Poor

SILICON CHIP

OUTPUT

PLASMA DISPLAY

By LEO SIMPSON

Man's Plasma Display

The Plasma Display described in our August issue created enormous interest among enthusiasts but many people complained about the high cost of the kit. For those people, we have come up with a much cheaper version and all the parts are readily available.

There is no doubt about it. The Plasma Display described in August really did create a lot of interest. Many people were fascinated with the concept and we had lots of phone calls from readers wanting to know if there was a cheaper way. We said there wasn't.

Then we had a letter from a reader asking if a large incandescent bulb could be used. Rather rashly, we said it wouldn't work. But then one of the members of our editorial advisory panel, Philip Watson, said that the Plasma Display article brought back memories of his boyhood experiments with a Ford "trembler" coil and a small incandescent bulb.

"Hmm," we thought, "maybe it's worth trying". We disconnected the large Plasma Display and connected the EHT output instead to the base of a 300 watt incandescent lamp which we happened to have on hand. Presto, it worked. The display was not as spectacular as from the large plasma container presented in August, mainly because the discharge path from the lamp filament to the glass envelope was nowhere near as long.

We noted that there were two main discharge paths, from the ends of the filaments to the glass envelope. There were also very small discharges from all the sharp points of the filament. These main discharges were pinkish with tinges of blue. And then, when observing the discharge in the dark, the whole bulb was lit up with a blue fluorescence. Beautiful.

Then we got really adventurous and tried an ordinary 40W bulb. Yep, it lit up too with a blue discharge. In fact, every bulb we tried would work.

"Why didn't we think of it before?" we thought. Well, it did require some lateral thinking and clearly, we hadn't been in lateral mode. But when you consider that an incandescent lamp is a perfectly sealed bulb containing a small quantity of inert gas, namely Argon, it should work. And it did.

So OK, virtually any incandescent lamp can be made to work with the EHT generator presented in our August issue. We have to be realistic though; it isn't perfect. It does have drawbacks.

First, as we have already noted, it is not as spectacular or as colourful. Nor can you order up the display you want. There is no choice. And the fact that the lamp filament has sharp points at each support means that the discharges will inevitably strike from those points.

PARTS LIST

- 1 large incandescent lamp, preferably rated at 300W or more
- 1 43mm giant Edison screw socket
- 1 black plastic instrument case (Altronics Cat. H-0483)
- 1 TV horizontal output transformer (not a tripler type)
- 1 printed circuit board, code SC 11111881, 185 x 100mm
- 1 50kΩ potentiometer (log or linear)
- 1 in-line 3AG fuseholder and 3A fuse
- 3 solder lugs
- 1 cordgrip grommet
- 1 1-way insulated terminal block

Semiconductors

- 3 2N3055 silicon NPN power transistors
- 1 BD140 silicon PNP power transistor
- 1 BC337 NPN transistor
- 1 15V 1W zener diode
- 1 1N4148 silicon diode
- 1 1N4007 silicon diode
- 2 1N4002 silicon diodes
- 1 1N5407 silicon diode
- 1 555 timer IC

Capacitors

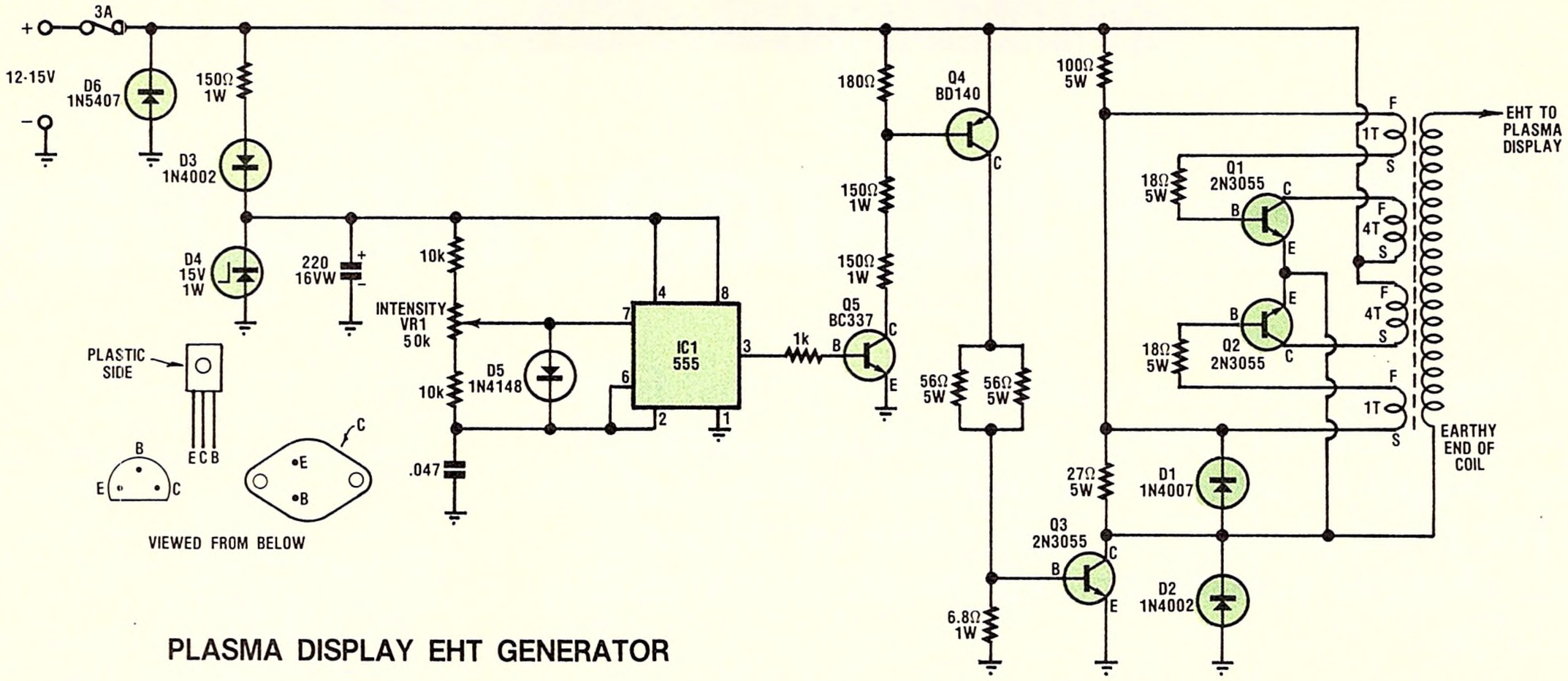
- 1 220μF 16VW PC electrolytic
- 1 .047μF metallised polyester

Resistors

2 x 10kΩ 0.25W, 1 x 1kΩ 0.25W, 1 x 180Ω 0.25W, 3 x 150Ω 1W, 1 x 100Ω 5W wirewound, 2 x 56Ω 5W wirewound, 1 x 27Ω 5W wirewound, 2 x 18Ω 5W wirewound, 1 x 6.8Ω 1W

Miscellaneous

Mica washers and insulating washers to suit TO-3 power transistors, rainbow hook-up wire, screws, nuts, lockwashers.



PLASMA DISPLAY EHT GENERATOR

Fig.1: transistors Q1 and Q2 drive an EHT transformer to produce high-voltage AC. This inverter circuit is rapidly turned on and off by Q3, which is driven by Q4, Q5 and IC1. VR1 varies the duty cycle to optimise the plasma display.

This is in contrast with the carefully rounded filaments of the Plasma Display which generate beautifully random discharges.

Second, and this is more of a problem, standard incandescent lamps are made from very thin glass. That means that when you touch the outside surface of the glass with your hand you can get quite a nasty tickle. In some cases you could even get a burn as the electric discharge can become quite concentrated. So placing your hands directly on the glass envelope is not recommended.

If you do it, you'll only do it once and then you'll stay right away from it.

Third, if you concentrate the electric discharge at one point on the glass envelope, say by bringing an earthed metal electrode in contact with the glass, you can puncture the envelope.

What happens is that the heat of the concentrated discharge actually melts the glass at that spot and the resulting stresses then cause a hair-line crack to develop. This quickly degrades the partial vacuum inside the bulb and the display is extinquished. So you have been warned. It is no great loss when you puncture a 100W bulb which costs less than a dollar. But if you puncture a 300W or 500W lamp it is a bigger loss.

On the positive side, we have found that there are two ways to improve upon the display available from the larger incandescent lamps. You can gain quite a worthwhile improvement by rapidly switching on and off the EHT supply. This reduces the tendency of the discharge to jump from one or two points on the filament and instead, to spread itself more uniformly.

Second, by placing an earthed wire "halo" above but not touching the glass bulb, you can obtain a more even distribution of the discharge. One of our readers suggested this idea.

And to see the display to the best effect, you should view it in pitch darkness.

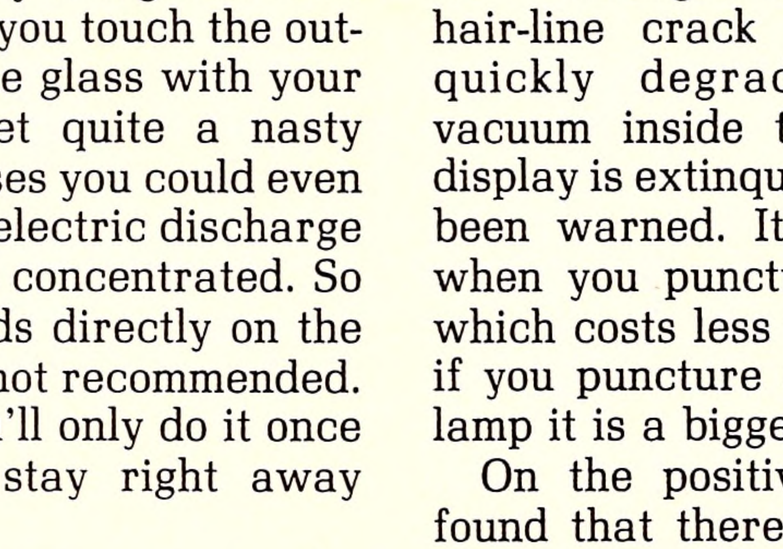


Fig.2: if you don't have a 12V battery charger, this circuit can be used to make up a suitable DC power supply. It uses a 15V 2A transformer to drive a bridge rectifier.

EHT Generator

As noted above, we have modified the EHT generator we produced for the Plasma Display described in August. Essentially, we are using an additional power transistor to rapidly switch the EHT generator on and off. The basic EHT generator remains much the same though, although we have improved the heatsinking. Lack of an adequate heatsink has proved to be a problem with some EHT transformers.

For those who did not see the original article, let's describe the basic EHT generator and then the circuitry for modulating it.

EHT stands for "extra high tension" and is the term used to describe high voltages of several

thousand volts or more, whether DC or AC. The EHT generator for the Plasma Display produces about 15,000 volts (15kV) AC at a frequency somewhere between 10kHz and 20kHz.

The basic EHT generator is a DC to AC converter which takes low voltage DC and steps it up to very high voltage AC at a high frequency. It uses two 2N3055 power transistors connected as a transformer-coupled multivibrator.

The transformer is a horizontal output transformer intended for a black and white television set. Normally a transformer of this type would be driven by the horizontal output transistor at 15,625Hz. For our circuit, the transformer is modified by adding two centre-tapped windings and these are driven by the two power transistors, as shown in the circuit of Fig.1.

For the moment, imagine that Q3 is turned on continuously so that the power is applied to the EHT generator all the time.

Each transistor's base is driven by a one-turn feedback winding while each collector drives half the main low voltage winding. When the circuit is oscillating, each transistor alternately turns hard on, which applies the full DC voltage across the associated winding, while the other transistor is biased off.

So the transistors apply a square wave voltage to the low voltage winding and this is stepped up by more than a thousand times in the high voltage secondary winding.

The 18Ω 5W resistors in series with the bases of transistors Q1 and Q2 are there to limit the amount of feedback current. They therefore have the effect of reducing the amount of damping on the transformer and thus improve efficiency.

Initial bias to start the circuit oscillating is provided by the 100Ω 5W and 27Ω 5W resistors.

Modulator

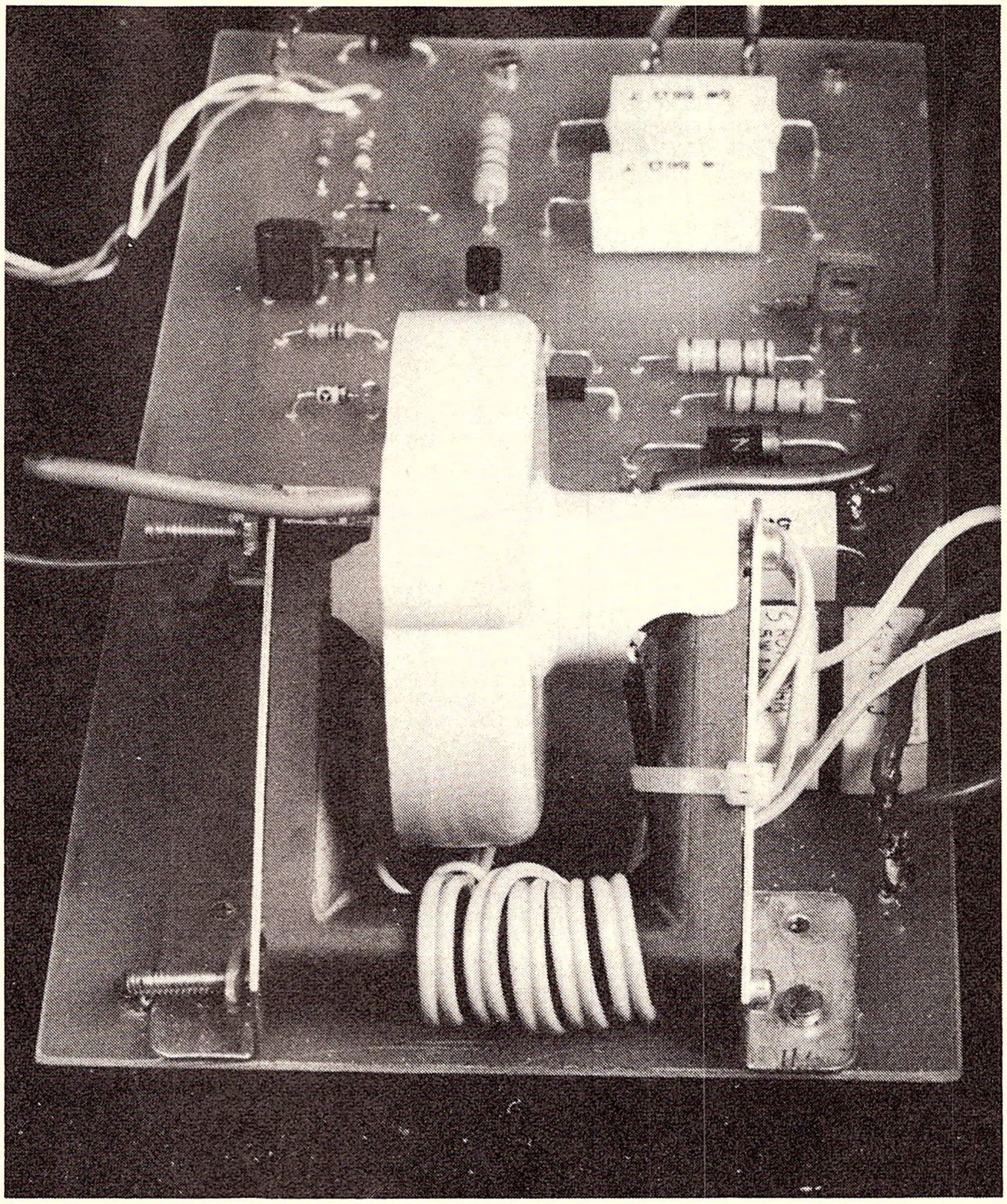
IC1, Q3, Q4 and Q5 comprise the modulating circuit for the EHT generator. Since the main DC supply via the 3 amp fuse can be pure DC or unfiltered DC from a battery charger, there is a need to produce a clean DC supply for IC1. This is provided by D3 and the 220μF capacitor, with voltage limiting being provided by the 15V zener diode D4. To prevent excessive current through the zener diode, a 150Ω 1W resistor is connected in series with D3.

IC1 is a 555 timer connected to oscillate continuously. The frequency of oscillation is set by the .047μF capacitor connected to pins 2 and 6, in conjunction with the associated 50kΩ potentiometer (VR1) and two 10kΩ resistors.

IC1 oscillates at a frequency of about 430Hz (actually between 415 and 450Hz, for our prototypes) and the duty cycle of the output pulse waveform varies between about 16% and 85%, depending on the setting of VR1.

Normally, it is not possible to achieve a pulse waveform with a duty cycle of less than 50% from a 555. However, the addition of diode D5 allows the duty cycle to be reduced to 15%. This makes for an interesting variation on the normal charge and discharge cycle of a 555. When the capacitor is charging to the upper threshold of the 555 (2/3Vcc), the charge path is via the upper 10kΩ resistor, the top portion of VR1 and diode D5.

When the capacitor is being discharged to the lower threshold of the 555 (1/3Vcc), the discharge path is via the lower 10kΩ resistor (connected to pin 2) and the lower portion of VR1, to pin 7.



This view shows how the 4-turn and 1-turn secondary windings are wound on the EHT transformer using two-core ribbon cable. When the windings are in place, they can be secured by running some hot candle wax over them or you can use a couple of plastic cable ties.

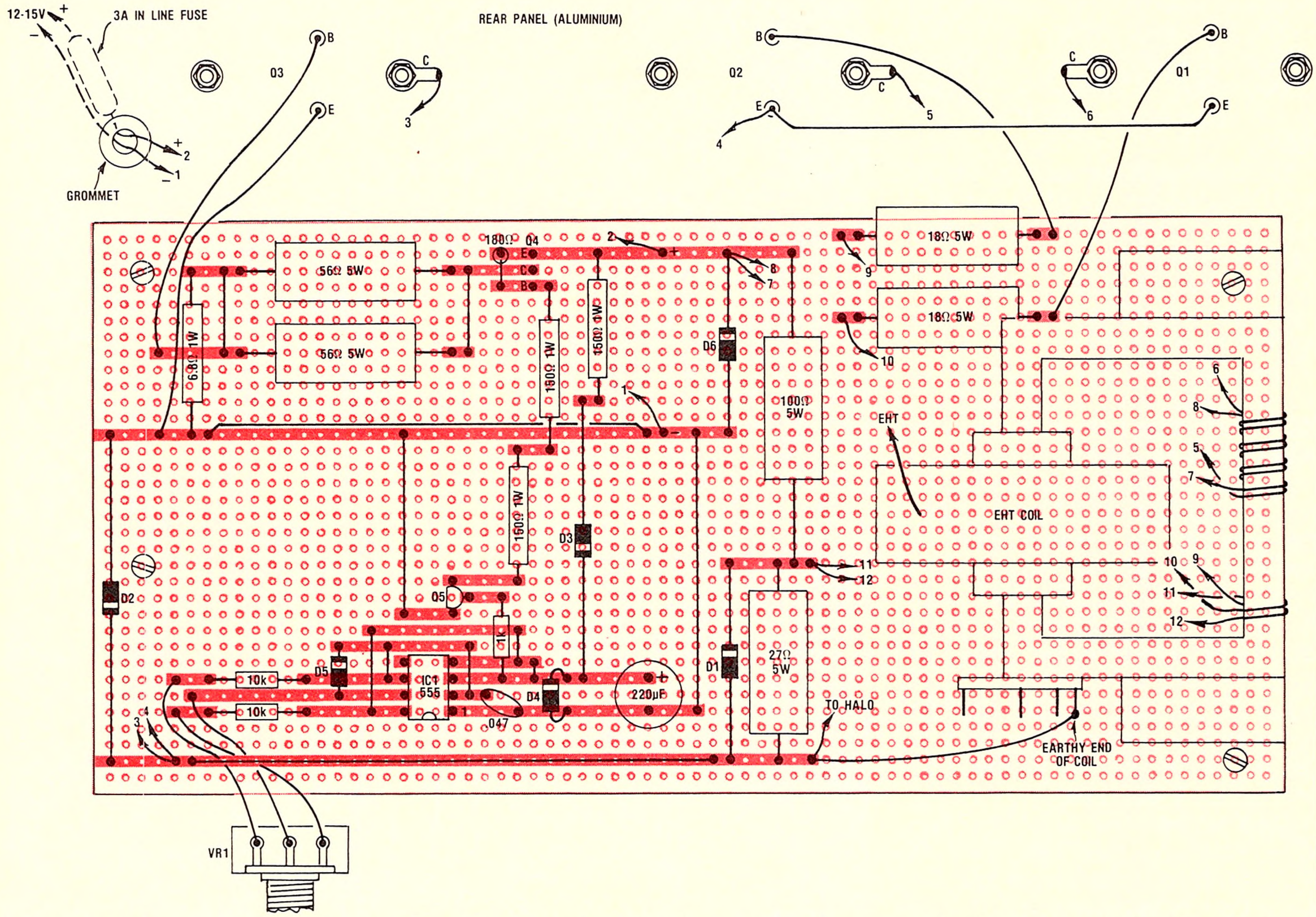
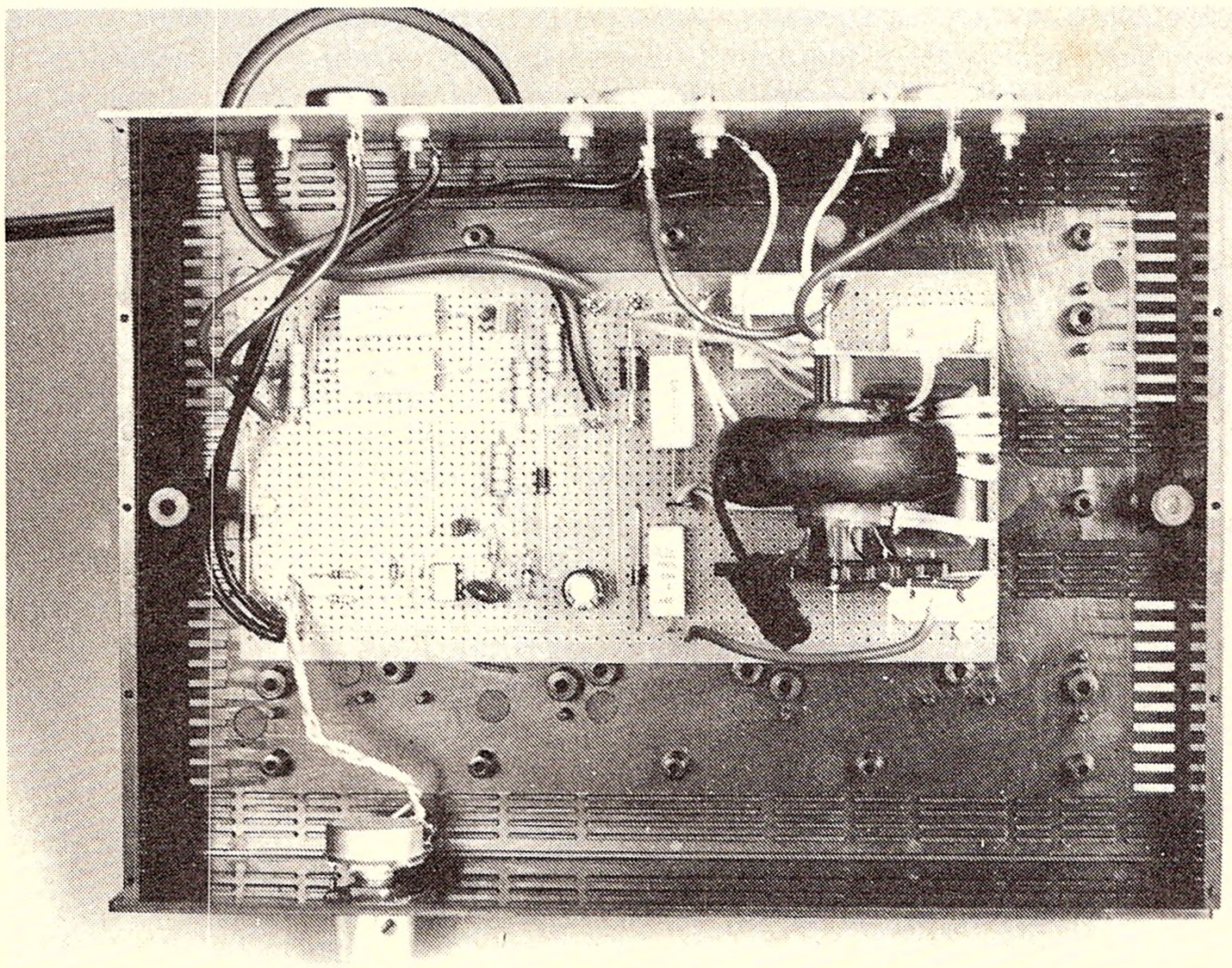


Fig.3: here's how to wire up the Veroboard version of the EHT generator. You can make the cuts in the tracks using an oversize drill but take care as it's very easy to make a mistake with Veroboard.



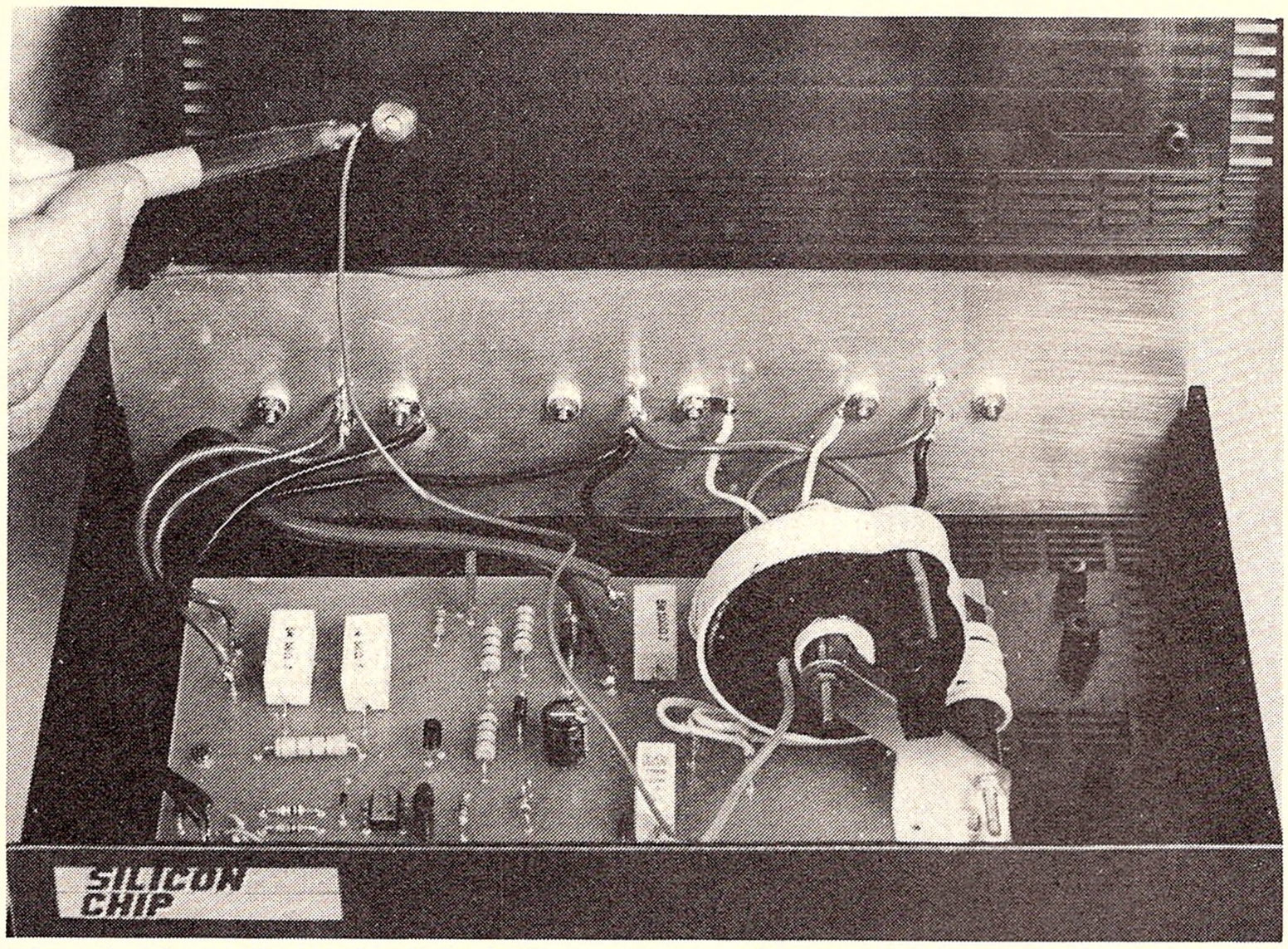
A standard plastic case with a metal rear panel can be used to house the EHT generator circuitry. The EHT lead is connected to a lead from the Edison screw socket via a 1-way terminal block. Don't touch the EHT transformer while the unit is operating.

The variable duty cycle pulse waveform from pin 3 of the 555 is fed to the base of Q5 which turns Q4 on and off. Q4, in turn, switches Q3 on and off and thus turns on and off the negative supply rail to the EHT generator circuit.

Diode D2 provides a current return path to the EHT coil of the transformer, so Q3 is protected against reverse current. D6, at the supply input, prevents damage in the event of the DC supply being reverse-connected. If that happens, the 3A fuse will blow.

As with the EHT generator for the original Plasma Display, any DC power supply capable of delivering 12 to 15 volts at more than two amps is adequate. In fact, virtually any 12V battery charger will do the job, provided it can deliver 2A or more.

If you don't have an adequate DC supply or battery charger, the circuit of Fig.2 will do the job. It uses a 15V 2A transformer driving a



The wire loop above the light bulb is connected to a screw terminal (near pen) on the lid of the case. From there, a lead is run to the earthy end of the EHT coil as shown on the wiring diagrams.

bridge rectifier. No filter capacitors are necessary.

Construction

We adopted quite a different method of construction for the Poor Man's Plasma Display. Instead of using a round stand based on plastic sewer pipe fittings, we have used a standard black plastic instrument case (Altronics Cat. H-0483 or equivalent). Because of the very high voltage applied to the base of the incandescent lamp, the plastic case is mandatory. We would not recommend a metal case.

The specified case also has ventilation holes which are desirable because the EHT transformer does get warm after a long period of operation.

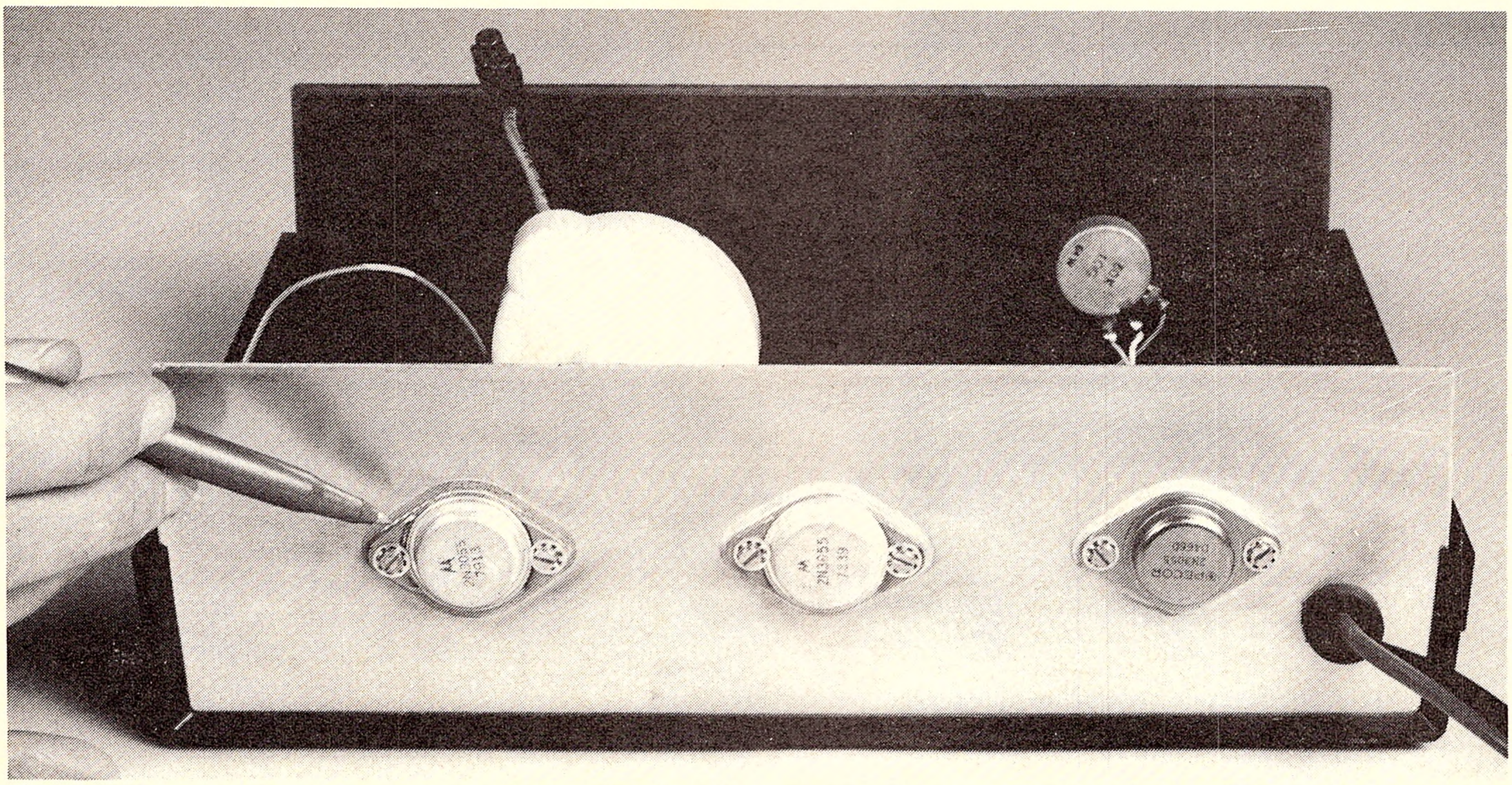
Fitted to the top of case is a ceramic giant Edison screw (GES) socket which is suitable for high power incandescent lamps. The lamp we used is rated at 1000W and cost around $40.

You can also use the more common 27mm Edison screw socket. Sockets and high power lamps are readily available from lighting retailers and wholesalers.

To provide heatsinking for the three power transistors, the rear panel of the case must be of aluminium. We made our own panel from 16-gauge aluminium but you can purchase 2.5mm thick natural or black anodised panels to match the case (Altronics Cat. H-0488, black or H-0489, natural).

The circuitry inside the case may be wired up on Veroboard or a printed board designed for the job. While the Veroboard version will certainly save you money, we only recommend it for experienced constructors as it is very easy to make a mistake in wiring it. The wiring diagram for the Veroboard version is shown in Fig.3.

We'll restrict our construction instructions to the printed board



The 2N3055 power transistors are mounted on the aluminium rear panel to ensure adequate heatsinking. Make sure that the transistor cases are electrically isolated from the panel as shown in Fig.5.

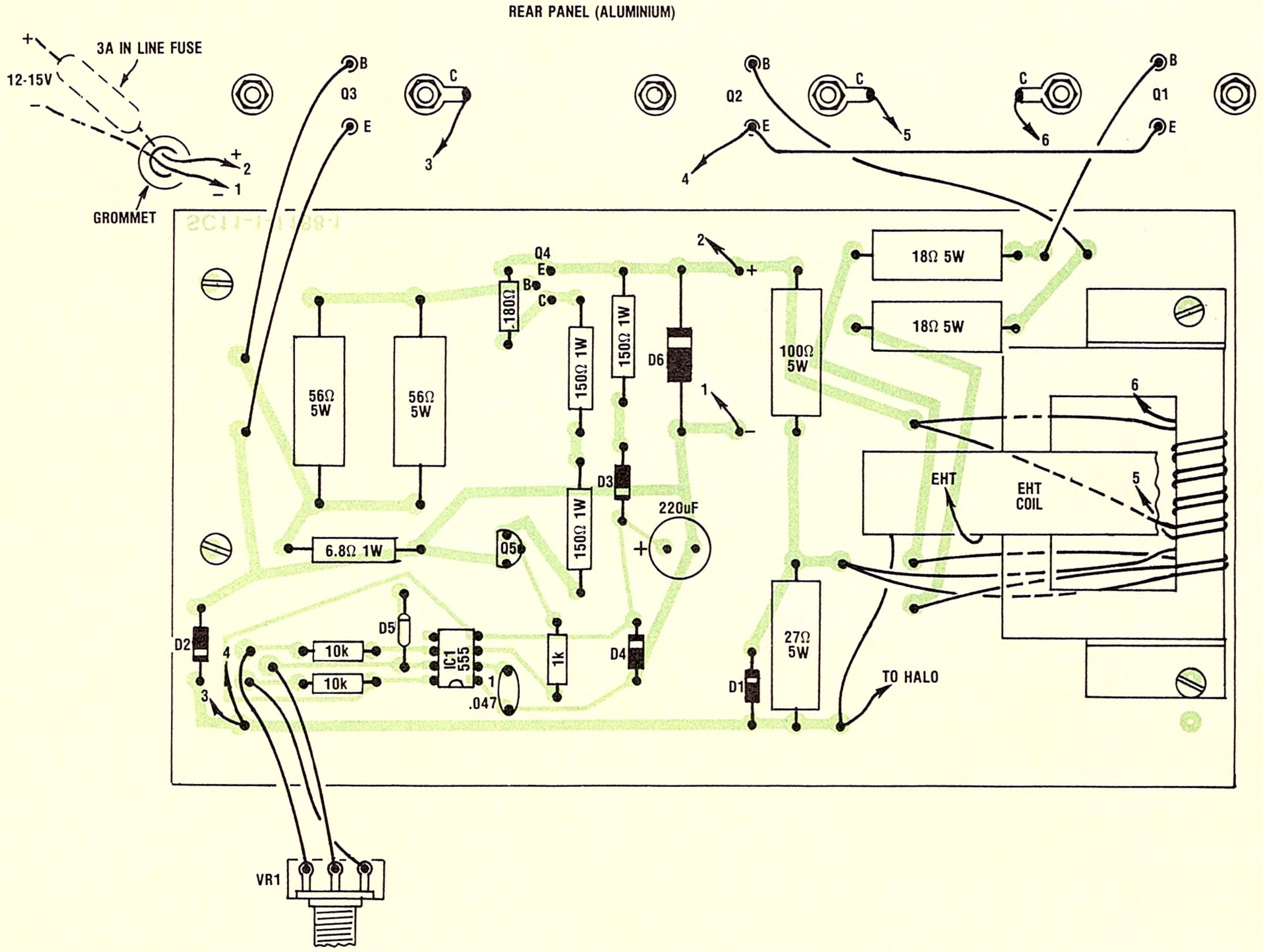


Fig.4: the PCB version of the EHT generator is much easier to assemble. Note the lead marked "to halo". This lead connects to the wire loop above the light bulb via the screw terminal on the lid.

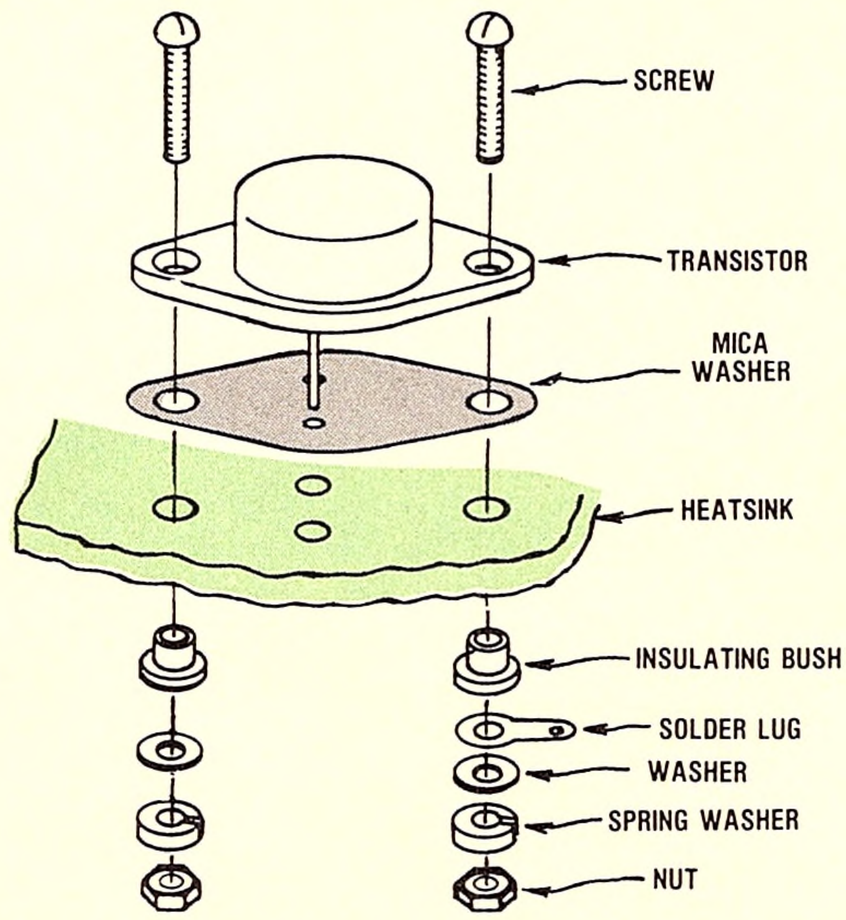


Fig.5: this diagram shows how the 2N3055 power transistors are isolated from the heatsink using mica washers and plastic insulating bushes. After each transistor is mounted, use your multimeter to confirm that its case is indeed isolated from the heatsink.

version. The board measures 185 x 100mm and is coded SC 11111881. Fig.4 shows the wiring details

The TV horizontal output transformer comes with a mounting bracket which makes it easy to mount on the printed board with two screws, nuts and lockwashers. You will have to drill holes in the board to match those in the mounting feet of your transformer.

Before you mount the EHT transformer, remove the existing low voltage winding (on the opposite leg to the large circular EHT encapsulated winding).

Now wind on the two new low voltage windings. We used ribbon cable for this purpose as it makes bifilar winding easy. Wind on the two 4-turn windings together and do the same with the two one-turn windings. Secure the windings in place by running some hot wax from a candle over them. Alter-

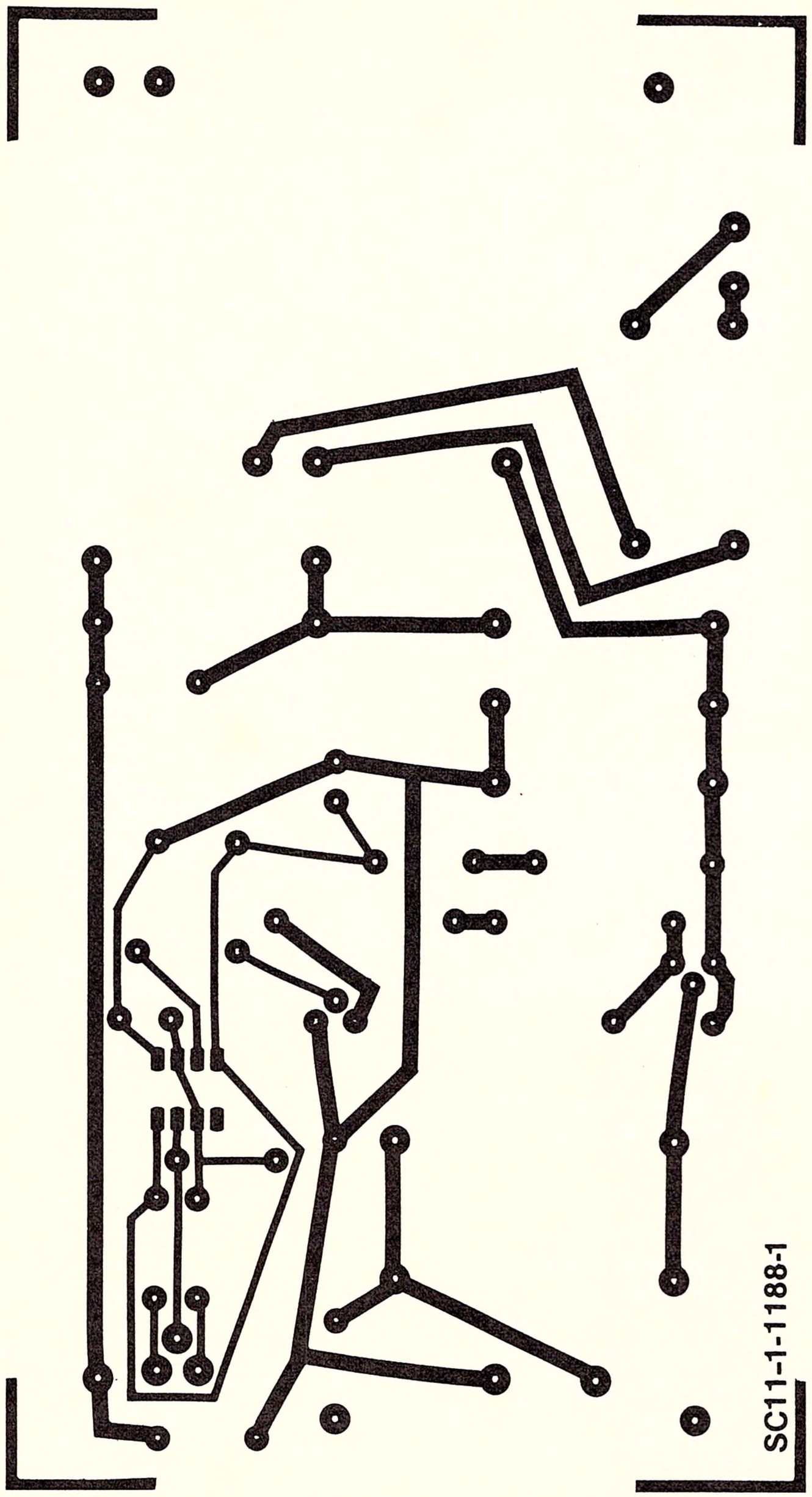


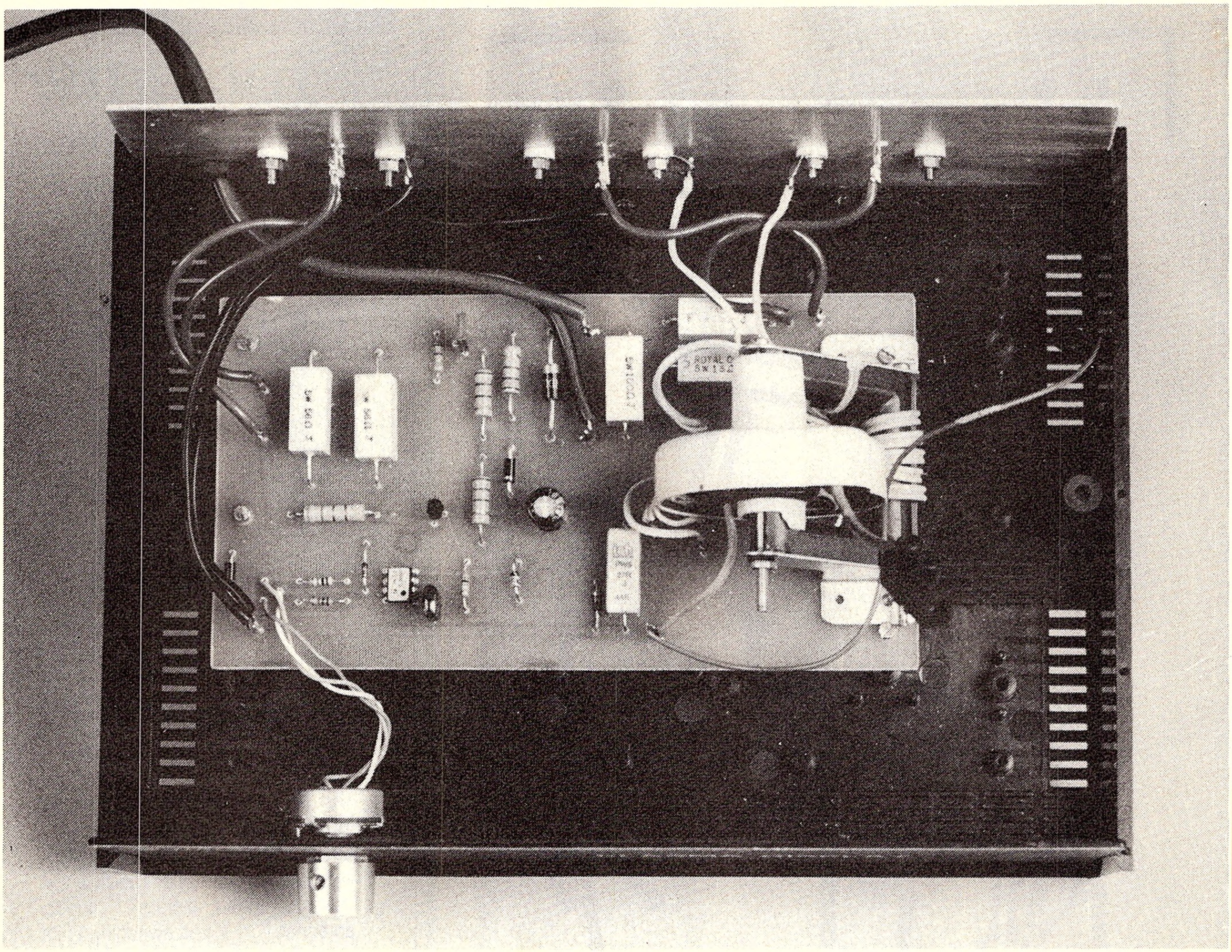
Fig.6: this is the full-size PC pattern. Etched PC boards are available from the usual retailers (see back page).

natively, use a couple of plastic cable ties.

The diagram of Fig.5 shows how the transistors are mounted on the heatsink (rear panel) using mica washers and insulating bushes. The transistor mounting surfaces and the heatsink should be lightly smeared with heatsink compound before they are assembled together.

An in-line fuseholder is used for the 3-amp fuse and the power flex is secured to a hole in the plastic base using a cordgrip grommet.

When you have finished the wiring check your work carefully to see



The circuit will work with a wide variety of EHT transformers (intended for black & white TV sets). Use PC stakes to terminate wiring connections to the board and don't forget to secure the transformer secondary windings.

that it agrees with the circuit and wiring diagrams. Now use an insulated terminal connector to connect a short length of stiff wire from the EHT output wire over to the earthy end of the EHT coil. Arrange the two ends so that there is a gap of about 7mm or so.

Apply power from your 12V battery charger or power supply to the EHT generator and note that a continuous arc occurs across the spark gap. OK, so it works. Let it run for 15 seconds or so and then turn the power off. Feel the transistor cases to make sure that they are not running hot.

After running for quite some time the transistors will become pretty warm but not so hot that you can't touch them.

Now it is merely a matter of connecting a short wire from the base connection in the Edison screw socket on the lid of the case to the EHT output from the transformer.

Now screw the plastic case together. Carefully screw your incandescent lamp into the Edison screw socket and apply power. A colourful discharge should immediately appear in the lamp.

Wire loop

You may like to try the effect of an earthed wire loop above the bulb, as suggested previously. You could make it out of tinned copper wire or from a coat-hanger. We connected ours to a screw terminal on the lid of the case, with a lead then running to the earthy end of the EHT coil on the printed board. Don't let the earthed wire come in contact with the bulb, to avoid the risk of puncturing it.

Remember too our warnings above about putting your hands directly on the lamp bulb. You can get quite a nasty sting from it. Keep your hands away from it.

We suggest that your Plasma Display be placed in the centre of a suitable table, not near the edge. You should avoid any chance of the Display being knocked to the floor. The resulting implosion could cause flying glass and you don't want the expense of buying a replacement bulb.

Other tricks

Because the Plasma Display creates a high voltage high frequency field around it, it can be used to light up fluorescent tubes which are in the vicinity. That's an interesting parlour trick. You can do the same thing with neon lamps. sc