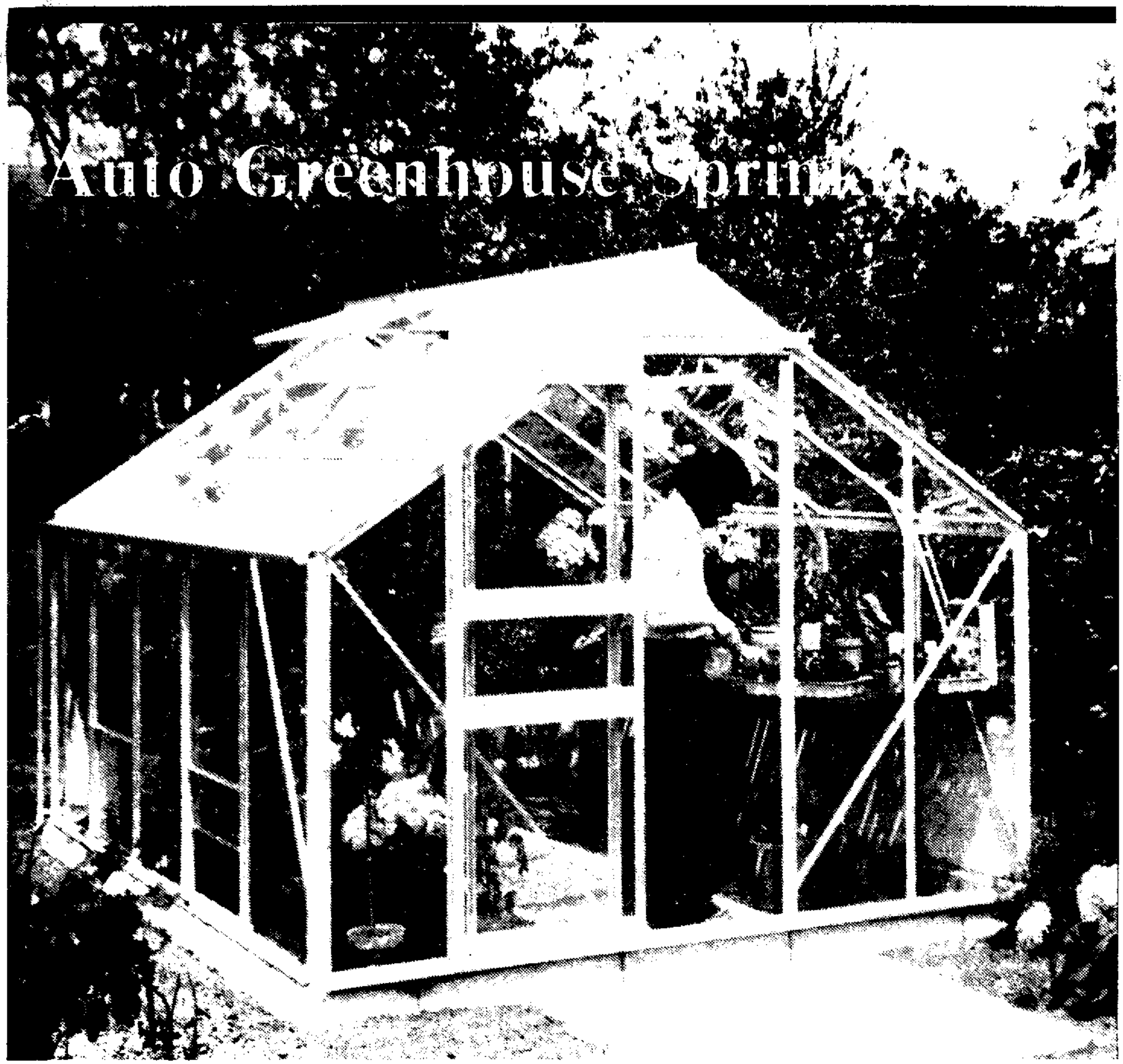


A summer plant-saver that works automatically, triggered by the falling moisture level in a plant pot.

by Owen Bishop

THE HOT sunny days that we hope to be having from now until September can play havoc with plants in a greenhouse. You need only to forget to water them once, or forget to open the windows on a warm day, and the plants are soon in a sorry state. Last minute watering *might* revive them but, on the other hand, it might not! This device not only warns you when the plants are beginning to need some water, but actually does the watering for you. You might need to supplement its action each evening by using the old-fashioned watering-can, but it will take care of those times during the day when a light sprinkling makes all the difference to the health of the plants.

The circuit consists of two sections. One part is concerned with sensing the water state of the plants and sounding an alarm when it gets too low. The other part turns on the pump to sprinkle the water. If you simply need a warning and are prepared to do the sprinkling yourself, there is no need to build the pumping section. If you are going to include the pump, you will certainly want the warning device, too. This sounds for about 30 seconds *before* the pump is turned on. Should you or the family happen to be admiring the tomatoes as the soil goes dry, the warning gives you plenty of time to retreat — out of the range of the sprinkler. The warning period can be extended if 30 seconds is not long enough.

Anyone who has ever watered a potted plant knows that it is effective to water for a short period, and then stop and allow the water to soak in before repeating the watering. The sprinkler works in this fashion too. The pump is turned on for 30 seconds, off for 30 seconds, repeating until the soil has been moistened to the right degree.

The Circuit

The amount of water in the soil is sensed by a circuit which measures the resistance of the soil between two metal rods buried

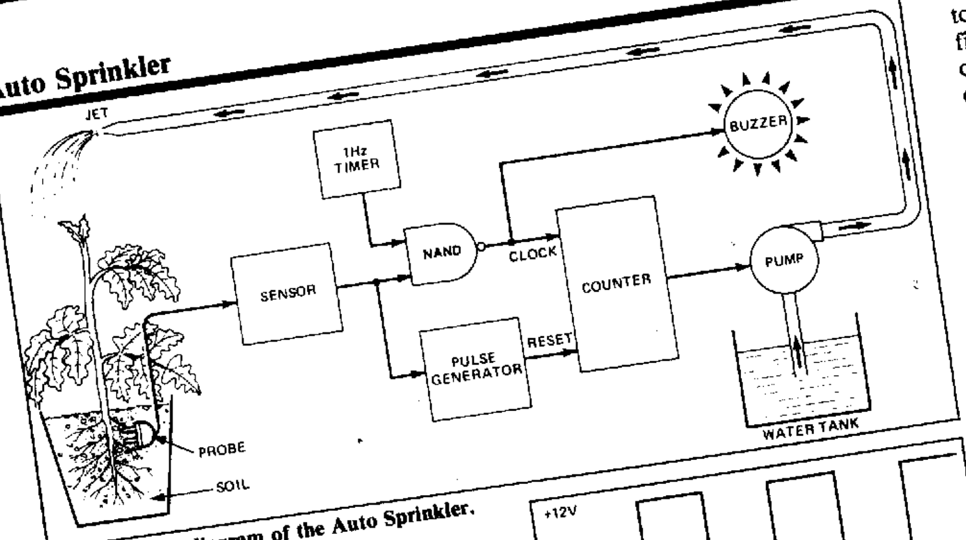


Figure 1 Block diagram of the Auto Sprinkler.

in the soil (the probe). If we pass a *direct current* through the soil, the water and dissolved salts in the soil act as an electrolyte. In a few minutes, polarisation occurs and the resistance changes. Instead, we use an *alternating current*, to avoid polarisation. This is generated by a 1 kHz oscillator (IC1) in the sensor circuit. The alternating potential is rectified by a diode (D1) and smoothed by a capacitor (C7) to give a steady potential. As the soil becomes drier, its resistance increases. This gives the alternating voltage greater amplitude and so the steady DC potential rises. This rising potential eventually triggers a Schmit trigger (IC3) causing its output to change abruptly from low to high (0 V to 12 V). The level at which this change occurs can be controlled by adjusting the 'Set Level' control, RV1.

The output of the sensor is combined with the output from the 1 Hz timer (IC2) by a NAND gate. When the output of the sensor is low (moist soil), the output of the gate is steady at 12 V. When the soil dries, the output begins to alternate between 0 V and 12 V at a rate of 1 Hz. These pulses switch an audible warning device on and off, providing a bleeping

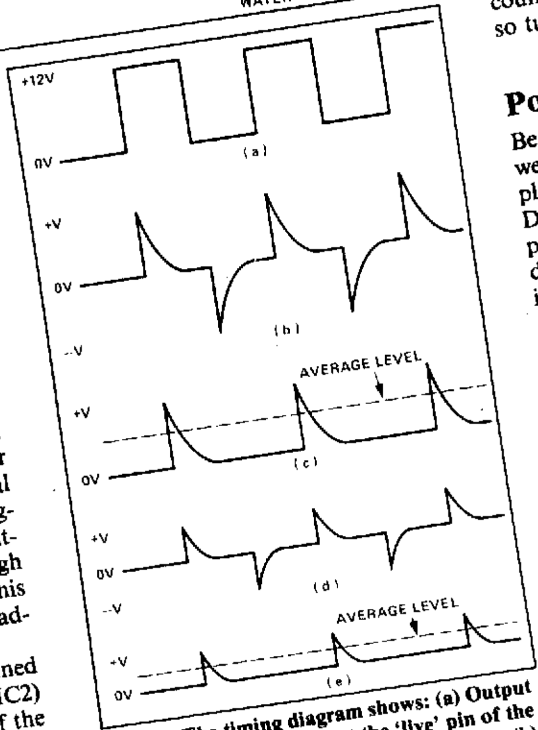


Figure 2 The timing diagram shows: (a) Output from IC1; (b) Waveform at the 'live' pin of the probe; (c) Junctions of D1 and C7; (d) As (b) but with wetter soil; (e) As (d) with wet soil — the average level is lower so the alarm is not triggered.

tone. The pulses are counted and, after a fixed number (say 32), the selected output of the counter goes to 12 V. This switches on the pump. The output alternates from 0 V to 12 V regularly at (say) 1/32 the rate of the time, giving periods of sprinkling followed by equal periods during which the water soaks into the soil.

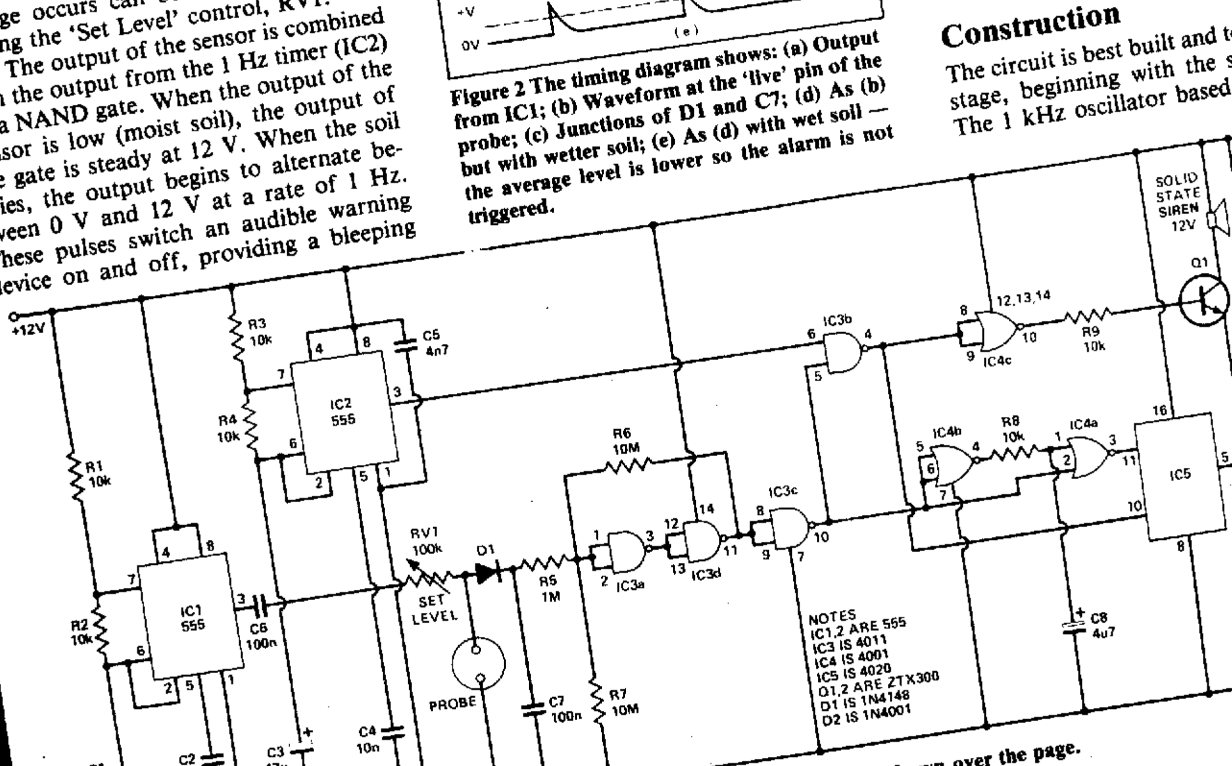
When the soil is sufficiently wet, the reverse actions occur. As the soi resistance drops, the DC potential fall and the Schmitt trigger output (IC3, pi 10) goes low, stopping the alarm. Th low-going edge triggers a pulse generat (two gates of IC4) which sends a sing high pulse to the reset input of t counter. This makes all its outputs go lo so turning off the pump.

Power Supplies

Before going on to constructional de we must consider the matter of powe plies. The circuit uses an unregulated DC supply. This is best taken f power-pack located indoors, with a duty lead to carry the current to the in the greenhouse. The pump is a shield-washer pump, which needs 2 A. A circuit for a suitable powe given later. If you have decided to only as a warning device, the p quirements are much less. Wi pump and its relay, the circuit about 45 mA and almost any sm pack can be used to provide th would be more suitable to loc cuit indoors, with a lead run *probe* in the greenhouse. A power supply could easily be the case.

Construction

The circuit is best built and t stage, beginning with the s The 1 kHz oscillator based



...pply unit is shown over the page.

first part to assemble, including C6. If an earphone is connected between the free terminal of C6 and the 0 V line, a high-pitched tone should be heard, indicating that the oscillator is working. If all is in order, wire up RV1, D1, C7 and the probe. In the prototype, the probe is a 2-pin 5-amp mains plug of the old type, which was found in the scrap box. The essentials are two stout metal rods, preferably of brass or some other corrosion-resistant metal or alloy. They should be about 1.5 cm long and mounted on an insulating base about 1.5 cm apart. Connect these to the circuit board with ordinary lighting wire. While testing, you need a potted plant, or at least a pot of moist potting compost or good loamy soil. The probe can be simply pushed into the soil when testing. Later, when the system is in use, it is better to bury the probe one to 2 cm deep in a pot of soil or the greenhouse bed. Place it on its side, so that the base does not prevent water from reaching the soil surface directly above the rods.

If you have an oscilloscope or FET voltmeter, the rectifying stage can be tested by connecting the probe of the scope to the junction of D1 and C7. As RV1 is turned, the voltage should range from about 1 V to about 10 V. Pulling the probe slightly out of the soil (simulating drying out) results in a rise in output voltage. Incidentally, the circuit does not work unless there is at least some conduction across the probe, so remember to water the plant occasionally, or your tests (and the plant) will probably fail.

Next build the Schmitt trigger circuit (IC3). Its output should flip neatly from 0 V to 12 V as RV1 is turned from one extreme to the other (with the probe in the plant-pot).

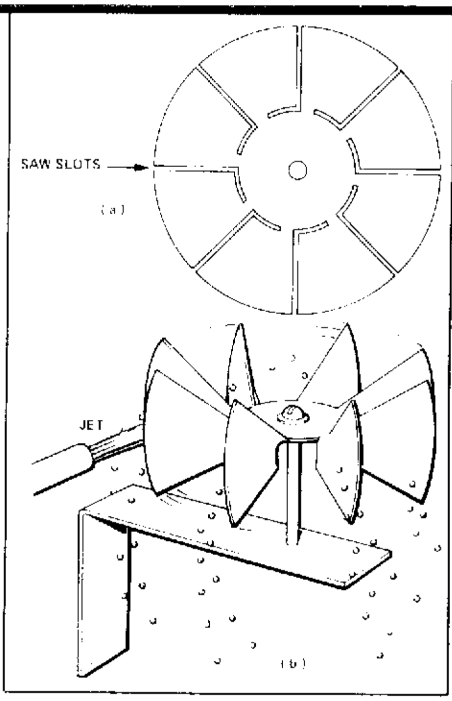


Figure 4 A simple turbine sprinkler: (a) cutting the wheel from a disc of sheet aluminum; (b) the turbine in operation. Note that the jet should be quite narrow or the plants will be flooded.

The next stage is to build the 1 Hz timer, based on IC2. Unless there is effective decoupling of the supply line between IC1 and IC2, the timer is triggered by noise from IC1. Decoupling capacitor (C5) was therefore placed as close as possible to the terminals of IC2. Too large a capacitor affects the operation of the sensor circuit, so keep to the value specified. The remaining gate of IC3 may now be wired in. With RV1 at one extremity (minimum resistance), the output of pin 4, IC3b, should be 12 V. At the other extremity it should alternate from 0 V to 12 V at approximately 1 Hz (the exact frequency does not matter).

One gate of IC4 simply inverts the output from IC3, so there should be no problems here. The other two gates form the reset pulse generator. This is not needed if you want only a warning, and no water pump. The pulse generator should normally have a low output which goes high very briefly when the output from IC3 goes low (i.e. when the soil has been watered enough). This pulse can be detected as an upward kick of the needle of a voltmeter connected to pin 3, IC4a.

The pump is controlled by the counter (IC5). First check the connections from IC3 and IC4. The output from IC5, pin 4, has 1/64 the frequency of the input and with a 1 Hz input, the output is low for 32 S and high for 32 S. This gives 32 S warning — to evacuate the greenhouse. If you think this is more than enough, take the output from pin 5 (as in Figure 3), which gives a 16-second warning. Since your timer may not be running at 1 Hz anyway, the best thing is to test the output from the various pins — dotted lines on the component overlay — and find the one which gives the timing you prefer. Mount the relay with its protective diode, D2, and the switching transistor Q2. Join the base of Q2 to the selected output pin of IC5 by way of R10. The tracks to which the relay switch terminals are soldered were made as short as possible but, since they are to carry heavy current, it is advisable to run a thick coating of solder

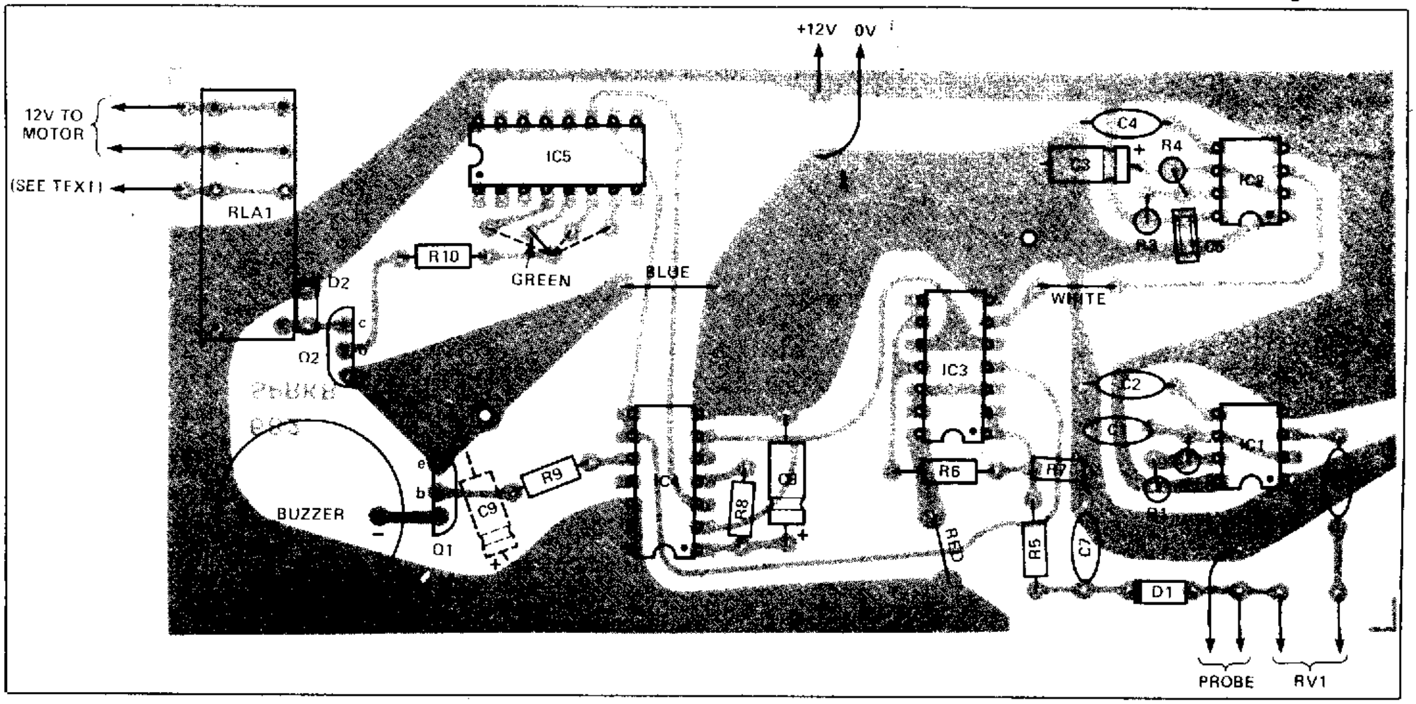


Figure 5 The component overlay. C9 may be included to damp out surges in the power supply caused by the operation of the relay. PCB links are colour-coded for convenience; the green link sets the warning time, as described in the text.

along them to aid conduction. Finally, mount the circuit board, RV1 and the pump in the case.

Installing The Sprinkler

The case housing the circuit should be sited well away from any area of the greenhouse which is to be sprayed or dripped on. A few trials may be needed to establish optimum operating conditions and methods, so perhaps it is best to mount the case temporarily, to begin with. The probe should be buried in a pot of soil. Preferably, this should have a plant in it too, to ensure that the soil loses water at the same rate as the soil in other pots. The probe can be buried in a bed if preferred, but it should be placed where it will receive an average amount of water and where it is likely to lose water at an average rate (i.e. not in the sunniest or shadiest part of the greenhouse).

The pump needs a supply of water. This is best held in a tank inside the greenhouse, so that the water is at the correct temperature. The tank should be covered, if possible, to exclude light, which encourages the growth of algae, and to exclude soil and dead leaves, which might clog the pump. Alternatively, the pump may be fed from a covered rainwater barrel or other tank outside the greenhouse. There could be an application here for those 'water level detector' devices which are so often featured in books of simple electronic projects. Mount one in the tank to warn you when the tank needs topping up!

WARNING: do not run the pump unless it has a supply of water. Without water, it draws excessive current, which could burn out the power supply.

There are several ways in which the water can be distributed to the plants. You may prefer to irrigate from below, in which case the tube from the pump branches to the trays or troughs in which the plants are standing. The trays are flooded repeatedly until the soil becomes saturated to the right amount. If you are using this system, it is advisable to bury the probe nearer to the bottom of its pot. Another method of distribution is to run lengths of tubing above the bench, suspended from the frame of the roof. The tube is perforated at intervals, so that water rains down on the plants beneath. A turbine sprinkler like that illustrated in the drawing scatters the water over a wider area. With all methods, you will probably need to use fine jets on the end of the tube, or screw clips on the tube to restrict the flow. Another point to be considered is what becomes of the water after it has drained away from the pots. If you have troughs on your bench, you could arrange for the water to drain back into the tank. This is more economical of the water and useful, should you want to leave the greenhouse unattended for several days.

Whatever methods you adopt, you will need to experiment with the distributing system to get it just right. You will need to find out which is the best position for the sensor and which is the best setting of the level control (RV1) of the sensor. Eventually you should be able to arrive at just the right system for your greenhouse and the particular plants you are growing.

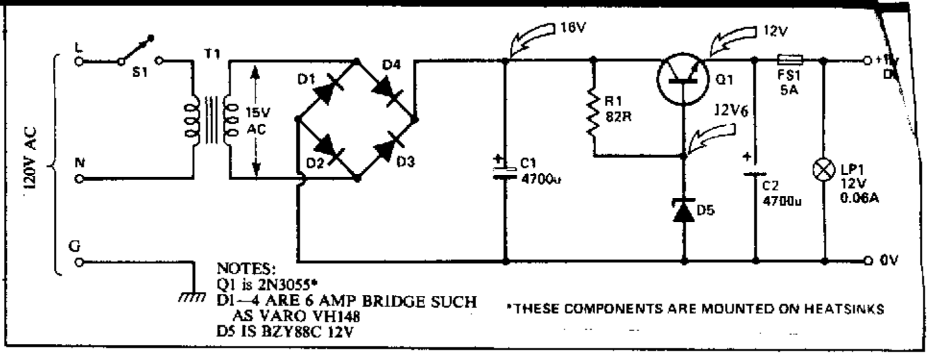


Figure 6 A power supply suitable for driving the complete unit, including the pump. Note that the output is a *nominal* 12 V.

PARTS LIST

Resistors
(all ¼ W, 5% carbon)

R1,2,3	10k
R5	1M
R6,7	10M
R8,9,10	10k

Potentiometers

RV1	100k carbon track, linear

Capacitors
(all polyester, except where indicated)

C1	47n
C2	10n
C3	47u 16 V electrolytic
C4	10n
C5	4n7 polycarbonate
C6,7	100n
C8	4u7 16 V electrolytic
C9	10u 16 V electrolytic

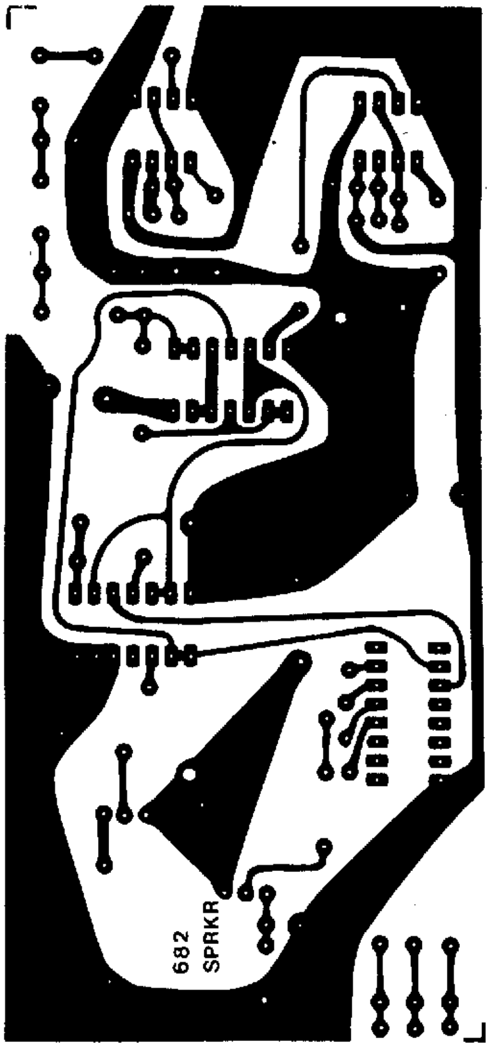
Semiconductors

D1	1N4148
D2	1N4001
Q1,2	2N3904 or other general purpose transistor
IC1,2	555 timer
IC3	CD4011BE quad 2-input NAND
IC4	CD4001BE quad 2-input NOR
IC5	CD4020BE 14-stage binary counter

Miscellaneous

RLA1	12 V miniature PCB relay

PCB; 1 mm terminal pins; Knob for RV1; 12 V audible warning device such as Radio Shack 273-065; PCB mounting; 12 V automobile washer pump unit; ABS case, approx. 180 mm x 110 mm x 50 mm; materials for making the probe (see text); bolts and nuts for mounting board and pump; plastic tubing and t-joints (standard 5 mm aquarium aerator tubing is suitable); water tank; materials for making the irrigating devices; connecting wire, solder.



The Auto Greenhouse Sprinkler PCB pattern. The large ares of copper are present to improve stability — they can be omitted if you include C9 on the board.