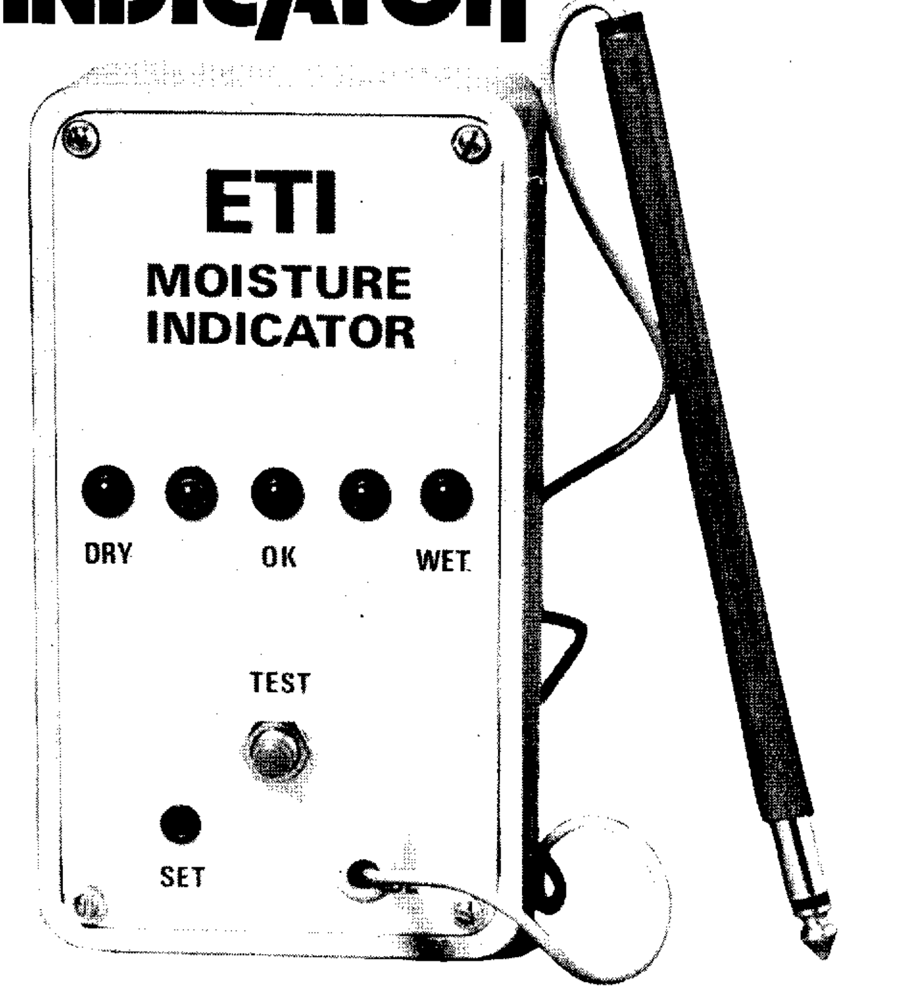
SOIL MOISTURE INDICATOR

TO A GREENHOUSE OWNER, or indeed to many indoor and outdoor gardeners the degree of moisture within a plant pot's soil or compost is important but relatively unknown. When pots were made of fired clay an expert could rap the pot with his knuckles and the 'ring' or 'thud' would show the need for watering! Nowadays however, the use of polythene sleeves and plastic containers gives too variable a sound for adequate guidance.

This circuit was developed to give an easy and accurate indication of the need for water or - just as important, very often - of a state of excess that tends to drown the roots of a plant.



Development

Ohmmeter measurements between probes in various soils and composts showed a surprising range of resistances, from about 3 kΩ to about 30 kΩ and further enquiry proved (as might have been expected) that soil acidity and probe dimensions also varied the readings; in particular the use of dissimilar metals for the probe tips gave enormous variations. Indeed some soil-probe combinations seemed to be trying to produce a reverse resistance reading when used in one way and then nearly full-scale - zero resistance - when the probe connections were reversed. The probe electrodes *must* be of the same metal, preferably solid and not plated.

Initial circuitry suggested that a fairly sensitive micro-ammeter would be needed, or at least an amplifier to drive a less sensitive instrument. A gardener could easily drop the completed apparatus and this could be an expensive accident; also, a pointer-type instrument led to queries about the 'needle is 2 mm further than last time', and 'not the same reading as last week' when (potted?) field trials were carried out in greenhouses. An LED display was therefore chosen as being cheaper, very robust and giving sufficiently repeatable results.

Construction

All the components with the exception of the LEDs, PB1, and SK1, which are mounted onto the front panel, are carried by the PCB. RV1, the sensitivity adjustment potentiometer, is made accessible via a hole drilled in the case.

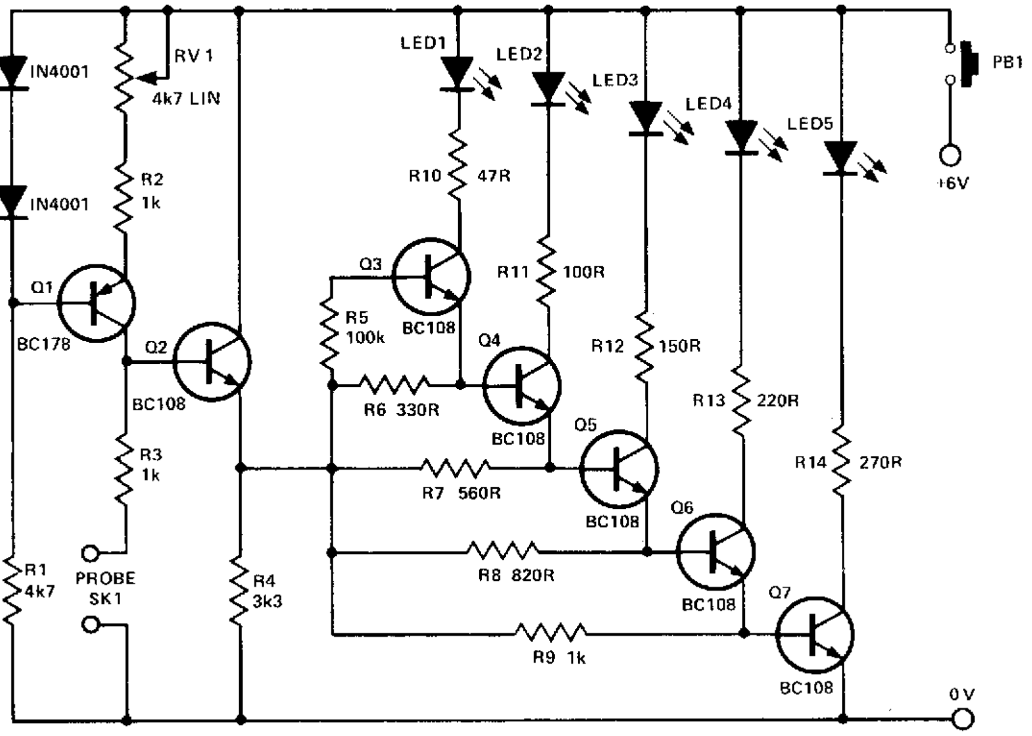
The most taxing part of constructing the device is the actual 'building up' of the probe. Ours was fabricated from a Japanese ¼" mono jack plug. Remove the cap, and upon inspecting the contents within, you will see that the tip contact is held in place by what appears to be a splayed rivet.

Take a file to this until the contact comes away freely. You can now remove the tip contact, earth contact and a spacing washer. However, we've not done yet. Hold the knurled 'body' of the plug in a vice or strong pliers, and physically pull the barrel out of it! (It may be necessary to make a small saw cut across the thread in order to achieve this.)

The barrel and tip portion is all you need for this job. A plastic sleeve is now visible over the central rod, and this too can be pulled out. Solder the probe lead to this as shown below, fixing the rod in a central position with some Araldite or similar adhesive.

Mounting the probe assembly is largely up to you, but we found that a 'Biro Minor' ballpoint, which is a cheap and universally available device, accepted the barrel like it was made for it.

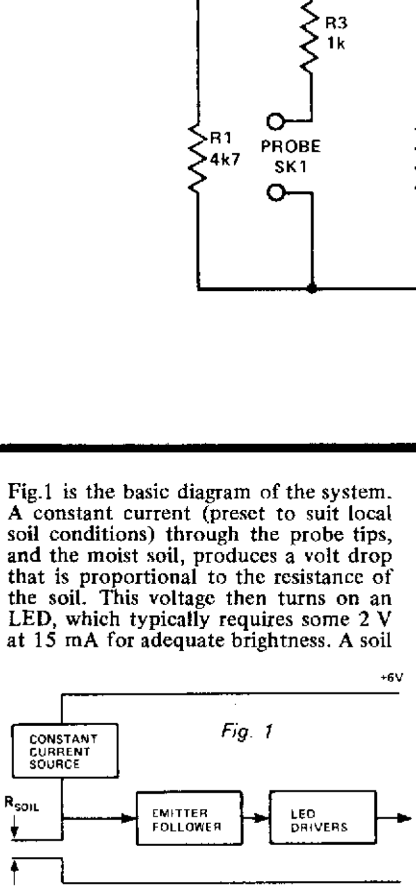
Wiring from the probe to the box should be strong but as flexible as possible, so that continued use does not take its toll and incorrectly monitored moisture drowns both your plant and reputation as a genius!



Circuit of the moisture indicator

HOW IT WORKS

Fig.1 is the basic diagram of the system. A constant current (preset to suit local soil conditions) through the probe tips, and the moist soil, produces a volt drop that is proportional to the resistance of the soil. This voltage then turns on an LED, which typically requires some 2 V at 15 mA for adequate brightness. A soil



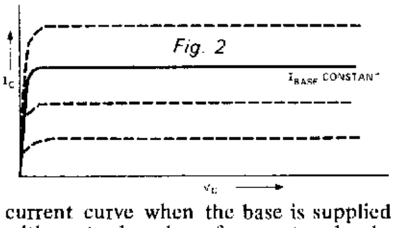
resistance that is higher or lower than that given by the correct moisture content should also be indicated, so five LEDs are incorporated to cover the range of 'too wet' to 'too dry'.

Using silicon transistors, an emitter-base voltage of about 0.6 V is sufficient to turn on the emitter-collector current of Q7 and further increase in voltage (or base current) then results in additional emitter-collector current flow if the load allows. By connecting Q6 emitter to Q7 base, Q6 base needs to be 0.6 V more positive than Q7 case, hence at about 1.2 V (at the base) Q6 as well as Q7 is conducting. Similarly Q5, 4, 3 will conduct at base voltages of 1.8, 2.4, and 3.0 V respectively.

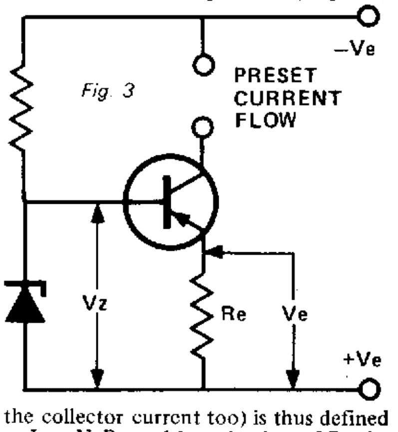
The current through an LED is limited to 15-20 mA by an additional series resistor (R10-14); the transistors Q3-7 are bottomed at this present collector current, a collector voltage then being only slightly more positive than its emitter when an LED is at full brilliance.

Resistors R5-9 are included to prevent the various base-emitter diodes from clamping the output of Q2 to a low value. The inclusion of these resistors and the required currents through them taken taken by the various bases means that the 0.6 V steps of voltage that should turn on Q3-7 are modified slightly. When the LEDs are illuminated the total base current drive for Q3-7 is in the order of 10-20 mA and this is supplied by Q2, an emitter follower.

A quick revision of theory reminds us that the collector characteristics of a transistor, Fig.2, shows a nearly constant-



current curve when the base is supplied with a steady value of current and voltage, this voltage being about 0.6 V. In Fig.3 the base voltage is clamped or set by a zener diode to a particular value, say Vz, and the emitter voltage is therefore about (Vz 0.6) V. The emitter current (and, for all practical purposes,

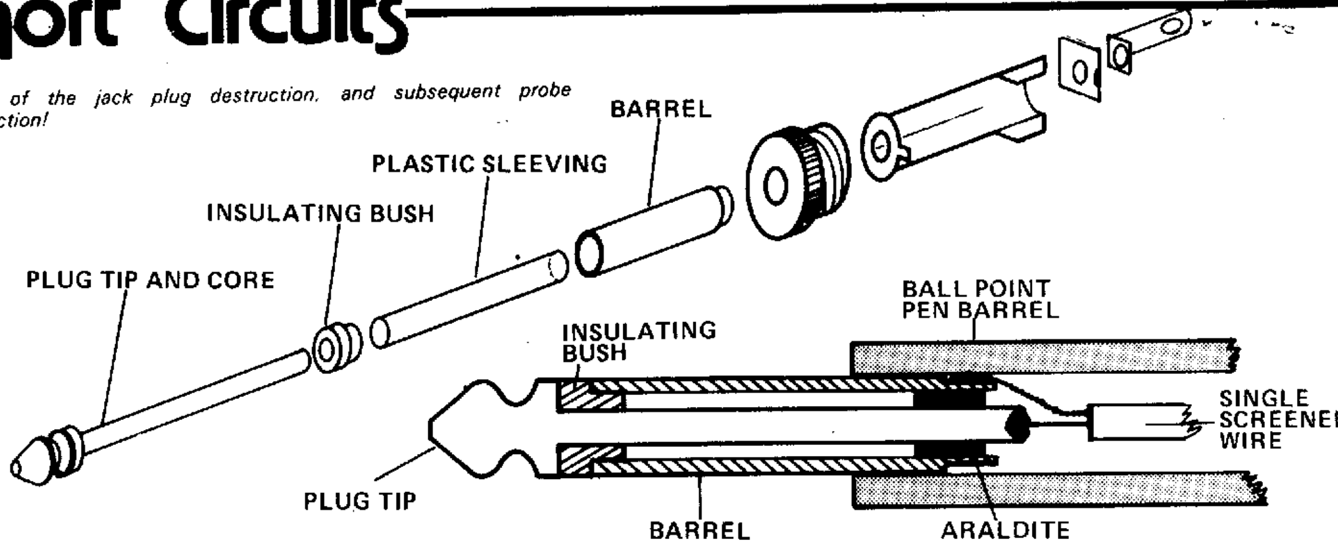


the collector current too) is thus defined as Ie = VeRe and by selection of Re the value of Ie (or Ic) is determined. As long as there is about one volt between emitter and collector the collector current remains constant at this chosen value - or at least until a resistor or load of too large a voltage and so robs the collector of its working voltage.

With only a 6 V supply Vz must be as small as possible and once again the fact that a forward biased silicon diode drops about 0.6 V is used. The two series-connected diodes D1-2 maintain Q1 base at about −1.2 V and the voltage drop across R2-RV1 is about 0.6 V.

Short Circuits

Details of the jack plug destruction, and subsequent probe construction!



Testing and Using

Before connecting the supply to the board, check carefully there are no 'bridges' present lest they lead you to troubled waters.

With the probe 'dry' all the LEDs should come on. With a short-circuit across it (i.e. VERY wet!) not one should be lit. Check the range of current in the probe, by short-circuiting with a milliammeter, to be about 0.1 mA to 0.6 mA approx.

Push the probe into soil of what you consider correct moisture, and adjust RV1 to light three LEDs. More moisture than this then lights *fewer* LEDs, whilst a drier soil lights more.

Perhaps one usage for this would be if you trotted off on holiday, leaving some willing person to take care of the plant-life while you sample the night-life. Once set the indicator could ensure that your instructions are carried out faithfully, and you don't return to see your favorite rubber plant impersonating a water-lily.

BUYLINES

The probe for this project was constructed from a ¼" Japanese mono jack plug, and a 'Biro-Minor' ballpoint pen available from most stationers. The case is a Norman F.B.1 fibre glass type available from H.L.Smith, 287 Edgware Road, London, W.2. at approximately £1.20 inc. VAT and p&p. All other components should be easily obtainable.

The approximate cost of construction, including box, is £6.50 inc. VAT.