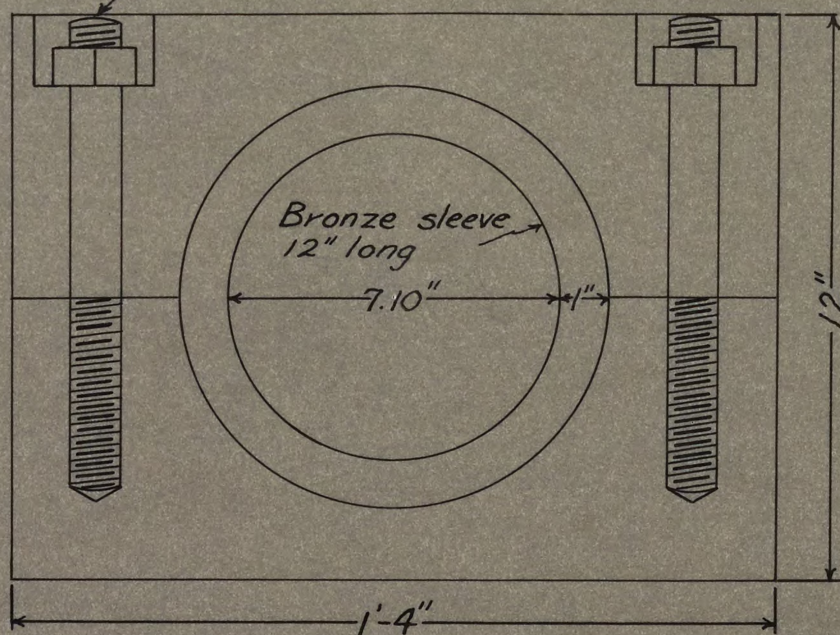
Isometric View of Gate Removed



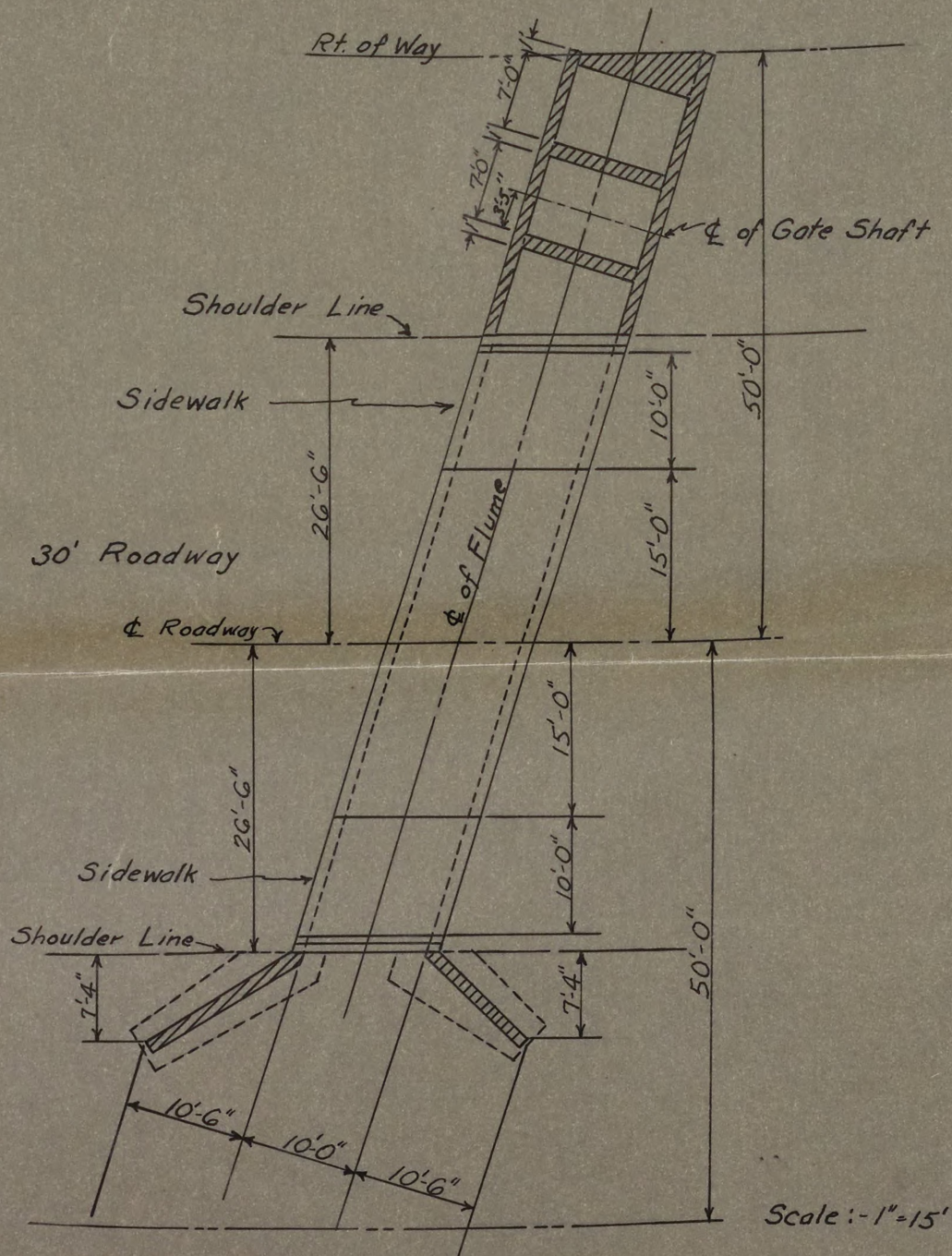
Details of Seals



1" Stud bolts - 10" long



Scale: 3" = 1'

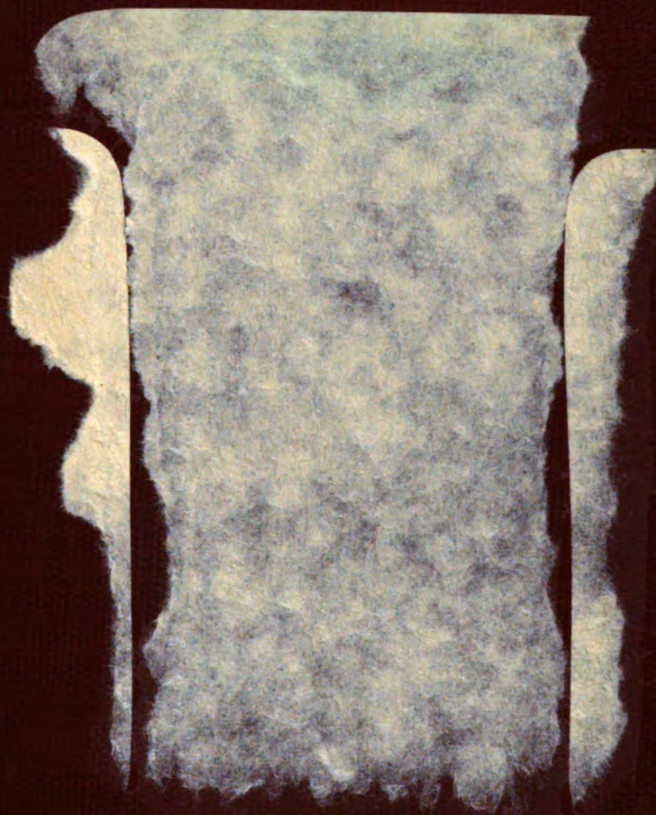


Plan of Flume showing Gate Location

EMMENTARY
TERRIAL

$\frac{1}{4}$ cup C
Eps-polyt 3 $\frac{1}{2}$ lb

1000/14.10.1941



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