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AUTOMATIC CONTROL GATES*

The modern requirement for close control of irrigation water at a minimum cost is focusing attention toward automatic control gates. Although automatic controls apply equally to closed conduits, this discussion will be limited to open channel distribution systems.

Since the operational demands vary with different installations, no single design or type of automatic control will fulfill all requirements. Furthermore, this discussion will not attempt to describe all such devices, but will necessarily be limited to a general description of a few automatic gates which have actually been installed.

Before describing the automatic gates, it may be well to consider a few of the common problems which have been encountered through field operation. The first one is that of the entrance to float wells. This does not imply that all float control gates have float wells, but many of them do; hence, the location and design of the entrance is an important consideration. Instances exist where a gate has become inoperative due to plugging of the entrance to the well with debris. This condition can be avoided by locating the entrance in a region of velocity sufficient to carry the debris away from the opening. In some cases the pipe leading to the float well has been extended into the canal a short distance from the bank, thereby assuring some velocity past the entrance. Obviously, the velocity cannot be sufficiently high to produce a low pressure at the entrance.

Another criteria in selecting the location of entrance to float wells is to avoid areas of local drawdown of the water surface, for instance, adjacent to a warped transition or in the face of a pier. Such a condition could prevent the gate from completely opening.

The second major problem in connection with automatic float control gates may be considered as excessive friction due to the gate seals or corrosion of the metal parts. A cure for corrosion lies, simply, in proper maintenance, but this fact must be recognized when considering the installation of automatic gates. Friction due to seals for those installations dependent upon operation of the gates by floats or counterweights rather

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*Most of the material in this discussion was obtained from C. W. Thomas, Engineer, Bureau of Reclamation, Fulbright Scholar, 1951-1952.

than with an external source of power such as an electric motor actuated by a float control switch, is practically unsurmountable if a water-tight gate is desired. Fortunately, however, most applications of an automatic gate are intended for control of water-surface elevation and not for a complete shut-off; hence, leakage by the gate is permissible, greatly simplifying the seal problem. In other words, if the fact is accepted that leakage will exist, the seal problem will present no serious difficulty.

The mal functioning of automatic gates due to the formation of ice is normally not encountered in connection with irrigation systems. If such a condition does exist, the cure lies in preventing the formation of ice by heat or perhaps by release of compressed air in such a manner to disturb the water surface sufficiently to preventing freezing.

I have chosen a few examples of automatic gates that are adaptable for use in irrigation channels or larger structures, such as, diversion dams or spillways. The first one is an overflow type termed an automatic flap leaf gate consisting of a leaf hinged at the upper end and assuming a horizontal position when completely lowered. Movement of the leaf is obtained by a pulley and cable arrangement connected to a counterweight operating in an adjacent float well. As the water rises and falls in the well, the buoyancy effect on the counterweight causes the gate leaf to rise and fall. If valves are provided to control the discharge through the float chamber, the movement of the gate can be manual. Depending on the length and rigidity of the gate, operation may be by a single cable attached to one end or a cable at each end of the gate.

As illustrated on the sketch of Figure 1 and the photograph, Figure 2, the gate is designed for control of the upstream water-surface elevation, but it could also be designed for control of a downstream water surface.

The second type of automatic control to be described has been applied to a gate very similar to the one previously mentioned in that the gate proper is a leaf hinged at the upper end with the flow passing over the top of the gate. However, operation is by means of beams suspended above the gate free of the water surface. The beams are hinged at the center with one end fastened to the gate and the other end counterbalanced in such a way that the varying pressure of the water against the gate causes it to rise and fall. This system has the advantage of simplicity and economy in that no float wells are required.

As may be seen from the schematic of Figure 3 and the photograph of Figure 4, this gate can only be used for control of the upstream water surface.

The automatic bear trap gate, Figure 5, represents an entirely different approach to an automatic control. In the raised position the gate may be described as consisting of two leafs hinged at the lower ends following the shape of an inverted V. As the gate lowers to pass water over the top, the upstream leaf slides over the other one.

In operation the gate is raised by introducing pressure on the inside of the structure and, of course, a decreased pressure will allow the gate to lower. A system of counterweights operating in float wells controls the balance of the gate. The seals required for this particular gate are probably more complex than for more common automatic controls. Figure 6 shows the beams for the downstream face of a large automatic bear trap gate.

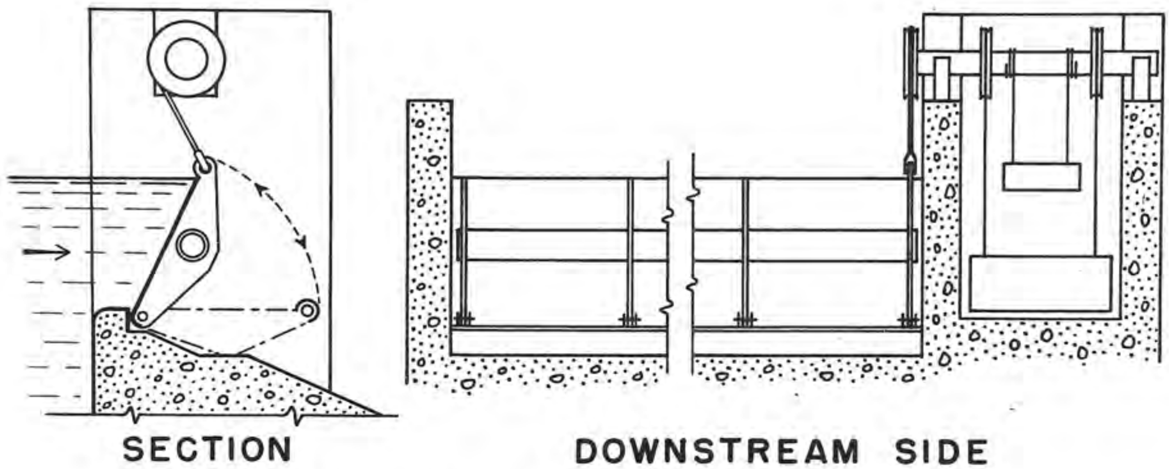
The automatic balanced flap leaf gate, Figure 7, is a very simple device requiring no floats or wells. It may be described as roughly approaching the shape of a pistol. In fact, this gate is sometimes referred to as the pistol gate. The hinged point may be considered at the trigger with the water flowing over the end of the barrel. The area beneath the handle of the pistol must be kept free of water pressure by means of an open drain. As the water surface rises on the upstream side, the pressure causes the pistol to point downward, thereby discharging a greater volume of water. Obviously, this gate cannot be used for downstream control. Figure 8 represents an illustration of the automatic balanced flap leaf gate.

Another type of automatic flap leaf gate, Figure 9, consists of a simple leaf hinged at the upstream end and controlled by a hydraulic cylinder with a connecting rod operating vertically from the underside of the gate. Pressure in the cylinder is controlled by a chamber located at an elevation sufficiently high to balance the pressure against the upstream side of the gate leaf. The height of the gate is therefore controlled by the pressure introduced into the hydraulic cylinder.

Probably the most common type of automatic gate in the United States is the automatic radial gate, Figure 10. Unlike all others in this discussion, the waterflow is underneath the gate which is controlled by a counterweight operating in a float chamber. The amount of water passing into the chamber is controlled by the elevation of the funnel-shaped inlet which may be readily raised or lowered manually to change the elevation of the gate if required for operating purposes. The gate may be used for the control of upstream water surface or the downstream one. Water must pass through the float chamber all the time but this is usually not a disadvantage. Figure 11 shows one of the many installations.

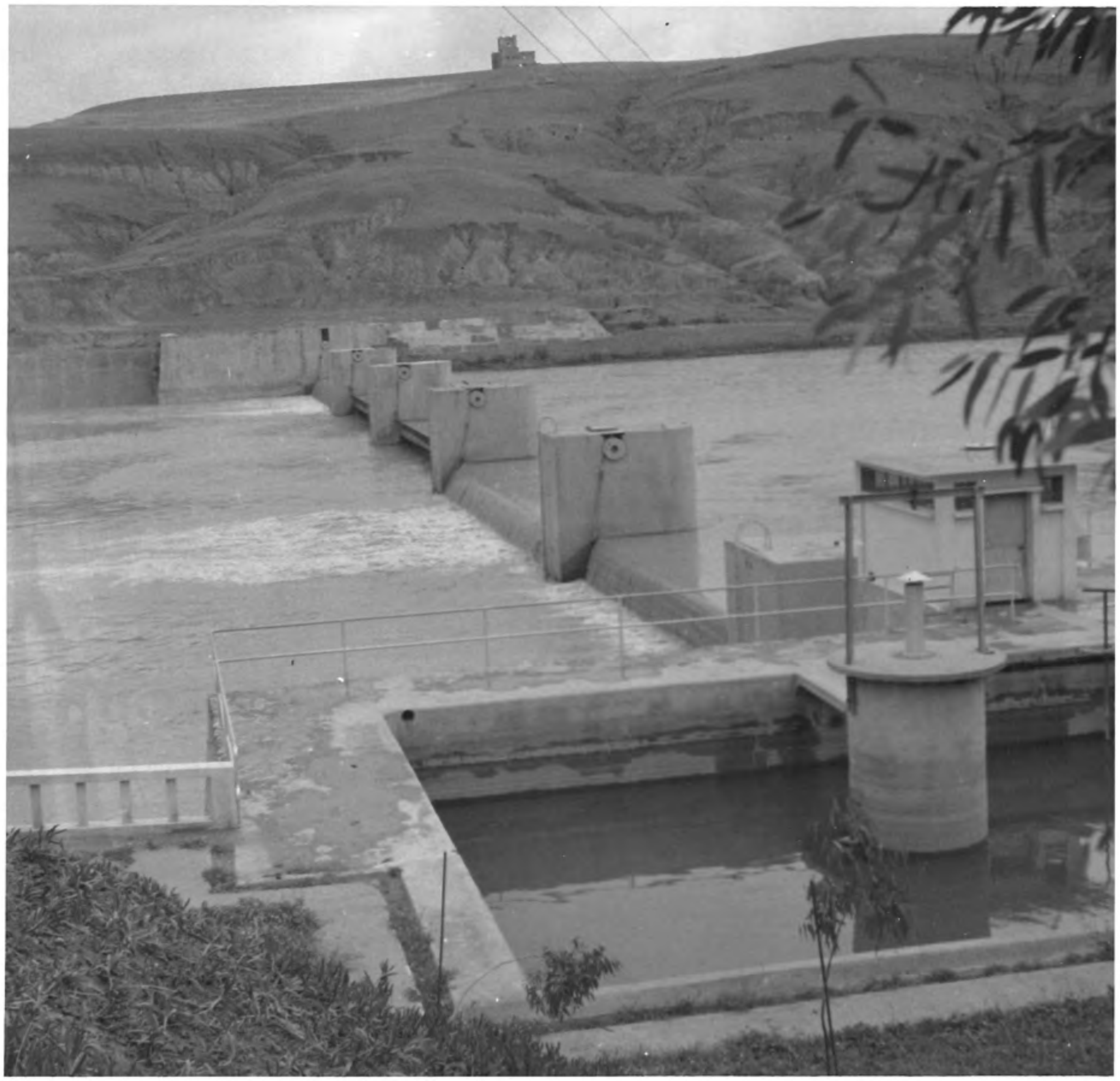
There are two other types of controls for an upstream water surface which are not automatic gates but do represent excellent methods of maintaining a near constant water-surface elevation in irrigation channels. One of these, Figure 12, is usually called a "duck bill" weir and in plan is in the shape of a V. Although the illustration shows the apex of the V pointing downstream, it is sometimes installed in the opposite direction. Either way will give satisfactory results, but the coefficient of discharge is not the same for the two different directions. A hole may be placed through the weir for flushing out any deposit of silt or for draining. A near constant head is maintained by the fact that the weir crest is very long.

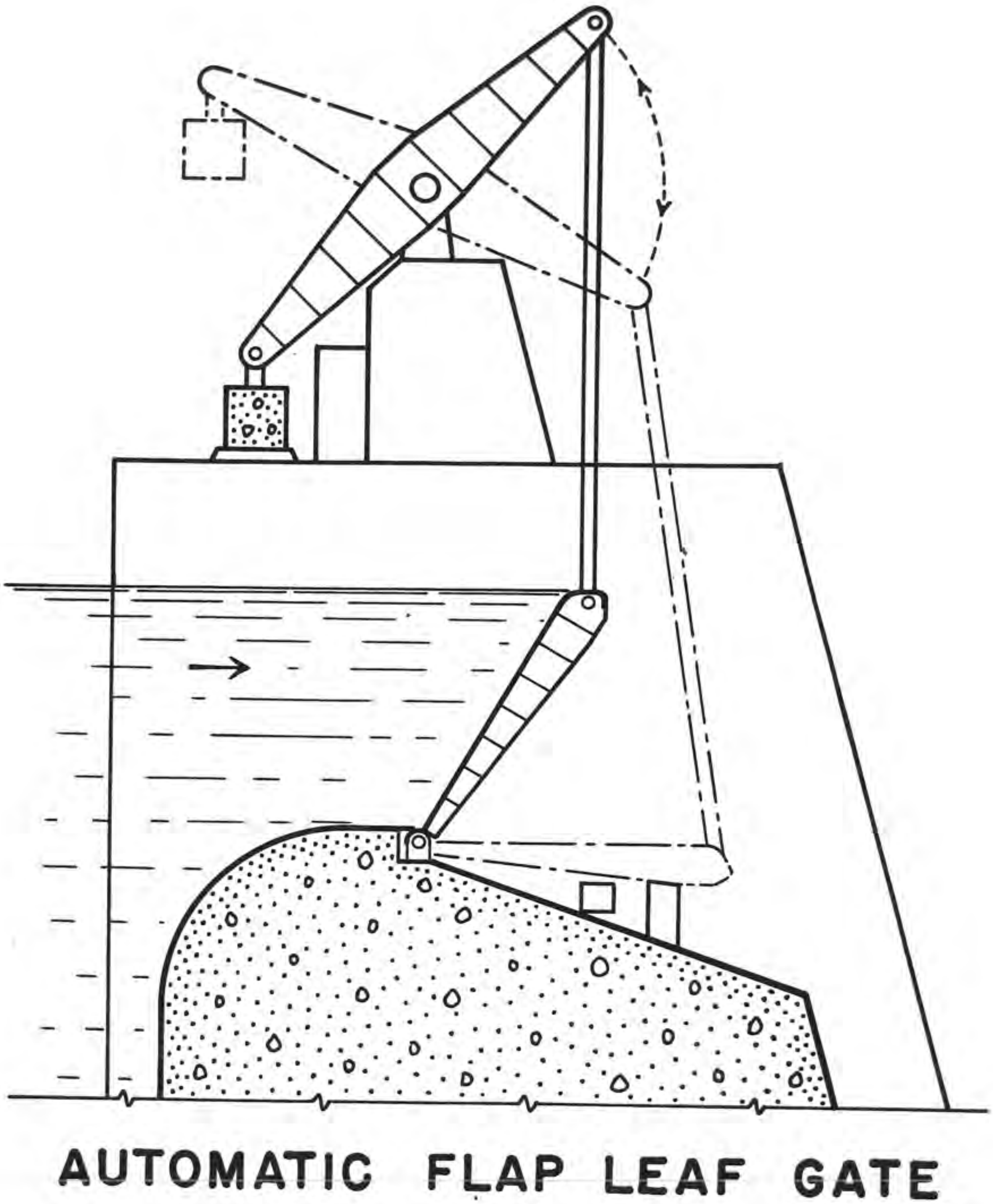
A similar device, Figure 13, is merely a straight weir installed diagonally in a canal to give a long crest length. The diagonal weir and the duck-bill type may be permanently constructed of concrete; but for those conditions where the water-surface elevation must be changed for operating purposes, these weirs should be constructed in the form of removable flash boards.



AUTOMATIC FLAP LEAF GATE

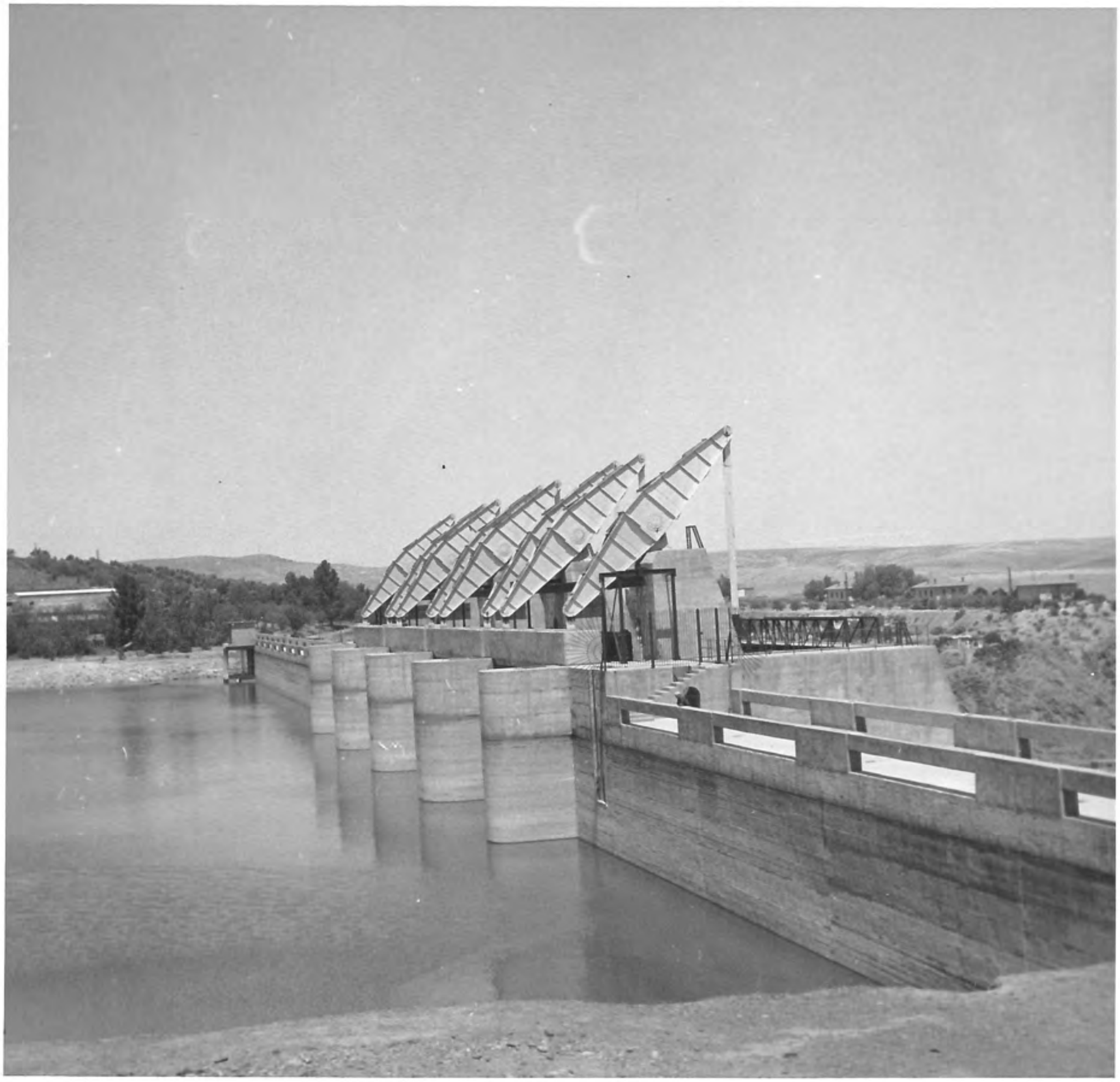
FIGURE 2

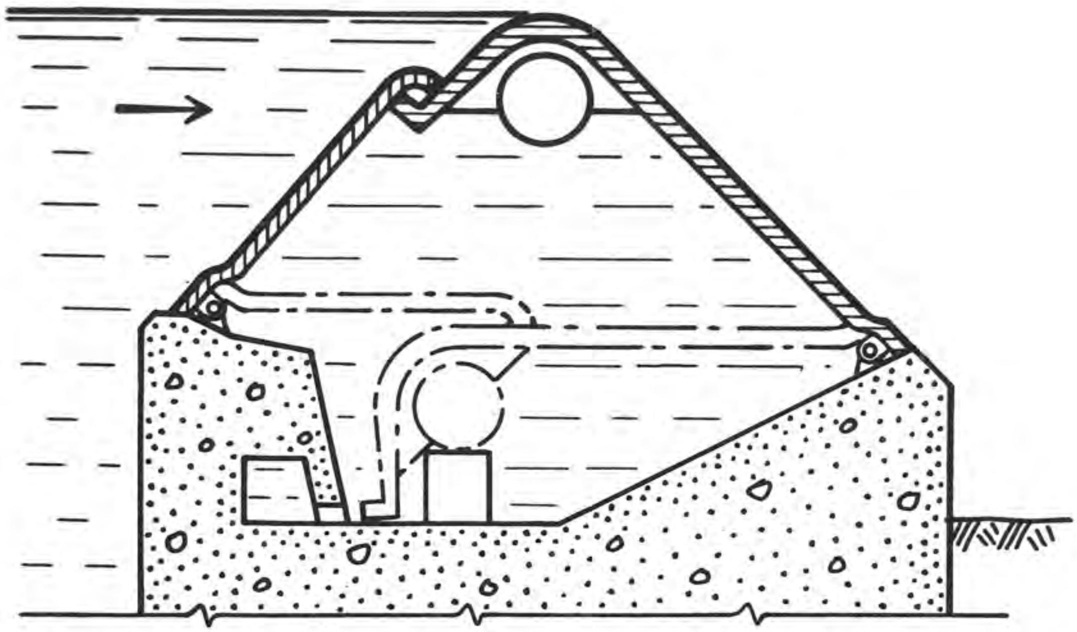




AUTOMATIC FLAP LEAF GATE

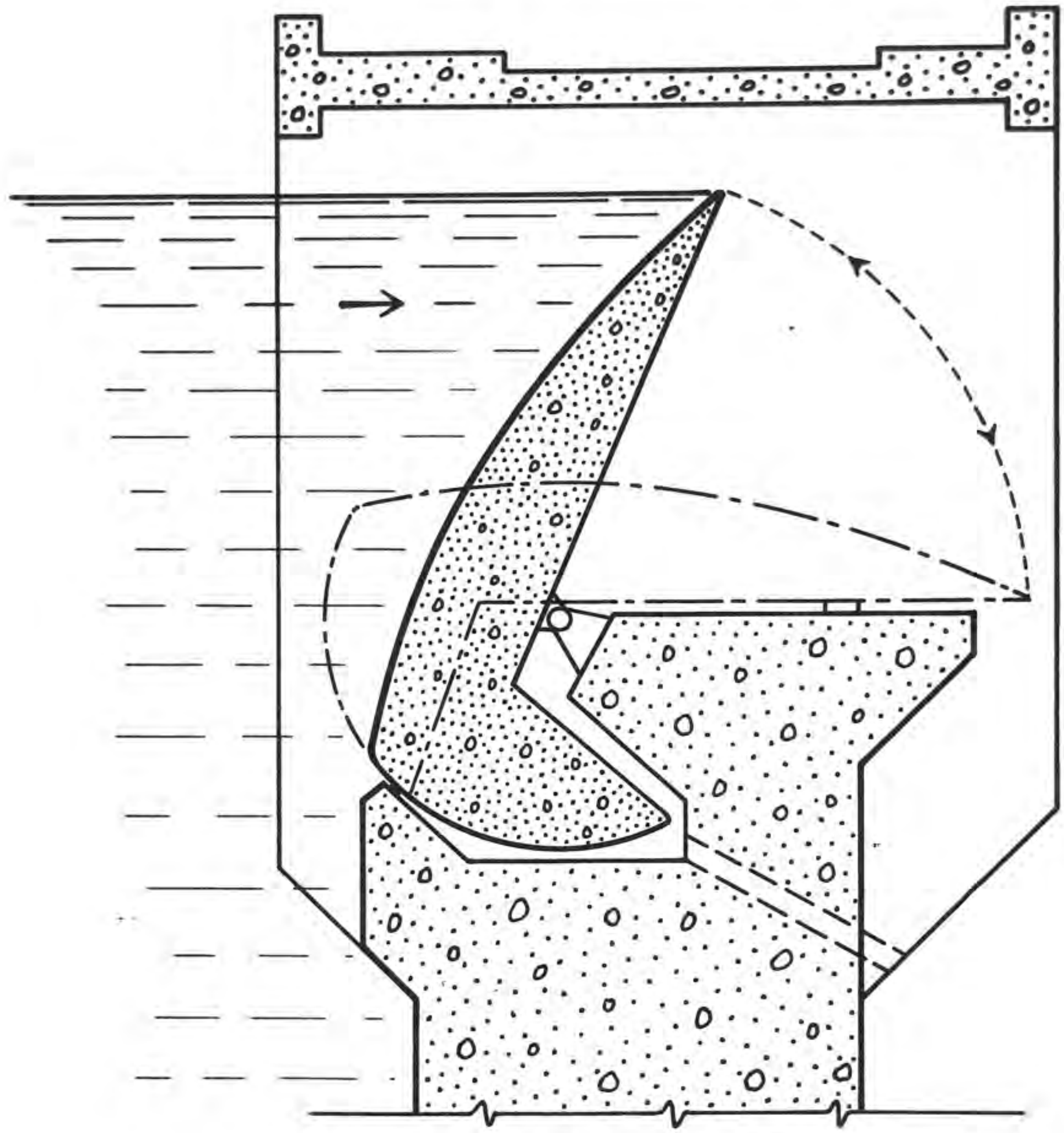
FIGURE 4





AUTOMATIC BEAR TRAP GATE

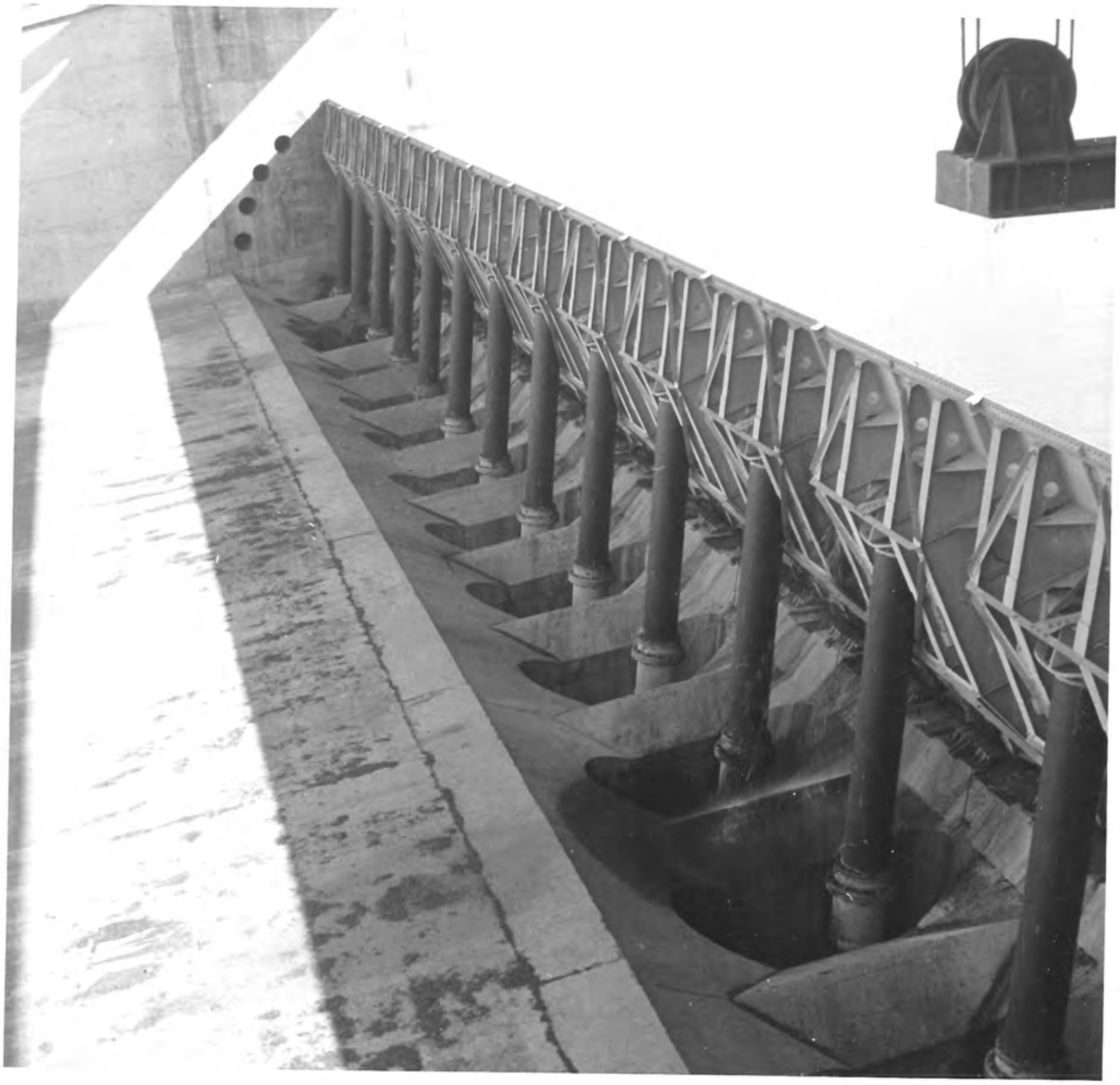
FIGURE 6

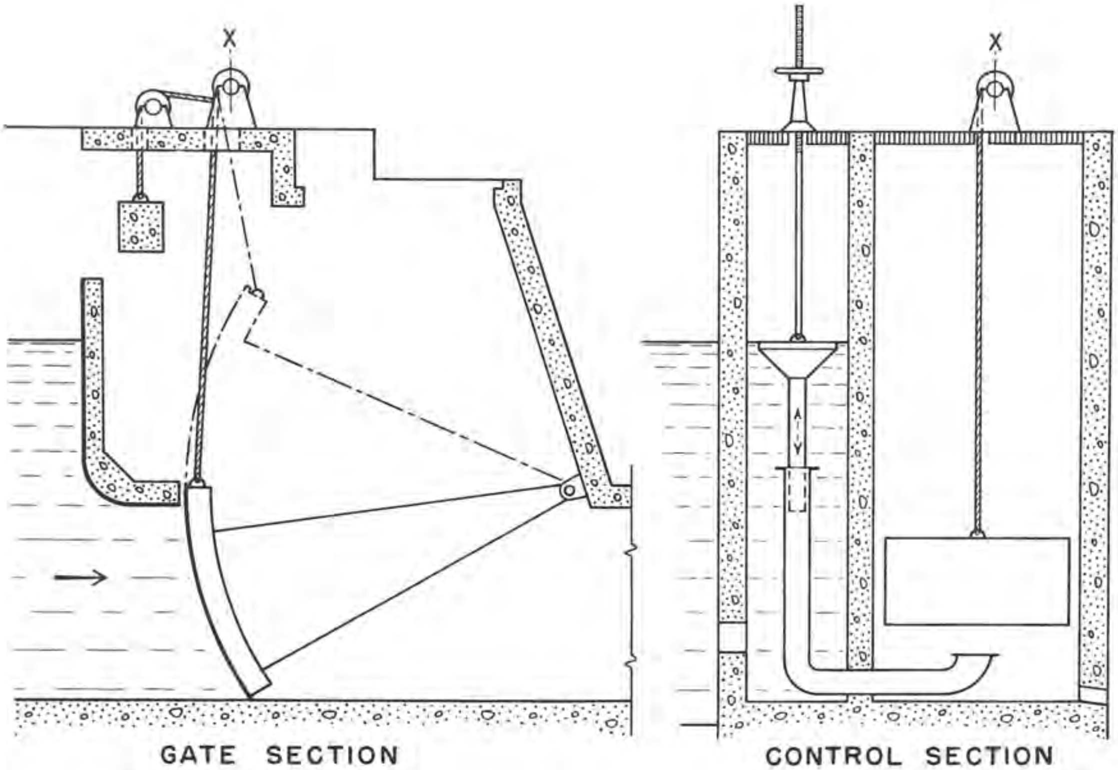


AUTOMATIC
BALANCED FLAP LEAF GATE

FIGURE 8

FIGURE 9





AUTOMATIC RADIAL GATE

FIGURE 11

FIGURE 12

FIGURE 13

APPENDIX 1

Supplemental information regarding
Figures 2, 4, 8, 9, 12, and 13

Figure 2

Charon Diversion Dam on the Chelif River in Algeria, North Africa. This dam diverts water to an open canal leading to the Inkerman Network which covers approximately 50,000 acres of which about 5,000 acres are presently irrigated. The dam consists essentially of five movable leaf gates hinged at the upstream edge. Each gate is 100.3 feet long by approximately 7 feet high. The gates are separated by 11.6-foot wide piers that contain float wells for automatic control. Cables attached to each end of the gate operate through systems of pulleys and shafts to submerged floats. During periods of high flow, the gates are flat on the crest of the dam. Suitable piping, controlled by valves located in the small house in the foreground, permit manual operation of the gates. The tank in the foreground provides stored water for manual manipulation of the gates and also serves as a settling basin for a domestic water supply for the area housing the caretaker and maintenance yards.

Figure 4

The spillway gates on N'Fis Dam on the Oved N'Fis, south of Marrakech, Morocco, North Africa. The dam has an over-all height of 172 feet, a crest length of 1,178 feet, and is a straight gravity section. The dam serves primarily to store irrigation water, but there is a small powerplant at the left end of the dam that operates only when irrigation water is being released or when there is a surplus. This flood spillway is located at the right end of the dam. In case of an extraordinary flood, water will pass over the entire dam. The flood spillway is controlled by four automatic bascule-type gates, each 50 feet long by 18.2 feet high. Counterweights are attached to the upstream ends of the beams over the gates, and the other ends of the beams lift the gates through the medium of steel straps. The gates are hinged along the upstream edge.

Figure 8

Triouzoune Dam on the Triouzoune River in the Massif Centrale portion of France. This dam is 90 feet high and has a crest length of about 480 feet. The flood spillway occupies 132 feet near the center of the dam and is controlled by three fully automatic balanced reinforced concrete gates, 29.7 feet long and approximately 15 feet high, separated by piers. The two low level outlets are each controlled with a single butterfly valve. This dam serves as a forebay for Neuvic D'Ussel Powerplant. The water is carried from the reservoir through a pressure tunnel to another stream valley in which the plant is located.

Figure 9

The flood spillway for Bou Hanifia Dam on the Oued Hammam in Algeria, North Africa, passes through a saddle at a considerable distance to the left of the dam. The spillway is designed to carry a maximum of 192,500 second feet. The flow is controlled by 16 completely automatic gates, each 16 feet wide and 20 feet high. The gates are hinged at the upstream edge and are operated by oil cylinders (servomotors). The pressure in the cylinders is adequate to maintain the gates in an "up" position until the water level in the reservoir reaches the top of the gate. Any additional raise overbalances the pressure in the cylinder and the gate lowers. Pressure in the cylinders is maintained by a pipe system leading to a reservoir located on a hill near the spillway. Auxiliary piping, valves, and pumps permit manual operation of the valves. There are dual manual controls as well as the automatic controls.

Figure 12

A lateral on the Beni-Amir network in the Oum Er Rbbia Valley of Morocco, North Africa. In this system there is considerable head to lose in some of the laterals. A "Duckbill" weir with the apex downstream is utilized as a combination drop structure and constant head device for the deliveries. This figure shows one of the weirs in a lateral. There are deliveries from both sides of the lateral just upstream. The weir provides a near constant head regardless of the discharge so that adequate control and measurement may be effected at the turnouts. The lateral was operating at near capacity when the picture was made.

Figure 13

On many of the laterals of the Sidi-Slimane network in Morocco, North Africa, there is adequate head to permit installation of long weirs instead of constant level gates at the turnouts. Such a weir is shown in this figure. The weir has been placed on a diagonal in the lateral. These weirs do an excellent job of maintaining a near constant head in the lateral. Some useful section is lost just downstream from each weir. Some sediment accumulates upstream from the weirs but in this system sediment is no problem.