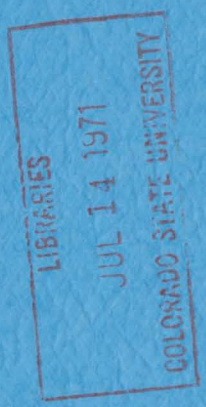
NATIONAL IRRIGATION SYMPOSIUM PAPERS

INDUSTRY INVOLVEMENT IN AUTOMATED SURFACE IRRIGATION SYSTEMS

By

E. G. Kruse



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INDUSTRY INVOLVEMENT IN AUTOMATED SURFACE IRRIGATION SYSTEMS

E. G. Kruse

Preceding papers have described many of the existing types of automatic surface irrigation systems. Most of the early versions of these systems were developed under the auspices of state or federal research agencies. More recently industry has become involved, in varying degrees, in the development, manufacture, promotion and sales of components or of complete automated systems. At the present time gates, valves, gate actuators, programmed controllers, safety switches and warning devices are among the products commercially produced specifically for application to automated surface systems.

The following sections describe several of the major areas of industry participation in the surface automation field.

Hydraulic Valves and Cylinders

Hydraulic pressure provides one means of transmitting power and signals from controllers to gates and valves in an automated irrigation system. Commercially available controls for open ditch irrigation include hydraulic cylinders and valves. Furrow irrigation can be automated with hydraulically controlled pipe gates. For both open ditch and gated pipe, remote and automatic controllers are available for either manual, remote control or fully automatic control of irrigation water.

A hydraulic, differential, double-acting cylinder has been developed that is unique in that it permits two-way operation of a cylinder with a three-way valve instead of the usual four-way valve. This cylinder has been used to control turn-out gates, drop gates and check gates in open ditch irrigation. Installations have been made in Yuma, Arizona; Brawley, California and Hawaii. The Yuma and Brawley installations are operated with rotary, three-way, eleven station controllers. The Hawaiian installation is operated with Japanese time clocks giving a semiautomatic operation.

A remote control pipe gate was invented by "Bud" Payne of the USDA office in Fort Collins and further developed for commercial production. Hydraulic water pressure is used to open and close sets of gates by remote control. Installations have been operated for the past two seasons at Mead and Scottsbluff, Nebraska, and for one season at Redfield, South Dakota. Designs using portable surface pipe or permanent buried pipe can be employed.

Available controllers present considerable versatility in system design. They can use water, air or electricity as the control medium. Automatic timing of irrigation sets from a few minutes to 24 hours is possible. Pedestal and wall mount models are available.

Construction of the above products using injection molded plastic components has the advantages of:

- -- Versatile design
- -- Low initial cost
- -- Easy installation
- -- Minimum maintenance
- -- Dependable service

All of the above products are in production. Limited quantities of equipment are available to educational and research organizations for approved projects. Distributorships and dealerships are also available.

Novel Fluidic Concepts for Automated Irrigation

This paper describes three novel concepts for the automation of surface irrigation systems. These concepts employ fluidics to implement the switching and/or timing logic necessary to regulate the total water flow. The first concept is completely fluidic in nature; the second adapts fluidics to an otherwise conventional method of irrigation--the siphon. The third concept deals with a new approach to gated-pipe irrigation systems. All of these concepts are potentially producible at attractive per/acre costs, although none are currently in production. The concepts presented have a common characteristic in that no auxiliary energy is required for their functioning except that available in the irrigation water flow. If desired, however, these concepts can readily be adapted to triggering by electrical impulses. The required energy of these electrical impulses is surprisingly low so that simple, low-cost, low-power radio or hard-wire telemetry can provide excellent control.

The first concept consists of a series of large fluidic diverters, which sequentially irrigate growing areas, using either "fill" logic, as shown in Fig. 1, in which irrigation flow is switched out of a particular growing area when the water reaches a predetermined level; or "time" logic, as shown in Fig. 2, in which a specific time interval of irrigation flow is established by a simple water timer.

The second concept involves the automatic control of conventional agricultural siphons using small fluidic diverters, as shown in Fig. 3. With this arrangement, crop areas along a lateral ditch may be automatically sequentially irrigated.

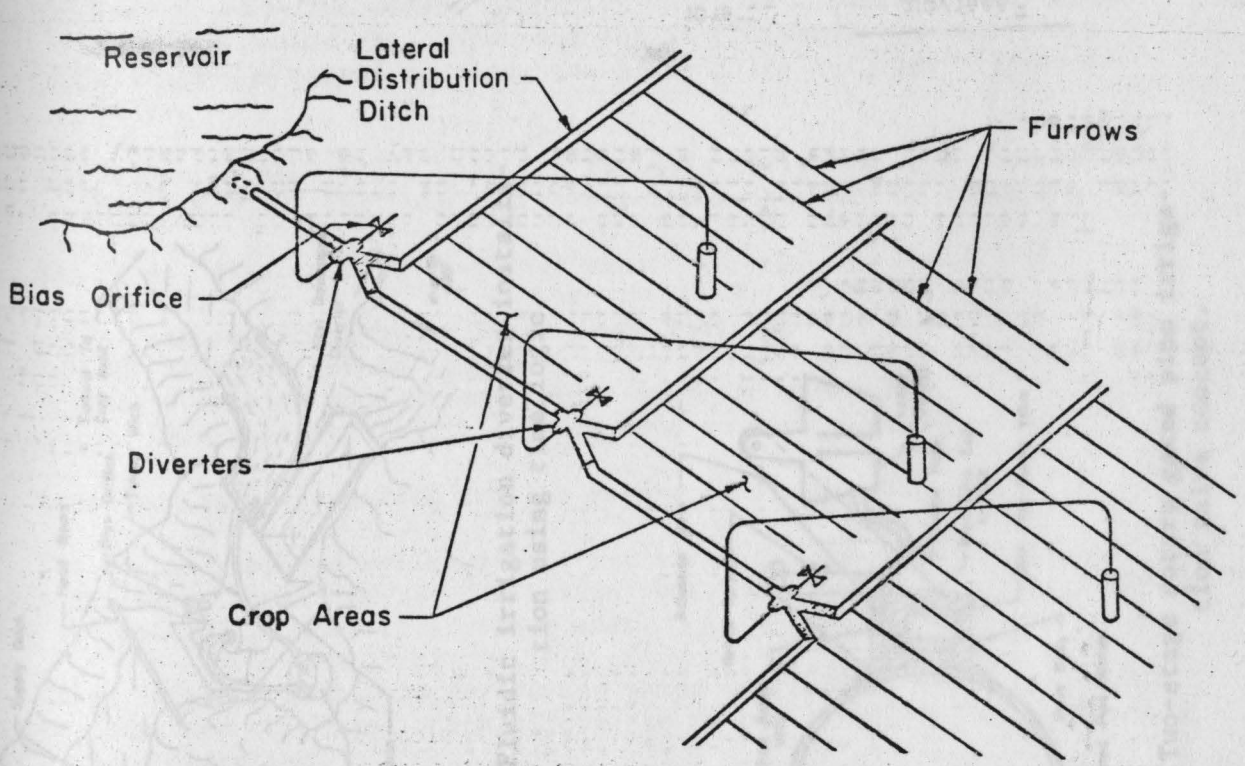

Fig. 1. High slope fluidic automatic irrigation system.

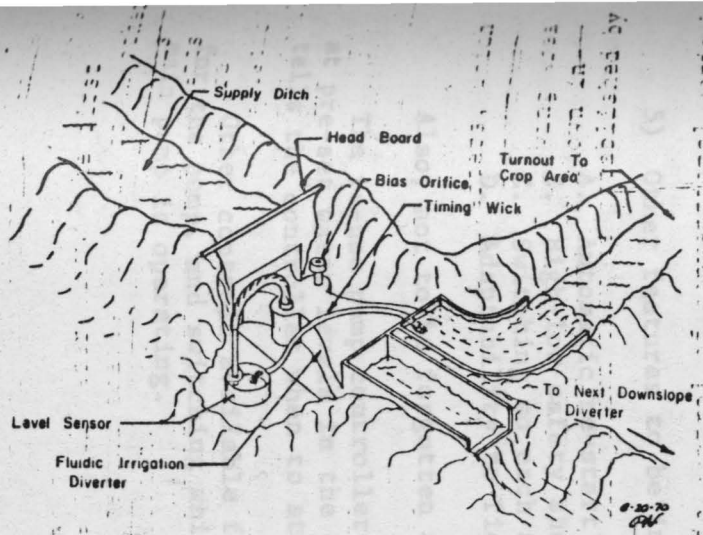

Fig. 2. Fluidic irrigation diverter installation using time logic.

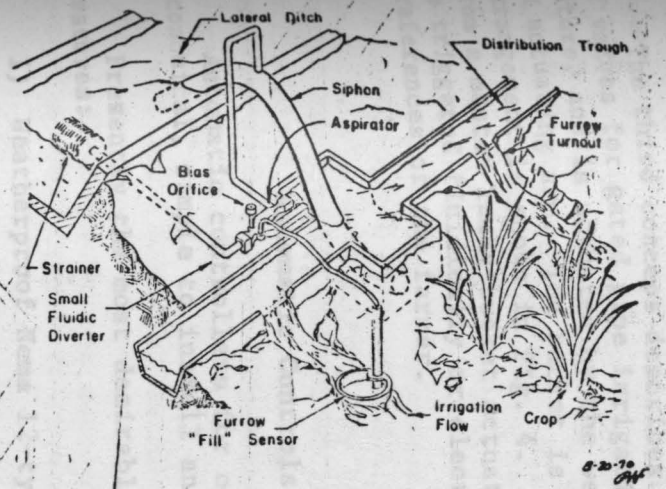

Fig. 3. Fluidic automatic irrigation siphon controller.

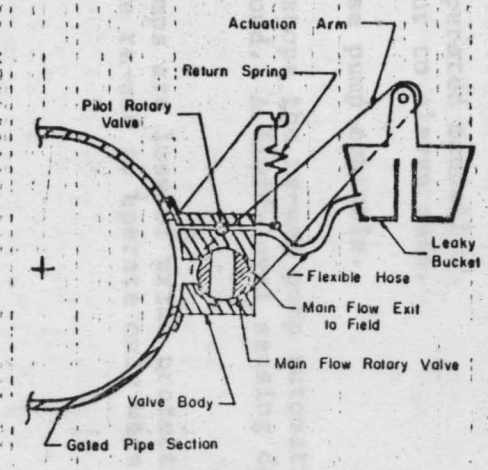

Fig. 4. Two-stage rotary gated pipe irrigation valve concept.

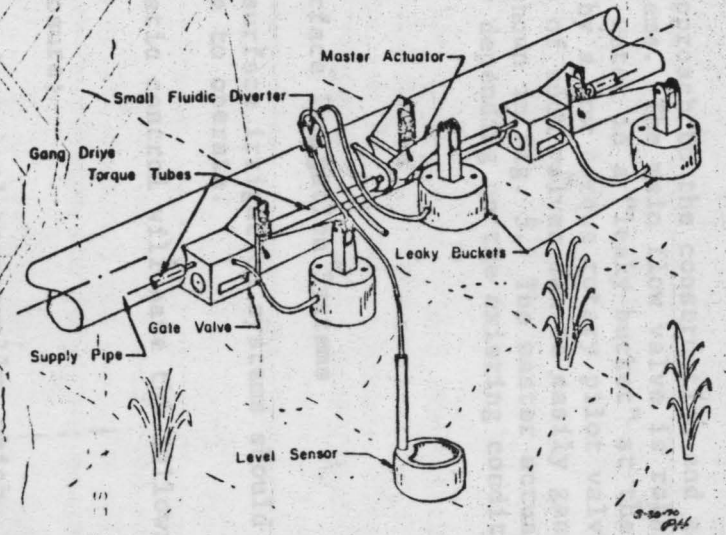

Fig. 5. Automated gated pipe irrigation system using two-stage rotary valves.

The third concept describes a new approach to the construction and actuation of valves for gated pipe irrigation systems. The main flow valve is rotary in nature, and is actuated by the weight of water in a "leaky bucket" at the end of an actuating arm. The bucket is filled by a low torque rotary pilot valve. This arrangement is shown in Fig. 4. A group of such valves can be easily gang-driven from a master leaky-bucket actuator as shown in Fig. 5. The master actuator can be triggered fluidically or electrically depending on the existing conditions and preferences of the farmer.

Automatic Controls for Surface Irrigation Systems

Automatic controllers for on-farm surface irrigation systems should be economical, simple to install and simple to operate.

Presently the most desirable automatic control will have the following features:

1) Weatherproof Nema 12-type enclosure;

2) Manual start-up. The controller is turned on manually, which automatically opens valve # 1 for irrigation set # 1. A pump start button is then pushed to start the pump.

3) Time Clock - The timing mechanism which is adjustable will time each irrigation set. When one set is finished, the time clock will give a signal to close the first valve and open the second valve.

4) Automatic Shut-Off - When the field is irrigated, the controller will turn off the pump and re-set the controller to valve # 1.

5) Other features to be included are:

   A. Automatic re-start after power failure;
   B. High-low safety shutdown;
   C. Switching so each set can be operated manually;
   D. Adaptability to fields with four to eleven sets.

Also, not to be forgotten are the re-use pump controls.

The re-use pump controller starts and stops the re-use pump automatically at pre-set water levels in the collection pond. A fluid level sensing device tells the controller when to start or stop.

Other controls available for re-use pumps are loss of prime protection for the pump, and switching which allows the re-use to operate only when the main pump is operating.

Measurement and Control for Water Distribution Systems

Control of water has become more essential to man than ever before. Automatic controls can provide you with economical means of operating water distribution systems. The control equipment can be all electronic and many of the calculations are performed by integrated circuits. This type of circuitry gives you the same type of reliability the astronauts had on their moon trips.

Water level can be measured with a T66 transmitter. This transmitter converts water level by means of a float, tape and counter weight to an electrical signal. The output signal may be used for control and/or telemetry. The reliability is enhanced by the use of corrosion resistant materials throughout. The sensitivity and overall accuracy are ± .1%. This provides you with a ± .01 foot out of 10 foot range. With a reliable water level measurement, the next step is control.

The first example of automatic control to be discussed is level control. A water level is compared to a set point. If a difference exists, the controller will calculate the proper amount of gate action required and move the gate by means of a motor operator. The controller calculates the following equation:

$$\Delta d = A\Delta L + B \int_0^{\infty} \Delta L dt$$

Δd: Gate movement in seconds

ΔL: Difference between water level and set point

A & B: Constants based on your site parameters.

Flow calculations and flow control are the second example. The T66 level transmitter is used again to provide inputs for water levels and gate or valve positions. The AC-70 flow computer can be programmed to your equations. Many equations are available for hydraulic structures. The calculations are all accomplished electronically. The equation for a Parshall flume $Q = CH^{1.6}$ requires only one level measurement. The flow equation $Q = AC\sqrt{2gh}$ requires two level measurements and a gate position measurement. The output of the flow computer can be 10V@ 5 ma representing full scale. This output signal could also be integrated to provide a total acre-foot reading. The 664-1B will now compare the flow set point to the actual calculated flow and adjust the gate or valve to maintain your desired flow using the same equation previously discussed.

Open and closed systems may be controlled with a C64-1B controller. Flow calculations are accomplished with an AC-70 computer for either open or closed systems. Outputs are available from all the equipment for telemetry to your decision making centers. All the circuitry is protected against the environment by sealing in selected epoxies. The instruments are designed to operate in your still well environments.

You may look to automatic control as a tool available to you for more beneficial and economical use of water.

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