District Pipe Systems

concrete irrigation systems compared in study of efficiency of open, closed, and semi-closed types

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Surging can be minimized in future designs in the open system of concrete pipe irrigation but the closed and semi-closed types—where surging is no problem—have much to offer.

The three types of water distribution system were compared with a view of the farmer's irrigation needs.

The systems used strictly for irrigation today are all of the open type.

Open System

In the open system pressure is kept within low limits—usually between six and 20 feet of water—by the installation of vertical open-top stands at periodical intervals.

When changes in delivery are needed, flow is adjusted at the uppermost portion of the system, and followed downstream, adjustments being made at each station along the line. At the downstream end of each branch, any excess flow is wasted until steps can be retraced and further adjustments made.

To prevent pressures within a farmer's system from affecting delivery, an overflow type delivery structure is used. These are required on the steeper slopes, and where delivery must be made at different portions of the system at one time.

The open system has many apparent advantages. Deliveries do not appreciably affect pressures in the distribution system, nor are they generally subject to fluctuations from such pressures. There is no dependence on mechanical devices, and there is no hammer problem.

The difficulties in the open system involve the entrainment of air in the overpour portion of the overflow stands, possibly resulting in surging. Placing a gate valve in the baffle of each overflow stand—B in the diagram below—may solve the difficulty but at least partially negates the regulating effect of the overflow stands because change in delivery at any point will affect deliveries up and down the entire system. The principal advantage of the overflow stand with gate valve—B in the diagram below—over a simple stand with gate valve—E in the diagram—is that any overflow returns to the line and is neither immediately wasted nor does it flood an area around the stand. However, a small flow, sufficient for regulation, often can be allowed to spill over the baffle without causing surges, and air entrainment does not always lead to surging.

Closed System

In a closed system the full flow is always available at every delivery gate as soon as opened, as with the domestic water system. Existing systems serve combined domestic, industrial, fire protection and irrigation needs. Overloading is prevented by enforcing a rotation system for irrigation, or serving on demand after previous conflicting demands have been satisfied.

Because deliveries are planned and pressures are relatively high, delivery rates are generally satisfactory to the farmer.

Operating efficiency of a closed system, the convenience to farmers during off-peak demand, the fire protection features, and waste protection make it an attractive method.

Chief disadvantages are that more steel is required in the pipe because of higher pressures, and precautions must be taken

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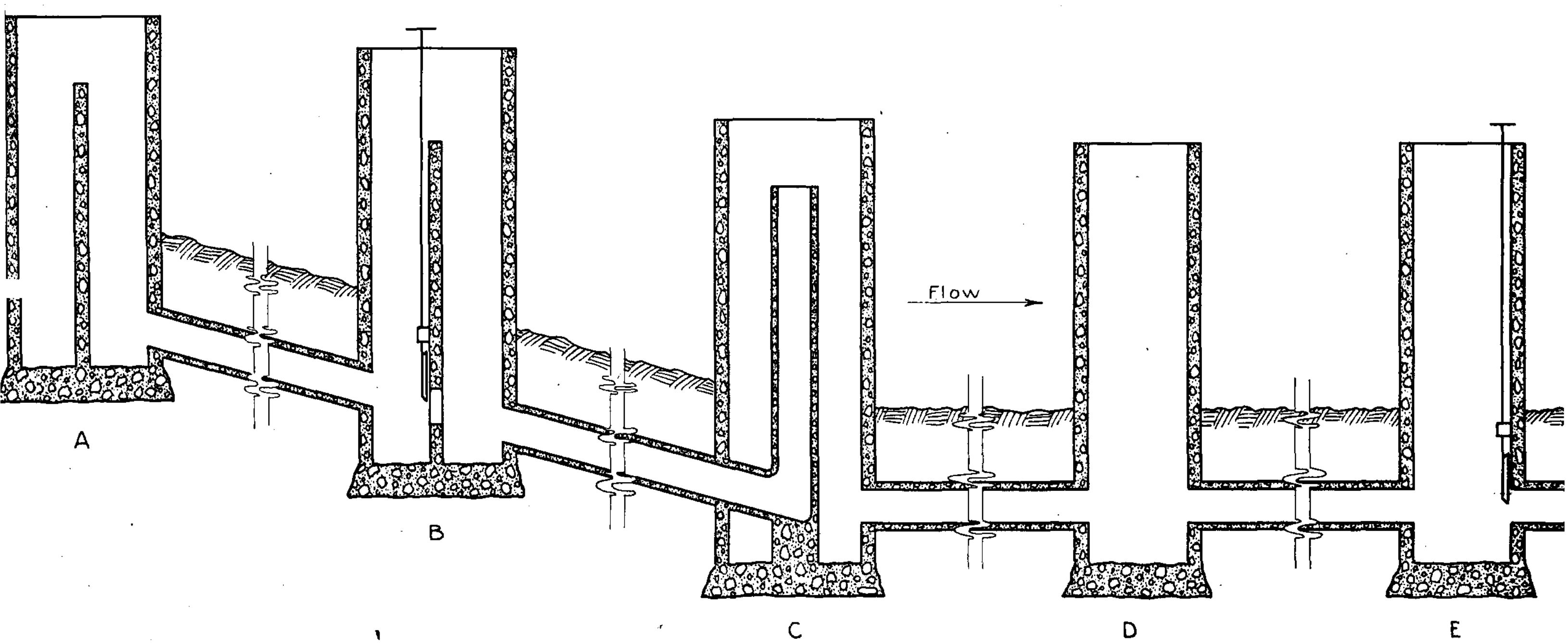

Portions of an open concrete pipe irrigation distribution system. Deliveries are at the upstream end of each stand. A is an overflow stand; B is an overflow stand with a gate in the baffle wall; C is an overflow stand consisting of a riser pipe within the larger stand; D is a simple stand; E is a simple stand with a gate over the outlet.

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to prevent water hammer. Also, it would not be feasible to use nonreinforced concrete pipe. The district systems tend to use reinforced pipe anyway—except in the smaller sizes—but this tendency seems not entirely justified unless advantage is taken of the reinforcing to move away from the open type design.

No large closed type system, strictly for irrigation, is available for study. Rough estimates for one area did not indicate a great difference in cost over an open system.

Semi-closed System

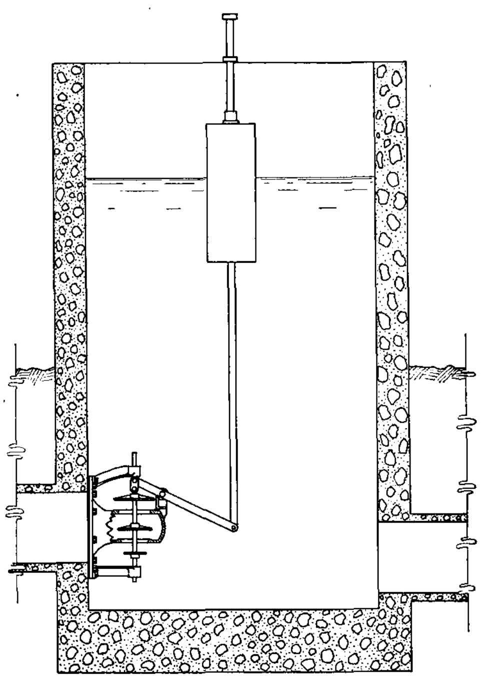
The semi-closed system combines features of both the open and the closed systems by substituting float valves in stands for the overflow stands. Pressures are kept within the same range as for the open system; use of nonreinforced pipe is not excluded and present systems can be changed over. Pressure at each delivery is not significantly affected by changes elsewhere in the system. Any change is immediately and automatically adjusted all the way upstream to the open source. There is no waste at the lower end, and no provisions need to be made for waste.

Each float valve regulates the pressure downstream and lets pass only the amount required, as fixed by the water level in the stand. At full flow the valves are wide open, giving minimum loss of head. A balanced float valve is now in commercial production.

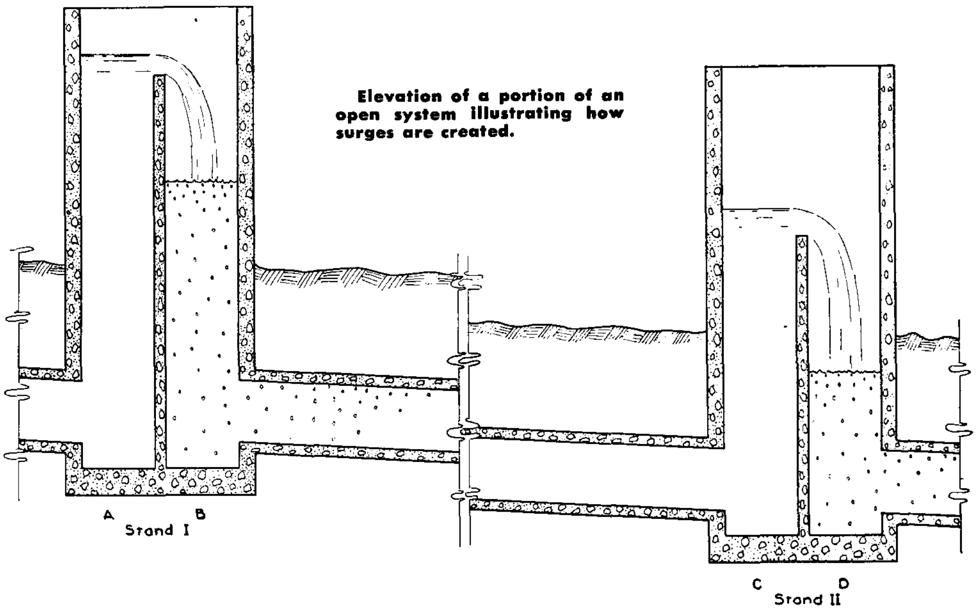
Principal objection to semi-closed systems is the danger of localized flooding around stands if something goes wrong with the float valve.

In the long run, there is no reason to believe semi-closed systems would be more expensive than the open type. One advantage is that on deliveries line meters and valves could be substituted for overflow structures without impairing the efficiency of the system. Provisions could be made for the farmer to shut off and cut down the flow himself provided there is some canal or reservoir storage upstream. There is no possibility of air entrainment in the system.

No semi-closed system is known to exist on a district basis but many are used on farms. To observe cost and efficiency of operation, at least one experimental semi-closed lateral should be constructed.



A float valve stand as used on semiclosed systems.



Elevation of a portion of an open system illustrating how surges are created.

Surges in Open Systems

Conditions were observed under which surge occurred in an open, recently constructed, system.

When surge occurs, air—as many small bubbles—is entrained in the water flowing over the baffle of stand I as illustrated in the diagram in columns two and three, and is carried into the pipe line. The grade of the pipe may be too flat for the air to collect at the top of the pipe and to flow back to the stand. Air coming to the top is re-entrained, and carried on. After a short interval the upper portion of B and adjacent pipe line becomes a mixed flow of air and water. The specific gravity is effectively lowered, causing a reversal of hydraulic gradient and flow from the lower stand II to the higher stand I. The level in B rises and air clears from the water. The level in B then drops and gradient returns to normal.

A complete cycle of gradients on the installations ranged from 50 to 75 seconds. In no place was air carried clear through a reach between stands but this observation is too limited to be conclusive.

The studies showed that vents downstream from the stand in which surging occurred had no significant effect.

At many stands air appeared to blow back continuously, and no surge trouble was experienced. This seemed to be related to the grade of the pipe. Where the grade was steep enough the air moved back along the crown of the pipe, and there was no surging. Whether the air would move upstream should depend on pipe roughness, grade and water velocity.

The amount of air carried into a pipe appeared to be related to the depth of the water above the pipe and the downward velocity which in turn is related to the cross-sectional area of the downstream portion of the stand.

These suggestions might minimize surging: *1.* Steepening the initial reaches of pipe downstream from a stand as much as possible to the extent that entrained air can blow back upstream. *2.* Enlarging the cross-sectional area of the downstream portion of the overflow stands.

In some cases surge seemed to build up gradually from stand to stand. In other cases complete stoppage of flow occurred during each cycle so there was nothing further to build up except to impose one cycle above another. In this case correction at the stand causing trouble is no insurance that future surges will not originate in downstream stands.

More trouble was observed at low than at high flows. The question might be raised whether there will be trouble at peak flow, assuming peak flow can be attained despite the surging, but all systems through a good part of the season are run at less than capacity.

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