LIGHTNING DISTANCE METER

Have you ever wondered just how close that bolt of lightning was? Well, don't wonder about it; check it out with this Lightning Distance Meter instead. The device uses common components & measures flash distances up to 19 kilometres.

By DARREN YATES

There are many situations where it can be useful to know the distance to an approaching thunderstorm. Perhaps you're just the curious type who likes to keep an eye on the weather or maybe you have a far more practical reason for wanting to know, such as when you're ploughing a field or you're out on the footy oval or golf course. Being caught out in the open in the middle of a thunderstorm is not a pleasant experience.

Of course, you could always abandon the game when the first lightning flash appears or you could use the old "1001" rule that you learnt as a kid. Whenever you saw a flash of lightning, you would count 1001, 1002, 1003 and so on, and when you heard the thunder you divided the last digit by five to determine how many miles away the "bolt" was. Armed with this information, you could then elect to do a runner when the lightning got too close for comfort – five miles if you were chicken or five feet if you were more adventurous!

Unfortunately, in this metricated age, most youngsters don't know what a mile is! So unless we apply a metric conversion to the 1001 rule, we either run the risk of getting zapped or abandoning a perfectly good game for nothing.

Alternatively, we could apply a more scientific approach to the problem. The answer is this Lightning Distance Meter. With a bit of eye, ear and hand coordination, you can work out the distance to a lightning flash within a kilometre of so.

There's nothing complicated about using the unit. Apart from the power switch, there are just three pushbutton controls and these are labelled Start, Reset and Stop. In addition, the front panel carries a row of LEDs and these are numbered from 1-10.

The principle of operation is quite simple. The speed of sound in air is about 1207km/h, which is equivalent to 1km every 3 seconds. So all the circuit does is light each LED in turn at 3-second intervals when the Start button is pressed. To use the unit, you simply press the Start button when you see the lightning flash and then press the Stop button when you hear the thunder. The LED that's lit then gives the distance to the flash (eg, if LED 6 is lit, then the distance is 6km).

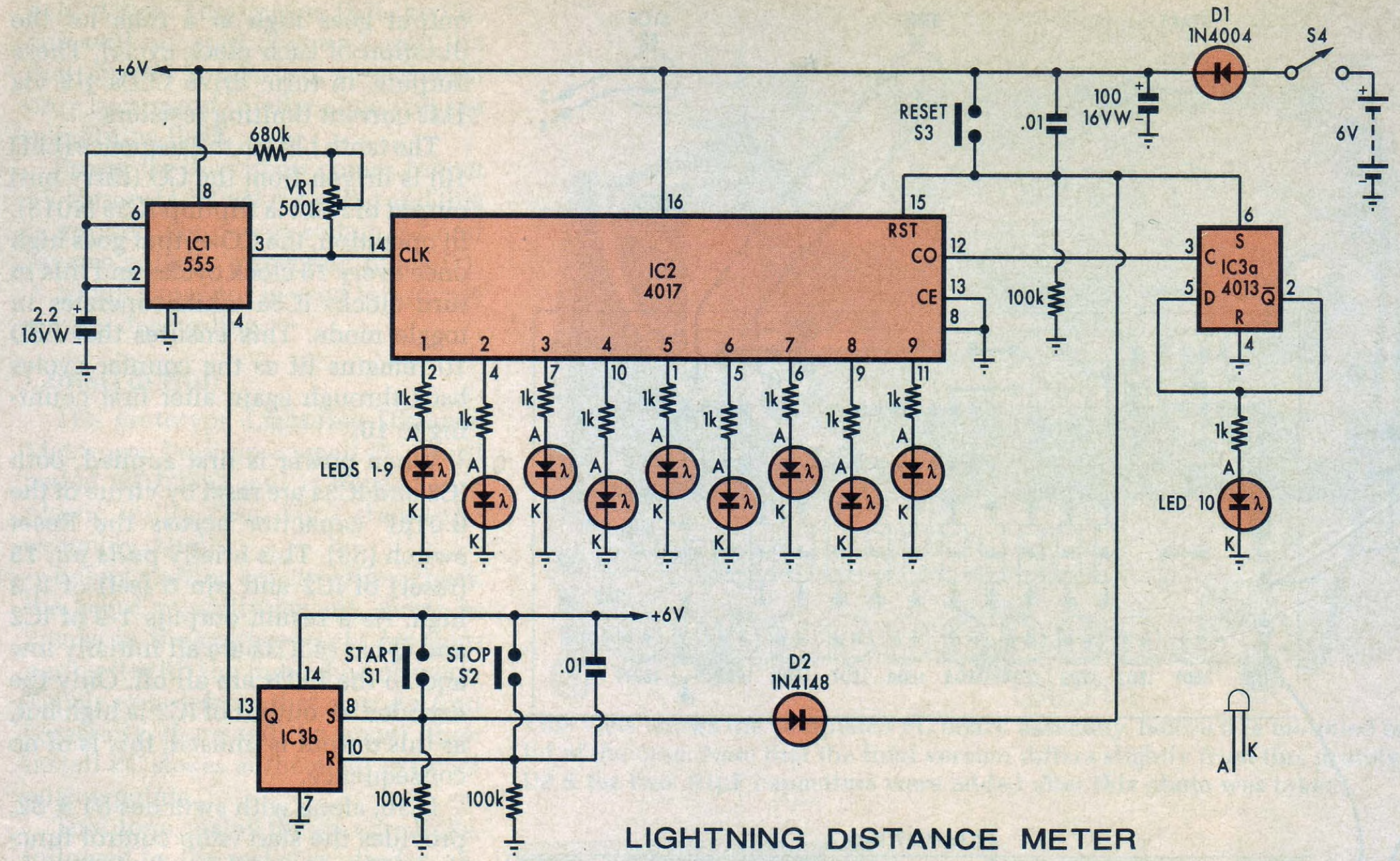


Fig.1: the circuit uses 555 timer IC1 to clock decade counter IC2. IC2's decoded 1-9 outputs go high in turn & drive the indicator LEDs. On the 10th count, the CO output goes high & this toggles flipflop IC3a to light LED 10. IC3b controls IC1 to start & stop the count.

If the distance is greater than 10km, the circuit first counts to 10 in the usual manner. LED 10 then remains lit while the circuit cycles through the first nine LEDs again. In this way, the circuit can effectively count up to a maximum value of 19. Thus, if both LED 4 and LED 10 are alight when the Stop button is pressed, for example, the distance to the flash is 14km.

When a count of 20 is reached, LED 10 goes out and the count starts all over again from zero (ie, the count continually cycles). So, for all practical purposes, the maximum count is 19. This is not really a problem however, since it is unlikely that you will be able to hear individual thunderclaps at distances greater than 19km.

The Reset button clears the counter used in the circuit and effectively "freezes" the circuit so that all LEDs are off. This reduces the current consumption to a bare minimum and is useful for maximising battery life if there is a substantial delay between each measurement.

However, the circuit is also automatically reset each time the Start button is pressed. This feature is handy if you are taking a number of measurements in quick succession, since you don't have to continually press the Reset switch.

How it works

Refer now to Fig.1 for the circuit details.

IC1 is a 555 timer which operates as an astable oscillator. It is wired here in a somewhat unconventional manner, however. Normally, the timing capacitor charges from the positive supply rail via a resistive network and discharges (via part of that network) into pin 7. In this circuit though, the timing capacitor (2.2µF) charges when IC1's pin 3 output goes high and discharges when pin 3 goes low.

PARTS LIST

- 1 PC board, code 08103951, 102 x 54mm
- 1 plastic case, 130 x 68 x 41mm
- 3 momentary normally-off pushbutton switches (S1-S3)
- 1 SPDT toggle switch (S4)
- 1 front panel label, 125 x 63mm
- 4 AA alkaline cells
- 1 long 4 x AA cell holder
- 1 500kΩ miniature horizontal trimpot (VR1)
- 4 15mm-long spacers
- 4 3mm x 25mm machine screws
- 4 3mm hex nuts

Semiconductors
- 1 NE555 timer (IC1)
- 1 4017 CMOS decade counter/decoder (IC2)
- 1 4013 dual D flipflop (IC3)
- 1 1N4004 silicon diode (D1)
- 1 1N4148 signal diode (D2)
- 5 5mm red LEDs (LED1-5)
- 5 5mm green LEDs (LED6-10)

Capacitors
- 1 100µF 16VW electrolytic
- 1 2.2µF 16VW electrolytic
- 2 .01µF MKT polyester

Resistors (0.25W, 1%)
- 1 680kΩ
- 3 100kΩ
- 10 1kΩ

Miscellaneous
Light duty hook-up wire, tinned copper wire for links

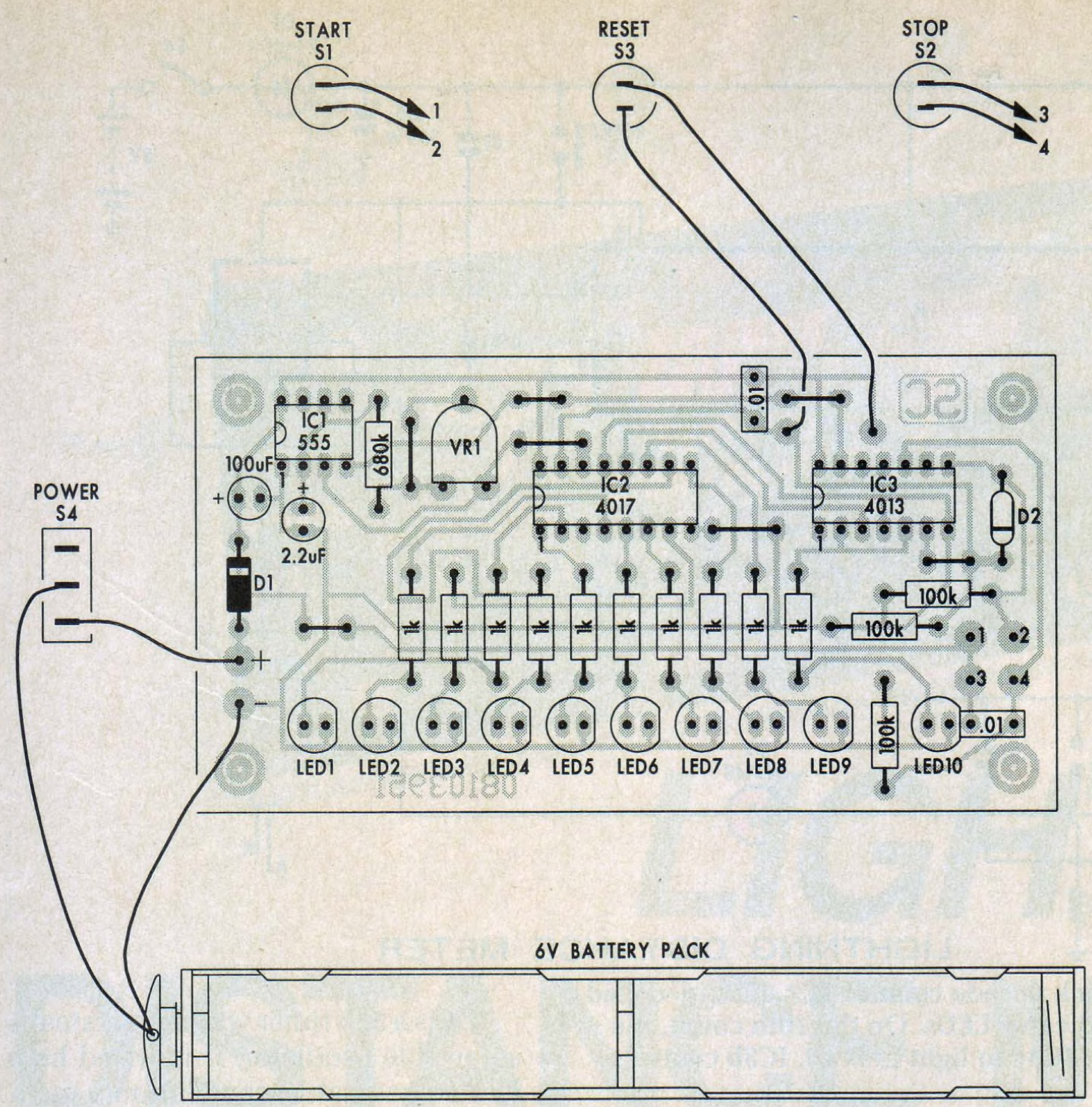


Fig.2: make sure that all polarised parts, including the LEDs, are correctly oriented during the PC board assembly. VR1 is used to adjust the 555 timer so that the circuit counts to 10 in 30 seconds.

The circuit works like this: at switch-on, pin 3 of IC1 goes high and the 2.2μF timing capacitor charges via VR1 and a 680kΩ resistor. When the capacitor voltage reaches 2/3Vcc (ie, 2/3 the supply rail voltage), pin 3 switches low and the capacitor discharges until it reaches 1/3Vcc. At this point, pin 3 switches high again and so the cycle is repeated indefinitely.

As a result, IC1 produces a square wave pulse train at its pin 3 output. VR1 is adjusted so that oscillator operates at a nominal 0.33Hz, which is equivalent to one positive going pulse every 3 seconds.

This signal is used to clock IC2, which is a 4017 decade counter. Its decoded 1-9 outputs are normally low but sequentially switch high in response to the clocking signal (ie, one output goes high at a time for the duration of each clock cycle). These outputs, in turn, drive LEDs 1-9 via 1kΩ current limiting resistors.

The tenth LED in the sequence (LED 10) is driven from the CO (carry out) output of IC2 via flipflop IC3a (4013). In operation, the CO output goes high once every 10 clock cycles and this in turn clocks IC3a which operates in toggle mode. This ensures that LED 10 remains lit as the counter cycles back through again after first counting to 10.

When power is first applied, both IC2 and IC3a are reset by virtue of the 0.01μF capacitor across the Reset switch (S3). This briefly pulls pin 15 (reset) of IC2 and pin 6 (set) of IC3 high. As a result, outputs 1-9 of IC2 and Q-bar of IC3a are all initially low and so the LEDs are all off. Only the decoded '0' output of IC2 is high but, as this output is unused, this is of no consequence.

IC3b, along with switches S1 & S2, provides the start\stop control function. When power is applied, its reset input (pin 10) is briefly pulled high via the .01μF capacitor across S2 and this ensures that the Q output (pin 13) is initially low. This, in turn, holds pin 4 (reset) of IC1 low and prevents IC1 from operating.

Pressing the Start button (S1) now pulls the set input of IC3b high and this toggles pin 13 high and releases the reset on IC1. IC1 now oscillates and clocks IC2 at 3-second intervals to light the LEDs in sequence. The count continues until the Stop button is pressed, at which point the Q output of IC3 goes high again and stops IC1. The count is now effectively frozen until either the Start button is pressed again or the Reset button is pressed.

Diode D2 is necessary to make the circuit start counting correctly. Without this diode, IC2 would be clocked by a high going pulse from IC1 as soon as the Start button was pressed and so the first LED would light immediately instead of after the required 3-second delay.

By including D2, IC2 and IC3 are reset when the Start button is pressed, which means that IC2 ignores the initial high-going pulse from IC1 and thus counts correctly.

There's one important point to note here, though. IC2 and IC3 are held reset for as long as the Start button is

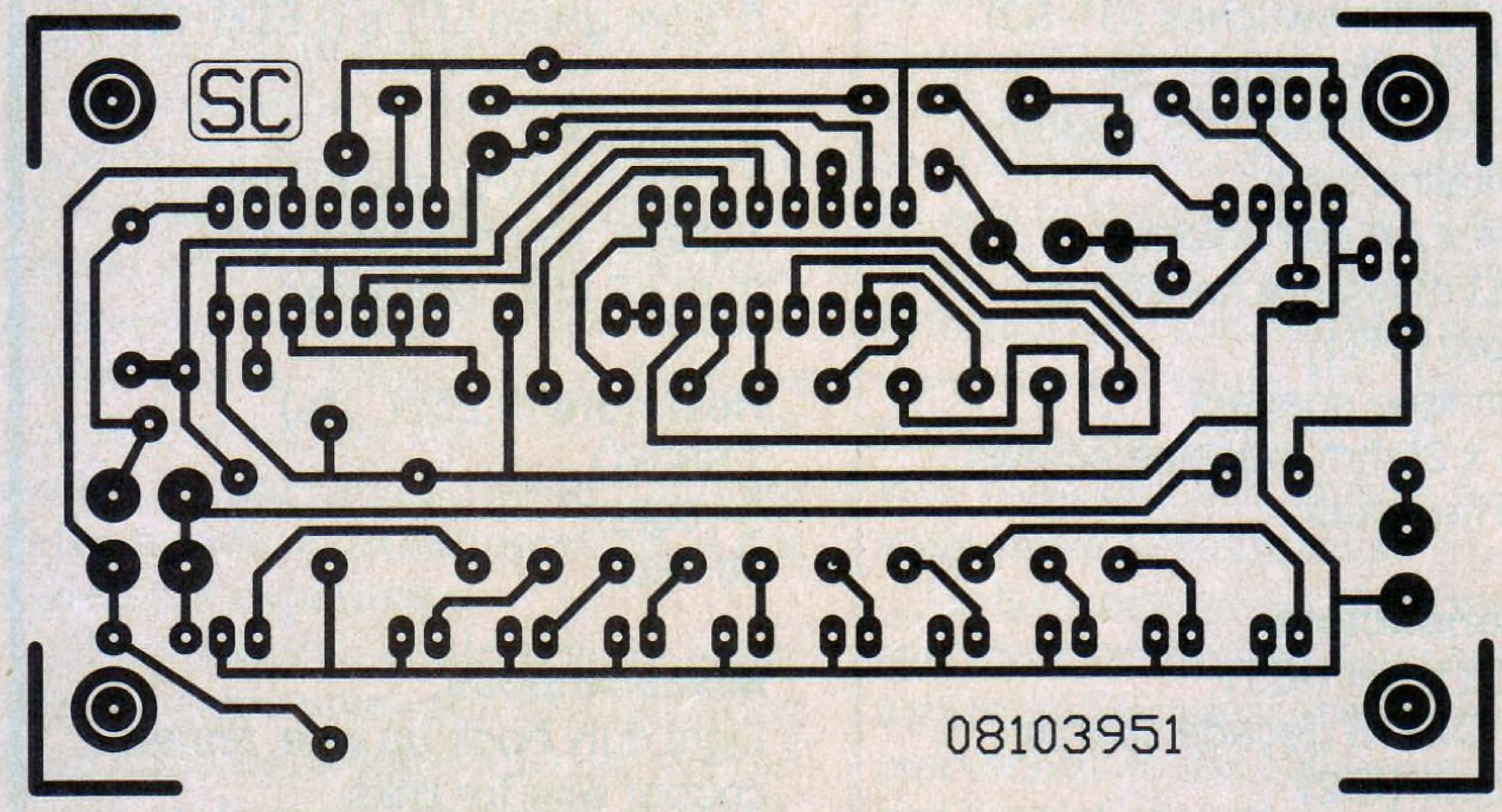


Fig.3: this is the full-size etching pattern for the PC board.

held down. This means that the circuit will not start counting until the Start button is released, so it should only be pressed briefly when you see a lightning flash.

Power for the circuit comes from a 6V battery (4 x 1.5V AA cells) and this is applied via power switch S4 and reverse polarity protection diode D1. A 100µF capacitor is used to provide supply decoupling.

Construction

The prototype Lightning Distance Meter was built on a small PC board coded 08103951 and is housed in a plastic utility case. Fig.2 shows the assembly details.

Before starting construction, check the board carefully for any shorts or breaks in the copper tracks by comparing it with the published artwork. Repair any defects that you do find (generally, there will be none), then install PC stakes at the eight external wiring points.

This done, install the six wire links, followed by the resistors, diodes, capacitors and the ICs. Take care to ensure that the polarised components are correctly oriented and be sure to use the correct type numbers for D1 and D2.

Trimpot VR1 can now be installed, followed by the 10 LEDs. Just load the LEDs into the board as shown on Fig.2 but don't solder or trim their leads at this stage. That step comes later, after the front panel has been attached.

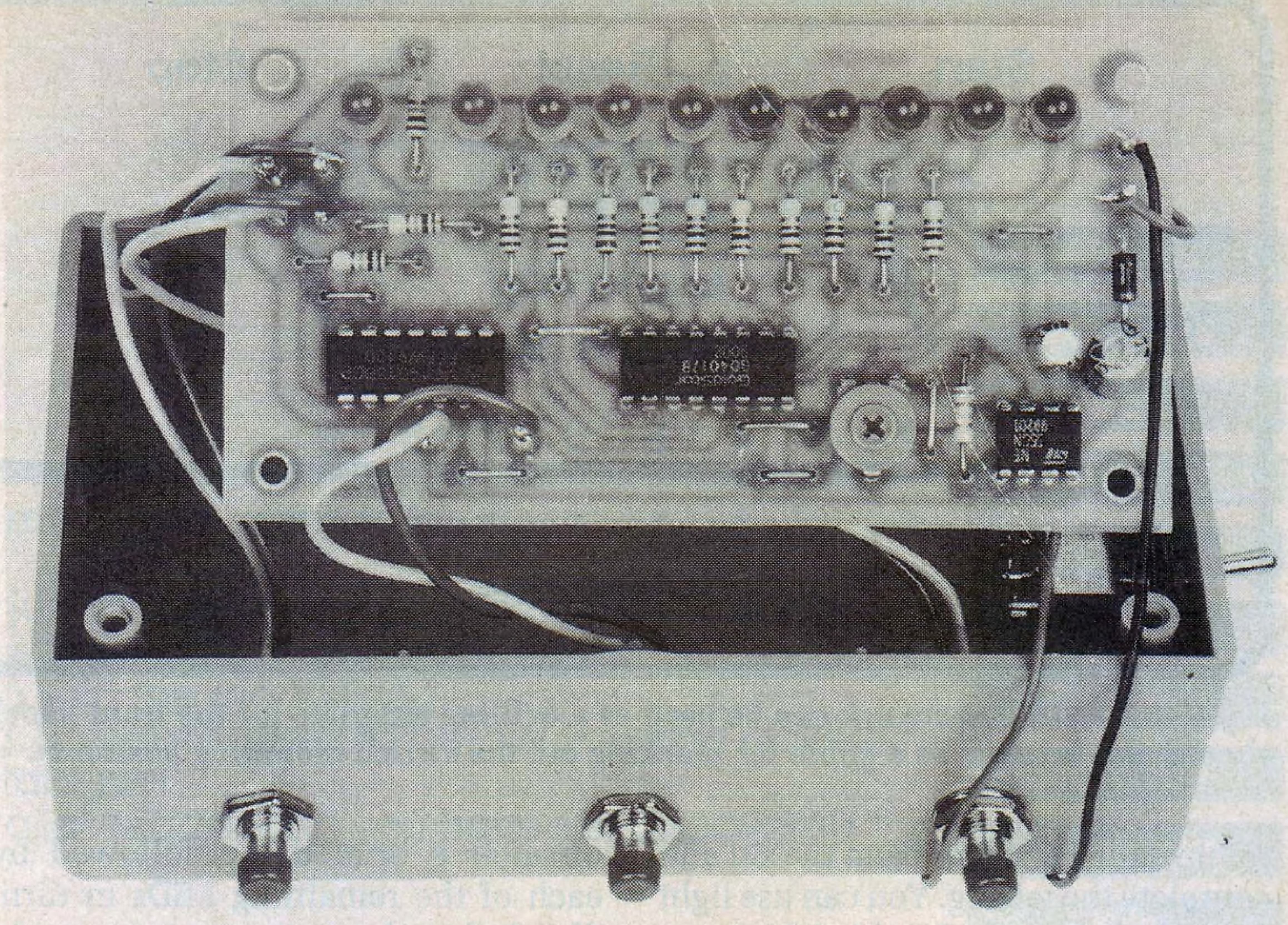
Take care to ensure that each LED is correctly oriented – the anode lead is the longer of the two. We used red LEDs for LEDs 1-5 and green LEDs for LEDs 6-10, since we reckoned that any flashes within 5km were too close for comfort.

The plastic utility case can now be drilled to accept the PC board, the four switches and the LEDs. The first step is to attach the front panel artwork to the lid. This can then be used as a template for drilling out the LED mounting holes. It's best to drill small pilot holes first and then carefully enlarge them using a tapered reamer until the LEDs are a good fit.

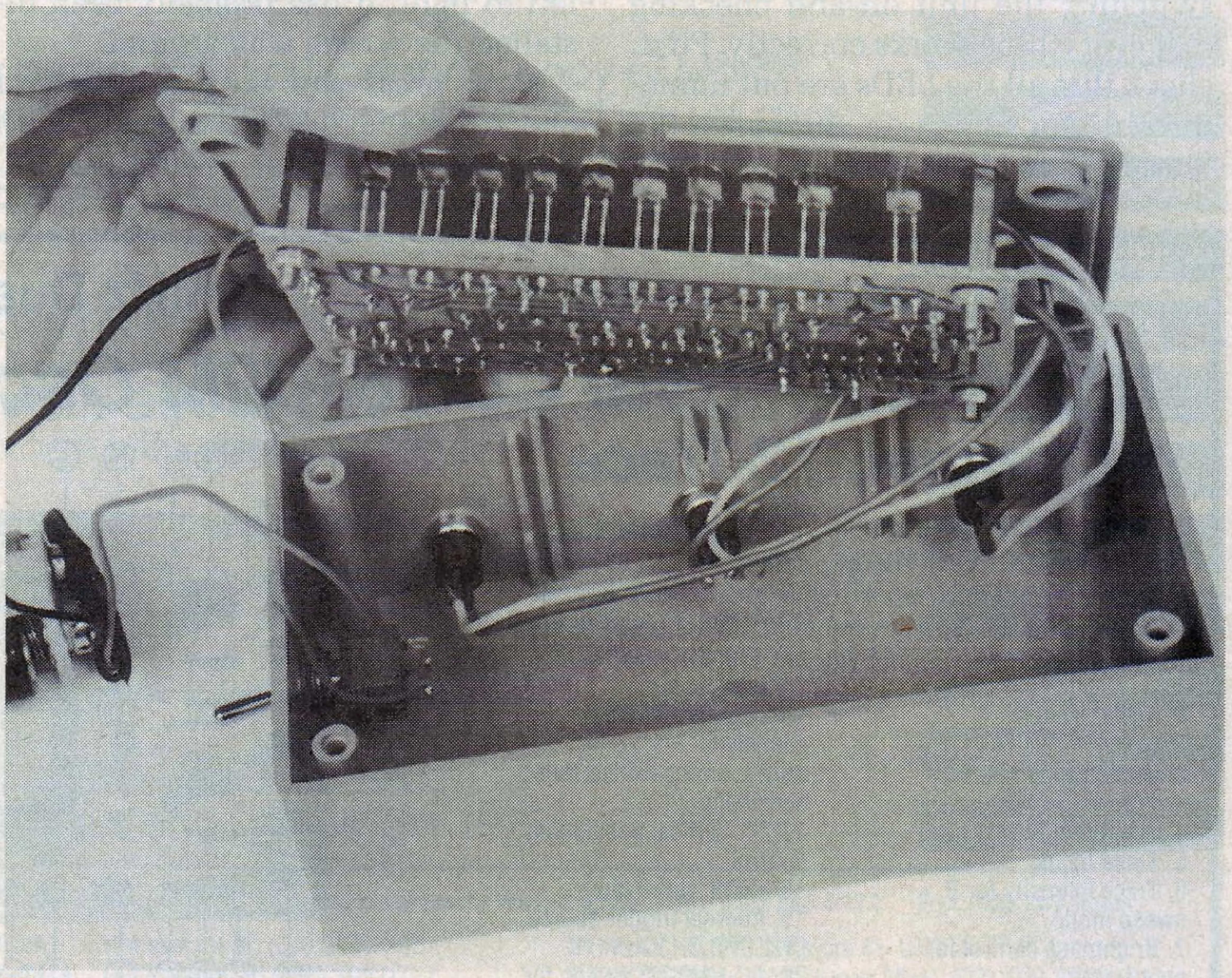
Once this has been done, use the PC board as a template for marking out its four mounting holes on the lid. Drill these holes to 3mm, then fasten the PC board to the back of the lid using 15mm spacers and machine screws and nuts. The 10 LEDs can now be pushed into their respective front panel holes and their leads soldered. Adjust each LED so that it just protrudes above the surface of the front panel.

The front panel can now be used as a guide for marking out the holes for the switches. The three pushbutton switches are mounted on the top of the case, while the power switch is mounted on the lefthand side. They must all be positioned towards the back of the case so that they clear the PC board when the lid is fitted.

Once the holes have been drilled, mount the switches in position, then



This view shows the completed PC board assembly, before it is mounted on the lid of the case. Note that the final version differs slightly from this prototype (ie, D2 & the two .01µF capacitors were added after this photo was taken).



The completed PC board is mounted on the lid on 15mm spacers & secured using machine screws & nuts. Arrange the LEDs so that they just protrude above the surface of the front panel.

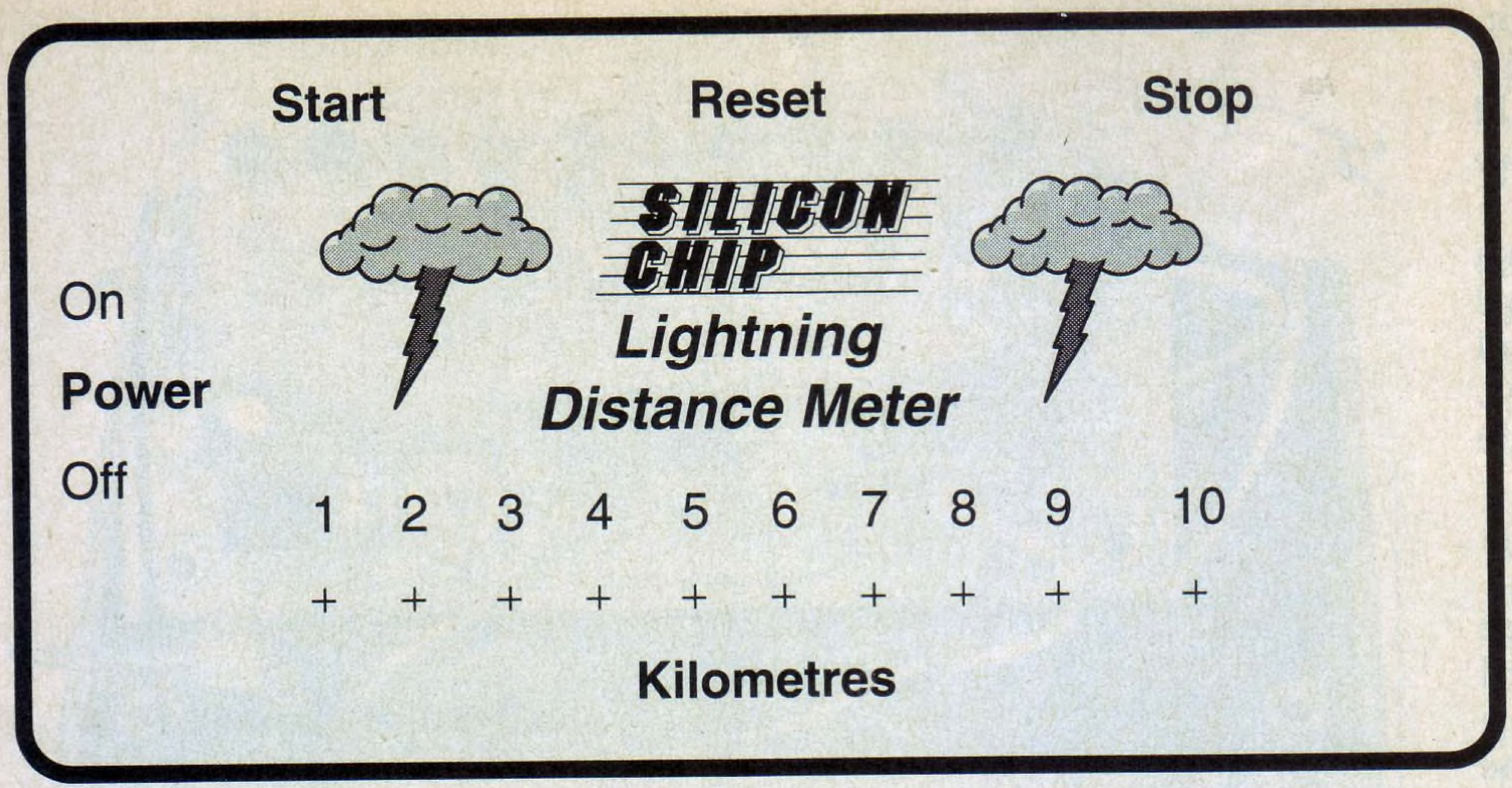


Fig.4: this full-size artwork can be used as a drilling template for the front panel. It should also be used as a guide for marking out the switch mounting positions.

remove the PC board from the lid and complete the wiring. You can use light duty hook-up wire for this job.

Smoke test

The test procedure simply involves switching the unit on and checking that everything works correctly. First, check that all the LEDs are out immediately after switch-on, then press the Start button. LED 1 should now come on after a brief delay, followed by each of the remaining LEDs in turn. Check that the unit counts correctly to 10 and that LED 10 then remains on as the count cycles through the first nine LEDs again. If any of the LEDs fail to light, it has probably been installed the wrong way around.

Now press the Stop button and check that the display "freezes", with the current LED(s) remaining on. Pressing the Start button again should now clear the display and restart the count.

Finally, check the operation of the Reset button. It should only be pressed after the Stop button has been pressed and should clear the display. Do not use the Reset button to restart the count if a count is already in progress, as this will give inaccurate results.

Calibration

Assuming that everything works correctly, the unit can now be calibrated so that its counts at the correct rate. As mentioned earlier, the sound from a lightning flash travels about 1km in 3 seconds. So, to calibrate the unit, simply adjust VR1 so that the unit takes 30 seconds to count up to 10km. This will have to be done on a trial and error basis. Rotating VR1 anticlockwise increases the time, while rotating VR1 clockwise reduces it.

Once thus has been done, you can complete the final assembly and wait for that next southerly-buster to blow up. **SC**