In 1980, the Micro computer was introduced to the automotive industry. This new device provided a significant improvement in the diagnostic and service capabilities of automotive vehicles. The microcomputer was designed to detect and record a variety of electrical and mechanical problems that could not be easily diagnosed using traditional methods. It was also capable of providing detailed information about the condition of the vehicle, allowing technicians to quickly identify and repair any issues.

The microcomputer was a revolutionary development in the automotive industry, and it paved the way for further advancements in the field. With the introduction of the microcomputer, automotive manufacturers were able to improve the reliability and performance of their vehicles, and customers were able to enjoy a safer and more enjoyable driving experience.
could, of course, be used to operate two individual solenoids. Presently, the controller will not operate dual-polarity type pilot valves, but a simple change of the final output drivers would allow this because the voltages and signals are compatible.

The operator controls programming with three SPDT, center off, toggle switches, which give six independent switch closures. Extensive software definition of these switch closures provides adequate control functions while leaving the panel uncluttered and avoiding the intimidating array of switches that some of our earlier controllers had. A four-digit LCD display shows the present time of day, program prompts, recalled parameters and system status, as selected by the operator (see Fig. 1).

![Image of a single-station timer being used with a dual coil pilot valve to control a water-operated irrigation valve.](image)

**Fig. 1 Single-station timer being used with a dual coil pilot valve to control a water-operated irrigation valve.**

**Software Design**

This controller was designed to be mid-range between a research tool in which every parameter is independently programmable, and an abuser-friendly unit that could be operated with almost no operator instruction.

The original software contained three different, rudimentary programs: simple on-off operation, automatic cutback mode, and surge irrigation control. The processor interrogates the location of a jumper on the circuit board to determine which program to run. Most program operations are contained in subroutines, called by the selected program.

It has become apparent that the on-off and cutback functions can be obtained by proper programming of the surge mode, therefore, these functions will be deleted in future models in favor of more operator-responsive input design. Only programming of the surge mode is detailed below.

The PROGRAM switch readies the controller to accept control data; if held closed more than 3 seconds, the function switches to RECALL of previously entered data. The STATUS switch calls for a display of what valves are open, and what cycle of surge is being timed presently. Held closed, the STATUS switch calls the MANUAL routine, which allows the operator to open and close selected valves. The STEP switch steps the program quickly to the desired parameter in the PROGRAM, RECALL or STATUS modes. The RESTART switch terminates any subroutine and returns control to the main program.

The HOURS and MINUTES switches increment these parameters, or the date and number of cycles. Holding either switch closed for more than three seconds advances the display at about two digits/second.

To program the controller, the operator selects PROGRAM mode, then enters parameters in the following order:

1. Present date (Julian or day of month),
2. Present time (24-hour format),
3. Date controller is to operate,
4. Time when first cycle is to start,
5. Duration of first surge cycle,
6. Surge cycle incremental time (00hr 00min to 23hr 59min),
7. Number of surge cycles (0 to 99),
8. Duration of post-irrigation.

To change any parameter, the PROGRAM mode and STEP switch bring the controller to the desired input, then changes are made as in initial programming. The controller will not act on out-of-range changes, such as altering the start time after the cycle is started, or changing to a lower number of cycles if that number has been exceeded.

To repeat a previously programmed irrigation cycle, the operator closes the RESTART switch when the STATUS readout indicates end-of-cycle. The initial irrigation date must be corrected to be in the correct relation to the present date and the controller is ready to run.

The part of the operating program containing shut-down and interrupt servicing instructions is copied to RAM storage. Using these instructions, the processor powers-down the eight pages of ROM memory and goes into an idle state. A time-base or operator-initiated interrupt brings the processor out of idle to service the interrupt. These manipulations reduce the cycle time of the processor to a few milliseconds per minute, unless valves need to be switched. The combination of an idle processor, powered-down memory, low clock rate of 100 kHz, and CMOS technology reduces the total quiescent-state power drain below 15 milliwatts.

Several safeguards against improper operation are built into the software. Since all parameters have been programmed and displayed for operator selection, there is no chance of setting an out-of-range value. If all parameters have not been properly programmed, the controller will not function, preventing runaway. Upon exiting the MANUAL mode, the controller will reset the valves to their states before MANUAL operations were begun. If the controller is in a subroutine longer than about 45 seconds without an entry being made, it will time-out and return to the main program.

Future units will monitor the battery voltage and warn the operator to change batteries before they become too low. If high-frequency surge irrigation proves acceptable, the software will be modified to accept a number of surge cycles greater than 99.

The hardware-software interactions are interrupt-driven, so the controller will perform its programmed functions regardless of what routine it is running at the time. Clock update is transparent to the user's operation so time used in programming and monitoring does not interfere with the clock setting.

To prevent damage to the system during valve state changes, the controller will always open a valve as its first output cycle if there is a choice.
Since surge flow irrigation is still in its infancy, cycle frequency, ratio, timing and other operational parameters are not yet defined for different soils and field conditions. Cycle periods varying from as short as 8 seconds to greater than one hour have been used. For time periods less than about 4 or 5 minutes, individually controlled outlet gates on the distribution pipe may be more feasible because of the time lag in filling and emptying the gated distribution pipe each cycle. Individually controlled outlets, however, would be much more costly because of the large number of outlets involved and the communication lines required to interconnect each outlet. For cycle time periods of 4 to 5 minutes or greater, it would generally be more economical to use a single-station timer and a pipeline valve for each irrigation set. If used at only one station, one set of fresh batteries should be sufficient to power the timer for one irrigation season. If the timer were to be moved from one location to another, particularly with very short cycle periods, the batteries may have to be replaced during the season.

In addition to being used with air- and water-operated irrigation valves, the timer will be tested to operate diverter valves in a single-pipe irrigation system as shown in Fig. 3 and open channel gates and turnouts as shown in Figs. 4 and 5. For these latter applications, only one of the timer's output terminals will be used.

For commercial production, the timer would be installed in a covered watertight enclosure. The experimental units used to date were not assembled in this type enclosure but additional units for research purposes will be installed in gasketed plastic boxes. The LCD display will be shaded to prevent it from blacking out when exposed to the sun or high temperatures.

**Fig. 4** Solenoid-actuated trip on a drop gate in a lined ditch controlled by the single-station timer.

**Fig. 5** Combination turnout gate with a single-station timer. The solenoid trip on the left is actuated to begin irrigation while the one on the right is actuated to terminate irrigation.

**SUMMARY**

A single-station microprocessor-based irrigation timer/controller was developed to (1) serve as a simple on-off timer to open one irrigation gate or valve and close another simultaneously; (2) provide programming and
June 17-20, pp. 136-142


REFERENCES

It can also be used to control various types of power networks in power channels. The system is especially effective in open channels and can also be used with field-proven performance and reliability. It uses a combination of field-proven performance and reliability. It uses a combination of field-proven performance and reliability.