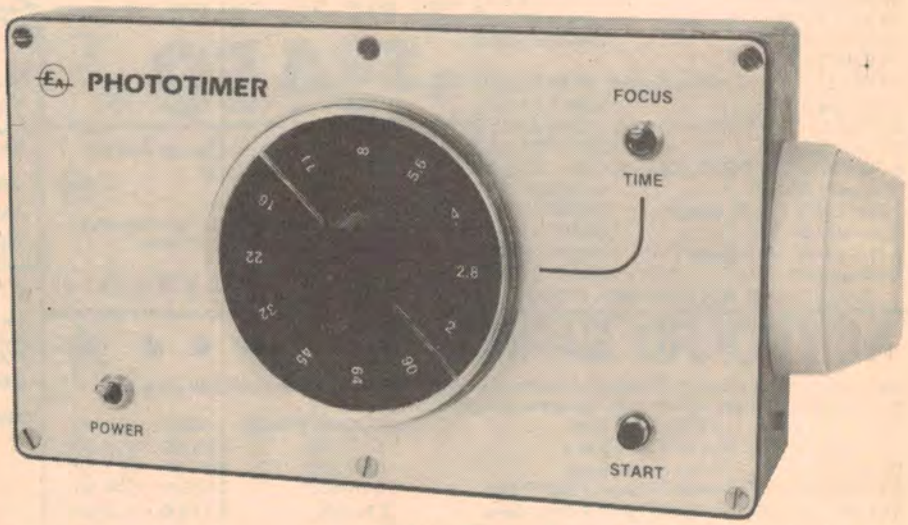
New design has 12 settings from 2 to 90 seconds

An easy-to-build photographic timer

Want an easy-to-build photographic enlarger timer that won't cost an arm and a leg? This new Phototimer has 12 separate settings ranging from 2 to 90 seconds, and can handle enlargers rated up to 300 watts.

by GREG SWAIN and JEFF SKEEN



Phototimer is housd in a metal case and uses a red neon lamp to backlight the dial setting. Unit can handle enlargers rated up to 300W.

Anyone who has ever timed photographic enlargements by means of a stopwatch will know just how tedious the whole process can be. With this simple unit, your troubles are over. At the push of a button, the unit will energise a 240V AC mains socket and switch the power off after the required interval. What could be easier?

Simplicity of operation combined with ease of construction were our main goals in designing this new "Phototimer". As can be seen from the photographs, the unit is built into a metal diecast case with a three-pin mains socket at one end to power the enlarger. A large handspan dial on the front panel indicates the timer setting in seconds, while a pushbutton Start switch initiates the timing sequence.

The remaining front panel controls consist of two toggle switches: a Power on/off switch, and a Focus/Time switch which switches the timer in or out of circuit.

When the Focus/Time switch is in the Focus position, the enlarger stays on continuously so that the photographic image can be focused onto the enlarger baseboard. However, when the switch is in the Time position, the enlarger is controlled by the timer. Pressing the Start button in this mode turns the enlarger light on for a period determined by the setting of the handspan dial.

Note that the Focus position overrides the timer. This means that if the switch is moved to the Focus position during a timing cycle, the enlarger will remain on and will not extinguish at the end of the timing cycle.

Since the Phototimer is to be used in a darkroom, illumination of the dial setting is necessary and this is provided by backlighting the appropriate number with a small neon lamp. This means that only the selected setting will be visible under darkroom conditions, thus minimising any chance of error. A red filter in front of the neon lamp (ie, the plastic bezel) removes any violet emissions, which are "bad news" for photographic work.

To readers not involved in photography, the calibrations on the handspan dial may seem rather unusual. The calibrations actually increase as a geometric progression, with the square root of 2 as the multiplier rate. This gives a 1, 1.414, 2, 2.828, 4 . . . sequence and means that to double the exposure time, the dial must be "clicked up" two divisions. This is a more logical arrangement than a linear scale for photographic work, since each step on the scale is equivalent to a "half stop" on a camera lens.

(On a camera, the stops are an indication of the effective lens diameter. Increasing the setting by one full stop doubles the exposure value).

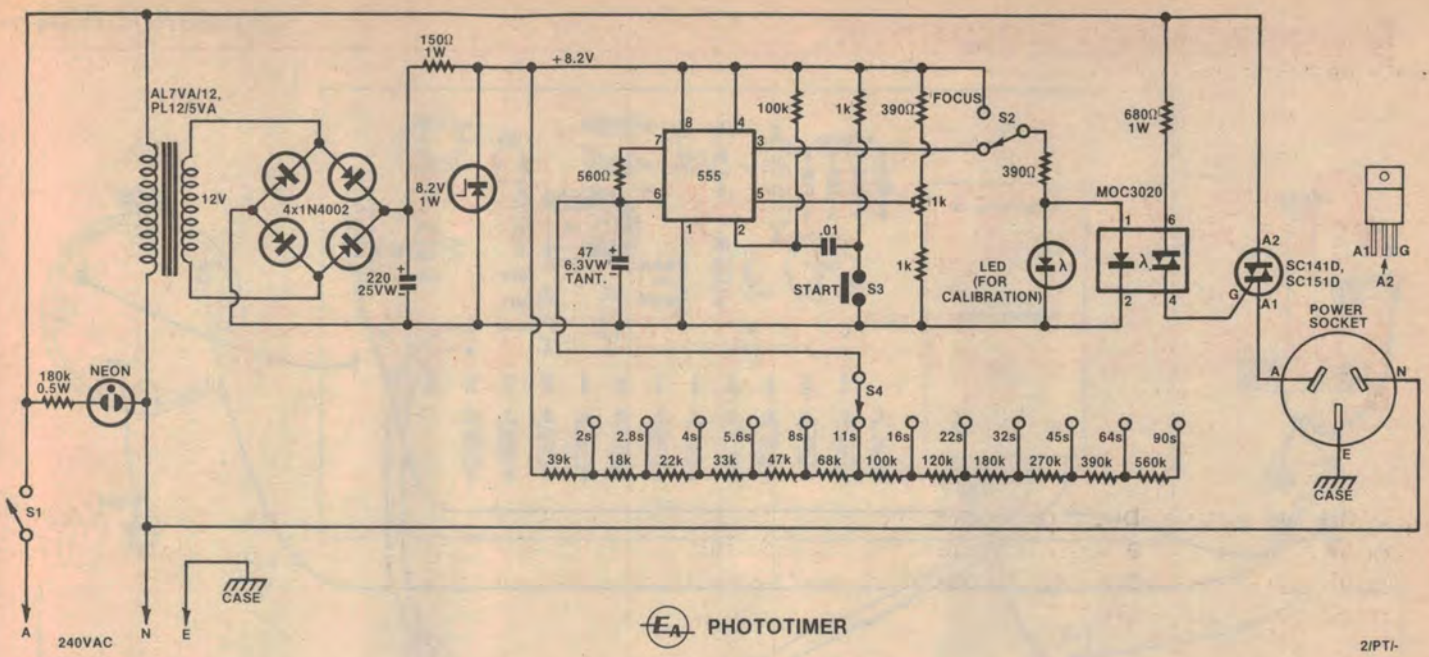
The circuit presented here is based on a design originally presented in May, 1973, but with some important modifications. In particular, our new unit uses a mains transformer and an opto-coupled Triac driver to provide full isolation between the low voltage and mains voltage parts of the circuit. The advantage here is that the unit does not have to be unplugged from the mains for calibration adjustments and, of course, is considerably safer to troubleshoot in the event of difficulties.

Other changes include an additional range to bring the minimum timer period down to two seconds, and a slight modification to the "start timer" circuitry to eliminate possible timer overrun if the Start button is held down.

How it works

Refer now to the circuit. It may be split into four sections: a power supply, a 555 IC timer, a MOC3020 opto-coupled Triac driver, and a Triac to control the mains supply to the enlarger lamp.

At the heart of the circuit is the 555 IC timer, wired here as a one-shot monostable, ie it delivers a positive DC



PHOTOTIMER

2/PTI-

PARTS LIST

1 printed circuit board, code 82pt4, 174 x 92mm
1 diecast aluminium box, 190 x 60 x 110mm
1 12V transformer: Arlec AL7VA/12, Ferguson PL12/5VA, or 2851
1 Scotchcal front panel, 191 x 112mm
1 mains cable and plug
1 mains cable clamp
2 earth lugs
1 surface-mounting mains socket
1 2-way mains terminal strip
1 12-position (single pole) rotary switch
2 SPDT toggle switches
1 momentary contact pushbutton switch
1 neon lamp with red bezel
1 handspan dial
4 12mm tapped brass spacers
4 rubber feet
1 large rubber grommet
3 small rubber grommets
20cm ribbon cable, 16-way
50cm black mains rated hook-up wire
1.5m red mains rated hook-up wire

SEMICONDUCTORS
4 1N4002 diodes
1 8.2V 1W zener diode
1 red LED
1 MOC3020, MOC3021 opto-coupled Triac driver
1 SC141D or SC151D Triac
1 NE555 integrated circuit

CAPACITORS
1 220μF 25VW PC electrolytic
1 47μF 6.3VW tantalum
1 0.01μF metallised polyester

RESISTORS (¼W 5%, unless specified)
1 x 560kΩ, 1 x 390kΩ, 1 x 270kΩ, 1 x 180kΩ, 1 x 180kΩ ½W, 1 x 120kΩ, 2 x 100kΩ, 1 x 68kΩ, 1 x 47kΩ, 1 x 39kΩ, 1 x 33kΩ, 1 x 22kΩ, 1 x 18kΩ, 2 x 1kΩ, 1 x 680Ω 1W, 1 x 560Ω, 2 x 390Ω, 1 x 150Ω 1W, 1 x 1kΩ large, flat mounting trimpot.

MISCELLANEOUS
Machine screws and nuts, solder, 2mm spaghetti sleeving etc.

pulse for a set time interval whenever a negative pulse appears on the trigger input (pin 2). The length of this pulse is determined by the external timing capacitor connected to pin 6 of the 555 (47μF) and the value of the timing resistors between pin 6 and the positive supply rail.

Here's how the circuit works. Initially, the 47μF timing capacitor is held discharged by a transistor inside the 555 IC. When a trigger pulse is applied to pin 2 (Start button pressed), the discharge transistor is turned off and the output (pin 3) of the 555 goes high. This output remains high while ever the voltage on the capacitor remains below a set threshold voltage (nominally ⅔ the supply voltage Vcc).

The 47μF capacitor now charges via the timing resistor(s) and, when it reaches the threshold voltage, the output at pin 3 goes low and the timing cycle ends. At the same time, the internal discharge transistor is turned on and discharges the 47μF capacitor via pin 7. A 560Ω resistor connected between pins 6 and 7 of the 555 limits the discharge current to a safe value.

Note that once this sequence of events has been started by the trigger pulse at pin 2, further trigger pulses have no effect until the output at pin 3 reverts to zero.

The length of the DC pulse delivered from pin 3 is a function of the time constant formed by the 47μF timing capacitor (C) and the timing resistance (R) selected by switch S4. Assuming that the threshold voltage of the 555 is set to ⅔Vcc, this is given by the equation

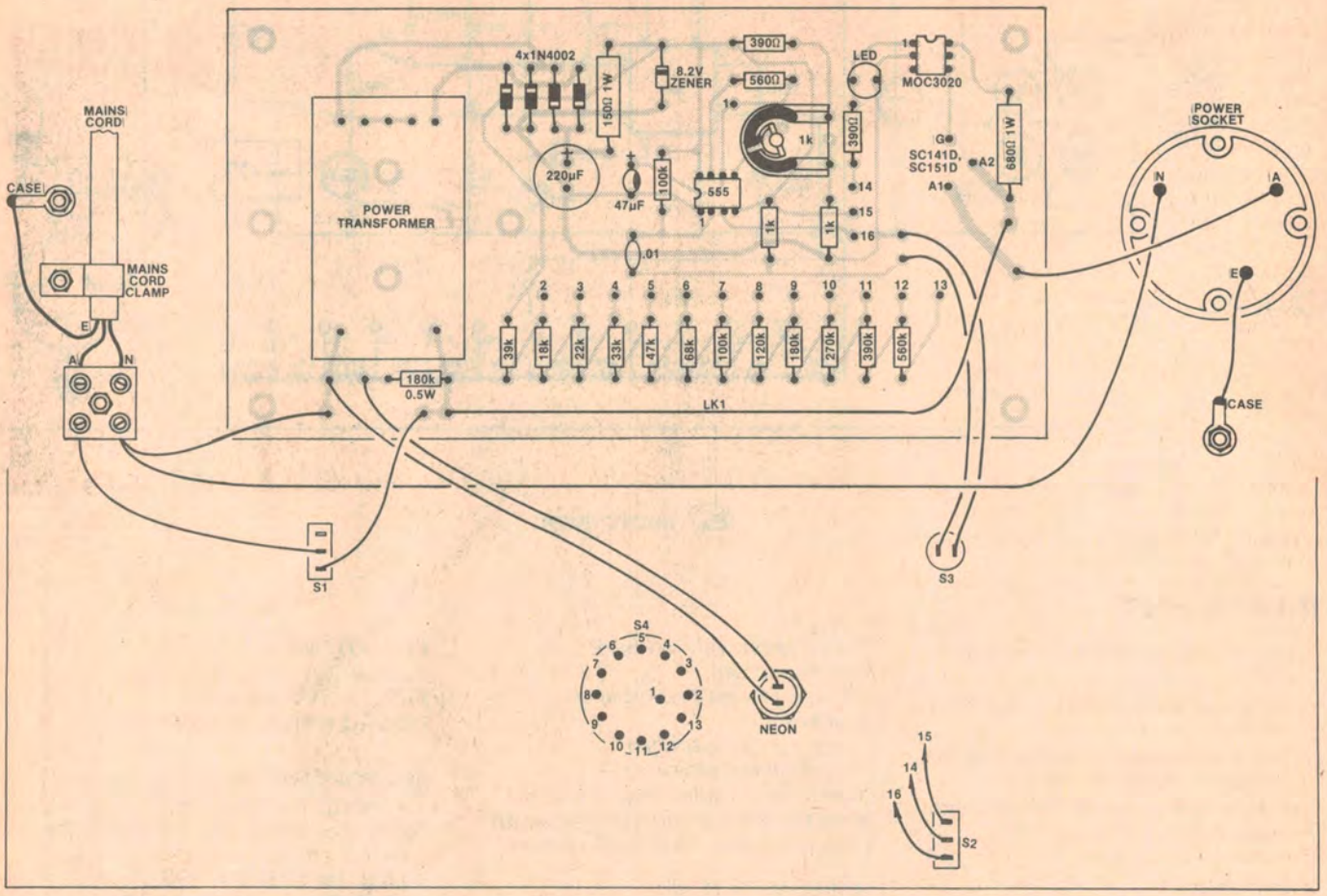
$$T(secs) = R.C \times 1.1$$

Where T is the length of the output pulse in seconds.

In this circuit, the threshold voltage (and hence the output pulse length) of the 555 is varied by applying a DC voltage to pin 5. This DC voltage is provided by a voltage divider network consisting of two fixed value resistors and a 1kΩ trimpot, and provides a means by which the circuit may be calibrated to compensate for component tolerances.

Negative-going trigger pulses to pin 2 of the 555 are provided by switch S3 and its associated RC network. Why the RC network? The reason is that if S3 directly shorted pin 2 to ground, timer operation could be affected by contact bounce. In other words, if S3 was held down for a period longer than the timer setting and then released, the timing cycle should accidentally be repeated.

The RC network prevents this from happening by restricting the trigger pulse to 1ms duration. It works like this: initially, both sides of the .01μF coupling capacitor are held high by the 100kΩ and 1kΩ resistors. When S3 is closed, both sides of the capacitor are pulled low to provide the trigger pulse to pin 2 of the 555. The 0.1μF capacitor then charges via the 100kΩ resistor and, after about 1ms, pulls pin 2 high again to end the trigger pulse.



Follow this diagram when wiring up the Phototimer, but do not install Lk1 or the MOC3020 until after calibration.

So keeping S3 depressed after the timing cycle has started has no effect on the circuit performance.

The output from the 555 is coupled via switch S2 and a 390Ω resistor to the MOC3020 opto-coupled Triac driver. When the pin 3 output of the 555 goes high, the LED inside the MOC3020 lights and triggers a photosensitive Triac output stage. This in turn causes current to flow to the gate of an SC141D power Triac, which turns on to activate the mains output socket.

The enlarger bulb will thus remain lit while ever the output of the 555 timer remains high and gate current is supplied to the power Triac by the opto-coupler. At the completion of the timing pulse, the opto-coupler turns off and the SC141D Triac switches off the enlarger at the end of the next mains half cycle, ie when the load current drops to zero.

The 680Ω resistor limits the repetitive surge current through the MOC3020 to a safe value of about 0.5A. Switch S2 switches the input to the MOC3020 between the output of the 555 timer and the positive supply rail. When the switch is in the Focus position, the LED in the MOC3020 is lit continuously and the enlarger lamp remains on.

Also shown on the circuit diagram is an external LED connected in parallel with the internal LED of the MOC3020 Triac driver. This LED is temporarily inserted into circuit during construction so that the unit can be safely calibrated before the mains active is connected to the output stage.

Power for the unit is obtained from a 12V transformer which feeds a bridge rectifier circuit and a 200μF filter capacitor. The resultant DC supply is then passed through a 150Ω current limiting resistor and regulated by an 8.2V zener diode. Backlighting for the dial is provided by a neon lamp wired in series with a 180kΩ resistor across the mains.

Construction

Our new Phototimer is built into a standard metal diecast case measuring 190 x 60 x 110mm. A metal case is mandatory for this project so that it can be earthed to guard against electric shock.

Construction is easy, with most components mounted on a printed circuit board (PCB) coded 82pt4 and measuring 174 x 92mm. Begin construction by mounting components on the PCB according to the wiring diagram, but do not install the MOC3020 or link Lk1 at this stage. Fit the resistors and capacitors first, followed by the 555 IC and the diodes.

Make sure that all polarised components are correctly oriented, and don't forget to install the calibration LED in the position indicated on the wiring diagram. The power transformer can also be fitted at this stage, and the board has been designed to accommodate both PCB-mounting transformers and the more conventional 2851 type with flying leads.

The Triac is installed so that its body lies flat against the PCB, as shown in the photograph. Readers should note that the metal tab of the Triac will be at mains potential when the project is operating, so watch it!

Once the PCB has been completed, you can commence fitting the hardware

We estimate that the current cost of components for this project is approximately

$48

This includes sales tax.

to the metal diecast case. Begin by temporarily positioning the various items in the case and mark and drill the necessary holes.

The mains cable enters through a grommeted hole and is securely clamped. Terminate the active (brown) and neutral (blue) leads in an insulated terminal block and connect the earth lead to a lug bolted to the chassis.

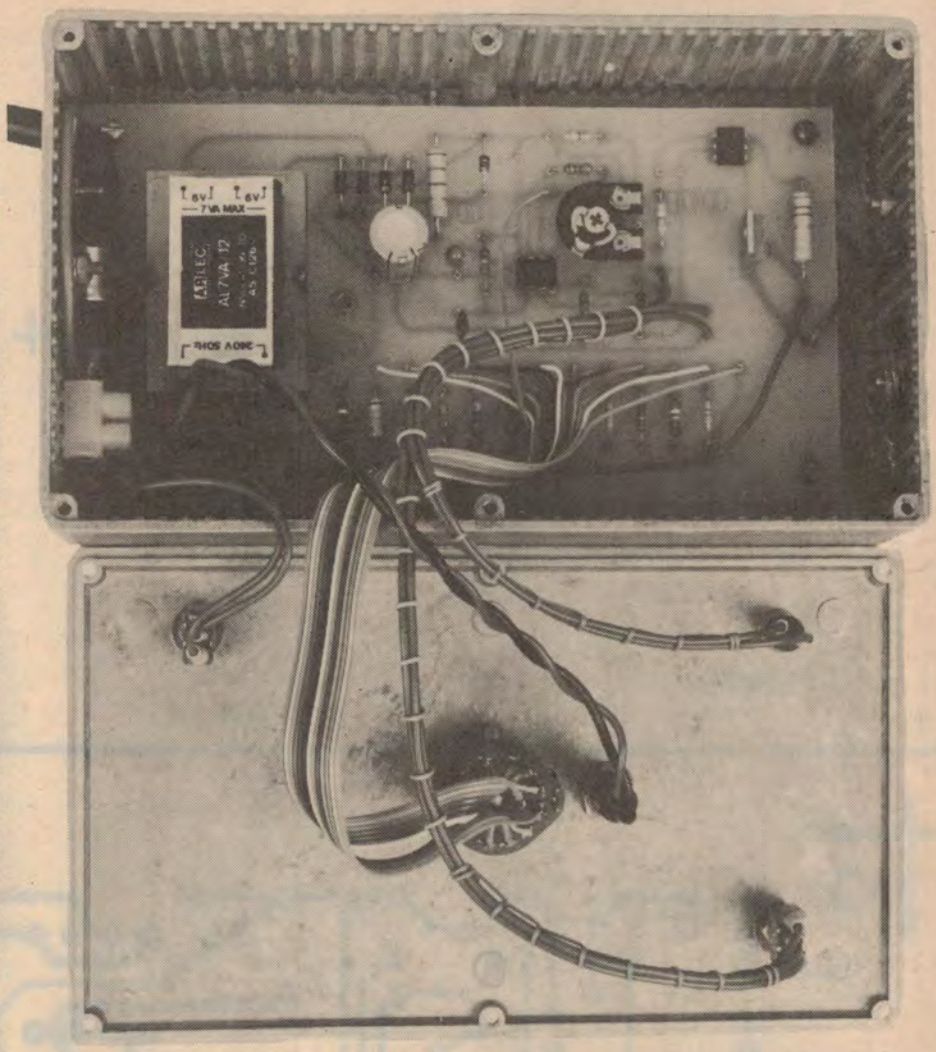
Wiring to the mains socket should also pass through grommeted holes to ensure safe operation. Make sure that you use mains-rated cable, and note the earth connection to the side of the case.

A Scotchcal adhesive label measuring 191 x 112mm provides an attractive finish to the Phototimer. Spray the label with a hard-setting lacquer (such as "Estapol") to prevent scratches and, when dry, affix it carefully to the lid of the case. Working from the Scotchcal side, drill holes in the lid and mount the front panel switches and the neon indicator lamp. Before mounting the 12-way rotary switch (S4), cut its shaft to a length of about 15mm.

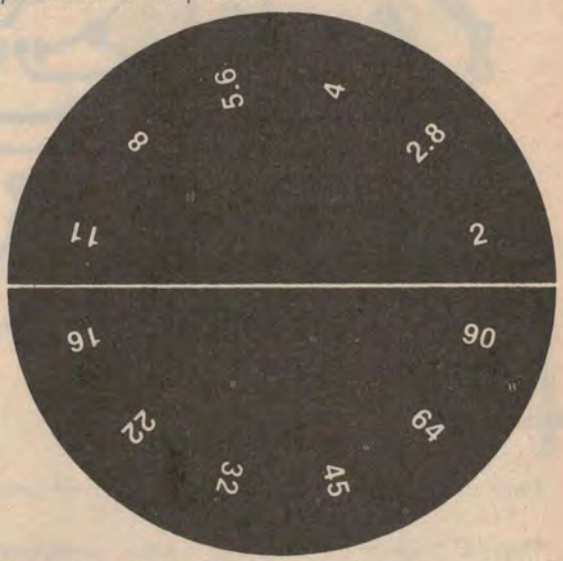
The wiring between the PCB and the front panel can now be completed, and the PCB mounted in the case using four 12mm standoffs. 13-way rainbow cable is used to make the connections to switch S4, but connections to S1, S2 and S3 and to the neon indicator must use mains rated cable. Lace the wiring to S2, S3 and S4 so that it cannot come into contact with any part of the circuit at mains potential if a wire should come adrift.

As an additional precautionary measure, plastic sleeving should be placed over the soldered connections to S1, S2 and S3 and on the neon indicator.

The handspan dial on the prototype was made using a film transparency. The best course for readers, however, is to photocopy the accompanying artwork and glue it to the back of the dial. This done, set the rotary switch (S4) to position 2 (ie select the 39kΩ resistor only) and press the dial onto the switch shaft with the "2" lined up against the calibration line.



Use mains-rated cable for all wiring connections, except to switch S4. Note that the Triac and associated circuitry operates at mains potential.



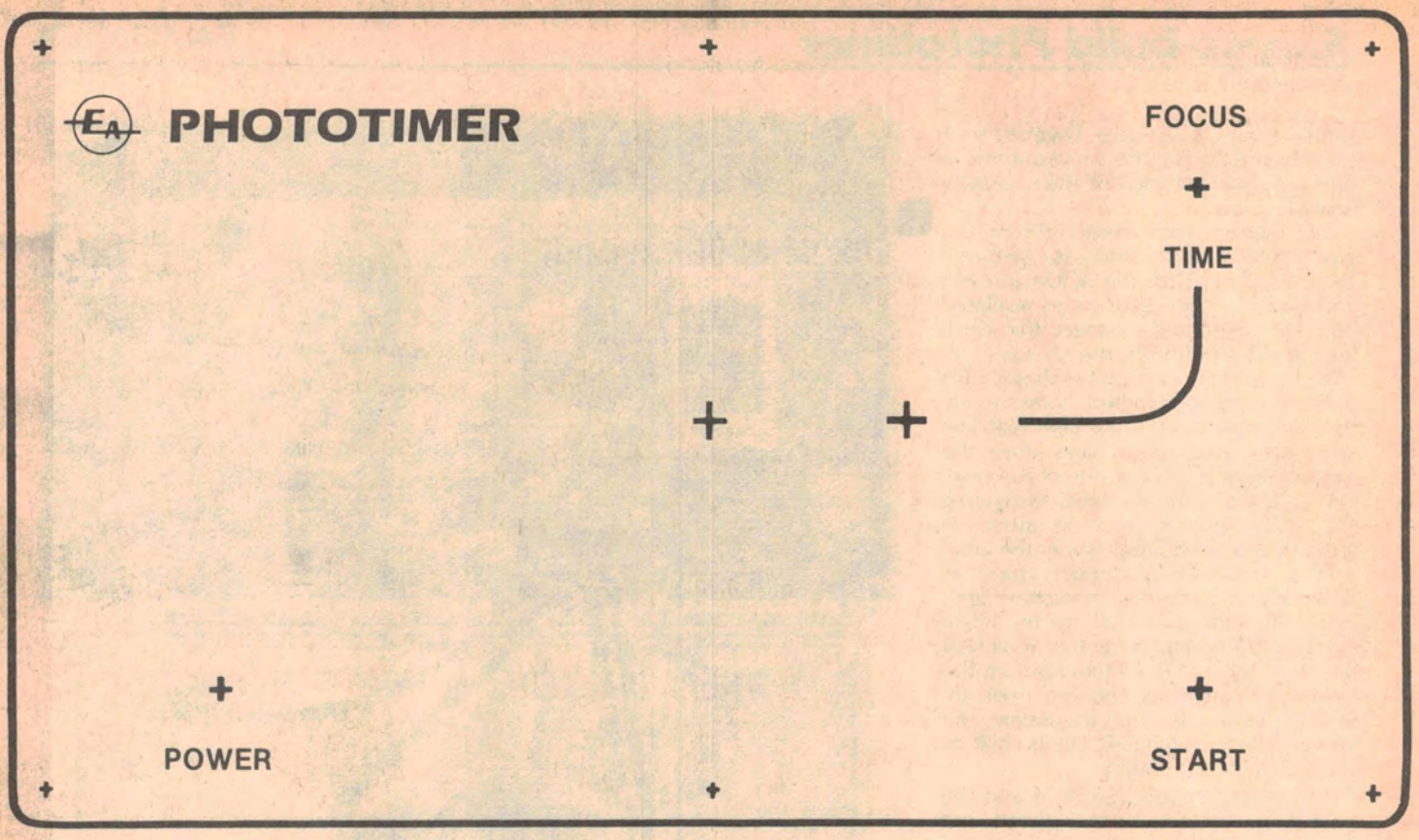
Right: Actual size artwork for the handspan dial.

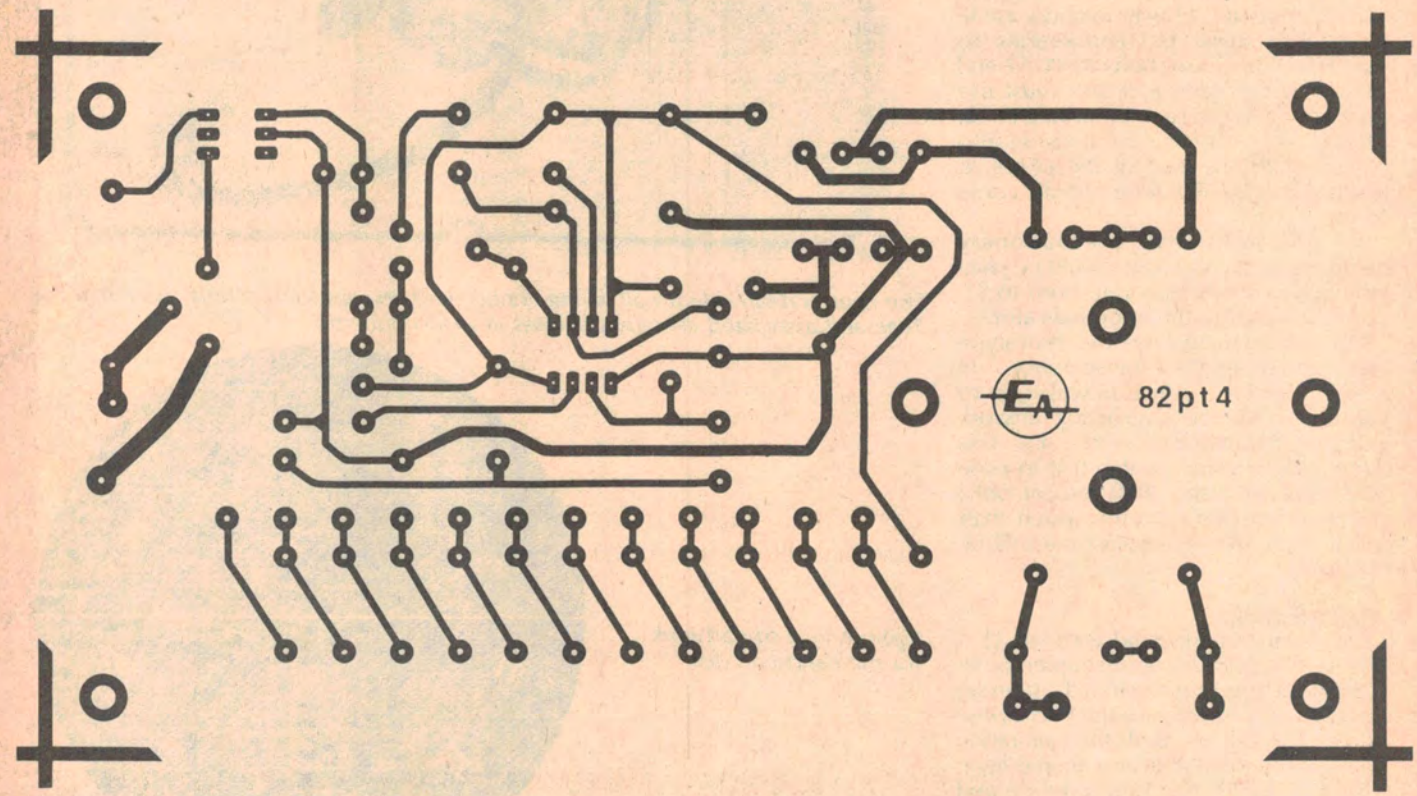
Calibration

Calbration is performed with link Lk 1 and the MOC3020 opto-coupler omitted. Check your wiring carefully, then set the Focus/Time switch to the Focus position and switch on. Both the calibration LED and the neon indicator should light.

Now switch to the Time position and check that the calibration LED goes out. Press the Start switch, and the calibration LED should immediately come on again and remain on for a period approximately equal to the setting on the dial.

To calibrate the Phototimer, set the dial to an intermediate setting (eg 16s) and press the Start switch. The LED should remain on for 16s and then extinguish. If it doesn't remain on for exactly 16s (which is more than likely), adjust the 1kΩ trimpot until it does. Finally, check the performance on the remaining ranges. A difference of a few seconds between the dial indication and the actual time on the high ranges will be due mainly to the 5% tolerance resistors specified and should be of no consequence.





Actual size artworks for the PCB and the front panel. Finished boards and panels are available from retailers.

That's it! Your new Phototimer is now calibrated.

Switch the power to the Phototimer off, unplug it from the wall socket and remove the calibration LED. All you have to do now is insert the MOC3020 opto-coupler and mains-rated link Lk1, and re-assemble the unit. The rubber feet are attached by screwing the mounting screws into the PCB standoffs.

As a final test, connect the Phototimer up to your enlarger for a trial run. Check that the enlarger lamp remains on when the Focus/Time switch is in the Focus position, that it goes off in the Time position, and that the lamp turns on for the set time period when the Start button is pressed.