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THE DEVELOPMENT OF AUTOMATIC IRRIGATION STRUCTURES AND DEVICES

by

Allan S. Humpherys and James A. Bondurant
Northwest Branch, Soil and Water Conservation Research Division

United States Department of Agriculture
(Idaho Agricultural Experiment Station cooperating)

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(The authors are Research Agricultural Engineers at the Snake River Conservation Research Center, USDA-SWC, Agricultural Research Service Kimberly, Idaho)

developed during the study are discussed in this paper. Brief mention will also be made to those structures for which development has been discontinued, since this information may be of interest to other researchers and possibly used in designing specialized structures. During the study, emphasis was placed on developing fully automatic structures which would operate from the energy of water flowing in the ditch and not require an external power source. The structures shown in Figure 1 were developed and field tested by the authors while located at Boise, Idaho.

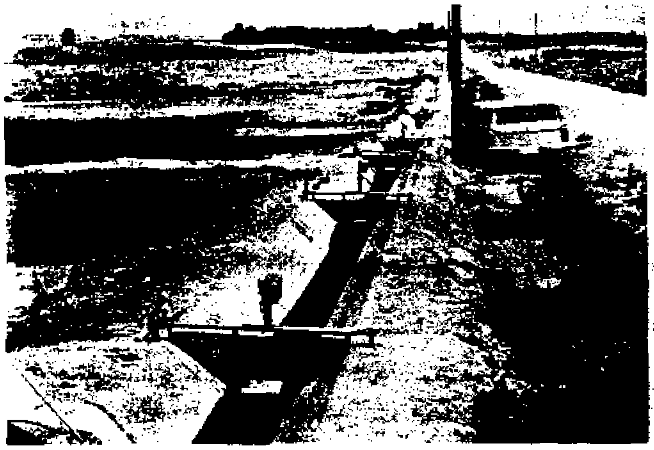

Fig. 1. Experimental, automatic structures being field-tested near Caldwell, Idaho. Shown are: water clock (the two upstream gates), timer, solenoid, and float-operated gates.

Automatic Check Gate Developments

A fully automatic mechanical gate for controlling irrigation water in a farm head ditch or lateral is shown in Figure 2 (Humpherys, et al, 1965c). This structure

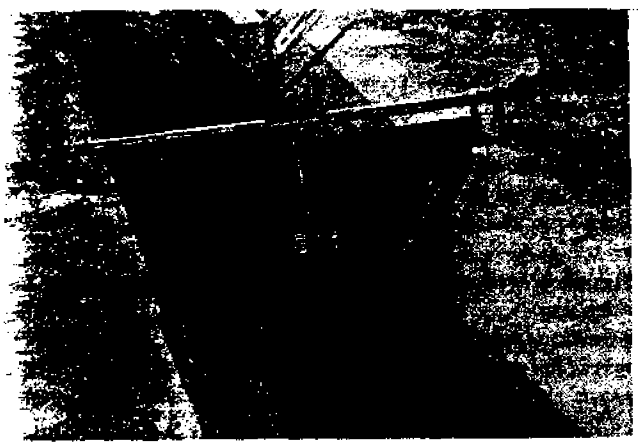

Fig 2. Rear View of basic check gate with water clock trip. The gate is partially open with the water clock mechanism in its tripped position.

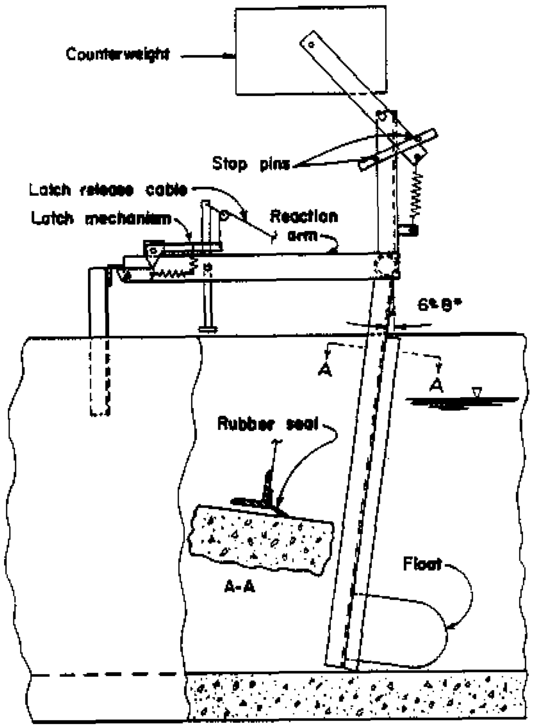

Fig. 3. Side view of basic gate in closed position. The counterweight is in its rear position.

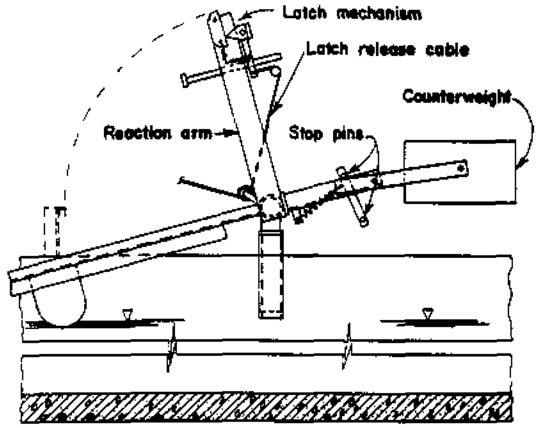

Fig. 4. Side view of basic gate in open position. The counterweight in this position helps to hold gate open.

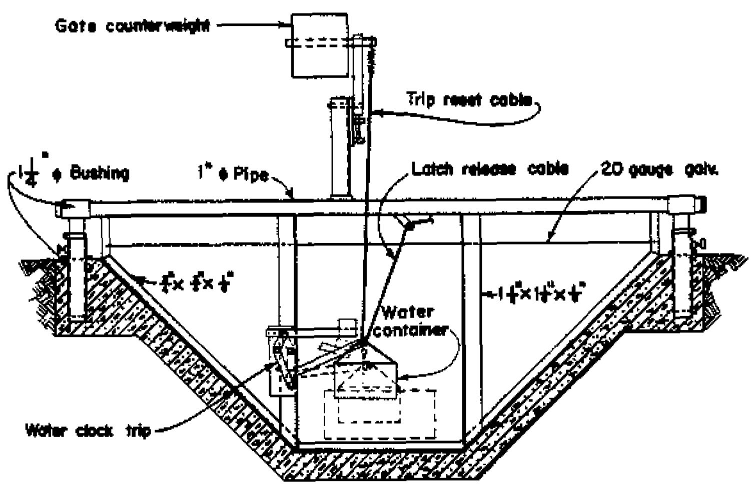

Fig. 5. Rear view of basic gate with water clock tripping mechanism.

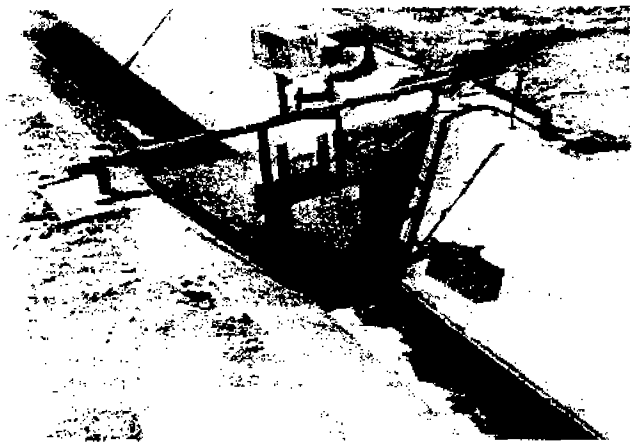

Fig. 6. Basic gate with float-operated tripping mechanism and a sinking float border outlet gate.

This structure has been field tested in combination with a sinking float-controlled border outlet gate to be described later. The outlet gate allows water to pass from the ditch onto the field for a given length of time, after which it closes. When it closes, the water level in the ditch rises until the float-controlled check gate trips. This type of installation is fully automatic since the check gate resets itself when water is removed from the ditch. The float-operated gate may also be used at the entrance to a waste channel as a safety structure. It will allow water to escape in case of a flood or malfunction of another structure and thus prevent overtopping of the ditch.

Electrically Controlled Gate. The basic check gate may be fitted with an electric solenoid, latch and trip as shown in Figure 7. The tripping mechanism

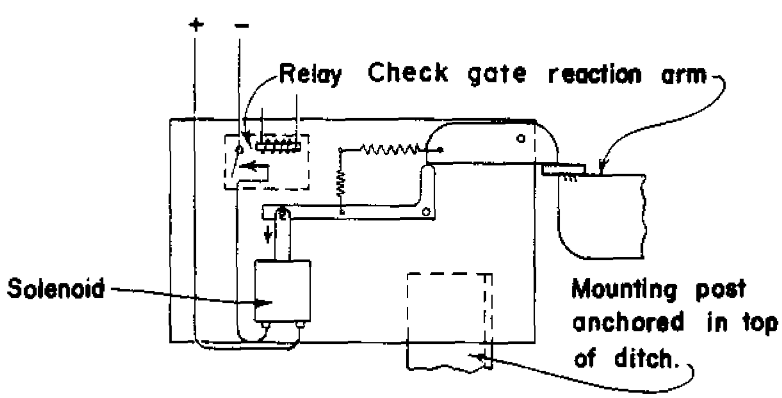

Fig. 7. Electric solenoid latch and trip mechanism for use with basic gate.

as shown in Figure 9. Unlike the movable counterweight, the fixed weight is sufficient to offset the weight of the gate. Therefore, a stop is required to limit the amount of gate rotation when it opens. Otherwise, the gate would rotate until the counterweight was in a vertically downward position in the ditch.

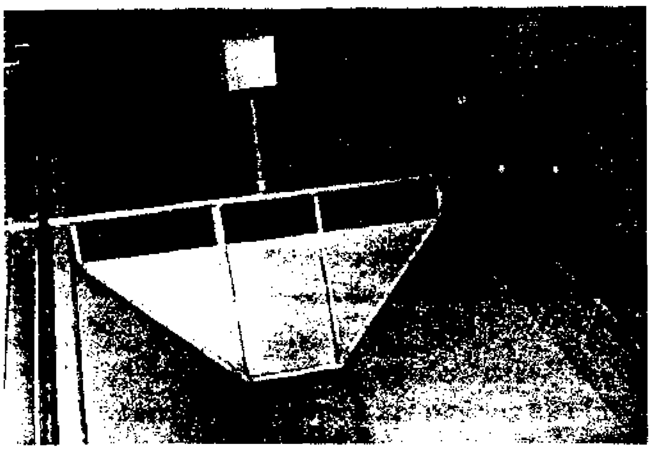

Fig. 9. Timer-operated gate. The timing mechanism is mounted at the end of the reaction arm.

Fig. 10. Basic gate with a sinking float-operated bypass section. The sinking float is connected directly to the bypass gate.

Suitable mechanical timers for this gate have not been available commercially. The available ones have been modified to fit the need. Availability of automatic resetting timers would make operation of this gate fully automatic.

Basic Gate With a Sinking Float Bypass. Another possible modification of the basic structure is the addition of a sinking float-controlled overflow section. This allows a portion of the water to bypass the gate at some predetermined time before the gate opens. This can be used to achieve a cutback flow for furrow irrigation. A model of this gate has been built, Figure 10, but little experimental work has been done and further development is needed.

Sinking Float-Type Structures

Several structures using the sinking float principle have been developed and experimentally tested in the field. A schematic illustration of the sinking float principle is shown in Figure 11. The float, which may be a part of the gate, is designed for the particular structure on which it is used. In operation, the float initially adds buoyancy to the gate or structure to which it is attached. Water is admitted into the float chamber at a controlled rate and causes it to sink. When the float sinks, the structure closes by its own weight, or its weight in combination with the pressure of water in the ditch. The length of irrigation is controlled by the length of time necessary for the float to sink.

The float is provided with a water inlet near the bottom and an air escape port at the top. A small control valve may be placed at either opening. It is usually preferable to place it on the air escape port where it will not clog as readily. This also allows the water inlet opening to be made large for ease in flushing sediment deposits from the float. Water entering the float is then controlled by the rate at which air is allowed to escape. In some cases, it is desirable to attach a tube to the air escape, as shown in Figure 11, to keep the port above water as the float sinks. The control valve, when placed on the end of this tube, always remains above the water surface.

The differential pressure between the inside and outside of the float is determined by the amount that the float sinks into the water when buoyant and may be changed by altering the shape of the float. This pressure differential causing the float to sink decreases as the structure becomes submerged since the submerged weight is less than that in air. Thus, the float sinks at a slightly decreasing rate with time. When the buoyant force on the float equals the weight of the structure, the structure closes rapidly. It remains closed while water is in the ditch, since the float cannot drain. When water is turned from the ditch, the float automatically drains through the water inlet opening near the bottom and thus becomes ready for the next irrigation.

Different types of valves have been used to control the rate at which the float sinks. Difficulty was experienced when small valves were placed at the bottom opening to control water entry. It was difficult to maintain a constant flow rate and the valves were easily clogged by sediment. When the control valve was placed on the air escape port some difficulty was also experienced in maintaining a constant flow rate at extremely small valve openings. Small stainless steel hypodermic needle tubing of various diameters and lengths has been successfully used in place of the valve to control the rate of air escape. Therefore, when the float differential pressure is very small it may be advisable to use a constricted opening formed by stainless steel tubing. Further development is necessary to calibrate small diameter flow tubes of various sizes and at different pressures. Moisture condensation in the flow tubes may be a problem in some areas and needs investigation.

Sinking Float-Operated Border Gate. A sinking float border gate was designed for use with other companion structures. It is used primarily at individual turnouts where structures are needed to prevent water from running onto the field from several turnouts simultaneously. In operation, the gate opens when water in the head ditch reaches a depth sufficient to give buoyancy to it. It remains open for a time and then automatically closes and remains closed while water remains in the ditch. The structure is made similar to a Tainter gate with a float mounted on or constructed integral with the front portion of the gate as shown in Figure 12. Sealing and friction problems may be reduced if it is made for installation in a trapezoidal outlet. The sinking float is fitted with a water inlet opening on the bottom and a controlled opening at the top. Water enters the float at a controlled rate as described above. When the gate loses buoyancy it automatically closes by its own weight.

When the irrigation ditch is emptied, water drains from the float and the gate becomes ready for the next irrigation. This particular border inlet gate was designed for use with a float-operated check gate previously described. The two companion structures working together form a completely automatic turnout into a border or field irrigated by furrows from an equalizing basin. This structure combination is very dependable and trouble free. Once installed in a properly designed system, it virtually eliminates the labor of irrigating.

Other gates of similar construction but without the controlled timing feature have been patented (Danel, 1940; Laszlo, 1955; Ponsar, 1958; and Hill, 1961). Before being manufactured for commercial sale one would have to determine if a license would be required from these patent holders. A public patent (Humpherys, 1965a) describing some sinking float structures does not have precedence over the above patents for this particular gate.

Turnout Openings. Another application of the sinking float is for use on small turnout openings. The float may be attached to a slide gate as shown in Figure 13. The development of this variation has not been pursued and further development is needed.

Paddle Wheel Type Turnout. A novel application for the sinking float is shown in Figure 15 where it is used in connection with a paddle wheel type border outlet. The paddle wheel is fitted with two floats, one of which is a sinking float. The sinking float makes possible the automatic diversion of water from the ditch for a given period of time. When water is first turned into the ditch, the conventional float releases a trip and allows the paddle wheel to rotate 270°, permitting water to flow onto the field. After opening, the sinking float begins timing the irrigation period. When it sinks, a trip is released which allows the paddle wheel to complete its full rotation cycle to the closed position. The gate then remains closed and prevents water from flowing onto the field throughout the remainder of the irrigation. When water is turned from the ditch, both floats become reset so that the paddle wheel is ready to begin operation with the next irrigation. An experimental model of this structure has been built but it has not been developed further.

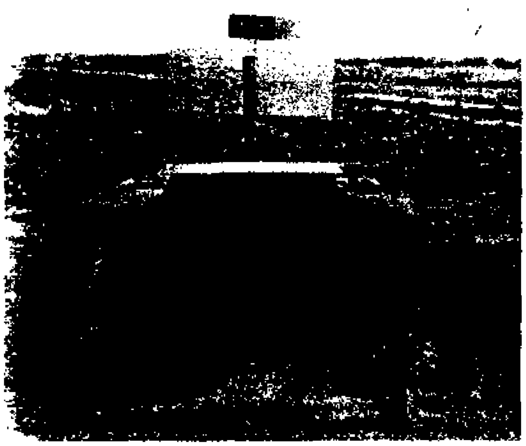

Fig. 15. Paddle-wheel border outlet gate with sinking float timer and trip mechanism.

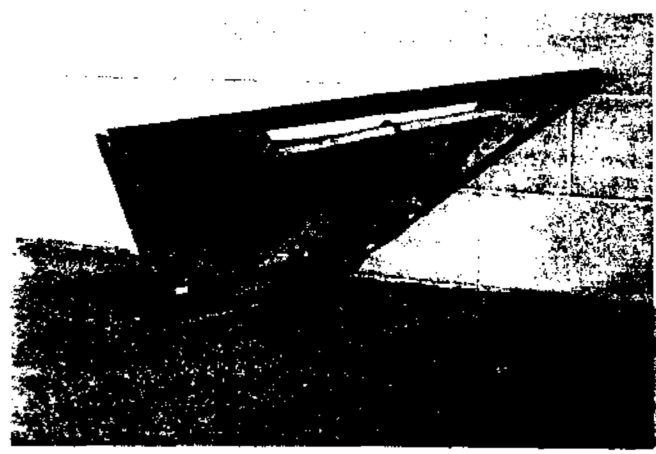

Fig. 16. Rear view of trapezoidal, center-of-pressure gate. Return spring tension is adjustable and provides for low-pressure buried pipelines.

Center of Pressure Gate

A gate using the principle of hydrostatic distribution and the resultant center of pressure for tripping is shown in Figure 16. The pivotal axis is placed at the lower quarter point. Thus, when the water level on the upstream side of the gate rises to a height where the center of pressure is above this axis, the gate automatically opens. This gate is well adapted for use with irrigated basins or as a companion check structure to other gates which create an incremental rise in the water surface needed for tripping, such as, the sinking float border outlet gate. Both rectangular and trapezoidal gates have been used.

These structures are self-closing. A spring returns the gate to the upright position when water ceases to flow across it. The gate, however, remains open as long as water is flowing. It is sealed against leakage by a rubber strip attached to the frame above the pivot axis and to the gate below this axis. Timers can be used for control. This gate has been used with timers in the Montana State University radio-controlled system.

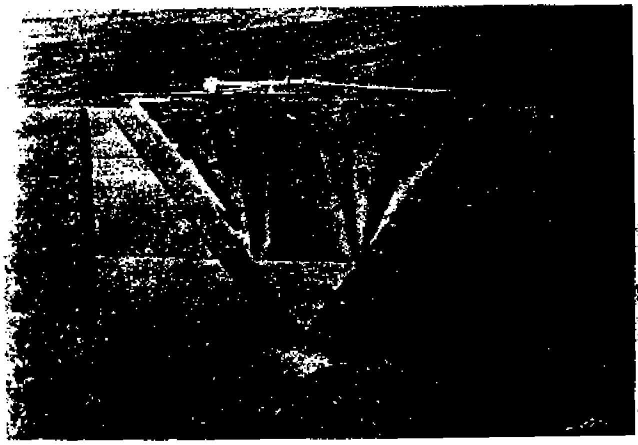

Fig. 19. Drawstring check gate mounted on a redwood frame. The timer is preset and is float-actuated.

Drawstring-Type Gates on Cutoff Walls. Figure 19 shows a butyl drawstring-type structure mounted on a redwood cutoff wall. Other drawstring curtain wall dams have been mounted on metal and precast concrete cutoff walls. These are operating satisfactorily and provide a relatively simple and economical structure for unlined ditches.

Fig. 20. Portable drawstring-type check dam in operation.

Portable Drawstring Dam. Another variation of the drawstring-type structure is shown in Figure 20. This is a large portable type which is used in the same manner as the conventional irrigation dam. It was designed for stream flows up to 5 or 6 cfs. To operate satisfactorily, the upstream edge of the dam needs to be buried or otherwise firmly anchored each time the dam is used.

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APPENDIX

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