

SECTION I, ENGINEERING SCIENCE

Automation of Irrigation for Conservation of Water and Labor

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The objectives of this research, an Oklahoma Agricultural Engineering Project, were to minimize the labor involved in furrow irrigation and to design means for accomplishing "cut-back" irrigation. "Automation" as used in industry has become virtually a new philosophy of manufacturing wherein man tries to transfer to machines many tedious control, decision-making, and data-processing activities. This research was an attempt to apply some of these principles to modern American agricultural irrigation.

Irrigation as commonly practiced requires a large amount of labor and results in non-uniform water application and avoidable losses. Water losses are due to ditch seepage, runoff from the field, and deep percolation below the crop root zone. These water losses are an unnecessary expense to the farmer.

A majority of the irrigated acres in this country are surface-irrigated. Many millions of acres are irrigated by the furrow method. Furrow irrigation has received considerable study over the last quarter of a century and methods have improved. The most notable of these is the "cut-back" method in which a large, but not erosive, initial stream is used to wet the furrow throughout its length. The furrow stream is then reduced to a flow equal to the intake rate of the soil for the length of furrow used. This method of irrigation improves the uniformity of application and reduces runoff losses. Unfortunately, it more than doubles an already high labor requirement and requires more skill. Therefore, this method has not received wide acceptance.

An analysis of the requirements for automation of cutback furrow irrigation revealed that one of the items needed was a different discharge tube to convey the water from the ditch to the furrow. This tube had to have a predictable discharge over a wide range of heads and especially at a low one. The hooded-inlet tube, simply a pipe sawed at 45 degrees with the projection at the top, is used for large-sized pipes, which serve as outlets for reservoirs and similar applications. Such tubes appeared to have merit as furrow tubes; however, the hydraulic relationships for short-tube flow with this type of device were unknown. The hydraulic relationships for outlet tubes of standard galvanized pipe were similarly determined.

Another requirement for automation of irrigation was gates that could be tripped automatically. The Idaho Agricultural Research Service has done considerable research on automated gates, so one of their gates was redesigned and adapted to fit our requirements.

Latching mechanisms tripped by solenoids were next designed. These were 110-volt units enclosed in metal boxes and using a third wire grounded electrical wiring system for safety from shock. A controller was designed using an electric time clock. After variable intervals of time, the electricity is turned on to the gates in sequence. Each solenoid is activated for about five seconds. The operator selects the time at which he wants individual gates to trip. This feature can compensate for unequal length rows or varying intake rates. The controller was connected to the solenoids by underground electrical cable.

Using the equipment developed, a 15-acre automated cutback irrigation system was installed on the Irrigation Research Station south of Altus, Oklahoma (Garton et al., 1964). The system has been in operation for two years. The cost of the system, excluding the automatic gates and controls, was an estimated \$75 per acre. The cost of the automated gates and control is unknown; but if they were commercially available, their cost would probably not exceed about \$25 per acre.

An earthen ditch used for siphon tube irrigation usually requires a man in constant attendance. On the basis of five irrigations per year and two man hours per acre per irrigation, the labor requirement would be ten hours per acre per year. If a cost of \$1.25 per hour for irrigation labor is used, the annual cost would be \$12.50 per acre for labor (exclusive of ditch building and maintenance costs). Using a 15-year expected life and 6% compound interest, the \$12.50 labor cost would justify an additional investment of \$121 per acre.

For a completely automated system, the labor requirement consists of closing five gates and pulling out the tabs on a time clock. For a system with manually removed check dams, the labor consists of inserting and removing five sheet-metal check dams. Either system has a very small labor requirement. Whether a fully automated system is justified in preference to one with manual dams depends on the value one places on convenience.

The design of this type of system involves some unknowns because the hydraulics of spatially varied flow have not been developed completely. A computer analysis of the problem has been made (Garton and Mink, unpublished) and pertinent values of the coefficients are currently being determined.

SUMMARY

Present methods of furrow irrigation are primitive when compared to the systems which can be built using the existing technology. A 15-acre system of automated cut-back furrow irrigation has been designed, built, and operated for two years at the Irrigation Research Station at Altus, Oklahoma. The labor requirement of the automated system is a negligible amount (about one minute per acre per irrigation).

The hydraulics of these systems are not completely understood, but are currently being studied.

As in factory automation, the decrease in total labor required will be accompanied by an increase in the skills level required. No labor will be required for starting siphon tubes, but labor will be needed for installing and trouble-shooting electrical and mechanical devices.

These systems, if properly designed, apply water more uniformly with reduced losses.

These systems divorce the decision of whether or not to make an application of irrigation water from reliance on the availability of an expensive and unpredictable labor supply.

LITERATURE CITED

- Garton, James E., R. P. Beasley, and A. D. Barefoot. 1964. Automation of cut-back furrow irrigation. *Agri. Engin.* 45 (6): 328-329.
- Garton, James E. and Albert L. Mink. Spatially varied flow in an irrigation distribution ditch. Paper presented at the 1964 Winter Meeting of the American Society of Agricultural Engineers, New Orleans, Louisiana.