If you're looking for an accurate way to control film developing times, then take a look at this Photographic Timer. It will switch on mains-powered fluorescent ultraviolet tubes or incandescent lamps rated at up to 1200W for a preset time ranging from 1-450 seconds.

Developing photos or making PC boards and front panels requires a controlled light source. Depending on the process, this could be based on special incandescent globes or ultraviolet tubes. In either case, the developing time needs to be accurately set so that the exposure is correct.

Now this is all well and good if you have a light box or enlarger which incorporates a timer but these are usually very expensive. What's more, controlling the mains power requires specialised circuitry, so we've come up with this low-cost Photographic Timer which should fit the bill.

It uses only a handful of components, including an optocoupled Triac driver to isolate the mains from the low-voltage control circuitry. We've also used an isolated-tab Triac to eliminate the need for an isolating kit.

By the same token, any project that requires 240V wiring must be done with extreme caution. We recommend that if you haven't worked with 240VAC wiring before, then it would probably be a good idea to give this project a miss or find an experienced constructor to build it for you.

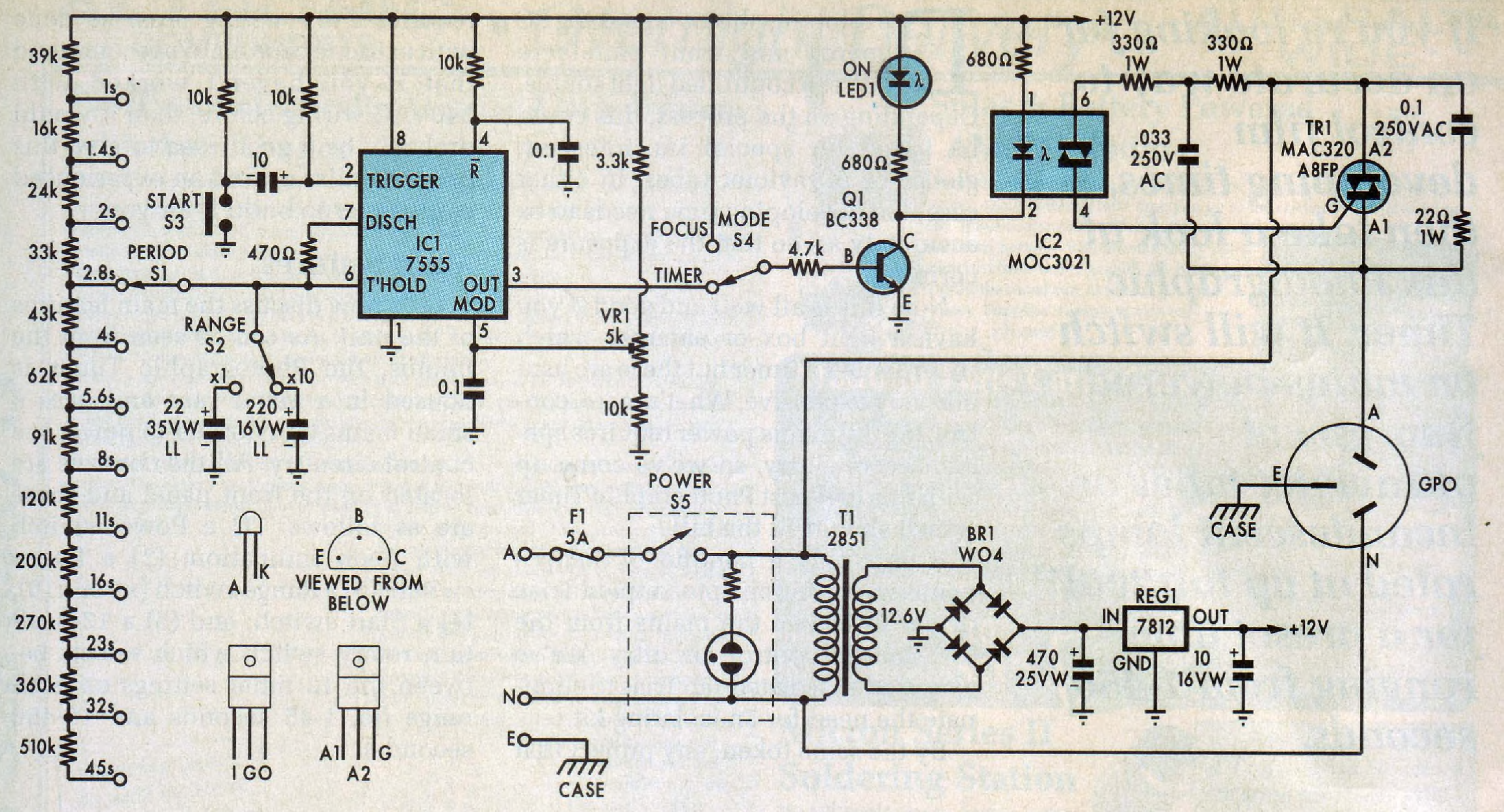
Main features

Let's now discuss the main features of the unit. As can be seen from the photos, the Photographic Timer is housed in a metal case and uses a small mains transformer to power the control circuitry. All the controls are located on the front panel and these are as follows: (1) a Power switch with neon indication; (2) a Focus switch; (3) a Range switch (x1 or x10); (4) a Start switch; and (5) a 12-position rotary switch which selects between the 12 timer settings on each range (ie, 1-45 seconds and 10-450 seconds).

A photographic timer for darkrooms

By JOHN CLARKE

The prototype was built into a compact metal case which is earthed. It provides timed periods ranging from 1-450 seconds over two ranges.



PHOTOGRAPHIC TIMER

Fig.1: the circuit uses 7555 timer IC1 to provide the timing period. When the start switch (S3) is pressed, its pin 3 output goes high & turns on Q1. Q1 then drives optocoupler IC2 which in turn switches on Triac TR1.

The Focus switch is typically used to switch a photographic enlarger lamp on so that an image can be focused prior to printing. The lamp is then switched off and the Start button pressed to initiate the exposure period. A red LED adjacent to the Start switch lights while ever power is applied to the 240V GPO socket mounted on the rear panel.

The 12 timing values are arranged in a geometric progression, with the square root of 2 (ie, 1.414) as the multiplier. This gives nominal values of 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 23, 32 and 45 seconds on the x1 range. This type of geometric progression is ideal for photographic work, since doubling the exposure time represents one stop.

What this means is that the selector switch effectively steps in half-stop increments. This order of resolution should be quite sufficient for photographic purposes and other general exposure work involving light boxes.

Circuit details

Let's now take a look at the circuit details – see Fig.1.

The circuit is based on a CMOS 7555 timer (IC1) which is connected in monostable mode. Switch S1 selects one of 12 outputs provided by a resistive divider network to set the basic timing interval, while S2 selects between two timing capacitors to provide the x1 or x10 range. The resulting RC time constant is connected to pin 6 (threshold) of IC1 and thus sets the overall timing interval.

Note that the two main timing capacitors selected by the Range switch (S2) are both specified as low leakage (LL) types. This is necessary because at high settings of S1, the charging current is very low. As a result, standard electrolytic capacitors with their higher leakage currents would never charge up to a level sufficient to end the timing cycle (ie, the lamps would never switch off).

The circuit works like this: at power on, the reset pin (pin 4) of IC1 is momentarily pulled low via a 0.1μF capacitor. This prevents the pin 3 output of IC1 from initially going high. After a short period, the reset input is then pulled high via a 10kΩ pullup resistor and the timer can function normally.

The timing sequence is initiated by pressing the Start switch (S3). This momentarily pulls the pin 2 trigger input of IC1 low via a 10μF capacitor and this, in turn, causes the pin 3 output to go high. The 10μF trigger capacitor then quickly charges via an associated 10kΩ resistor to end the trigger pulse. This ensures that the timing period cannot be influenced by holding S3 switch down.

When S3 is released, the 10μF timing capacitor discharges via a second 10kΩ resistor connected between the switch and the positive supply rail (Vcc). The circuit is then ready for the next trigger input.

Once triggering has occurred, the pin 3 output stays high while the timing capacitor charges via the resistive

Main Features

- Controls loads up to 1200W
- Timer operates from 1-45s in 12 steps for x1 range; & from 10s-450s (7.5min) in 12 steps for x 10 range
- Timing steps arranged in 1.41:1 increments (equivalent to half a stop)
- Focus switch
- Red "safe light" indicators
- Compact case
- Isolated control circuitry & isolated tab Triac

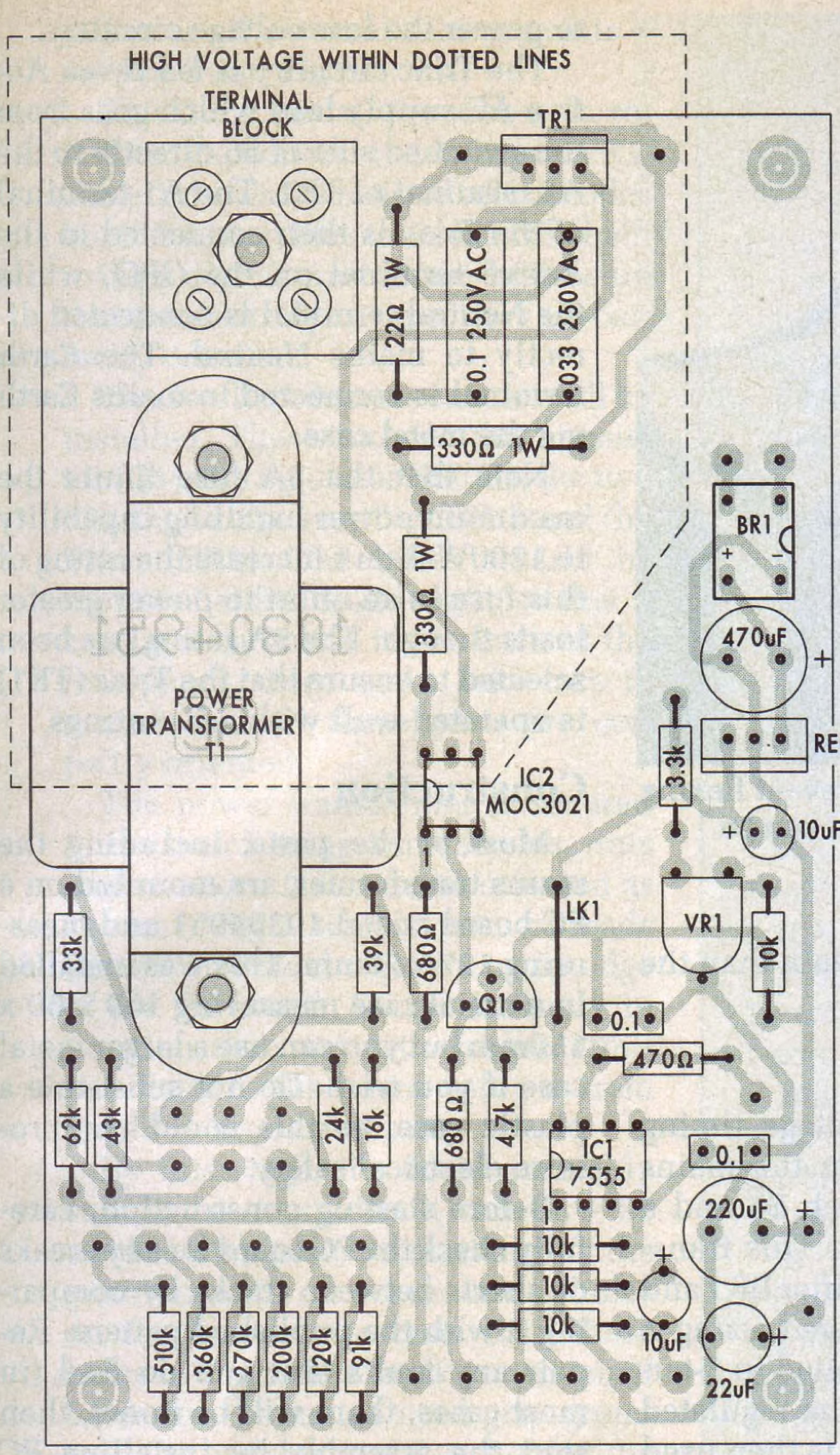


Fig.2: install the parts on the PC board as shown here & note that the parts enclosed by the dotted lines operate at mains potential when power is applied.

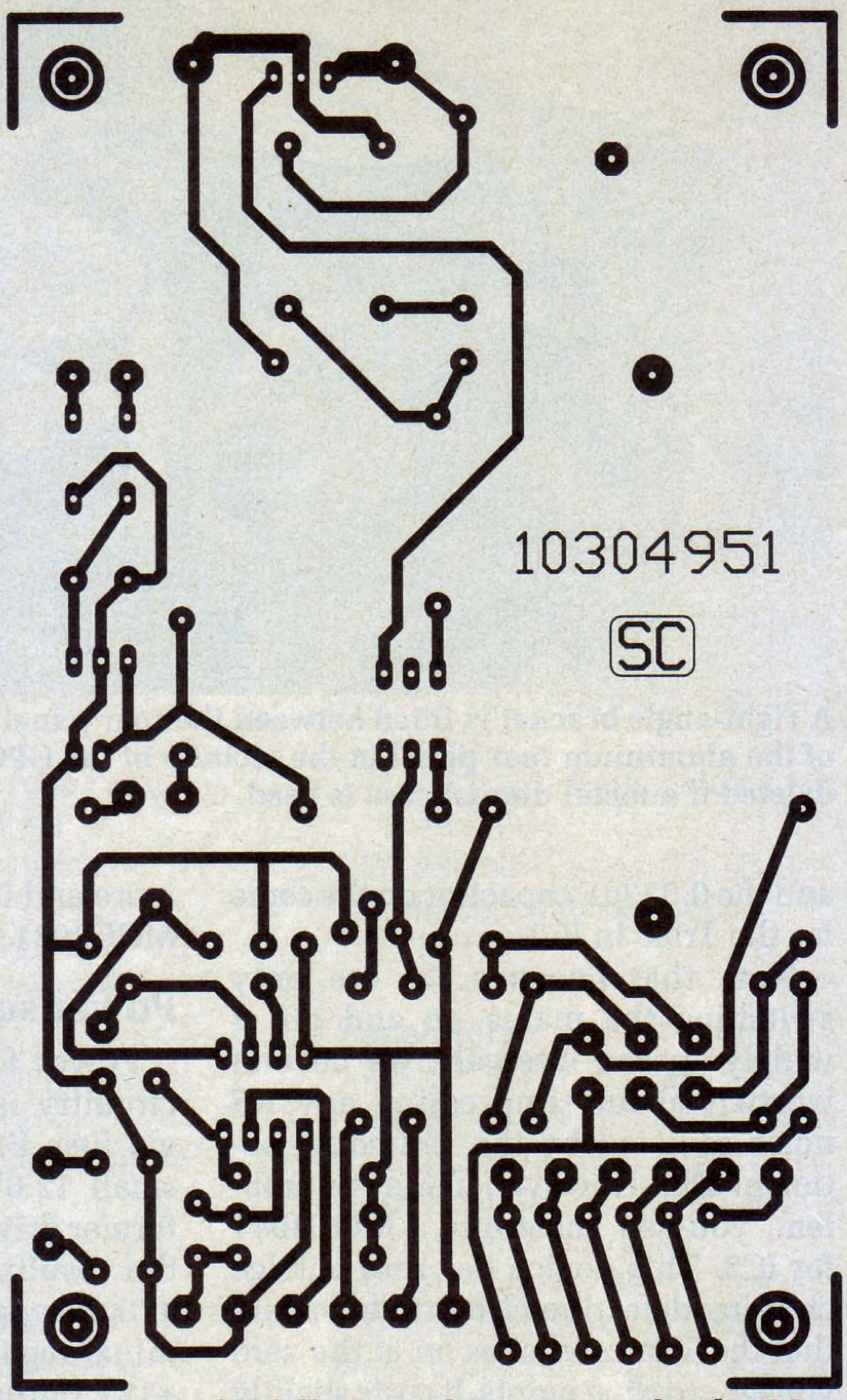


Fig.3: this is the full-size etching pattern for the PC board. It is a good idea to check carefully for etching defects before mounting any of the parts.

network selected by S1. When the capacitor voltage subsequently reaches a preset threshold, pin 3 goes low again and the timing period ends. The timing capacitor on pin 6 then discharges via the 470Ω resistor connected to pin 7. This resistor limits the capacitor discharge current to prevent damage to the IC.

The pin 6 threshold voltage is nominally 2/3Vcc but, in this circuit, can be shifted about this value by adjusting the voltage applied to the modulation input at pin 5. This is achieved using VR1 which forms part of a resistive divider connected across the supply rails. Basically, VR1 functions as a calibration control and is necessary because the timing capacitors have a very wide tolerance range (±20%).

In practice, it's simply a matter of calibrating the unit on the x1 range for one setting. The x10 range should then be within 5%, provided that the 22μF and 220μF capacitors are supplied matched – see parts list.

Power control

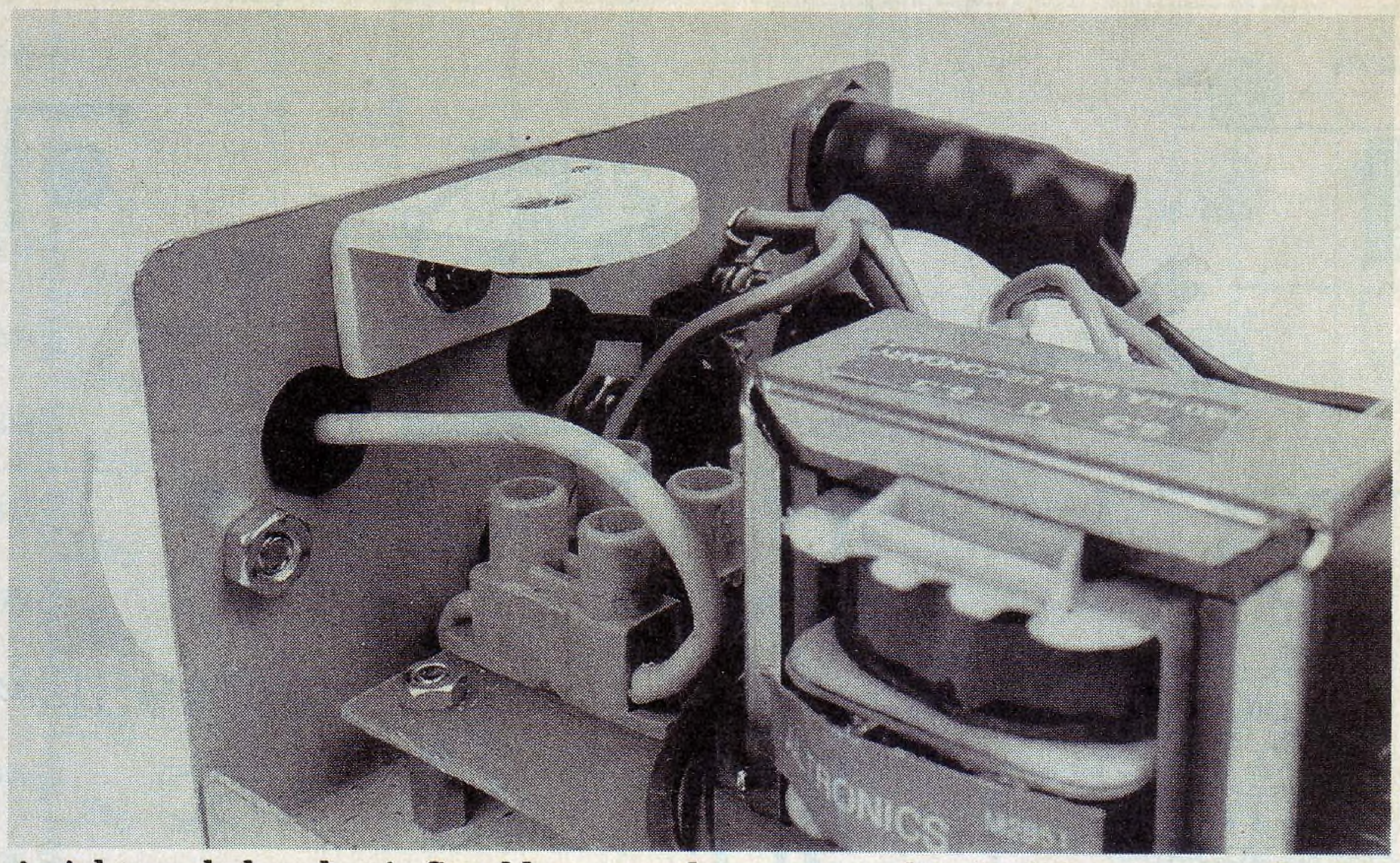
Assuming S4 selects the TIMER position, IC1's pin 3 output drives transistor Q1 via a 4.7kΩ base current limiting resistor. Q1 thus turns on whenever pin 3 is high (ie, for the duration of the monostable period). Alternatively, when S4 selects the FOCUS position, Q1's base is pulled to the positive supply rail and so the transistor is permanently held on.

Q1 in turn drives IC2 which is a MOC3021 optocoupled Triac driver. Its job is to provide very high voltage isolation between the low voltage control circuitry and the switched mains voltage. When Q1 turns on, an internal LED between pins 1 and 2 of IC2 also turns on and this triggers an internal Triac between pins 6 and 4. Finally, IC2 triggers TR1, an MAC320A8FP isolated tab Triac, which turns on and connects the Active mains line to the Active pin on the GPO.

The 22Ω 1W resistor and the 0.1μF capacitor provide a snubber network for TR1, while the two 330Ω resistors

Warning!

Potentially lethal mains voltages are present on some components on the PC board when power is applied to this unit (see Fig.2). Do not attempt to build this unit unless you are experienced at working with mains voltages. Also, do not attempt to work on any high voltage circuitry while the unit is plugged into the mains.



A right-angle bracket is fitted between the rear panel & the lid to prevent flexing of the aluminium rear panel in the vicinity of the GPO. This bracket can be deleted if a metal diecast case is used.

and the 0.033μF capacitor do the same for the Triac in IC2.

Note that because we are only switching the mains on and off at widely spaced intervals, we haven't worried about suppressing any RF noise radiated by the switching action of TR1. However, if this is a problem, you can substitute a MOC3041 for IC2. This device has zero voltage crossing detection circuitry to ensure that the Triac switches on at the zero voltage crossing points. It costs slightly more and is harder to obtain than the MOC3021 though.

Power supply

Power for the low-voltage timing circuitry is derived from the mains via fuse F1, power switch S5 and a small 12.6V transformer. This transformer drives bridge rectifier BR1 and the resulting DC is filtered using a 470μF capacitor and applied to 3-terminal regulator REG1. The regulated +12V output from REG1 is then used to power the low voltage circuitry.

The Triac circuitry is fed by an Active AC supply lead which goes from the switched side of S5 directly to the A2 terminal of TR1. The A1 terminal of the Triac is then connected to the Active terminal on the GPO, while the Neutral terminal is connected directly to mains Neutral. The Earth terminal is connected to mains Earth via the metal case.

Note that the 5A fuse limits the maximum power handling capability to 1200W. Don't increase the rating of this fuse in an effort to power greater loads though. The 5A rating has been selected to ensure that the Triac (TR1) is operated well within its ratings.

Construction

Most of the parts, including the mains transformer, are mounted on a PC board coded 10304951 and measuring 127 x 76mm. This was installed in a metal case measuring 100 x 60 x 150mm but you can use a larger metal case if you wish. Do not substitute a plastic case, as this could compromise electrical safety.

Before starting construction, carefully check the PC board for any breaks or shorts between tracks by comparing it with the published pattern. Repair any faults that you do find (in most cases, there will be none), then start the assembly by installing PC

TABLE 1: RESISTOR COLOUR CODES

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	510kΩ	green brown yellow brown	green brown black orange brown
❑	1	360kΩ	orange blue yellow brown	orange blue black orange brown
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	1	200kΩ	red black yellow brown	red black black orange brown
❑	1	120kΩ	brown red yellow brown	brown red black orange brown
❑	1	91kΩ	white brown orange brown	white brown black red brown
❑	1	62kΩ	blue red orange brown	blue red black red brown
❑	1	43kΩ	yellow orange orange brown	yellow orange black red brown
❑	1	39kΩ	orange white orange brown	orange white black red brown
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	24kΩ	red yellow orange brown	red yellow black red brown
❑	1	16kΩ	brown blue orange brown	brown blue black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	2	680Ω	blue grey brown brown	blue grey black black brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	2	330Ω	orange orange brown brown	orange orange black black brown
❑	1	22Ω	red red black brown	red red black gold brown

stakes at all external wiring points – see Fig.2 and Fig.3.

This done, install the wire link, resistors, capacitors and trimpot VR1. Table 1 shows the resistor colour codes but it is a good idea to also check them using a digital multimeter. Make sure that the electrolytic capacitors are correctly oriented.

The semiconductors can now all be installed. These include the transistor (Q1), the regulator (REG1), the two ICs, the bridge rectifier (BR1) and the Triac (TR1). The latter should be mounted at full lead length, so that it can later be bolted to the back of the rear panel. Once again, take care to ensure that all these parts are correctly oriented.

The power transformer is secured to the board using 3mm screws, nuts and washers. It should be oriented as shown in Fig.3, with its primary leads (brown and blue) adjacent to the edge of the PC board. Secure it firmly in position, then secure the mains terminal block to the board using a 3mm machine screw and nut.

By this stage, the board assembly should be complete. It can now be used as a template for marking out the positions of its corner mounting holes on the base of the case. Drill these holes to 3mm, then mark out and drill holes for the mains cord grip grommet, the panel mount fuse holder, the GPO socket, the earth lug and the Triac (TR1). Fig.4 shows how these parts are arranged on the rear panel.

The position of the Triac mounting hole can be determined by temporarily positioning the board in the case on 9mm spacers. At the same time, be sure to position the hole for the cord grip grommet so that it will clear the PC board. Drill a small pilot hole initially, then carefully ream and file the hole to the correct shape so that the grommet is a snug fit. This is necessary to ensure that the mains cord will be firmly anchored.

The hole positions for the GPO can be marked out by using it as a template. It should be oriented as shown on Fig.4 (ie, with the Earth terminal towards the bottom). The entry holes for the Active, Neutral and Earth leads must be fitted with small rubber grommets to protect the lead insulation.

PARTS LIST

1 PC board, code 10304951, 76 x 127mm
1 front panel label, 100 x 52mm
1 metal cabinet, 100 x 60 x 150mm or similar
1 10A panel mount mains socket (HPM Cat. N0 35 or equivalent)
1 12-position single pole rotary switch (S1)
2 SPDT toggle switches (S2,S4)
1 momentary pushbutton normally open switch (S3)
1 SPST mains rocker switch with integral Neon (S5)
1 2851 12.6V 150mA mains transformer (T1)
1 M205 panel-mount fuse holder
1 M205 5A 250VAC fuse
1 10A 250VAC 2-way terminal block
1 14mm diameter knob
1 cord grip grommet for 10A mains flex
1 10A mains cord & plug
3 5.5mm ID grommets
1 right angle bracket plus screws & nuts (see text)
1 5mm LED bezel
1 solder lug
4 9mm tapped spacers
5 12mm x 3mm dia. screws & nuts
4 9mm x 3mm dia. screws & nuts
1 3mm dia. star washer
1 30mm length of 6-way rainbow cable
2 30mm lengths of 6-way rainbow cable
1 120mm length of blue hookup wire
1 120mm length of red hookup wire
1 120mm length of yellow hookup wire
1 200mm length of brown 10A mains wire
1 100mm length of blue 10A mains wire
1 50mm length of 0.8mm tinned copper wire
5 100 x 2.4mm cable ties
1 70mm length of 19.1mm diameter heatshrink tubing
25 PC stakes
1 5kΩ miniature horizontal trimpot (VR1)

Semiconductors
1 TLC555CP, LMC555CN, 7555 or equivalent CMOS timer (IC1)
1 MOC3021 opto-isolated Triac driver (IC2)
1 WO4 1.2A 400V DIP bridge rectifier (BR1)
1 7812, 12V 3-terminal regulator (REG1)
1 MAC320A8PF 8A isolated tab Triac (TR1)
1 BC338 NPN transistor (Q1)
1 5mm diameter red LED (LED1)

Capacitors
1 470µF 25VW PC electrolytic
1 220µF 16VW RBLL electrolytic
1 22µF 35VW RBLL electrolytic
2 10µF 16VW PC electrolytic
2 0.1µF MKT polyester
1 0.1µF 250VAC plastic film
1 0.033µF 250VAC plastic film
Note: the 220µF capacitor should be selected so that its measured value is 9.5-10.5 times larger than the measured value of the 22µF capacitor.

Resistors (0.25W, 1%)

1 510kΩ	1 24kΩ
1 360kΩ	1 16kΩ
1 270kΩ	4 10kΩ
1 200kΩ	1 4.7kΩ
1 120kΩ	1 3.3kΩ
1 91kΩ	2 680Ω
1 62kΩ	1 470Ω
1 43kΩ	2 330Ω 1W
1 39kΩ	1 22Ω 1W
1 33kΩ	

Miscellaneous
Heatsink compound (for Triac), solder, heatshrink tubing.

Right angle bracket

As can be seen from the photographs, a right angle bracket was fitted to the rear panel of the prototype, just above the GPO. This bracket is secured to the rear panel by the top GPO mounting screw and to the lid using a screw and a captured nut. This was done to add rigidity to the aluminium rear panel on the prototype, to prevent flexing as the plug is pushed in and out.

If a metal diecast case or a steel case

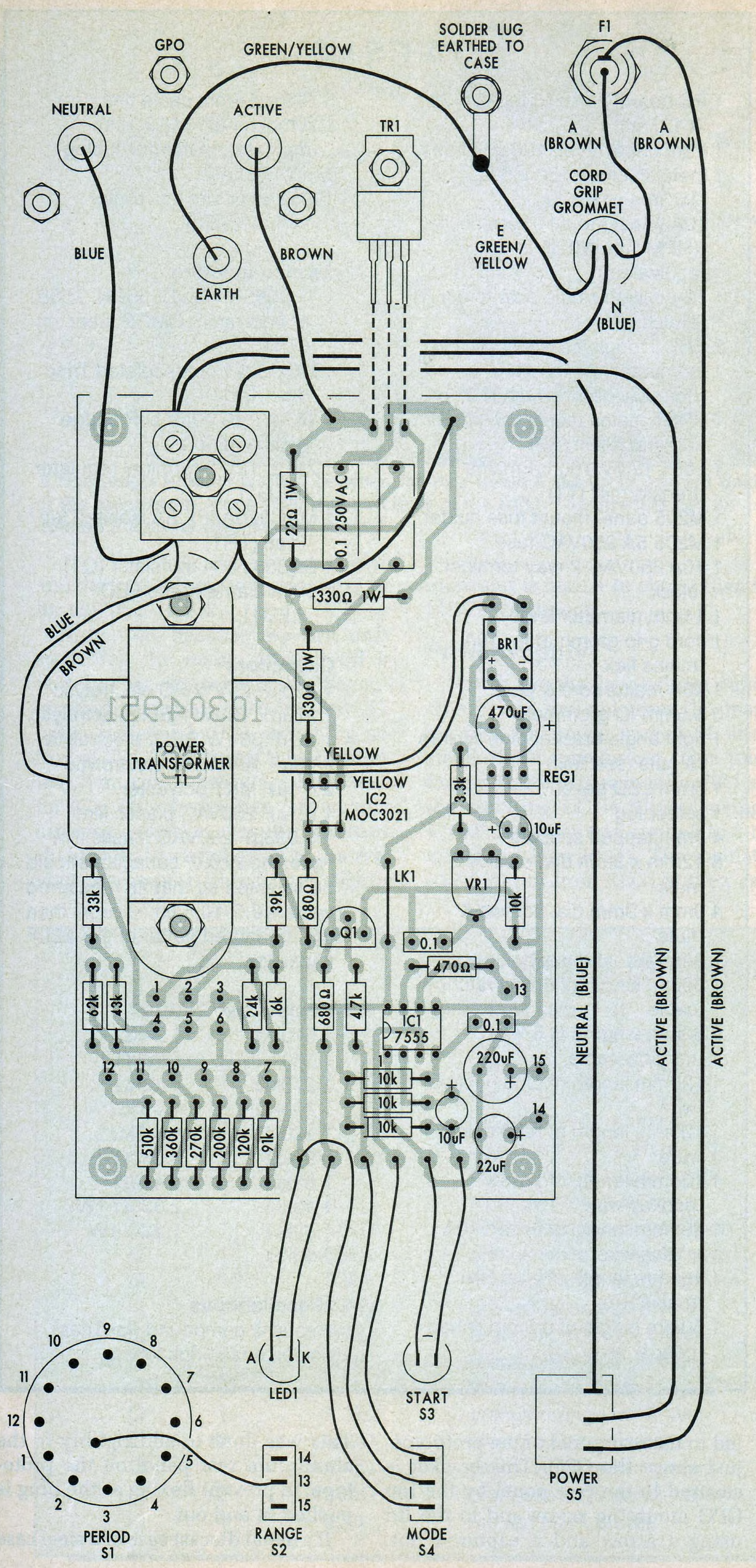


Fig.4 (left): follow this diagram carefully when wiring up the Photographic Timer & be sure to use mains-rated cable for all 240V wiring. The Triac (TR1) should be smeared with heatsink compound before it is bolted to the rear panel. Make sure that the earth lug is firmly secured.

is used, this bracket can be left out. However, it must be included where the rear panel is made from light-gauge aluminium.

The front panel label can now be affixed to the case and used as a template for drilling out the switch mounting holes. A hole will also have to be drilled to accept the LED bezel. The hole for the mains switch can be made by drilling a series of small holes around the inside perimeter of the cutout area, then knocking out the centre piece and carefully filing the hole to shape.

This done, mount the PC board in the case on 9mm spacers and install all front and rear panel components except for the rotary switch (S1). When mounting the earth solder lug, be sure to scrape away any paint from around the hole to ensure a good contact. The solder lug should be firmly secured using a star washer under the nut to prevent it from coming loose.

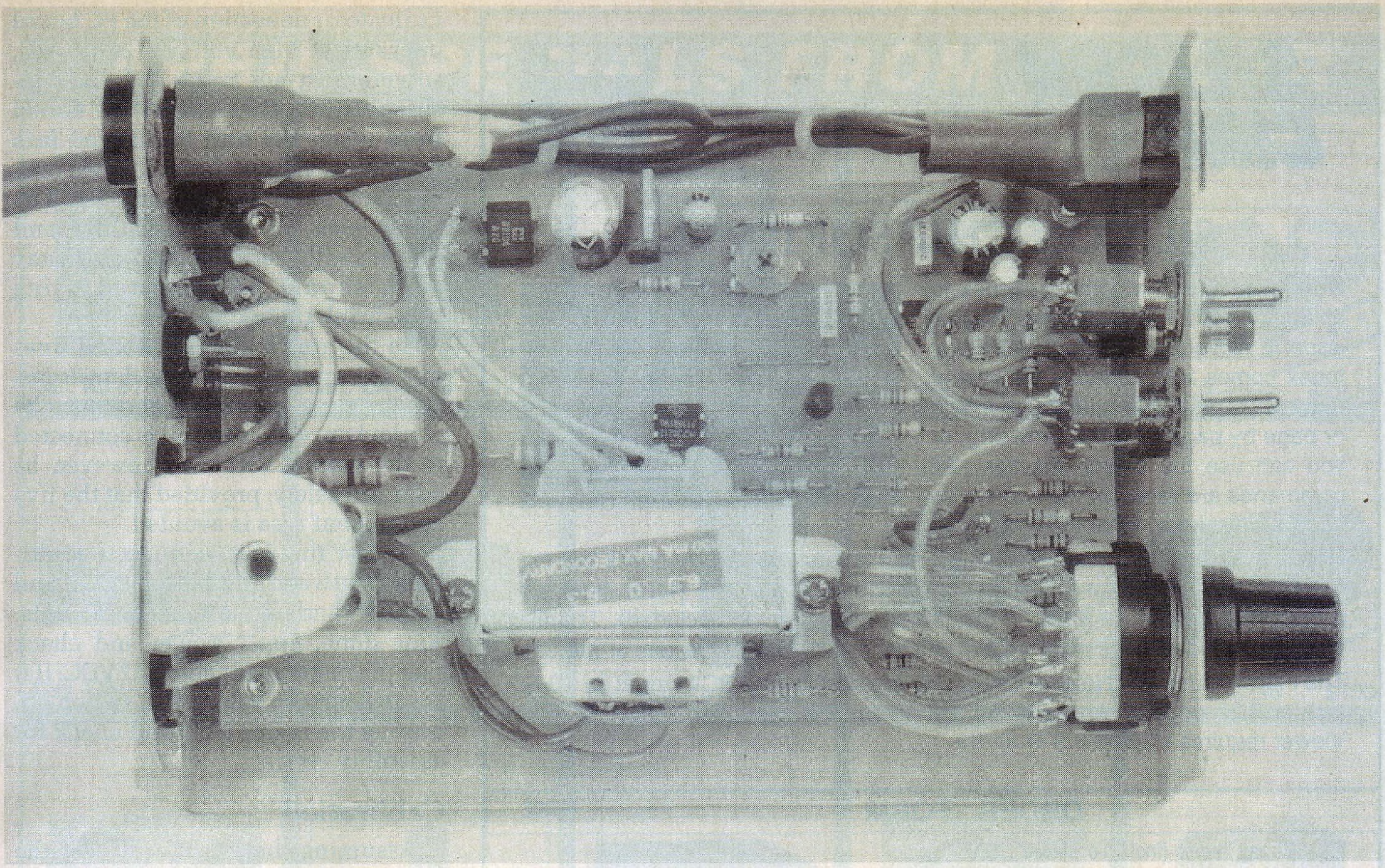
The Triac can be directly bolted to the case since its tab is isolated. Smear a small amount of heatsink compound between the mating surfaces before bolting it to the case to aid heat transfer. Warning: do not substitute a Triac with a non-insulated tab, as this will create a short between mains active and the case.

The shaft of the rotary switch can now be trimmed to suit the knob. In addition, its locking tab washer must be removed to allow the switch to select all 12 positions. This locking tab can be accessed by first removing the mounting nut and washer. Do not mount the switch yet, as it is easier to wire outside the case.

Wiring

The construction can now be completed by installing the wiring as shown in Fig.4. Rainbow cable is used for the connections to S1. Use a 6-way cable for pins 7-12 and two 3-way cables for pins 4-6 and 1-3.

When all the connections have been made, install the switch with the 6-



Use cable ties to keep the mains wiring neat & tidy & be sure to sleeve the fuseholder & power switch with heatshrink tubing to prevent accidental electric shock. Note that some components on the PC board operate at high voltage – see Fig.2.

way cable at the bottom and tighten the nut. Adjust the switch so that the marker on the knob aligns with the "1" on the front panel when the switch is fully anticlockwise. Don't forget the connection from S1's wiper to S2.

The connections to S2 and S4 are run using light duty hookup wire, while S3 only requires very short lengths of tinned copper wire to connect it to the board. Note that its terminals are bent sideways to prevent contact with other PC stakes. LED 1 has its leads connected directly to the PC stakes (note: the anode lead is the longer of the two).

The remainder of the wiring (ie, to the terminal block, fuseholder, power switch S5 and earth lug) must be run using mains-rated cable. Use brown cable for the Active connections, blue for Neutral and green/yellow for Earth.

Strip back about 130mm of the outer sheath of the mains cord before pushing it through the entry hole on the back of the case. This done, clamp the mains cord using the cord grip grommet and terminate the Earth lead to the solder lug. A second Earth lead must then be run from the solder lug to the Earth terminal on the GPO.

The wiring to the fuseholder and power switch can now be run. Before making these connections, slip some heatshrink tubing over the leads. After the connections have been made, push the heatshrink tubing over the switch and fuseholder bodies and shrink it down with a hot air gun (see photo). This will insulate the connections to these devices to guard against accidental contact.

Finally, complete the wiring to the terminal block and to the GPO, then secure the mains wiring with cable ties as shown in the photograph. The transformer secondary leads and the low-voltage wiring to S2 and S4 should also be secured using cable ties. This will prevent any accidental contact between the low-voltage and high-voltage sections of the circuit if a lead comes adrift.

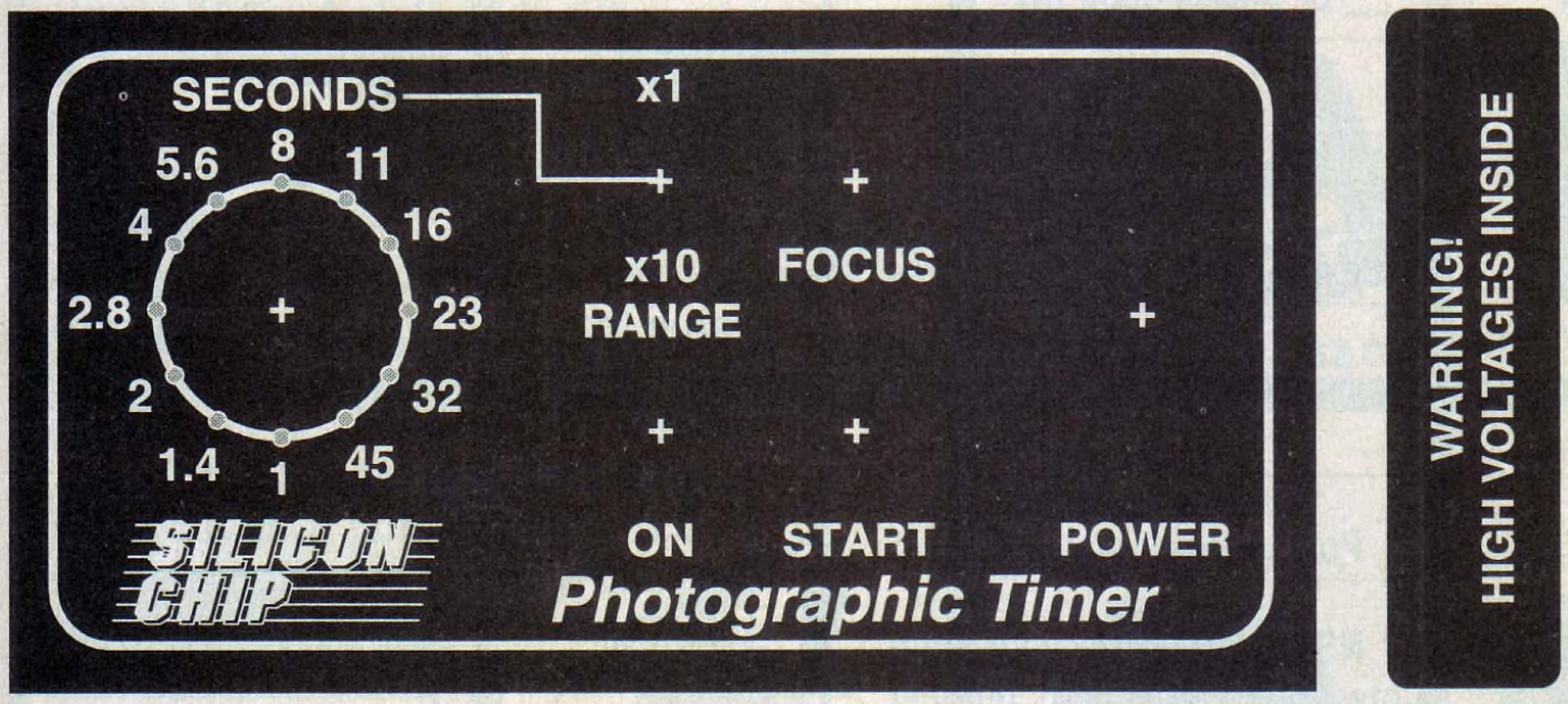


Fig.5: this full-size artwork can be used as a drilling template for the front panel. The warning label at right should be stuck to the lid of the case.

Testing

Exercise extreme caution when testing the Photographic Timer. As Fig.2

indicates, **one section of the PC board operates at high voltage (240V AC), so you must not touch any parts inside the area enclosed by the dotted lines when the unit is plugged into the mains.** This includes the two connections on either side of TR1. The same goes for the fuseholder and power switch terminals which, in any case, should be insulated using heatshrink tubing (see above).

So the area inside the dotted lines on Fig.2 must be treated as dangerous. At no time should the circuit be worked on while the unit is connected to the mains. VR1 can, however, be adjusted safely, provided that the live component area is avoided.

To test the unit, connect a multimeter between the tab of REG1 and link LK1 and set the meter to DC volts. This done, apply power and check that the meter reads about 12VDC. If it is substantially below this, switch off, unplug the mains cord and check for assembly errors.

Calibration

Assuming that all is well, set the Focus switch to off, select the 16-second range (using S1 & S2), and press the Start button. Check that the LED immediately comes on and stays on for a short period of time. If it does, adjust calibration control VR1 on a trial and error basis until the period is exactly 16 seconds. Note: wind VR1 clockwise to increase the period and anticlockwise to decrease it.

If the LED fails to come on, switch the Focus on. If the LED now comes on, check the circuitry around IC1. Conversely, if the LED stays out, check transistor Q1 and the LED polarity.

Calibration on the x10 range position can now be checked. Provided that the timing capacitors have been properly selected, it should be within 5% of the expected value. If the period is too low and accuracy is critical, simply pad the 220μF capacitor until the correct period is obtained. This can be done by connecting a low-value (eg, 10μF) capacitor in parallel with the 220μF capacitor on the underside of the board (be sure to use a low-leakage type and don't forget to pull that mains plug from the wall).

Finally, attach the lid, plug a lamp into the output socket and check that it lights for the preset time when the Start button is pressed. The Photographic Timer is now finished. **SC**