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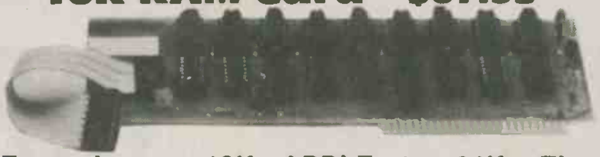

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COMPONENT NOTATION AND UNITS

We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!

First, decimal points are droppoed and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.

Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

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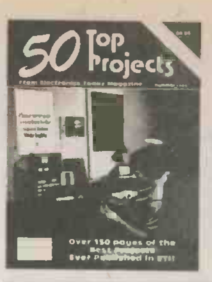


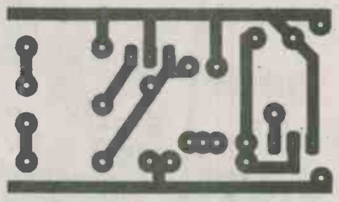
A soldering iron under Ed Zapletol's control is considered a dangerous weapon. We've been trying to get him to build the Temperature-Controlled Soldering Iron project for some time now, but he says he has no use for an iron that doesn't raise instantaneous blisters. He has the scars on his hands to support his viewpoint.

Cover photograph by Bill Markwick.

1) Test Equipment

6 **Dual Logic Probe**
A double purpose logic probe that meets a most important requirement: it's cheap.

10 **Electronic Thermometer**
How hot does that circuitry get? A modified voltmeter can give you the answer.



12 **Crystal Marker**
The ETI Crystal Marker produces a square wave output for any one of six selected frequencies.

14 **RPM Meter**
The perfect instrument for measuring rotation, but it won't work on a counter stool at the local donut shop.

18 **Semiconductor Tester**
When your semiconductors arrive home from a long night at Scratch Daniel's Saloon, they might have trouble remembering which end is up. Here's how to set them straight.

21 **Universal Timer**
Our Universal Timer has two ranges and produces a thirty second alarm at the end of each timing period.

23 **Pulse Generator**
This project sounds like it could be used to give breathing life to your robot, but it has a more important mission.

27 **Universal Counter**
A counter design that can be utilised in many different applications.

34 **LED VU Meter**
Ever wonder if there is anything untoward going on in those cables? This project allows you to play the role of chaperone.

37 **Temperature-Controlled Soldering Iron**
An iron that is too hot or too cold can wreak havoc on the quality of your projects.

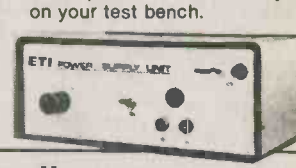
40 **AF Signal Generator**
A simple-to-build signal generator that encompasses features normally found only in more expensive designs.

2) Power Supplies

42 **Power Pack**
An adjustable voltage power pack that can make your daily battery purchase a thing of the past.

44 **Nicad Charger**
When your nicads are feeling a little down, pep them up with some kind words and a few hours on this device.

48 **Bench Power Supply Unit**
A compact unit that'll look just perfect on your test bench.



3) Audio

53 **4-Input Mixer**
If the audience has trouble hearing your harmonica above the rest of the band during an electric version of 'Tutti Frutti', try this mixer.

55 **150 Watt Amp**
"150 watts!" said The Kingston Trio's John Stewart. "Boy! 'Tom Dooley' will really sound neato with all that power!"

62 **Sound Bender**
A cheap ring modulator with a built-in sine/triangle modulation oscillator and a pan pot output mixer.

50 Top Projects

64 **LED Level Meter**
This LED Level Meter is ideal for any application requiring a wide dynamic range level display.

70 **Tape Recorder Optimiser**
This little design will help to keep your recordings up to snuff.

72 **Scratch Filter**
If you've got an itch, scratch it. And if you've got a scratch, remove it.

74 **Loudspeaker Protector**
If loudspeakers had guardian angels, they'd all be called St. Overload.

4) Sound Electronics

77 **AM Radio**
The AM band is making a comeback these days. With this project, you can get your fill of spotty news reporting and double entendre jokes.

79 **Drum Machine**
If the original North Americans had built this project, they wouldn't have gotten cramps in their wrists banging on hollow logs outside the council longhouses.

85 **Steam Loco Whistle**
A shrill horn blast cuts through the stillness of the night as a train thunders over a level crossing. Your wife wakes up and asks if there is a volume control on your latest ETI project.

5) Home

88 **Electronic Doorbuzzer**
A reliable solid state alternative to the age old solenoids and chimes.

90 **Low Power Pilot Light**
A power-on indicator that doesn't drain the batteries that it is supposed to be saving.

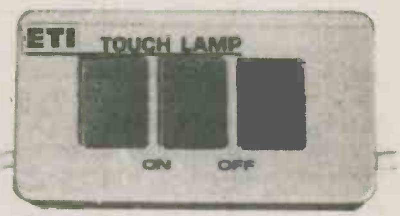
91 **Micro Power Thermal Alarm**
For situations where temperature variations can be harmful, this alarm will let you know if all is not well.

93 **Bicycle Speedometer**
Bicycles are classed under the same law as cars, so if you ride through many 20 km/h school zones, this project may save you from ticket problems.

96 **Musical Doorbell**
A doorbell that you can program to play the first measure of the "I'm in the Bathtub Blues."

98 **Background Noise Simulator**
A project for those readers without children.

100 **Touch Lamp**
A battery-powered design that helps eliminate all that nightly fumbling in the dark.



102 **Emergency Lighting Unit**
When Ontario Hydro is hiding its light under the proverbial bushel, this unit will help you to see your way clear of the situation.

106 **Infra-Red Alarm**
As much as most of us hate to admit it, burglar alarms are a necessity in this day and age.

6) Automobile

111 **Antenna Extender**
With ETI's power antenna controller, you can keep your antenna out of the hands of the local zip gun fanatic.

113 **Headlight Delay**
If you happen to own a '32 Auburn, installing one of these units might lose you some points at the next Concours.

115 **LED Tachometer**
A great way to measure the speed at which that rattly wrist pin finally let loose.

118 **Bargraph Voltmeter**
How to keep a close eye on that $5.00 battery that was guaranteed for nineteen starts.

120 **Bodywork Checker**
Used car salesmen will hate you on sight when you come walking into the lot with one of these gadgets. But then, being disliked by a used car salesman is similar to being disliked by a wart.

122 **Engineer's Stethoscope**
The ideal way to find out if the bolt you dropped down the carburetor is still banging around down there somewhere.

7) Photography

125 **Contrast Meter**
Overexposed? Underexposed? Let this meter do all of the hard work.

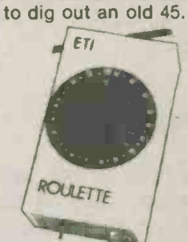
128 **Photo Timer**
An indecent exposure can be very unflattering to your talents. This project will provide you with all the counselling that you will probably need.

130 **Enlarger Timer**
Let's face it, muttering one and two and ... just does not make it in the highly technical world of photography. How to time your enlargements professionally.

133 **Flash Sequencer**
Stop action photography often creates exciting images, and this unit makes for pretty cheap excitement.

8) Games

136 **Roulette**
We bring Las Vegas into your home. Minus, of course, the free drinks, and if you want to hear Frank Sinatra, you'll have to dig out an old 45.



140 **Reaction Tester**
No, not another public opinion measurement device from Gallup.

142 **Win Indicator**
For the competitive among us; a way of measuring your greatness.

145 **Alien Attack**
Being surprised in the shower by a band of aliens is no great fun, and swinging at them with your soap-on-a-rope is not very diplomatic. The aliens in this game are not real.

148 **Joystick**
Using keyboard commands for a video game is a lot like staring up an elephant's trunk; an ugly way to spend your time.

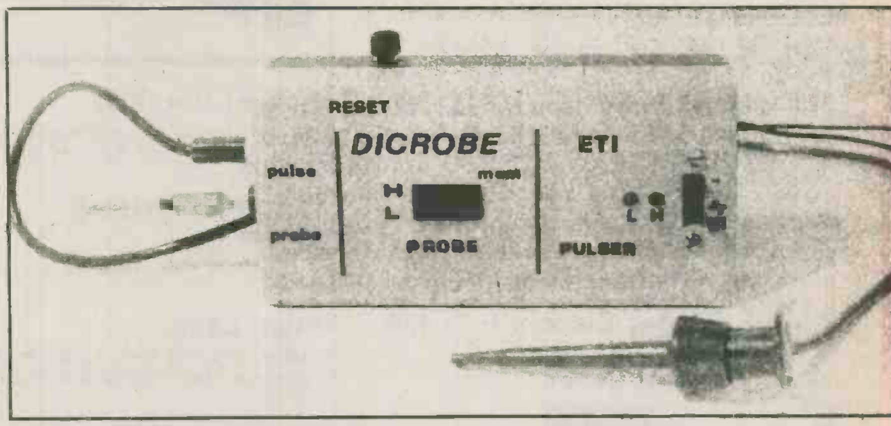
150 **Russian Roulette**
A design that's just in fun. Don't tuck it into the waistband of your pants when you go down to the sub shop for a late night snack.

152 **Double Dice**
When one die isn't enough, and three is too many.

1

Dual Logic Probe

With all the logic probe designs that have been published, you didn't think we could come up with an original design, did you? Oh ye of little faith ... this one's cheap, compact, and clever. Design and development by Phil Walker.



Using the case and construction techniques specified gives a neat little project.

THIS 'project par excellence' from the ETI workshop is a very useful dual purpose logic tester. It is designed with CMOS in mind and uses mostly logic ICs of that family. Our prototype gives results with pulses down to 200 nS wide at frequencies from DC to over 2 MHz.

The ETI Dicrobe is designed as a dual purpose test instrument. One half of it is a reasonably conventional logic probe giving indications for logic high, low, and pulsing states while also having a transition memory to store those events you might otherwise miss. All these conditions are displayed on a seven-segment LED display to give a practical representation of conditions at the probe tip.

Probing For Pulses

The other half of the unit is a logic pulser which automatically senses the logic level of the secondary probe and gives it a short pulse to the opposite state. This can either be a square wave drive at about 5 Hz or 2 uS pulses, again repeated five times per second.

Two LEDs indicate the logic state on this probe but no indication of pulse conditions is given. The two parts of the instrument can be used independently or together. This enables a considerable amount of useful testing to be carried out with this unit alone.

For instance, the pulser could be applied to a clock input while the primary probe looks at the outputs to see if anything happens. Both probes could be applied to a part of the circuit to see if it is shorted to 0V or the positive supply; in this case pulses will be seen if everything is OK (even if there is an output from a gate driving it).

On TTL circuits the probe may not operate so quickly due to the low supply voltage but a useful indication of functions should be possible. Bear in mind, however, that the logic high and low levels for TTL are much lower relative to the supplies than for CMOS.

A Tour Round The Circuit

The primary probe circuit uses a 4049 to sense the input, with the advantage of high speed, high input impedance and CMOS logic thresholds. The output from three sections of this drives the edge detector and two segment drivers. The edge detector drives a set-reset latch (to store the fact that a transition occurred) and a monostable (to give indication of previous conditions).

The secondary probe circuit is a little simpler than the primary probe as it is not designed for high speed. Part of a hex Schmitt trigger senses the input and the result of this is stored on a set-reset latch. Another part of the Schmitt package works as an oscillator at about 5 Hz and drives two other sections via CR networks to provide reset pulses for the set-reset latch and enable pulses for the output circuit.

The output transistors are connected so that they are normally off. When a pulse is to be applied to the output the logic drivers apply base drive to one of the transistors. The particular transistor driven is the one which gives a pulse of the opposite polarity to the normal state of the circuit point to which the probe is connected. After the pulse the state of the circuit is sensed ready for the next pulse.

The three-position switch allows the secondary probe to act as a straight logic probe or an automatic pulser with short duration or square wave pulsing.

Construction

The PCB for this project has been designed to fit inside a small plastic box. There is very little room to spare inside the box so great care must be taken to use small components and make the connecting wires as thin and short as possible.

A fine tipped soldering iron is essential for this project and great care must be taken to avoid solder splashes between tracks. The ICs can be mounted in sockets of the low profile type and the seven-segment display should be mounted in a socket as well. For the display we used some Soldercon connectors; these are taller than the low profile sockets on the other ICs and held it higher above the board to project through the case lid when assembled. Apart from the LEDs and two resistors, all the other components mount normally on the PCB. Take care to get the diodes, transistors, ICs and capacitor the correct way round. The LEDs are mounted so that they will project through the lid.

Two resistors have to be mounted on end so refer to the overlay to see where they should go. Two wire links are needed near IC1 so don't forget these either. The links are close together and should be made with insulated wire. When wiring up, connect lengths of 6" or so to all the connection points indicated except the power supply, which should be 18" or so.

Fit the sockets for the probes into the end of the box where the board mounting pillars are closest together. They must be as near to the bottom of the box as possible. Also fit the reset switch into the side of the box in a similar manner. This switch must be very small to fit in the space provided. If a suitable component cannot be obtained, increase the value of R3 to 10M and use two small bolts as a touch switch. This is suggested only as a last resort!

A small grommet should be inserted in the opposite end of the box to the probe connectors to take the power supply wires. The box lid must have holes cut or drilled in it to clear the display, LEDs and mode switch SW1. SW1 is bolted to the lid and the interpin connections made before wiring to the board.

When fitting the PCB into the box the wires from it must all pass over the ends as there is not enough clearance at the side for them. The probe and switch wires should be short or they will get in the way of the lid. Our prototype used small grommets cut in half as spacers between the PCB and the mounting pillars to get the correct height.

Probing Deeper

The probes themselves were very simple. The main one was a piece of brass threaded rod turned to a point in a drill with a file. This was soldered into a metal tube taken from a piece of plastic connector block. A small piece of thick wire was soldered into the 2 mm plug and then this was soldered into the other end of the metal tube. You may care to experiment with a sewing machine needle instead of the brass rod as these form very durable probe tips.

The other one was simply a piece of wire with a spring probe on the end terminated in another 1 mm plug.

The two probes are interchangeable as required. Power supply wires can be terminated in crocodile clips or anything convenient.

What's The Diagnosis?

The probe is intended for diagnostic work on CMOS circuits where the main part is used to look for the effects caused by the pulser probe being applied to an earlier part of the circuit. This lets us find faults in com-

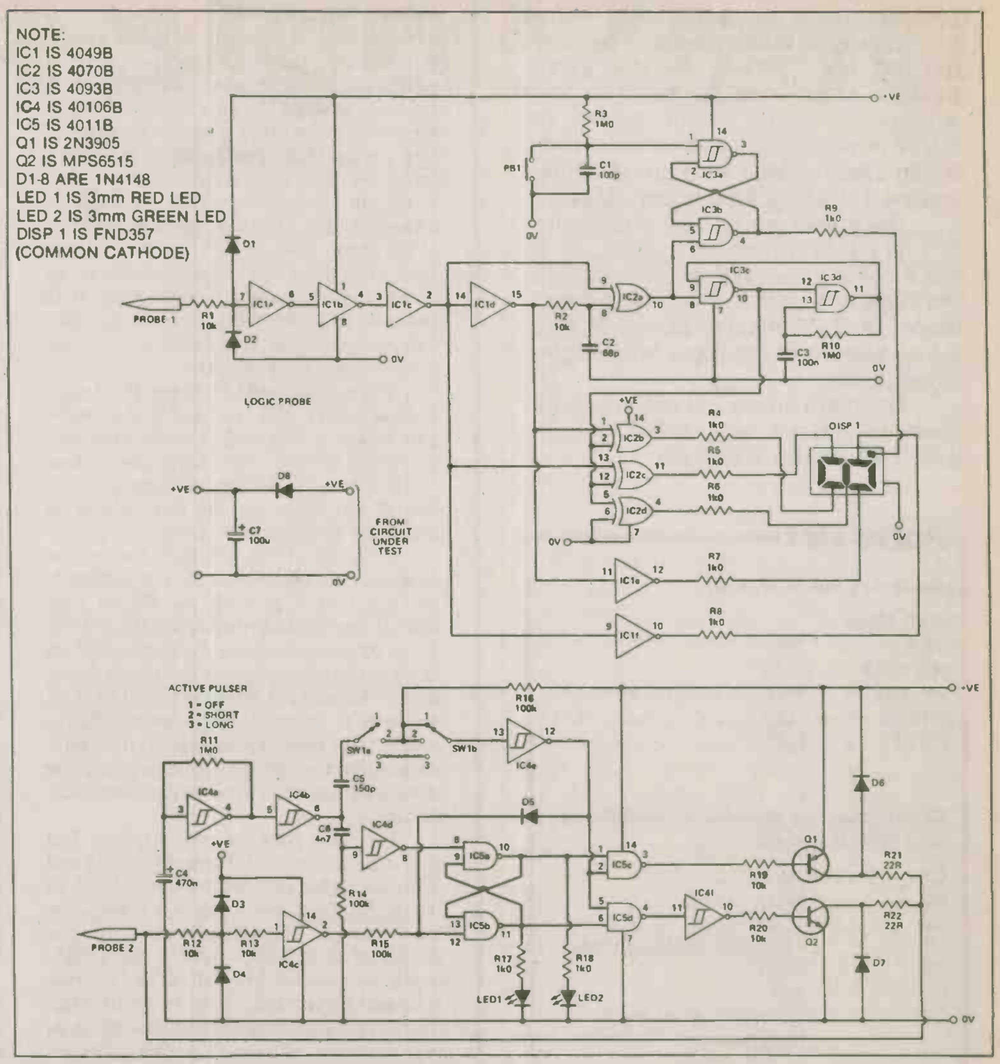


Fig. 1 Complete circuit diagram of the logic probe.

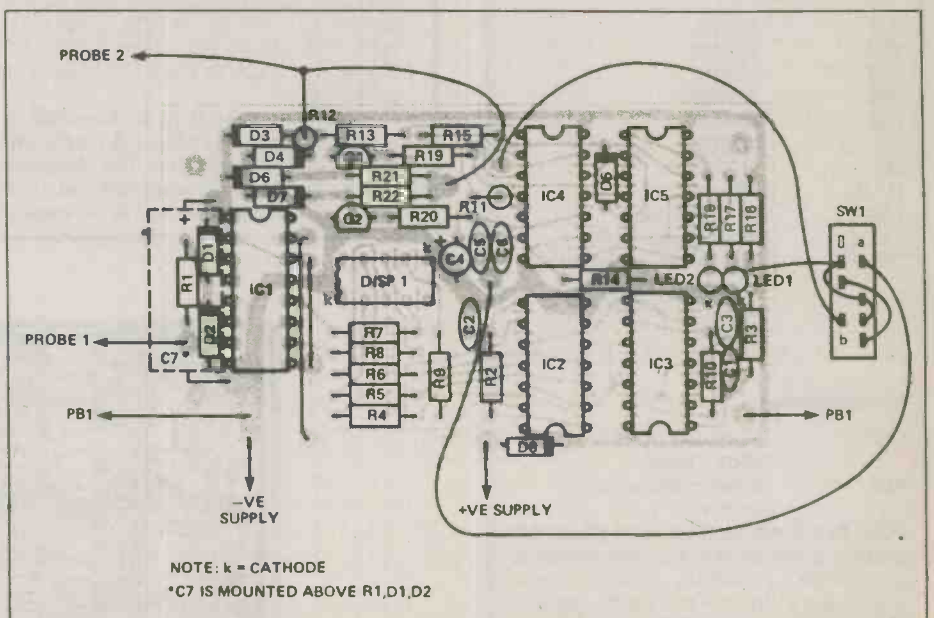


Fig. 2 Component overlay. Note that one end of R12 is soldered to two flying leads, not the board.

ponents such as gates and many counters and other devices. By connecting both probes to the same point, a check can be made to see whether a short circuit exists to either power rail (no pulses detected). It cah also be used as a crude signal source if nothing else is available.

The pulser works best if the point to which it is attached is static, as it has a fairly slow response time. Note that when it is in the active pulsing mode, the LED display does not give a true picture of the logic level at the pulse probe.

The main probe will catch pulses down to 200 nS with a 9 V supply which should be adequate.

Parts List

Resistors (all ¼ W, 5%)

R1,2,12,13, 19,20	10k
R3,10,11	1M0
R4-9,17,18	1k0
R14-16	100k
R21,22	22R

Capacitors (all miniature ceramic except where stated)

C1	100p
C2	68p
C3	100n
C4	470n 35V tantalum bead
C5	150p
C6	4n7
C7	100u 25V axial electrolytic

Semiconductors

IC1	4049B
IC2	4070B
IC3	4093B
IC4	40106B
IC5	4011B
Q1	2N3905
Q2	MPS6515
D1-8	1N4148
LED1	3mm red LED
LED2	3mm green LED
DISP1	0.4" seven-segment common cathode display (FND357 or similar)

Miscellaneous

SW1	3-position miniature slide switch
PB1	subminiature push-button

PCB; two 2mm sockets and plugs for probes; piece of brass rod or studding for probe; crocodile clips; 10-way Soldercon strip; low profile IC sockets (if used); small grommets, wire, screws etc; case.

How It Works

MAIN LOGIC PROBE

This part of the circuit is based around IC1,2 and 3. The input from the probe tip passes via a simple protection network R, D1 and D2 to IC1a. This device senses the logic level at the probe tip while also presenting a very high impedance to the circuit under test. Two more sections of the device, IC1b and IC1c, are used to speed up the transition time when the logic state changes at the input. The output from IC1c is used by IC1f to drive one of the segments of the display. IC1c's output is inverted by IC1d and used by IC1e to drive another segment. These two display segments form the immediate logic state indicator.

The outputs from IC1c and IC1d go to IC2b and IC2c. IC2 is a quad exclusive-OR gate which in this case is being used as a controlled inverter. The outputs from these two sections drive two more segments of the display but these are the ones which indicate the previous logic state.

To detect a transition from one state to another, the output from IC1c is applied to one input of IC2a while the output from IC1d is applied to the other via R2 and C2. These components cause the inputs to IC2a to be slightly out of phase with each other. In their normal rest state the inputs to IC2a would be at opposite logic levels causing the output to be high, but for a short time after a transition the inputs to IC2a will be at the same level and the output will be low during this period.

This low pulse has two effects. The first is to set the latch formed by IC3a and IC3b such that the decimal point LED in the display is lit, indicating that a transition has occurred. The second is to force the output of IC3c high, enabling the astable oscillator formed around IC3d. In fact IC3c and IC3d form a monostable to effectively stretch input pulses and transitions so that they can be seen. The low pulse on IC3c input puts a high on IC3d input which, since C3 has been resting at a high level, will make the output of IC3d go low immediately. This forces IC3c output to remain high via its second input until C3 discharges enough to allow IC3d output to go high again.

The output of IC3c is connected to IC2d which acts as a buffer to drive the centre segment of the display. This flashes to indicate that a transition has occurred. IC3c output also drives IC2b and IC2c, causing them to invert the signal on their other input while the monostable is active. The effect of this controlled inversion is that the last transition is mimicked on the display.

The transition memory, IC3a,b, can be reset at will by pressing PB1. The decimal point on the display will go dark until another transition occurs at the input.

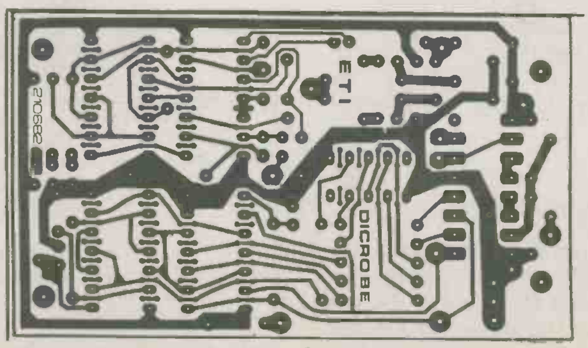
PULSER PROBE

The input from the probe tip is sensed by IC4c, part of a hex Schmitt trigger. Some protection is provided by R12, R13, D3 and D4 against excess input voltage. The output from IC4c goes to the latch formed by IC5a and IC5b via R15. A low on IC4-c output will set the latch such the LED1 is alight and LED2 is off.

IC4a, R11 and C4 form a slow speed oscillator which, via a buffer IC4b, drives the pulse generation circuits. On the rising edge of the output from IC4b, IC4d is driven by C6 and R14 to produce a low pulse of short duration. This pulse tries to reset the IC5a,b latch but will only succeed if IC4c output is high. This updates the latch every cycle of the slow clock.

On the falling edge of the slow clock a signal may be passed to IC4e via C5 and Sw1. Position 1 of the switch does not allow the pulse to pass and the circuit acts as a slow logic probe only. Position 2 of the switch allows the signal through but connects R16 into the circuit such that it forms a differentiator with C5 and makes the output from IC4e appear as short pulses. In position 3 the output of IC4b is coupled to IC4e via C5 virtually without change. This means that the pulses will be approximately 50% duty cycle.

The output from IC4e (consisting of a low logic level with or without positive-going pulses) passes to IC5c and IC5d. The other inputs to these gates are taken from the output of the input sense latch, IC5a and IC5b. If the output of IC4e goes high, then one or other of the outputs of IC5c or IC5d will go low. A low level on IC5c will turn Q1 on via R19 and pull the probe to a high level via R21. If IC5d goes low instead, IC4f output will go high and turn Q2 on via R20. This will pull the pulser probe to the negative supply via R22. D6 and D7 provide a small amount of protection for this part of the circuit while D8 provides overall polarity protection for the probe supply.



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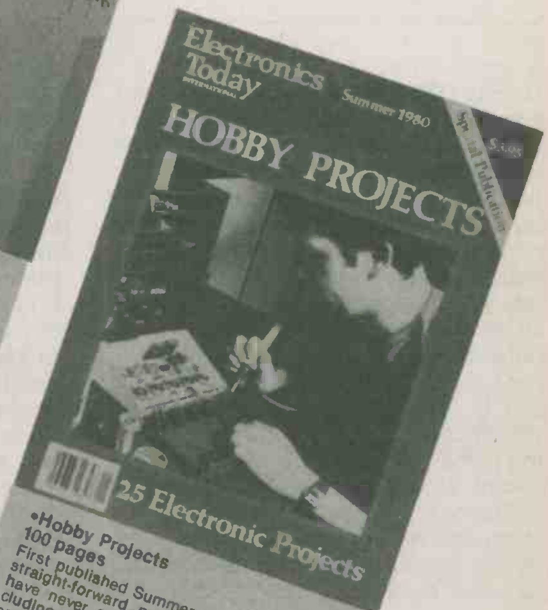

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Electronic Thermometer

Convert your meter to read temperature with this simple add-on unit.

USING THIS CIRCUIT you can convert any voltmeter capable of reading 0-1V to a 0-100 °C temperature probe. The device that makes this possible is National Semiconductor's LM335. This is a temperature-sensing integrated circuit housed in a T0-92 transistor type package which acts as a shunt regulator giving an output voltage of 10 mV per degree. The chip gives a 0V output, not at 0°C as you might expect but at absolute zero, minus 273 °C. This means that an output voltage of 2.73 V is obtained at freezing point. To get a 0 V output from the circuit at 0°C, all we need to do is compare the output of the chip with a reference voltage of 2.73 V, which we obtain from a second integrated circuit, the TL430C.

Construction

Begin by mounting resistors R1,2,3,4,5, integrated circuit IC1 and variable resistor RV1 into the printed circuit board (PCB), as shown in Fig. 2. As IC1 and IC2 look alike make sure you've picked up the right device, the TL430C. Check its orientation against the overlay diagram.

Now connect a voltmeter with its negative lead to 0 V and its positive lead to the junction of R4 and R5. With the unit connected to a 9 V battery, you should be able to adjust RV1 to obtain a reading of 2.73 V. Disconnect the meter and battery if all is well, and solder R6, RV2 and IC2 into the PCB, taking care with IC2's orientation.

Reapply power and connect the meter this time with its negative lead to the junction of R4 and R5, and its positive lead to the junction of R6, IC2 and RV2.

By adjusting RV2 you should obtain a reading corresponding to the ambient temperature. If the temperature is 25 °C adjust RV2 for a reading of 0.25 V.

Only one calibration is needed as this sets the chip accurate to within 1 °C over a range of -10 °C to -100 °C.

Now, mark and drill the case to fit the panel meter and on/off switch. Mount the PCB, battery, switch and meter into the case and wire up the project as shown in Fig. 2.

If you wish to make a temperature probe, you can mount IC2 remotely from the PCB. Choose a mounting to suit your application, taking care that the leads cannot be bridged or short-circuited if measuring water temperature, for example. In fact, it is a good idea to encapsulate the complete IC in epoxy resin or similar, if you intend to use the probe to measure water temperature.

And there you have it. With just two comparatively cheap chips and a handful of components, you have a complete linear temperature measurement system.

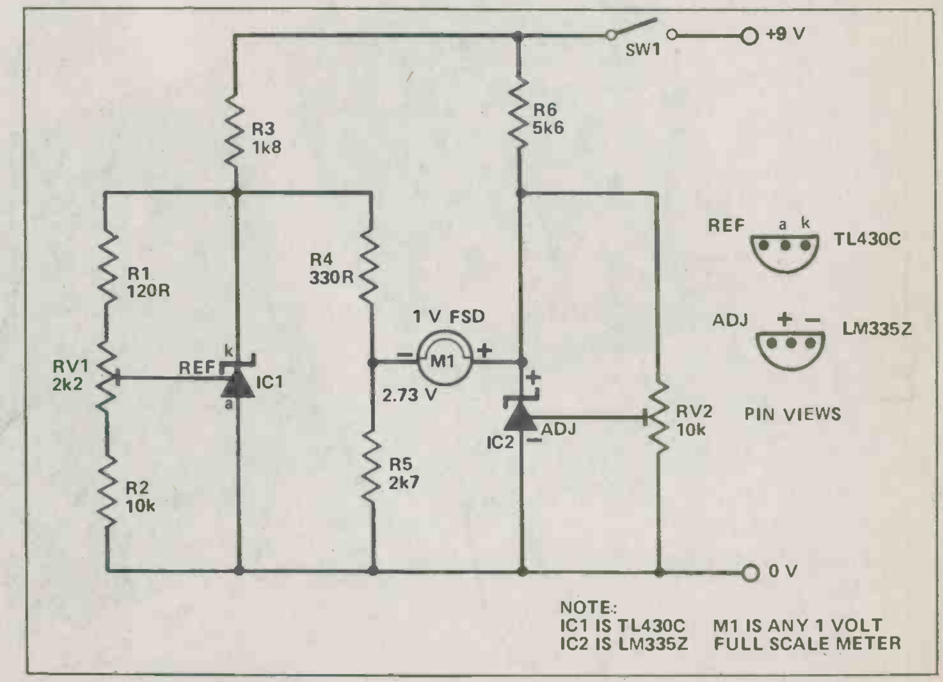


Fig. 1. Circuit of the ETI Thermometer.

Parts List

RESISTORS (All ¼ W, 5%)

R1	120R
R2	10k
R3	1k8
R4	330R
R5	2k7
R6	5k6

POTENTIOMETERS

RV1	2k2 miniature horizontal preset
RV2	10k miniature horizontal preset

SEMICONDUCTORS

IC1	TL430C adjustable zener
IC2	LM335Z temperature sensor

MISCELLANEOUS

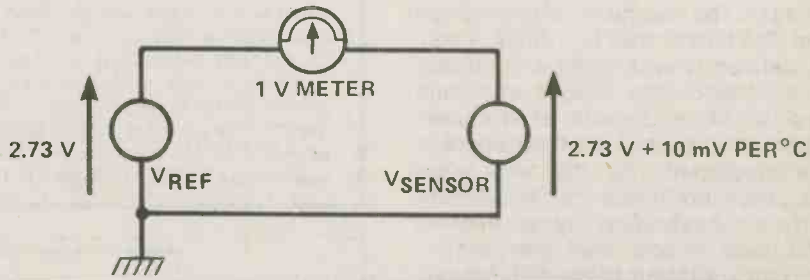
M1	any meter capable of indicating 0-1 V (for 0-100°C measurement range)

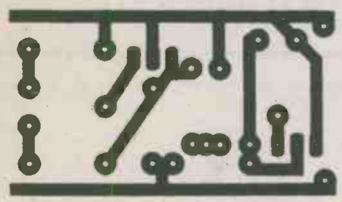
Case to suit.

How It Works

The heart of the circuit is the LM 335Z solid state temperature sensor. When a current of 400 uA to 5 mA is pássed through this device, a voltage of 10 mV per degree is developed across it. At 25°C (room temperature) a voltage of 2.98 V will be produced, not the 0.25 V (0.01 x 25) that you might expect. This is because the output is proportional to absolute temperature and 0°C is 273K so 25°C is (273 + 25 ÷ 100) V, ie, 2.98 V. So that the meter will read zero for 0°C, we generate a reference voltage of 2.73 V corresponding to 0°C, 273 K (the 'K' is for Kelvin — Lord Kelvin, a physicist).

The reference voltage is produced using a special integrated circuit, the TL430C. This chip is connected just like the LM335Z and has a terminal which monitors the output voltage via potential divider R1, RV1, R2. The TL430C will regulate the voltage at its output until a voltage of about 2.7V appears at its reference input. This occurs for an output voltage of about 3V. Unlike the LM335Z whose output will change with temperature, the TL430C is designed to be temperature independent and its output will drift by less than 50 parts per million, per degree Centigrade (ie, not more than 150 uV/°C). The required reference voltage of 2.73 V is obtained from the 3V output via potential divider R4, 5. This network is required because the reference voltage (and so the minimum output voltage) may range between 2.5V and 3V for different samples of the device. Preset RV1 accommodates this variation, enabling a 3 V output to be obtained from any sample. To obtain a temperature measurement, a 1V FSD meter is simply connected between the reference voltage from IC1 and the output of IC2.





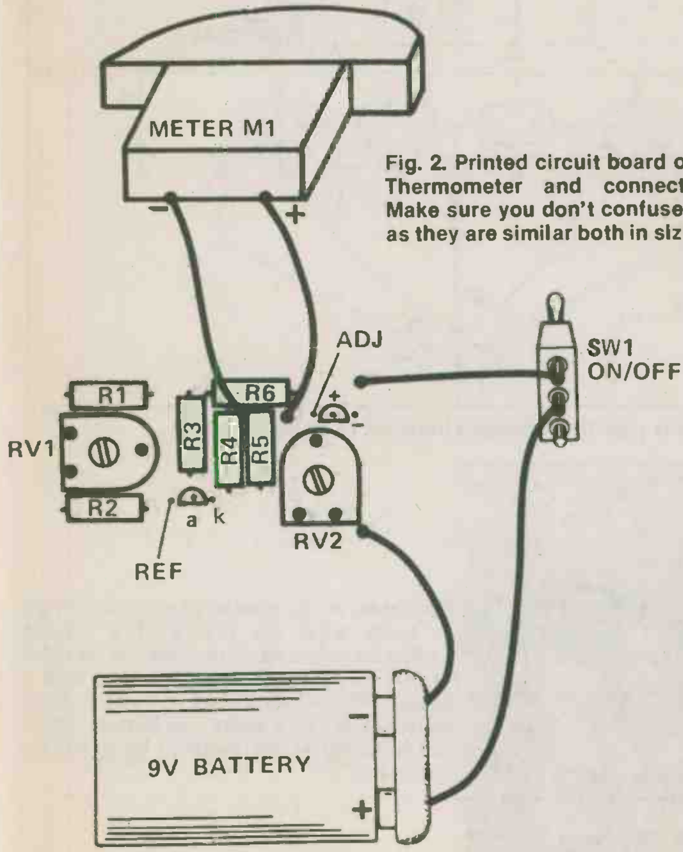


Fig. 2. Printed circuit board overlay of the Thermometer and connection details. Make sure you don't confuse IC1 with IC2 as they are similar both in size and shape.

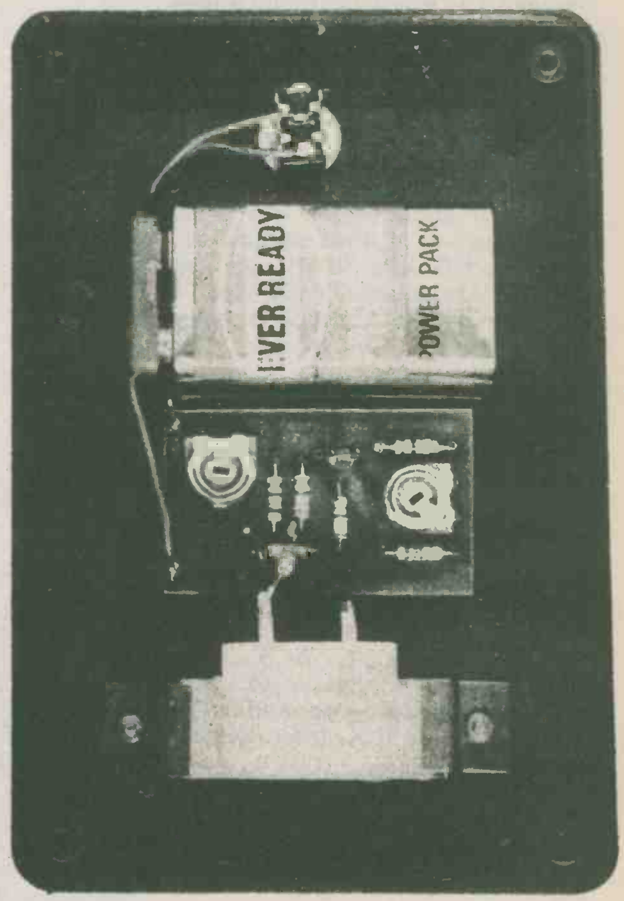
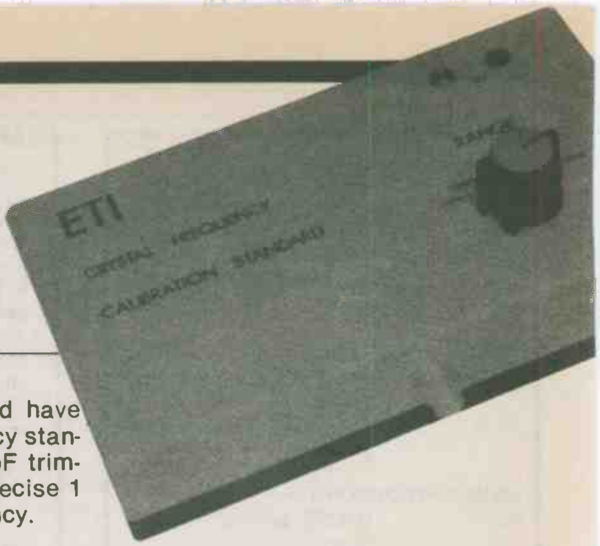


Fig.3. Internal view of the Thermometer. Keep all leads short and neat.

Crystal Marker



A simple but useful piece of test gear. Ideal for spot calibrating radio dials, 'scope timebases, etc.

THIS SIMPLE piece of test gear produces a square wave output with any one of six selected frequencies or periods. The outputs which range from 100 Hz (10 mS) to 1 MHz (1 uS), are derived from a crystal oscillator via decade divider stages and thus have a high degree of frequency/period precision. The instrument is thus specifically intended to be used as a precision frequency/period standard, for calibrating items such a radio dials, 'scope timebases, etc.

To calibrate a radio dial, loosely couple the output of the instrument to the radio antenna (i.e., dangle a bit of wire near to the aerial), switch to the 1 MHz range and then tune the radio through its ranges, marking off the dial points at which the 1 MHz signal and its harmonics (up to about 30 MHz) are heard as a heterodyned 'zero beat' audio signal. Then repeat the procedure at lower standard frequencies (100 kHz, 10 kHz, etc) until the dial is adequately calibrated.

To calibrate a 'scope timebase, simply connect the output of the calibration standard to the Y amplifier of the 'scope and then run through the timebase ranges, checking that the indicated periods agree with those of the calibrator.

Construction

This is a fairly simple project and construction should present few problems. Most components are mounted on a single PCB. Note here that five links are used on top of the PCB and that the crystal and the five ICs must all be mounted in suitable sockets.

When the PCB construction is complete, mount it in a suitable box and make the interconnections to SW1, SW2 SK1 LED1-R9 and B1. The unit is then ready for use.

The basic instrument has a typical accuracy of better than 0.01% with the C2 value shown. If you want better accuracy than this and have access to a precision frequency standard , replace C2 with a 100pF trimmer and adjust it to give a precise 1 MHz crystal oscillator frequency.

How It Works

The heart of the instrument is the crystal oscillator designed around Q2-Q3. Q3 is wired as a common base amplifier. Its collecter signal is buffered by emitter follower Q2 and then coupled back to Q3 emitter via the series-resonant 1 MHz crystal, thereby causing Q2-Q3 to oscillate at the crystal frequency. The oscillator output signal is then amplified by Q1 and converted to a clean square wave by Schmitt trigger IC1a.

The 1 MHz square wave from IC1a is used to clock a chain of cascaded decade dividers to generate standard frequencies of 100 kHz, 10 kHz and 100 Hz. All of these signals are made available at output socket SK1 via SW2 and are individually buffered by Schmitt inverters (IC1b to IC1f).

The instrument is powered from a single 9V battery. LED 1 illuminates while SW1 is closed.

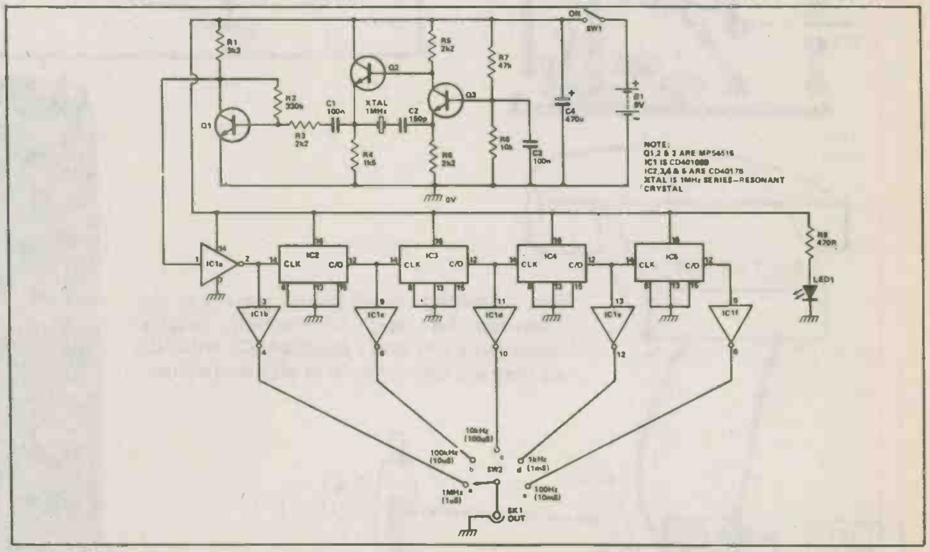
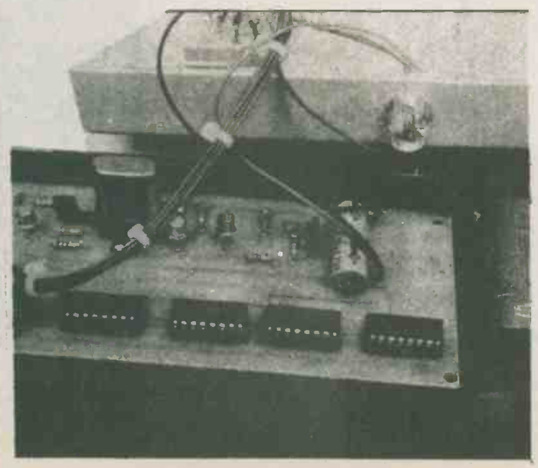
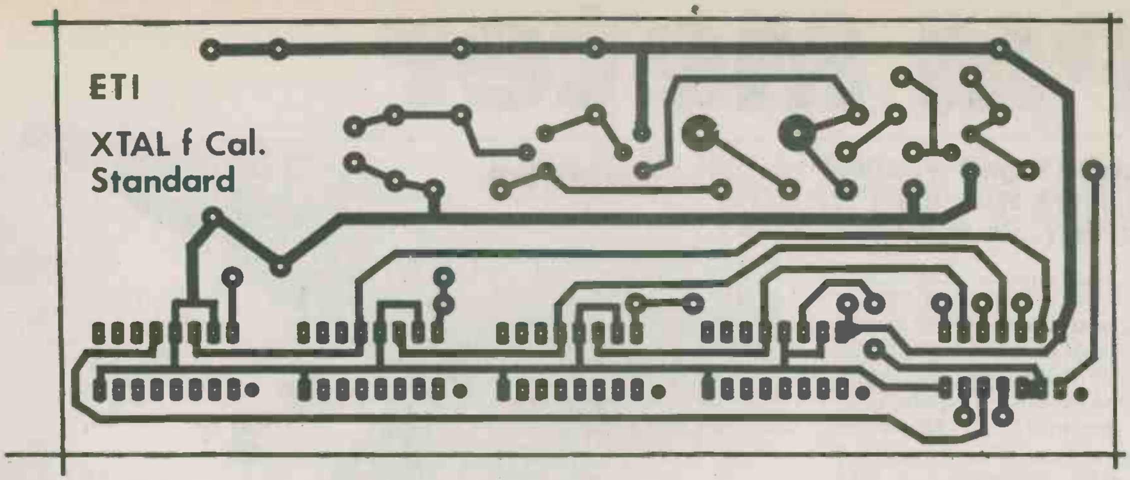


Fig. 1 Circuit diagram. R9 is mounted offboard between LED1 and SW1.



For those of you who have always wanted to know what the inside of a crystal calibrator looks like but were too bashful to ask, here it is. You could go mad with a power drill (or sharpened boy scout) drilling holes for PCB bolts and battery clips. We've found sticky pads to be perfectly adequate.



Crystal Calibrator

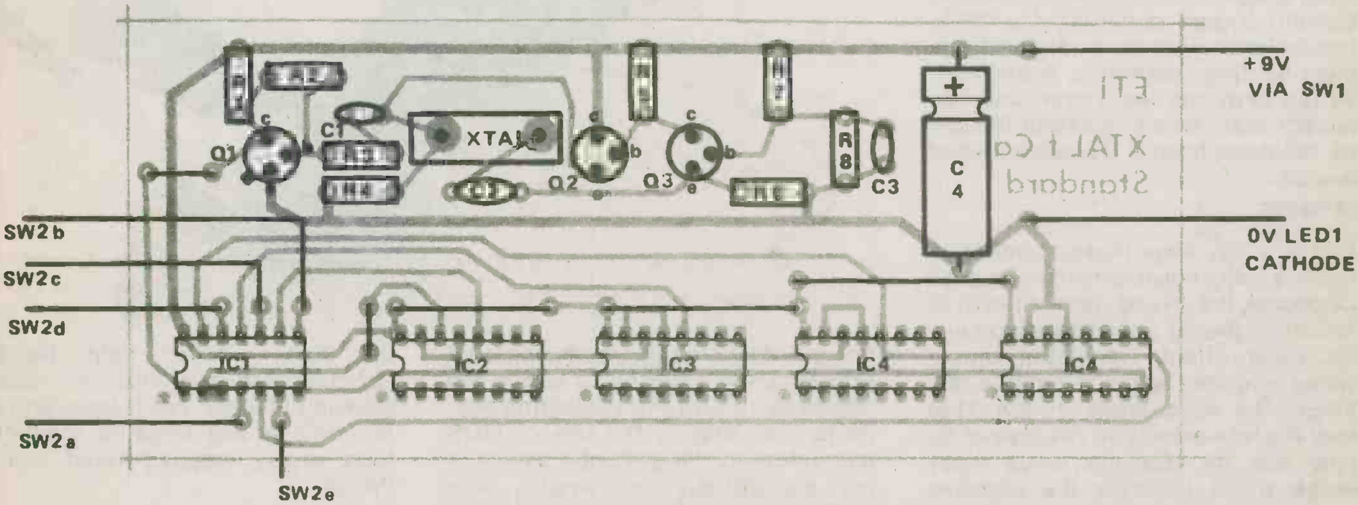


Fig. 2 Component overlay. The ICs are mounted in sockets. Construction of the board is fairly straightforward.

Parts List

Resistors all ¼W, 10%

R1	3k3
R2	330k
R3,5,6	2k2
R4	1k5
R7	47k
R8	10k

Capacitors

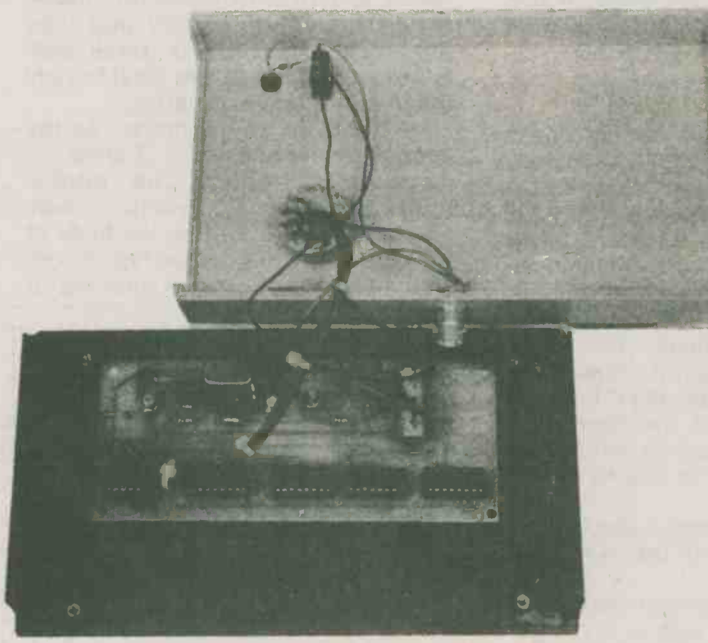
C1,3	100n ceramic
C2	150p polystyrene
C4	470u 25V electrolytic

Semiconductors

IC1	CD40106B
IC2,3,4,5	CD4017B
Q1,2,3	MPS6515
XTAL	1 MHz
LED1	TIL 220

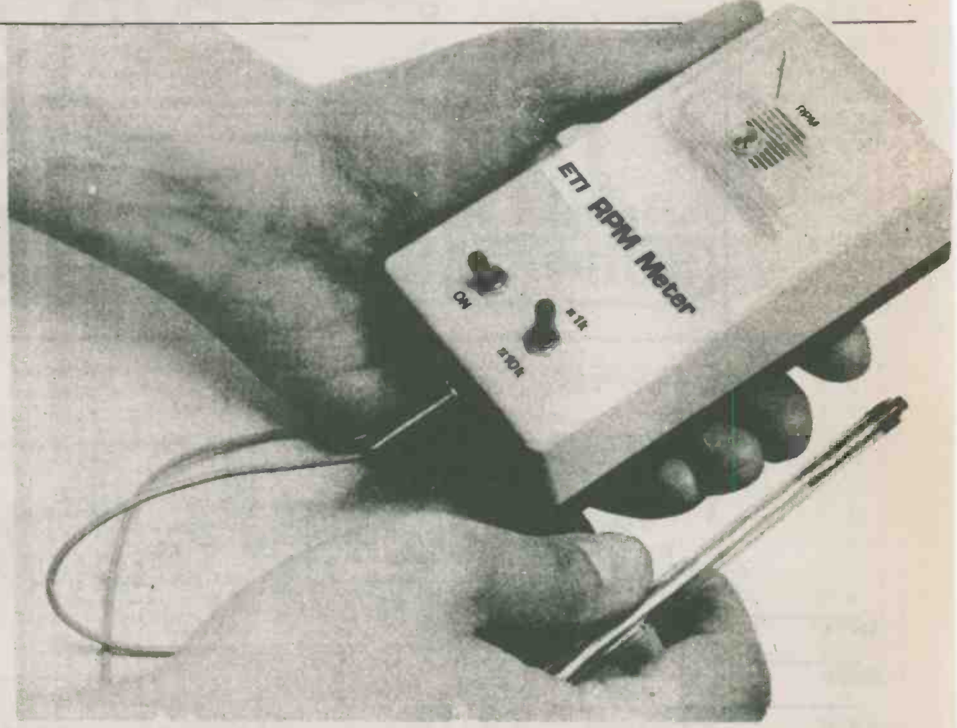
Miscellaneous

SW1	SPST miniature toggle
SW2	1 pole 5 way rotary switch
Case	
SK1	BNC (50R) Socket
knob to suit	



We can confidently predict that you won't have any trouble fitting the specified components into the case used!

RPM Meter



Can you count from 0—30,000 in one minute? With the ETI Electronic Rev Counter you can!

THIS LINEAR SCALE revs-per-minute counter lets you measure the speed of rotating objects from about 300 RPM to 30,000 RPM. Use of a light-sensitive probe means no mechanical linkage is required and faster or slower speeds could be measured with only simple modifications. The input stage features a self-adjusting Schmitt trigger circuit that enables the probe to work in a range of ambient lighting conditions. A single 9V battery provides the power, and low current drain means a useful life will be obtained from a 9V battery-sized source.

01 34555

Can you rearrange those numbers to make a well-known phrase or saying? Of course, it's an anagram of the 3140 MOSFET (Metal Oxide Semiconductor Field Effect Transistor) operational amplifier and the familiar 555 timer. The advantages of the 3140 over the less-expensive 741-type of op amp are: its common mode input range which includes the negative supply rail, faster output slew rate and very high input impedance — millions of megohms. All these characteristics are exploited in this design, so don't use a 741 — it won't work.

Construction

Build up the printed circuit board (PCB) first. Insert and solder resistors followed by capacitors. Capacitor C5 is polarised, so make sure you get it the right way round. Figure 2 gives details of component locations.

Next, insert and solder PCB pins at the nine points where off-board connections are made. This may seem unnecessary but it means that you can make (and remake if needed) all connections after the board has been fitted into the box so that all wiring is neat, and not in a 'bird's-nest' state.

Now solder in zener diode ZD1, making sure that it is the right way round.

Use integrated circuit sockets to hold the two ICs. As well as making it easier to substitute and test ICs, the sockets enable you to whip out the chips if they are required for another project without having to attack the finished unit with a hot soldering iron. (Note that despite the use of MOS transistors in the 3140, the device is not susceptible to damage from static electricity and no special handling precautions are required.)

Mark and drill the case for the meter and two switches. Fit these, the PCB and the battery into their final positions. Two or three self-adhesive foam pads are ideal to hold the circuit board and battery.

Now, wire up the project as the connection details in Fig. 2 show.

Finally, mount the phototransistor in an old felt-tip or ballpoint pen, after covering the body of the sensor transistor (see Fig. 3) with a short length of opaque sleeving to cut down ambient light. Readily-obtainable heat-shrink, or rubber, sleeving is ideal, but if you can't obtain this a few turns of insulating tape, neatly wrapped round, will do the job.

Calibration And Use

Calibration is very simple. All you need to do is switch to the 0—3,600 RPM range and point the sensor at an electric light bulb. The light from the lamp will be modulated at the 60 Hz line frequency corresponding to a 3,600 RPM signal (60x60). Wait a moment for the auto-Schmitt input stage to adjust itself; you may have to point the sensor away from the lamp slightly, until the meter gives an indication. Then adjust RV1 for a reading of 3,600

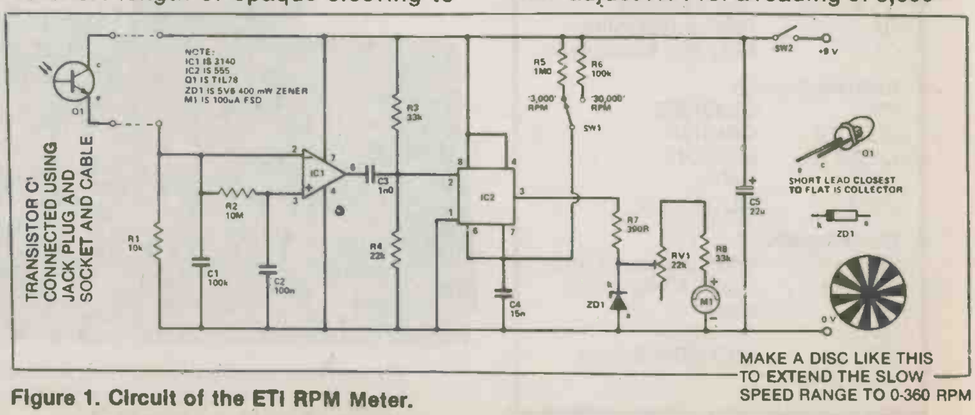
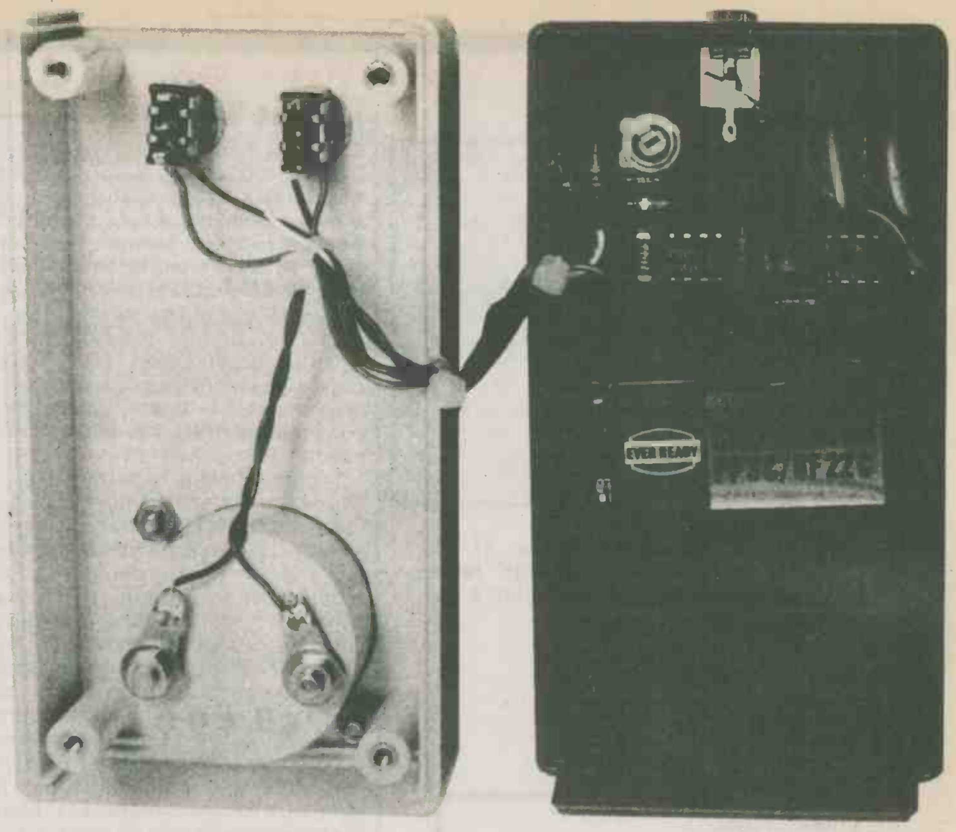


Figure 1. Circuit of the ETI RPM Meter.

RPM, full-scale on the meter. In fact, because the lamp brightens for each half-cycle of the mains, its output frequency is 120 Hz. However, on the 3,600 RPM range, the unit is unable to respond to a 120 Hz input and indicates 3,600 RPM. By switching to the 36,000 RPM range, you should obtain a true reading of 7,200 RPM. For this reason you should always commence your measurements with the unit switched to the 36,000 RPM range.

In use, the object to be measured is arranged so that the sensor sees an increase in reflected light once per revolution. For example, you can measure the speed of an electric motor by slipping a short length of black sleeving over its shaft. Paint one side of the sleeving with white paint so that the sensor sees white and black sections alternately as the shaft revolves. Although the input stage will compensate automatically for various lighting conditions it may sometimes be helpful to illuminate the shaft with the light from a small flashlight. One of those with a lens-end pre-focus bulb is ideal.

To obtain a 0-360,000 RPM range, use a 10k resistor for R5. To measure slower revolutions, simply arrange for more black/white transitions per revolution using striped paper wrapped around the shaft or a radially patterned disc mounted on a rotating wheel. Ten black/white stripes per revolution give a 0-360 RPM range and so on. There are many techniques for measuring the speed of rotating objects. This unit is cheap and simple to build and calibrate providing an excellent introduction to electronic measurement systems. Build one for your lab or workshop or just for fun—amaze your friends with a 'revolution' in electronics!



Internal view of the ETI RPM Meter.

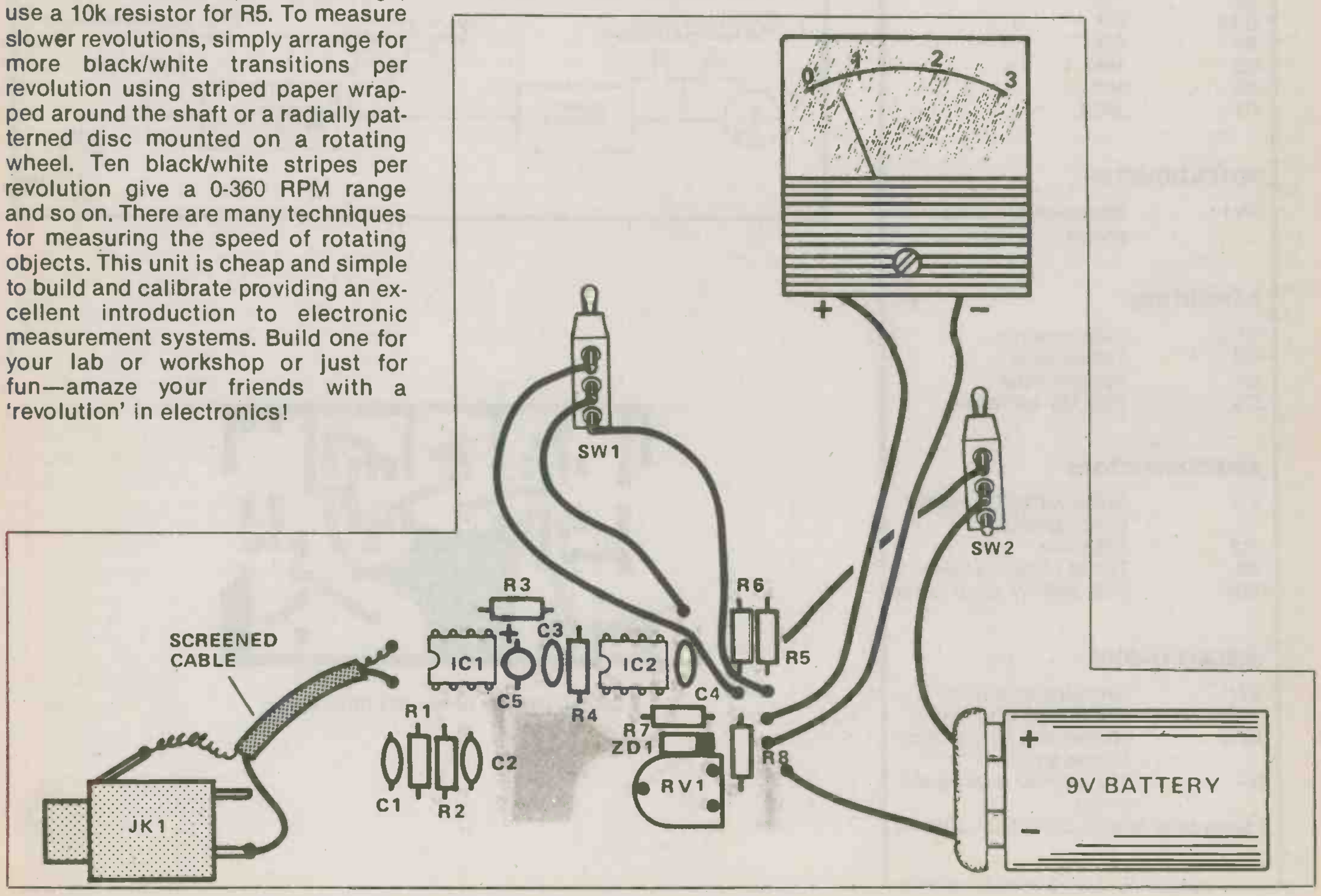


Figure 2. Printed circuit board overlay along with connection details of the project.

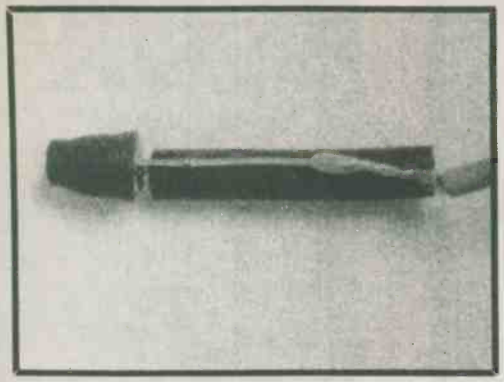


Figure 3. Close-up details of the phototransistor, insulated with rubber sleeving, prior to insertion into a pen body.

How It Works

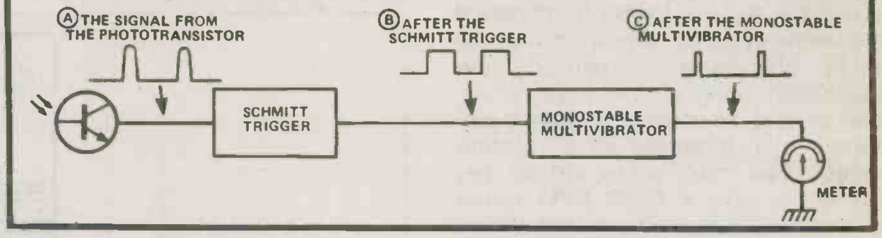
The input signal is 'squared up' by the Schmitt trigger whose output drives a monostable multivibrator; i.e. each time the monostable is triggered by the Schmitt trigger it produces an output pulse whose period is determined by the associated resistor. A simple changeover switch selects the appropriate timing resistor for the selected measurement range. The output from the monostable is used to drive a meter — the closer the pulses (ie, a greater RPM), the more the meter needle moves.

Light falling on transistor Q1 causes a current to flow through it (because it is a photo-transistor) and a voltage is developed across resistor R1. If the light is modulated i.e. goes brighter and dimmer, the voltage across R1 will rise and fall in sympathy. Capacitor C1 removes any noise spikes which may have been picked up by the connecting leads and the resultant signal goes to the inverting input of IC1. This is an op amp used as a comparator; comparing the voltage at the inverting input. We obtain the reference voltage by low-pass filtering the input voltage with R2 and C2. An input signal producing a voltage across R1 which ranges from 1V to 4V will result in a reference voltage of about 2.5 V, the average of the peak and trough values. The exact reference voltage will also be a function of the input's mark-to-space ratio which should ideally be 50% (i.e. equal light and dark areas on the rotating surface).

The output of IC1 consists of a squarewave at the same frequency as the input signal. This output signal triggers the 555 timer on each falling edge. A differentiating circuit C3, R3 and R4 is used to produce a short trigger pulse. The 555's monostable output pulse is a function of range setting resistors R5 and 6.

To make the unit less sensitive to falling battery voltage the output of IC2 is clipped by ZD1, a 5V6 zener diode, and the meter is driven from this voltage through a current-limiting series resistance comprising RV1 and R8.

Current pulses from IC2 are averaged in the meter, the deflection of which indicates the input frequency scaled in RPM. To allow for variations in component tolerances, full-scale deflection is obtained from an 80% duty cycle. The supply is smoothed by C5 which should be mounted close to IC2.



Parts List

RESISTORS

R1	10k
R2	10M
R3,8	33k
R4	22k
R5	1M0
R6	10k
R7	390R

POTENTIOMETER

RV1	22k miniature horizontal preset

CAPACITORS

C1,2	100n ceramic
C3	1n0 ceramic
C4	15n polyester
C5	22u, 16V tantalum

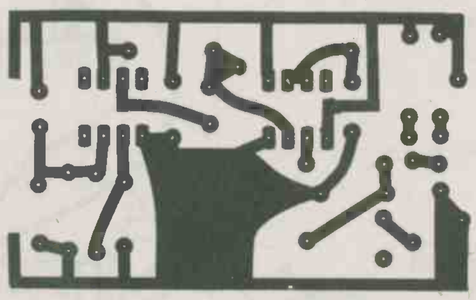
SEMICONDUCTORS

IC1	3140E MOSFET operational amplifier
IC2	555 timer
Q1	TIP 78 photo-transistor
ZD1	5V6, 400mW zener diode

MISCELLANEOUS

SW1	single-pole, double-throw toggle switch
SW2	single-pole, single-throw toggle switch
M1	100 uA FSD moving-coil meter

3.5mm jack plug X socket (or similar)
Case to suit.



PCB foil pattern of the ETI RPM Meter.

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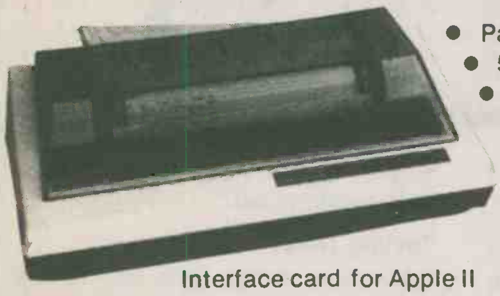

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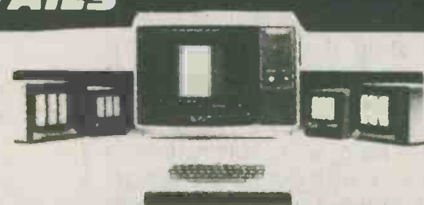

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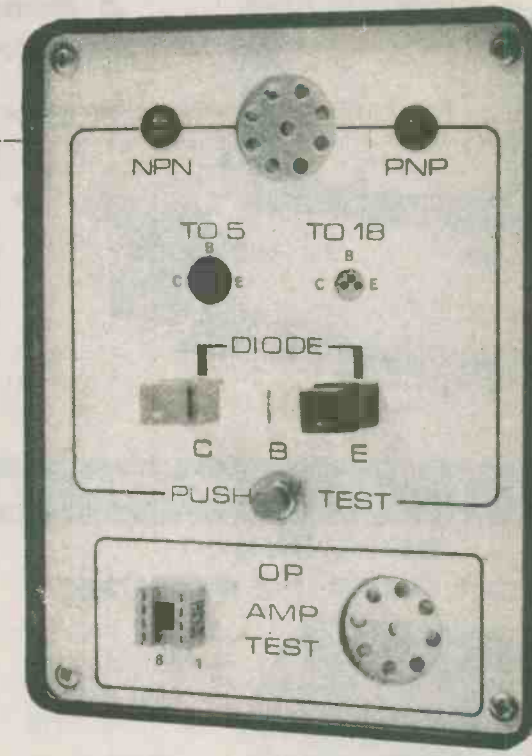
Semiconductor Tester



Check out your semiconductors with this cunning but simple project. It's brilliant, even if we do say so ourselves (and we do). Design by Rory Holmes. Development by Tony Alston.

WHEN YOU'VE completed your latest design, a brilliant project which not only solves the world energy crisis but proves that Einstein made a small mathematical error as well, it can be very frustrating if you rush to your junk box and discover that you can't breadboard the circuit because the markings have rubbed off your transistors. To help with this problem we've come up with our latest design, a brilliant project which tells you which lead is which, whether the transistor is OK, what polarity it is and its approximate gain. Diodes and LEDs may also be tested, and for good measure we've thrown in an op-amp checker. The world energy crisis you'll have to figure out for yourself.

Construction

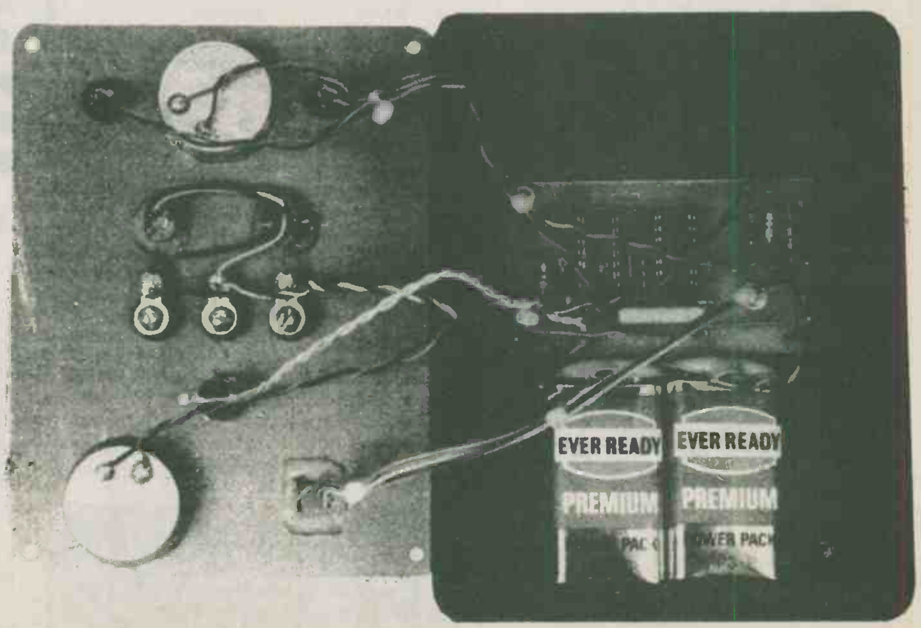
Assembly is straightforward if the recommended PCB is used. Make sure to orientate IC1, IC2, D1 and D2 correctly and use sockets for the ICs to avoid damage by soldering them. Remember to put the three wire links on the PCB!

Although there are quite a few off-board connecting wires, these should not be a problem if the circuit diagram, overlay and internal photos are studied carefully. Only one transistor test socket is shown on the circuit diagram but several types can be wired in parallel (as we did) to accommodate various types of transistors. The T0-5 and T0-18 types were epoxled to the front panel, as was the eight-pin DIP socket for the op-amp tester. Three insulated test terminals were also included for testing other types of transistors, diodes and LEDs.

TX1 and TX2 are crystal mike inserts. Warning; most inserts have one terminal connected to their case and as we've used a metal front panel for this project, TX2 should be insulated from this panel. Otherwise, TX1 and TX2 will be common linked and as the circuit diagram shows that TX1 is connected to 0V, TX2's connection to IC1, IC2 and C2 will be incorrectly taken to 0V. We got round the problem when we glued a circular fibre washer to one insert before fixing it to the front panel.

Testing Times

Transistors are plugged into the appropriate socket, and any type may be tested; NPN, PNP, small signal or power. No selection of NPN or PNP is necessary as this is done automatically by the tester. When the



push-to-test button is pressed, an intermittent tone is produced. The frequency of the tone is proportional to the gain of the transistor, giving a rough guide. The LEDs also flash alternately in time with the pulsing tone; the LED that is on at the same time as the tone indicates the polarity of the transistor. If the transistor has no gain or is open circuit there will be no tone, although the LEDs will still flash. If the transistor has a large leakage current or is shorted, there will be a 'two-tone' sound. If the transistor has been inserted the wrong way there will be either no tone or a very high-pitched tone.

Diodes and LEDs may be tested across the 'C' and 'E' terminals. If it is OK, the LED under test will flash, accompanied by an intermittent high-pitched tone and flashing indicators. Ordinary diodes require a series resistor (any old value) and should then produce an intermittent tone and flashing LEDs as before; the coincidence of flashing LED and tone indicates the anode.

Op-amps are plugged into the IC socket and no push-switch is required; power is only applied when the IC is inserted, and a good IC produces a continuous tone from the second insert

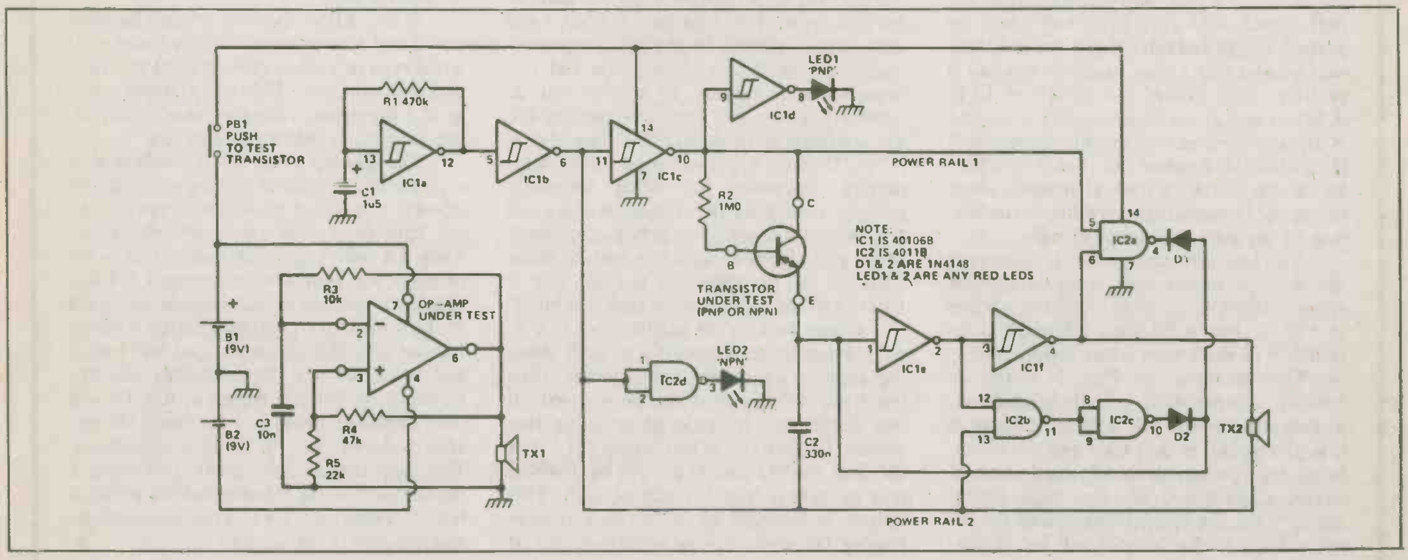


Fig. 1 Circuit diagram of the Component Tester.

Parts List

Resistors (all ¼W, 5%)

R1	470k
R2	1M0
R3	10k
R4	47k
R5	22k

Capacitors

C1	1u5 25V tantalum
C2	10n disc ceramic
C3	330n polyester

Semiconductors

IC1	40106B
IC2	4011B
D1,2	1N4148
LED1	0.2" red LED
LED2	0.2" green LED

Miscellaneous

PB1	momentary push-button
TX1,2	crystal mike inserts

2 9V batteries and clips; transistor sockets; IC sockets; case to suit.

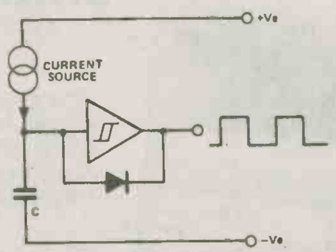
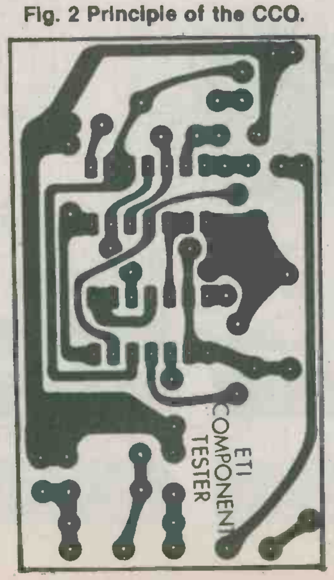


Fig. 2 Principle of the CCO.



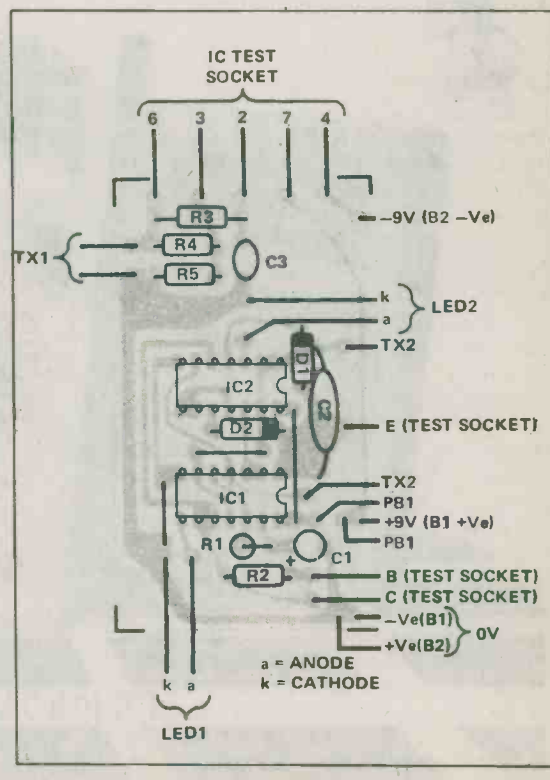


Fig. 3 Component overlay.

How It Works

The op-amp tester and transistor tester are completely separate circuits; we shall deal with the transistor tester first. IC1a, a Schmitt trigger inverter, forms a low frequency square wave oscillator with a period (determined by R1 and C1) of about 1 second. This square wave is used to switch the polarity of the 'power rails' (labelled 1 and 2 in the diagram) of the test transistor and its associated oscillator circuitry.

IC1b is used to buffer the square wave, and its output (on pin 6) is used to drive 'power rail 2'. This switching signal from IC1b is also fed to the input of IC1c, which inverts it and drives 'power rail 1'. Thus for half a second in each cycle rail 1 will be positive (high) and rail 2 (low); for the other half second rail 1 goes negative and rail 2 positive. Each power rail drives an LED (LEDs 1 and 2) via inverter gates IC1d and IC2d, such that an LED will be illuminated if its associated power rail is at 0 V. These LEDs will therefore flash alternately when the circuit is operating, providing an indication of the state of the power rails.

The oscillator circuit that is connected across these power rails is essentially the simple current-controlled oscillator shown in Fig. 2, but with some adaptations to enable it to work with either supply polarity. The oscillator of Fig. 2 works as follows. Assume C is initially discharged, so that the input to the Schmitt inverter is low; the output is thus high and the diode, being reverse biased, is effectively out of circuit. Capacitor C will now begin charging up from the current source and the input voltage to the Schmitt will be increasing. When the input passes the Schmitt threshold the inverter output will switch low; the diode is now forward biased and will rapidly discharge the capacitor. The process then repeats, producing a square wave output from the inverter with a frequency that is proportional to C and the current from the souce. The bigger the current from the source, the faster C will charge and the higher the frequency will be.

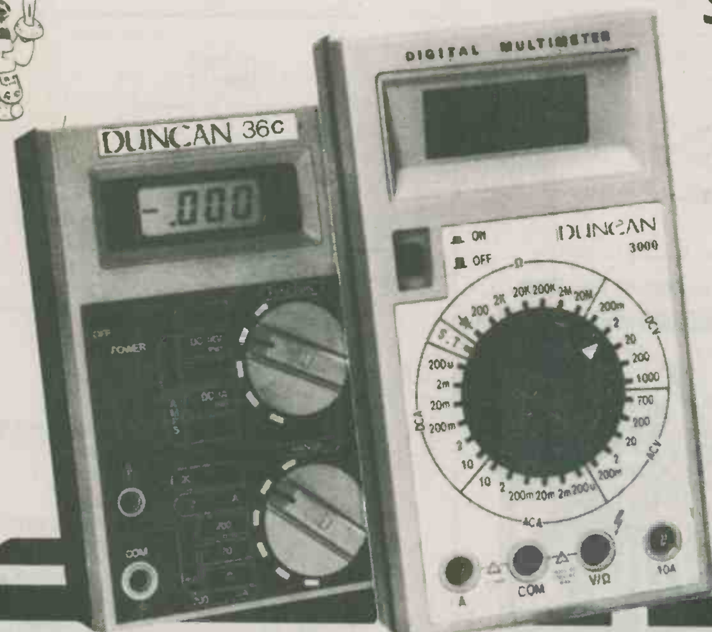
The current source in our actual circuit is provided by the transistor under test, R2 supplies a small base current to the transistor, and the current flowing from the emitter will be proportional to the gain of the transistor. If the transistor is PNP it will only supply current to the CCO (current-controlled oscillator) when power rail 1 is negative with respect to power rail 2. Similarly, power rail 1 must be positive for the oscillator to function if the transistor is NPN. Thus the CCO will produce an intermittent frequency for either transistor polarity (assuming the transistor is a good one) with a frequency roughly proportional to the gain. If the frequency is audible when LED1 is on, the transistor is PNP, and if LED2 and the tone coincide then it is NPN.

Going back to the oscillator of Fig. 2, we see that if the oscillator is to work when the supply connections are reversed, then the diode polarity must also be reversed. In our circuit this is achieved by using two diodes, D1 and D2. When power rail 1 is at 0V, and NAND gate IC2b will be disabled and its output (pin 11) will be high. This output is inverted by IC2c, thus reverse biasing D2 which is now effectively out of circuit. At the same time power rail 2 will be high, enabling NAND gate IC2a whose output (pin 4) will follow the logic level on the output of the Schmitt trigger IC1e via IC1f. Thus when IC1e goes low during an oscillation cycle, the cathode of D1 will also go low, forward biasing the diode and discharging C2 for the next cycle.

When the voltage on the two power rails is reversed a similar action occurs, but with D1 switched out of circuit and D2 providing the discharge path. The intermittent square wave produced at the output of IC1f is fed to crystal transducer TX2 which gives an audible note.

If an LED or diode is connect between the C and E terminals of the test scoket, it appears to be a large-value current source in one direction only. Hence the circuit reacts as if a high-gain transistor were in circuit, and polarity is indicated as before.

The op-amp under test is configured as a simple RC relaxation oscillator. When the op-amp is plugged in, assume that its output (pin 6) is high (positive saturation). Then C3 will begin charging up to +9V through R3 with a time constant C3.R3. When the voltage on C3 reaches one-third of the positive supply (this fraction is set by R4 and R5), the op-amp output will switch low, with R4 and R5 providing positive feedback for Schmitt trigger action. C3 will then discharge towards —9V, until the op-amp switches back to positive saturation. This cycle repeats indefinitely, producing a square wave at the op-amp output which is fed to transducer TX1. This produces an audible note if the op-amp is good. ●



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Universal Timer

Our two-range (1-10 and 10-100 min) timer has excellent stability and produces a 30 second pulsed alarm sound at the end of each timing period. The unit is line powered, can switch 15 A loads and can give either make or break timing operation. Designed by Ray Marston. Project development by Steve Ramsahadeo.

MOST analogue (pot controlled) long-period timers published in electronics magazines use a 555 one-shot IC and a large electrolytic capacitor as their main timing elements. Unfortunately, conventional electrolytic capacitors have very wide tolerances (typically –50% to +100%) and suffer from relatively large and unpredictable leakage currents. Consequently, these simple circuits cannot be relied upon to give accurate or repeatable timing periods or to give periods significantly exceeding 15 minutes or so.

Our ETI Universal Timer gets away from the conventional design approach, with its inherent disadvantages, by using an astable clock generator and a divide-by-8192 CMOS counter as its main timing elements, the astable period being controlled by a pot and a highly stable polyester capacitor. Consequently, our timer has excellent accuracy and stability and can fully span the 1 min to 100 mins timing range in two switch-selected decade ranges.

Our timer has a few other unusual features. It is line powered and has a relay-switched power output socket that can be used to feed juice to external loads (heaters, lamps, etc.); the relay can switch currents of up to 15A and a mode switch enables the timer to give either make or break timing operations of the external loads.

Timing operations are initiated by a push-button start switch and a pulsed-tone alarm sounds for 30 seconds to give an audible warning on the completion of each timing cycle. The unit has a variety of practical uses in the home, workshop, darkroom, etc.

Construction

Most of the circuitry (with the exception of T1, the relay, the switches and pot) is mounted on a single PCB, the construction of which should present few problems. Note that IC1-3 (CMOS types), should be mounted in suitable sockets and voltage regulator IC4 needs to be fitted with a small heat-sink.

When construction is complete, fit the PCB in a suitable case, together with the power transformer and the heavy-duty relay (which MUST be fitted in the specified socket) and proceed with the interwiring. Take special care over the interwiring of the relay contacts and SW2 and the 120V connections. Finally, drill a small hole (roughly 4 mm) in the tip of the case, bond the acoustic transducer below it and connect it to the rest of the circuitry.

Testing

When the unit is complete, give it a functional test as follows. First, plug the unit in and check that its neon indicator illuminates when SW2 is set to TIMED BREAK position and turns off when SW2 is set to TIMED MAKE. Now set RV1 to its minimum position, set SW1 to the '1-10 min' range and firmly operate PB1. Check that the neon immediately changes state, indicating that the relay has turned on and the timing period has begun; also check that the relay turns off again at the end of the timing period (roughly one minute) and that the acoustic alarm operates and generates a pulsed-tone signal for roughly 30 seconds when the timing period is complete.

Calibration

Once the unit is functioning correctly, you can proceed with the scale calibration. The obvious (and very time consuming) way to do this is to check the timing periods obtained by varying RV1 against a stop watch, by trial and error, until suitable RV1 calibration points are found.

Alternatively

If you have access to a reasonably accurate scope, a far easier way to calibrate the timing scale is to directly measure the period of the IC1 clock

Parts List

Resistors all ¼ W 5%	
R1	2k2
R2,10	39k
R3,9	1M0
R4	6k8
R5	4k7
R6	470R
R7	27k
R8	2M2
R11	47k
Potentiometer	
RV1	470k Linear
Capacitors	
C1,3,9	100n polycarbonate
C2	1u0 polycarbonate
C4	47u 25 V axial electrolytic
C5	10u 63 V electrolytic PCB type
C6	220n polycarbonate
C7	10n polycarbonate
C8	1000u 25 V axial electrolytic
Semiconductors	
IC1	ICM7555
IC2	CD4020B
IC3	CD4011B
IC4	78M12 or 7812
Q1	2N5087
BR1	50 V, 1 A bridge rectifier
D1	1N4148
D2,3	1N4001
Miscellaneous	
SW1	1 pole rotary switch
SW2	DPDT toggle 15 A
PB1	momentary push button
Tx1	transducer such as Radio Shack 273-065
RLA	12 V coil resistance > 100R, 3 pole changeover, contacts rated at 120 V, 20 A and 11 pin relay base 25 A rated
T1	12 V, 6 VA

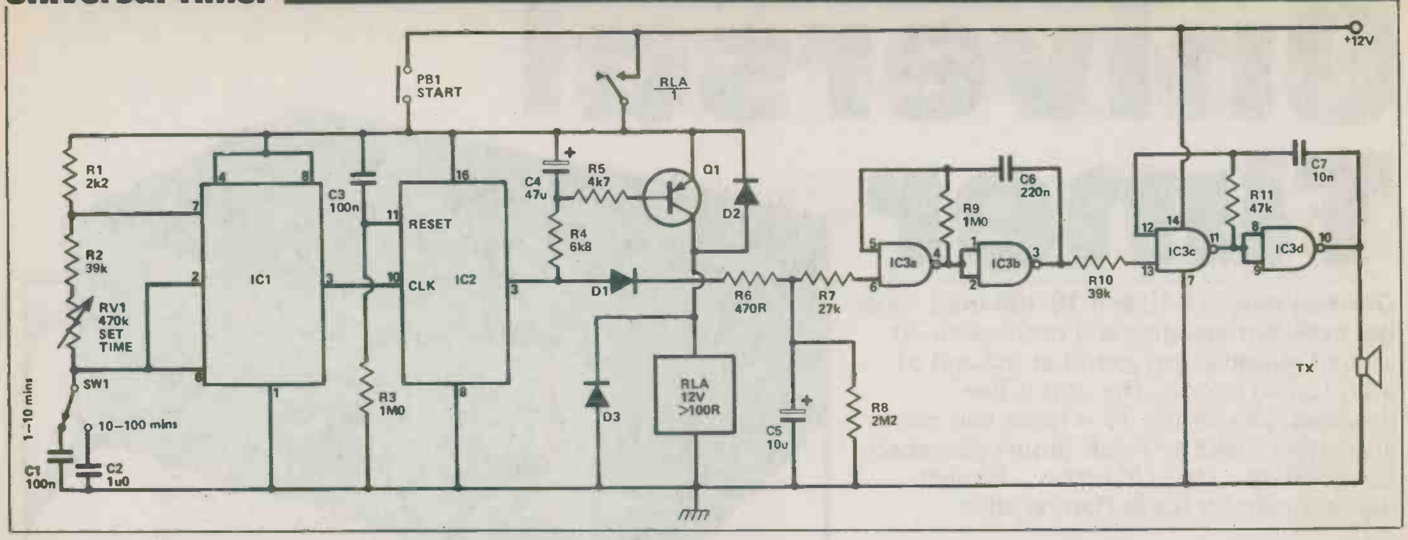


Fig. 1. Circuit diagram

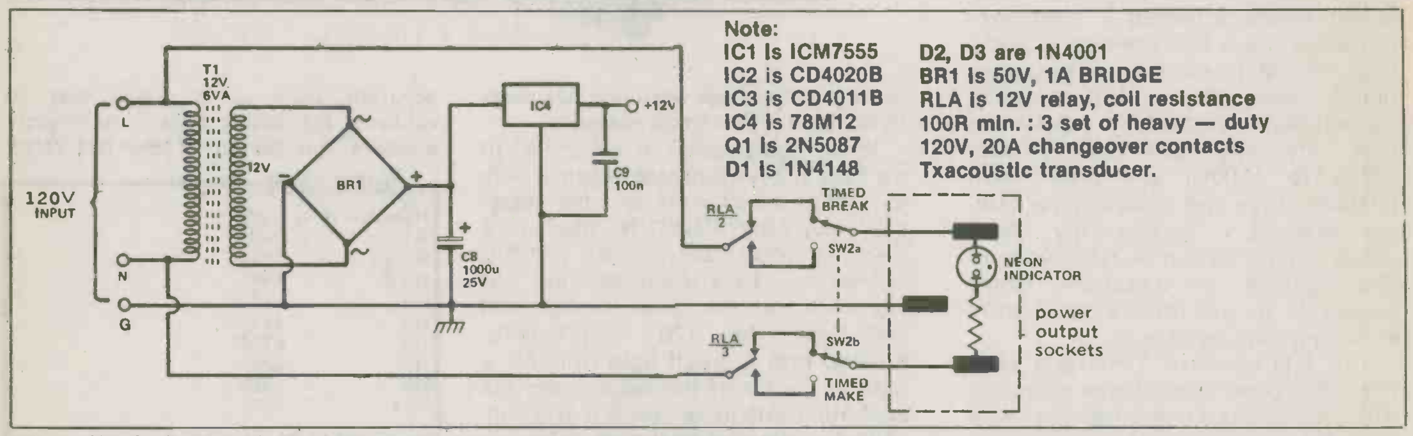
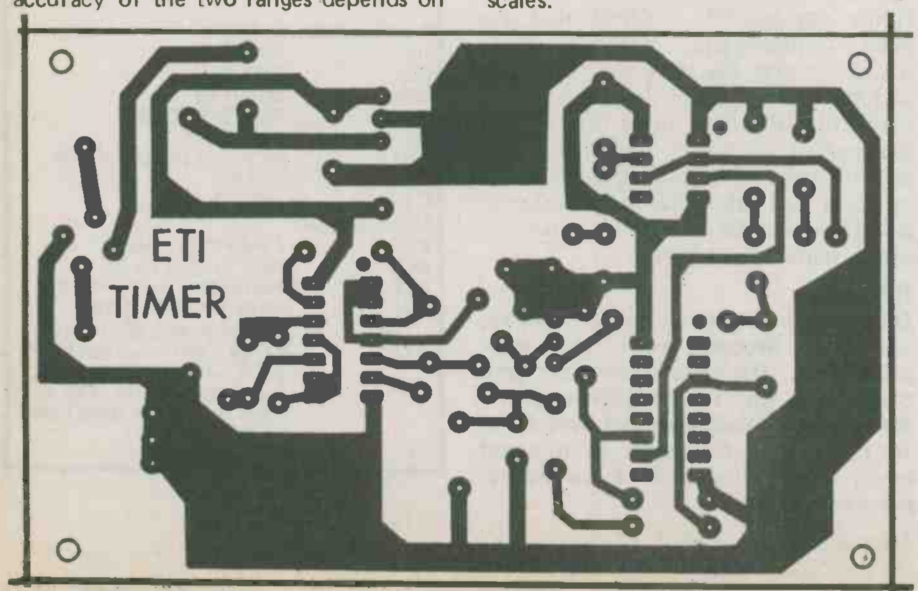


Fig. 2. Circuit diagram of the power supply, incorporating the switched relay output.

waveform, noting that a period of 7.32 mS corresponds to a timing period of precisely one minute. Thus, 1 min = 7.32 mS 5 mins = 36.6 mS, 10 mins = 73.2 mS, etc.

The upper timing range of SW1 is approximately a decade up on the lower range, so a single calibration scale can serve for both ranges. The tracking accuracy of the two ranges depends on the relative accuracies of C1 and C2 and will typically be within 10% if good polyester components are used. If you want precise tracking you can achieve it by replacing C2 with a 820nF polyester capacitor and then padding its value up by trial and error, until precise coincidence of the '5 min' and '50 min' points is obtained on the two range scales.



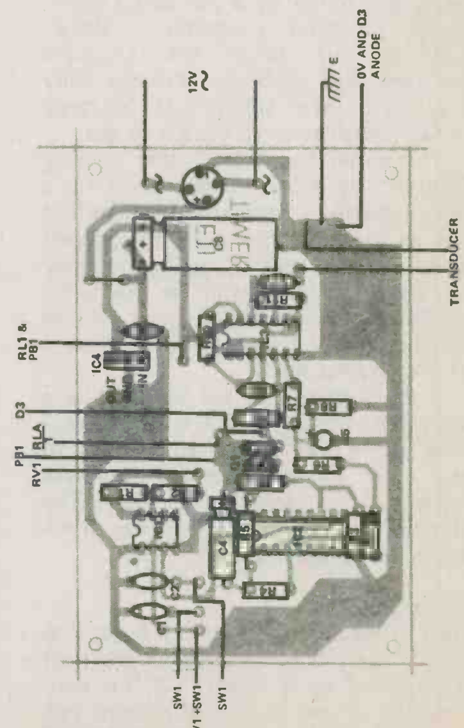
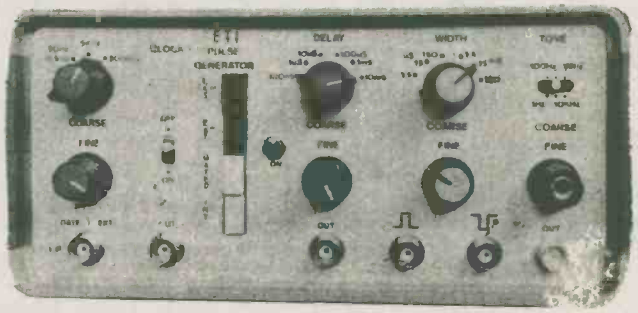


Fig. 3. Component overlay

Continued on page 26

Pulse Generator

A versatile piece of test gear that can be used as a single or dual pulse generator, a delayed-pulse generator, or a direct or delayed tone-burst generator.



PULSE GENERATORS HAVE a variety of applications in the modern electronics workshop/laboratory. In its simplest form, a pulse generator can be used for testing the performance characteristics of a common digital circuit or for testing the transient responses of AF or RF amplifiers. In a more advanced form, as a delayed-pulse/toneburst generator, the instrument can be used for simulating or implementing sophisticated systems such as ultrasonic movement detectors, range-finders, or RADAR systems.

The ETI pulse generator is the most versatile instrument that you could possibly wish for. It has two built-in pulse generators (a delay and a width generator), which can be effectively clocked in parallel or series. When parallel clocking is used, the unit simultaneously generates two independently controlled pulses from each clock pulse. When series clocking is used, the unit generates an output pulse that is delayed from the clock pulse by a period set by the delay generator. The pulse width and delay times are both fully variable over the range 100 nS to 150 mS.

The two pulse generators can be clocked from either internal or external signals. The internal clock generator spans the full range of 0.5 Hz to 500 kHz and can be used directly or can be gated by external signals. The clock signal is made available externally via an output socket.

The delay pulse of the unit is made externally available via a single output socket, while the main width pulse is available in direct and inverted form via a pair of sockets. The main pulse can also be used to trigger and gate an internally generated tone burst signal, which is available via another socket. The tone burst signal is fully synchronised to both the clock signal and the leading edge of the main pulse and is fully variable over the 1 Hz to 1 MHz range.

All outputs of the unit are buffered and short-circuit proof. The outputs are driven by TTL and are fixed-amplitude with typical rise and fall times of about 20 nS. The complete unit consumes a mean current of about 40 mA and can be powered from either a 6 V battery pack or from a line-derived 5 V regulated supply.

Construction

First, wire up the PCB as shown on the overlay, noting the use of a large number of Veropins for making external connections. Take the usual precautions over the polarity of semiconductors and electrolytics. Note that two connecting links are used on the top of the PCB and that, on the underside of the board, insulated wire links are made from pin 1 of IC3 to pins 1-2 of IC5 and from pin 6 of IC3 to pins 9-10 of IC5.

When construction of the PCB is complete, fit it into a suitable case, make the interconnections to all switches/pots/sockets, connect the circuit to a suitable power supply, and test/debug the circuit as follows.

Testing

Turn SW2 to the INT CLK position, monitor SK2 on channel 1 of a two-channel 'scope and switch SW7 on. If the clock generator circuitry is operating correctly, a rectangular clock signal should be visible on the 'scope and should be variable over the 0.5 Hz to 500 kHz range using RV1 and SW1. If a clock signal is not visible, check through the SW2-IC6 and IC1 circuitry to find the error. If all is well, turn SW2 to the GATED CLK position and check that the generator

Parts List

Resistors all ¼ W 5%

R1	22k
R2	10M
R3	1k0
R4	4k7
R5,7,10, 11,12	47R
R6,8	1k5
R9	10k

Potentiometers

RV1	22k logarithmic
RV2,3	22k linear
RV4	2M2 logarithmic

Capacitors

C1,8,14,16	1u0 polycarbonate
C2,6,12,17	10n polyester
C3,18	47p ceramic
C4,10	82p ceramic
C5,11	1n0 polycarbonate
C7,13,19,20	100n polyester
C9,15	10u 16 V tantalum
C21	1000u 10 V axial electrolytic

Semiconductors

IC1,4	CD4046B
IC2,3	74121
IC5	7408
IC6	7414
Q1	2N4123
D1,2	1N4148

Miscellaneous

SW1,3,5	1 pole rotary switch
SW2	2 pole changeover (4 off interlocking pushbutton type)
SW4	SPDT miniature toggle
SW6	3 position slide switch
SW7	SPDT slide switch
SK1,2,3, 4,5,6	BNC 50R sockets

7 knobs, Case

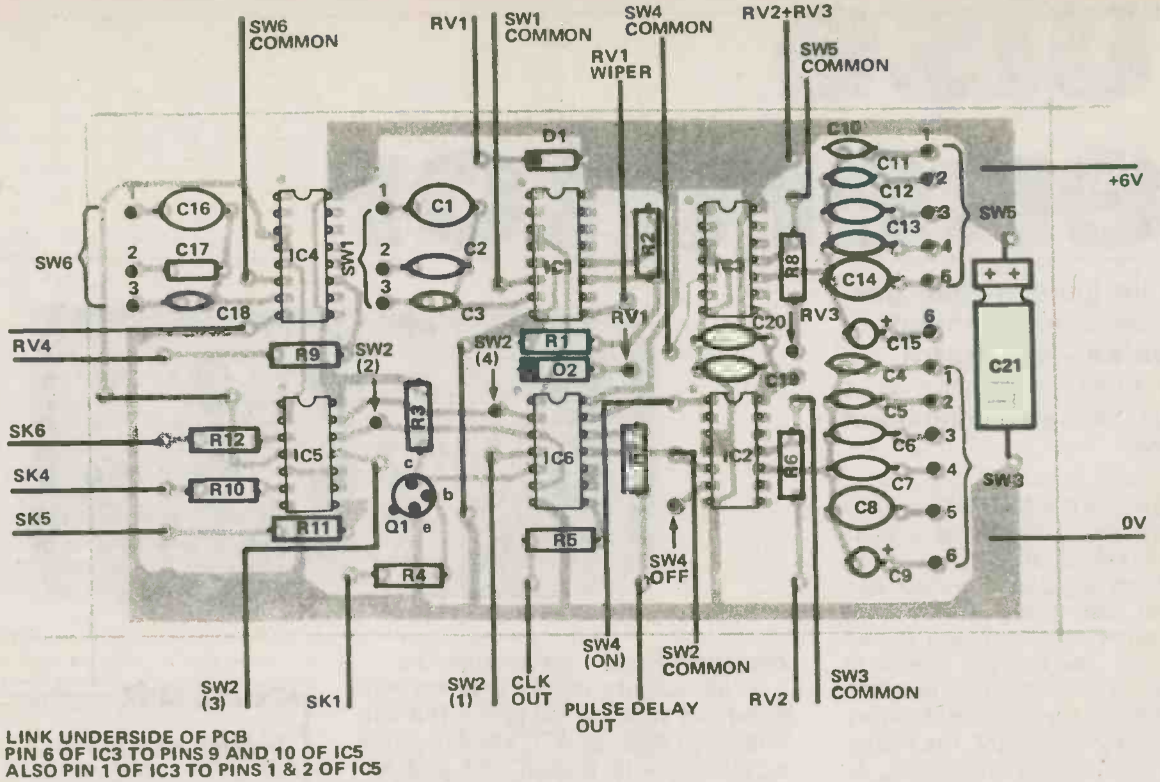
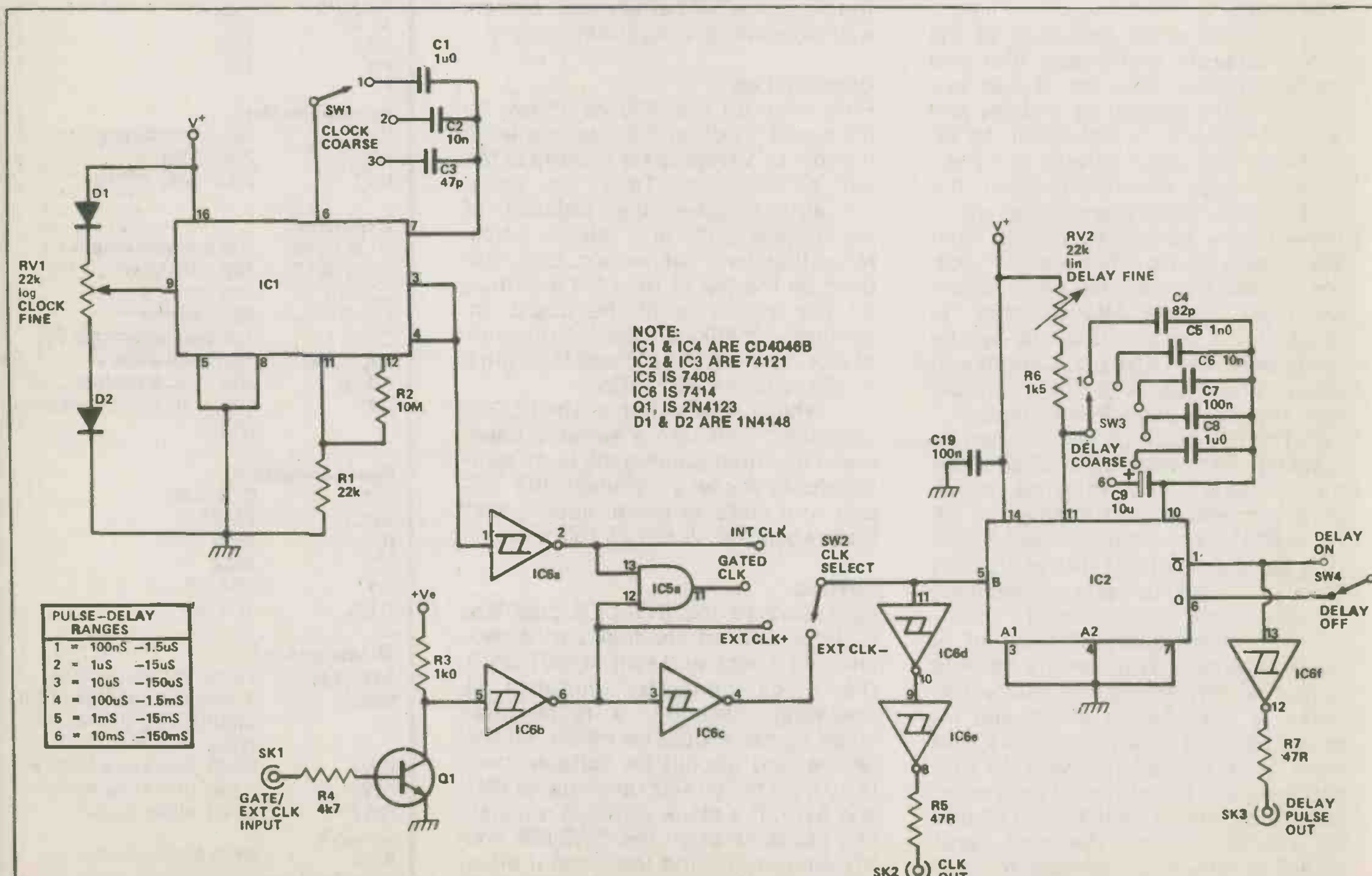


Fig. 1 Component overlay.



PULSE-DELAY RANGES	
1 =	100nS –1.5uS
2 =	1uS –15uS
3 =	10uS –150uS
4 =	100uS –1.5mS
5 =	1mS –15mS
6 =	10mS –150mS

Fig. 2 Circuit diagram. Pulse delay, pulse width and clock generator ranges are shown in the tables.

How It Works

The circuit comprises a clock generator (IC1), two pulse generators or monostables (IC2 and IC3), one gated tone generator (IC4) and a few gates and inverters. The most fundamental elements of the project are the two pulse generators, which are designed around 74121 TTL monostable ICs. In our particular application, these monos are triggered by the positive transition of a clock signal applied to pin 5 and then generate an output pulse with a duration determined by the R-C timing components connected to pins 10 and 11.

Note that these monostables generate a positive output pulse at pin 6 and an inverted or negative pulse at pin 1. Thus, if IC3 is triggered by pin 6 of IC2, both monos will effectively trigger at the same time (effective parallel clocking) and the IC3 pulse will not be delayed relative to the main clock signal. If IC3 is triggered by pin 1 of IC2, on the other hand, the IC3 pulse will be delayed relative to the main clock signal. In practice, both the delay and the main pulse widths are fully variable over the range 100 nS to 150 nS by independent controls.

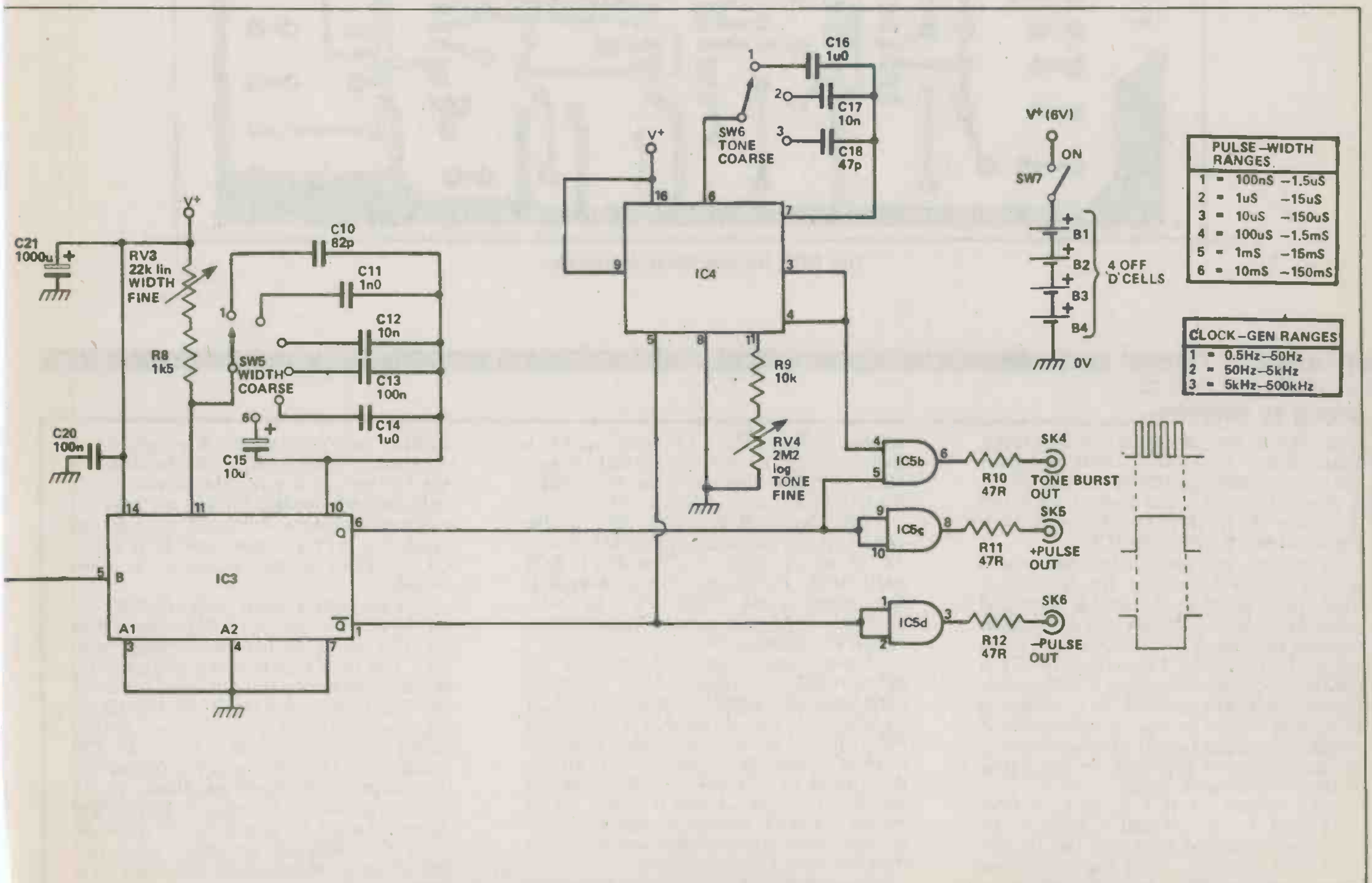
The pulse generators can be clocked by an internal clock generator (IC1) or by external clock signals. The internal clock generator is designed around the VCO section of a 4046B phase-locked loop and can span the range 0.5 Hz to 500 kHz in three switch-selected overlapping bands. Each band spans a range of roughly 200:1 controlled by RV1. The output of this generator is buffered by IC6a (a TTL Schmitt inverter) and can be used to clock the pulse generators either directly or by AND gate IC5a. In the latter case, the gate signal must be gated on by an external signal applied to socket SK1.

External gate or clock signals can be applied to SK1. These signals are amplified and inverted by Q1 and re-inverted and cleaned up by IC6b. The resulting signals can be used either to gate the internally-generated clock signals via IC5a or to directly clock the pulse generators via SW2. In the latter case, the pulses are generated in phase with the external clock signals when SW2 is in the EXT CLK + position, or in antiphase in the EXT CLK – position. The final clock signals to IC2 are double-inverted by IC6d-IC6e and made externally available at SK2.

The pulse output of the IC2 delay circuit is buffered and made externally available at SK3 by IC6f. Simultaneously, the direct and inverted main-pulse outputs of IC3 are made available at sockets SK5 and SK6 respectively by buffer stages IC5c and IC5d. A tone burst signal is also available at SK4 and is generated as follows.

IC4 is a wide-range square-wave generator designed around the VCO section of a 4046B CMOS IC. This generator can span the range 1 Hz to 1MHz in three switch-selected overlapping ranges, with each range spanning a 200:1 band controlled by RV4. The output of this oscillator is fed to one input of AND gate IC5b and the positive pulse output of IC3 is fed to the other input of the AND gate. IC4 is enabled only when pin 5 is pulled low. In our circuit, pin 5 is coupled directly to the inverted pulse output of IC3. consequenctly, the IC4 signals and have a burst duration equal to the pulse width of IC3.

The complete pulse generator project consumes a mean current of about 40 mA and can be powered from a 6 V battery pack or from an external 5 V regulated supply.



can be gated on and off by SK1 signals. Finally, check that external clock signals (from SK1) are available at SK2 when SW2 is turned to the EXT CLK + or − positions.

Now, with SK2 still connected to channel 1 of the 'scope and with SW2 in the INT CLK position, monitor SK3 on channel 2 of the 'scope. With the 'scope synchronised to channel 1, check that a delay pulse is synchronously generated at SK3 and is fully variable by RV2 and SW3.

Next, monitor SK5 output on channel 2 of the 'scope, turn SW4 to the DELAY OFF position and check that a width pulse is synchronously generated at SK5 and is fully variable by RV3 and SW5. If all is well, turn SW4 to the DELAY ON position and check that the width pulse can be delayed relative to the clock using the RV2-SW3 delay controls. Check that an inverted version of the output pulse is available at SK6.

Finally, check that a tone burst pulse-controlled signal is available at SK4 and that the tone frequency is fully variable by the RV4-SW6 tone controls.

When making the above functional tests, note that the pulse period (or the sum of the pulse periods in the delay mode) must always be less than the period of the clock signal and that the period of the tone signal must be less than that of the width pulse.

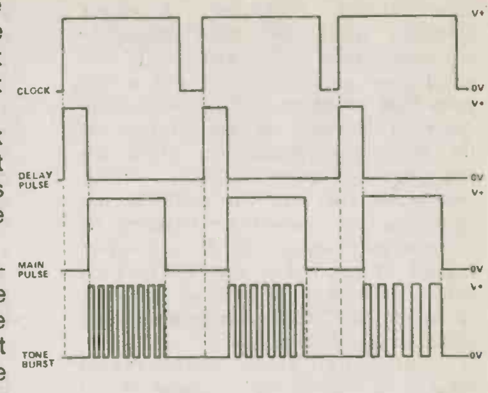
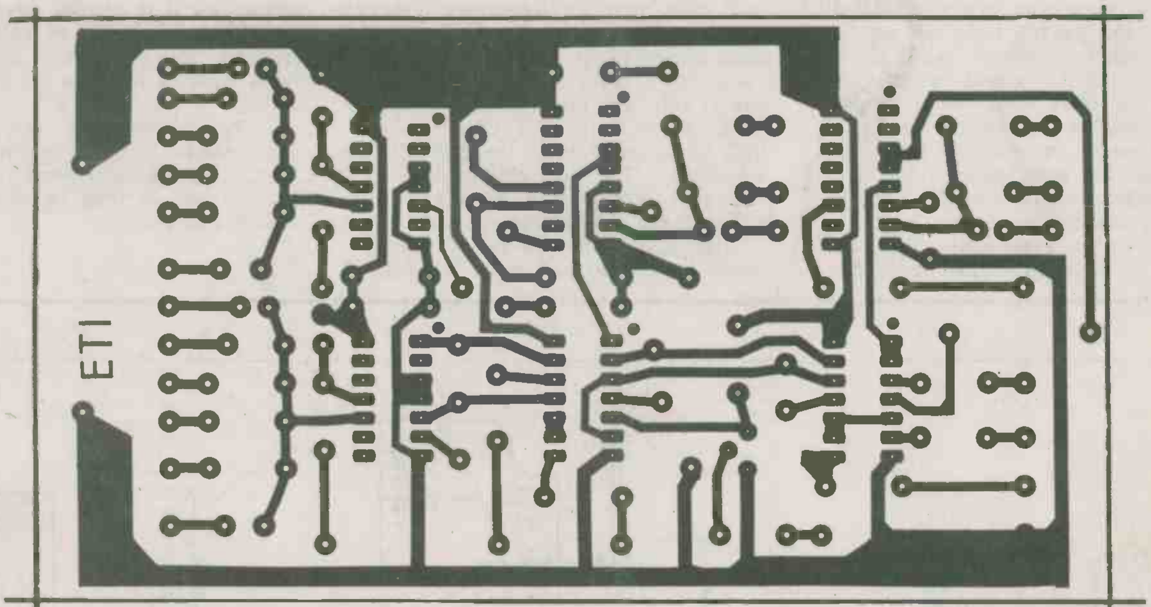


Fig. 3 Pulse timing diagram.



The PCB for the Pulse Generator.

Universal Timer

Continued from page 22

How It Works

The circuit comprises four main blocks, these being an astable clock generator (IC1), a multi-stage binary divider (IC2), a relay driver (Q1) and a gated alarm-call generator (IC3), all powered from a 12 V regulated line provided by IC4.

The clock generator is designed around IC1, a CMOS version of the 555 timer. The chip is wired in the astable mode and generates clock signals with periods variable over the 7.3 mS to 732 mS range via RV1 and SW1. The output of IC1 is used to clock the multi-stage CMOS binary counter designed around IC2, which is effectively wired in the 'divide-by-8192' mode; the output (pin 3) of this counter is normally low but goes high on the arrival of the 8192nd clock pulse.

The output of IC2 is used to drive relay RLA on via Q1 and to gate on the alarm-call generator (IC3) via the D1-R6-C5-R8-R7 network. This generator comprises a fast astable (IC3c-IC3d) and a slow astable (IC3a-IC3b). The slow astable is gated on by a momentary high output from IC2 and then gates the fast astable on and off at a rate of about 2 Hz.

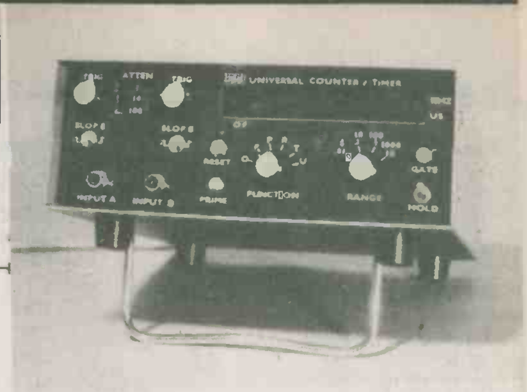
The alarm-call generator part of the circuit is permanently connected to the 12 V supply lines, but the IC1-IC2-Q1 parts of the circuit are only connected to the supply rails when PB1 or relay contacts RLA/1 are closed. The complete circuit functions as follows.

Timing operations are initiated by momentarily closing PB1, thereby connecting the supply to the IC1-IC2-Q1 circuitry. As PB1 is closed, a reset pulse is fed to pin 11 of IC2 via C3 and causes the counter's registers to set to zero, driving the output of IC2 low. As IC2's output goes low it drives Q1 and the relay on via R4-R5, thereby causing contacts RLA/1 to close and maintain the supply to the circuitry once PB1 is released.

As soon as PB1 is closed, IC1 starts to oscillate and generate clock pulses, which are then counted by IC2. On the arrival of the 8192nd clock pulse the output of IC2 switches high, turning Q1 and the relay off and causing contacts RLA/1 to open and break the supply connections to IC1-IC2-Q1. The timing sequence is then complete.

C4 imposes a slight turn-off delay on Q1, so that the output of IC2 remains high for 100 mS or so before the relay turns off. This brief high period is sufficient for the IC2 output to fully charge C5 via D1 and R6, thereby activating the IC3 alarm-call generator, which produces an audible pulsed-tone signal in the PB-2720 transducer. Once the relay has turned off, the charge on C5 slowly leaks away via R8 until, after about 30 seconds insufficient charge remains to gate IC3a on, at which point the alarm-call generator turns off. The entire operating sequence is then complete.

Universal Counter



Stand up and be counted: a universal counter based on Intersil's ICM7226, by Bill Miller and Jan Vincent.

A QUIET REVOLUTION has been taking place for the past few years. Until now the lowly digital counter has required row upon row of TTL packages and plenty of power to keep the lights flashing. Then Intersil stepped into the arena with a new high density IC, the ICM7226. All those decade registers, crystal oscillators, timing logic and display drivers have been integrated into one small package that can drive eight LED displays, count at a rate of 10MHz, provide period and time measurements, and test itself. That means lower cost and easier construction for a high-quality counter. And, since the chip is CMOS, power drain is minimised, the chip runs cooler, and there is less heat to affect accuracy.

Now if that was not enough, we wanted more. So we added more. This construction project gives you a complete universal counter with all the features found on a professional frequency counter plus a few added bonuses, like extended range (to 120MHz in all modes), input attenuators, trigger level adjustments on the panel, slope selectors, easy to use controls and a priming circuit to allow you to measure time of just about any one-shot event you could dream up.

The counter is unique in that it is small enough to fit into a standard instrument enclosure, complete with power supply and all the front-end circuitry, right next to your signal generator or radio transmitter. And its construction, with separate display and electronics board, makes the whole unit go together smoothly. You can probably find many other uses for this counter, and there are plenty of applications which would benefit from a simple-to-use counter.

Besides the IC construction and the small size, our counter has these other features. You can measure down to DC with two separate DC-coupled inputs with industry standard 1-megohm input impedance. There's an external adjustable trigger-level control for each channel to adjust input sensitivity on either

How It Works

The counter is constructed around Intersil's universal counter chip, the ICM7226B, which contains most of the circuitry necessary to produce a timer/counter. It combines a high frequency oscillator, a decade timebase counter, an 8 decade counter and latches, a 7 segment decoder, digit multiplexer and 8 segment and 8 digit driver for directly driving a common cathode LED display. The project can be divided into four sections for this discussion; the VHF front end, the LF front end, the 7226, and the power supplies.

VHF front end

The basic element of the VHF front end is the prescaler IC from National Semiconductor (DS8629N). This unit provides the necessary preamplification of the incoming signals to bring them up to the levels required to drive the digital logic. In addition, it prescales the input frequency by dividing it by a factor of 100. This block has a low input impedance needed by high frequency inputs and is protected from overloads by a resistor-capacitor-diode network. The output from this chip is a TTL compatible signal in the rang eof 100k Hz to approximately 1.2MHz, and is applied through Sw7 to the input of the 7226 counter chip.

Low Frequency front end

The low frequency front end is comprised of an input attenuator, a J-FET preamplifier, resistor-diode input protection circuit, and a level adjustment circuit. The input attenuator allows the user to select the required sensitivity to prevent false triggering of the counter due to noise or spurious pulses applied to the input. Once the proper input signal level has been selected, the signal is applied to the J-FET preamp, which provides wideband amplification from DC to approximately 10MHz. The input sensitivity is typically 50mV at 10MHz.

IC1 is an op amp which inverts the incoming signal and performs two functions. It adjusts the trigger level by adding a DC component to the signal and it acts as a Schmitt trigger to square up the signal before it is applied to the logic circuitry. Part of the trigger circuit allows you to apply an inverted or non-inverted signal to the 7226, giving you the capability of triggering on the positive or negative going edge of the waveform. This selection enables the measurement of time for periodic pulses and one shot events. The final output of the low frequency front end is a TTL compatible signal in the range from DC to approximately 10MHz, and is applied directly to the input of the 7226 counter chip. Note, there are two low frequency front end circuits used in this project, one for each input to the counter chip. The two channels are used in combination to measure time intervals of repetitive pulses or events, and in measuring the frequency ratio of two incoming frequencies. A complete discussion of the operation of these types of measurements is found in the description of the operating functions.

ICM7226 counter chip

As stated previously, the basic block of the counter is the Intersil ICM7226B decade counter chip. This counter can function as a frequency counter, period counter, frequency ratio (f_a/f_b) counter, time interval counter or as an event totaliser. The counter uses a 10MHz crystal timebase, and has an on-chip oscillator circuit. For period and time interval measurements, the 10MHz timebase is used to provide 0.1 uS resolution. In the frequency mode, gating times are user selectable from 0.01 sec, 0.1 sec, 1 sec or 10 sec ranges. A complete discussion of the various functions can be found in the list of operating functions and on the Intersil datasheet.

Power supplies

The final section is comprised of four low current power supplies. The basic requirement is to supply well regulated power to the logic chips and the front end circuits. The four supplies are very simple and make extensive use of monolithic regulating ICs. The four supplies required are +10.5 Volts, +5.1 Volts, -10.0 Volts and -5.0 Volts. The printed circuit boards have been designed with the on-board supplies, including the power transformer.

Parts List

Resistors ¼ W, 5%

R1,101	910K
R2,102	91K
R3,17, 18,19,20, 29,31,103	10K
R4,6,10, 23,104, 106,110	100R
R5,105	1M
R7,12,15,16, 107,112	1K
R8,108	1K5
R9,109	200R
R11,111	51K
R13,113	22K
R14,114	20K
R21	100K
R22	22M
R24,30	470R
R25	See Text
R26	820R
R27	47R, 2 Watt
R28	47K
R32	390K
R33	1M2
R38	47R

Switches

SW1,101	DP3T mini slide
SW2,102	SPST mini toggle
SW3	SP6T rotary
SW4	DP4T rotary
SW5	spst N/O mom.
SW6	SPST mini toggle
SW7	TPDT mini toggle
SW8	SPST toggle
SW9	SPST N/O mom.

Capacitors

C1,101	15pF ceramic 300V
C2,102	270pF ceramic 300V
C3,103 4,104	10nF mini
C5,6	100nF mini
C7	22uF 16V tantalum
C8	10nF mini
C9	47pF ceramic 5%
C10	33pF ceramic 5%
C11	5.5 - 65pF trimmer Phillips 010GA/60E
C12-16	10nF ceramic
C17	100nF ceramic
C18	2200uF 25V radial electrolytic
C19	1000uF 25V radial electrolytic
C20	22uF 16V tantalum
C21,22	100nF mini
C23	6u8 16V tantalum
C24,28	4u7 16V tantalum
C25	100nF mini
C26,27	10nF ceramic

Potentiometers

RV1,RV101	2k2 horiz trimmer
RV2,RV102	5k linear

Misc.

Transformer	Hammond 161F20 20V 220 mA
Case	Approx 7x9x3 inch

printed circuit board, knobs, ribbon cable, coax mini cable RG174/II fuse holder, power cord.

Semiconductors

D1,D101 D2,D202 D3,D4,D5 D6,D7	1N4148 or similar
D8,D9	1N4001
Q1,Q101	J308 FET
Q2,Q102	2N3646
Q3	2N4401
Q4	2N6027
IC1,IC101	TL810CN
IC3	MC1458
IC4	ICL7226BIPL
IC5	DS8629N
IC6	LM340T-5 (do not use 7805)
IC7	78L05
IC8,IC9	79L05
IC2	74LS86
IC10	7404
display	2 x NSB5881
LED	mini red LED
Crystal	10MHz 22pF 35R

ing collared (insulated feedthrough) wirewrap pins soldered to both the display and the display board. Be sure to add the seven jumpers to the display board before the completed unit is mounted on the front panel.

Mount all the switches and controls on the front and back panels. Begin wiring up the interconnections by using the component overlay as a guide. The easiest method is to use a length of ribbon cable for all the interconnections. The signal cable must be a high quality shielded cable from the input jacks to the printed circuit board. Be sure to bring the cases of SW1 and SW101 and both trigger level pots to the ground (0 volts), or better yet bring the whole front and back panel to ground level. This prevents hum pick up or spurious coupling between the controls and the inputs.

A few very important precautions are necessary. Keep all signal carrying cables away from the 7226 and the display. The 500Hz multiplex frequency is easily induced into the front end circuit. Check and double check the polarity of the 7226 before applying power; this is a very expensive IC to destroy by applying reverse power.

Using coloured ribbon cable, connect the rotary switches to the PCB (see rotary switch detail drawing). Finally, secure the crystal to the board using a drop of silicon sealant.

Calibration

Calibrating the counter is a snap if you have a frequency standard available. Ideally, that standard should be better than ±0.0005% accurate at room temperature to get the maximum accuracy. Using a 10MHz source, connect the frequency standard and turn on the counter. For best results you should calibrate at room temperature and allow at least five minutes for the counter to stabilise before starting. You should get a reading very close to 10MHz, then adjust trimmer capacitor C11 until the reading is exactly 10MHz. Disconnect the standard and you are ready to go.

If a standard is not available, use a source of known frequency, and adjust C11 for the closest reading possible. Always allow the equipment to warmup before taking any measurements to get the best accuracy. See the schematic for details on adjusting trim pots RV1, RV101.

Now that the counter is completed you will want to begin using your new test instrument. Be sure to connect your signal to the correct inputs, adjust the input attenuator for the correct signal levels; x1 for signals to 1V RMS; x10 for signals to 2V RMS; and x100 for signals over 2V RMS. These levels overlap.

Using the counter is straightforward and needs little explanation. Remember that the decimal point denotes kilohertz for the low frequency inputs and megahertz for the VHF input. All times are in microseconds. If the prescaler oscillates, connect a 100k resistor from pin 6 to 0V on the bottom of the PCB. This reduces sensitivity and will get rid of any oscillations.

The counter has a wide range of functions to match the wide operating frequency range. The six basic functions that can be selected are:

Frequency measurement — Using the prescaler circuit, frequencies to more than 120MHz can be accurately measured, with little or no loading of the external circuit. By selecting the gating time, the accuracy of the reading is dependant only on the calibration of timebase oscillator of the 7226 counter. Signals of less than 10MHz are applied to the channel A input, which has an impedance of 1M.

Period measurements — The counter can handle input signals to approximately 2MHz in the period measurement mode. The 7226 provides an accurate timebase which is counted and gated by the incoming signal, the result being displayed and scaled in microseconds. The operation of the period measurements is such that the displayed value is an average reading, averaged over several measurement cycles. For period and time interval measurements, the 10MHz timebase gives a 0.1 microsecond resolution, that can be read down to the nanosecond range.

Time Interval — The time interval function allows you to measure the time between two events, such as the time between two pulses. This function requires either a repetitive signal applied to input A and B, or for the two inputs to be prepared before the signals are applied. This is the function of the priming circuit; it prepares the counter inputs for a single event on the two inputs. As input A goes negative the internal counter begins counting time in 0.1 microsecond units. When input B drops, the counter stops and displays the time interval between the two transitions. To initiate the counter into the primed one-shot mode, take the following steps. Set trigger level controls to 11:00 o'clock and scope switches to the open or non-inverting position. The function switch must be in the (time) mode and the range switch in the .01 - 1 range. Depress the prime switch and hold in momentarily. If the gate light does not go out then press reset and try the prime switch again. The gate light turning off indicates the unit is primed and the next transition at input A will start the count and A pause at input B will finish it, displaying the result in uSec. This function will display one-shot events from fractions of a uSec, to 10 Sec.

Unit counter — The counter can be used as a high speed unit or event counter. It can actually count at a rate of 120 million events per second, and display more than 90 million on the display. The operation is very straight-forward. By applying a signal to input A, which drops from a positive voltage level to a ground or negative voltage level, the counter will increment once for each positive to negative transition. The counter is returned to zero by depressing the RESET button, or the display may be held at any value by using the HOLD switch, The hold switch does not reset the counter; it simply prevents further input pulses from incrementing the count. Normal operation is continued upon returning the hold switch to the normal position.

Frequency Ratio — The frequency ratio function allows you to display the relative ratio between two frequencies. In connecting two signals to input A and B, the higher frequency signal should be connected to input A. The resulting display is an average measurement of the ratio between the two inputs. For obvious reasons this ratio must always be equal to or greater than 1. The maximum frequency for this mode of operation is approximately 10MHz at input A and 2MHz at input B.

Oscillator — The counter can be used to monitor the internal timebase by selecting the OSCILLATOR function.

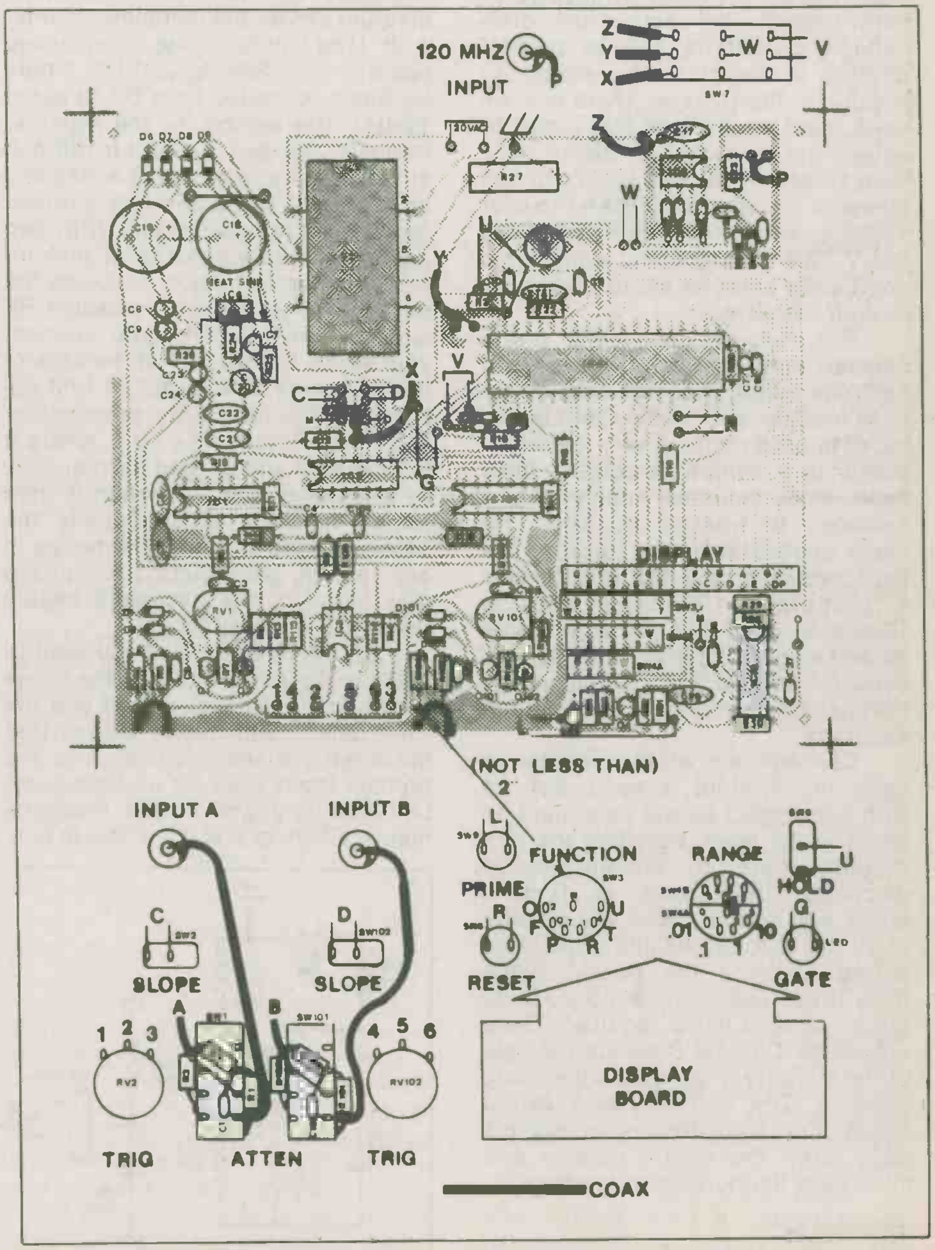


Fig. 1. Parts placement.

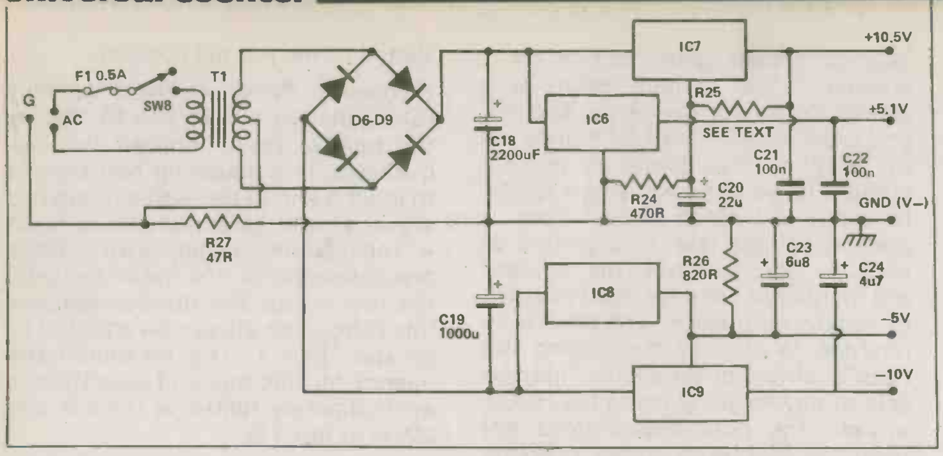


Fig. 2. The PSU.

positive or negative-going signals. plus, there's an input attenuator to help protect the input from over-voltage conditions and to prevent damage in the event of overload. At about the 10MHz level, there is a second input circuit that takes over to extend the range of the 7226 to more than 120MHz. With this input you can measure signals from 150kHz to over 120MHz, with a sensitivity of about 50mV. This counter could work with a short whip antenna set up near your radio transmitter.

The display has some pretty special features as well. There is a LED eight-digit, half-inch display for easy reading, and leading-zero blanking of unused digits. A very important bonus is a switch selectable time-base. Most counters supply only a 1-second time-base, too short for many applications and too long for high frequency use. Our counter has a complete timebase with a 10-second gate time for audio work as well as selectable settings of 1 second, 0.1 second and 0.01 second for the best speed in measurement at full accuracy.

Construction of the counter is easy and straight forward, but, as with any project proper care must be taken in the work. Handling the IC's requires care to prevent static discharge from tools or fingers; check and double check the polarity of all the IC's, diodes and transistors before applying the power. Aside from these basic precautions, there are no special skills required. There are seven IC's that make up the bulk of the circuitry, plus a few other components. The careful board layout keeps the high frequency signals away from the digital display and minimizes the number of jumpers.

The circuit

As mentioned earlier, the counter is based on a single IC that contains the essential electronics for a complete universal counter. The schematic diagram shows the complete counter with three inputs — one for extended operation to 120MHz, and two inputs for basic operation from DC to about 10MHz. The reason for the separate frequency ranges is that it is difficult and expensive to design a wide-band input circuit to handle this extreme range of input conditions. With two types of inputs, we can tailor each for maximum performance, and keep the cost low. If you wish to measure RF signals above 10MHz, you connect your signal to the input at the back of the enclosure. The signal is first applied to a combination preamplifier and ECL/TTL prescaler chip, where it is amplified and divided in frequency by a factor of 100. The result is then routed to SW7, which selects the 120MHz range or the 10MHz range. In our version, we mounted S1 on the rear apron of the enclosure beside the high frequency input.

On the other hand, if you want to apply a signal that falls in the range of DC to 10MHz, you would use the front panel connections. Notice that the input marked Channel A is the primary input used for all frequency, unit counting and period measurements. Channel B is used only in conjunction with Channel A for measurements of time intervals. More on how to use it later. From the input, the signal is amplified and converted to TTL levels, adjusted for trigger level sensitivity and slope, and applied to the counter chip. This chip contains the complete universal counter circuit including a crystal oscillator, time-base divider, control logic, eight decade counters, eight latches and display multiplexing circuits.

Construction

For best results, you should use PC boards to speed construction. The first matter of business in constructing the unit is to build up the power supply. The printed circuit board has been designed to accommodate the power transformer and all the power supply components. Use a fine tip soldering iron and the smallest gauge solder you have. All the components for the power supply except R25 can be installed. Be sure to polarise all the diodes, capacitors and the regulators correctly. Now, temporarily connect a 1k pot and a 220 ohm resistor in series, and place this combination into the circuit instead of R25. Apply power and check the voltages. Using the temporary 1k pot, adjust for 10.5 volt (point "h" on the PCB). Replace the pot-resistor combination with the nearest value fixed resistor for R25.

Thanks to that one big IC, the rest of the counter is easy to assemble. Mount all other components on the board, being careful to avoid solder bridges and to double check polarities. Use IC sockets for the large IC's. Once the main board is assembled, clean the bottom of the board with flux remover.

Prepare the front and back panel. In our version, all the controls except the high frequency input and control switch are mounted on the front panel.

Assemble the display board us-

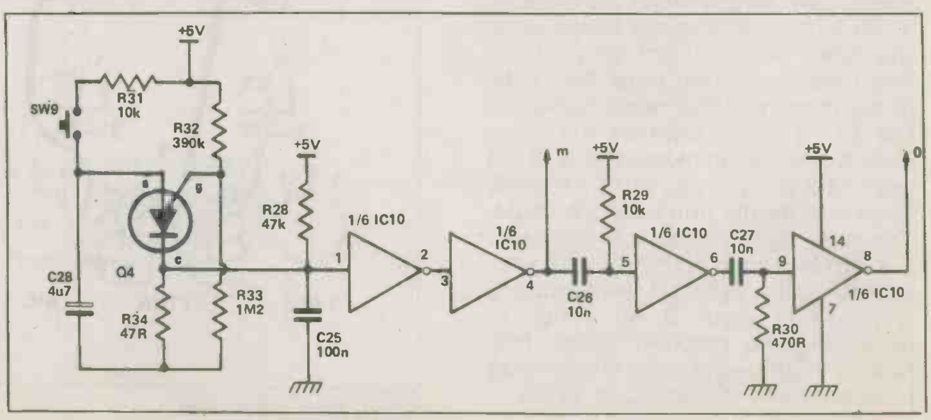


Fig. 3. The priming circuit.

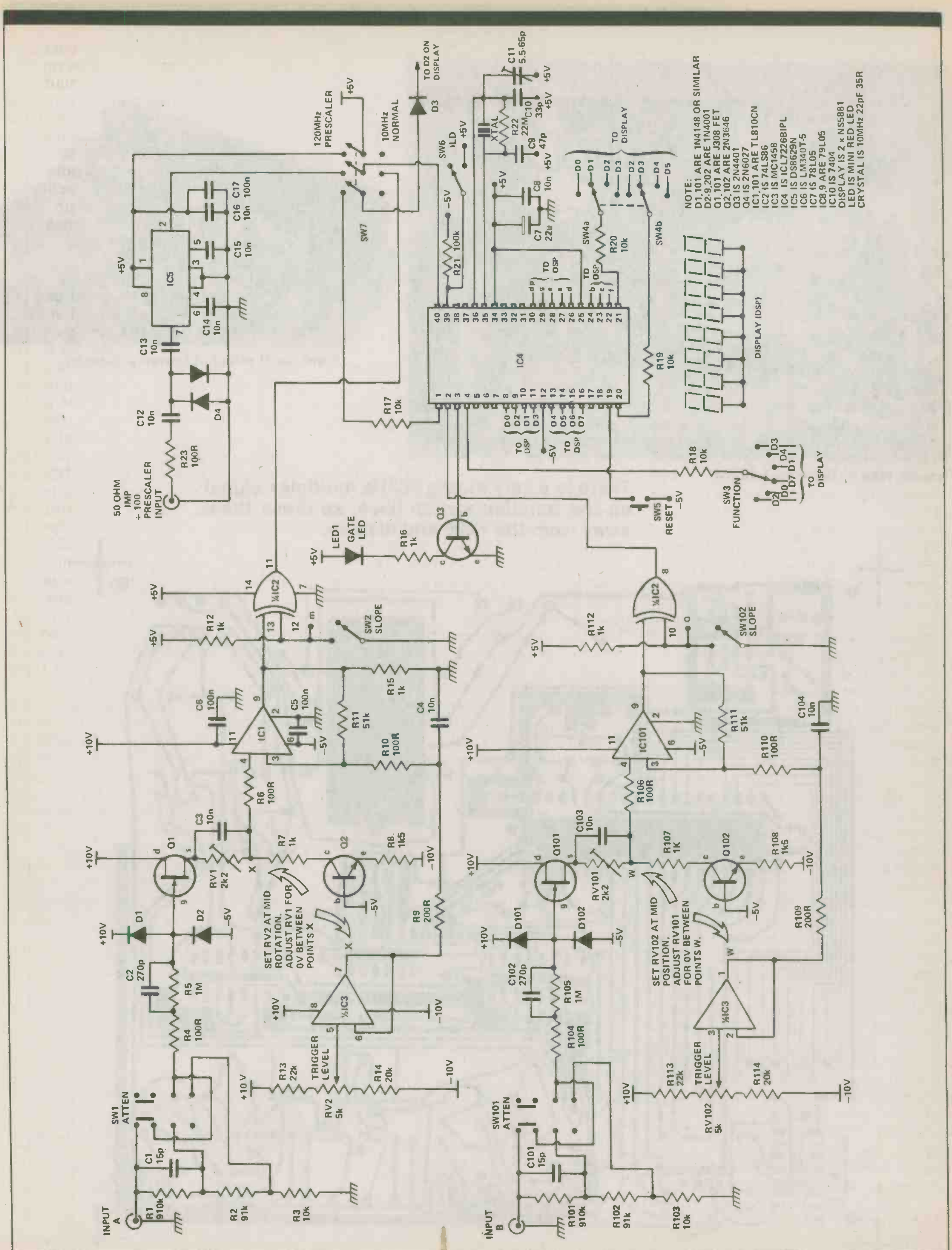
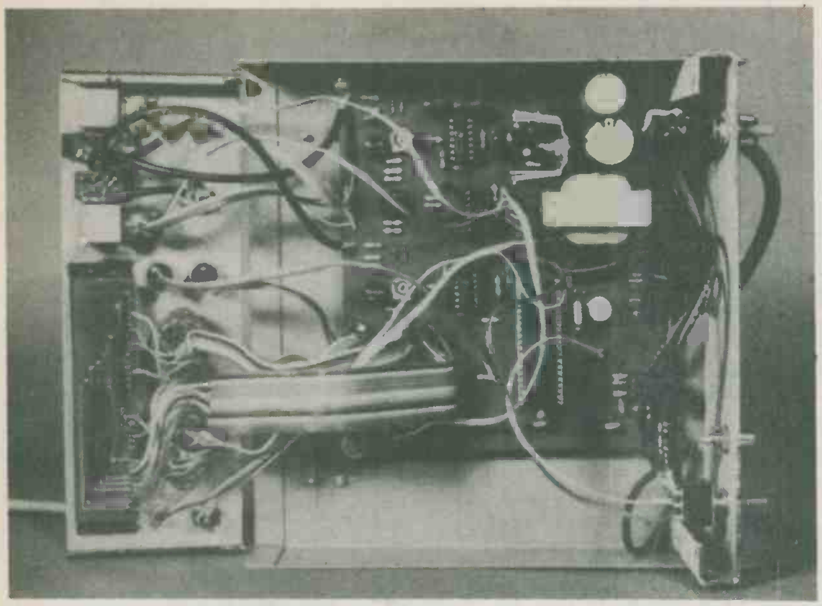
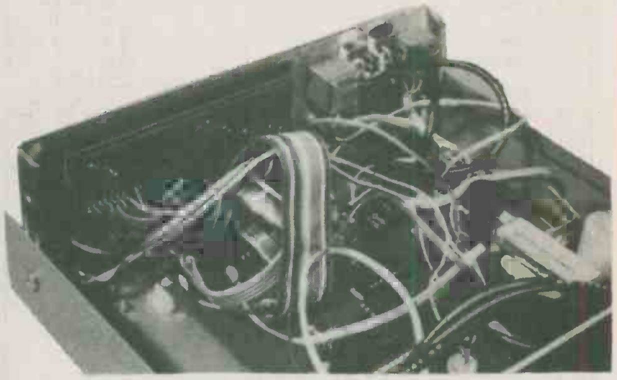


Fig. 4. The circuit diagram.



Interior view of Universal Counter.



Front panel wiring of Universal Counter.

There is a very strong 500Hz multiplex signal on the function switch lines, so dress them away from the 7226 and display.

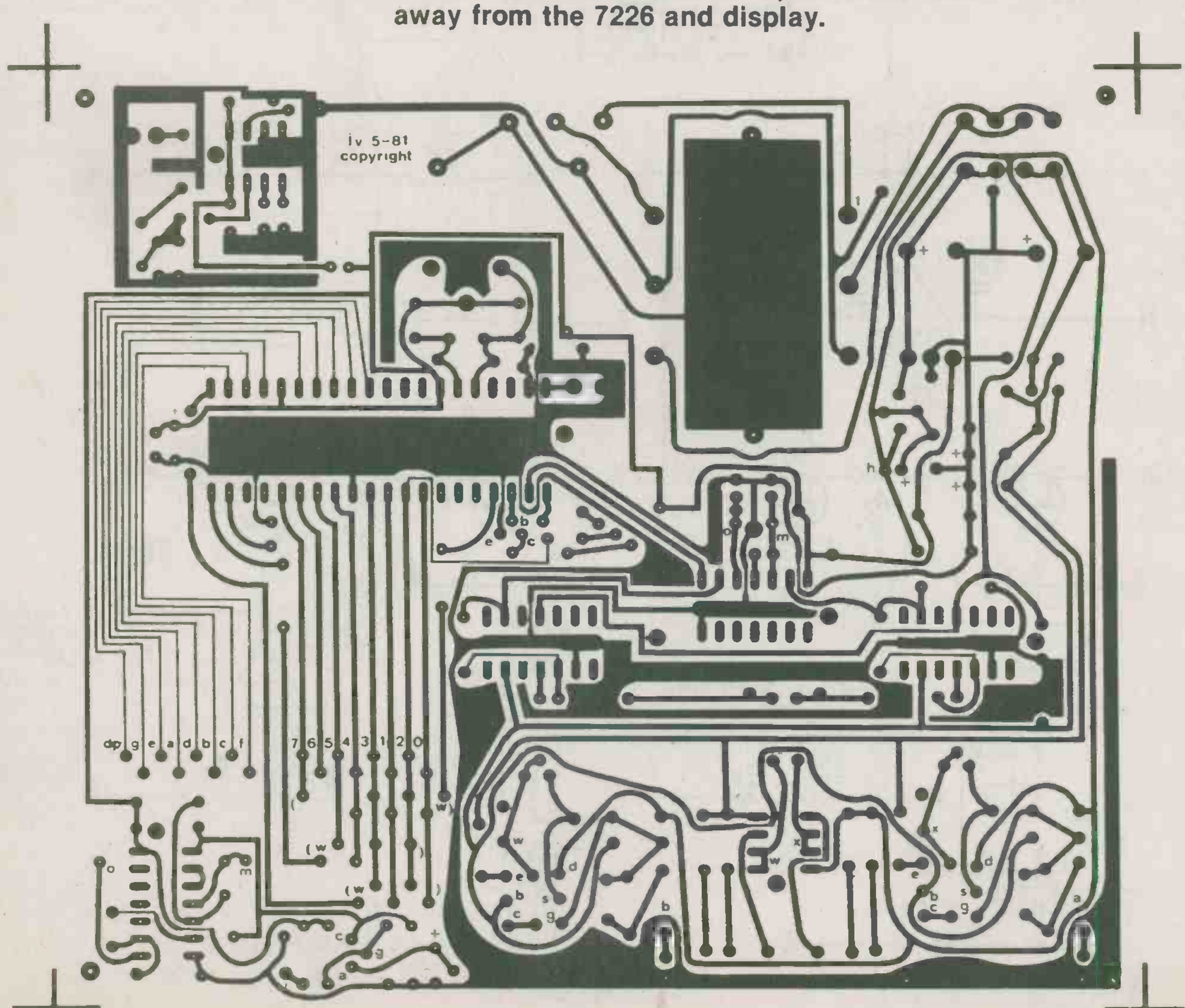


Fig. 5 The PCB.

February 1977
Features: CN Tower, Biorythm Calculator, VCT, 555 Timer Applications, Yamaha B1 Review, Scope Test Your Car.
Projects: 5W Stereo Amp, Philips Speaker System, Reaction Tester, Patch Detector, Heads or Tail, SCR Tester.

December 1978
Features: Designing Oscillators, Ham Spectrum Chart, Principles of Video, Getting into Video.
Projects: Digital Anemometer, Tape Noise Eliminator, EPROM Programmer.

February 1979
Features: Quarks, Op-Amps, Binary to Decimal and Back.
Projects: SW Radio, Phasemeter, Light Chaser.

April 1979
Features: Designing Audio Amps, Solar Power, RF Chokes, What Quad terms mean.
Projects: Differential Temperature Controller, Audio Compressor, Wheel of Fortune Game.

May 1979
Features: Space Shuttle Communications, Transducers in Measurement & Control, Research in Canada.
Projects: Light Show Controller, AM Tuner, VHF Antenna (pt.1) PCB Drill.

May 1980
Features: Delay Lines, Standing Waves, Microwave Cooking Artifical Intelligence.
Projects: Click Eliminator, Soil Moisture Indicator Fuel Level Monitor, 16K RAM Card.

June 1980
Features: Electronic Warfare, PLL Synthesis, CA3130 Circuits, Canadian Sound Archives, Magnetic Power Control, CLIP.
Projects: Function Generator, Dynamic Noise Filter, Overspeed Alarm.

November 1980
Features: Designer Circuits Special, Cassette Decks and Tapes, Attenuators, Project Daedalus, Thermistors.
Projects: Guitar Practice Amplifier, 6 W Siren, Infra-Red Remote Control.

December 1980
Features: Transducers in Audio, Floppy Disks, 10 Simple Transistor Circuits, Electric Cars, S1 Units.
Projects: Digital Test Meter, RIAA Preamp, Survival Game.

January 1981
Features: Studio Techniques, Premium Batteries, Edison Effect, Alarm Circuits.
Projects: Electronic Ignition, Digital Frequency Meter, EPROM Eraser, Coin Toss.

Februrary 1981
Features: Electronics in Photography, Audio Filter Design, Piezo Electricity, Modems, Choosing a Printer, Selecting a Floppy Disk.
Projects: Ultrasonic Burglar Alarm, Fuzz Sustain Unit, Process Timer.

March 1981
Features: The Ubiquitous Oscilloscope, VFET Applications, Photocells, Test Gear.
Projects: Hum Filter, Drum Synthesiser, Shark Game.

June 1981
Features: Project Galileo, Story Behind Stereo, Solder, Computerese.
Projects: 1573A VCA, High Speed Cassette Interface, Double Dice, Bicycle Speedometer.

July 1981
Features: LM3914 Circuits, How to Solder, Faraday, Auto Sound Survey, Project Fault-Finding.
Projects: Universal Timer, Bargraph Car Voltmeter, Engineer's Stethoscope, Computer Motherboard.

August 1981
Features: Recording Tape and Tape Recording, Anatomy of a Micro, Holograms, Wein Bridge Oscillators, 55 Circuits.
Projects: Infra-Red Alarm, Bench PSU, Wired Sound.

September 1981
Features: Thick Film Circuits, A look at CP/M, Gm Revisited, Hum Loops, Ex-OR Gates.
Projects: LED Vu Meter, Russian Roulette, LED Tacho, Emergency Light Unit.

October 1981
Features: Scope Survey, Graphic Equalizer Design, I/O Devices, Dolby C, Black Hole Theory.
Projects: Tape Optimizer, Antenna Extender, Win Indicator, Pulse Generator.

November 1981
Features: Canada in Space, Digital Design Handbook, Maxwell, POKEing the ZX80, VIC-20 Review, PWM Explained.
Projects: Alien Attack, Headlight Delay, Drum Machine, Computer Joysticks.

December 1981
Features: Bandpass Circuits, Tubes, Early Radio in Canada, Speaker Design (pt. 1).
Projects: Universal Counter, Musical Doorbell, 4-Input Mixer.

January 1982
Features: Speaker Design (pt.2), Big Bang Theory, Acorn ATOM Review, SLR Cameras, Micropower Circuits.
Projects: 4-Way Loudspeaker, Movement Alarm, Temperature Controlled Iron.

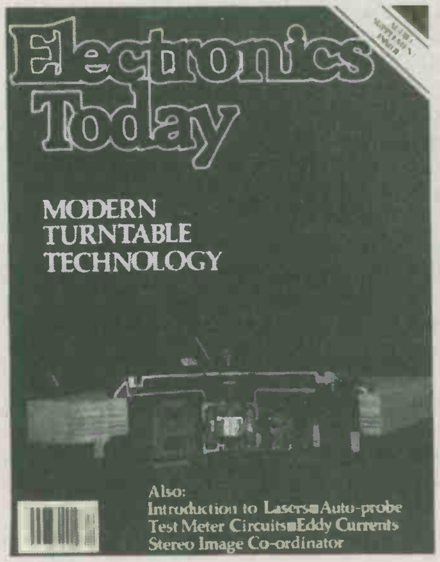
February 1982
Features: 50 Circuits, ATOM Review, Electronic Signs Industrial Robots, Amplifier Class, dBx, SW Aerials
Projects: Flash Sequencer, Enlarger Timer, Sound Bender

March 1982
Features: Printers, Ni-Cads, ZX81 Review, Perfect Sound, Gluons, CMOS Circuits.
Projects: Music Processor, Crystal Marker, Ni-Cad Charger, Reaction Tester.

April 1982
Features: Satellite Applications, 4066B Circuits, TRS-80 Model II Review, Fessenden, Electric Pencil.
Projects: Ten Simple Projects Special.

May 1982
Features: Shroud of Turin, Faster than Light Travel, CMOS Circuits, Modems, Drone Speaker, 6809 Computer Review, Optical Disk Recorders.
Projects: AF Signal Generator, Super Dice, LED Level Meter.

June 1982
Features: Fibre Optics, Lasers in Hi-Fi, Leptrons, Xerox Computer Review, Hertz, 50 More Circuits.
Projects: Phono Preamp, Roulette Game, Light Wand, Stylus Organ.



July 1982
Features: The Electronic Office, Heath/Zenith Computer Review, The 'Scope, The Hall Effect, Marconi.
Projects: Negative Ion Generator, Sticks Drum Box, Heads and Tails, Voltage Controlled Audio, Scratch Filter.

August 1982
Features: Thirty Years of Canadian TV, Osborne Computer Review, Light Memory, Intro. to I-Ching, BBS, Hex Notation, High Performance Op-amps, Rogers
Projects: I-Ching Computer, Synthesiser 1, Semiconductor Tester.

September 1982
Features: Telidon, Aspects of the 'Scope, UPC Codes, TRS-80 Model III Review, Crossover Networks, Ace 100 Computer Review, Stephenson, Into Digital (part 1).
Projects: Synthesiser JI, 150 Watt Amp, Bodywork Checker.

October 1982
Features: Electronics In Cars, if800 Computer Review, Particle Beam Fusion, DAC-ADC Circuits, History of Early Radio, Supercooled Magnetic Sensors, Panasonic Link Computer Review, XR2206, Into Digital (part 2).
Projects: Intelligent Terminal, Pest Control, Nicad Charger.

December 1982
Features: Radio Astronomy (part 1), Junction FETS, Satellite TV, 6500 CPUs, Apple Pirates, IBM PC Computer Review, Multiflex Computer Review, Henry, Into Digital (part 4).
Projects: Contrast Meter, Series 5000 Preamp (part 1), Hand Clap Synthesiser.

January 1983
Features: Electronics in the Newsroom, Constant Current Generators, 14 Computer Evaluations, Atari 800 Computer Review, Radio Astronomy (part 2), Smith-Corona TP-1 Printer Review, ZX 81 Revisited, Josephson Junctions, Into Digital (part 5).
Projects: Sound to Light Modulator, Digital Millivoltmeter, Series 5000 Preamp (part 2).

February 1983
Features: Electronics in Farming, Column Loudspeaker Design, CP/M for the Apple II, ZX Interfaces, Hero Robot, Torch Computer Review, High Definition TV, Membrane Switches, VMOS, Into Digital (part 6).
Projects: Styrofoam Cutter, Audio Spectrum Analyser, Series 500 Preamp (Conclusion).

March 1983
Features: Voiceprints, Closed Captioning, dbx, Starlab, Zenith Computer Review, ZX 81 Printer Review, Chess Robot Review, Superfet, Into Digital (part 7).
Projects: Dual Logic Probe, Digital Kitchen Scales, Soundtrack.

May 1983
Features: Shockley, Using biFET and biMOS Op Amps, Surplustronics, Ace 1200, and Orange Peel Computer Reviews, History of Rada, Electromusic Techniques (part 1), Computing in Britain, Into Digital (part 9).
Projects: Graphic Equaliser, Digital Capacitance Meter, Audio Analyser (part 2).

June 1983
Features: Outdoor P.A., Instrumentation Techniques (part 1), TRS-80 Model 100 Computer Review, Saturn Up Close, Electromusic Techniques (part 2), Introduction to Microcomputers, Equal Tempered Scale, Into Digital (part 10).
Projects: Polyphonic Touch Organ, Tanover, Overload Indicator, Proximity Detector.

July 1983
Features: OKLO Natural Nuclear Reactor, MPU Support Chips, Light and Power From DC, Selecting a Computer System, Electronics in Fine Art, Commodore 64 Computer Review, TV Stereo Sound, Instrumentation Techniques (part 2), A Look At Cantel/Teleguide, Into Digital (part 11).
Projects: Satellite TV Receiver (part 1), Reverb Amp, Audio Oscillator, Bomb Drop Sound Effects.

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Toronto, Ontario
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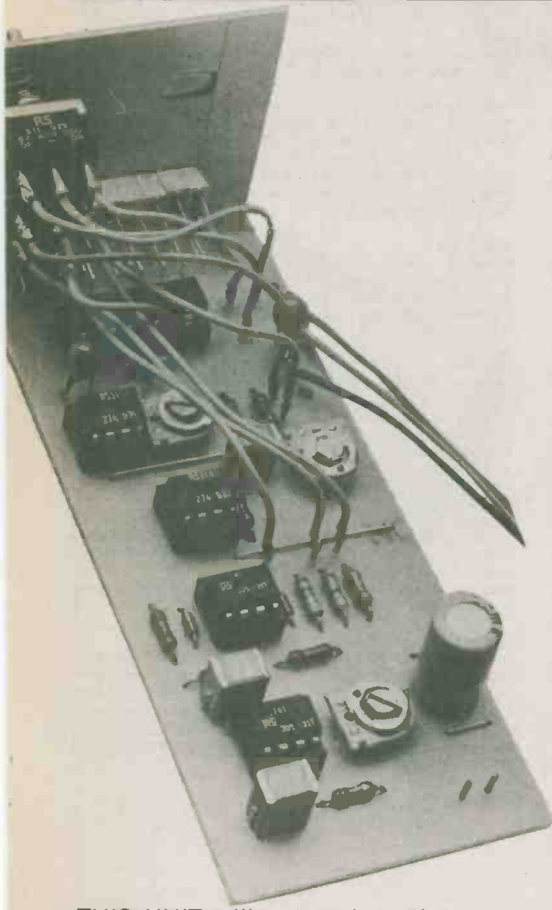
LED VU Meter

This meter can be adapted to various levels of operation and is an excellent way to watch what goes on in those secretive shielded cables.



THIS UNIT will not replace the conventional VU or PPM meter; no LED display could fulfill the spec. However, with an output in 3 dB steps and a choice of a dot or bar display, it will make a useful and attractive addition to any audio system.

5 Into 1 = 10

With the log function achieved directly inside IC5, the use of four separate op-amps to condition the signal may seem extravagant. However, the circuit design precludes the use of a conventional quad op amp package like the 324 and the final circuit exploits the good, all-round, economical performance of the 741s and the extremely high input impedance of the 3140s. The display consists of ten LEDs and these can be illuminated in a dot or bar format. Selection is by a SPDT switch, or a wire link may be permanently connected. Sensitivity of the unit is high. The gain of the first amplifier stage is adjustable and a full scale reading can be obtained with an output of just a few millivolts.

To keep down cost and avoid complex circuitry, a half-wave rectifier has been used. The meter has switchable resistors giving a peak programme response with fast attack and slow decay and a volume unit response with slower approximately equal response times. The response characteristics for each mode may easily be changed by selection of a few resistors and have little Interacton with each other.

Construction And Setting Up

Use of our PCB makes construction simplicity itself and results in quite a compact and attractive unit. The PCB has been designed to accommodate stackable rectangular LEDs as shown in our photos. However, any type and colour of LEDs may be used. There are only four wire links to be inserted and the remaining components may be inserted as they come to hand. It is good practice to leave the semiconductors until last and use of sockets for the ICs makes substitution for fault-finding easy. Although ICs 3 and 4 feature FET input stages, these are well protected and no special handling precautions are required.

When completed, the unit may be set up by short-circuiting the input and, with a DC-coupled 'scope or sensitive voltmeter connected to the output (pin 6) of IC4, adjusting RV2 until the output reaches 0 V. Then apply the maximum signal you wish to indicate and with the unit set to VU adjust RV1 for a full scale reading. Now switch to PPM and adjust RV3 until a full scale reading is just obtained.

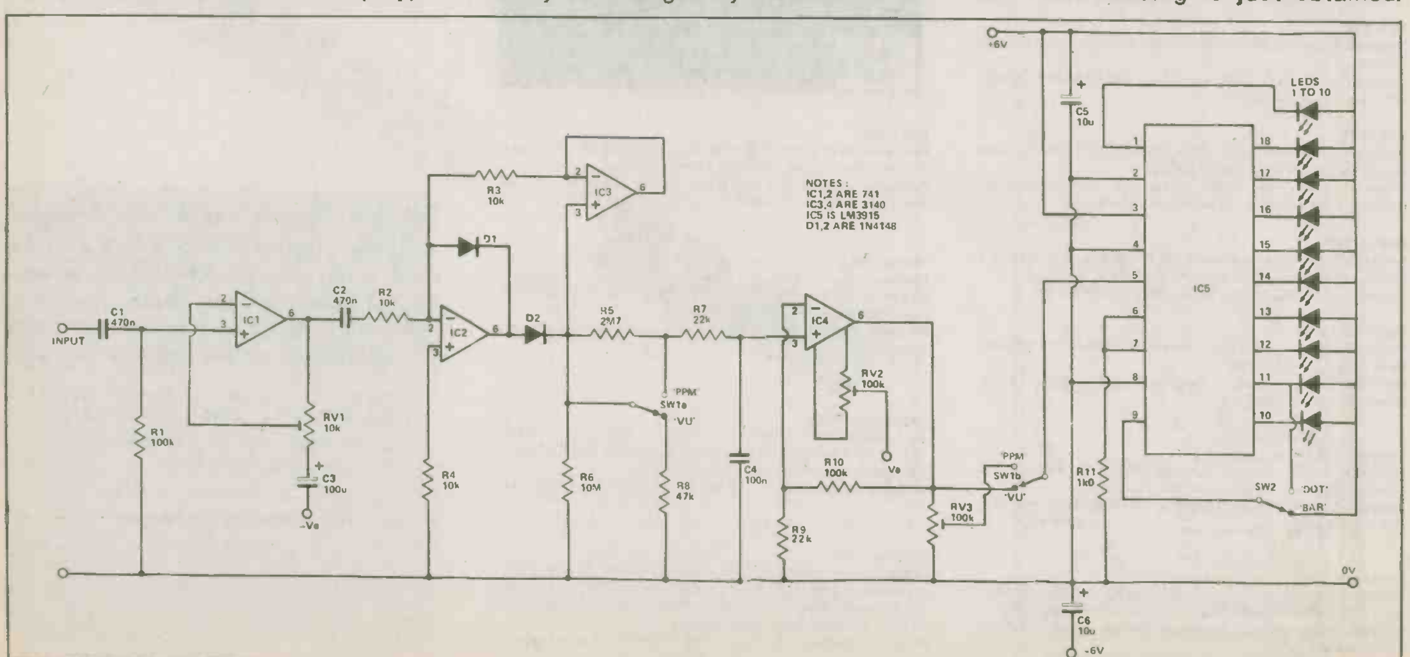


Fig. 1. The circuit diagram.

The unit will cover a wide range of input levels, though for very high input signal levels you may have to attenuate the driving signal. A simple resistive divider will easily accomplish this. Do yourself a favour and have a peak at better VU today.

Parts List

Resistors (all ¼ W, 5%)

R1,10	100K
R2,3,4	10K
R5	2M7
R6	10M
R7,9	22K
R8	47K
R11	1K0

Potentiometers

RV1	10K min horiz. preset
RV2,3	100K min horiz. preset

Capacitors

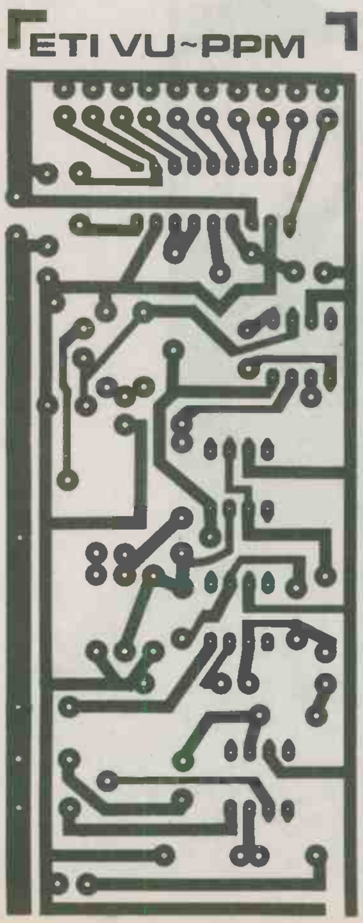
C1,2	470n polycarbonate
C3	100u electrolytic
C4	100n polycarbonate
C5,6	10u tantalum

Semiconductors

IC1,2	741
IC3,4	3140
IC5	LM3915
D1,2	1N4148
LEDs	any LED

Miscellaneous

PCB, DPDT switch, SPDT switch, connectors, etc.



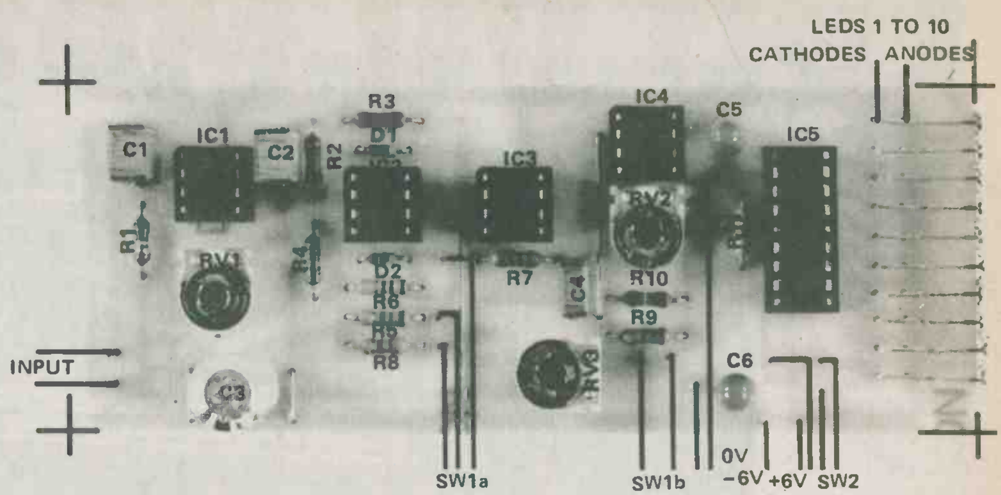


Fig. 2. Parts location.

How It Works

The circuit consists of an AC amplifier driving a half-wave rectifier whose output charges a capacitor via a switched resistor network. The charge on the capacitor is then amplified and drives the bargraph chip either directly or via a potentiometer.

The signal is input via C1 to the non-inverting input of IC1. Resistor R1 provides DC bias for IC1, which is connected as a variable gain AC-coupled amplifier. This arrangement avoids offset problems when the gain is increased which would severely limit the usefulness of the stage.

The output of IC1 drives the half-wave rectifier built around IC2. The circuitry here follows fairly conventional lines except for the inclusion of IC3 in the feedback loop. Use of this BIFET chip with its negligible input current enables high values of resistance and a low value (100n) of storage capacitance to be used with the consequent advantage of a relatively low current drive producing a high rate of voltage change. Without IC3 in circuit and with SW1a in the 'PPM' position, C4 would charge quickly via R7 but would discharge almost as fast through R7 and R3. In the final circuit, the charge path is via R7, but the discharge path is via R7 and R6, giving a fast attack and slow decay time. Diode D1 acts as a clamp for a positive input and prevents IC2 from going into saturation. In the 'VU' mode, C4 charges via R5 and R7 and discharges through R5, 7, 6, 8. The ratios of these resistors produce almost equal attack and decay times.

As any load on C4 would interfere with the time constant of the RC network, another BIFET op-amp is used as a non-inverting amplifier with a gain of about five. Offset adjustment is provided for this stage with RV2; enabling the output to be accurately zeroed. Owing to the greater insertion loss of the RC network in the 'VU' mode, RV3 is included so that a full scale reading can be obtained for the same overall input level in both modes.

The bargraph chip IC5 handles the display. The input signal from SW1b is applied to pin 5, about 1V2 gives a full scale reading. The internal resistor chain gives an output in 3 dB steps; the ten LEDs providing a 30 dB range, a ratio of 32:1. No attempt has been made to 'tailor' the response of this chip as the LM3916 with an internally set VU response should be available in the future. It will probably be a pin for pin, plug-in replacement. Current through the LEDs is set at about 10 mA by R11 and capacitors C5, 6 provide decoupling.

A power supply of plus and minus six volts is recommended. A lower voltage may restrict the output swing of IC4 making a full scale reading unobtainable in the 'PPM' mode. Too high a positive supply may result in destruction of IC5 through excessive dissipation. Absolute maximum dissipation for this chip is 660 mW. If you use a positive supply greater than 6 V then the LEDs should be returned to the positive supply via a dropper resistor or a zener diode. IC5 produces either a 'dot' or 'bar' display depending on the connection of pin 9 to pin 11 or to the positive supply. Although SW2 is shown on the circuit diagram, the connection may be made permanently with a wire link.

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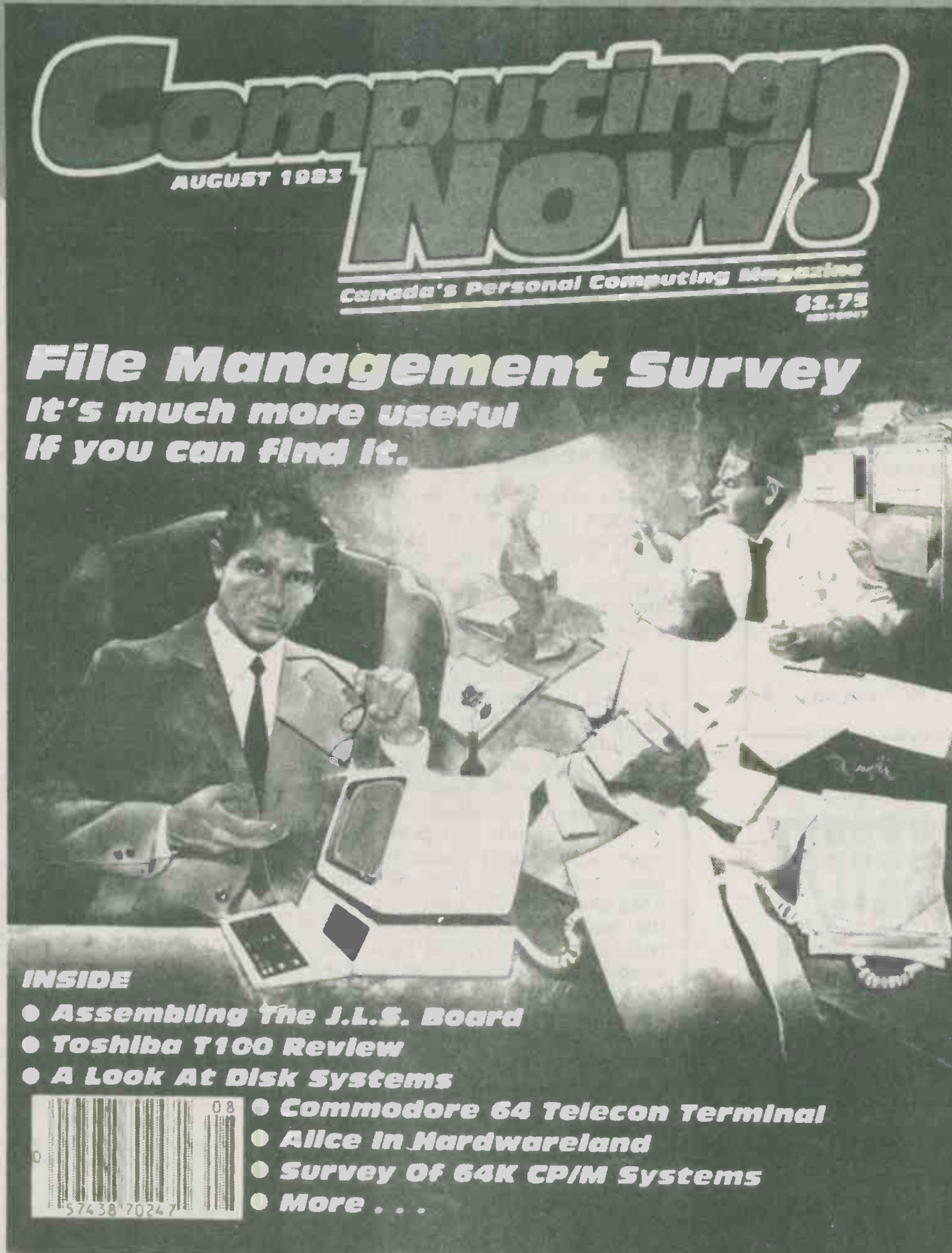

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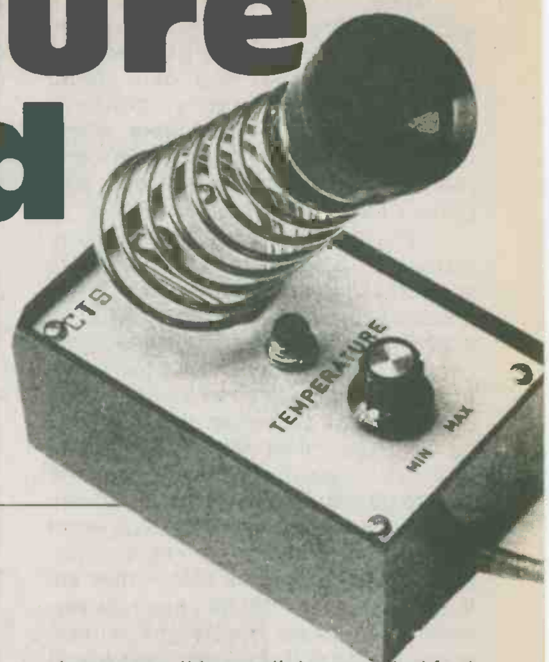
Temperature Controlled Soldering Iron



Tame your soldering iron with this ingenious temperature controlled soldering station

A MAJOR FACTOR in the art of soldering concerns the ability of your soldering iron to do its job. For instance, if the iron is a high wattage type, say 100 watt, it obviously shouldn't be used to solder sensitive ICs into circuit (you may even find it lifts the track from the board because of the intense heat — never mind damaging the ICs!). Likewise, if the iron is only a 15 watt job, then it won't have the necessary power to solder components onto a hefty ground buss.

There are two ways in which an efficient level of soldering can be obtained — either use a specific iron for a corresponding job (which means you need a selection of three or four irons) or use a temperature controller which heats the iron to the correct temperature for any chosen use. It is a well documented fact that good control over soldering tip temperature not only improves the quality and integrity of soldered connections but also greatly increases efficiency and extends tip life, while reducing troublesome oxide buildup on the tip.

How It Works

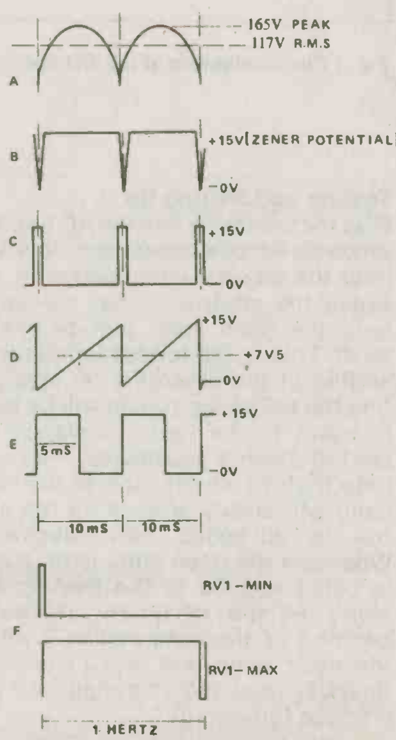
The incoming line voltage is switched via SW1 which is integral with the temperature control RV1. The line voltage is then full wave rectified by D1-D4. The resulting pulsating DC (illustrated in waveform 'A') can deliver the same heating power to a resistive element as 120V AC. The pulsating DC will heat the soldering iron element and illuminate the neon whenever the silicon controlled rectifier SCR1 is gated on by the combined logic of IC1 (1 hertz variable duty cycle multivibrator) and IC2 (zero voltage crossover detection and SCR gate driver). Without gate drive SCR1 will cease to conduct each time the pulsating DC returns to 0V.

The line potential pulsating DC is dropped via R1 and R2 and clamped to a pulsating +15V via ZD1. Waveform 'B', which is produced by the clamping action of ZD1 also pre-regulates the supply voltage for the integrated circuits. D5 prevents the power supply filter capacitor C1 from filtering out the sync pulses.

IC1 and the associated components form a variable duty cycle astable multivibrator with a frequency of 1 Hz.

At the fully counter-clockwise position of RV1, the output of this astable is low (logic 0) for 99% of the 1 second period. At the fully clockwise or maximum setting of the RV1, the astable output is high (logic 1) for 99% of the period. Waveforms 'F' show

MEASURED BETWEEN COMMON (-Vcc) & POINTS INDICATED.
WARNING: COMMON IS AT LINE POTENTIAL ABOVE GROUND.



these two modes. Mid-positions of RV1 produce outputs which vary between these two extremes. In summary, the setting of RV1 will vary the ratio between the logic '1' state and the logic '0' state (duty cycle) without appreciably altering the period of the complete cycle.

The line synchronisation signal illustrated in waveform 'B' is coupled to the input of IC2a via voltage divider R8 and R9 which protects IC2a from the sync signal which is a slightly higher in potential from IC2's operating supply. IC2a inverts the line sync signal shown in waveform C and improves the transition between the logic levels. IC2b, c and d serve as a logic AND gate i.e. only when its two inputs (pins 5 AND 6) are at logic 1, will the output (pins 10 and 11) be at logic 1.

Therefore, whenever the line sync pulse is at 0V (logic 0 inverted to logic 1 by IC2a) and the output of the proportionally controlled astable is at logic 1, a pulse is applied to the gate of the SCR. This applies power to the soldering iron element in fully controlled bursts.

The combination of all sections described above results in SCR1 being gated on only near zero crossings of the line voltage. This eliminates RFI. The on-off ratio and therefore the soldering iron temperature is proportional to the setting of the temperature is proportional to the setting of the temperature control RV1.

Now, all this sounds great. All you have to do do is rush out and buy yourself one of these tremendous gadgets and then you can solder away to your heart's content, whatever the job. But here's where you will hit a slight problem. A complete soldering system will cost you quite a few weeks' pocket money.

One simple alternative to holding up the local bank is the ETI temperature controlled soldering station, which will enable you to convert any 15-100 W soldering iron to a fully controlled iron, capable of intermittent hobby use to full time production use, as well as providing a convenient soldering stand. (If you have a choice, most electronic soldering applications are best handled using a 40 watt to 60 watt iron with this controller).

The 4000 series CMOS ICs were selected for their cheapness and versatility and to give the electronics enthusiast some insight into just how versatile these ICs are. The design has incorporated zero voltage switching which eliminates radio frequency interference (RFI) caused by phase control of line voltage and the potentially destructive spikes created by thermostatically or 'magnetically' controlled soldering irons. The soldering iron temperature can be varied from full off to full on while the iron is in use. A visual indication of controller operation is also provided.

The output waveform consists of controlled bursts of pulsating DC and is, therefore, suitable for resistive element soldering irons only. (Soldering irons or guns that use transformers cannot be used with the project). This waveform was selected to simplify power supply design, reduce internal power dissipation and eliminate costly sensitive-gate triacs which would be required for direct interface with CMOS logic.

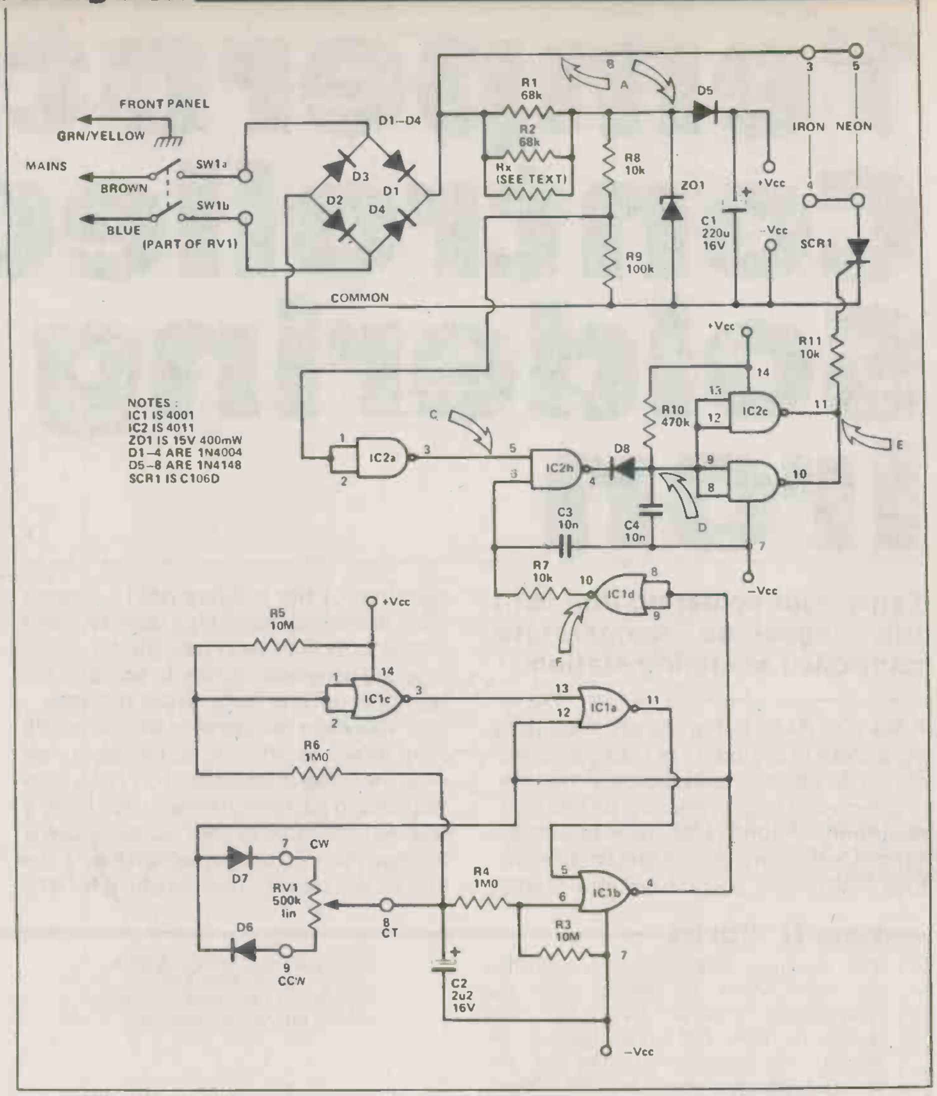


Fig. 1 Circuit diagram of the ETI Soldering Station.

Construction

Construction is reasonably straightforward — start with the PCB. Nothing special here, just remember to mount R1 and 2 (along with Rx if used) about three or four mm from the board, to help heat dissipation.

Remember that IC1 and 2 are CMOS and we advise the use of IC holders (not essential, but helpful). Next, mount the spring and holding bolt, neon and RV1 on the front panel and follow the wiring diagram of Fig. 3 to connect up your soldering station.

The cable ties at the line input and iron output grommets are necessary to avoid strain on the cable connections. The PCB simply slides into one of the grooved slots in the case, eliminating the use of special mounting procedures. Finally, make sure that the ground connection on the front panel is a good one.

Testing and Setting Up

Plug the controller into the AC line. Advance the temperature control clockwise until the power switch clicks on. Advance the control further clockwise until the neon lamp just begins to flash. This is the lowest temperature setting of the controller. At this setting the soldering iron tip will be barely warm to the touch. Advance the control further clockwise. You will note that the on-off ratio of the neon lamp will slowly change as the control is advanced fully clockwise. Whenever the neon lamp is lit, power is being applied to the heating element. At the maximum clockwise position of the temperature control, the neon lamp will remain on continuously and the soldering iron will produce full output.

The controller takes advantage of the 'thermal mass' of the soldering iron in maintaining a reasonably constant temperature at the tip (the larger the iron, the better the regulation). Any fluctuations in tip temperature due to increased or decreased loading can be easily compensated for by adjusting the temperature control as required. If the neon lamp comes on at full intensity at the full counter-clockwise position and does not flash on and off, the wires to the 100k potentiometer (R3) are probably reversed.

Warning

The circuit described here does not use an isolation transformer and therefore all sections of the circuit must be considered dangerous.

It is advisable not to operate the device without its case.

NOTE:
Rx — Install an additional 33k 1 Watt resistor if the line voltage in your area falls below 110 volts.

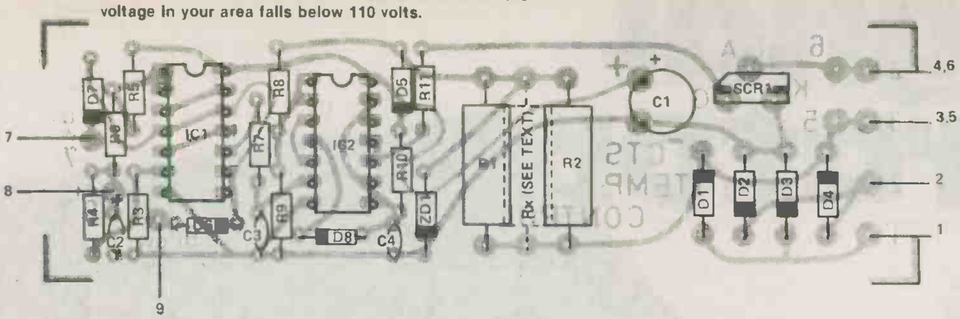
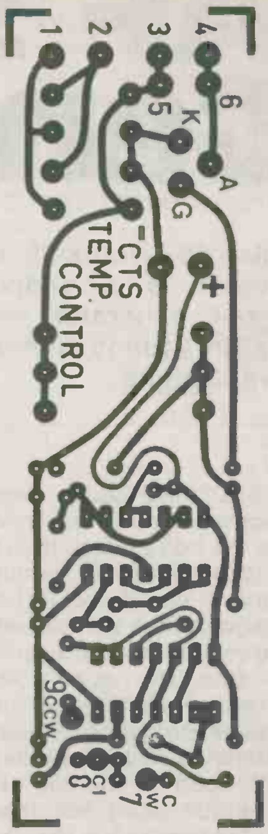


Fig. 2. (above) Overlay diagram for the Soldering Iron controller.



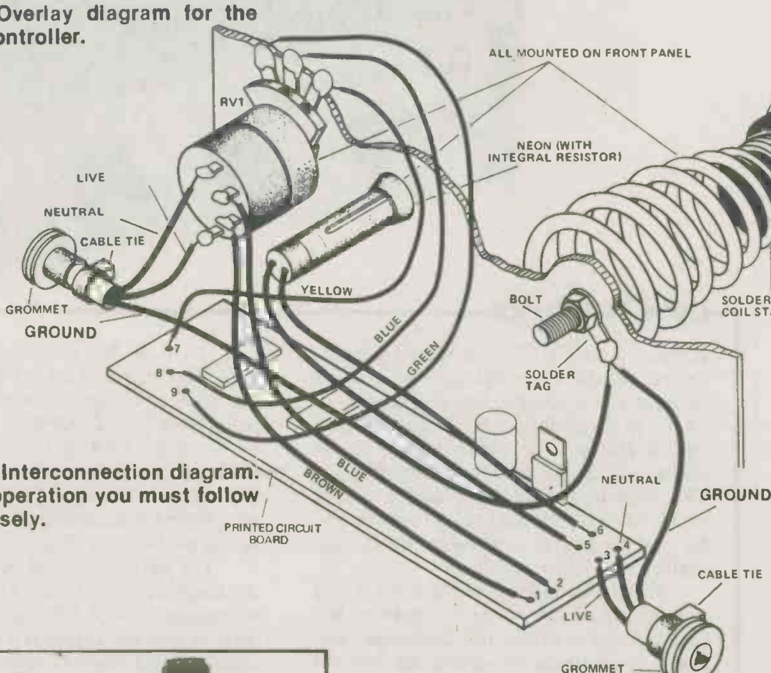
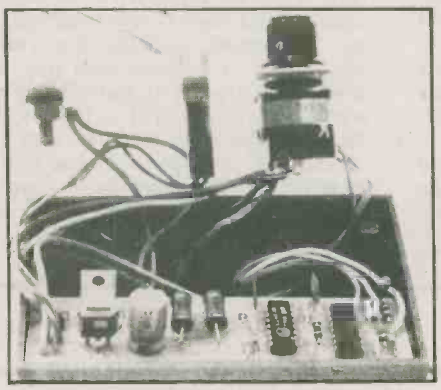
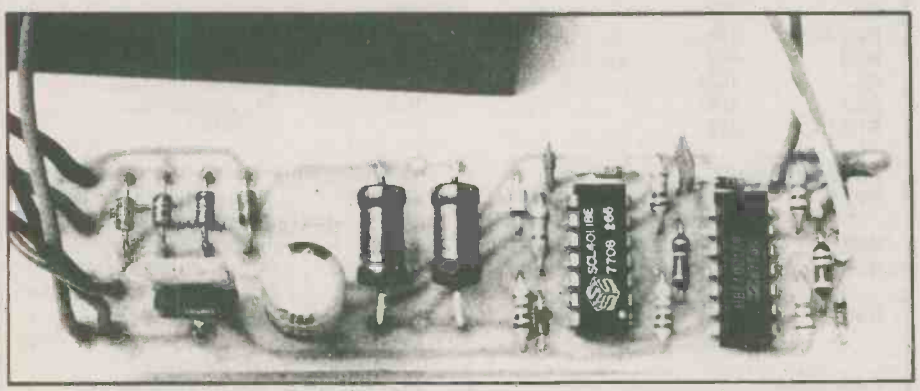


Fig. 3 Wiring the interconnection diagram. To ensure safe operation you must follow this diagram closely.





Parts List

RESISTORS (All ¼W, 5%, except where stated)

R1,2,x	33k 1 watt
R3,5	10M
R4,6	1M0
R7,8,11	10k
R9	100k
R10	470k

POTENTIOMETERS

RV1	500 k lin with double-pole, single-throw switch

CAPACITORS

C1	220u 16 V printed circuit mounting electrolytic
C2	2u2 16V tantalum
C3,4	10n ceramic

SEMICONDUCTORS

IC1	4001 quad NOR gate
IC2	4011 quad NAND gate
ZD1	15V 400 mW zener diode
D1-4	1N4004
D4-8	1N4148
SCR1	C106D

MISCELLANEOUS

Spring mount for soldering iron
Neon with integral resistor
Knob for potentiometer
Case to suit
Grommets and cable clips
Heavy weight (for bottom of case)

AF Signal Generator

This do-it-yourself test gear project is a simple-to-build signal generator with many features found on more expensive designs.

THERE IS NO doubt; if you dabble in electronics much and build more than just the odd project, then test gear of all descriptions is a must. Furthermore, if the project is in the audio category, then somewhere along the line you will need an audio source.

Of course, using a bit of ingenuity, the clever ETI reader might use the auxiliary output of a stereo system as a signal, but there are disadvantages with such a method: neither the amplitude (size) nor the frequency (pitch) of the signal can be accurately specified. What you really need is a signal generator like this project, providing a selection of waveforms (sine, triangular or square) with fully variable amplitudes with the added facility of a controllable DC bias to the output signal. All this is achieved with only a two-IC circuit which operates from two 9V batteries.

Construction

There is nothing critical in the construction of this project if you use our design of printed circuit board. Everything is quite straightforward. Solder in resistors first, followed by capacitors and IC sockets and finally insert the two ICs.

Following the connection diagram in Fig. 2 you should now connect the switches, potentiometers, battery clips and output sockets and test out the project before insertion into its case. Set all presets and pots to midposition and switch on. By connecting the output to a suitable amplifier (e.g., your stereo system), adjust the output to a suitable level using the amplitude control, RV6.

Now, turn SW1 to 'sine' and open SW3 (i.e., switch off the DC bias). Adjustment of RV4 and RV5 should remove any distortion and a perfectly 'clean' note should be heard. Turn the frequency control RV2 fully anti-

How It Works

Integrated circuit IC1 is a special purpose device, capable of generating sine, triangle or square waveforms (or derivations of these), to a high accuracy. The frequency of the waveforms is primarily defined by the charge and discharge rate of capacitor C2. This capacitor should be, ideally, a type whose value is very stable with temperature, e.g., a mica type, although others are usable, with lower accuracy.

The charge rate of the capacitor is also a function of the value of resistor R3. Likewise R4 controls the discharge rate. For a symmetrical waveform R3 and R4 should be of equal value. Preset RV3 allows adjustment of these two resistors to ensure that the charge rate of the capacitor exactly equals the discharge rate and so the waveform is symmetrical.

The voltage at pin 8 of the integrated circuit also controls the frequency of the generated waveform (over a 1000:1 range). Thus, by sweeping the control voltage on this pin between Vcc and (⅔ Vcc + 2V) i.e., 5 to 9 V, the frequency of the waveform varies from 20 Hz to 20 kHz. The control voltage is derived from potential divider RV1,2 and R1.

Presents RV4 and 5 allow sine wave distortion to be minimised to only 0.5%, and this is best achieved by listening to the sine wave and adjusting the two presets until distortion is no longer audible.

The outputs of this integrated circuit are found at pins 2 (sine), 3 (triangular) and 9 (square). Switch SW1 selects one of the wave shapes and connects it to the amplifier circuit of IC2, via RV6, the amplitude control. The amplifier is configured as a mixer, although in its simplest mode (i.e., with SW3 open) the IC is just an inverting amplifier, whose output is centred symmetrically about 0V. However, with SW3 closed, a DC bias voltage is mixed with the waveform and the output can be moved up or down in voltage, still having the same AC amplitude.

Parts List

Resistors (All ¼W, 5%)

R1	18k
R2,7,9	10k
R3,4	4k7
R5	10M
R6,8	15k
R10,13,14	47k

Potentiometers

RV1,3	1k0 miniature horizontal preset
RV2	10k linear potentiometer
RV4,5	100k miniature horizontal preset
RV6	100k logarithmic potentiometer

Capacitors

C1,3,4	100n ceramic
C2	4n7 mica

Semiconductors

IC1	8038 waveform generator (Exar)
IC2	741 operational amplifier

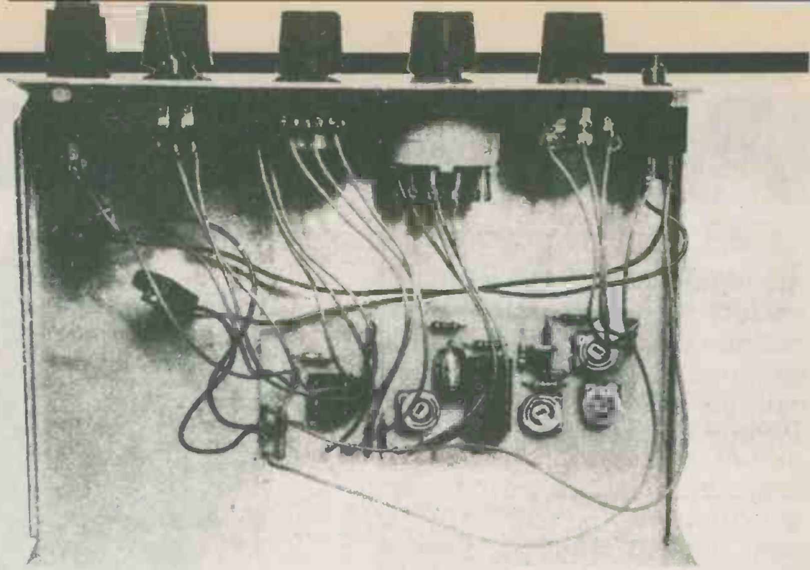
Miscellaneous

SW1	single-pole, three-way rotary switch
SW2	double-pole, single-throw toggle switch
SW3	single-pole, single-throw toggle switch

Case to suit
Battery clips and batteries
Knobs, output sockets, IC sockets

clockwise to its lowest frequency setting and adjust RV1 until the lowest note possible from the generator is heard. One further adjustment can be made with RV3 if you have an oscilloscope; varying the preset will alter the duty cycle (best observed on square wave) which should be 50%; i.e., high for half the wavelength and low for the other half. If you don't have the use of a 'scope leave this preset at midposition and the adjustment won't be far out.

Finally the project can be housed in a suitable case.



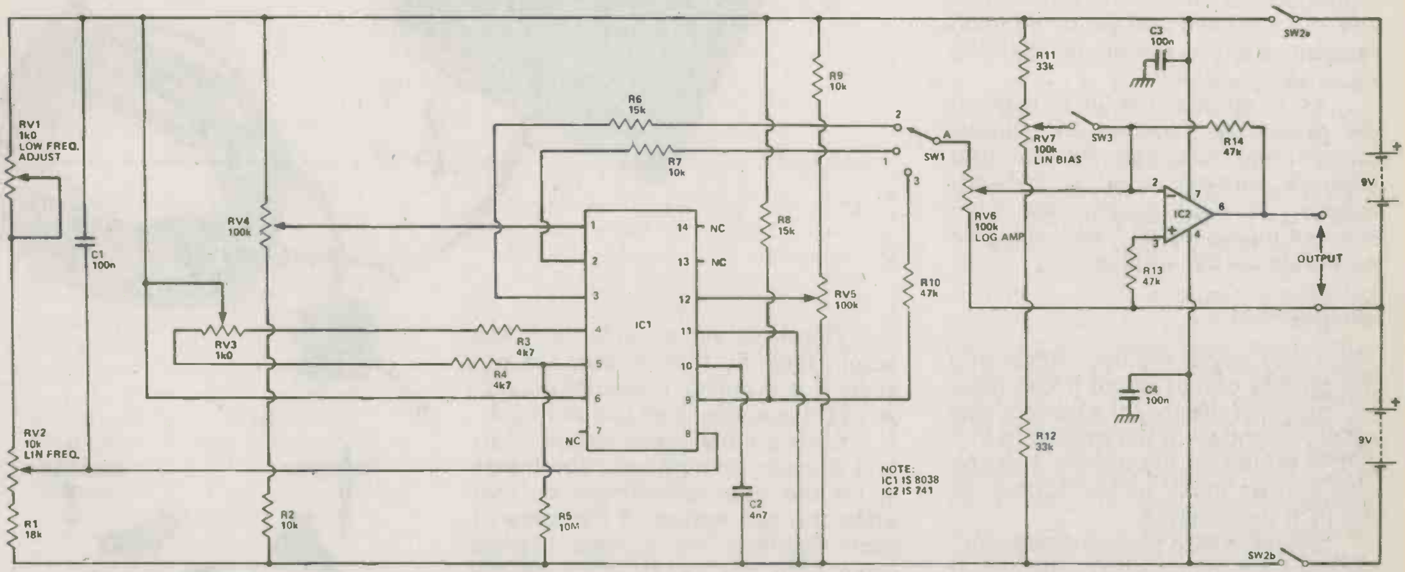


Fig. 1 The Audio Signal Generator circuit diagram.

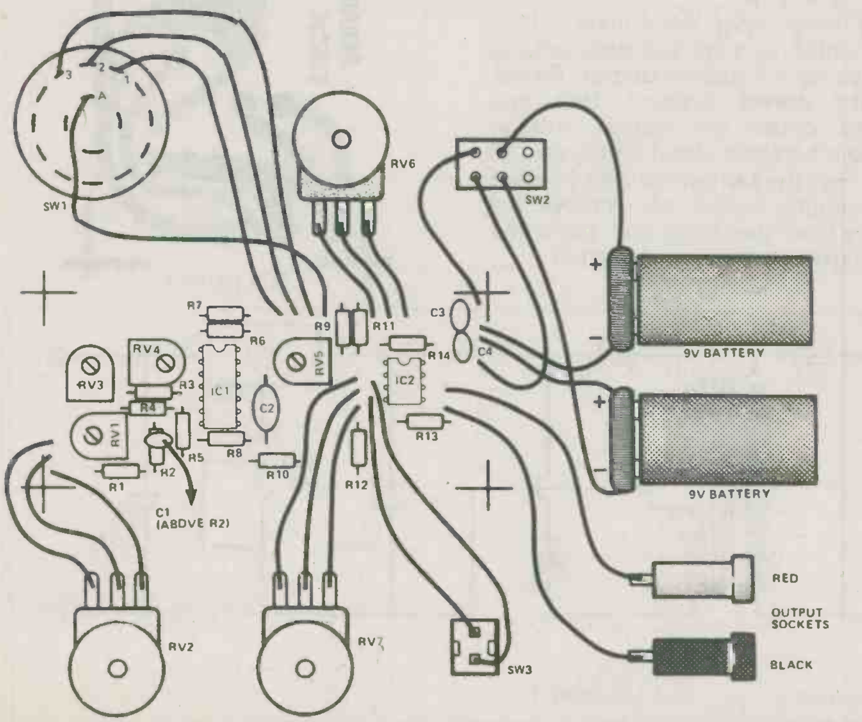
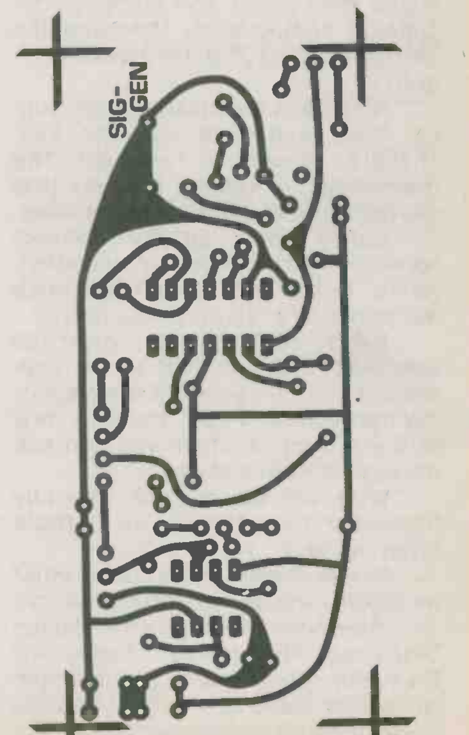


Fig. 2 Overlay of the PCB and connection details of the Audio Signal Generator.

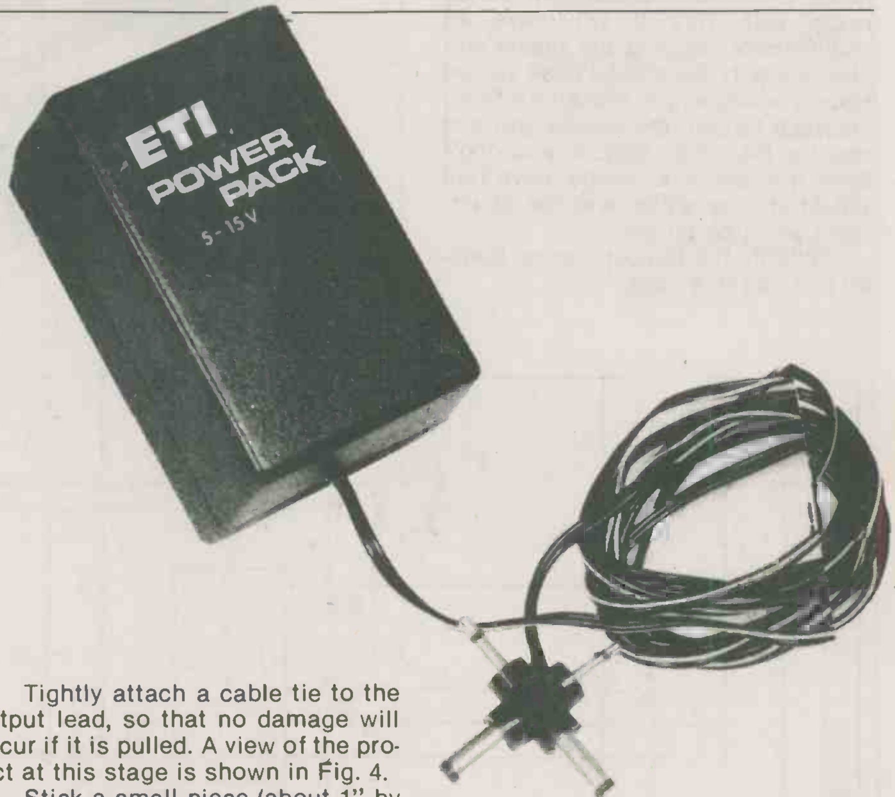


The foil pattern of the Audio Signal Generator.

2

Power Pack

An ideal project for users of battery-powered calculators, radios, cassette players etc., because the ETI Power Pack can be adjusted to give the voltage you require.



OUR CIRCUIT (Fig. 1) gives a regulated output of between 5V and 15V DC, adjusted and set by a preset resistor. Current output is anything up to about 350 mA.

An integrated circuit is used in the project to regulate the output voltage and although this IC (the 7805) is normally used in a fixed-voltage (5 VDC) supply we have adapted the circuit so that it will give a variable output voltage.

Construction

Insert and solder the two diodes into the printed circuit board (PCB) making sure that they are the correct way round, as shown in the overlay in Fig. 2. The bodies of the diodes must be mounted as close to the surface of the PCB as possible.

Solder in PCB pins wherever connections are to be made to the circuit board, then insert and solder all remaining components, following the overlay diagram. Clip the heatsink on to IC1.

Now open the plastic power supply case and take out the sub-chassis. Break or cut off the transformer mounting lugs so that the transformer will fit into the case.

Using good quality contact adhesive and following manufacturers' instructions as to use, stick the transformer to the sub-chassis.

Next, using the contact adhesive, stick the PCB to the sub-chassis to fit underneath the edge of the transformer. Fig. 3 shows a view of the project in which you can see the details at this stage.

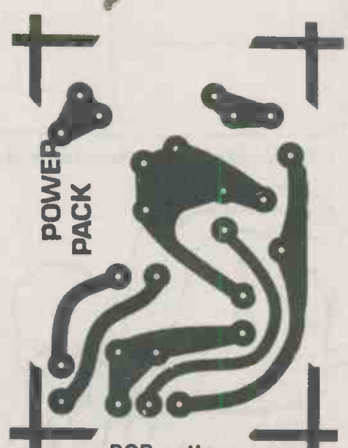
Wire up the project carefully following the connection details given in Fig. 2.

Solder leads to the transformer terminals, inside the power supply case, and bend the leads up to the top of the case. Refit the sub-chassis and then solder the remaining ends of the AC power leads to the PCB and the transformer, where shown in Fig. 2.

Tightly attach a cable tie to the output lead, so that no damage will occur if it is pulled. A view of the project at this stage is shown in Fig. 4.

Stick a small piece (about 1" by ½") of foam sponge onto the inside lid of the case, positioned so that when the two halves of the case fit back together, the sponge pushes down onto the transformer, preventing movement.

Finally, plug the supply into a wall outlet, turn on, and measure the voltage at the supply output. By adjusting preset resistor RV1 you should obtain an output voltage variable between about 5 VDC and 15 VDC. Set the output voltage to what you require, switch off, remove the supply from the outlet and screw the two halves of the case together.



PCB pattern

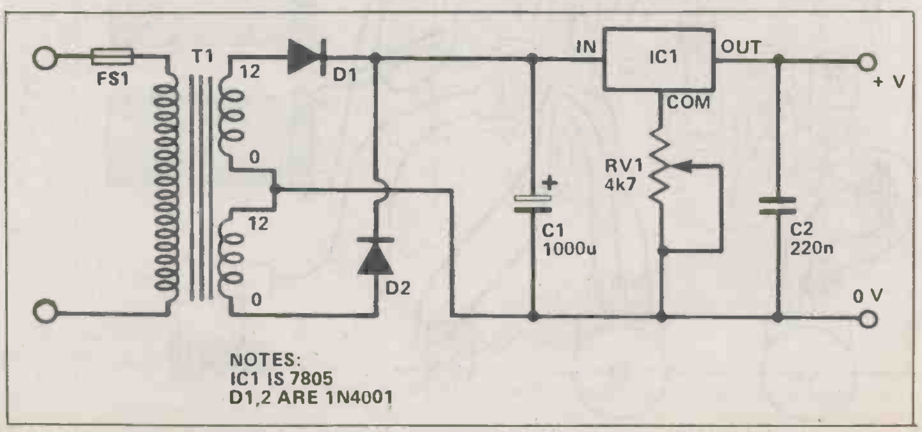


Fig. 1. Circuit of the Power Pack.

Parts List

POTENTIOMETER

RV1	4k7 miniature horizontal preset

CAPACITORS

C1	1000u, 25V electrolytic
C2	220n polyester

SEMICONDUCTORS

IC1	7805, 1A voltage regulator
D1,2	1N4001, 1A diodes

MISCELLANEOUS

T1	0-12-0-12V, 6VA miniature transformer

Printed circuit board mounting fuse clips

FS1	500 mA, fuse

Case.

How It Works

The workhorse of this project is a voltage regulator integrated circuit which sets the output voltage (V_{OUT}) to a value determined by the setting of the preset resistor.

The input voltage (V_{IN}) comes from the rectified output of transformer T1. Diodes D1 and 2 give full-wave rectification of the 12 VAC transformer output.

Capacitor C1 provides smoothing of the rectified voltage and V_{IN} will be about 18 VDC.

Integrated circuit IC1 is a 5V voltage regulator, and whatever the output voltage of the circuit, V_{REG} will always be 5 VDC.

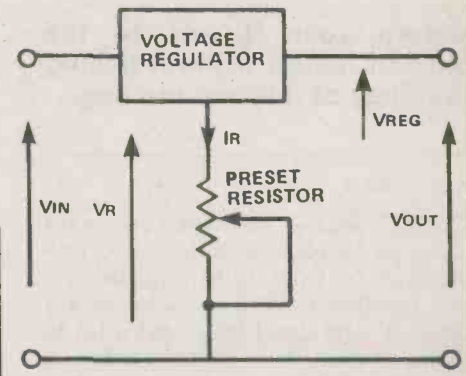
The value of current I_R, is 1.5 mA for IC1 (from manufacturers' data) so we can calculate the voltage across the preset resistor from Ohm's law. For example, if the value of the preset is 1k0 then:

$$V_R = 1.5 \text{ mA} \times 1000, = 1.5 \text{ V}.$$

The output voltage is simply the sum of the two voltages, ie,

$$V_{OUT} = 1.5 + 5 = 6.5\text{V}.$$

Thus, by varying the value of the preset resistor the output voltage can be varied.



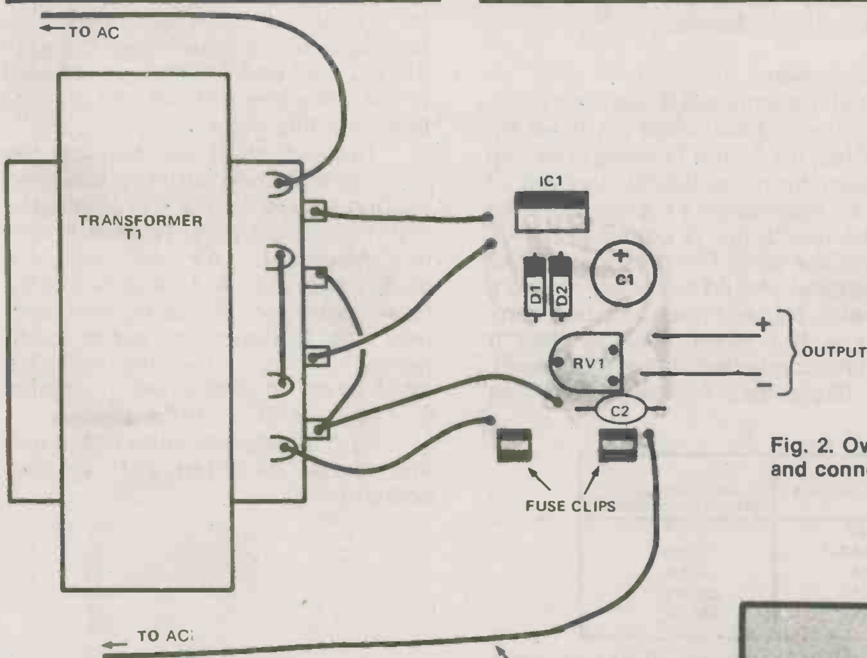


Fig. 2. Overlay of the PCB for the project and connection details.

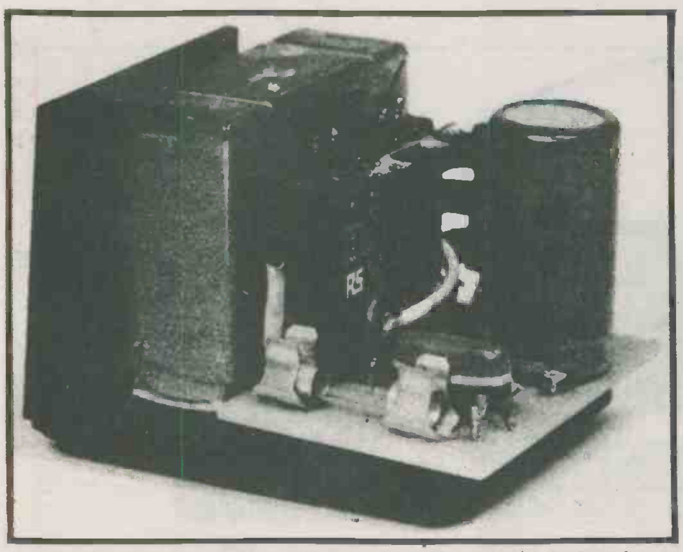


Fig. 3. View of the project fitted to the sub-chassis, before insertion into the case.

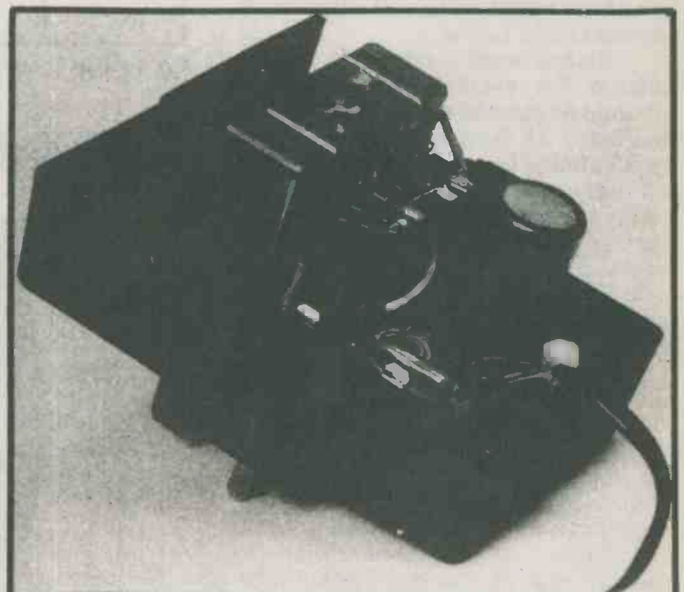
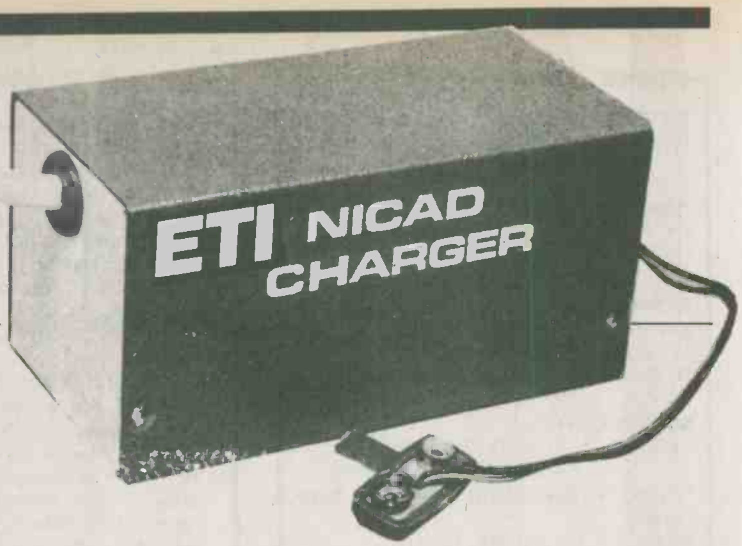


Fig. 4. Internal details of the Power Pack.

Ni-Cad Charger



Return your Nicads to the glow of health without risking the glow of internal melting.

ISN'T IT SAD — just when you want to listen to your favourite radio programme on your little squawk-box, you inevitably find the batteries are defunct. And don't they cost a lot to replace? Well, here is the answer to all your problems — rush out and buy some nicad cells for your battery-powered calculator, transistor radio or cassette player etc. Although they are more expensive initially, you can recharge them again and again on the ETI Nicad Charger, thus saving $$$$$s overall! With this project, whenever your batteries run down an overnight charge will revitalise them to their full vigour.

Nicad cells can be recharged many hundreds of times but they need a regulated charge current. Our charger provides this regulation and, in the mode shown in Fig. 2, it will handle up to six AA size cells. It can be easily modified to suit other sizes as described below.

Nicads need a constant current charge. For example AA cells need about a 65 mA charge, for a set period (normally 12 hours and so an overnight charge is ideal). For other sizes of cells, different charge currents are required. The table in Fig. 1 shows typical values of current required for various-sized cells. Altering our charger to suit other cells is a cinch, as the output current is set solely by R1.

Its value in ohms is equal to:

$$\frac{0.65}{\text{the required charge rate in amps.}}$$

So, for any required charge current, choose the nearest preferred value of resistor to the calculated value.

Output currents of more than 80 mA will require a larger transformer because this should have a secondary current rating at least 20 mA more than the charge current. Higher charge currents might also make it necessary to fit Q1 with a more substantial heatsink.

Construction

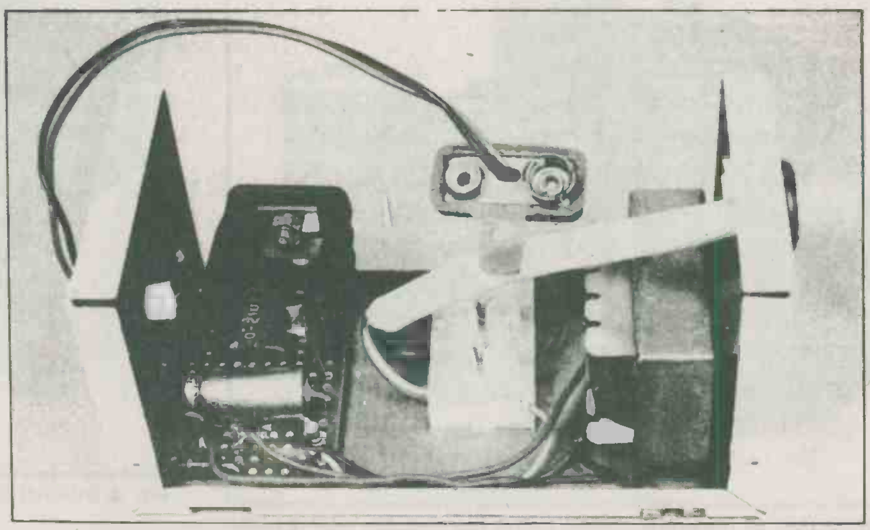
The components are mostly assembled on one standard-size (24 holes by 10 strips) 0.1" pitch Veroboard as can be seen from the wiring diagram of Fig. 3. Transformer T1 is not mounted on the board, but is bolted to the inside of the case. For reasons of safety the case should be a type having a screw-on lid, and must not be a clip-on type. If a metal case is uned it must be connected to the AC ground. It is likely that T1 will have flying leads rather than tags, and a connector block will then be needed to facilitate the connections between the AC cord and T1. The ground lead to the component panel can also be taken via this block.

The output of the unit can be taken to a 9V type battery connector, making quite sure that it is connected with the correct polarity. Plastic battery holders for AA size cells are readily available, and these have a 9V type connector. These holders connect the batteries in series (connected '+' to '−') — the batteries must never be connected in parallel ('−' to '−' and '+' to '+').

Q1 may become quite hot in use and should be fitted with a small heatsink.

SIZE OF CELL	CHARGE CURRENT (FOR 12hr CHARGE)
9V	100mA
AAA	20mA
AA	65mA
C	250mA
D	500mA

Fig. 1 Table of charge currents for various cells.



The interior of the charger

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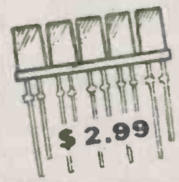

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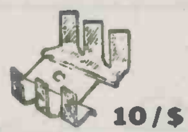

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How It Works

The line voltage is stepped down to a more suitable potential by transformer T1, with D1, D2, and C1 then full-wave rectifying and smoothing the output of T1 to give a low voltage (about 14V under load) DC supply. This supply cannot be connected directly across the nicad cells as these have an extremely low internal resistance, and would place virtually a short circuit across the supply. The supply in turn would damage the cells, which should not be charged at a higher current than that recommended by the manufacturer, and would also result in the destruction of the supply circuit!

A current regulator must be included to ensure that the cells are charged correctly, and this is the purpose of Q1, Q2, R1 and R2, which are used in a conventional constant-current generator configuration. Transistor Q1 is biased hard into conduction by R2, and current therefore flows through R1, Q1 and the cells being charged. The current is limited to a safe level by Q2 which becomes biased into conduction by the potential developed across R1. This results in Q2 tapping off some of the base current for Q1, so that the impedance of Q1 increases.

Therefore, even with a low impedance across the output, such as that of the nicad cells, the output current passed by Q1 is stabilised by Q2 at a safe level, since Q2 can reduce the bias on Q1 to practically zero if necessary. As Q2 is a silicon device it requires a base bias voltage of about 0.65 V to bring it into normal conduction, and so the circuit stabilises with about this potential across R1. From Ohm's Law it can be seen that about 65 mA flows through R1, Q1, and the cells under charge (0.65 V divided by 10R gives 0.065 A, or 65 mA), which is about the correct charge for AA size cells.

Parts List

RESISTORS (All ⅓ watt 5%)

R1	10R
R2	680R

CAPACITOR

C1	100u 25V electrolytic

SEMICONDUCTORS

Q1	TIP41A NPN power transistor
Q2	MPS6515 NPN Transistor
D1,D2	1N4002

MISCELLANEOUS

T1	12-0-12V 100mA transformer

10 x 24 hole 0.1" Veroboard case, battery holder, battery clip, AC cord, connector block, fitted heatsink, etc.

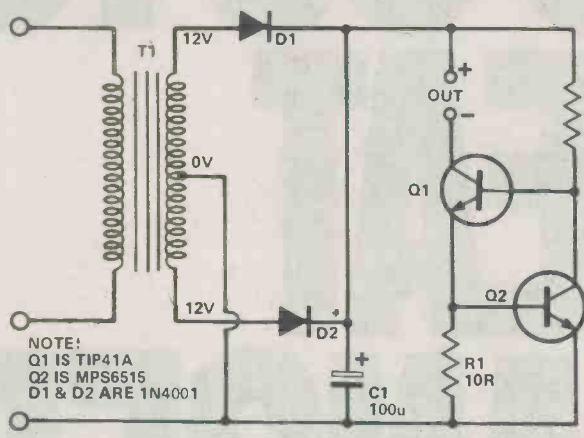

Fig. 2 Circuit diagram.

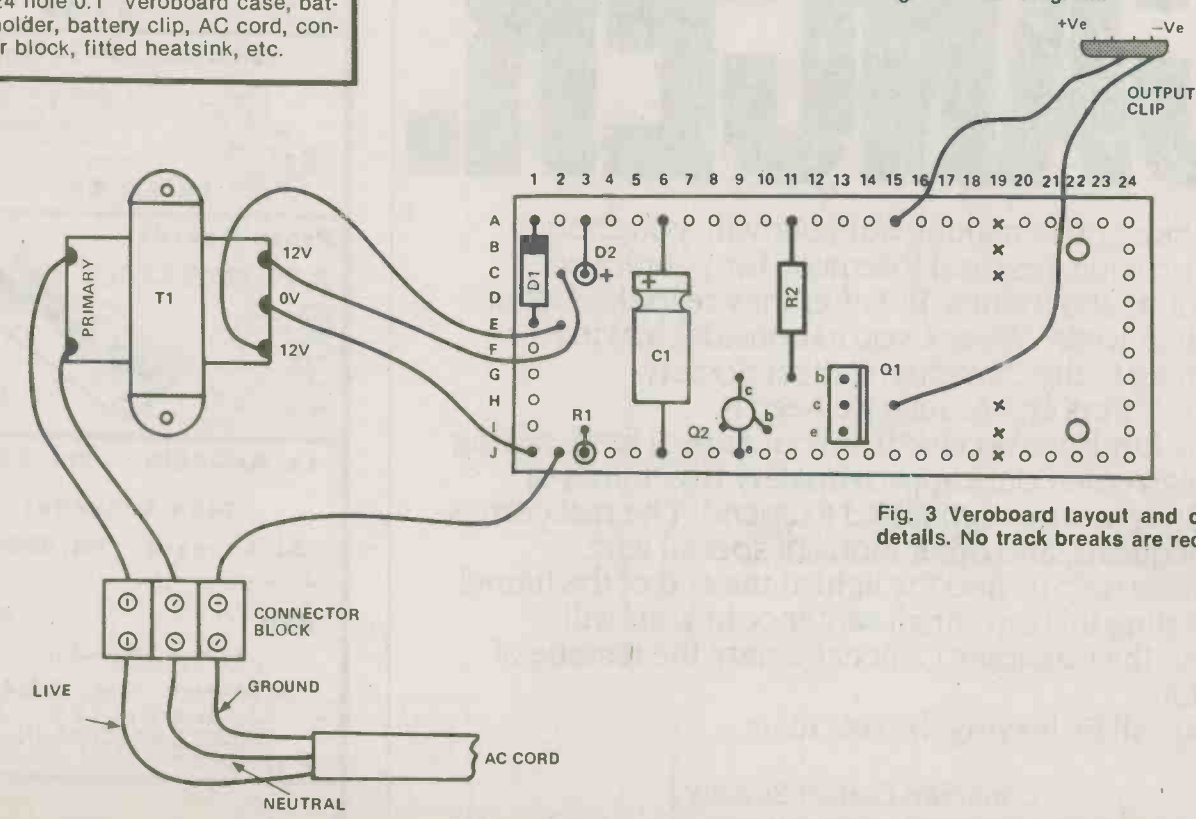

Fig. 3 Veroboard layout and connection details. No track breaks are required.

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Bench Power Supply Unit

Designed with the beginner in mind, this bench power supply unit combines high performance and quality and yet is simple to build.

TEST AND EXPERIMENTAL equipment remains perhaps one of the most popular project areas in electronic hobbyist magazines. Rightly so, of course — the home constructor would find it difficult to build and test his projects without test gear — and the most fundamental piece of equipment (bar a test meter) is arguably a power supply. The beginner naturally uses dry cells as a power supply for his first few projects, but eventually there comes a time when his requirements are for a voltage which is impossible to obtain with batteries (eg 20 V) or a higher current than batteries can supply (e.g. 1 amp).

Bear in mind that a good power supply unit is worth its weight in gold. Consider this: you would only have to purchase 30 or 40 x 9V cells at today's prices and the power supply would be paid for!

And so the scene is set! Enter from the wings to rapturous applause the PSU, a power supply with six switched output voltages (although you can adapt to a fully variable 1V5 to 20V supply if you wish). One simple, three terminal integrated circuit, (the LM317K) does all the hard work and it features a maximum output current of 1.5 amps, more than adequate for 99% of projects. The IC is called a voltage regulator and this particular variety has been around for three or four years now. That must say something for its quality and reliability in these days of rapidly changing technology. The alternative is a voltage regulator, using relatively expensive discrete transistors. However, of necessity these discrete component voltage regulators are complicated if they are to be as efficient as their IC counterparts. Because of this, there are more things to go wrong (as we all know, the well-known 'Murphy's Law states what can go wrong — will!)

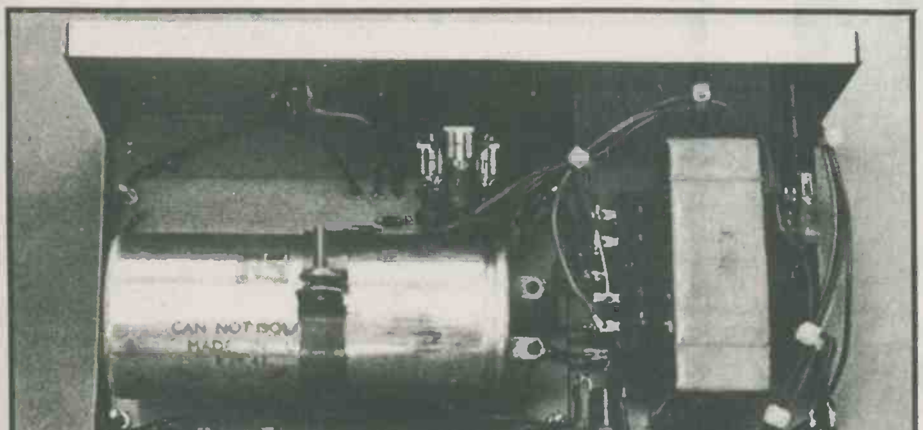
Given that all connections are correct our PSU is virtually indestructible. Even a direct short circuit on the output will do no damage, an internal current limiter keeps things in order. In this way, of course, there is less likelihood of a circuit under test being damaged if, say, it has a short circuit due to a solder bridge between tracks. A simple dry cell battery would continue to pass current at its highest rate until removed, by which time damage may have been done. The LM317K continually monitors its own output current and if it is too high it "folds back", ie, it switches the output current off. When the short circuit is removed or repaired the regulator automatically switches the current back on.

Construction

Care must be taken with the primary part of the circuitry, ie, everything up to and including the power transformer T1 (the left hand side of the circuit diagram of Figure 1).

The first constructional step is the marking and drilling of the case. Ideally, a mild steel case should be used, in order to reduce electrical interference with other equipment which may be positioned close to the power supply. Mount the transformer on the base, leaving enough room for the PCB, bearing in mind the size of the capacitor C1. Bolt the fuse holders power on/off and DC on/off switches, neon (with integral resistor), output sockets and IC1 to the case, leaving only the six-way rotary switch and the PCB out.

Insert a grommet in the cable hole, push through the power cable so that enough cable is inside the case to complete all of the AC line side wiring(figure 3). We have shown all wires to be loose in the figure but when wiring up your supply, form all wires around the edge and keep them together using cable ties lacing cord or ordinary string — whatever you have at hand. Fasten the cable as it comes through the case wall using a bolt-on cable clip or similar. This



Inside our Bench Power Supply Unit.

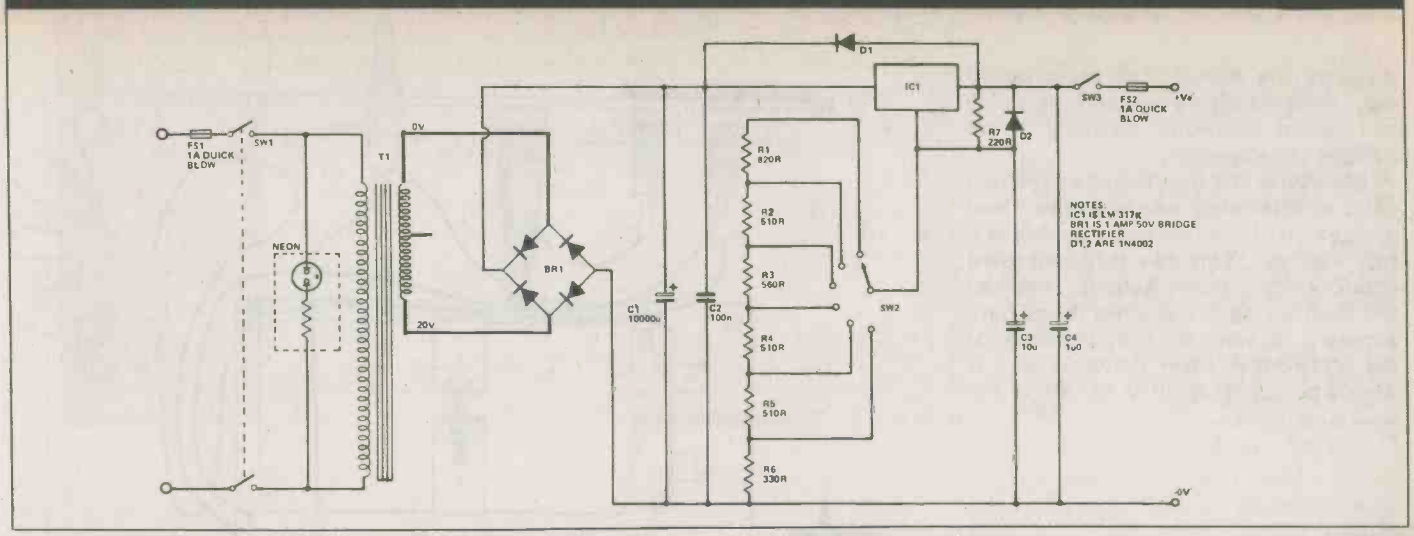


Fig. 1. The ETI Bench PSU circuit diagram. There's not a lot in it, but what is there does the job well.

How It Works

Transformer T1 provides the necessary step-down function from 120 VAC to 20 VAC which the rest of the circuit requires. It also isolates the low voltage side from the high-voltage (line) side ie there is no *electrical* connection from line to low voltage output.

The 20 V AC obtained at the transformer secondary is rectified by bridge rectifier BR1 to DC. Filter capacitor C1 "smooths out the bumps" providing a fairly level input voltage of about 28 V DC to the voltage regulator IC1.

The output voltage of IC1 is given by the formula $V_{out} = 1V25\ (1 + R2/R1)$.

where R2 and R1 are as in the figure at the right by fixing the value of R1 at 220R then R2 can be calculated from the above to be

$$R2 = 220 \left(\frac{V_{OUT}}{1V25} - 1 \right)$$

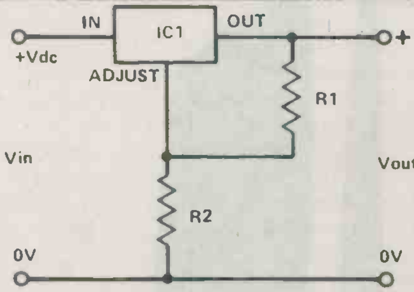
Simply by inserting whatever value of Vout we require into the formula, we obtain the necessary value of R2.

$$\text{eg } R2 = 220 \left(\frac{3}{1V25} - 1 \right) = 308R$$

The nearest preferred value is 330R, therefore the output voltage is slightly over 3 volts DC. This resistor corresponds to R6 in the circuit of the ETI PSU and position 1 of the rotary switch SW2. By combining R6 with R5 in series and by turning SW2 to position 2, an overall resistance of

$$330 + 510 = 840R$$

is obtained giving a voltage of 6 VDC. Similarly the remainder of the voltage steps, ie, 9 V, 12 V, 15 V and 20 V are obtained by adding further resistors into circuit by means of SW2.



The resistor chain and SW2 could be replaced by a potentiometer to give a continuously variable output voltage but an expensive panel meter will then be required, to allow reading of the voltage. Switched resistors give a sufficient range of voltages and obviously keep the cost down considerably.

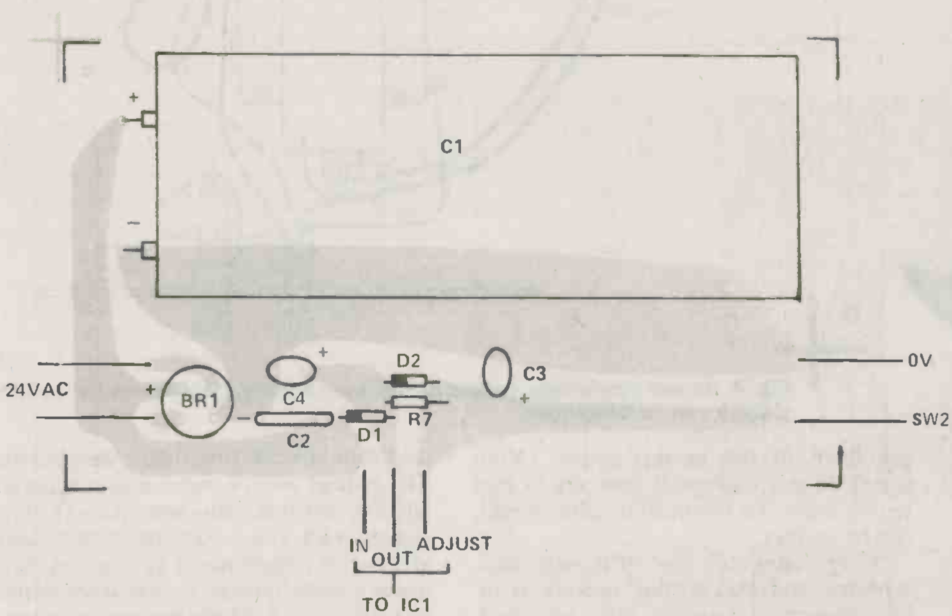


Fig. 2. Overlay details of the printed circuit board. It is important that capacitor C1 is polarised correctly.

Parts List

RESISTORS (All ¼W, 5%)

R1	820R
R2,4,5	510R
R3	560R
R6	330R
R7	220R

CAPACITORS

C1	10,000u 40 V electrolytic, single ended
C2	100n polyester
C3	10u 35 V tantalum

SEMICONDUCTORS

IC1	LM317K voltage regulator
BR1	1A, 50 V bridge rectifier
D1,2	1N4002 diode

MISCELLANEOUS

SW1	Double-pole, double-throw toggle switch
SW2	6-way rotary switch
SW3	Single-pole, double throw toggle switch
FS1,2	Panel mounting fuse-holders and 1 Amp quick-blow fuses.
Neon	Panel-mounting with integral resistor
T1	20V, 20VA power transformer

Grommet, cable clip, knob, 2 x 4mm O/P sockets, case to suit, mounting clip for C1.

prevents the cable from being pulled out. Alternatively, you could use a plug and socket connector assembly as we did (see photographs).

We advise the use of rubber sleeving to cover the joints where a power lead joins external hardware eg a switch or a fuse holder. This can help safeguard against electric shock hazards. You can test your wiring at this point if you have a meter. Measure the output voltage of the transformer when switched on. It should be about 25-30 V AC under no-load conditions.

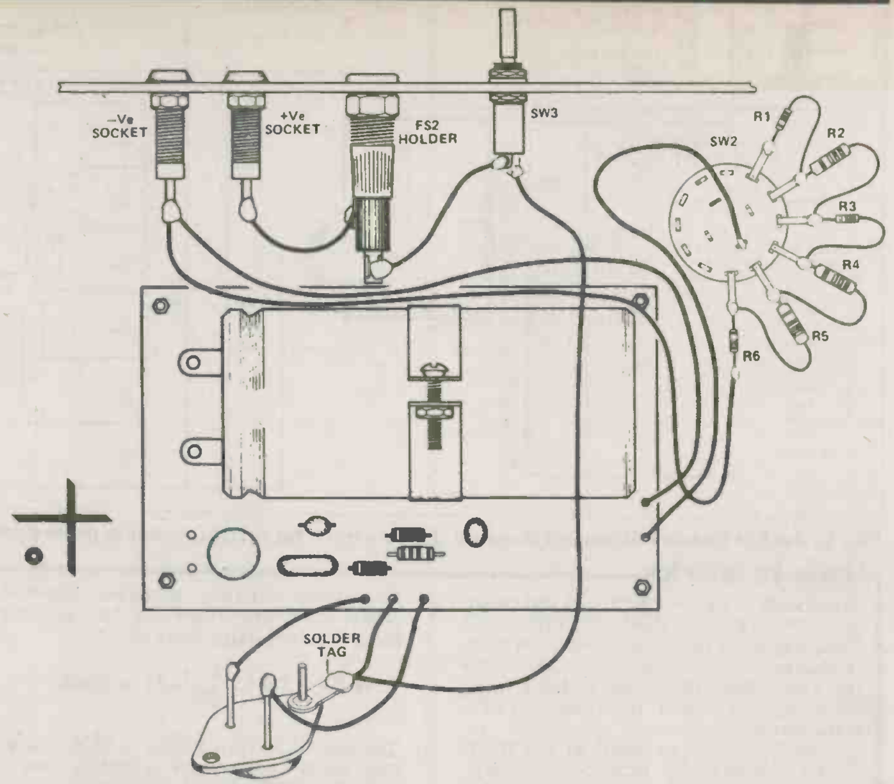


Fig. 3. The low voltage side of the Bench PSU project.

The PCB pattern.

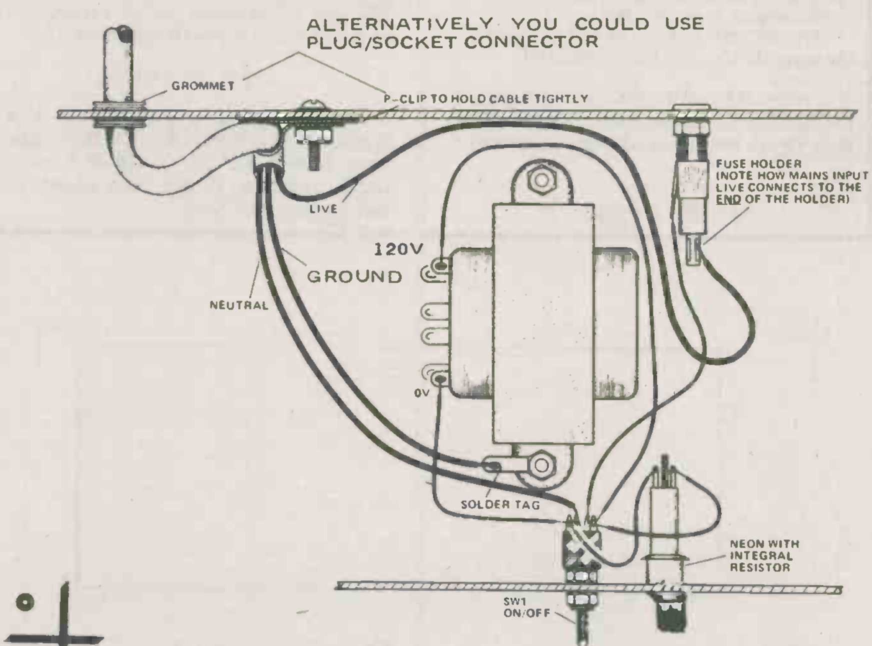


Fig. 4. Shows connection details of the line circuitry. Care is needed as line voltage can be dangerous.

Once the line voltage side has been wired in, the PCB can be completed. Mount C1 on the board using a capacitor clip and solder the tags to the board making sure it is polarized correctly, ie, the tag close to the red dot or positive marking on the capacitor goes to the positive connection on the PCB. Then SW2 (the rotary switch and resistors) can be mounted. Note how the resistors are mounted on SW2 and make sure you get them in the correct order. You won't do any damage if they are in the wrong order but the output voltages will not be correct.

Next, wire up the PCB, the two switches and the output sockets as in the connection diagram, again taking all leads neatly around the outside of the case and tying them together. Finally, wire in IC1 to the PCB.

At this stage, the PSU is complete and should work first time. Measure the DC output using a meter and check that all the settings are correct. If you possess a 25 V or a 30 V panel meter, an alternative suggestion is to insert a 4K7 linear potentiometer in the front panel instead of the SW2-resistor combination, with the meter across the output and use it to give a reading of the now fully variable output voltage.

ETI book shelf

PROJECTS

BP48: ELECTRONIC PROJECTS FOR BEGINNERS **$5.90**
F.G. RAYER, T.Eng.(CEI), Assoc.IERE
Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the 'No Soldering' section so this may considerably increase the scope of projects which the newcomer can build and use.

221: 28 TESTED TRANSISTOR PROJECTS
R.TORRENS **$5.50**
Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

BP49: POPULAR ELECTRONIC PROJECTS **$6.25**
R.A. PENFOLD
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS
AB007 **$10.45**
An ideal sourcebook of Solid State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

BP71: ELECTRONIC HOUSEHOLD PROJECTS **$7.70**
R. A. PENFOLD
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS **$8.10**
R.A. PENFOLD
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windshield Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

BP69: ELECTRONIC GAMES **$7.55**
R.A. PENFOLD
In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP95: MODEL RAILWAY PROJECTS **$8.10**
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects: striboard layouts are provided for each project.

BP93: ELECTRONIC TIMER PROJECTS **$8.10**
F.G. RAYER
Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

110 OP-AMP PROJECTS
MARSTON
HB24 **$13.45**
This handbook outlines the characteristics of the op-amp and present 110 highly useful projects—ranging from simple amplifiers to sophisticated instrumentation circuits.

110 IC TIMER PROJECTS
GILDER
HB25 **$11.45**
This sourcebook maps out applications for the 555 timer IC. It covers the operation of the IC itself to aid you in learning how to design your own circuits with the IC. There are application chapters for timer-based instruments, automotive applications, alarm and control circuits, and power supply and converter applications.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING **$8.10**
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

PH250: EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONICS PROJECTS **$10.45**
A. BARBER
This book takes the mystery out of solid state electronics and enables the reader to build such useful devices as: series regulated power supplies, light dimmers, solar cell operated radios, hi-fi amplifiers, light indicators for battery operated equipment and much more.

110 THYRISTOR PROJECTS USING SCRs AND TRIACS
MARSTON.
HB22 **$13.45**
A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects range from simple burglar, fire, and water level alarms to sophisticated power control devices for electric tools and trains. Integrated circuits are incorporated wherever their use reduces project costs.

110 CMOS DIGITAL IC PROJECTS
MARSTON
HB23 **$11.75**
Outlines the operating characteristics of CMOS digital ICs and then presents and discusses 110 CMOS digital IC circuits ranging from inverter gate and logic circuits to electronic alarm circuits. Ideal for amateurs, students and professional engineers.

BP76: POWER SUPPLY PROJECTS **$7.30**
R.A. PENFOLD
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

There are other types of power supplies and a number of these are dealt with in the final chapter, including a cassette power supply, Ni-Cad battery charger, voltage step up circuit and a simple inverter.

BP84: DIGITAL IC PROJECTS **$8.10**
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike.

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS **$7.55**
F.G. RAYER, T.Eng.(CEI), Assoc. IERE
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc. are considered.

BP73: REMOTE CONTROL PROJECTS **$8.60**
OWEN BISHOP
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP99: MINI—MATRIX BOARD PROJECTS **$8.10**
R.A. PENFOLD
Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Doorbuzzer, Low-voltage Alarm, AM Radio, Signal Generator, Projector Timer, Guitar Headphone Amp, Transistor Checker and more.

BP103: MULTI-CIRCUIT BOARD PROJECTS **$8.10**
R.A. PENFOLD
This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

Tab1431: DIGITAL ELECTRONIC PROJECTS **$21.45**
Build a deluxe code oscillator, a digital game called Climb-the-Mountain, a clock with alarm, a metric measuring wheel, a modular decade counter, even a 14-note music generator. 17 projects in all.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1 **$9.35**
R.A. PENFOLD
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build, in turn, every project shown.

BP106: MODERN OP-AMP PROJECTS **$8.10**
R.A. PENFOLD
Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

CIRCUITS

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 **$8.25**
R.A. PENFOLD
Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 **$9.35**
R.A. PENFOLD
70 plus circuits based on modern components aimed at those with some experience.

The GIANT HANDBOOK OF ELECTRONIC CIRCUITS
TAB No.1300 **$28.45**
About twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS **$5.50**
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home.

This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee.

BP87: SIMPLE L.E.D. CIRCUITS **$5.90**
R.N. SOAR
Since it first appeared in 1977, Mr. R.N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on.

BP42: 50 SIMPLE L.E.D. CIRCUITS **$3.55**
R.N. SOAR
The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.). A useful book for the library of both beginner and more advanced enthusiast alike.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS **$8.10**
OWEN BISHOP
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicycle speedometer to a novelty 'Duck Shoot'; a number of power supply circuits are Included.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS **$5.50**
F.G.RAYER, T.Eng.(CEI),Assoc.IERE
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP44: IC 555 PROJECTS **$7.55**
E.A. PARR, B.Sc.,C.Eng., M.I.E.E.
Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP24: 50 PROJECTS USING IC741 **$4.25**
RUDI & UWE REDMER
This book, originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader. Translated from the original German with copious notes, data and circuitry, a "must" for everyone whatever their interest in electronics.

BP83: VMOS PROJECTS **$8.20**
R.A. PENFOLD
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits. A number of varied and interesting projects are covered under the main headings of: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

BP88: HOW TO USE OP AMPS **$9.35**
E.A. PARR
A designer's guide covering several op amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

BP65: SINGLE IC PROJECTS **$6.55**
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

BP97: IC PROJECTS FOR BEGINNERS **$8.10**
F.G. RAYER
Covers power supplies, radio, audio, oscillators, timers and switches. Aimed at the less experienced reader, the components used are popular and inexpensive.

IC ARRAY COOKBOOK
JUNG
HB26 **$14.25**
A practical handbook aimed at solving electronic circuit application problems by using IC arrays. An IC array, unlike specific-purpose ICs, is made up of uncommitted IC active devices, such as transistors, resistors, etc. This book covers the basic types of such ICs and illustrates with examples how to design with them. Circuit examples are included, as well as general design information useful in applying arrays.

BP50: IC LM3900 PROJECTS **$5.90**
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbylst. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here; this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

223: 50 PROJECTS USING IC CA3130 **$5.50**
R.A.PENFOLD
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

224: 50 CMOS IC PROJECTS **$4.25**
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

THE ACTIVE FILTER HANDBOOK
TAB No.1133 **$14.45**
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design.

The book introduces filters and their uses. The basic math is discussed so that the reader can tell where all design equations come from. The book also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM
AB004 **$11.45**
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent in practical digital circuits.

MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS
TAB No.800 **$20.45**
MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS
TAB No.804 **$24.45**
Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK
TAB No.1199 **$18.45**
If you've ever tried to find specs for a so called 'standard' chip, then you'll appreciate this book. C.L. Hallmark has compiled specs and pinouts for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS
AB016 **$13.45**
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

HP117: PRACTICAL ELECTRONIC BULDING BLOCKS BOOK 1 **$8.10**
Virtually any electronic circuit will be found to consist of a number of distinct stages when analysed. Some circuits inevitably have unusual stages using specialised circuitry, but in most cases circuits are built up from building blocks of standard types.

This book is designed to aid electronics enthusiasts who like to experiment with circuits and produce their own projects rather than simply follow published project designs.

The circuits for a number of useful building blocks are included in this book. Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements.

PH253: ELECTRONIC DESIGN WITH OFF-THE-SHELF INTEGRATED CIRCUITS
Z. MEIKEIN & P. TACKRAY **$13.45**
A real help for do-it-yourselfers, this handy guide tells professionals and hobbyists alike how to take components off the shelves, arrange them into circuitry, and make any system perform its desired function.

REFERENCE

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE **$12.25**
ADRIAN MICHAELS
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

BP108: INTERNATIONAL DIODE EQUIVALENTS GUIDE
ADRIAN MICHAELS **$8.35**
This book is designed to help the user in finding possible substitutes for a large user orientated selection of the many different types of semiconductor diodes that are available today. Besides simple rectifier diodes also included are Zener diodes, LEDs, Diacs Triacs, Thyristors, Photo diodes and Display diodes.

BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES **$2.80**
B.B. BABANI
This guide covers many thousands of transistors showing possible alternatives and equivalents. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

BP14: SECOND BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES **$4.80**
B.B. BABANI
The "First Book of Transistor Equivalents" has had to be reprinted 15 times. The "Second Book" produced in the same style as the first book, in no way duplicates any of the data presented in it. The "Second Book" contains only additional material and the two books complement each other and make available some of the most complete and extensive information in this field. The interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East Germany, Belgium, Austria, Netherlands and many other countries.

TOWER'S INTERNATIONAL OP-AMP LINEAR IC SELECTOR
TAB No.1216 **$13.45**
This book contains a wealth of useful data on over 5,000 Op-amps and linear ICs — both pinouts and essential characteristics. A comprehensive series of appendices contain information on specs, manufacturers, case outlines and so on.

CMOS DATABOOK
TAB No.984 **$9.95**
There are several books around with this title, but most are just collections of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of logic devices . . . the missing link in getting your own designs working properly. Highly recommended to anyone working with digital circuits.

Tab1538: ELECTRONIC DATABOOK — 3RD EDITION $30.00
Any electronic job will be easier and less time consuming when you have instant access to exactly the nomogram, table, chart or formula you need, when you need it. All this and much more is included in this completely revised and updated version of one of the most respected information source in the electronics field. Generously indexed, this handbook is devided into six sections: Frequency Data; Communication; Passive Components; Active Components; Mathematical Data; Formulas and Symbols and Physical Data.

Tab1516: TOWERS INTERNATIONAL MICROPROCESSOR SELECTOR **$31.45**
Towers Selector books have gained an international reputation for completeness and usefulness. This volume gives you all the data you will normally need to select the right chip.

MISCELLANEOUS

BP101: HOW TO IDENTIFY UNMARKED IC'S **$2.70**
K.H. RECORR
Originally published as a feature in 'Radio Electronics', this chart shows how to record the particular signature of an unmarked IC using a test meter, this information can then be used with manufacturer's data to establish the application.

AUDIO AND VIDEO INTERFERENCE CURES
KAHANER
HB21 **$9.45**
A practical work about interference causes and cures that affect TV, radio, hi-fi, CB, and other devices. Provides all the information needed to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are included. Also, it supplies simple filter diagrams to eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

BASIC TELEPHONE SWITCHING SYSTEMS
TALLEY
HB27 **$16.00**
The Revised Second Edition of this book, for trainee and engineer alike, includes updated statistical data on telephone stations, and new and improved signaling methods and switching techniques. It also includes E & M signaling interface for electronic central offices and automatic number identification methods used in step-by-step, panel and crossbar central offices.

INTERRELATED INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBYIST AND CB'ER
MENDELSON
HB29 **$11.45**
This book provides a variety of appealing projects that can be constructed by anyone from the hobbyist to the engineer. Construction details, layouts, and photographs are provided to simplify duplication. While most of the circuits are shown on printed circuit boards, every one can be duplicated on hand-wired, perforated boards. Each project is related to another projects so that several may be combined into a single package. The projects, divided into five major groups, include CMOS audio modules, passive devices tohelp in benchwork, test instruments, and games.

BASIC CARRIER TELEPHONY, THIRD EDITION
TALLEY
HB28 **$16.45**
A basic course in the principles and applications of carrier telephony and its place in the overall communications picture. It is abundantly illustrated, with questions and problems throughout, and requires a minimum of mathematics.

Tab1309: THE ACOUSTIC AND ELECTRIC GUITAR REPAIR HANDBOOK **$25.00**
Literally everything the amateur or professional musician needs to know to properly maintain his instruments, plus all the how-to's for making reparis from simple tuning to major overhauls.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING **$8.10**
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 **$12.45**
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS
AB018 **$10.45**
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

ELECTRONICS BEGINNERS

PH255: COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS, 2nd Edition
J. DOUGLAS-YOUNG **$10.45**
Packed with scores of easy-to-understand diagrams and invaluable troubleshooting tips as well as a circuit finder chart and a new section on logic circuits.

PH251: BEGINNER'S HANDBOOK OF IC PROJECTS
D. HEISERMAN **$17.45**
Welcome to the world of integrated circuit (IC) electronic projects. This book contains over 100 projects (each including a schematic diagram, parts list, and descriptive notes.)

PH252: DIGITAL ICs: HOW THEY WORK AND HOW TO USE THEM
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4-Input Mixer

Four into one will go with this mini-mixer. Why not build one for your band today?

IF YOU ARE IN A BAND and your PA has a range of inputs you may wonder why you need a mixer. Well, one of the advantages is that when you bass player thinks he is not loud enough to be heard over the rest of you, it's up to someone else to turn him up! Otherwise, you can so easily get that snowball effect where one musician turns up the volume only to be followed by all the rest and so on until every sentient being within earshot suffers premature deafness (pardon?).

Many bands these days seem to have started on nothing and are maintained on a shoe string. If yours falls into this category, then this is the project for you. No-one is going to claim it's hi-fi but it is cheap. Using 741 op-amps will produce plenty of power versus cost.

Construction

We built our unit into a small plastic case and mounted all the pots on the aluminum top cover, making the required connections with shielded cable. Take care not to produce a ground loop when connecting up. The remaining components can be mounted on our PCB; only three wire links are required to supply the op-amps negative supply. We used polycarbonate capacitors mostly, taking advantage of their small size and

How It Works

The heart of the circuit is IC2, an op-amp connected as a conventional virtual ground summing amplifier. This stage mixes the input signals and also has a gain of 10 to compensate for the insertion loss of the passive tone control network. There are three high level inputs and one low level which is input to IC1. This stage provides non-inverting amplification with a gain of about 20. Independent volume controls are provided for each input and the signals are mixed in IC2 before being passed to the tone control network. This provides a 40 dB range of control with an insertion loss at midband of — 20 dB.

This output from the tone control is AC coupled to unity-gain voltage follower IC3. AC coupling avoids the problem of wiper 'track noise', which would result from the irregular capacitor charge and discharge currents. R16 is inserted in the output of IC3 to isolate the op-amp from the large capacitive load presented by a long length of screened cable. Potentiometer RV7 provides overall volume control and capacitors C14 and C15 decouple the power supply lines. Two 9V batteries provide power for the unit and current consumption will be just a few milliamps.

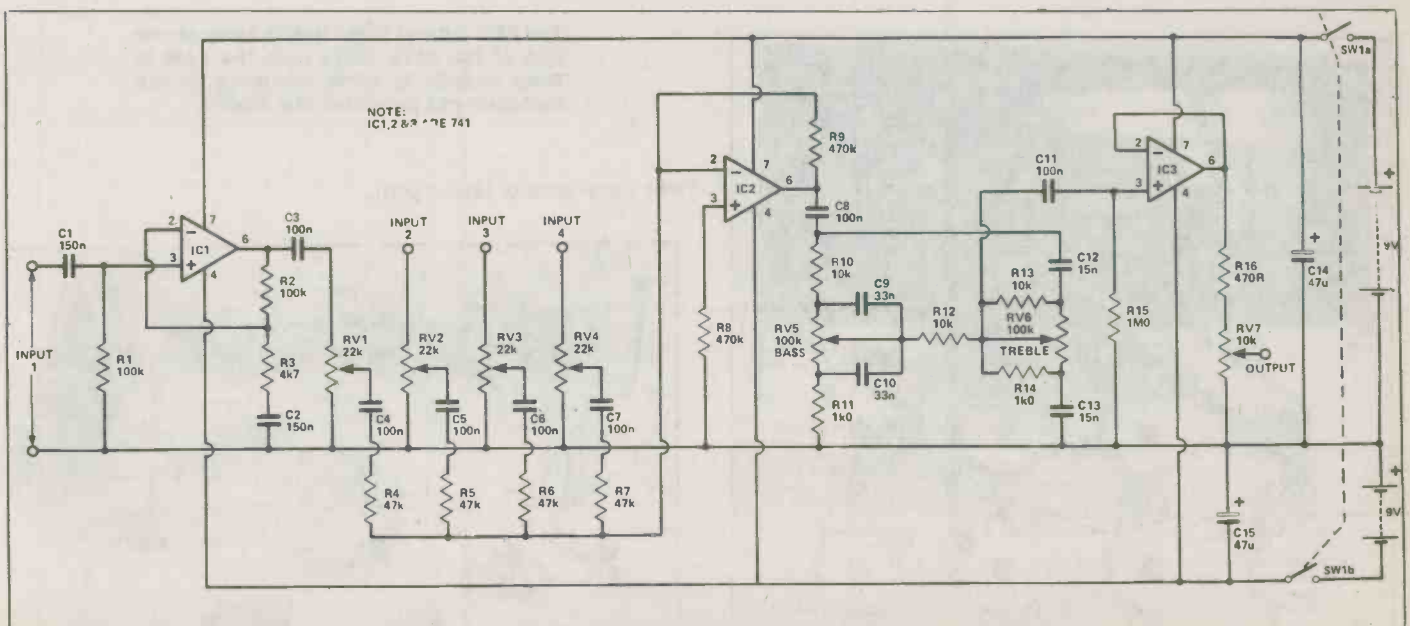


Fig. 1 Circuit diagram.

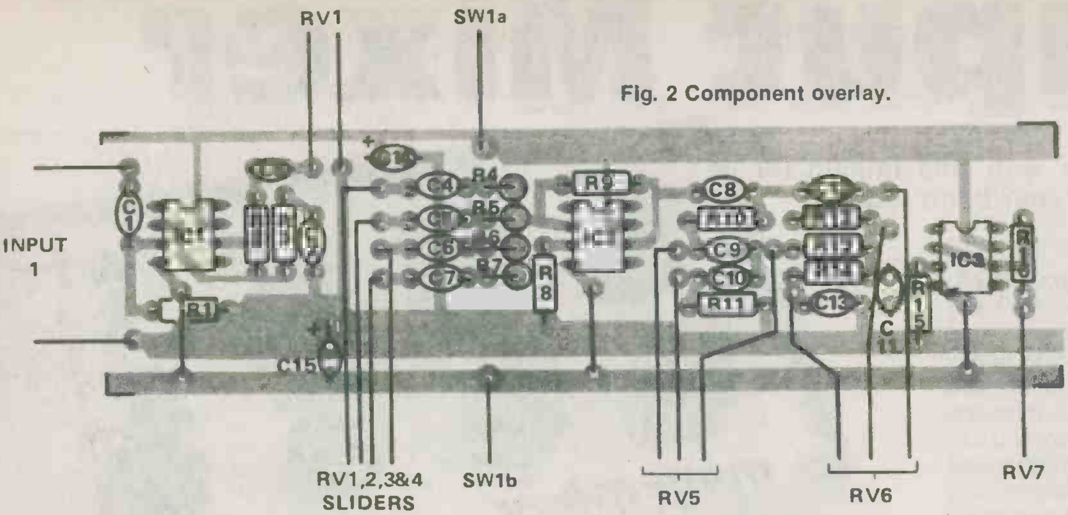
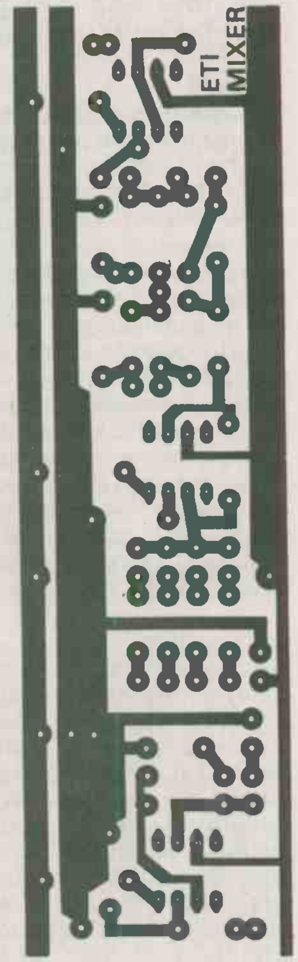


Fig. 2 Component overlay.



good characteristics, though polyester types can be substituted. There are no special precautions to take. Just make sure you put the ICs in the right way up and get the polarity of the two tantalum capacitors right.

Remember, if you ever reverse-bias a tantalum cap by more than about 3 V it's dead certain that you'll have blown it up and it'll no longer be a capacitor; more a low-value resistor with the inevitable effect on circuit operation. No problems with this project, though. Simply build it, fix it and mix it!

Parts List

Resistors all ¼ W 5%

R1,2	100k
R3	4k7
R4,5,6,7	47k
R8,9	470k
R10,12,13	10k
R11,14	1k0
R15	1M0
R16	470R

Potentiometers

RV1,2,3,4	22k logarithmic
RV5,6	100k logarithmic
RV7	10k logarithmic

Capacitors

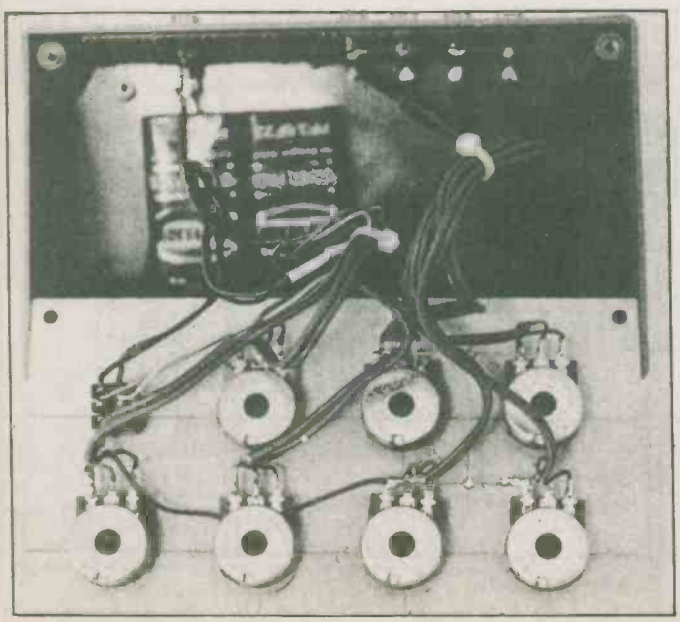
C1,2	150n polycarbonate
C3,11	100n ceramic
C4,5,6,7,8	100n polycarbonate
C9,10	33n polycarbonate
C12,13	15n polycarbonate
C14,15	47u 16V tantalum

Semiconductors

IC1,2,3	741

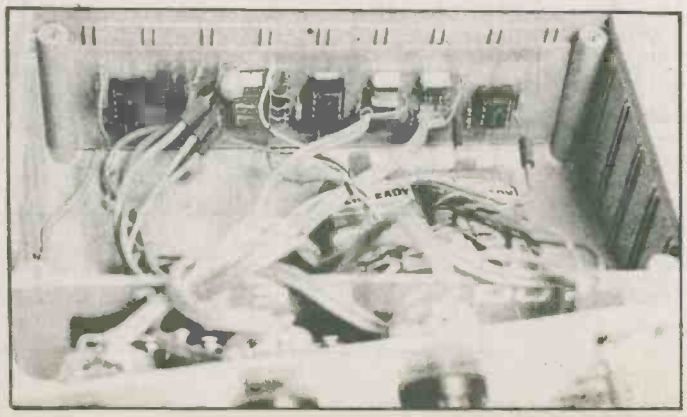
Miscellaneous

Case, connectors, batteries, DPDT switch, etc.



The PCB (above) tucks neatly away at one end of the case. Make sure the case is deep enough to allow clearance of the batteries and potentiometer bodies.

Front panel control layout (left).



150 Watt Amp

Here's a high power, general purpose power amplifier module for guitar and PA applications employing rugged, reliable MOSFETs in the output.

THE CIRCUIT USED in the MOSFET Power Amp is a development from one published in the Hitachi application notes for these MOSFETs. The original circuit used very high-gain bipolar driver transistors developed especially by Hitachi for use as MOSFET drivers. Unfortunately these devices are at present unavailable in Canada. Since these are an extremely fast device, replacement by more common bipolars limits the open loop bandwidth and causes the amplifier to be unstable. The main departures from the Hitachi circuit are therefore to ensure a stable design with common transistors.

We used a complementary video output pair as drivers, supplying good slew rate and V_{CEO} figures at a reasonable price. The resulting power amp module is fast and stable, with distortion figures completely adequate even for many high fidelity applications. The module is easy to construct and capable of withstanding continued clipping or full-power operation for extended periods when provided with a suitable heatsink.

Why MOSFETs?

The power MOSFET is a relatively recent development and offers several distinct advantages over the more common bipolar transistor. To understand these differences it is helpful to look at some of the characteristics of bipolar output transistors.

Most power amplifiers employ bipolar transistors in a common-collector or emitter-follower configuration. The relationship between the output signal voltage and the input signal voltage is a function of the load impedance and the forward transfer admittance of the particular device. Forward transfer admittance is commonly given the symbol y_{fs} and its non-linear characteristic gives rise to distortion in the output stage. With bipolar transistors, the greatest non-linearity occurs for low input voltages, typically between 0V and 0.6V. Once outside this voltage range the forward transfer admittance is high and quite linear. So most of the distortion generated in a bipolar output stage occurs at low signal voltages and is called crossover distortion.

The most common method used to overcome this problem is to make use of bias current. A fixed voltage of around 0.6V is applied to the bases of the output transistors so that the applied signal voltage does not have to operate the transistor over the most non-linear region. However, a problem arises with this technique because this voltage must be controlled extremely accurately. Even 0.5V in excess of the correct voltage will saturate the output devices, probably destroying them. Furthermore, as the output devices heat up due to normal operation, the bias voltage must be decreased to maintain the same operating conditions. This is very difficult to do accurately enough, so the power amp is often running either with insufficient bias current or is dangerously close to destruction.

The problem occurs because the bipolar transistor has a positive temperature coefficient. This means that as the temperature of the device is increased the collector-emitter current will increase if the base-emitter voltage is held constant. The increased current causes further heating and a further increase in current. This condition is called thermal runaway and results in the destruction of the output device.

Another problem with conventional bipolar output transistors is speed. The techniques used in the construction of these devices to ensure broad SOAR characteristics (SOAR stands for Safe Operating ARea) usually conflict with those to ensure high speed. Since the output transistors must handle the largest currents they are usually the slowest devices in the amplifier and determine the maximum signal slope that can be handled by the amplifier before distortion results. Distortion generated by this mechanism is called *slew-induced distortion* and *transient inter-modulation distortion.* Once unnecessarily high signal slopes have been removed by a suitable filter at the input of the power amp the only solution is to increase the slew rate of the output devices.

One of the major advantages of power MOSFETs is their extremely high speed. When driven correctly the MOSFETs used in this project can switch a current of around 2A in 30 nanoseconds! This is roughly 100

SPECIFICATIONS

Power output
150 W RMS into 4 ohms
100 W RMS into 8 ohms
(at onset of clipping)

Frequency response
20 Hz to 20 kHz, +0 −0.5 dB
10 Hz to 60 kHz, +0 −3 dB
(measured at 1 W and 100 W levels)

Input sensitivity
1 V RMS for full output

Hum
−98 dB below full output

Noise
−114 dB below full output

Total Harmonic Distortion
0.006% at 1 kHz
0.03% at 10 kHz
(measured at 12 W level)

Stability
Unconditional — tested to full output driving 3.5 uF short circuit at 10 kHz.

times the speed of commonly available bipolars. Another advantage of MOSFETs is their very high input impedance. Unlike the bipolar transistor, they are a voltage-controlled device and require only enough drive current to overcome their input capacitance. Probably their most important advantage over bipolar transistors, however, is that they have a negative temperature coefficient. Heating causes an increase in the resistance of the device, so MOSFETs are inherently self-protecting. If one part of the device attempts to conduct more current it heats up more than the surrounding region, increasing its resistance, which distributes current over the rest of the device. Similarly, if several devices are used in parallel, the negative temperature coefficient will ensure that all devices share current equally. In guitar and PA applications the negative temperature coefficient of MOSFETs provides the amplifier with unprecedented reliability, and the high speed helps to eliminate the problem of slew-induced distortion.

On the other hand a disadvantage with MOSFETs arises from their relatively low forward transconductance when compared to a good bipolar transistor. Although the transconductance of bipolars is highly non-linear when the base emitter voltage is below 0.6V, it increases dramatically once outside this region. The MOSFET, although not as non-linear for small voltages, never achieves the forward transconductance of the bipolar transistor. The distortion generated by the power MOSFETs is therefore higher than that of bipolar transistors and must be reduced to acceptable limits through the use of negative feedback. This is not a real problem, however, since the high input impedance eliminates at least one stage of a conventional bipolar amplifier design. This allows a simpler circuit with fewer active devices and consequently improved stability margins, allowing greater levels of overall negative feedback before oscillation results.

HEATSINKING

The heatsink will need to dissipate around 100 W when the module is run at full output for lengthy periods. A heatsink with a thermal capacity of around 0.65°C/watt is recommended if free-air cooling is contemplated.

If fan-forced cooling is contemplated, then a heatsink rated at 1.2 to 1.5°C/watt should be used. A 225 mm length of commonly available extruded 'fan' type heatsink will do the job. This type of heatsink is flat on one side, the other side having two sets of fins fanning out from a central channel. A suitable length will set you back about $10. A fan will set you back around $20 to $30, unless you have one laying around.

Construction

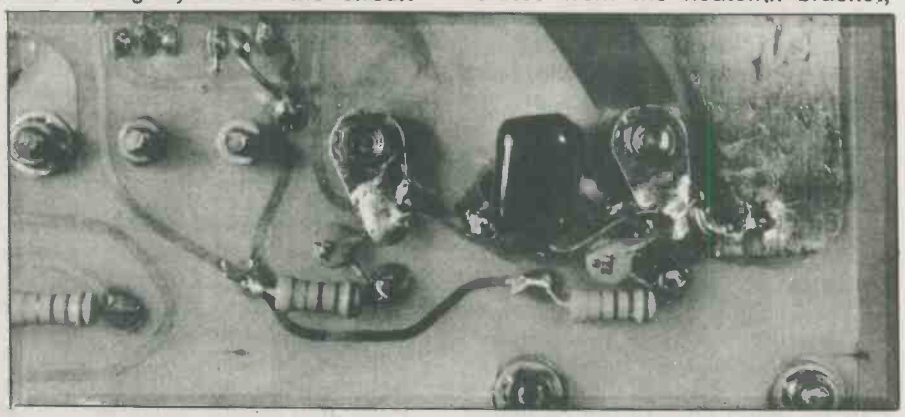
Construction of the MOSFET Power Amp is relatively simple, since all the components mount on the pc board, including the output transistors and power supply components. The design of a good pc board pattern is often as difficult as the design of the original circuit! This is especially true for power amplifiers or any circuit in which both large and small currents are involved. The problem of large currents occurs because of voltage drops across ground return paths, destroying the integrity of ground reference points for small signal currents. To overcome this problem, the pc board must be designed to ensure the validity of the grounding arrangement. If at all possible, the pc board published should be used, as departures from this design could seriously affect amplifier performance.

Commence construction by soldering all the resistors onto the circuit board with the exception of the four OR22 output resistors. These effectively connect all the sources of the MOSFETs together and make it difficult to locate faults in the mounting of the MOSFETs. Solder the 1W resistors slightly above the circuit board since these can become hot under certain conditions. The components marked with an asterisk on the circuit diagram are mounted on the rear of the pc board. They should be mounted close to the MOSFETs. Do not solder the resistors to the rear of the circuit board at this stage. These are best left until after the MOSFETs have been mounted.

Solder the capacitors onto the circuit board with the exception of those on the rear of the board and the two large electrolytics. The 100u capacitor C3 is the only other electrolytic, so be careful with the orientation of this component. The capacitor is marked to indicate which of its leads are to be connected to a positive or negative voltage. Check the correct orientation on the overlay diagram. This also applies to the diodes and zener diodes used in the circuit, which can be mounted next.

Both the driver and power transistors are mounted on a length of aluminium angle extrusion, which is bolted to the pc board by bolts through the transistor mounting holes. This is shown in the accompanying diagrams. The extrusion is used to conduct the heat generated by the output and driver transistors to the heatsink, which will also be bolted to the extrusion. Drill all the necessary holes before proceeding further. Make certain the holes are free of burrs or shavings that might otherwise cut through the transistor insulating washers. This is best done with a couple of twists of an oversize drill (i.e., around 13mm diameter).

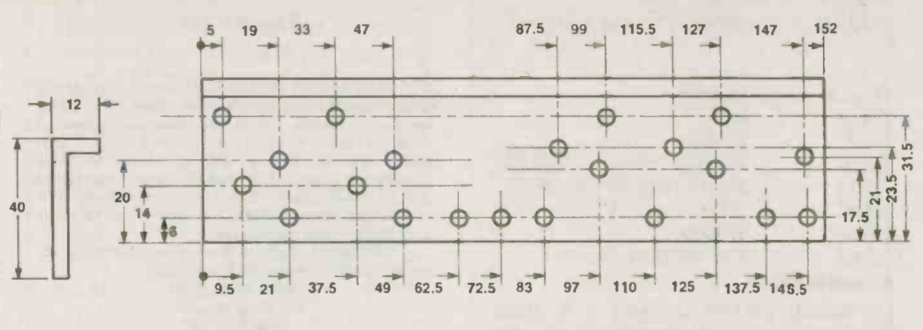
The bolts holding the MOSFETs in place also serve to make electrical connections to the cases of the devices. These bolts must be insulated from the heatsink bracket,



Compensation capacitors are required for the two 2SK134 output MOSFETs (Q8 and Q9) to equalise the input capacitances between the n-channel and p-channel output devices. They are mounted under the board as shown here. Solder lugs are placed on top of the mounting nuts and held with another nut each. C6 and C7 mount from these to the pads shown, while C7 mounts between them. Note the resistors mounted under the board.

ALL 4 mm DIA.
MATERIAL 40 x 12 x 3 ALUMINIUM ANGLE EXTRUSION
Drilling details for the heatsink bracket assembly. All dimensions are in millimetres.

BRACKET DRILLING DETAILS



which will be at ground potential. This is done with the use of short insulating sleeves cut from a length of 'spaghetti' insulation. Use a small quantity of heatsink compound on both sides of the transistor insulating washers to ensure good thermal contact. Insert the sleeves in the holes of the heatsink bracket and mount the four MOSFETs as shown in the accompanying diagram.

The four driver transistors can now be mounted. Again, use transistor insulating washers between the metal sides of the transistors and the heatsink bracket, although insulating sleeves are not necessary.

Once all the transistors have been mounted on the heatsink bracket use a multimeter to check for any short circuits to the heatsink bracket by measuring the resistance from the case of each MOSFET, and from the centre lead of each driver transistor, to the bracket. The measurements should show open circuit on all transistors. If a short does exist the transistor should be removed and remounted, possibly with a new insulating washer. Finally, solder the leads to the transistors.

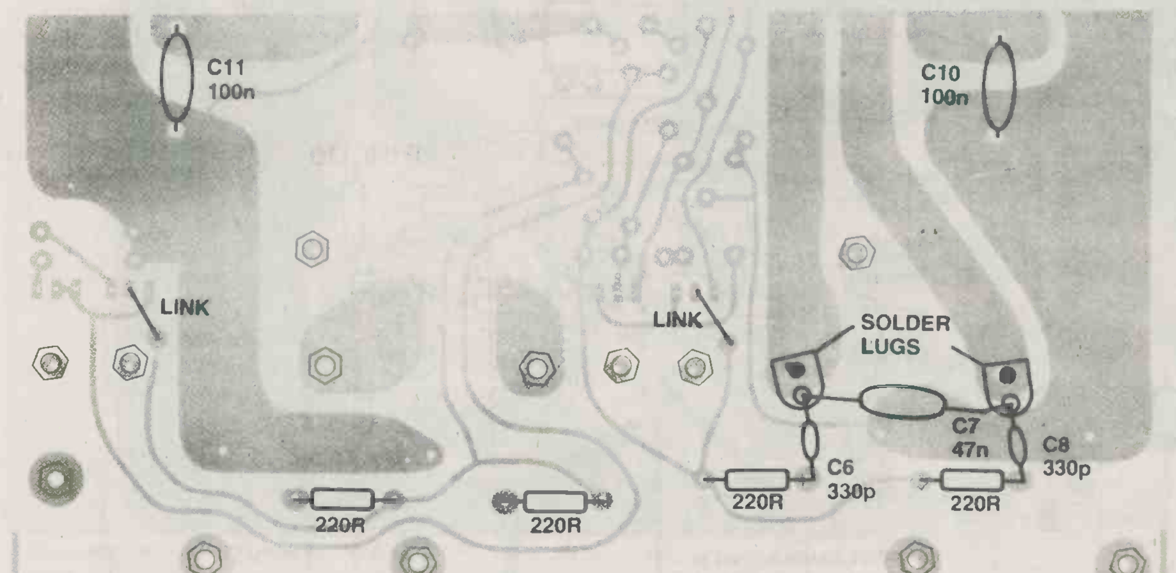
Once the MOSFETs and drivers have been mounted, the remainder of the components can be mounted on the pc board, including the small signal transistors and the components on the rear of the pc board. Mount the two 8000u electrolytic capacitors last. Mount the four OR22 resistors now, leaving around 5mm between the resistor and the board. Ensure that all components mounted on the rear of the pc board are mounted close to the board with their leads cut as short as possible.

The output inductor, L1, is formed by winding 20 turns of 0.8 mm enamel wire around a 14 mm former.

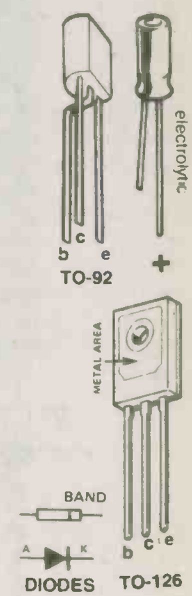
Powering up

Supply fuses have not been included on the pc board because the resulting resistance necessitates the use of a second set of electrolytic capacitors close to the output devices. To protect the loudspeakers in the case of failure of the power amp a fuse should be used in series with the loudspeaker cable.

Before powering up check all stages of construction, including the orientation of all polarised components. Check that no shorts exist between the cases of the output devices and the heatsink bracket. Mount the heatsink bracket to a suitable heatsink, again using heatsink compound to ensure good thermal contact. Do not connect a loudspeaker at this time. Adjust RV1 to centre and RV2 fully counterclockwise, as viewed from the positive rail side of the pc board. If all is in order, connect the module to the power transformer and switch on. Using a multimeter on the 1V range, adjust RV2 so that the voltage between the ends of RV2 reads 0.8V. Now adjust RV1 so that the voltage between the output terminal and ground is as close to zero as possible. Ideally, a digital multimeter should be used for this measurement since most analogue meters do not have the necessary resolution. Adjust TV1 to achieve a dc voltage on the output of less than 10 mV, if possible. If your multimeter does not allow measurement of voltages this small, leave RV1 set at the centre position. When both of these adjustments have been made, the module is ready for operation.



TRACK SIDE OVERLAY DIAGRAM



150 Watt Amp — Parts List

Resistors (all ½ W, 5% unless stated)

R1,2	100k
R3,11	1k
R4,5,18-21	220R
R6,7	3k9
R8	22k
R9	680R
R10	10k
R12,15,16,17	100R
R13	33k
R14	10k 1W
R22-25	0R22 W
R26	4R7 1W
R27	1R 1W
RV1	100R preset
RV2	250R preset

Capacitors

C1,9	220n
C2	2n2
C3	100u/25V electrolytic
C4	33p ceramic
C5	6n8
C6,8	330p ceramic
C7	47n
C10,11	100n
C12,13	8000u/75V electrolytic

Q1,2,3	BC546
Q4,5	BF470
Q6,7	BF469
Q8,9	2SK134 Hitachi MOSFET
Q10,11	2SJ49 Hitachi MOSFET
D1-4	1N914
D5-8	1N5404
ZD1,2	12V 400mW zener

Miscellaneous

pc board; plastic bobbin; 5 A fuse (speaker fuse, not mounted on pc board); fuse holder; 1m of 0.8mm enamel-covered copper wire; 155mm length of aluminum extrusion, 40mm x 12mm, for use as the heatsink bracket; assorted nuts and bolts, hookup wire, etc; two solder lugs.

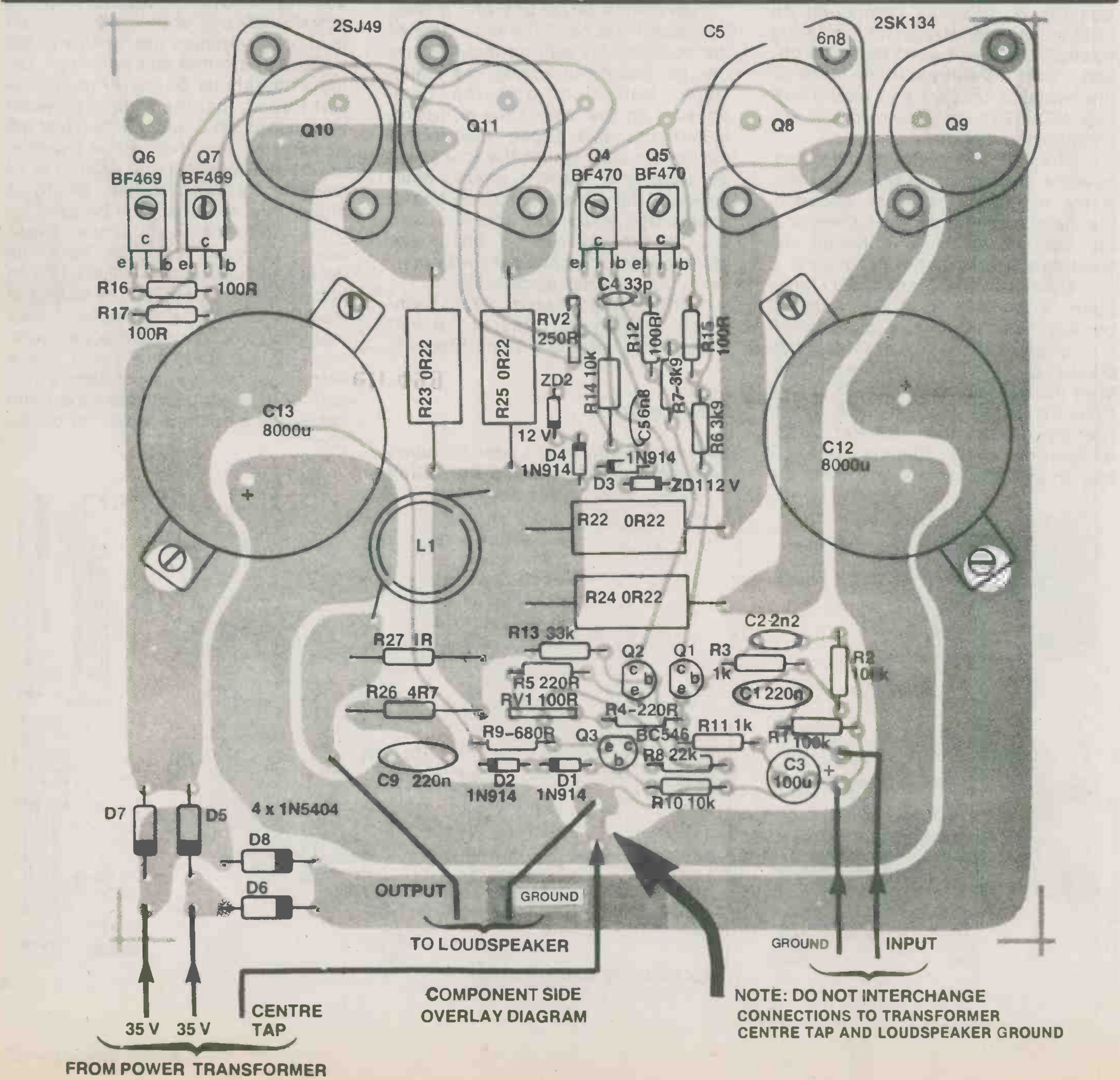
Special Note:

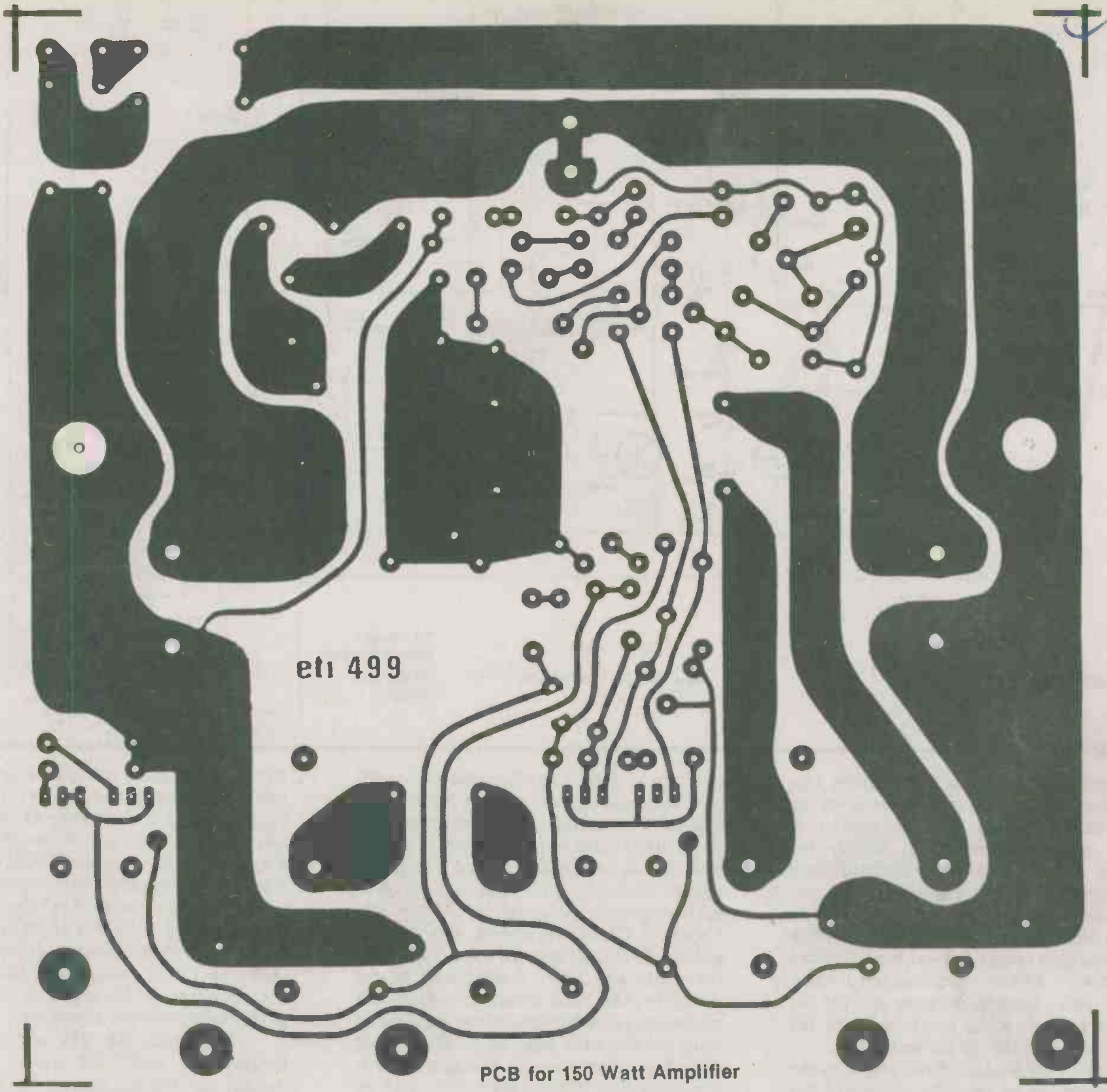
The tricky bits are the semiconductors. The bipolar transistors, as you may have noticed, have rather unusual numbers. These are European parts, as there just aren't suitable 2N types to do the job (that don't cost a fortune and come in 1000 lot minimums). However, Philips of Canada assures us that all Philips distributors carry these little fellows, or can get them. Readers are urged not to try to substitute these transistors.

The output devices have been specially imported for this project by our friends:

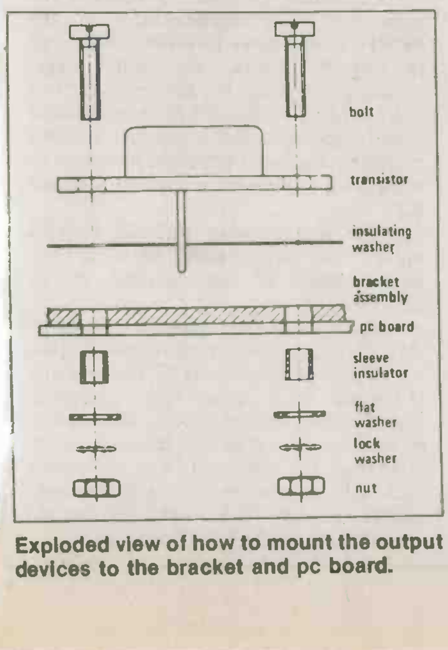
Altair Electronics
660 Progress Ave.,
Kingston, Ont
K7M 4W9
Phone: (613) 384-3876.

They're priced at $7.95 each. Readers having difficulty finding these transistors may contact us for a list of Philips distributors.





PCB for 150 Watt Amplifier



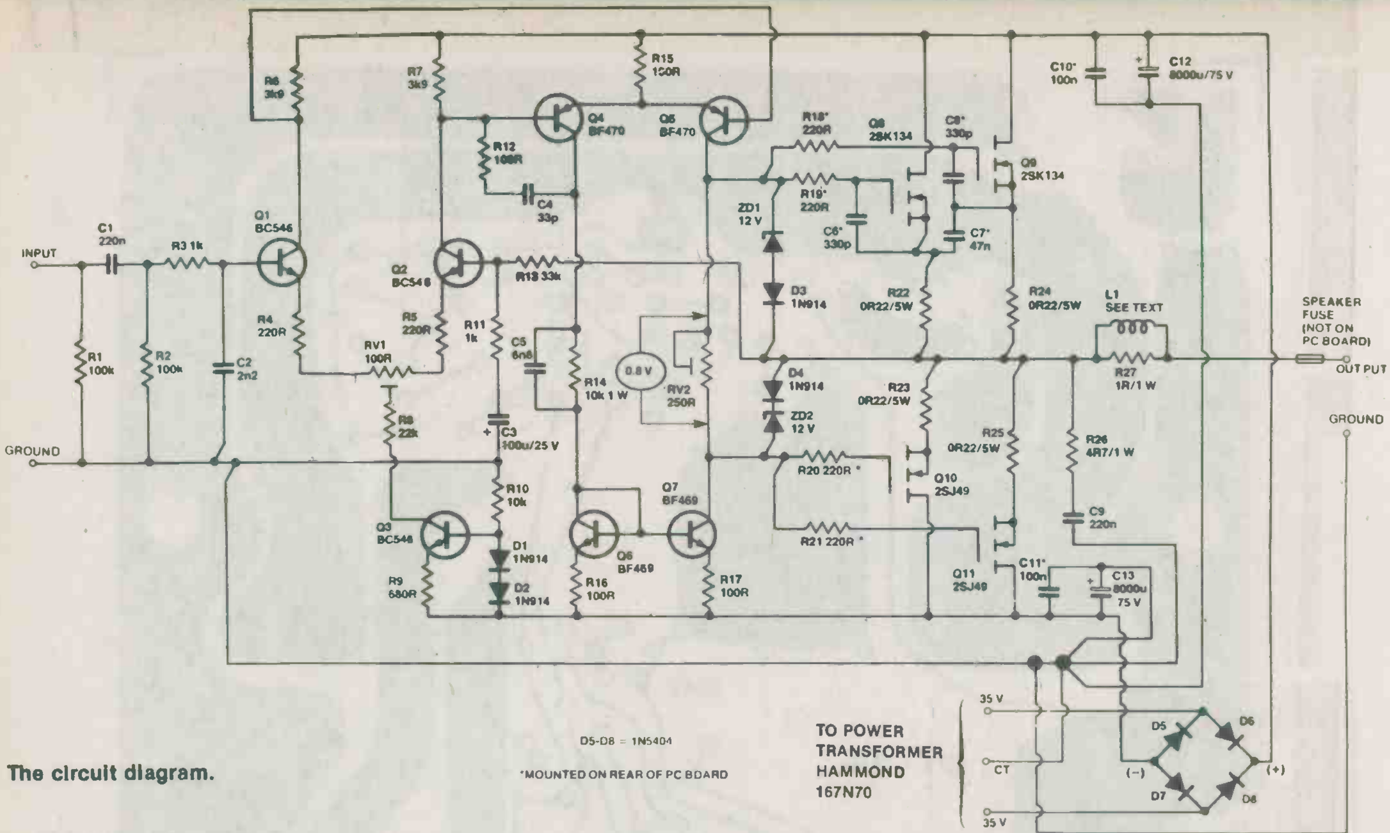
Exploded view of how to mount the output devices to the bracket and pc board.

For the R26-C29 network to provide an effective high frequency load to the output stage it is imperative that C9 (220n) have low self inductance. From experience, we have found Philips polycarbonates meet this requirement. High frequency instability, if not outright oscillation, may result if this requirement is not met.

To a lesser extent, the same applies to C7, C10 and C11. Note that C7 ac-couples the sources of Q8 and Q9 together, so that the self inductance of the source ballast resistors R22 and R24 is no longer important, preventing high frequency instability in this section of the output stage brought about by the inductance of the wirewound ballast resistors.

Performance

We have tested the prototype into both inductive and capacitive loads and at all times it performed impeccably. The sound is clean and smooth with no sign of the harshness sometimes experienced with transistor power amps. The high speed of MOSFETs helps to ensure freedom from slew-induced distortions and the amp clips cleanly with no sign of instability.



The circuit diagram.

How It Works

The circuit is a development from one published in Hitachi's application notes for these MOSFETs. The original circuit uses driver transistors designed by Hitachi for use as MOSFET drivers. Unfortunately these devices are not available at the present time, so most of the differences are to ensure stability and low distortion with a more readily available driver. We have used the BF469, BF470 complementary video output pair. These transistors provide the necessary speed so as not to degrade the performance of the output transistors.

One of the most difficult stages in the development of an amplifier module of this type is the pc board design. Separation of the large currents flowing to the electrolytic capacitors from signal ground is absolutely imperative if low distortion is to be obtained. An earlier pc board using exactly the same circuit gave distortion figures as high as 1% when driven into 8 ohms at around 10 W RMS! The problem was simply interaction between charging currents to the electrolytic capacitors and the ground reference to the input differential pair. For best performance use the pc board design published with this article and pay special attention to all ground and supply connections. In particular ensure that the connections to the centre point of the transformer and the loudspeaker ground are soldered into the correct positions on the pc board. Although these two points are immediately adjacent on the pc board they are not equivalent electrically due to the slight resistance of the board. If these wires are connected the wrong way around the distortion will be increased possibly by as much as 20-30 dB!

Transistors Q1 and Q2 form an input differential pair. Their function is to compare the output signal with the input signal and drive the voltage amplifier transistors in the driver stage with the necessary correction signal, sometimes called the error voltage or error signal. The base of Q1 is held at ground potential by resistor R2. Capacitor C1 in conjunction with R2, R3 and C2 forms an input filter, which defines the upper and lower 3 dB points of the amplifier. This filter therefore restricts the maximum possible signal slope capable of being driven to the input of the differential pair. This is an essential function since it eliminates slew-induced distortions such as TIM, provided that the rest of the power amp has a slew rate in excess of this limit.

The gain of the differential pair is around 17, so most of the open loop gain is done by the driver transistors Q4 and Q5, and their associated current mirror formed by Q6 and Q7. The series RC network C4, R12 ensures stability of the amplifier by decreasing the gain of the driver stage at very high frequencies, while keeping the phase shift produced within 90°.

As stated above, transistors Q6 and Q7 form a current mirror. The purpose of these devices is to ensure the current through the two driver transistors remains identical. At the same time the very high impedance represented by Q7 on the collector of Q5 ensures high open loop gain, and consequently low distortion through the relatively large amount of negative feedback available. RV2 varies the voltage between the gates of the output MOSFETs and therefore the amount of bias current through the output transistors. If the voltage across this preset is set to around 0.8V the bias current will be approximately 80 mA, which is about right. If the bias current is decreased completely by turning RV2 fully away from the MOSFET end of the board, the MOSFETs will remain off until a signal is fed to the input. This is pure class B operation and results in the coolest operation of the power amplifier. The disadvantage, however, is that a slight increase in distortion, called crossover distortion, will result. In PA or guitar applications this is not a problem, so the amplifier can be used in this mode without hesitation.

The diodes D3, D4 and the zener diodes ZD1 and ZD2 ensure that the voltage between the gates of the FETs and their sources never exceeds 12.6 V, the most common cause of MOSFET failure.

Capacitors C6 and C8 equalise the capacitive input characteristics of the MOSFETs and make it considerably easier to correctly stabilise the output stage. Capacitor C7 brings the sources of the two 2SK134 MOSFETs to the same potential at high frequencies, and overcomes possible problems that might otherwise be caused by inductance in the source resistors R22 and R24.

The four resistors R22-R25 help to match the difference between the characteristics of the different output devices.

The passive filter network formed by R26, C9 ensures that the module always has a load at high frequencies. If the amplifier is tested with large high frequency sinewaves this resistor will become extremely hot, but this does not indicate a fault condition. The inductor L1 and the resistor R27 help to ensure total stabillity into capacitive loads, such as when driving extremely long loudspeaker leads.

LEAVE IT TO US TO BEAT CANCER.

When you're making out your will, you should provide, first and foremost, for your loved ones and friends. But after they're looked after, then what?

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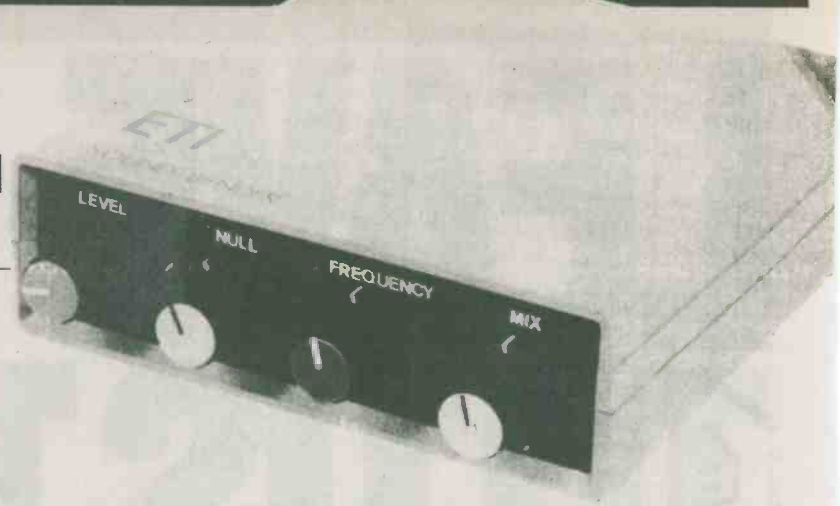
Canadian Cancer Society

CAN CANCER BE BEATEN? YOU BET YOUR LIFE IT CAN.

Sound Bender



This neat little ring modulator has a built-in wide-range sine/triangle modulation oscillator and a 'pan pot' output mixer, but can be built (less the case) for under $25.00.

ONE OF THE MOST popular types of cheap sound-effects units is the so-called 'ring modulator' or four-quadrant multiplier. These units have two inputs, one being a voice or music audio signal and the other being a simple sine or triangle oscillator waveform. The output of the unit is equal to the product of the two instantaneous signal amplitudes. In other words, the oscillator effectively amplitude-modulates the voice/music signal, to give some very interesting changes in the apparent signal content of the original voice/music material.

The ETI Sound Bender is a fully self-contained version of the popular ring modulator circuit. Naturally, however, our project has few special features. First, it has a built-in modulation oscillator that can span the frequency range 3 Hz to 5 kHz using a single control pot and which can produce either sine or symmetrical-triangle output waveforms. Second, the actual ring modulator is based on a precision four-quadrant multiplier circuit that is integrated into the oscillator chip; the multiplier balance is externally adjustable, enabling the unit to be used either as a 'sound bender' or as a simple sine/triangle audio generator. Finally, the unit incorporates a two-channel audio mixer in its output stage, which enables the original and modulated audio signals to be mixed in any desired ratio (ranging from 'all original' to 'all modulated') by a single pan-pot type control.

Our unit is designed to operate from nominal audio input signal levels of about 100mV RMS or greater and can simply be interposed between the output of the preamplifier and the input of the main amplifier of an existing audio system. The unit is battery powered by a stack of eight 1V5 cells and typically consumes about 12 mA.

Construction

The ETI Sound Bender is a fairly simple project and construction should present very few problems. Build up the PCB as shown by the overlay, noting the use of 16 Veropins to facilitate the circuit interwiring, then fit the PCB into a suitable case and complete the interwiring to the off-board components, noting that the two halves of RV4 are connected in opposite directions. On our prototype unit the four control pots are fitted on the unit's front panel and the two switches and the input/output terminals are fitted on the rear panel. As you can see from the photographs,

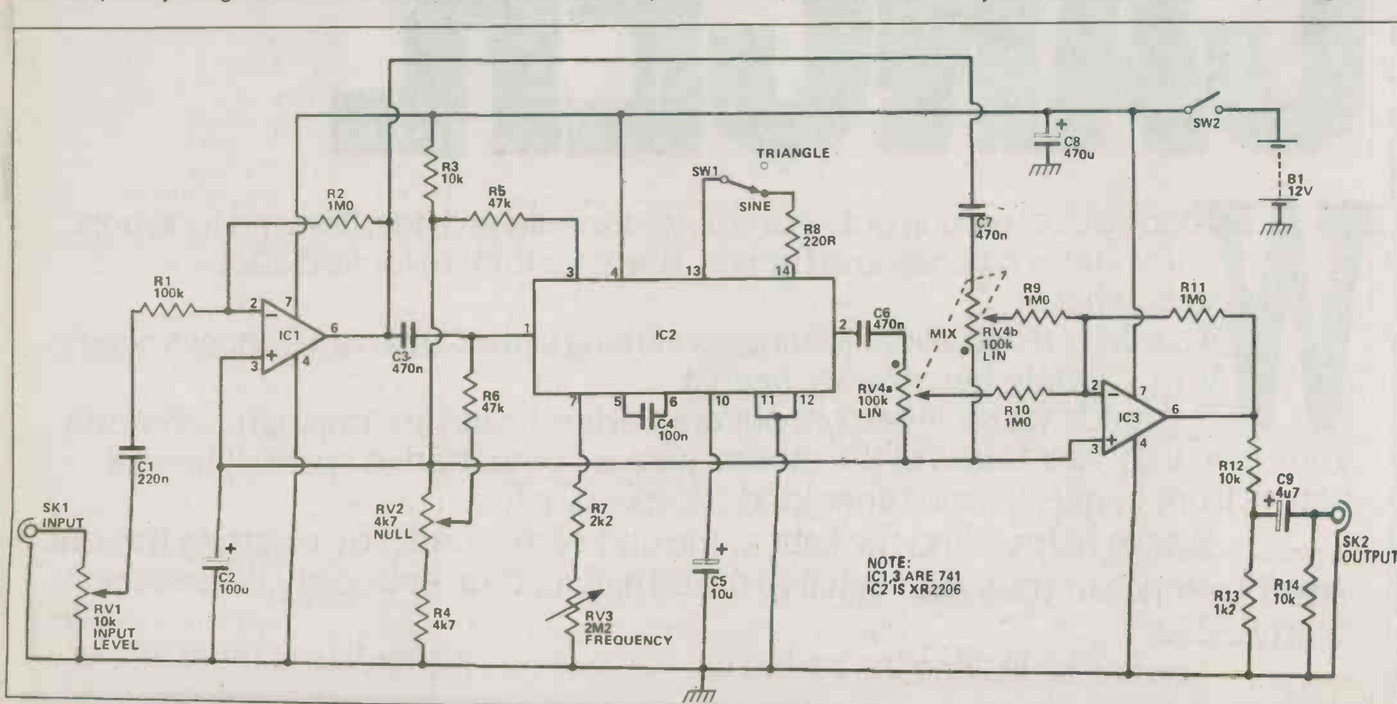
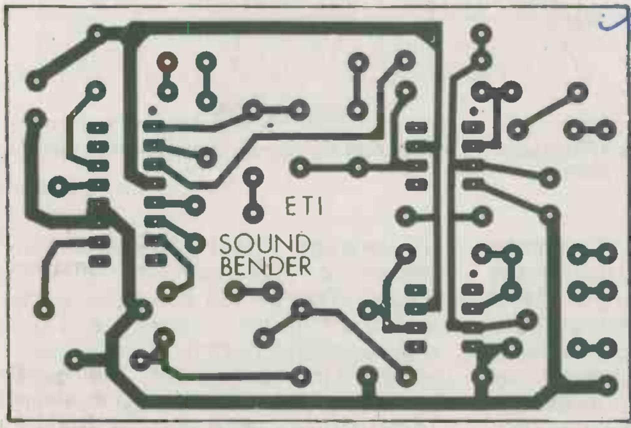


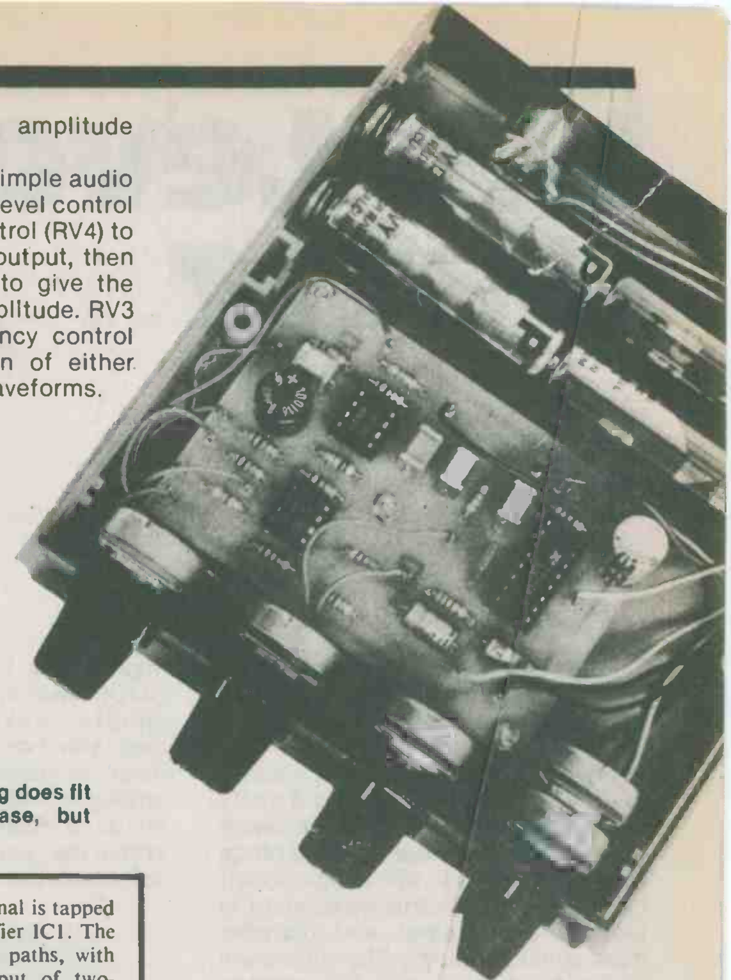
Fig. 1 Complete diagram of the ETI Sound Bender.

the circuitry and battery pack make a fairly tight fit in the case.

The unit is very easy to use. Simply connect the output to an audio power amplifier/speaker combination, adjust RV2 (null) for zero output tone, then connect a voice or music Input signal and see how the sound can be 'bent' using the frequency and mix controls. Level control RV1 is simply adjusted to give good sensitivity without amplitude limiting (clipping).

To use the unit as a simple audio generator, turn the input level control down and set the mix control (RV4) to give a 'modulation only' output, then adjust null control RV2 to give the desired output signal amplitude. RV3 then acts as the frequency control and SW1 gives selection of either sine or triangle output waveforms.





Everything does fit in the case, but only just!

How It Works

The heart of this unit is IC2, an XR2206 function generator chip that incorporates a wide-range sine/triangle waveform generator and a precision four-quadrant multiplier within a single package. The output of the waveform generator is internally connected to one input of the multiplier, and the other input of the multiplier is accessible at pin 1: the output is available at pin 2.

In our application, the generator can produce either sine or symmetrical-triangle waveforms, depending on the setting of SW1, and its frequency (determined by C4-R7-RV3) can be varied over the range 3 Hz to 5 kHz via RV3. The pin 1 input of the multiplier is biased by RV2, which is normally adjusted to balance the multiplier so that it produces zero output when zero signal input is applied to pin 1.

The audio input signal is applied across RV1 and a fraction of this signal is tapped off and applied to X10 amplifier IC1. The output of IC1 splits into two paths, with one path passing to one input of two-channel audio mixer IC3 via RV4b, and with the other path passing to the input (pin 1) of IC2, which has its output (pin 2) taken to the other input of the IC3 mixer via RV4a. Note that mix controls RV4a and RV4b are connected in opposite directions so that they control the mixing action in 'pan pot' fashion, giving a final output from IC3 that ranges from 'all original signal' to 'all modulated signal' in the extreme settings of RV4. The output amplitude of IC3 is divided by 10 (by R12-R13), so that the final output signal has an amplitude roughly equal to that of the input signal feeding IC1, thereby giving the Sound Bender a good overall signal-to-noise ratio.

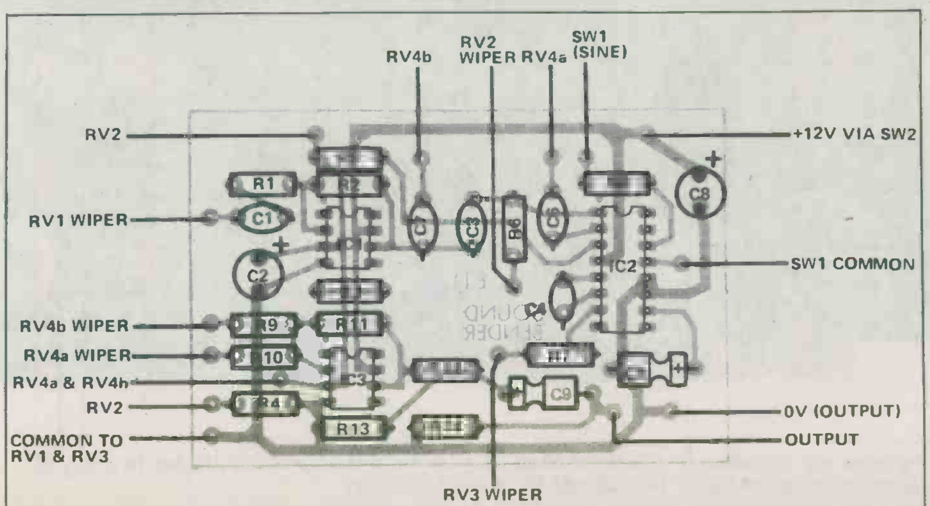


Fig. 2 Component overlay.

Parts List

Resistors
(all ¼ W, 5%)

R1	100k
R2,9,10,11	1M0
R3,12,14	10k
R4	4k7
R5,6	47k
R7	2k2
R8	220R

Potentiometers

RV1	10k linear
RV2	4k7 linear
RV3	2M2 linear
RV4	100k dual linear

Capacitors

C1	220n polycarbonate
C2	100u 16V PCB electrolytic
C3,6,7	470n polycarbonate
C4	100n ceramic
C5	10u 25V axial electrolytic
C8	470u 16V PCB electrolytic
C9	4u7 16V axial electrolytic

Semiconductors

IC1,3	741
IC2	XR2206

Miscellaneous

SW1,2	SPDT miniature toggle
SK1,2	phono sockets
PCB	

battery holders (two off).

LED Level Meter

The LED level meter described here is ideal for any application requiring a wide dynamic range level display. Naturally, two are required for stereo applications.

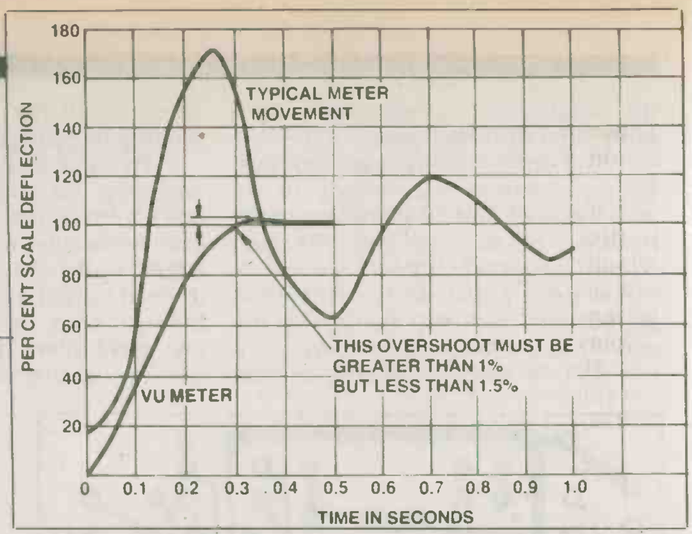
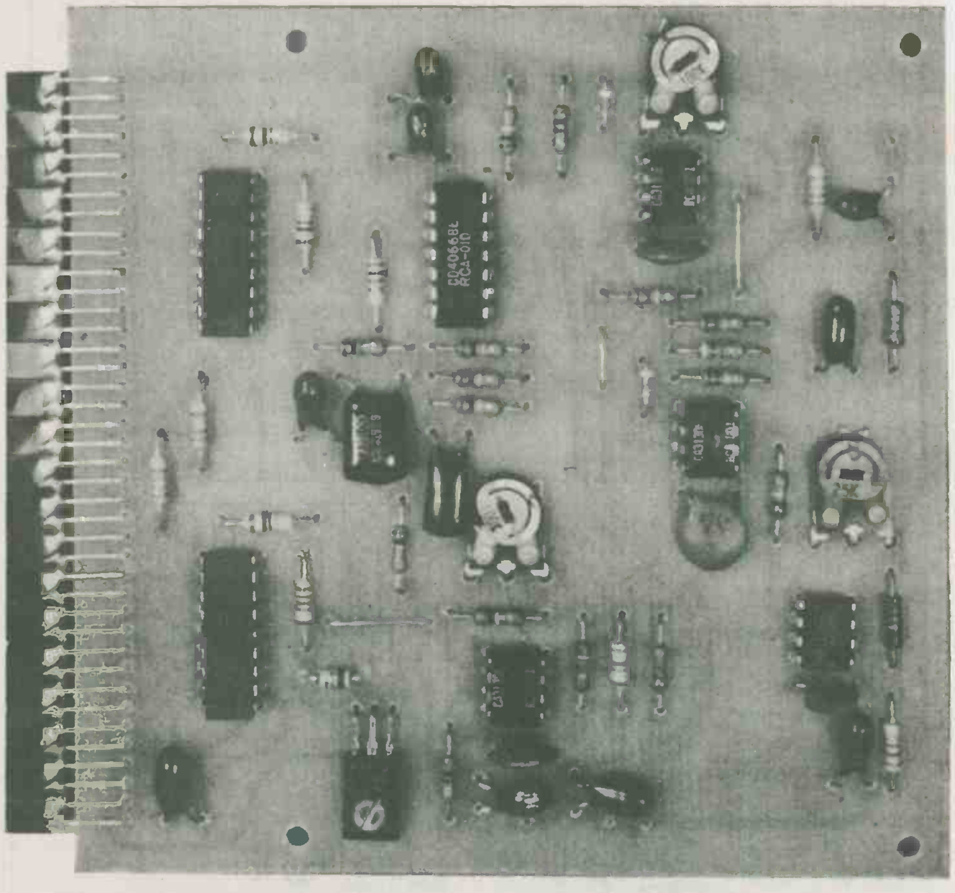


Fig. 1 'Ballistics' of a VU meter compared to conventional moving-coil meter.

THE ETI LED LEVEL meter overcomes a number of the drawbacks inherent in mechanical VU meters by replacing the meter movement with a row of light emitting diodes driven by a pair of dB LED display drivers. Twenty LEDs are used, with 3 dB between each LED, so the total dynamic range displayed is 60 dB. The circuit monitors both the true peak and the average signal level and displays both simultaneously. The difference between the peak and the average voltages of a sinewave is around 3 dB, so with a sinewave applied consecutive LEDs will light. With music applied however, the difference between the two LEDs will be substantially greater, depending on the transient nature of the signal applied.

Fig. 2 shows a complete circuit diagram for the LED level display. The input is fed first to a prescaling amplifier formed by an LM301 op-amp, IC1, and the associated passive components. This stage has adjustable gain, set by the preset RV1 that allows the 0 dB point to be set to the desired reference voltage. This will be covered in greater depth later, in the setting up procedure. The output of the prescaling stage is connected to the input of a full wave rectifier formed by IC2 and its associated components. The output of the full wave rectifier is fed to an averaging filter formed by R9 and C6, and to a peak follower formed by IC3 and associated components. The peak follower has a rapid attack/slow decay characteristic so that it responds quickly to any transients but decays slowly so the transient can be seen easily on the display. The outputs from the peak follower and the averaging filter are connected to the inputs of two CMOS analogue switches.

The outputs of these switches are connected together and go to the input of the LED display. Two more CMOS switches are used to form a square wave oscillator. This oscillator has out of phase outputs used to drive the signal-carrying analogue switches alternately off and on at a relatively high frequency. When the switch connected to the output of the averaging filter is on, the average signal voltage is connected to the input of the LED display. This switch is subsequently turned off by the oscillator and the other analogue switch turned on, connecting the output of the peak follower to the LED display. So, only one of the two LEDs is on at any instant, but the rapid switching speed



Full-size reproduction of the completed project. Note the components are laid flat to permit close stacking of two boards for a stereo display.

between them and the persistence of vision make them both appear to be on.

Input signals to the LED display portion of the circuit are fed simultaneously to the LM3915 driving the upper 30 dB display and via a voltage amplifier to the lower 30 dB display.

The resistors R26 and R27 set the reference voltage of IC7 at 3.1 V and 30 dB below this voltage is

$$\frac{-30}{20} = \log\frac{x}{3.1}, \text{ or } 98\text{ mV}.$$

Now, the top LED driven by IC6 must correspond to this voltage, so the required gain around IC5 is 5.34/98 mV or 54.6. The values of the resistors R19 and R18 set this gain at (180 + 33 + 3.9)/3.9 or around 56 which is a good enough approximation, amounting to an error of less than 0.5 dB.

Internally, the LM3915 consists of a string of comparators; each one compares the input signal to a reference voltage it derives from a ten-way potential divider (see Fig. 3). The accuracy of the LM3915 is determined by these internal resistors and is therefore very good. To ensure the display is accurate over the entire 60 dB range it is only necessary to ensure that the changeover from one LM3915 to the

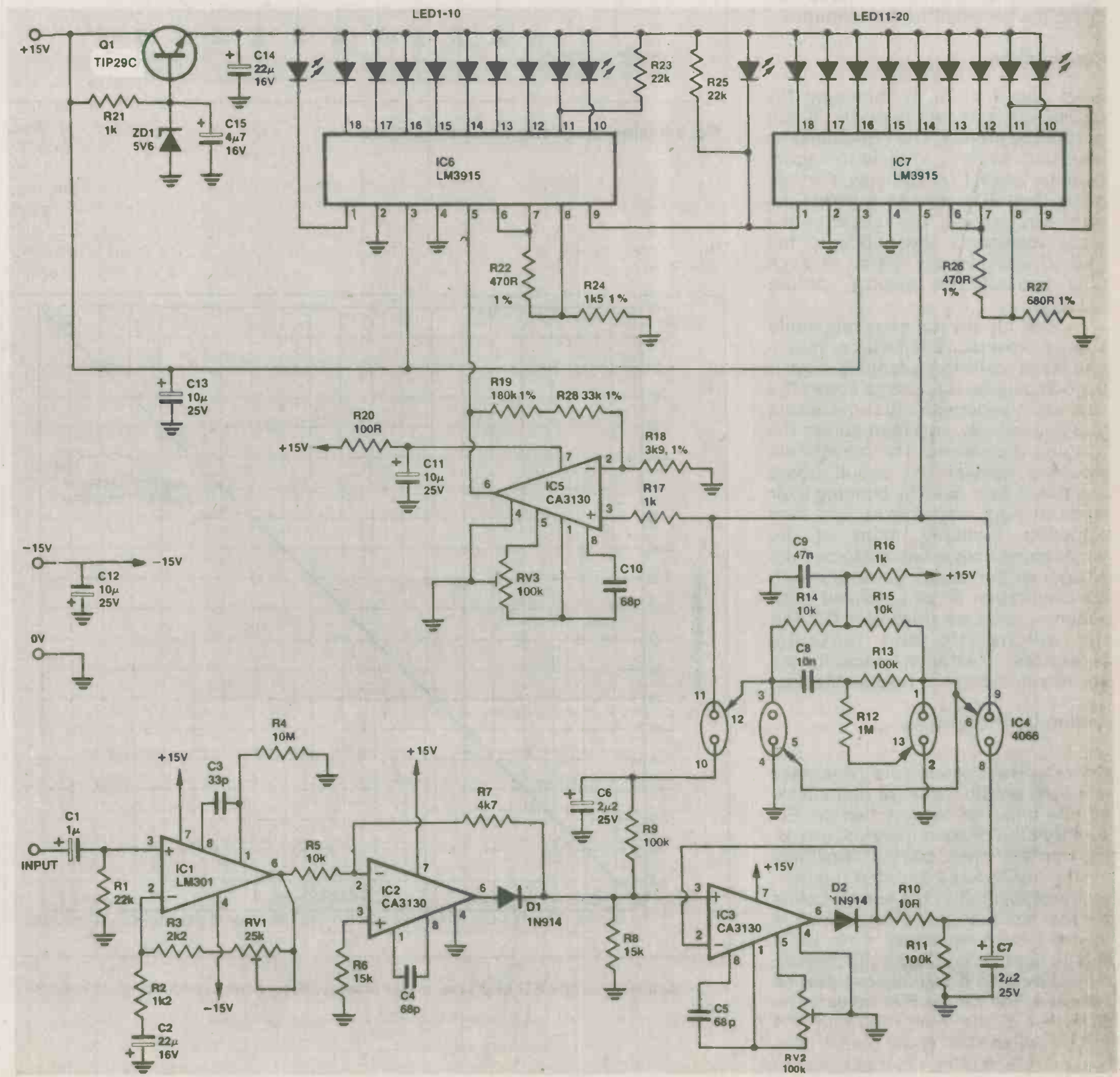


Fig. 2 Circuit diagram of the LED level meter.

other is accurate. Resistors R18, R19, R22, R24, R26, and R27 have been specified as 1% tolerance types for this reason.

Transistor Q1 forms a simple voltage regulator delivering 5V to the LEDs. This decreases the power dissipation in the LM3915s. The current consumption from the positive rail is around 100 mA while the negative rail needs only several milliamps. If the display is to be used from an existing power supply in a preamplifier for example, care should be taken to ensure that the relatively high positive rail current does not upset the preamplifier performance.

Construction

Start construction by mounting the LEDs. This is by far the most difficult part of the project. The LEDs must be inserted evenly and with equal heights, and this is not easy. Furthermore, the LEDs must be inserted the right way around. The longer of the leads represents the anode of the LED. Check the orientation of each LED against the overlay, before soldering.

Now all the other components can be mounted. The order of mounting is not really important although it is good general practice to solder the passive components first (resistors and capacitors), and then solder the ICs and transistors. The presets are mounted against the circuit board and this is best done by bending their leads at right angles first, and then soldering. Similarly, many of the larger capacitors may have to be folded against the board. Be careful with the orientation of all polarised components, such as transistor Q1 and the electrolytic and tantalum capacitors. Tantalum capacitators are very intolerant of reverse biasing.

Setting Up Proceedure

Once all the components have been mounted on the pc board and checked, the unit can be switched on. Ensure that the power supply you are using has sufficient current capability for the positive rail and that it is correctly connected to the supply points on the circit board. If the input is touched with a finger two LEDs should light and move up the display. If all is well the dc offsets can now be adjusted. The preset RV2 adjusts the dc offset of the peak follower. This will be adjusted to equal the dc level of the average filter, i.e. that from the output of the full wave rectifier. The overall dc offset can be nulled by

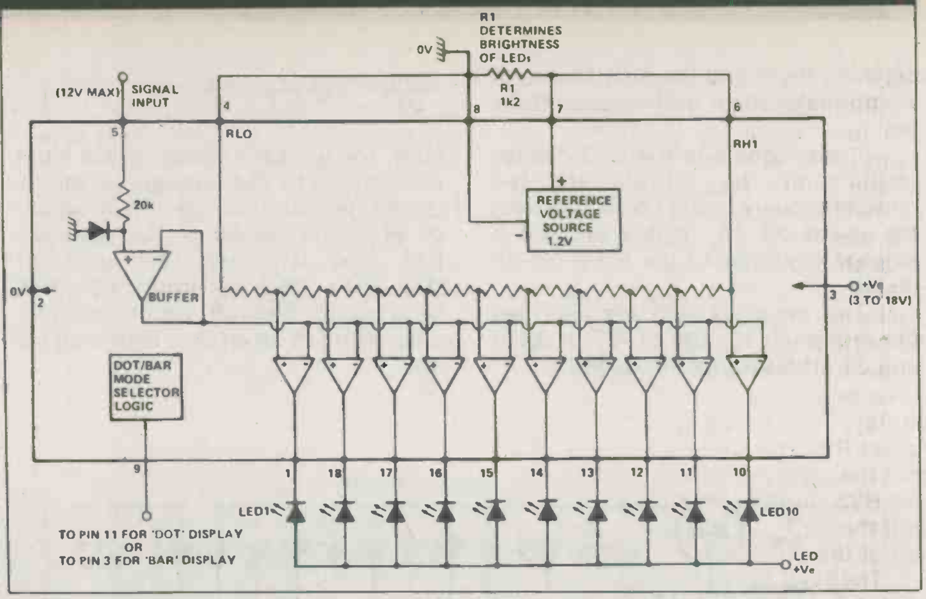


Fig. 3 Internal block diagram of the LM3915.

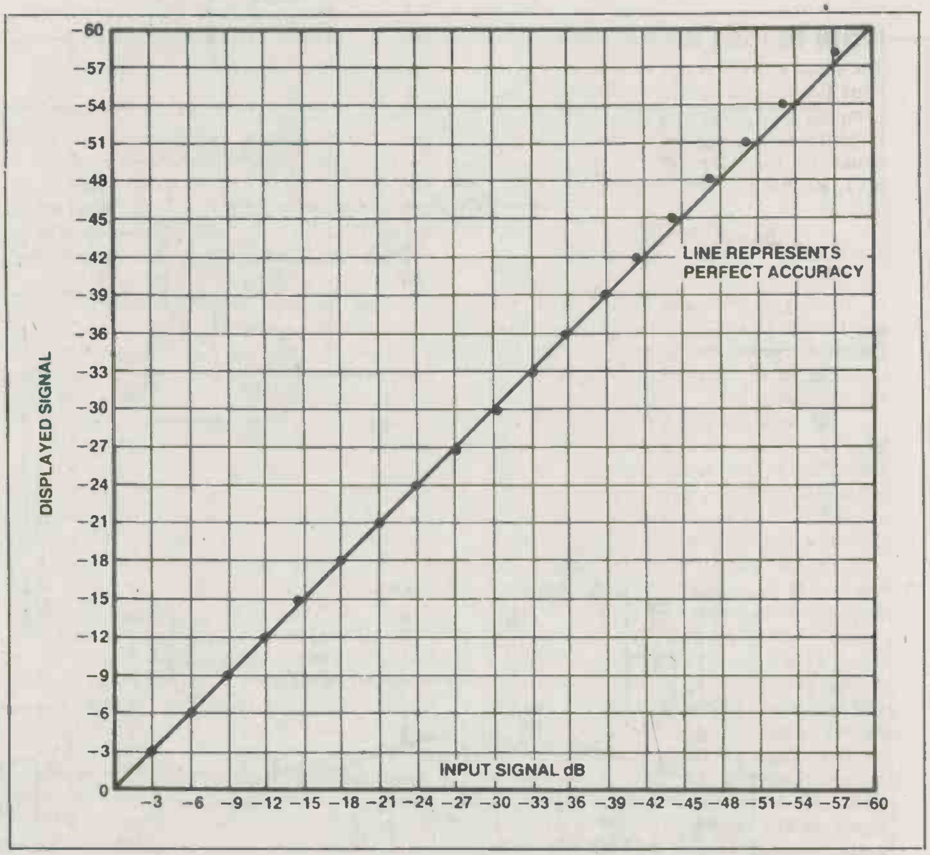
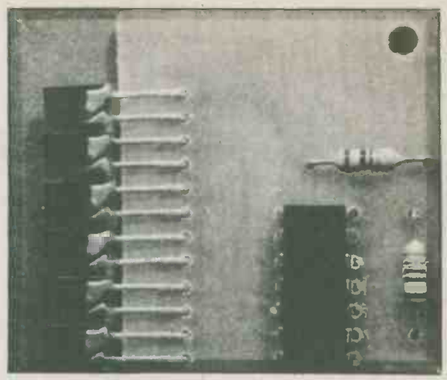


Fig. 4 Accuracy of the ETI LED level meter display (dots) compared to 'perfect accuracy' (line).

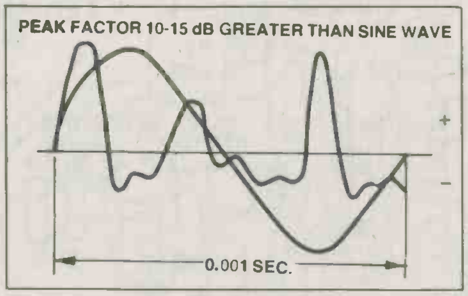
RV3.

First connect the input of the LED level meter to ground on the board. This ensures that no signal voltage will be present when the adjustments are made. Now turn both RV2 and RV3 fully clockwise; both LEDs should run off the bottom of the display. Turn RV3 slowly counterclockwise until the second LED from the bottom has just turned on. If RV2 is now turned counterclockwise also, a second LED will light on the display. This is the peak level LED. Adjust RV2 to superimpose this LED onto the second bottom LED. Now adjust RV3, turning it clockwise again until the LED has just run off the bottom of the display.

The final stage in the setting up procedure is to align the meter for the appropriate 0 dB level. Preset RV1 varies the gain of the prescaling amplifier stage formed by IC1. Adjustment of this preset will vary the input voltage required to light the top LED between 260 mV and 2.5 V. If your application requries 0 dB to be a higher voltage than 2.2 V, use a potential divider at the input to decrease the input signal voltage. If more gain is required increasing the value of the preset from 25k to 100k will decrease the necessary input voltage to around 70 mV, which should be sufficient for most applications.



Close-up of the pc board showing orientation of the LEDs. IC7 at lower right.



A typical 'music' signal may have a completely different peak-to-average ratio compared to a sinewave, and the peaks are often not symmetrical in amplitude about the zero axis. The duration of peaks may be as short as 50 microseconds.

How It Works

The input stage consists of a variable gain amplifier formed by IC1 and its associated components. This is a conventional IC amplifier circuit in which the gain is determined by the values of the components RV1, R3 and R2. Specifically:

$$A_V = \frac{R2 + R3 + RV1}{R2}$$

So the bigger the value set on RV1, the greater the gain. Capacitor C2 has the effect of decreasing this gain for very low frequencies, or dc, decreasing the dc offset on the output.

The second stage is the full wave rectifier or 'absolute value generator'. As mentioned in the text, most full wave rectifiers require more than a single op-amp, so this stage will be of use in any application requiring a full wave rectifier with minimum component count. For negative-going signals the stage functions as an inverting amplifier with a gain of 0.5. This is determined by the values of R5 and R7. when the input signal goes positive the output is driven hard against its negative supply voltage, which in this case is 0 V. So the output stage is turned off, and has a relatively high output impedance. In this state the resistors R5, R7 and R8 form a potential divider and connect the input signal to the output directly. Again, the output voltage is one half of the input voltage. In order for this circuit to work, the output stage in the op-amp must be CMOS so that the output can go completely to 0V and have an output impedance high enough not to short out the signal voltage from the potential divider. This is the reason the CA3130 is used. Furthermore, this is a relatively fast device which ensures that the full wave rectifier will have a frequency response that covers the entire audio spectrum. The one disadvantage of the circuit is that it requires a high load impedance since the output signal for positive-going input signals is obtained from the potential divider and not from the op-amp itself. In this application the load is around 100k (R9) which causes negligible error.

The output of the full wave rectifier is fed simultaneously to an average filter formed by R9 and C6, and to the peak hold circuit formed by IC3 and its associated components. The peak hold circuit is really nothing more than a 'precision diode' that charges a capacitor to the peak voltage. The precision diode is formed by including a conventional signal diode in the feedback loop of a fast op-amp. If an input signal is applied which is less than the forward voltage drop of the diode, the stage is effectively in open loop gain (around 320,000 for the CA3130). The output voltage will rise very quickly, turning the diode on. Since the output of the diode is connected to the inverting input of the op-amp, the stage functions with unity gain once the diode has been turned on. Capacitor C5 ensures stability of the stage while preset RV2 allows adjustment of dc offsets due to this stage. The output of the peak hold circuit charges capacitor C7 through resistor R10. The combination of R10 and C7 defines the attack rate of the peak detector.

As shown, the value of R10 is 10 ohms and this is small in comparison to the output impedance of the CA3130, but is included in case some applications require the peak detector to have a slower attack rate. With the values shown, the LED level meter will display single 50 uS pulses accurately and this is entirely adequate for any audio application.

Resistor R11 discharges the capacitor and its value of 100k dictates a decay rate of around one second. This gives the level meter its rapid attack, slow decay characteristic and enables even short transients to be spotted.

As explained in the text, both the average and the peak levels of the signal are displayed simultaneously. This is accomplished by multiplexing the outputs of the peak and average detectors. This is done by switching between the output of these two circuits at a relatively high frequency (say a few hundred Hertz). In the circuit, this is done with CMOS transmission gates. The 4066 was chosen mainly because its on resistance is a little lower than the older 4016 and this enables the remaining two gates in the package to be used as the driving oscillator. The oscillator is formed by resistors R12 to R15 and capacitor C8, with the associated two transmission gates. The frequency of the oscillator is determined by the values of R13 and C8 at around 150 Hz.

IC5 functions as an amplifier stage as discussed in the text. Once again dc offset adjustment is provided, this time by RV3. Capacitor C10 provides the necessary compensation to ensure stability. Details of the two LED drivers and the amplifier formed by IC5 are in the main text.

The transistor Q1 and the associated components R21, C15 and ZD1 form a simple 5V regulator to power the LM3915s. Capacitor C14 is essential for stability of the LED drivers and must be mounted close to the LEDs.

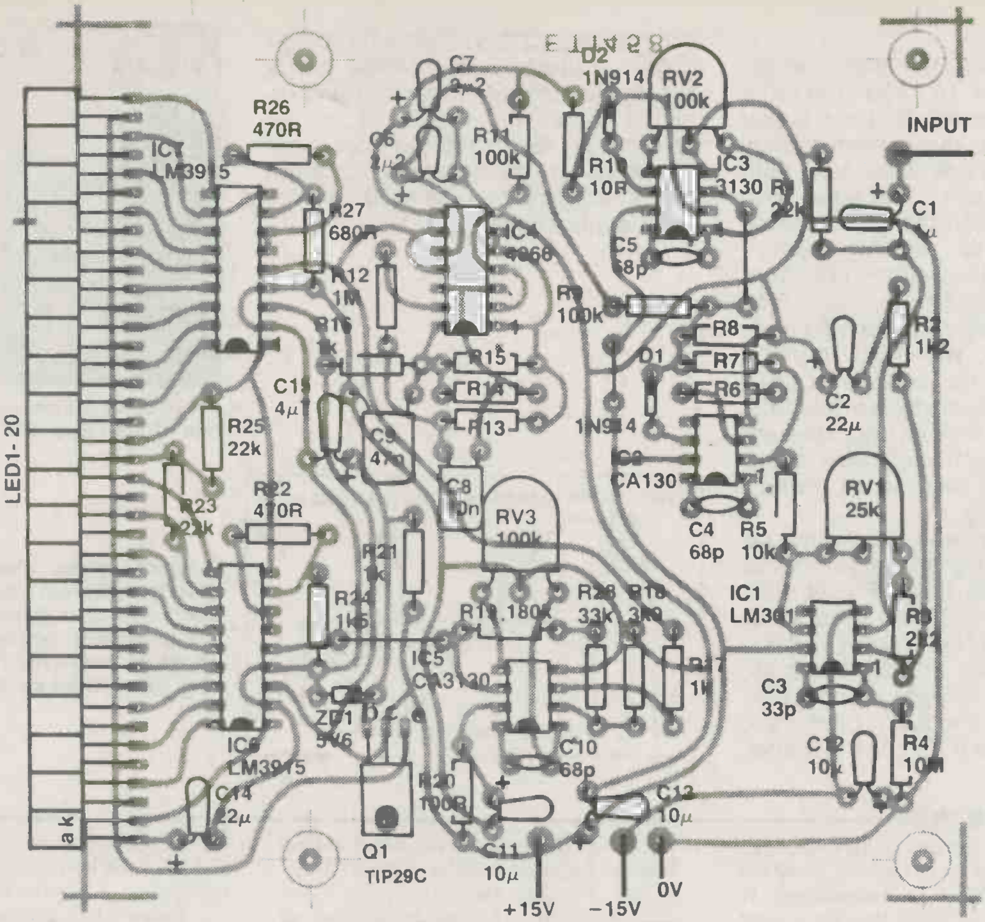
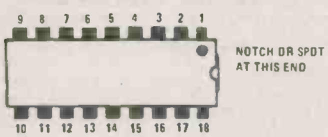
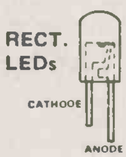
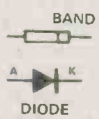
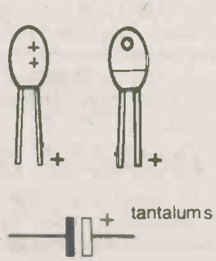


Fig. 5 Component overlay.









Parts List

Resistors (all ½ W, 5% unless marked otherwise)

R1,23,25	22k
R2	1k2
R3	2k2
R4	10M
R5,14,15	10k
R6,8	15k
R7	4k7
R9,11,13	100k
R10	10R
R12	1M
R16,17,21	1k
R18	3k9 1%
R19	180k 1%
R20	100R
R22,26	470R 1%
R24	1k5 1%
R27	680R 1%
R28	33k 1%
RV1	25k min trimpot
RV2, RV3	100k min trimpot

Capacitors

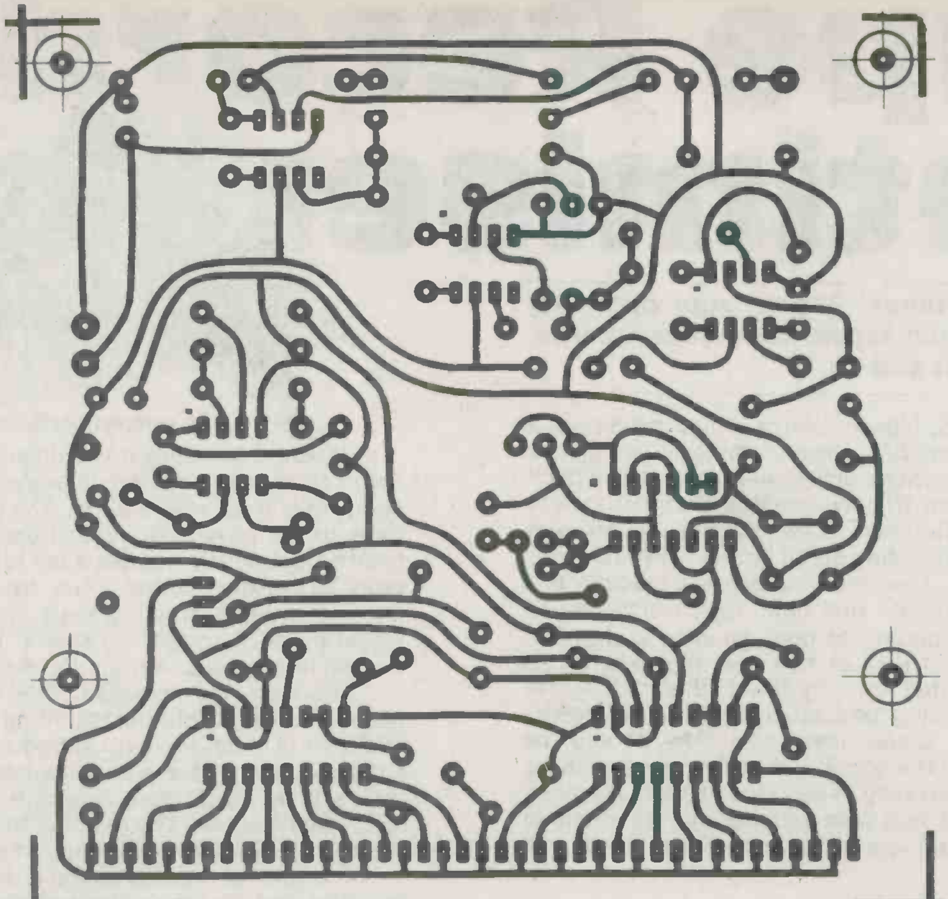
C1	1u/6V tant.
C2,14	22u/16V tant.
C3	33p ceramic
C4,5,10	68p ceramic
C6,7	2u2/25V tant.
C8	10n
C9	47n
C11,12,13	10u/25 V tant.
C15	4u7/16V tant.

Semiconductors

IC1	LM301, 8-pin DIL
IC2,3,5	CA3130, 8-pin DIL
IC4	4066
IC6,IC7	LM3915
D1,D2	1N914 or sim
ZD1	5V6 zener diode
Q1	TIP29C
LED1-20	Siemens LD80-2 or sim.

Miscellaneous

pc board one bolt and nut.



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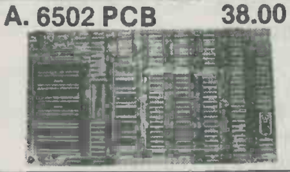

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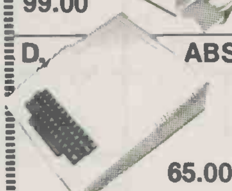

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Tape Recorder Optimiser

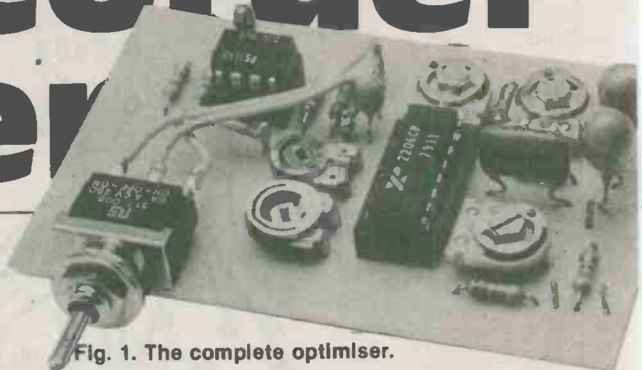


Fig. 1. The complete optimiser.

Optimise your tapes. Record your optimisations. Record your tapes. Tape your records. The list goes on and on.

YOUR ATTENTION, please. We have just developed a new magnetic recording tape of hitherto unheard-of audio fidelity and general universal splendor. The backing is pressed from tri-polyethelate-chloromethostyro-esterine, a revolutionary new plastic which was discovered by a Mongolian gerbil farmer who dabbled in molecular physics. The recording oxide is made from a new alloy of Uranium^{238} and neon gas, which can be utilised at an astounding 24 dbm, yielding a signal to noise ratio of 10^3. Users of this new tape should be aware, however, that due to the highly radioactive nature of the recording medium, a minimum of three inches of reactor grade lead shielding should be employed between the operator and the cassette deck.

You should also keep in mind that a slight readjustment of the bias of your tape recorder may be required in order to make full use of the properties of this new tape.

Iron Filings

Magnetic recording tape is usually a plastic ribbon, often not having been discovered by a Mongolian gerbil farmer, coated with a magnetic material, such as iron oxide. There are several other mediums currently in use, such as chromium dioxide, and so forth, but they all work in much the same way. When you buy the tape, the particles of the recording medium are arranged in a random pattern on the backing. When you run it through the recorder, they get positioned so as to represent the change in flux density corresponding to the audio you're trying to record. They get set up this way by the changing magnetic field of the recording head.

It would be handy if you could just fire some audio into a tape head and have it impressed on the tape, but, sadly, this is not where it's at. The particles on the tape have to be physically repositioned by the recording head's field, which requires a fair bit of energy at first, in order to get them going. Thus, the tape would be very non-linear when small signals were happening, and would produce something similar to cross over distortion on larger ones. A drag, to be sure.

Therefore, we have bias. Bias is an ultrasonic sine wave which rides into the recording head along with the audio. It is much too high in frequency to be recorded, but it does stir up some unrest among the particles, and makes them much more receptive to being influenced by the audio signal. The result is that the tape becomes much more sensitive, and much more linear.

The level of the bias signal is actually quite critical; too little, and the tape will not be as sensitive as it could be, and too much, and the high frequency component of the signal will actually partially erase itself. The optimum bias point, on modern cassette recorders, can be found by simply setting the level for a reasonably flat frequency response.

In fact, this can be simplified even more, for most situations, by getting the machine to be equally sensitive to two carefully chosen frequencies. In other words, if the low frequency response is equal to the high frequency response, we're laughing. This little project will do just that, with no fiddling around with the ol' function generator and 'scope. It will allow you to quickly check the bias setting for each type of tape you use in

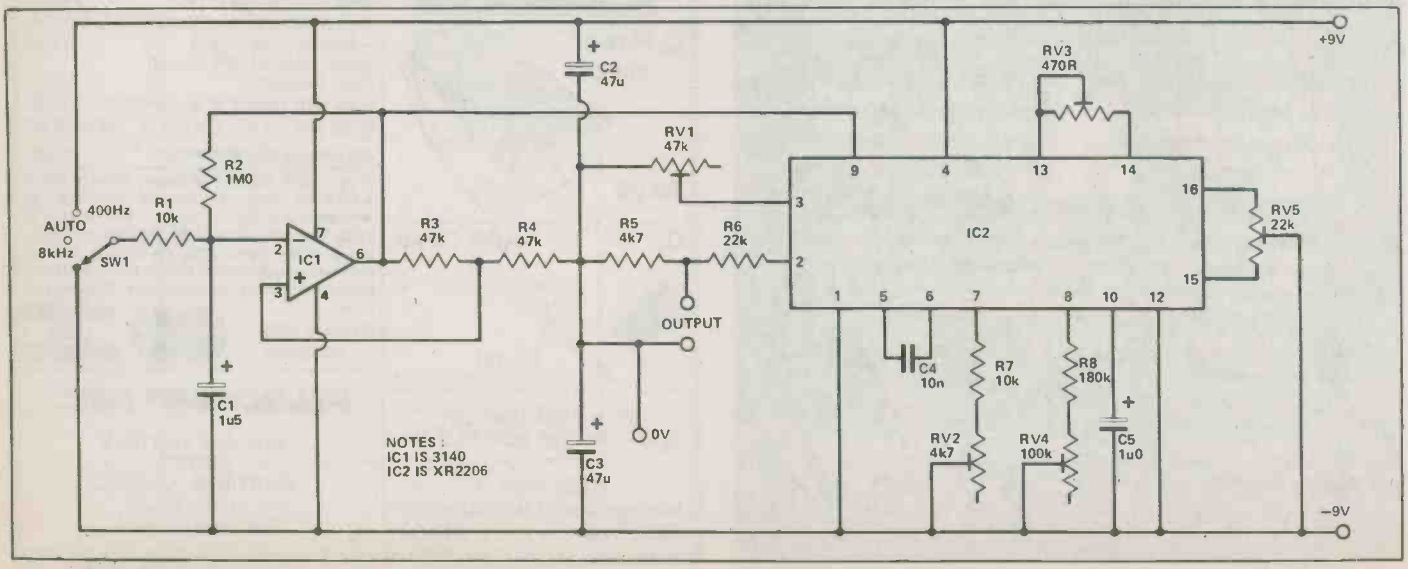


Fig. 2. The circuit diagram.

your deck, and, if you want to crawl inside with a screwdriver, to optimise the settings for your favourite tapes.

Getting It Together

The easiest approach to building the optimiser is to use our PCB. For one thing, it holds the trim pots. There isn't anything tricky in building the project. A 'scope would be helpful in setting it up, but you can get by without one.

Set RV5 to mid position, and RV3 to maximum. With the circuit running, twist RV1 to produce a 4 volt triangle wave at pin 2 of IC2. Then rotate RV3 until you get it looking like a clean sine wave, at about 2 volts. RV2 sets the low frequency tone, and RV4 the high. These should be 400 Hz and 12.5 kHz, respectively. If you haven't got a way to measure these frequencies, you can use fixed resistors for these pots, 250K for the low and 12k5 for the high, which will get you pretty close. The absolute frequencies aren't too important.

Using it

Using the optimiser is simple. Drop in the tape you want to check, and set your tape bias selector switches to the appropriate positions. Leave the Dolby off. Record the two tones at 0 vu, and then play them back. The levels of playback, as shown on the recorder's meters, will indicate whether the two tones have, in fact, come off the tape at equal levels. If they differ significantly, you should adjust the bias setting to get them as close as possible.

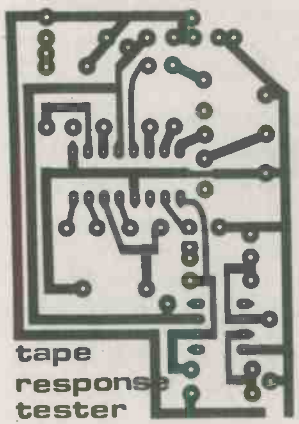


Fig. 3. The PCB

Tape Recorder Optimiser

Note: Cassette tapes are very easy to overload at high frequencies; this will make it appear as though the playback level at 12 KHz is too low, even though the machine is correctly adjusted. To avoid this it may be necessary to record the test tones at -10 VU or less.

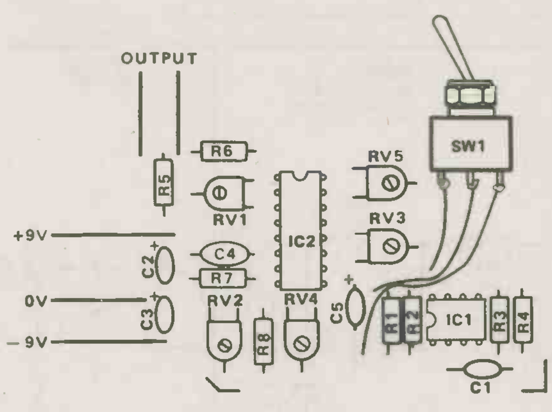


Fig. 4. The PCB overlay.

How It Works

Most of the work is taken care of by IC2. This chip generates a triangle waveform which is shaped internally to produce the sine wave output. Frequency is controlled by the value of C4 and choice of resistance from pin 7 or 8 to the negative supply. Only one resistor is actively connected at any moment. Selection is achieved by controlling the voltage applied to pin 9. When the voltage at pin 9 is above two volts, or if the pin is open circuit, then the timing resistor connected to pin 7 is selected. When the signal at pin 9 drops below one volt, control is transferred to the resistor at pin 8.

Changeover is accomplished automatically by connecting the output of IC1, an op-amp configured as an astable oscillator, to pin 9. A high or low output can be 'forced' by switching R1 to either supply rail via SW1. With SW1 in the 'centre-off' position, the op-amp will switch at slightly less than 1 Hz producing alternating tones from the unit. Frequencies are set by adjustment of RV2 and RV4.

The output signal is developed across R5, 6. Any convenient ratio may be chosen for these components to provide any desired output level up to a few volts peak to peak. A split supply was chosen as it facilitates circuit design. In any case IC2 needs at least a ten volt supply, precluding the use of a single battery. Current consumption is low and two 9V batteries provide a convenient source of power. Frequency stability with falling battery voltage is good and standard dry batteries are quite adequate. Capacitors C2, 3 provide overall decoupling.

Parts List

RESISTORS

R1,7	10k
R2	1M
R3,4	47k
R5	4k7
R6	22k
R8	180k

POTENTIOMETERS

RV1	47k min horiz preset
RV2	4k7 min horiz preset
RV3	470R min horiz preset
RV4	100k min horiz preset
RV5	22k min horiz preset

CAPACITORS

C1	1u5 tantalum
C2,3	47u tantalum
C4	10n polyester
C5	1u0 tantalum

SEMICONDUCTORS

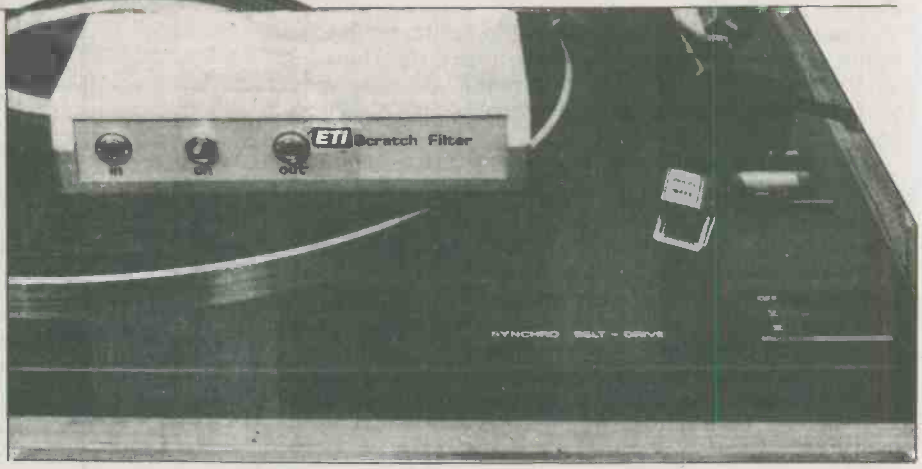
IC1	3140
IC2	XR2206

MISCELLANEOUS

PCB, IC sockets, single pole centre-off change-over switch.

Scratch Filter

Hisssssss-------! That's what happens if you build this simple scratch filter and use it when you listen to noisy records. It can help to reduce surface noise picked up by your stereo.



IF YOU HAVE a record collection, you almost certainly have at least a few records that would benefit from the use of our scratch filter. The problem with disc recordings is that even if they are well cared for they inevitably show signs of wear in the quality of reproduction obtained. This loss of quality appears as a loss of treble response and a background of almost constant clicking and popping sounds. As these sounds consist largely of high frequency components it is possible to reduce them substantially using a filter having a response that attenuates high frequencies, but does not significantly affect lower frequencies. The price that has to be payed for the reduced noise is the slight loss of wanted treble signals as well. However, it is probably true to say that most people prefer noise-free reproduction even if there is a loss of treble output.

Construction

Following Fig. 2, make up the Veroboard. Start by breaking the tracks of the board at the shown positions. You can do this with a Veroboard cutting tool; alternatively a 1/8" hand-held drill bit can be used for the job.

Next insert and solder the components one at a time, starting with resistors followed by capacitors and then semiconductors.

Mark and drill your chosen case to fit the input and output sockets and the on/off switch. Two boards and two sets of input and output sockets are required for a stereo scratch filter, but the battery and on/off switches are common to both channels in this event.

Finally, wire up your project as shown in Fig. 2.

Using The Filter

Ideally the scratch filter should be connected between the preamplifier and power amplifier stages of the hi-fi amplifier or receiver, and in many cases this will be possible using the 'tape monitor' facility. However, as the circuit has a high input impedance it is possible to connect it between a crystal or ceramic pick-up and the input of the amplifier, and this method should also give good results.

It is also possible to use the filter between a magnetic cartridge and the input of the amplifier if you put a 100k resistor across the input of the filter to give a suitable input impedance to match the cartridge. However, this method is not recommended since it will give a significant reduction in the signal to noise ratio of the system, and it is quite likely that stray pick-up of AC hum and other interference will be a problem.

Parts List

RESISTORS (All ¼W, 5%)

R1	1M0
R2	2M2
R3,4,5	4k7

CAPACITORS

C1	100n polyester
C2	1u, 25V electrolytic
C3	22n polyester
C4	3n3 polystyrene
C5	10u, 25V electrolytic

SEMICONDUCTORS

IC1	TL071CP low noise operational amplifier
Q1	MPS-A18 NPN transistor

MISCELLANEOUS

SW1	single-pole, single-throw toggle switch

Case to suit
Veroboard, 24 hole x 10 strip
Input and output sockets (SK1 and SK2) 9V battery + connector.

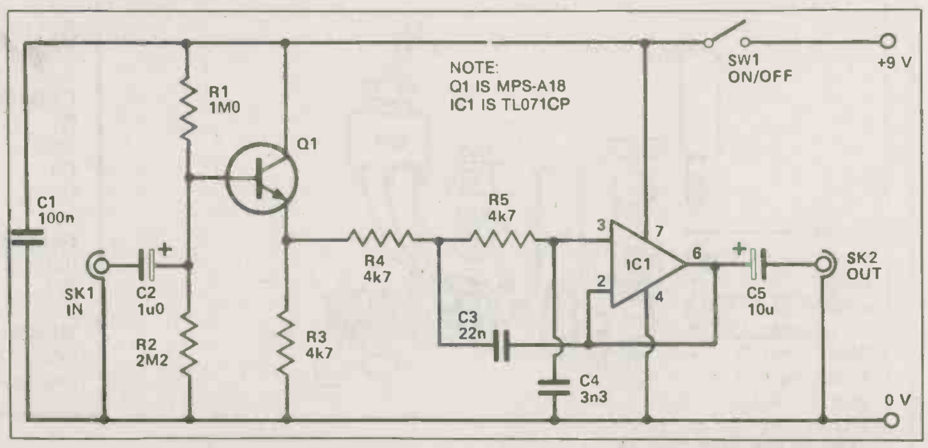


Fig. 1 Circuit of Scratch Filter.

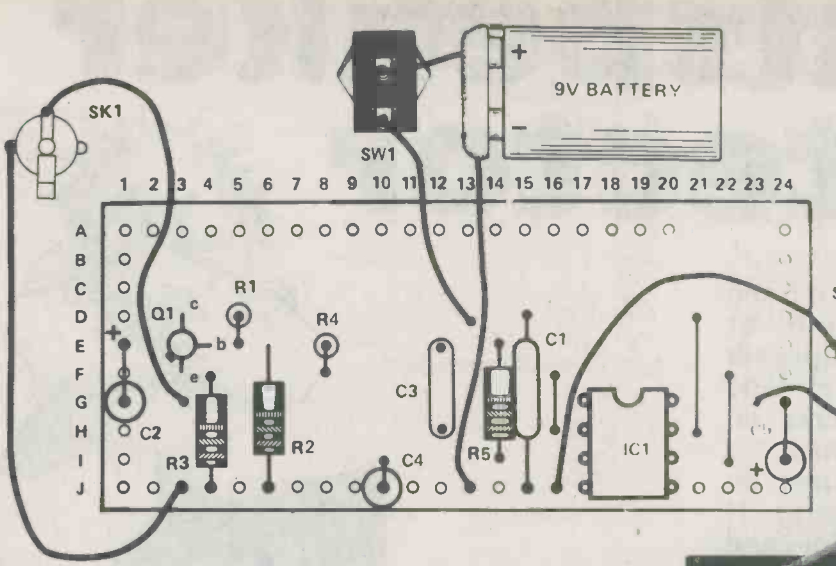
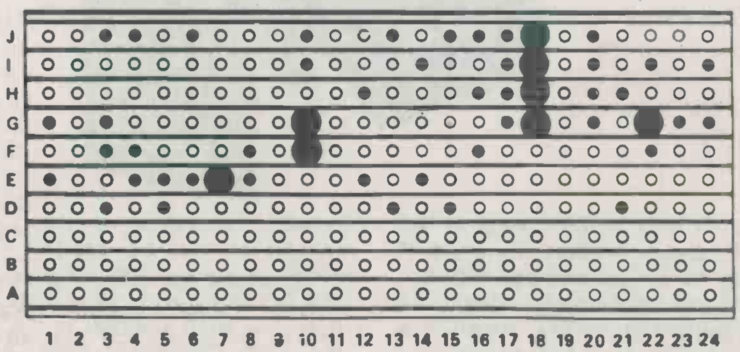
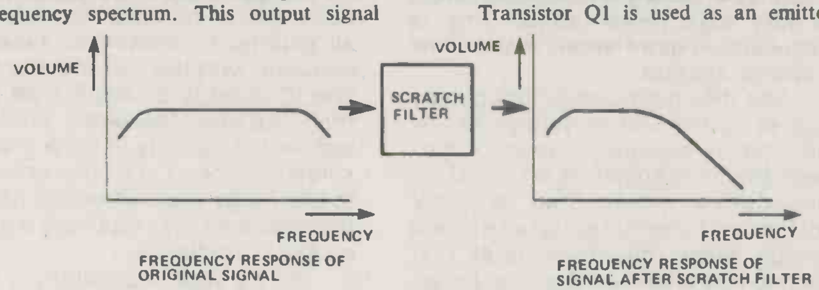


Fig. 2 Veroboard layout of the project, showing component locations and track breaks underneath the board.



How It Works

A sound signal, obtained from the cartridge of a record player might have a 'flat' frequency response, so named because the output volume is level over a large part of the frequency spectrum. This output signal



may contain surface noise from a worn record. However, noise (i.e., surface noise) consists of high frequency components.

Passing the signal through a scratch filter gives an output signal amplitude which, above a corner frequency, decreases with increasing frequency. Thus unwanted surface noise is reduced in volume compared to the majority of the sound signal.

Fig. 1 shows the circuit diagram of the filter, and this uses a conventional 12 dB per octave circuit (i.e., above the corner frequency, doubling the frequency causes a four-fold reduction in gain).

Transistor Q1 is used as an emitter follower buffer stage at the input which gives the circuit a high input impedance of about 500k, and ensures that the filter is fed from a relatively low source impedance and gives the required response.

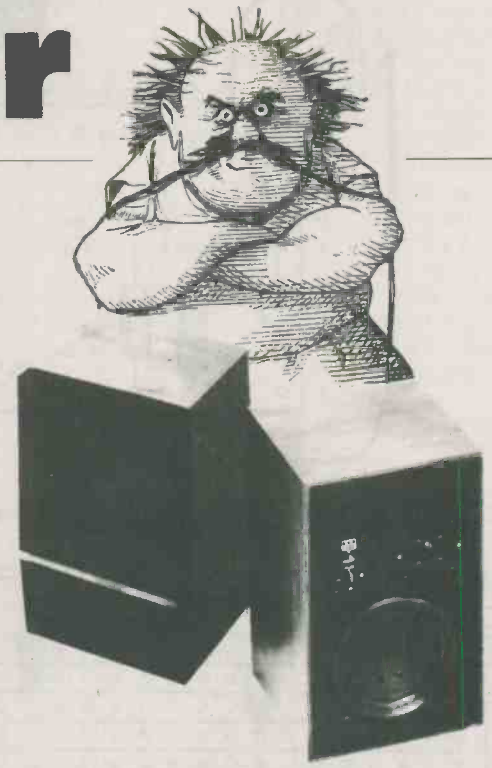
The filter circuitry uses R4 plus R5 in series, together with C4, to give a simple RC low pass filter action. Integrated circuit IC1 is used with 100% negative feedback from its output (pin 6) to its inverting input (pin 2) so that it acts as a unity voltage gain buffer stage, and prevents loading on the output from affecting the response of the filter.

A simple RC filter provides a roll-off rate of only about 6 dB per octave, and tends to give only a very gradual initial roll-off, with the ultimate 6 dB per octave roll-off only being reached well above the point where the response starts to fall away significantly. This gives rather poor performance in practice with only limited noise reduction and a small but significant loss of signals at middle audio frequencies.

This problem is overcome by the inclusion of capacitor C3, which has no significant effect on the circuit at low frequencies.

The situation is very different at higher frequencies where C4 produces significant losses through R4 and R5, resulting in the output voltage change being less than that at the junction of R4, R5, and C3. Although C3 is always less than 100% effective, it does now have some effect on the circuit, producing additional losses through R4 at high frequencies.

Loudspeaker Protector



This unit affords both dc and over-power protection of loudspeakers or loudspeaker systems rated at up to 1500 watts! The unit requires no power supply and has no discernible audible effect on sound quality, making it suitable for both hi-fi and sound reinforcement applications.

YOU'VE JUST unpacked and connected that shiny new 400 watt amplifier you've always wanted, and you lower the tonearm expectantly. There's a short detonation, and smoke gently and silently curls from the speaker grille cloth. Nobody had pointed out to you that those bargain basement speakers could only handle 15 watts.

Never, you say? You always check such things? Murphy's Law lies in wait: power amps fail occasionally, and a shorted output transistor can connect the power supply directly to the speaker coil, applying a steady 30 to 50 volts DC, usually enough to char the coil or rip the mountings apart.

A solution to this is the ETI Signal Powered Loudspeaker Protector. It is applicable to almost all speakers, and can fit inside the cabinet itself. Since the unit is powered by the audio signal, there are no batteries to fuss with, and unlike a fuse, it automatically resets when the overload is removed. It can also tell the difference between applied DC and low-frequency signals, and can be adjusted to cut out at a desired signal level without tripping on loud but harmless transients.

The self-powering feature is not only convenient, but adds no audible distortion to the signal, even with low-wattage amplifiers having rather high output impedances.

This is done in this case by placing a fullwave rectifier across the speaker lines and charging a 1000u capacitor through a 47 ohm resistor. The worst possible load presented to the speaker line is therefore 47 ohms and this is only while charging the capacitor and for signal voltages in excess of 12 V. This ensures that the unit has no discernible effect on audio quality but makes possible a truly 'set-and-forget' loudspeaker protector that can be mounted inside the loudspeaker enclosure if desired.

The protector tests for both dc and over-power, which can be adjusted by a preset on the board to suit a particular loudspeaker or application. The circuit also uses a new filter design with an almost 'brick wall' response enabling it to be connected to very high power amps. This is discussed in more detail in the 'How it Works' section.

The maximum power that can be applied to the unit is determined by the type of regulator transistor (Q1) used. We have specified a TIP31C for this device which has a 100V collector-to-emitter breakdown voltage. Since the emitter is at 12V, the maximum voltage that can be applied to the unit is 112V. This is equivalent to an amp capable of supplying approximately 784 watts into an 8 ohm load or 1568 watts into a 4 ohm load. If the amplifier to be used is capable of powers greater than these the regulator transistor should be substituted for a device with a higher V_{ceo} rating. The relay pulls around 40 mA when operated, so power dissipation in the regulator transistor will be around 4 watts when dropping 100 volts. Although this is not a particularly high dissipation it is high enough to lie outside the Safe Operating Area rating of many high voltage transistors, so be careful when choosing an alternate regulator transistor.

Construction

Construction is straightforward since all of the components are mounted on the pc board. The usual precautions should be taken to ensure that all polarised components have been mounted with the correct orientation. The IC used is a CMOS type and is therefore static sensitive. Solder this last and preferably using a grounded soldering iron. It is a wise precaution to discharge yourself before handling the device by first touching a grounded metal appliance.

It is a wise precaution to space the 2.5W resistor, R2, off the pc board slightly. In the case of a high powered loudspeaker going faulty with dc this component will get quite hot and spacing improves ventilation around the component and prevents the possibility of charring the pc board. If you can't obtain a 2.5 watt type (e.g. Philips PR52), then a 5W type may be substituted.

Before mounting the unit check operation by connecting around 20V dc across the speaker input terminals on the pc board. The relay should cut in after about one tenth of a second. If the protector passes this test connect the speaker wiring. If the preset is turned fully down (turn it counter-clockwise when viewing the board with the components on top and the relay to the right) the relay will cut in when the power exceeds around 20 watts for an extended period. The protector allows transients to the full supply rail to pass but will prevent a continuous 20W from being applied to the loudspeaker. To increase this, turn the preset clockwise until the desired response is achieved.

How It Works

The signal from the power amp is rectified by the fullwave rectifier formed by D1-D4. The output of this is fed through a 12V regulator circuit formed by Q1 and its associated resistors and zener diode, and charges the electrolytic capacitor, C1. The output of the rectifier is also fed to the input of the dc sense and over-power detection circuitry.

IC1 gates a and c form the dc filter. Resistors R4 and R6 form a Schmitt trigger with a small deadband. When the signal goes above the trigger voltage the output of the trigger swings hard to the positive supply rail of the IC, charging C2 through the 220k resistor, R8. Resistors R10 and R11 with gate c form a second Schmitt trigger monitoring the voltage across C2. If the voltage across C2 reaches the trigger voltage of this second Schmitt, gates d, e and f are activated, pulling in the relay contacts and disconnecting the loudspeaker. It takes about 100 ms to charge C2 through R8, and on normal audio content the output of gate 'a' will be driven low before this occurs, discharging C2 rapidly through D6. Only signals which do not have a zero crossing for longer than 100 ms will trigger the protector.

The over-power protector consists simply of a voltage divider feeding a third Schmitt trigger. Whenever the signal voltage exceeds the trigger voltage the output of gate 'b' is driven high and C3 starts to charge. If this condition persists for long enough the output gates are turned on and the relay pulls in. Note that both the dc and over-power sense circuits charge C3 when activated. The circuits are decoupled from this capacitor by diodes so that, once charged, C3 can only be discharged by the parallel resistor R12 (the effect of the input impedance of the gates is negligible). Since it takes about one second to discharge this capacitor, the relay will hold in for this time. The protector, therefore, reconnects the loudspeaker approximately one second after the fault condition has been removed.

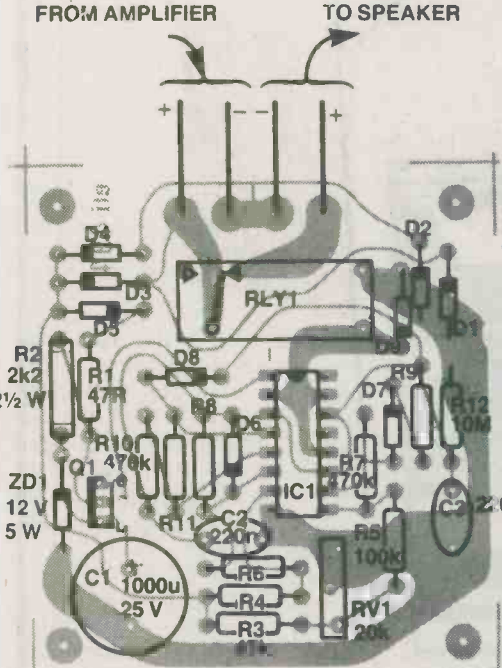
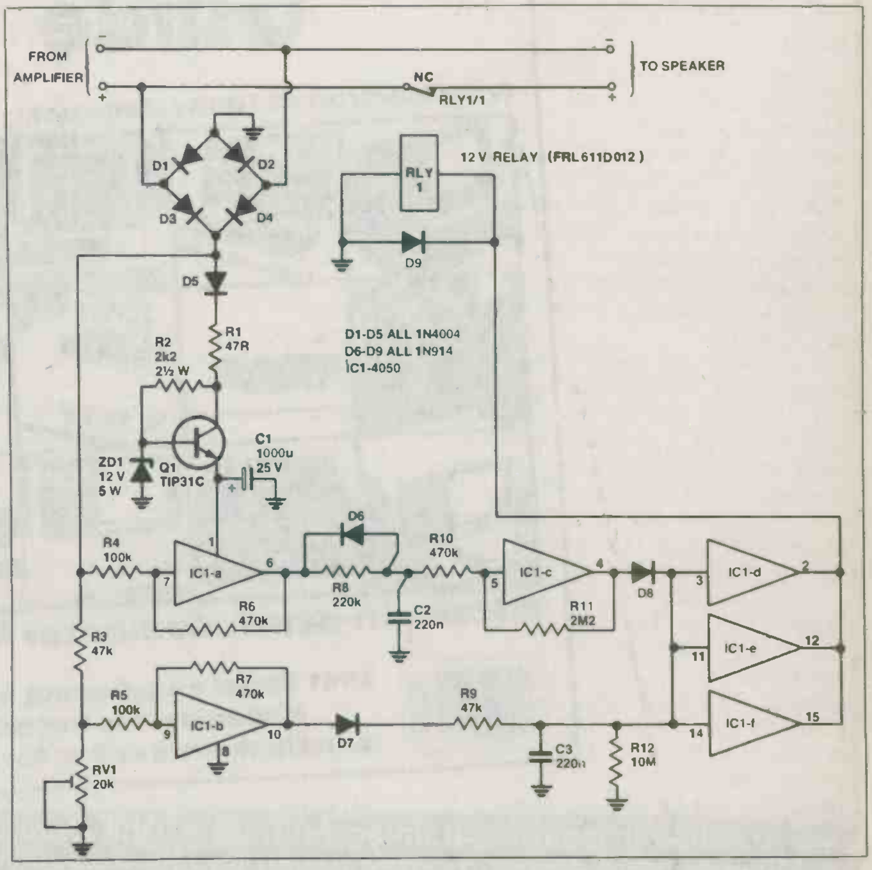


Fig. 1. The component overlay.



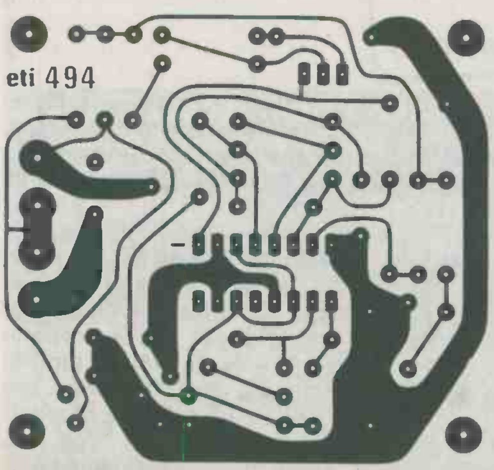


Fig. 2. The PCB.

Parts List

Resistors (all ½W, 5% unless noted)

R1	47R
R2	2k2, 2½W
R3,9	47k
R4,5	100k
R6,7,10	470k
R8	220k
R11	2M2
R12	10M
RV1	20k min. trimpot

Capacitors

C1	1000u/25V electro
C2,3	220n

Semiconductors

D1-5	1N4004, EM404
D6-9	1N914, 1N4148
IC1	4050 hex buffer
Q1	TIP31C
ZD1	12V, 5W zener

Miscellaneous

pc board; RL1 — Fujitsu FRL611D012, 12 volt SPDT 10A contacts or Guardian 1345-IC-12D or similar relay (pc mount type).

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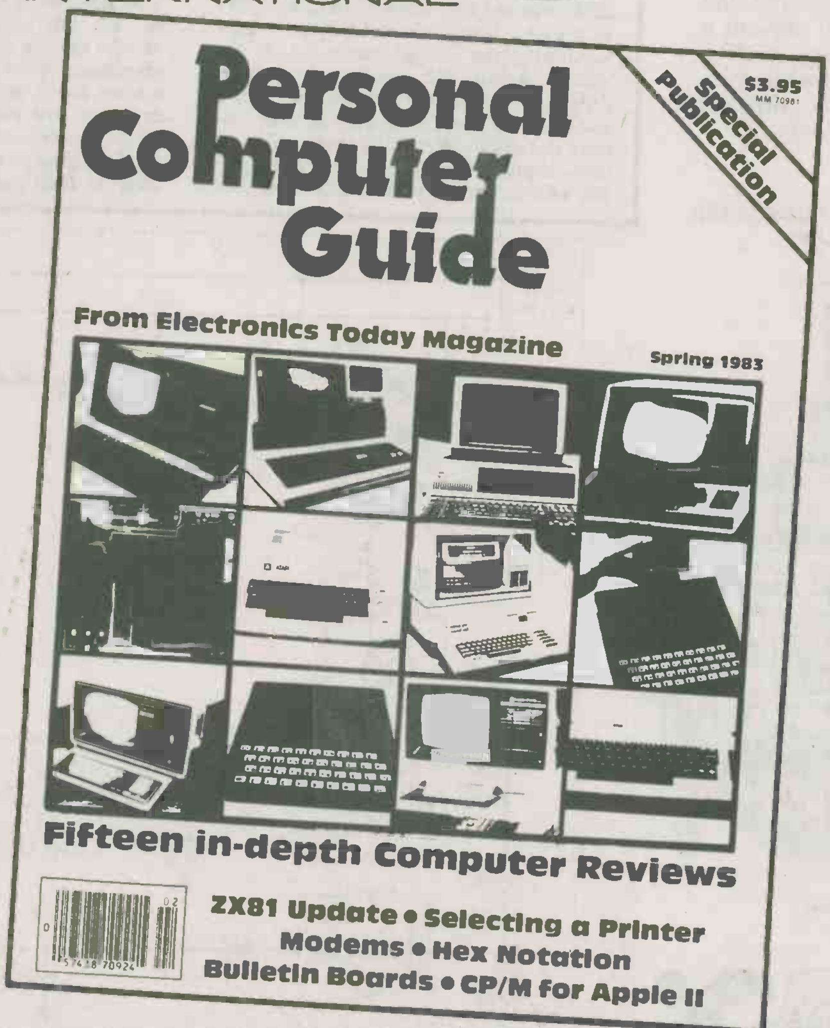

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4

AM Radio

Comb the airwaves with our pocket-sized, low cost personal AM radio.

THERE HAS BEEN no shortage of designs for simple AM personal radios over the past few years, and these almost invariably seem to be based on the Ferranti ZN414 device. One could be forgiven for thinking that there is no viable alternative to the use of this IC, but it is in fact possible to produce a simple medium wave receiver circuit that will give good results using just a couple of transistors as the active devices. Just for a change then, we decided to use transistors in the present design.

The set provides good reception of reasonably strong signals, and by adding a couple of leads to purposely introduce positive feedback the sensitivity can be boosted to the point where numerous stations can be received at a good volume. The output is for a crystal earpiece — magnetic types are not suitable for use with the set.

Construction

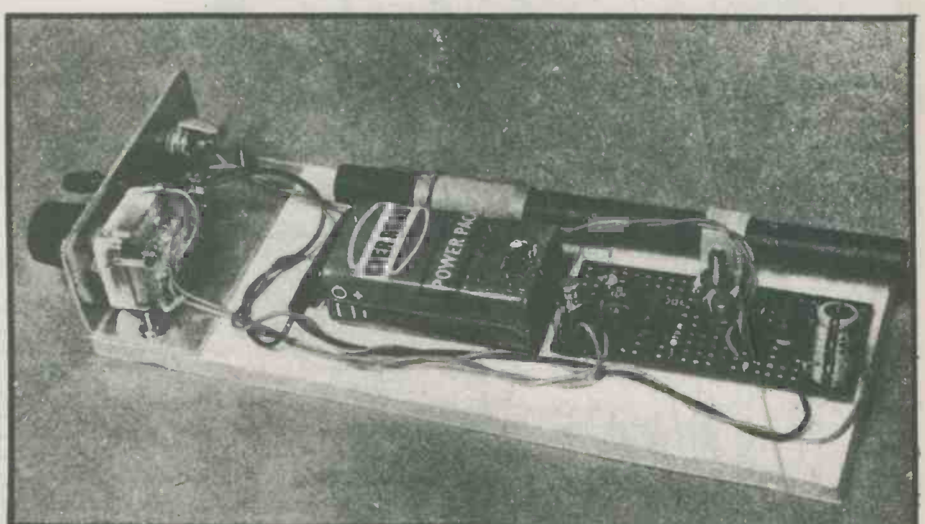
Most of the components, including the ferite aerial, are mounted on one of the standard size (24 holes by 10 strips) 0.1'' matrix Veroboards. Details of the components layout and wiring of the receiver are shown in Fig. 2.

A P-style cable grip is used to mount the ferrite aerial on the component panel, and apart from this the board is assembled in the usual manner. Be careful that you do not overlook the single break in the copper strips, and it is advisable to make this before fitting the components into place. The leadout wires of T1 are made of a special type of wire called Litz wire (which has a very low resistance at radio frequencies) and have ready-prepared ends. It is recommended that these leads should be left full length as Litz wire can be difficult to tin with solder, and you may find it difficult to connect these leads if you trim off the prepared ends!

There are a number of plastic cases available which will comfortably accommodate the set, but be careful not to underestimate the size of the case required. The ferrite rod is about 125 mm long and the case must obviously have an internal dimension of at least this figure. A metal case is not suitable as it would screen the ferrite aerial and no stations would be received!

The set should cover the entire AM band if the aerial coil is positioned almost right at the end of the ferrite rod, and it should be glued or taped in place here. The set has a slight excess of coverage and so the position of the coil on the rod is not too critical.

It should be possible to receive a few stations quite well when the set is first tested, but improved results can be obtained by adding the two single-strand insulated leads, as shown in Fig. 2. These will increase the feedback applied over the RF amplifier and, up to a point, the closer together the wires are brought, the better the performance of the set. However, bringing them too close will result in the set oscillating and blocking proper reception. The two wires should therefore be positioned as close together as possible without this occurring at any setting of CV1. Once the optimum position has been found, the leads should be secured with insulating tape. If moving the two leads closer together results in reduced performance the phasing of T1 is incorrect, and the two leads from the small winding of T1 should be transposed.



By mounting the project on a suitable board it can be carefully inserted into a case.

How It Works

Fig. 1 shows the circuit diagram of the radio, and the circuit breaks down into three basic stages: an RF (radio frequency) amplifier, a detector, and a single audio amplifier stage.

The RF amplifier uses Q1 as a straightforward common-emitter amplifier which gives high gain. T1 is the ferrite aerial, with tuning capacitor CV1 giving coverage of slightly more than the whole of the standard medium wave broadcast band. The tuned winding of T1 has quite a high impedance, and signals from this winding cannot be fed directly to the relatively low-input impedance of Q1 as this would give a very inefficient signal transfer and unacceptable results. A low-impedance coupling winding on T1 is therefore used to match the output of the aerial to the input of Q1.

Coil T1 is connected so that a phase inversion of the signal is produced, and a further phase inversion takes place through Q1. This brings the collector of Q1 and the hot end of T1's main winding in phase, and there is inevitably a certain amount of stray feedback between these two points. This feedback results in some of the output of Q1 being fed back to the input where it is amplified once again. This boosts the sensitivity and selectivity of the receiver. By purposely encouraging this feedback it is possible to obtain a very substantial increase in performance, although excessive feedback (or 'regeneration' as it is often called in this application) must be avoided. Otherwise the circuit will break into oscillation and the set will not function properly.

The output of Q1 is fed to a simple detector circuit which uses diode D1 to provide rectification and C2 to give RF filtering. Resistor R3 gives D1 a slight forward bias which gives improved detection efficiency.

Capacitor C3 couples the audio output of the detector to a second common-emitter stage which uses Q1 and directly feeds the crystal earphone. The current consumption of the circuit is only about 2.5 mA, and a 9V battery is sufficient to give many hours of use.

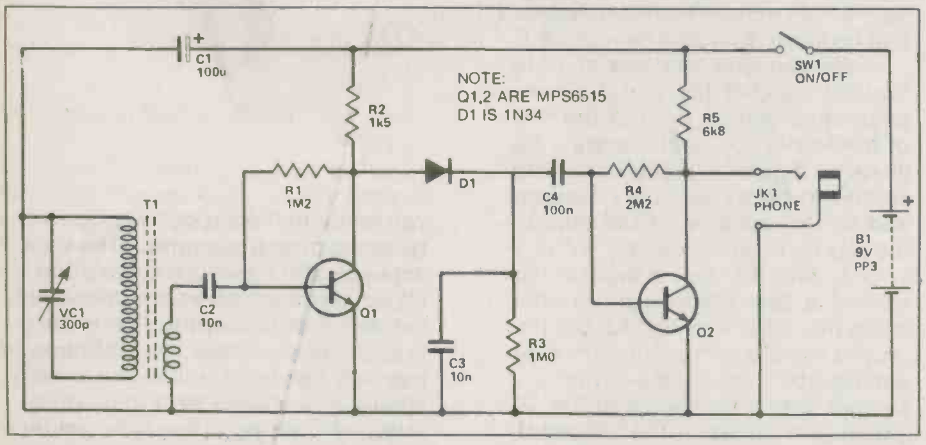


Fig. 1. The circuit diagram of the ETI Miniature AM Radio.

Parts List

RESISTORS (All ¼ W, 5%)

R1	1M2
R2	1k5
R3	1M0
R4	2M2
R5	6k8

CAPACITORS

C1	100u, 10V electrolytic
C2,C3	10n polyester
C4	100n polyester
CV1	226p polyvaricon variable capacitor

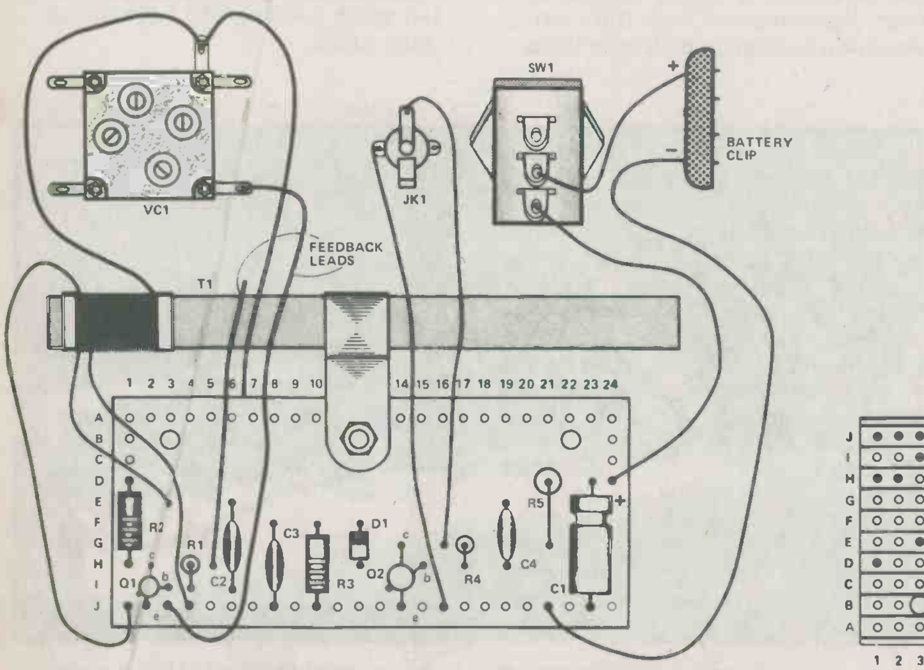
SEMICONDUCTORS

Q1, Q2	MPS6515
D1	1N34

MISCELLANEOUS

SW1	single-pole, single-throw toggle
T1	ferrite aerial
JK1	3.5 mm Jack socket

10 strip x 24 hole Veroboard
Crystal earphone
Case to suit
Battery and clip
Knob to suit.



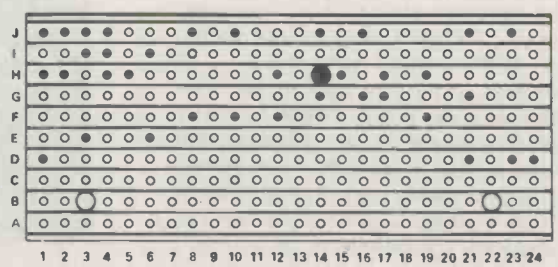


Fig. 2. Connection details of the project along with Veroboard overlay and underside track break.

Drum Machine

Drums, cymbals, snares and bongos. You can simulate these instruments with this 'double percussion' project. The instruments can be played either manually or automatically using built-in sequencer.

THIS ATTRACTIVE LITTLE musical instrument has two 'percussion simulator' channels. Channel 1 can be used to simulate the sounds of normal drums only: channel 2 can be used to simulate the sounds of all types of drums, including snares, plus metallic percussion sounds such as cymbals, etc. On each channel, the envelope decay times and the basic musical tones, etc., are fully variable using the manual controls to enable a wide range of percussion sounds to be simulated. The outputs of the two channels are mixed internally and can be fed to an external power amplifier from a single output socket. The complete instrument is powered from a 12V battery pack.

Play it, Sam

The instrument can either be played manually, automatically, or by a combination of the two methods. In the manual mode, each channel can be played using a small speaker, connected to the channel input. The speaker acts as a 'drum-head' transducer and triggers a percussion sound when the cone is tapped with a finger or stick.

The instrument can be played automatically using the built-in eight-step double sequencer. Each channel of the sequencer is used to control one of the channels of the percussion instrument, and can be programmed with a DIP package of eight SPST switches to generate any one of a variety of rhythms. The sequencer can be used in the fully automatic mode, in which it continuously cycles through the eight-step sequence, or can be used in a triggered, or manual initiate, mode in which it runs through a single eight-step sequence each time that an external switch is momentarily closed. The manual initiate facility enables the internally-generated rhythm to be manually synchronised to an external beat (with a foot switch, etc), or to be introduced into the music only in those parts where it is required.

The manual and automatic playing methods operate in the OR mode. In other words, manually-initiated percussion sounds can be played at the same time as the automatically initiated sounds. A particularly attractive way of using the instrument is to play it mainly in the manual mode, but to occasionally bring in a few bars of automatic sequencing with a foot switch, using the manual initiate facility. The unit thus acts as a highly versatile musical instrument.

Construction

The circuitry is built up on two PCBs, a single large board being used to hold all of the components (except the pots and switches) of the main double percussion instrument, and a smaller board being used for the components of the sequencer circuit. The unit uses a good deal of interwiring between the PCB and the total of eleven control pots, etc., so some care is required in the construction.

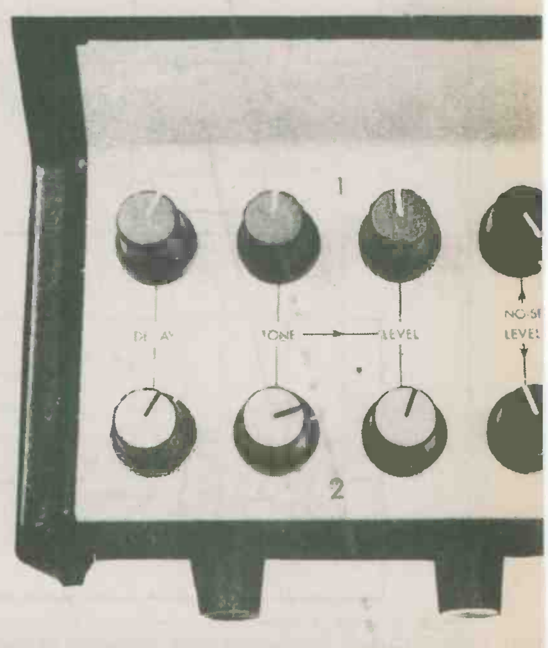
Start the construction by building up the main PCB, taking the usual care over the component polarities. Use Veropins to facilitate the connections from the PCB to the ten control pots.

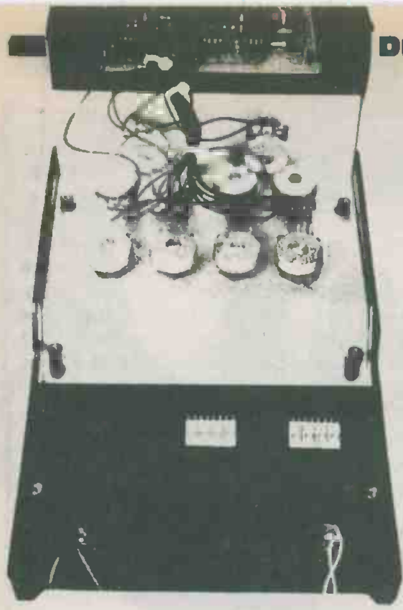
When construction of the main PCB is complete, give it a functional check by temporarily connecting the ten pots to the unit, wire a couple of small speakers (impedance not important) to the two input terminals, connect the unit to a 12 V supply and take the output to an external power amplifier. Check that plain drum sounds can be manually generated on channel 1, and all types of percussion sounds from channel 2. Note on channel 2 that Q5 is used as a white noise source (for generating cymbal sounds, etc), and may have to be selected on test to produce an adequate noise level.

Proceed next with the construction of the sequencer circuit on the smaller PCB. Note that the two sets of DIP switches MUST be mounted in sockets, and that capacitor C2 is mounted on the underside of the PCB.

You can now proceed with the assembly of the two boards and all other components in the case. To complete the construction, fit all the remaining switches and sockets into place and complete the interwiring. We recommend that you use jack sockets to connect the two 'drum head' speakers to the unit, configured so that the input pins short out if the speakers are removed.

When using the completed unit, note that if the 'drum head' speakers are not used, they must be replaced by short circuits, to eliminate the possibility of circuit instability.





The DIP switches are epoxied to the top of the case as shown here. The sequencer board can then be secured by plugging the DIP sockets onto the exposed pins.

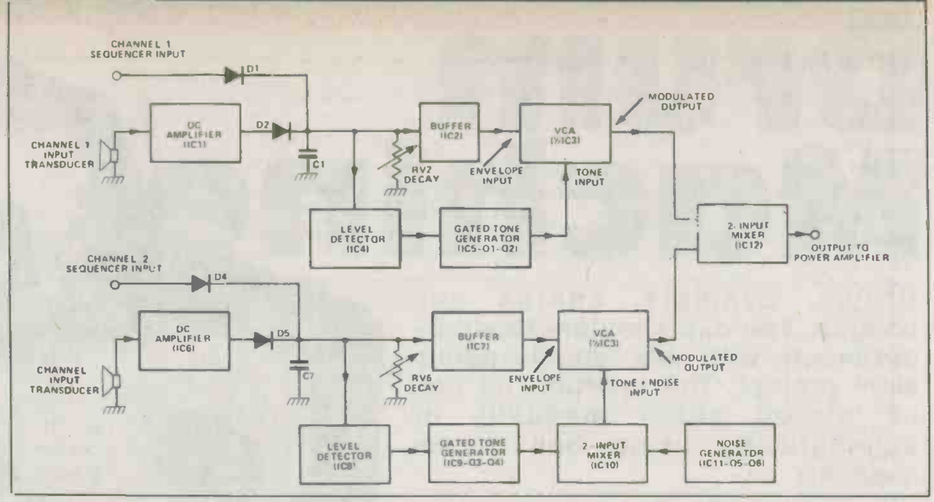


Fig. 1 Block diagram of the complete drum machine.

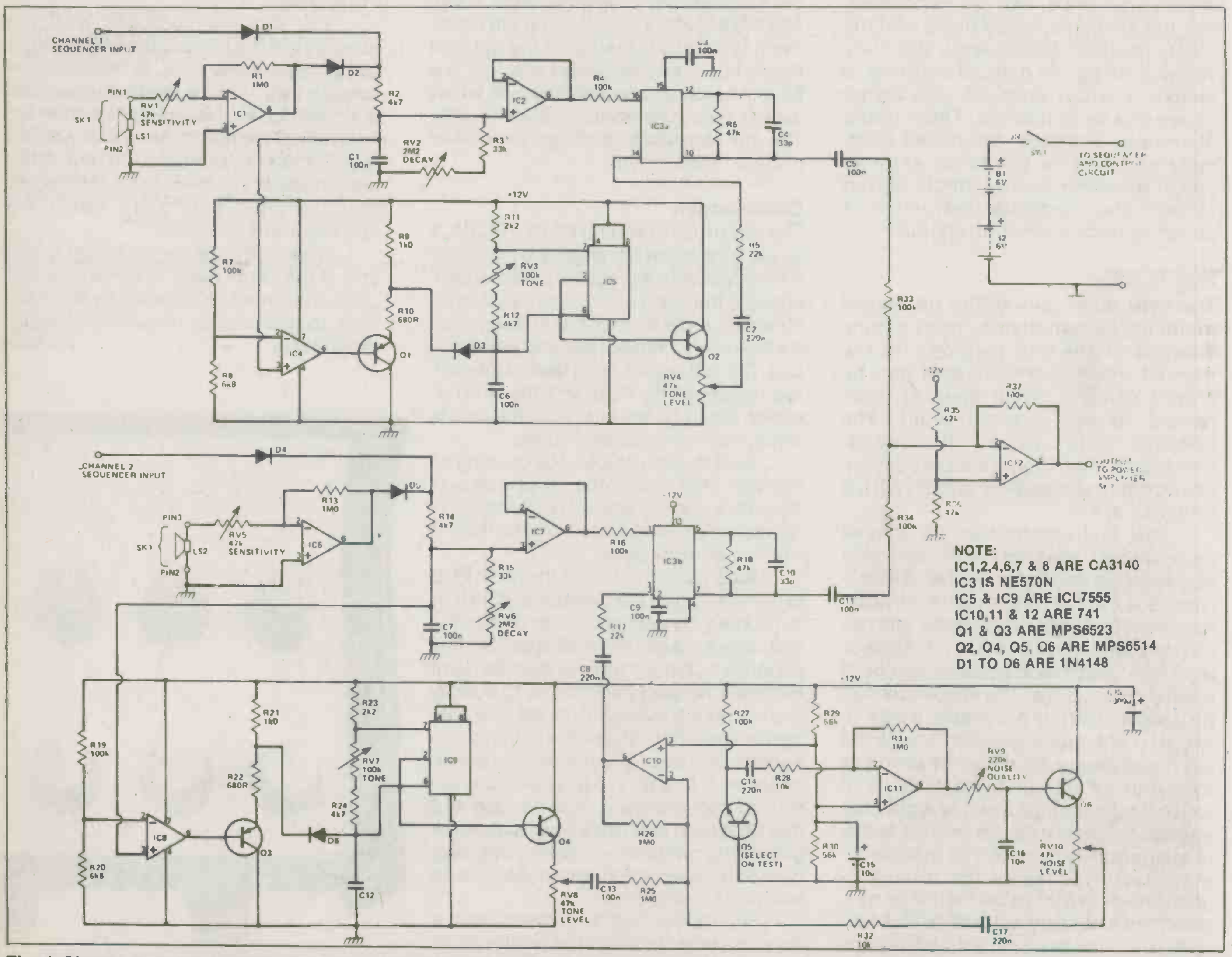


Fig. 2 Circuit diagram of both channels of the drum sound generator.

How It Works

The basic instrument contains two essentially similar channels (see block diagram), each comprising a voltage-controlled amplifier (VCA), a gated tone generator and an envelope generator. The envelope generator produces the characteristic fast-attacks/slow-decay modulation waveform of a percussion instrument and can be activated by either an external transducer (a speaker) or the pulse input of an automatic sequencer unit.

The outputs of the two channels are added in a two-input mixer and are made available at a phono socket, where they can be fed to a power amplifier. The channel 1 circuitry produces modulated tone signals only, and can be used to generate a range of simple drum sounds. The channel 2 circuitry incorporates a noise generator and a two-input mixer as well as a tone-generator, and can be used to repreduce all of the sounds of channel 1 plus snare drums, cymbals, etc.

The two channels of the instrument are basically similar, so let's start off with a detailed description of channel 1. When used in the manual mode the instrument is played using an external transducer such as a speaker (LS1), which is connected to the input of high-gain DC amplifier IC1. Each time that the transducer is tapped, the output of IC1 jumps abruptly positive and rapidly charges C1 via D2-R2: C1 then discharges exponentially via R3-RV2, to produce the characteristic fast-attack/slow decay modulation waveform of a percussion instrument. The waveform is then fed to one half of dual VCA IC3 via unity-gain buffer IC2, where it is used to control the gain of the VCA.

Note that the C1 modulation generator can be activated by either the transducer or by a pulse signal fed to C1 via D1-R1 from the independent sequencer circuit (auto mode). The C1 voltage is monitored by comparator IC4, which gates on astable IC5 whenever the C1 voltage exceeds a few hundred millivolts. The astable generates a symmetrical ramp waveform, which is buffered by Q1 and fed to the 'tone' input of VCA via level control RV4. The tone of the astable can be varied over the range 83 Hz to 1.4 kHz with RV3.

Thus, each time the channel is activated (by the transducer or by a sequencer) a modulation waveform is fed to one input of the VCA and a tone signal is fed to the other, to produce a modulated tone signal at output pin 10 of IC3. The signal is fed to one input of two-input mixer IC12. A wide variety of drum sounds can be simulated by suitable adjustment of RV2, RV3 and RV4.

Channel 2 is similar to channel 1, except that the output of the tone generator (from RV8) is fed to the VCA via a two-input mixer designed around IC10. The other input to this mixer is derived from a noise generator designed around Q5-IC11 and Q6. Here, the reverse-biased base-emitter junction of Q5 is used as a noise source and the noise signal is then amplified by IC11, filtered by RV9-C16 and made available via level control RV10.

The instrument is powered from a 12V supply, derived from eight 1V5 cells. This supply is also used to power the Auto-Manual Eight-Step Sequencer unit.

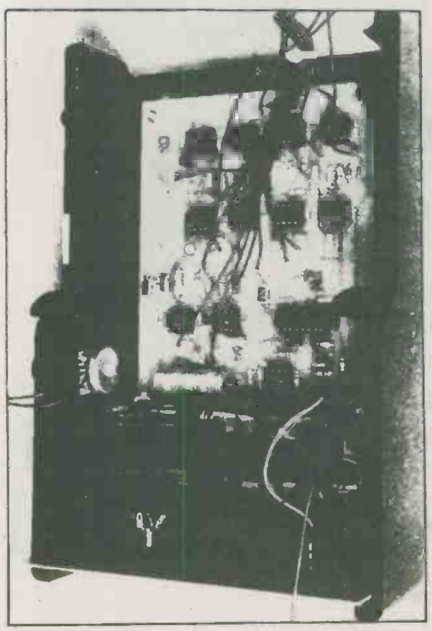
The sequencer unit has two output channels, each of which produces a single or repeating sequence of up to eight 5 mS output pulses: the sequencing period can be varied over a wide range by a clock (or 'tempo') generator, and individual pulses can be programmed in or out on each channel with a dual-in-line package of eight SPST switches. The unit is designed to automatically sequence the double percussion instrument.

The unit comprises a clock generator (IC1), a 4017 counter (IC2) and two sets of switch-programmable clock/decoder coincidence detectors (IC1 and D3 to D18). The clock generator is designed around a 555 astable and generates a series of 5mS pulses, with the inter-pulse period variable over a wide range by RV1. The pulses are used to clock IC2.

IC2 is a 4017 counter with ten decoded outputs. These outputs sequentially go high on the arrival of each new clock pulse, with only one output being high at any moment in time. On each channel the decoded 4017 outputs that are required are fed to one side of a two-input AND gate (IC3a-IC3b or IC3c-IC3d) via a bank of diodes and switches, while the 5mS clock pulse is fed to the other side of the AND gate. The programmed sequence of 5 mS pulses are thus generated at the output of each AND gate.

When the unit is operated in the manual mode, the 4017 sequences automatically for the first eight clock pulses and then stops as its '9' output goes high and activates the inhibit pin: the single automatic sequence can be re-initiated by momentarily closing PB1 and thus resetting the 4017 to see a double clock pulse as the '9' output goes momentarily high, thereby causing the '0' output to go high as the IC resets but then causing the '1' output to go high almost immediately. The net effect of all this is that that the sequence repeats continuously when SW3 is set to the auto mode.

Below: The sound generator board and batteries are mounted in the lower half of the case. RV1 (tempo control) can be seen mounted on the side — all other pots are situated on the front panel.



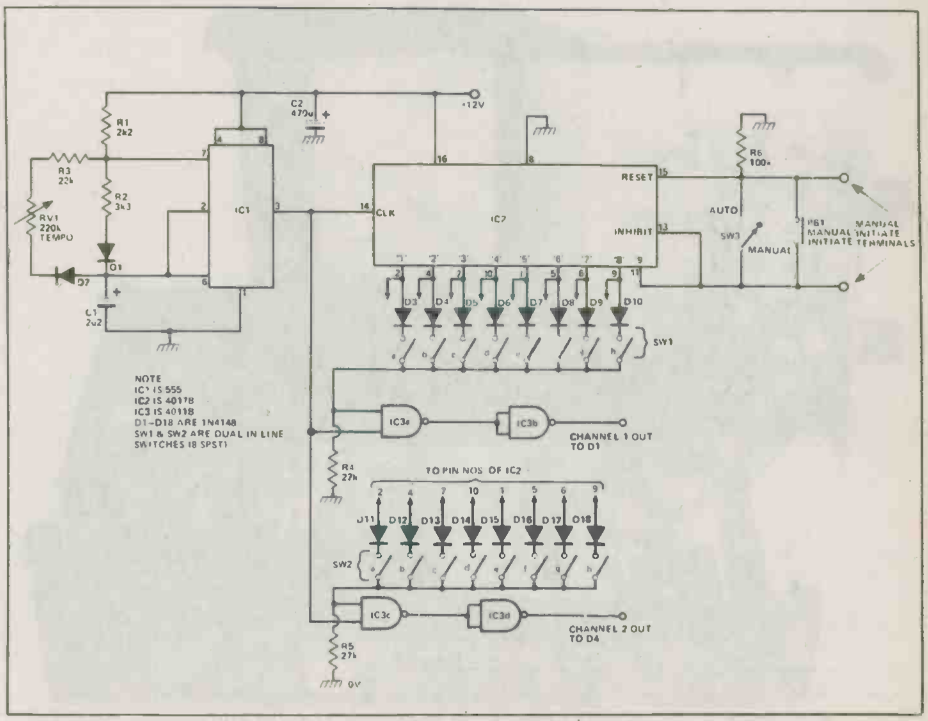
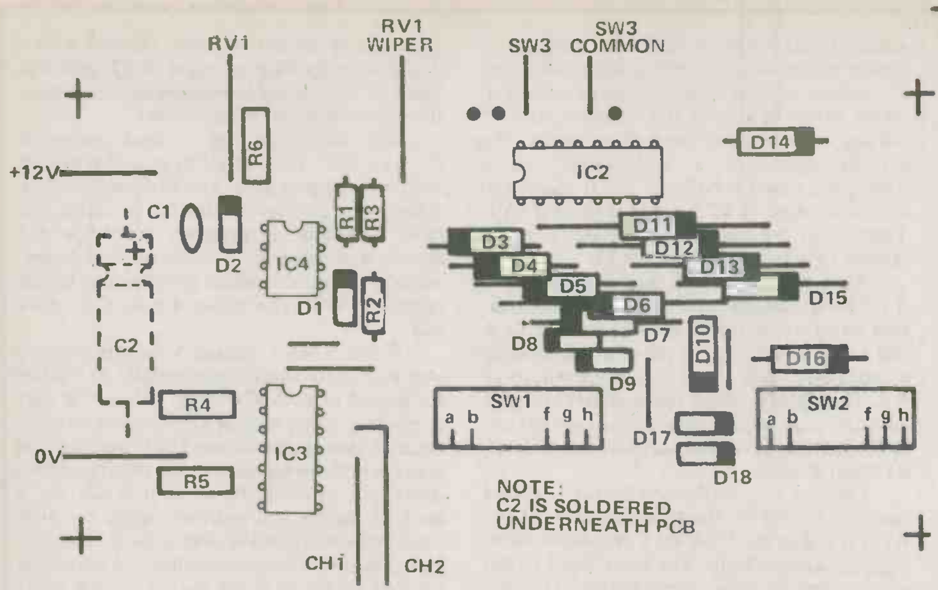


Fig. 3 Circuit diagram of the eight step sequencer unit.



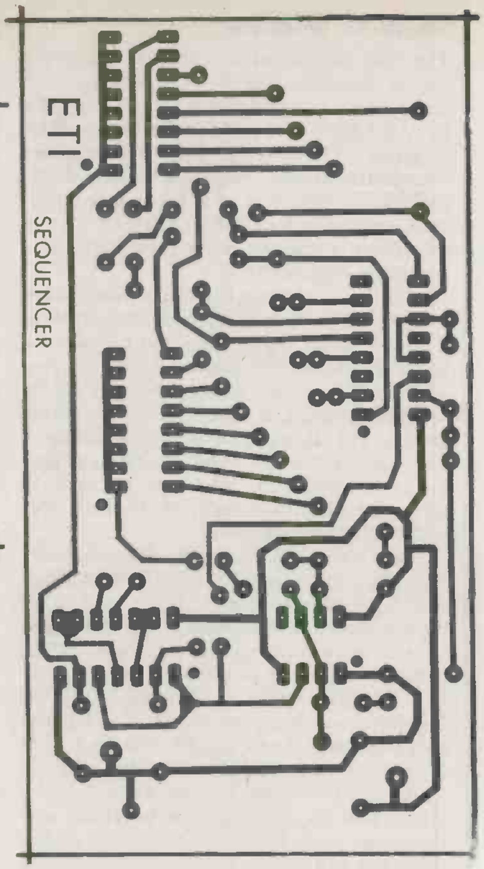
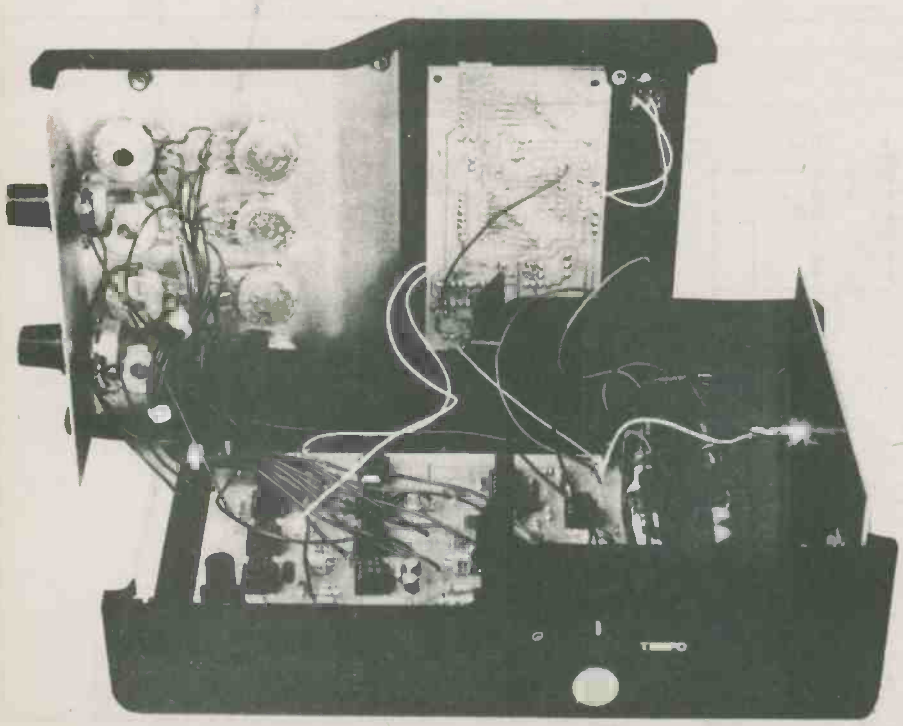
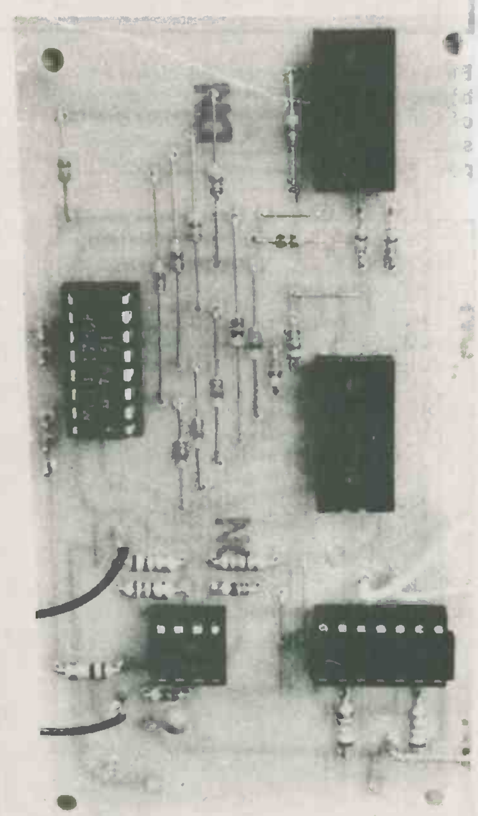


Fig. 4. Component overlay for the sequencer board. Note that C2 is soldered underneath the PCB, and an insulted link should be soldered between IC2 pin 8 and the 0V rail.

Below: With the case open you can see how the boards and controls are interwired. The sequencer board (right) is secured to the top of the case by pressing the empty sockets onto the pins of the DIP switches.





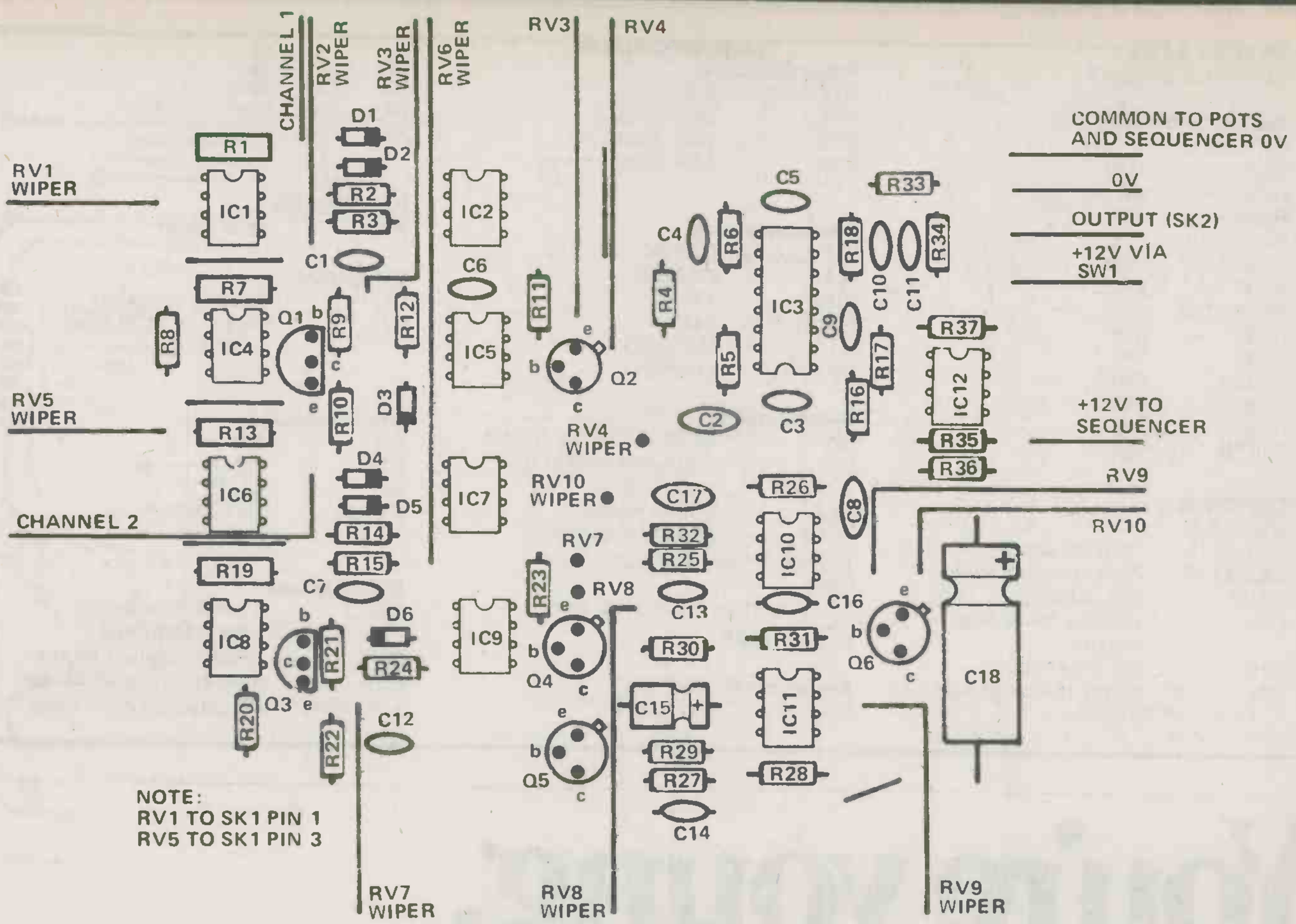
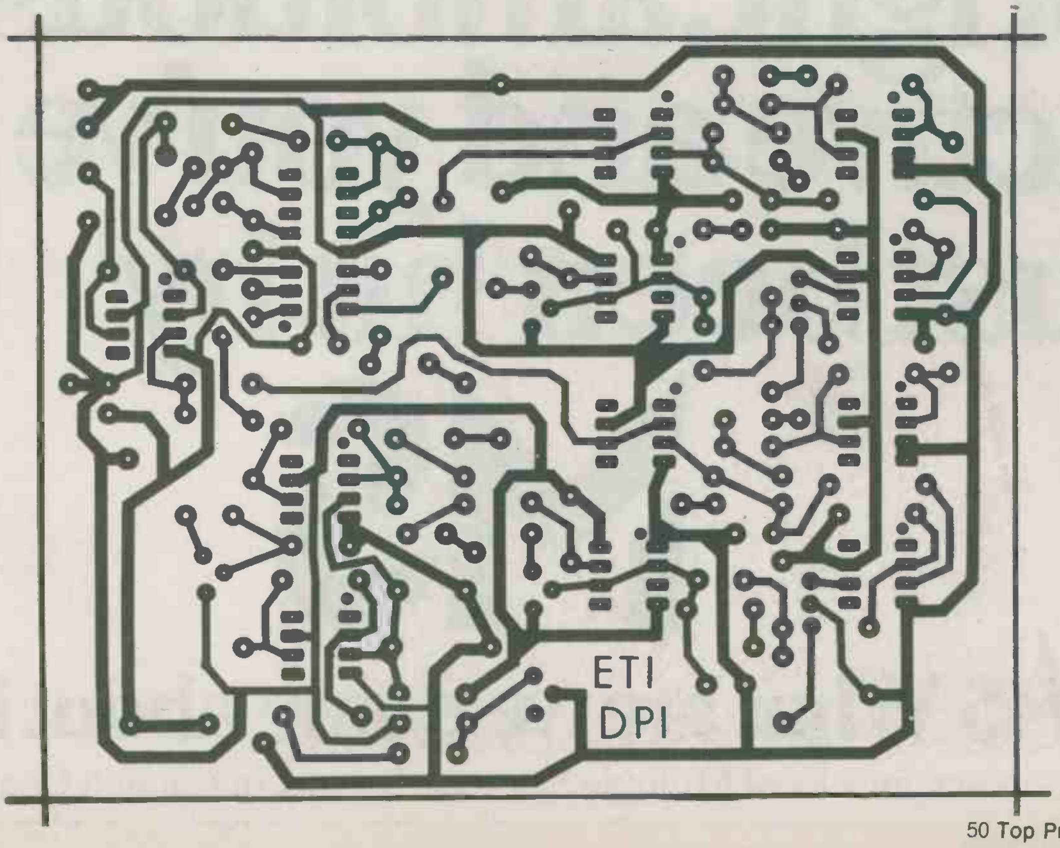


Fig. 5 Component overlay for the sound generator board.



PCB foil pattern

Parts List

CONTROL CIRCUIT

Resistors (all ¼ W, 5%)

R1,13,25, 26,31	1M0
R2,12,14,24	4k7
R3,15	33k
R4,7,16,19 27,33,34,37	100k
R5,17	22k
R6,18,35,36	47k
R8,20	6k8
R9,21	1k0
R10,22	680R
R11,23	2k2
R28,32	10k
R29,30	56k

Capacitors

C1,3,5,6,7 9,11,12,13	100n ceramic
C2,8,14,17	220n polycarbonate
C4,10	33p ceramic
C15	10u 25V axial electrolytic
C16	10n ceramic
C18	1000u 16V axial electrolytic

Potentiometers

RV1,3,4,8,10	47k linear
RV2,6	2M2 linear
RV3,7	100k linear
RV9	220k linear

Semiconductors

IC1,2,4,6,7,8	CA3140
IC3	NE570N
IC5,9	7555
IC10,11,12	741
Q1,3	MPS6523
Q2,4,5,6	MPS6514

Miscellaneous

SW1	SPST miniature toggle
SK1	3 pin DIN socket and plug
SK2	phono socket
LS1,2	50mm loudspeaker

10 knobs, caps and nut covers
Case
2 four section battery holders.

SEQUENCER

Resistors (all ¼ W, 5%)

R1	2k2
R2	3k3
R3	22k
R4,5	27k
R6	100k

Potentiometers

RV1	220k linear

Capacitors

C1	2u2 35V tantalum
C2	470u 25V axial electrolytic

Semiconductos

IC1	555
IC2	4017B
IC3	4011B
D1-D18	1N4148

Miscellaneous

SW1,2	8-SPST dual-in-line lateral switches
SW3	SPST miniature toggle
PB1	momentary push button

1 off collet knob, cap and nut cover.

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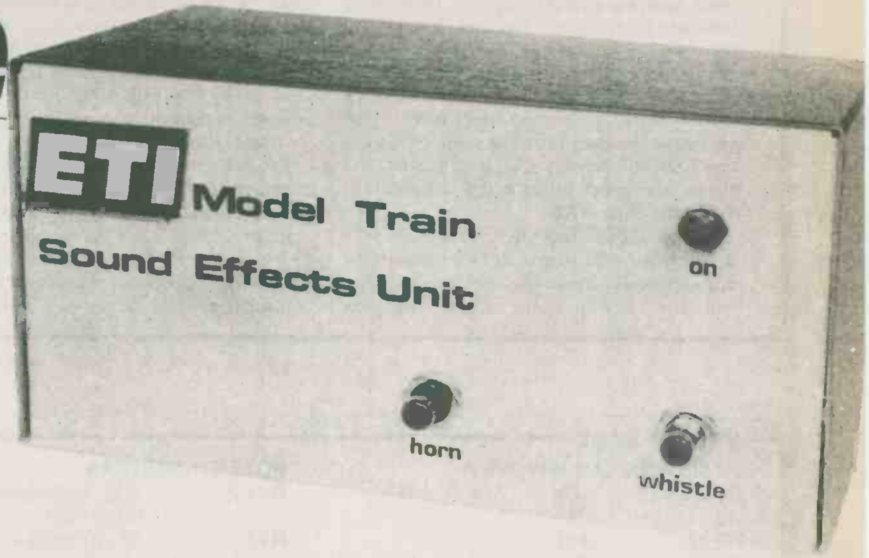
Steam Loco Whistle

Some additional sounds to frighten the tiny plastic people around your model railway.



OUR LATEST MODEL train sound generator is a realistic steam locomotive whistle, created electronically.

Four transistors are used to generate the whistle sound and a single integrated circuit mixes this sound with that produced by our previous train sound effects circuits.

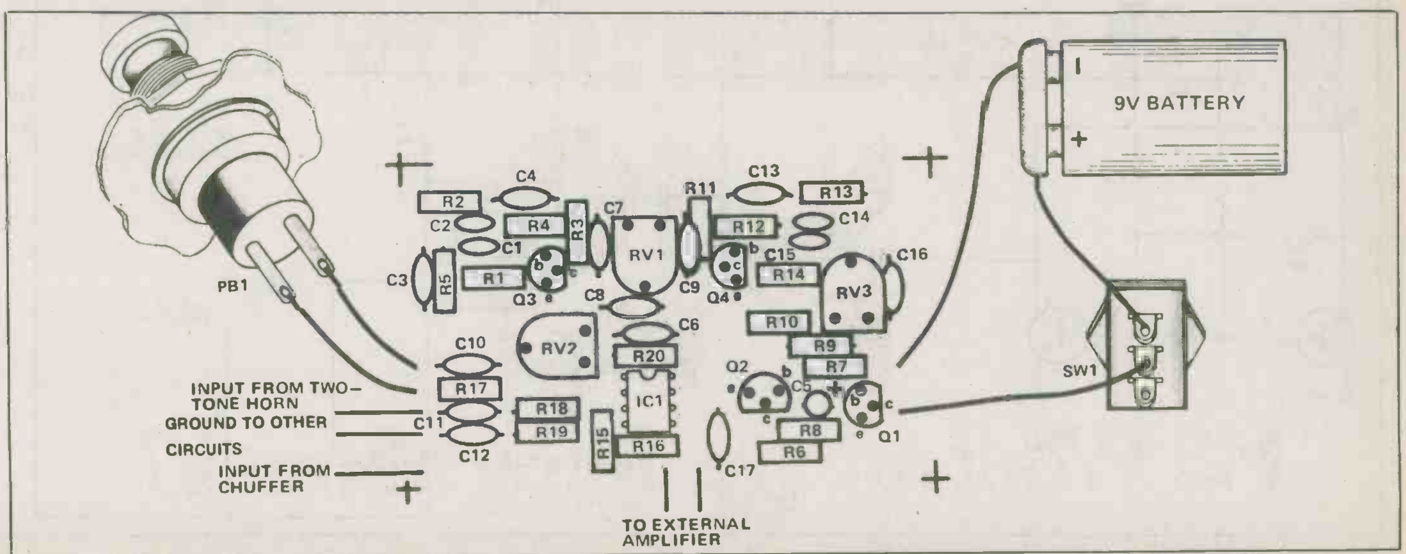
The whistle can be built and used individually or as an integral part of a complete sound effects unit, built in one case like ours.

Construction

The whistle is built on a printed circuit board so construction is very easy. Follow the layout in Figure 1 inserting and soldering each component in turn, starting with the resistors followed by capacitors and finally semiconductors. The IC is cheap (a 741) so you may not feel it worth the cost of a holder. If so, solder it carefully, allowing each pin to cool before soldering the next.

Connection details for this project are given in Fig. 1. Drill the case for all connections and switches and simply connect the power supply, i.e., the 9V battery, to the board side of the on/off switch. The output lead from the whistle board to the output jack socket should be a screened lead, with the shielding taken to 0V.

Fig. 1. Overlay and connection details for the project.



How It Works

The waveform of a steam whistle is a complex combination of two main things: white noise and an audio frequency oscillation. Both are fairly easy to recreate electronically.

White noise is usually made by a 'noisy' zener diode, the output being amplified to the required level. The generator we used is of the same type as in the 'Chuffer' project; i.e., a transistor (Q1) biased into zener mode and a simple transistor amplifier (Q2).

The audio frequency oscillation is a straightforward mixture of two similar (but not identical) sinewaves, which after their addition produce a more complex waveshape than either of the two individual waves. The sinewave generators are known as 'Twin-T' oscillators because the feedback components (e.g. R1,2 and C3, and C1,2 and R5) around the transistor (Q3) are in the shape of two letter Ts. The frequency is set by the values of the feedback components and in this circuit is fixed. The other oscillator frequency is variable because one of the resistors is replaced by a preset (RV3). At RV3's mid-position the frequency is about the same as that of the other oscillator.

Preset RV1 mixes the two sinewaves so that an appropriate waveform is obtained. Similarly, RV2 mixes this waveform with the white noise produced elsewhere in the circuit. Adjustment of all three presets will result in the required sound.

Integrated circuit IC1 is an operational amplifier used as a simple mixer/amplifier which combines the steam whistle, chuffer, and two-tone horn sounds into one, suitable for amplification by an external amplifier (say your stereo system).

The gain of the mixer is determined by the ratio of R20 to the input resistances, R17, 18 or 19, of the channel concerned and so by varying the chosen resistor the levels of the individual sounds in the mix can be altered to suit.

Parts List

RESISTORS (All ¼W, 5%)

R1,2,8,18	100k
R3,11	47k
R4,12	1M0
R5	12k
R6	6k8
R7	470k
R9	15k
R10	1k
R13,14	82k
R15,16,17	22k
R19	27k

POTENTIOMETERS

RV1,2	1M0 miniature horizontal preset
RV3	22k miniature horizontal preset

CAPACITORS

C1,2,14,15	4n7 ceramic
C3,16	47n ceramic
C4,13	10n polyester
C5	470n, 35V tantalum
C6,7,8,9,10, 11,12,17	100n polyester

SEMICONDUCTORS

IC1	741 operational amplifier
Q1-4	2N2925 NPN transistor

MISCELLANEOUS

SW1	single-pole, single-throw toggle switch
PB1	push-to-make switch

Case to suit.
Battery and clip

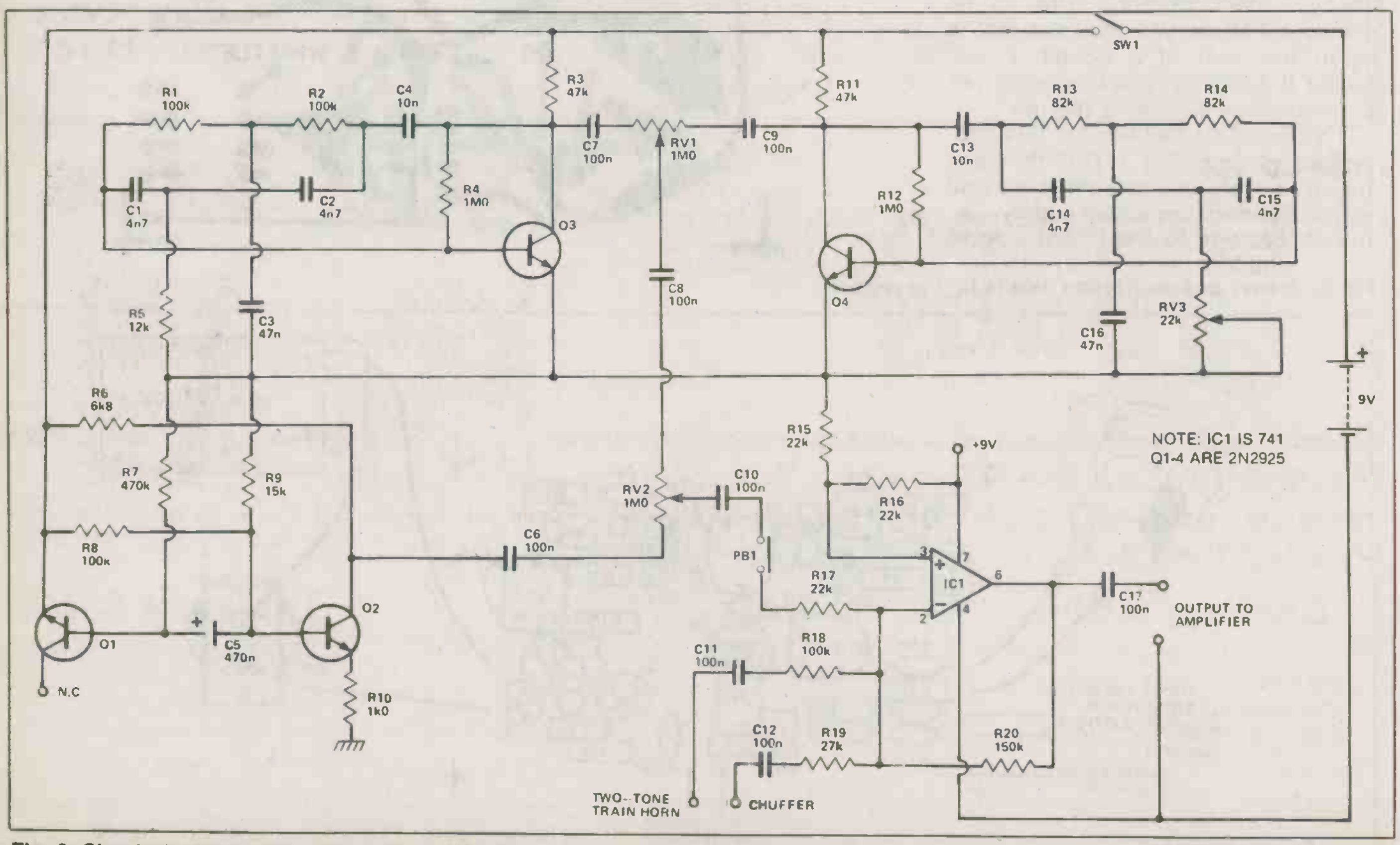


Fig. 2. Circuit diagram of the Steam Loco Whistle.

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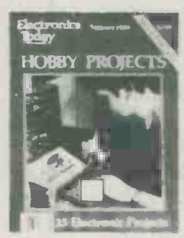

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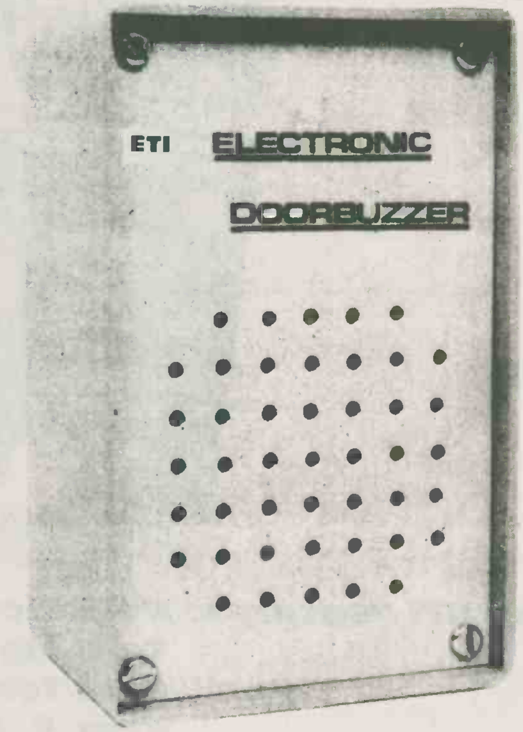
5

Electronic Doorbuzzer

This easily-built project for the home is an ideal alternative to the more expensive, commercially available door chimes.



ALTHOUGH AT FIRST sight an electronic doorbuzzer may seem to have no advantages over electro-magnetic types, it will probably be more reliable and longer lasting. A further advantage is that you can build it yourself at low cost. Our electronic doorbuzzer produces a warbling tone that is quite attention-catching, but should not prove to be objectionable to other members of the household. For simplicity of construction and installation, the ETI Electronic Doorbuzzer is battery-powered, and a 9V battery should last virtually its shelf life (typically about six months or more) within the project.

Construction

Start construction with the Veroboard by cutting the tracks underneath the board, where shown in Fig. 2. Use a cutting-tool or a small (1/8") hand-held drill bit for this job. Hold the cutting edge onto the hole in question. Press gently and then rotate the tool or bit clockwise, until the copper track has broken in a clean-edged circle. Make sure no loose pieces of copper swarf bridge across to adjacent tracks.

Insert and solder all resistors and capacitors in the positions indicated in Fig. 2. Now solder in the IC socket, if you intend to use one, and transistor Q1. Push fit the IC into its socket (or solder it into the board).

Following the connection details of the project, wire-up the board into its box.

Glue the speaker to the rear of the front panel of the box, behind a grill of some kind. This can be a cutout with a piece of speaker cloth fitted behind it, or a simpler solution is to drill a neat matrix of small holes. Make sure you don't get any glue on the speaker cone itself — only on the outside rim.

The hole for the lead to the bell button must be made in the casing, and it is a good idea to fit this with a small grommet which gives a neat finish and protects the lead.

Finally, mount the case securely to the wall where it is required, and wire it to the bell button.

How It Works

Integrated circuit IC1 is used as the basis of the tone generator, and it is a standard 555 used as a free-running oscillator. Capacitor C4 charges to about ⅔ of the supply voltage via R5 and R6, and then discharges down to approximately ⅓ supply by way of R6 and IC1. This process repeats indefinitely, with the main output at pin 3 of IC1 going high while C4 is charging, and low while it is discharging. The waveform produced here is fed to a loudspeaker which consequently emits an audio tone.

The ⅔ supply voltage threshold at which C4 starts to discharge is modified by applying a control voltage to pin 5 of IC1. When this voltage increases the charge and discharge times of C4 are lengthened, giving decreased operating frequency. As the voltage reduces the charge and discharge times of C4 also reduce, so that a higher operating frequency results. The tone produced by the second generator is therefore frequency-modulated by means of a control voltage applied to IC1 pin 5.

The warbling effect is obtained by using a control voltage that rises and falls a few times per second. The character of the output signal depends to a large extent on the waveshape of the modulating signal, and a waveform similar to a sawtooth is used in this circuit. This is of the type that rises fairly steadily in voltage and then suddenly falls back to its minimum level. This actually gives a steady decline in output frequency followed by a rapid return to the initial frequency although this action occurs too rapidly to be clearly heard, and a pleasant warbling effect is produced.

A unijunction relaxation oscillator is used to generate the modulating signal. Capacitor C2 charges through resistor R3 until a charge voltage of about 7V is achieved, whereupon C2 rapidly discharges through Q1 and R2. Transistor Q1 then switches off, C2 commences to charge once again, and so on. R4 couples the output of Q1 to pin 5 of IC1.

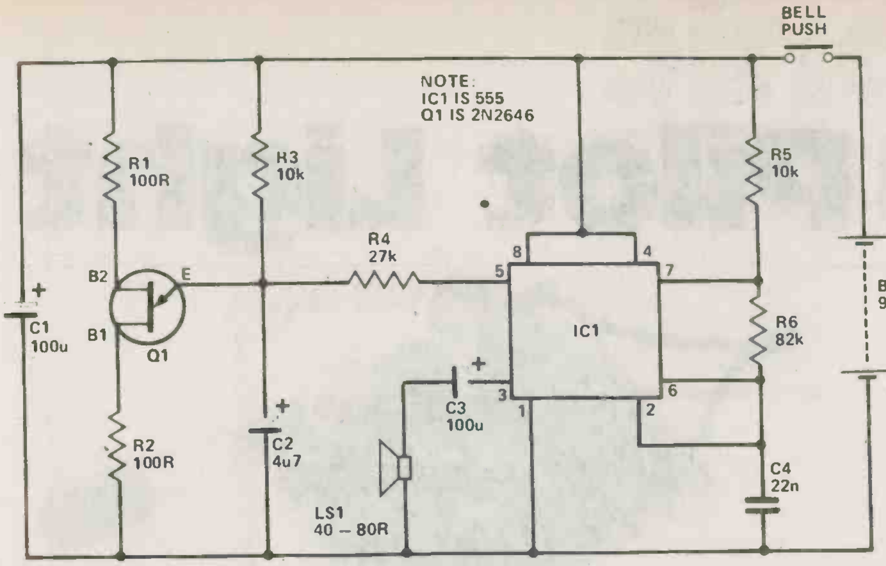


Fig. 1 Circuit of the ETI Electronic Doorbuzzer.

Parts List

Resistors (All ¼ W, 5%)

R1, R2	100R
R3, R5	10k
R4	27k
R6	82k

Capacitors

C1,3	100u, 10V electrolytic
C2	4u7, 25V electrolytic
C4	22n polyester

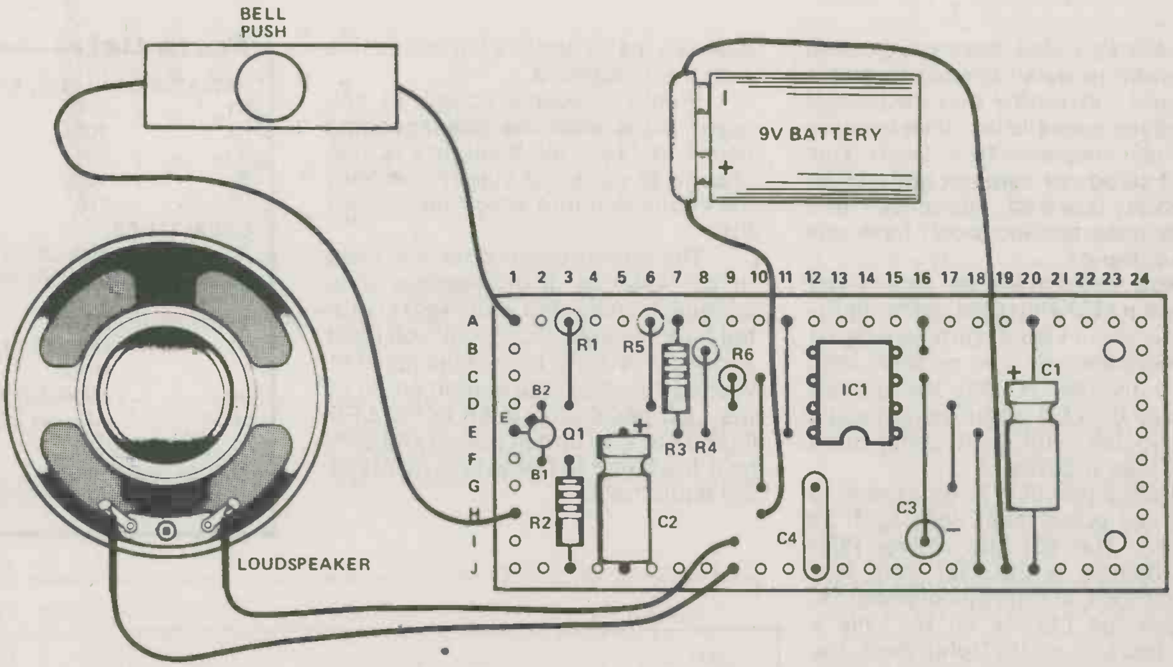
Semiconductors

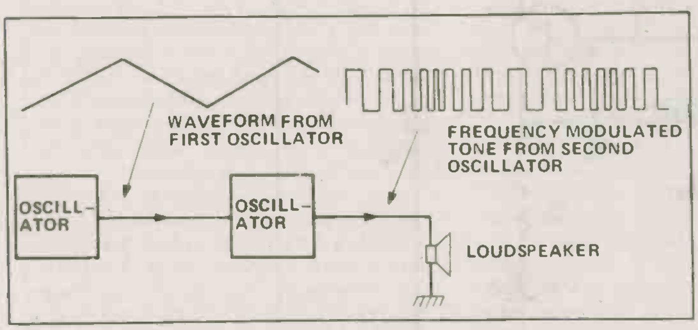
IC1	555 timer
Q1	2N2646 unijumction transistor

Miscellaneous

LS1	miniature 40-80R loudspeaker
Veroboard	24 hole x 10 strip, 0.1" matrix

Case to suit
9V battery and clip
Doorbell button and connecting cable





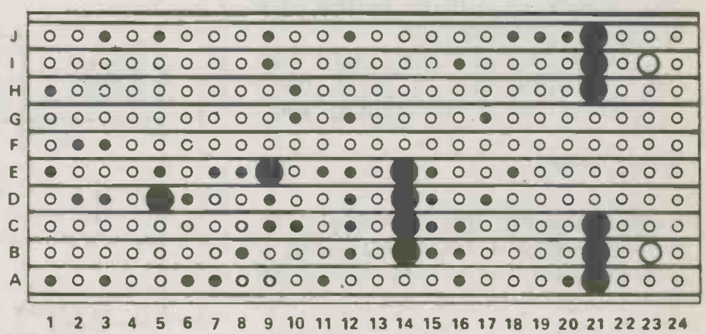


Fig. 2 Veroboard overlay, underside track breaks and component locations, and connection details.

Low Power Pilot Light

Build yourself this simple circuit to fit inside battery-powered equipment — it will warn you that you have left the equipment on and that you are wasting valuable battery power.

HOW MANY TIMES have you gone to your radio to listen to your favourite program, only to find that the battery is dead because the last time you tuned in you forgot to turn it off? This sort of thing can happen quite often to battery-powered equipment and the chances are you won't have any fresh batteries.

Now, wouldn't it be nice if you could fit a LED pilot light to the equipment to give a visual warning when it has been left on? The problem with such a method is that the current drawn by the LED (about 20 mA) could result in the pilot light using more power than it saves.

A more practical alternative is to use a low power pilot light such as this one. The ETI Low Power Pilot Light flashes a LED for only very short periods, at intervals of about 1s. Because the LED is on for only a small fraction of the total time, the average current consumption is very low. Thus battery life will not be significantly reduced with the use of this project, even if the battery is a small, low capacity type.

A flashing LED pilot light also has the advantage of being more noticeable than a non-flashing type.

Construction

Insert and solder the five resistors into the Veroboard, according to Fig. 2, followed by the two capacitors. Make sure you polarise the capacitors correctly.

Now, mount transistors Q1 and 2, checking before you solder each one in that it is the right way round.

Solder in LED1, the same way round as shown in Fig. 2. Now, bend it down so that it lies in a horizontal line with the Veroboard.

Finally, solder a couple of coloured leads from the corresponding points (red to +9V; black to 0V) long enough to go to the supply points of the equipment into which the project fits.

The circuit board does not need to be fastened down because it is adequately mounted when LED1 is fitted into its panel clip. So, all you need to do now is drill a hole in the panel of your battery-powered equipment to fit the LED panel clip, push in the LED (complete with circuit board) and connect the board to the supply points of the equipment.

Parts List

RESISTORS (All ¼ W, 5%)	
R1	1M2
R2	100k
R3	18k
R4	10k
R5	1k8
CAPACITORS	
C1	1u0, 16V electrolytic
C2	10u, 16V electrolytic
SEMICONDUCTORS	
Q1	MPS6515 NPN transistor
Q2	2N3905 PNP transistor
LED1	0.2" red LED + panel clip
MISCELLANEOUS	
Veroboard, 8 strip x 11 hole, 0.1" matrix	

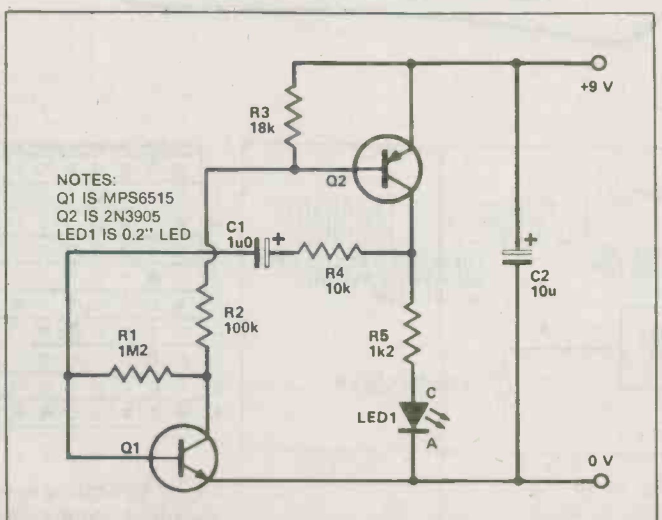


Fig. 1. Circuit of the Low Power Pilot Light.

Continued on page 105

uPower Thermal Alarm

This over or under-temperature alarm consumes a mere 3.5 uA of quiescent current, yet the alarm delivers 1W of peak audio power.

PRECISION TEMPERATURE alarms have a variety of practical uses in the home: they can be used to indicate ice conditions in the attic, over-temperature conditions in the greenhouse or fire conditions in any part of the building. Trouble is, all conventional systems draw quiescent currents of several milliamps and will flatten a 9V battery after less than two days of continuous operation. Drag!

ETI's new Micropower Thermal Alarm system can be used as either an over- or under-temperature alarm; it is specifically designed to overcome the battery flattening problem.

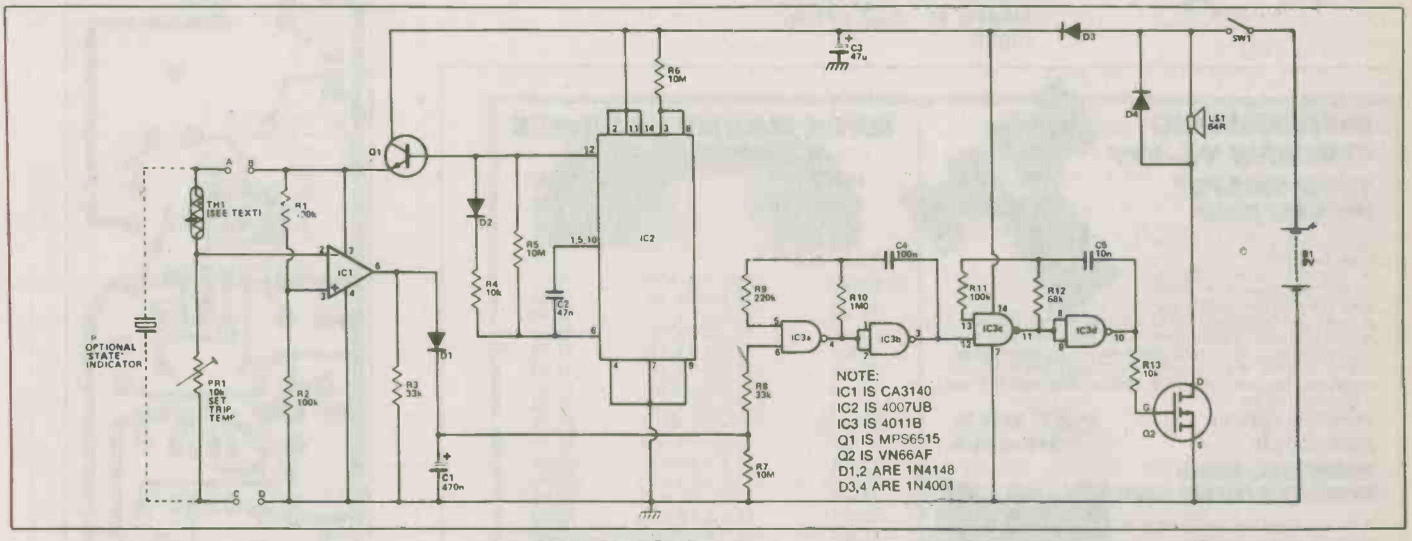
Construction

The entire circuit, other than the thermistor, speaker and battery, is mounted on a small PCB and construction should present few problems. Note, however, that the circuit uses some high-value resistors, so take care to keep the board clean during and after assembly; when construction and testing is complete, you can coat the entire circuit with varnish, to exclude the shunting effects of moisture and dirt.

The circuit is designed to work with a negative-temperature-coefficient (NTC) thermistor th has a resistance in the range 1k0 to 10k at the desired alarm temperature; the VA1066S is suitable for use at all 'normal' temperatures. TH1 and PR1 can be configured to give either over or under-temperature alarm operation; with the connections shown in the circuit diagram, the unit acts as an under-temperature (ice warning, etc) alarm; for over-temperature operation, simply transpose the TH1 and PR1 positions using the links provided on the PCB. In practical use, the thermistor is mounted remote from the PCB.

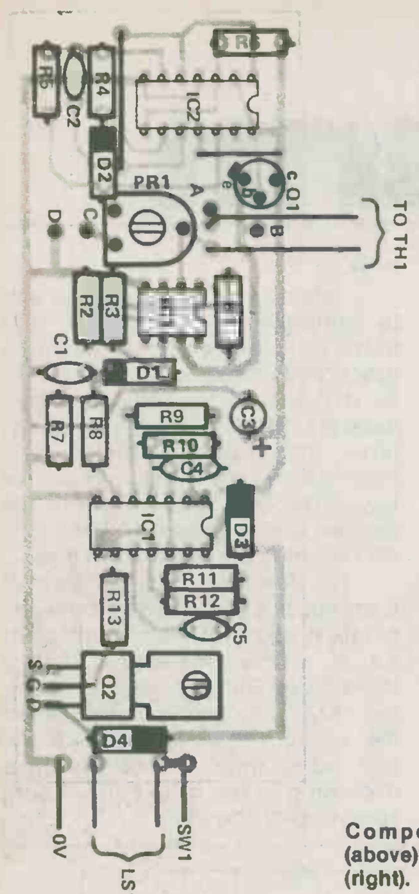
When construction of the unit is complete, fit the speaker and battery in place and give the unit a functional check by adjusting PR1 so that the alarm activates; then back-off PR1 so that the alarm turns off again (after a few seconds delay). Finally, raise (or lower) the TH1 temperature to the desired alarm value and then trim PR1 so that the alarm activates.

If desired, an acoustic transducer can be wired between points A and C of the circuit to act as a state indicator. This transducer will generate an audible click once every second when the circuit is working correctly, and adds only a fraction of a microamp to the total current consumption of the unit.



Parts List

Resistors (all ¼W, 5%)	
R1,2,11	100k
R3,8	33k
R4,13	10k
R5,6,7	10M
R9	220k
R10	1M0
R12	68k
Potentiometers	
PR1	10k miniature horizontal preset
Capacitors	
C1	470n 16V tantalum
C2	47n ceramic
C3	47u 16V tantalum
C4	100n ceramic
C5	10n ceramic
Semiconductors	
IC1	CA3140
IC2	4007UB
IC3	4011B
Q1	MPS6515
Q2	VN66AF
D1,2	1N4148
D3,4	1N4001
Miscellaneous	
TH1	VA1066S or Philips 635-01472
SW1	SPST miniature toggle
LS1	64R loudspeaker
TX1	Radio Shack piezo (optional) buzzer 273-065



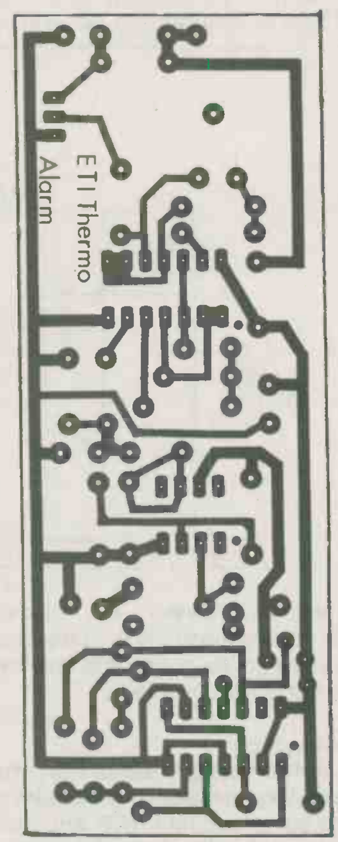
How It Works

The circuit comprises three main sections, these being a thermal switch (TH1-PR1-R1-R2 and IC1), a sample pulse generator (IC2 and Q1), and an alarm generator (IC3 and Q2). The thermal switch circuit is quite conventional: TH1-PR1-R1-R2 are wired as a simple bridge across the inputs of voltage comparator IC1. The action is such that the output of IC1 is normally low (at 0V) but switches high when the TH1 temperature falls below a value preset by PR1 (the circuit can be made to give over-temperature switching by transposing the TH1 and PR1 positions). If this conventional circuit were powered from a continuous DC source, it would draw several milliamps of quiescent current.

The sample pulse generator circuit is designed around IC2, which is configured as a special micropower oscillator and produces a 300 us pulse at pin 12 roughly once every second. This pulse is used to connect power to the IC1 thermal switch circuitry via emitter follower Q1, thus reducing its mean current consumption by a factor of 3000 relative to the 'normal' DC value. Thus, if the TH1 temperature is above the preset alarm level on the arrival of the sample pulse, the IC1 output (pin 6) will be low and no charge will be fed to C1 via D1, but if the temperature is below the preset level the output of IC1 will switch high for the duration of the sample pulse, rapidly charging C1, the C1 charge is used to activate the IC3 alarm generator circuitry.

IC3a-IC3b are connected as a gated 6Hz astable, with the output fed to the input of 1 kHz gated astable IC3C-IC3d; IC3d has its output fed to an external speaker via VFET power amplifier Q2. Thus, when the C1 voltage is zero, the two IC3 astables and Q2 are cut off and the alarm generator circuitry consumes zero quiescent current, but when the C1 voltage is high the 6 Hz astable is gated on and pulses the 1 kHz astable on and off, generating a powerful pulsed-tone alarm signal in the speaker. The supply to the major sections of the circuit is decoupled from LS1/Q2 transients by D3 and C3.

Component overlay (above) and PCB pattern (right).



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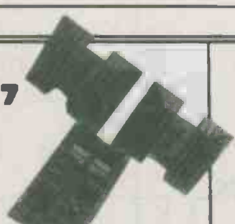

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19 x 6	17 x 5.5 x 12	47.50
19 x 5	17 x 4.5 x 12	43.50
19 x 4	17 x 3.5 x 12	42.50
19 x 3	17 x 2.5 x 10	37.50
19 x 2.5	17 x 2 x 10	36.50
17 x 6	15.5 x 5.5. x 9	41.50
17 x 4	15.5 x 3.5 x 9	36.50
17 x 2	15.5 x 1.5 x 9	33.50
12 x 6	11.5 x 5.5 x 7	29.50
12 x 4	11.5 x 3.5 x 7	25.50
12 x 2	11.5 x 1.75 x 7	23.50

6502 PARTS	PRICE
1. 6502 MOTHER BOARD	50.00
2. PACKAGE 101 = ALL IC's, RAMs, 6502 AND BLANK 2716's	120.00
3. PACKAGE 102 = ALL RESISTORS, CAPACITORS, DIODES, TRS, CRYSTAL, COIL AND JACKS	26.00
4. PACKAGE 103 = ALL IC SOCKETS AND 50-PIN EDGE CONNECTORS	40.00
5. SWITCHING POWER SUPPLY	105.00
6. KEYBOARD w/NUMERIC PAD	130.00
7.CASE	99.00
(1-7), TOTAL	515.00
8. W&T MOTHER BOARD WITH ALL PARTS BLANK EPROMS	325.00

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Bicycle Speedometer

0 — 99 MPH in sixty minutes — that's how long it will take you to build this all electronic, solid-state speedometer.

WITH FUEL getting more expensive, the world's oil supply running out and gas disappearing in a puff of smoke, it can't be long now before pedalpower makes a comeback. We can see it now; CB freaks with cycle mounted rigs and six-foot whips on the back. Of course there will be lots of research into optimum wheel size, cruising speed etc. That's where this dandy little project will come to your aid. Featuring a two-digit readout, bright red LED display with 1 MPH resolution updated every few seconds, it can be built in a trice (ideal if your bike has three wheels) and powered from a single 9 V battery.

Swift And Silent

There have been many bike speedometer designs published over the years but never before has so much been brought to so many with so little. Yes, only Electronics Today can do this for you! No, seriously, before this gets totally over done, we'll explain. Only three ICs are required plus the two displays and a handful of passive components. The whole thing is very easy to put together so you can assemble it whichever way you like best. The speedometer works by detecting each revolution of the bike's wheel using magnetically-sensitive reed switches with one or more bar magnets mounted on the wheel. The faster you go, the more pulses are counted and the speed displayed increases. The display blanks out while the counters are advancing to avoid a distracting flicker and the count period is set up by adjustment of a single resistor when the speedometer is mounted on your bike. Okay, so it doesn't tell your weight, but it won't burn a hole in your pocket either!

Construction/Setting Up

Nothing to cause any problems here. As usual we'd recommend you use sockets for the ICs. If you use our PCB design you should have success first time though the circuit is simple enough to

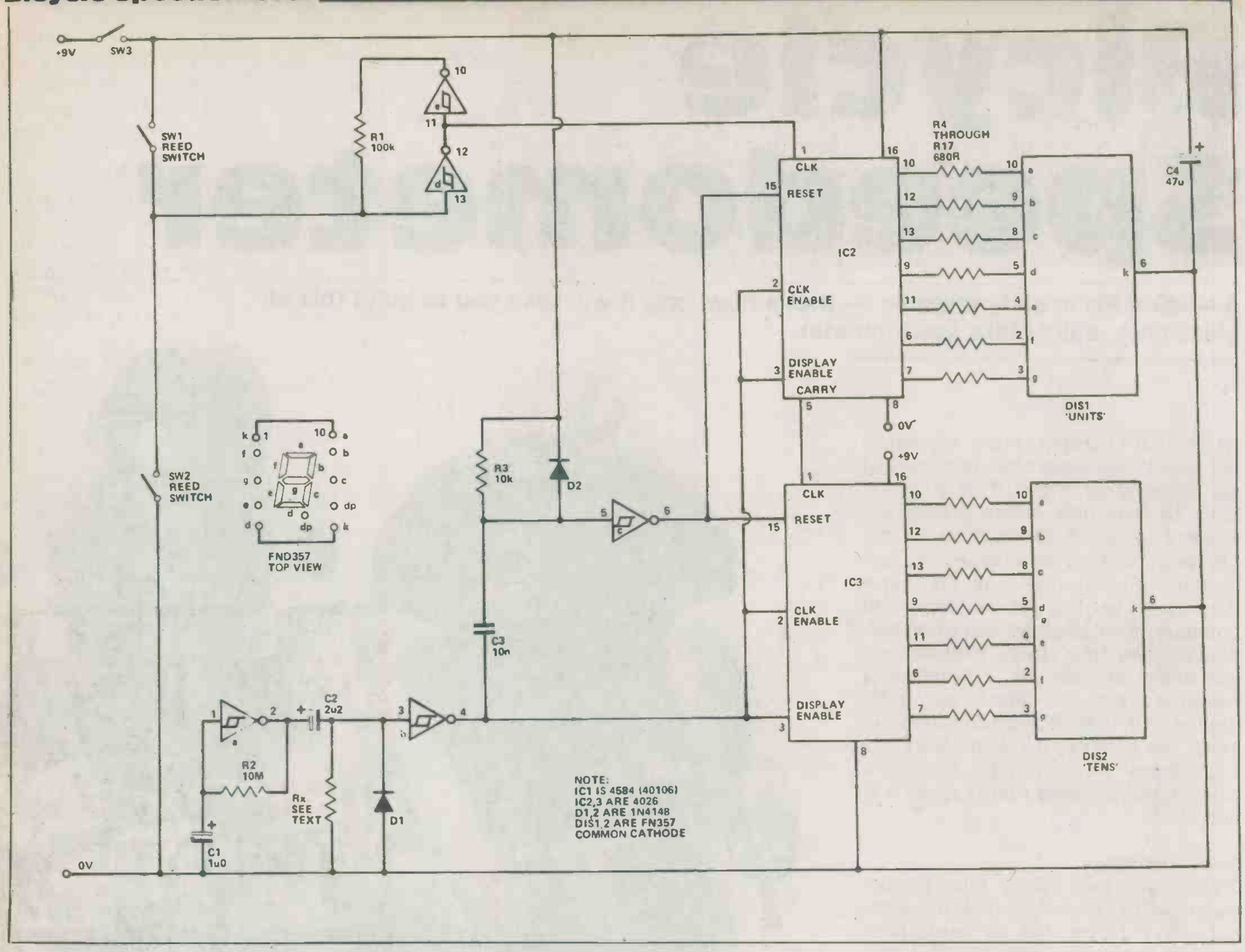


Figure 1. Circuit diagram of the Bicycle Speedometer.

be put together on Veroboard or whatever comes to hand . . . except for the original breadboard which went out of fashion when ICs arrived. (You try knocking nails into a piece of wood the size of a postage stamp . . . and anyway, you would look silly with a breadboard between the handlebars!)

Reed switches come with two main switch actions, either single-pole, double-throw or single-pole, double-throw (changeover). You can use two of the former or simply one of the latter (with its centre contact connected to the common point on the circuit board for the two switches (see Fig. 2).

Reed switches are usually supplied as glass tubes with the switch contacts brought out to tags at either end. For better protection against the elements a single pole double throw reed switch is ideal. You can however, do as we did, and get by with two single throw units.

The relationship between wheel diameter, gate period and number of

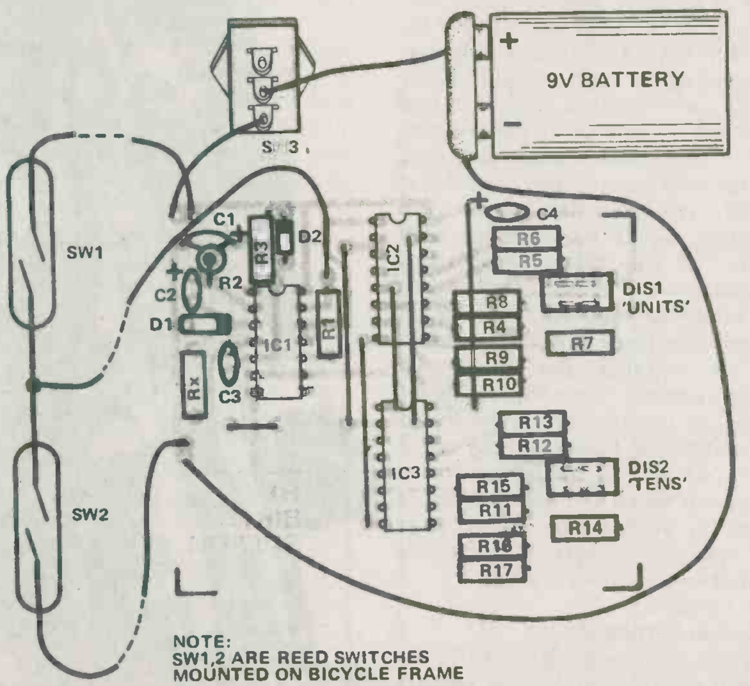
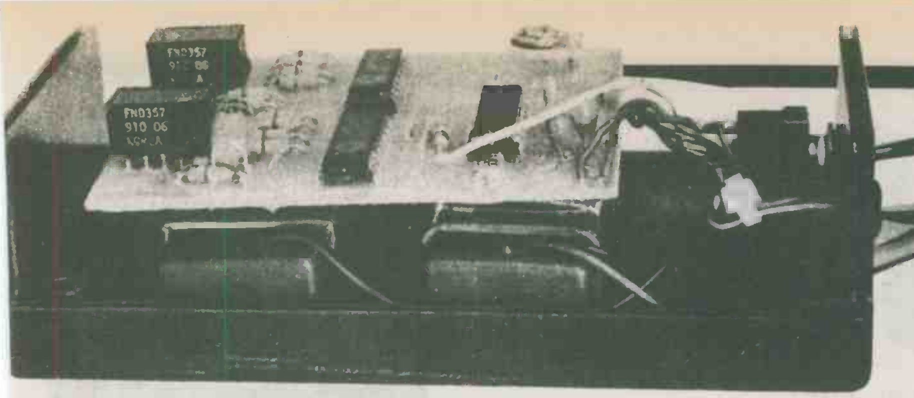
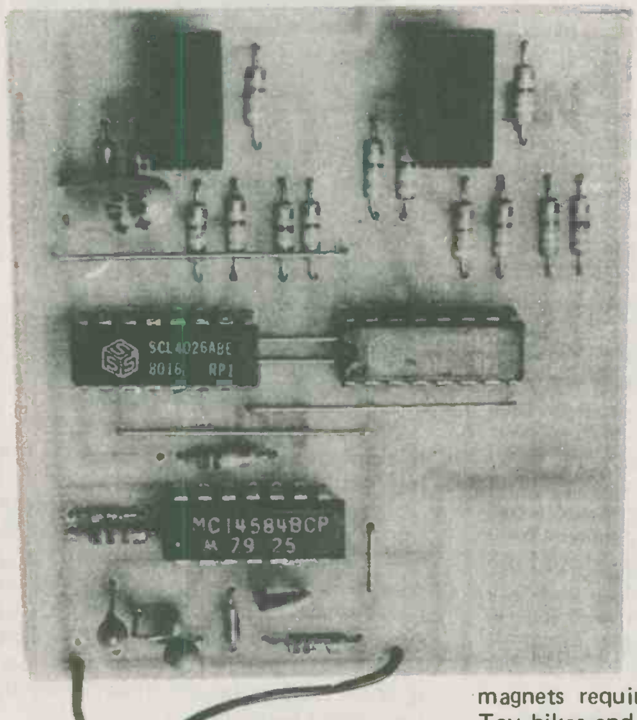


Figure 2. Overlay and connection details. Remember that SW1 and SW2, the reed switches, can be combined as one changeover type reed switch.



Side view of speedometer, showing the two batteries.



Component layout of PCB.

Parts List

RESISTORS

R1	100k
R2	10M
R3	10k
R4-R17	680R

POTENTIOMETER

Rx	1M0 linear potentiometer

CAPACITORS

C1	1u0, 16 V tantalum
C2	2u2, 16 V tantalum
C3	10n ceramic
C4	47u, 16 V tantalum

SEMICONDUCTORS

IC1	4584 or 40106 hex inverting, Schmitt trigger
IC2,3	4026
D1,2	1N4148 diode
DIS1,2	FND357, common cathode, 7-segment displays

MISCELLANEOUS

SW1,2	reed switch inserts
SW3	single-pole, double-throw toggle switch

Magnets
Battery and clip
Case to suit

magnets required is not a simple one. Toy bikes and bikes with 'baby' wheels will get away with one or two magnets. To obtain a reasonable gate period with larger wheels you'll need to use more magnets. In practice, fix between five and 10 small magnets (the type usually supplied with reed switches) around the rim of the wheel (the more the merrier). To stop them falling off it's best to glue them in place or secure them with pads of double-sided tape. Once fixed, a dab of paint or varnish will prevent them from getting rusty.

Connect a 1M0 potentiometer or preset at the Rx position, get on your bike and adjust the pot until you get the right speed reading. Now, measure its value and make it up from fixed value resistors or just fasten the pot or preset onto the board — there's plenty of room.

If you use separate reed switches, make sure that both are never on at once or the battery will be short — circuited through them. To safeguard against this you can connect 10k resistors in series with the wires from the battery.

Ideally you'll need a box with a clear lid so you can see the display without having to cut holes in the box, which would let in water. It's best to mount the box centrally on the bars so that, if the bike takes a tumble no damage will be done. Lacquer the back of the board so that if any condensation appears in the box no shorts will result. The circuit takes about 40 mA of current when running so two batteries in parallel are advisable and there's just enough room under the PCB to put them.

Alternatively, you might like to make a proper facia panel to hold a whole set of instruments (oil pressure, ammeter, etc!?) Watch this space!

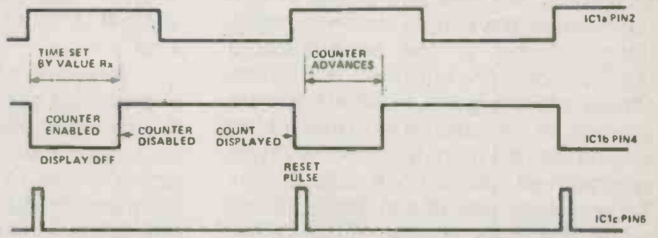
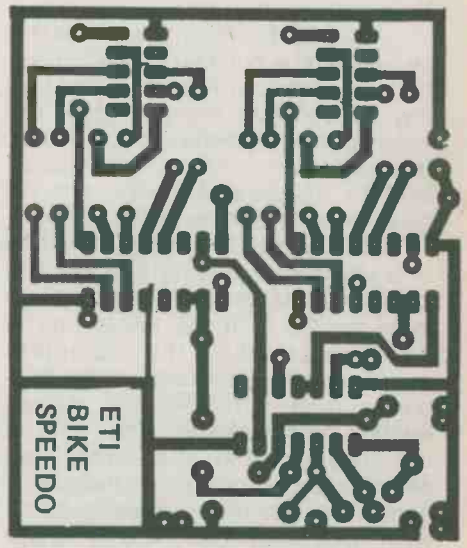


Figure 3. Waveforms within the circuit not to scale.



How It Works

A low-frequency astable oscillator provides the master clock for the circuit. IC1a, R2, C1 take care of this. Pulses are then differentiated and squared up by IC1b and IC1c to provide clock enable and reset signals. Figure 3 shows this in detail.

Integrated circuits IC2 and IC3 form a two-digit counter and display driver, which needs only correct timing and clock pulses to operate both 7- segment displays. While IC1b's output is low the counters are enabled and clock pulses from IC1d cause the counters to advance. When IC1b goes high the counters are disabled and the count is displayed on the 7-segment displays. The combination of IC1d and IC1e forms a simple but effective debouncing circuit. Some form of signal conditioning circuit like this is nearly always required when mechanical switches are interfaced to digital counters. Resistors R4 through R17 limit the current in the displays and C4 provides overall decoupling.

Musical Doorbell

An inexpensive programmable doorbell project for your home. This instrument will play any nine-step melody of your choice.

MODERN DOORBELLS come in two basic types, the simple electrical 'ding-dong' (chime) or the sophisticated microprocessor-controlled multi-tune Oh Canada, etc. types. In either case you pay your money and have to accept the sounds that the manufacturers have pre-programmed into your particular device. If you ever get tired of your bell's limited range of sounds, you have little option but to buy a new unit.

We have decided to overcome this by designing a musical doorbell project that the owner can self-program to play any desired (but brief) melody. The essence of our project is that it is simple; it is devoid of hard-to-get micros, PROMs, double-sided PCBs, etc, yet gives an entertaining performance.

Our doorbell is designed to play a nine step melody made up of a selection of five basic notes or tones. The melody lasts for 2-3 S. If the bell-button is briefly operated, the complete melody plays once only; if the bell-button is held closed, the melody repeats continuously. The unit is designed so that the owner can select or 'program' his own melody by hard wiring the interconnections between various pins on the unit's PCB. The nine step, five note choice enables any one of a selection of almost two million (5^9) different melodies to be programmed into the unit!

A feature of our doorbell is that it incorporates a bistable electronic switch that connects power to the unit in such a way that it consumes virtually zero power when in the 'standby' mode. Whenever the bell-button is pressed, the bistable connects power to the unit for the duration of the tune play and then automatically disconnects the power when the melody is complete; this facility ensures long battery life.

Construction

Construction of this unit should present very few problems, if the overlay is followed with care. Note that IC1 and IC3 are CMOS devices and are best mounted in suitable sockets. Also note that an insulated link is connected between pin 3 of IC2 and pin 14 of IC3 on the underside of the board and that Veropins are used to facilitate top-side connections on the PCB.

When construction of the PCB is complete, connect up a suitable speaker, battery and push-button switch and prepare to give the unit a functional check. When selecting a speaker, note that output volume is proportional to speaker impedance and that a high impedance unit will give the loudest results.

When you are ready to try out the unit, connect a flying lead from D1 to one of the A-E note-select points and press PB1 to test the first note in the sequence. You can then wire in the D2 to D9 note-selection connections, one at a time, to establish the rest of the sequence, testing the unit at each step in the wiring sequence.

Once you've finished 'programming' your unit you can fit the PCB, battery and speaker into a suitable box, hang the unit on your front door and finally connect it up to a suitable push-button switch.

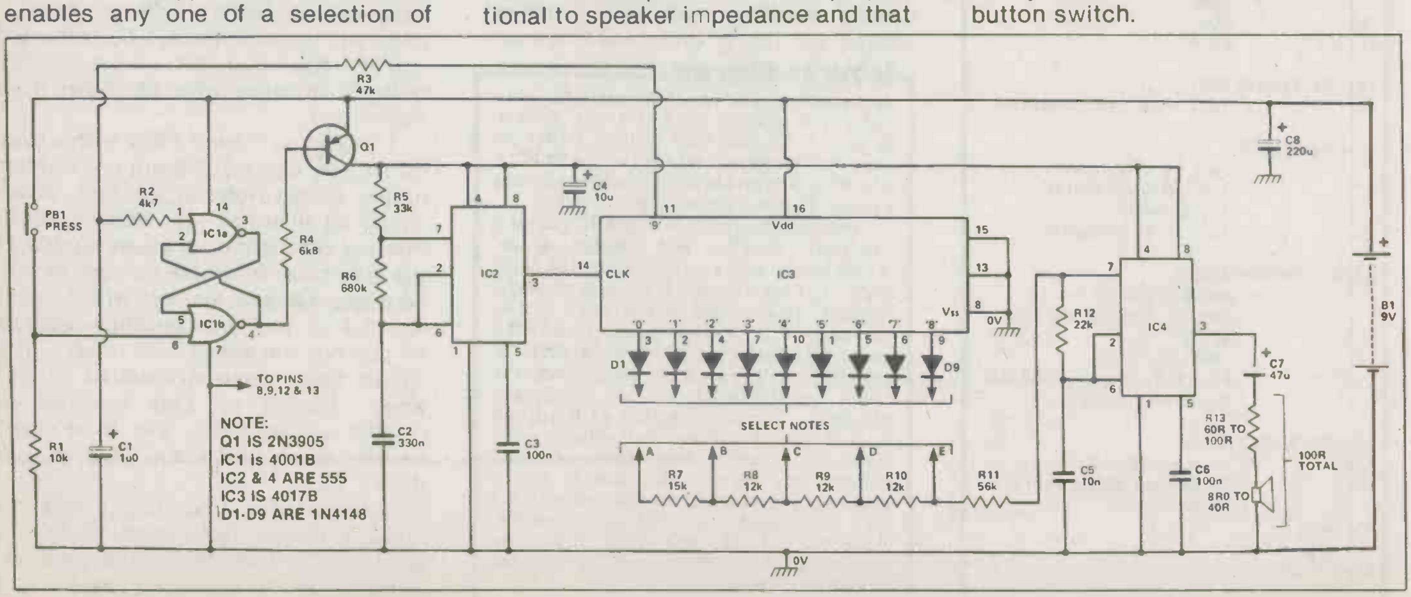
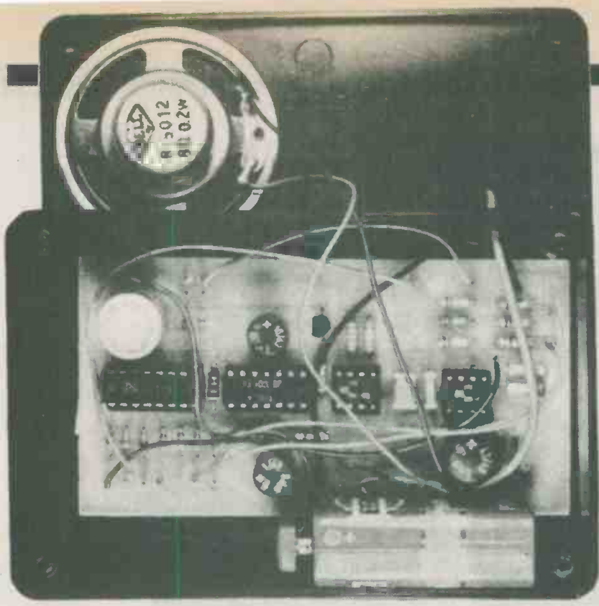
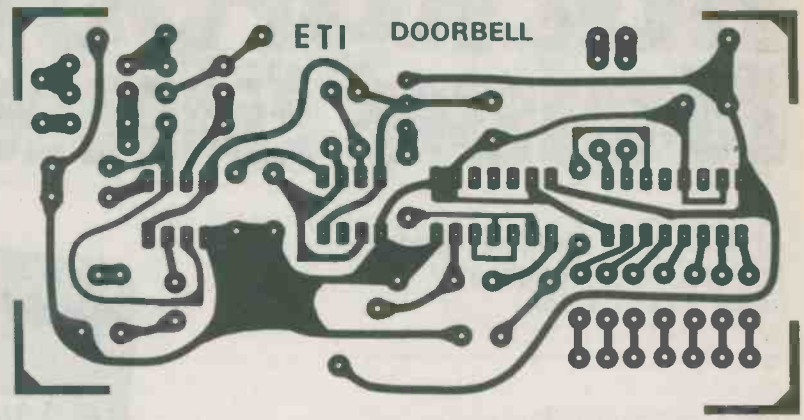


Fig. 1. Circuit diagram of the Musical Doorbell. The connections you make between diodes D1-D9 and the points A-E determine the tune that is played.





How It Works

The circuit comprises a bistable (IC1) and a transistor power switch (Q1), two 555 astable multivibrators (IC2 and IC4) and a 4017 decade counter/divider (IC3). The bistable (IC1) is designed around two gates of a CMOS 4001B and controls the base bias of Q1, which in turn controls the positive power supply connections to IC2 and IC4, the two 555 chips.

Normally, the output (pin 4) of the bistable is high, so Q1 receives no base drive and is cut off. Under this condition, IC2 and IC4 consume no power: IC1 and IC3, being CMOS devices, also draw negligible power under this condition. The entire circuit, in fact, consumes a typical 'standby' current of only a micrpamp or so.

The circuit is activated by briefly pressing PB1, thereby causing the IC1 bistable to change state and connect power to the IC2 and IC4 astables via Q1. IC2 is wired as a low frequency astable (a few Hertz) and delivers clock pulses to IC3. IC3 is a 4017B decade counter/divider; it has ten decoded outputs, which sequentially go high on the arrival of successive new clock pulses, only one output being high at any given time. In our application, the first nine decoded outputs are used to sequentially select (via D1 to D9) timing resistors in a second astable, the IC4 tone generator, which drives a speaker via C7.

The first nine clock pulses from IC2 thus cause nine tones to be sequentially selected via the R7-11 resistor network. On the arrival of the tenth clock pulse, pin 11 of IC3 goes high and resets the IC1 bistable via R3 and C1, thereby cutting off Q1 and removing power from IC2 and IC4, thus completing the operating cycle.

The action of the IC1 bistable is such that, if PB1 is briefly pressed, the instrument plays a single sequence of nine notes (total duration is 2-3 S) and then automatically switches off. If PB1 is held closed, however, the sequence continuously repeats. Note that the owner can set up any tone sequence that he wishes by suitably interconnecting the diode outputs of IC3 to the 'A' to 'E' selection pins on the R7-11 note-selection chain.

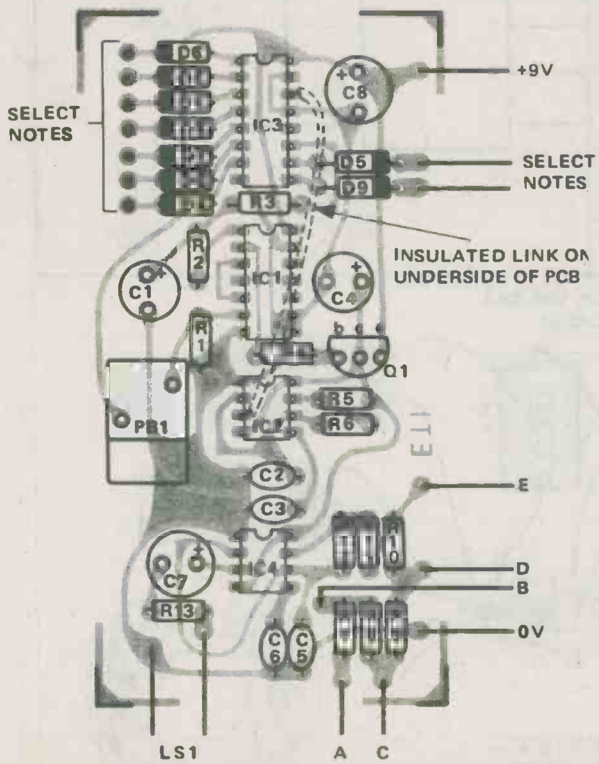


Fig. 2. Component overlay.

Parts List

Resistors All ¼W, 5%		Capacitors	
R1	10k	C1	1u0 63V electrolytic PCB type
R2	4k7	C2	330n polycarbonate
R3	47k	C3,6	100n polycarbonate
R4	6k8	C4	10u 63V electrolytic PCB type
R5	33k	C5	10n polycarbonate
R6	680k	C7	47u 25V electrolytic PCB type
R7	15k	C8	220u 25V electrolytic PCB type
R8,9,10	12k		
R11	56k		
R12	22k		
R13	100R		
Semiconductors		**Miscellaneous**	
IC1	4001B	LS1	Any 8R0 to 40R speaker: see text
IC2,4	555	PB1	momentary action
IC3	4017	B1	9V
Q1	2N3905	Case	
D1-9	1N4148		

Background Noise Simulator

At last — a psycho-physical project, which helps you concentrate and relax.

IT IS A medical fact that human concentration operates in short bursts (up to about 20 minutes) after which the individual requires a few seconds of relaxation before continuing with the work at hand. You can see this effect yourself when reading a book or studying: every now and again you break from concentration and look up, perhaps simply to see what time it is or to make a cup of coffee.

It is also known (and fairly obvious) that the level of background noise can affect the length of concentration bursts — for instance, too much noise prevents you from working at all (just try concentrating when workmen are digging up the road outside!). Not so obvious is the effect caused by too little background noise. Concentration under such a condition becomes very difficult and can be impossible with absolutely no background noise.

Well, the ETI Background Noise Simulator has been designed to deal with the last problem. After building this project readers who suffer from lack of concentration, due to lack of background noise, can breathe sighs of relief. Of course, we can't guarantee that you will all be transformed into geniuses able to rewrite relativity theories, but we can promise that you should be able to experiment with some interesting psychological effects. For instance we tried the project out with our art department, along the corridor in the ETI offices and they told us that if we didn't go drown our machine in the nearest bucket of water and let them get back to sleep, they wouldn't invite us to next year's Christmas party. With that threat in mind we left them to it.

Construction

This project offers a choice of construction techniques: either Veroboard or PCB can be used to build it up. Overlay and connection

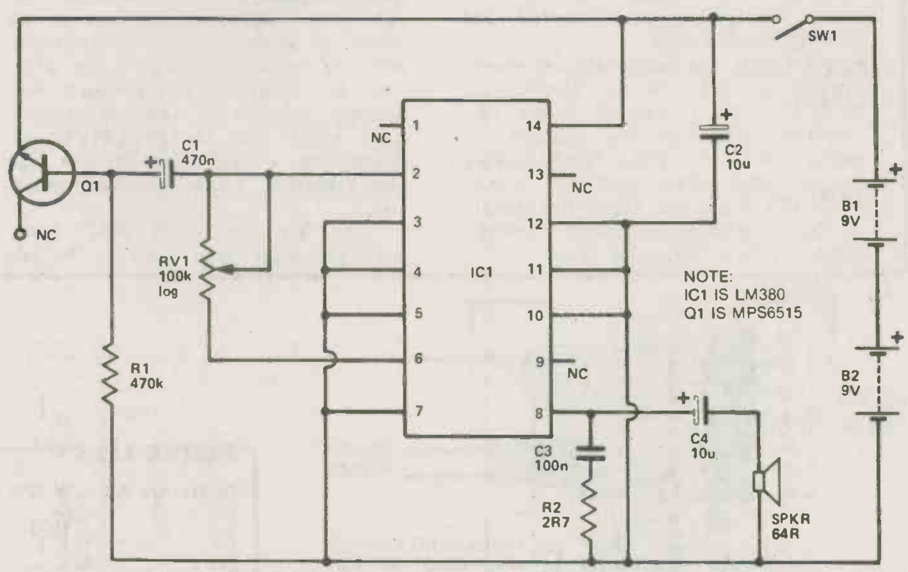


Fig. 1. From this circuit diagram you can see the unusual way Q1 is in circuit.

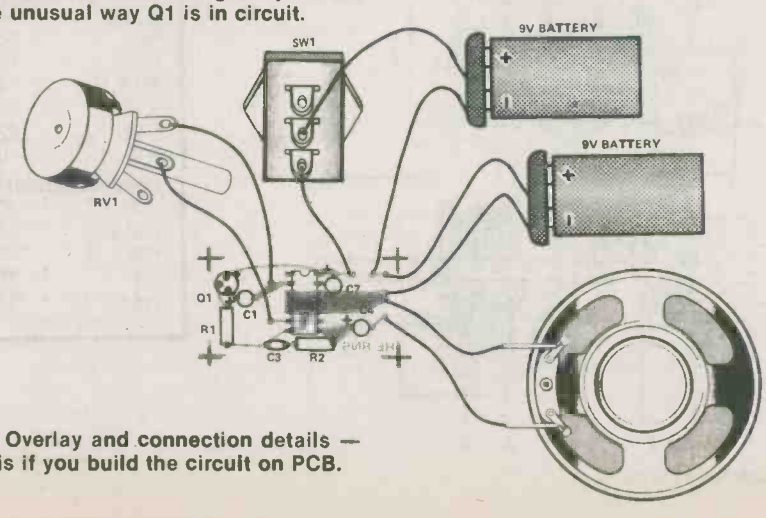


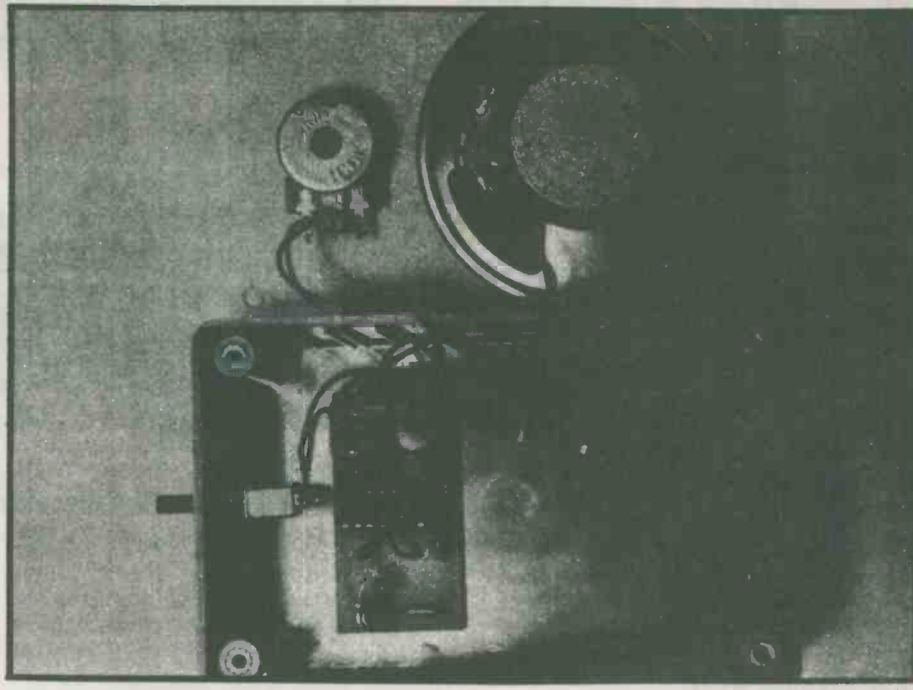
Fig. 2. Overlay and connection details — use this if you build the circuit on PCB.

details are given for them both in Figs. 2 and 3.

When using Veroboard, remember to break the tracks where necessary, as indicated in the underside view of the board in Fig. 2 and check that no short circuits are formed by loose swarf or solder bridges between tracks. Track breaks can be made using either the correct tool or simply a hand-held 1/8" drill bit, by holding it on the hole in question and twisting gently clockwise.

Insert resistors first, followed by capacitors and finally semiconductors. The diagrams show component position and connection details. Follow them carefully, making sure all polarised components are inserted the same way round as indicated.

After connection of the speaker and a suitable power supply, the project should work satisfactorily first time. It then only remains to build the board into a suitable case.



Parts List

RESISTORS

R1	470k
R2	2R7

POTENTIOMETER

RV1	100k logarithmic potentiometer

CAPACITORS

C1	470n, 16V tantalum
C2,3	100n polyester
C4	10u, 16V printed circuit mounted electrolytic

SEMICONDUCTORS

IC1	LM380 2W power amplifier
Q1	MPS6515 NPN transistor

MISCELLANEOUS

SW1	single-pole, single-throw toggle switch

IC socket (14-pin)
Miniature speaker —64R
Batteries and clips

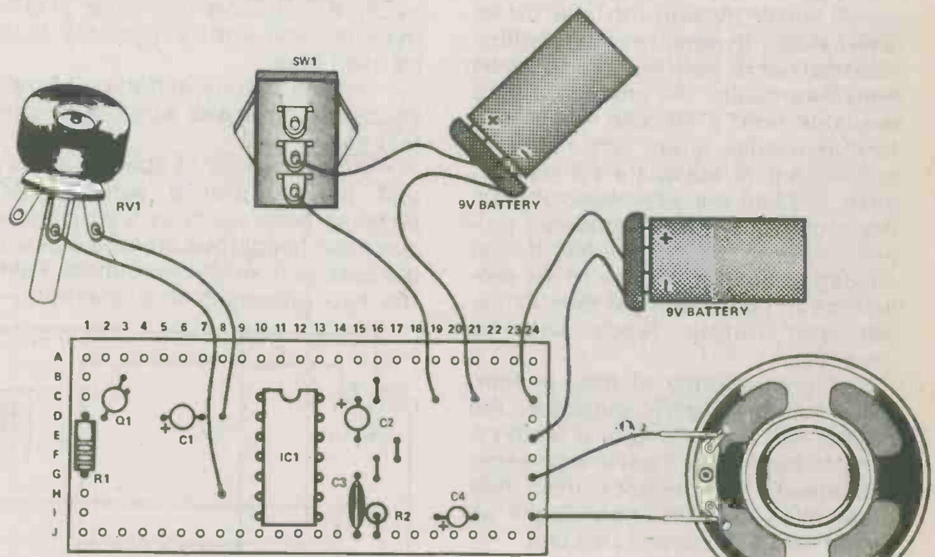
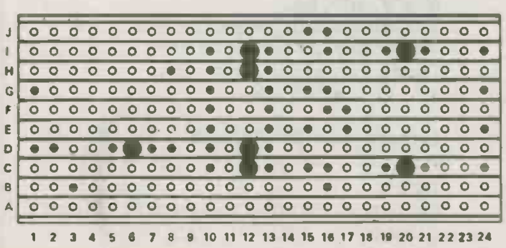


Fig. 3. Veroboard layout and connections along with underside view.



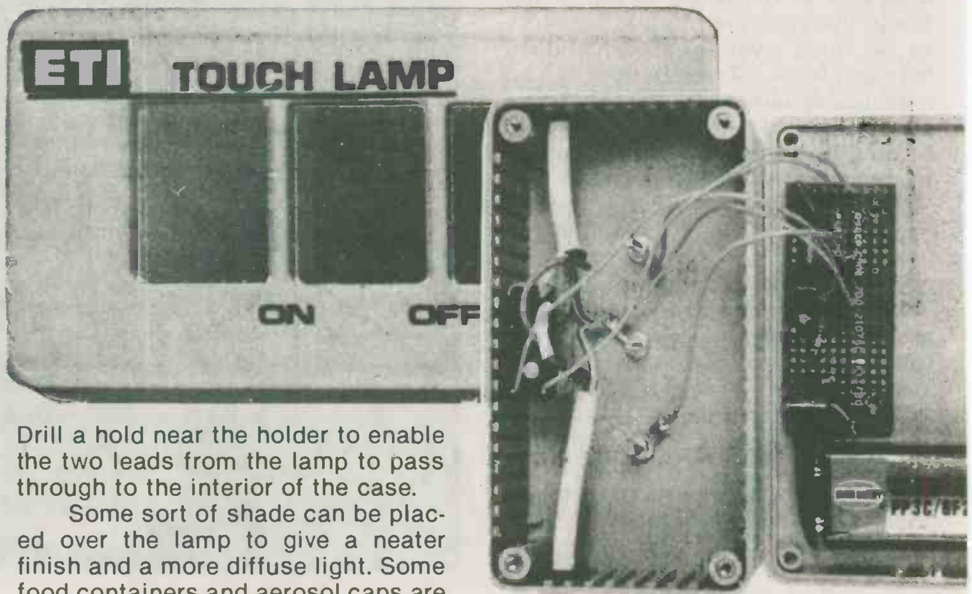
How It Works

The heart of this project is none other than our old friend the LM380. The IC has all the necessary circuitry to form an amplifier with over 2W of output power. Of course we don't need all of that power in this application — in fact only ¼ W is ample — but the LM380 remains one of the cheapest amplifier ICs around (regardless of output power) so we stuck with it.

Transistor Q1 forms the noise generator. It is connected in a rather unusual manner (see the circuit diagram in Fig. 1), with its emitter positive relative to its base. In this mode, a transistor is transmogrified into what is essentially a zener diode — a noisy one at that, providing a fairly large amplitude (50 mV) of noise at its base. Integrated circuit IC1 amplifies the noise (RV1 acting as a volume control) to drive the speaker and give the background noise.

Touch Lamp

Left in the dark? This project gives simple on/off touch control of your battery or AC powered bedside light.



IF YOU'RE TIRED of fumbling around in the dark in search of the lamp switch, and then fumbling around trying to actually operate the switch, our touch-operated bedside lamp is just what you need. It is a very simple and economic battery operated design which has a negligible stand-by current. The use of a touch switch makes the lamp extremely easy to operate even in the dark, since once you have found the touch contacts the unit virtually operates itself!

You can use this project to either turn a small 6V bulb on and off or alternatively to operate a relay (which can be used to switch a line-powered bulb on and off). The amount of light available from a 6V bulb, such as a flashlight bulb, is not very much, of course, but is adequate for its purpose and has the advantage of making a completely self-contained project with no trailing wires. If you choose to build in a relay to the project (as in our prototype) then AC input and output leads will be necessary.

A point worthy of note is that, wired for line control purposes, the project will not only turn a lamp on and off, but in fact most line powered equipment. The project may find other uses, therfore, particularly as an aid for handicapped persons.

Construction

Build up the project using one of the standard sized (24 hole by 10 strip) pieces of Veroboard, carefully following the overlay details in Fig. 2 . Make sure the transistors are inserted correctly.

Drill the case lid to fit the three touch contacts, which can be specially bought contacts, or simply three pan head bolts. Mount the contacts using soldertags (to provide connection points) and nuts.

You must now decide whether you want the project to operate a small bulb or a relay. If you choose the small bulb, then mount it in a holder fitted to the top of the case. Drill a hold near the holder to enable the two leads from the lamp to pass through to the interior of the case.

Some sort of shade can be placed over the lamp to give a neater finish and a more diffuse light. Some food containers and aerosol caps are made of a suitable thin white plastic material, and a little ingenuity must be used here.

Fit the battery and circuit board inside the case and wire up the project as in Fig. 3.

If you choose to operate a relay and thus control a separate AC powered lamp (such as a bedside or overhead lamp) then drill the sides of the case to fit rubber grommets. Push the two grommets into position — they will protect the cable from being damaged.

Fasten the relay to the bottom of the case (double-sided, self-adhesive pads are ideal for this purpose) and connect the project as shown in Fig. 4.

Use cable ties on the AC input and output leads to prevent them from being accidentally pulled out.

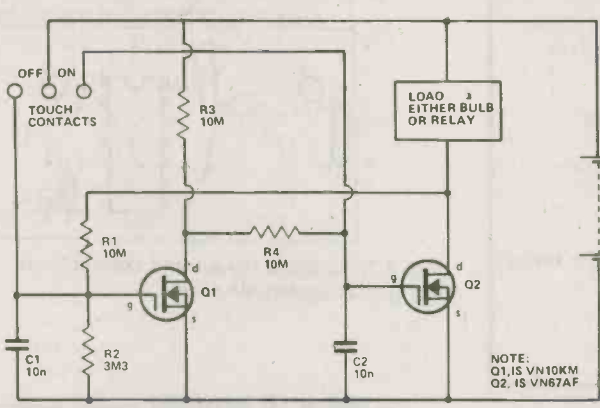


Fig. 1 Circuit of the ETI Touch Lamp.

Parts List

Resistors (All ¼ W, 5 or 10%)

R1	10M
R2	3M3

Capacitors

C1,2	10n polyester

Semiconductors

Q1	VN10KM VMOS transistor
Q2	VN67AF or VN66AF VMOS power transistor

Miscellaneous

Suitable plastic case
Veroboard, 24 hole x 10 strip
Touch contacts.
9V type battery clip

Either: Bulb holder and a 6V 100 mA bulb for AA-sized cells and a plastic holder
Or: 6-12V operated relay (100R coil, or greater)
9V battery

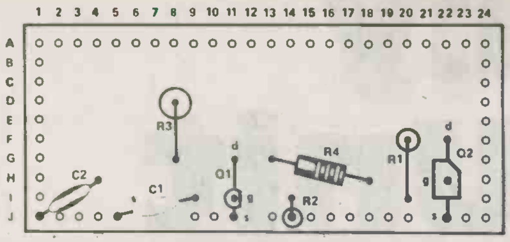


Fig. 2 Veroboard layout of the project. Note that there are no track breaks to make underneath the circuit board.

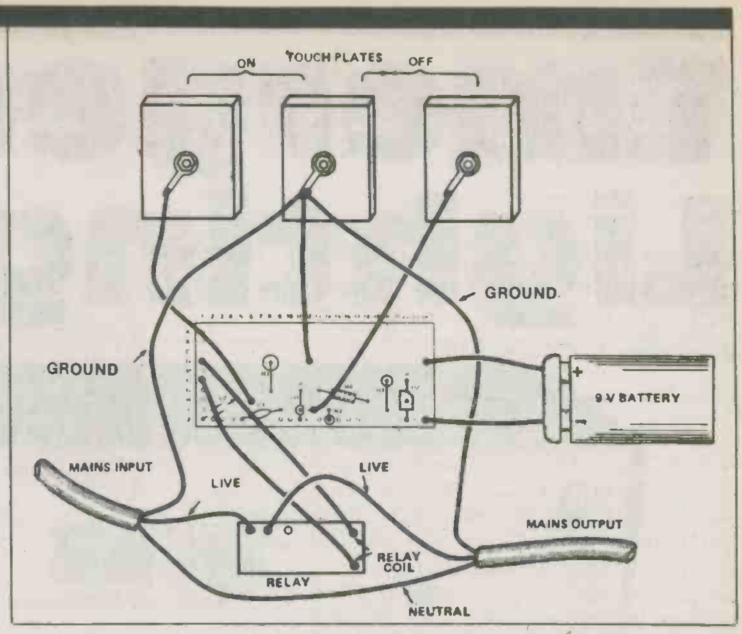


Fig. 4 Project connection details to control line powered equipment.

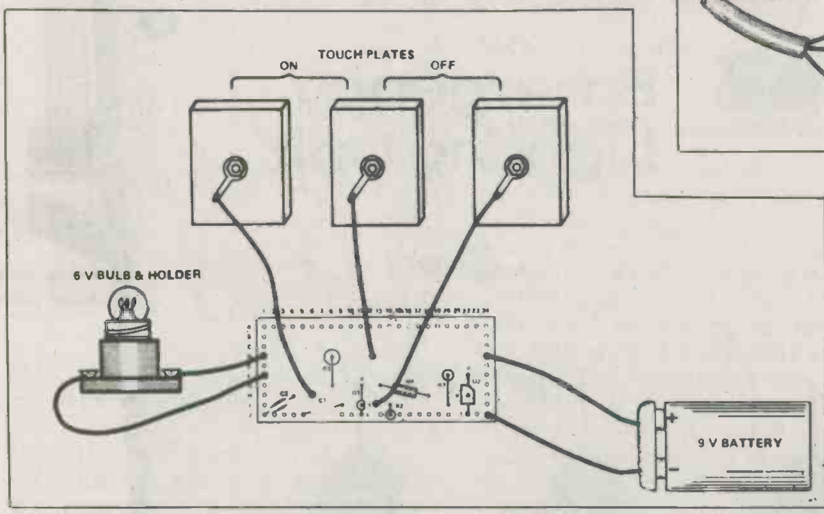


Fig. 3 Connection details of the project if you choose to operate a low voltage bulb.

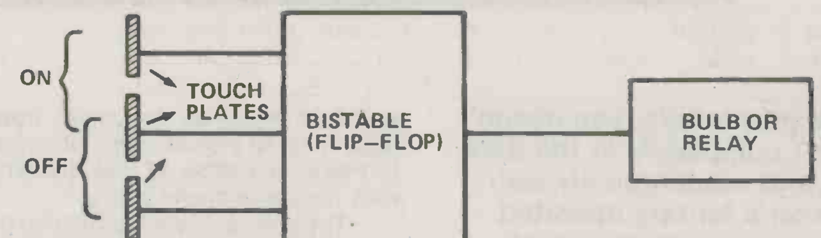
How It Works

The Touch Lamp circuit consists of a simple bistable. A common name for a bistable is a flip-flop, and this helps to explain the action of the circuit.

When the top two touch plates (the ON plates) are touched, the bistable is turned on and its output voltage goes positive (i.e., it 'flips') and stays in this state.

When the lower two touch plates (the OFF plates) are touched, the bistable is turned on and its output voltage goes to zero (i.e., it 'flops').

The output of the flip-flop is used to turn a bulb or a relay on and off.



When power is first applied, the circuit takes up a state where transistor Q1 is biased into conduction by way of the load and resistor R1. This gives practically 0V at the drain terminal of Q1, and transistor Q2 is therefore cut off as it receives no significant bias voltage via resistor R4. Both transistors are VMOS types and are therefore voltage operated — unlike ordinary bipolar devices which are current operated.

If the two 'ON' touch contacts are activated, the skin resistance of the operator is placed between Q2's gate and the positive supply rail. Although this resistance is almost certain to be very high, the high input impedance of Q2's gate ensures that the gate of Q2 is taken a few volts positive so that Q2 is biased into conduction. The load is therefore switched on.

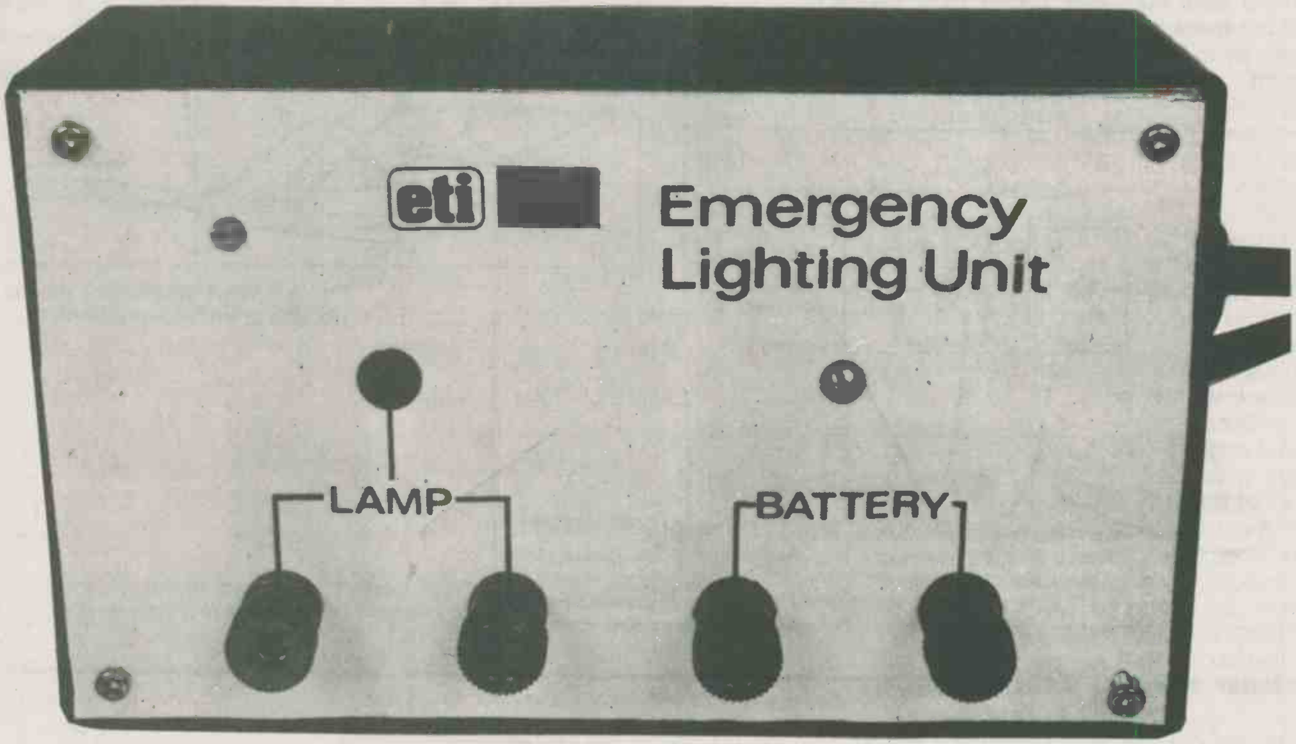
Transistor Q2's drain terminal is now at a very low potential, and is further reduced by the voltage divider action of resistors R1 and R2 so that Q1 now becomes switched off. The voltage at the drain terminal of Q1 thus rises to virtually the full positive rail voltage, and Q2 will be biased into conduction by way of R4 when the operator's finger is removed from the touch contacts. This latches the circuit in the 'ON' state.

The circuit can be returned to the 'OFF' condition by touching the two 'OFF' contacts. The places the skin resistance between the positive rail and Q1's gate so that Q1 is biased into conduction. Its drain voltage falls back to almost zero so that Q2 and the lamp are both switched off. Transistor Q2's drain voltage rises to almost the full positive supply voltage again so that Q1 is latched in the on state as a result of the bias voltage received via R1. Thus the circuit stays in this state with the lamp switched off when the touch contacts are no longer operated.

The circuit can obviously be triggered from one state to the other indefinitely by operating the appropriate pair of touch contacts, and capacitors C1 and C2 are used to filter out any electrical noise which could otherwise produce spurious operations.

VMOS devices require no significant input current and will work at very low drain currents. This makes possible a circuit having a low stand-by current: the quiescent current consumption of this circuit is typically only about 1 uA.

Emergency Lighting Unit



If the power fails, you needn't be left completely in the dark. This unit automatically switches on a battery operated lamp as soon as the power goes off and keeps the battery always fully charged and ready for action.

IF YOU'VE ever lived in a large city like Toronto on a hot July day when everyone has their air conditioners going, then you probably know what it's like to be suddenly and completely without power.

Being deprived of the TV and hi-fi for a while could well be good for the imagination and improve your conversational skills no end, but trying to find the toothpaste in a pitch black bathroom is simply infuriating!

In these circumstances, even a low intensity light is infinitely better than none at all. With this in mind we've designed this project, which switches on a 12 volt lamp of up to 24 watts as soon as the main power fails. It could also be used, of course, to power any other 12 volt appliance with the same power rating.

The emergency lamp runs on current supplied by a 12 volt battery, which is kept fully charged when not in use by a trickle of current. We used a NiCad battery for our prototype, but there is no reason why you shouldn't use a lead/acid accumulator instead because the charging current is kept so low there is no risk of overcharging and damaging the cells. The charging current is determined by a current limiting resistor, which must be chosen to suit the capacity and charge characteristics of the battery you are using. We have provided a table which lists the necessary values of this resistor for different batteries.

We've also included a red LED on the front panel of the unit, to show when it is operating (i.e. when the battery is discharging). This may seem superfluous, because after all you can see for yourself whether a lamp is lit or not, but if you are using the unit to run a fish tank heater or suchlike, then an indication that the unit is operating will be reassuring.

Construction

All the components are housed in a plastic case with an aluminum front panel that has terminals for the battery and lamp connections. The LED which indicates power failure is set in the panel above the lamp terminals.

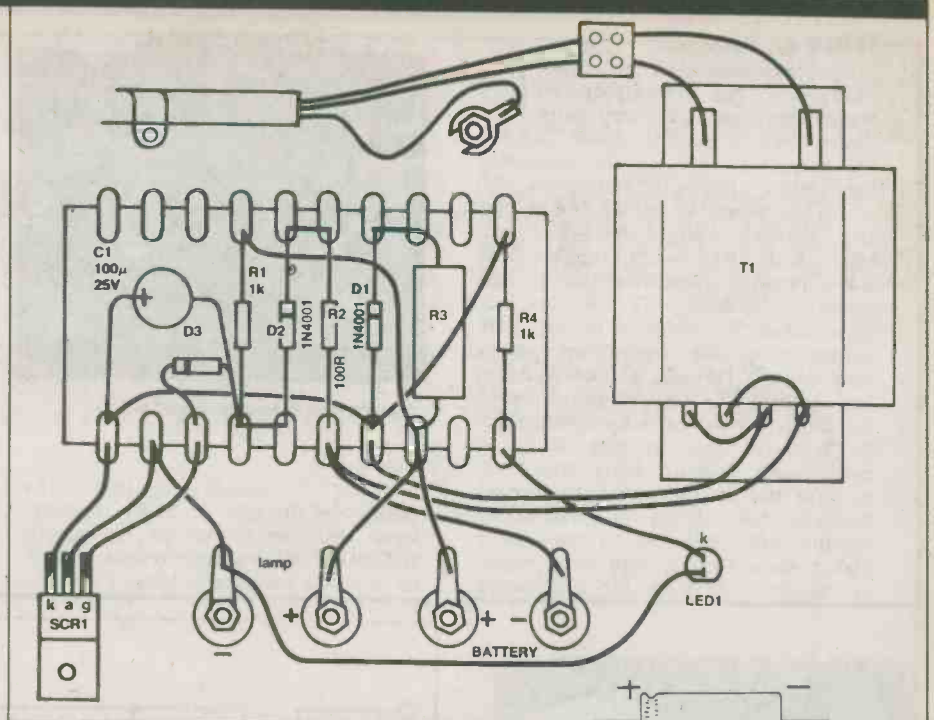
As the circuit is very simple, we decided to mount the electronics on a length of twin tag strip. Mount the components as shown in the diagram on this page, being careful with the orientation of the diodes and the electrolytic capacitor.

The current limiting resistor R3 sets the charging current to the batteries and must be selected to suit the voltage and capacity of the battery. Consult the table for the correct value. This resistor may run quite warm, so it should be mounted so that it is spaced about 5mm above the tag board for adequate ventilation.

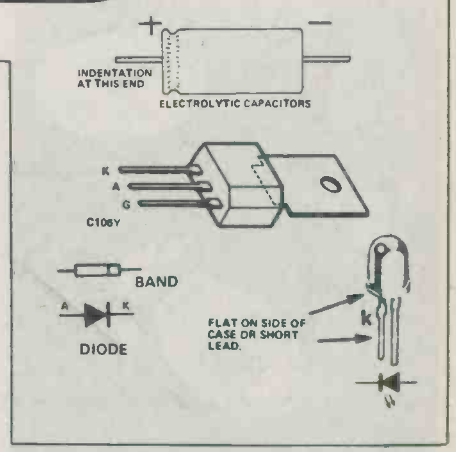
If the emergency lamp draws 1 A or less, the SCR does not need a heatsink; if the lamp draws between 1 A and 2 A, the SCR can be mounted on the aluminium front panel with an insulating mica strip between it and the metal. For load currents over 2 A a heavier SCR with its own heatsink would have to be used, but we do not recommend drawing this much current because this is an emergency lamp and you won't want to discharge the battery too quickly.

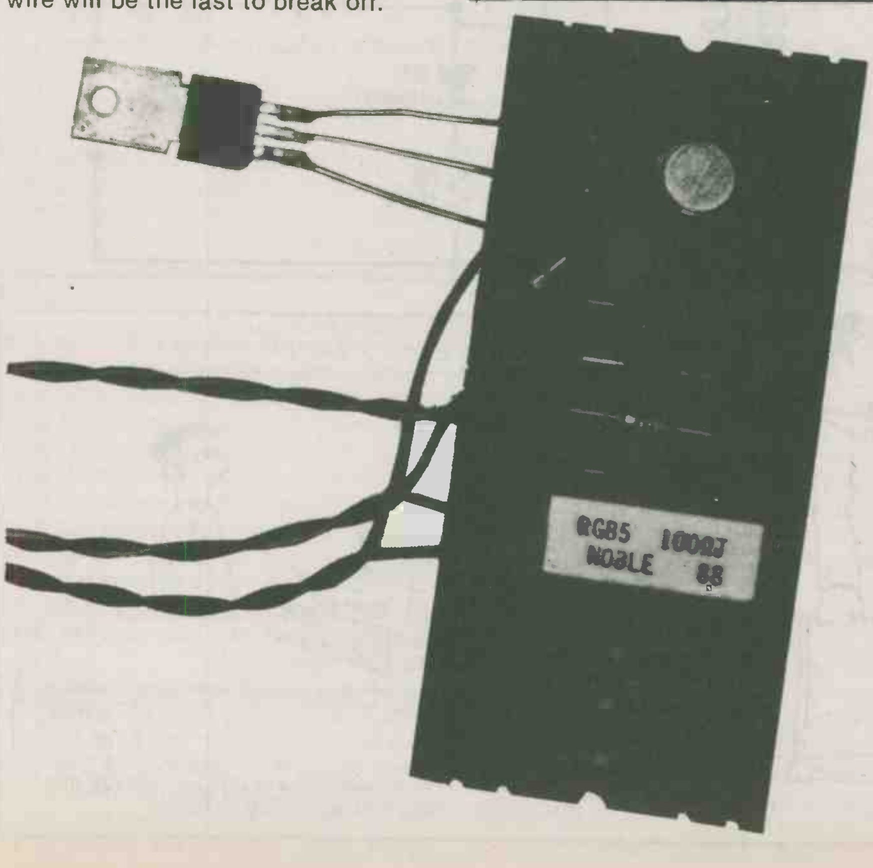
Next wire the connections from the tag board to the LED, the terminals and the transformer. Be extra careful with all of these connections and use insulated hookup wire for all wiring, including connections across the tags on the tag board. The transformer is mounted in the top right corner of the box, leaving enough room for the terminals and the tag board.

Secure the power lead by passing it into the box through a clamping type grommet. Connect the ground wire of the line cord to the solder lugs on the transformer case and to the the front panel. Make sure that these connections are well made and that there is slack left on the power ground wire, so that if the cable is pulled out of the grommet the ground wire will be the last to break off.



BATTERY CAPACITY	VALUE OF R3 (5W, 5%)
500 mAh	82R
1.2 Ah	33R
2 Ah	22R
4 Ah	10R
6 Ah	6R8





Parts List

Resistors (½ W, 5% unless otherwise specified.)

R1	1K
R2	100R
R3	Current limiting resistor, See table
R4	1K

Capacitor

C1	100u electrolytic, 25V

Semiconductors

D1,D2	1N4001 or similar silicon diode
D3	1N34 or similar germanium diode
LED1	TIL220R or similar red LED
SCR1	C106Y or similar

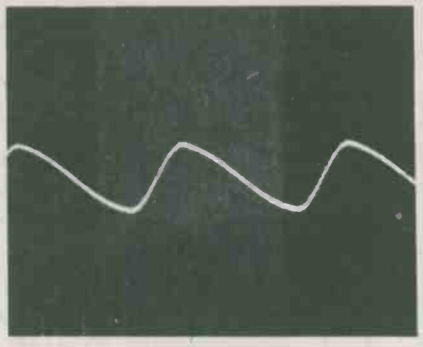
Miscellaneous

Transformer with 120V primary and 12V secondary rated at 1.5A; 12V NiCad battery; plastic box to suit (155mm x 95mm x 50mm); four screw terminals, two red, two black; 12V light bulb and socket.

How It Works

When the power is on, the circuit float charges a NiCad battery from a transformer and rectifier. When the power fails, a control circuit switches the battery through to the emergency light and the LED on the front panel.

When power is on the NiCad battery is trickle charged through a rectifier diode D1, which supplies half wave rectified current pulses to the battery. Capacitor C1 smooths out these pulses by charging to the peak voltage from the transformer secondary through D2 and R2 and discharging through R1 and the battery when the output from the transformer falls. the discharge time constant of C1 is much longer than its charge time constant, so that it does not have time to discharge fully during the transformer negative half cycle. So C1 stays at a high positive voltage, with some ripple, as can be seen from the oscilloscope photograph.

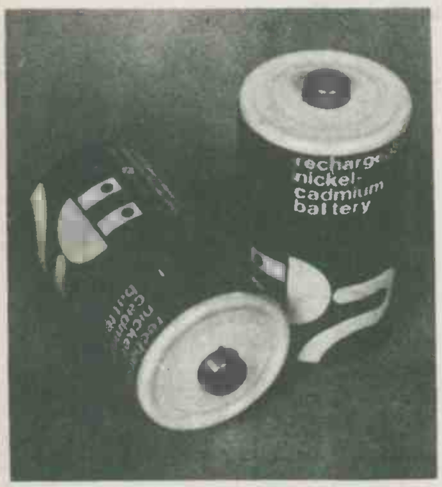


Waveform at the positive lead of C1.

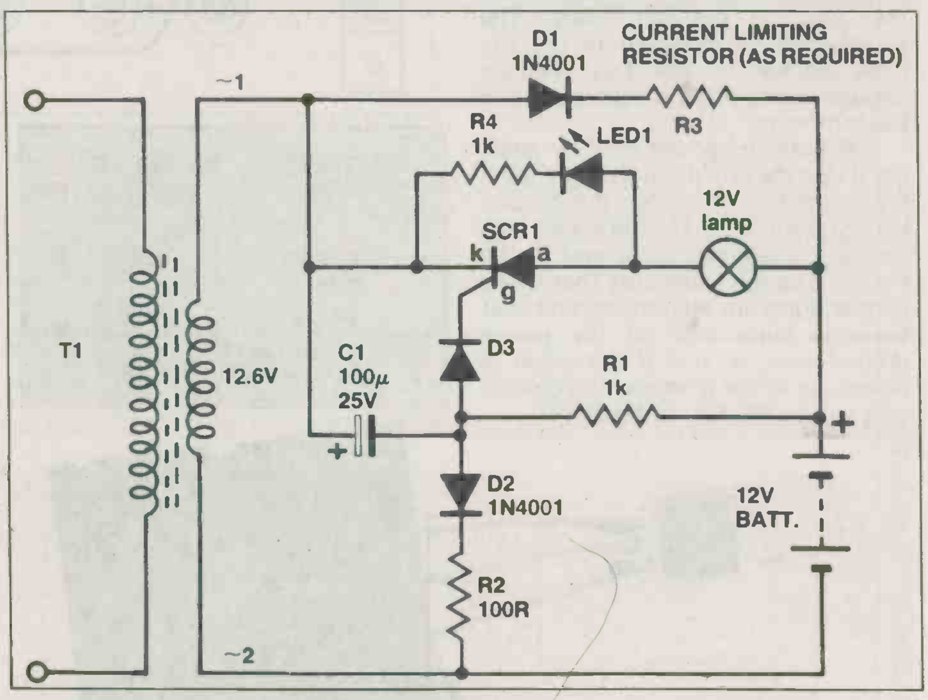
As C1 remains charged, the voltage on the gate of SCR1 is always lower than the voltage on its cathode and SCR1 is therefore reverse biased, so that the emergency lamp is switched off. LED1 is also reverse biased and not illuminated.

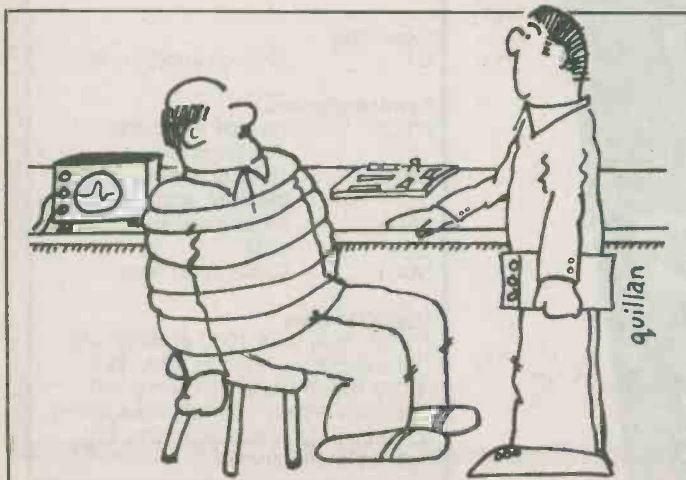
When the power fails the output from the transformer falls to zero and C1 starts to discharge through R1 and the battery. Once C1 is fully discharged it begins to charge in the reverse direction from the battery until the voltage on the gate of SCR1 is about 0.6 volts higher than the voltage on its cathode. SCR1 then switches on, lighting the emergency lamp. LED1 is now forward biased and illuminated. The voltage on C1 does not rise any further and the capacitor is not damaged by the reverse polarity because the voltage across it is less than the forming voltage of the electrolyte.

When the power returns, C1 charges again through D2 and R2, turning off SCR1 and resetting the circuit.



NiCad batteries may be used with this project and they can be obtained in ratings from 500 mAh up to 2 Ah capacity. Sealed lead-acid batteries can be obtained in higher capacities





"My wire wrap gun went out of control."

"They don't need to be connected to anything — they're not test probes, they're acupuncture needles."

Continued from page 90

Low Power Pilot Light

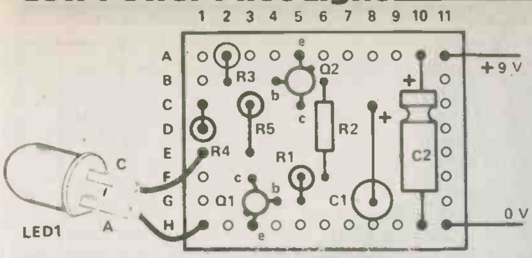
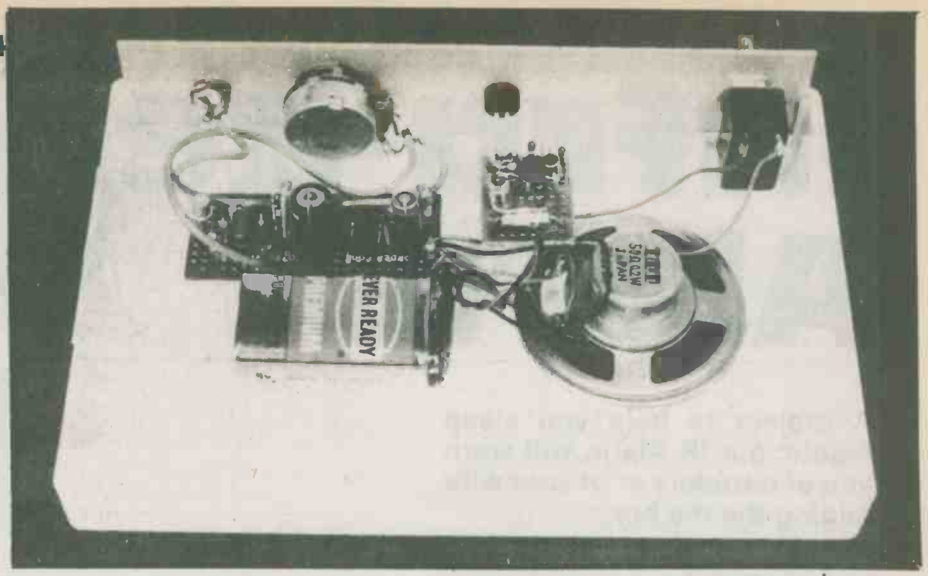


Fig. 2. Veroboard layout. Note no track breaks are required.



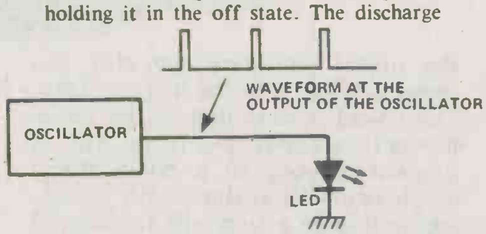
How It Works

This project consists of a simple oscillator, producing pulses which light the LED at about one-second intervals.

The LED is on for only about 5% of the total time. Thus the average current consumed by the circuit is very small, so it won't waste battery energy while doing its job.

Initially transistor Q1 is biased into conduction by resistor R1, and it in turn biases Q2 into conduction via current limiting resistor R2. Transistor Q2 therefore supplies a current to LED1 through R5. Capacitor C1 then charges from the supply lines through Q2, R4, and the base circuit of Q1, causing a substantial base current to flow into Q1. This results in Q1, Q2 and LED1 all being switched on.

Capacitor C1 soon becomes fully charged, and the large base current to Q1 ceases. Transistors Q1 and Q2 then start to switch off, and the voltage at Q2's collector falls, forcing a reduction in the potential at Q1's base since the voltage across C1 remains unaltered. This results in Q1, Q2 and LED1 all switching off. Capacitor C1 now discharges through R4, R5, LED1, and the base circuit of Q1, reverse biasing Q1 and holding it in the off state. The discharge path has a higher resistance than the charge path, giving the required relatively long off time of the LED. When C1 has discharged, R1 again biases Q1 into conduction, and the cycle commences from the beginning once again.



Resistor R3 is needed to ensure that leakage currents do not cause Q2 to be partially switched on when it should be turned off, which would reduce the efficiency of the unit. Capacitor C2 is a supply decoupling component and it prevents the pilot light circuit transmitting noise spikes to the main equipment via the supply lines.

ETI BUILDING KIT/MAGAZINE BINDER

Now you and your children can have hours of fun constructing all sorts of models and buildings using the amazing new ETI vinyl-covered building kit. The flexible joints allow you to make an almost infinite variety of shapes, provided that they all look pretty much like the one in the photograph. Sturdily made, spill-proof and nicely fitted with chrome metal hardware (car and blocks not included).

If you should get fed up making model houses, these kits can also be used to hold a year's worth of ETI issues. A clever spring arrangement allows insertion and removal of issues without punching or cutting. They're available postpaid for $8.00 (Ontario residents add 7% PST). Send to: ETI Binders, Unit 6, 25 Overlea Blvd., Toronto, Ont. M4H 1B1.

Infra-Red Alarm

A project to help you sleep nights: our IR Alarm will warn you of intruders or of your wife raiding the ice box.

THIS UNUSUAL infra-red beam alarm project has a maximum useful range of about 10 meters and can form the basis of a first-class domestic or commercial security alarm system.

The project comprises two units — an infra-red transmitter and an IR receiver with a relay output. Both of our prototype units are line powered. The receiver unit contains facilities for operating the relay in either the latch or non-latch mode and for externally disabling the relay (for 20 seconds) via concealed 'by-pass' switches so that authorised persons can pass through the beams without activating the alarm.

The most unusual feature of our alarm system is the use of a dual-beam infra-red link. The two beams are spaced a few inches apart and both beams must be broken simultaneously to operate the alarm. Our system thus responds only to objects greater than the dual-beam size and cannot normally be false-triggered by moths or other insects passing through the beams or settling on the transmitter or receiver diodes.

IR-Beam Principles

Infra-red beam systems present a certain paradox in that the beam is not particularly directional (the transmitter and receiver do not need to be pointing directly at one another) yet the actual 'link' is highly directional and can be broken by a matchstick-sized obstruction placed anywhere along the link. To understand the paradox, try the following simple test.

Pick out a spot-size object (a spot of paint or a screw head, etc). Now move around the room, noting that the object is visible from many different angles and that the visual communication beam is thus not particularly directional. Now, from any convenient viewing position, look at the object with one eye only and move a finger into the line of sight. The object is obscured — the visual link is thus highly directional. This is a good analogy of a conventional single-beam IR system, with the object acting as a single IR source and the eye as a single IR detector. This system is susceptible to false-triggering by moths or other small insects that stray into the beam or settle on the transmitter or receiver diodes.

Make Mine A Double

Now take the above visual test a bit further and pick out two spot-sized objects that are spaced roughly 7.5 cm apart and again check that they are visible from many different angles. Now look at the objects with both eyes and try to break the visual link by moving various items into the line of sight. You'll notice that the visual link can only be broken by a solid item with a width greater than the spacing of the two objects (7.5 cm), but that this item can break the link if placed anywhere along the line of sight.

This latter test is a good analogy of our dual-beam alarm system, with the two object spots acting as the two IR sources and the two eyes acting as the two IR detectors. Our system can only be activated by objects greater than a certain size and cannot normally be false-triggered by moths or other insects that stray into the beams or settle on the transmitter or receiver diodes. The beams are not unduly directional and do not require the use of lenses to complete the IR link, so installation is simply a matter of roughly pointing the transmitter and receiver towards each other.

Transmitter Construction

The transmitter construction should present few problems. We used two PCBs on our prototype, one for the line power supply and the other for the actual transmitter circuit. Take the usual precautions over component polarity when assembling the boards and use sockets when mounting the two ICs.

When PCB construction is complete, make all necessary interconnections, taking special care to ensure that the two infra-red LEDs and LED 1 are fitted with the correct polarity. Now switch on. If all is well, LED 1 will glimmer dimly, indicating correct transmitter action. If you have a 'scope you can check that the correct output waveform is generated across the two IR LEDs.

The completed unit can now be fitted in a suitable case, with the two IR LEDs pointing out from the box front. The IR LED spacing determines the minimum object size that will be detected by the system; we used a spacing of about 4 cm on our prototype unit.

Receiver Construction

The receiver unit also uses two PCBs, one for the power supply and one large board for the preamp/main receiver. Some care is needed in the construction of the large board, due to the use of a compact layout and miniature components.

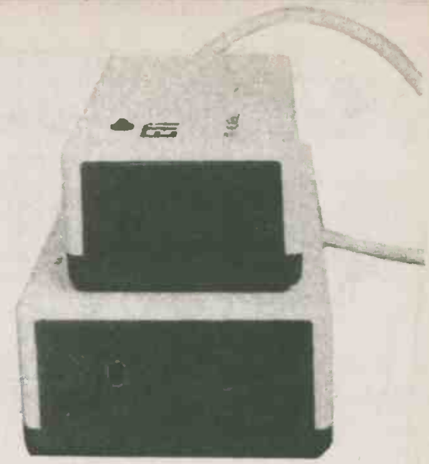
When construction of the boards is complete, fit them into a suitable case, together with T1, and make all necessary interconnections, taking special care to ensure that the two IRDs are connected with the correct polarity. The connections between the IRDs and the large PCB should be kept as short as possible to avoid unwanted pick-up. The IRDs should be mounted on the front of the cases, with the same spacing as used for the transmitter IR LEDs.

Setting Up

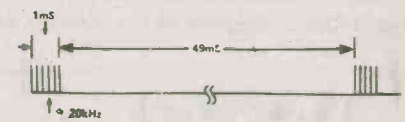
When construction is complete, set PR1 and PR2 to mid-value and enable the relay in the non-latching mode. Now space the Tx and Rx a meter or two apart, roughly facing one another, and turn the receiver on, but not the transmitter. The relay (RLA) and LED 1 should turn on after a delay of about 20 seconds, indicating that no IR signal is being received.

Now turn on the transmitter and check that the relay and LED 1 turn off. Reduce the setting of delay control PR1 until relay 'chatter' starts to occur, accompanied by flashing of LED 1, and then turn PR1 back until the chatter/flashing ceases. This point marks the minimum delay setting that can be used with the system.

Now temporarily cover (with a finger) the face of one of the IRDs, reduce the setting of sensitivity control PR2 until RLA/LED 1 turn on and then turn PR2 back slightly past the point at which both components turn off. You should now find that RLA/LED 1 turn only when both IR beams are broken simultaneously. The switch-on delay can at this stage be increased beyond the minimum established value if required.



The two IR LEDs and IR detectors are mounted in the case ends.



TRANSMITTED OUTPUT WAVEFORM

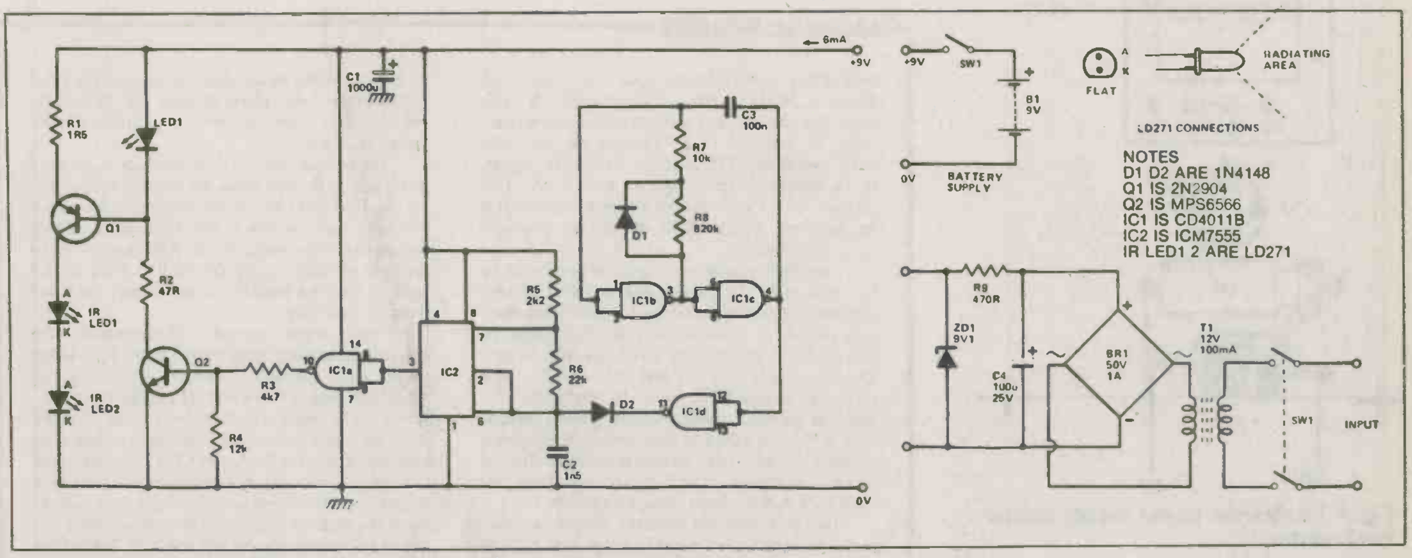


Fig. 1 Circuit diagram of the transmitter and its own power supply.

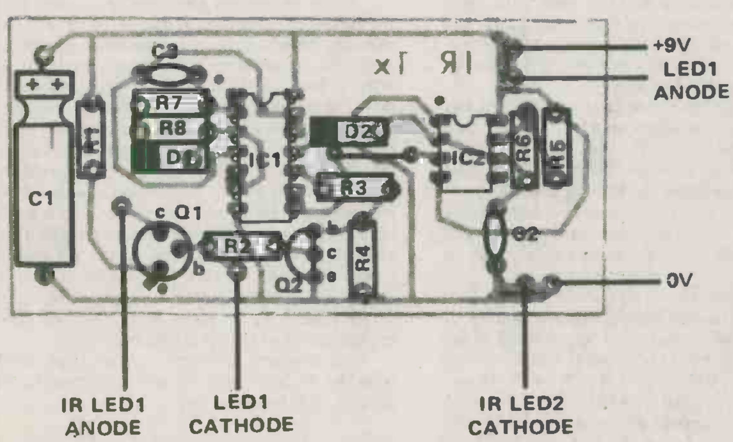
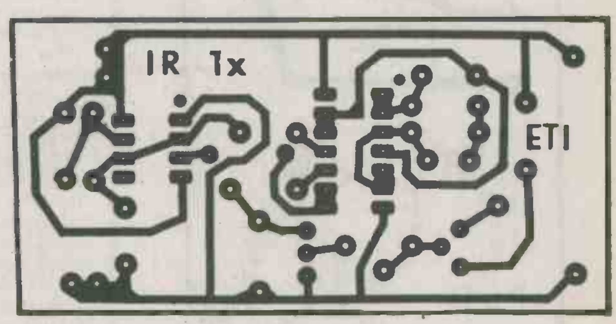


Fig. 2 Transmitter component overlay.



The transmitter PCB.

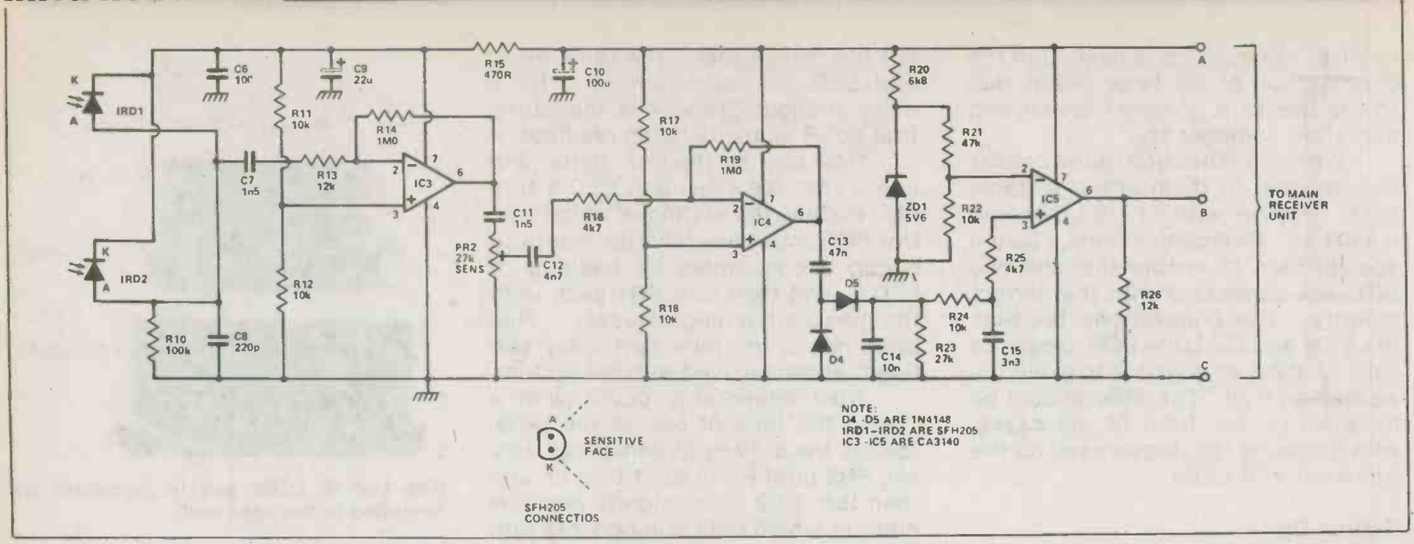


Fig. 3 Circuit diagram of the receiver preamp.

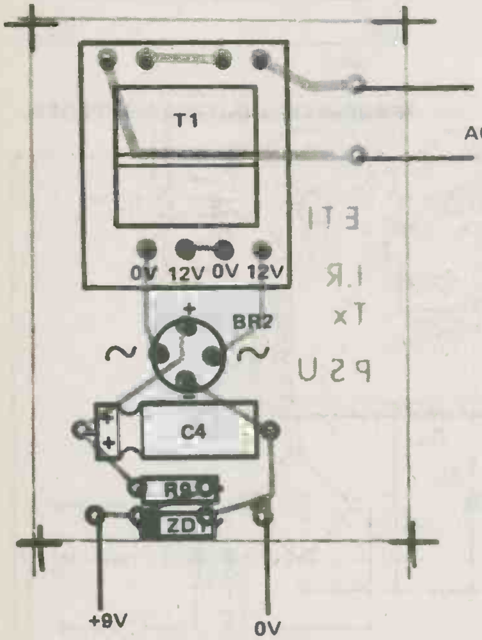
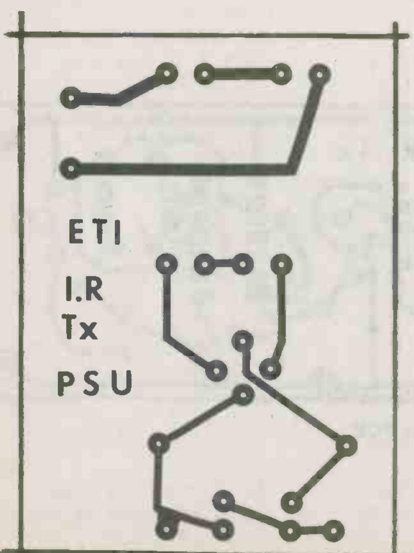


Fig. 4 Transmitter power supply component overlay.



How It Works

The IR transmitter beam signal comprises 1 mS bursts of 20 kHz pulses, repeated at 50 mS intervals. The transmitter generates peak IR diode currents of 600 mA but, because of the wide mark/space ratio (1:50) of the transmitter signal, the *mean* transmitter current is a mere 6 mA. This current can be provided by either a battery or a line powered supply. Both options are shown in the circuit diagram.

The basic transmitter signal is generated by IC1 and IC2. IC1b-IC1c are wired as a non-symmetrical astable multivibrator producing alternate periods of 1 mS and 49 mS. The output of this astable is buffered by IC1d and used to gate 20 kHz astable IC2 on and off via D2. The resulting waveform is used to gate 600 mA constant-current generator Q1-R1-LED 1 on and off via IC1a and Q2 and thus feed high energising currents to the two series-connected infra-red transmitter diodes. The high-current transmitter pulses are derived from storage capacitor C1.

The two infra-red detector diodes are connected in parallel and wired in series with R10, so that the detected IR signal is developed across R10. The signal is amplified by IC5. The output of IC4. These two amplifier stages have their responses centered on 20 kHz, with third order low-frequency roll-off provided via C7-11 and C12 and with similar high-frequency roll-off provided by C8 and the internal compensation capacitors of the two ICs.

The amplified output of IC4 is rectified and smoothed by voltage-doubler D4-D5 and associated C-R networks and fed to voltage-comparator IC3, fed to sensivity control RV2 and then further amplified by IC5 (at point B) takes the form of a series of repetitive positive-going pulses when a strong IR beam signal is present, or of a logic 0 signal when the beam is broken. The B signal is passed to the main receiver unit.

To understand the operation of the main receiver unit, assume initially that the emitter of Q1 is shorted to ground. The output signal of the preamplifier circuit is fed to point B and rectified and smoothed by the D1-C1-R1 PR1 network and the resulting DC signal is inverted by IC1a and fed to one input terminal of composite AND gate IC1b-IC1c. This signal takes the form of logic 0 if the IR beam is unbroken, or logic 1 if the beam is broken. The response time to a break can be varied via PR1.

The second input to the composite IC1b-IC1c AND gate is derived from the positive supply line via the R2-C2-R3 switch-on delay network and is normally high (within a few seconds of supply switch-on). The output of the AND gate is fed to the base of relay driving Q1 via R7. SW1 can be used to connect (enable) or disconnect the relay from Q1 collector.

Thus, under normal circumstances, the presence of a beam signal results in the IC1a input to the AND gate being low, in which case the AND gate output is low and Q1 and RLA are off. When the IR beam is broken the IC1a input to the AND gate goes high, so the AND gate output goes high and drives Q1 RLA and LED 1 on (assuming that SW1 is closed). An exception to this action occurs for a brief period following power switch-on of the receiver unit, when the relay-driving circuit is effectively disable via the R2-C2-R3 delay network. Note that the relay can be operated in either the latching or the non-latching mode via SW2.

In the description above we've assumed that the emitter of Q1 is shorted directly to ground. In practice, however, the connection to ground is made via Q2 collector. Normally, the input to IC1d is low, so IC1d output is high and Q2 is driven to saturation via R9 and acts as an effective short circuit, so the above action is normally obtained. Q2 can, however, be cut off at any time, thereby disabling the relay circuit, by momentarily closing PB1 or PB2. This action causes C3 to charge rapidly via R4 and cut off the Q2 base drive via IC1d. The base drive is restored roughly 20 S after the release of PB1/PB2 as the C3 charge leaks away via R5. This 20 S disable facility allows an authorised person to pass through the IR beam without activating the alarm by first momentarily operating one of the PB1/PB2 buttons.

The complete IR receiver circuit is powered from the AC line via the T1-BR1-C5 network and the IC2 12 V regulator chip.

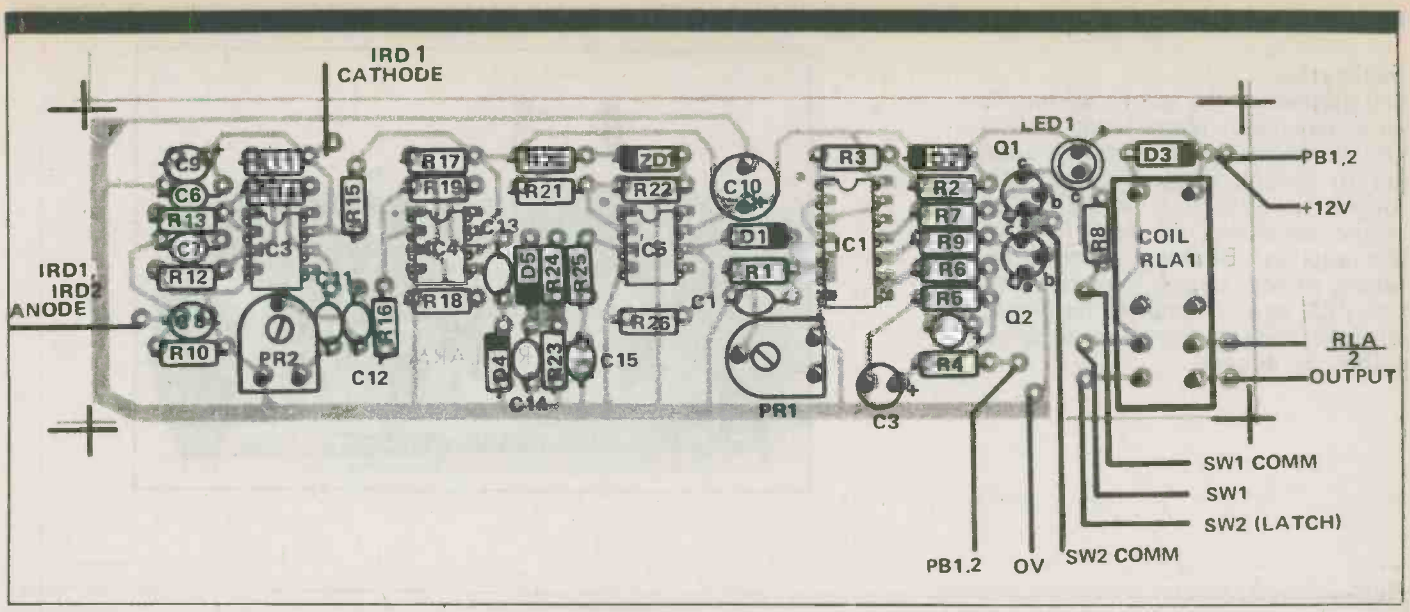
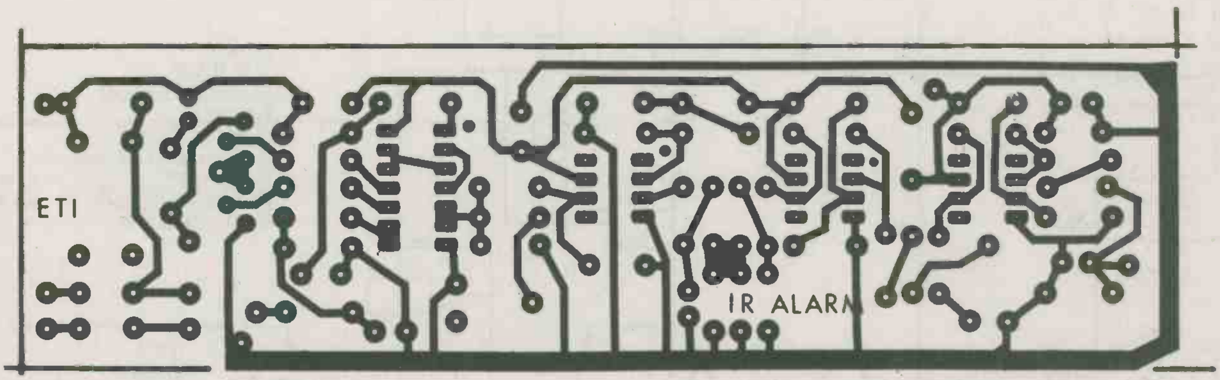


Fig. 5 Component overlay of the combined preamp and receiver board.



PCB and the receiver PCB.

Parts List

TRANSMITTER

Resistors All ¼ W, 5%

R1	1R5
R2	47R
R3	4k7
R4	12k
R5	2k2
R6	22k
R7	10k
R8	820k
R9	470R

Capacitors

C1	1000u 16 V electrolytic
C2	1n5 polycarbonate
C3	100n polycarbonate
C4	100u 16 V electrolytic

Semiconductors

IC1	CD4011B
IC2	ICM7555
Q1	2N2904
Q2	MPS6566
IR LED 1,2	LD271
BR1	50 V, 1A
D1,2	1N4148
ZD1	9V1

Miscellaneous

T1	12 V 100 mA
SW1	DPDT miniature toggle
	Case for transmitter

RECEIVER

Resistors all ¼ W, 5%

R1,5	470k
R2	2M2
R3,7,16,25	4k7
R4,15	470R
R6,13,26	12k
R8	680R
R9	1k2
R10	100k
R11,12,17, 18,22,24	10k
R14,19	1M0
R20	6k8
R21	47k
R23	27k

Potentiometers

PR1	2M2 miniature horizontal
PR2	27k miniature horizontal

Capacitors

C1,4	220n polycarbonate
C2	6u8 25 V tantalum
C3	47u 16 V tantalum
C5	1000u 16 V electrolytic
C6	100n polycarbonate
C7,11	1n5 polycarbonate
C8	220p ceramic
C9	22u 25 V tantalum
C10	100u 16 V PCB type
C12	4n7 polycarbonate
C13	47n polycarbonate
C14	10n polycarbonate
C15	3n3 ceramic

Semiconductors

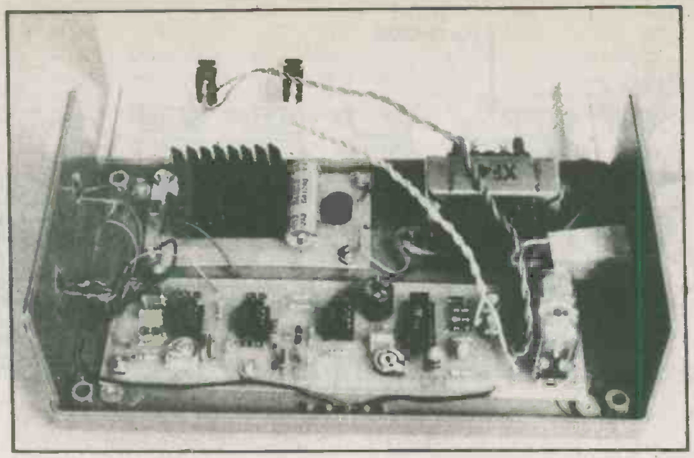
IC1	CD4093B
IC2	7812 + 12 V
IC3,4,5	CA3140
Q1,2	MPS6515
D1,4,5	1N4148
D2,3	1N4001
IRD1,2	SFH205
BR1	50 V 1A

Miscellaneous

T1	12 V 3 VA
RLA	2 Pole N/O 12V 120R Coil
SW1,2	SPDT miniature toggle
SW3	DPDT miniature toggle
	Case for Receiver

Installation

Installation of the alarm system is simplicity itself. Merely space the Tx and Rx the required distance apart (up to several meters), point them roughly towards each other and then adjust sensitivity control PR2 until the required switching action is obtained. Hidden bypass switches (PB1 and PB2) can, if required, be placed on either side of the beam to allow authorised access.



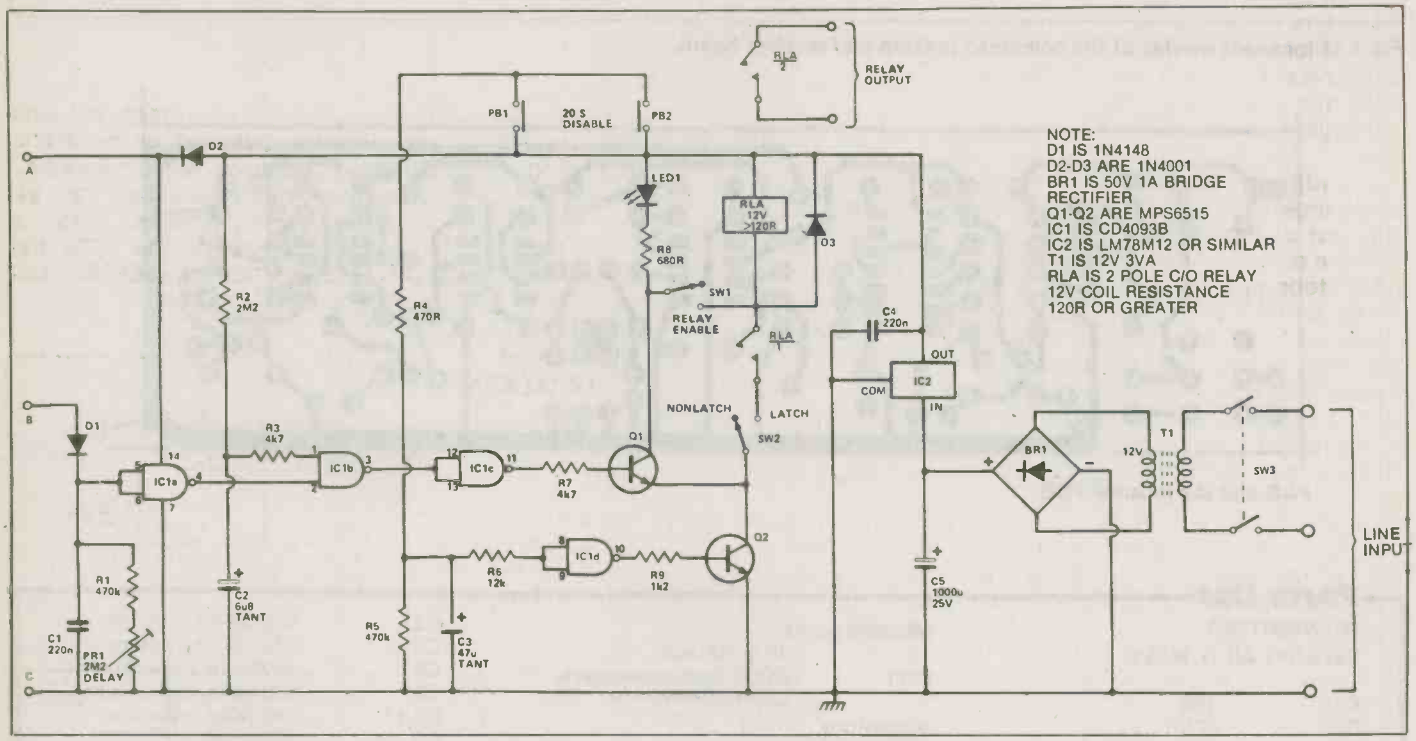


Fig. 6 Circuit diagram of the receiver and power supply.

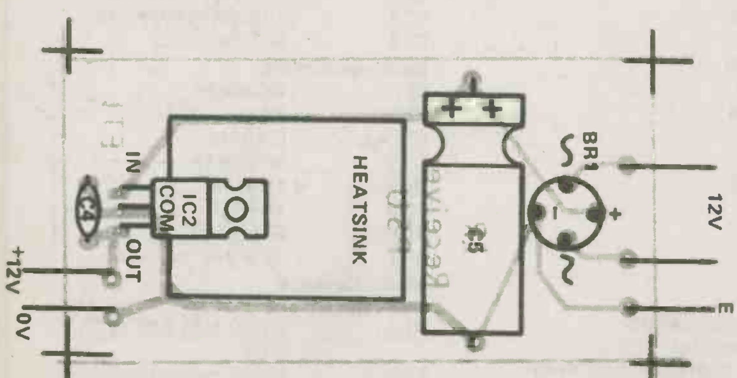
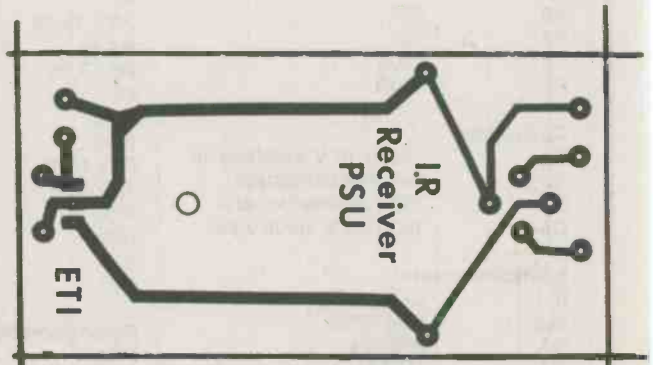
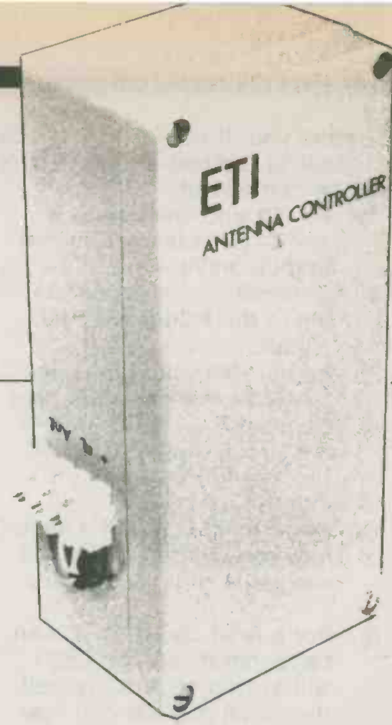


Fig. 7 Component overlay of the receiver power supply board.



The receiver power supply PCB.

Antenna Extender



If you intend to buy (or already own) a motorised antenna, then you shouldn't be without this intelligent gadget which automatically controls your aerial's ups and downs.

THERE IS A LARGE PROPORTION of motorists who have had the misfortune of losing their car aerial through a car-wash, through accidental breakage or maybe to the young vandal eager to add another victim to his list.

Judging by the number of coathangers that have found their way out of the family wardrobe and into the orifice where the chrome rod once stood, one only has to wait anxiously for the coathanger industry to replace the car aerial. It is not surprising that with these catastrophic events prevailing, drivers are reluctant to replace their aerial. However, if you install a motorised antenna incorporating the ETI antenna controller, it will reduce the risk of losing your aerial.

The unit is designed to replace the manual operation of 'holding' the antenna switch in the 'on' position to activate the aerial. The ETI controller overcomes this hindrance by sensing whether the radio is 'on' or 'off' state and automatically extending or retracting the aerial.

Better Safe Than Sorry

There are also certain fail-safe features which are incorporated to comply with the manufacturer's instructions. These are:

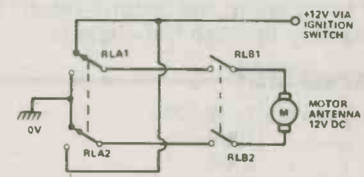
(i) when the antenna has extended it should not be switched from up to down or vice versa without waiting for at least 3 s before the next operation.

(ii) switching the radio on and off repeatedly will have no effect while the aerial is in operation.

With these features our project supersedes most commercial units already available.

Construction And Setting Up

Construction is straightforward. All components, including the relays, are mounted on a single PCB. Begin construction by inserting all low profile components, i.e. wire links, PC pins and sockets, followed by resistors, diodes, capacitors and transistors, observing the orientation of all polarised components. R15 is soldered underneath the PCB between the junction of PR2/PR3, and the positive end of C5.



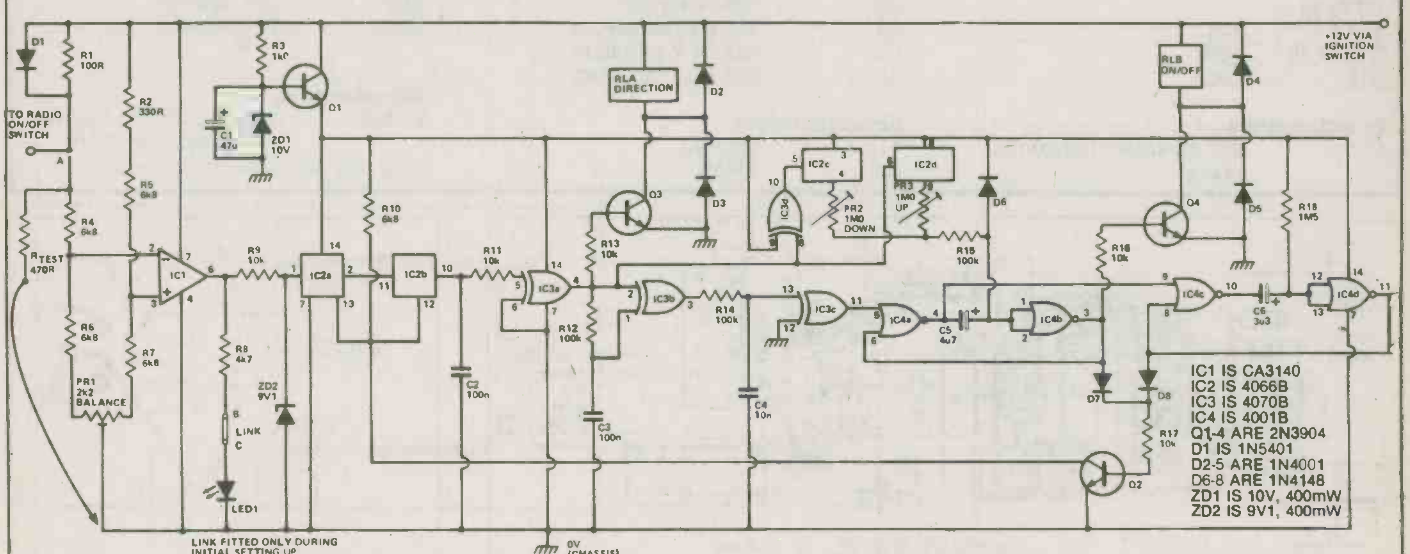


Fig. 1 Circuit diagram of the Antenna Extender.

Before you fit the PCB in its box the following setting-up procedure should be carried out:

1) Fit IC1 and link points B and C. (This is used for setting up only.)
2) Connect a 12 V power supply to the PCB supply terminals.
3) Adjust PR1 until LED1 just turns on; mark this position.
4) Connect R_{TEST} as shown on the circuit diagram. Adjust PR1 until LED1 turns off; mark this position.
5) Disconnect R_{TEST}. PR1 should now be adjusted to the midway setting of steps 3 and 4.
6) For a final check, R_{TEST} can be reconnected and LED1 will switch on; if all is well the remaining ICs can now be fitted.

We mounted our PCB on three ¼" spacers. When it comes to hooking up the unit, there should be no complications as there are only four wire connections to consider. These are made via a four-way terminal block on the side of the case. The 0 V connection is made to the internal ground terminal of the case. The completed unit can be secured in a suitable place underneath the hood, thus completing the ground return to the battery through the chassis.

How It Works

IC1 is configured as a voltage comparator with a fixed reference voltage at pin 3; pin 2 is arranged in the same way except that D1 is included as the sensor. If a load is present (i.e. the car radio is switched on), the voltage at pin 2 will fall to a value of (V_{cc} – 600) mV, this being the forward voltage drop of the diode. This change of voltage is now compared to the reference at pin 3. As the voltage has decreased the output of IC2 will switch to approximately the supply voltage.

PR1 is incorporated in the circuit to balance the tolerances of R4, 5, 6 and 7 so that with any extreme changes of voltage or temperature, the comparator will reliably detect a change at pin 2.

The output of IC1 is fed to IC2a and b (bilateral switches). These switches are normally closed, but with a low signal at their controls (pins 12 and 13) the switches will open, breaking the connection to the rest of the circuit and providing the necessary inhibit facility. ZD1 is added to suppress transients that might cause false triggering.

If the car radio is switched on the output of IC2b is high; this voltage is fed to the input of a non-inverting gate (IC3a). The output of this gate determines the relay direction via Q3, as well as providing the input to the edge detector IC3b. The function of this gate is to give a positive-going pulse whenever its input changes state. R14 and C4 are added for protection against spikes that occur during switching. IC3 squares the output of the edge detector, so a reasonably narrow pulse is available to trigger the first monostable (IC4a, IC4b). The output of IC4b energises RLB via Q4 for a period set by PR2 and C5 (this is not more than 5s). RLB is now supplying power to the motor antenna with a polarity determined by RLA, so while the monostable is turned on the antenna will extend. When this period has ended, pin 4 of IC4a will assume a high state, triggering the second monostable (IC4c, IC4d). The outputs of both monostables are fed to a diode OR gate and inverted by Q2 to open the bilateral switches. This gives a total inhibit time of approximately 6 s, allowing 3 s for the antenna to extend, plus a further 3 s delay before the next operation can take place.

D6 ensures that C5 is fully discharged at the end of the monostable period, to prevent false triggering by residual charge.

When the radio is switched off, the output of the comparator and IC3a will be low. As pin 8 of IC3d is at 0 V, its output will be high which closes IC2c; at the same time IC2d opens and the down sequence is activated. The monostable and RLB follow the same mode of operation as already described.

Q1 and associated components (R3, C1 and ZD1) provide a regulated supply for the CMOS devices.

Parts List

Resistors (all ¼ W, 5%)		PR2,3	1M0 miniature horizontal preset	IC3	4070B
R1	100R			IC4	4001B
R2	330R	**Capacitors**		Q1-4	2N3904
R3	1k0	C1	47u 16V tantalum	D1	1N5401
R4,5,6,7,10	6k8	C2	100n polycarbonate	D2-5	1N4001
R8	4k7	C3	100n ceramic	D6-8	1N4148
R9,11,13 16,17	10k	C4	10n polycarbonate	ZD1	10V, 400mW
R12,14,15	100k	C5	4u7 35 V tantalum	ZD2	9V1, 400mW
R18	1M5	C6	3u3 16 V tantalum		
Potentiometers		**Semiconductors**		**Miscellaneous**	
PR1	2k2 miniature horizontal preset	IC1	CA3140	RLA,B	double pole changeover, coil resistance 205R.
		IC2	4066B	Four-way terminal block, case.	

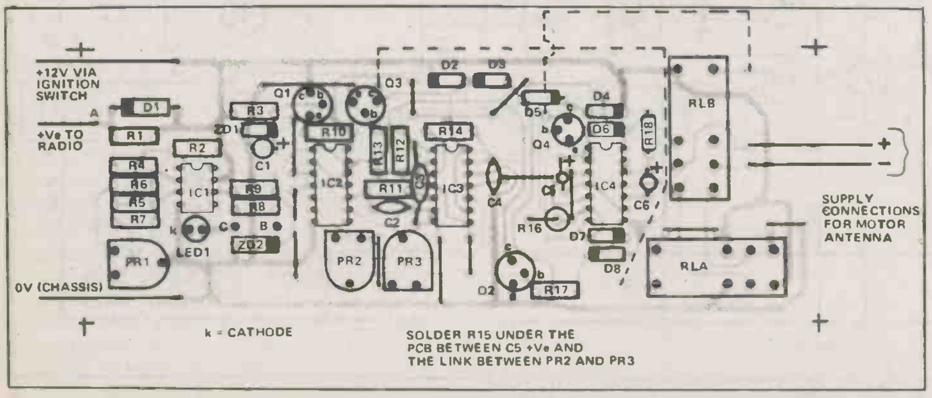


Fig. 2 Component overlay. Note that R15 is soldered beneath the PCB.

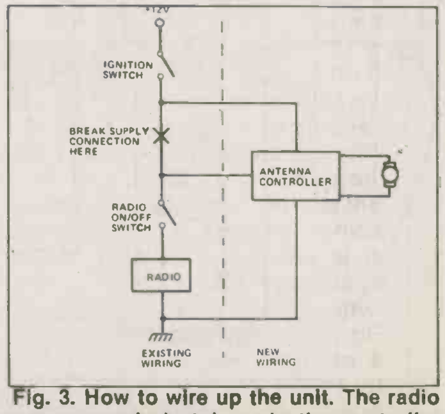


Fig. 3. How to wire up the unit. The radio power supply is taken via the controller board.

 Continued on page 114

Headlight Delay

Use your car headlights to give post-parking illumination with this simple unit.

THIS SIMPLE LITTLE UNIT lets you use your car headlights to illuminate your pathway for a pre-set period of about 50 seconds after you have parked the vehicle. At the end of this period the unit turns the lights off automatically.

The unit thus enables you to avoid walking into trash cans or tripping over junk that may be obstructing your private driveway, and helps you avoid stepping into various nasties that may be laying on the public sidewalk. The unit is easy to install in the vehicle.

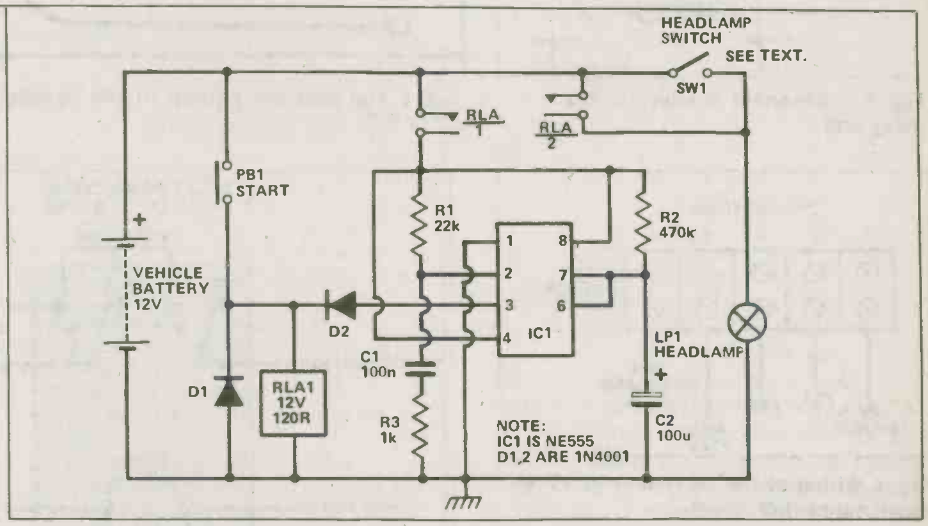
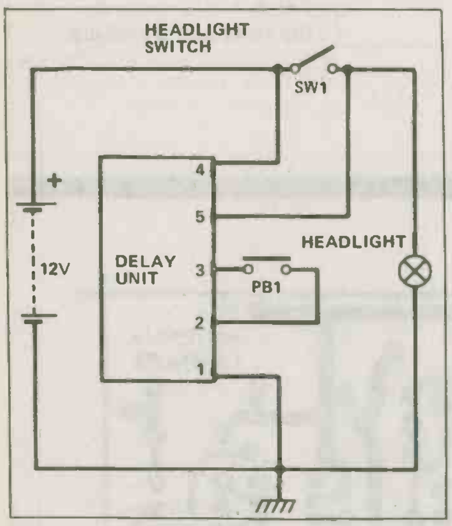


Fig. 1 Circuit diagram of the unit.



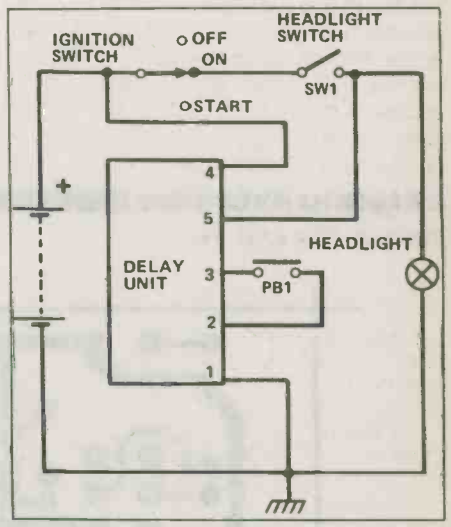


Fig. 2a (Left): Connection of the dealy unit to a car system where the headlights are independent of the ignition switch.
Fig. 2b (Right): Connection to all other systems.

Construction and Use

Construction of the unit should present no problems at all. The relay can be any 12V type with a coil resistance of 120 ohms or greater, and with two or more sets of N.O. contacts that are rated at 3 amps or greater.

When it comes to installing the unit, note that two methods of connection to the vehicle are possible. On some vehicles the headlight switch is connected directly to the battery so that the headlights operate even when the ignition is turned off (see Fig. 2a). In this case take connection 4 of the 5 way terminal block directly to the live side of headlamp switch SW1, and connection 5 to the headlamp side of SW1.

The alternative connection is shown in Fig. 2b. Here, the headlight switch is wired in series with the vehicle's ignition switch, so that the headlights only operate when the ignition is turned on. If your vehicle uses this type of connection, take connection 4 of the 5 way terminal block to the live side of the ignition switch, and take connection 5 to the headlamp side of SW1.

How It Works

The unit is designed around a type-555 timer with a relay output. The relay has two sets of normally-open contacts. Normally, START switch PB1 and the relay contacts are open, so zero power is fed to the timer circuit and (assuming that HEADLIGHT switch SW1 is open) the headlights are off. Circuit action is initiated by briefly closing push-button switch PB1.

When PB1 is momentarily closed power is fed directly to the relay coil, and the relay turns on. As the relay turns on contacts RLA/2 close and apply power to the headlights and contacts RLA/1 close and apply power to the timer circuit, but pin 2 of the IC is briefly tied to ground via C1 and R3 at this moment, so a negative trigger pulse is immediately fed to pin 2 of the IC and a timing cycle is initiated. Consequently, pin 3 of the IC switches high at the moment that the relay contacts close, and thus locks the relay on irrespective of the subsequent state of switch PB1.

The 555 is wired as a one-shot timer or monostable with a timing period of about 50 seconds (determined by R2 and C2). Thus, the relay and headlights are held on for the duration of this 50 second timing period. At the end of the timing period pin 3 of the IC switches to the low state, so the relay turns off and contacts RLA/1 and RLA/2 open, removing power from the timing circuit and the headlights. The operating sequence is then complete.

Headlight Delay

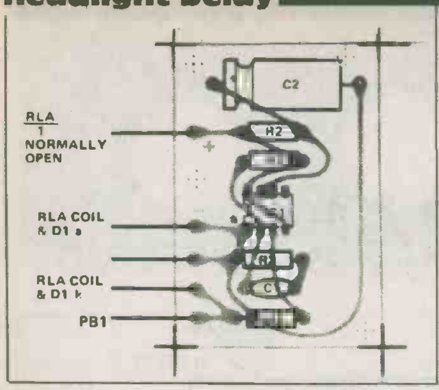


Fig. 3 Component overlay for the delay unit.

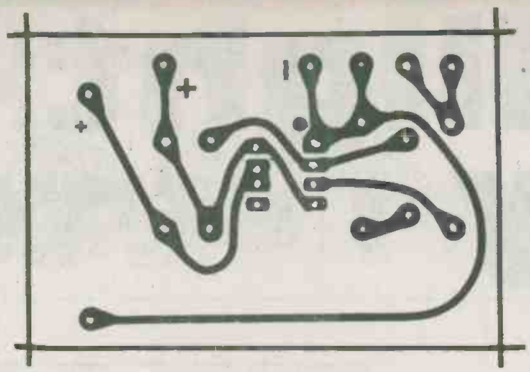


Fig. 5 Full size foil pattern of the headlight delay PCB.

Parts List

RESISTORS

R1	22k
R2	470k
R3	1k

CAPACITORS

C1	100n polyester
C2	100u elect.

SEMICONDUCTORS

IC1	NE555
D1,2	1N4001

MISCELLANEOUS

Relay rated at 3A 2 pole n/o 120 ohms or more SPST push button 5 way terminal block rated at 5A case.

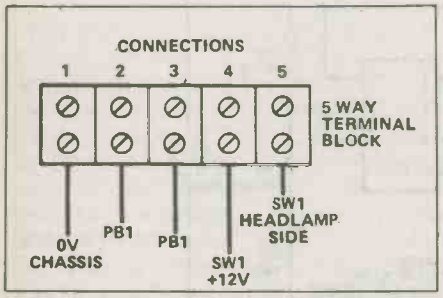


Fig. 4 Wiring of the delay unit to a 5 terminal connection block.

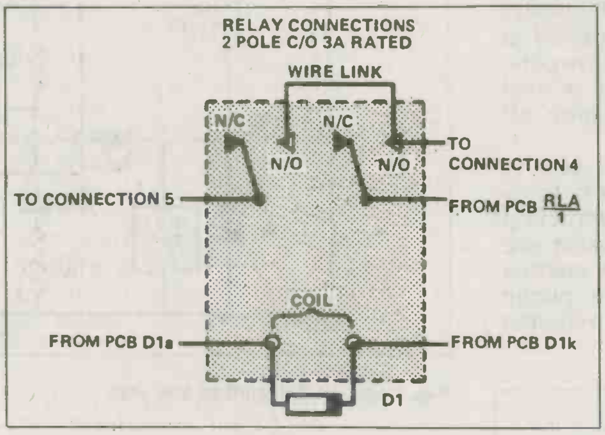
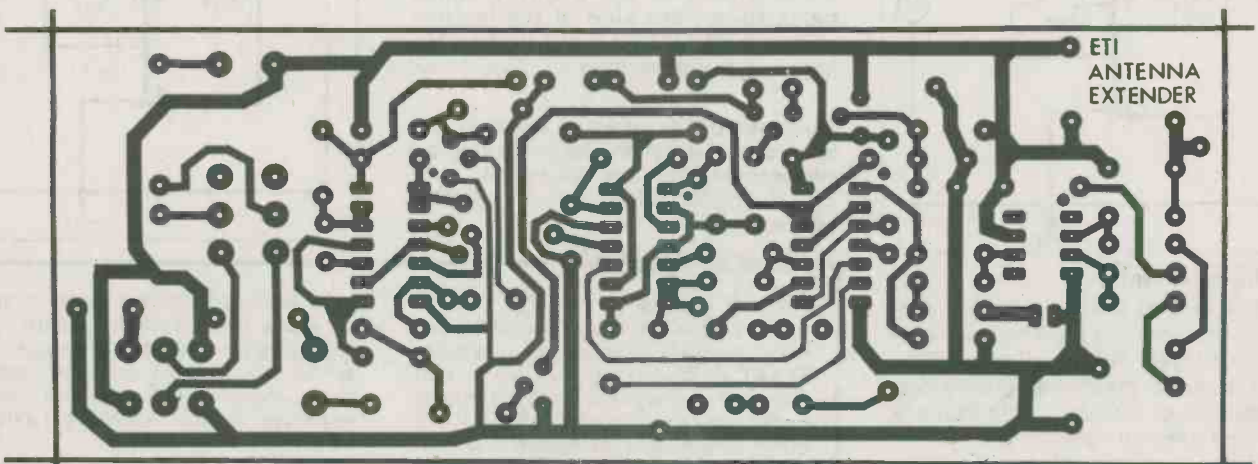


Fig. 6 The relay and D1 wiring.

Antenna Extender

Continued from page 112



PLEASE MENTION ETI WHEN REPLYING TO ADVERTISEMENTS.

LED Tachometer

A unique two-range tach that gives an analogue RPM display on a bar of 21 LEDs. The display flashes to indicate an alarm condition when the RPM exceed a preset limit.

THE ETI TACH/ALARM is an all solid-state project. It displays engine speed in analogue form (like a conventional tach) as an illuminated section of a line of 21 LEDs. The length of the illuminated section is proportional to the engine speed, so that half of the scale is illuminated at half of full-scale speed, and so on. In other words, the display is in bar rather than dot form.

The Tach/Alarm can be used with virtually any type of multi-cylinder gas engine. It has two speed ranges, each of which can be calibrated by a preset pot to give any full-scale speed range required by the individual owner. Our prototype is calibrated to give full scale readings of 10,000 RPM and 1,000 RPM on a four-cylinder, four-stroke engine. The lower range is of great value when adjusting the engine's ignition and carburetor for recommended idle speeds. The upper range has adequate resolution (500 RPM per step in our case).

A unique feature of our product is the provision of a visual over-speed alarm facility, which causes the LED display to rapidly flash on and off when the RPM exceed a preset level; the tach continues to indicate the actual RPM under the alarm condition. Tachs are normally placed directly in front of the driver in sports/racing cars, so this visual alarm system is a highly effective 'attention getter' in such vehicles.

The unit is designed for use only on vehicles with 12V electrical systems. It can be used with conventional or capacitor-discharge (CD) ignition systems and is wired into the vehicle with three connecting leads. It can be used on vehicles with either negative or positive ground electrical systems.

Construction

The complete unit, including the 21 LED display, is mounted on a single PCB. Take care over the construction, paying special attention to the following points:

(1) Our prototype uses a display comprising a linear row of 21 square LEDs, mounted horizontally on the PCB. You may prefer to use a semicircular display of LEDs, in which case you can mount the display on a separate board of your own design, with suitable connections to our board. In either case confirm the polarity and functioning of each of the 21 LEDs, by connecting in series with a 1K0 resistor and testing across a 12V supply, before wiring into place on the PCB. Note that the LED colours can be mixed, if required.

If you use the same display form as our prototype, bend and adjust the LED leads so that each LED slightly overhangs the edge of the PCB when soldered into place.

(2) Seven link connections are made on the PCB. Also note that the exter-

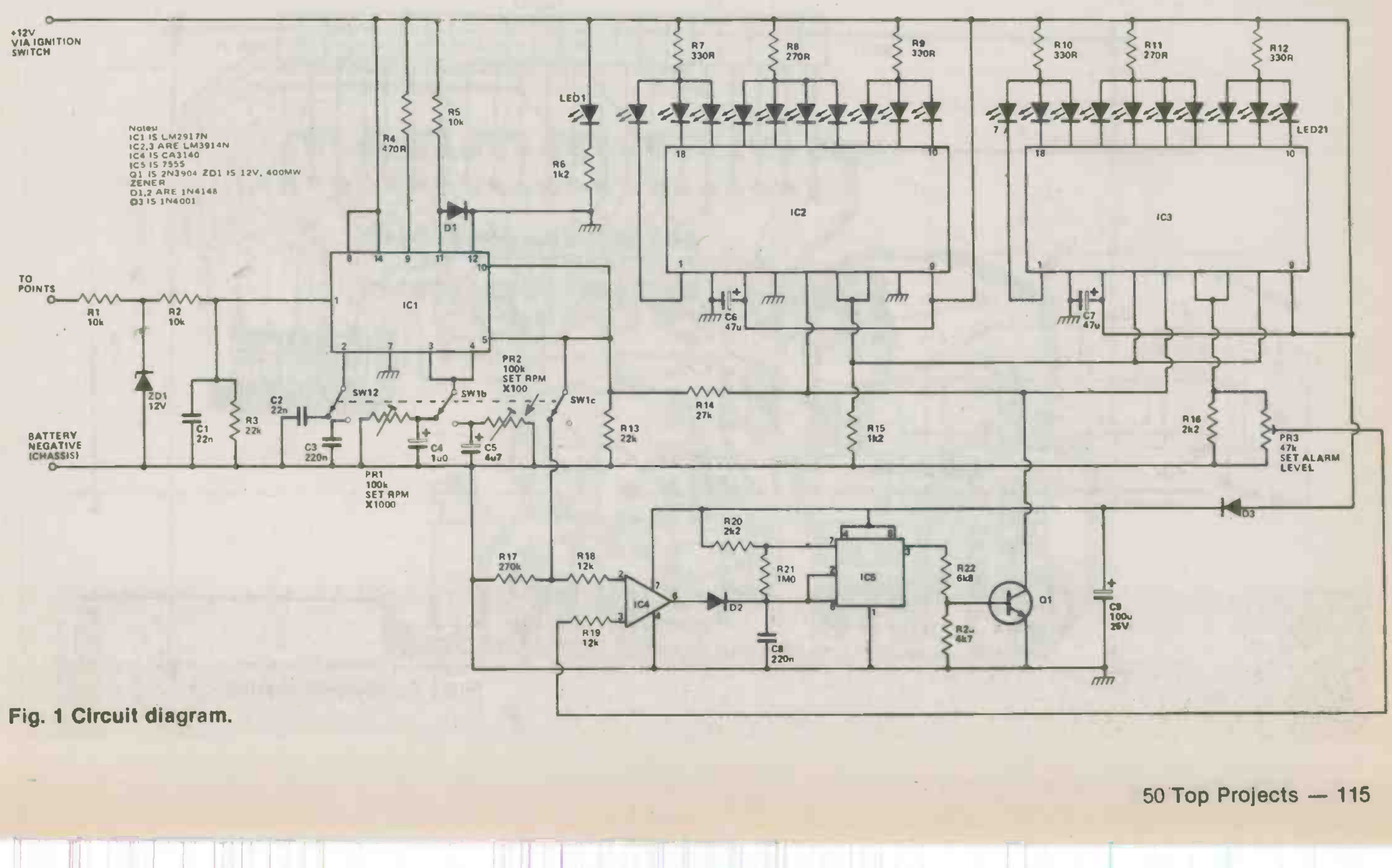


Fig. 1 Circuit diagram.

nal connections to the unit (0V, + ve and points) are made via solder terminals (Veropins).

(3) Range-changing is achieved via a three-pole two-way switch. On our prototype we've used a slide switch for this purpose.

(4) Note that the values of C2 and C3 must be chosen to suit the engine type and full-scale RPM ranges required (see the conversion graph). Our prototype, calibrated to read 10,000 RPM and 1,000 RPM on a four-cylinder four-stroke engine, uses C2 and C3 values of 22nF and 220nF respectively.

When the construction is complete, connect the unit to a 12V supply and check that only LED1 illuminates. If all LEDs illuminate, suspect a fault in the wiring of IC1.

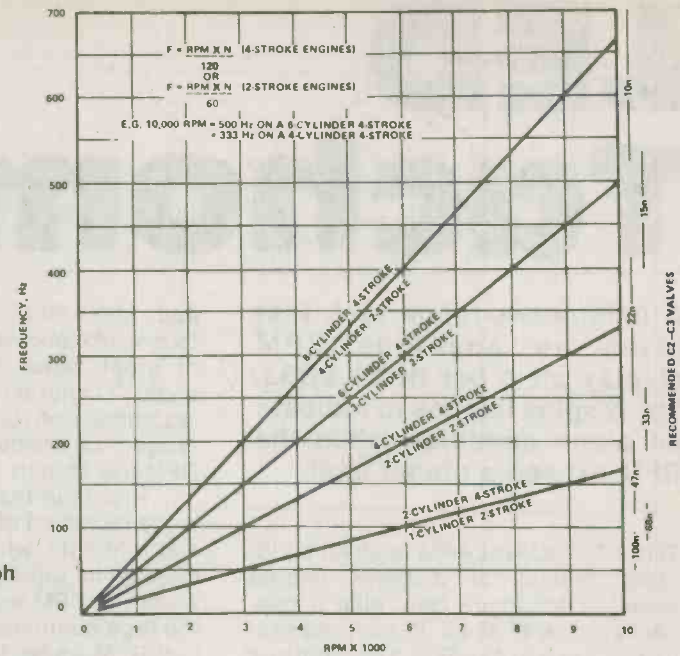


Fig. 2 Conversion graph to determine the values of C2 and C3.

Calibration

The unit can be calibrated against either a precision tachometer or against an accurate (2% better) audio generator that gives a square wave output of at least 3V peak-to-peak. The method of calibration against an audio generator is as follows.

Connect the tach to a 12V supply and connect the square wave output of the audio generator between the 0V and points terminals of the unit. Check against the conversion graph to find the frequency needed to give the required high range full-scale RPM reading on the type of engine in question and feed this frequency into the tach input. Switch SW1 to its high range (10,000 RPM on our prototype) and adjust PR1 for full-scale reading. Now set the generator to the alarm frequency and adjust PR3 so that the display flashes. Recheck both adjustments.

Now switch SW1 to its low range (1,000 RPM on our prototype), set the required full-scale frequency and adjust PR2 for a full-scale reading on the tach. Note that the alarm facility is inoperative on this range.

Installation

The completed unit can either be mounted in a special cut-out in the vehicle's instrument panel or (preferably) can be assembled in a home-made housing and clipped on top of the instrument panel. In either

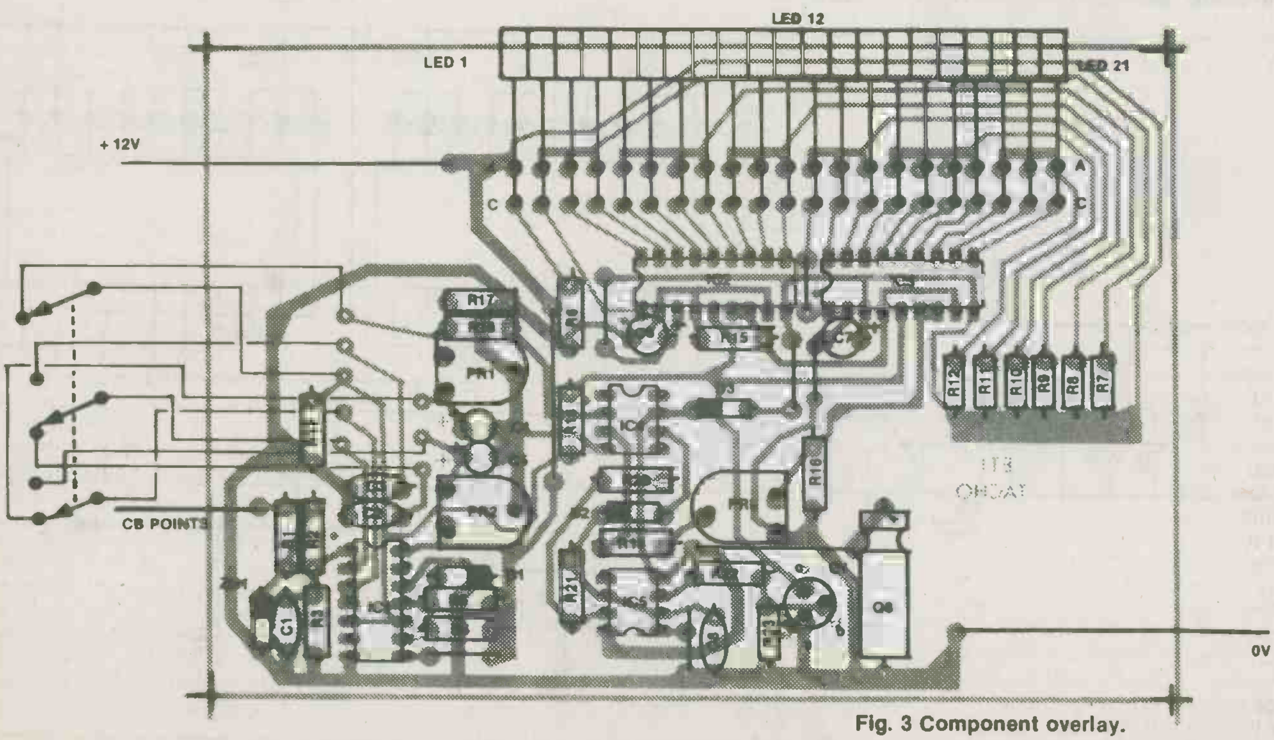
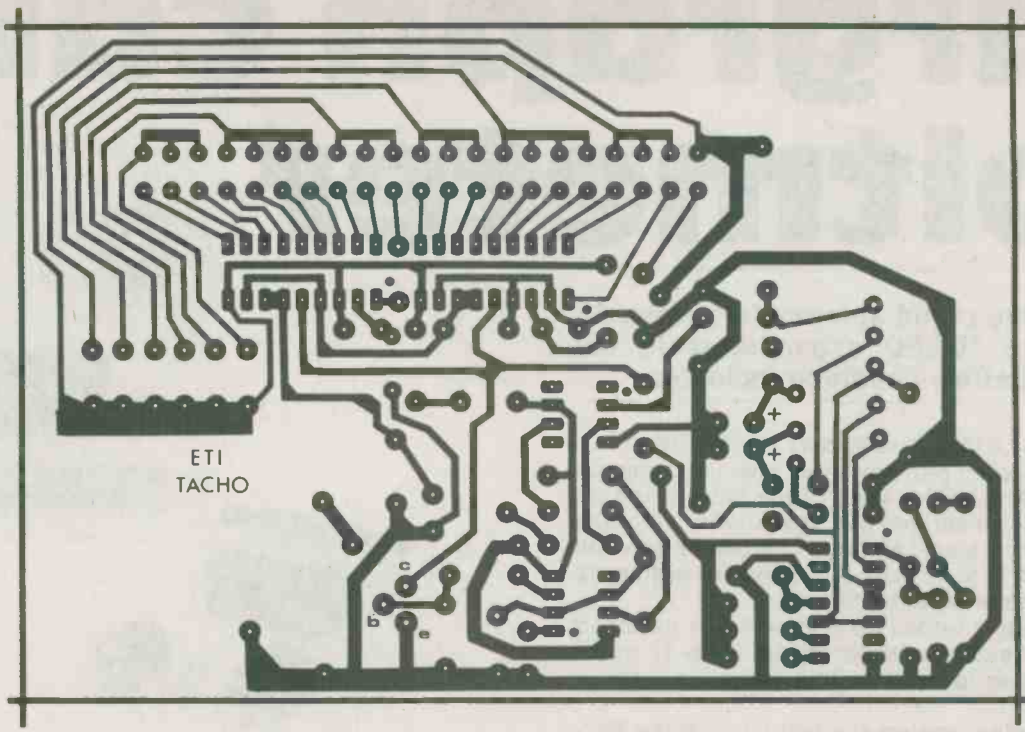


Fig. 3 Component overlay.



How It Works

The ignition signal appearing on a vehicle's points has a basic frequency that is directly proportional to the RPM of the engine. Our tach works by picking up the signal, extracting its basic frequency, converting the frequency to a linearly-related DC voltage and then displaying this voltage (and thus the RPM) on a line of 21 LEDs. The basic tach can thus be broken down, for descriptive purposes, into an input signal conditioner section, a frequency-to-voltage converter section and a LED voltmeter display section.

The input signal conditioner section comprises R1-R2-R3-ZD1-C1. The points signal of a conventional ignition system consists of a basic RPM-related rectangular waveform that switches alternately between zero and 12V, onto which various ringing waveforms with typical peak amplitudes of 250V and frequencies up to 10 kHz are superimposed. The purpose of the input signal conditioner is to cleanly filter out the basic rectangular waveform and pass it on to the F-to-V converter. It does this first by limiting the peak amplitude of the signal to 12V via R1 and ZD1 and then filtering out any remaining high frequency components via R2-R3-C1. The resulting clean signal is passed on to the input (pin 1) of IC1.

IC1 is a frequency-to-voltage converter chip with a built-in supply voltage regulator. The operating range of the IC is determined by the value of a capacitor connected to pin 2 and by a timing resistor and smoothing capacitor connected to pins 3-4. In our application, two switch-selected presettable ranges are provided. The DC output of the IC is made available across R13 and is passed on to the high-impedance input terminals of the IC2-IC3 LED voltmeter circuit via series resistor R14. R14 is essential to the operation of the alarm section of the tach.

IC2 and IC3 are LED display drivers. Each IC can drive a chain of 10 LEDs, the number of LEDs illuminated being proportional to the magnitude of the IC's input signal. Put simply, the ICs act as LED voltmeters.

In our application, the two LM3914 ICs are cascaded in such a way that they perform as a single 20-LED voltmeter with a full-scale range of 2V4. This full-scale value is determined by precision voltage references built into the ICs. The full-scale reference voltage (2V4) is generated across R16 and PR3. The configuration of our voltmeter is such that it gives a bar display, in which LEDs 1 to 11 are illuminated at half-scale or LEDs 1 to 21 are illuminated at full-scale. R7 to R12 are wired in series with the display LEDs to reduce the power dissipation of the two ICs. LED 1 is permanently illuminated so that the RPM display does not blank out completely when the engine is stationary with the ignition turned on.

The alarm section of the tach is fairly simple. IC4 is wired as a voltage comparator with a stable reference voltage fed to its non-inverting (pin 3) input from PR3 and with an RPM-related voltage fed to its inverting (pin 2) input from R13 via SW1c. The output of IC4 is used to enable or disable astable multivibrator IC5 and the output of IC5 is used to enable or disable the inputs to the IC2-IC3 voltmeter via Q1 and R14.

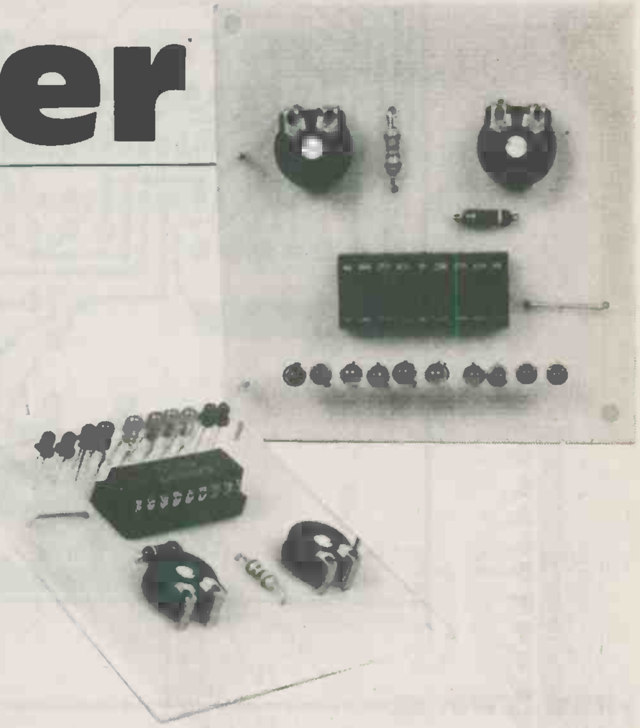
At low engine speeds (below the alarm level) the input of IC4 is driven high, thereby disabling the IC5 astable by preventing C8 from discharging. Under this condition the output of IC5 is driven low, cutting off Q1 and enabling the tach circuit to operate in the normal way.

At high engine speeds (at or above the alarm level) the output of IC4 is driven low, thereby enabling the IC5 astable to operate at a rate of roughly 2 Hz and alternately drive Q1 on and off. In the moments that Q1 is cut off, the tach operates in the normal way, but in the moments that Q1 is driven on its collector pulls the pin 5 input terminals of IC2 and IC3 to near-zero volts and thereby effectively blanks the LED displays. The LEDs flash rapidly under the alarm condition, but continue to indicate RPM values.

The alarm point can be set in any position on the tach scale by PR3. SW1c is used to disable the alarm section when the tach is set to its low (1,000 RPM in our prototype) range. Note that the power supply to the alarm is decoupled from the main supply by D3 and C9.

Continued on page 119

Bargraph Car Voltmeter



A 'must' for the proud automobile owner. An all solid-state 10-LED expanded-scale car voltmeter or battery-condition indicator.

A VOLTMETER is a useful accessory to have fitted to a car since it can, when properly used, give the owner an excellent indication of the state of the battery and its charging circuit. Under no-load conditions, with the engine turned off, a sound and well charged battery will give a reading of 12 to 13 volts. Any value lower than 12 volts indicates a defective battery.

With the engine turned off and all lights switched on, the battery reading should fall to 11 to 12 volts. Again, any reading lower than this indicates a faulty battery.

With the engine running at a fast idle and the electrical system lightly loaded, the battery reading should rise to between 13 and 14 volts. A reading below the lower value indicates a faulty alternator or a defective regulator. A reading above the upper value indicates a defective regulator.

You'll notice from the above statement that the range of voltmeter readings that are of interest span only a very limited range, from say 10.5 volts minimum to 15 volts maximum, so a special type of 'suppressed zero' voltmeter should ideally be used in the car.

Our car voltmeter is very special. It is an all solid-state design that gives a readout on a two-coloured line of ten LEDs (light emitting diodes). The unit has excellent long-term and thermal accuracy once it has been initially calibrated to span the range 10.5 to 15 volts. The unit is very easy to install in the vehicle and has a total building cost of only 10 dollars or so. The unit gives a 'dot' display in which only one of the ten LEDs is illuminated at any one time.

Construction And Use

The entire circuit, including the ten LEDs, is built up on a small PCB and construction should present very few problems. Note that IC1 is an 18-pin device and also that it should be fitted to the PCB via a suitable holder. We advise testing each one of the LEDs, to confirm its functioning and polarity, before fitting it to the PCB.

To check each LED, connect it in series with a 470R resistor and then connect the combination across a 12-volt supply. If necessary switch the LED connections until the LED illuminates, under which condition the lead closest to the positive supply rail is the anode.

When construction is complete, double-check the circuit wiring and connect the unit to a variable voltage DC supply that can span the 10-15 volt range. Monitor the supply voltage with a reasonably accurate meter and calibrate the unit as follows.

Set the supply to 15 volts and adjust RV1 so that LED 10 just turns on. Reduce the supply to 10 volts and adjust RV2 so that LED 1 just turns on. Recheck the settings of RV1 ADN RV2. The calibration is then complete and the unit can be installed in the vehicle by taking the '0' volt lead to chassis and the '+12 volt' lead to the vehicle's battery via the ignition switch.

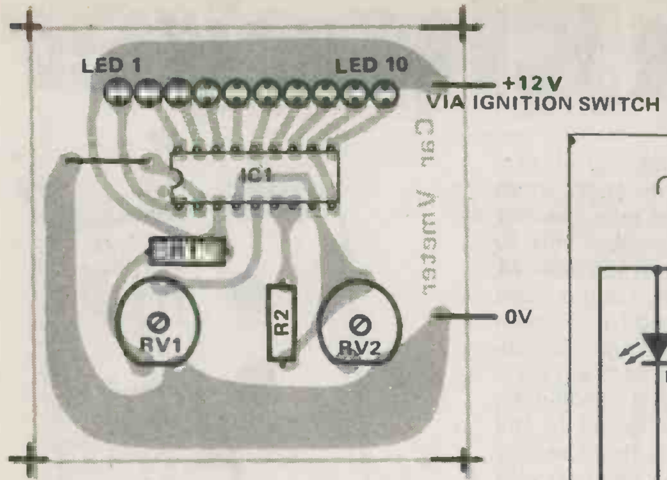
Parts List

Resistors (all ¼ W 5%)		**Semiconductors**	
		IC1	LM3914
R1	4k7	LEDs	
R2	1k2	1,2,3,9,10	TIL 209
		LEDs	
Potentiometers		4,4,6,7,8	TIL 211
RV1,2	4k7 preset		

How It Works

There is little we can say other than the ICI acts as a LED-driving voltmeter that has its basic maximum and minimum readings determined by the values of R2 and RV2. When correctly adjusted, the unit actually spans the approximate range 2.5 volts to 3.6 volts, but is made to read a supply voltage span of 10-10.5 volts to 15 volts by interposing potential divider R1-RV1 between the supply line and the pin-5 input terminal of the IC.

The IC is configured to give a 'dot' display, in which only one of the ten LEDs is illuminated at any given time. If the supply voltage is below 10.5 volts, none of the LEDs illuminate. If the supply equals or exceeds 15 volts, LED 10 illuminates.



PCB overlay for the Voltmeter (left). Note the position of IC1. PCB foil patter (lower left). Take care to avoid solder splashes.

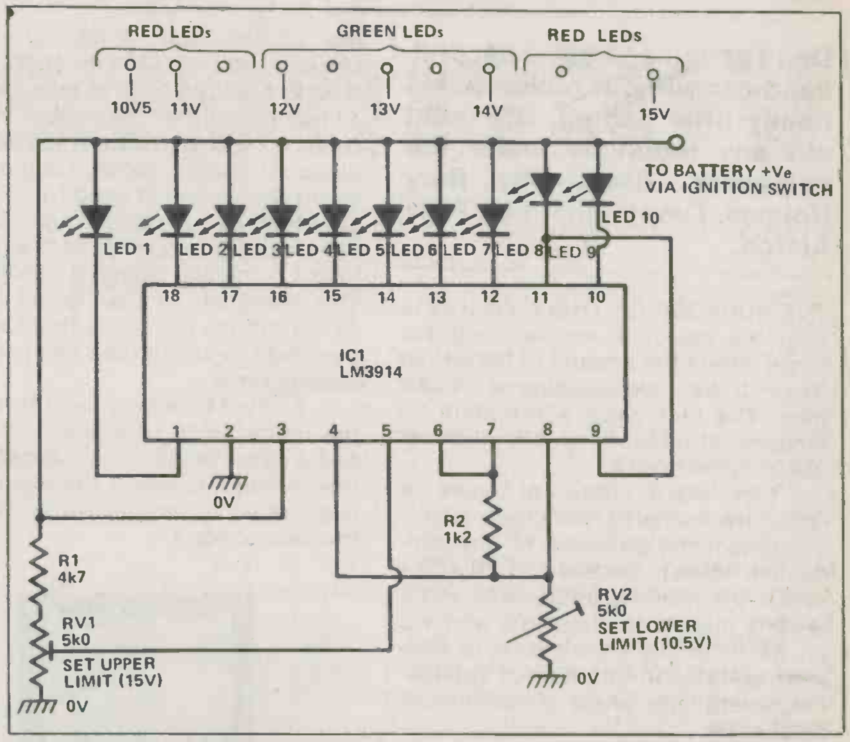


Fig. 1. Circuit diagram of the ETI Bargraph Car Voltmeter. The choice of a box is determined by the type of installation required.

Led Tachometer

Continued from page 117

case try to fit some kind of light shield to the face of the unit, so that the LEDs are shielded from direct sunlight.

To wire the unit into place, connect the supply leads to the tach via the vehicle's ignition switch and connect the unit's points terminal to the points terminal on the vehicle's distributor.

The lower range of the tach is of great value when adjusting the engine for correct idle. It is thus advantageous to arrange the tach housing so that it can be easily dismounted from the instrument panel.

Parts List

Resistors all ¼ W, 5%

R1,2,5	10k
R3,13	22k
R4	470R
R6,15	1k2
R7,9,10,12	330R
R8,11	270R
R14	27k
R16,20	2k2
R17	270k
R18,19	12k
R21	1M0
R22	6k8
R23	4k7

Potentiometers

PR1,2	100k miniature horizontal preset
PR3	47k minature horizontal preset

Capacitors

C1,2	22n polycarbonate
C3,8	220n polycarbonate
C4	1u0 35V tantalum
C5	4u7 35V tantalum
C6,7	47u 16V tantalum
C9	100u 25V electrolytic

Semiconductors

IC1	LM2917N
IC2,3	LM3914
IC4	CA3140
IC5	ICM7555
Q1	2N3904
ZD1	400mW 12V
D1,2	1N4148
D3	1N4001
LED1-21	Red, square type.

Miscellaneous

SW1	3-pole double throw switch

PCB, case.

Bodywork Checker

Don't go out and buy a second-hand car without building this handy little gadget. It'll point out any problems under the paintwork. Design by Rory Holmes. Development by Tony Alston.

THE PURPOSE OF THIS project is to help the selective second-hand car buyer detect the amount of body-filler used under well-disguised repair jobs. The unit gives a two-state indication of metal or plastic, ('OK' or 'BAD' respectively).

Our metal detector uses a capacitive sensing principle, which will detect the presence of any conductive object. Because of this the circuitry is much simpler and more reliable than metal detectors working on an inductive principle. It is also more suitable in this type of application where large areas of metal must be checked.

In use the device is switched on and lightly run over the car panels; if it runs over an area of body-filler the 'BAD' light will come on, otherwise it should read 'OK'.

Construction

The case is the most important part of this project as it is also part of the electronic sensing circuit. Take a careful look at the photographs of the finished project and you can clearly see the sensor area at the bottom rear of the case. First cut a rectangular hole (30x35mm) about 8mm from the bottom edge of the case and 14mm from either side; make sure to clean off any burrs from the hole. A piece of single sided copper clad board (24x30mm) is used for the sensor plate. This is centrally glued (copper side out) to a piece of plain plexiglass or similar material (35x45mm). This assembly is then glued to the case from the inside, so that the copper clad board will then be flush with case surface.

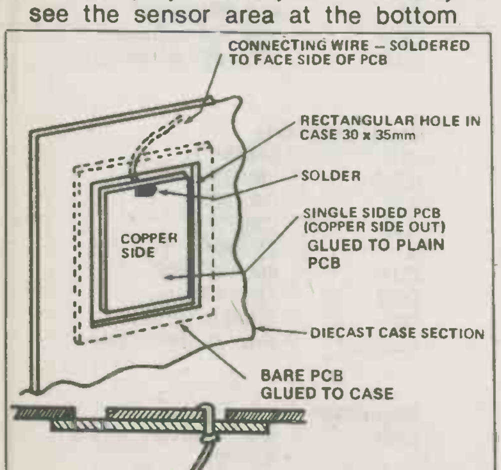
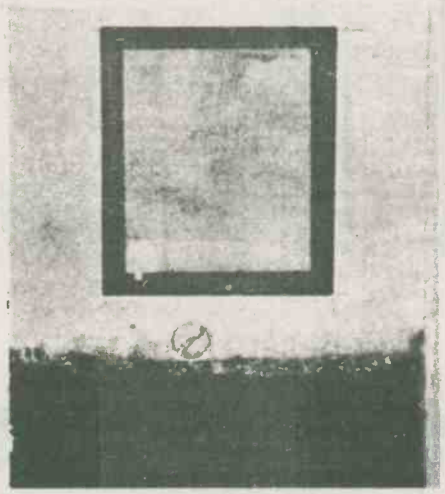


Fig. 1 This cutaway diagram shows the constructional details for the sensor plate.

A small hole is drilled through to the copper side of the sensor plate and a short length of insulated wire, long enough to reach the main PCB, is soldered to the copper surface of the sensor plate.



With the protective felt peeled back to reveal the sensor, you can see how the fixing screws should be countersunk so they lie flush.

The components can now be assembled and soldered to the main PCB as shown on the overlay diagram, making sure to correctly orientate D1, D2, IC1 and IC2 and the LEDs. Make sure to fit the link adjacent to IC1.

A short length of insulated wire is connected from the PCB to a solder tag fixed to the case; make sure this is a good connection as it forms part of the detecting circuit. The connecting lead from the sensor plate is soldered to the main PCB as indicated. A further insulated lead is taken from this same point on the PCB and held against the side of the case by a piece of insulating tape to form a capacitive trimming circuit (see photograph and refer to the setting up procedure). The LEDs are directly mounted on the PCB and appropriate holes are drilled in the front case panel to allow these to pass through.

In the internal shot, note how the trimming wire is taped to one side of the case.

Finally, a piece of felt cut to size is then glued to the rear of the case, covering the sensor plate; this prevents the case from scratching the car bodywork and upsetting your friendly second-hand car dealer!

Setting Up

Setting up the circuit is straightforward; PR1 controls the detecting sensitivity and PR2 the metal/plastic switching threshold. When altering the presets bear in mind that replacing the case lid will slightly offset the adjustments, so replace the lid after each adjustment to check the effect.

Start with maximum sensitivity, i.e., set PR1 to its full resistance (counterclockwise). Then place the case, sensor side down, onto a non-conductive object. With the lid off, PR2 can now be adjusted until the switching threshold is found. When the 'OK' LED is on, back off preset PR2 until it just extinguishes and the 'BAD' LED comes on (indicating no metal). The unit can now be placed against a metal surface and the 'OK' LED should re-light.

The trimming wire capacitively couples a small degree of HF voltage into the detector, effectively altering the switching threshold. Its effect can be varied by trimming the length. By experimenting with this if necessary, together with PR1 and PR2, a suitable switching action can easily be found.

Note that the human body is a fairly good conductor; you can prove this by holding your hand against the sensor, when the 'OK' LED should come on. This resulted in one member of staff wandering round the office, checking out the female employees and reassuring them that all was well.

How It Works

CMOS inverter gates IC2a and IC2b form a high frequency oscillator of about 150 kHz. This signal is connected directly to the case, which in turn is capacitively coupled via the sensor to the high-impedance detector circuitry based around IC1. This unusual way of screening the circuit prevents the user's hand from affecting the capacitance between the detector input and the 0V ground rail.

D1, D2, C1, and PR1 rectify the signal from the sensor and pass this voltage to the positive input of the op-amp, which is configured as a simple comparator. PR1 is used to set the input impedance and hence the sensitivity of the sensor. PR2 sets the switching threshold voltage on the non-inverting input to the comparator. When the coupling capacitance is increased, due to a conductive object lying across the case and sensor, the high frequency signal strength arriving at the detector will increase, raising the voltage on pin 3 of the comparator above the threshold, and switching the output from pin 6 fully positive.

IC2c, d are connected as a Schmitt trigger with R4 supplying positive feedback. This sharpens up the switching action coming from the comparator and further provides suitable drive signals for the two LEDs. These drive signals are buffered and current-limited by IC2e,f which power the LEDs. When metal is detected LED2 is lit and LED1 is off; the converse is true if metal is absent.

Parts List

Resistors (all ¼W, 5%)

R1	22k
R2	8k2
R3	100k
R4	8M2

Potentiometers

PR1	4M7 miniature horizontal preset
PR2	47k miniature horizontal preset

Capacitors

C1	4n7 disc ceramic
C2	470p polystyrene

Semiconductors

IC1	CA3140
IC2	4069B
D1,2	1N4148
LED1,2	5mm red LEDs

Miscellaneous

SW1	miniature rocker switch

Battery and clip; diecast case.

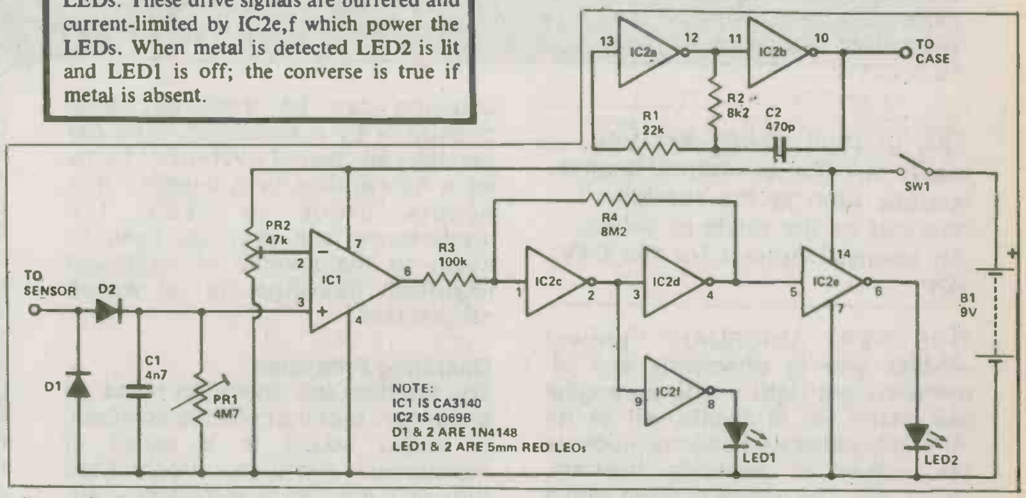


Fig. 2 Circuit diagram.

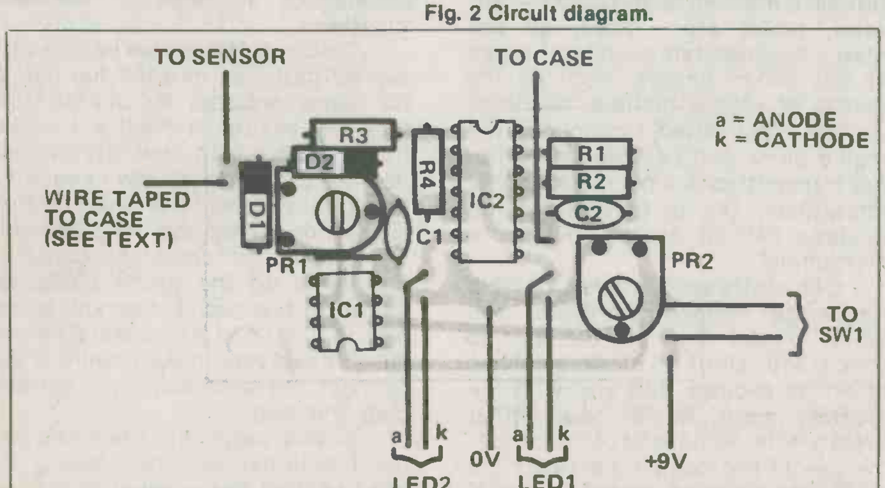
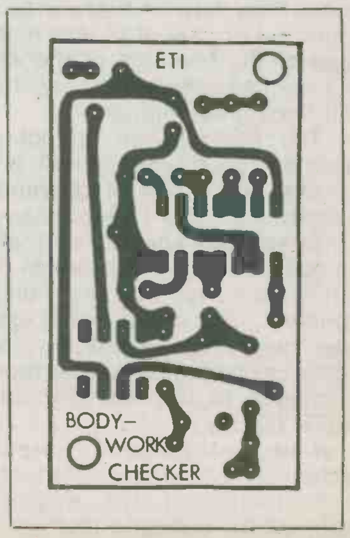
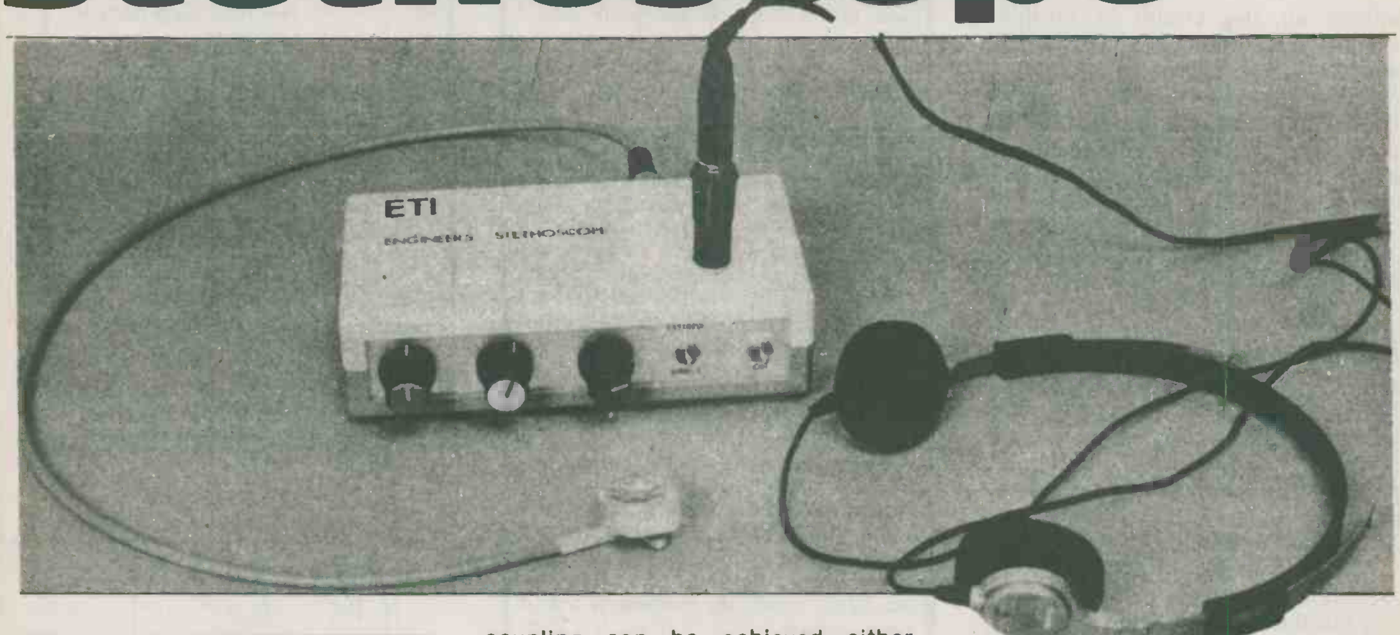


Fig. 3 Component overlay of the ETI Bodywork Checker.



Engineer's Stethoscope



This unusual device lets you locate or listen to internal engine sounds, such as the rumble of bearings or the rattle of valves. An essential project for the DIY nut.

THIS VERY UNUSUAL project enables you to effectively and effortlessly get right inside an engine and listen to, or locate, all of its internally-generated sounds, such as the noises of bearings, pistons, valves, etc. The device is fitted with a double filter network that can be used to pick out one set of sounds (such as those of the bearings or the valves, etc.) from all others, thus facilitating fault-finding on engines.

The Stethoscope project comprises an acoustic probe unit, a 'box-of-tricks' and a pair of conventional headphones. The headphones help muffle ambient sounds, so that you can concentrate on the sounds of the stethoscope even in a very noisy environment. The probe unit is used to make mechanical contact with the engine or mechanism under test and is coupled to the 'box-of-tricks' by flexible leads.

The probe unit relies on mechanical coupling or contact between itself and the engine (or whatever) for acoustic pick-up. The coupling can be achieved either directly or by a metal rod. The rod can take any one of a variety of forms eg a screwdriver or a needle. If a needle probe is used, the stethoscope can even be used to listen to the sounds of individual jewelled bearings in a watch mechanism.

Operating Principles

The stethoscope operation relies on the simple fact that what is commonly called sound is a series of mechanical vibrations transmitted through a medium of some sort — air, water, metal etc. Thus, all the internally-generated sounds of a gas (or any other) engine, such as the sounds of valves, pistons, bearings, etc, are transmitted throughout the engine block and can readily be further transmitted down a metal rod (or screwdriver, etc) to the body of an acoustic pick-up device such as a microphone.

Our stethoscope relies on this mechanical coupling principle. We use a crystal mike as the pick-up device, with all of its air holes blocked off (to exclude dirt) and with the coupling made to its body either directly or by some kind of metal rod. The use of rod coupling enables the source of a given sound to be precisely located within (say) an engine block, by simply probing to find the position of maximum noise. If a needle probe is used, the sound source can be located with pin-point accuracy.

Construction

The Stethoscope circuit is fairly simple and construction should present very few problems. Wire up the PCB first, noting the use of 20 Veropins to facilitate interwiring, as shown in the component overlay. When wiring up RV1 and RV2 take special care to connect the two halves of each component in the same phase, so that the resistances increase or decrease together.

On our prototype we've fitted the two 9V batteries into the top half of the case, secured by double-sided tape. We've fitted a small jack socket to the case top to facilitate connection to the external low-impedance headphones and have used a 3-pin socket for connecting the probe unit.

Finally, to complete construction, wire up the probe circuit as shown in the circuit diagram, taking care to fit Q1 and R1 as near as possible to the crystal mike terminals and connect the assembly to a suitable plug and lead.

At this stage, give the unit a simple functional test by placing the head against the speaker of a small radio. Check that tone quality and volume can be varied with the three

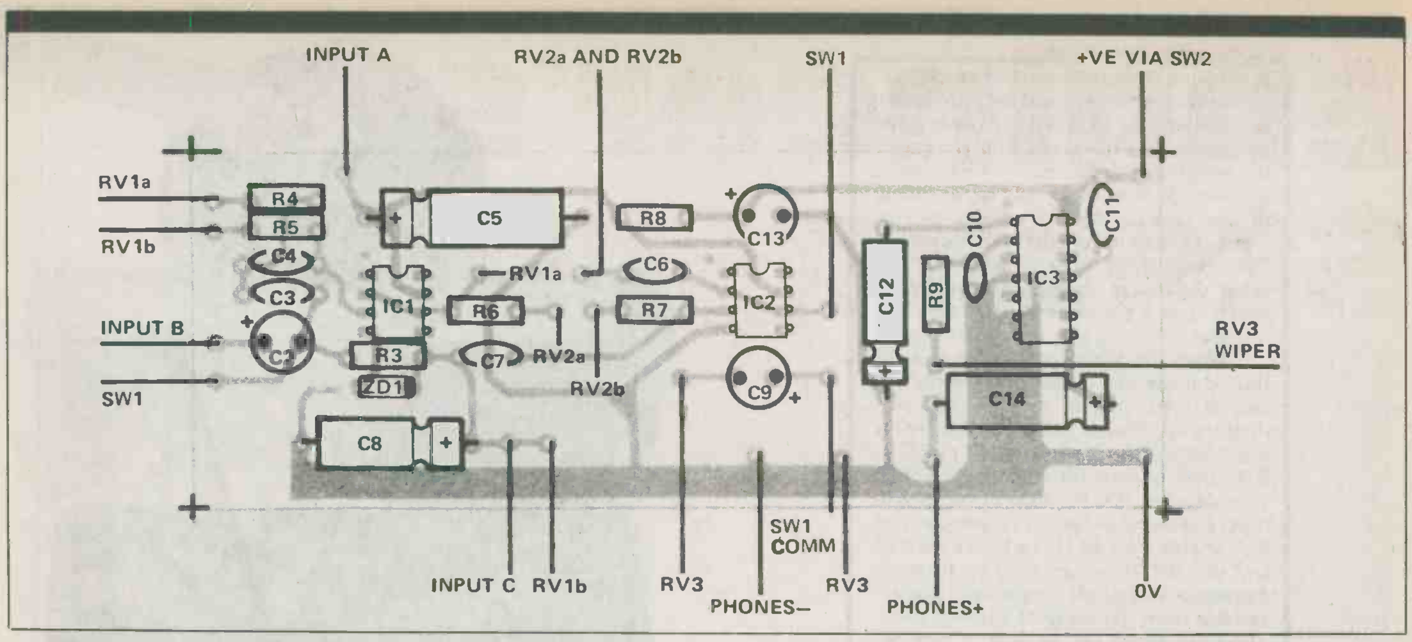


Fig. 1. Component overlay.

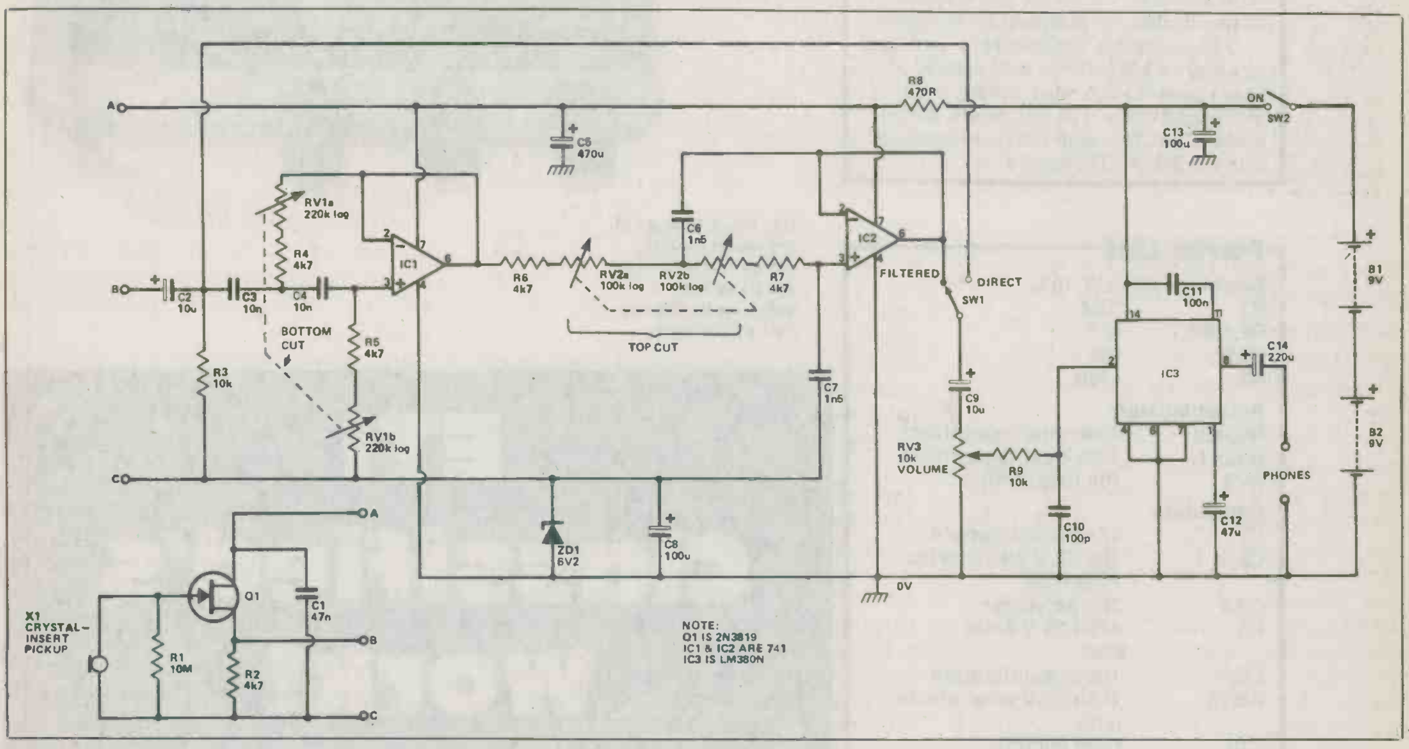
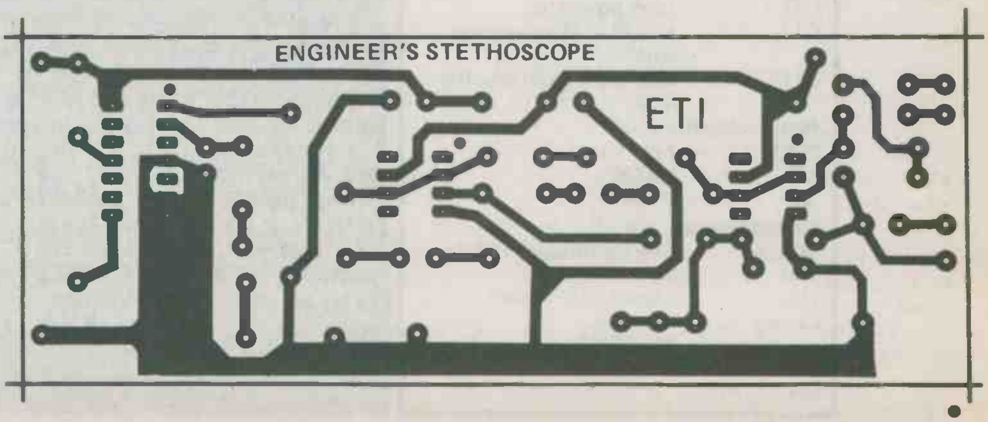


Fig. 2. Circuit diagram.

controls. When the above test is satisfactory, complete the probe construction by blanking off (with tape) air holes in the insert (to exclude dirt and oil) and encapsulate the electronics in wax or resin. On the completed circuit the probe can work as it stands or can be epoxied to a screw terminal or clip (or both) that can be used to make connections to a variety of probe types (metal rods, a screwdriver, etc). The Stethoscope is intended for use with a pair of headphones of not less than 8R0 impedance.

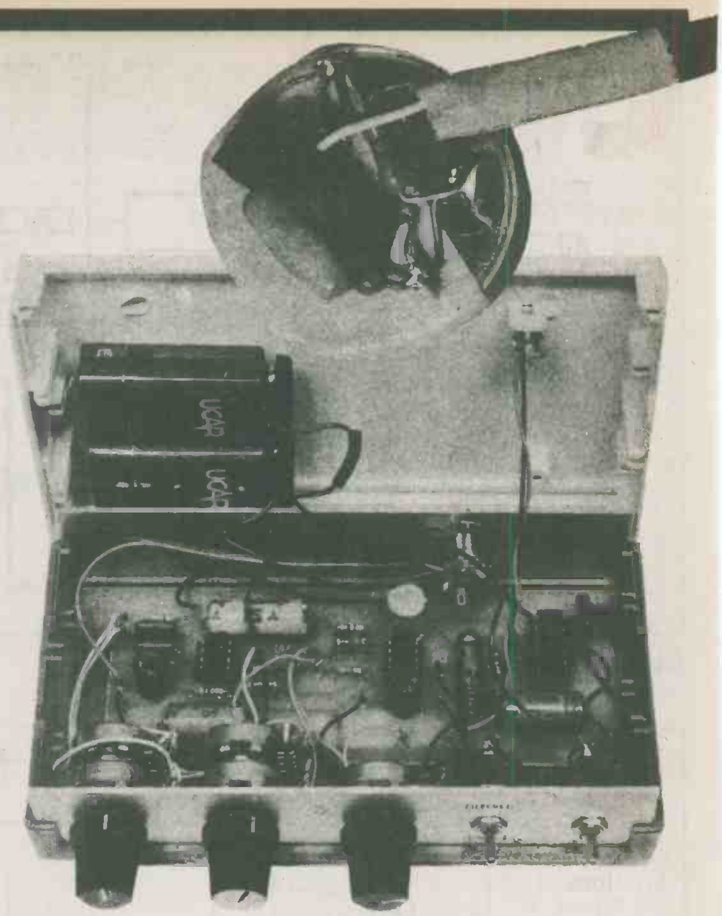


How It Works

A common crystal mike is used as the pick-up device, with the external mechanical sound vibrations being fed to its body either directly or by a metal rod from the engine (or whatever) under test. FET source follower Q1 is wired directly to the output of the pick-up device, to give a low-inpedance output from the resulting probe. The output of the probe circuit is then fed, either directly or through a double filter network, to a power amplifier stage (IC3) and then on to a pair of headphones.

When the stethoscope is used in the filtered mode, the output of the probe circuit is first passed through high-pass (bottom-cut) filter IC1 and then on to the power amplifier via low-pass(top cut) filter IC2. both of these filters are second-order variable types. The IC1 filter can be used to reject signals below roll-off frequencies that are variable from 80 Hz to 3 kHz via RV1 and the IC2 filter can be used to reject signals above roll-off frequencies that are variable from 700 Hz to 15 kHz via RV2. These two filters can be used to pick out specific sounds, such as the low-frequency rumble of bearings or the high-frequency rattle of valves, from the broad spectrum of sounds that are generated by an engine.

The complete stethoscope is powered by a pair of 9 V batteries and typically consumes about 15 mA when driving a pair of 8R0 headphones. The split power supplies to the IC1-IC2 op-amp filters are generated with the aid of ZD1 and C8.



R1, R2, C1, and Q1 are wired directly across the mic. insert. We fixed our batteries to the top half of the case.

Parts List

Resistors All ¼W 10%	
R1	10M
R2,4,5,6,7	4k7
R3,9	10k
R8	470R
Potentiometers	
RV1a,b	220k dual logarithmic
RV2a,b	100k dual logarithmic
RV3	10k logarithmic
Capacitors	
C1	47n polycarbonate
C2,9	10u 63 V electrolytic, PCB type
C3,4	10n polyester
C5	470u 25 V axial elec
C6,7	1n5 polycarbonate
C8,13	100u 25 V axial electrolytic
C10	100p ceramic
C11	100n polyester
C12	47u 25 V axial electrolytic
C14	220u 25 V axial electrolytic
Semiconductors	
IC1,2	741
IC3	LM380
Q1	2N3819
Miscellaneous	
SW1,2	DPST miniature toggle
SK1	3-pin socket
SK2	3.5mm jack socket
Case	Vero No. 202-21040
3 off knobs to suit	
Crystal mike	

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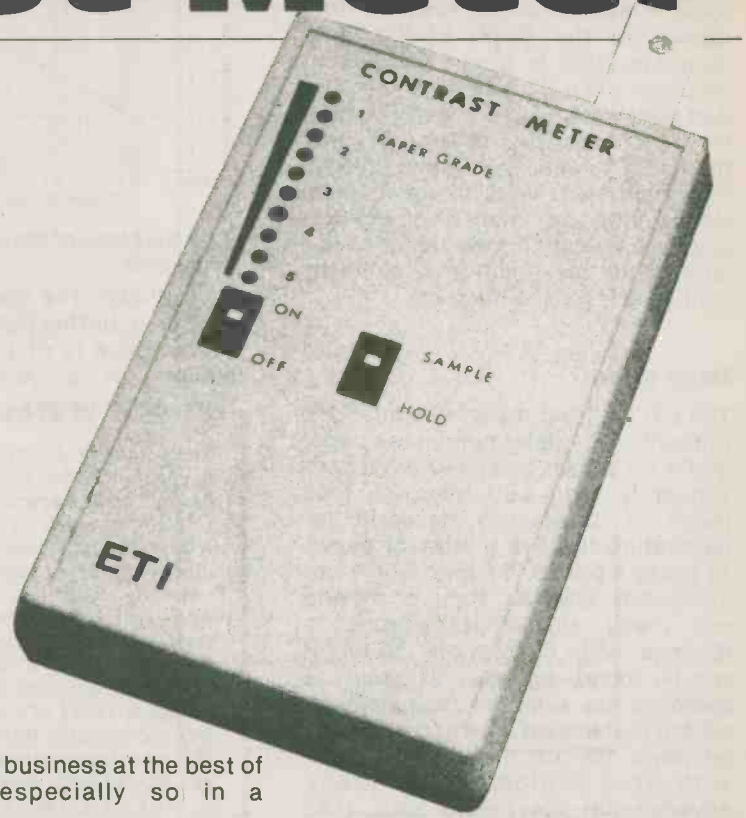
7

Contrast Meter

What's black and white and read all over? Answer — a photographic negative, providing you've built this simple and useful device. Design and development by Rory Holmes.



CONTRAST RATIO is a very important quality of photographic negatives that must be assessed during the printing process, in order to select the correct grade of photographic paper. The contrast of negatives depends on the type of film used, the lighting conditions and the developing process; consequently five grades of printing paper are available to enable the full range of tones from black to white to be reproduced from any negative. Grade 1 is termed the softest and it is used with the highest contrast negatives. At the other end of the scale, grade 5 is the hardest paper, which will enhance the tonal variations of poor contrast negatives.

During the design stage of this project we experimented initially with two separate photodetectors which measured the instantaneous light difference between two points. There are a number of problems with this approach, as the photodiodes and their associated amplifiers must be carefully matched in light sensitivity.

Secondly, the lightest and darkest points of the image must be known exactly, and the two photodetectors need to be simultaneously positioned on these points while the reading is taken. This is an awkward business at the best of times, but especially so in a darkroom!

We considered that a different approach was required and developed the circuit of Fig. 1 to overcome some of these difficulties. Only one photodetector is used and the peak positive and negative voltages obtained from different light levels are followed and stored independently by sample and hold circuits.

Now, as long as the photodiode is scanned at some time through the lightest and darkest points of the image, the peak detectors will memorise the maximum and minimum voltages, and thus provide a contrast measurement.

The photodetector input stage of our meter is rather unusual in its configuration. Photodiodes are usually used in the 'photovoltaic mode' where the photocurrent developed and measured is linearly proportional to the light intensity. Our input amplifier has an extremely high input

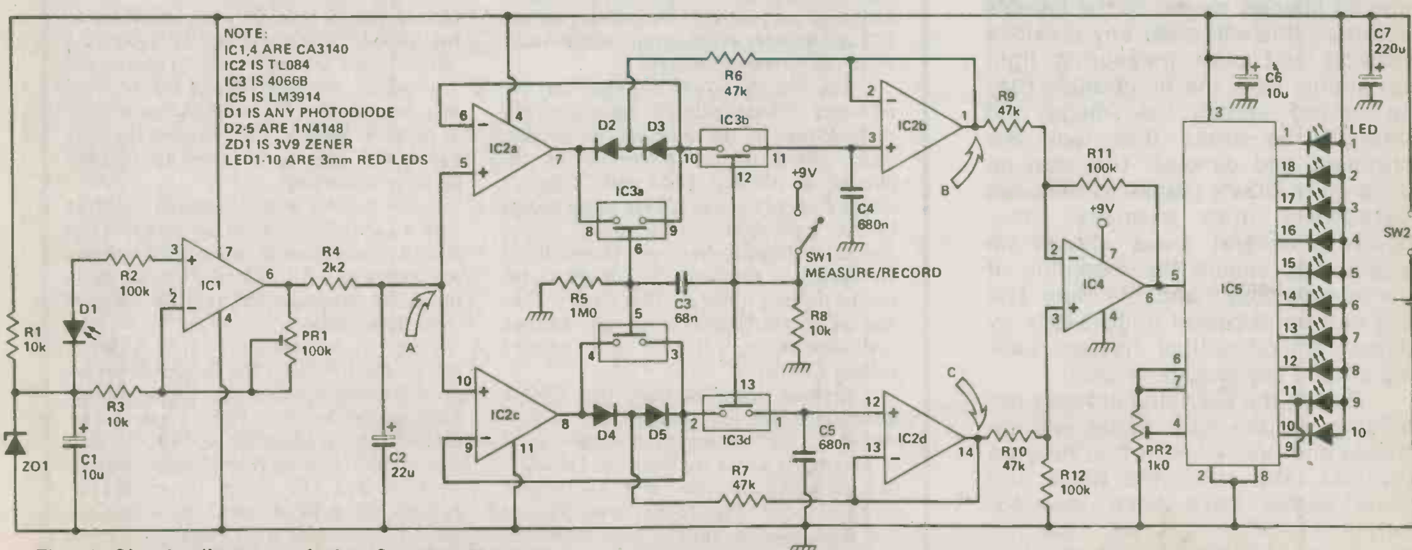


Fig. 1 Circuit diagram of the Contrast Meter.

impedance and thus measures the open circuit voltage generated by the photodiode. This voltage is logarithmically proportional to irradiance as the graph of Fig. 2 illustrates. This is a very convenient property since the sampling circuitry can now work on the log of the light level to provide maximum and minimum values. By simply subtracting these two values with a differential amplifier we obtain a voltage that is logarithmically proportional to the ratio of the maximum and minimum light levels, i.e. the contrast.

Meter Made

The ETI contrast meter was intended primarily to determine the paper grade for a well balanced print; consequently a 10 LED bargraph type meter is sufficiently accurate for calibrating the five grades of paper. At today's prices this also works out somewhat cheaper than a moving coil meter and is less prone to damage. After calibration, the meter will be found very easy to use. It is switched on with the 'sample/hold' switch in the 'hold' position and placed down flat on the enlarger base with the photodetector probe anywhere in the image area. (The photodiode has been mounted in a separate probe with its amplifier in order to keep it as close to the focused image plane as possible. If it were much higher than this the detecting element would pass through an unfocused image, giving a false contrast reading).

Any red safety lights should be switched off before the reading is taken to avoid error since the photodiode is responsive at this wavelength. The sample/hold switch should now be moved to the sample position; this will clear any previous reading and start measuring light variations. Now the photodiode may be moved across the image and through the areas that look the brightest and darkest. This can be done quite slowly thanks to the peak detectors' long memory time; however, several areas should be scanned to ensure the recording of the true maximum and minimum. The eye can be deceived quite easily by those cunning optical illusions lurking among the shades of grey!

During the scanning process the reading on the LED scale will increase and finally level-off at the true contrast ratio when the black and white peaks have been covered. Before removing the meter from the image area the sample/hold shoud be set to 'hold'. The meter will now be immune to further light variations and will continue to display the contrast reading for a considerable time, thanks to the even longer memory of the sample/hold circuitry!

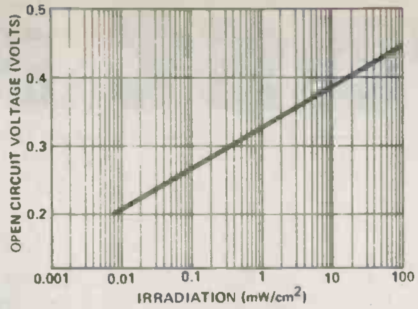


Fig. 2 Response of the photodiode used in this project.

A true ratio is provided by the meter and thus the contrast reading for a given negative will be independent of the light source intensity and enlargement size (photographic aberrations known as "circles of confusion" may produce sources of error under certain conditions). Negatives may thus be compared or matched for contrast.

Construction

The meter is built into a slim style plastic enclosure. This houses the battery and main PCB on which all

How It Works

The general circuit arrangement consists of a photo-amplifier which feeds a voltage derived from varying light levels in an enlarger, to a pair of peak detectors. One follows the peak positive voltage and the other the peak negative voltage. The capacitors used for storing the voltage peaks in the followers also form part of sample and hold circuits which are then switched to 'hold' after measurement. Their outputs represent the maximum and minimum values of light intensity. A differential amplifier then computes the ratio of these values and the result is displayed on an LED bargraph meter.

IC1, a CA3140 CMOS op-amp, is used as the photodetector amplifier. It is configured as a non-inverting DC amplifier with a gain variable from unity to about 10, set by PR1. Although IC1 can have input and output voltages all the way to ground, this facility is not used owing to the driving requirement of the TL084 quad op-amp. This requires inputs at least 1V above ground, and thus IC1's output is offset by a reference voltage of 3V9 provided by R1, ZD1 and C1. The anode of the photodiode is connected via R2 to the non-inverting terminal of IC1 which has an effectively infinite input impedance. Thus the open circuit voltage generated by the photodiode is amplified according to the gain set around IC1 and appears at the output on pin 6 added to the reference voltage.

The voltage at point A (ignoring the reference offset) will be logarithmically proportional to the intensity of incident light, owing to the properties of the photodiode (see Fig. 2) R4 and C2 form a simple filter to remove 120 Hz ripple caused by AC light bulbs. This voltage is fed directly to the peak detectors. These circuits are essentially the same, the difference being the polarity of the rectifier diodes. They operate in exactly the same way, and we shall deal only with the peak positive voltage follower.

Assume initially that the CMOS analogue switch IC3c is open and IC3d is closed. C5 will be connected to the output of op-amp IC2c via the rectifiers D4 and 5 (we can ignore the action of R7 for the moment). C5 will charge up via the rectifiers to the most positive voltage peak when the voltage at point A on the non-inverting terminal is greater than the capacitor voltage applied to the inverting terminal. The voltage held on C5 will droop over a period of time due to leakage current through the rectifiers D4 and 5 and the input bias current of IC2c. IC2c was chosen as a FET op-amp with a low input bias current and R7 is included to reduce the diode leakage current.

IC2d is connected to C5 as a straightforward high impedance voltage follower to buffer the stored voltage. When the input voltage to IC2c at point A drops below the peak value, IC2c's output will go negative, reverse biasing D4. However, IC2d applies the capacitor voltage via R7 to the anode of D5, effectively removing leakage current through D5.

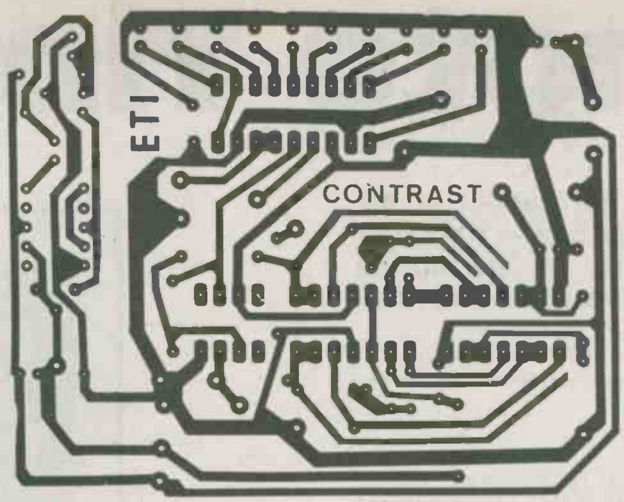
The peak positive value of the signal at A thus appears at point C, and likewise the peak negative value at point B. When the analogue switch IC3d is now opened, C5 is disconnected from the peak detector and acts in conjunction with IC2d as a sample and hold circuit thus isolating the measured values from further light variations.

When SW1 is open, R8 and R5 hold the control pins 13 and 5 of IC3 low, opening both analogue switches. This is the 'hold' mode. When SW1 is now closed, the control pin 13 is taken high, switching to the 'sample' mode. C3 and R5 produce a positive pulse (about 50 mS) on control pin 5 to briefly short out D4 and D5, so resetting the peak detector to the current voltage at point A. When C3 has charged the IC3c switch will open again, allowing the peak detector to function.

IC4 is wired as a differential amplifier with a gain of 2, to subtract the voltage at point C from point B. Since these voltages are the log of the light levels, the output on pin 6 will represent the contrast ratio of these light values.

IC5 is a standard LED bargraph driver, the LM3914. The input voltage on pin 5 is converted linearly to illuminate one LED on a scale of 10. Full scale deflection (LED 10) is set internally at 1V2; the zero scale deflection is set by PR2 anywhere between 0V and 1V2 during the calibration process. C6, a 10 uF tantalum, is required for IC5 to ensure stability from oscillation.

the parts are mounted. Since the light sensing element must be as close to the enlarger base plane as possible, we have mounted it externally on a separate small PCB with its associated amplifier. A probe to house the external sensor is made from a short length of aluminium channel extrusion. Figure 3 shows the dimensions for the probe; if the



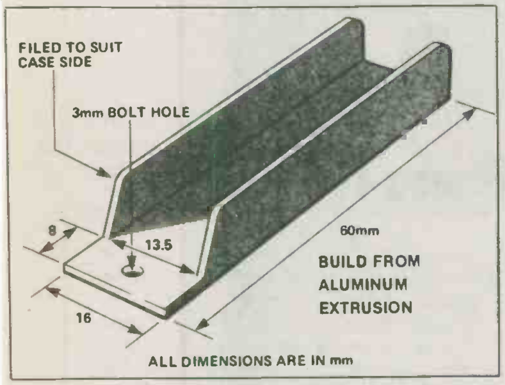
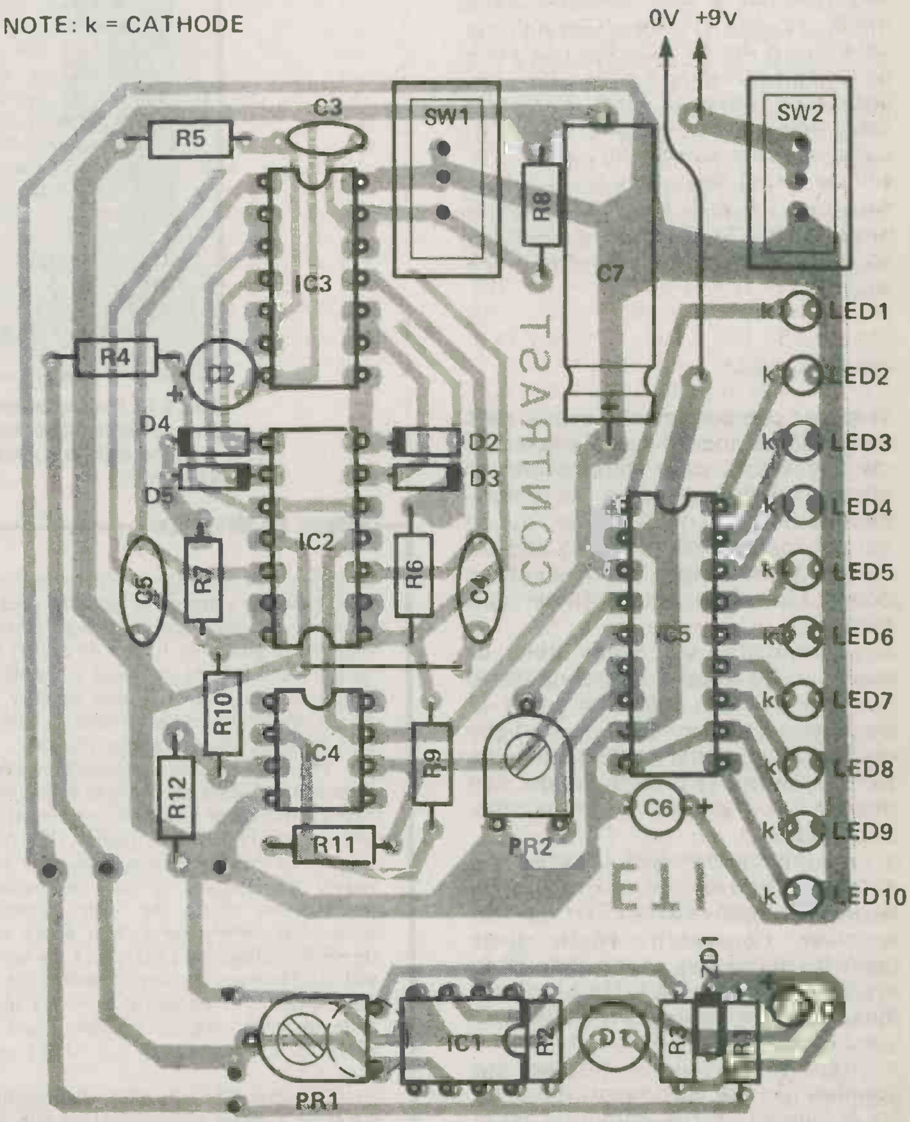


Fig. 3 Details for the aluminum extrusion that houses the photoprobe.

NOTE: k = CATHODE



Parts List

Resistors (all ¼W, 5%)

R1,3,8	10k
R2,11,12	100k
R4	2k2
R5	1M0
R6,7,9,10	47R

Presets

PR1	100k subminiature horizontal preset
PR2	1k0 miniature horizontal preset

Capacitors

C1	10u 35V tantalum
C2	22u 25V tantalum
C3	220u 16V electrolytic
C4,6	82n polycarbonate
C5	68n ceramic

Semiconductors

IC1,4	CA3140
IC2	TL084
IC3	4066B
IC5	LM3914
D1	Any photodiode, e.g. TIL413
D2,3,4,5	1N4148
LED1-10	3mm red LED

Miscellaneous

SW1,2 miniature slide switches
Case; PCB; B1 9V battery (preferably alkaline type).

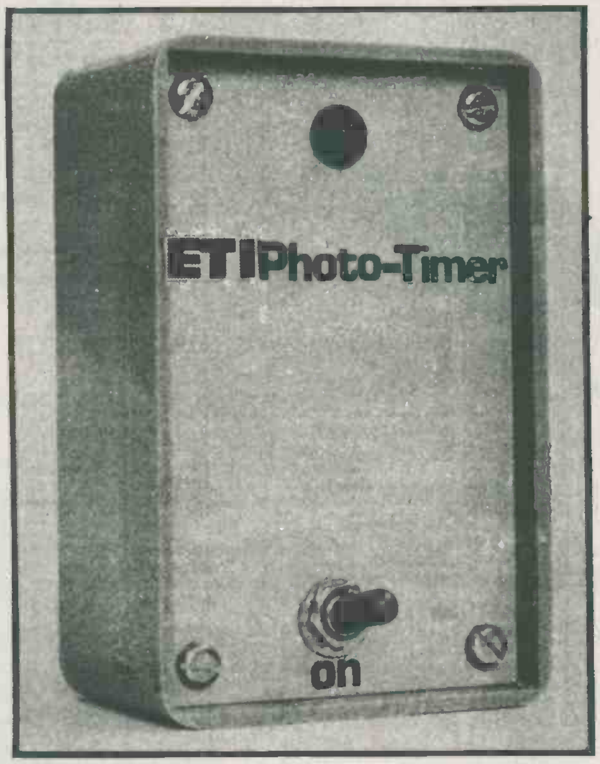
Continued on page 132

Photo Timer

You won't get caught in the dark with this one — time your photographs to perfection with this cheap-to-build, simple project.

WE COULD NOT BE accused of over-complication with this simple photographic timer project, which uses only about half a dozen components. The unit has a LED indicator which flashes regularly at one second intervals, and it can be employed as a simple enlarger timer or to time exposures lasting several seconds with the camera set to 'B' or 'T'. There are many other uses for this timer.

It is inexpensive and extremely simple to construct, being well within the capabilities of even a complete beginner: it makes an ideal first project.



The ETI Photographic Timer will fit into any suitable-sized small case and when finished will be a valuable addition to the darkroom.

Construction

The few components fit easily onto one of the standard size (24 holes by 10 strips) 0.1" pitch Veroboards, as shown in Fig. 2. Building the component panel could not be easier, but be careful to connect LED1, Q1 and C1 the correct way round, and be sure to connect the battery clip with the right polarity.

Practically any small metal or plastic case should be adequate to house the timer. Indicator LED1 is mounted on the front panel using one of the special panel holders available for the device. This panel holder can provide the mounting for the component board.

Potentiometer RV1 is given the correct setting by trial and error, comparing the flash rate of LED1 against a clock or watch which gives seconds indication. In use the unit is started by closing SW1. The shutter is opened or the enlarging lamp is switched on at the first flash, and then the appropriate number of flashes are counted. On the last count, the shutter is closed or the enlarging lamp switched off. The period from switch-on to the first flash is slightly more than one second, and should not be used as part of the timing period.

How It Works

A unijunction relaxation oscillator makes a good basis for a project of this type since it gives the necessary short pulses of current required to give brief flashes of a LED indicator, and it does not need a stabilised supply to give good frequency stability. A circuit of this type is also simple, as can be seen from the circuit diagram (Fig. 1).

There is normally a resistance of a few thousands of ohms between the base 1 and base 2 terminals of a unijunction transistor, and a potential divider circuit is therefore formed by the unijunction device Q1 and resistor R2. Because of the comparatively low resistance of R2, the voltage appearing across this component is well below the threshold voltage of LED1, and the latter will not light up. The input impedance at the emitter of a unijunction is very high under normal operating conditions, and at switch-on C1 charges by way of R1 and RV1.

Capacitor C1 continues to charge until it reaches a charge voltage of about 80% of the supply voltage, and Q1 then triggers. This results in the emitter-to-base 1 impedance of the device dropping to a level of just a few ohms. A rapid discharge takes place through Q1 and the parallel impedance of R2 and LED1, the latter being brought into the state of conduction by the current flow through R2 and the consequent rise in the voltage across this resistor. Because of the low impedance of C1's discharge path its charge diminishes very rapidly to the point where Q1 is no longer maintained in the 'triggered state', and Q1 quickly reverts to its original state. Thus there is only a brief pulse of current through LED1, and it produces only a brief flash.

With Q1 back in its original state C1 is free to charge up once again, but the charge on this component soon reaches the trigger potential of Q1 once again, causing the device to trigger and discharge C1. This cycle is repeated indefinitely, giving a regular series of flashes from LED1. Potentiometer RV1 controls the charge rate of C1 and in practice it is adjusted to give the required flash rate of one per second.

The current consumption of the circuit is only about 1 to 2 mA, and each 9V battery gives many hours of use.

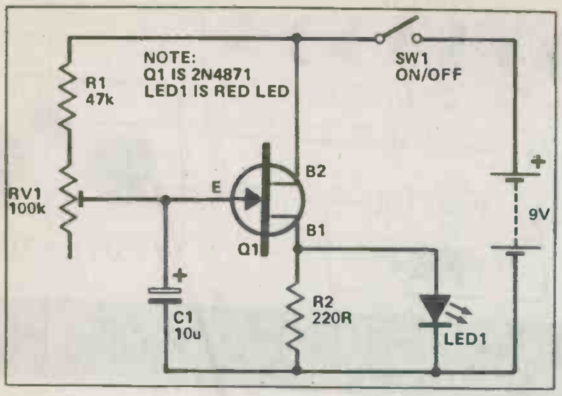


Fig. 1. Circuit diagram of this simple project.

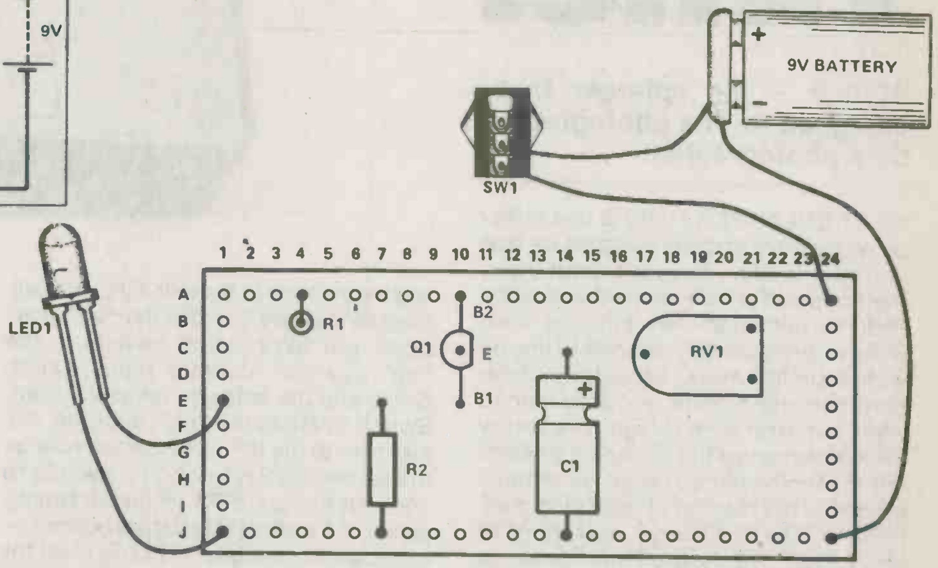


Fig. 2. Veroboard layout and connection details. Note there are no track breaks.

Parts List

RESISTORS (All ¼ W, 5%)

R1	47k
R2	220R

POTENTIOMETER

RV1	100k miniature horizontal preset

CAPACITORS

C1	10u, 25V electrolytic

SEMICONDUCTORS

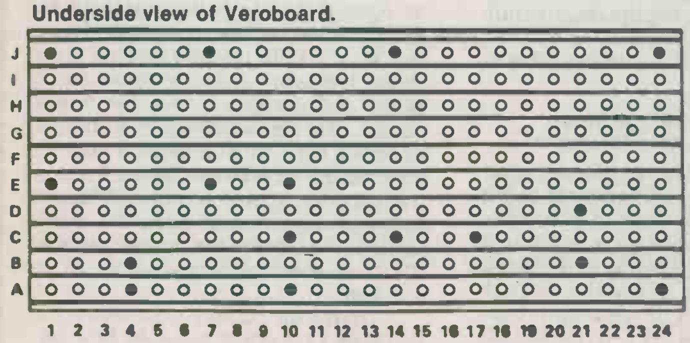
Q1	2N4871 unjunction transistor
LED1	0.2" red LED

MISCELLANEOUS

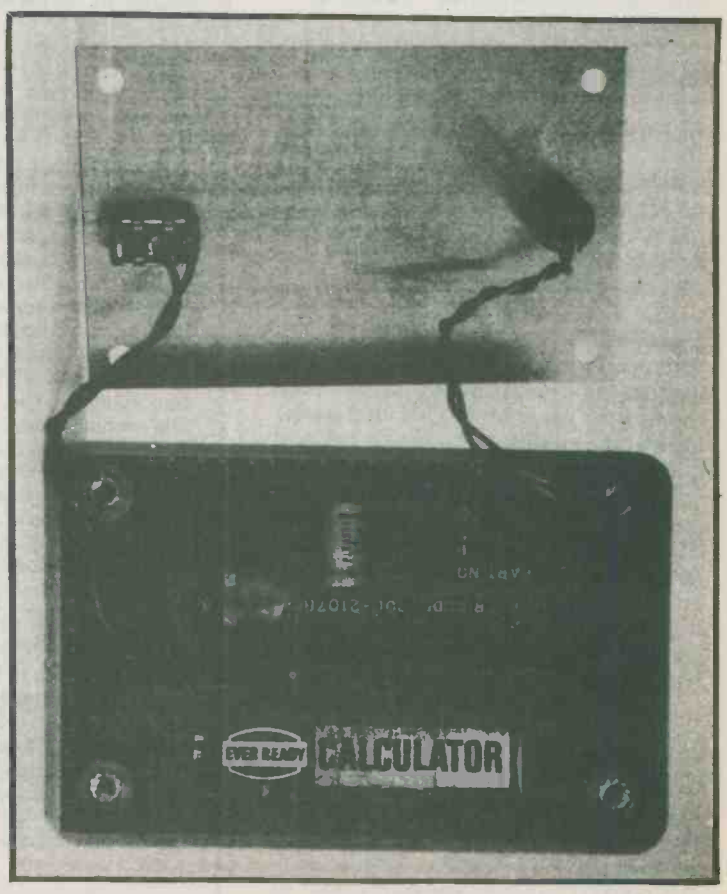
SW1	single-pole toggle switch

Case to suit
10 strip x 24 hole 0.1" Veroboard, battery and clip.

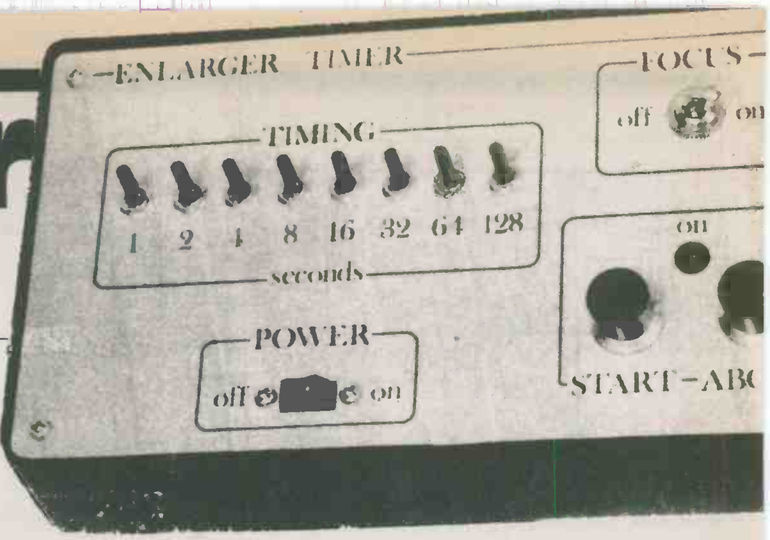
Underside view of Veroboard.



Inside the ETI photo timer



Enlarger Timer



At last — an enlarger timer designed for the photographer by a photographer.

MOST ENLARGER TIMERS use either potentiometers or rotary switches for time period selection; however, both these methods suffer from some drawbacks. First, the potentiometers, although inexpensive, are generally difficult to line up with a timing mark, especially under darkroom conditions, and also tend to wear out after long usage. The rotary switch overcomes the alignment problem but the timing period range is normally limited to the number of click stop positions — mostly 12 ways, maximum 18 ways. The ETI Enlarger Timer does not suffer from either of these problems; it uses only eight toggle switches in conjunction with the 2240 programmable timer IC to offer a wide range of accurate and easily selected timing periods ranging from one second to 4 minutes 15 seconds in one-second steps.

This flexibility is due to the programmable eight bit counter, oscillator and control flip/flop featured within the timer IC. Having set the time base to 1S using PR1, R4 and C2, each single switch (SW1-8) will give the basic timing periods of 1,2,4,8,16,32,64 and 128 s; by switching in more than one switch, any combination of timing periods can be achieved as previously mentioned.

Construction

As can be seen from the photographs, all switches and push-buttons are mounted on the front panel together with the LED indicator. Suitable AC power input and output sockets are mounted on the rear case panel, input nearest the transformer, output (for the enlarger) by the PCB. The PCB design will enable an easier and neater assembly, but make sure to orientate components D1-D5, Q1, IC1, C2, C3 and LED1 as shown in the overlay diagram. Note that C2 must be a tantalum bead type.

Once all the components are mounted on the PCB and the switches, LED1, sockets and transformer are wired to the board, make sure that the panel assembly does not hit the transformer or the relay when fitted into the case.

Setting Up

This couldn't be easier; having checked all connections, connect the timer to the AC and the enlarger to the unit. First put switches SW1-8 and SW10 in the "off" positions, put SW9 (on/off switch) in the "on" position, operate focus switch SW10 and the enlarger lamp will light. Switch SW10 to the "off" position. Adjustment to the timing range can now be made; switch SW1 only (1 s switch) to "on" and adjust PR1 to give a timing period of 1 s after PB1 (start) is pushed — a stopwatch or digital watch is ideal for this.

Using The Timer

Switch on SW9 (on/off switch) and power will be applied to the circuitry. SW10 can be used for focusing the enlarger; switch off SW10 once this is done. Select the timing period required using a combination of SW1-8, push PB1 and the enlarger lamp timing cycle will commence; after this period the timer will stop/reset. LED1 will be on during the timing period as a visual indication. If cancellation of a timing period is needed press PB2, which will abort and reset the timer. If any interference from RLA/2 is experienced, fit a 100n 600V capacitor as marked on the circuit and overlay diagrams (C4).

How It Works

The heart of the ETI Enlarger Timer is the 2240 programmable timer IC which features a time base oscillator, programmable eight bit counter and a control flip-flop that can be used in monostable or astable mode. Here it is used in the monostable mode.

On application of a positive pulse to pin 11 (trigger) via PB1 and R1, the timing cycle is started. The trigger input activates the time base oscillator, enables the counter section and sets the counter outputs low from their normally high states. This switches on Q1 and activates RLA for the time duration as set by the SW1-8 combination. The timing sequence is completed when a positive pulse is applied to pin 10 (reset) via R3 from the output bus, disabling the time base and counter sections and returning the counter outputs to a high state.

The duration of the timing cycle T_0 is given as:

$$T_0 = nT = nRC \text{ seconds}$$
(R in ohms, C in farads)

where T (= RC) is the time base period as set by the timing components at pin 13 (PR1, R4 and C2) and n is an integer in the range of 1 less than or equal to n less than or equal to 255 as determined by the combination of counter outputs (pins 1-8) via SW1-8 to the output bus. The time base as set by PR1, R4 and C2 is 1S.

The binary-counter outputs are the open collector type and can be shorted together to the common pull-up resistor R6. Thus the time delays associated with each counter input can be added together; for example, if pin 6 is connected by SW6 to the output bus the duration of the timing cycle, T_0 is 32 T. (T is 1S as previously stated). Similarly, if pins 1, 5, and 6 are all connected to the output bus via their appropriate switches SW1, SW5 and SW6, the total time delay is 49T (1 + 16 + 32). In this manner the timing cycle can be programmed to be from 1 S to 255 S (four minutes 15 S) in 1 S steps by proper choice of switches SW1-8.

The enlarger lamp is powered from the AC outlet socket and receives its current via the RLA/2 contacts for the duration of the selected timing period. An LED is incorporated as a visual indicator; it is switched on by RLA/1 and remains on for the timing period. Manual cancellation is provided for by PB2 which applies a positive pulse to pin 10; this can be used at any point in the timing period. SW10, the focusing switch, over-rides the RLA/2 contact regardless the output state of IC1 thus enabling the enlarger to be focused.

The power supply consists of T1, D2-D5 and C3 which provides filtering.

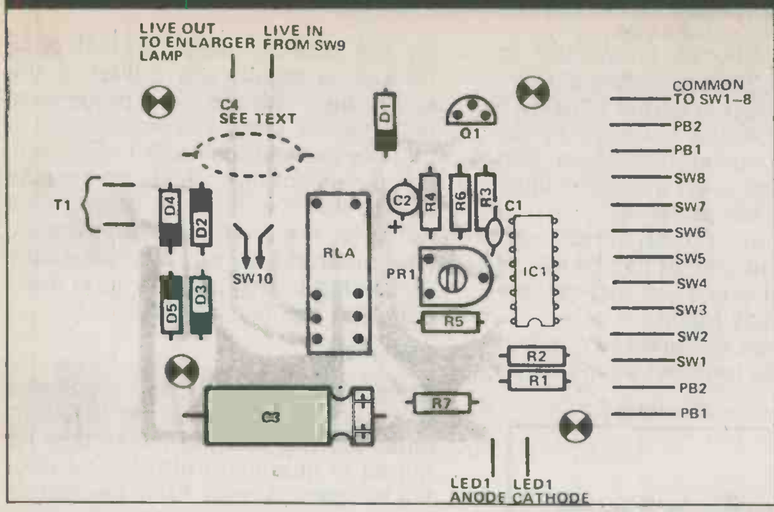
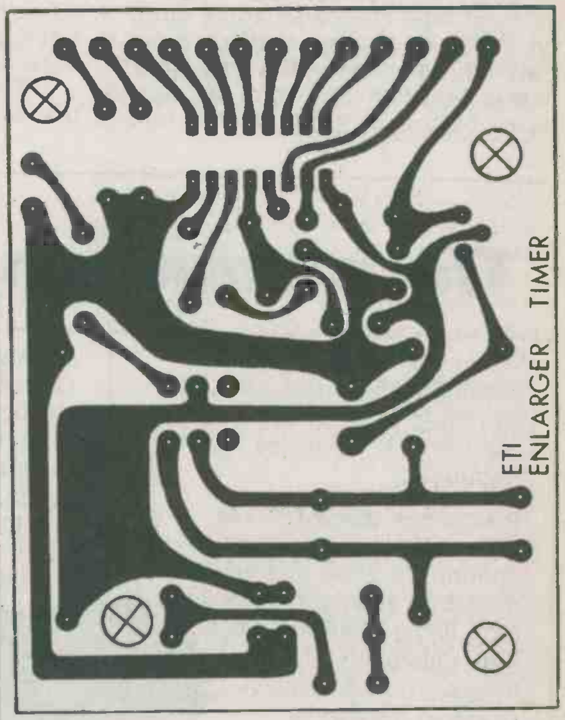


Fig. 1 Component overlay of the Enlarger Timer.



Parts List

Resistors (all ¼ W, 5%)		Q1	2N3702
R1,2,6	10k	D1	1N4148
R3	47k	D2-5	1N4001
R4	33k	LED1	0.2" red LED
R5	22k		
R7	1k5		
		Miscellaneous	
Potentiometer		PB1,2	momentary action push-button
PR1	22k miniature horizontal preset	SW1-8	SPST miniature toggle
Capacitors		SW9	SPST 3A miniature rocker
C1	10n disc ceramic	SW10	SPST 3A toggle
C2	22u 16V tantalum	RLA	12V DPDT PCB-mounting,
C3	1000u 25V axial electrolytic		
C4	100n 600V		
Semicondutors			
IC1	uA2240CP		

Transformer (12V, 250mA or similar); AC outlet socket; PCB ; power cord; case to suit.

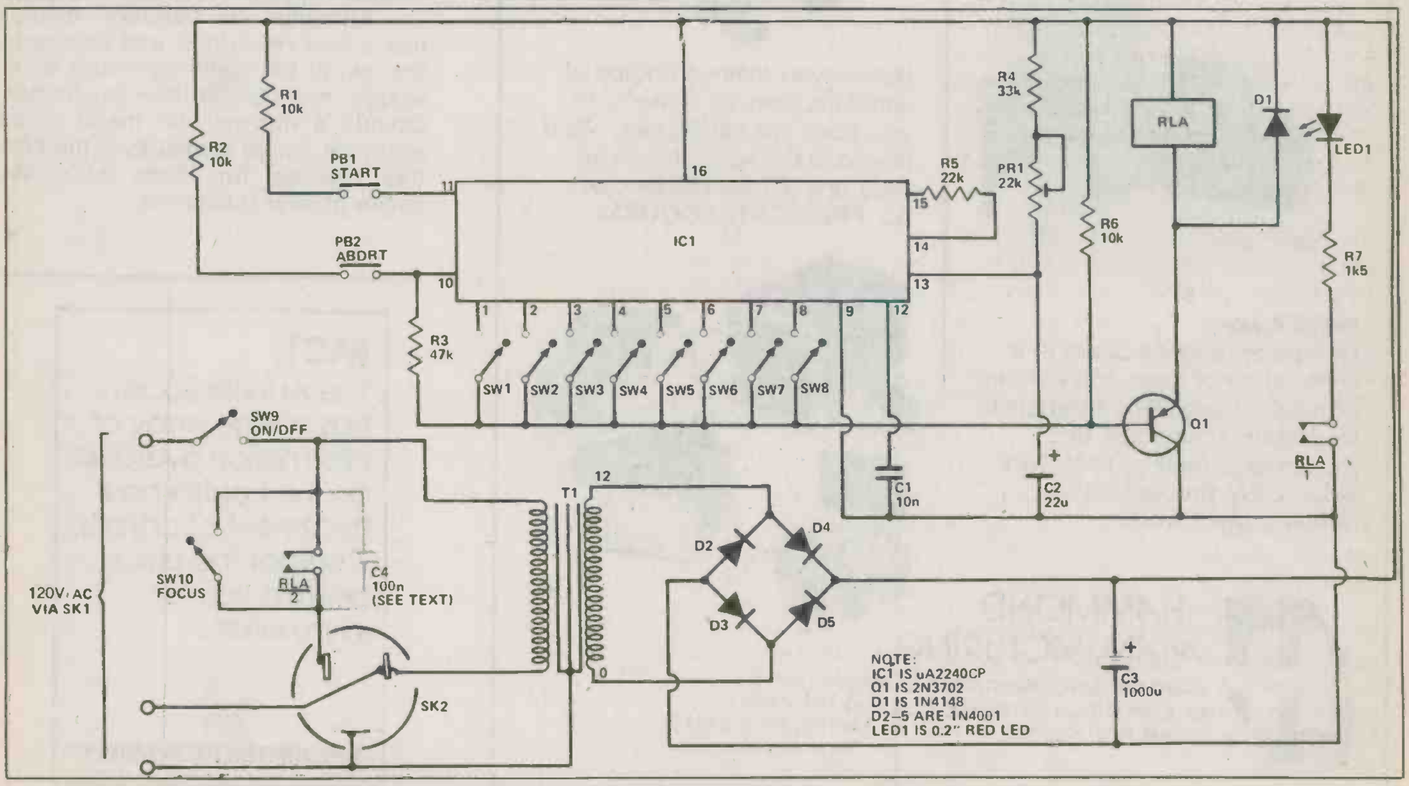


Fig. 2 Complete circuit diagram of the timer. C4 may be necessary to suppress switching noise from the relay contacts.

Continued from page 127

aluminum channel proves difficult to obtain, a piece of the slotted aluminum extrusion used for commercial shelf-racking systems is ideal. This is available from most DIY stores in short lengths with the required internal width. After filing or cutting to the right size, a piece of insulating tape should be stuck down on the inside to prevent shorting out the PCB. As shown in the diagram, a hole is drilled on the end for bolting it to the bottom of the case. This bolt should eventually be connected to circuit ground, thus providing screening for the photoamplifier. The two PCBs for probe and main meter circuits are laid out as one board, and should be sawn apart along the lines shown on the foil patterns.

For other construction arrangements, the circuit can be left as a single board, since the interconnections are already made.

Three wires are used to connect the two boards together as indicated on the overlay; these should pass through a small hole drilled in the case side where the metal probe case is bolted on. When the probe board is mounted and stuck down in its channel, a piece of thin aluminum sheet is cut to form a lid with appropriate holes for the photodiode and preset. (The photodiode case is internally connected to the cathode, so it must not short against the lid).

Calibration

Start with preset PR1 fully clockwise to set a gain of 1; also set PR2 fully anticlockwise, setting the voltage required to illuminate the lower end of the bargraph at zero. First, measure a high contrast negative that is known to require grade 1 paper for a good average contrast after developing. Initially a low contrast reading will be obtained, say about grade 4 or 5. Now, adjust PR1 anticlockwise to increase the gain of the photoamplifier. Take another measurement, when the contrast reading should be greater. Repeat this process until a grade 1 is consistently recorded.

Now select a negative with very poor contrast ratio, one known to require paper grade 5 for bringing out the contrast. Take measurements several times while adjusting only PR2 clockwise, until the bottom end of the scale illuminates at grade 5. The other contrast grades should now fall linearly between these points and can be checked for accuracy.

Although the bargraph display has a low resolution and accuracy, the rest of the metering circuit is obviously much better than this; consequently a moving coil meter could easily be added to measure the contrast voltage for those who may desire greater resolution.

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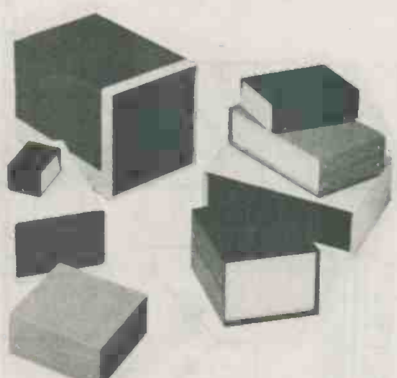

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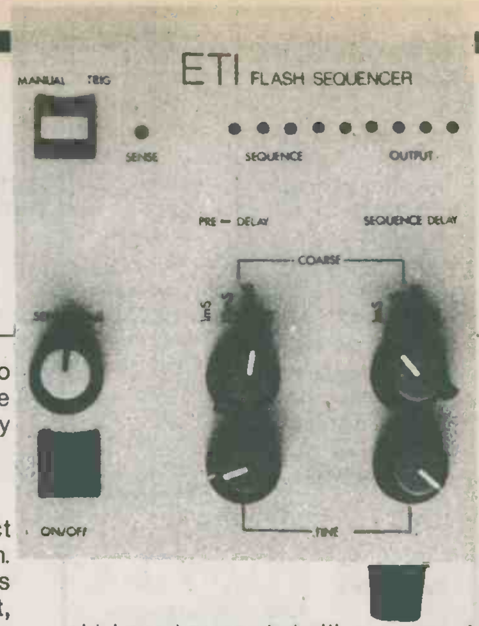
Flash Sequencer



Here's a project that lets you do something new with a flashgun, or nine. Make mobile matter into marvellous multiple images.

THE HUMAN eye is an extremely complex sensor, capable of discriminating shapes and colours in an extremely high optical noise environment. Researchers are only just realising the computational complexity of image analysis, shape recognition, perspective compensation, telemetry and all the other tasks that our eyes and brain perform continuously.

Yet, probably because of this complexity, there is one area in which the eye's performance is rather poor: speed. Any discrete movement shorter than an eighth of a second becomes blurred and at a repetition rate of 18 to 25 events per second, everything blends into a continuous movement. Unfortunately, in real life, events happen a lot faster than that and to try to analyse and understand them, we need some device that can effectively reduce the flow rate of information.

Strobe Shots

When the number of images of the subject is small, we can simply superimpose them. The result is strobography. The pioneers of this method (Mach, Foucault, Helmholtz) used the high intensity discharges of Leyden jars (the first capacitors) as the light sources. Nowadays, you can obtain much more accurate results with a battery of electronic flashes, a camera and our flash sequencer!

The basic idea is that when an event occurs, it triggers a series of flashes at a constant and known rate. Being of very short duration (on the order of a microsecond), the flashes effectively immobilise the subject in its consecutive positions, which can be recorded with a camera. As an example of possible analysis, the change in position during a known time can give the velocity. The change of velocity to the next frame gives the acceleration, and so on. The position, intensity and colour of each flash can give further meaning to the recorded positions.

Multi-option Multiflash

One of the basic practical problems in strobography is the triggering of the sequence. The most useful sensors are contact, audio and optical, and all three are provided for in our design. Furthermore, an adjustable pre-delay allows the flash sequence to commence a short time after the triggering pulse, should this be necessary for the right effect. Both the pre-delay and sequence delay can be continuously adjusted from 100 uS to 1 S per flash and thus practically all situations are allowed for. A manual trigger and LED readout are provided to make the time settings for a particular picture easier to adjust. A camera X flash socket allows for a sequence to be triggered from the camera, in exactly the same way as a single flash. In this case, make sure that the exposure time is longer than the total sequence time.

Using The Unit

There are two possible modes of operation for this device. It is either:

- Triggered by the event to be recorded, using a suitable sensor (adjusted just below the triggering point) and the pre- and sequence delays being set for the desired effect. In this case, the camera shutter has to be open during the whole of the sequence. Therefore a manual operation of the shutter (B setting) and very little or no ambient light will be necessary. The diaphragm should be set to one stop less than the calculated aperture for the flash and subject-camera distance used.
- Set off by the camera in exactly the same way as a single flash. This method is

How It Works

The sensor is a simple level crossing comparator, the signal source being selected by SW1. Resistor R6 at the offset compensation input of IC1 provides an imbalance of the input differential stage, so that RV1 can set the threshold level both over and under 0V. LED1 is an aid to adjustment and should be just flickering when RV1 is properly set.

A manual trigger is provided for test purposes. Irrespective of the input conditions of IC1, when PB1 is activated the strobe pin (pin 8) has direct control of the output. Thus pin 6 of IC1 is sent high and the flash sequence is triggered.

The next two stages are the pre-and sequence timers. They work in the same way, except for the enable conditions. The difficulty here is a reliable and repeatable delay. In all monostables, energy is charged and discharged between two levels. Our problem is that the stable level must be the same as the power off state; it must be reached in a much shorter time than the shortest delay (100 uS) without a negative supply to draw on; and the time control must be linear.

The stage works as follows: IC2a and IC2b lock to the charging position (low and high outputs respectively) as soon as an impulse is received through C1. C2 begins to charge through the range resistor. The output of IC3a is high, so IC4's inverting input is higher than its non-inverting input and its output is low. This output is fed back to IC3a's input so we have a steady state. As soon as the voltage on C2 reaches the limit set by RV2, IC4 switches high; IC3a switches low; the voltage at the inverting input of IC4 is zero, giving a Schmitt trigger action. A change of state can only occur now when C2 is discharged to 0V (power off state). This is done by IC3b and C3, which was initially positively charged. As IC4 goes high, IC3b goes low. The voltage on the negative side of C3 is driven below zero potential. D4 is now forward biased and passes a current from C2 into C3. D3 and IC2b suppress the charging current. This continues until the voltage on C2 is just under 0V, at which point IC4 switches over to its low position again.

The low to high transition of IC4 has been transmitted through IC2c and IC2d to the IC6 clock input. This results in the 'O' output, which was at logic 1, going low, thus disabling the pre-delay stage and enabling the sequence timer through IC3c. At the same time output '1' goes high, triggering triac SCR1 and firing the first flash. The sequence timer (still enabled) operates in the same way as the previous stage, except that the charging current is continuously enabled and astable operation results. Each one of the impulses shifts the high output of IC6, successively triggering the following flashes until the '0' output is reached again. This disables the sequence timer and allows the pre-timer to receive a new impulse from the sensor, ready for a new cycle.

The output control elements are triacs, rather than SCRs, because not all electronic flashes conform to the 'positive centre/ground shield' standard connection.

Flash Sequencer

Parts List

Resistors (all ¼W, 5%)

R1	1M5
R2,4,44	1M0
R3,9	22k
R5	680k
R6,16,17, R18,19	10k
R7,26-34	1k0
R8,12,22	470k
R10,20	4k7
R11,21	47k
R13,23	4M7
R14,24	120k
R15,25	12k
R35-43	470R

Potentiometers

RV1	100k logarithmic
RV2,3	100k linear

Capacitors

C1	100n polycarbonate
C2,5	1u0 polycarbonate
C3,6	100u 10V tantalum
C4	47u 16V tantalum
C7	100n ceramic

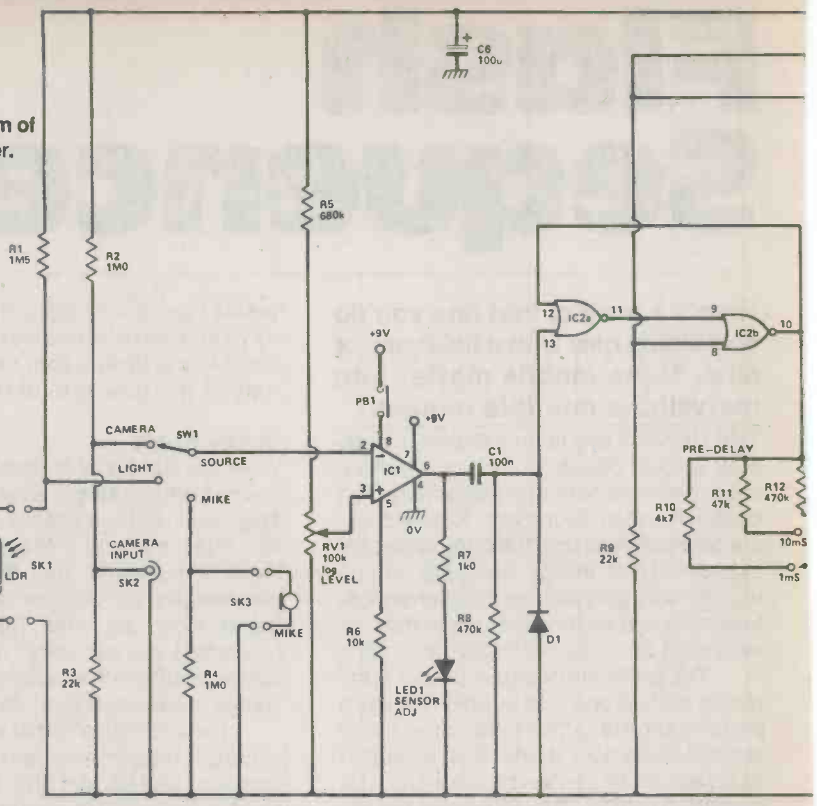
Semiconductors

IC1,4,5	CA3140
IC2	4001B
IC3	4049B
IC6	4017B
SCR1-9	TIC206D
D1-6	1N4148
LED1	0.125" yellow LED
LED2-10	0.125" red LED

Miscellaneous

PB1	push-button N.O.
PB2	push-button N.C.
SW1,2,3	one-pole rotary switch
SK1,3	phono socket
SK2,4-12	3mm coaxial flashgun sockets
9v battery holder, case	

Fig. 1 Circuit diagram of the Flash Sequencer.



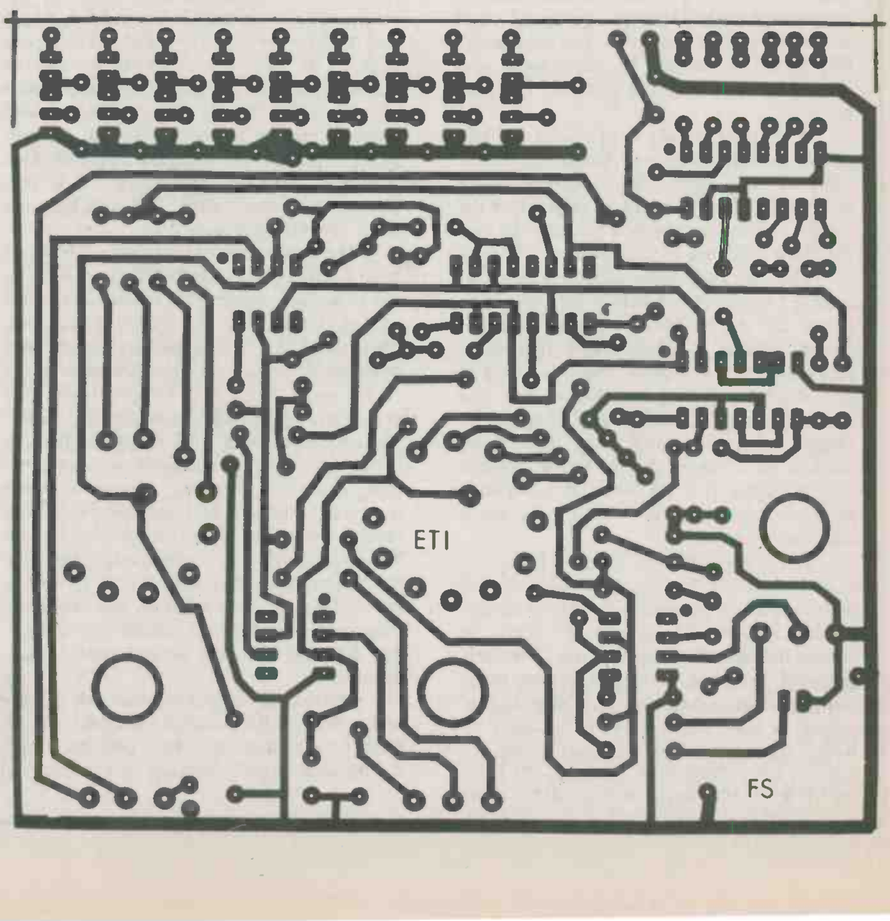
somewhat more flexible for event durations of the same order as the human reaction time (about a tenth of a second). In that case, the synchronisation is made through an ordinary extension lead from the X socket of the camera to the 'contact' input of the sequencer. Care must be taken to set an exposure time longer than the total sequence time. The diaphragm setting is determined in the same way as in the previous method.

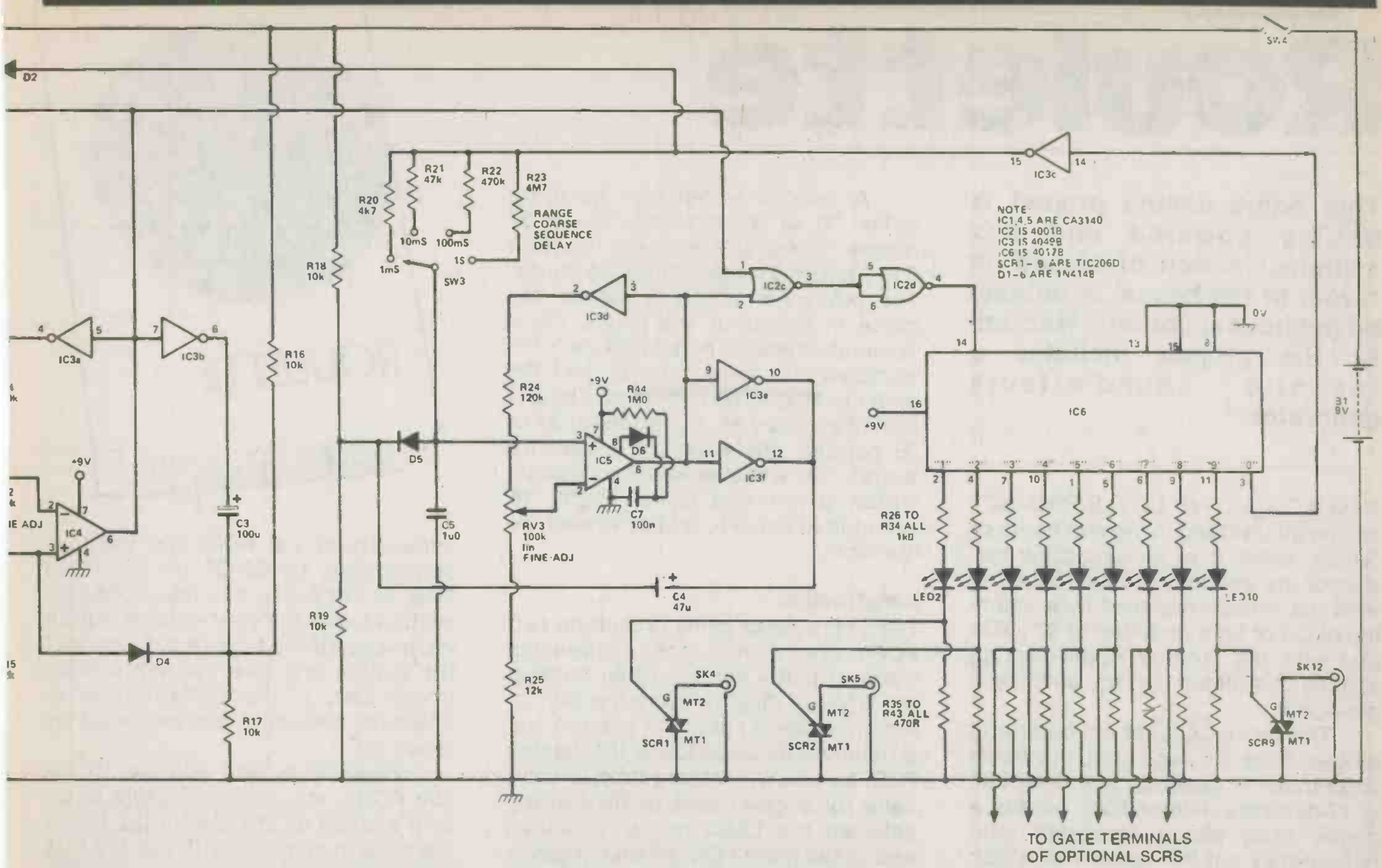
In both cases, the flashes are connected to the sequencer either directly or through ordinary extension leads, and can be distributed along the path of the subject or grouped as a battery. It is generally easier to work with flashes of the same type or at least of the same intensity. In the case of flashes with auto-exposure circuitry ('computer' flashes), the setting should be to manual (or the sensors masked with opaque tape), in order to avoid interactions from the previous flash.

Construction

Construction should be fairly straightforward, as all the components (except PB1, SW1, SW4 and the LEDs) are mounted on a single PCB to minimise interwiring. Note that the number of output stages is entirely up to you; if you want less than nine flashguns to be triggered, leave out the unwanted triacs together with their associated LEDs, resistors and sockets.

When fitting the rotary switches, the tags will have to be trimmed off to fit the PCB holes. Some of the unused tags have been cut off completely to allow PCB tracks to pass through — the overlay shows which ones remain.





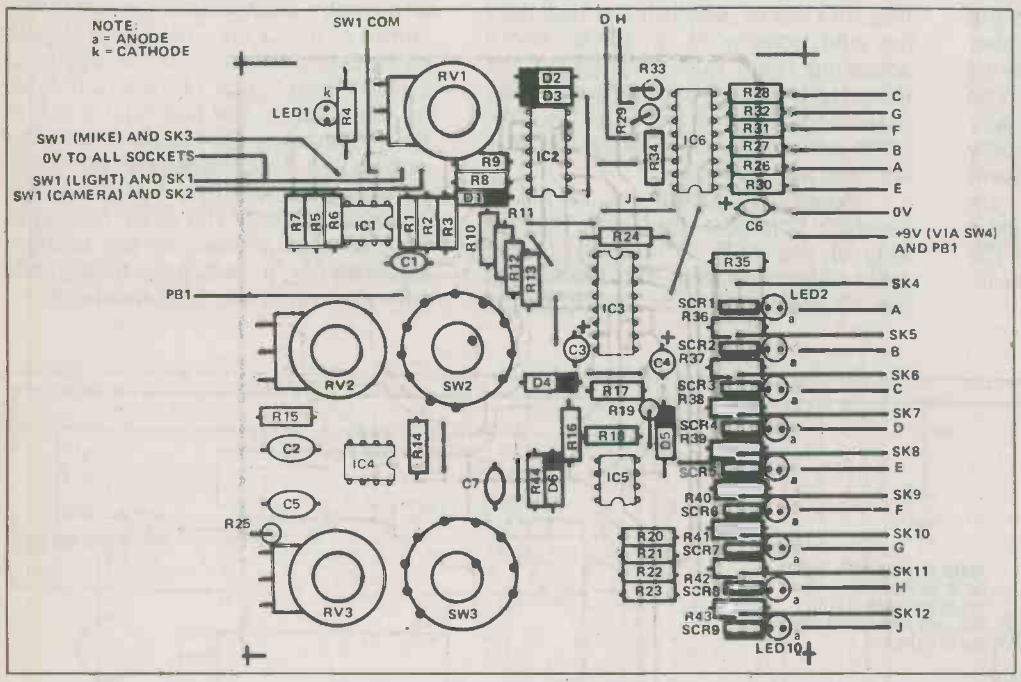


Fig. 2 Overlay for the sequencer. Some of the tags of SW2 and SW3 are cut off before mounting — the dots indicate which tags remain.

The board can now be mounted on ¾" spacers and holes marked out and drilled to accommodate the LEDs and switch and potentiometer spindles.

The next stage is to wire the LEDs, sockets and off-board switches. When this is completed a visual check of the whole project should be made.

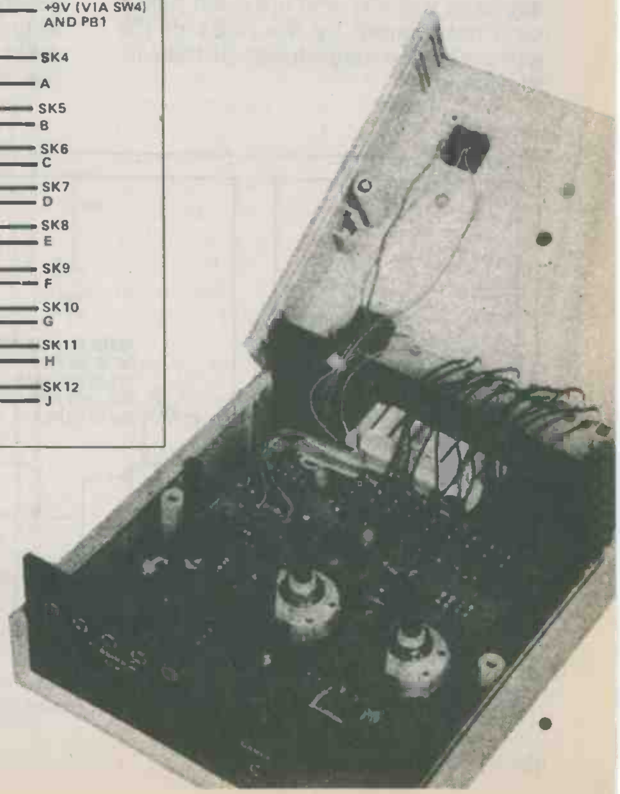
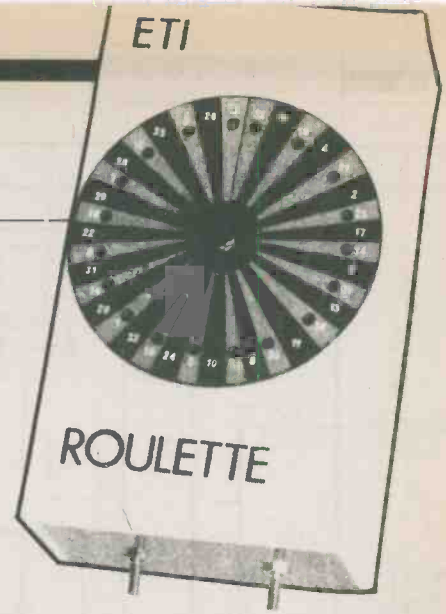


Fig. 3 Inside the sequencer. Although the overlay shows the LEDs mounted on the PCB for clarity, they are actually mounted on the case top and connected to the board by flying leads.

8

Roulette



This home casino project is battery powered and has switch-selection of biased (in favour of the house) or unbiased (no house) options. Naturally, the project includes a realistic sound-effects generator.

THIS ATTRACTIVE LITTLE PROJECT can be guaranteed to provide hours of fun at home. It is an electronic version of the well known roulette game, with the 'wheel' replaced by a spinning circle of light on a ring of 37 LEDs and with the familiar wheel-clicking sounds simulated by an electronic generator.

The basic concept of roulette is quite simple. On each spin, the wheel can randomly generate any one of 36 or 37 numbers (1-36 or 0-36). To start a game, each player forecasts (and bets money on) the number at which the wheel will stop by forecasting the number, or the colour of the number (red or black), or any of a variety of characteristics of that number. The wheel is then spun and eventually comes to rest against some randomly determined number, at which point the players with that number are declared winners and are each paid a sum determined by the rules of the game and the magnitudes of their initial bets.

A real-life wheel may generate either 36 or 37 numbers. On a 37 number wheel, the numbers run from 0 to 36, with 0 representing the house. The presence of the 0 biases the game in favour of the house. On a 36-number wheel there is no zero; the numbers run from 1 to 36 and the game is said to be unbiased. The ETI roulette game has an option for 37 or 36 number operation via a selector switch. The wheel is 'spun' via a push-button switch and takes roughly 15 seconds to come to rest after each initial spin.

Construction

The ETI roulette game is built on two PCBs, one holding most of the electronic circuitry and the other holding the 37-LED display. Construction of the main board shouldn't present any problems. Construction of the display PCB, however, is rather fiddly, since it calls for a great deal of hard-wiring between the LEDs (using Veropins) and to the main PCB. When constructing this board, confirm the functioning and polarity of all LEDs before soldering them into position on the PCB. Note that all cathodes go to the outer segments of the PCB ring. All LEDs should be given equal heights (as long as possible).

When the LEDs are in place, carefully interwire them (on the top side of the PCB) to conform to the main circuit diagram and then make the 10 connections to IC2 (from the underside of the PCB) and the four connections to Q2-Q5 on the main PCB. At this point, wire the two toggle switches and the push-button switch into place, fit the transducer, connect the battery and give the unit a functional test. If the LEDs fail to illuminate correctly, re-check your interwiring.

When all is well, you can fit the two PCBs, etc. into a suitable case. Drill a circle of 37 holes in the top of the case to coincide with the 37 LEDs and fit the push-button switch in the centre of the circle. The display board can be secured behind the case top by smearing drops of clear adhesive on the sides of the heads of a few of the LEDs and pushing them into the case holes. The project can be finished off by marking the roulette wheel artwork on top of the case. Note that the numbers marked on the roulette scale do not, in fact, have to coincide with any particular LED numbers.

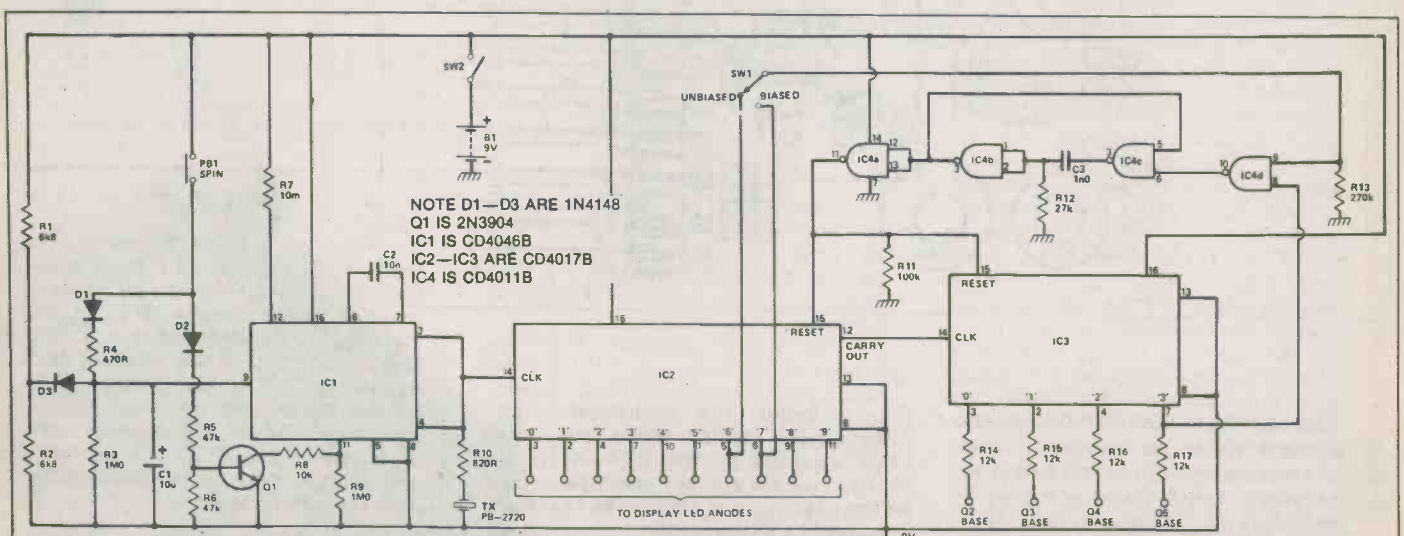


Fig. 1 Main circuit diagram. Biased and unbiased game options can be switch-selected.

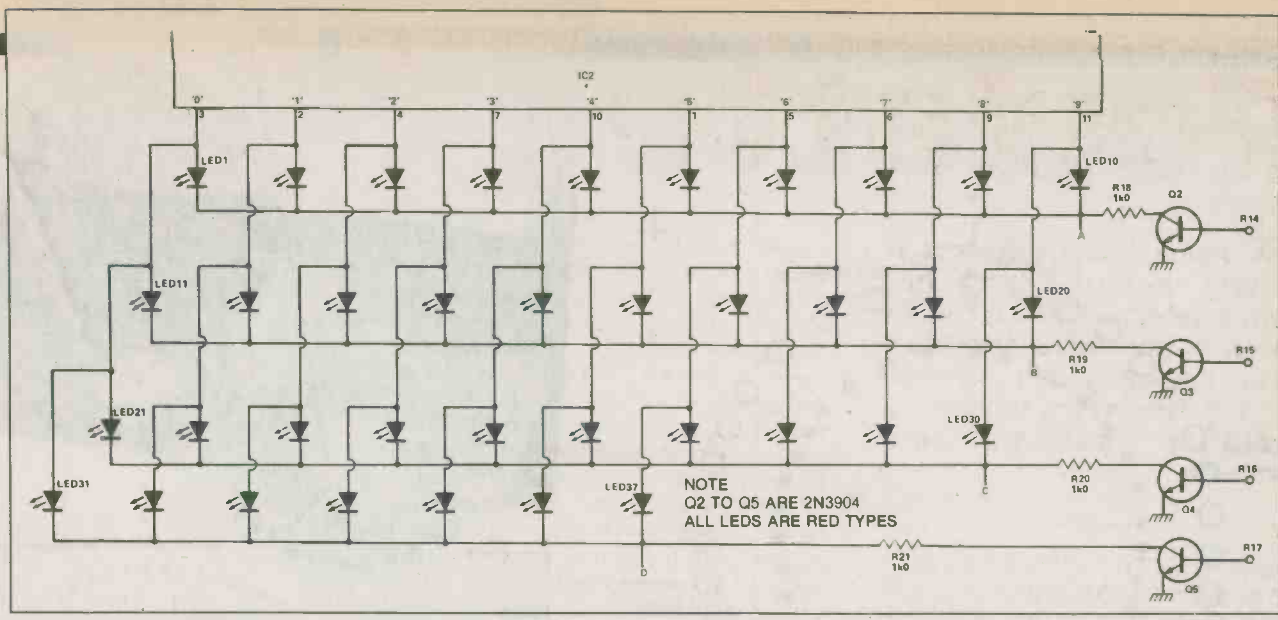


Fig. 2 LED display circuitry.

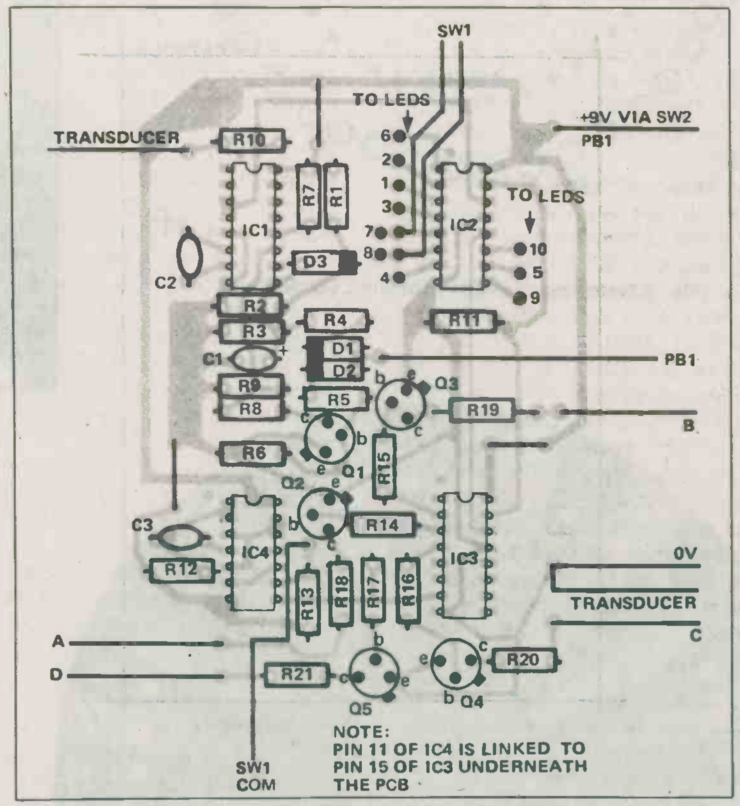


Fig. 3 Component overlay of the main circuit board. Don't forget the under-board link.

How It Works

The circuit comprises a clock generator (IC1-Q1) and a multi-stage counter/decoder network (IC2-IC3-IC4) that drives a circle of up to 37 LEDs in the dot mode. The counter/decoder network is deceptively simple. CD4017 decade counter/decoders IC2 and IC3 are wired in series so that IC2 counts in units and IC3 counts in tens when the clock signal is fed to pin 14 of IC2. The '3' output of IC3 and the '6' or '7' output of IC2 are NANDed via IC4d and used to trigger monostable IC4b-IC4c, which generates a 16 uS pulse and resets both counters to zero via IC4a each time that these two outputs go high simultaneously. The cascaded counters thus divide the clock signal by a fixed ratio of 36 or 37 (depending on the setting of SW1) and effectively produce 36 or 37 fully decoded outputs, which are used to sequentially turn on LEDs in the roulette ring or wheel.

The LED ring comprises three segments of 10 LEDs and one segment of seven LEDs. The anode drive to all LEDs is controlled by IC2 (the units counter), but the cathode paths of the LEDs are controlled by IC3 (the tens counter) via transistors Q2 to Q5. Thus, on the '15' count the '5' output of IC2 goes high and Q3 is driven on via the '1' output of IC3, so that only LED 15 illuminates. This multiplexing technique enables the 37 LEDs to be driven by fairly simple counter/decoder circuitry, which turns the LEDs on sequentially and produces an apparently-rotating ring of light.

The clock generator circuitry is delightfully cunning and is designed around the VCO section of a 4046 B phase-locked loop chip. The frequency of this oscillator is controlled by the value of C2, the resistance between pin 11 and ground and the voltage on pin 9. Slight bias is applied to the VCO by R7 to ensure that the VCO frequency falls to zero when the pin-9 voltage is reduced to zero. The output of the VCO is available at pins 3-4 and is fed directly to the input of IC2 and by R10 to the transducer (Tx), which produces a click sound each time a clock transition is generated.

The VCO circuit operates as follows. When PB1 is closed, pin 9 of IC1 is pulled high via D1-R4 (thus charging C1 to maximum voltage) and Q1 is turned on by D2-R5, thus connecting R8 between pin 11 of IC1 and ground. Under this condition the VCO operates at a few tens of kilohertz and causes the LED display to appear to spin at a rate of several hundred revs per second, so that the number of spins cannot be predicted by PB1.

When PB1 is released Q1 turns off, so that only R9 is connected between pin 11 and ground and C1 abruptly discharges to half-supply volts through D3-R2. Under this condition the wheel rotates at an initial visible rate of about two revs/sec. From this moment, C1 discharges exponentially through R3, so the pin-9 voltage and the wheel spin rate steadily decreases until, after about 15 S, the VCO stops generating and the wheel comes to rest. The operating sequence is then complete.

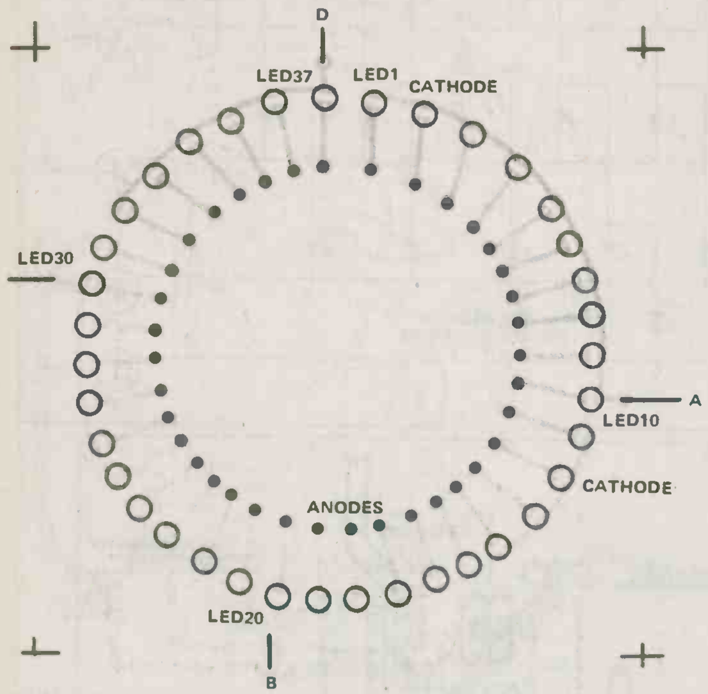
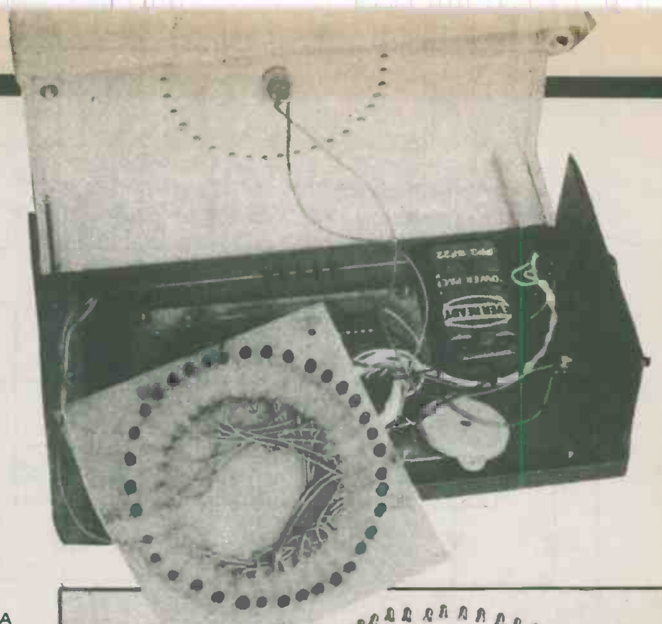
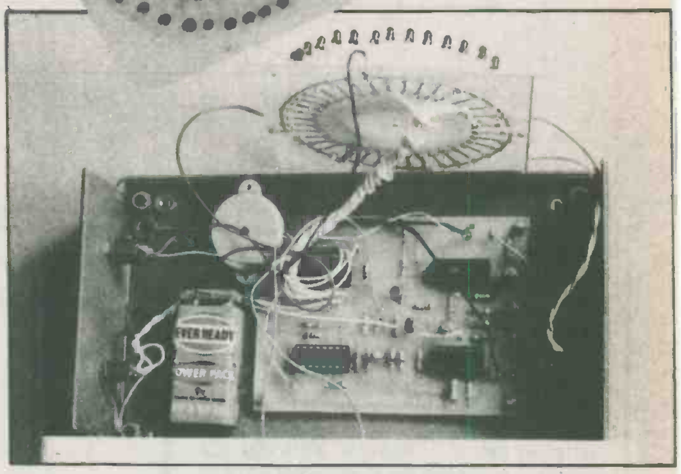


Fig. 4 Component overlay for the LED display.





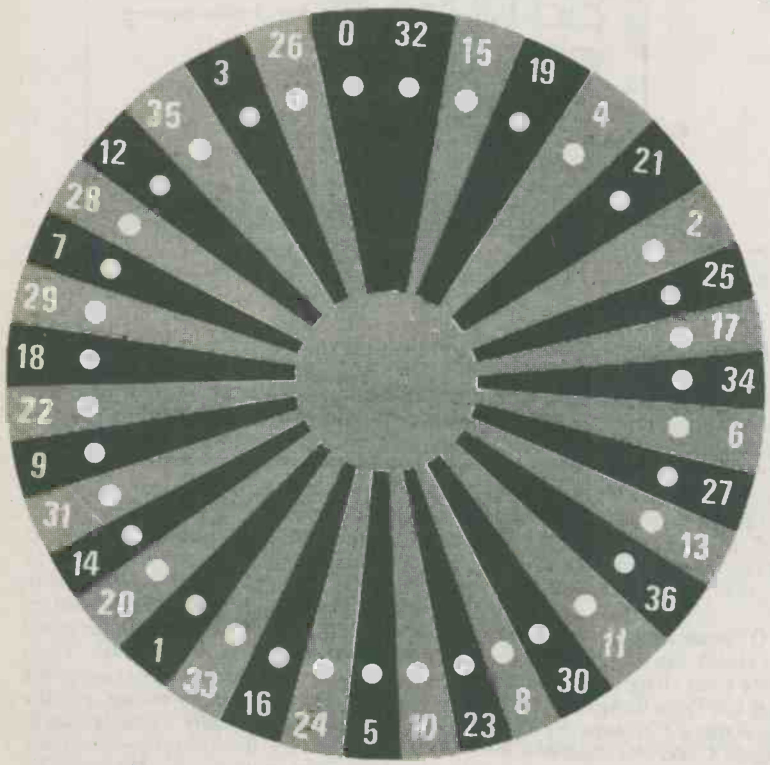


Fig. 5 Design for the 37 LED display.

Parts List

Resistors (all ½ W, 5% unless marked otherwise)

R1,2	6k8
R3,9	1M0
R4	470R
R5,6	47k
R7	10M
R8	10k
R10	820R
R11	100k
R12	27k
R13	270k
R14,15,16,17	12k
R18,19,20,21	1k0

Capacitors

C1	10u 35V tantalum
C2	10n polycarbonate
C3	1n0 polycarbonate

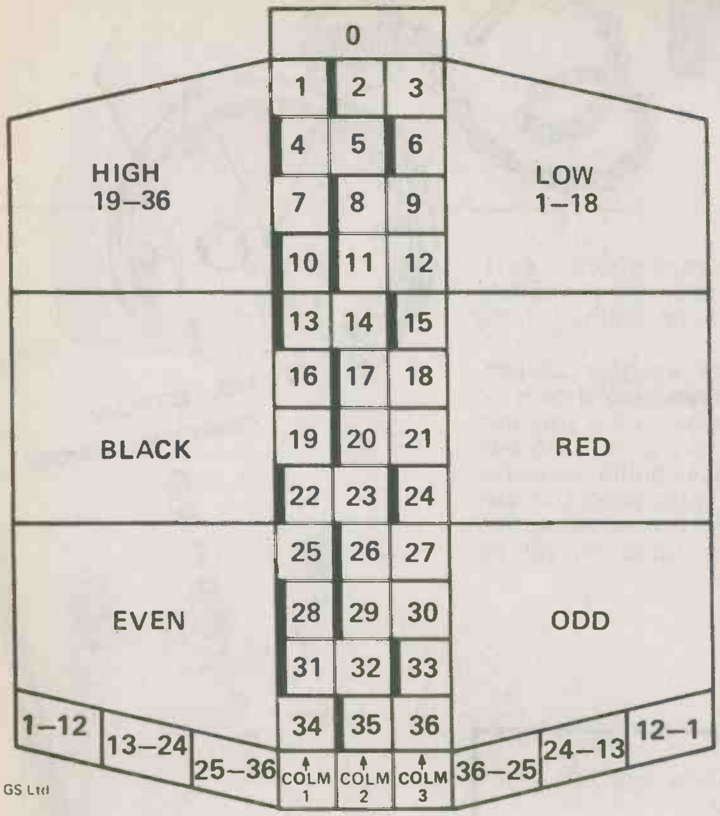
Semiconductors

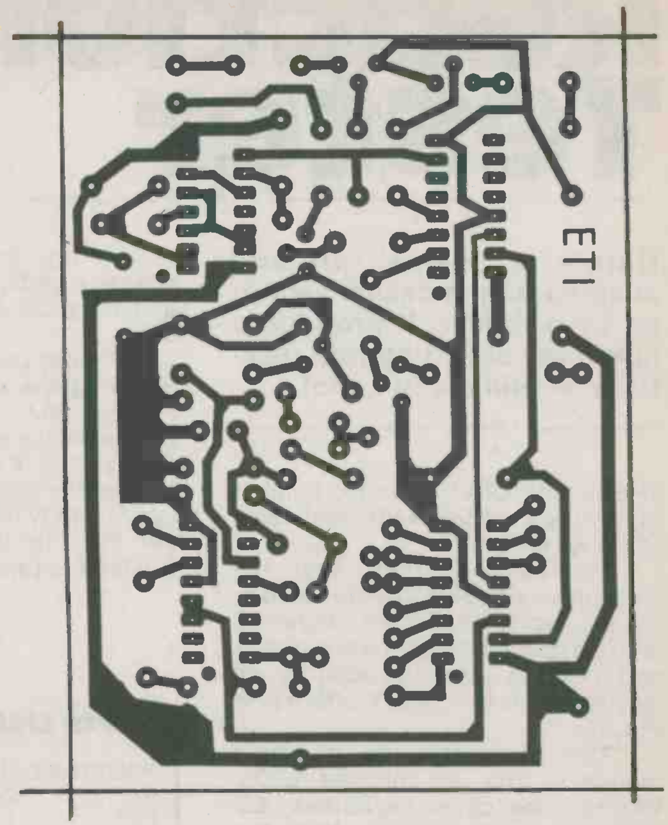
IC1	CD4046B
IC2,3	CD4017B
IC4	CD4011B
Q1,2,3,4,5	MPS6515
D1,2,3	1N4148
LED1-37	0.125" diameter (Red)

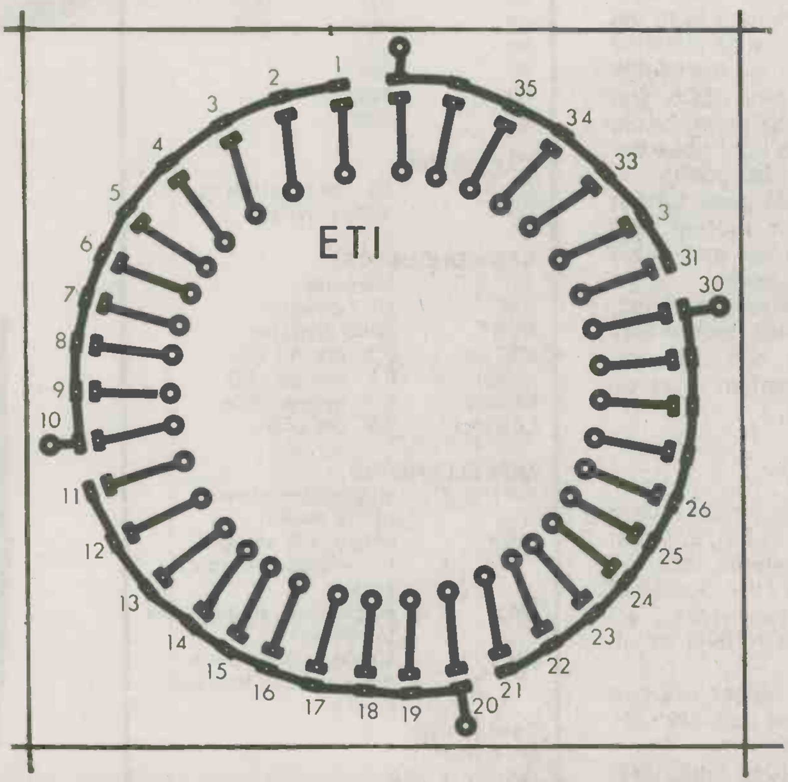
Miscellaneous

PB1	momentary push button
	Case
SW1,2	SPDT miniature toggle

1 9V battery
Transducer such as Radio Shack 273-065.

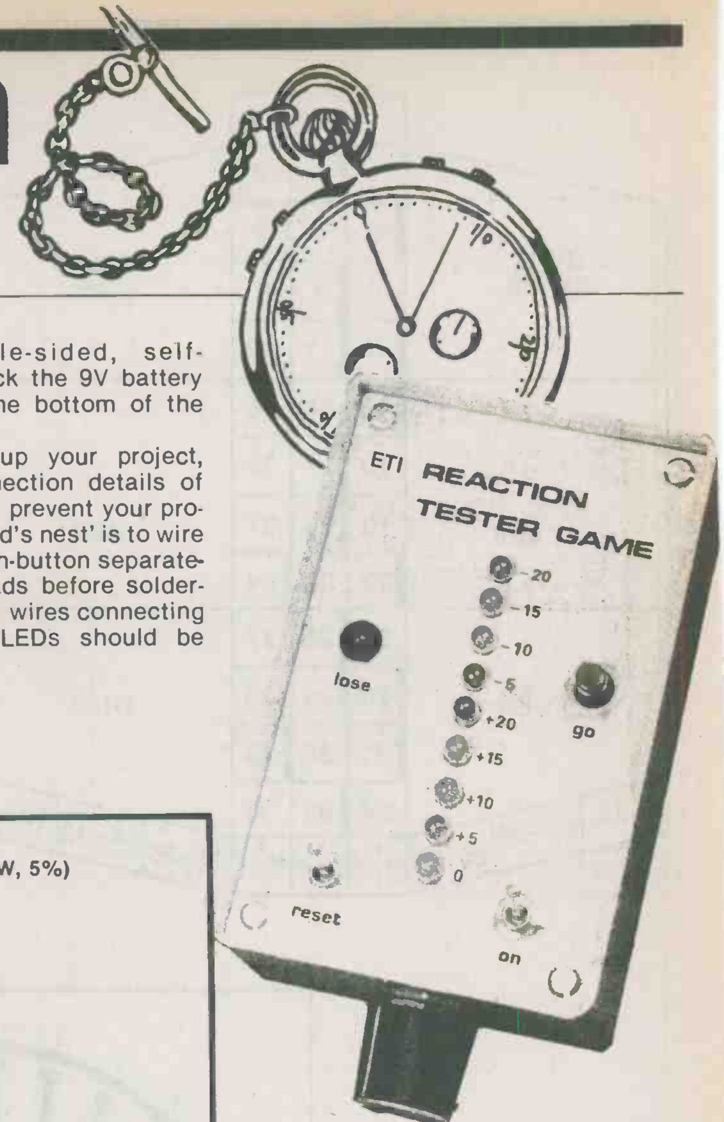






We've supplied the Roulette Game front panel construction and interwiring with this PCB.

Reaction Tester



Here's a 'game' project, adapted from a design sent to us by a reader. It provides a novel way of testing your reactions — and it's fun, too!

THERE ARE ONLY a limited number of ways you can use a 4017 and a 555. Or so we thought.

We used to think that the stockpile of possible ways of combining the two ICs had been exhausted until we opened the mail one morning and saw this ingenious idea for an electronic game from A. Trafford (see Fig. 1).

The game has, as its main feature, a row of coloured LEDs. When you switch on; the bottom LED lights up, ready for play. When the 'GO' button is pressed the light moves up the row. The idea is to get the light as far up the row as possible — the higher up the row, the higher your score — but not past LED5. You see, LED5 gives maximum score (+20 points) and if the light goes further up than this you lose points.

Finally, if the light goes further then LED9 (-20 points) another LED (LED10—LOSE) lights up, and stays on until you reset the game.

Now, as far as we're concerned, this game must definitely be the very last way that these two ICs can possibly be used together — or do you know differently?

Construction

Following the printed circuit board (PCB) overlay details in Fig. 2, insert and solder all components into the board, starting with the low-level components (ie, resistors, IC sockets). Solder in PCB pins at all connection points.

Next, insert and solder the two capacitors making sure capacitor C1 is the right way round.

Push the two ICs into their sockets, and insert and solder the thyristor SCR1 into place making sure that the polarity of all semiconductors is correct.

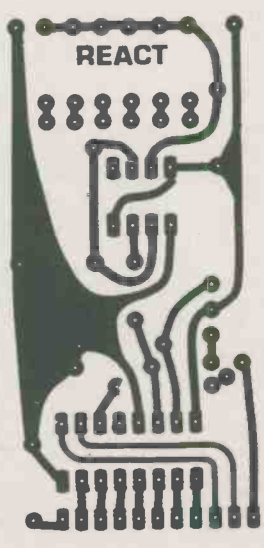
Now, mark and drill the case for switch SW2 and fit it into position.

Using double-sided, self-adhesive pads, stick the 9V battery and the PCB to the bottom of the case.

Finally, wire up your project, following the connection details of Fig. 2. A tip to help prevent your project becoming a 'bird's nest' is to wire each switch or push-button separately, twisting the leads before soldering. Similarly the 11 wires connecting the PCB to the LEDs should be twisted together.

Parts List

RESISTORS (All ¼W, 5%)	
R1	2k2
R2,7	10k
R3	18k
R4	27k
R5	39k
R6	47k
R8	22k
R9	820R
R10	470R
CAPACITORS	
C1	1u, 10V electrolytic
C2	100n polyester
SEMICONDUCTORS	
IC1	555 timer
IC2	4017 counter
SCR1	C103 thyristor
LED1-4	0.2" green LEDs
LED5	0.2" orange LED
LED6-9	0.2" yellow LEDs
LED10	0.2" red LED
MISCELLANEOUS	
SW1	single-pole, six-way rotary switch
SW2	single-pole, double-throw biased toggle switch
SW3	single-pole, single-throw toggle switch
PB1	single-pole, push-to-make release-to-break switch
Case to suit	
Knob to suit	
Battery + clip	



PCB pattern for Reaction Tester Game

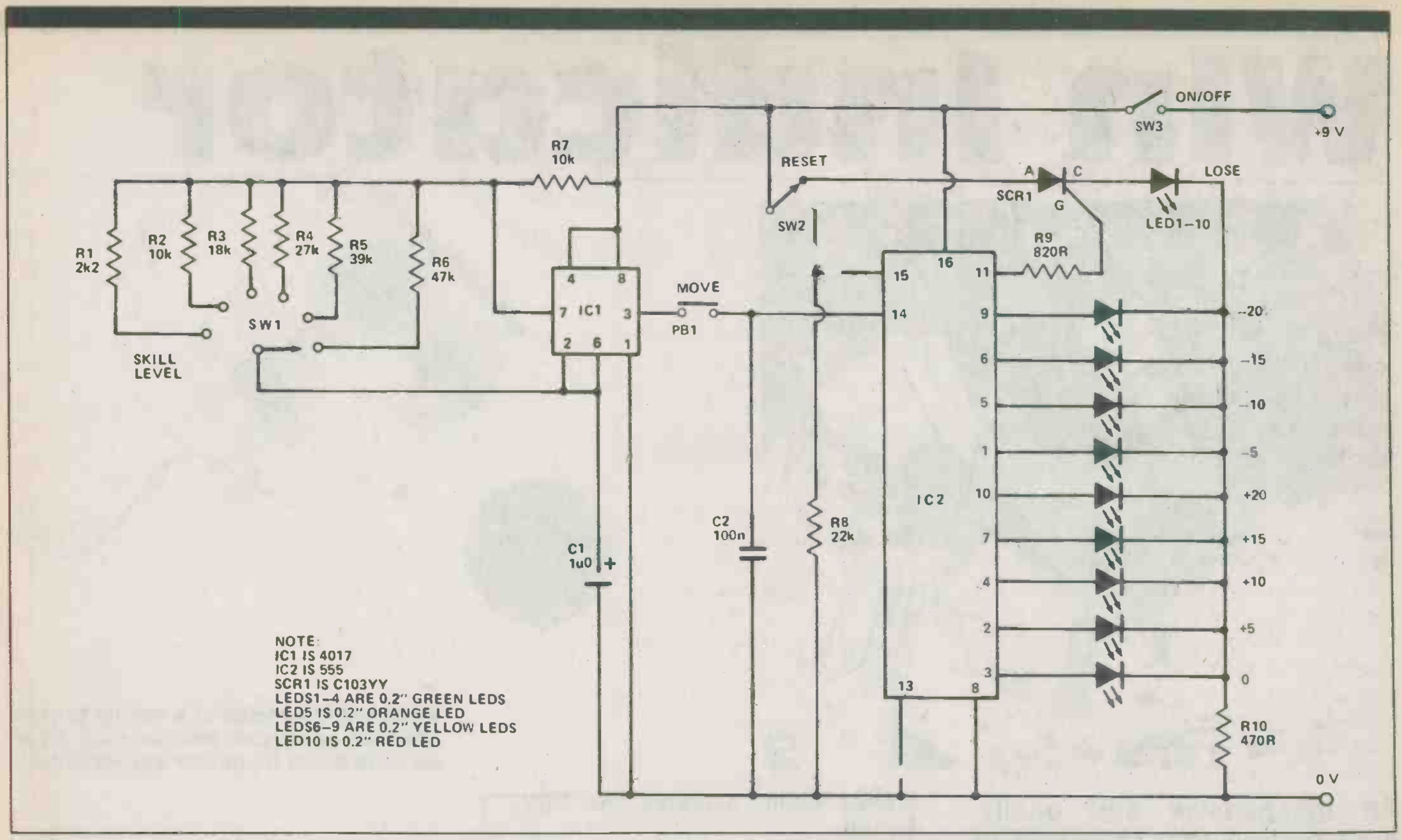
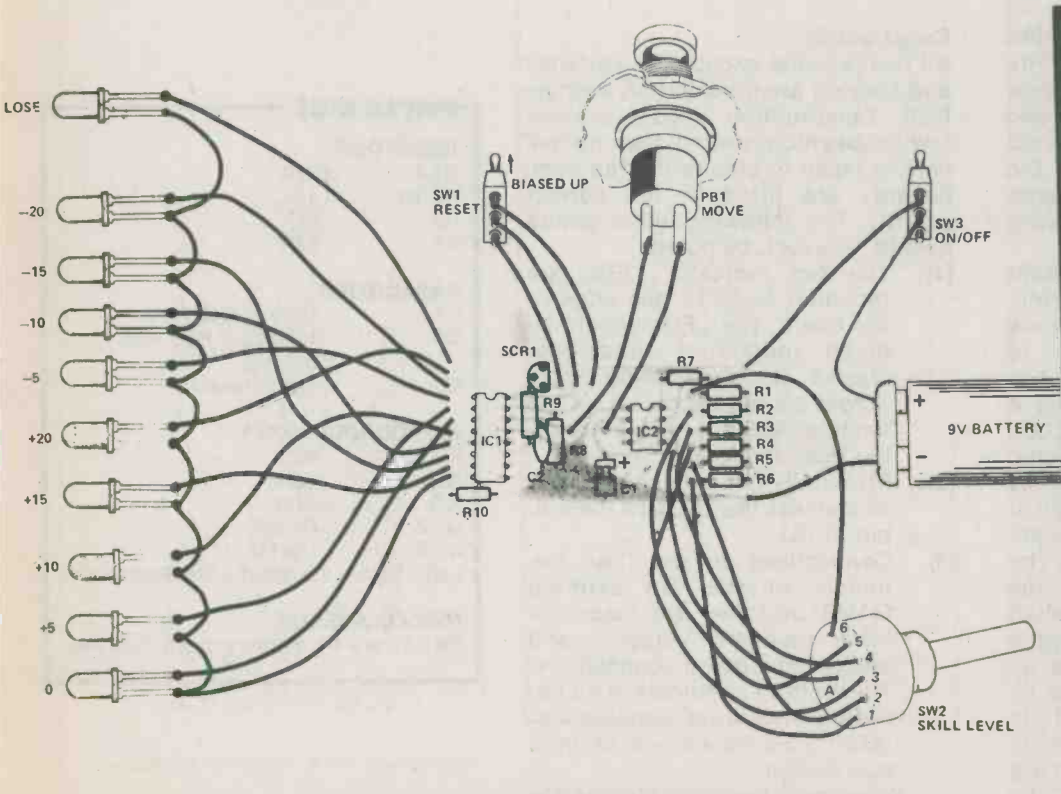


Fig. 2. PCB overlay and connection details of the project. From this you can see how one terminal of each LED (ie, their cathodes) are commoned and connected to resistor R10.



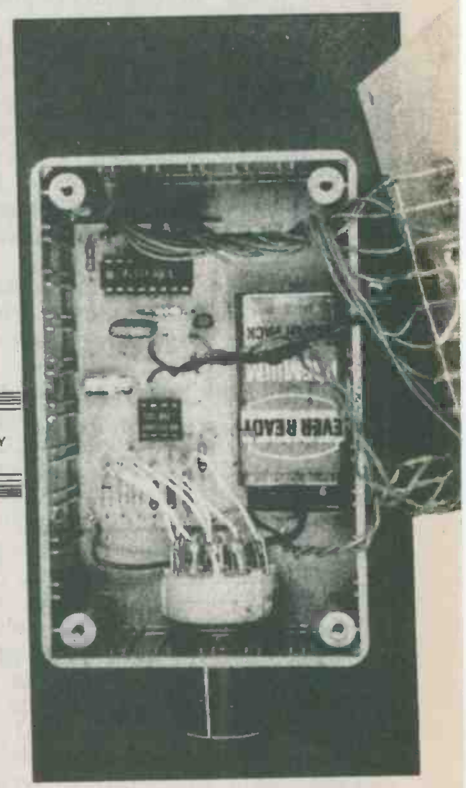
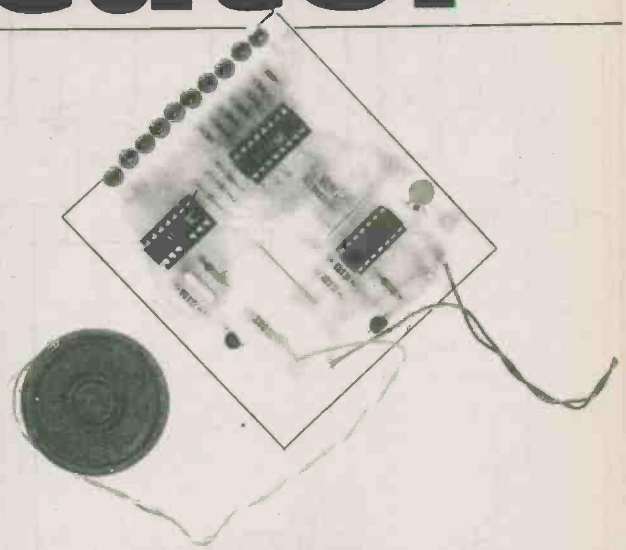


Fig. 1. Circuit of the ETI Reaction Tester Game.

Continued on page 144

Win Indicator



We've left the choice of a box up to you. The LED panel can also be used as a separate board for remote applications.

An inexpensive and easily-built project that is bound to be a winner with all games enthusiasts with ten or fewer arms.

THIS PROJECT IS DESIGNED TO BE used in those 'first-person-to-press-the-button-wins-the-game' types of activities that are so popular at parties and fund-raising functions. The device enables up to ten contestants to participate in such games and gives a virtually infallible audio-visual indication of the true winner of the game, even when all contestants seem to operate their push-buttons simultaneously.

In this project, each contestant is assigned a numbered push-button, with which an identically numbered LED (light-emitting-diode) is associated. Prior to the start of each game, the game referee presses a RESET button, which causes all LEDs to turn off and causes an electronic scanning circuit to start sequentially inspecting the state of each switch at a rate of several thousand scans per second. The 'game' switch to be subsequently operated causes the scanning action to lock at the switch position and activate a simple memory circuit, which energises an audible alarm and latches on the individual numbered LED that is associated with the winning switch; all subsequent switch operations are ignored by the unit. The alarm and the winning LED remain on until the referee again operates the RESET switch.

The ETI Multi-Input 'Game Won' Indicator circuit is powered from a single 9 volt battery and is an easy and inexpensive project to build. It can be used with any number of GAME switches up to a maximum of ten. Unwanted switches are simply omitted from the circuit.

Construction

All components except the switches and speaker are mounted on a single PCB. Construction should present few problems, provided that normal care is taken to ensure that all components are fitted in the correct polarity. The following minor points should, however, be noted.

(1) The ten indicator LEDs are mounted close to one edge of the board. The LEDs should be given individual functional checks (by connecting them across a 9 volt supply via a 470R limiting resistor) before soldering them into place.

(2) Five under-board links are used to connect the LEDs to the output of IC1.

(3) Connections to the 'top' terminals of the ten external GAME switches are made via three topboard Veropins and seven under-board connections. The 'bottom' terminals of all ten switches are wired together and taken to R2 via a single Veropin connection.

When construction is complete you can connect the unit to a speaker and a 9 volt battery and give it a simple functional test, as already described. The completed unit can then be fitted into a suitable case of your own choice.

Parts List

RESISTORS	
R1,4	27K
R2,3,6	12K
R5	68K
R7	82R
CAPACITORS	
C1	180p polystyrene
C2	100u 25 V PCB electrolytic
C3	47n polyester
SEMICONDUCTORS	
IC1	4017
IC2	4001
IC3	4011
Q1,2	2N2925
D1,2	1N4148
Led1-10, are standard 0.2in. Red leds	
MISCELLANEOUS	
PB1-11 are momentary push buttons.	

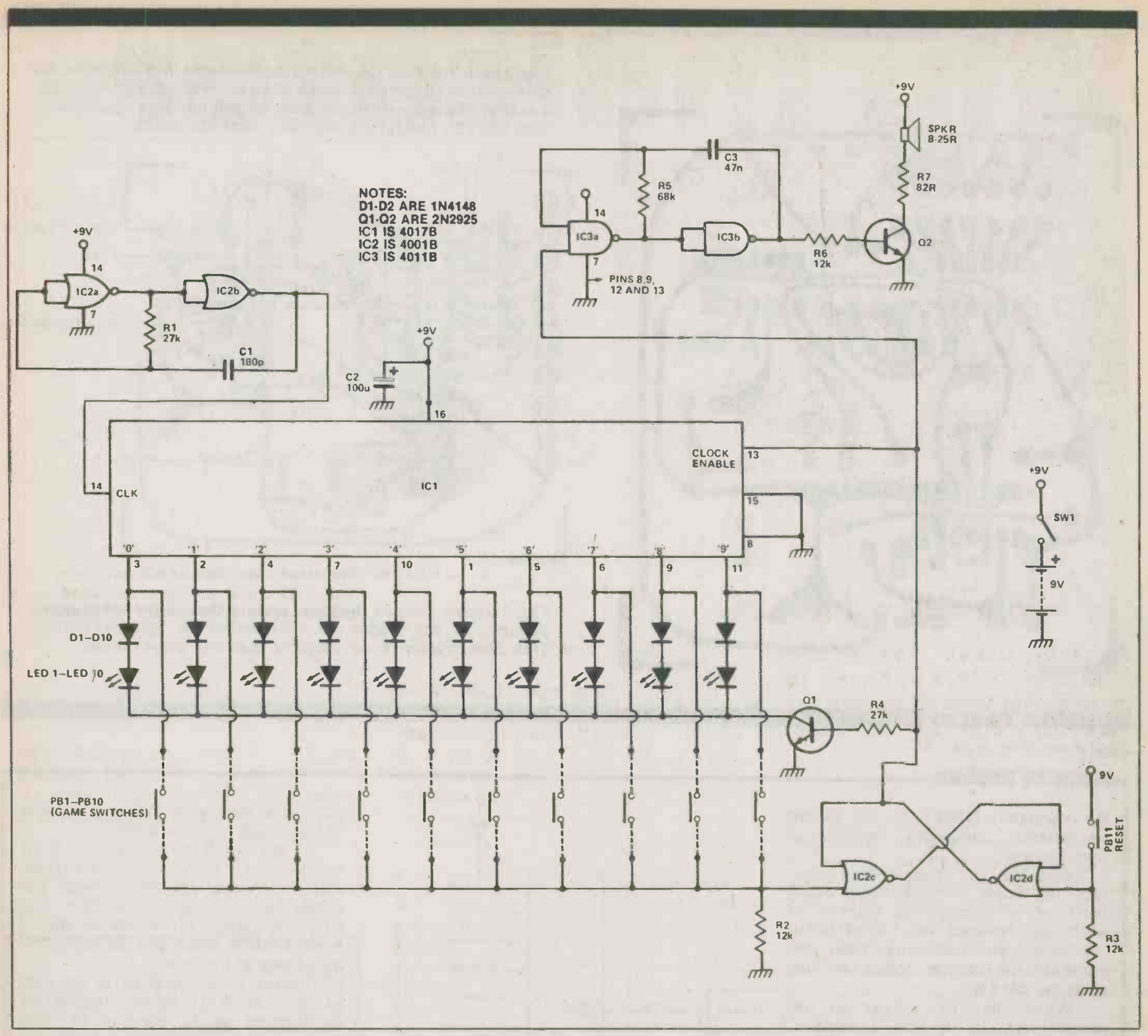


Fig. 1 The circuit diagram of the Win Indicator.

How It Works

IC1 is a 4017 'decade-divider-with-ten-decoded-outputs'. When this IC receives clock signals its ten decoded outputs sequentially go high in synchrony with the clock signals, with only one output being high at any given moment of time. An indicator LED is wired between each of these current-limited outputs and ground via switching transistor Q1. IC2a-IC2b are wired as a fast astable 'clock' generator that is permanently operational when on/off switch SW1 is closed. IC2c-IC2d are wired as a simple bistable that can be SET by a brief positive pulse across R2 or RESET via PB11. The output of the bistable is fed to the CLOCK ENABLE terminal of IC1, to the base of Q1 via R4 and to the input of a gated sound generator that is built around IC3 and Q2.

At the start of each 'game' the IC2c-IC2d bistable is reset via PB11. Under this condition IC1 accepts clock signals but Q1 is turned off, so none of the LEDs are operational. The IC3-Q2 sound generator is also turned off. In this mode of operation, sample or 'scanning' pulses are sequentially applied to one side of each of the normally-open game switches at the 'clock' rate.

If any of the PB1-PB10 GAME switches become momentarily closed during this operation the scanning pulse will pass through the switch to the SET position. Under this condition the CLOCK ENABLE terminal of IC1 goes high, causing the IC to lock at that scan position. Simultaneously, Q1 turns on, causing the LED associated with the winning switch to illuminate and give a visual indication of the game winner. The sound generator also activates at this time, giving an audible indication of the 'game won' state. The audio/visual indication then remains on until the bistable is reset via PB11 or until the circuit is turned off via SW1.

Win Indicator

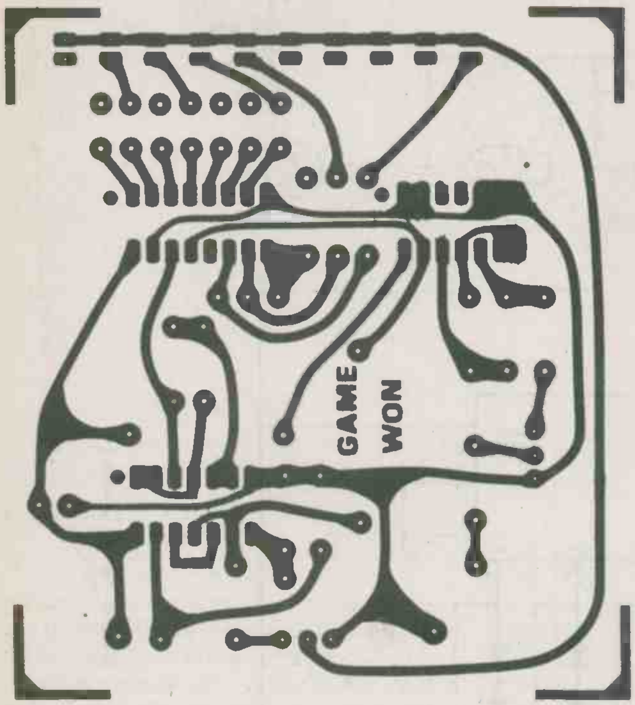


Fig. 2 Left. The PCB foil pattern for the Game Win Indicator. As was mentioned earlier, the use of an all-in-one design is purely a matter of personal choice. The unit will function equally well with the LED Indicator panel on a separate board.

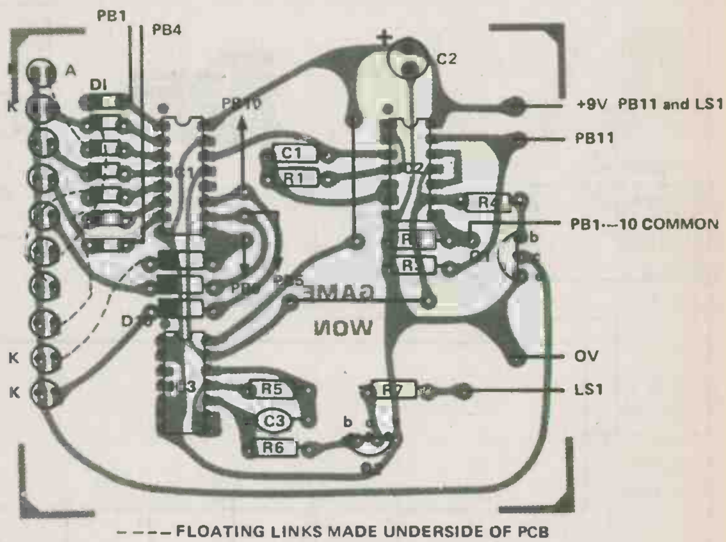


Fig. 3 Above. Overlay diagram. Ensure that all polarised components, i.e. ICs, diodes etc. are inserted the right way round. This causes more 'dead' projects than any other factor.

Reation Tester

Continued from page 141

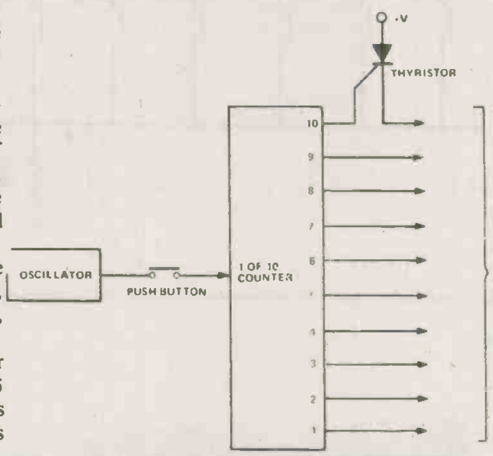
How It Works

An oscillator formed by an astable multivibrator continually oscillates at a set frequency.

Pressing the push-button connects the output of the oscillator to the input of a counter, the outputs of which are connected to a row of LEDs. On every positive pulse from the oscillator the counter counts on and lights the next LED.

When the '10' output of the counter turns on it fires a thyristor, which holds LED 10 on, permanently, until power is disconnected.

The astable multivibrator oscillator is configured round a 555 timer. The frequency of oscillation is determined by one of the resistors R1-6, and the chosen resistor is switched into circuit by a switch SW1.



A 4017 (IC2) is used as a '1 of 10 counter' and every time push-button PB1 is pressed, the 4017 counts the output pulses of the 555 oscillator. The first nine outputs of the counter directly drive LEDs which give an indication of the state of the count.

Output 10 is connected to the gate of thyristor SCR1 thereby turning on the thyristor on the count of 10. This thyristor drives LED 10, the LOSE indicator.

Switch SW2 disconnects power from the thyristor, thus turning off LED 10, and also resets the counter to a zero count. ●

Classifieds

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Alien Attack

Hand-held games are becoming just as popular as the arcade versions (we can play in the comfort of our own office!) so we just had to publish our own version.

ONCE UPON A TIME you could only blast the hordes of little green aliens by taking a trip to your nearest pub or amusement arcade. But it wasn't long before you could indulge your violent tendencies in the privacy of your own home with TV game versions. Nowadays it's possible to avoid withdrawal symptoms wherever you may be by purchasing a hand-held version — the invaders are even turning up in calculators. Now ETI presents a simple-to-build hand-held game that, while lacking the refinements of commercial machines (such as custom-designed little 'alien' LEDs), is still a lot of fun to play with and offers a full range of sound effects.

The 'field of battle' and the score display both take the form of a line of LEDs. When the game is switched on, 'aliens' begin to drop towards you, their passage being shown by the LEDs in the display lighting one after another. When the tenth and final LED is lit, you have to fire your laser at the alien by pushing the 'fire' button. If you're successful, the score display is increased by one and another alien launches his attack. For simplicity and low cost, a simple binary counter is used to register the score.

The catch is that as you destroy the aliens, the speed at which they fall increases quite rapidly. The game has a built-in time limit of about 25-30 s, and the object is to achieve the highest score before the game ends. Your reactions have to be pretty accurate because firing the laser when the ninth LED is lit will zero your score.

Four voltage-controlled oscillators are provided, giving the familiar tromp-tromp-tromp, laser fire, falling bomb and explosion noises. An on-off switch is provided for the sound so that battery life may be extended, if desired. The unit consumes approximately 15 mA with sound or 5 mA without.

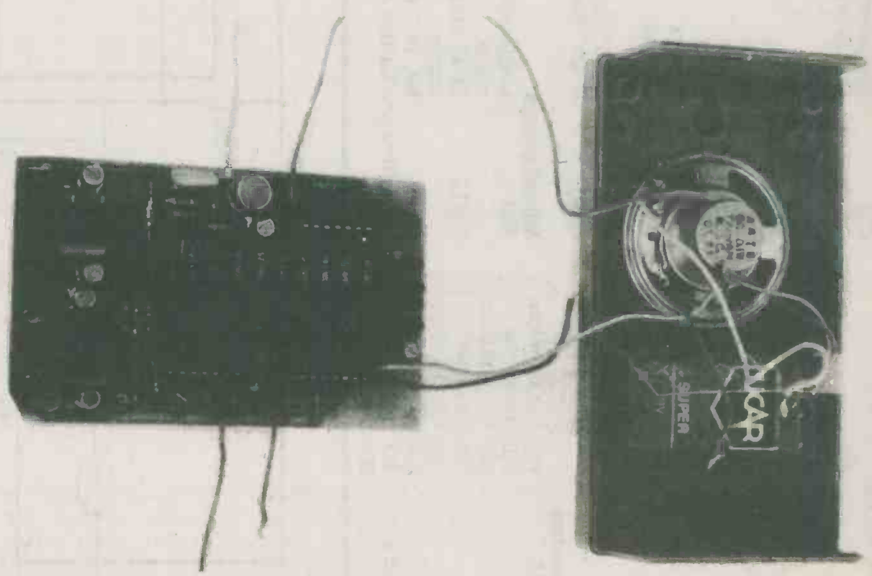
Construction

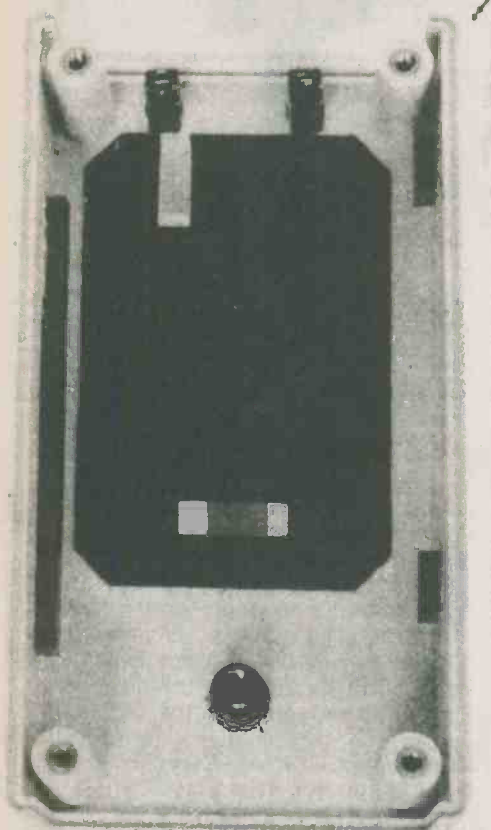
The circuit is built on a single PCB but for reasons of space this is fairly cramped and several components are mounted vertically. Tantalum capacitors are also used instead of ordinary electrolytics because of their small size. Solder all the components in place as shown on the overlay, using a soldering iron with a fine bit and lots of 'due care and attention'; the PCB tracks are very fine. Take the usual precautions when handling the CMOS ICs.

Note that R29 and C13 are not located on the PCB but are soldered onto the loudspeaker lead — the photographs should make this clear.

A T-shaped hole is cut in the top of the case to reveal the LEDs and a piece of red plastic can be stuck over the aperture to improve the viewing contrast. Of course, you'll have to cut holes in it above the green LEDs or they'll disappear! The three switches are also mounted on the top of the case; the loudspeaker is fixed to the bottom after drilling a few holes to let the sound out. Thin plastic strips are glued to the sides of the case to support the PCB the correct distance from the cutout. Now the interwiring can be completed and the case screwed together.

This completes the construction of the project; now you can be the envy of your fellow commuters and annoy total strangers in your efforts to beat your last score.





This photograph shows the red filter and plastic mounting strips glued into the top of the case.

Parts List

Resistors (all ¼W, 5%)

R1	4M7
R2-11,18	2k2
R12,24,26, 27,28	100k
R13,15,20,23	1M0
R14,16	22k
R17,21	470k
R19	10k
R22	330k
R25	180k
R29	150R

Capacitors

C1,13	10u 16V tantalum
C2	220n polyester
C3	22u 16V tantalum
C4	15n polyester
C5	1u0 16V tantalum
C6	8n2 polycarbonate
C7,9,10	4u7 16V tantalum
C8	33n polyester
C11	10n polyester
C12	47n polyester

Semiconductors

IC1	4017B
IC2	4081B
IC3,4	4011B
IC5	4024B
Q1-4	2N3904
D1-9	1N4148
LED1-9, 11-14	0.125" red LED
LED10,15	0.125" green LED

Miscellaneous

PB1	single pole push-to-make
SW1,2	SPST ultraminiature toggle
LS1	8R, 1½" diameter

9V battery and battery clip, case.

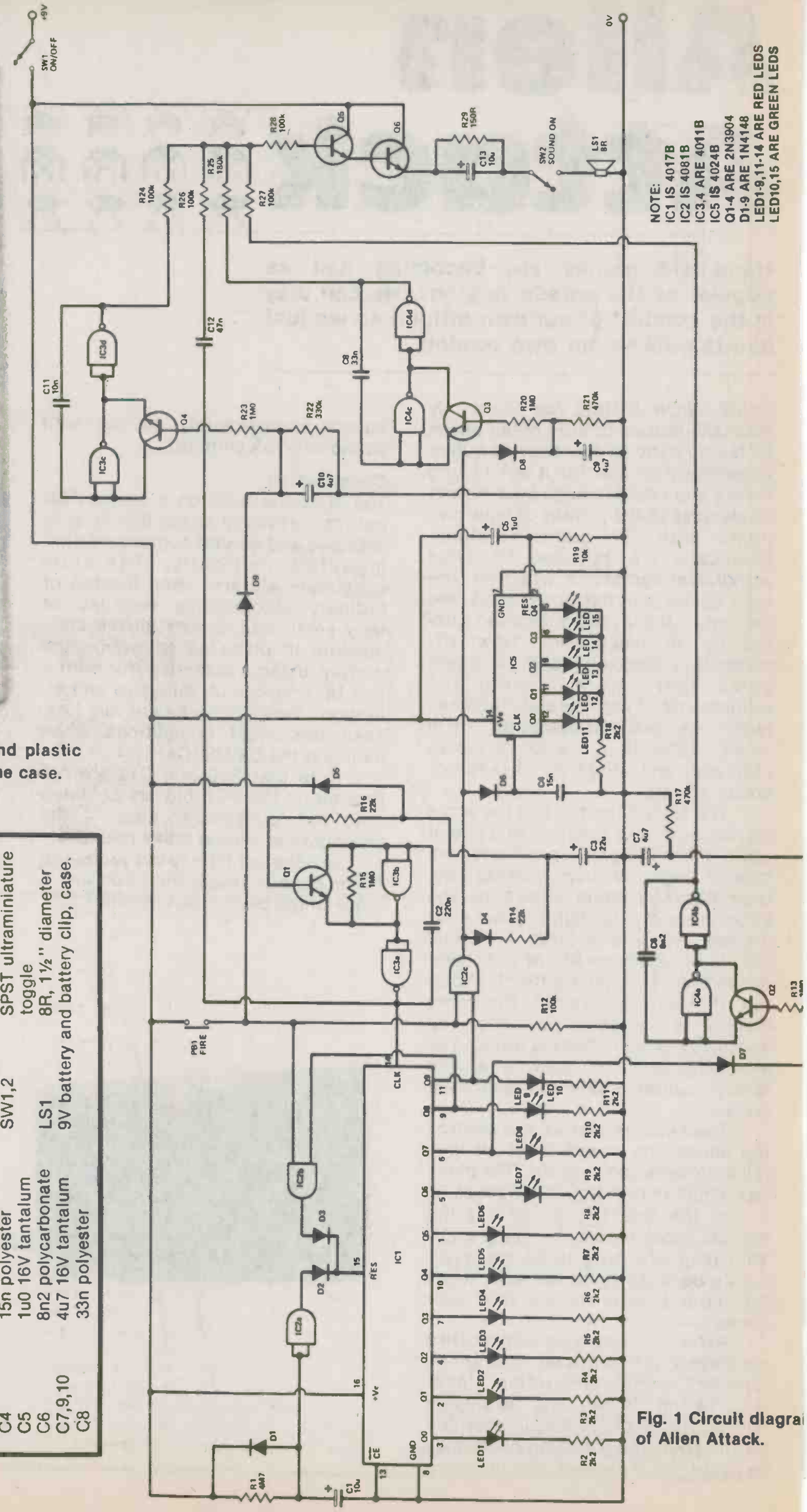
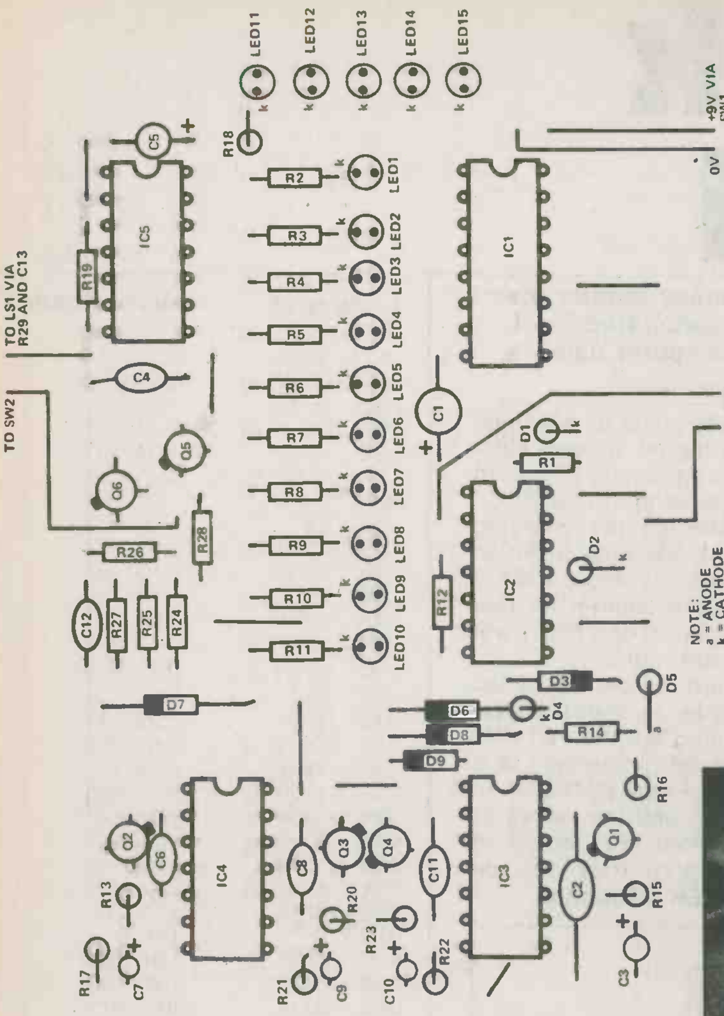


Fig. 1 Circuit diagram of Alien Attack.



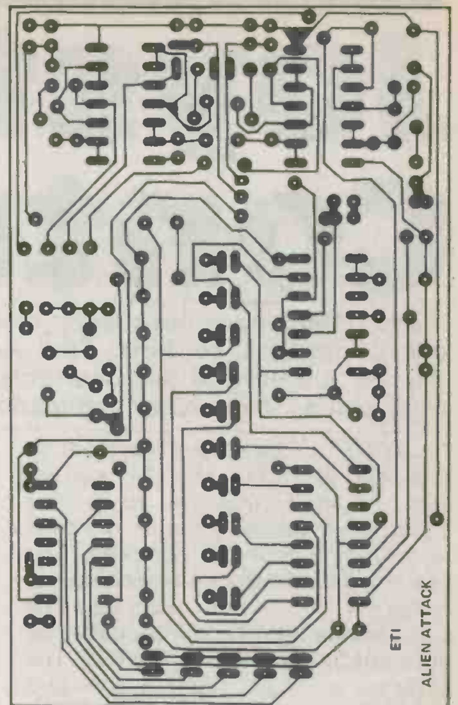
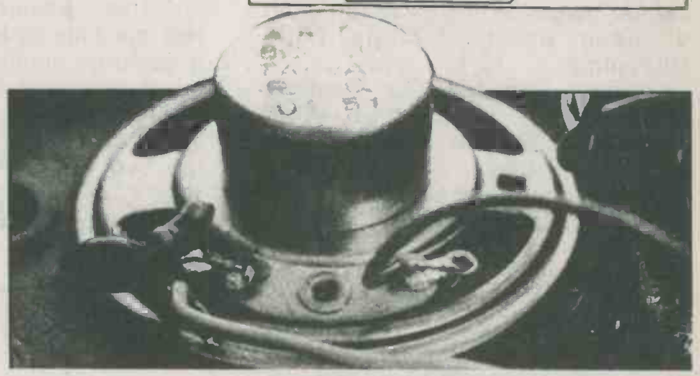


Fig. 2 Component overlay.



Here you can see R29 and C13 soldered to the loudspeaker.

How It Works

The circuit falls into four basic sections — the decade counter IC1, which lights LEDs 1 to 10 in turn; the binary counter IC5, which provides the scoring for the game; four voltage-controlled oscillators (VCOs) which provide the sound effects; and the mixer-amplifier, which drives a small loudspeaker.

The VCOs use the common CMOS oscillator circuit, but with a difference. Instead of using a fixed resistor with a capacitor to determine the frequency, a transistor replaces the resistor and functions as a variable resistor.

Taking the VCO formed by IC4a and IC4b as an example, it can be seen that with no connection to the base of Q2, the collector-emitter resistance will be very high, preventing C6 from charging and thus disabling the oscillator. However, if a voltage is applied to Q2's base the collector-emitter resistance will fall in proportion to the applied voltage. Thus the time taken for C6 to charge will be proportional to this voltage, and so will the frequency of operation of the oscillator.

If a capacitor and resistor are connected from the base of the transistor to ground, then fully charging the capacitor will give the highest oscillator frequency. As the capacitor discharges via the resistor, the frequency will fall until the circuit again stops oscillating.

In the case of the IC3a-IC3b VCO, the lowest frequency is determined by R15.

When the circuit is switched on, C5 provides a power-on reset pulse to IC5, thus extinguishing LEDs 11 to 15. C1 will also start to charge via R1 and when the voltage on C1 eventually reaches the threshold of gate IC2a counter IC1 will be held reset, thus ending the game. With the values shown, this should take approximately 25 s.

The IC3a-IC3b VCO will clock IC1, lighting LEDs 1 to 10 in turn. When LED8 lights a pulse will be fed to the VCO formed by IC4a and IC4b, giving a falling frequency.

If the 'fire' button (PB1) is pressed, then the IC3c-IC3d VCO will be enabled. Pressing PB1 when LED10 is lit will result in IC2c enabling the VCO formed by IC4c and IC4d, and also charging C3 by an amount determined by R14. Thus the VCO driving IC1 will increase in frequency. IC5 will also be clocked, adding one to the score. C4 debounces the clock input.

If PB1 is pressed when LED9 is lit, a reset pulse is sent to IC1 by IC2b, thus preventing cheating.

The four oscillator outputs are mixed by R24-27 and C12. Q5 and Q6 act as an amplifier, driving an 8R speaker, through the filter formed by R29 and C13. This filter prevents excessive DC from reaching the speaker, as would happen if one of the VCO outputs stayed high.

Because IC2a has no hysteresis applied to the input, as the voltage on C1 reaches the gate's threshold the output will oscillate, which results in the aliens making several abortive attacks. D1 and D5 ensure that capacitors C1 and C3 are discharged at the end of each game when the circuit is switched off. This ensures that the game length and starting speed of the aliens are the same for each game.

Joystick Control

Video games have never been more popular, but many require the use of joystick controls. This A-to-D converter, submitted by I. Forster will provide such controls for any microcomputer using a 6502, will as many other applications.

THIS ARTICLE describes a system for analogue-to-digital (A-to-D) conversion, originally intended to provide cheap and simple joystick controls for a Commodore PET computer. The system should work on any computer having a USER port, although the software necessary will probably be different to that used by the PET. The software is in 6502 machine code and can be merged with a BASIC program or used as a machine code subroutine.

Apart from joystick controls there are a number of other possibilities inherent in the principle. A few of these are described, although no practical results have been obtained with these circuits yet. The field is open for the experimenter!

There are a number of improvements possible, such as using both the X and Y registers in the 6502 as counters, giving 64K resolution on an input. Hardware improvements are also very definitely possible, although beyond a certain point it would probably be much cheaper to build a dedicated device.

Joystick Controls

The circuit for use with a joystick unit is shown in Fig. 1. Two of these are necessary, one for the X axis, one for the Y. The flow diagram for operation is shown in Fig. 2. X volts is the transfer voltage of one gate in the 4081BE. This is not very predictable and better results could be obtained using a Schmitt trigger of some kind, such as the op-amp circuit shown in Fig. 3 or a CMOS Schmitt gate. If C1 is increased, keeping the charging resistor constant, the time taken to reach X volts becomes larger. If C1 is made too large the counter (in this case the X register of the 6502) will overflow and count round.

The software is disassembled Hex machine code, as shown below. It could be entered via the PET TIM monitor or as a data statement in a BASIC program. From BASIC it is called by SYS 826 and the values of the two conversions are stored in 1022(X) and 1023(Y); they can be retrieved by a PEEK instruction.

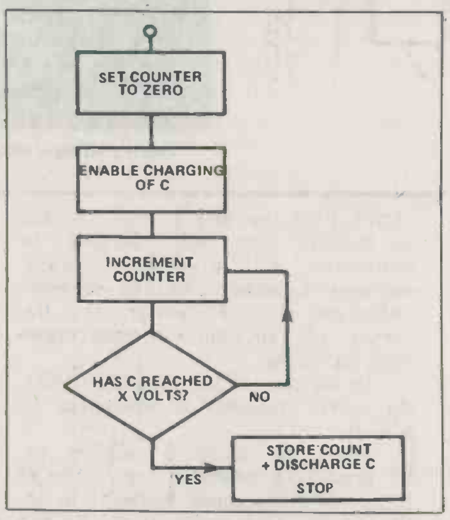


Fig. 2 Flow diagram for the ADC.

LOC'N	CODE	INSTRUCTION
033A	78	SEI
033B	A9 55	LDA *55
033D	8D 43 E8	STA E843
0340	A9 00	LDA *00
0342	8D 4F E8	STA E84F
0345	A9 01	LDA *01
0347	8D 4F E8	STA E84F
034A	A2 00	LDX *00
034C	E8	INX
034D	AD4F E8	LDA E84F
0350	C9 A3	CMP *A3
0352	D0 F8	BNE 034C
0354	A9 00	LDA *00
0356	8D 4F E8	STA E84F
0359	8E FE 03	STX 03FE
035C	E8	INX
035D	E0 FF	CPX *FF
035F	D0 FB	BNE 035C
0361	A9 55	LDA *55
0363	8D 43 E8	STA E843
0366	A9 00	LDA *00
0368	8D 4F E8	STA E84F
036B	A9 04	LDA *04
036D	8D 4F E8	STA E84F
0370	A2 00	LDX *00
0372	E8	INX
0373	AD4F E8	LDA E84F
0376	C9 AC	CMP *AC
0378	D0 F8	BNE 0372
037A	A9 00	LDA *00
037C	8D 4F E8	STA E84F
037F	8E FF 03	STX 03FF
0382	E8	INX
0383	E0 FF	CPX *FF
0385	D0 FB	BNE 0382
0387	58	CLI
0388	60	RTS

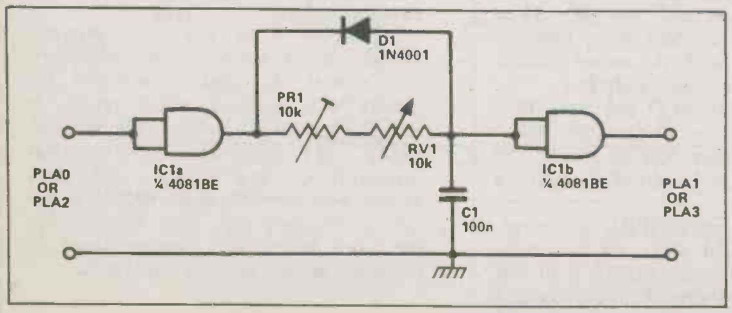


Fig. 1 Simple joystick version of the analogue-to-digital converter.

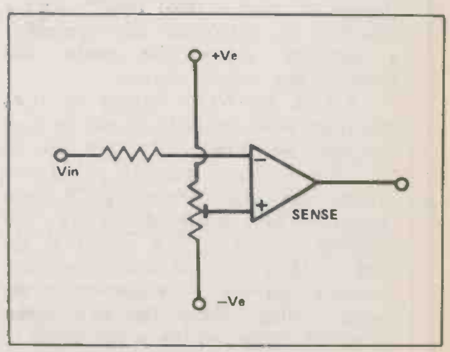


Fig. 3 Using an op-amp as the sensing device allows the transfer voltage to be chosen to suit.

Simple Sums

The calculations involved are simple and are shown below.

Let X be the transfer voltage of IC1b — ie the voltage at which IC1b's output switches high. Then the time taken to get to X volts can be derived thus:-

$$Q = C1 \times V$$

where Q is charge
V is voltage

Also $Q = I \times t$
where I is current
t is time

so $t = C1 \times V/I$

Since V = X(transfer voltage)

$t = C1 \times X/I$

But $I = V_{DD}/R$

where R depends on the setting of PR1 and RV1

So $t = C1 \times S \times R/V_{DD}$

$C1, X, V_{DD}$ are constant and so it is proportional to R.

Time And Again

Two other circuits are shown in Fig. 4 and Fig. 5 which use the principle of measuring the time taken to charge a capacitor. In both cases the symbol labelled 'sense' is a Schmitt trigger of some kind. The voltage across the analogue gates of the 4016BE should be less than the power supply to the chip. However, a simple op amp prescaler theoretically allows voltages up to the breakdown voltage of the resistors used to be measured. All the levels returned to the PET must be 5 V logic, so the 4016, inverter and sense output should all be 5 V logic. IC1b in Fig. 4 could be removed, although this complicates calculations because the capacitor will not start charging from 0 V.

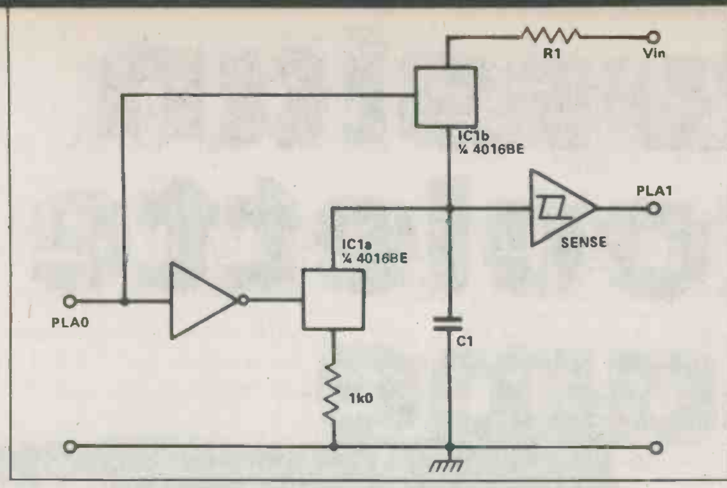


Fig. 4 Experimental voltmeter.

The circuit of Fig. 5 is designed as a frequency meter with a range of 0-100 kHz. The 741 produces a square wave of the same frequency as the input. MM1 is a positive-edge-triggered monostable with a period of 10 uS; its output is fed via a diode, analogue gate and resistor to charge the capacitor. The leakage of the capacitor could be very significant so care must be used in selecting the values of R and C as well as component types.

Current can be measured by using a virtual ground type circuit for an op-amp. With a 741 only about 10 mA can be measured since it can only sink a maximum of 20 mA. A resistive divider network or a power op amp could improve this.

Conclusion

The circuits described are fairly crude but could offer useable results to the amateur electronics experimenter. Expense is a major factor in most circuits, and most of these could be built for a few dollars. Of course, you need a computer! Beware of locking your machine into endless loops — this is harmless to the computer but very wearing on your nerves. If not already provided, setting up a way of using the NMI (nonmaskable interrupt) on your processor might be advisable. Good luck!

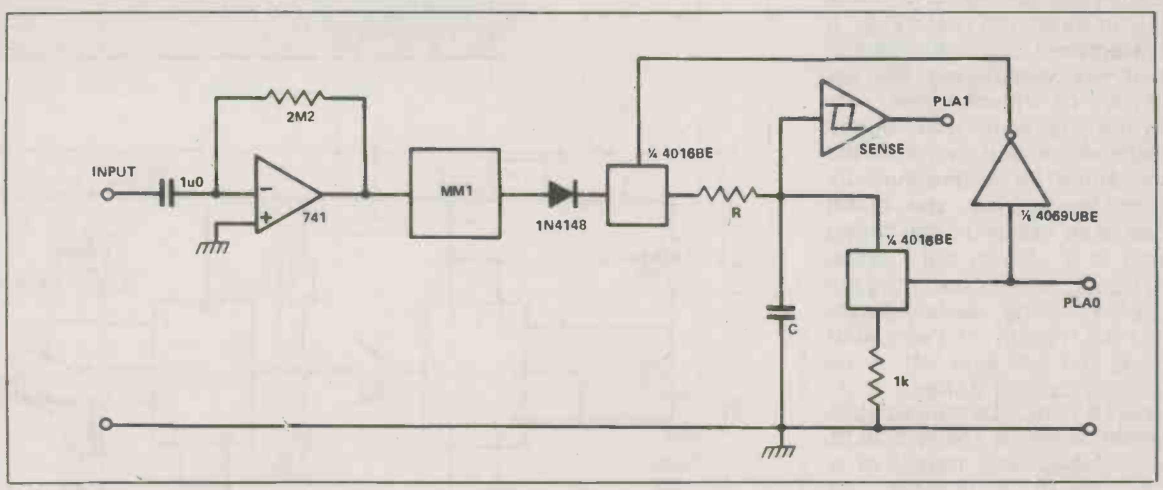


Fig. 5 Experimental frequency meter.

Russian Roulette Game

This one will just kill you — a harmless electronic simulation of a dangerous game. Save the expense of redecoration: better still, save your life — with this fun-filled game from ETI.

RUSSIAN ROULETTE as a game apparently originated in the officers' mess of army posts around the world, where shell-shocked officers would gamble with their own lives merely as a relief to boredom. The idea was to load one bullet in the chamber of a revolver, then to spin the chamber so the nobody would know exactly where the bullet was in relation to the firing pin. One of the men would then hold the gun pointed to his own head, pull the trigger and — if he was lucky (an average of 5 out of 6 times) — click, if not (1 out of 6) — bang.

The ETI Russian Roulette Game harmlessly imitates the real thing. It uses an integrated circuit to clock in a cycle of six, simulating the six bullet spaces of the chamber. By operating the spin switch the 'bullet' is automatically moved round — the chamber is spun. Each time the 'trigger' switch is pressed, the bullet comes one step closer to the 'firing pin', which is a LED in our game. When the bullet reaches the firing pin the LED lights, 'killing' the last player who pulled the trigger. The winner of the game is the last one left — he buys the next round of drinks.

As you can see, we managed to fit our prototype inside the handle of a full-sized polystyrene model of a gun (a 4" Smith & Wesson .44 Magnum). There is, of course, no reason why an ordinary plastic potting box can't be used: we chose a gun simply to make it look good. So, we'll leave the choice of casing up to

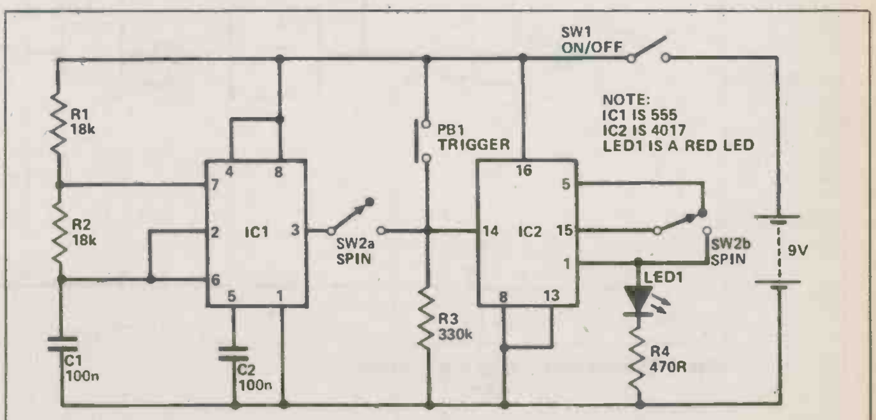


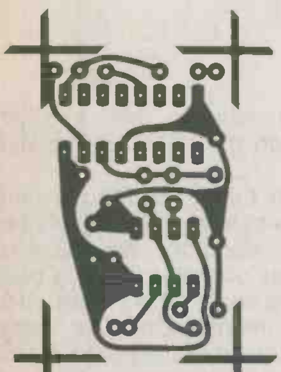
Fig. 1 Circuit diagram

you and deal only with the electronics.

If you are restricted by size, as we were, then you should use our PCB design. The circuit shouldn't be much bigger if you build it on Veroboard but those extra few millimetres might just give you the edge. Begin by inserting the resistors, followed by the two capacitors as shown in the overlay in Fig. 2.

At this point we normally advise you to use IC sockets but if you are troubled by lack of space then solder the ICs directly into the board. The 4017 is a CMOS chip and as such should be handled carefully. Use a grounded soldering iron and, as with any semiconductor, solder one pin at a time, letting the device cool before soldering the following pin.

Next, connect the switches, LED and battery as shown in Fig. 2 using a good-quality momentary-action push switch for PB1. Then switch on and try it out.



PCB pattern

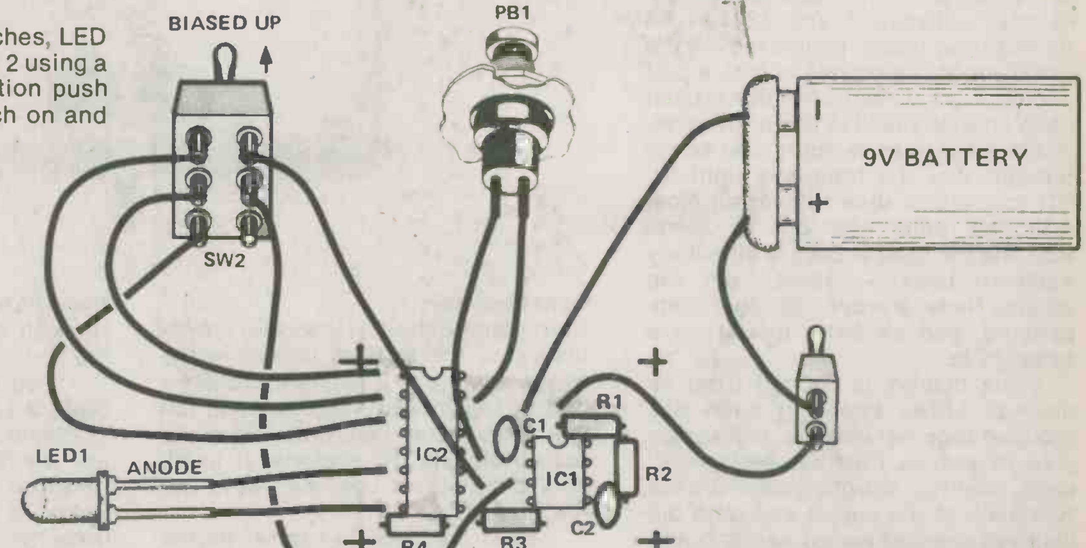


Fig. 2 Overlay of the printed circuit board.

Parts List

RESISTORS (All ¼ W, 5%)

R1,2	18k
R3	330k
R4	470R

CAPACITORS

C1,2	100n ceramic

SEMICONDUCTORS

IC1	555 timer
IC2	4017 decade counter/divider
LED 1	red LED

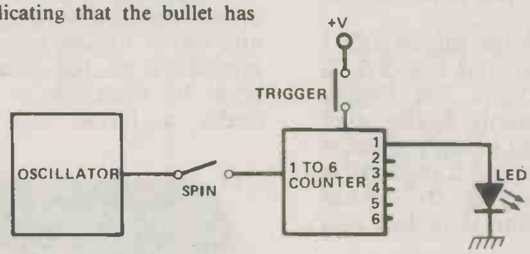
MISCELLANEOUS

SW1	single-pole, single-throw miniature toggle switch
SW2	double-pole, double-throw miniature toggle switch
PB1	single-pole, single-throw, momentary action push switch

9 V battery + clip
Case to suit

How It Works

An oscillator clocks the counter whenever the spin switch is pressed. Upon release the state of the counter is not known. Pressing the trigger switch clocks the counter on, one step. If that is the number one output, the LED lights indicating that the bullet has been fired.



The oscillator is formed around a 555 astable multivibrator circuit operating at about 250 Hz. This frequency is defined by the resistor/capacitor chain R1,2 and C1 according to the formula:

$$f = \frac{1.45}{(R1 + 2R2) \times C1}$$

Switch SW2 is the spin switch, which does two jobs when pressed: it connects the oscillator to pin 14, the clock input of the 4017 counter, and it isolates the LED so that it cannot flash. Releasing SW2 stops the 4017 from clocking. Each press of the trigger switch, PB1, provides one pulse to the clock input and thus moves the 4017 on one step. When the output of the counter corresponds to the LED connection the LED lights up.

Double Dice

"Double 'em up?" says the jack at the Vegas craps table. "Sure," you respond, "but this time I want to use my own set." And you hand him the ETI Double Dice.

A LARGE percentage of games need some system whereby a random number between 1 and 12 can be quickly and easily generated — the usual way of doing this is with a pair of dice. A good electronic dice project hasn't materialised in any of the electronic magazines recently and so we thought that the time was right for ETI to produce dice to beat all dice. Although quite ingenious in operation, the ETI Double Dice is simplicity itself to built — apart from the display there are only 18 other components, and all parts mount on a small PCB.

The display is formed from individual LEDs, seven in each die, grouped together into the well-known dice formation. Five ICs perform all logic, control, counting and driving functions of the circuit and both die displays are completely random and non-synchronised.

The device is touch-controlled: simply placing a finger over the two contacts starts operation of the dice. The LEDs light up and are seen to flash at a fast rate (showing that the 1 to 6 sequence is in operation.) Upon removing the finger, the LEDs stop flashing and hold the last number displayed.

After a short time, all the LEDs extinguish, showing that the dice is ready for its next "roll". The display period is defined, mainly, by the value of capacitor C1, and using the value shown a period of about 5 seconds is obtained. Increasing its value lengthens illumination time and vice versa.

LEDs need a fair amount of current to give a reasonable illumination and if they remained on at all times, battery life would be severely limited. The self-cancelling function reduces the average current consumption of the circuit and therefore prolongs battery life.

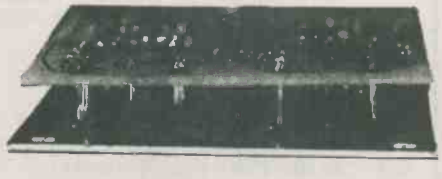
Construction

Start construction by inserting the six links into the PCB as shown in the overlay diagram. It is helpful to use a pair of long-nosed pliers to bend the link wires before insertion. Resistors, capacitors and IC sockets, if used, should be put in now, but leave the ICs till last.

Next, insert LEDs 1 to 14 into the board in the double dice information. Mount them about 10 to 15 mm above the PCB so that they stand above the maximum height of the other components. Connect the switch, battery and touch contacts (two wires will do for test purposes), plug in the five ICs, switch on and test the project.

Housing the PCB in a case should not be a problem. Suggestions are: either mount your board on the underside of the case lid, drilling holes for the LEDs to mount into, or make a panel out of coloured transparent plastic (or similar) through which the LEDs will be visible.

You can make your touch contacts out of virtually any small pieces of electrical conductor. We chose to use the heads of metal drawing pins inserted through the case lid. Soldered connections can be made underneath the lid to the board. If you do the same, remember that a metallic lid conducts and the contacts will have to be insulated from it.



Side view of the Double Dice showing the position of the LEDs.

Parts List

RESISTORS (All ¼W, 5%)	
R1	4M7
R2	220k
R3	10M
R4,8	2k7
R5,9	1k0
R6,10	680R
R7	270k
CAPACITORS	
C1	1u0 polycarbonate
C2,3	100n polyester
SEMICONDUCTORS	
IC1	4001 quad, 2-input NOR
IC2,4	4025 triple, 3-input NOR
IC3,5	4522 programmable BCD counter
LED1-14	miniature red LEDs

MISCELLANEOUS
single-pole, single-throw toggle switch
battery clip
case to suit
touch contacts

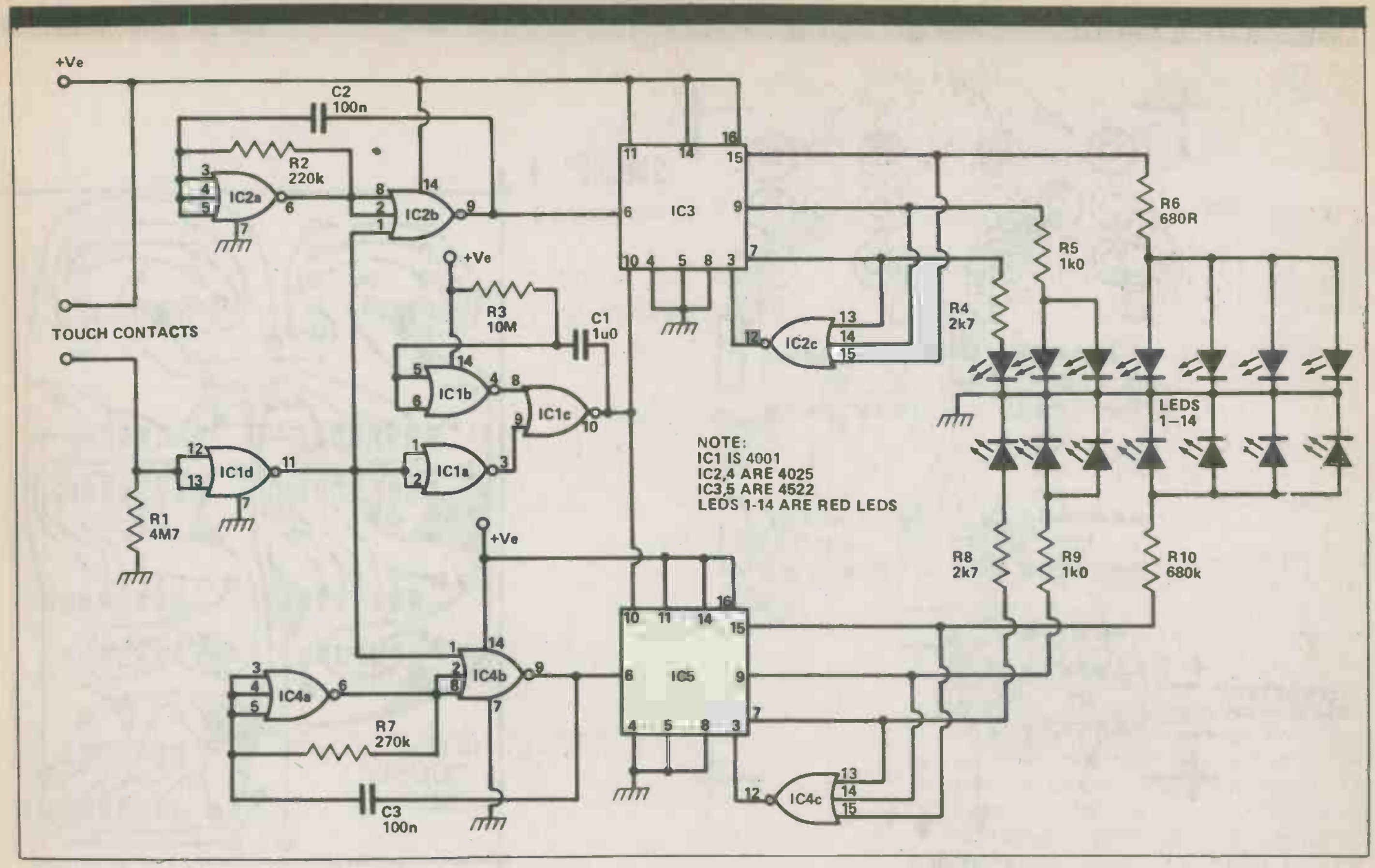
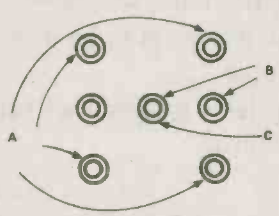


Figure 1. Circuit diagram of the Double Dice.

How It Works

The circuit of theDouble Dice can be seen in Fig. 1. By cross-referring to it, the operation of the dice may be more easily understood. Most of the circuit is duplicated for each dice (IC2,3 and common components) – the action of the other dice is identical (using IC4 and 5 instead).

A	B	C	NUMBER DISPLAYED
OFF	OFF	ON	1
OFF	ON	OFF	2
OFF	ON	ON	3
ON	OFF	OFF	4
ON	OFF	ON	5
ON	ON	OFF	6



The LEDs are formed on the PCB to a standard dice configuration as in Fig. 3. In this diagram the individual points have been grouped together into three categories A, B and C. By looking at the numbers on a dice in turn, a table can be drawn up, as in Fig. 3. to show that all LEDs in any one category must be either on or off at the same time. Therefore, we can consider the groups as single logical levels in a set code. It just happens that the set code required is part of the binary code, of which the part ot interest is shown in Fig. 4 against the corresponding denary, or ordinary number value.

ICs which count in binary are readily available and the 4522 (IC3) does just that.

DENARY NUMBER	BINARY NUMBER		
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

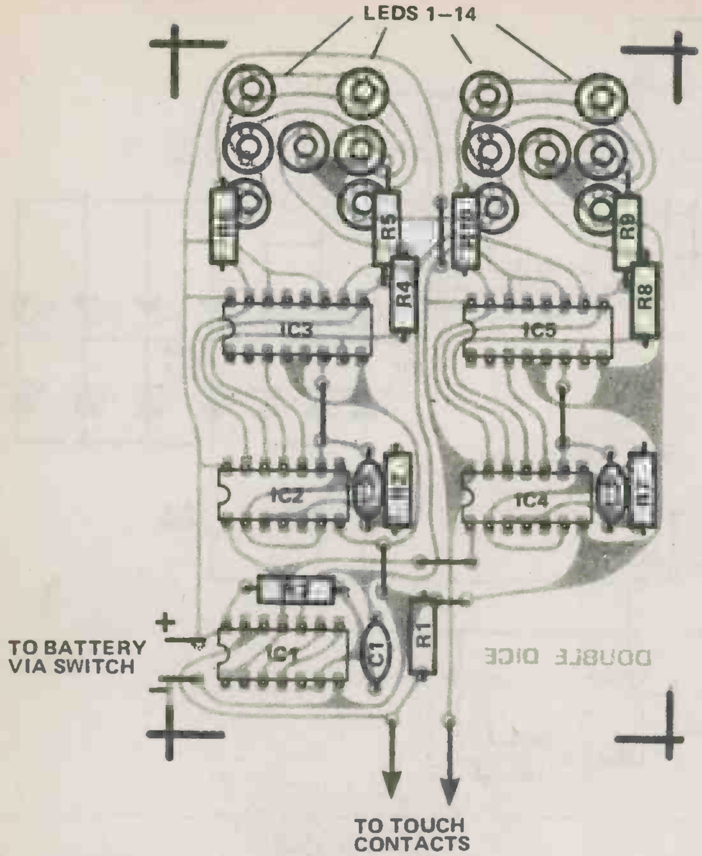
THE PART OF THE BINARY CODE WHICH IS OF INTEREST

It is a *down* counter, meaning that it starts its cycle at binary 15 and counts down to 0. On the next count after 0 it would (normally) reset to 15 and start the cycle over again. However, we have taken advantage of the fact that the 4522 is a programmable counter which can, on a commmand pulse, be programmed or set to a particular number in its cycle. In our circuit this number is 6 (represented by the logic levels at pins 14, 11 and 5, that is 1, 1, 0). The command pulse is obtained from the output of IC2c, which is at logic 1 only when its three inputs are 0. These inputs are in parallel with the LED drive outputs of IC3 so that as the number 0 is displayed by the LEDs the counter automatically jumps to the number 6. The interval between the count to 0 and the display of 6 is so small that to the human eye it appears that the counter progresses naturally from 1 to 6.

IC2a and b form a simple astable multivibrator which produces a square wave of about 100 Hz and which clocks the counter whenever pin 1 of IC2 is at logic 0.

The part of the circuit which is common to both sides is that of IC1. Pins 12 and 13 of this IC are held normally low by R1, a very high resistance. The output of IC1d is therefore normally high (the gate is acting as an inverter). If a finger is placed on the touch contacts, skin resistance takes the input to this gate high, and the output, pin 11, goes low. This pin is connected to pin 1 of the astable which as detailed above, clocks the counter.

As well as enabling the astable, pin 11 is connected to the input of a monostable multivibrator with an 'on' period of about 5 seconds so that as a finger is put on the touch contacts the monostable enters its 'on' state. The output of the monostable is connected to pin 10 of the counter so that during the 'on' state the LED display is allowed to function. At the end of the 5 second on-period the monostable switches off and the display is disabled (the LEDs are held off) thus saving unnecessary battery drain.



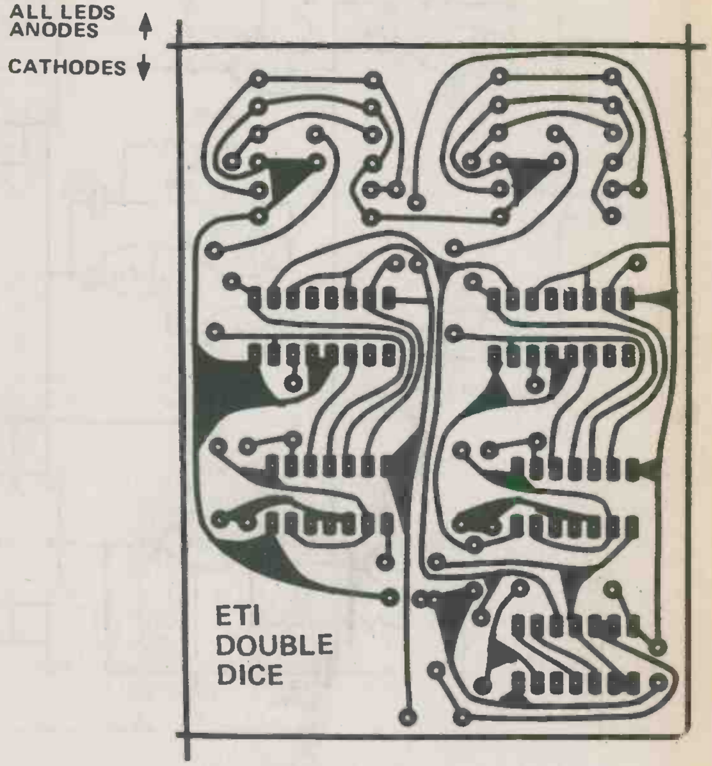


Figure 2. Overlay diagram for the Double Dice.

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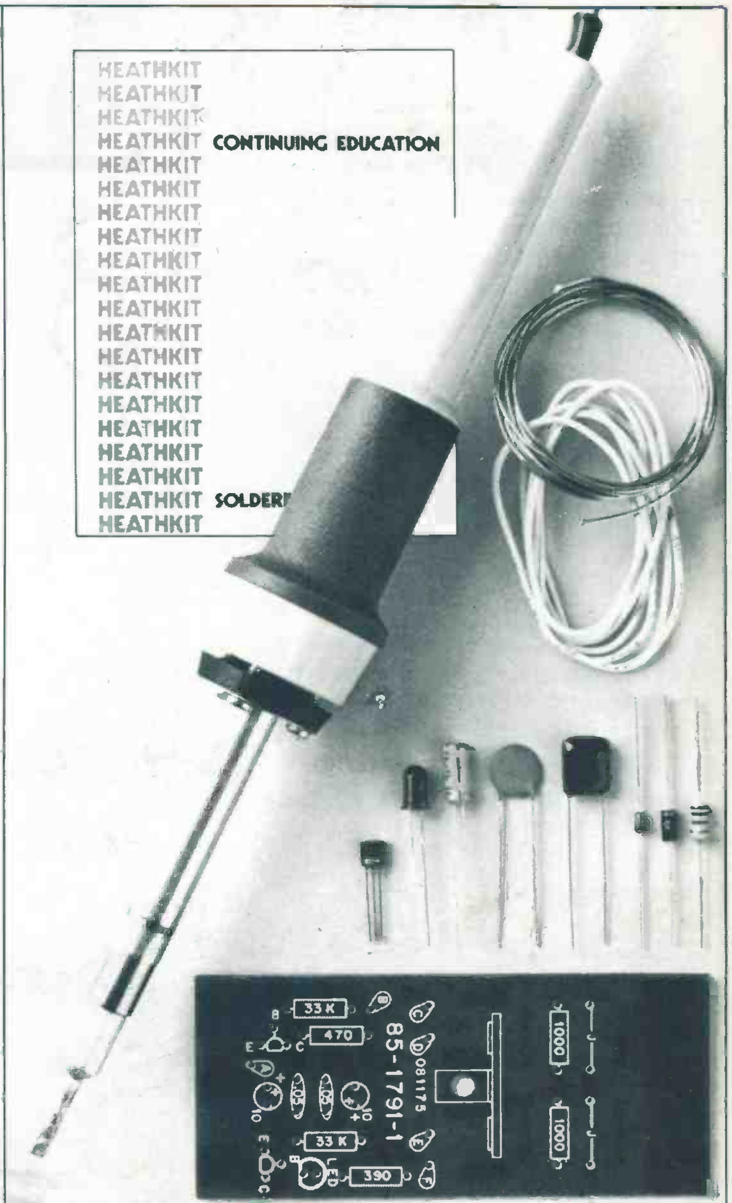

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