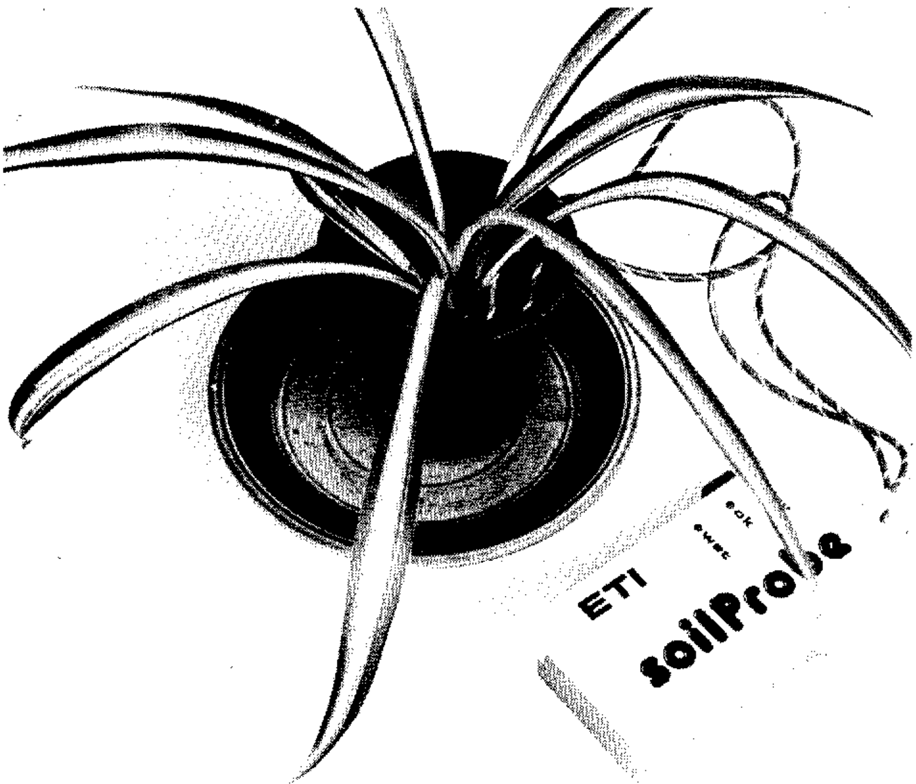
SOIL MOISTURE DETECTOR

Check out the roots scene with this ETI soil probe and have happier, healthier plants.



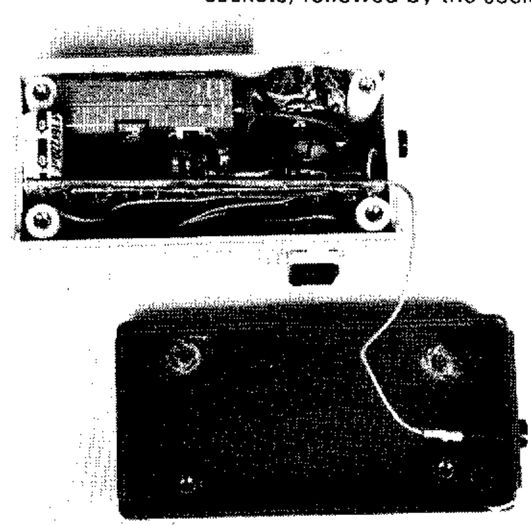
THIS COMPACT UNIT enables you to accurately check the moisture content of your plants' soil in one simple operation. Its range and sensitivity may be adjusted to complement the most fastidious horticulture and horticulturist. The unit works by measuring the resistance of the water in the soil between two probes and comparing it with a previously selected internal resistance adjustable between 1k and 250k.

A Better Buzz

A small 9 volt battery powers the circuit which is built around a few cheap CMOS chips and a low power quad op-amp. To avoid undesirable electrolytic effects at the probes, the resistance bridge is AC energised. We don't known if the plants like this but we have had no complaints. The probes may be made of any conducting material or just tinned copper wires placed in the soil a few inches apart and a couple of inches deep. The circuit will tolerate wire leads up to a few feet in length and no special screening is required. A three level comparator whose pass range is internally preset indicates whether the soil is too wet, dry or OK and the required resistance is set by adjustment of a case-mounted potentiometer.

Construction and Use

Construction is straightforward provided care is taken and attention paid to the polarity and orientation of the diodes and capacitors. Wire links should be inserted first, note that some of these are mounted under the integrated circuit sockets, followed by the sockets



What is it that is on the inside. ETIs Soilprobe exposed

themselves, resistors, capacitors, transistor and diodes. The ICs should be inserted last after the off-board components have been connected. Also ensure that the flying leads have all been soldered into place and that the LEDs are connected correctly. A short lead, indent or flat on the plastic encapsulation usually indicates the cathode. We used miniature LEDs, two red and one green. However, any desired colour may be used. 2mm sockets were used to connect the probe leads and the power source was a 9V battery.

Some difficulty will be encountered in inserting Q1 as the base and collector leads have to be reversed. Use spaghetti insulation to prevent shorts.

In use, the unit is turned on; the probes plugged in, and RV2 adjusted until the OK LED lights. This setting may be noted and recorded on a calibrated scale. As the probes are simple and cheap to make they may be left permanently buried in the soil and a set made for each plant, facilitating the repeatability of measurements.

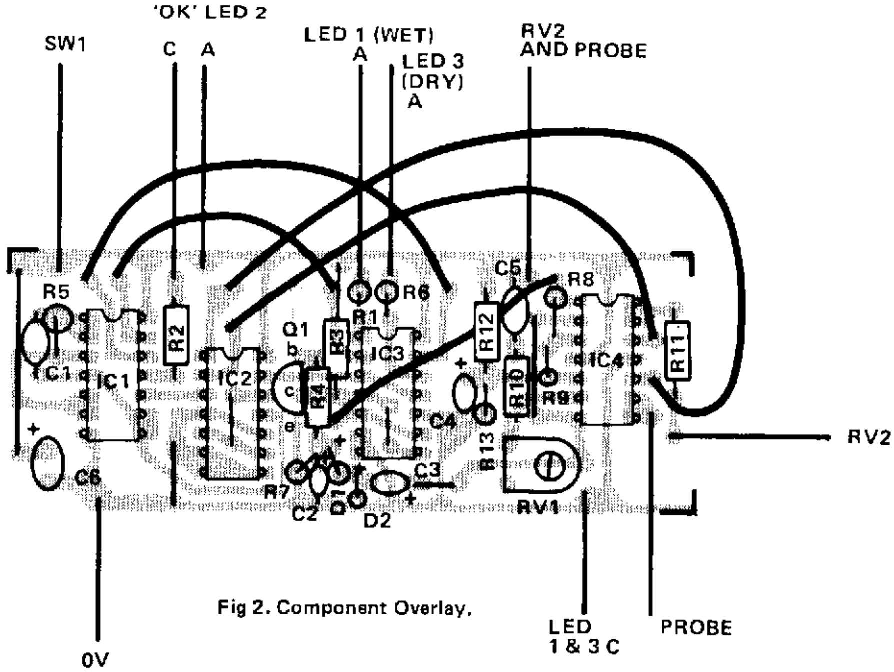


Fig 2. Component Overlay.

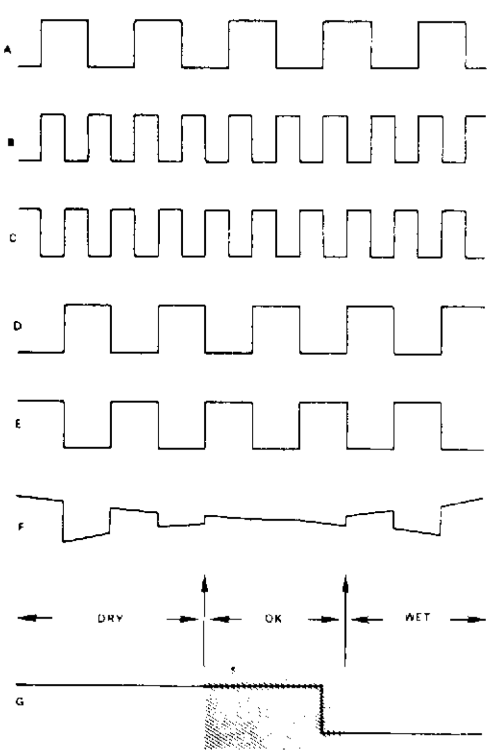


Fig 1. Waveforms associated with the ETI Soil Moisture Indicator, resulting in an LED display of whether the soil is wet, OK or dry.

HOW IT WORKS

The circuit consists of an AC energised bridge whose two active arms are formed by R11 plus RV2 and the soil resistance between the probes. Its operation may be best understood by reference to the circuit diagram and Fig.1. IC1a and IC1b are configured as an astable oscillator whose squarewave output (Fig. 1b) clocks IC2a. This signal, inverted by IC1c (Fig.1c), clocks IC2b.

The antiphase Q and $\bar{Q}$ outputs of IC2b are buffered by IC4a and IC4b whose outputs (Fig. 1d and 1e) drive the resistance bridge formed by R11 plus RV2 and the soil resistance between the probes. R11 protects the amplifier outputs against inadvertent short circuits.

The output of IC2a (Fig. 1a) is a squarewave of the same frequency, phase shifted by 90 degrees. This means that the edges of the waveform are coincident with the centre of the squarewave from IC2b (Fig 1d and 1e) and facilitates phase detection by IC3a and IC3b. When the soil resistance measured between the probes is equal to the resistance of R11 plus RV2, the signals from IC4a and IC4b will cancel out. However, when an imbalance occurs, there will be an error signal whose phase will depend on whether the soil has a greater or lesser resistance than the other arm of the bridge. The amplitude of the error signal will also diminish as the bridge approaches balance (Fig. 1f).

This signal is coupled via C5, R10 to amplifier IC4c and squared up to provide CMOS input levels by schmitt trigger IC4d, where it is input to IC3a and IC3b and clocked in by the signal from IC2a. The outputs of IC3a and IC3b will follow the phase of the input: reflecting the state of imbalance of the bridge, and either LED 1 or LED 3 will be lit (Fig. 1g).

The amplified signal from IC4c is also fed via C3, D1 and D2 to C2 which will acquire a charge proportional to the level of the input. This drives Q1 which controls the direct, clear, and set inputs of IC3a and IC3b respectively. When the input signal is insufficient to turn on Q1, these inputs are driven to their active high state by R3.

This causes both LED 1 and LED 3 to extinguish and the condition (shown shaded in Fig. 1g) is detected by nand gate IC1d whose output goes low causing LED 2 to light. The sensitivity of the circuit to this condition is preset by adjustment of RV1 which controls the gain of IC4c. The required soil resistance is set by RV2. The circuit is powered from a 9V battery decoupled by C6. A mid voltage point is provided by R12 and R13 decoupled by C4.

PARTS LIST

RESISTORS		POTENTIOMETERS		SEMICONDUCTORS	
		RV1	470k preset	IC1	4011B
R1, 2, 6	820R	RV2	250k lin	IC2, 3	4013B
R3, 4, 10	100k			IC4	LM324
R5	10M	CAPACITORS		Q1	2N3904
R7, 12, 13	10k	C1	1n	D1, 2	IN4148
R8	1M	C2	4u7	LED 1, 2, 3	0.125"
R9	100R	C3	10u	MISCELLANEOUS	
R11	68R	C4	22u	PCB	
		C5	220u	SW1	SPST

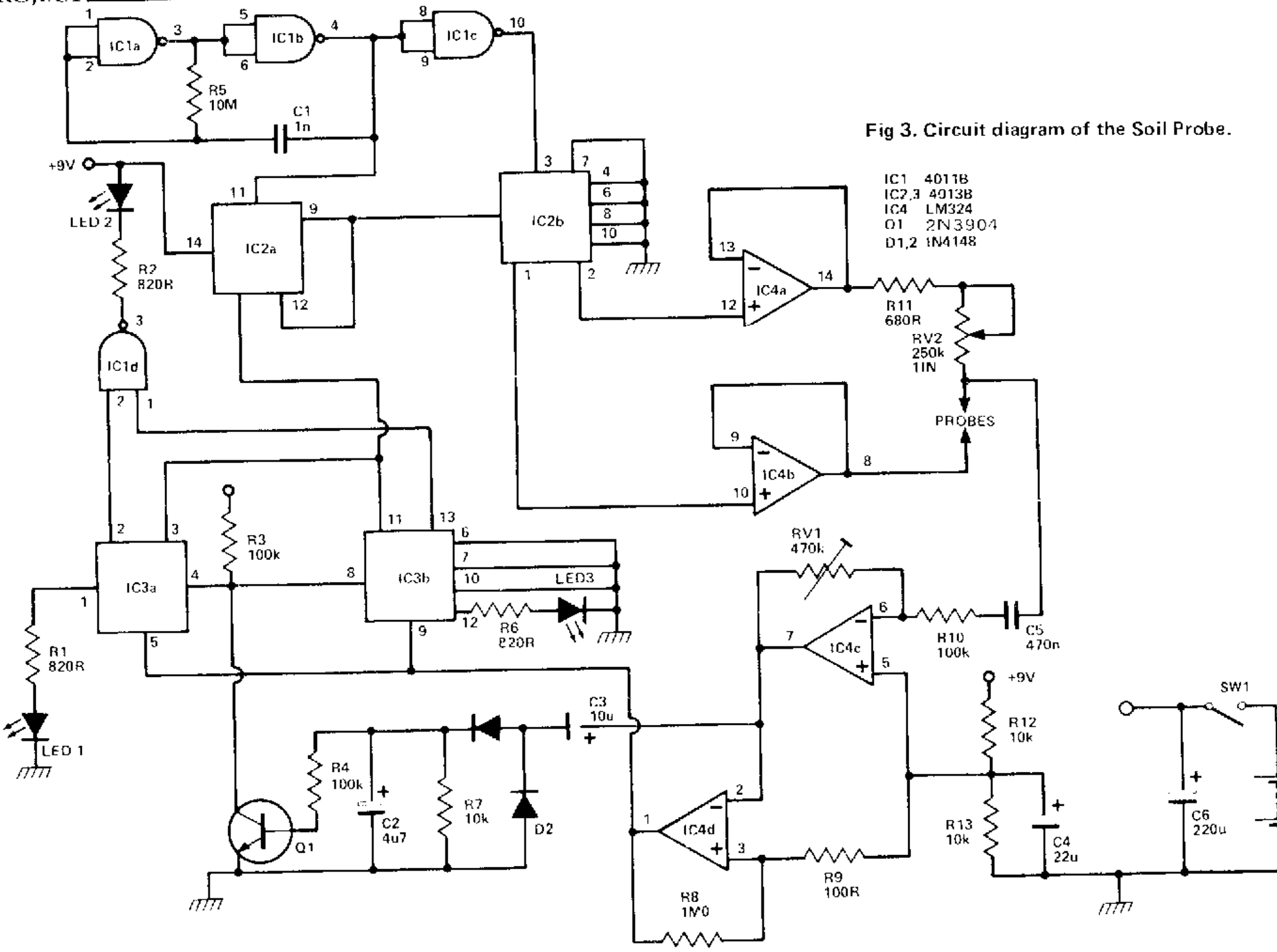
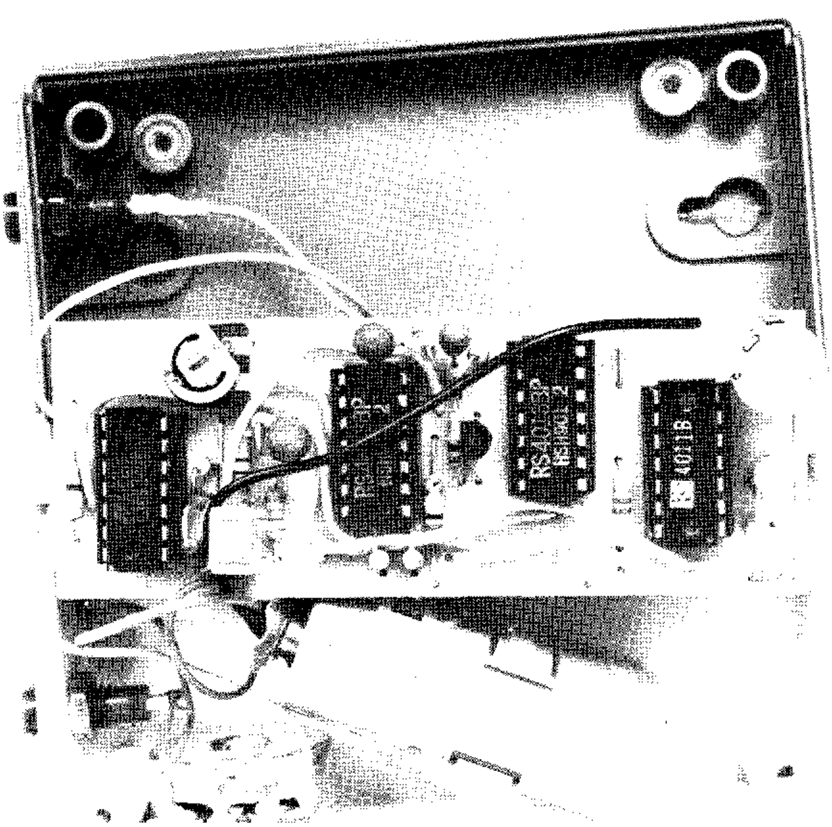
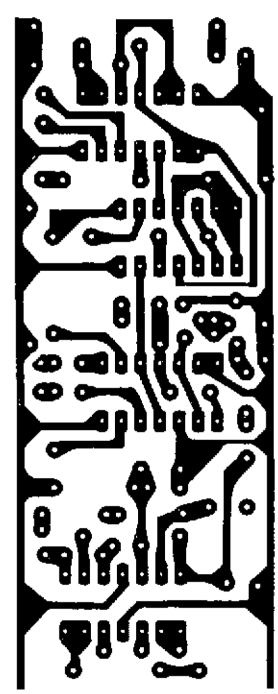


Fig 3. Circuit diagram of the Soil Probe.





An internal view of the Soil Moisture Indicator, showing the position of the four IC's.