SOME METHODS OF KEEPING THINGS BLOOMING IN YOUR PLOTS WITHOUT REALLY TRYING!

GARDEN WATERING

THIS ARTICLE is really intended for use by wives, to get their electronically-oriented men out of the workshop and into the garden!

The project provides an arrangement for checking comparative moisture levels in soil, and an arrangement responsive to a predetermined level of moisture. Further development allows for automatic watering or sounding of an alarm. A particularly attractive application takes the form of automatic watering of valuable indoor plants.

The circuits are almost ridiculously simple, and yet provide considerable interest in their preparation, construction and use.

OPERATING PRINCIPLE

Soil conductivity varies with moisture content, so that an absolute or a comparative measurement of conductivity can be translated into a corresponding measurement of moisture content. Elaborate instrumentation has been used for years in places like agricultural research stations to provide very accurate determination of soil moisture content and to control plant environments. However, intelligent use of a very simple arrangement providing only comparative indications can be very useful.

One arrangement to be described generates a tone, the frequency of which is dependent on soil conductivity, that is, on moisture content. Another arrangement triggers an external function when the soil conductivity falls below a predetermined level. The reader can gain useful experience to facilitate use of these arrangements by researching his own soil conditions.

SOIL CONDUCTIVITY

If an ohmmeter is connected to two wires pushed a few centimetres into the ground, a resistance reading will be obtained. This resistance varies with the dampness of the soil. However, this is an over-simplification, as will be found if the ohmmeter connections are reversed almost inevitably a different reading will be obtained.

The situation becomes even more interesting if a high impedance voltmeter on a low range is connected to the wires, as a reading will usually be obtained. This potential may arise in various ways or in a combination of ways. Stray currents will usually be found, particularly near dwellings, arising from earth returns of power reticulation systems, galvanic action at buried waterpipes, and so on. Furthermore, because the soil almost certainly will not have a neutral pH balance, but will be either acidic or alkaline, two electrodes will themselves produce a battery action.

In addition to all this, soil characteristics vary a great deal. In the author's case, resistance (reciprocal of conductivity) readings which formed part of a preliminary exercise to get the "feel" of things varied

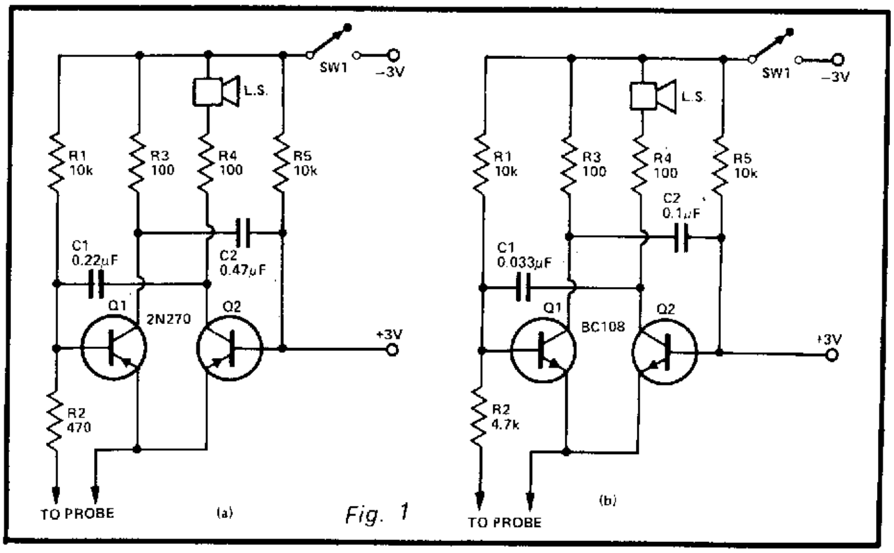

Fig. 1

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considerably in apparently similar soils measured at the same time. For example, comparatively thin wires, about 18 gauge tinned copper, showed readings varying between 15 k and 200 k for what appeared to be a reasonable range of dampness in good, "imported" garden soil. The use of thin wires was found less reliable and consistent than the use of flat electrodes or substantial rods.

Flat electrodes with effective surface areas of, say, 3-4 square centimetres in similar conditions produced a range of 10 k to 25 k. In an open yard with a heavy clay sub-soil and little dirt on top, two 8 gauge rods about 25 mm apart gave readings of 800-2000 ohms the day after a good rainstorm, and up to 15 k (on average) after a few dry days.

Indoor plants are a special case as they have only a finite amount of water available, that is, the soil being restricted to a pot, cannot call up sub-surface moisture as happens in the open garden. Potting soils can dry out to produce quite high resistance values, say several hundred thousand ohms even when substantial electrodes are used. Of course this represents a condition in which a plant will already have permanently wilted.

THE PROBE

The probe can take a variety of forms, being basically two spaced electrodes inserted into the soil. However, the most successful form comprises at least two flat electrodes, rather than wires, although wires become more acceptable over 12 gauge and merging into rods. In either case a reasonably substantial exposed surface area of, say, 3-4 square centimetres produces acceptable operation in most soils.

For permanent insertion and for use with soft, friable soils, flat electrodes will probably be found most attractive, whilst for portable use with heavier soils, rod electrodes are probably best. Whilst the details are optional and dependent on the constructor's workshop resources,

The electrodes should be made of material which will not corrode. Monel metal or stainless steel are suitable. Short term experiments with tin plate are fine, but something better is needed for long-term use.

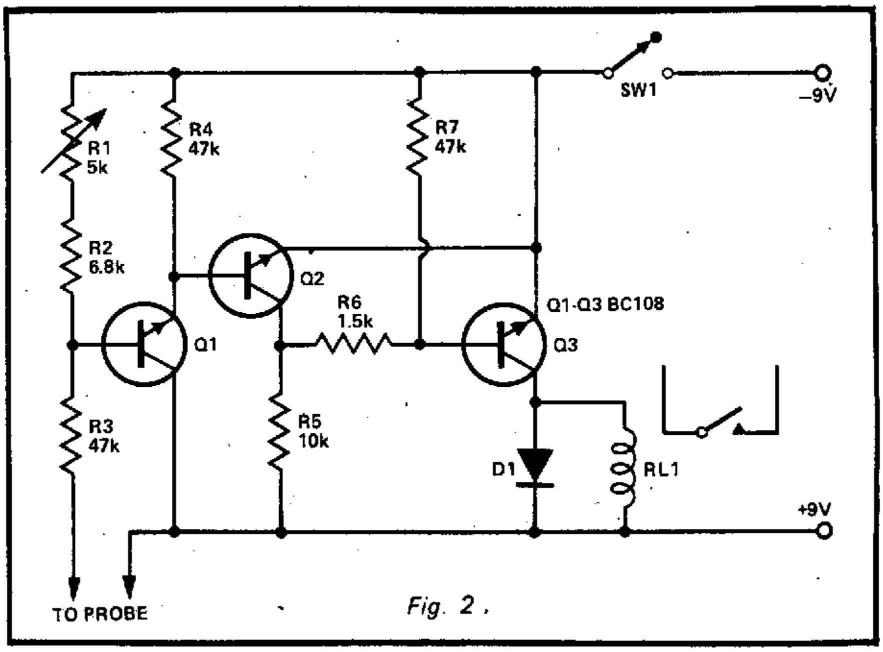

Fig. 2.

THE MOISTURE MOOD

In rather light-hearted vein the first arrangement to be described has been given a fancy name to make up for the fact that it really needs no description at all! One example using junk-box parts and two re-cycled 2N270 Ge pnp transistors is seen from Fig.2a to be a simple multivibrator, with the addition of a small speaker. Alternatively a low impedance ear plug could be used in lieu of the speaker.

With the probes in air, the circuit delivers a continuous low-pitched tone, which then increases in pitch as the probe is inserted in the soil. The higher the pitch the higher the moisture content. In cases of very high soil conductivity the note may rise above the level of hearing; in this case ~~increase~~ the 0.22 mfd capacitor until the highest audible pitch is obtained with a saturated area of soil.

THE WATER TRIGGER

The second device is shown in Fig.3. Its function is primarily the continuous monitoring of soil moisture content responding to a fall below a predetermined level to initiate an action. This circuit comprises a simple trigger, which operates the relay RL for values of soil conductivity below a level preset by the 5 k variable resistor. The soil

The circuits will also cater for house plants conductivity is sensed by a probe connected to the terminals shown. The circuit is very simple and reliable, and will operate anywhere between 6 and 12 volts or more, provided the supply voltage provides sufficient energisation for the relay. If a very low current relay is used, an appropriate limiting resistor can be inserted in the common emitter leads of Q2, Q3.

The only point really requiring attention in this circuit is the base circuit of Q1, here comprising the probe terminals, two fixed resistors (47 k and 6,8 k) and a 5 k variable resistor. There are two possible approaches. One can insert a large value of variable resistor (say 250 k – 500 k) in place of the 6.8 k fixed and 5 k variable shown. This produces a circuit which will accept a wide range of values across the probe terminals, but will in general result in the adjustment of the variable resistor being far too wide, and all cramped at one end. The alternative is to decide the probable range of values across the probe terminals, based on tests of the kind described earlier, and then select values to suit. To see how this is done, the author's case will be worked through.

The triggering point of the circuit is with about 1.25 volts at Q1 base, but do not try to measure it with a low impedance voltmeter. This voltage corresponds to a supply voltage division at Q1 base of 1.25:7.75, so that the voltage between Q1 base and the positive supply rail is 6.2 (7.5 ÷ 1.25) times the voltage between Q1 base and the negative rail. Therefore the resistances in the two parts of the circuit need to have the same relationship. This ignores Q1 base current, which has fallen to a negligible value near the triggering point.

Initially a range of 500-25 000 ohms across the probe terminals was chosen as being correct for the application intended, based on tests plus a margin. For the 500 ohm case, therefore, 47 k + 50 = 6.2x, where x is the resistance Q1 base to supply negative. This produces x = 7661 ohms. Similarly for the 25 k case, 47 k + 25 k = 6.2x, so that x = 11613 ohms. This shows a variation in x of 11613 – 7661 = 3952 ohms. However, this is an awkward value, the nearest reasonable value being 5 k. Then 11613 – 5 k = 6613, the obvious choice for the fixed resistor being 6.8 k. Checking back then with these values, for 5 k + 6.8 k = 11.8 k, so that + 47 k = 73.16 k (11.8 x 6.2), so that the probe resistance is 73.16 k – 47 k = 26.16 k. For 6.8 k alone and the 5 k variable all out of circuit, the probe + 47 k = 42.16 k (6.8 x 6.2), giving a negative value for the probe resistance (42.16 – 47 = 4.84). Thus the chosen values provide for a probe variation of zero to 26.16 k ohms, slightly wider than required. Similar simple calculations will provide values suitable for any other range of probe values.

WATER TRIGGER APPLICATIONS

One of the circuits of Fig.2, less the probe connections, can be connected into the circuit of Fig.3 in place of the relay and protective diode. A resistor of about 1 k would also be needed in the common emitter lead of Q2, Q3 and Fig.3. This combination draws about 8-10 mA in the alarm condition.

However the most important application of the trigger circuit is as an automatic waterer. Consider the case of an indoor planter box. The probe will indicate water content in the soil and trigger the circuit at a preset point. The relay is used to operate a low-voltage water pump, such as an aquarium pump, to pump water from an available supply into the plant container. If the water is well distributed over the surface, for example using a meandering tube with many small holes, the soil moisture content will be increased fairly evenly until the probe decides the minimum level has been left behind. At this stage the circuit resets and awaits further transpiration and evaporation. ●