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APRIL 1977

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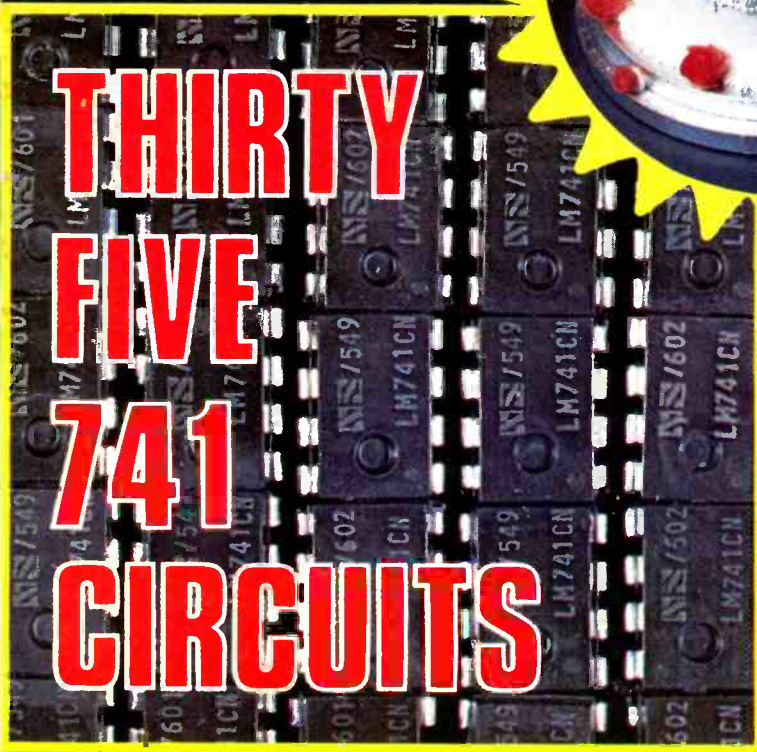

THIRTY FIVE 741 CIRCUITS

ALSO INSIDE:

5 YEAR INDEX

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NEWS . . . CONSTRUCTION . . . DEVELOPMENTS . . . AUDIO

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APRIL 1977 VOL. 6 No. 4

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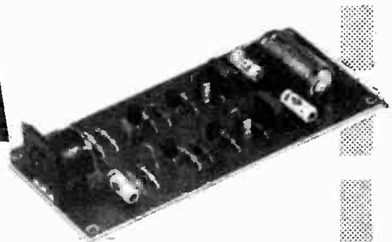
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



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It is provided with a standard DIN input socket for ease of connection. Full instructions supplied. **£2.85**

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A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
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P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz.
Supply — 20-35V at 20mA.

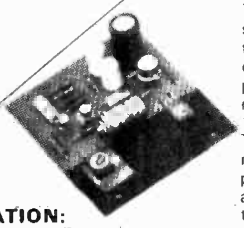
Dimensions 299mm x 89mm x 35mm.

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £29.55** plus 85p postage.

TEAK 60 AUDIO KIT:
Comprising: Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £**
plus 85p postage.

AL- 20-30

AUDIO AMPLIFIER MODULES



The AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 5 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 0.25%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV.RMS**

AL20 5w R.M.S. £2.95 AL30 10w R.M.S. £3.25

STEREO 30

COMPLETE AUDIO

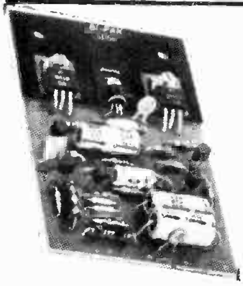
7+7 WATTS R.M.S.

P & P 45p

£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £5.25 plus 62p p & p



AL 60

25 Watts (RMS)

★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£4.35

NEW

PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL 20/30 Amplifier Modules. Features include on/off volume. Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE **£1.30**

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.75

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news digest

DISPLAY OF FLEXIBILITY

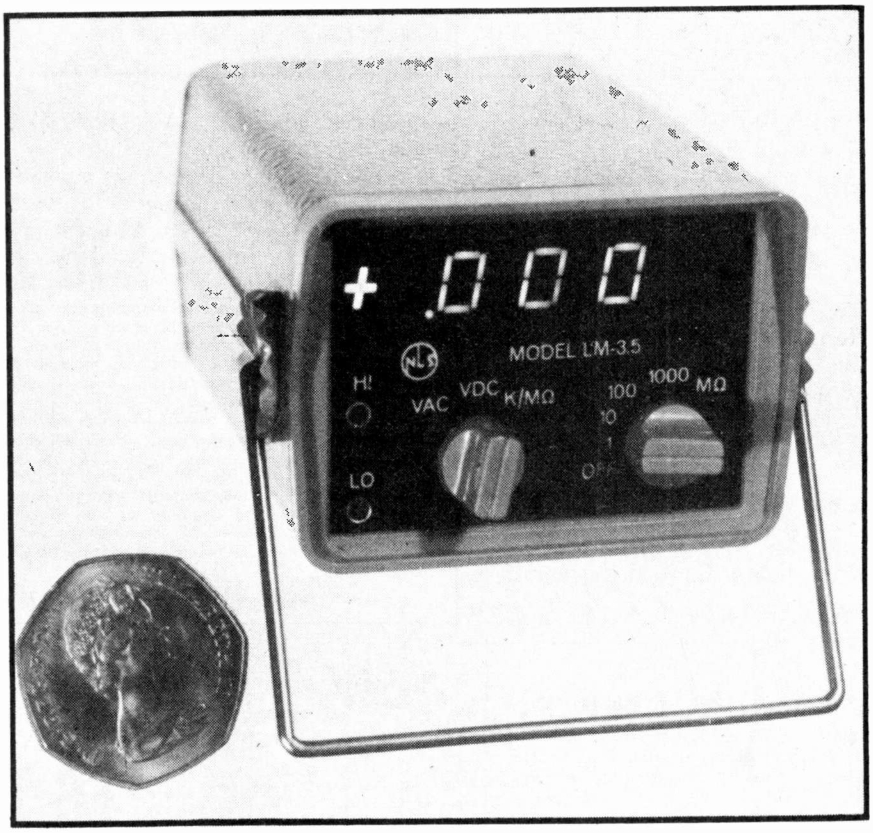
O.K. so what is it? Briefly, it's a 4 function calculator with 8 digit green display. Additionally, it has a 4 position programme switch. Set it to 'Time' and touch the 'Time' button and it displays day of month, hours and minutes. At the same time it indicates day of week and seconds by flashing periods. (If the machine is operating from the adaptor it will continue to display time until you touch 'Time' again.) Move the slide to 'ST' (for stopwatch) and touch the 'Time' button and it becomes a 10th of a second stopwatch. Touch the 'LAP' button and it holds the display whilst continuing to count out of display - touch the 'LAP' button a second time and it picks up elapsed time in display.

You can set 4 separate alarms and the time is accurate to ±15 seconds per month (0° - 40°C). The 199 year calender compensates for varying month lengths and leap years.

Finally, in addition to normal mathematical calculations, the CQ1, allows calculations involving hours, minutes, seconds and elapsed between any two dates (1901 - 2100) to be computed. Price £35.95 RRP.

Casio Electronics Co. Ltd., 28 Scrutton Street, London, EC2.

FOR MEASURING SMALL MULTIS?



Four miniature digital multimeters made by Non Linear Systems Inc., are now available from Lawtronics. Each DMM is powered by internal rechargeable batteries, giving 2-3 hours operating life and is supplied with a charger unit.

Although each unit uses the same miniature case (1.9 x 2.7 x 4ins.), the 3, 3½, and 4 digit displays are 0.3ins. high, and have 25 ranges. The LM3, 3 digit is accurate to 1% of reading and the LM4, 4 digit is 0.03% of reading.

Instruments are normally supplied with a tilt stand. Prices start from £82, including batteries and charger.

Lawtronics, 139 High Street, Edenbridge, Kent TN8 5AX.

GIANTS LETTING CMOS DOWN

Across the pond in the USA there is a nice little session of throat-cutting going on. Texas are really clanging prices down on a range of MSI chips, including counters, multiplexers and registers.

Meanwhile back at the ranch National are reacting to Motorola's slash in January with similar hackings themselves. RCA on the other hand, have quietly taken their levels down without telling anybody.

FED UP SCRATCHING AROUND?

Researchers at University College London, have designed a prototype unit to eliminate completely surface clicks (scratches) from records. Completely different in concept to the usual top-cut filter, this unit detects the scratch (by monitoring the difference signal between the L and R channels), edits it from the output, and replaces it with an extrapolated signal which is indistinguishable from the original music.

The circuitry consists of a highpass filter (200Hz) automatic level control and amplitude detector.

Upon recognising a scratch signal, the detector turns on a 'cross-fade'. A 6ms. delay is placed into the line to give the circuit time to do this. Once it finds a scratch, it waits 3ms. before firing the cross fader such that it edits all the scratch signal.

Don't go rushing down to your local hi-fi store and demand a demo just yet, however. Commercial exploitation of this wonder will depand on the ready supply of an A-D converter, at a price such that the overall circuit can be marketed at less than Britain's G.N.P.

ZILOG SECONDED

Mostek are second sourcing the Z80 MPU from Zilog. The two companies are working in cahoots as regards MPUs to produce this family of chips. Distronic distribute them in Britain.

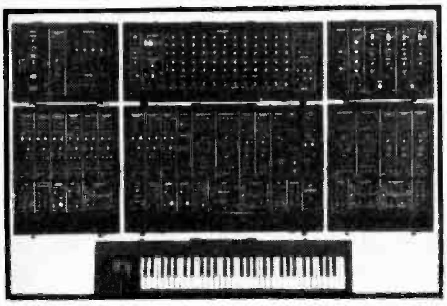
The n-channel Z80 family includes high performance CPU, programmable parallel controller, programmable I/O controller, versatile counter-timer and high-speed direct memory access controller.
Distronic Ltd., 50/51 Burnt Mill, Elizabeth Way, Harlow, Essex.

MURKOFILES SHIFTING

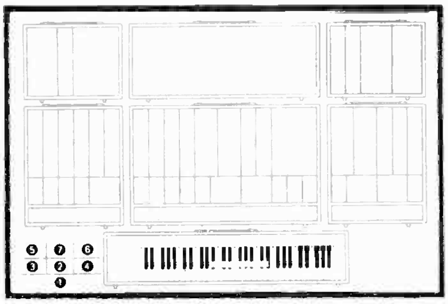
Signetics will be next with a single chip MPU, this to compete with Intel's 8048. It is an eight-bit system, will have 2K of ROM on board, and be titled 2645. Amen.

THE WORLD'S BEST SYNTHESISER?

System 700 by Roland Electronics is claimed to be the ultimate in synthesisers. It is certainly quite a machine. The illustrated version costs £9000, although construction is modular. There just isn't enough room in the magazine to begin to describe



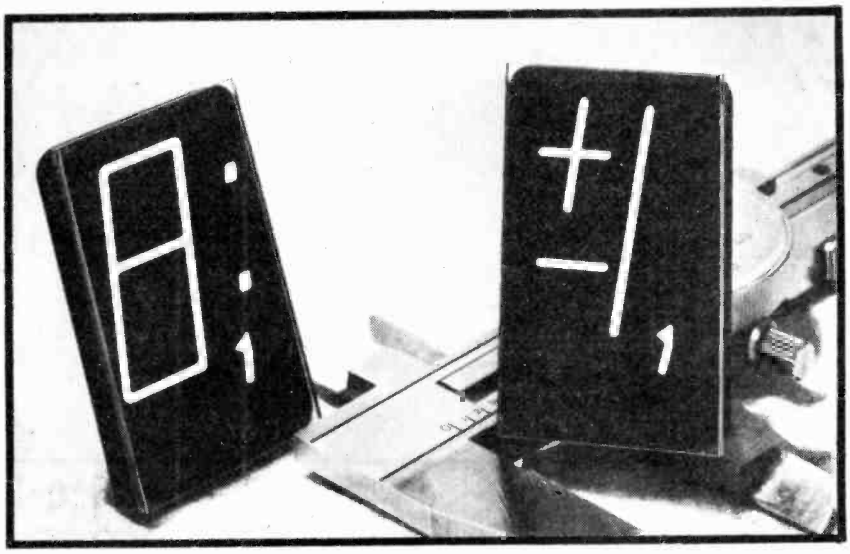
what it will do. One nice touch is the ability to be controlled by a musical instrument or voice. (There are 47 modules in the system.) Anyway if you're in London - go and hear it



yourself. It is on display at Freedmans, 629 High Road, Leytonstone, London E.11. Tell 'em ETI sent you!

P.S. If you know of a better synthesiser - let's hear about it!

WHAT A GAS



Some very clever displays just released from Beckman Instruments Ltd. are these SP101 and 102 GAS DISCHARGE packages! One inch high and looking remarkably like L.E.D.s, they require 160V DC at 70 uA to operate, being visible at 60 feet +, even in sunlight.

The colour is orange, and the characters are of the 'no gap between segment' type which can look very attractive. They are very slim, and well-suited to 'packed out' housing designs. *Beckman Instruments Ltd., Queensway, Glenrothes, Fife, KY7 SPU.*

THINK OF HIRE THINGS

It's worth remembering that when you need some particular piece of equipment - be it bionic or electronic - there is usually no need to mortgage the cat in order to buy it.

One *very* valid alternative exists, and that is to hire it. Most people need test gear for a limited time anyway, and purchase is not really economically justifiable in such cases.

A company called 'Livingstone Hire' will lease you whatever you need from a catalogue containing some 3,000 items. Most of their business is with companies big or small - but even if it's just little ole you, they'll probably be able to help.
Livingstone Hire Ltd., Shirley House, 27 Camden Road, London NW1 9NR.

THE FASTEST DRAW(ER) IN THE WEST

Tektronix's new storage scope, the 7834, possesses a writing speed of 25000 mm/us., which is around 55,000,000 m.p.h., or about 1/9th. of the speed of light.

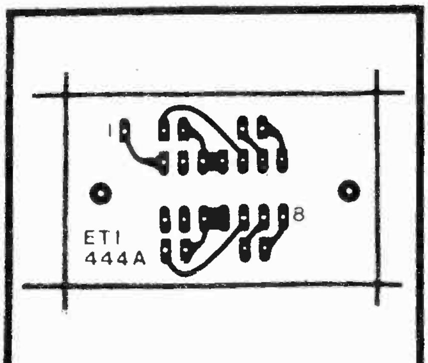
Single shot rise times as low as 1.4 ns., and repetitive signals down to 900 pico-seconds, can be displayed as the machine has a 400MHz mainframe. Plug-in modules extend the capabilities considerably.

Let's hope deliveries are as fast.
Tektronix Ltd., Beaverton House, P.O. Box 69, Harpenden, Herts.

5 WATT STEREO - THE CHIPS ARE DOWN!

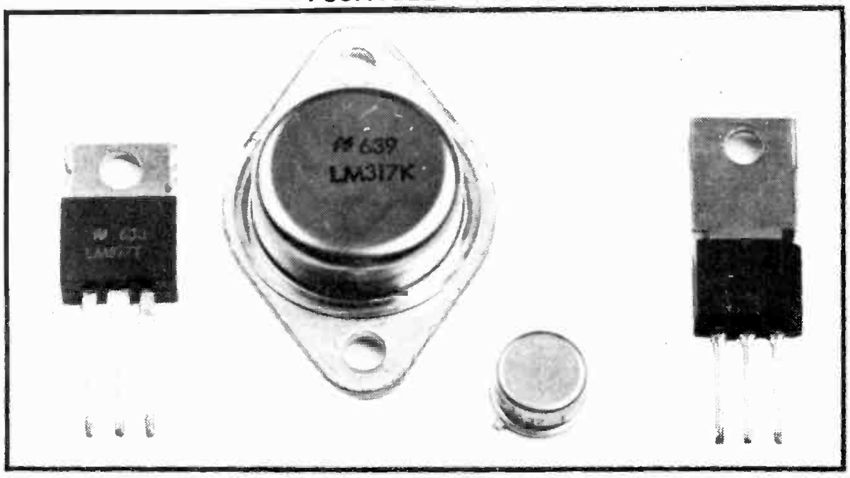
We believe that some readers may be having difficulties in obtaining the version of the LM379 used in the 5 Watt Stereo project in our January issue.

Maplin Electronics can supply readers with these devices, in the package which fits our PCB. The price is a *reduced* £4.56 all inclusive (from £5.43). For the address see the ad on the outside back cover. If you've already got the PCB, the new version of the LM379, won't fit - see the mod below.



This small PCB will sit on top of the original board, enabling the new version of the power amplifier chip to be utilised simply in place of the package we used in the first place.

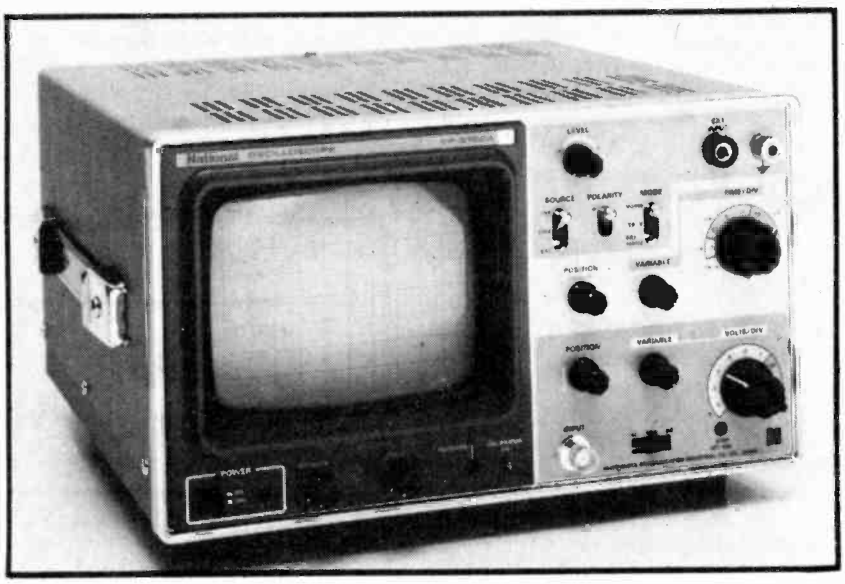
POSITIVELY REGULAR



This three terminal, positive voltage regulator, capable of supplying in excess of 1.5 amps, and adjustable over an output range of 1.2V to 37V, has recently been announced by Jermyn. Requiring only two external resistors to set the output voltage, the LM317 has typical line and load regulation figures of 0.01%V and 0.1V respectively, these being superior characteristics to those of most standard fixed voltage regulators. As this floating regulator sees only the input to output differential voltage, supplies of several hundred volts can be regulated providing the maximum differential of 40V is not exceeded. Current limit, thermal overload, and safe area protection are all incorporated within this regulator which also has 80dB ripple rejection and 1% temperature stability. *Jermyn, Sevenoaks, Kent.*

WATCH ORDERS AND ORDERS AND ORDERS AND...

We have had so many orders for our LCD watch offer that our original order was used up (twice over!) on the day of arrival. New stocks *are* available, and we are endevouring to keep any delay to a minimum. We hope to keep to our original 28-day order period, but if we don't make it—please be patient with us!



NATIONAL AT 10MHZ

This VP5100A is a general purpose DC–10MHz scope of 10mV maximum sensitivity. It is of reasonable proportions - 148 x 260 x 260mm. - and supposedly easy to lift about the place. Seven sweep rates from 0.1us. to 0.1s. per division are provided, as is TV mode for viewing video signals. It is being distributed by Telenic Altair, 2 Castle Hill Terrace, Maidenhead, Berks.

A CHIP OFF THE OLD EMPIRE!

A small British firm (aren't they all?) has taken on the might of the American semiconductor complexes in the battlefield of T.V. games. Sportel, as they are called, are producing their own COLOUR chip (30,000 a month in fact).

As well as all the usual party tricks, their 40 pin blob speeds up the ball after 4 bat strikes, automatically, and goes into 'Deuce type scoring in a game of tennis. Score is displayed as huge characters between one point being scored and the next service. The game will initially be offered as a built-in unit by Tyne marketing.

RUSSIAN AROUND WITHOUT PETROL

Soviet research has gotten a good way along the road to *electric* 'cars for the people'.

One path - taken by Leningrad Technological Institute - leads to a 12kW air-magnesium storage battery, and employs a Moskvitch 408 as its base. Their leading contender however, is made in the Ukraine, and is based on a - wait for it - Zaporozhets vehicle which I hope is more driveable than it is pronounceable. Claimed range is 65 miles, and speed 45 m.p.h.

Why couldn't they call it a Mini or something?

RADAR RAIN

Eighty towns in the USA use a computerised radar system to predict local weather. Oslo will be the first European convert to this meteorological microwave methodology.

The idea behind the system is to examine cloud formations and precipitation within a 200km. radius of the city. The equipment costs about £55,000 and does the work of 1,000 independent stations.

In this manner the computer provides accurate information of when and for how long rain or snow will fall. Relevant data will be stored on past weather, and all information presented on two V.D.U.s.

CAT OF THE YEAR?

We have just received our copy of the new Maplin Supplies catalogue. Only one word describes the publication — superb! Looking rather like a telephone book in appearance, the book contains 216 pages on a very large page format (about the size of an ETI page) and has such a large range of components that Maplin have seen fit to include *three* indexes!

Six major projects are also included a good range of books is also present. A *superb* job and well and truly worth the 50p you'll need to claim one.

—ETI SUPPLEMENT—

R. M. Marsten describes thirty-five

741 OP-AMP APPLICATIONS

OPERATIONAL AMPLIFIERS (OP-AMPS) CAN be simply described as high-gain direct-coupled voltage amplifier 'blocks' that have a single output terminal but have both inverting and non-inverting input terminals. Op-amps can readily be used as inverting, non-inverting, and differential amplifiers in both a.c. and d.c. applications, and can easily be made to act as oscillators, tone filters, and level switches, etc.

Op-amps are readily available in integrated circuit form, and as such act as one of the most versatile building blocks available in electronics today. One of the most popular, i.e. op-amps presently available is the device that is universally known as the '741' op-amp. In this article we shall describe the basic features of this device, and show a wide variety of practical circuits in which it can be used.

BASIC OP-AMP CHARACTERISTICS AND CIRCUITS

In its simplest form, an op-amp consists of a differential amplifier, followed by offset compensation and output stages, as shown in Fig. 1a. The differential amplifier has inverting and non-inverting input terminals, a high-impedance (constant current) tail to give a high input impedance and a high degree of common mode signal rejection. It also has a high-impedance (constant current) load to give a high degree of signal voltage stage gain.

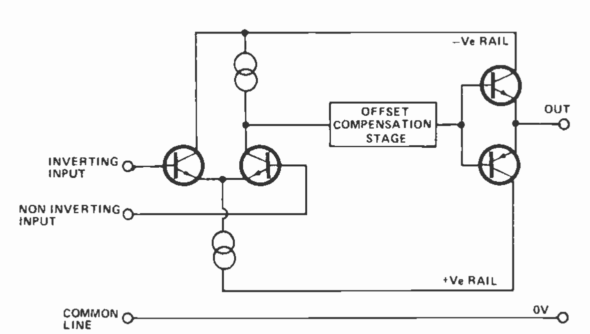


Fig. 1a Simplified op-amp equivalent circuit.

The output of the differential amplifier is fed to a direct-coupled offset compensation stage, which effectively reduced the output offset voltage of the differential amplifier to zero volts under quiescent conditions, and the output of the compensation stage is fed to a simple complementary emitter follower output stage, which gives a low output impedance.

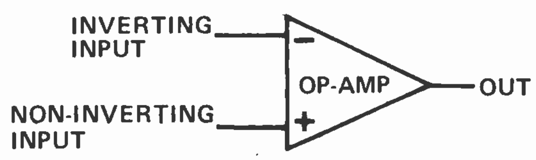


Fig. 1b Basic op-amp symbol.

LINES OF SUPPLY

Op-amps are normally powered from split power supplies, providing +ve, −ve, and common (zero volt) supply rails, so that the output of the op-amp can swing either side of the zero volts value, and can be set at a true zero volts (when zero differential voltage is applied to the circuits input terminals.)

The input terminals can be used independently (with the unused terminal grounded) or simultaneously, enabling the device to function as an inverting, non-inverting, or differential amplifier. Since the device is direct-coupled throughout, it can be used to amplify either a.c. and d.c. input signals. Typically, they give basic low-frequency voltage gains of about 100 000 between input and output, and have input impedances of 1M or greater at each input terminal.

Fig. 1b shows the symbol that is commonly used to represent an op-amp, and 1c shows the basic supply connections that are used with the device. Note that both input and output signals of the op-amp are referenced to the ground or zero volt line.

SIGNAL BOX

The output signal voltage of the op-amp is proportional to the DIFFERENTIAL signal between its two input terminals, and is given by:

$$e_{out} = A_0(e_1 - e_2)$$

where A_o = the open-loop voltage gain of the op-amp (typically 100 000).

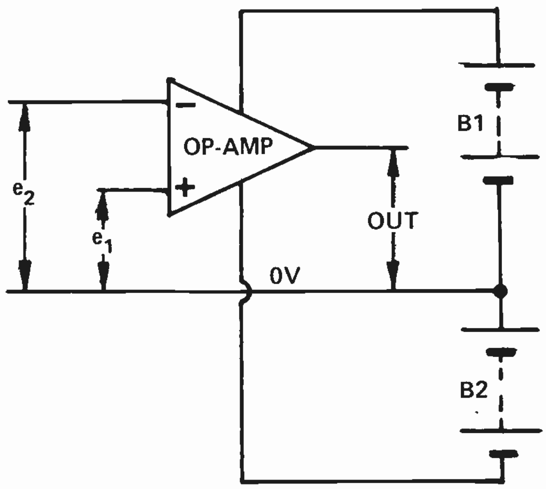


Fig. 1c Basic supply connections of an op-amp.

e_1=signal voltage at the non-inverting input terminal.

e_2=signal voltage at the inverting input terminal.

Thus, if identical signals are simultaneously applied to both input terminals, the circuit will (ideally) give zero signal output· If a signal is applied to the inverting terminal only, the circuit gives an amplified and inverted output· If a signal is applied to the non-inverting terminal only, the circuit gives an amplified but non-inverted output.

By using external negative feedback components, the stage gain of the op-amp circuit can be very precisely controlled.

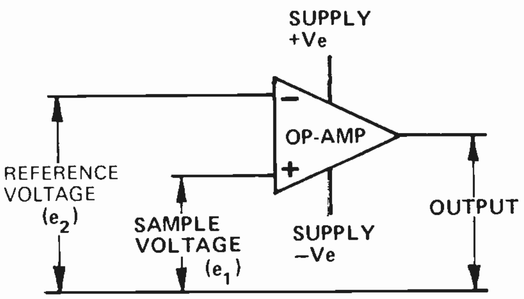


Fig. 2a Simple differential voltage comparator circuit.

TRANSFER REQUEST

Fig. 2a shows a very simple application of the op-amp. This particular circuit is known as a differential voltage comparator, and has a fixed reference voltage applied to the inverting input terminal, and a variable test or sample voltage applied to the non-inverting terminal. When the sample voltage is more than a few hundred microvolts below the reference voltage the op-amp output is driven to saturation in a positive direction, and when the sample is more than a few hundred mircovolts below the reference voltage the output is driven to saturation in the negative direction.

Fig. 2b shows the voltage transfer characteristics of the above circuit. Note that it is the magnitude of the differential input voltage that dictates the magnitude of the output voltage, and that the absolute values of input voltage are of little importance. Thus, if a 1V reference is used and a differential voltage of only 200uV is needed to switch the output from a negative to a positive saturation level, this change can be caused by a shift of only 0.02% on a 1V signal applied to the sample input. The circuit thus functions as a precision voltage comparator or balance detector.

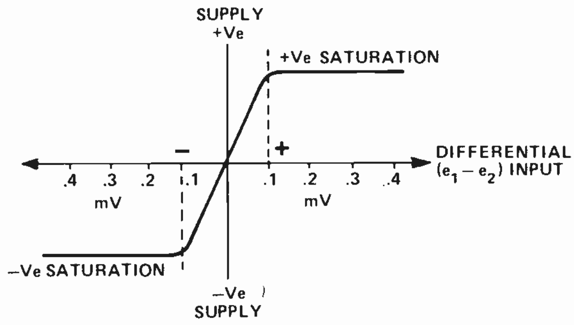


Fig. 2b Transfer characteristics of the differential voltage comparator circuit.

GOING TO GROUND

The op-amp can be made to function as a low-level inverting d.c. amplifier by simply grounding the non-inverting terminal and feeding the input signal to the inverting terminal, as shown in Fig. 3a. The op-amp is used 'open-loop' (without feedback) in this configuration, and thus gives a voltage gain of about 100 000 and has an input impedance of about 1M. The disadvantage of this circuit is that its parameters are dictated by the actual op-amp, and are subject to considerable variation between individual devices.

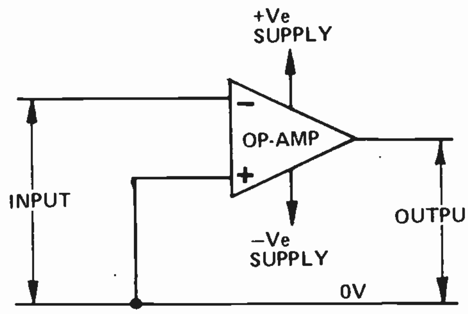


Fig. 3a Simple open-loop inverting d.c. amplifier.

CLOSING LOOPS

A far more useful way of employing the op-amp is to use it in the closed-loop mode, i.e., with negative feedback. Fig. 3b shows the method of applying negative feedback to make a fixed-gain inverting d.c. amplifier. Here, the parameters of the circuit are controlled by feedback resistors R_1 and R_2. The gain, A of the circuit is dictated by the ratios of R_1 and R_2, and equals R_2/R_1.

The gain is virtually independent of the op-amp characteristics, provided that the open-loop gain (A_o) is large relative to the closed-loop gain (A). The input impedance of the circuit is equal to R_1, and again is virtually independent of the op-amp characteristics.

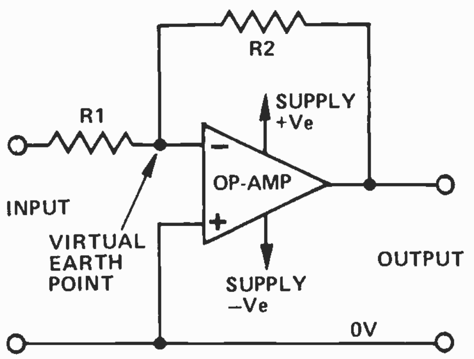


Fig. 3b Basic closed-loop inverting d.c. amplifier.

VIRTUALLY AT EARTH

It should be noted at this point that although R_1 and $R_2$0 control the gain of the complete circuit, they have no effect on the parameters of the actual op-amp, and the full open-loop gain of the op-amp is still available between its inverting input terminal and the output. Similarly, the inverting terminal continues to have a very high input impedance, and negligible signal current flows into the inverting terminal. Consquently, virtually all of the R_1 signal current also flows in R_2, and signal currents i_1 and i_2 can be regarded as being equal, as indicated in the diagram.

Since the signal voltage appearing at the output terminal end of R_2 is A times greater than that appearing at the inverting terminal end, the current flowing in R_2 is A times greater than that caused by the inverting terminal signal only. Consequently, R_2 has an apparent value of R_2/A when looked at from its inverting terminal end, and the R_1-R_2 junction thus appears as a low-impedance VIRTUAL EARTH point.

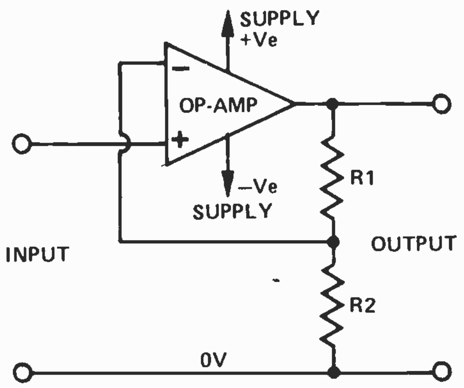


Fig. 4a Basic non-inverting d.c. amplifier

INVERT OR NOT TO INVERT . . .

It can be seen from the above description that the Fig. 3b circuit is very versatile. Its gain and input impedance can be very precisely controlled by suitable choice of R_1 and R_2, and are unaffected by variations in the op-amp characteristics. A similar thing is true of the non-inverting d.c. amplifier circuit shown in Fig. 4a. In this case the voltage gain is equal to $(R_1+R_2)/R_2$ and the input impedance is approximately equal to (A_0/A)Zin where Zin is the open-loop input impedancw of the op-amp. A great advantage of this circuit is that it has a very high input impedance.

FOLLOW THAT VOLTAGE

The op-amp can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting d.c. amplifier, as shown in Fig. 4b. In this case the input and output voltages of the circuit are identical, but the input impedance is very high and is roughly equal to $A_0 \times Z_{in}$.

The basic op-amp circuits of Figs. 2a to 4b are shown as d.c. amplifiers, but can readily be adapted for a.c. use. Op-amps also have many applications other than as simple amplifiers. They can easily be made to function as precision phase splitters, as adders or subtractors, as active filters or selective amplifiers, as precision half-wave or full-wave rectifiers, and as oscillators or multivibrators, etc.

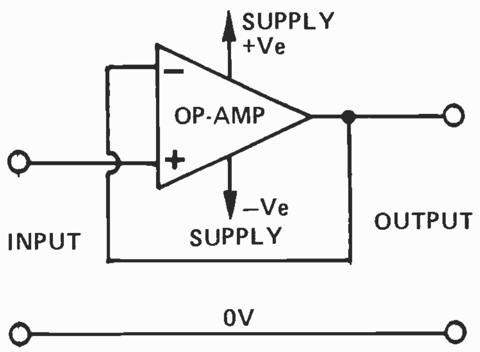


Fig. 4b Basic unity-gain d.c. voltage follower

OP-AMP PARAMETERS

An ideal op-amp would have an infinite input impedance, zero output impedance, infinite gain and infinite bandwidth, and would give perfect tracking between input and output. Practical op-amps fall far short of this ideal, and have finite gain, bandwidth, etc., and give tracking errors between the input and output signals. Consequently, various performance paramaters are detailed on op-amp data sheets, and indicate the measure of 'goodness' of the particular device in question. The most importance of these parameters are detailed below.

OPEN-LOOP VOLTAGE GAIN, A_0. This is the low-frequency voltage gain occuring directly between the input and output terminals of the op-amp, and may be expressed in direct terms or in terms of dB. Typically, d.c. gain figures of modern op-amps are 100 000, or 100dB.

INPUT IMPEDANCE, Z_{in}. This is the impedance looking directly into the input terminals of the op-amp when it is used open-loop, and is usually expressed in terms of resistance only. Values of 1M are typical of modern op-amps with bi-polar input stages, while F.E.T. input types have impedances of a million Meg or greater.

741 SUPPLEMENT

OUTPUT IMPEDANCE, Z_o. This is the output impedance of the basic op-amp when it is used open-loop, and is usually expressed in terms of resistance only. Values of a few hundred ohms are typical of modern op-amps.

INPUT BIAS CURRENT, I_b. Many op-amps use bipolar transistor input stages, and draw a small bias current from the input terminals. The magnitude of this current is denoted by I_b, and is typically only a fraction of a microamp.

SUPPLY VOLTAGE RANGE, V_s. Op-amps are usually operated from two sets of supply rails, and these supplies must be within maximum and minimum limits. If the supply voltages are too high the op-amp may be damaged, and if the supply voltages are too low the op-amp will not function correctly. Typical supply limits are ±3V to ±15V.

INPUT VOLTAGE RANGE, $V_{i(max)}$. The input voltage to the op-amp must never be allowed to exceed the supply line voltages, or the op-amp may be damaged. $V_{i(max)}$ is usually specified as being one or two volts less than v_s.

OUTPUT VOLTAGE RANGE, $V_{o(max)}$. If the op-amp is over driven its output will saturate and be limited by the available supply voltages, so $V_{o(max)}$ is usually specified as being one or two volts less than V_s.

DIFFERENTIAL INPUT OFFSET VOLTAGE, V_{io}. In the ideal op-amp perfect tracking would exist between the input and output terminals of the device, and the output would register zero when both inputs were grounded. Actual op-amps are not perfect devices, however, and in practice slight imbalances exist within their input circuitry and effectively cause a small offset or bias potential to be applied to the input terminals of the op-amp. Typically, this DIFFERENTIAL INPUT OFFSET VOLTAGE has a value of only a few millivolts, but when this voltage is amplified by the gain of the circuit in which the op-amp is used it may be sufficient to drive the op-amp output to saturation. Because of this, most op-amps have some facility for externally nulling out the offset voltage.

COMMON MODE REJECTION RATION, c.m.r.r. The ideal op-amp produces an output that is proportional to the difference between the two signals applied to its input terminals, and produces zero output when identical signals are applied to both inputs simultaneously, i.e., in common mode. In practical op-amps, common mode signals do not entirely cancel out, and produce a small signal at the op-amps output terminal. The ability of the op-amp to reject common mode signals is usually expressed in terms of common mode rejection ratio, which is the ratio of the op-amps gain with differential signals to the op-amps gain with common mode signals. C.m.r.r. values of 90dB are typical of modern op-amps.

TRANSITION FREQUENCY, f_T. An op-amp typically gives a low-frequency voltage gain of about 100dB, and in the interest of stability its open-loop frequency response is tailored so that the gain falls off as the frequency rises, and falls to unity at a transition frequency denoted f_T. Usually, the response falls off at a rate of 6dB per octave or 20dB per decade. Fig. 5

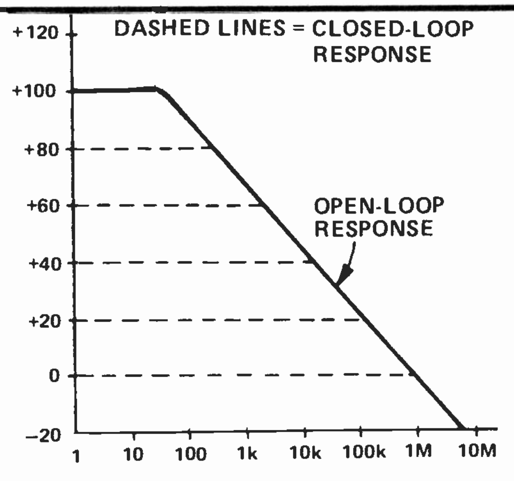


Fig. 5 Typical frequency response curve of the 741 op-amp.

shows the typical response curve of the type 741 op-amp, which has an f_T of 1MHz and a low frequency gain of 100dB.

Note that, when the op-amp is used in a closed-loop amplifier circuit, the bandwidth of the circuit depends on the closed-loop gain. If the amplifier is used to give a gain of 60dB its bandwidth is only 1kHz, and if it is used to give a gain of 20dB its bandwidth is 100kHz. The f_T figure can thus be used to represent a gain-bandwidth product.

	PARAMETER	741 VALUE
A_o	OPEN-LOOP VOLTAGE GAIN	100dB
Z_{IN}	INPUT IMPEDANCE	1M
Z_o	OUTPUT IMPEDANCE	150R
I_b	INPUT BIAS CURRENT	200nA
$V_{s\ (MAX)}$	MAXIMUM SUPPLY VOLTAGE	±18V
$V_{i\ (MAX)}$	MAXIMUM INPUT VOLTAGE	±13V
$V_{o\ (MAX)}$	MAXIMUM OUTPUT VOLTAGE	±14V
V_{io}	DIFFERENTIAL INPUT OFFSET VOLTAGE	2mV
c.m.m.r.	COMMON MODE REJECTION RATIO	90dB
F_T	TRANSITION FREQUENCY	1MHZ
S	SLEW RATE	1V/uS

Table 1 Typical characteristics of the 741 op-amp.

SLEW RATE. As well as being subject to normal bandwidth limitations, op-amps are also subject to a phenomenon known as slew rate limiting, which has the effect of limiting the maximum rate of change of voltage at the output of the device. Slew rate is normally specified in terms of volts per microsecond, and values in the range 1V/uS to 10V/us are common with most popular types of op-amp. One effect of slew rate limiting is to make a greater bandwidth available to small output signals than is available to large output signals.

THE 741 OP-AMP.

Early types of i.c. op-amp, such as the well known 709 type, suffered from a number of design weaknesses. In particular, they were prone to a phenomenon known as INPUT LATCH-UP, in which the input circuitry tended to switch into a locked state if special precautions wre not taken when connecting the input signals to the input terminals, and tended to self-destruct if a short circuit were inadvertently placed across the op-amp output terminals. In addition, the op-amps were prone to bursting into unwanted oscillations when used in the linear amplifier mode, and required the use of external frequency compensation components for stability control.

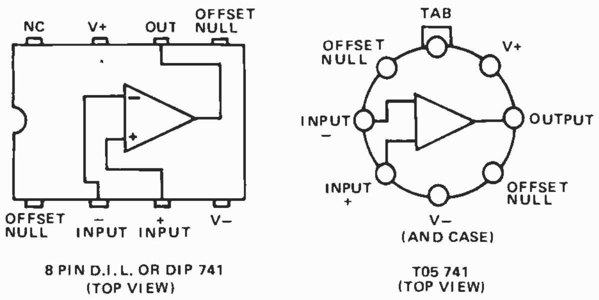


Fig. 6 Outlines and pin connections of the two most popular 741 packages.

These weaknesses have been eliminated in the type 741 op-amp. This device is immune to input latch-up problems, has built-in output short circuit protection, and does not require the use of external frequency compensation components. The typical performance characteristics of the device are listed in Table 1.

The type 741 op-amp is marketed by most i.c. manufacturers, and is very readily available. Fig. 6 shows the two most commonly used forms of packaging of the device· Throughout this chapter, all practical circuits are based on the standard 8-pin dual-in-line (D.I.L. or DIP) version of the 741 op-amp.

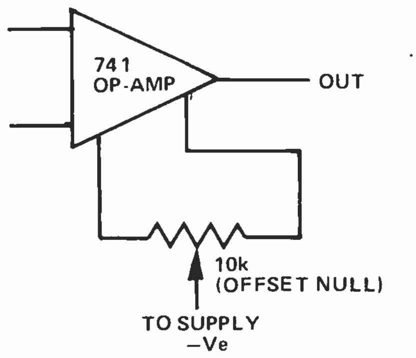


Fig. 7 Method of applying offset nulling to the 741 op-amp.

The 741 op-amp can be provided with external offset nulling by wiring a 10k pot between its two null terminals and taking the pot slider to the negative supply rail, as shown in Fig. 7.

Having cleared up these basic points, let's now go on and look at a range of practical applications of the 741 op-amp.

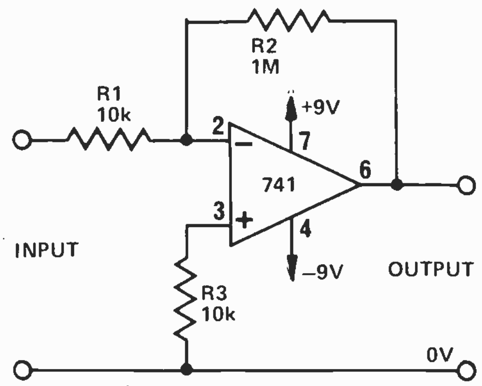


Fig. 8a x100 inverting d.c. amplifier.

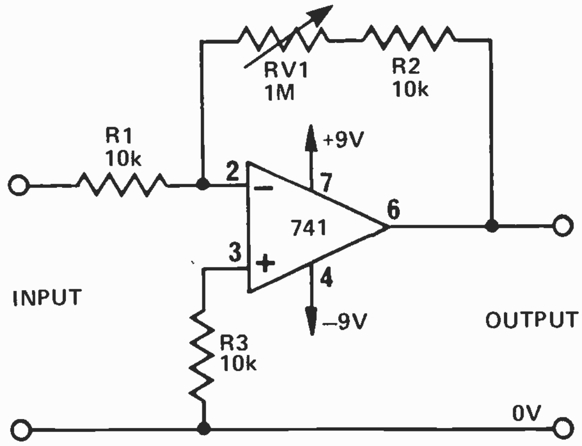


Fig. 8b Variable gain (x1 to x100) inverting d.c. amplifier.

BASIC LINEAR AMPLIFIER PROJECTS. (Figs. 8 to 11).

Figs. 8 to 11 show a variety of ways of using the 741 in basic linear amplifier applications.

The 741 can be made to function as an inverting amplifier by grounding the non-inverting input terminal and feeding the input signal to the inverting terminal. The voltage gain of the circuit can be precisely controlled by selecting suitable values of external feedback resistance. Fig. 8a shows the practical connections of an inverting d.c. amplifier with a pre-set gain of x100· The voltage gain is determined by the ratios of R_1 and R_2, as shown in the diagram.

The gain can be readily altered by using alternative R_1 and/or R_2 values. If required, the gain can be made variable by using a series combination of a fixed and a variable resistor in place of R_2, as shown in the circuit of Fig. 8b, in which the gain can be varied over the range x1 to x100 via R_2.

VARIATIONS

A variation of the basic inverting d.c. amplifier is shown in Fig. 9a. Here, the feedback connection to R_2 is taken from the output of the R_3–R_4 output potential divider, rather than directly from the output of the op-amp, and the voltage gain is determined by the ratios of this divider as well as by the values of R_1 and·

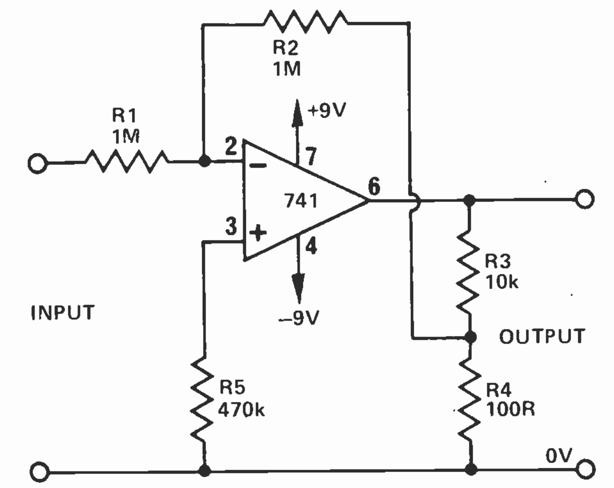


Fig. 9a High impedance x100 inverting d.c. amplifier.

R_2. The important feature of this circuit is that it enables R_1, which determines the input impedance of the circuit, to be given a high value if required, while at the same time enabling high voltage gain to be achieved.

The basic inverting d.c. amplifier can be adapted for a.c. use by simply wiring blocking capacitors in series with its input and output terminals, as shown in the x100 inverting a.c. amplifier circuit of Fig. 9b.

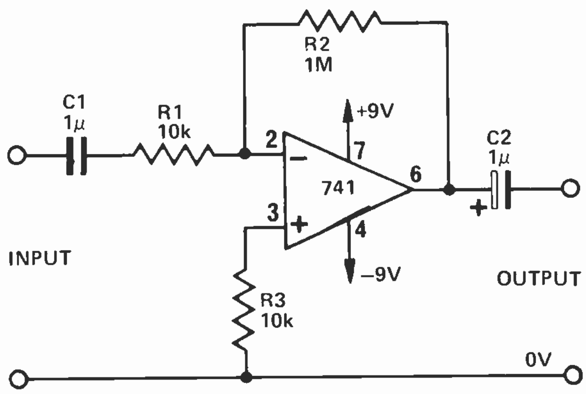


Fig. 9b x100 inverting a.c. amplifier.

NON-INVERTING . . .

The amp can be made to function as a non-inverting amplifier by feeding the input signal to its non-inverting terminal and applying negative feedback to the inverting terminal via a resistive potential divider that is connected across the op-amp output. Fig. 10a shows the connections for making a fixed gain (x100) d.c. amplifier.

The voltage gain of the Fig. 10a circuit is determined by the ratios of R_1 and R_2. If R_2 is given a value of zero the gain falls to unity, and if R_1 is given a value of zero the gain rises towards infinity (but in practice is limited to the open-loop gain of the op-amp). If required, the gain can be made variable by replacing R_2 with a

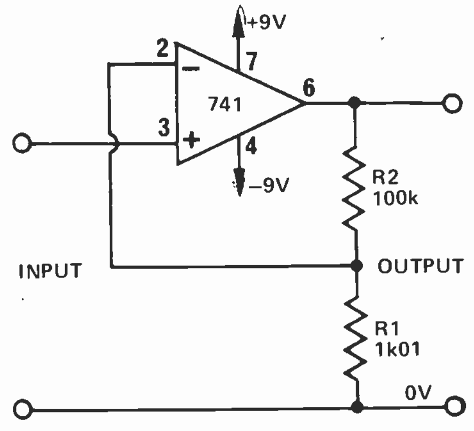


Fig. 10a Non-inverting x100 d.c. amplifier.

potentiometer and connecting the pot slider to the inverting terminal of the op-amp, as shown in the circuit of Fig. 10b. The gain of this circuit can be varied over the range x1 to x100 via R_1.

. . . AND RESISTANCE TO INPUTS

A major advantage of the non-inverting d.c. amplifier is that it has a very high input resistance. In theory, the input resistance is equal to the open-loop input resistance (typically 1M) multiplied by the open-loop voltage gain (typically 100 000) divided by the actual circuit voltage gain. In practice, input resistance values of hundreds of megohms can readily be obtained.

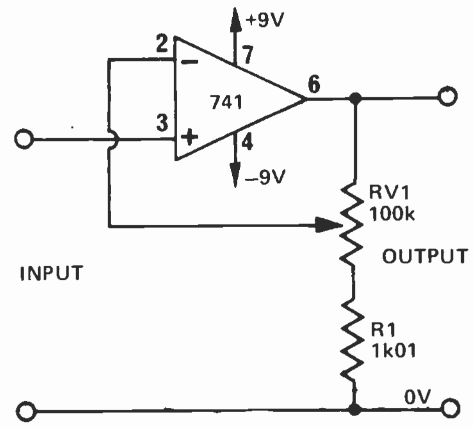


Fig. 10b Non-inverting variable gain (x1 to x100) d.c. amplifier.

BLOCKING OUT

The basic non-inverting d.c. circuit of Fig. 10 can be modified to operate as a.c. amplifiers in a variety of ways. The most obvious approach here is to simply wire blocking capacitors in series with the inputs and outputs, but in such cases the input terminal must be d.c. grounded via a suitable resistor, as shown by R_3 in the non-inverting x100 a.c. amplifier of Fig. 11a. If this resistor is not used the op-amp will have no d.c. stability, and its output will rapidly drift into saturation.

Clearly, the input resistance of the Fig. 11a circuit is equal to R_3, and R_3 must have a relatively low value in the interest of d.c. stability. This circuit thus loses the non-inverting amplifier's basic advantage of high input resistance.

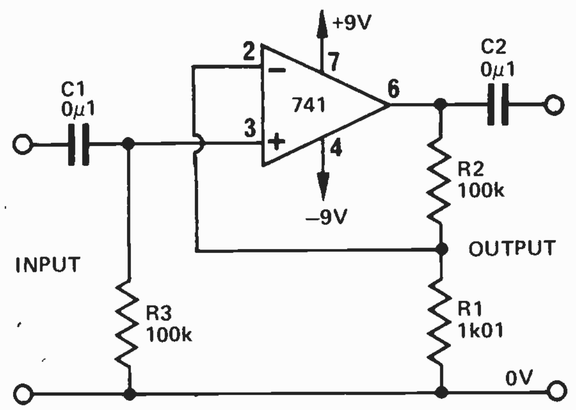


Fig. 11b Non-inverting, high input-impedance, x100 a.c. amplifier.

DRIFTING INTO STABILITY

A useful development of the Fig. 11a circuit is shown in Fig. 11b. Here, the values of R_1 and R_2 are increased and a blocking capacitor is interposed between them. At practical operating frequencies this capacitor has a negligible impedance, so the voltage gain is still determined by the ratios of the two resistors. Because of the inclusion of the blocking capacitor, however, the inverting terminal of the op-amp is subjected to virtually 100% d.c. negative feedback from the output terminal of the op-amp, and the circuit thus has excellent d.c. stability. The low end of R_3 is connected to the C_3–R_1 junction, rather than directly to the ground line, and the signal voltage appearing at this point is virtually identical with that appearing at the non-inverting terminal of the op-amp.

Consequently, identical signal voltages appear at both ends of R_3, and the apparent impedance of this resistor is increased close to infinity by bootstrap action.

This circuit thus has good d.c. stability and a very high input impedance. In practice, this circuit gives a typical input impedance of about 50M.

VOLTAGE FOLLOWER PROJECTS (Figs. 12 to 13).

A 741 can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting amplifier. Fig. 12a shows the practical connections for making a d.c. voltage follower. Here, the input signal is applied directly to the non-inverting terminal of the op-amp, and the inverting terminal is connected directly to the output, so the circuit has 100% d.c. negative feedback and acts as a unity-gain non-inverting d.c. amplifier.

The output signal voltage of the circuit is virtually identical to that of the input, so the output is said to 'follow' the input voltage. The great advantage of this circuit is that it has a very high input impedance (as high as hundreds of megohms) and a very low output impedance (as low as a few ohms). The circuit acts effectively as an impedance transformer.

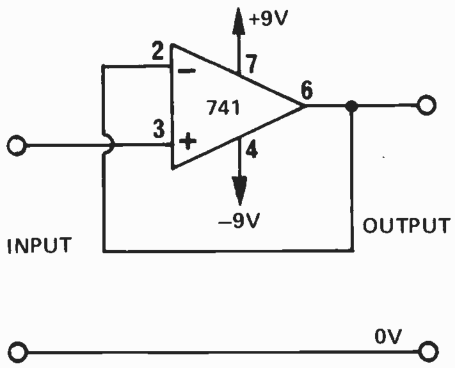


Fig. 12a d.c. voltage follower.

PRACTICE, AND ITS LIMITS

In practice the output of the basic Fig. 12a circuit will follow the input to within a couple of millivolts up to magnitudes within a volt or so of the supply line potentials. If required, the circuit can be made to follow to within a few microvolts by adding the offset null facility to the op-amp.

The d.c. voltage follower can be adapted for a.c. use by wiring blocking capacitors in series with its input and output terminals and by d.c.-coupling the non-inverting terminal of the op-amp to the zero volts line via a suitable resistor, as shown by R_1 in Fig. 12b. R_1 should have a value less than a couple of megohms, and restricts the available input impedance of the voltage follower.

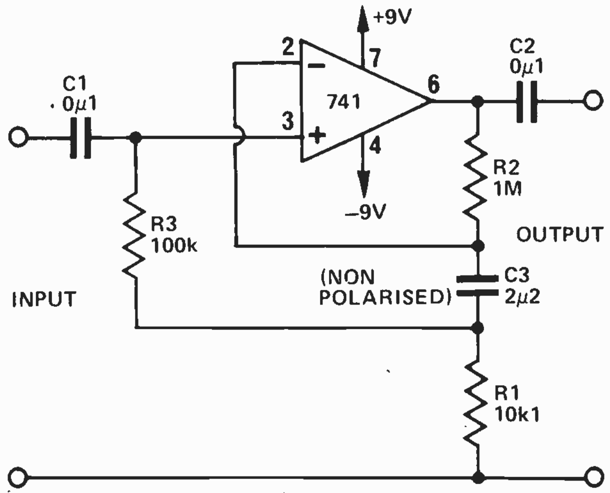


Fig. 11a Non-inverting ~~x100~~ x100 a.c. amplifier.

LACED UP OHMS

If a very high input-impendance a.c. voltage follower is needed, the circuit of Fig. 12c can be used. Here, R_1 is boostrapped from the output of the op-amp, and its apparent impedance is greatly increased. This circuit has a typical impedance of hundreds of megohms.

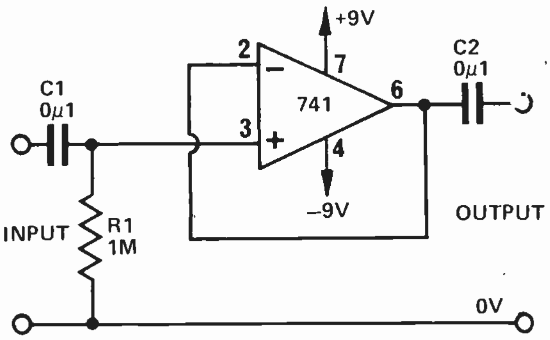


Fig. 12b a.c. voltage follower.

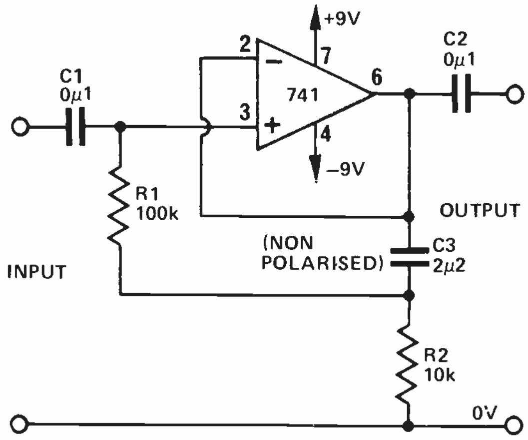


Fig. 12c Very high input-impedance a.c. voltage follower.

DRIVING CIRCUITS AMP-LY

The 741 op-amp is capable of providing output currents up to about 5mA, and this is consequently the current-driving limit of the three voltage follower circuits that we have looked at so far. The current-driving capabilities of the circuits can readily be increased by wiring simple or complimentary emitter follower booster stages between the op-amp output terminals and the outputs of the actual circuits, as shown in Figs. 13a and 13b respectively.

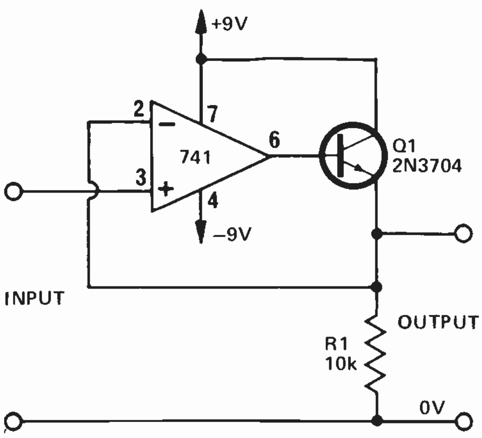


Fig. 13a Unidirectional d.c. voltage follower with boosted output (variable from 0V to +8V at 50mA.)

Note in each case that the base-emitter junction(s) of the output transistor(s) are included in the negative feedback loop of the circuit. Consequently, the 600mV knee voltage of each junction is effectively reduced by a factor equal to the open-loop gain of the op-amp, so the junctions do not adversely effect the voltage-following characteristics of either circuit.

The Fig. 13a circuit is able to source current only, and can be regarded as a unidirectional, positive-going, d.c. voltage follower. The Fig. 13b circuit can both source and sink output currents, and thus gives bidirectional follower action. Each circuit has a current-driving capacity of about 50mA. This figure is dictated by the limited power rating of the specified output transistors. The drive capability can be increased by using alternative transistors.

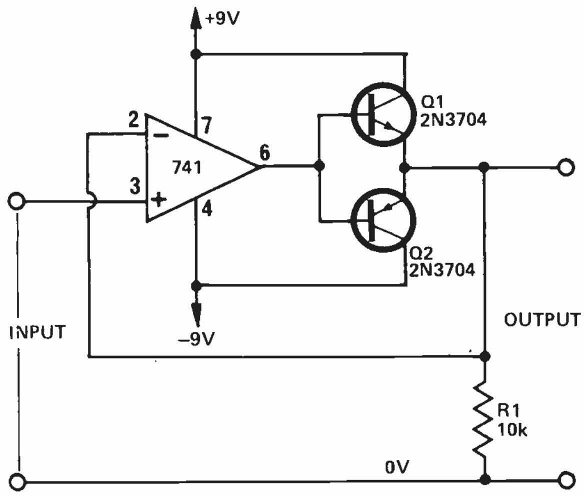


Fig. 13b Bidirectional d.c. voltage follower with boosted output (variable from 0V to± ±8V at 50mA).

MISC AMP PROJECTS (Figs. 14 to 22)

Figs. 14 to 22 show a miscellaneous assortment of 741 amplifier projects, ranging from d.c. adding circuits to frequency-selective amplifiers.

Fig. 14 shows the circuit of a unity-gain inverting d.c. adder, which gives an output voltage that is equal to the sum of the three input voltages. Here, input resistors R_1 to R_3 and feedback resistor R_4 each have the same value, and the circuit thus acts as a unity-gain inverting d.c. amplifier between each input terminal and the output. Since the current flowing in each input resistor also flows in feedback resistor R_4, the total current flowing in R_4 is equal to the sum of the input currents, and the output voltage is equal to the sum of the imput voltages. The circuit shown with only three input connections, but in fact can be provided with any number of input terminals. The circuit can be made to function as a so-called 'audio mixer' by wiring blocking capacitors in series with each input terminal and with the output terminal.

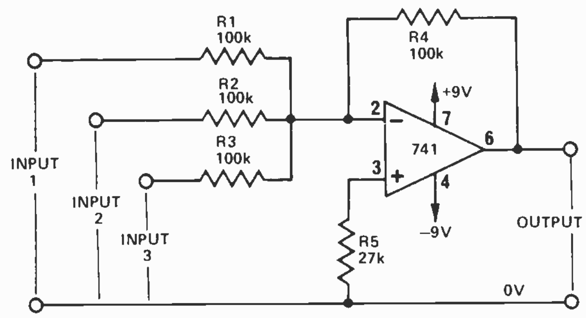


Fig. 14 Unity-gain inverting d.c. adder, or 'audio mixer'.

FIG. 15 shows how two unity-gain inverting d.c. amplifiers can be wired in series to make a precision unity-gain balanced d.c. phase-splitter. The output of the first amplifier is an inverted version of the input signal, and the output of the second amplifier is a non-inverted version.

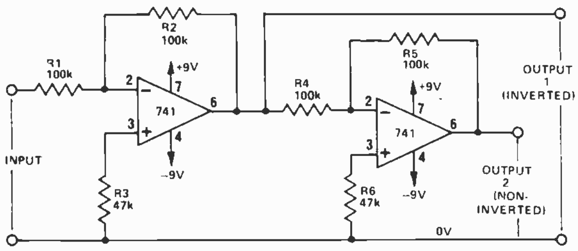


Fig. 15 Unity-gain balanced d.c. phase-splitter.

FIG. 16 shows how a 741 can be used as a unity-gain differential d.c. amplifier. The output of this circuit is equal to the difference between the two input signals or voltages, or to e_1-e_2. Thus, the circuit can also be used as a subtractor. In this type of circuit the component values are chosen such that $R_1/R_2=R_4/R_3$, in which case the voltage gain $A_v=R_2/R_1$. The circuit can thus be made to give voltage gain if required.

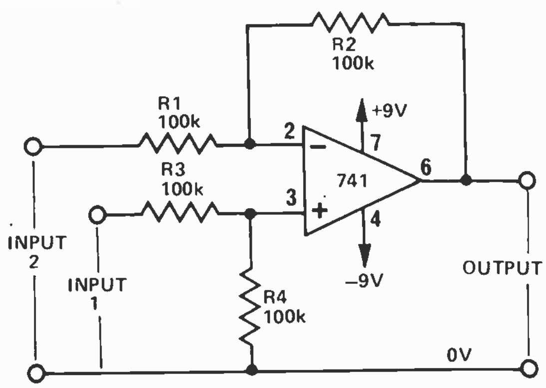
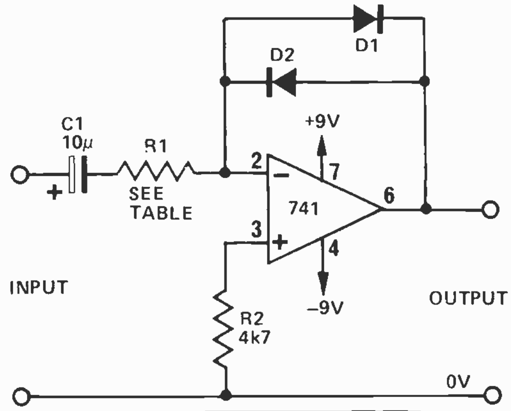


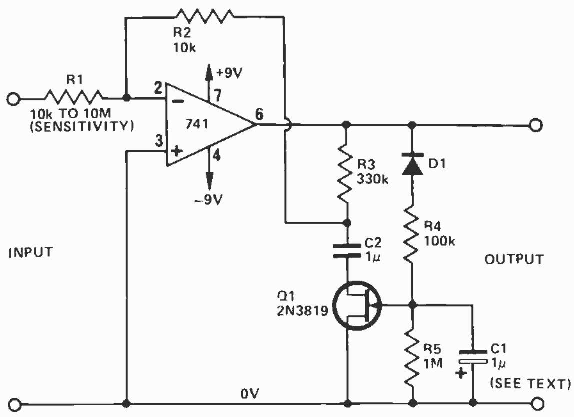
Fig. 16 Unity-gain differential d.c. amplifier, or subtractor.

FIG. 17 shows the amp can be made to act as a non-linear (semi-log) a.c. voltage amplifier by using a couple of ordinary silicon diodes as feedback elements. The voltage gain of the circuit depends on the magnitude of applied input signal, and is high when input signals are low, and low when input signals are high. The measured performance of the circuit is shown in the table, and can be varied by using alternative R_1 values.



INPUT VOLTS (R.M.S)	R_1 = 1kΩ		R_1 = 10kΩ	
	V_{OUT} (R.M.S)	GAIN	V_{OUT} (R.M.S)	GAIN
1 mV	110 mV	X 110	21 mV	X 21
10mV	330 mV	X 33	170mV	X 17
100mV	450 mV	X4 5	360mV	X 3 6
1V	560 mV	X0 56	470mV	X 0 47
10V	600 mV	X0 07	560mV	X0 056

Fig. 17 Circuit and performance table of non-linear (semi-log) a.c. voltage amplifier.



V_{IN} (R_1 = 10KΩ)	V_{IN} (R_1 = 100KΩ)	V_{IN} (R_1 = 1MΩ)	V_{IN} (R_1 = 10MΩ)	V_{OUT}
50 mV	500 mV	5 V	50 V	2.85 V
20 mV	200 mV	2 V	20 V	2.81 V
10 mV	100 mV	1 V	10 V	2.79 V
5 mV	50 mV	500 mV	5 V	2.60 V
2 mV	20 mV	200 mV	2 V	2.03 V
1 mV	10 mV	100 mV	1 V	1.48 V
500 μV	5 mV	50 mV	500 mV	0.89 V
200 μV	2 mV	20 mV	200 mV	0.40 V
100 μV	1 mV	10 mV	100 mV	0.20 V
50 μV	500 μV	5 mV	50 mV	0.10 V

Fig. 18 Circuit and performance details of constant-volume amplifier.

741 SUPPLEMENT

FIG. 18 shows how the 741 can be used together with a junction-type field-effect transistor (JFET) to make a so-called constant-volume amplifier. The action of this type of circuit is such that its peak output voltage is held sensibly constant, without distortion, over a wide range of input signal levels, and this particular circuit gives a sensibly constant output over a 30dB range of input signal levels.

The measured performance of the circuit is shown in the table. C_1 determines the response time of the amplifier, and may be altered to satisfy individual needs.

ACTION TAKEN

The action of the Fig. 18 circuit relies on the fact that the JFET can act as a voltage-controlled resistance which appears as a low value when zero bias is applied to its gate and as a high resistance when its gate is negatively biased. The JFET and R_3 act as a gain-determining a.c. voltage divider (via C_2), and the bias to the JFET gate is derived from the circuits output via the D_1-C_1 network. When the circuit output is low the JFET appears as a low resistance, and the op-amp gives high voltage gain.

When the circuit output is high the JFET appears as a high resistance, and the op-amp gives low voltage gain. The output level of the circuit is thus held sensibly constant by negative feedback.

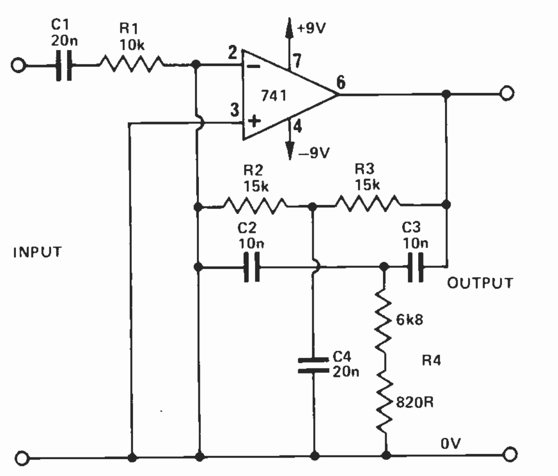


Fig. 19 1kHz tuned (acceptor) amplifier (twin-T).

CHOOSE YOUR FREQUENCY

The 741 op-amp can be made to function as a frequency-selective amplifier by connecting frequency-sensitive networks into its feedback loops. Fig. 19 shows how a twin-T network can be connected to the op-amp so that it acts as a tuned (acceptor) amplifier, and Fig. 20 shows how the same twin-T network can be connected so that the op-amp acts as a notch (rejector) filter. The values of the twin-T network are chosen such that $R_2 = R_3 = 2 \times R_4$, and $C_2 = C_4/2$, in which case its centre (tuned) frequency $= 1/6.28\ R_2.C_2$. With the component values shown, both circuits are tuned to approximately 1kHz.

Finally, to complete this section, Figs. 21 and 22 show the circuits of a couple of variable-frequency audio filters. The Fig. 21 circuit is that of a low-pass filter which covers the range 2.2kHz to 24kHz, and the Fig. 22 circuit is that of a high-pass filter which covers the range 235Hz to 2.8kHz. In each case, the circuit gives unity gain to signals beyond its cut-off frequency, and gives a 2nd order response (a change of 12dB per octave) to signals within its range.

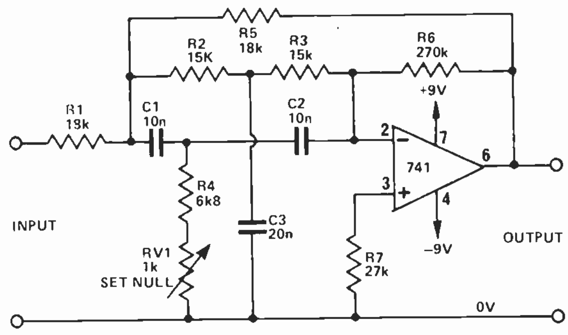


Fig. 20 1kHz notch (reject) filter.

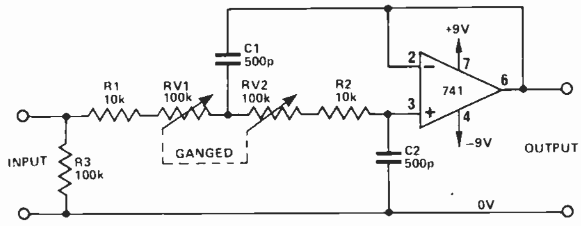


Fig. 21 Variable low-pass filter, covering 2.2kHz to 24kHz.

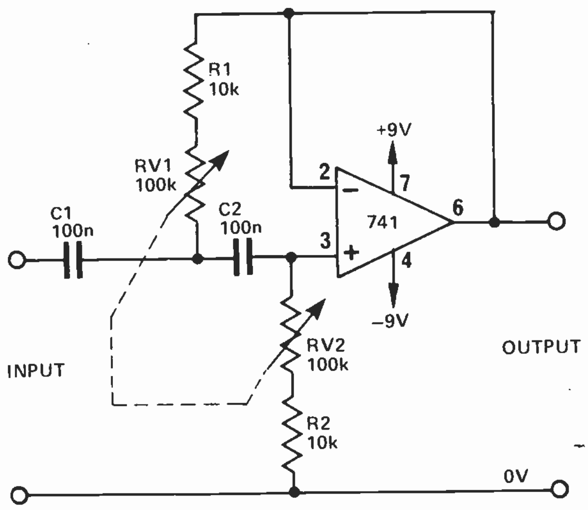


Fig. 22 Variable high-pass filter, covering 235Hz to 2.8kHz.

—741 SUPPLEMENT

INSTRUMENTATION PROJECTS (Figs. 23 to 31)

Figs. 23 to 31 show a variety of instrumentation projects in which the 741 can be used. The circuits range from a simple voltage regulator to a linear-scale ohmmeter.

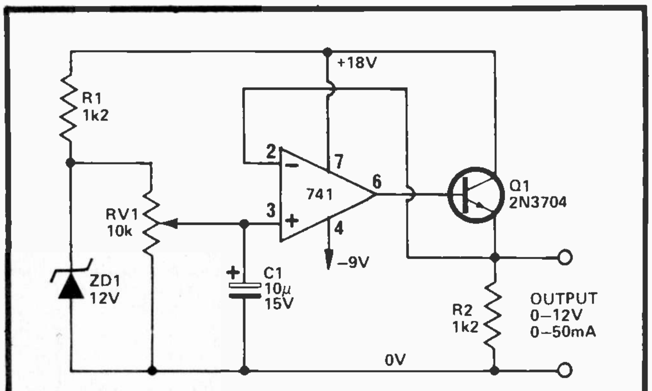


Fig. 23 Simple variable-voltage supply.

FIG. 23 shows the circuit of a simple variable-voltage power supply, which gives a stable output that is fully adjustable from 0V to 12V at currents up to a maximum of about 50mA. The operation of the circuit is quite simple. ZD_1 is a zener diode, and is energised from the positive supply line via R_1. A constant reference potential of 12V is developed across the zener diode, and is fed to variable potential divider RV_1.

The output of this divider is fully variable from 0V to 12V, and is fed to the non-inverting input of the op-amp. The op-amp is wired as a unity-gain voltage follower, with Q_1 connected as an emitter follower current-booster stage in series with its output.

This, the output voltage of the circuit follows the voltage set at the op-amp input via RV_1, and is fully variable from 0V to 12V. Note that the circuit uses an 18V positive supply and a 9V negative supply.

Also note that the voltage range of the above circuit can be increased by using higher zener and unregulated supply voltages, and that its current capacity can be increased by using one or more power transistors in place of Q_1.

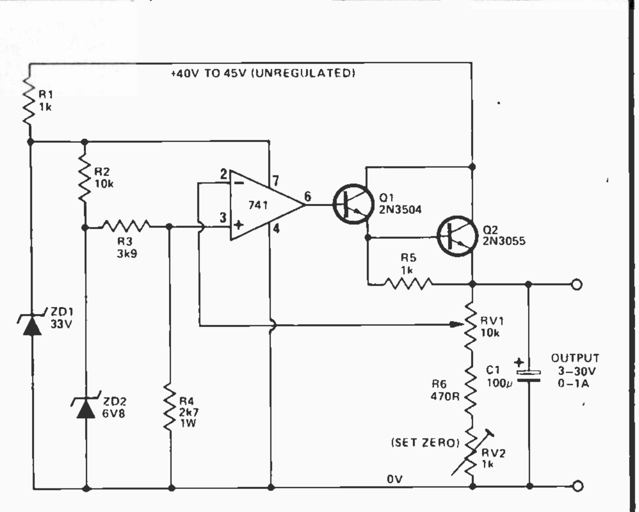


Fig. 24 3V - 30V, 0-1 amp stabilised p.s.u.

FIG. 24 shows how a 741 op-amp can be used as the basis of a stabilised power supply unit (P.S.U.) that covers the range 3V to 30V at currents up to 1A. Here, the voltage supply to the op-amp is stabilized at 33V via ZD_1, and a highly temperature-stable reference of 3V is fed to the input of the op-amp via ZD_2.

The op-amp and output transistors Q_1-Q_2 are wired as a variable-gain non-inverting d.c. amplifier, with gain variable from unity to x10 via RV_1, and the output voltage is thus fully variable from 3V to 30V via RV_1. The output voltage is fully stabilized by negative feedback.

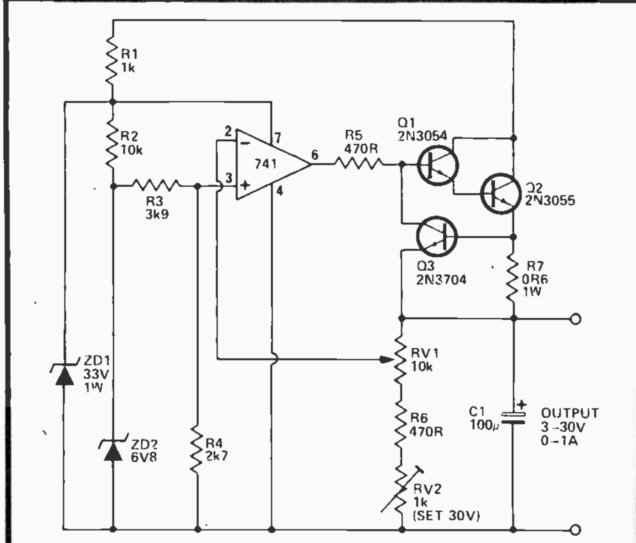


Fig. 25 3V - 30V stabilised p.s.u. with overload protection.

FIG. 25 shows how overload protection can be applied to the above circuit. Here, current-sensing resistor R_9 is wired in series with the output of the regulator, and cut-out transistor Q_3 is driven from this resistor and is wired so that its base-collector junction is able to short the base-emitter junction of the Q_1-Q_2 output transistor stage.

Normally, Q_3 is inoperative, and has no effect on the circuit, but when P.S.U. output currents exceed 1A a potential in excess of 600mV is developed across R_9 and biases Q_3 on, thus causing Q_3 to shunt the base-emitter junction of the Q_1-Q_2 output stage and hence reducing the output current· Heavy negative feedback takes place in this action, and the output current is automatically limited to 1A, even under short-circuit conditions.

FIG. 26a shows how a 741 can be used in conjunction with a couple of silicon diodes as a precision half-wave rectifier. Conventional diodes act as imperfect rectifiers of low-level a.c. signals, because they do not begin to conduct significantly until the applied signal voltage exceeds a 'knee' value of about 600mV.

When diodes are wired into the negative feedback loop of the circuit as shown the 'knee' voltage is effectively reduced by a factor equal to the open-loop gain of the op-amp, and the circuit thus acts like a near-perfect rectifier.

The overall voltage gain of the Fig. 26a circuit is dictated by the ratios of R_1 and R_2 to R_3, as in the case of a conventional inverting amplifier, and this circuit thus gives a gain of unity. The circuit can be made to

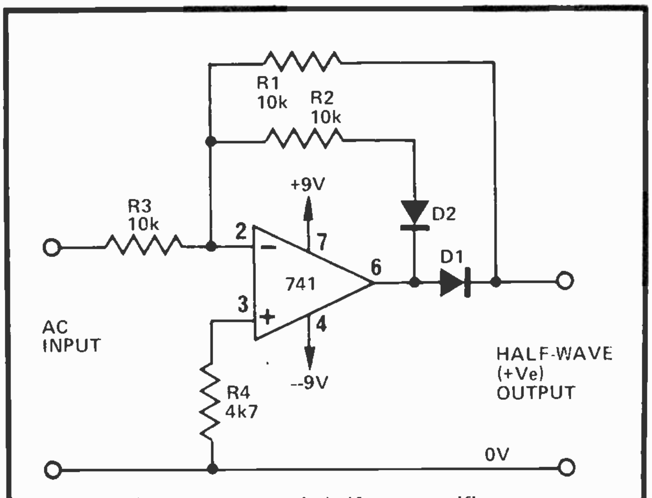


Fig. 26a Precision unity-gain half-wave rectifier.

act as a precision half-wave a.c./d.c. converter by designing it to give a voltage gain of 2.22 to give form-factor correction, and by integrating its rectifier output, as shown in Fig. 26b.

Note that each of the Fig. 26 circuits has a high output impedance, and the outputs must bot be fed into loads having impedances less than about 1M.

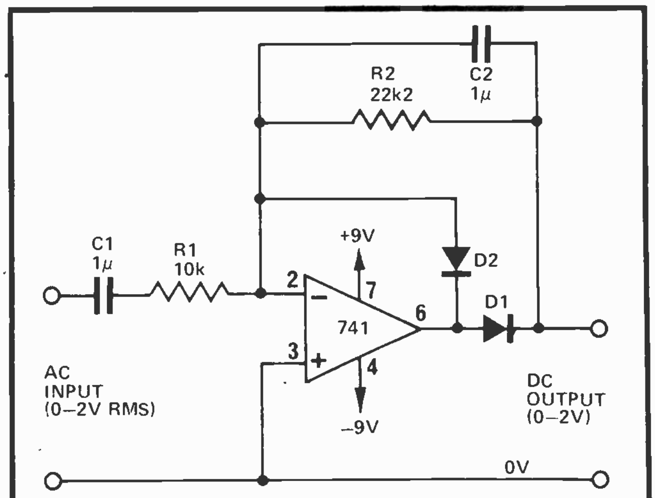
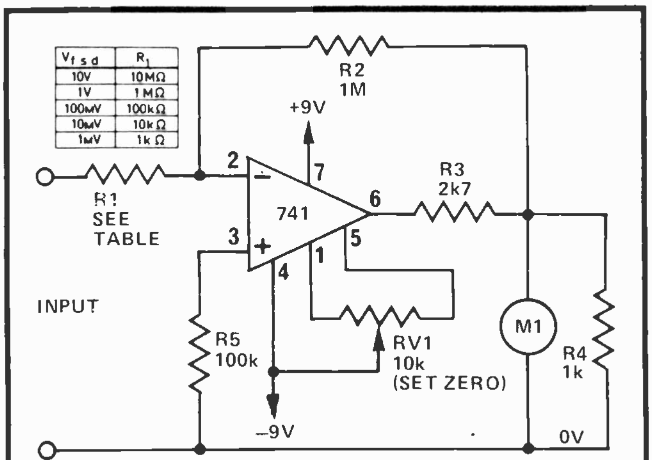


Fig. 26b Precision half-wave a.c./d.c. converter.

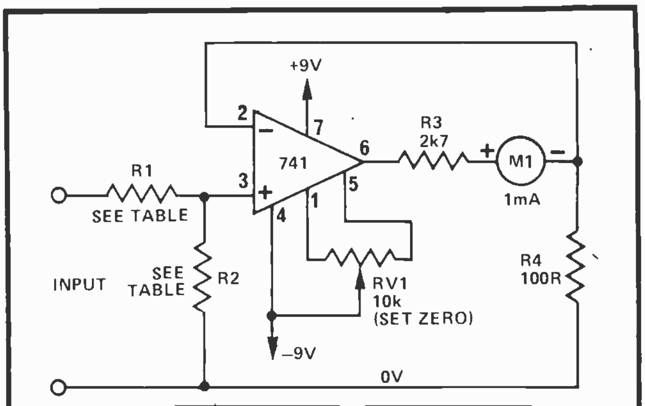


V_{fsd}	R_1
10V	10MΩ
1V	1MΩ
100mV	100kΩ
10mV	10kΩ
1mV	1kΩ

Fig. 27 High-performance d.c. voltmeter converter.

FIG. 27 shows how op-amp can be used as a high-performance d.c. voltmeter converter, which can be used to convert any 1V f.s.d. meter with a sensitivity better than 1k/V into a voltmeter that can read any value in the range 1mV to 10V f.s.d. at a sensitivity of 1M/V· The voltage range is determined by the R_1 value, and the table shows some suitable values for common voltage ranges.

FIG. 28 shows a simple circuit that can be used to convert a 1mA f.s.d. meter into a d.c. voltmeter with any f.s.d. value in the range 100mV to 1000V, or into a d.c. current meter with any f.s.d. value in the range 1uA to 1A. Suitable component values for different ranges are shown in the tables.



VOLTMETER

f.s.d.	R_1	R_2
1000V	10MΩ	1kΩ
100V	10MΩ	10kΩ
10V	10MΩ	100kΩ
1V	900kΩ	100kΩ
100mV	0Ω	100kΩ

CURRENT METER

f.s.d.	R_1	R_2
1A	0Ω	0.1Ω
100mA	0Ω	1Ω
10mA	0Ω	10Ω
1mA	0Ω	100Ω
100μA	0Ω	1kΩ
10μA	0Ω	10kΩ
1μA	0Ω	100kΩ

Fig. 28 Simple d.c. voltage or current meter.

FIG. 29 shows the circuit of a precision d.c. millivoltmeter, which uses a 1mA f.s.d. meter to read f.s.d. voltages from 1mV to 1000mV is seven switch-selected ranges.

FIG. 30 shows the basic circuit of a precision a.c. volt or millivolt meter. This circuit can be used with any moving-coil meter with a full scale current value in the range 100uA to 5mA, and can be made to give any full scale a.c. voltage reading in the range 1mV to 1000mV. The tables show the alternative values of R_1 and R_2 that must be used to satisfy different basic meter sensitivities, and the values of R_3 and R_4 that must be used for different f.s.d. voltage sensitivities.

HOME OHM

Finally, to conclude, Fig. 31 shows how the 741 op-amp can be used in conjuncton with a 1mA f.s.d. meter to make a linear-scale ohmmeter that has five decade ranges from 1k to 10M.

The circuit is divided into two parts, and consists of a voltage generator that is used to generate a standard test

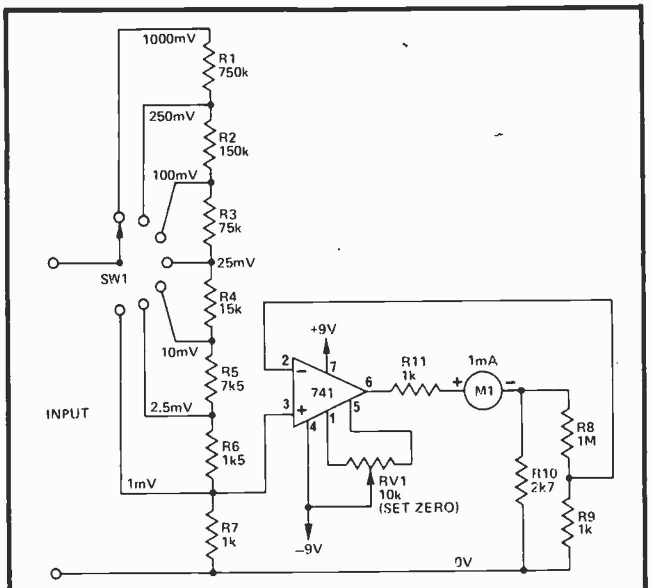
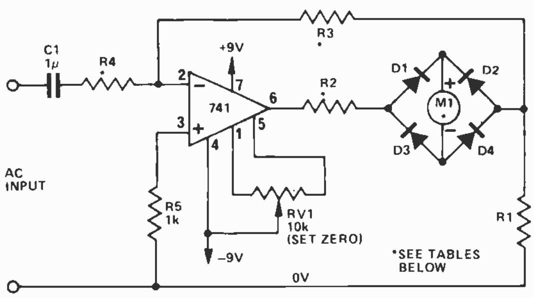


Fig. 29 Precision d.c. millivoltmeter.



M_1	R_1	R_2
100μA	9kΩ	27kΩ
500μA	1.8kΩ	5.6kΩ
1mA	900Ω	2.7kΩ
2.5mA	360Ω	1.5kΩ
5mA	180Ω	470Ω

VALUES FOR USE WITH DIFFERENT METER MOVEMENTS

V_{fsd}	R_4	R_3
1000V	10MΩ	10kΩ
100V	10MΩ	100kΩ
10V	10MΩ	1MΩ
1V	1MΩ	1MΩ
100mV	100kΩ	1MΩ
10mV	10kΩ	1MΩ
1mV	1kΩ	1MΩ

DIFFERENT f.s.d. VOLTAGE SENSITIVITIES

Fig. 30 Precision a.c. volt/millivolt meter.

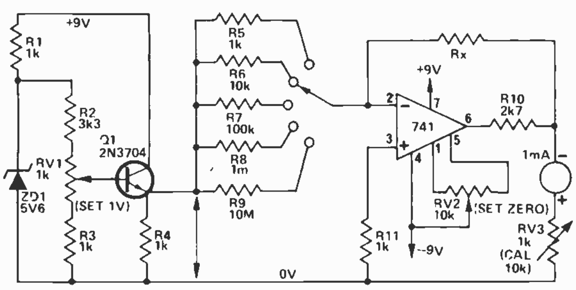


Fig. 31 Linear-scale ohmmeter.

voltage, and a readout unit which indicates the value of the resistor under test.

The voltage generator section of the circuit comprises zener diode ZD_1, transistor Q_1, and resistors R_1 to R_4. The action of these components is such that a stable reference potential of 1V is developed across R_4, but is adjustable over a limited range via RV_1. This voltage is fed to the input of the op-amp readout unit. The op-amp is wired as an inverting d.c. amplifier, with the 1mA meter and RV_3 forming a 1V f.s.d. meter across its output, and with the op-amp gain determined by the values of ranging resistors R_5 to R_9 and by negative feedback resistor R_x.

Since the input to the amplifier is fixed at 1V, the output voltage reading of the meter is directly proportional to the value of R_x, and equals full scale when R_x and the ranging resistor values are equal. Consequently, the circuit functions as a linear-scale ohmmeter.

CALIBRATION

The procedure for intially calibrating the Fig. 1.31 circuit is as follows. First, switch the unit to the 10kΩ range and fix an accurage 10kΩ resistor in the R_x position. Now adjust R_3 to give an accurate 1V across R_5, and then adjust R_{12} to give a precise full scale reading on the meter. All adjustments are then complete, and the circuit is ready for use.

MISCELLANEOUS 741 PROJECTS

The 741 op-amp can be used as the basis of a vast range of miscellaneous projects, including osillators and sensing circuits. Four such projects are described in this final section.

FIG. 32 shows how the 741 op-amp can be connected as a variable-frequency wien-bridge oscillator, which covers the basic range 150Hz to 1.5kHz, and uses a low-current lamp for amplitude stabilisation. The output amplitude of the oscillator is variable via RV_4 and has a typical maximum value of 2.5V r.m.s. and a t.h.d. value of 0.1%. The frequency range of the circuit is inversely proportional to the C_1-C_2 values· The circuit can give a useful performance up to a maximum frequency of about 25kHz.

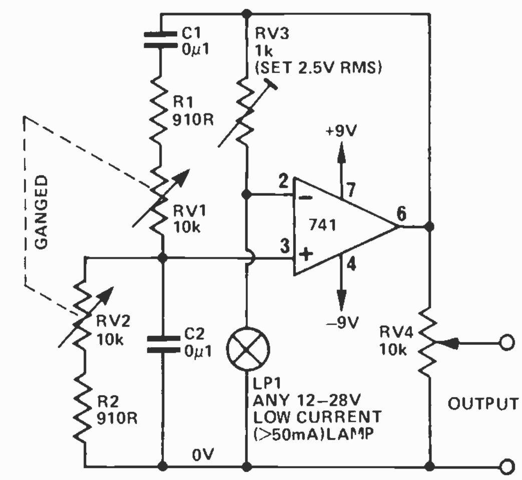


Fig.32 150Hz - 1.5kHz Wien-bridge oscillator.

Fig. 33 shows how either a 741 or a 709 op-amp can be connected as a simple variable-frequency square-wave generator that covers the range 500Hz to 5kHz via a single variable resistor. (The circuit produces a good symmetrical waveform.)

The frequency of oscillation is inversely proportional to the C_1 value, and can be reduced by increasing the C_1 value, or vice-versa. The amplitude of the square wave output signal can be made variable, if required, by wiring a 10kΩ variable potential divider across the output terminals of the circuit and taking the output from between the pot slider and the zero volts line.

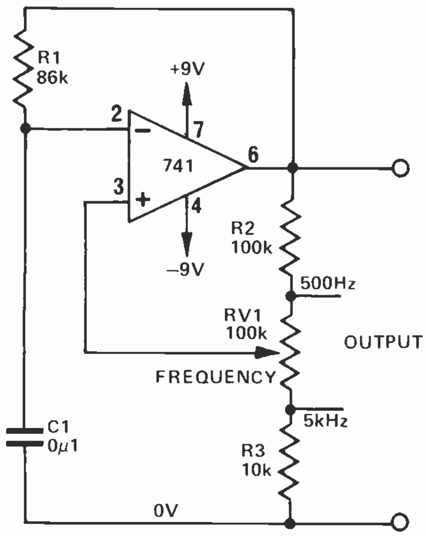


Fig. 33 Simple 500Hz - 5kHz square wave generator.

FIGS. 34 and 35 show a couple of useful ways of using the 741 op-amp in the open-loop differential voltage comparator mode. In each case, the circuits are powered from single-ended 12V supplies, and have a fixed half-supply reference voltage applied to the non-inverting op-amp terminal via the R_1-R_2 potential divider and have a variable voltage applied to the inverting op-amp terminal via a variable potential divider.

The circuit action is such that the op-amp output is driven to negative saturation and the relay is driven on when the variable input voltage is greater than the reference voltage, and the op-amp output is driven to positive saturation and the relay is cut off when the variable input voltage is less than the reference voltage.

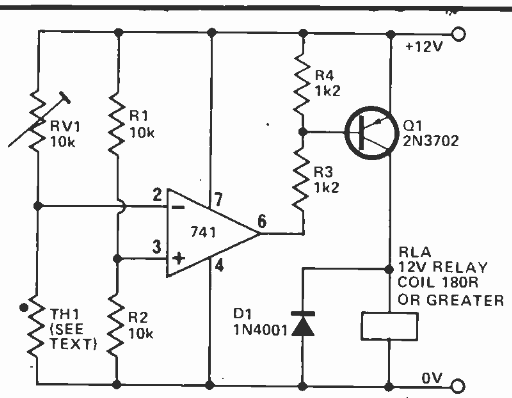


Fig. 34 Precision frost or under temperature switch can be made to act as a fire or over temperature switch by transposing R_1 and TH_1 positions.

FROSTY RECEPTION

The Fig. 34 circuit is that of a precision frost or under-temperature switch, which drives the relay on when the temperature sensed by thermistor TH_1 falls below a value pre-set via RV_1. The circuit action can be reversed, so that it operates as a fire or over-temperature switch, by simply transposing the RV_1 and the TH_1 positions. In either case, TH_1 can be any negative-temperature-coefficient thermistor that presents a resistance in the range 900Ω to 9kΩ at the required trip temperature.

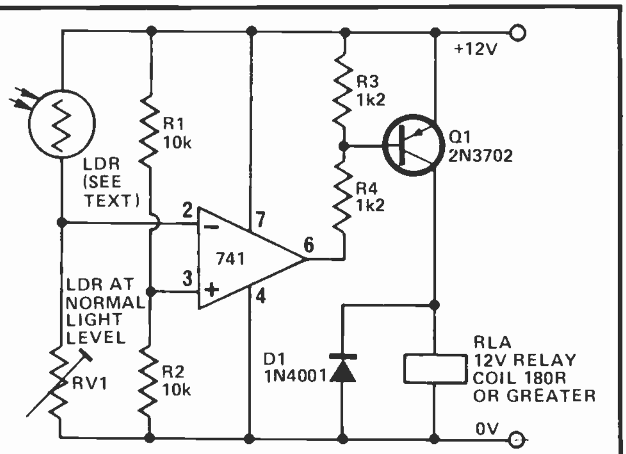


Fig. 35 Precision light-activated switch can be made to act as a dark-activated switch by transposing R_1 and LDR positions.

LIGHT WORK

The Fig. 35 circuit is that of a precision light-activated switch, which turns the relay on when the illumination level sensed by light-dependent resistor LDR exceeds a value pre-set by RV_1. The circuit action can be reversed so that the relay turns on when the illumination falls below a pre-set level by simply transposing the RV_1 and LDR positions. In either case, the LDR can be any cadmium-sulphide photocell that presents a resistance in the range 900Ω to 9kΩ at the desired switch-on level. ●

ASCII KEYBOARD

THIS PROJECT, NUMBER 631, FORMS THE FIRST PART OF OUR MPU HOME SYSTEM, THE ENCODER BOARD PROVIDES FULL ASCII OUTPUT, AND CAN BE USED WITH MOST COMMERCIAL KEYBOARD UNITS.

TO COMMUNICATE WITH A computer you need some sort of input device and some sort of output reader. The input unit can be a series of switches on which you set up the required code and press a button to enter each character. While this is economical in parts it is not economical in time.

This encoder project is designed to allow very easy access to the computer whilst being reasonably economical. It is very flexible and allows for almost any keyboard to be used. Control functions can be activated by a single key if desired and lower case letters can be eliminated at the flick of a switch.

The output from the keyboard is in the form of a parallel bus and the data has to be serialised to provide a universal input which will then communicate with any computer designed to work with a teletype.

DESIGN FEATURES

When we first looked at a keyboard encoder we intended to use a single chip device to simplify design. However, looking at the devices available and their limitations (and cost and availability) it was decided to compromise and use the HD0165 keyboard encoder. This IC has been available for many years and we use it to decode the first 4 lines. For the other three lines we decided to use discrete components. The eighth line is not used at this stage (it is used for a parity check after serialisation).

Initially the use of a 16 x 3 matrix was contemplated. Then we would use the shift and control keys to get the other outputs. However, not all keys with the same three-line code (b5, 6, 7) are upper case (or lower case). On our keyboard 0 1 ... : ; are lower case, and = ? are upper case; yet all have an output code 3. The same applies to other rows and the matrix has thus expanded to 16 x 7. To get the control functions a control and the function key have to be pressed simultaneously, which is inconvenient for commonly-used functions (such as space or line feed).

Consequently an additional three lines are used and this allows any of the control functions to be activated by a single key.

Most VDUs or microcomputer operating systems cannot handle lower-case letters and therefore outputs are provided which can be linked to ensure that a shift command is given automatically when any key from A-Z is pressed.

When connecting to the keyboard we had to decide how to wire the contacts. The easiest and neatest way is to use a double-sided pc board with plated-through holes. Using such a board it is hard to solder the other side when it is against the keyboard!

The alternative, and the approach we chose, is to link the underside of the keyboard using "solderable" enamelled wire and normal hookup wire to the control card. This takes a little time to wire but is much cheaper and is universal. Although we used a

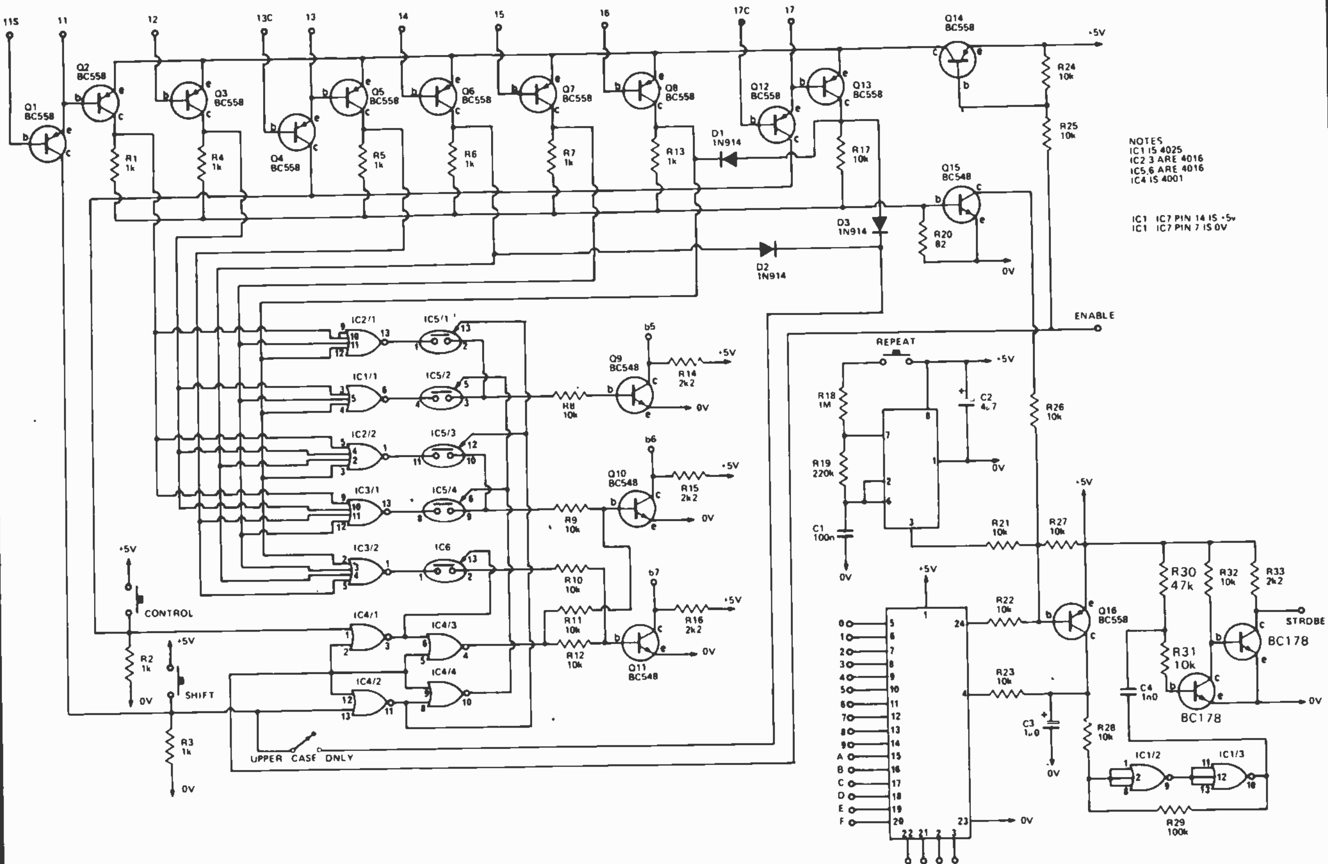


Fig. 1. Circuit diagram of the encoder.

How it works

The Harris HDO165 IC is a 16-line keyboard encoder; if any one of its 16 inputs is taken high (+5V) an output code appears on the four output lines. At the same time another output (pin 4) goes low and another output (pin 24) goes low to indicate this.

In this project we use this IC to generate the least significant four bits (b1, b2, b3, and b4) of the seven bits we need to represent the complete character.

To decode the other three bits we used discrete transistors and CMOS gates. Each key joins one of the inputs of the HDO165 to one of the points 11-17. If the enable line is low (i.e. 0V) Q14 will be hard on and we will have 5V (less a little) on the emitter of Q2,3,5,6,7,8 and 13. The input of the HDO165 appears as a resistor of about 500-600 ohms, to 0V. Therefore connecting (say) point 14 to point 3, we turn on Q6 giving +5V at its collector and also the HDO165 gives an output corresponding to three (0011).

The high output from Q6 gives a high on the inputs of IC 2/2 and IC3/2 causing the outputs of these gates to be low. The other gates, IC1/1, IC2/1 and IC3/1 have high outputs. If the control or shift key is not pressed, we have a '0' at the input of IC4/1 and IC4/2 giving a high output from these gates and hence a low output from IC4/3 and IC4/4. This enables IC5/1, IC5/3 and IC6. These ICs are simply electronic switches with a resistance of either 300 ohms (on) or infinity (off).

Therefore Q9 will be on as IC2/1 is high, Q10 will be off as IC2/2 is low and Q12 will also be off as IC3/2 is low. This gives a total output of 110 0011 which represents 63 (hex) or lower case c.

We will leave you to work out the other combinations. If the shift key is pressed, IC5/2, IC5/4 and IC6 are enabled selecting a different code (upper case C is 43 hex) and if the control key is pressed, Q10 and 11 are turned on by IC4/3 and Q9 is controlled by IC1/1 and IC2/1 ('control C' is 03 (hex), representing ETX).

When a key is pressed the output (pin 4) of the HDO165 goes low and C3 is discharged via R23. After about 10ms. the gates IC1/2, 3, which are connected as a schmitt trigger, operate and the output (IC1/3) goes low. This is coupled via C4. Q17/18 act as a monostable giving a negative-going pulse of about 200µs wide. When one key is pressed about 0.4V is developed across R20, not quite enough to turn on Q15. If a second key is pressed in a different row, the additional current in R20 will forward-bias Q15 which will then turn on Q16. This holds C3 charged, independent of the HDO165. If two keys are pressed in the same row on output (pin 24), the HDO165 detects this and goes low and Q16 is again turned on disabling the strobe pulse.

If the repeat button is pressed IC7 oscillates at about 10Hz and the pulsing alternately turns Q16 on and off generating strobe pulses at about 10 per sec.

The output of Q6 (A-O) and Q17 (P-Z) are diode ORed and if the 'upper case only' link or switch is closed it automatically gives a shift command. For the control functions additional inputs are used in Q1, Q4 and Q12. If the input to one of these transistors is connected to one of the HDO165 inputs it still turns on the transistor associated with it and also lifts either the control or shift inputs as required.

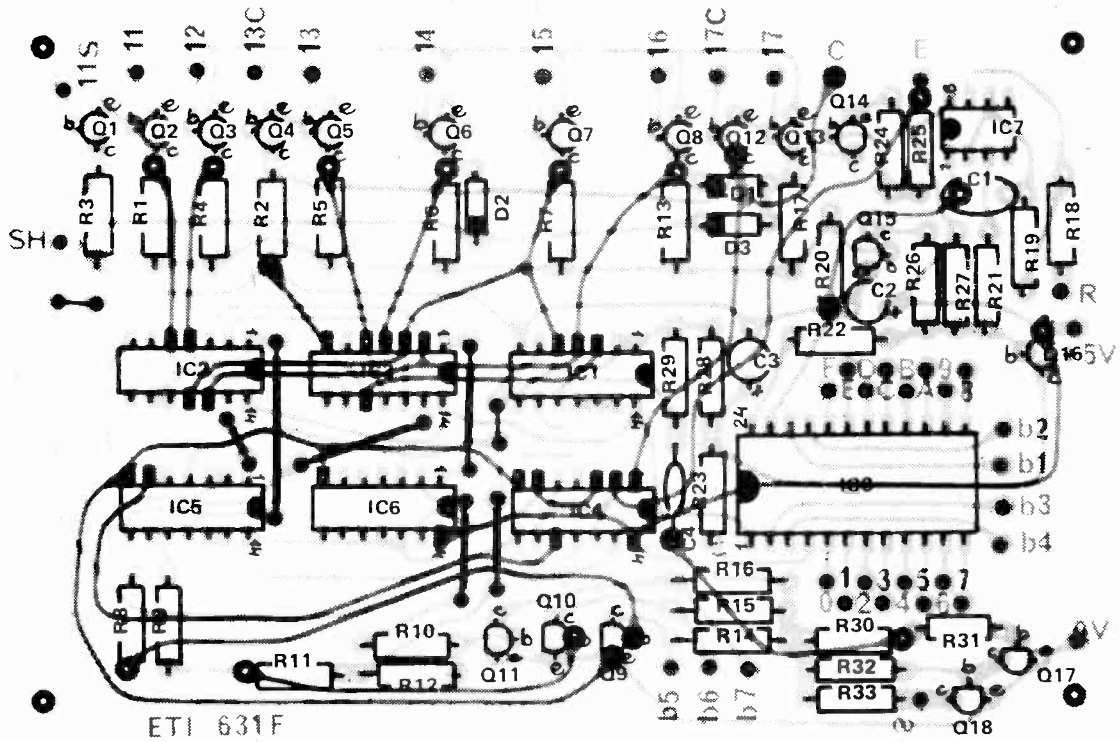


Fig.2. Component overlay of the encoder.

double-sided board for the control logic we don't require plated-through holes, as both sides can be easily soldered.

CONSTRUCTION

Assemble the PCB board with the aid of the overlay in Fig 2. When soldering the components use a small iron and make sure *all* connections on the component side are soldered as well as those on the copper side. The links on the component side must be insulated where they cross copper tracks, to prevent shorting.

Because you have to solder on both sides of the PCB you cannot use ICs sockets (unless they are wire-wrap types). The exception here is the HD0165 where all connections are on the copper side. Note also that the HD0165 is not CMOS or MOS and requires no special handling.

To make wiring easier mark the keys on the underside of the keyboard, to indicate what functions they represent. Now using "solderable" enamelled wire join the points as given in Table 1. The connection from the control board is also given and this should be made

CONTROL CARD	KEYBOARD SEQUENCE			
0	0	P	@	SP
1	1	Q	A	
2	2	R	B	
3	3	S	C	
4	4	T	D	
5	5	E	U	
6	6	F	V	
7	7	G	W	
8	8	H	X	BS
9	9	I	Y	TAB
A	:	J	Z	LF
B	[	;	K	ESC
C	\	L	,	
D	—	M	]	CR
E	Λ	.	N	
F	DEL	0	/	

CONTROL CARD	KEYBOARD SEQUENCE
11	: ; 0 9 8 7 6 5 4 3 2 1
12	— / . ,
13	@
14	L O I K J M N H B G F C D E A
15	Λ \ [ ]
16	DEL
17	P U Y T R V X Z S W Q
11S	SP
13C	BS TAB LF CR
17C	ESC

TABLE 1 ETI 631

How to wire up the keyboard

Parts List

Resistors all ½ W 5%	
R1-R7	1 k
R8-R12	10 k
R13	1 k
R14-R16	2k2
R17	10 k
R18	1 M
R19	220 k
R20	82R
R21-R28	10 k
R29	100 k
R30	220 k
R31	100 k
R32	10 k
R33	2k2
Capacitors	
C1	100 n polyester
C2	4µ7 25 V
C3	1 µ 25 V
C4	1n0 polyester
Semiconductors	
D1-D3	1N914
Q1-Q8	BC558 or BC108
Q9-Q11	BC548 or BC178
Q12-Q14	BC558 or BC108
Q15	BC548 or BC178
Q16	BC558 or BC108
Q17, 18	BC178
Integrated Circuits	
IC1	4025 (CMOS)
IC2, 3	4002 (CMOS)
IC4	4001 (CMOS)
IC5, 6	4016 (CMOS)
IC7	NE555
IC8	HD0165

SYSTEM 6S

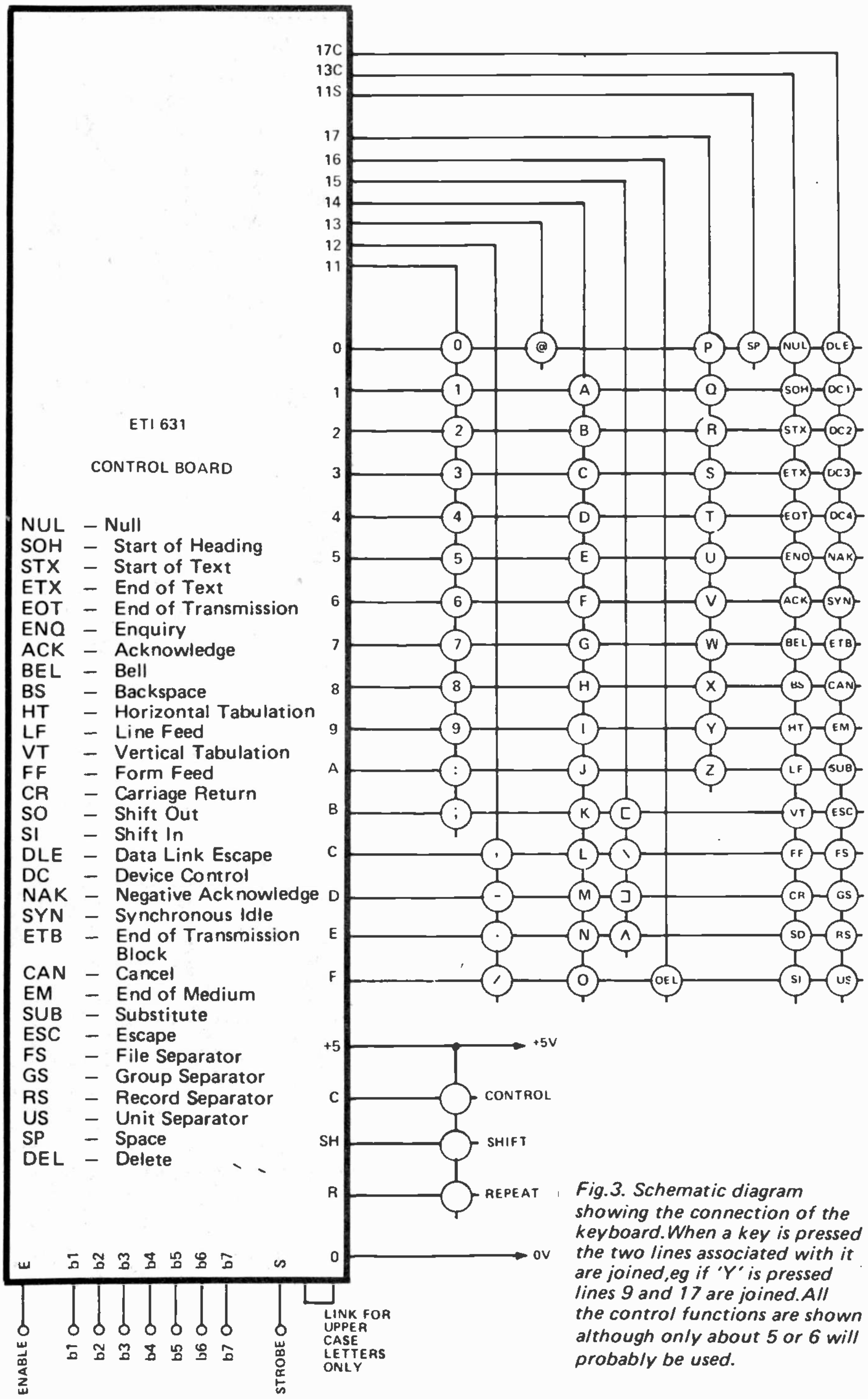


Fig.3. Schematic diagram showing the connection of the keyboard. When a key is pressed the two lines associated with it are joined, eg if 'Y' is pressed lines 9 and 17 are joined. All the control functions are shown although only about 5 or 6 will probably be used.

using normal hookup wire. The control functions can be wired between the points given either by taking two wires back to the control board or finding the same wire, if previously used, on the keyboard and linking across.

We have not described a housing for the unit as it will probably be mounted along with the VDU and UART (possibly under a TV set).

However, the control card can mount under the keyboard by spacing it up slightly. It may be necessary to have a piece of metal (Bacofoil, etc) under the keyboard/control card, connected to 0V. (To prevent 50Hz pickup into the wiring to the keyboard.) The effect of this is unwanted outputs from the strobe or non-operation of the strobe output.

To supply the unit 5V at 50mA is needed. To enable the keyboard a low (0V) is needed on that input. The data output are positive logic (ie, "1" is +5V) and the strobe output is active low.

Connecting the keyboard to a hex display gives an easy check that all wiring is correct. The list in Table 1 gives the character the access, the ASCII code, and the hex code. Alternatively 7 LEDs can be connected (cathode to 0V) across the outputs

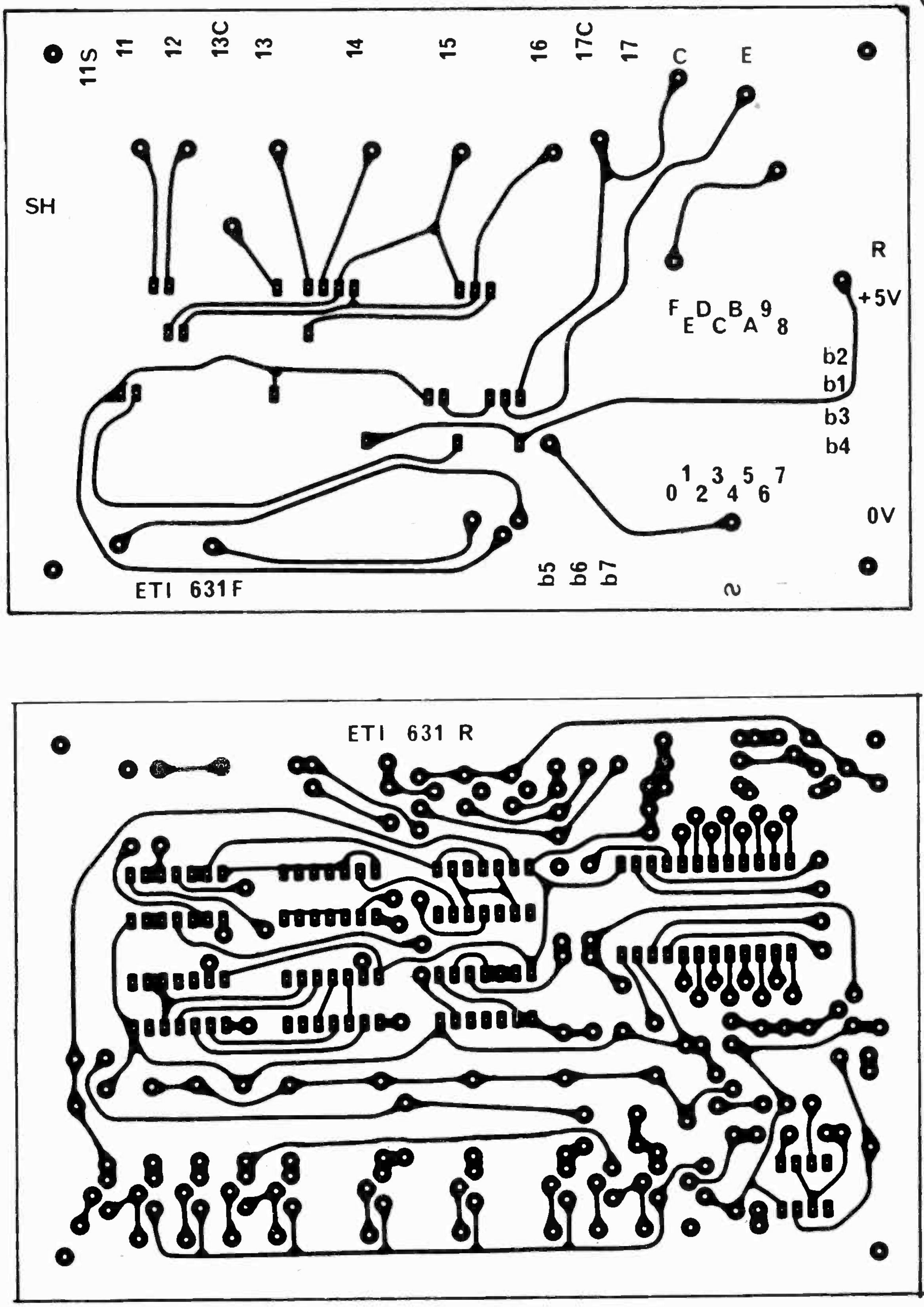


Fig.4. Printed circuit layout(both sides) Full size 150 x 100 mm.

TABLE 2

FUNCTION	ACCESS	b7	b6	b5	b4	b3	b2	b1	HEX CODE
NUL	CTRL @	0	0	0	0	0	0	0	0 0
SOH	CTRL A	0	0	0	0	0	0	1	0 1
STX	CTRL B	0	0	0	0	0	1	0	0 2
ETX	CTRL C	0	0	0	0	0	1	1	0 3
EOT	CTRL D	0	0	0	0	1	0	0	0 4
ENQ	CTRL E	0	0	0	0	1	0	1	0 5
ACK	CTRL F	0	0	0	0	1	1	0	0 6
BEL	CTRL G	0	0	0	0	1	1	1	0 7
BS	CTRL H	0	0	0	1	0	0	0	0 8
HT	CTRL I	0	0	0	1	0	0	1	0 9
LF	CTRL J	0	0	0	1	0	1	0	0 A
VT	CTRL K	0	0	0	1	0	1	1	0 B
FF	CTRL L	0	0	0	1	1	0	0	0 C
CR	CTRL M	0	0	0	1	1	0	1	0 D
SO	CTRL N	0	0	0	1	1	1	0	0 E
SI	CTRL O	0	0	0	1	1	1	1	0 F
DLE	CTRL P	0	0	1	0	0	0	0	1 0
DC1	CTRL Q	0	0	1	0	0	0	1	1 1
DC2	CTRL R	0	0	1	0	0	1	0	1 2
DC3	CTRL S	0	0	1	0	0	1	1	1 3
DC4	CTRL T	0	0	1	0	1	0	0	1 4
NAK	CTRL U	0	0	1	0	1	0	1	1 5
SYN	CTRL V	0	0	1	0	1	1	0	1 6
ETB	CTRL W	0	0	1	0	1	1	1	1 7
CAN	CTRL X	0	0	1	1	0	0	0	1 8
EM	CTRL Y	0	0	1	1	0	0	1	1 9
SUB	CTRL Z	0	0	1	1	0	1	0	1 A
ESC	CTRL [	0	0	1	1	0	1	1	1 B
FS	CTRL \	0	0	1	1	1	0	0	1 C
GS	CTRL]	0	0	1	1	1	0	1	1 D
RS	CTRL ^	0	0	1	1	1	1	0	1 E
US	CTRL DEL	0	0	1	1	1	1	1	1 F
SP	SHIFT 0	0	1	0	0	0	0	0	2 0
!	SHIFT 1	0	1	0	0	0	0	1	2 1
"	SHIFT 2	0	1	0	0	0	1	0	2 2
#	SHIFT 3	0	1	0	0	0	1	1	2 3
$	SHIFT 4	0	1	0	0	1	0	0	2 4
%	SHIFT 5	0	1	0	0	1	0	1	2 5
&	SHIFT 6	0	1	0	0	1	1	0	2 6
'	SHIFT 7	0	1	0	0	1	1	1	2 7
(	SHIFT 8	0	1	0	1	0	0	0	2 8
)	SHIFT 9	0	1	0	1	0	0	1	2 9
*	SHIFT :	0	1	0	1	0	1	0	2 A
+	SHIFT ;	0	1	0	1	0	1	1	2 B
,	,	0	1	0	1	1	0	0	2 C
-	-	0	1	0	1	1	0	1	2 D
.	.	0	1	0	1	1	1	0	2 E
/	/	0	1	0	1	1	1	1	2 F
0	0	0	1	1	0	0	0	0	3 0
1	1	0	1	1	0	0	0	1	3 1
2	2	0	1	1	0	0	1	0	3 2
3	3	0	1	1	0	0	1	1	3 3
4	4	0	1	1	0	1	0	0	3 4
5	5	0	1	1	0	1	0	1	3 5
6	6	0	1	1	0	1	1	0	3 6
7	7	0	1	1	0	1	1	1	3 7
8	8	0	1	1	1	0	0	0	3 8
9	9	0	1	1	1	0	0	1	3 9
:	:	0	1	1	1	0	1	0	3 A
;	;	0	1	1	1	0	1	1	3 B
<	SHIFT ,	0	1	1	1	1	0	0	3 C
=	SHIFT -	0	1	1	1	1	0	1	3 D
>	SHIFT .	0	1	1	1	1	1	0	3 E
?	SHIFT /	0	1	1	1	1	1	1	3 F

FUNCTION	ACCESS	b7	b6	b5	b4	b3	b2	b1	HEX CODE
@	@	1	0	0	0	0	0	0	4 0
A	SHIFT A	1	0	0	0	0	0	1	4 1
B	SHIFT B	1	0	0	0	0	1	0	4 2
C	SHIFT C	1	0	0	0	0	1	1	4 3
D	SHIF D	1	0	0	0	1	0	0	4 4
E	SHIFT E	1	0	0	0	1	0	1	4 5
F	SHIFT F	1	0	0	0	1	1	0	4 6
G	SHIFT G	1	0	0	0	1	1	1	4 7
H	SHIFT H	1	0	0	1	0	0	0	4 8
I	SHIFT I	1	0	0	1	0	0	1	4 9
J	SHIFT J	1	0	0	1	0	1	0	4 A
K	SHIFT K	1	0	0	1	0	1	1	4 B
L	SHIFT L	1	0	0	1	1	0	0	4 C
M	SHIFT M	1	0	0	1	1	0	1	4 D
N	SHIFT N	1	0	0	1	1	1	0	4 E
O	SHIFT O	1	0	0	1	1	1	1	4 F
P	SHIFT P	1	0	1	0	0	0	0	5 0
Q	SHIFT Q	1	0	1	0	0	0	1	5 1
R	SHIFT R	1	0	1	0	0	1	0	5 2
S	SHIFT S	1	0	1	0	0	1	1	5 3
T	SHIFT T	1	0	1	0	1	0	0	5 4
U	SHIFT U	1	0	1	0	1	0	1	5 5
V	SHIFT V	1	0	1	0	1	1	0	5 6
W	SHIFT W	1	0	1	0	1	1	1	5 7
X	SHIFT X	1	0	1	1	0	0	0	5 8
Y	SHIFT Y	1	0	1	1	0	0	1	5 9
Z	SHIFT Z	1	0	1	1	0	1	0	5 A
[	[	1	0	1	1	0	1	1	5 B
\	\	1	0	1	1	1	0	0	5 C
]	]	1	0	1	1	1	0	1	5 D
^	^	1	0	1	1	1	1	0	5 E
_	SHIFT DEL	1	0	1	1	1	1	1	5 F
	SHIFT @	1	1	0	0	0	0	0	6 0
a	A	1	1	0	0	0	0	1	6 1
b	B	1	1	0	0	0	1	0	6 2
c	C	1	1	0	0	0	1	1	6 3
d	D	1	1	0	0	1	0	0	6 4
e	E	1	1	0	0	1	0	1	6 5
f	F	1	1	0	0	1	1	0	6 6
g	G	1	1	0	0	1	1	1	6 7
h	H	1	1	0	1	0	0	0	6 8
i	I	1	1	0	1	0	0	1	6 9
j	J	1	1	0	1	0	1	0	6 A
k	K	1	1	0	1	0	1	1	6 B
l	L	1	1	0	1	1	0	0	6 C
m	M	1	1	0	1	1	0	1	6 D
n	N	1	1	0	1	1	1	0	6 E
o	O	1	1	0	1	1	1	1	6 F
p	P	1	1	1	0	0	0	0	7 0
q	Q	1	1	1	0	0	0	1	7 1
r	R	1	1	1	0	0	1	0	7 2
s	S	1	1	1	0	0	1	1	7 3
t	T	1	1	1	0	1	0	0	7 4
u	U	1	1	1	0	1	0	1	7 5
v	V	1	1	1	0	1	1	0	7 6
w	W	1	1	1	0	1	1	1	7 7
x	X	1	1	1	1	0	0	0	7 8
y	Y	1	1	1	1	0	0	1	7 9
z	Z	1	1	1	1	0	1	0	7 A
{	SHIFT [	1	1	1	1	0	1	1	7 B
¦	SHIFT \	1	1	1	1	1	0	0	7 C
}	SHIFT]	1	1	1	1	1	0	1	7 D
~	SHIFT ^	1	1	1	1	1	1	0	7 E
DEL	DELETE	1	1	1	1	1	1	1	7 F

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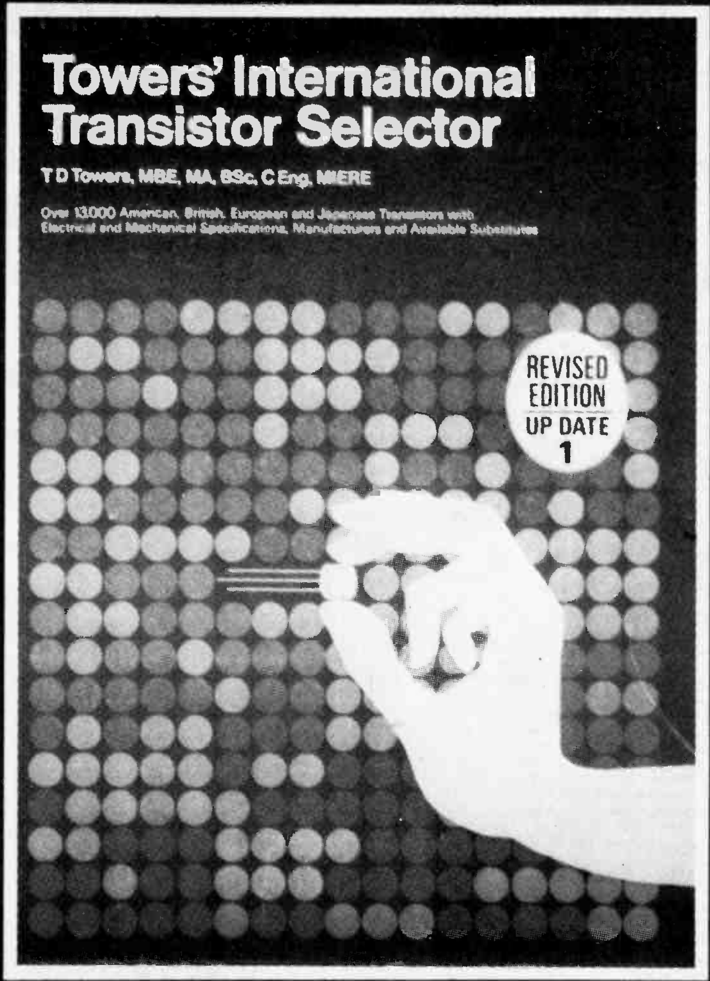

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This is a fairly new venture for the 'board people' — a complete wiring-pen outfit, including pen and wire-reels, magnifier, wiring harnesses, pins, wire-cutters, pin insertion tool, and dil prototyping board. A definite essential if you do a fair bit of digital work, and very useful indeed for prototyping ANY kind of circuit. (Worth £18.15)

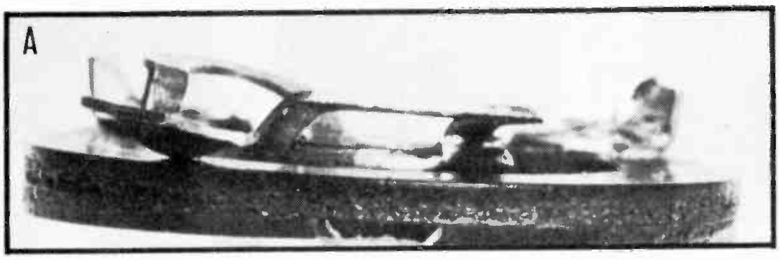
RULES OF THE GAME

1. Any persons in any way connected with the competition are ineligible to enter. This includes employees of firms manufacturing the prizes, and of Modmags Ltd.
2. The decision of the judges shall be regarded as final.
3. The prizes will be awarded to the first five correct entries drawn after the closing date, which shall be April 30th. No correspondence can be entered into regarding the competition.
4. All entries must be on the coupon from the magazine. Photostats are not acceptable.
5. Results will be published in the July issue of ETI, and winners notified by post.

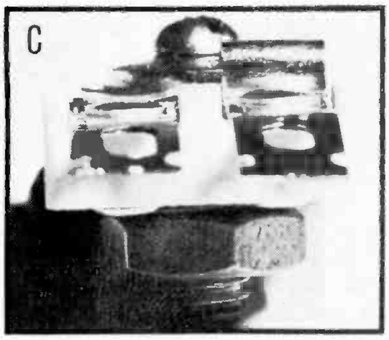
THDAY COMPETITION

A bit of a change this time. Below are eight photographs of electronic components or equipment. All you have to do is to tell us what they are. Of course we've taken them from as obscure an angle as possible – just for fun. None of the items depicted is as rare as it looks; you will certainly have seen them all many times from many angles. Fill in the answers on the coupon. For instance, if you think A is an atomic tea-strainer and butterfly mincer, write that next to A on the coupon. One hint: A is not an atomic tea-strainer.

Competition closes 30/4/77 and the results will be announced in the July issue of ETI. Good luck – and why didn't you send us a card?

A


B


C


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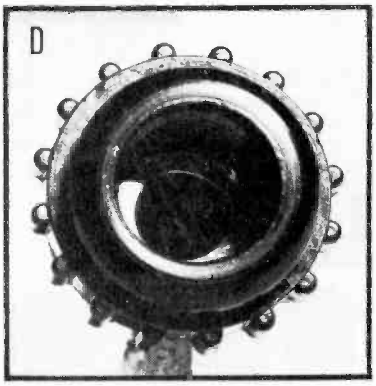
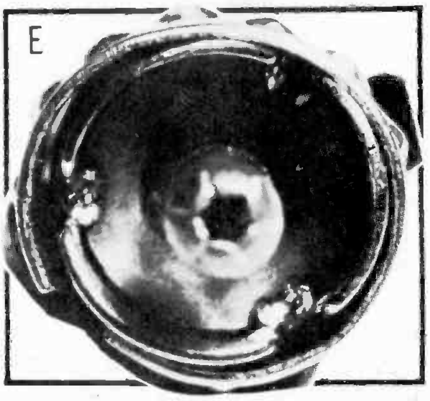


E


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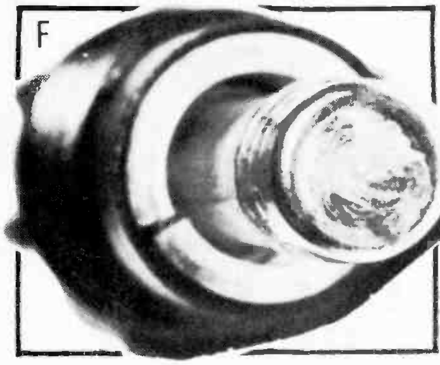
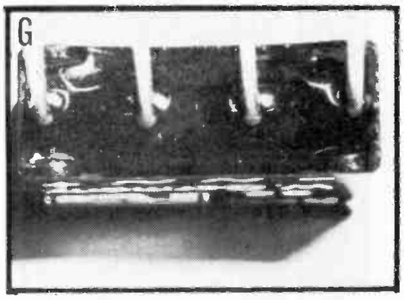
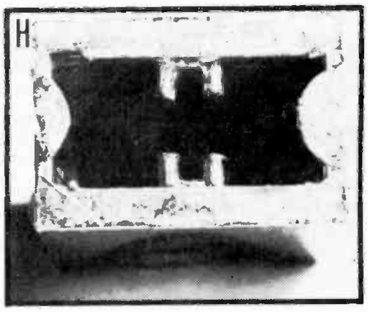


G


H


To: BIRTHDAY COMPETITION, ETI Magazine 25-27 Oxford Street, London, W1R 1RF. Closing date: 30/4/1977.

A.................................... E.................................... *NAME:*....................................

B.................................... F.................................... *ADDRESS:*....................................

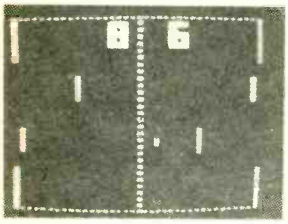
C.................................... G.................................... ....

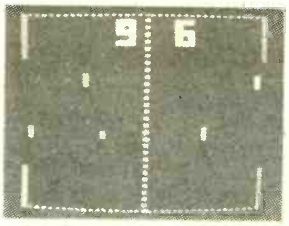
D.................................... H.................................... ....

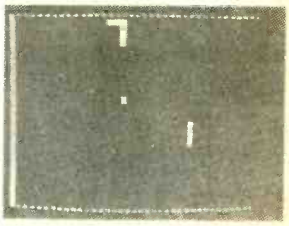
electronics today international

What to look for in the May issue-on sale April 1st.

At last: a single-chip TV game!



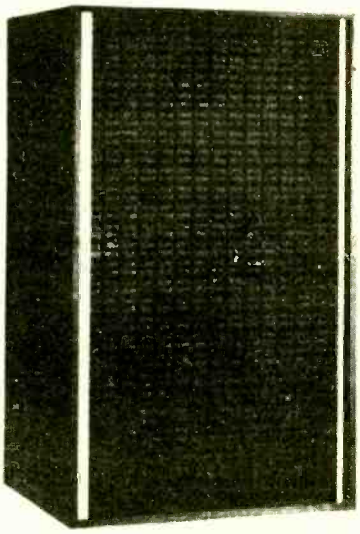




We've done it again! Next month we're presenting a really comprehensive DO-IT-YOURSELF T.V. game design. Our unit plays football, tennis, squash and a practice game. All have two speed action, variable reflection angle, and *naturally* on screen scoring and full sound effects. Boundaries are clearly shown, and the size of bat can be altered. If you think you can play T.V. tennis try playing our game with small bats and variable angle!

The game is based on the G.I. AY-3-8500 chip, the retail price of which is £15. However, for those of you who will be building this project, Maplin Electronics (see back cover for address) are making a special offer of *£8.99 inc.* until April 18th. (Trade enquiries are welcomed!) A full kit of parts will be available upon publication of the article.

Hi-Fi Speaker Enclosure



Our first venture into speaker design is a large bookshelf/small, free-standing, high quality enclosure. We avoided the usual 'megalithic monster' syndrome, and paid very special attention to the crossover and enclosure design instead — both sadly neglected areas. The result is an enclosure which has a performance that totally belies its size, and is very simple (and reasonably cheap!) to construct. The crossovers are available ready built off the shelf — so no coil winding — and full woodwork details are given in the article.

I^{2}L

We've heard about I^{2}L, you've heard about it, but until now it has been almost impossible to find out what this new technique is, where it can be used and what advantages it has over TTL and/or CMOS.

In the May issue we tell all.

The Valves that Won the War

The last world war was the first fought using technology and the Allies eventually outstripped the Axis powers and that led to our victory as much as the cheerful Tommy and the resiliant Ivan. Radar was perhaps the one most important development but this only became practical and portable with the development of the klystron.

SHORT CIRCUITS

SIGNAL INJECTOR/TRACER
A handheld unit with its own amplifier and oscillator. The amp is usable separately from the oscillator, and provides very reasonable quality for circuit checking.

METRONOME
A two-transistor design with a wide range from several seconds to several per second — and we include a fixed position with a beat rate that shows some evidence that stammerers can be helped.

Features mentioned on this page are in an advanced state of preparation but circumstances, including late developments may affect the final contents.

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2N696	0.35	2N3704	0.15	40362	0.48	BC161	0.50	BD135	0.37	BFX89	1.25
2N697	0.30	2N3705	0.15	40363	1.20	BC167	0.12	BD136	0.37	BFY50	0.34
2N698	0.62	2N3706	0.16	40406	0.58	BC168	0.12	BD137	0.38	BFY51	0.38
2N699	0.55	2N3707	0.18	40407	0.45	BC169	0.12	BD138	0.38	BFY52	0.36
2N706	0.24	2N3708	0.16	40408	0.65	BC170	0.16	BD139	0.40	BFY53	0.34
2N706A	0.12	2N3709	0.18	40409	0.65	BC171	0.14	BD140	0.40	BFY90	1.37
2N708	0.21	2N3710	0.16	40410	0.65	BC172	0.12	BD239	0.40	BRY39	0.50
2N709	0.50	2N3711	0.18	40411	2.85	BC177	0.20	BD240	0.45	BSX20	0.31
2N718	0.27	2N3712	1.20	40594	0.75	BC178	0.20	BD241	0.45	BSX21	0.32
2N718A	0.50	2N3713	2.30	40595	0.85	BC179	0.23	BD242	0.47	BU105	1.50
2N720A	0.80	2N3714	2.45	40673	0.73	BC182	0.11	BD243	0.60	BU205	2.20
2N914	0.35	2N3715	2.55	AC126	0.37	BC182L	0.14	BD244	0.62	ME0402	0.20
2N916	0.30	2N3716	2.80	AC127	0.44	BC183	0.11	BD245	0.65	ME0404	0.15
2N918	0.38	2N3771	1.85	AC128	0.37	BC183L	0.14	BD246	0.66	ME0412	0.20
2N929	0.25	2N3772	2.00	AC151V	0.35	BC184	0.12	BD529	0.42	ME4102	0.10
2N930	0.26	2N3773	2.90	AC152V	0.50	BC184L	0.14	BD530	0.47	ME4104	0.10
2N1131	0.60	2N3789	2.90	AC153	0.49	BC207	0.12	BDY20	1.13	MJ480	1.35
2N1132	0.60	2N3790	3.10	AC153K	0.55	BC208	0.11	BF115	0.38	MJ481	1.55
2N1613	0.35	2N3791	3.10	AC176	0.40	BC212	0.14	BF117	0.70	MJ490	1.35
2N1711	0.37	2N3792	3.50	AC176K	0.60	BC212L	0.17	BF121	0.55	MJ491	1.85
2N1893	0.38	2N3794	0.20	AC187K	0.55	BC213	0.14	BF123	0.55	MJ2955	1.25
2N2102	0.60	2N3819	0.36	AC188K	0.55	BC218L	0.16	BF152	0.25	MJE340	0.58
2N2218	0.33	2N3820	0.38	AD161	0.85	BC214	0.16	BF153	0.25	MJE370	0.58
2N2218A	0.37	2N3823	0.75	AD162	0.85	BC214L	0.17	BF154	0.25	MJE371	0.60
2N2219	0.30	2N3904	0.21	AF106	0.55	BC237	0.14	BF159	0.35	MJE520	0.45
2N2219A	0.32	2N3906	0.22	AF109	0.75	BC238	0.12	BF160	0.30	MJE521	0.65
2N2220	0.35	2N4036	0.67	AF124	0.65	BC239	0.15	BF161	0.60	MJE2955	1.40
2N2221	0.22	2N4037	0.55	AF125	0.65	BC251	0.15	BF166	0.40	MJE3055	0.85
2N2221A	0.26	2N4058	0.20	AF126	0.65	BC253	0.22	BF167	0.38	MP8111	0.35
2N2222	0.25	2N4059	0.20	AF127	0.65	BC257A	0.17	BF173	0.38	MP8112	0.40
2N2222A	0.25	2N4060	0.20	AF139	0.69	BC258A	0.17	BF177	0.30	MP8113	0.45
2N2368	0.25	2N4061	0.17	AF186	0.50	BC259B	0.18	BF178	0.35	MPF102	0.30
2N2369	0.25	2N4062	0.18	AF200	0.70	BC261A	0.21	BF179	0.35	MPSA05	0.23
2N2369A	0.25	2N4126	0.17	AF239	0.74	BC262B	0.19	BF180	0.40	MPSA06	0.24
2N2646	0.75	2N4289	0.20	AF240	0.98	BC263C	0.24	BF181	0.40	MPSA12	0.35
2N2647	1.40	2N4919	0.65	AF279	0.80	BC300	0.45	BF182	0.45	MPSA55	0.24
2N2904	0.36	2N4920	0.70	AF280	0.85	BC301	0.45	BF183	0.45	MPSA56	0.24
2N2904A	0.37	2N4921	0.50	BC107	0.15	BC303	0.60	BF184	0.38	MPSU05	0.50
2N2905	0.37	2N4922	0.55	BC108	0.15	BC307	0.20	BF185	0.35	MPSU06	0.56
2N2905A	0.38	2N4923	0.70	BC109	0.15	BC308	0.18	BF194	0.14	MPSU55	0.55
2N2906	0.28	2N5190	0.60	BC113	0.17	BC309C	0.25	BF195	0.13	MPSU56	0.60
2N2906A	0.25	2N5191	0.70	BC115	0.19	BC317	0.14	BF196	0.14	TIP29A	0.45
2N2907	0.21	2N5192	0.75	BC116	0.19	BC318	0.12	BF197	0.17	TIP30A	0.49
2N2907A	0.22	2N5195	0.90	BC116A	0.20	BC327	0.20	BF198	0.18	TIP31A	0.50
2N2924	0.15	2N5245	0.35	BC117	0.22	BC328	0.19	BF200	0.35	TIP32A	0.50
2N2926	0.13	2N5294	0.40	BC118	0.16	BC337	0.19	BF225J	0.25	TIP33A	0.80
2N3019	0.55	2N5295	0.40	BC119	0.30	BC338	0.21	BF244	0.35	TIP34A	0.90
2N3053	0.30	2N5296	0.40	BC121	0.45	BC547	0.12	BF245	0.34	TIP35A	2.50
2N3054	0.60	2N5298	0.40	BC132	0.30	BC548	0.12	BF246	0.75	TIP36A	3.35
2N3055	0.70	2N5447	0.15	BC134	0.15	BC549	0.13	BF254	0.24	TIP41A	0.70
2N3390	0.25	2N5448	0.15	BC135	0.15	BCY30	1.03	BF255	0.24	TIP42A	0.80
2N3391	0.25	2N5449	0.19	BC136	0.19	BCY31	1.06	BF257	0.37	TIP29c	0.60
2N3391A	0.25	2N5457	0.32	BC137	0.14	BCY32	1.70	BF258	0.45	TIP30c	0.65
2N3392	0.16	2N5458	0.33	BC140	0.40	BCY33	1.00	BF259	0.49	TIP31c	0.66
2N3393	0.15	2N5459	0.29	BC141	0.45	BCY34	1.20	BFR39	0.28	TIP32c	0.75
2N3394	0.15	2N5484	0.34	BC142	0.30	BCY38	2.00	BFS21A	2.60	TIP33c	1.10
2N3439	0.88	2N5486	0.38	BC143	0.30	BCY42	0.60	BFS28	1.04	TIP34c	1.20
2N3440	0.64	2N6027	0.53	BC147	0.12	BCY58	0.25	BFS61	0.30	TIP41c	0.85
2N3441	0.85	2N6101	0.65	BC148	0.11	BCY59	0.25	BFS98	0.27	TIP42c	0.95
2N3442	1.35	2N6107	0.42	BC149	0.13	BCY70	0.25	BFX29	0.38	TIP2955	0.65
2N3638	0.16	2N6109	0.42	BC153	0.27	BCY71	0.26	BFX30	0.40	TIP3055	0.55
2N3638A	0.16	2N6121	0.38	BC154	0.27	BCY72	0.24	BFX84	0.40	TIS43	0.30
2N3639	0.30	2N6122	0.41	BC157	0.12	BD115	1.20	BFX85	0.41		
2N3641	0.20	2N6123	0.43	BC158	0.11	BD116	1.20	BFX87	0.40		
2N3702	0.17	2N6126	0.45	BC159	0.14	BD131	0.51	BFX88	0.40		
2N3703	0.15	40361	0.45	BC160	0.50	BD132	0.54				

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CA3020A	2.29	LM3302N	1.40	TAA700	3.91
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CA3046	0.89	MC1303	1.47	TBA500	2.21
CA3048	2.23	MC1304	1.85	TBA500Q	2.30
CA3049	1.66	MC1305	1.85	TBA510	2.21
CA3052	1.62	MC1306	1.00	TBA510Q	2.30
CA3053	0.60	MC1310	1.91	TBA520	2.21
CA3080	0.68	MC1312	1.98	TBA520Q	2.30
CA3080A	1.88	MC1327	1.54	TBA530	1.98
CA3086	0.51	MC1330	0.92	TBA530Q	2.07
CA3088	1.59	MC1350	0.75	TBA540	2.21
CA3089	2.52	MC1351	1.20	TBA540Q	2.30
CA3090	3.80	MC1352	0.97	TBA550	3.13
CA3130	0.94	MC1357	1.45	TBA550Q	3.22
LM301A	0.65	MC1458	0.91	TBA560Q	3.22
LM301N	0.44	NE555	0.53	TBA570	1.29
LM304	2.45	NE556	1.05	TBA570Q	1.38
LM307N	0.65	NE565	1.20	TBA641B	2.50
LM308C	1.82	NE566	1.65	TBA651	1.80
LM308N	1.17	NE567	1.80	TBA700	1.52
LM309K	2.10	SAS560	2.50	TBA700Q	1.61
LM317K	3.00	SAS570	2.50	TBA720Q	2.30
LM318N	2.25	76001N	1.57	TBA750	1.98
LM323K	6.40	76003N	2.55	TBA750Q	2.07
LM339N	1.75	76008K	2.50	TBA800	1.20
LM348N	1.91	76013N	1.70	TBA810	1.16
LM360N	2.75	76013ND	1.57	TBA820	1.03
LM370N	3.00	76018K	2.50	TBA920	1.79
LM371N	2.25	76023ND	1.57	TBA920Q	2.99
LM372N	2.15	76033N	2.55	TBA940	1.62
LM373N	2.25	76110N	1.46	TCA160C	1.85
LM374N	2.25	76114N	1.87	TCA160B	1.61
LM377N	1.75	76116N	2.06	TCA270	2.25
LM378N	2.25	76131N	1.30	TCA280A	1.30
LM379N	3.95	76226N	1.94	TCA290A	3.13
LM380-8	0.90	76227N	1.51	TCA420A	1.84
LM380N	0.98	76228N	1.75	TCA730	3.22
LM381A	2.45	76530N	0.91	TCA740	2.76
LM381N	1.60	76532N	1.50	TCA750	2.30
LM382N	1.25	76533N	1.30	TCA760	1.38
LM384N	1.45	76544N	1.44	TCA800	3.13
LM386N	0.80	76545N	2.09	UAA170	2.00
LM387N	1.05	76546N	1.44	UAA180	2.00
LN388N	1.00	76550N	0.41		
LM389N	1.00	76552N	0.65		
LM702C	0.75	76570N	2.08		
LM709C	0.65	76620N	1.10		
LM709N	0.45	76650N	1.10		
LM710C	0.60	76660N	0.60		
LM710N	0.60	76666N	0.92		
LM723C	0.85	TAA301A	1.50		
LM723N	0.75	TAA320A	1.15		
LM741C	0.65	TAA350A	2.48		
LM741N	0.50	TAA521	1.00		
LM741-8	0.40	TAA522	1.90		
LM747N	0.90	TAA550	0.60		
LM748-8	0.50	TAA560	1.60		
LM748N	0.50	TAA570	2.30		
LM1800	1.76	TAA611B	1.85		
LM1808	1.92	TAA621	2.15		
LM1828	1.75	TAA661A	1.32		

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16 pin	0.18
22 pin	0.30
24 pin	0.35
28 pin	0.45
40 pin	0.55

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Data Sheet 5p+SAE

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6 amp	0.75	12 amp	1.10
8 amp	0.80	16 amp	1.60

THYRISTORS Plastic C106 116

5 amp 100V	0.35	8 amp 100V	0.43
5 amp 200V	0.40	8 amp 200V	0.49
5 amp 400V	0.49	8 amp 400V	0.62

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W005	0.30	BY164	0.57
W01	0.32	B40C1500	0.48
W02	0.34	B40C3200	1.10
W04	0.40	B80C1500	0.75
W06	0.50	B80C3200	1.15

SEE MARSHALL'S FOR CMOS

CD4000	0.24	CD4018	1.15	CD4042	0.96
CD4001	0.24	CD4019	1.15	CD4043	1.15
CD4002	0.24	CD4020	1.27	CD4044	1.06
CD4006	1.34	CD4021	1.15	CD4045	1.59
CD4007	0.24	CD4022	1.10	CD4046	1.52
CD4008	1.10	CD4023	0.24	CD4047	1.15
CD4009	0.64	CD4024	0.84	CD4049	0.64
CD4010	0.64	CD4025	0.24	CD4050	0.64
CD4011	0.24	CD4027	0.64	CD4510	1.56
CD4012	0.24	CD4028	1.02	CD4511	1.79
CD4013	0.64	CD4029	1.30	CD4516	1.56
CD4014	1.15	CD4030	0.64	CD4518	1.43
CD4015	1.15	CD4031	2.53	CD4520	1.43
CD4016	0.64	CD4037	1.60		
CD4017	1.15	CD4041	0.96		

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SN7401	0.21	SN7413	0.51	SN7440	0.21	SN7470	0.46	SN7485	1.85	SN74118	0.99	SN74157	0.98	SN74180	1.77
SN7402	0.21	SN7416	0.61	SN7441	1.03	SN7472	0.38	SN7486	0.41	SN74119	1.80	SN74160	1.41	SN74181	3.70
SN7403	0.21	SN7417	0.61	SN7442	0.78	SN7473	0.43	SN7490	0.61	SN74121	0.49	SN74161	1.41	SN74190	1.91
SN7404	0.26	SN7420	0.21	SN7446	1.23	SN7474	0.43	SN7491	0.98	SN74122	0.45	SN74162	1.41	SN74191	1.91
SN7405	0.26	SN7423	0.39	SN7447	1.17	SN7475	0.58	SN7492	0.61	SN74123	0.58	SN74163	1.41	SN74192	1.62
SN7406	0.74	SN7425	0.39	SN7448	1.17	SN7476	0.51	SN7493	0.61	SN74141	1.03	SN74164	1.23	SN74193	1.62
SN7407	0.74	SN7427	0.39	SN7450	0.27	SN7480	0.45	SN7494	0.74	SN74145	1.06	SN74165	1.23	SN74196	1.17
SN7408	0.29	SN7430	0.21	SN7451	0.21	SN7481	1.10	SN7495	0.78	SN74150	1.66	SN74167	3.70	SN74197	1.17
SN7409	0.29	SN7432	0.39	SN7453	0.21	SN7482	0.67	SN7496	1.03	SN74151	1.11	SN74174	1.52	SN74198	2.93
SN7410	0.21	SN7437	0.55	SN7454	0.21	SN7483	1.33	SN74100	1.15	SN74153	1.11	SN74175	1.35	SN74199	2.93

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	TIL209		0.24				

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ETI DATA SHEET

MK 50361-50362 ALARM CLOCK — MOSTEK

THESE ARE MOS CIRCUITS, using depletion-load ion implantation process. Both chips work in 12 or 24 hr mode and will drive displays directly. Features included are: 10mA/segment LED drive; low voltage backup (9v); forward or reverse time setting; intensity control; non-MPX display; 24hr alarm in three modes — tone, radio or tone plus radio; variable 'snooze' (1-59 mins); count hold; summer/winter time switch; clear on switch on; leading zero suppression in 12hr mode. ON 50362 ONLY: Four Year Calendar; choice of date display format; second alarm time.

The snooze inhibits an activated alarm for 10min periods. The 'sleep' will activate the radio for between 1-59 mins (adjustable).

POWER FAILURE

At the occurrence of power failure, the digits will flash at 1Hz to indicate incorrect time displayed. Set 2 (forward) switch should be closed (once power is restored). This mode is triggered when the colon output goes to V_{SS} and may occur at initial power-on.

DISPLAY MODE

The input is three state. Operation is as follows:

Display Input	Mode
V_{SS}	Alarm time displayed
Open	Time displayed
V_{DD}	Seconds displayed

When in alarm mode, the time displayed is that to which the alarm is set. It may be altered by use of the time set procedure, given below.

SETTING

The setting mode allows either a forward setting *or reverse setting* of the display. The setting inputs are:

Set 1 or Set 2 Input	Mode
V_{SS}	Forward Set
Open	—
V_{DD}	Reverse Set

When either the set 1 input or set 2 input is connected to V_{SS} the display will increment. Connecting the input to V_{DD} will decrement the display. When the display is not being set, the inputs should be left open. The set 1 input changes the hours digits at two counts per second. The set 2 input changes the minute digits at two counts per second. Carrys or borrows are not allowed during time setting.

DISPLAY FORMAT

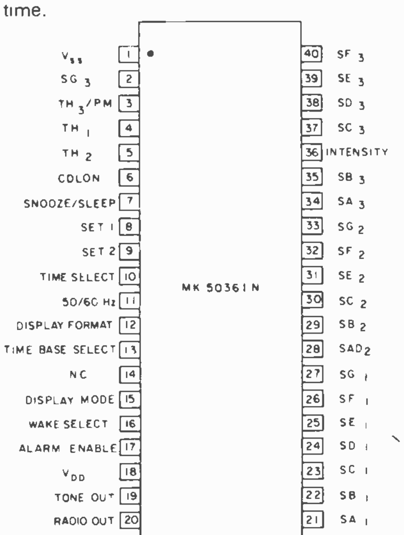
The display format is used to select a 12 hour display, 24 hour display or to blank the display. The connections are:

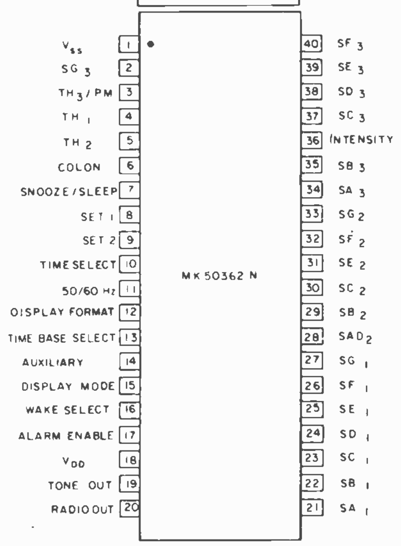
Display Format Input	Mode
V_{SS}	12 Hour
Open	Blank Display
V_{DD}	24 Hour

In the 12 hour mode, the hours digits will display time in 12 hour format with a PM output. When the input is connected to V_{DD}, the format will be 24 hour time. In the blank mode the segment outputs will float, allowing wire-or conditions.

COLON

In normal operation, the colon flashes at one Hertz rate for an activity indicator. The colon output conducts to V_{SS} with a 50% duty cycle in the 60Hz mode and 40% duty cycle in the 50Hz mode. The colon is off when displaying calendar, seconds or sleep time.





INTENSITY

The intensity input regulates the current of the segment outputs and colon output.

The intensity input regulates the current of the segment outputs and colon output. Over a range from 3KΩ to 30KΩ for the intensity resistor (R_{SENSE}), the following equation may be used to predict segment current (I_{SEG}):

$$I_{SEG} = 18 \frac{V_{FWD\ LED\ (in\ volts)}}{R_{SENSE\ (in\ Kohms)}} mA$$

Segment current is relatively independent of the voltage on the segment pins, therefore the LED display voltage supply need not be well filtered. For minimum value of R_{SENSE} (intensity control resistor), care should be taken to insure total circuit power dissipation does not exceed safe operating limits.

AM/PM OUTPUT

When in the 12 hour operating mode, the TH3/PM output conducts to V_{SS} when active. The indicator will change states when the hours change from 11 to 12. When in the 24 hour mode this output drives segments A, D & G on the most significant digit. Consideration must be given to wiring the display to accommodate both 12 hour and 24 hour operation using the same display.

TIME SELECT (Daylight saving time)

Connection of the time select pin to V_{SS} will advance the time by one hour. By opening the connection, the time will return to the original time. Connecting this input to V_{DD} will reset the clock to the Power Up mode.

ALARM ENABLE/WAKE SELECT

The alarm can operate in three modes according to the voltage on the wake select pin. The states are defined as:

Wake Input	Mode
V_{SS}	Tone
Open	Radio
V_{DD}	Radio followed by Tone

The Alarm enable pin enables alarm 1 when connected to V_{SS}. If it is left open it will disable the alarm due to an internal resistor. When the alarm occurs it may be disabled and immediately re-enabled and will activate 24 hours later at the alarm time. The alarm will self-disable after one hour of operation. The output tone will be in the range of 200 to 1000Hz and conducts to V_{SS} 8.3% of the time at a 1Hz rate.

Radio out, when activated by either the alarm or sleep function, will conduct to V_{SS}.

When the radio followed by tone mode is selected, radio out conducts to V_{SS} at alarm time. Eight minutes later the tone output will be enabled. Both remain on until inhibited by the alarm enable control, snooze, or the automatic alarm reset which occurs after one hour.

SNOOZE/SLEEP INPUT

The snooze and sleep inputs use a single pin to select snooze or sleep. The connections are:

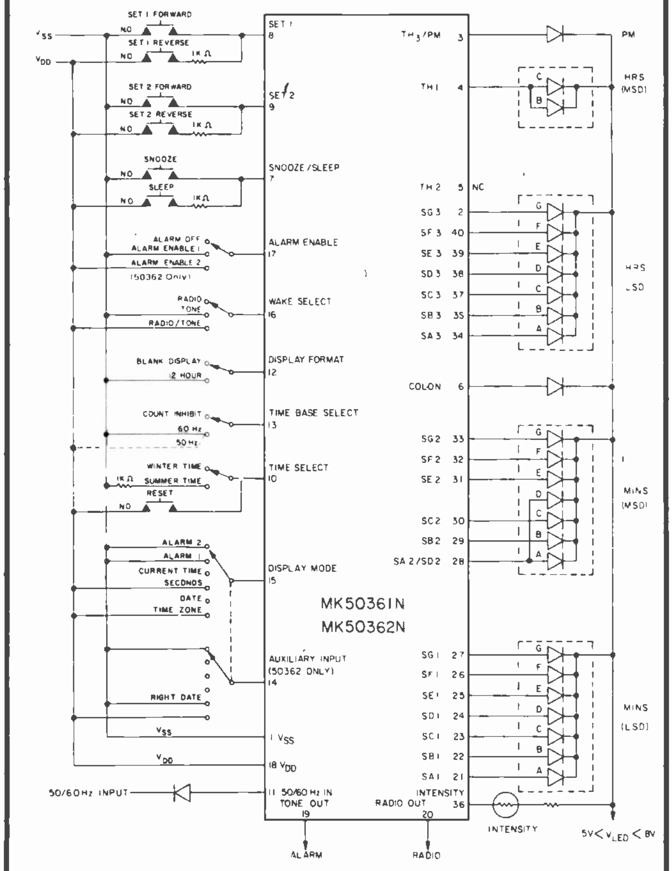
Snooze/Sleep	Mode
V_{SS}	Snooze
Open	No Change
V_{DD}	Sleep

The Snooze feature will temporarily turn off an activated radio and tone outputs to allow an additional 10 minutes' sleep. Momentarily connecting snooze to V_{SS} will activate the snooze. If left open an internal pull-down resistor will maintain the snooze feature inoperative.

Connection of the pin to V_{DD} will display the sleep time in minutes in the minutes digits. The time will start at 10 minutes, and the set 2 input is used to set the sleep time. Radio out will conduct to V_{SS} for the amount of time set. After the time decrements to zero radio out will turn off, provided that the Snooze/Sleep input is not being held at V_{DD}.

If the snooze is active, the sleep input will reset the snooze function. The snooze input will reset an active sleep time.

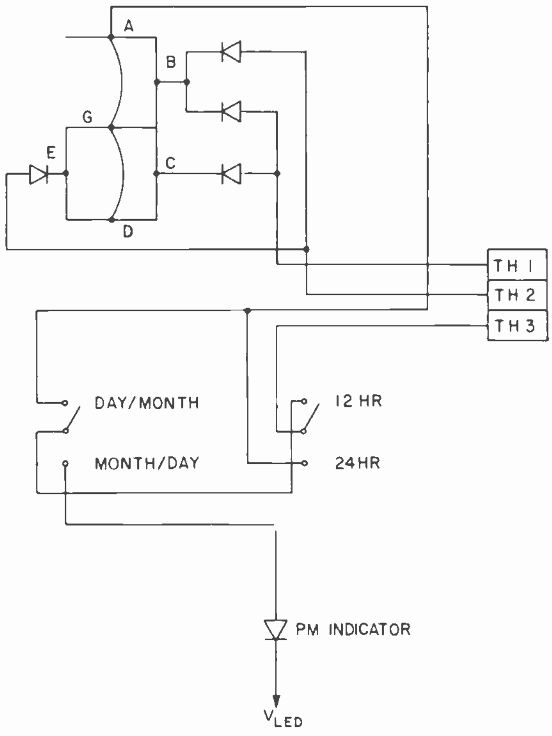
GENERALIZED CIRCUIT (12 HR. DISPLAY FORMAT)



RECOMMENDED OPERATING CONDITIONS (0°C to 45°C)

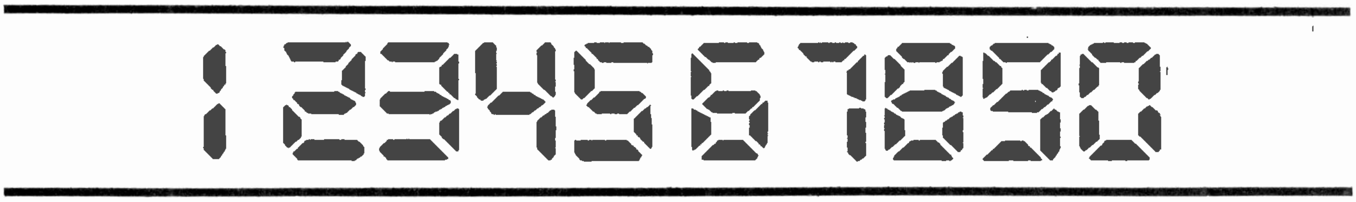
PARAMETER	Min	Max	Units
Operating Voltage, V_{DD}	−12	−16	Volts
Standby Voltage, V_{DD}	−8.0	−12	Volts
Input Logic Levels: Set 1, Set 2, Display Mode, Snooze/Sleep, 50/60Hz, Display Format, Alarm Enable, Wake Select, Time Select, Time Base Select, Auxiliary	V_{SS} −1.0	V_{SS}	Volts
	V_{DD}	V_{DD} + 1.0	Volts
Intensity Control	3	30	K–OHMS
Segments, Colon		−26	Volts

SELECTABLE 12 HR. OR 24 HR. DISPLAY



THESE CHIPS ARE AVAILABLE FROM PRONTO ELECTRONIC SYSTEMS LTD. 645–647, HIGH ROAD, SEVEN KINGS, ESSEX, IG3 8RA. PRICE- £8.00 inc.

DISPLAY FONT



FUNCTION SETTING

The displayed function is set using the set inputs while the appropriate function is displayed using the display mode input and auxiliary input. The set 1 input changes the hours or month digits at two counts per second. The set 2 input changes the minute or date digits at two counts per second. Carrys or borrows are not allowed during setting except for an illegal month date combination.

The MK 50362N contains an auxiliary input which allows the selection of additional features. All other functions operate like the MK 50361N.

The additional features are selected by using the Display Mode Input and the Auxiliary Input. The selection is:

Function	Display Mode Input	Auxiliary Input
Alarm 1 Set	V_{SS}	Open
Current Time	Open	Open
Seconds	V_{DD}	Open
Month Date	Open	V_{SS}
Date Month	Open	V_{DD}
Alarm 2 Set	V_{SS}	V_{SS}
Time Zone	V_{DD}	V_{DD}

MONTH—DATE CALENDAR

The calendar is a four year calendar. Connecting the Auxiliary input to V_{SS} will display a Month-Date format. A Date-Month format can be selected by connecting the Auxiliary input to V_{DD}. The display mode input must remain open.

SECOND ALARM TIME

The second alarm time can be displayed by connecting the Display Mode input and the auxiliary input to V_{SS}. To enable the alarm, the Alarm Enable pin should be connected to V_{DD}. Alarm 2 will not have an automatic shutoff. Disabling either alarm will reset snooze.

The HD-0615 Keyboard Encoder is a 16 line to four-bit parallel encoder intended for use with manual data entry devices such as calculator or typewriter keyboards. In addition to the encoding function, there is a Strobe output and a Key Rollover output which energises whenever two or more inputs are energised simultaneously. Any four-bit code can be implemented by proper wiring of the input lines. Inputs are normally wired through the key switches to the +5.0V power supply. Full typewriter encoding up to eight bits can be accomplished with two Encoder circuits by the use of double pole key switches or single pole switches with two isolation diodes per key. Outputs will interface with all popular DTL and TTL logic families. The circuit is packaged in a hermetic 24-pin dual in-line package and operates over the temperature range of 0°C to + 75°C.

TRUTH TABLE

INPUTS																OUTPUTS					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	$\overline{St.}$	$\overline{K_{RO}}$
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H
H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	L	H
L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	L	H
L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	H	H	L	H
L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	L	H
L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	H	H	L	H	L	H
L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	H	L	H	L	H
L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	H	L	L	H	L	H
L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	H	L	H
L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	H	H	H	L	L	H
L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	H	H	L	L	H
L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	H	L	H	L	L	H
L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	H	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	H	H	L	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	H	L	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	H	L	L	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	H
ANY TWO OR MORE HIGH																X	X	X	X	L	L

ELECTRICAL CHARACTERISTICS

	PARAMETER		SYM.	LIMITS MIN.	TYP.	MAX.	UNITS	TEST CONDITIONS
	Input Current	"1"	I_{IH}			17	mA	V_{IN} = +5 0V
D.C.	Output Voltage	"0"	V_{OL}		+0.2	+0.4 +0.4	V	V_{IH} = +4.5V I_{OL} = 10mA V_{IH} = +3.5V I_{OL} = 3.2mA
		"1"	V_{OH}	+2.4	+4 0			V_{IL} = Open Circuit, I_{OH} = −240 μA
	Power Supply Current	Operating	I_{CC}			52	mA	One Input at +5.25V
		Maximum	I_{CCM}			88	mA	All Inputs at +5.25V
A.C.	Skew Time (Note 1)		T_{SK}		80	200	ns	T_{Case} = 25°C V_{CC} = V_{IN} = +5.0V C_L < 50pF

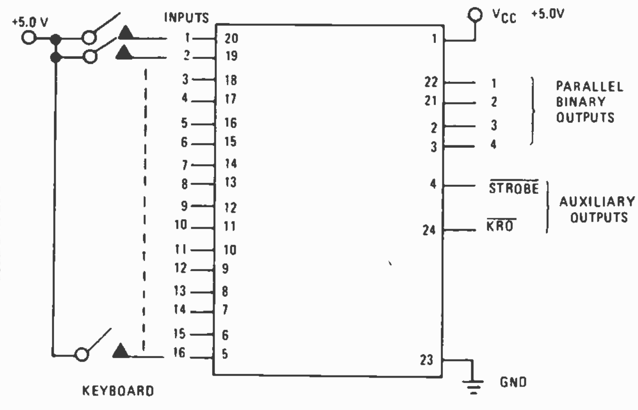


Figure 1. GENERAL CONFIGURATION FOR ENCODING TWO TO SIXTEEN KEYS

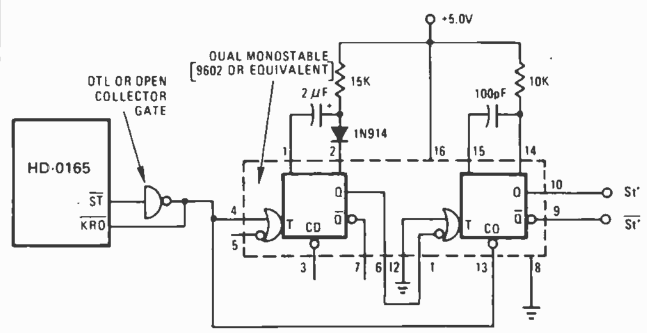


Figure 2. SWITCH BOUNCE ELIMINATION

THE ENCODER IS AVAILABLE FROM PRONTO ELECTRONICS, ADDRESS PAGE 39, FOR £8.10 inc.

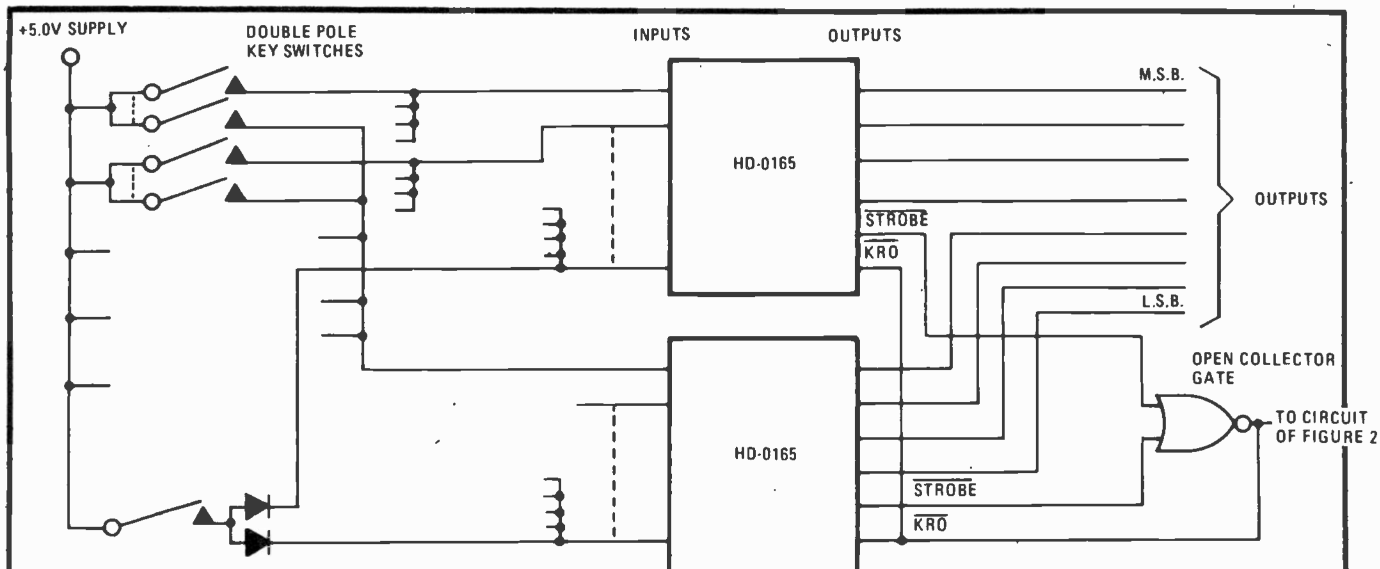


Figure 3. ENCODING UP TO 256 KEYS

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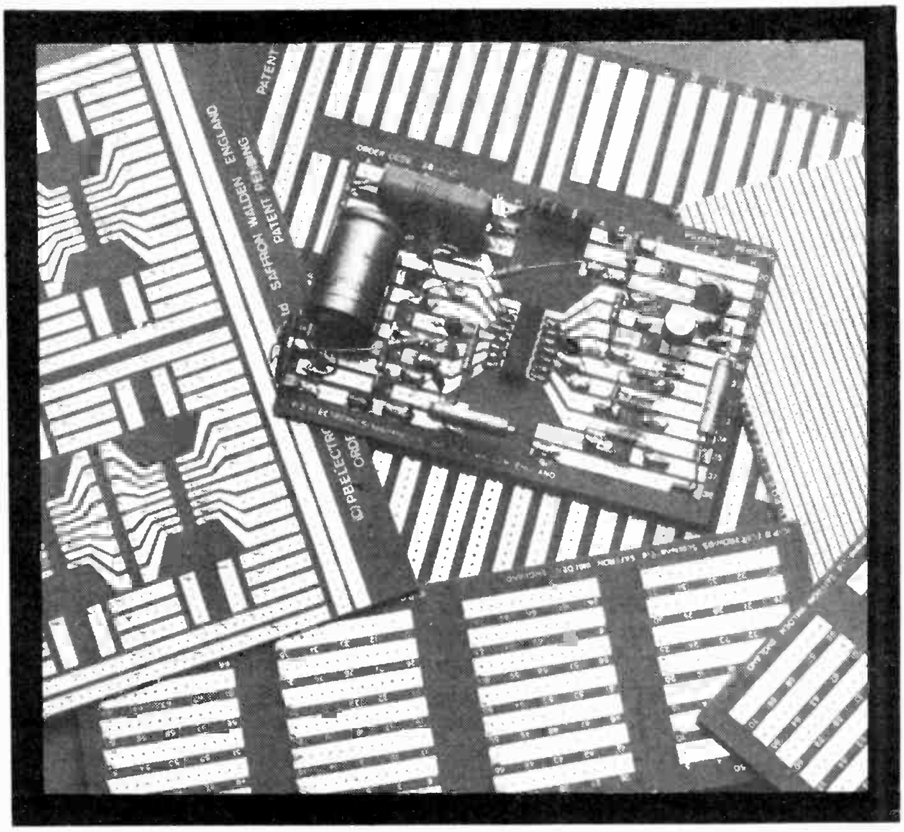
Blob Board is a superb new aid to the home constructor, it allows prototypes to be built quickly and accurately, without the need to work out complex component patterns first.

Normally half the price of previously competitive boards, they allow the user to go direct from circuit diagram to completed board in a matter of minutes and without the use of messy chemicals. Component layout can be drawn directly onto the Blob Board, with a felt-tip eliminating many of the errors which can occur in transferring from circuit diagram to ordinary PCBs.

Components can be re-used and re-soldered making circuit prototype modifications and amendments both fast and easy. All Blob Boards are roller-tinned to facilitate easy and reliable soldering, and are reusable. The boards in this months offer have been chosen to make up two packs — one for the I.C. experimenter, and one for discrete users. The savings are at least 30% on RRP — this on a price **already** very low, for such a useful tool.



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SHORT CIRCUITS

BENCH SUPPLY

A NEW COMPONENT from Fairchild makes this power supply much simpler than other designs of similar capability. The 78MGT2C is a long title, in fact written in our type, the name is longer than the device!

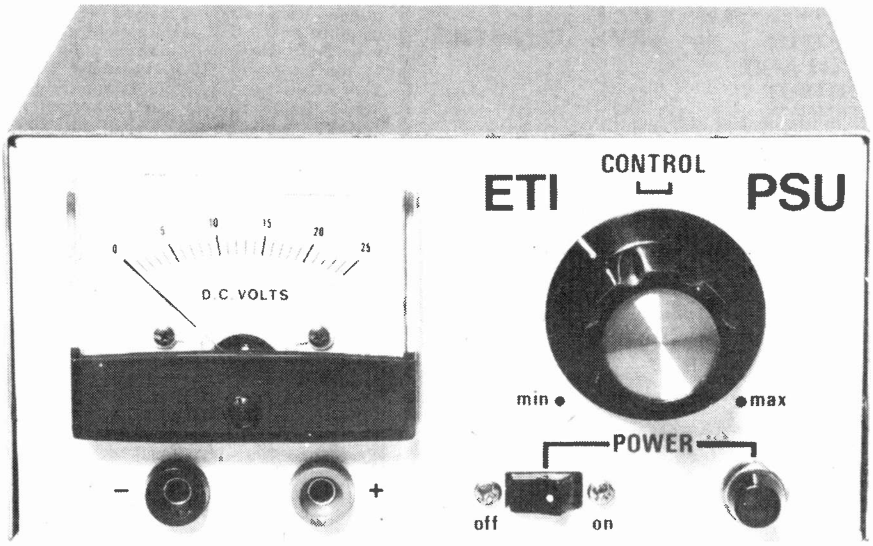
The meter should be looked upon as an optional 'luxury' extra. The design will function perfectly without it, and will be nearly a fiver cheaper to construct. Use a decent pot, and calibrate it.

CONSTRUCTION

Physically the most difficult part of construction will undoubtedly prove to be drilling the case. Mount all the components to the PCB as shown in the overlay, noting that BR1 and C1 are mounted onto T1, not the board.

The short circuit protection resistor R2 is specified as 0R5 (½ ohm) at 5W. You could use two 1R in parallel (at 2.5W each) if you have trouble obtaining the component.

Q2, the output series pass transistor, must be isolated from the case which functions as its heatsink. Also ensure the connections to C1 do not short to the case while you're at it! The heatsinks for IC1 can be bent to any convenient shape or size, the minimum size for which may be taken to be that which we used! There is no DC (output) fuse, as the IC can look after itself better than any fuse!

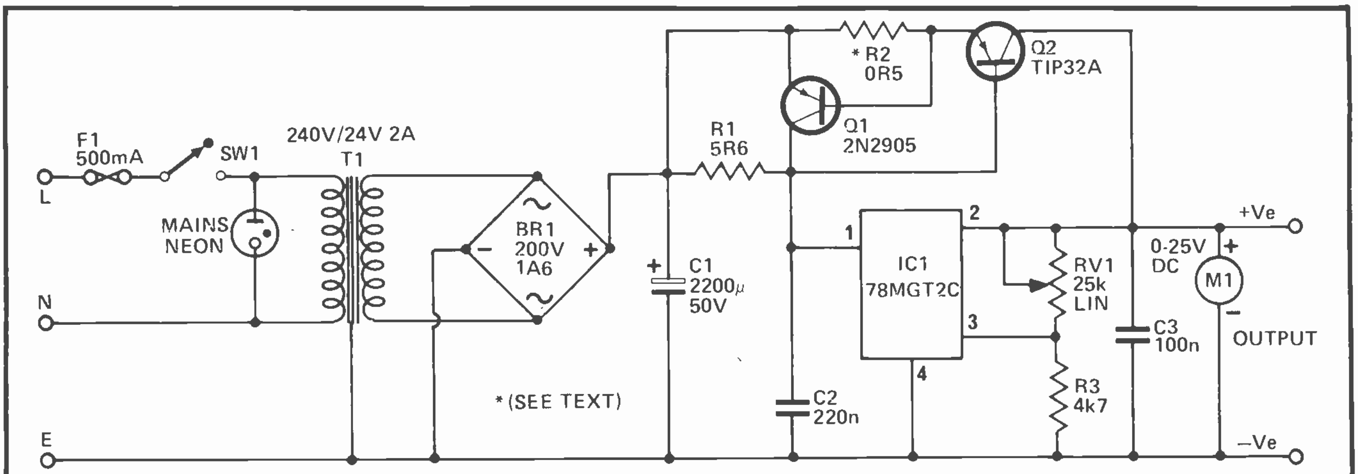


How it works

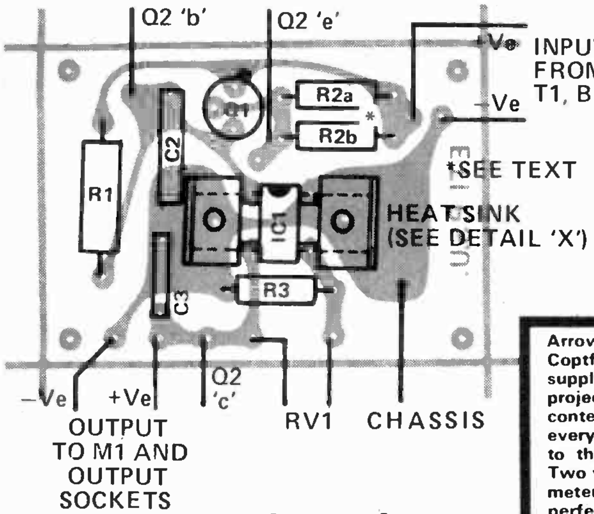
What can we say? IC1 does all the work. C1 is provided to smooth out the full wave rectified DC from BR1. The voltage at the output pin 2 of IC1 is varied by varying the control voltage applied to pin 3.

Q2 is used to enable more current to be drawn than IC1 could provide. Unaided, it could supply 500mA. In this circuit loads can draw in excess of 1.5A without the supply shutting down. Should the dissipation of the chip exceed safe limits, the output will be limited.

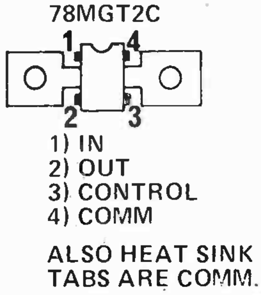
Short circuit protection for the series pass transistor is provided by R2 and Q1. C2 and C3 provide input and output bypassing, and their retention is recommended to ensure stability in all possible conditions.



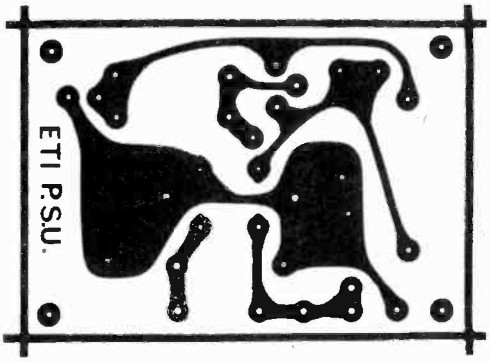
Circuit diagram of the Bench Supply



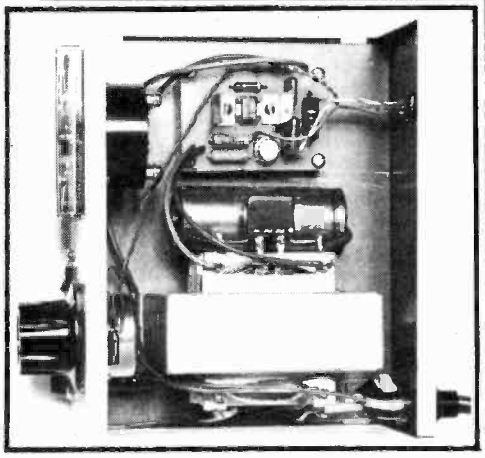
Component Overlay



Arrow Electronics Ltd., Leader House, Coptfield Road, Brentwood, Essex, are supplying a COMPLETE kit of parts for this project. Complete here is used in its proper context. The P.C.B. is screen-printed, and everything you need is in there, right down to the case and P.C.B. stand-off pillars! Two versions are available, with or without meter (0-50V not as our prototype, but perfectly compatible) at £12.60 or £16.60 inclusive respectively.



PCB Foil Pattern (full size)



Parts List

RESISTORS
R1 5R6 1W
R2 0R5 5W *(SEE TEXT)*
R3 4k7 ½W

CAPACITORS
C1 2,200u 50V electrolytic
C2 220n polyester
C3 100n polyester

SEMICONDUCTORS
Q1 2N2905 or similar
Q2 TIP 32A or similar
IC1 uA78MG T2C (positive voltage regulator)
BR1 200V 1.6A Bridge Rectifier

POTENTIOMETER
RV1 25k Lin. rotary

SWITCH
SW1 Off/On rocker type 3A 240V

METER
M1 0-25V DC panel type

CASE
Samos S6 Doram: 984 - 481

TRANSFORMER
T1 240V - 24V 2A type

MISCELLANEOUS
Knob, insulating kit for Q2, fuse holder, fuse, 4mm. red and black sockets, grommet, P.C.B. pillars, nuts, bolts, etc, flex, 3-core mains flex, mains neon.

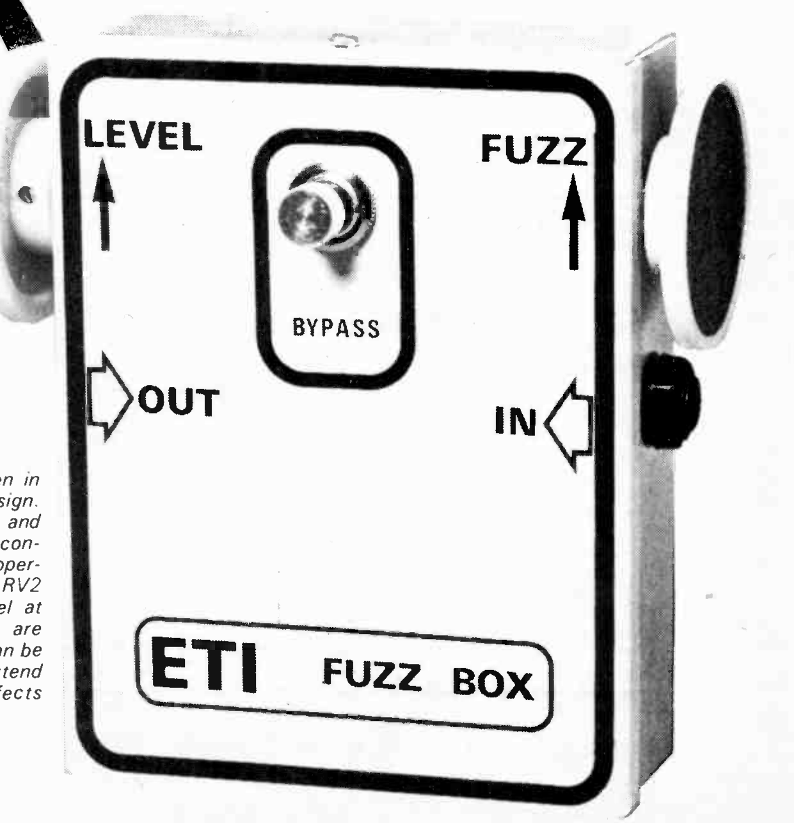
FUZZ BOX

STRANGE AS IT SOUNDS, by far the most popular and sought after effect these days is distortion. More fuzz boxes have been constructed and purchased than any other of the myriad types of guitar 'modifiers' on the market.

Although the aim is basically very simple, some very high prices are being asked, which would tend to make one think (or hope!) that there is more to the principle th ın meets the soldering-iron. We've кept our's simple: the total cost including board, case and footswitch (£1.50 alone) should be approximately £6.00.

CONSTRUCTION

The stereo jack SK2 is used to switch the unit on and off; when a mono jack is inserted it shorts two contacts, and completes the supply circuit. The PP6 battery specified

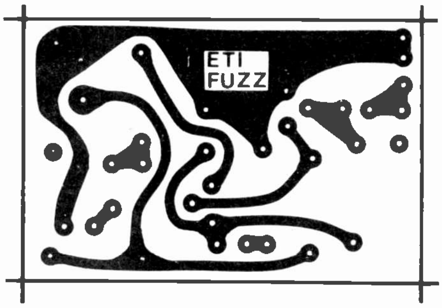


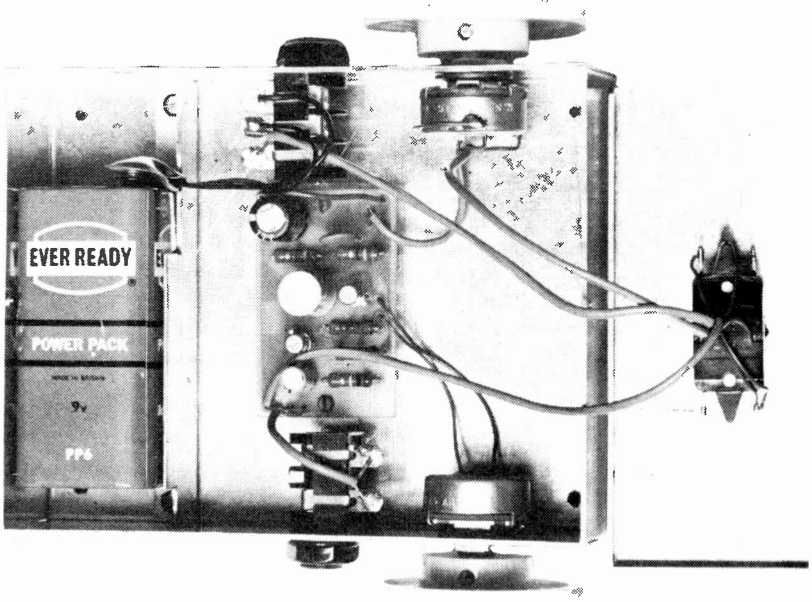
Care has been taken in the mechanical design. The bypass switch and both level and fuzz controls can be foot-operated whilst playing. RV2 can be set so level at fuzz and bypass are equal, however it can be used with RV1 to extend the range of effects possible.

How it works

Transistors Q1 and Q2 amplify the incoming signal, and the gain is such that the input will 'overload' when used with an electric guitar. RV1 adjusts the amount of feedback present, and hence voltage gain.

The output is therefore a 'squared' version of the input signal, the amount of 'squaring' being variable by RV1.





Parts List

RESISTORS	All ½W 5%
R1	39k
R2	100k
R3	680R
R4	5k6
R5	56R

CAPACITORS	
C1	10u 16V electrolytic
C2	100u 16V electrolytic
C3	47n ceramic
C4	47u 16V electrolytic

SEMICONDUCTORS	
Q1,2	BC108 or similar

POTENTIOMETERS	
RV1	1k Lin. rotary
RV2	100k Log. rotary

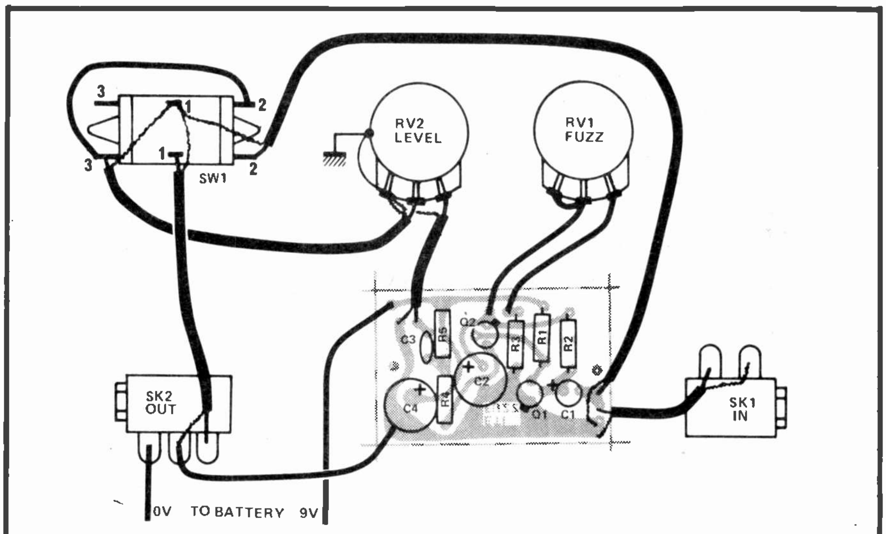
SWITCH	
SW1a,b	Double pole, change over, push on/push off, footswitch. Bulgin SM270 type or similar is available from two advertisers: ANCO, 50 Rainsford Rd., Chelmsford - or MAPLIN, P.O.Box 3, Rayleigh, Essex Essex. Approx.price: £1.50

SOCKETS	
SK1	Mono ¼" jack socket
SK2	Stereo ¼" jack socket

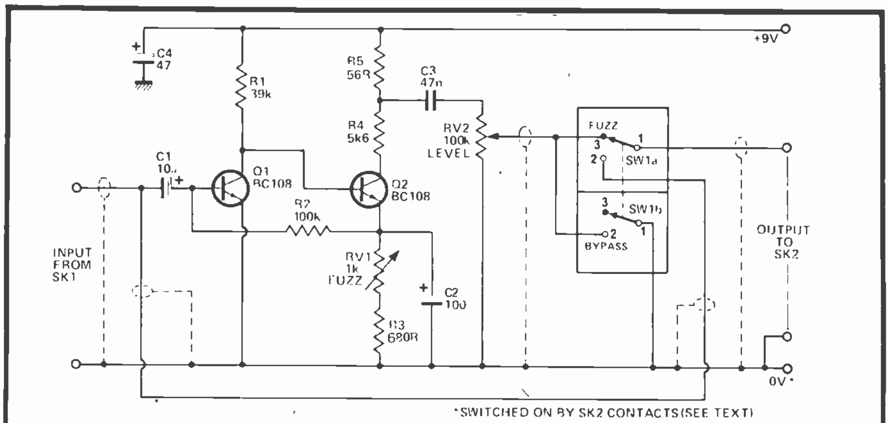
CASE
6" x 4" x 2" approx. Metal type from H.L.Smith (130 x 103 x 50mm.)

MISCELLANEOUS
2 large knobs, P.P.6 battery, battery clip, screened wire, P.C. board pillars, nuts, bolts, etc., P.C. board as shown.

APPROX' COST:
£6.00 inc. board and battery.



Component Overlay



Circuit Diagram

should last a long, long time, as current drain is quite small. Use screened wire where shown on the circuit; to link SW1 and the output, and the 'bypass' signal with the output.

This switch, SW1, not only switches the signal through the circuit, but also takes the output from RV2 to ground when in the 'non-fuzz' position, preventing breakthrough of the distorted signal onto the line.

Assemble the PCB in the usual manner; watch the orientation of the transistors lest you get a 'fuzzed' junction. Take the case of RV2 to the 'earthy' side of the pot. ●

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RPO2 30 Meg. Free-standing moving-head disk drive and control.
TU10 Magnetid Tape Units, 9-track 800 bpi, rack-mounted
TU20 Magnetic Tape Unit, 9-track, 45 ips. TU55 DECtape drives.
DF32 Disck Drive and Control. **DS32** Slave Drives also available.
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RK11/RK05 Disk Drive and Control.
TU60 Dual Cassette Drive and Control
RTO2 Alphanumeric Data Entry Display and Control
DEC Interface and Feature Boards: DC11-AC, DC11-DA, DL11C, DL11E, KD8E, KL8E, KE11F, KW11, KC8E, MC8EJ, MM11F, MR8E M7239 G235 KE11 DB11 M8342 G1110/G231 H754
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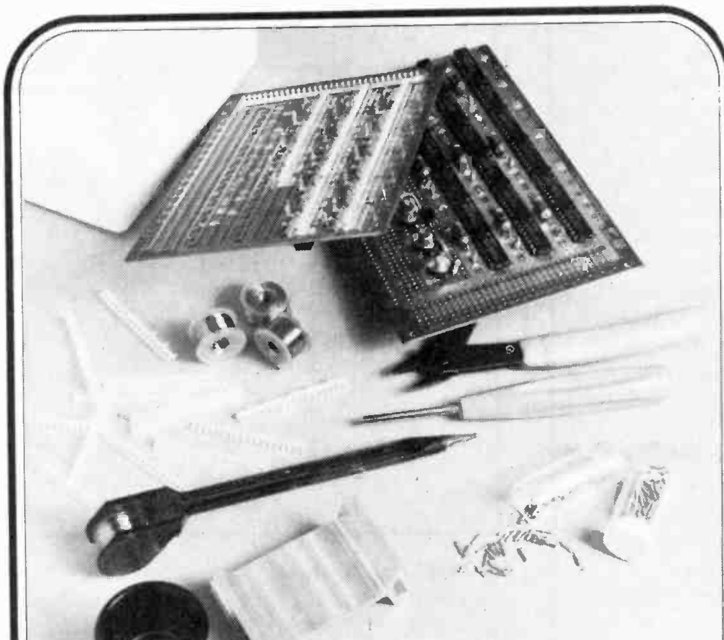

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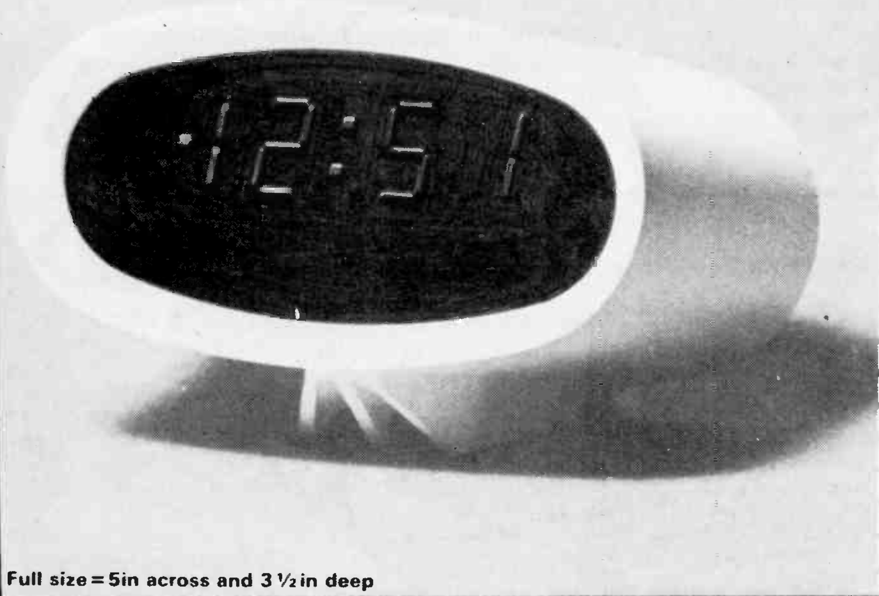

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WIREWOUND RESISTORS

PART 9

This month concerns itself with the usually higher powered wirewound resistor variety

These resistors are made by winding a length of resistance wire on a bobbin (usually of ceramic or fibreglass), the ends being anchored to terminations on the ends of the bobbin. Bobbins are usually cylindrical-shaped or flat. The bobbin and element are generally encapsulated in an impervious coat of vitreous enamel — some styles have the whole bobbin encapsulated in a square ceramic boat, having either axial or radial leads. These are generally the lower power types, up to 20 W.

There are two general types of coating applied to wirewound resistors. One is called Pyrosil D-Coat and consists of a combination of silicone resins and refactory material (which prevents oxidation) of the wire element) and is designed for high temperature operation. It is capable of withstanding temperatures corresponding to five times rated load. The other encapsulation material is known as Tropical C-Coat, another silicone compound and is designed to protect the element under extreme environmental conditions (particularly humidity). The power rating is different for similar resistors coated with different coatings. Resistors coated with tropical C-Coat can only operate at half the power of similar resistors encapsulated with Pyrosil D-Coat.

Terminations for wirewound resistors come in a wide variety of styles. The smaller, low power, types (particularly the completely encapsulated types) often have radial or axial leads and sometimes terminal lugs. High power types may have ferrules on each end — and are plugged into large clips; alternatively they may have terminal lugs, Edison screw threads or flying leads.

The resistance element usually consists of nickel — chromium alloy wire (nichrome). Precision wirewound resistors are usually wound with Eureka wire.

Very high power types and some very low resistance types are sometimes wound with flat-tape element instead of wire. It is usually wound edge-on to the bobbin to improve heat dissipation from the element.

Wirewound resistors are made in wattage ratings to 250 W, commonly, and up to 1 kW or more for special applications. There are three basic construction styles: cylindrical, flat and encapsulated ceramic-boat style. The first two are also available as adjustable resistors, having portion of the element exposed and a moveable terminal in contact with it.

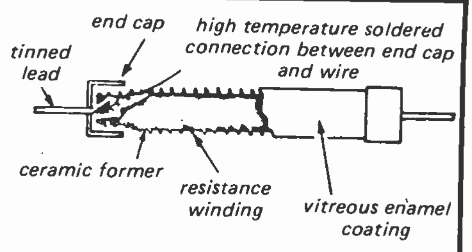


Fig. 1. Typical construction of small, cylindrical style wirewound resistor.

TEMPERATURE

Wirewound resistors can have excellent temperature characteristics — as low as 5 ppm/°C, but generally less than 200 ppm/°C for the common types.

These resistors exhibit good stability, usually better than 2%, precision types having stabilities better than 0.05%. Common types are available in tolerances of ±5% and ±10% depending on

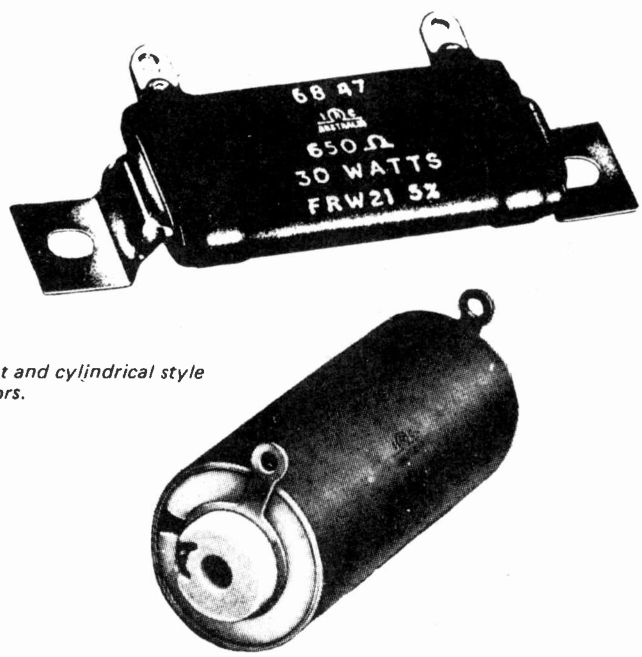


Fig. 2. Typical flat and cylindrical style wirewound resistors.

WIREWOUND RESISTORS

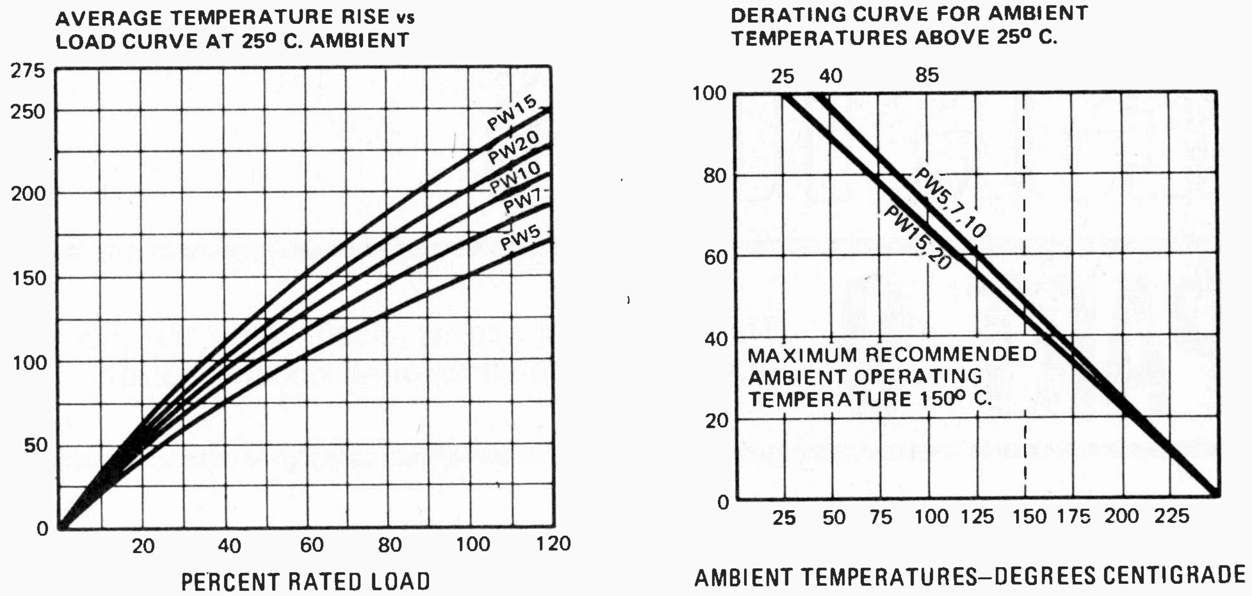


Fig. 3. Temperature rise and power derating curves for encapsulated (ceramic boat) style wirewound resistors.

construction style. Tolerance down to 1% can be obtained in precision types.

The noise level and voltage coefficient of wirewound resistors is negligible.

Owing to their construction, wirewound resistors are quite inductive and are generally only useful at low frequencies. Their inherent inductance can be decreased with special winding techniques — occasionally found in precision resistors, but as most wirewound resistors are predominantly used in dc and/or low-frequency circuits where their high power rating is required, this does not present much of a problem.

MAXIMUMS

Wirewound resistors may be operated at temperatures up to 350°C but most common types have a maximum operating temperature (ambient + temperature rise due to power dissipation) of 290-300°C for Pyrosil D-Coat types and 190-200°C for Tropical C-Coat types. Temperature rise and power derating curves for the common cylindrical and flat style resistors are given in Figure 4. The power ratings are based on the ability of the resistor to give long service at full rated load up to the nominated ambient temperature. For higher ambient temperatures, the resistors are derated according to the curve shown. The full rated load is based on a temperature rise of 250°C from ambient of 40°C for Pyrosil D-Coat and a rise of 150°C from the same ambient for Tropical C-Coat. For the encapsulated lower power varieties, typical temperature rise and derating curves are given in Figure 3. These have a maximum recommended operating temperature of 150°C.

MOUNTING & SURROUNDING

Care must be taken in the mounting of wirewound resistors to prevent the high operating temperature affecting surrounding components. The cylindri-

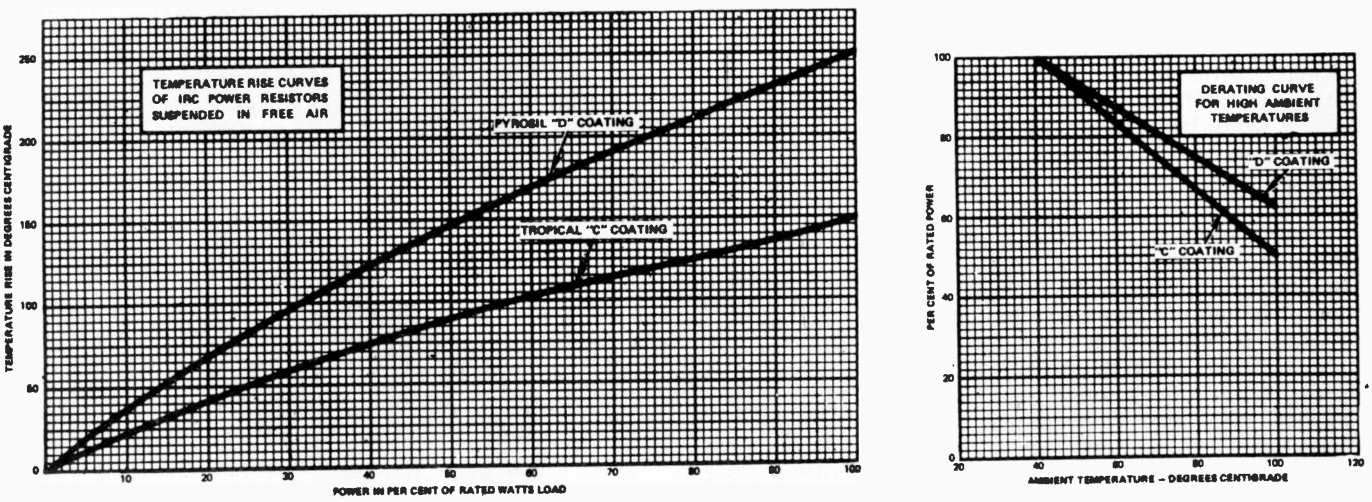


Fig. 4. Temperature rise and power derating curves for common cylindrical and flat style wirewound resistors.

cal types usually have a hole through the middle through which heat may escape by convection. Mounting these vertically where possible is recommended to keep their operating temperature down. The flat style are mounted using formed 'leaves' which fit into the ends of the former (see Figure 2) — which is hollow, these conducting heat away through the mounting bolts. They are designed for either vertical or horizontal mounting, either singly or in stacks. This style is most suited to applications requiring a high power resistor to be mounted in a limited space. Recommended stacking arrangements are illustrated in Figure 5. When stacked, each resistor affects the temperature of the adjoining resistor(s). To limit the temperature rise of the hottest unit it is necessary to limit the power applied to each resistor (depending on the number of resistors in the stack) according to the percentages shown in the table in Figure 5.

It is a wise precaution with the axial or radial-lead types to mount them so that they are clear of any other components, chassis, pc board, etc by at least their diameter or width, to provide sufficient ventilation and to prevent damage to other components.

TABLE 5. General characteristics of Wirewound Resistors.

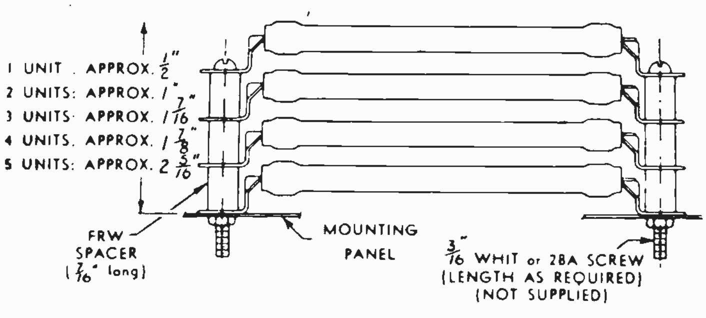
Rated Wattage (D-Coat)	Typical Sizes (Overall)			Typical Resistance Ranges: Fixed Type	Adjustable Type (max.)
CYLINDRICAL STYLE					
(to 40°C)	Length	Diameter			
5 W	23 mm	10.3 mm		0.5 Ω – 5 k	–
10 W	44.5 mm	10.3 mm		0.75 Ω – 12 k	–
20 W	50.8 mm	16.7 mm		1.0 Ω – 25 k	5 k
25 W	63.5 mm	16.7 mm		1.0 Ω – 30 k	6 k
30 W	76.2 mm	16.7 mm		1.5 Ω – 40 k	7.5 k
40 W	89 mm	23 mm		3 Ω - 60 k	12.5 k
50 W	114.3 mm	23 mm		3 Ω – 88 k	20 k
75 W	165 mm	23 mm		5 Ω – 130 k	25 k
50 W	81 mm	33.3 mm		4 Ω – 80 k	16 k
65 W	114.3 mm	33.3 mm		4 Ω – 120 k	22.5 k
100 W	165 mm	33.3 mm		5 Ω – 200 k	37 k
150 W	216 mm	33.3 mm		5 Ω – 270 k	51 k
200 W	267 mm	33.3 mm		5 Ω – 340 k	62 k
FLAT STYLE (Width = 14 mm, Mounting Height = 12.7 mm)					
(to 40°C)	Length	Mounting Holes (ϕ to ϕ)			
20 W	31.8 mm	50.8 mm		0.5 Ω – 10 k	–
30 W	50.8 mm	70 mm		0.5 Ω – 25 k	6 k
50 W	89 mm	108 mm		1.5 Ω – 50 k	13 k
65 W	121 mm	140 mm		2.0 Ω – 20 k	19 k
75 W	153 mm	172 mm		2.5 Ω – 100 k	25 k
ENCAPSULATED STYLE					
(to 40°C)	Length	Width	Height		Inductance (typical)
5 W	22.2 mm	9.5 mm	8.7 mm	0.5 – 4.7 k	5.1 µH @ 900 Ω; 20 µH @ 3.3 k
7 W	35.3 mm	9.5 mm	8.7 mm	1.0 – 12 k	8 µH @ 2.4 k; 33 µH @ 9 k
10 W	47.6 mm	9.5 mm	1.0 – 20 k		13 µH @ 3.9 k; 56 µH @ 15 k
(to 25°C)					
15 W	47.6 mm	12.7 mm	12.7 mm	1.0 – 20 k	13 µH @ 3.9 k; 56 µH @ 15 k
20 W	63.5 mm	12.7 mm	12.7 mm	1.0 – 4.7 k	

FAILURE

Wirewound resistors fail occasionally. This may be due to one of the following reasons. In high value types, the resistance wire is very thin. The slightest blemish creates a weak point which may eventually cause the wire to break. In the coated types, expansion differences between the ceramic bobbin and the enamel coating may cause cracking of either the coating or the bobbin allowing moisture to penetrate and attack the resistance wire. The wire may corrode under constant dc load conditions due to chemical action in the enamel coating of the component. This latter problem is rare.

Precision wirewound resistors are wound on special bobbins, generally using Manganin wire, and encapsulated or covered in an insulating coating. They are sometimes epoxy-moulded. Other styles are hermetically sealed in a ceramic container. Wire leads or solder lugs are used as terminations. Precision wirewound resistors are not generally designed to dissipate power. Power types are available however, generally consisting of a conventionally constructed wirewound resistor wound to a tight tolerance or selected, and mounted in an extruded aluminium case. This assists heatsinking, allowing precision resistors to be rated up to powers of 200 W.

The general characteristics of the three basic styles of wirewound resistor are illustrated in Table 5. Typical inductance values for the lower power, encapsulated styles are also given for low and high values. ●

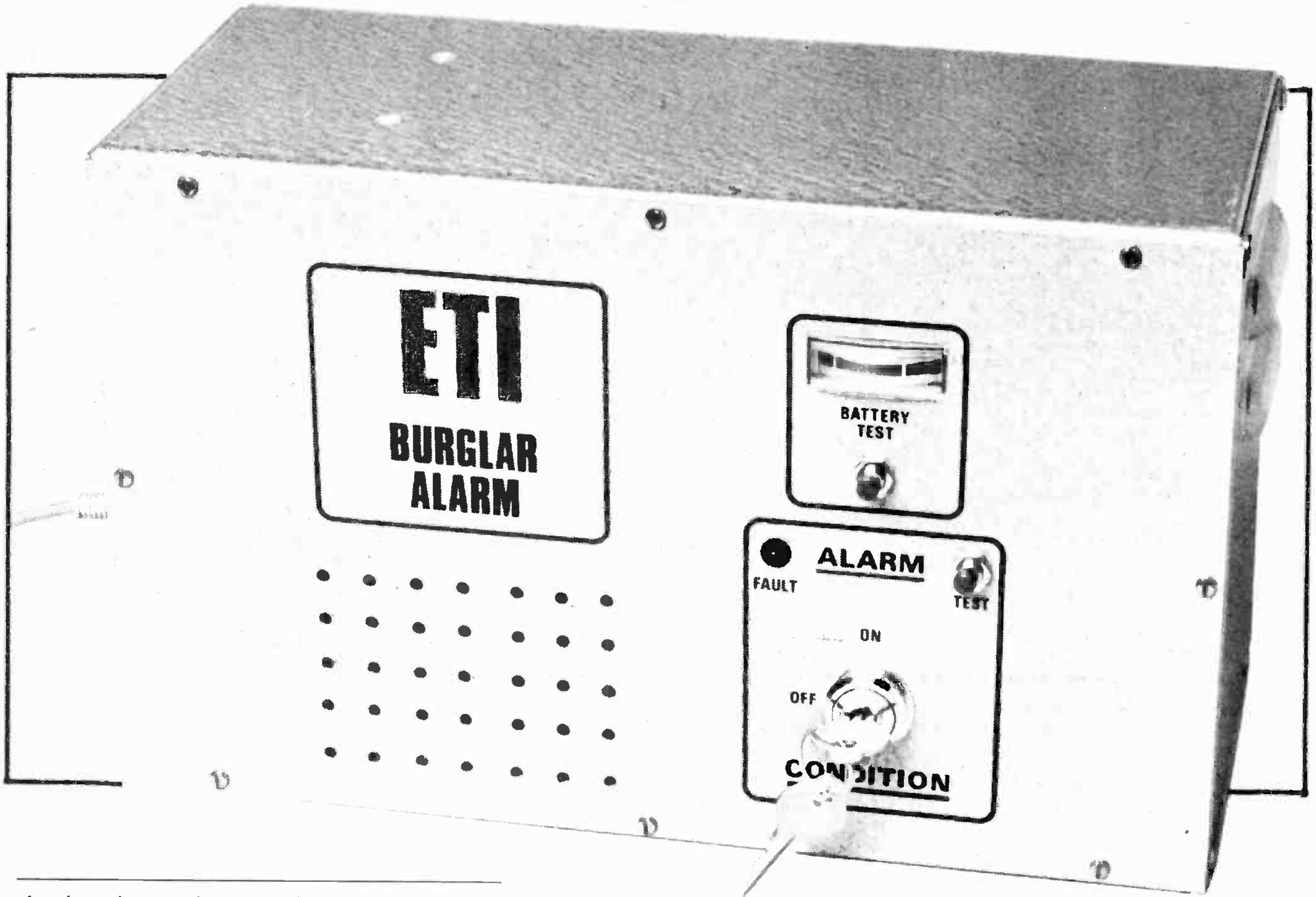


Kind of "Stack" Mounting Employed	% REDUCTION IN RATING When No. of Units Stacked Is		
	2	3	4
Resistors Stack-Mounted on a Horizontal Panel Reduce Rating by:	25%	45%	60%
Resistors Stack-Mounted on a Vertical Panel Reduce Rating by:	18%	30%	35%

Fig. 5. Recommended method of stacking the flat style of wirewound resistors and the necessary power derating. No more than four resistors should be in a stack.

ETI Project

BURGLAR ALARM



A simple and versatile control unit, with internal siren and battery.

FOLLOWING ON from last month's Burglarproof Your Home article, we present the ETI burglar alarm. The circuit is simple, reliable and versatile. Based on a single CMOS chip, the standby current is very low, making a mains power supply non essential. Several versions are possible, depending on the particular circumstances where it will be used. We built the simplest version, and will describe it fully, with details of possible modifications and additions.

BASIC UNIT

The basic unit is self-contained, apart from sensor switches. A 12V HP1 battery is used as the power supply, this battery is capable of powering the system for about a year, if the siren is not activated! When in the alarm condition the HP1 will power the siren for about 6 hours continously. A battery test facility is included in the design, which displays the on load voltage. We used a Carters "Mini-Mite" 12v siren, which is also inside the case. This siren has a sound output of about 93dB at 3 metres -- quite loud!

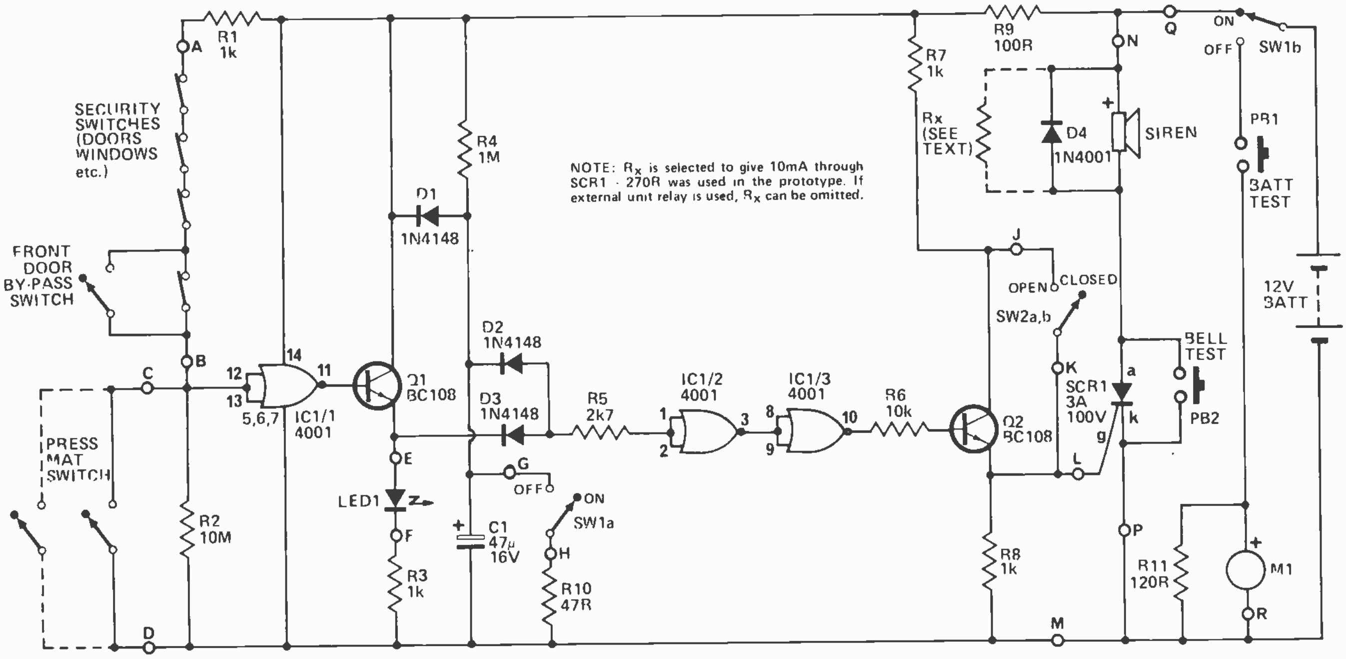
Other features of the basic unit are, on/off keyswitch on front panel, bell test button and LED fault indication. The box itself is fitted with anti-tamper micro-switches, so that it can only be opened in the off position, without sounding the alarm.

Another important feature is the 30 second delay facility. This ensures that when you switch the unit on -- the alarm will not sound for 30 seconds but any fault will light the front panel LED. Also if you have to walk over a pressure mat or open an alarmed door, to leave, you have the delay to do it in.

SENSORS AND SIRENS

Three types of sensor can be used with the system. Normally open circuit types, such as pressure mats; and normally closed types such as reed switches biased by magnets. Changeover contacts can also be used, wired to break the normally closed circuit and short the open circuit when operated, this is possible as one wire is common to both circuits. Connection to the unit is via a standard 180 5 pin din plug and socket, all the pins are not used, and external bell

ETI BURGLAR ALARM



Circuit diagram of basic alarm

units can be wired via this connector if required.

As shown the unit is suitable for shop display protection, caravan protection or even as a tent alarm — a pressure mat under your ground sheet! For some homes the internal siren will be all that is needed, however, the only way to find out is to try it. If you get lots of complaints from your neighbours or a rapid visit by men dressed in blue — it's loud enough! Obviously it is best to try it out at a civilised time — not 4 am. If the internal siren is not loud enough, you will need an external alarm. This will be described further on.

If a shunt switch is not fitted to the main exit, the alarm will sound on entry, this can be unpopular with neighbours. So a shunt switch is strongly recommended.

OPERATION

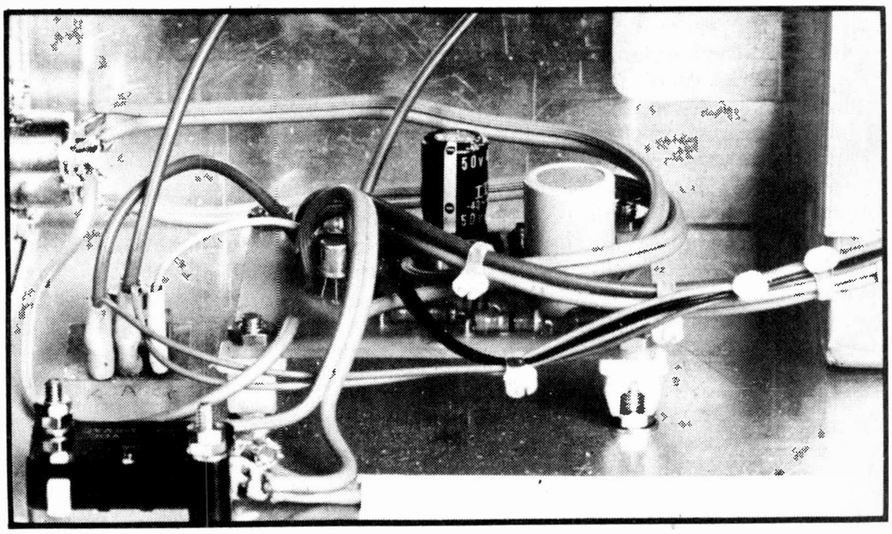
In operation the unit is turned on, by the front panel keyswitch. If the LED lights it means that part of the circuit is either open or closed incorrectly, if this happens switch off and find the open door, or chair on pressure mat etc. To check if you have found the fault switch on again — the LED should remain unlit. A point to note is that you can test the battery with the unit switched off — this is to prevent the battery being flattened by a burglar keeping the test button depressed (if he managed to get up to the box without setting off the alarm).

Assuming that you have fitted a shunt switch to the exit, you can now leave and lock the door behind you. This is why a shunt switch inside the main lock is preferred to a separate shunt switch, if you forget to operate a separate switch the door is unprotected.

INSTALLATION

Bearing in mind the general guide lines given last month, the installation can be worked out. Points to remember are, cover all external doors, and if uneconomical to protect all windows — to cover the internal doors as well, with the odd pressure mat in hallways and on stairs to complete the protection.

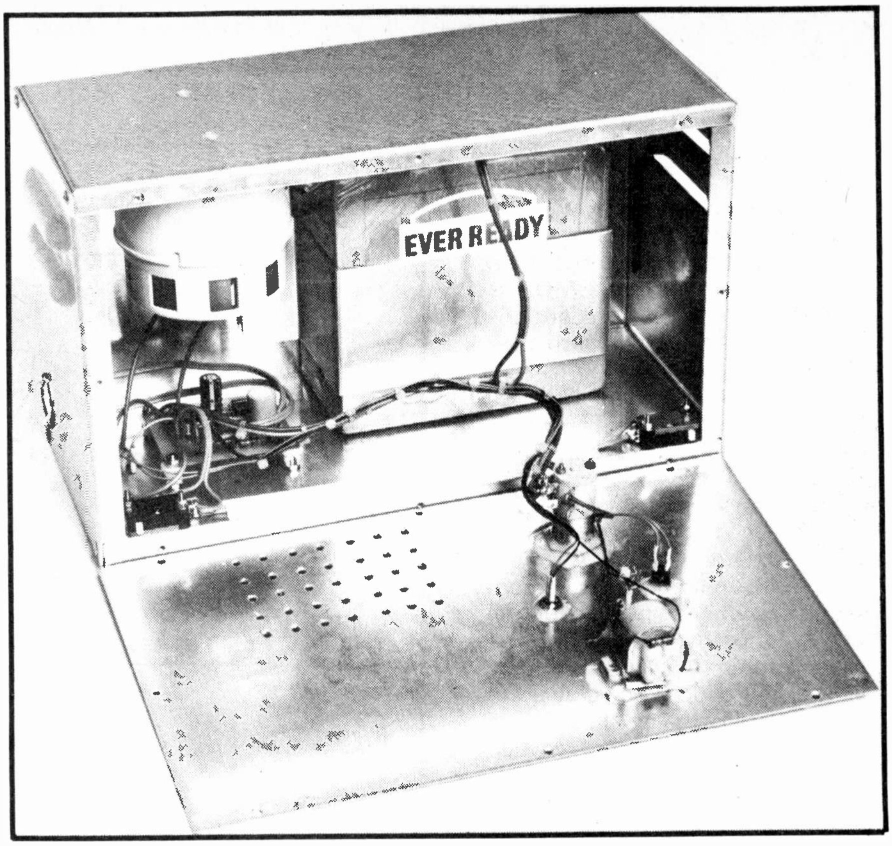
Even though single core wire can be used for the closed circuit wiring, we prefer to use 3 or 4 core throughout, as this gives more flexibility in sensors and also creates uncertainty in the mind of a would be by-passer. It also looks like telephone wiring if installed neatly.



Close-up of board and wiring, this was an earlier version — hence slightly different to overlay shown.

How it works

The circuit is based around a 4001 CMOS quad NOR gate, with the gates connected as invertors (cheaper than using invertors!). The input to ICIa is derived from the closed circuit sensors and the open circuit sensors. In the normal state the output is low and Q1 is off. When either R2 is shorted or the positive supply from R1 is interrupted the gate changes state. Q1 is turned hard on and LED 1 illuminates. R4 and C1 form a timing circuit, which prevents ICIB from giving a low output for 30 seconds from switch on. After this period, if LED1 is on ICIB and ICIC charge state switching on Q2, which triggers SCR1 which self latches. Rx is to make sure SCR1 passes at least 10mA if a bell is used which breaks its own circuit. R11 is selected to draw 100mA to simulate a load for the battery. R10 makes sure that C1 is fully discharged when the alarm is switched off, in order to get consistent timing periods.



General view of the basic unit, note anti-tamper microswitches (SW2 a,b)

Parts List

Resistors *all 5% ½W*

R1,3,7,8	1k
R2	10M
R4	1M
R5	2k7
R6	10k
R9	100R
R10	47R
R11	120R
RX	(see text)

Capacitors

C1	47 F 16V tantalum

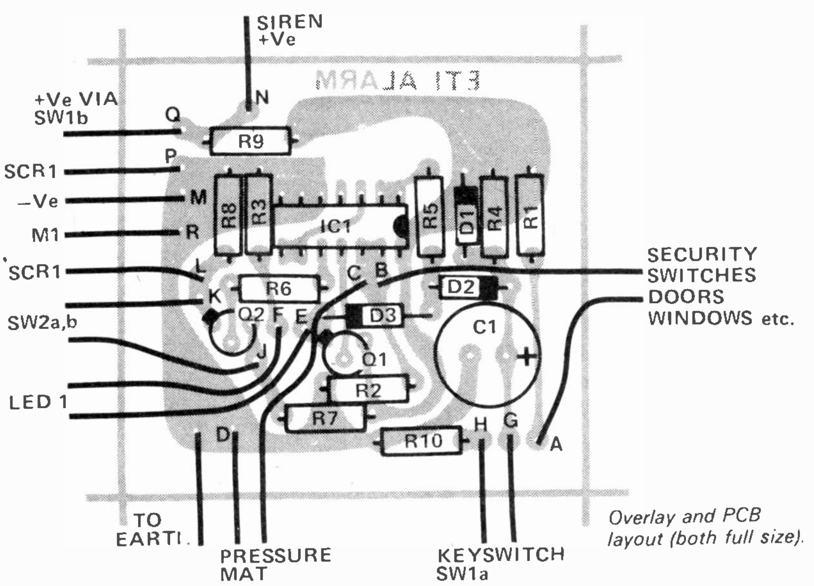
Semiconductors

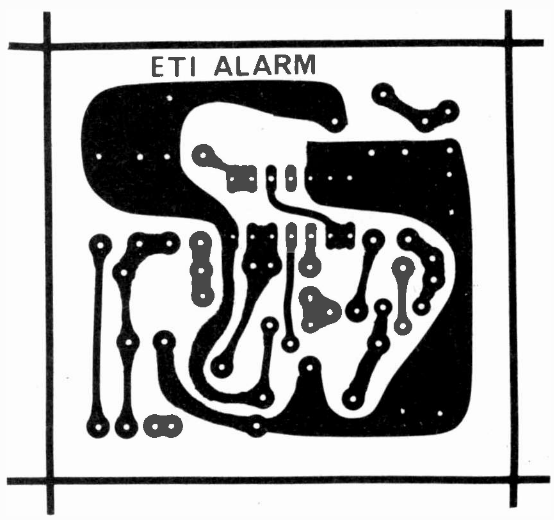
IC1	CD4001A
Q1,2	BC108 or similar
D1,2,3	IN4148 or similar
D4	IN4001 or similar
SCR1	100V 3A thyristor
LED1	TIL 209 or similar
SW1 (a,b)	Lockswitch (Doram 337-964)
SW2 (a,b)	Microswitch (normally open)
PB1,2	Push to make, release to break
Sensor switches	see text

Miscellaneous

Meter	Panel type 0-15V (Doram 259-561)
Case	11½ x 5 x 7 inches (H. L. Smith type W £4 59 inclusive)
Battery	HP1 + connector (Sesco 28.63.15 and 28.63.55)
Siren	Carters "Mini-mite" (Sesco 24.45.20)

PCB, nuts, bolts, wire, 5 pin Din plug and socket. Insulating kit for SCR1 etc
NB: Battery, connector and siren available from Sesco (Security) Ltd, Chapel Road, Hounslow, Middlesex TW3 1TX for £9.23 inclusive.





Overlay and PCB layout (both full size).

ETI BURGLAR ALARM

On returning open the main door and then switch the unit off.

CONSTRUCTION

Construction is quite straightforward, most of the components are mounted on a PCB. The main point to watch is that CMOS is involved, the usual precautions should be taken. Make sure your iron is earthed and fit the IC last. All bolts must be fitted with two nuts to prevent external removal. The front panel mounted parts should be epoxyed into place, also to prevent external tampering. The two microswitches SW2a+b should be fitted so that the front panel keeps them depressed when in place. General layout is easily seen from the photographs.

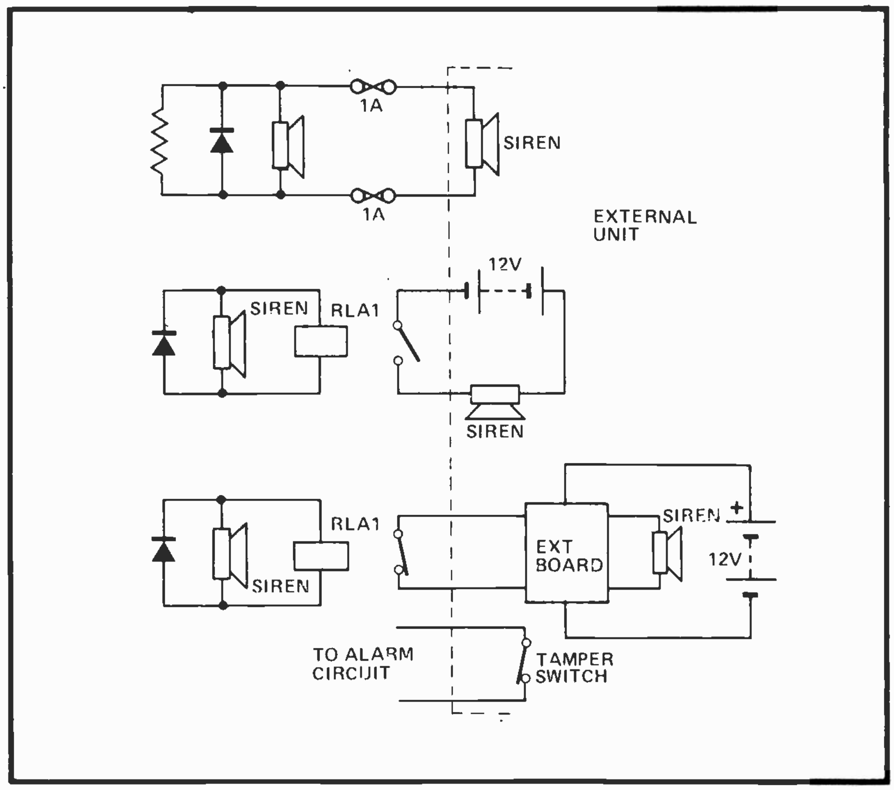
The unit should be screwed in position through the back panel when complete.

EXTERNAL UNITS

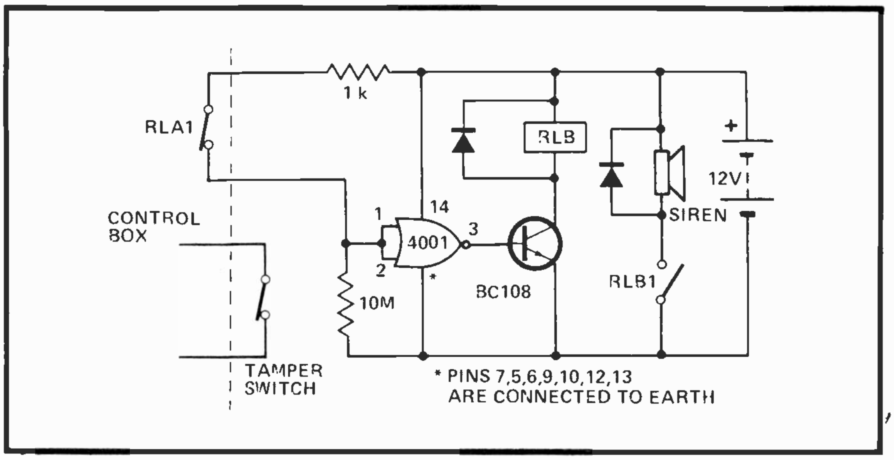
If an external siren or bell is needed there are three ways this can be done. The simplest, but least secure is to run it in parallel to the internal siren via twin wires. A 1A fuse should be placed in each of the leads — so that a short circuit will not flatten the battery. Obviously the battery life will be reduced when powering two alarm sirens.

The second method is to run a relay in parallel with the internal siren, the external unit then needs its own power supply. The relay should be mounted at the main unit. The external power supply can be another battery or a mains power supply.

The disadvantage of both these methods, is that if the wires are cut the external alarm will not sound. Although if the cable is run inside metal tubing this is not so much of a problem.



Top: Simplest external siren circuit.
Middle: Addition of a 12 volt relay (RLA1) gives another simple external siren circuit.
Bottom: Most secure method, involves the use of a CMOS chip, circuit below.



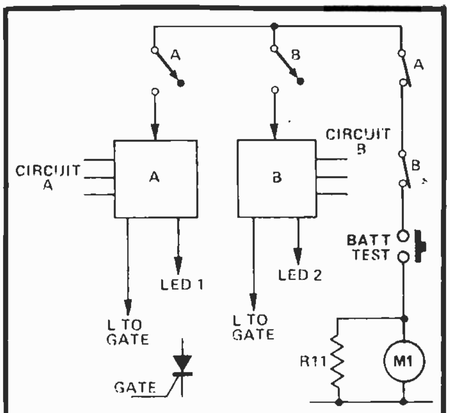
BEST METHOD

The best method is to use a sensor circuit with a relay output. This can be obtained from another CMOS circuit similar to the main unit — only simpler. Again a relay is connected across the siren but if the wires to it are cut the external siren will sound. The standby current is about 1 μA so the battery can be left connected permanently. A suggested interwiring diagram is shown.

UP AND DOWN

Another possible modification is to add an upstairs/downstairs facility to the main unit. This can be done by duplicating the main board and adding an extra keyswitch to the front panel, together with a second LED. The interconnection for this is also shown.

The batteries should be checked at least once a month, and replaced when on load they register below 11 volts. ●



Method for interconnecting two modules for up/down circuits.

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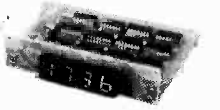

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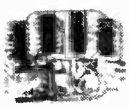

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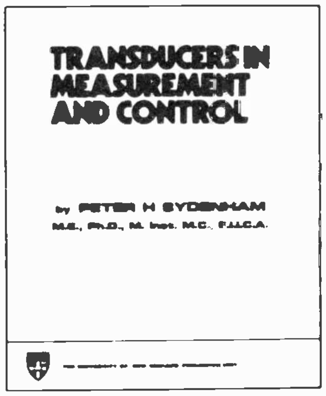

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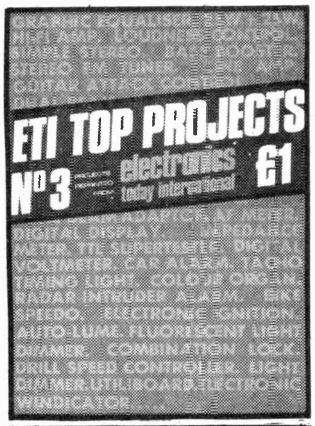

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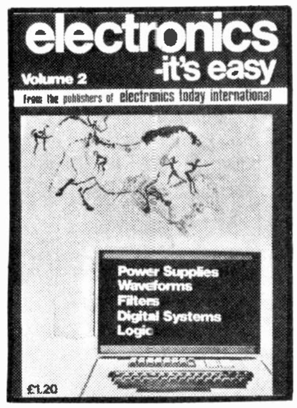

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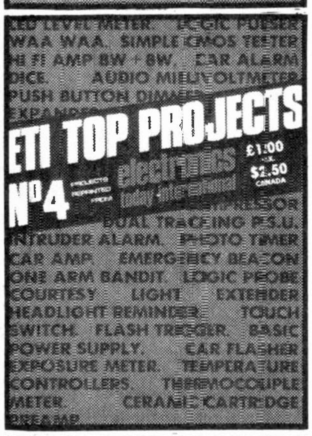

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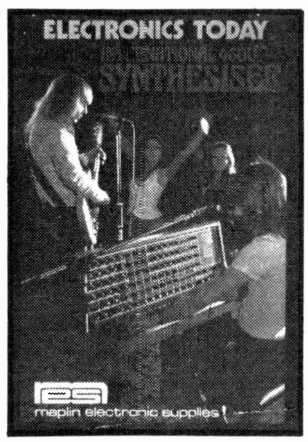

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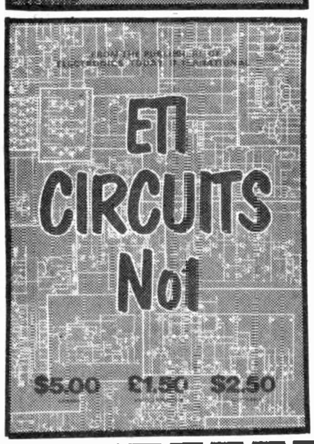

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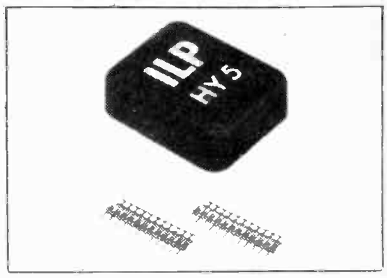

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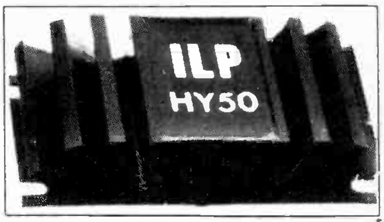
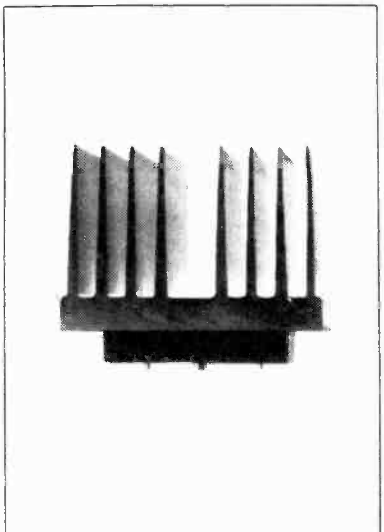
SPECIFICATIONS:
OUTPUT POWER 15W R.M.S. into 8Ω. DISTORTION 0.1% at 15W.
INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16kHz — 3dB.
SUPPLY VOLTAGE ± 18V.
Price £4.75 + 59p VAT P&P Free.

HY50
25 Watts into 8Ω



The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.
APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier.
SPECIFICATIONS: INPUT SENSITIVITY 500mV.
OUTPUT POWER 25W RMS in 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 25W at 1kHz.
SIGNAL/NOISE RATIO 75dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB.
SUPPLY VOLTAGE ± 25V. SIZE 105.50.25mm.
Price £6.20 + 77p VAT P&P free.

HY120
60 Watts into 8Ω



The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.
FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components.
APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV.
OUTPUT POWER 60W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 60W at 1 kHz.
SIGNAL/NOISE RATIO 90dB. FREQUENCY RESPONSE 10Hz-45kHz —3dB. SUPPLY VOLTAGE ±35V.
Size 114 x 50 x 85mm.
Price £14.40 + £1.16 VAT P&P free.

HY200
120 Watts into 8Ω

The HY200, now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — Integral Heatsink — No external components.
APPLICATIONS: Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV.
OUTPUT POWER 120W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.05% at 100W at 1kHz.
SIGNAL/NOISE RATIO 96dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V.
SIZE 114 x 100 x 85mm.
Price £21.20 + £1.70 VAT P&P free.

HY400
240 Watts into 4Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components.
APPLICATIONS: Public address — Disco — Power slave — Industrial.
SPECIFICATIONS:
OUTPUT POWER 240W RMS into 4Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.1% at 240W at 1 kHz.
SIGNAL/NOISE RATIO 94dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V.
INPUT SENSITIVITY 500mV. SIZE 114 x 100 x 85mm.
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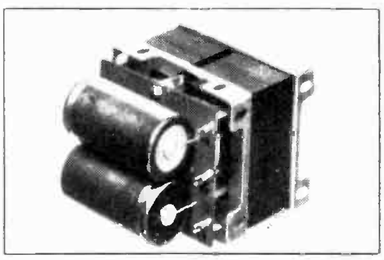

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PSU90 suitable for one HY200 **£11.50** plus 92p VAT P/P Free
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ELECTRONICS —it's easy! PART 38

TRANSMISSION LINE THEORY

ELECTRONIC systems consist of basic analogue and digital subsystems interconnected to provide the required overall input-output relationships. It is important for the various subsystems to be interfaced correctly if they are to perform as intended. But with this condition satisfied, one cannot just assume that subsystems merely connect together without need to consider any other parameters in the interconnection process.

In practice the individual circuit assemblies may be geographically apart — such as the remote control of off-shore oil wells by a shore-based computer, the recording of test data from a missile, the control of banking accounts by a central computer centre or the sensors of a refinery which connect to the central control room. Each of these required some form of telemetry system.

When making connections it is also important, especially when noise sources are present that will interfere with the signal, to ensure that the signal is transferred from stage to stage without significant noise pick-up or signal degradation.

TRANSMISSION LINKS

Several different transmission methods exist in which the signal is confined — open wires, coaxial cables and waveguides, optical fibres etc. Alternatively, information can be transferred via open radiation paths — radio, optical or acoustic links. The required signal bandwidth is one of the primary factors deciding which method is used. In radiation methods it is often necessary to use a carrier frequency higher than the signal bandwidth dictates because low frequency carriers will not radiate as well for the same amount of transmitted power.

Confined Signal Links: The simplest links are formed using an open-wire circuit (supported on insulators) or a multicore cable (such as is used in local telephone distribution).

Although apparently trivial, lines may, in fact, be an important part of the system. They are not as simple as they first appear because they have a frequency response that must be adequate for the signal bandwidth to be transmitted. Open-wire lines would not normally be used beyond 10MHz. Above that coaxial cables are needed — these are useful to about 5000MHz.

When current flow in a conducting line, magnetic and electric fields are set up around the wires. Figure 1 shows these plotted for the various kinds of cable. Open configurations radiate energy, the amount increasing with the frequency of the signal. A line is, in reality, a distributed inductance and capacitance component which also has losses due to the resistance of the wire and the resistance to ground. Figure 2 shows how lines can be considered as a lumped-element equivalent circuit which can be analysed more easily. Depending upon the factors that are negligible for a particular case the equivalent can be reduced to simpler circuits — see Fig. 3. For example, at very low frequencies (less than say 100 kHz) a medium length line may be represented by the series resistance of the cable shunted by the capacitance of the line. Typical

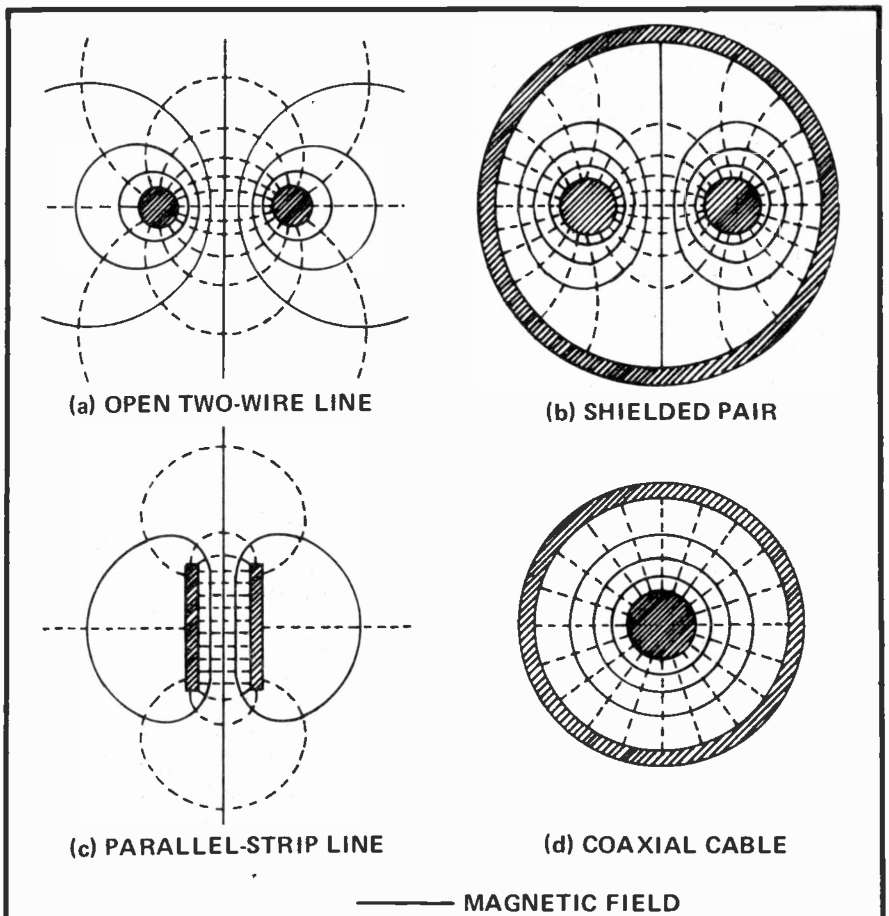

Fig. 1. Currents flowing in signal wires generate electric and magnetic fields. Enclosed configurations can be used at higher frequencies because these fields are contained.

ELECTRONICS–it's easy!

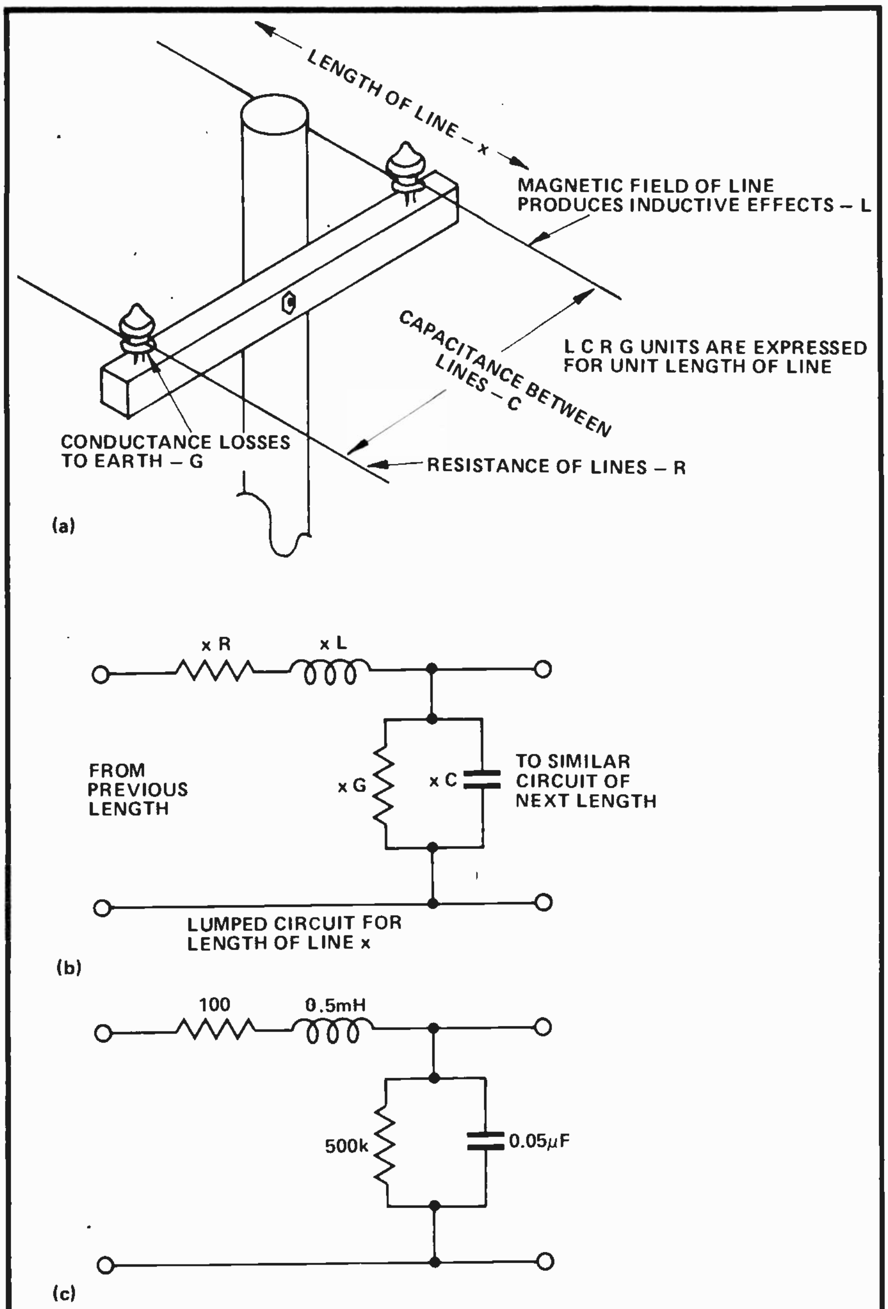

Fig. 2. Transmission links are systems in which R, L and C are distributed uniformly over the length. For convenience we can consider the line as being composed of cascaded lumped-equivalent elements.
(a) A length of low frequency telephone line.
(b) Approximate lumped-element equivalent.
(c) Representation values for 1 km. of medium-size telephone line with earth return. (Actual constants vary widely depending upon design of line).

cables may have a resistance of around 0.05 ohm per metre and a capacitance of 100 pF per metre. Hence a long length of shielded or open cable could provide a considerable shunting effect that attenuates and phase shifts the signal.

APPLY OHMS LAW

When connecting high output-impedance sensors to lines, as little as one metre of cable may be sufficient to markedly attenuate the signal. It's a matter of applying Ohms law to the suitable equivalent circuit.

Because of the reactive effects of the cable the higher frequency signals transmitted will be degraded more than the low frequencies — for example, square waves become rounded as well as attenuated. The high-frequency performance of the line may be improved by "loading" it with inductors placed at regular intervals. The inductance value is chosen to tune out the inherent capacitive reactance at the upper frequency where response begins to fall off, a method that extends the bandwidth some way beyond the inherent, unloaded upper limit. This is used, for example, to broaden the bandwidth of submarine cables.

CO-AXIAL

The coaxial cable, shown in Fig. 4, by virtue of the surrounding external shield (Fig. 1) acting as the second wire, has no external field and, therefore, does not radiate energy. Because of this a well designed coaxial cable will pass from dc to microwave frequencies — that is, such a cable can have a bandwidth of about 5000 MHz. Coaxial cable is, therefore, potentially able to transfer much more information than open wires. It does however need a common earth connection (asymmetric) and can't be used in a balanced mode (see later). The bandwidth of practical coaxial cables is limited by resistive and dielectric losses. In practice waveguides are generally used at frequencies above 1000 MHz or so.

WAVE GUIDES

Waveguides consist of precise pipework — they look as if they had been made by a precision plumber! Waveguides carry travelling electromagnetic waves of very high frequency and behave vaguely in the same way that pipes carry water. They cannot however be used for low frequency transmission.

The cross-sectional area of a waveguide is inversely proportional to the design frequency. As a general rule of thumb guide the upper frequency limit of a waveguide is where the wavelength of the signal becomes one quarter of the guide aperture — millimetre wavelength signals (50 GHz or so) being the practical upper limit.

OPTICAL FIBRES

Beyond this, a still wider bandwidth is obtainable using optical fibre transmission elements which will pass radiation in the visible lignt region) 10^{14} Hz to 10^{15} Hz). At our current state of technology, however, scientists have only been able to detect the frequencies of far infra-red signals (around 10^{11} Hz). We cannot, as yet, monitor individual cycles of light with electronic detectors.

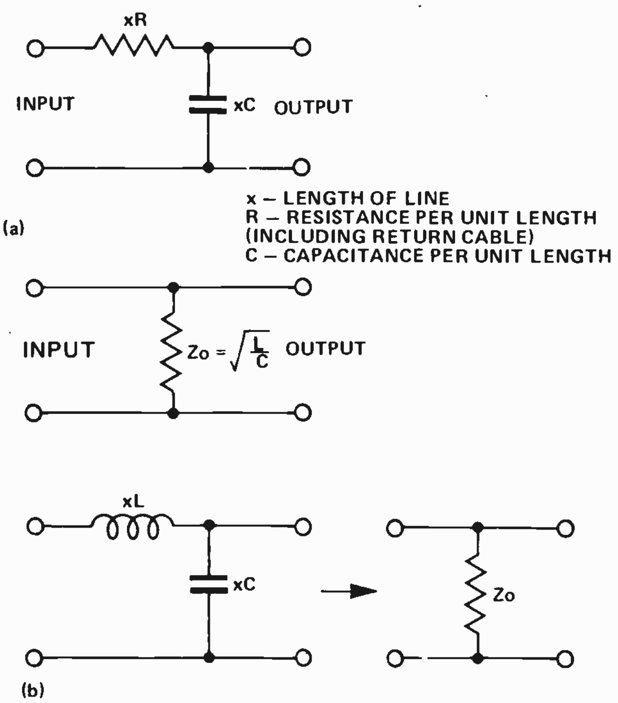

Fig. 3. In certain practical cases the lumped equivalent reduces to simpler situations situations.
(a) Low frequency (negligible L assumption) short line in which only C and R are dominant. The R, C values are found from maker's data.
(b) High frequency lossless line (negligible R and G assumptions). The input and output impedances of the line are equal and constant regardless of length.

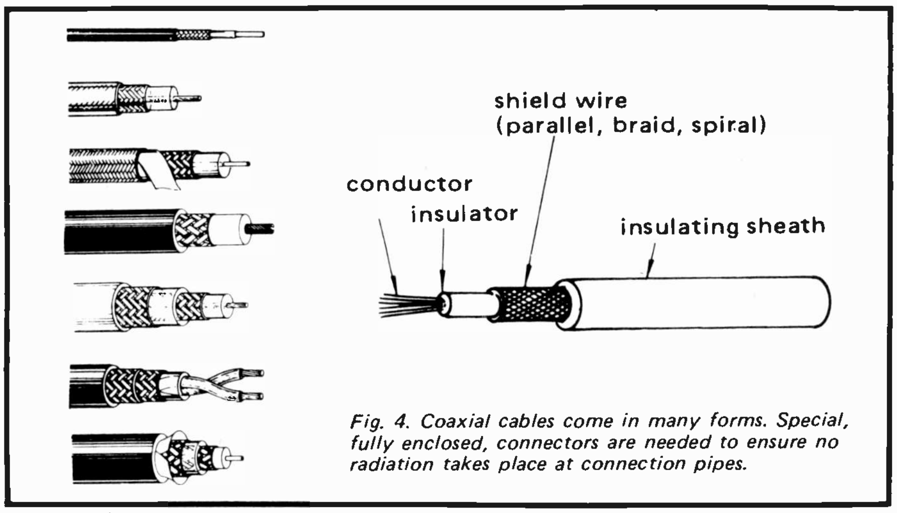

Fig. 4. Coaxial cables come in many forms. Special, fully enclosed, connectors are needed to ensure no radiation takes place at connection pipes.

LUMPED LINES

When the losses of the line are insignificant (G = 0, R = 0, in Fig. 2b) the lumped-equivalent of the transmission lines reduces to L in series and C shunting, as shown in Fig. 3b. The nett result is, rather surprisingly, that the line exhibits only resistance of a fixed value when looking into the ends. This is called the characteristic impedance, Zo, for which Zo = (inductance per unit-length/capacitance per unit length) ½. The line appears to be purely resistive and the Zo value is decided by the design of the line or cable, not by its length! Examples are 600 ohm telephone lines, 75 ohm colour TV coaxial feeder cable. This means, in practice, that we can interconnect units on the basis of matching all connections to the Zo of the cable without having to worry about the cable length. If this rule is observed, no high-frequency energy will be reflected at the termination to change the information being transmitted . (The need for correct matching was also mentioned in the previous discussion about filters). However, if the line is very long matching must still be applied to obtain maximum transfer, but account must now be taken of losses. For example a typical 75 ohm coaxial cable will have losses of the order of 2 to 5 dB per one hundred metres.

Radiation Links: Electrical signals fed into open wires radiate energy out into the surrounding medium. As well as this radiated energy there also exists a "near field" that remains established, storing energy. This is the field we associate with, say, an electromagnet. As the frequency rises the ratio of radiated energy to stored energy increases. For this reason we are able to build efficient radio systems provided the frequency is kept above 100 kHz or so. Lower frequencies can be used as transmission systems but the power input needs rise enormously for the same distance radiated in free space. (The Omega navigation system uses extremely powerful VLF signals because of their ability to penetrate deep into the waters of the ocean). Beyond the gigahertz frequency region, circuitry becomes impracticable with current technology.

Even though the radiated energy must be at a very high frequency to operate efficiently we may not necessarily need to use the bandwidth available on the carrier, modulation techniques are used to super-impose a relatively narrow bandwidth signal on to the carrier. It might be thought that optical and infra-red links use extremely high carrier frequencies (330000 GHz for red light) but in these applications the carrier is not modulated on an individual cycle basis but rather as a variation of a continuous dc link. Fig. 6 is a modern link designed to transmit television plus speech commands — a bandwidth of 7.5MHz. Acoustic links using soundwave propagation operate with frequencies as low as 10Hz to well above the 10MHz region. These can be modulated on the individual cycle basis.

Skin Effect: The alternating magnetic field produced around a wire has the effect of causing the current flowing in the wire to flow at a greater density in the outer region of the wire. The higher the frequency the more pronounced this so-called skin-effect. At the very high frequencies so little current flows in the centre of the cable that the centre is often omitted completely, thus a tube is used as a conductor. For example, at 1 MHZ the majority of the current flows in a copper cable to a deoth of only 60 um whereas at 60 Hz the distance would be 8.6 mm depth. This also means that the effectivle resistance of a wire rises significantly with frequency — by factors of 100.

Process Industry Telemetry Links: Process plants such as oil refineries, paper mills, brick kilns, power stations and aluminium refining plants are monitored by using hundreds of sensors connected to the control-room area via instrumentation links. These are invariably wired using shielded wire or coaxial cable. Because of the extreme electrical noise level of

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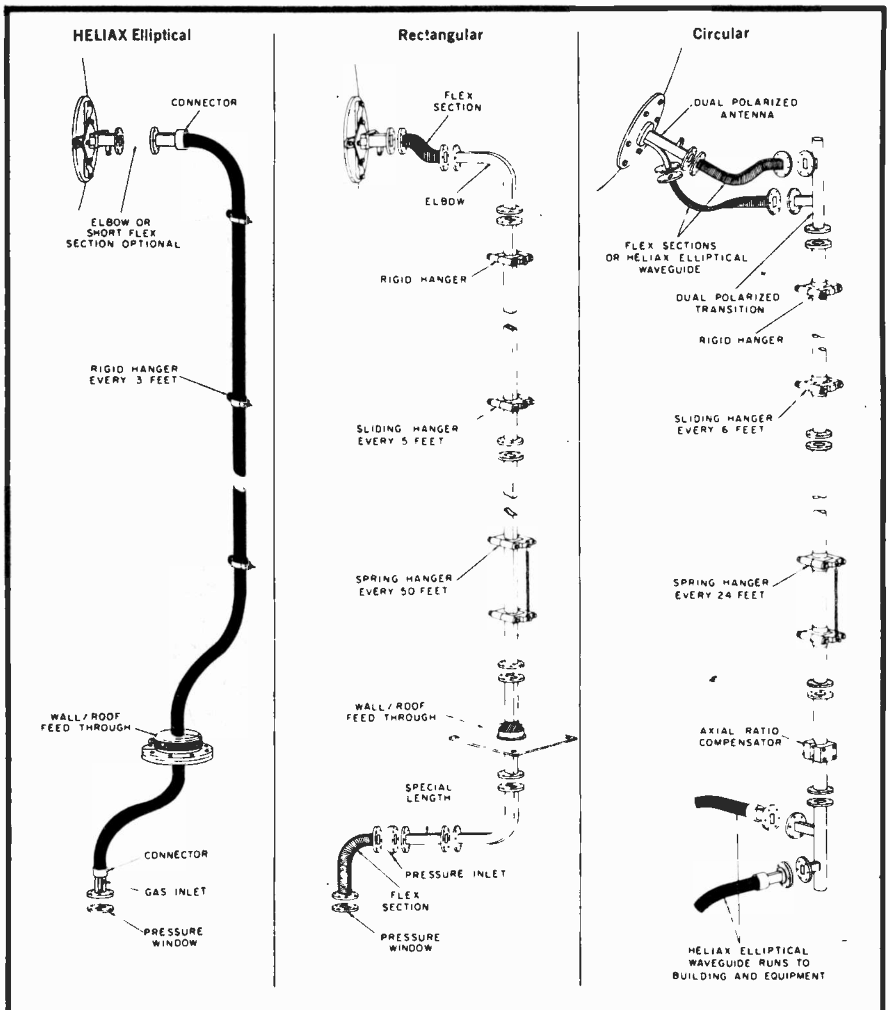


Fig. 5. Waveguides transmit electro-magnetic energy via travelling fields that are conveyed through the pipework.

such plants and low output signal level of the senors these links could pick up significant noise thus degrading the senor information. Over the years process instrument suppliers have standardised the design of the control systems, and their installation and noise pick-up by the cable has been avoided by several methods.

The first strategy is to superimpose the information signal on to a standing current or voltage thus raising the wanted signal level above expected noise levels. The two systems commonly used transmit the signal range of the data through 4-20 mA DC or 10-50 mV DC systems. An 0-20 mA system is also common. Current transmission has the advantage that the circuit is of low impedance — a few ohms — which reduces the level of induced noise power. Figure 7 is an example of these practices — Honeywell's arrangements used to test the temperature and pressure of natural gas wells in the Leman Field of the North Sea.

SAFETY PRECAUTIONS

Often the sensor has to be placed at a location where an explosion could result from a spark or excessive overheating of a malfunctioning sensor circuit. The most obvious way of overcoming this is to place the whole unit in an explosion-proof enclosure. This, however, has disadvantages the cost is high, and testing and maintenance difficult due to the need to shut off the power when the enclosure is opened.

The alternative, more modern, method is known as intrinsic safety. As inflammables require a specific level of energy to ignite them, explosion can be prevented by ensuring that the sensor stage cannot, under any conditions, provide enough ignition energy. No enclosures are needed and the circuit can be maintained whilst it is operating. Originally the concept was implemented by ensuring the senor circuitry could not draw, or produce via storage, more than a specified power level. This level was found by experiment in a test rig set up for the situation involved.

The more recent idea is to use "safety barriers." At the exit from the declared hazardous area, the cables terminate into a zener-diode and attenuator arrangement which ensures that the current and voltage entering the area are limited to safe values. Figure 8 shows the circuit of a zener barrier. Another safety device uses a solid-state closely-coupled electro-optic link which provides DC electrical isolation between its input and output, the information being transferred from a light-emitting-diode mounted next to a silicon photo-diode detector. These ensure that overvoltage or induced earth-loop currents cannot enter the isolated hazardous area.

MEDICAL MATTERS

In electro-medical instrumentation, safety precautions of another kind are vital to ensure the senor does not act as a pathway for a dangerous level of electric-current into the patient. At 240 VAC the human body's resistance, hand to hand is around 2000 ohms — 100 mA will flow. If totally connected (as by a conducting fluid) the resistance reduces to 200 ohm — 1 A will flow. About 75mA through the body will produce heart fibrillation; only 150 uA, through the heart itself, is needed to produce this effect. A person can usually hold (with the fingers) and release as much as a 10mA, 240 VAC current — beyond that the muscles become paralysed. Skin moisture largely decides the hand to hand resistance. When dry it will be (at 240 V) 2500 ohms and moist 1000 ohms. *Thus a hand-to-hand 240 V encounter will provide a shock at least double the fibrillation level!*

The instrumentation must, where the metal parts are earthed, be wired with the active, neutral and earthing wires connected correctly. Double-insulated systems avoid this problem. Earth-leakage balanced — core breakers are worth using. These defect minute difference currents in the active and neutral, tripping a breaker if they rise above milliamperes.

The sensor attached to the patient must not be capable of providing a lethal level of energy by means of feedback from the instrumentation.

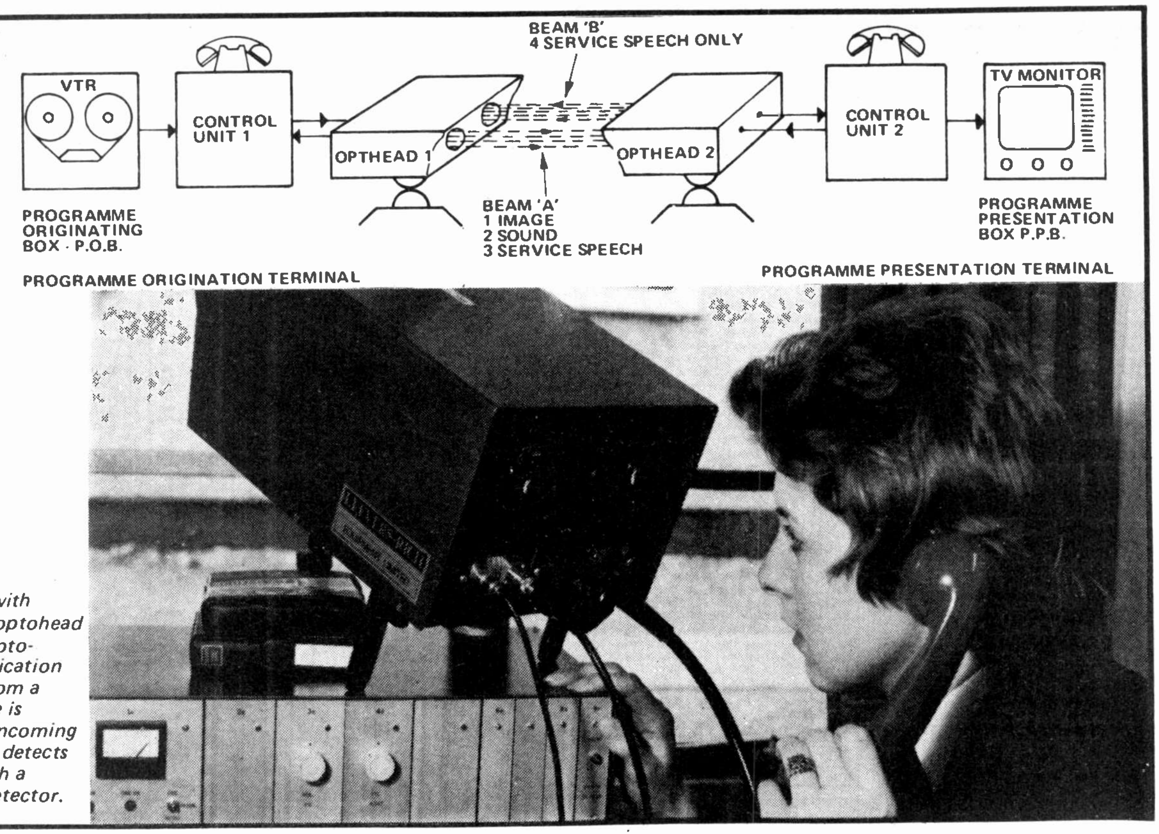


Fig. 6. Schematic with photograph of the optohead of a Leevers-Rich opto-electronic communication link. The output from a light emitting diode is modulated by the incoming signal. The receiver detects the modulation with a solid-state photo-detector.

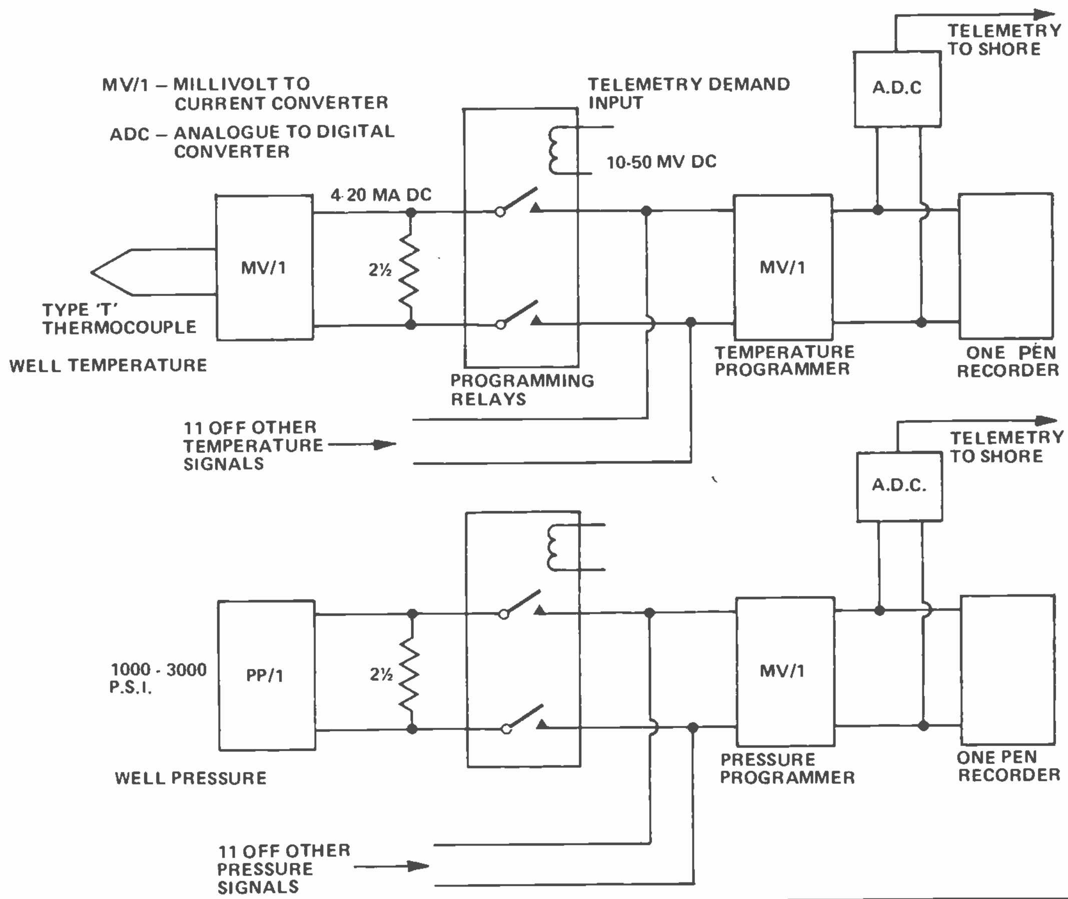
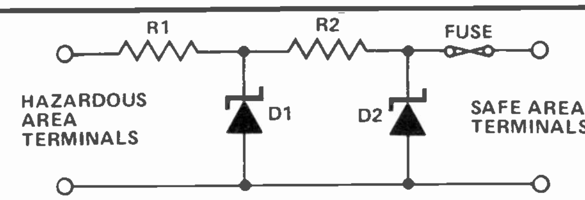


Fig. 7. Process measurement link arrangements used between the oil-well and the off-shore platform. The A/D units send the data to a shore-based computer by digital telemetry links.

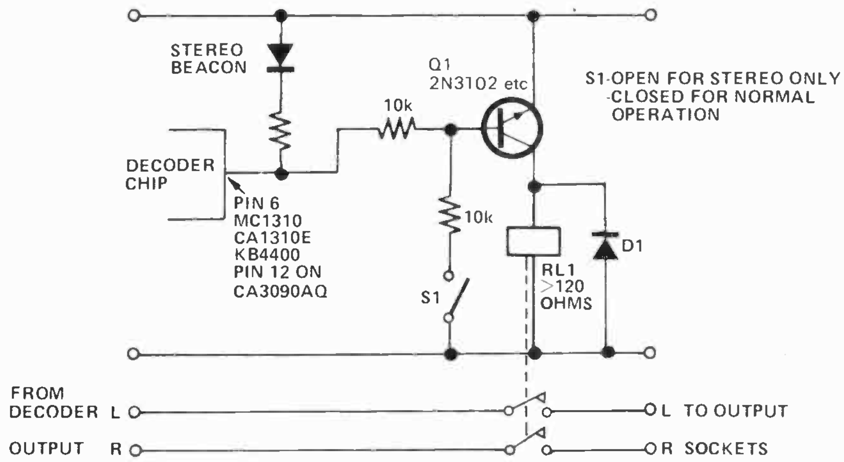
Fig. 8. Circuit used in a Zener barrier.



tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.



STEREO ONLY

This circuit allows only stereo broadcasts to be outputed by a tuner using either a 1310 or 3090 type stereo decoder chip. In both cases the stereo beacon driver is used to switch the audio output of the tuner. When a stereo signal is being received the beacon driver output is low which turns the Q1 and energises reed relay RL1. The two contacts which switch the output lines are closed and the stereo signal is available at the tuner output sockets. RL1 can be any reed relay with a coil resistance greater than 120 ohms and two normally open contacts.

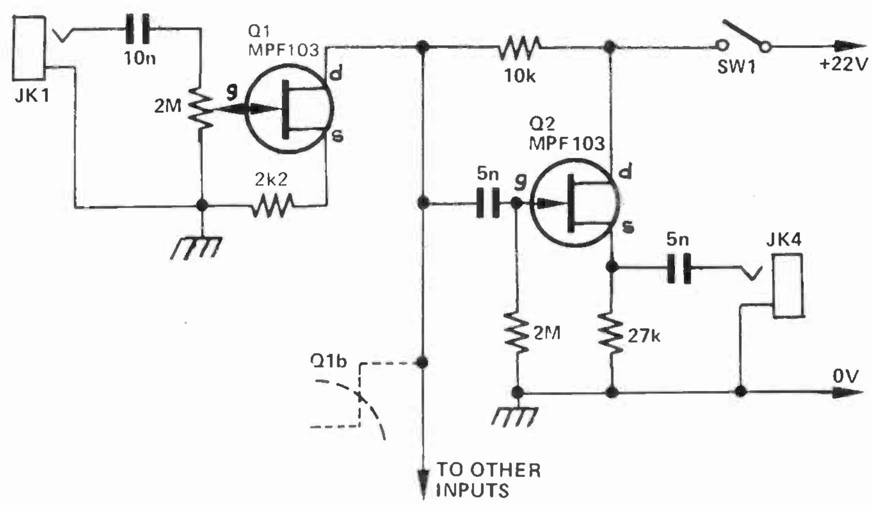
BASIC MIXER

This simple mixer circuit will work with two or three channels, providing excellent input isolation and exceptional frequency response, extending well over the top end of the audio spectrum.

It is usable by one or more instruments plus microphone, or with special effects, such as mixing an input with pink noise, to give 'surf'.

The unit will give 8db gain, and since low-level signals are involved, should be housed in an aluminium box. If a mains supply is used, the usual anti-hum precautions must be taken.

It is useful to use scaled slider potentiometers, so that effects may be re-created.



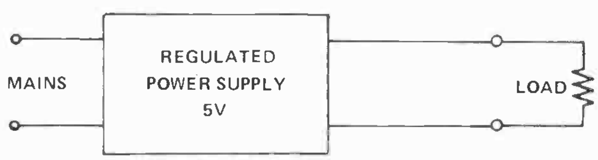


Fig. 1

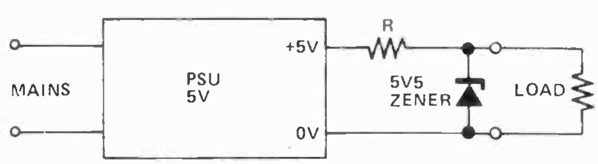


Fig. 2

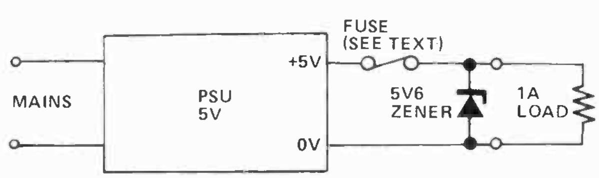


Fig. 3

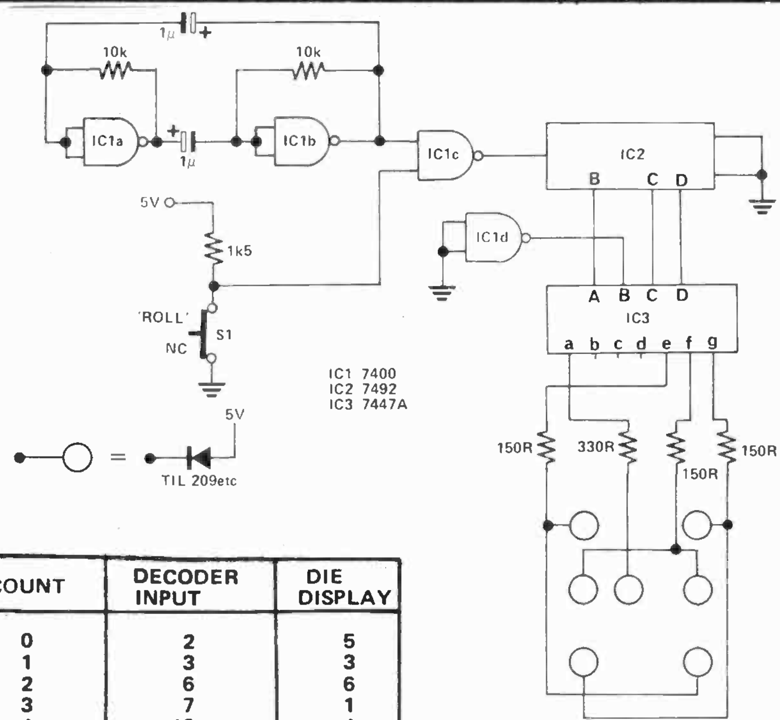
PROTECTION FROM TTL PSU FAILURE

With this circuit, a fault in the sophisticated PSU might cause the output voltage to rise above about 5.5V, (the maximum allowable) and thus cause damage to the ICs.

A simple zener regulator across the output as in Fig. 2 with a zener voltage of about 5.5V, means that at normal voltage, the zener is effectively open circuit. The effect of the load resistor R, would be to eliminate all the regulation of the main PSU.

In the circuit shown in Fig. 3, there is no load resistor to cause regulation problems, and the zener normally appears as an open circuit. But as soon as the voltage rises above about 5.5V the zener tries to draw a great deal of current and the fuse blows, cutting off the supply from the load.

tech-tips

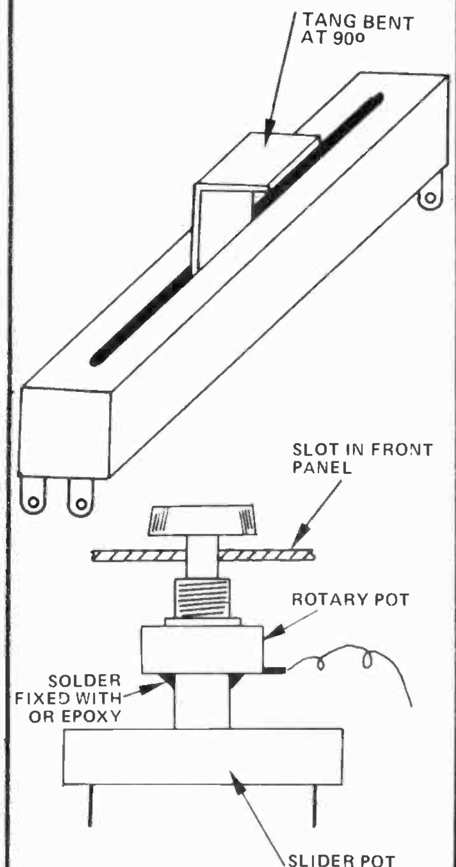


COUNT	DECODER INPUT	DIE DISPLAY
0	2	5
1	3	3
2	6	6
3	7	1
4	10	4
5	11	2
0	2	5

3 CHIP DIE

This differs from previously published circuits in that decoding, count and drive LED is achieved by a single 7 segment decoder/driver chip.

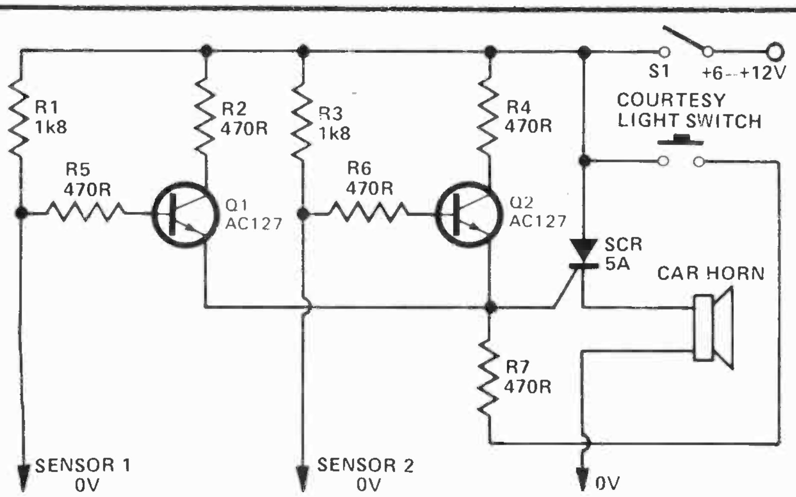
IC1a and b form a multivibrator, providing clock pulses for the counter IC2. IC1c gates the pulses to the counter when the 'roll' switch, S1, is opened. IC1d is used to provide a logic 1 for the B input of the decoder, IC3



JOYSTICK

Shown is an idea used successfully to provide a 'joystick' type of control with a television football game, by mounting an ordinary rotary type potentiometer on the tang of a slider potentiometer. The rotary control is attached to the circuit board via flying leads.

Radio control enthusiasts could use the idea in conjunction with a proportional system, giving a very cheap alternative to 'joysticks'.



CAR RADIO PROTECTOR

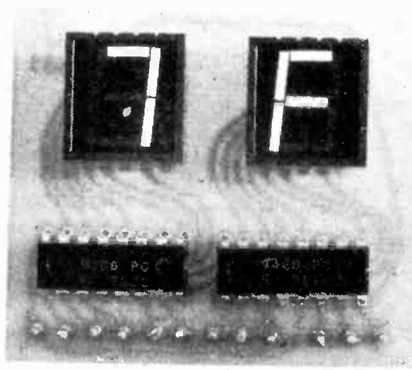
Many circuits have appeared for protecting radios and stereos in soft-top motor cars whose interiors are readily accessible to thieves. These circuits however, have the disadvantages of high parts count and expensive relays to switch on and latch the alarm.

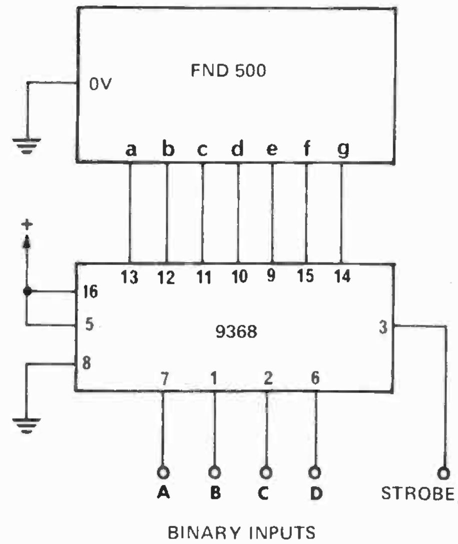
The circuit operates as follows: sensor leads 1 and 2 are connected to the chassis of the equipment to be protected, therefore holding the bases of Q1 and Q2 at earth potential, and thus switched off. If one of the sensor leads is broken, current flows to the base of the respective transistor and switches it on. This gates the SCR and sounds the alarm. The self-latching characteristics of the SCR now make the transistor and its sensor lead inoperative and the alarm can only be stopped by switching off the concealed switch, S1.

To prevent thieves tampering with the wiring, a seperate car horn and courtesy light switch (obtained from a breaker's yard) were fitted under the bonnet. If thieves cut the normal horn wires the alarm is unaffected; also any attempt to lift the bonnet to disconnect the battery will trigger it. The sensor leads are multistrand flexible cable with only one strand connected to the equipment, therefore easily broken while trying to remove it from the dashboard.

The transistors used are not critical and most NPN. general purpose transistors should suffice. The stand-by current is very low (typ. 13mA), and therefore is designed to be left switched on. The owner can never forget to switch on the alarm when leaving the vehicle. He must, however, switch off before lifting the bonnet.

HEX DISPLAY





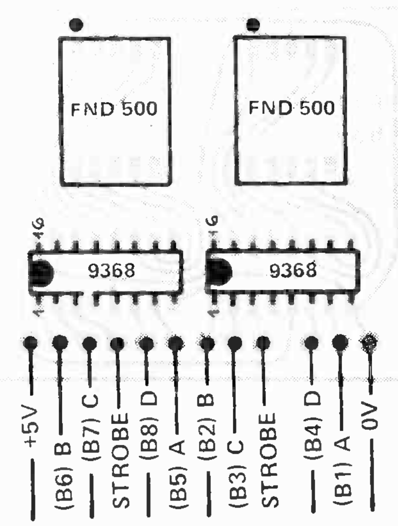
The circuit diagram of one half of the display.

THERE ARE MANY SITUATIONS in which the computer enthusiast wants to see the data on a parallel binary data bus (such as the one carrying the output from the terminal keyboard in this issue). Certain conventions have arisen to provide standard ways of displaying and manipulating large binary data words — because we are not equipped to handle information in the form of words like 00000000 or 11111111 (or words from 0000000000000000 to 1111111111111111.

Conventionally parallel buses are organised in multiples of four lines, and in microcomputing the most common bus-width is eight lines. Binary display is easily achieved — data on the bus is strobed into a latch and the contents of this latch are used to set up a display on eight LEDs. This project provides a small board with two displays to read an eight-bit word. If one display is all that is needed (to read a four-bit word) half of the design can be used — just saw the PCB in half.

The data is loaded into a latch on the 9368 IC when the strobe line is taken low. This IC also contains the display drivers and all the electronics for decoding. The inputs are standard TTL-level and positive-logic ('0' <0.4V, '1' >2.4V).

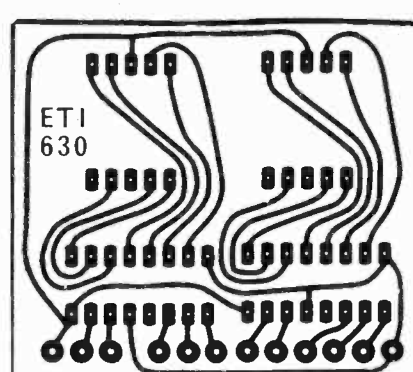
The power-supply requirement is a single +5V.



Component overlay for the ETI 630 board shown below.

SPECIFICATION ETI 630

No of digits	Two
Number system	Hexadecimal (base 16).
Display format	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, b, C, d, E, F.
Data input level	TTL positive logic.
Strobe input level	TTL active low.
Power supply	5 V, ± 0.25 V. Current consumption depends on display.



ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

LAST MONTH I mentioned the new GI TV games chip which allows you to play up to six games on your TV by adding a few simple controls and components. This chip will only play "Ball and Paddle" games such as tennis, hockey and pelota, although the two Rifle games included on the chip allow shooting with a photo-sensor at the target (otherwise known as the ball).

GI have now released further details of their second generation of TV games including volleyball, tank warfare and a road race. Essentially the latest additions fall into two categories: multigame chips — which mate with other chips to increase the variety of games and cartridge programmable chip sets which use any or all of GIs lines of 16, 8 and 4 bit MPUs.

All of the dedicated circuits are designed round a few basic chips, and with these you can build home TV games similar to those which are now becoming popular in arcades. In upgrading the standard "Ball and Paddle" games GI have added some interesting but basically useless gimmicks. These include differently coloured scores for each player, dual axis paddle control, and for squash, a ball which changes colour to indicate whose turn it is to hit it!

With the new multigame chips the user can choose from four chips, one with the six basic paddle games, one with the simple games plus colour options, one with eight games or one with the tank battle alone.

With the add-on circuits you can add three variations of volleyball, a road race, a chase game or a battle between surface ships and submarines.

One of the other chips in this range is a five game chip which plays a set of games in which players have 16 directions to move a vehicle or fire a missile, to make things as simple as possible GI have used simple squares to denote a player's pieces rather than using a tank shape or car shape.

For the higher priced game GI have a selection of games which use one of their MPUs to do a lot of the work, some of these games include blackjack, a slot machine, Noughts and Crosses and a Lunar Landing game. For further info you can write to GI at 63 Mortimer St, London W1.

LANDED IN LUNAR-CY

A game such as Lunar Lander can be played in three ways, as a picture game with a small rocket controlled by a joystick, as a numbers game with pictures given for height, speed, fuel, etc, or as a combination of the two. The "pretty pictures" version need a graphics generator whereas the alphanumeric only version relies wholly on your ability to read and understand the digital instrument readings given on a VDU. This second approach to TV games is more interesting for the home user as more brainpower is needed as opposed to the paddle game where skill and manual dexterity are of prime importance.

The object of a lunar landing game is to judge your landing speed and the amount of decelleration required at any given height. Decellerating uses fuel and only counteracts the effects of gravity which causes acceleration, if you use too much fuel too soon you have none left for final manouvering and you land with a bump. If you do not use enough fuel early on then you cannot reduce your speed enough before impact, burn too much fuel when you are going slowly and you can end up going upwards. Add a few unseen calamities randomly such as fuel leak suddenly losing you half of your supply and you have the makings of a rather good game.

COUNTER MOVES

The basis of the game is a set of digital counters giving the results from a simple algorithmic calculation based on changing input parameters. Sound complex? If you assume that your rocket passes into manual control at 5,000 feet up you have 100 units of fuel left and your present rate of fall is 150 feet per second it is relatively simple to work out the situation one second later.

If you do not fire your retro-rockets then gravity will increase your speed by about 5 feet second to 155 ft/sec, also you have travelled for one second at 150 ft/sec (ignore increase in speed at present) and thus your new height is 4,850 feet. With no fuel burn, after ten seconds you will be at 3,275 feet and going down at 200 ft/sec, carry on at that rate and there won't be much left of you or your rocket.

BURNING BOATS

Let us assume that your retro-rockets give you 10 ft/sec speed change in one second, thus if you now burn your fuel your speed is going to reduce by 10 ft/sec to 190 ft/sec and then to 180, 170, etc. Thus after another ten seconds your status is height = 1,725 feet, speed = 100 ft/sec and fuel = 90 units, the next ten seconds reduce these to 80 units of fuel at 1,175 feet with a speed of zero, if you continue to burn your fuel you will start going up and so you had better turn off the rockets.

After 15 seconds of free fall and five seconds of burn you will be down to 375 feet and going at 25

Seconds	Height	Speed	Fuel
0	5000	150	100
10	3275	200	100
20	1725	100	90
30	1175	0	80
40	950	50	80
50	375	25	75
51	350	30	75
52	320	35	75
53	285	25	74
54	260	30	74
55	230	35	74
56	195	25	73
57	170	30	73
58	140	35	73
59	105	25	72
60	80	15	71
61	65	20	71
62	45	10	70
63	35	15	70
64	20	5	69
65	15	10	69
66	5	0	68
67	5	5	68
68	0	10	68

ft/sec. The table shows the final approach from this point onwards.

A landing at 10 ft/sec is like jumping off a ten foot wall, a lot better than landing at several hundreds of feet per second. By changing the parameters slightly and adding random fuel losses the game can become very exciting. The game is based on an algorithm (calculation) based on the changes in speed and fuel usage.

If you started out with only 30 units of fuel then the game would be more of a contest in fuel management, in the above example the 30 units would have run out after 63 seconds and you would have landed two seconds later but at 20 ft/sec.

GAME AT MANAGING

Other types of simple or complex management games of this type can be played with a MPU simply by programming it to do the calculations which can thus become more complex and have more random factors. For those of you who find the idea interesting there is a book by Hewlett-Packard called "What you do after you hit Return" (part no HP 36000-91005) obtainable from Hewlett-Packard Ltd., King St. Lane, Widdersh, Wokingham, Berks at £4.45 (Quote part number).

This book details the logic and a "BASIC" listing of about 50 games ranging from simple word and number games up to "Star Trader," Civil War and Stockmarket games. Comparing these games to the "Ball and Paddle" games is like comparing a spinning top to Monopoly, one is a short bit of fun suitable for pubs and arcades and the other is a multi-person competitive thinking game. Both types will be coming onto the consumer market later this year so start saving your pennies now!

DON'T SWEAR TO IT!

Some months ago we mentioned the problem of seven-segment to BCD conversion and several people came up with 3 or 4 chip solutions and even the idea of using a 74188 PROM, NatSemi have now announced (re-announced?) the DM86L25, "The one commercially available device specifically designed to do the job." It has two output enables, the ability to accept either positive or negative logic and the ability to recognise four letters, a minus sign and a blank — I wonder what the four letters are? ●

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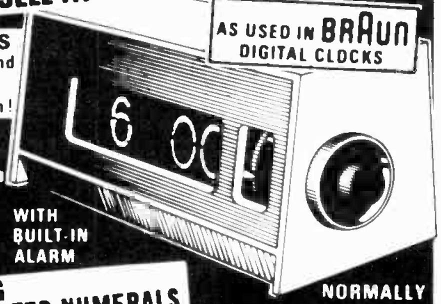

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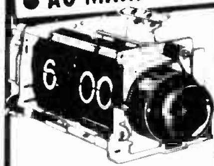

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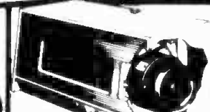

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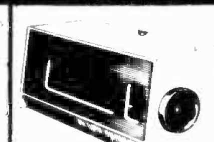

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