# Sprinkler controller

Watering large areas of market gardens can be a tedious business where limited water pressure restricts the number of sprinklers to one or two at the time. The automatic switching system described here enables a large number of sprinklers to be switched on in succession. It could also be used for watering lawns.

This project came about due to my interest and work in electronics, and through working on my father's potato farm. Several paddocks are out of reach of water pumped from our dam. Therefore, we must resort to using water from the street main which, at the best of times, will drive only one sprinkler. For years these paddocks have been watered in this fashion, which meant that, every two or three hours, someone had to go and shift the sprinkler. That is, until I came up with the idea of a portable sprinkler controller.

After some looking around, I found an electric solenoid valve ideal for the job and, after a lot of head scratching, came up with a circuit for controlling the taps. I built my project on a moveable platform, which I will describe later. The biggest benefit is that I am now able to water during the night, when there is maximum pressure and minimum evaporation.

The circuit is built on two printed circuit boards. One is a timer board which gives an output pulse every 1, 2, 2.5 or 3 hours, depending where S1 is set. The second board consists of 10 output transistors (500mA output current) which are sequentially switched each time a pulse is received from the timer board.

Each board is designed to take a 16-way edge connector with 0.1in spacing, such as is available from Dick Smith under catalogue number P2816. These are used to provide interconnection between the two boards, and also from each board to various external components. In the case of the timer board these include switches S1 and S2, and, for the control board, the solenoid valves, the two batteries, S3 etc.

## How it works

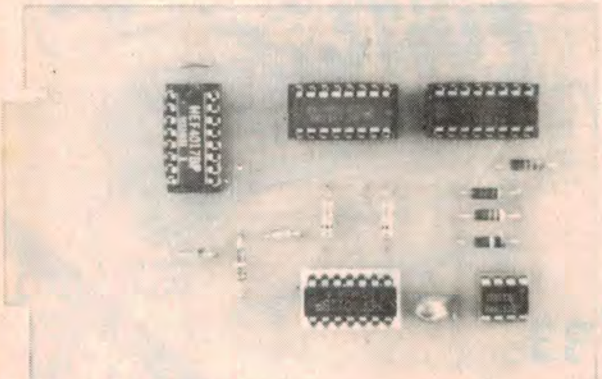
The timebase for the timer is an LM555 timer (IC1) operating at 5.5Hz. The 12kΩ timing resistor shown should give this time approximately, but may need to be modified to cope with any spread of the 10μF capacitor. Provision is made on the printed circuit board to add or substitute a trimpot if the timing is critical.

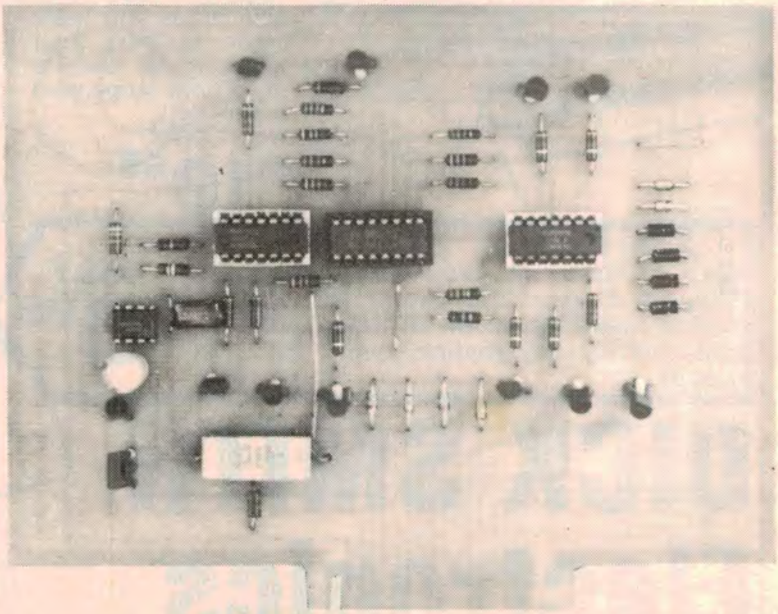
Following this are two 4518 dual decade counters (IC2-IC3) which divide the 5.5Hz 10,000 times, giving a negative going pulse at pin 14 (IC3) once every half hour. IC4 is a Johnson counter and is wired to divide the half hour pulses at its pin 13 by 2, 4, 5 or 6 to give a negative going pulse every 1, 2, 2.5 or 3 hours at pins 2, 7, 10, and 1 respectively.

Switch S1b selects whichever one of these pins is required for a particular time, while S1a is connected so each switch position is one stage of the Johnson counter ahead of S1b. For example, in position 1HR, a negative going pulse is delivered to pin 13 of IC6 after one hour. Simultaneously, position 1HR of S1a receives a positive going pulse which is fed to the reset pins of IC2, IC3 and IC4, and this resets all the counters to zero. Therefore, pin 13 (IC6) will receive another negative going pulse only after a further one hour. The 12kΩ resistor is used to keep the reset line down to the zero line during counting.

Switch S2, a pushbutton type, is used to reset all counting to zero when a new watering cycle is commenced.

When S2 is depressed, S2a sends a positive pulse to the reset lines of IC2, IC3 and IC4. Section S2b functions in conjunction with IC5, a 4011 quad 2-input NAND gate. Two of these are used as a flipflop, as shown, to send a pulse to pin 13 (IC6) when S2 is depressed. The flipflop is used to avoid contact bounce.





*THE TIMER board (above) delivers an output pulse every 1, 2, 2.5 or 3 hours, depending on the setting of S1. Note that the final version differs slightly from the prototype.*

*THE SPRINKLER CONTROLLER board (right) controls the 10 water sprinkler solenoids. Both PCBs plug into 16-way edge connectors and are easily removed from the case for servicing.*

# for vegetable gardens

## *Controls up to 10 outputs*

by L. J. VELLA

When S2 is depressed the flipflop output changes to 1. When it is released the output goes to zero. This negative pulse will move the output along one stage, and activate the first solenoid.

The output board is made up of several sections. Basically, it switches the 10 output solenoids sequentially each time pin 13 (IC6) receives a negative going pulse from the timer board. The heart of this board is another 4017 Johnson counter (IC6). This counter can be pulsed by either a positive or negative going pulse. In this case, pin 14 is held at the positive rail which enables pin 13 to be triggered by the negative pulses from the timer board. Pin 15 is held at zero to disable the reset function.

From IC6 the 10 outputs are connected to 10 two-stage amplifiers. The first stage consists of two LM3086 integrated circuits, each of which contains five low power NPN transistors. The second stage consists of 10 2N4356 transistors which are capable of 500mA collector current. Diodes D3-D12 are used to suppress any back EMF when the coils of the valves are turned off.

A useful optional addition to the circuit is a LED indicator connected across each solenoid to indicate which one is energised at any time. These can be fitted by connecting the commoned cathodes of the LEDs to the common solenoid rail via a 680Ω resistor. The anode of each LED is then connected to its respective active solenoid line.

### Richdel solenoid

The Richdel 204LG solenoid is made by Richdel Inc, Carson City, Nevada, USA. The units used by the author were purchased from Donald Dons and Son Pty Ltd, Baxter Rd, North Geelong, Victoria 3215. Phone (052) 78 8100. The price paid was $29.50 each. It should also be possible to purchase the solenoids from other large plumbing supply houses, so check suppliers in your town or city first.

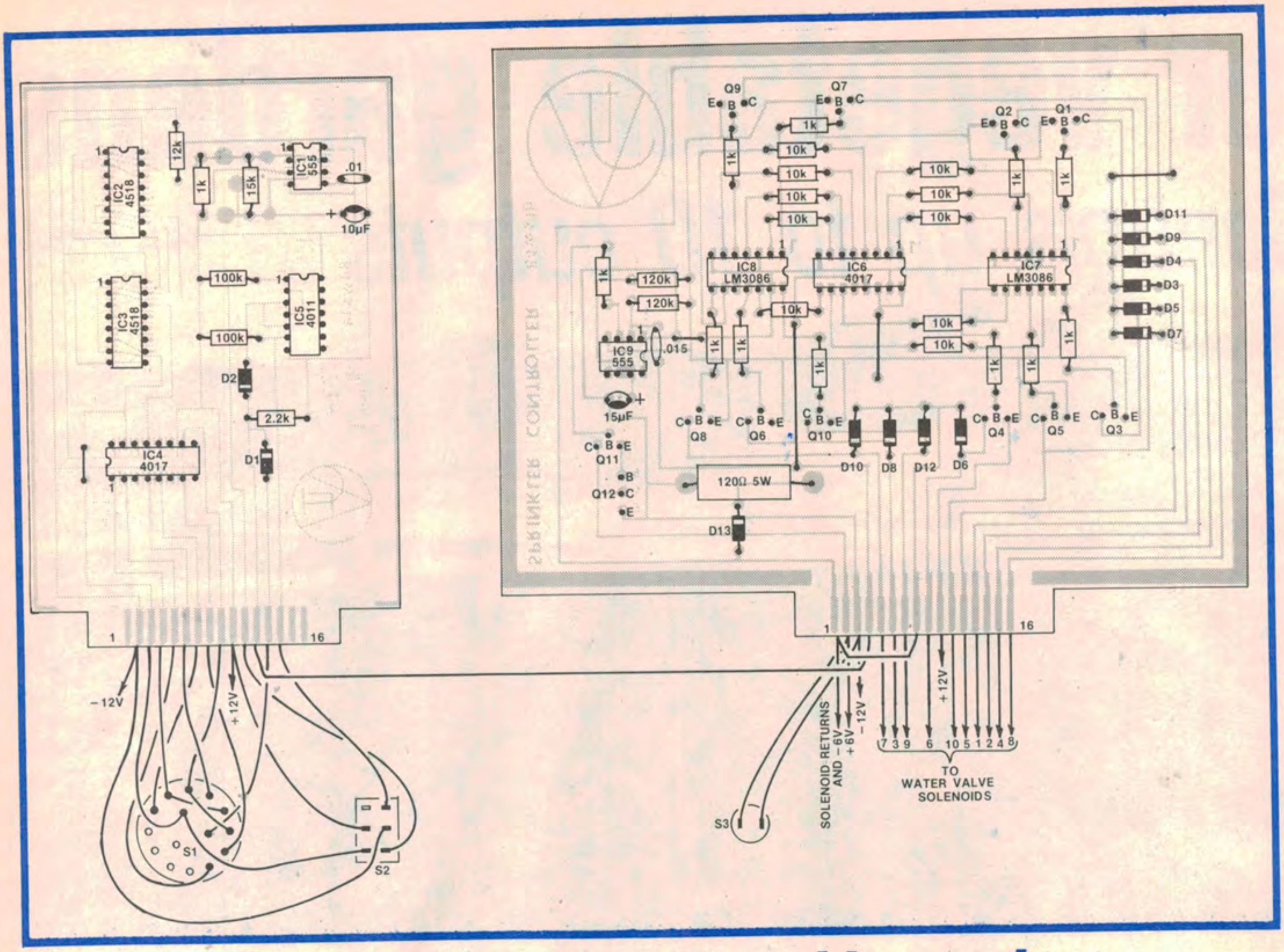
A problem that I encountered in my prototype was the pull-in current of the water solenoid coils. The water solenoids I used were Richdel R204LG which use a coil designed for 24V AC. In spite of the coil problem, I wanted to use these, as they were ideal mechanically for my project. They can be plumbed into 25mm piping, can control pressures up to 1000 pascals, with a flow rate of 160 litres per minute, and are relatively cheap. Another attraction was the low power requirements (5.7VA at 24V AC), thus avoiding the use of relays to switch heavy currents.

*The author's unit was mounted on a mobile platform which also carries the solenoids, the hoses and the 12V car battery.*

At 24V AC the pull-in current is 480mA, which then drops to about 200mA due to inductive reactance. But when used on DC (I used a 12V car battery for my supply) the resistance is 30 ohms which, at 12V DC, should draw 400mA. In practice (due to some losses) it draws only 320mA, which, in some circumstances, will not operate the armature.

To overcome this problem, I designed a circuit which connects a 6V Big Jim battery in series with the coils and 12V supply for two seconds. This gives, after losses, 15V across the coil, at a current of 500mA, which is more than enough to pull in the armature.

The circuit is quite simple. As each output turns on, a negative going pulse is fed to the trigger input of 555 timer IC9 via a .015μF capacitor. IC9 is configured

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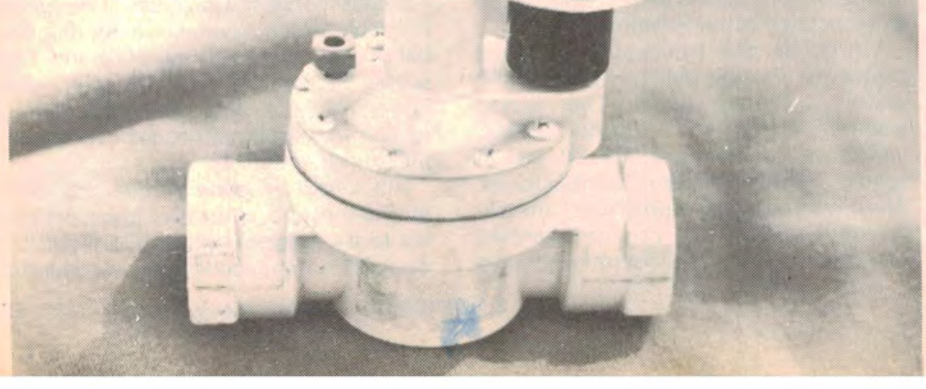
here as a monostable with a period of about two seconds. When its pin 3 output goes high, Q11 and Q12 turn on and connect the 6V supply in series with the output transistor selected, its associated solenoid and the 12V supply.

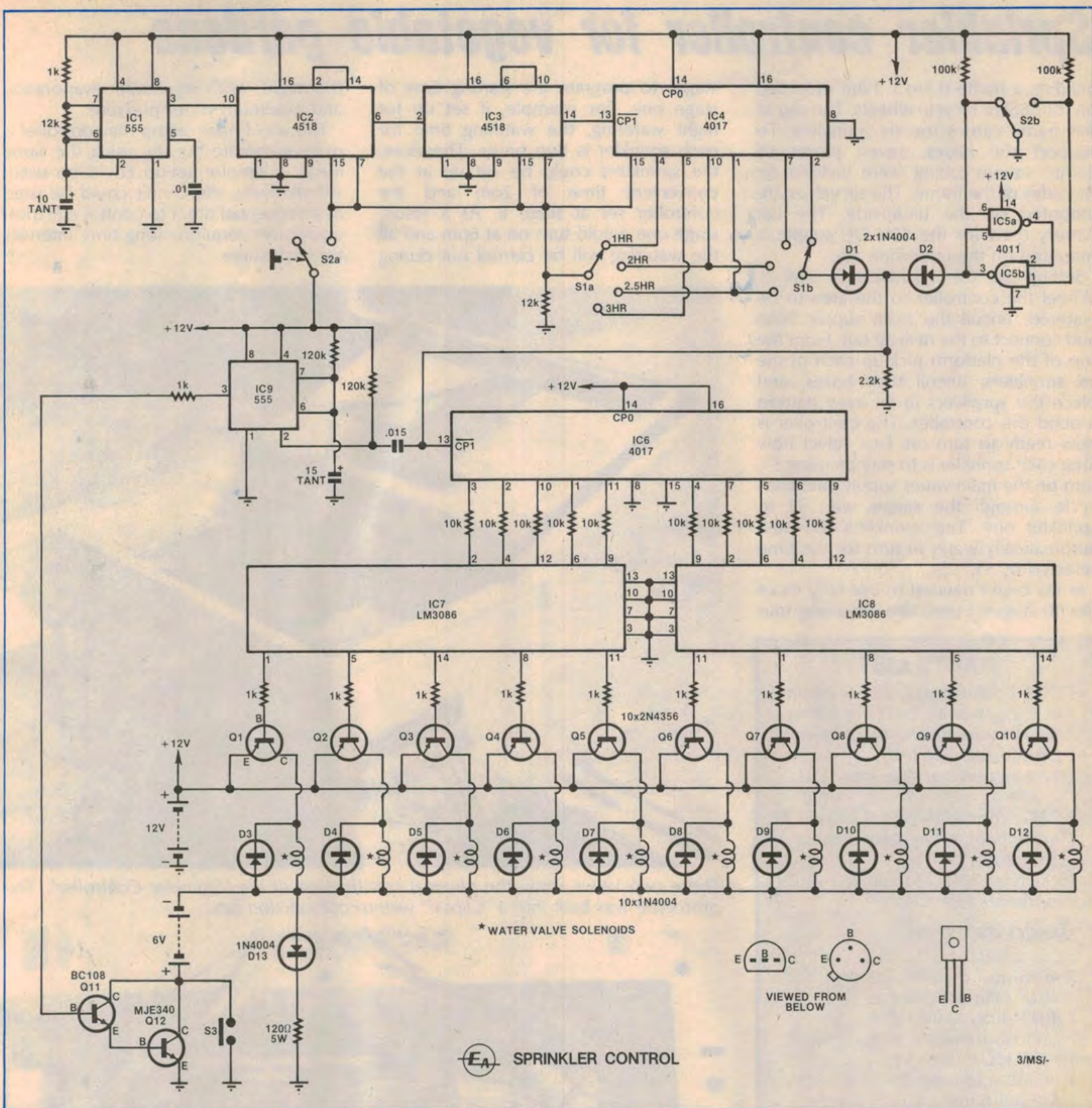
At the end of the two second delay period, Q12 turns off and disconnects the 6V supply. The current through the solenoid coil now drops to around 70mA due to the 120Ω 5W resistor in series with diode D13. This scheme significantly increases the discharge cycle time of the 12V car battery while providing sufficient holding current to keep the solenoid on.

One problem with the above circuit concerns the optional LED indicators. When Q12 is off, only about 2V is developed across the energised solenoid, insufficient to illuminate the LED effectively. To overcome this problem, I connected a N/O spring loaded switch (S3) between the emitter and collector of Q12. This switches the 6V supply in to give adequate LED brightness. Delete S3 if the LEDs are not used.

As a point of interest, if the circuit is not required to cycle through all the 10 outputs, connect the reset function (pin 15) of IC6 to the stage following the one you require. For example, if only six stages are required, stage 7 (pin 5, IC6) should be connected to the reset pin. Now, after the last stage required turns off (stage 6), stage 7 goes positive and resets the 4017 back to stage 1.



*Left: the Richdel 204LG water sprinkler solenoid. Other solenoids with similar specifications may also be suitable.*




(Note: besides using this controller for controlling water valves, it could also be used to control relays, which in turn may control anything you desire.)

The four time periods I used were 1, 2, 2.5 and 3 hours, but by changing the point along the two dual decade counters at which pin 13 (IC4) picks up the signal, or by changing the number of times IC4 multiplies the signal at pin 13 (IC4), a time period of up to five hours can be achieved.

## Construction

Because of the exposure to water from the sprinklers, the electronic hardware was built into a "Clipsal" electrical waterproof junction box No. 265/7. S1 is mounted inside the box. For adjustment, a screwdriver slot was cut in the shaft and access is provided through a 20mm electrical plain-to-screwed conduit fitting mounted in the side of the box.

This opening is sealed with a plug made from a short piece of 20mm conduit, filled with silastic. To make an adjustment, the plug is unscrewed, the shaft rotated with a screwdriver, and the plug re-inserted to prevent the entry of water. Switches S2 and S3 are mounted on a small piece of aluminium. This is then secured to the underside of the lid. A large hole was cut in the lid above each switch and these holes sealed from the bottom with a thin piece of rubber. The holes above the rubber are filled with liquid silastic. Therefore, by pushing the silastic layer, S2 and S3 can be operated with no entry of water.

The LEDs are mounted in appropriate size holes drilled in the lid, the LEDs being sealed into the holes with silastic. The terminal strip used is a Belling Lee unit which has terminal screws at the top and solder posts at the back. Holes were drilled to pass these solder posts through the side of the box. Silastic is used from the inside as a seal against moisture.

In my case the sprinkler controller had to be portable. I achieved this by

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building a frame 0.9m x 1.8m mounted on four 68cm bicycle wheels. The top of this frame carries the six sprinklers. To support the hoses, seven pieces of 25mm square tubing were welded on the sides of the frame. The six valves are mounted on the underside. The car battery used for the 12V DC supply is mounted on the underside also.

Setting up the sprinklers is simple. Wheel the controller to the area to be watered, uncoil the main supply hose and connect to the nearest tap. From the top of the platform pick-up each of the six sprinklers, uncoil their hoses, and place the sprinklers in an even pattern around the controller. The controller is now ready to turn on. First select how long each sprinkler is to stay on using S1, turn on the main water supply, and then cycle through the stages with S2 to sprinkler one. The sprinklers will now automatically water in turn for the time selected by S1.

In my case I needed to use only six of the 10 stages. I used the remaining four stages to program the starting time of stage one. For example, if set up for night watering, the watering time for each sprinkler is two hours. Therefore, the sprinklers could be set up at the convenient time of 2pm and the controller set at stage 8. As a result, stage one would turn on at 6pm and all the watering will be carried out during the night, with minimum evaporation and maximum water pressure.

The way I have set up my controller is quite elaborate but, by using the same ideas, a simpler set-up could be used. Alternatively, the circuit could be used as a sequential timer to control electrical equipment requiring long time intervals for each stage.

## PARTS LIST

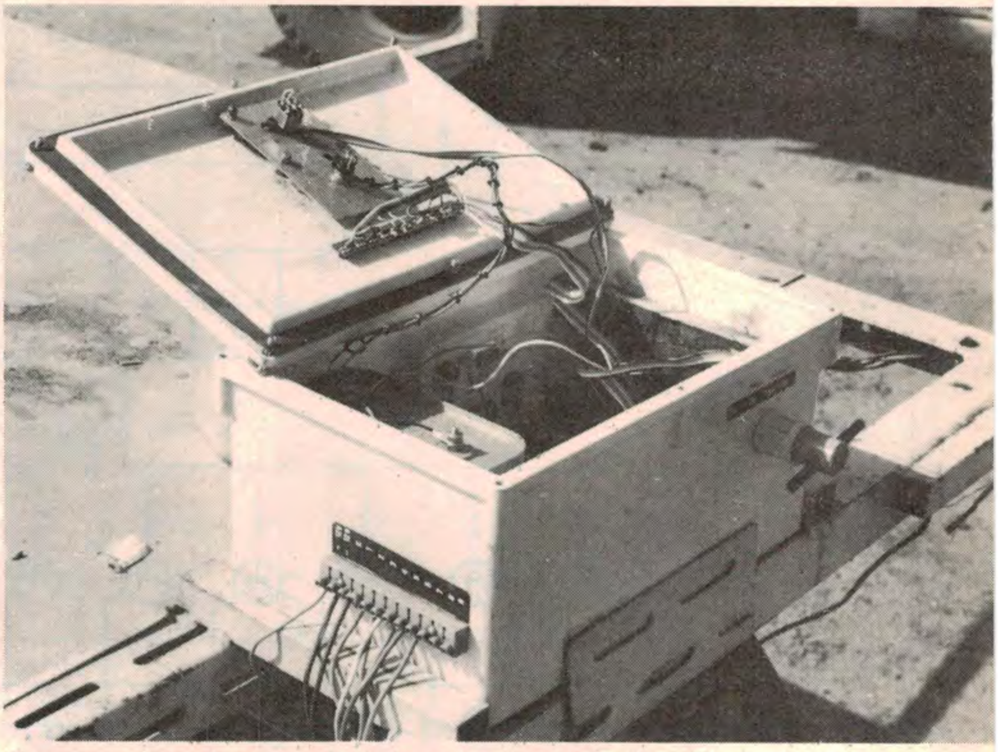
*1 PCB, code 84ws1a, 123 × 80mm*
*1 PCB, code 84ws1b, 161 × 128mm*
*2 16-way edge connectors (0.1-inch)*
*1 case to suit (see text)*
*1 12-way terminal strip (see text)*
*1 2-pole 4-position rotary switch*
*1 DPDT momentary contact switch*
*1 single pole momentary contact switch*
*10 Richdel 204LG (or similar) water sprinkler solenoids*

*SEMICONDUCTORS*
*2 555 timers*
*2 4518 dual decade counters*
*2 4017 Johnson counters*
*1 4011 quad NAND gate*
*2 LM3086 transistor arrays*
*10 2N4356 transistors*
*1 BC108 transistor*
*1 MJE340 transistor*
*13 1N4004 diodes*
*10 LEDs (optional, see text.)*

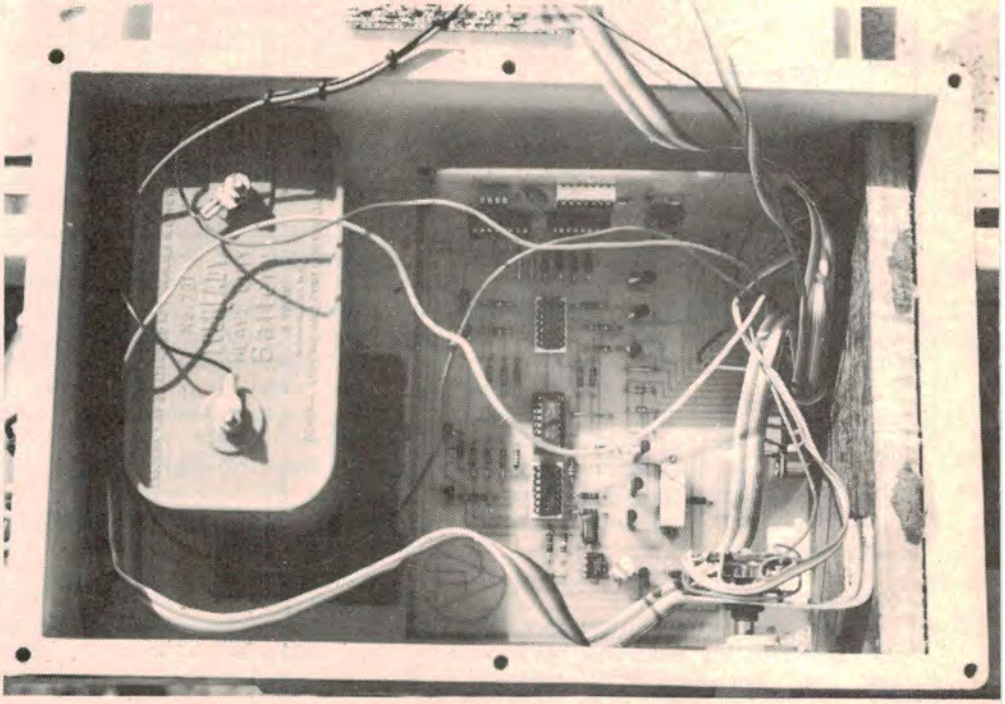
*CAPACITORS*
*1 15μF/16VW tantalum*
*1 10μF/25VW tantalum*
*1 .015μF metallised polyester*
*1 .01μF metallised polyester*

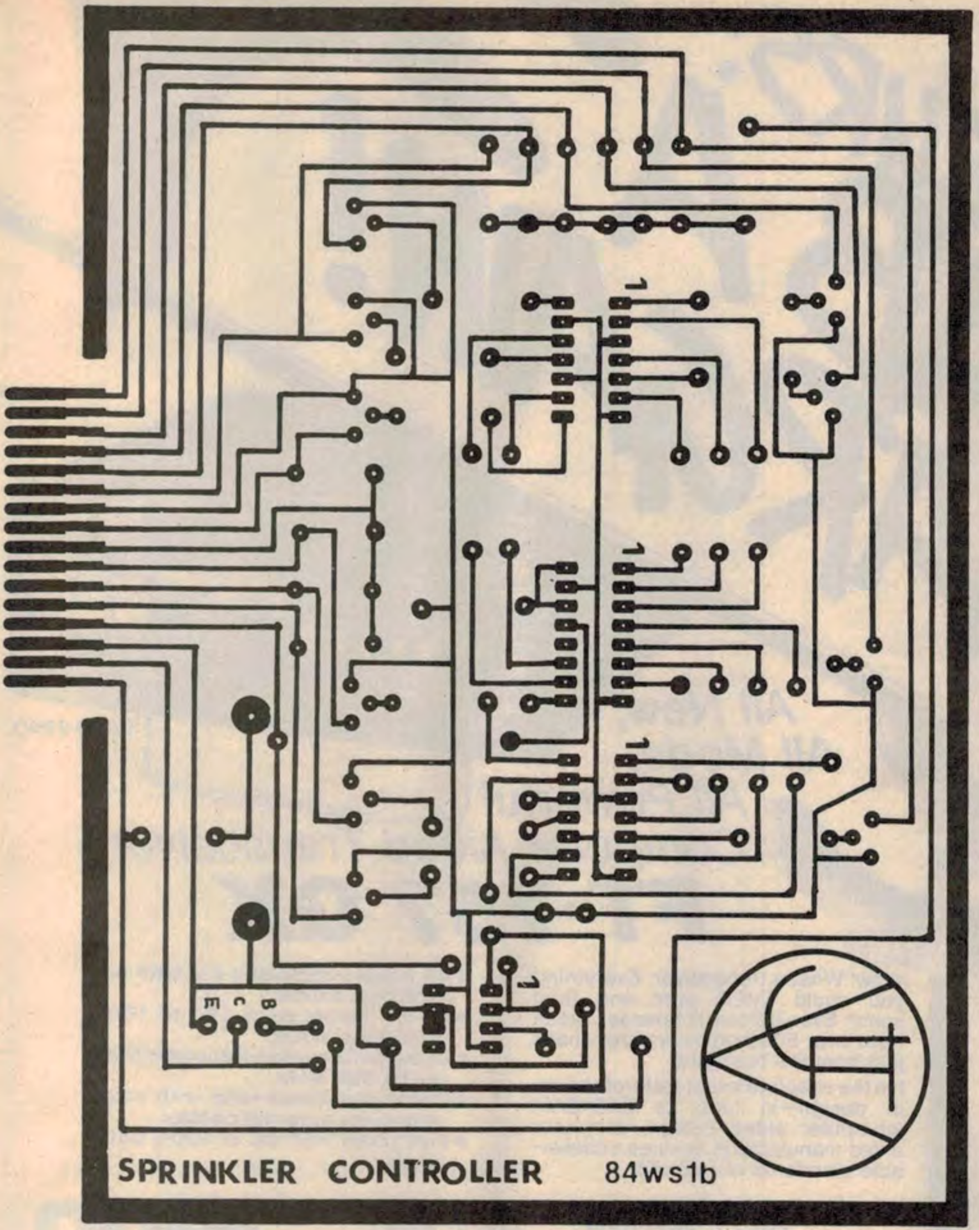
*RESISTORS (½W, 5% unless stated)*
*1 × 120kΩ, 2 × 100kΩ, 1 × 22kΩ, 2 × 12kΩ, 10 × 10kΩ, 1 × 2.2kΩ, 12 × 1kΩ, 10 × 680Ω (optional for LEDs), 1 × 120Ω 5W*

*MISCELLANEOUS*
*Hook-up wire, machine screws and nuts, spacers, solder etc.*



*These two views show the physical construction of the "Sprinkler Controller". The prototype was built into a "Clipsal" waterproof junction box.*





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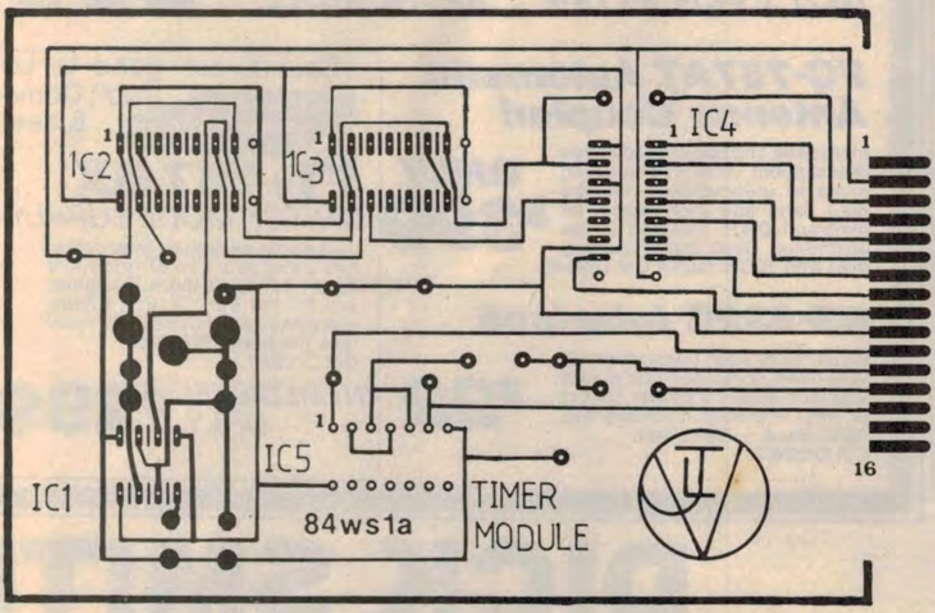
SPRINKLER CONTROLLER 84ws1b

IC2
IC3
IC4
IC1
IC5
84ws1a
TIMER MODULE
1
16