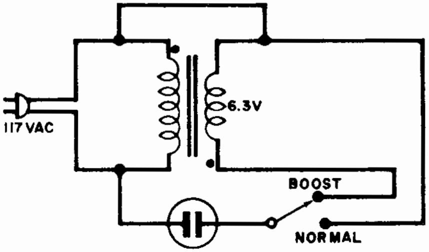
LINE-VOLTAGE COMPENSATOR

Boosts the power–supply voltage when it drops too low

BY HARRY J. MILLER

In areas where low power-line voltage is common, a filament transformer can be used as a voltage booster. A 6.3-volt transformer can be used as shown in the figure. When the switch is placed in the BOOST position, the transformer acts as an autotransformer, increasing the voltage across the socket terminals by about 6 volts. When selecting a filament transformer for this application, determine how much current in amperes the load will draw. Then select a transformer whose secondary winding can safely handle this load current.

The dots shown near the transformer denote phasing of the windings. If you do not know how the transformer is phased, you can determine this experimentally. Connect the secondary wires one way, power the circuit, place the switch in the BOOST position and measure the voltage across the power socket. If it is higher than the line voltage (the voltage across the primary), the transformer has been wired correctly. If the voltage across the socket is less than the line voltage, reverse the secondary wires. If the transformer has been incorrectly wired with respect to phase, it acts as a "bucking" autotransformer which has a lower output voltage than it has input voltage. ◇



With the switch in BOOST, line voltage is raised about 6V.

DURING the summer months, when power demands peak, brownouts are an all too common occurrence. As power companies cut back on the amount of voltage delivered to the ac outlets in your home, the picture on your TV receiver is likely to shrink and lose color, your lights might dim slightly, and some of your appliances may have difficulty operating on the unaccustomed low voltage. Some electrically operated appliances can even be irreparably damaged if they are operated on too low a voltage.

Most people just grit their teeth and try to bear with the inconveniences of the brownout situation. This is one way to approach the problem, but a more practical approach would be to use a device that will restore the line voltage level to normal. This is exactly what the Power Guard is designed to do. It is completely automatic. As the line voltage begins to fall below a predetermined level, the Power Guard compensates for the reduction by boosting the voltage available at its output. Then, when the power company restores normal service, the Power Guard switches itself out of the line, to remain ready to go into action again when the next brownout occurs.

About the Circuit. A voltage-sensing circuit that operates a relay, causing it to switch a transformer in and out of the ac line is the heart of the Power Guard (see Fig. 1). The sensing circuit is made up of the voltage divider formed by *R1* and *R2,* neon lamp *I1,* and silicon controlled rectifier *SCR1*.

When switch *S1* is set to ON, line voltage is applied across the *R1/R2* divider network. Assuming that this potential is greater than 105 volts ac, *I1* will fire. This, in turn, indicates that the power available at the wall outlet is at a "normal" level. By adjusting *R2,* the line potential at which *I1* is triggered can be varied.

When *I1* comes on, it applies current to the gate of *SCR1,* triggering the silicon controlled rectifier into conduction and energizing relay *K1*. When this happens, the relay's lower set of contacts places output receptacle *SO1* directly across the ac line. Capacitor *C1* across the solenoid of *K1* eliminates the possibility of relay chatter that would normally be caused by the rectified voltage coming through *SCR1.*

When a brownout occurs and the line voltages drops below the value predetermined by the setting of *R2, I1* extinguishes and removes gate current from *SCR1*. This causes the SCR to cut off on the next zero crossing of the line voltage and deenergizes *K1.* This, in turn, switches the secondary of *T1* into the circuit, which is designed to add the primary and secondary voltages. This "boosted" voltage is then delivered to *SO1.* The magnitude of the voltage boost depends on the secondary voltage of *T1* at the reduced line voltage. The point at which the boost comes into play depends on the setting of *R2*. (Note also that, when the boost circuit is operating, *I2* comes on to provide a visual indication that line voltage is down.)

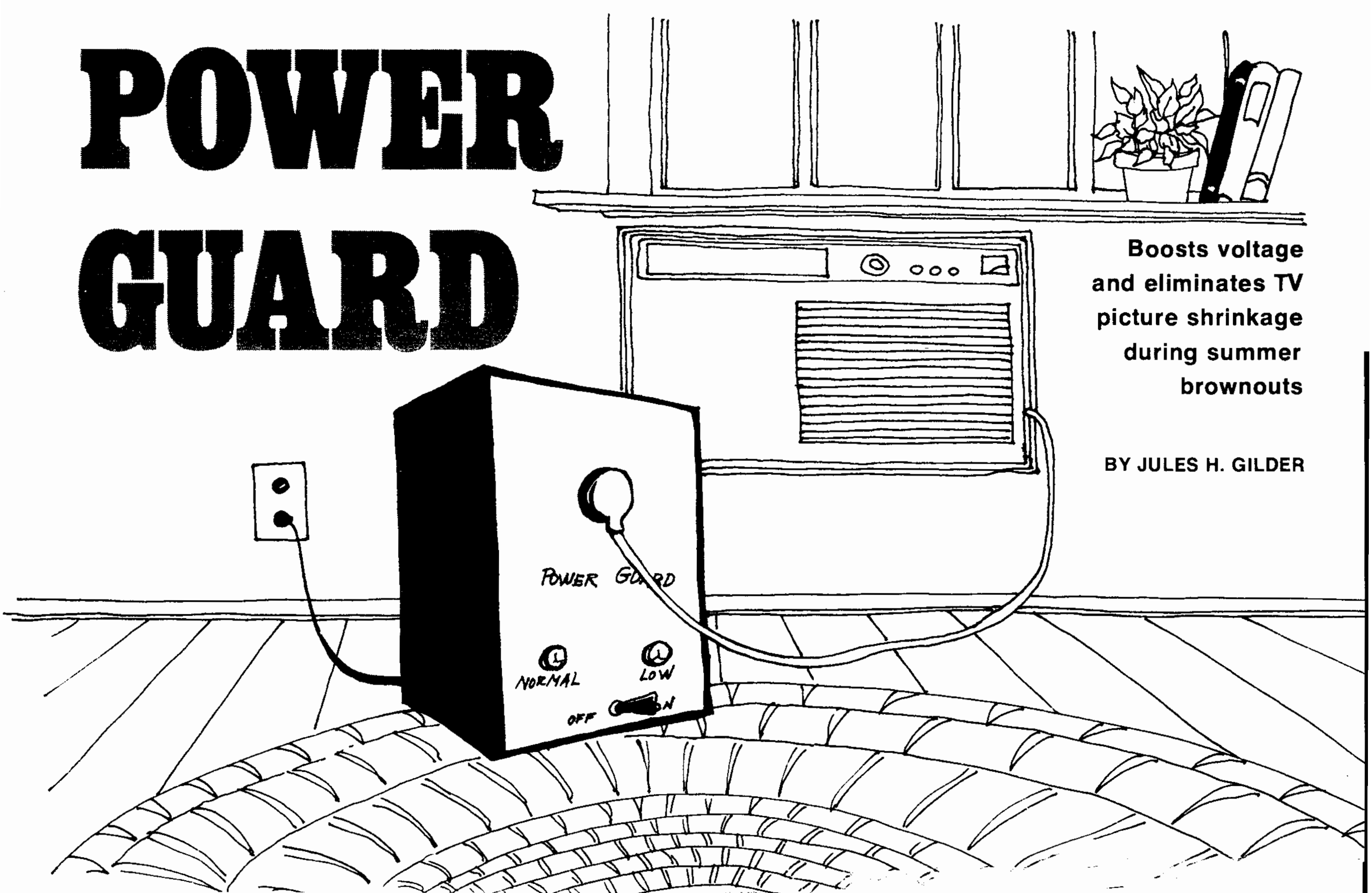
Tracking, the opening and closing of the relay's contacts caused by minor changes in line voltage, is eliminated by *I1*. The reason for this is that the neon lamp's firing voltage is higher than that required to maintain it in the ionized state. So, while the lamp requires about 110 volts to fire, it will not extinguish until the line voltage drops to 105 volts.

CONSTRUCTION

THE POWER GUARD

Boosts voltage and eliminates TV picture shrinkage during summer brownouts

BY JULES H. GILDER



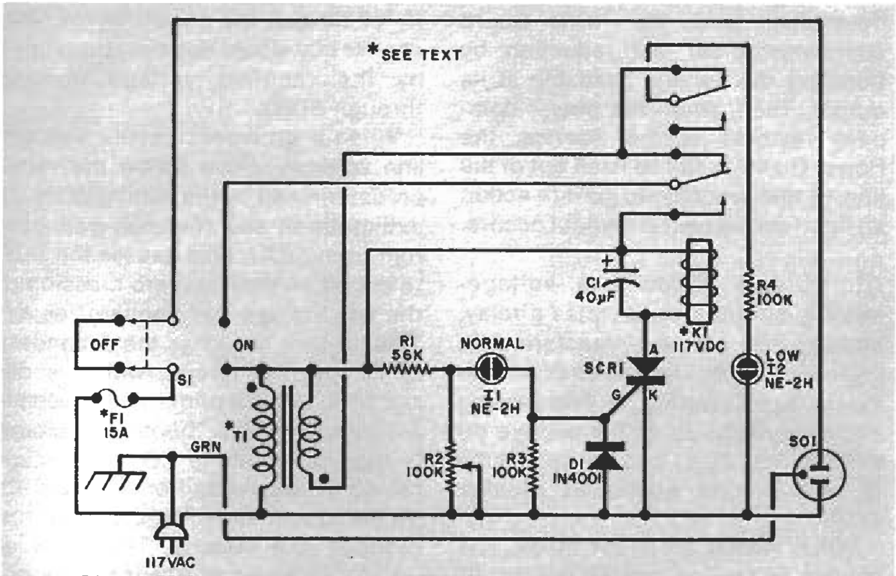


Fig. 1. Voltage-sensing circuit switches transformer in and out of circuit to keep voltage up during brownout.

PARTS LIST

C1—40-μF, 200-volt electrolytic capacitor
D1—Silicon rectifier (1N4001 or similar)
F1—15-ampere fuse (3AB, 15A)
I1, I2—NE-2H neon lamp
K1—117-volt dc relay with dpdt contacts rated at 20 amperes or more
R1—56,000-ohm, ½-watt resistor
R2—100,000-ohm trimmer potentiometer
R3, R4—100,000-ohm, ½-watt resistor
S1—Heavy-duty dpdt power switch rated at 25 amperes or more
SCR1—200-volt silicon controlled rectifier (HEP-R1211 or similar)
SO1—Three-contact chassis-mounting ac receptable
T1—Autotransformer (Allied Electronics Cat. No. 705-0144 16-ampere or 705-0104 8-ampere type) or high-current filament transformer (See text)
Misc.—Metal chassis box; heavy-duty three-wire line cord with plug attached; fuse holder for F1; perforated board and solder clips; machine hardware; hookup wire; solder; etc.

Since most electrical appliances and electronic instruments are designed to operate properly on line voltages ranging from 105 to 125 volts, no change in performance will be noted until the line drops below 105 volts. Using this as the trigger point, you can add between 10 and 20 volts to the potential available during the brownout to obtain normal service.

Placing *S1* in its OFF position effectively removes the Power Guard from the system. With *S1* set to OFF, therefore, the line voltage is coupled directly to *SO1*.

Construction. The circuit of the Power Guard is very simple. Hence, it can easily and conveniently be assembled on a piece of perforated epoxy-fiberglass or phenolic board. The transformer can then be mounted on the floor of a metal case large enough to accommodate it and the board assembly without crowding. Don't forget to leave room for *SO1* to mount on the front of the case and for the line cord exit hole and fuse holder on the rear of the case. If you build a 15-ampere Power Guard, you should have no difficulty mounting all of its components in a standard (preferably steel) metal case measuring 9" × 7" × 6" (22.9 × 17.8 × 15.2 cm).

Since you will be working directly with line voltages, it is very important that you check all wiring carefully before you apply power. Make certain you use a three-wire line cord and connect the neutral (green) lead to chassis ground via a large solder lug and to the third contact on *SO1*.

It is best to use an autotransformer for *T1*. However, if you can't locate one, you can substitute an ordinary filament transformer. If you do use a filament transformer, you must take care to assure that the primary and secondary are properly phased to provide a boost in voltage. (The transformer's secondary must also be rated at a greater current than would be drawn by any load plugged into *SO1*.) To determine the proper phasing, wire the transformer as shown in Fig. 2 and measure the potential at the "output" leads. Transpose the secondary leads and again measure the output voltage. The connection scheme that yields the higher voltage is the proper phasing setup.

Setup and Use. To use the Power Guard properly, it is necessary to first adjust *R2* so that the system triggers *SCR1* at the correct voltage level. The simplest way to adjust *R2* is to plug the Power Guard into a variable transformer and decrease the potential applied to the system's power plug to 105 volts. If you don't have access to a variable transformer, a filament transformer connected as a "bucking" instead of "boosting" autotransformer can be used.

When the potential is 105 volts, adjust *R2* so that *I1* just extinguishes. At this point, the relay in the system should not be energized, and the booster winding in the Power Guard should be in the circuit. If you measure the voltage at *SO1* it should be between 110 and 120 volts ac.

Once *R2* has been adjusted for the proper triggering level, it need not be touched again. The Power Guard is ready to use.

Appliances can be permanently plugged into *SO1* and the Power Guard's switch set to OFF when no brownouts are expected. Then, during the months when you can expect brownouts, just flip the switch to ON,

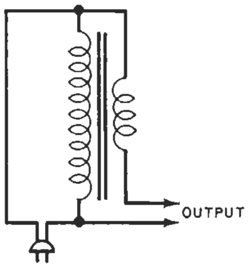


Fig. 2. Circuit to determine proper transformer phasing.

and the system will automatically adjust itself to the varying conditions as they occur.

If a high-current transformer is used for *T1* and the contacts on *K1* can handle the load, a single Power Guard can be used to service several appliances simultaneously. In this case, you can mount several *SO1*-type receptacles on the front of the Power Guard's front panel and wire them into the system in parallel with each other. Don't forget to also replace fuse *F1* when you go to the higher power-handling capacity of the system. ◈

555 timer isolates equipment from excessive line voltage

by R. J. Patel
Tata Institute of Fundamental Research, Bombay, India

Instruments and appliances can be easily damaged when the line voltages that power them become excessively high or low, but a voltage-sensing circuit using the 555 timer will disconnect the equipment from the power lines if the set limits are exceeded. This circuit offers a better alternative for protecting instruments than a voltage stabilizer circuit, which is usually effective for detection and compensation of short-term variations only.

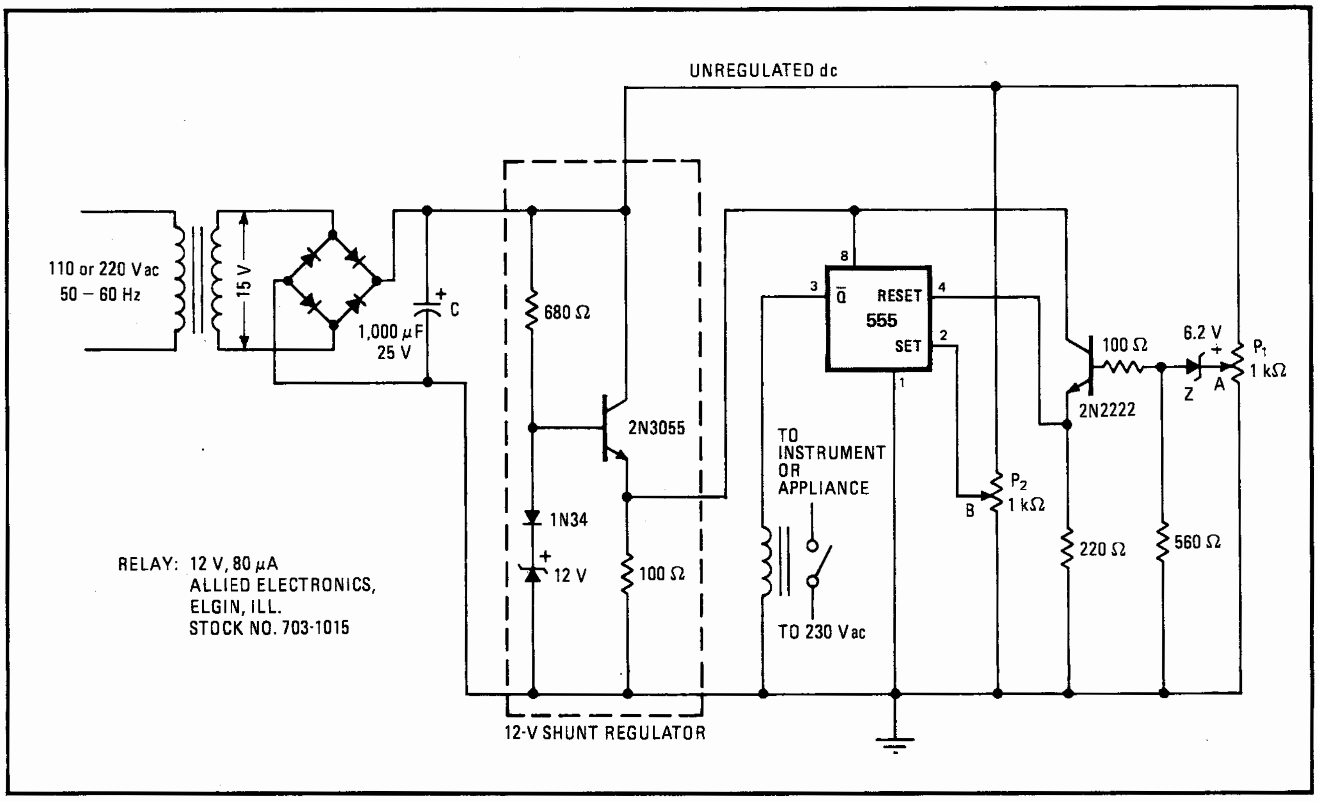
As shown in the figure, the line voltage is converted to approximately 15 volts by the step-down transformer, whose turns ratio is determined by the magnitude of the incoming voltage at the primary winding. This voltage is rectified, then filtered by capacitor C and applied to a 12-v regulator in order to bias the timer and the 2N2222 sense transistor. The magnitude of the unregulated voltage varies proportionally with the line voltage, as is to be expected, and this voltage is continually sampled by potentiometers P_1 and P_2, the upper and lower threshold controls.

The 555 timer is used in the bistable mode, and its state is a direct function of the voltages on its set and reset ports, pins 2 and 4, respectively.

Under normal conditions—that is, when the supply line voltage is within the set limits—the unregulated dc voltage at point A is sufficient to fire zener Z, saturating the transistor. Pin 4 of the timer rises rapidly to 12 v; when this voltage exceeds two thirds of the 12-v bias voltage on the timer, or 8 v, pin 3 moves high and the relay is energized.

If the ac line voltage is below the low set value, the voltage at A is below the value needed to fire the zener, and the relay is de-energized. When the line voltage shoots above the set upper limit and the dc voltage at pin 2 exceeds one third of the 12-v supply voltage, the relay is de-energized as pin 3 moves low.

The upper and lower set limits can be set with an accuracy of ±5 v of the true ac line voltage if precision potentiometers are used. There is no set-point hysteresis, because of the avalanche breakdown characteristics of the zener Z. Any transients generated by the power line are rendered harmless by the large filter capacitor C. ☐

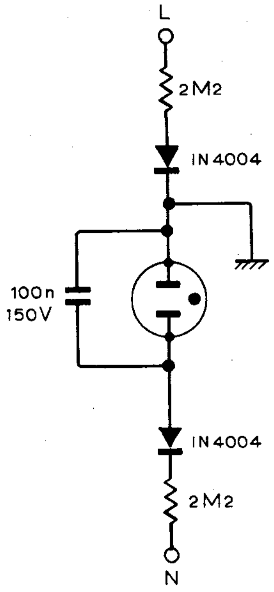


Line-voltage monitor. 555 timer circuit senses if ac line voltage is above or below set limits, then de-energizes line relay if necessary, removing power from equipment. Simple circuit uses set-control potentiometers P_1 and P_2 to monitor unregulated dc voltage, whose value is directly proportional to the ac line voltage. Timer and 2N2222 transistor require the regulated power source.

WARNING INDICATOR

A small modification to the "Earth warning indicator" described by R. H. Troughton (Circuit Ideas, April issue) will enable it to give further warnings of potential danger, especially when the layperson is connecting electrical equipment to the mains supply. Connecting wires to the wrong pins so as to produce a hazardous condition would be indicated immediately if the accompanying circuit were fitted in electrical appliances – ahead of the fuse and on/off switch.

As well as warning of an unearthed unit, it will repeatedly flash if the live and neutral wires are reverse connected (meaning usually that the equipment fuse is in the wrong line for full protection). It will flash if the earth wire is mistakenly connected to the live pin of a plug – provided the neutral wire

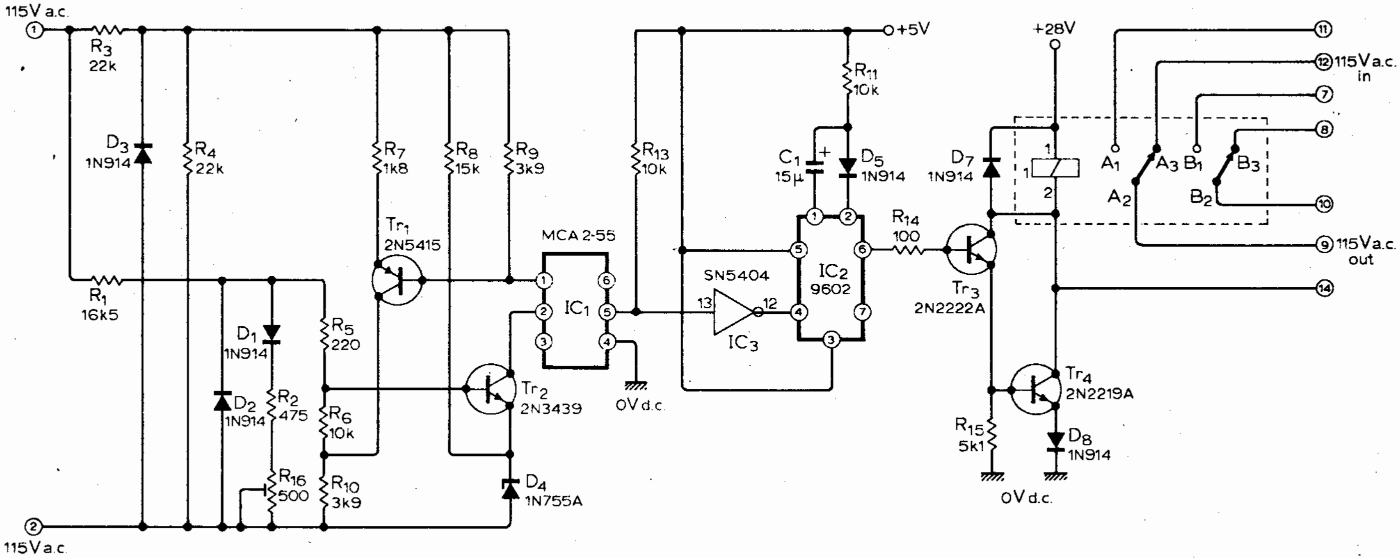


is connected to either the neutral pin or the earth pin (laypersons usually manage to connect each of the three wires to different pins – it's just that they aren't always the right ones).

Should the earth and neutral wires be connected in reverse, it is not immediately dangerous (where neutrals are made earth potential) but would become potentially dangerous if the neutral wire then became open circuit. The instant this happened, the neon would begin flashing a warning of the danger – and the misconnections.

Possible instructions to the purchaser could read: "After fitting the plug (follow the colour coding carefully), stand away from the appliance, plug into the wall-socket and switch on. Do not touch the appliance if the warning lamp is flashing – Simply switch off, pull the plug and recheck the connections. . . .

Ralph Lewis,
Liverpool 7.



A.c. line sensor

A line sensor is used to protect delicate equipment from sustained over-voltage. This circuit will disconnect the supply if it exceeds a pre-set level.

Transistor Tr_2 senses the input, which can be varied by R_{16}, and turns on if the base voltage exceeds V_{be} + 7.5V. When this occurs the opto-coupler IC_1 conducts and switches Tr_1 on. Positive feedback produces a fast switching action and the circuit remains on until the alternating voltage falls below the pre-set level. The output pulse is shaped by IC_3 and used to trigger the monostable IC_2. As long as the time constant C_1R_{11} is longer than the duration of the pulse, pin 6 is high so the relay is activated which disconnects the alternating supply. When the a.c. falls below the pre-set level the monostable reverts to the stable state and switches on the supply.

F. E. George,
College of Arts, Science and Technology,
Jamaica.