electronics today INTERNATIONAL

JANUARY

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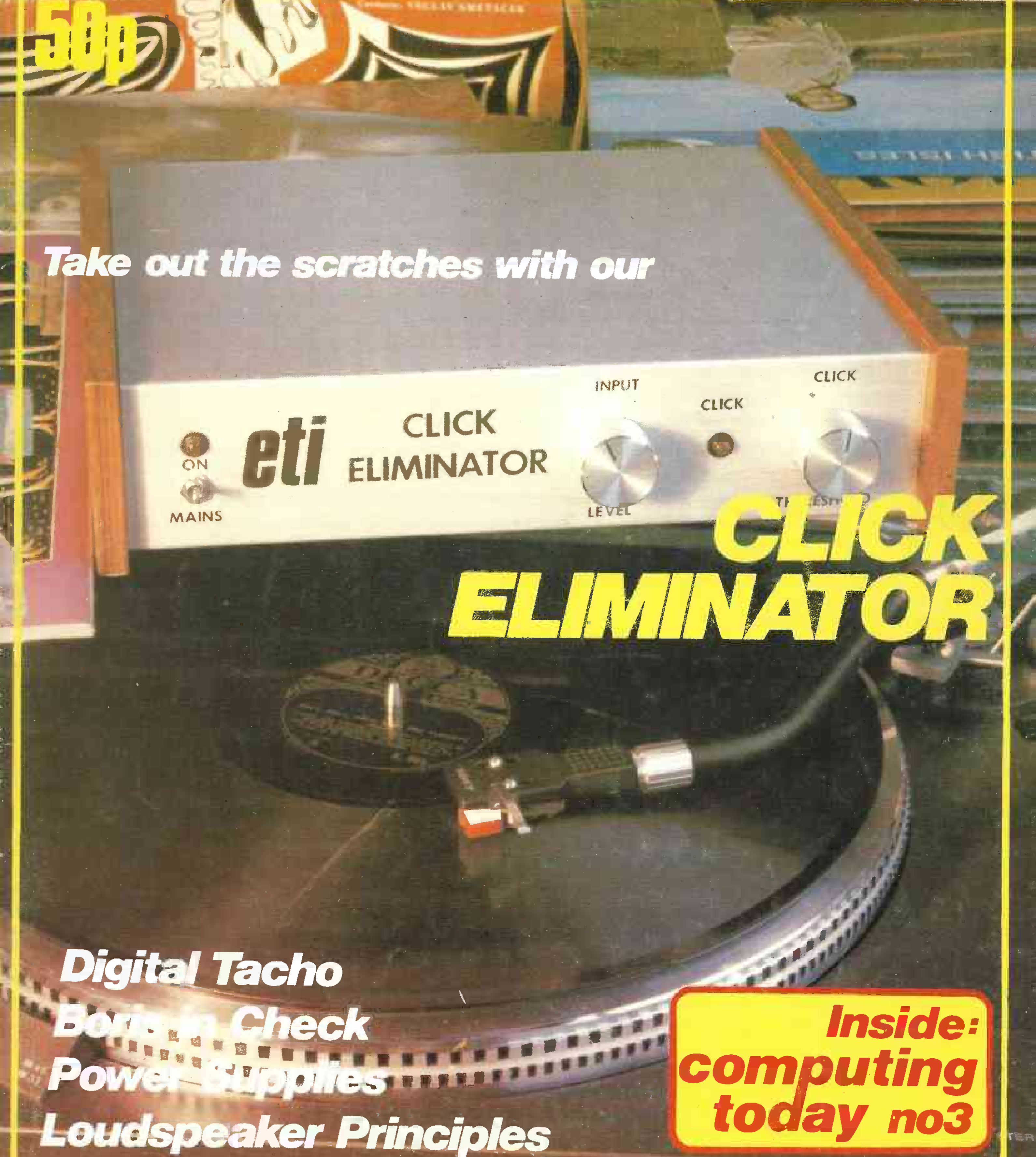


Take out the scratches with our

CLICK ELIMINATOR

Digital Tacho

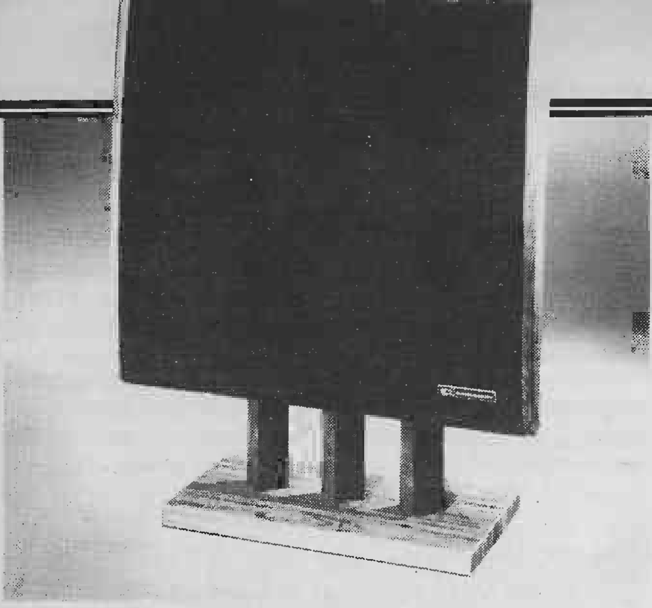
Bomb in Check

Power Supplies

Loudspeaker Principles

Inside: computing today no3

...NEWS....PROJECTS....MICROPROCESSORS....AUDIO...



The DQ10. This design makes use of what the makers term a 'phased array'. This means that the driver units are staggered so that their effective radiator 'points' are equi-distant from the listener which eliminates the time delay distortion (phase linear?) flat baffle designs are prone to. In addition each driver is mounted on its own optimum sized baffle to minimise diffraction problems.

Transmission Lines

This is another method of 'losing' the rear radiation of a drive unit, or making it think it is working into an infinitely long column. This is achieved by having a maze of woodwork inside the enclosure which is filled with graduated damping material. In this way total column length can be far greater than enclosure dimensions.

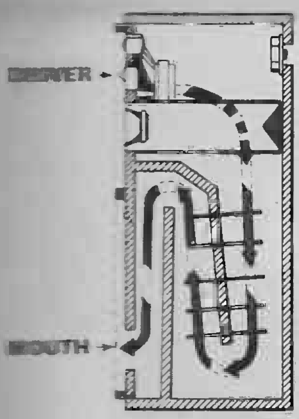
If the far end of the column is open then help is afforded to the bass performance in much the same way as bass reflex cabinets.

The design is usually for almost total absorption of the rear wave — and this leads to a gradual and smooth fall off in bass response due to the almost constant velocity working conditions for the cone.

Conversely to both acoustic suspension and basis reflex loading methods, transmission line methods lower the bass resonance of the drive units and hence enhance LF performance.

IMF have championed this technique for long time passing now, and as exampled in their products transmission line bass possesses a 'solid' quantity totally different to that from the other methods. It is more extended and more realistic. Used in a large enough room there is no better way to replay the lower registers.

Oh for a successful combination of transmission line bass and electrostatic HF!

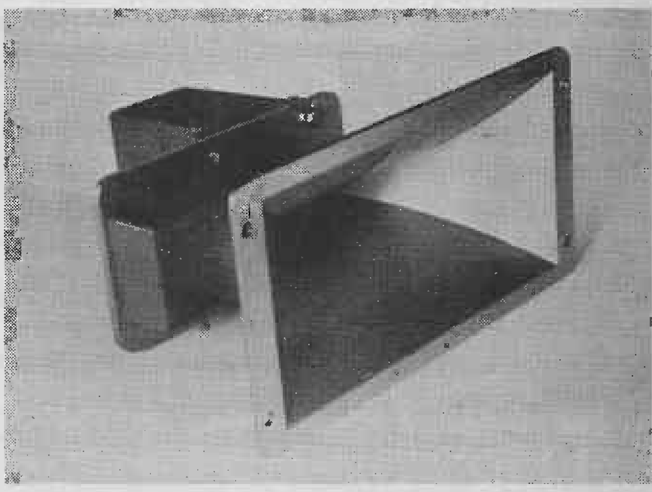


The basic principle behind the transmission line speaker enclosure. The air from the rear of the cone gets 'lost' down the line.

Horn Loading

A method of designing to considerably reduce required driver excursion for a given acoustic output. The driving element is coupled to its air load by a gradually 'flaring' throat — usually exponental in cross section.

The horn converts the high pressure, low velocity sound energy present in the region of the driver into low pressure high velocity waves for propogation. The advantages of this type of loading are good damping of the driver, low distortion but a limited frequency response.

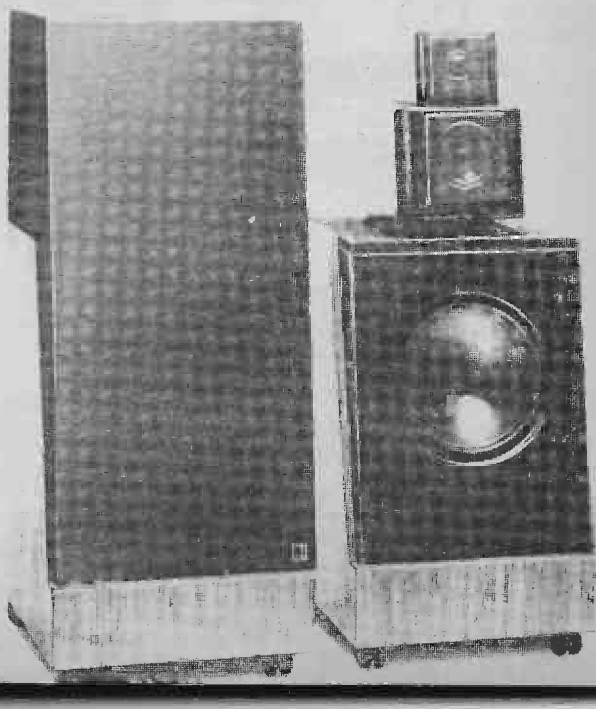


The Decca London ribbon unit, loaded by a caternoidal horn. The flare can be clearly seen in this photo leading down to the ribbon itself somewhere in that block at the back!

To design a single horn to cover the entire audio spectrum is a confused exercise, and one yielding impractical results for domestic use, since an exponential horn to reproduce 30 Hz has a mouth of 1.5m diameter and is some 4m long! Folding the horn back and forth within an enclosure can reduce dimensions, and the American firm Klipsch market units which employ the room walls as extensions of the horn to reach lower frequencies. Usually though, the system is used to load MF and HF units within a system.

Advantages of this principle are phenomenal efficiency $\approx$ 10% compared with 1% for bass reflex for bass reflex and 0.1% for transmission lines, and an attack unmatched by any other cone driver recipies. ▶

KEFs 105 linear phase design. The upper two enclosures are rotatable to aid stereo imagery. Note the rounded edges to prevent re-radiation and the staggered drivers with respect to the listener. ▶



ELECTROSTATIC

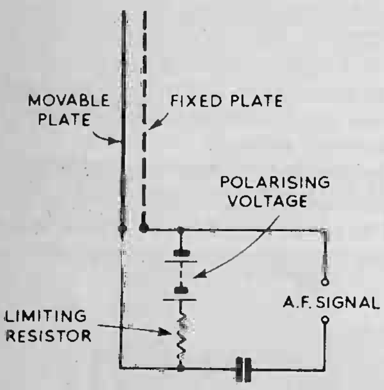
As we have seen the moving coil design suffers because the cone area is unevenly driven by the electrical music signal. The electrostatic principle, developed by both David Tombs and Peter Walker (of the Acoustical Manufacturing Company) is an attempt to produce a unit in which the entire surface of the unit is driven by the input signal.

At its most basic the design consists of two plates as shown in the diagram. The moveable plate is made to have as low a mass as possible and is so suspended that it cannot touch the fixed plate at any point in its travel. The fixed plate will usually in fact take the form of a etal 'mesh'. A high polarising voltage≈5kV is applied between the plates, and the audio signal superimposed on this.

An electrostatic force—such as that which holds dust on to LPs and LPs onto turntables—is thus generated between the plates and the moveable one vibrates in sympathy with variation in the input signal.

A refinement of this is the push-pull system where the moving plate is situated between two fixed meshes as shown in the drawing. The polarising voltage is DC in nature, from a very high impedance source, and is of the order of 5kV once again.

The outer plates (meshes) are fed from a step-up transformer connected to load the incoming signal. This applies a high voltage electrical AC signal to these plates (the music signal) and causes the center plate to move in sympathy with this. Distortion is greatly reduced using this push-pull arrangement and can equal 0.5% in a good design.



Scheme of operation for electrostatic loudspeakers. On the top we have the basic single ended design, and below that the commercially employed, much-improved push-pull scheme as employed by Quad and Koss amongst others.

This system first appeared on the market many many years ago in the form of the Quad electrostatic system—which remains largely unsurpassed for lack of colouration and mid-range clarity.

The advantage of driving the plate evenly over its whole area show up as a linear frequency response—no rippling or 'break-up'—very low distortion and a good transient performance due to low driver mass.

However this system does have inherent drawbacks. Consider the Quad system as an example. It is noted for its mid-range clarity and its high frequency accuracy—but also for its lack of extreme bass and its beaming of top end signals—poor vertical dispersion.

The reason for this is its physical size. Since the push-pull radiator is by nature a dipole radiator—sound emitted both front and back, some cancellation at frequencies whose wavelength exceeds the plate dimension is inevitable.

The Quad is also very room sensitive for this same reason. Rear radiation can be dumped, but not without acoustically loading the plate—an undesirable excursion into non-linearity. At high frequencies there is low energy in the wave to absorb, and so this is easier to affect without adverse consequences on the drive plate.

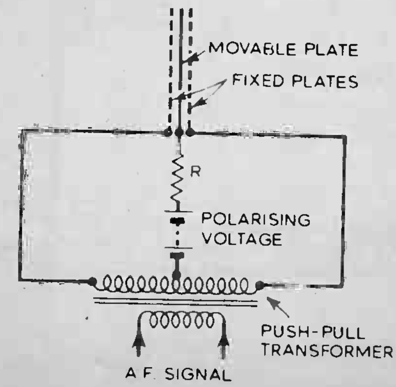
KLH made a brave attempt to reach the theoretical size of plate for good bass response with their superb KLH9 full range units. These are almost exactly door sized—and you need **two** per channel! And they cost £2000 a pair. And they are probably unbeatable by any speaker on the market for sheer accuracy and delicacy. Their size endows them with a hefty bass punch too. Units to sell your soul for. (Anyone listening down there?)

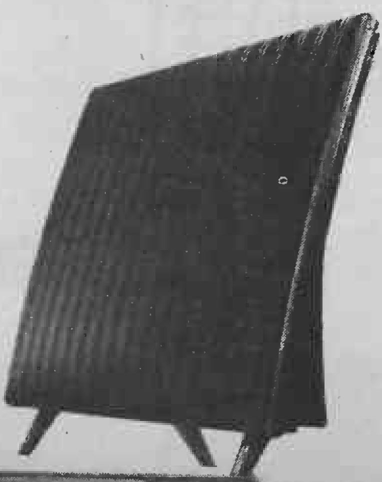
Loading Problems

Another less serious drawback is that transformer into which the electrical signal is fed. This presents an awkward load to the amplifier, and can produce some nasty effects from transistor amps.

Modern designs however—Lecson, Quad and the rest, can cope perfectly and experience no traumas when presented with the wickedly reactive termination characteristic of electrostatic speakers.

Many attempts have been made to marry together electrostatic mid-high drivers with cone bass units. B&W DM70 was perhaps the first (and the best!) but not have been entirely successful. Perhaps its simply that the superior distortion and colouration properties of the electrostatics will always show up the bass units!





ISODYNAMIC

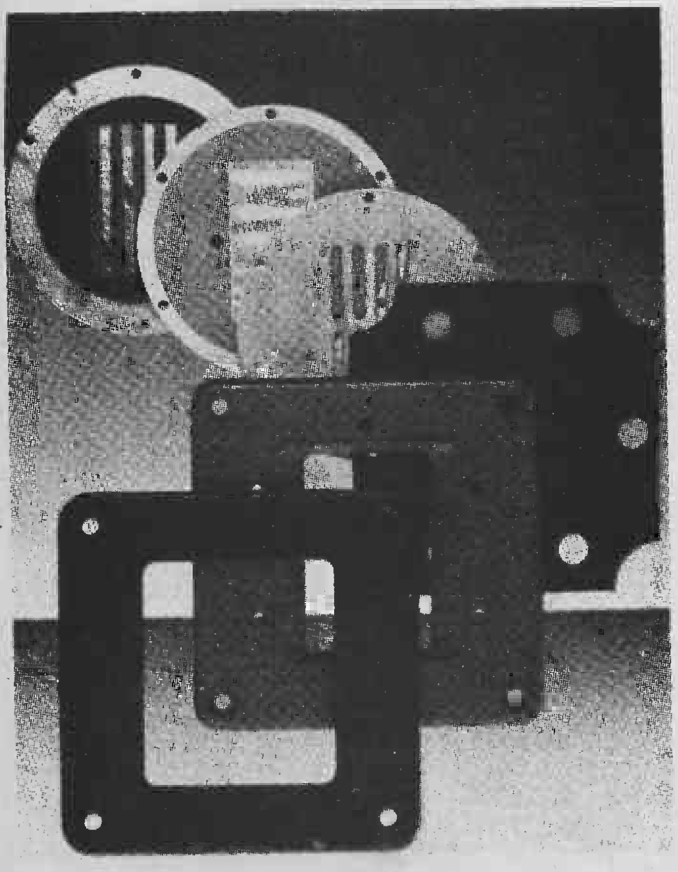
With the release of the Stathearn 21000 speakers, and the new Wharfedale series incorporating Isodynamic tweeters, this approach is gaining ground. It certainly has a lot of promise, which we shall undoubtedly see exploited as time goes on.

The principle was pioneered by Wharfedale with their Isodynamic headphones some six years ago or so. It is really an attempt to gain the advantages of the electrostatic system, without the need for high voltages and attendant drawbacks.

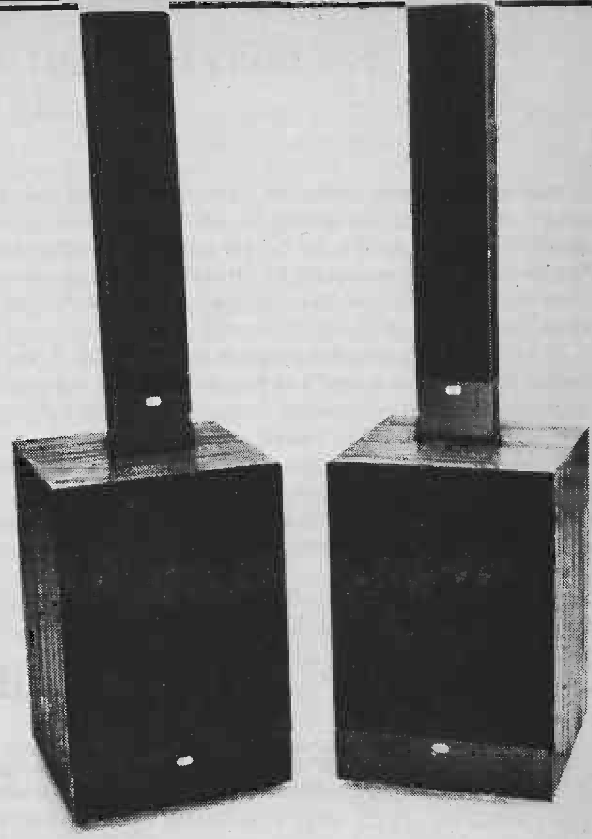
A drive unit built to this principle consists of a thin sheet of mylar, or some such material, with a conductive track bonded onto it in a pattern which covers the surface in as symetrical manner as possible. This conductor acts as the voice coil of the speaker, and when an electrical signal is passed through it it responds to nearby magnets by moving the diaphragm in sympathy.

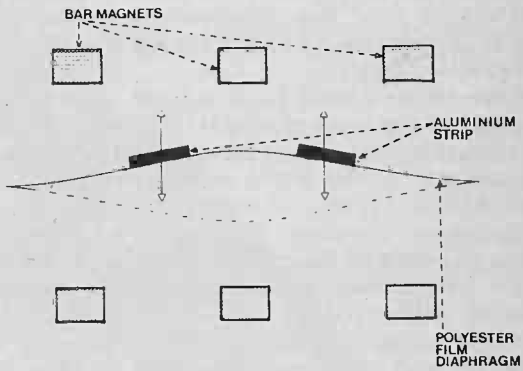
Once again colouration is low, and driver mass small—but also once again to obtain bass means large areas, and conductors capable of handling large currents. Strathearns units are above 500Hz operators only and are transformer coupled to the input. Wharfedale employ their invention in high frequency units only.

A pity—but one we might see rectified sometime in the future.

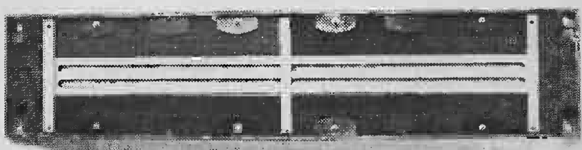


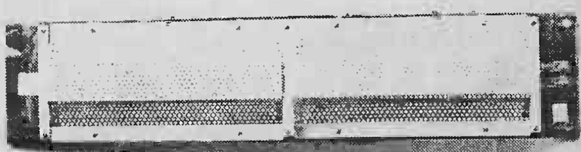
Exploded view of the Whardedale Isodynamic tweeker. The driver plane — second from the rear — uses a material 25 microns thick with an etched aluminium circuit.





The 21000 from all angles. At the top we have the full system. Below that the diagram shows the operating principle of the SLC1. The polyester diaphram acts as the speaker cone. Below this caption two internal views of the unit. The radiating areas can be seen in the top diagram, and the lower rear view illustrates the damping material to control rear radiation.





▶

RIBBON

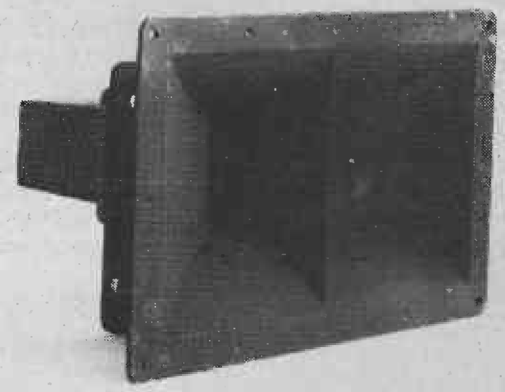
If we take the voice coil of moving coil speakers, and make this the active element, instead of the cone, we would do away with a lot of the causes of colouration in the process. Mass would be much smaller, break-up or rippling would be greatly reduced, if not eliminated and thus transient handling improved.

The ribbon loudspeaker does exactly this. A very thin metal 'ribbon' is suspended between the magnet pole faces and the signal passed through it. It will vibrate with the signal, and thus produce the sound output

Acoustic output is low, and horn loading is usually employed to alleviate this problem.

Once again obtaining bass is a major problem, and moving coil units will take over from the ribbon as the frequency decreases.

Decca market an excellent example of this principle, which operates above 2.5kHz.



Decca's ribbon loudspeaker. This features a ribbon element one tenth the thickness of human hair, and is horn loaded to increase efficiency. An 'acoustic lens' can also be fitted to aid sound dispersion.

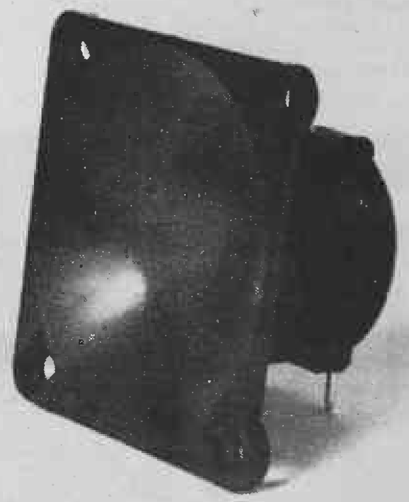
PIEZO-ELECTRIC

In the July 1976 edition of ETI we reviewed the Motrola KN 6006A, the first piezo-electric unit to be released commercially. Since that time many commercial loudspeaker enclosures have employed piezo-electric tweeters for their total insensitivity to crossover networks, phenominal transient response and clean subjective sound quality.

Piezo-electrics have been around in hi-fi for a long time now in the guise of crystal/ceramic cartridges. The principle of operation is based upon the fact that stress a piezo-electric crystal and a voltage proportional to the applied force is produced across its ends.

Conversely therefore if we apply a varying voltage across the ends of the crystal, mechanical deformation occurs, sympathetic to that voltage. No magnets aare required, and no coil is used.

In the Motorola design two thin slices of ceramic material—lead zirconite-lead titante in case it makes your life the fuller for knowng are epoxied onto a brass separator, and nickel electrodes deposited on to a facilitate connection. In order that the discs respond correctly to the input, they are polarised in opposite senses, so that on application of a common signal one disc expands and the other contracts—acting in the same direction therefore on the air load.



Motorola's KN 6006 piezo-electric high frequency driver. The actual driver is the small section at the rear, and the horn is to increase acoustic efficiency.

Pros . . . . . .

Since the impedence curve for the unit shows a steep rise in value with falling frequency, the unit does not need a crossover to reject low frequencies.

A perfect tweeter.

Since there is no voice coil or cone the driver mass is significantly lower than an equivalent conventional speaker.

Being composed of a ceramic material heat dissipa tion is less of a problem also, and the Motorola can stand 35V RMS for protracted periods with no signs of distress.

Due to the nature of its impedence, it is difficult to compare efficiency with normal units, suffice it to say that 4V RMS produces 105d BA at 18ins distance, and that this can be considered efficient!

. . . . . . And Cons.

Some amplifiers may not like the load any more than electrostatic units, but since these things are normally used with a good deal of attenuation and response shaping circuitry between them and the valued output stages this should not be too great a problem.

Subjectively these units have always sounded a little 'hard' to me, and never as smooth as a good dome unit like the Isophon or Celestion 2000 designs. Still personal taste and all that . . . . . .

Once again acoustic efficiency is low, and horn loading is employed.

MOTIONAL FEEDBACK

Although this perhaps only a modification of earlier systems, the performance gains at LF are such that it warrants a closer look.

Motional feedback is a form of feedback control of the driver cone in moving coil systems. The power amplifier are mounted within the enclosure, a separate amp for each drive unit, and so signal feed is from a preamplifier. The system is marketed by Philips.

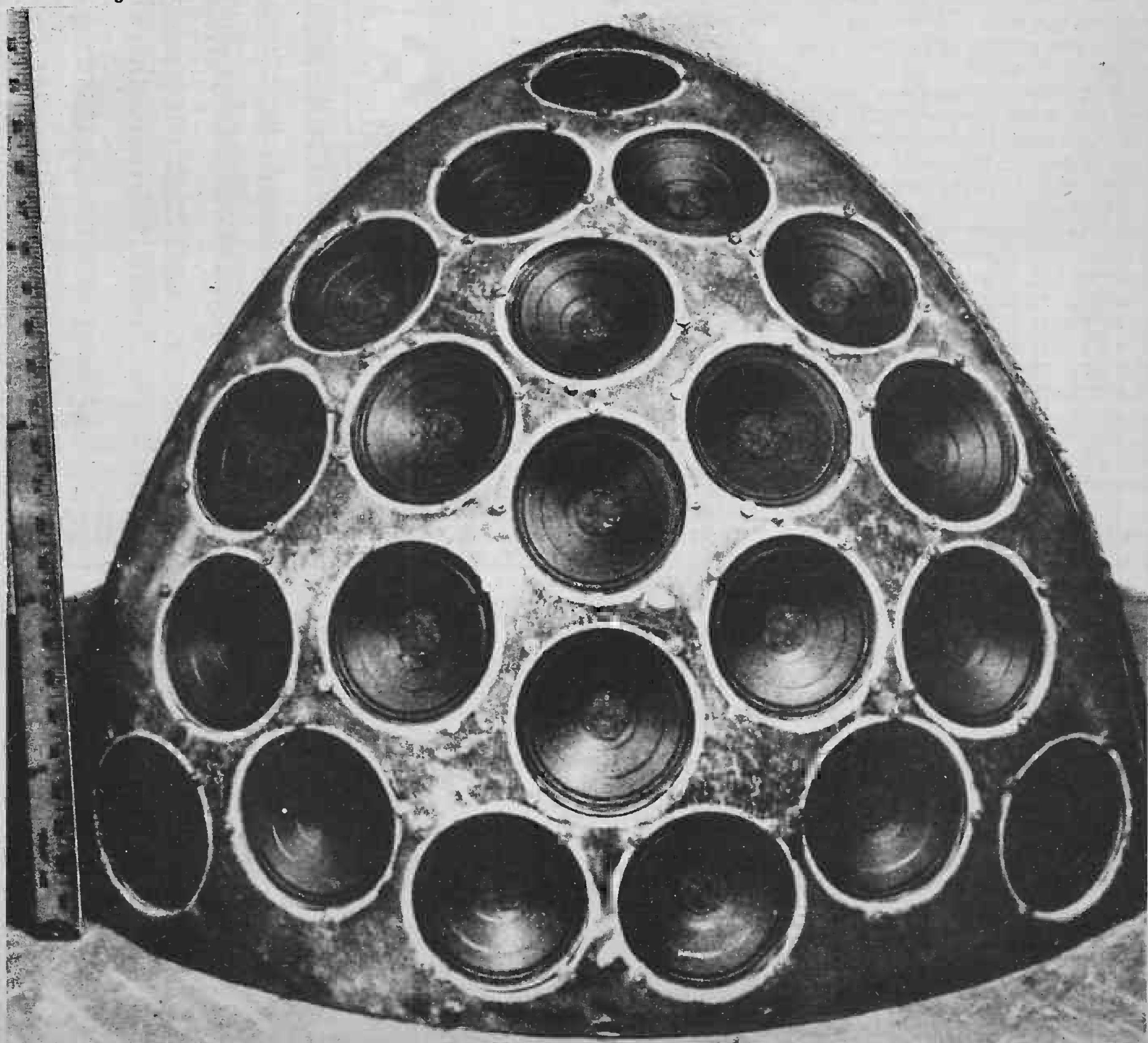
The main advantage of this extra complication lies at the bottom end of the range where the output for given enclosure volume is considerably enhanced. The complication lies in the sensor fitted onto the driver.

This is mounted on a small PCB and is a ceramic acceleration sensor. This generates a signal proportional to the actual driver output, and this is compared electronically to the incoming audio. Correction is applied to remove any errors present. Cross over is carried out at small signal level, and active filters with all their inherent superiority are applied.

There is a 'slave' output which allows the enclosures to be stacked up to increase power handling and effective output. ETI

Philips loudspeaker RH 544 Motional Feedback design. This unit incorporates a separate bass power amplifier, and a lower power amplifier for mid-high frequencies. Bass performance is exceptional for the tiny enclosure size, but other areas of output are undistinguished.

This is one-eigth of the perfect speaker! Many experts consider that elusive device to consist of a pulsating sphere operating in free field conditions. Bose built this approximation to test pulse waveform response. From here sprung the excellent Base 901 series III loudspeaker.



CAR TACHOMETER

We've been contemplating a digital car tacho, but have been put off by resolution and response speed problems. However this Phase Locked Loop design overcomes these quite neatly — so here it is!

WE HAD OFTEN considered the design of a digital tacho for automobile use, but had rejected several schemes as we were unable to get both good resolution and response time — the two seemed to provide a very good demonstration of Heisenberg's Uncertainty Principle.

Consequently, we were rather pleased when Mike Pratt of SM Electronics came to us with his phase-locked loop based design which got round the problem. Would we like to do it as a project, he asked? Obviously, we said yes, and here it is.

This tacho features a fast response time, coupled with 10 Hz resolution, through the use of a phase locked loop frequency multiplier. It can be set up, by means of a single link, to work on 4, 6 or 8 cylinder motors.

Design Features

To measure the revolutions per minute of a motor is simply a matter of counting the number of ignition pulses over a given time. With a four-cylinder, four-stroke motor there is such a pulse twice per revolution. Therefore if we count these pulses for 30 seconds we will have revs/min with a one cycle resolution. Obviously this is much too long a sample period for practical use in a motor car and some compromise has to be made.

The usual solution is to use a 100 rev resolution and a sample time of 0.3 seconds (on 4 cylinders). We considered this inadequate which is why we have not published a design until now.

In this design an oscillator is used which is phase locked to the ignition pulses except at a higher frequency (x8 for 4 cylinder) allowing a short sample time (0.375sec) with a 10 rev resolution. By using a different multiplication factor compensation for different numbers of cylinders can be made. Unfortunately with the multiplication factors used (x8, x6, x4) the sample time for 6 cylinders is not exactly the same as that used for 4 and 8 cylinder motors. Altering the ratios to x12, x8 and x6 would enable a 0.25 sample time to be used for all ranges, but this is not possible with the divider IC utilised in this design.

Construction

Assemble the PCB with the aid of the overlay ensuring the components are orientated correctly. The tantalum capacitors normally have a + mark indicating the positive load, or a dot on the side. When soldering the CMOS ICs (4, 6, 7) earth the tip of the soldering iron.

Note that there is one feedthrough or link between the two sides of the board near C10

Calibration

Initially place a link between the point 'C' and the terminal corresponding to the number of cylinders. Now with the power supply connected feed a 50 Hz signal of between 12 and 30 V into the points input using the 0 V as common. Now adjust RV1 until the display reads 1500 RPM for 4 cylinders, 1000 for 6 or 750 for an eight cylinder car. ►

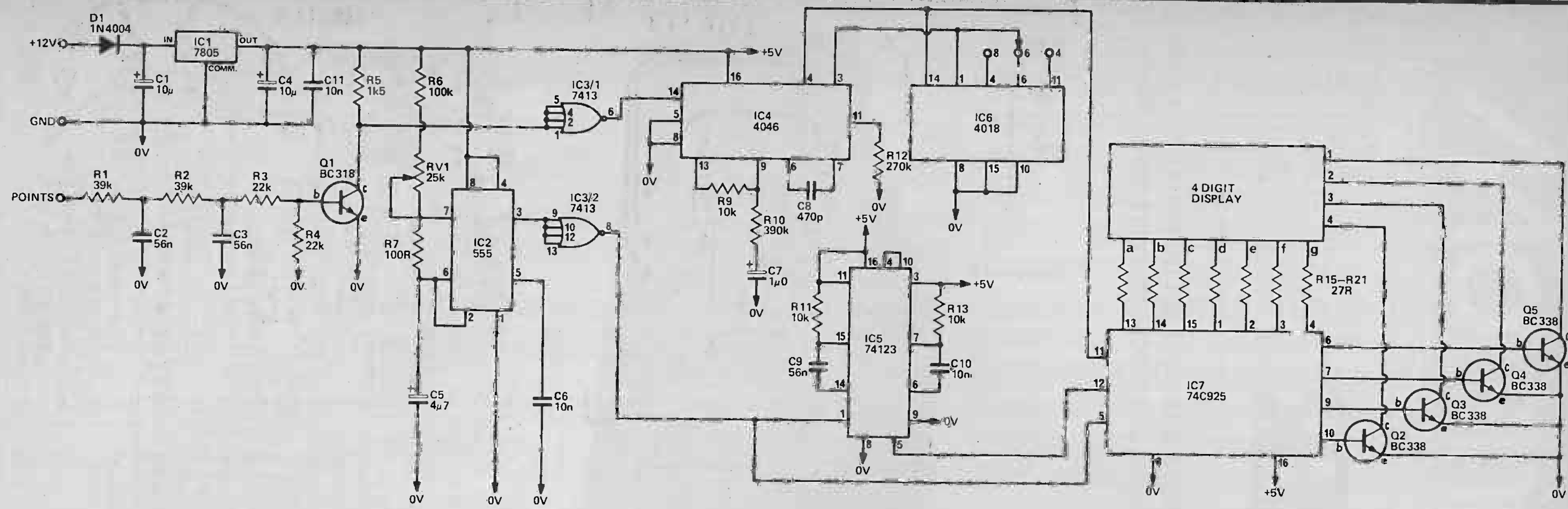


Fig. 2. Full circuit diagram for the digital car tacho unit.

HOW IT WORKS

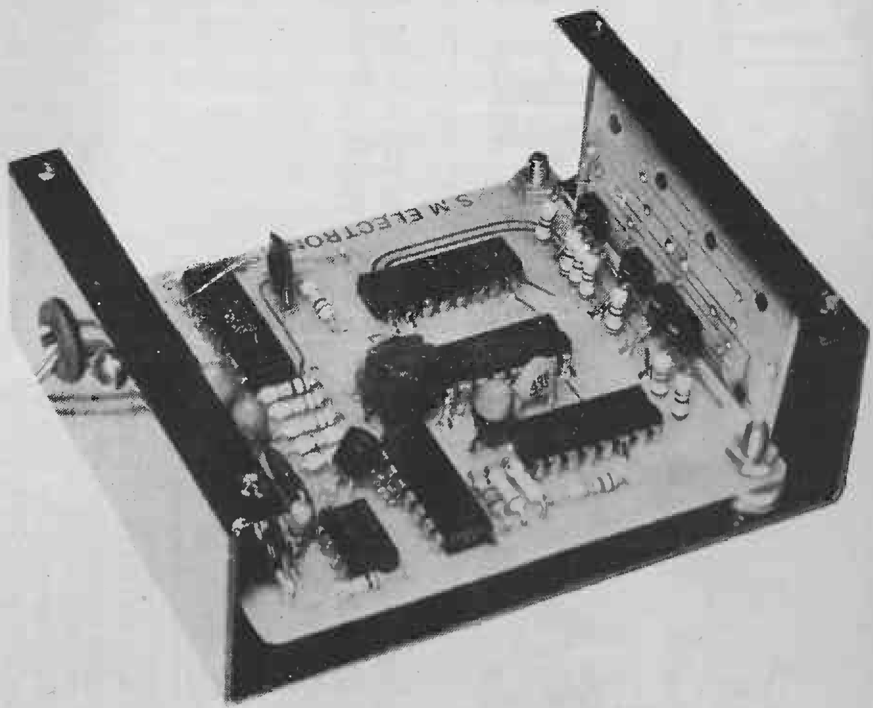
The output from the points of the distributor is basically a 0 to 12V square wave with a 200 volt pulse on the rising edge. A filter network, R1-R4, C2, 3 is used to remove the high voltage pulse (and points bounce) and Q1 buffers it giving a +5 to 0V output on its collector. As the filter network removes the sharp edge of the input a schmitt trigger is needed on the output of Q1 to give fast edges. IC3/1 is used for this.

The output of IC3/1 is connected to the input of the phase-locked loop IC (4046). This IC has an internal voltage controlled oscillator and its output is divided by 4, 6 or 8 by IC6 and this lower frequency is fed back to the phase-locked loop IC. The IC then compares this frequency to that at its input and adjusts the internal oscillator until it is the same. The result is a frequency which is an exact multiple of the input.

The time base is generated by IC2 (555) which has a negative output pulse, about 300 μs wide every 375 ms (or 333 ms for 6 cylinder). This is inverted by IC3/2 and is used as the strobe pulse for the 4 digit counter IC7. This pulse also triggers the first of the monostables in IC5 which gives a 200 μs delay before triggering the second half of IC5; this gives a 40 μs pulse to reset IC7 back to zero.

IC7 is a 4 digit counter with a latch (store) and seven segment decoder driver. It needs four external transistors to drive the digits but the segment drivers are internal. As we need only a three digit counter, i.e. for good resolution, with the right hand permanently zero the least significant digit is connected to the second right digit, etc, with the most significant digit connected to the right hand digit. Provided one does not exceed 9990 RPM this digit will remain on 0 as intended!

The 555 timer, the TTL and the 74C925 needs a regulated +5V and IC1 provides this with D1 preventing damage due to reverse polarity inputs.



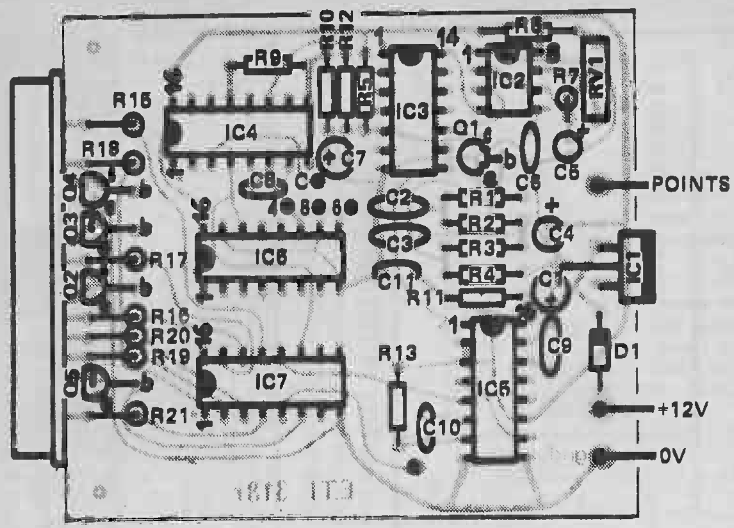
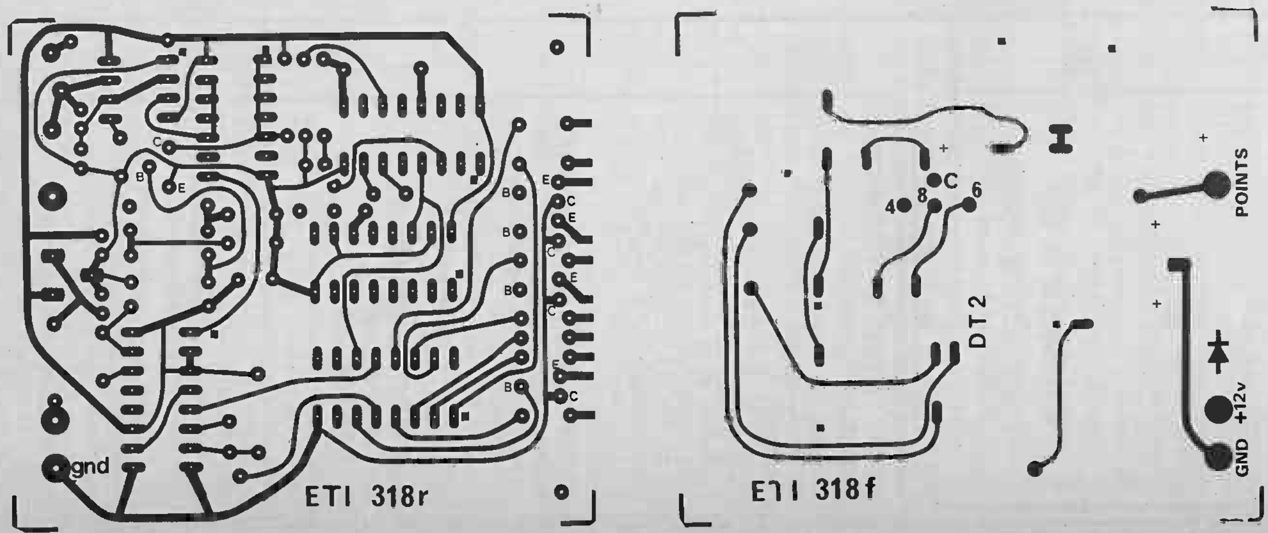


Fig. 1. The component overlay for the board. The board is double sided although only the lower surface is shown here. Note the link between the two surfaces of the board near C10.

Fig. 3. PCB foil patterns shown full-size.



SPECIFICATION

Range	**100 to 9990 RPM**
Resolution	**10 RPM**
Reading rate	
4 or 8 cylinders	**2.66 per second**
6 cylinders	**3 per second**
Power supply	**7 to 15V@ 400mA**
Suitable ignition systems	**standard**
	CDI
	transistor assisted
	***it will not operate on 'pointless' systems**

BUYLINES

The components employed here are all readily available from any of the major mail order companies advertising in this issue. Note that the counter is a CMOS chip, and not a standard bi-polar TTC chip. The standard component will not operate on this mode.

PARTS LIST

RESISTORS	all ¼ W, 5%
R1,2	39k
R3,4	22k
R5	1k5
R6	100k
R7	100R
R8	not used
R9	10k
R10	390k
R11	10k
R12	270k
R13	10k
R14	not used
R15-R21	27R
POTENTIOMETER	
RV1	25k trim
CAPACITORS	
C1	10u 25V tantalum
C2,3	56n polyester
C4	10u 25V tantalum
C5	4µ7 25V tantalum
C6	10n polyester
C7	10u 25V tantalum
C8	470p ceramic
C9	56n polyester
C10	10n polyester
C11	10n ceramic
SEMICONDUCTORS	
IC1	7805 regulator
IC2	555 timer
IC3	7413 dual schmitt
IC4	4046 PLL
IC5	74123 dual mono
IC6	4018 divide by n
IC7	74C925 4 digit counter
Q1	BC318
Q2-Q5	BC338
D1	1N4004
Display	NSB5881
MISCELLANEOUS	
PCB	
Case to suit	

POWER SUPPLIES

One more from Tim Orr. This time he takes us through a series of different methods for powering up circuits. On the way he explains the theory behind each.

THE JOB OF producing stable regulated power rails has been much simplified by the introduction (about seven years ago), of three terminal fixed voltage regulators. These devices can make the power supply design problem relatively simple, but even so the designer must be fully aware of a lot of other important details that can cause poor results. Firstly, consider a simple unregulated power supply, fig. 1.

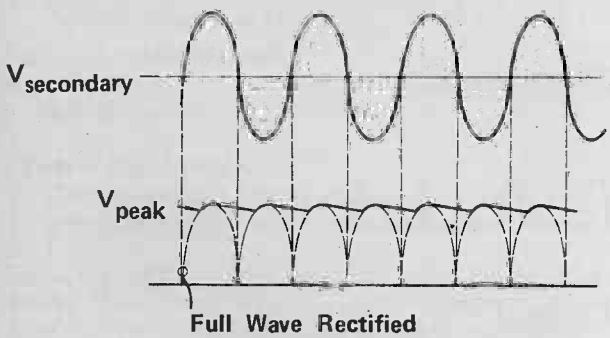


Figure 1. Below: an unregulated power supply. Above: The output (with a load resistor).

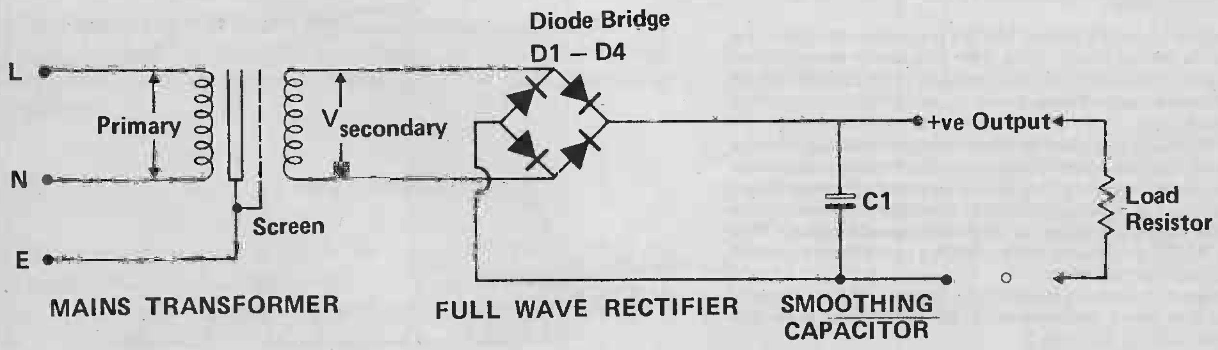
The function of a mains isolating transformer is to physically separate the user end of a piece of equipment from the 'potentially'(!) lethal mains voltage. The transformer also provides a suitable voltage which can be rectified and smoothed and connected to a voltage regulator. This is the secondary voltage of a transformer and it is measured in VRMS at a particular loading.

That is, if the transformer is rated at 15V at 10VA, then the output voltage will be 15V when the load upon the transformer secondary is 10VA (10 watts).

If the load is removed the output voltage will rise. The percentage change from load to no load is known as the TRANSFORMER REGULATION and is typically of the order of 20%.

To convert the V_{RMS} voltage to a DC voltage it must be multiplied by 1.4142. Thus a 15VRMS (loaded) transformer secondary will generate 21V2 DC when full wave rectified and smoothed, which will rise to 25V45 DC when the load is removed (assuming 20% regulation see Fig. 1).

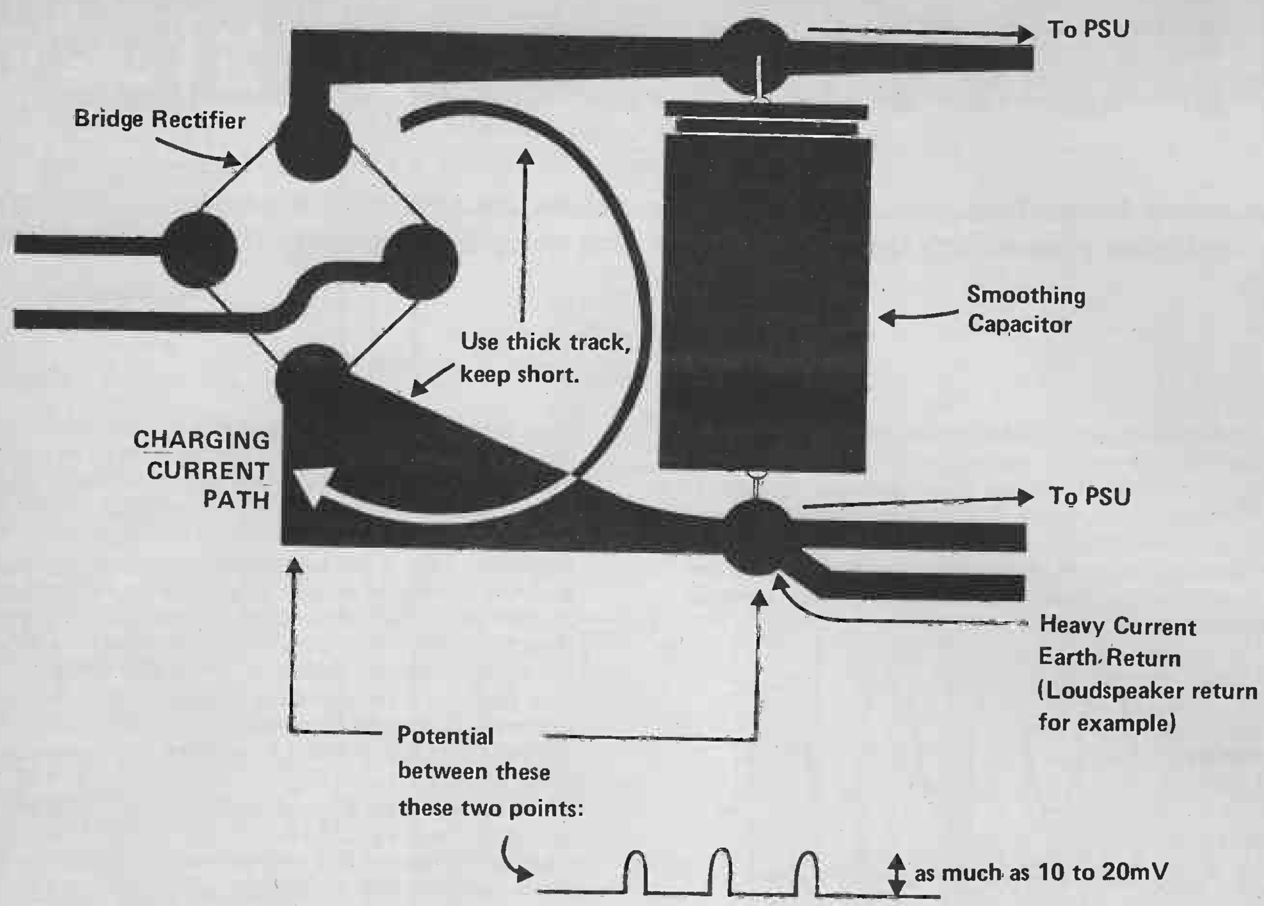
Thus care has to be taken when selecting a transformer such that the smoothing capacitor working voltage is not exceeded. Also, make certain that the polarity on this capacitor is correct, they can LITERALLY explode if wired up backwards! ▶



This piece of hardware has three sections, a step down, isolating transformer, a diode bridge and a smoothing capacitor. The transformer is driven from the mains, the voltage of which varies depending on where you live (it's 250V/RMS in Fulham). Some transformers have got a copper screen which isolates the primary winding from the secondary windings. For the purpose of safety, this should be connected to earth.

Also, for maximum safety, connect the 220/240/250 tapping to mains LIVE. Another type of mains transformer uses what is known as a split bobbin, the primary is wound on one bobbin, the secondary on another. Thus the two windings are inherently physically isolated, and so no safety screen is included. These two transformer types are generally constructed on what is known as an 'E' core; take one to bits and you will find that it is constructed out of lots of 'E' shaped laminations. These 'E' laminations are butted into 'I' laminations, and clamped together. This butting together of the laminations can cause magnetic field problems. The wider the gap between the 'E' and 'I' laminations, the larger the magnetic field around the transformer.

The magnetic field generates a significant amount of induced hum in nearby electronics, this can be overcome by using a low leakage torroidal transformer which is constructed from circular laminations. The primary and secondary windings are wound through the centre of the torroid (see if you can imagine how). The torroidal transformer, by virtue of its 'continuous' laminations results in a low stray field and a low profile design, making it ideally suited for audio amplifier applications.



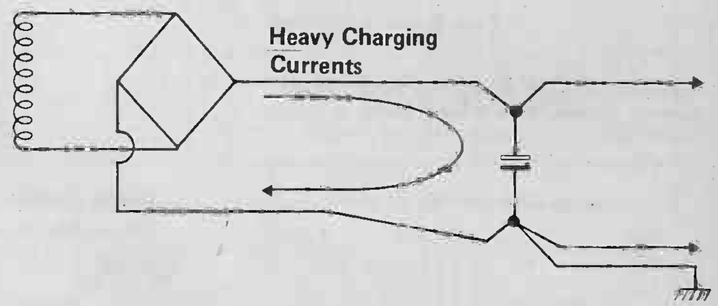
When a load is placed upon the power supply shown above, the output voltage appears as a DC voltage on top of which is a ripple voltage. This can be thought of as two separate periods, a charge period where the capacitor is charged up by the power supply and a discharge period where the load discharges the capacitor.

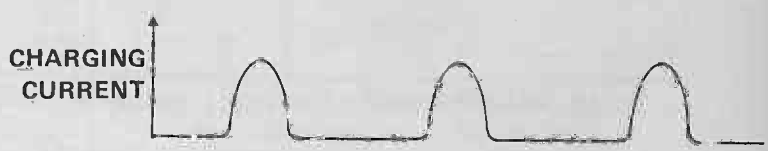
This charging and discharging generates a ripple voltage which has a period of 10 ms (100 Hz). A load current of 100 mA, and a 100U capacitor will result in a ripple voltage (Vpp) of about V7.

As a rule of thumb I usually allow 1 to 1V5 maximum ripple if a voltage regulator is being used. This will generally result in an output ripple of less than 1 mV. If this ripple were to be obtained by just using a larger capacitor, then a 700,000U-capacitor would be required!

Generally the discharge period is much longer than the charge period. This means that the transformer is only supplying power for short periods, in fact during the charge period. During these periods the smoothing capacitor is rapidly charged, and it is quite common for these current surges to exceed several amps. This can cause mains BUZZ problems when laying out printed circuit board designs for power supplies.

The correct layout is shown below the circuit. If the current surge is 1 A and the track resistance is 20 milliohms then the voltage developed will be 20 mVpp.





Voltage regulators

A voltage regulator takes a varying unregulated input voltage and produces a fixed regulated output voltage. There is a wide range of fixed voltage three terminal regulators to choose from, with a choice of maximum current handling, output voltage and positive or negative operation. The data sheets for these devices contain lots of seemingly complex pieces of information and so a glossary of terms is now included.

Ripple Rejection

The ratio of the ripple voltage at the regulator input to that at the output, generally expressed in dB. Typically of the order of 60 dB (1000 to 1), that is 1 Vpp of ripple at the input ends up as 1 mVpp at the output.

Temperature Coefficient

The output voltage change for a change in regulator temperature, expressed in mV/°C.

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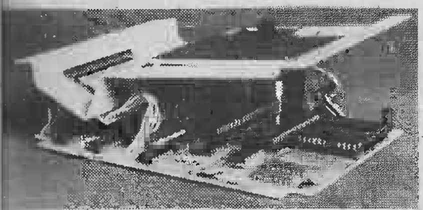
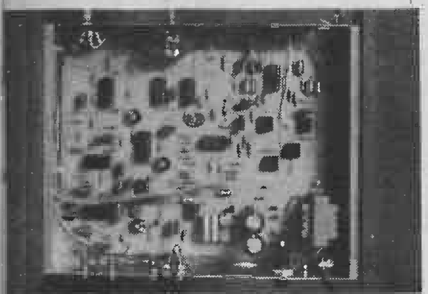
JANUARY 1979 VOL 8 NO 1

Time we did this p.84



Check it out p.81



De-click de hi-fi p.73

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Input Voltage range
The range of voltages over which the regulator will function normally. For example, a 12V regulator may work from 14V5 to 30V. At 14V5 the regulator will 'drop out' and lose its regulation. Regulators generally need 2 to 2V5 in excess of their output voltage. At 30V the regulator will go 'pop' (time to buy a new one).

Output voltage
The voltage at the output terminal with respect to ground. Generally within ± 5% of stated value.

Line Regulation
The ratio of the change in the output voltage caused by a change in the input voltage, typically of the order of 0.2%.

Load Regulation
The output voltage change for a specific change in output load current.

Short Circuit Current
The output current when the output is shorted to ground.

Output Noise Voltage
The RMS noise voltage measured at the regulators output, not including any ripple.

Power Dissipation
The maximum power that the regulator can safely generate on a particular heatsink.

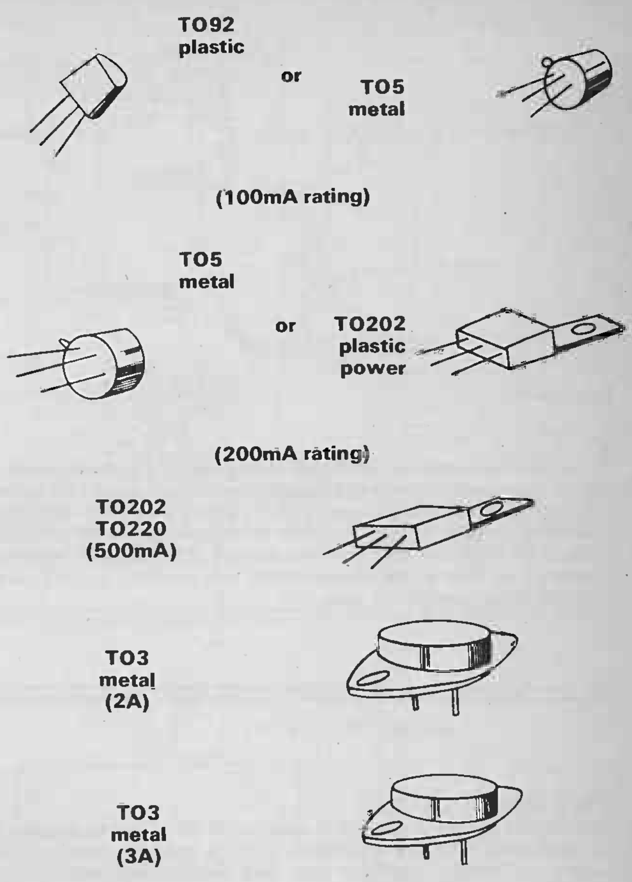
As a rule of thumb the regulator case should not exceed about 80° C (which is hot to touch). However, always run the device at as low a temperature as possible. It is thermal ageing that eventually kills electronic devices and for higher temperatures the ageing process is disproportionally faster.

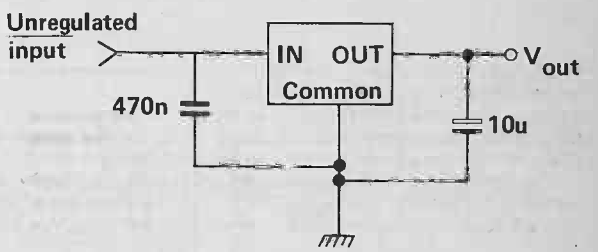
Some applications of voltage regulators are given below.

The table below relates the secondary voltage of a transformer to the peak voltage at rated load and the off load voltage, which will be considerably higher.

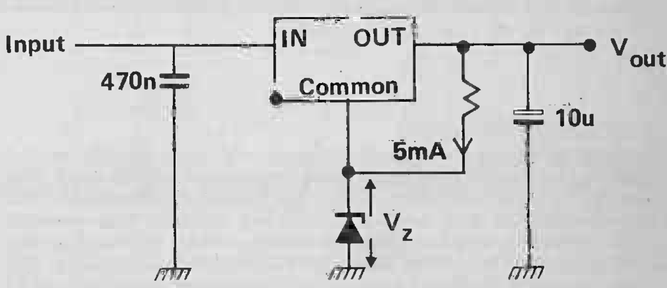
TABLE ONE

V secondary at rated load	V peak at rated load	V peak off load transformer regulation 20%
5 VRMS	7V07	8V48
6 VRMS	8V48	10V18
9 VRMS	12V72	15V26
10 VRMS	14V14	16V97
12 VRMS	16V97	20V36
15 VRMS	21V21	25V45
20 VRMS	28V28	33V93
25 VRMS	35V35	42V42
30 VRMS	42V43	50V92
35 VRMS	49V50	59V40
40 VRMS	56V57	67V88

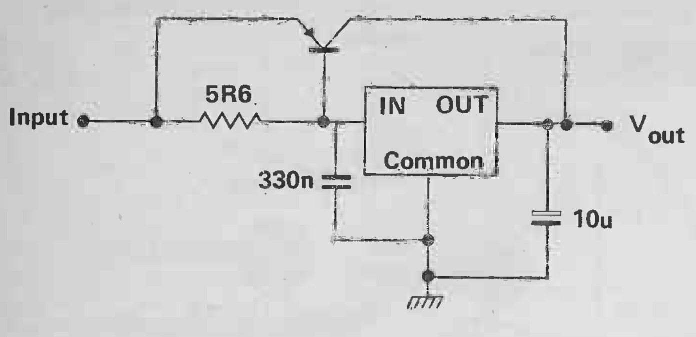


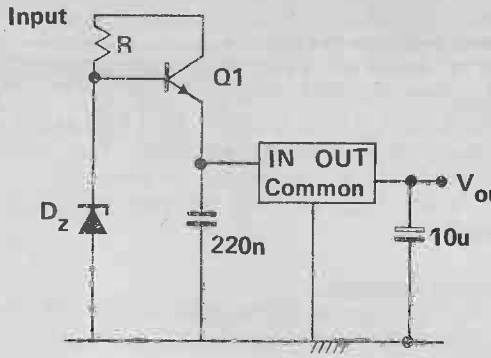


A)
This circuit shows a conventional arrangement of a three terminal device. It is advisable to use a decoupling capacitor connected close to the input terminals. This prevents high frequency instability. If this capacitor is left out then regulation can sometimes be greatly reduced. The decoupling capacitor on the output helps reduce the impedance at high frequencies, where the regulator loses its performance. For best results use a tantalum capacitor.



B)
The output voltage of a regulator can be increased by applying a voltage to the common terminal. This can be done by using a zener diode.



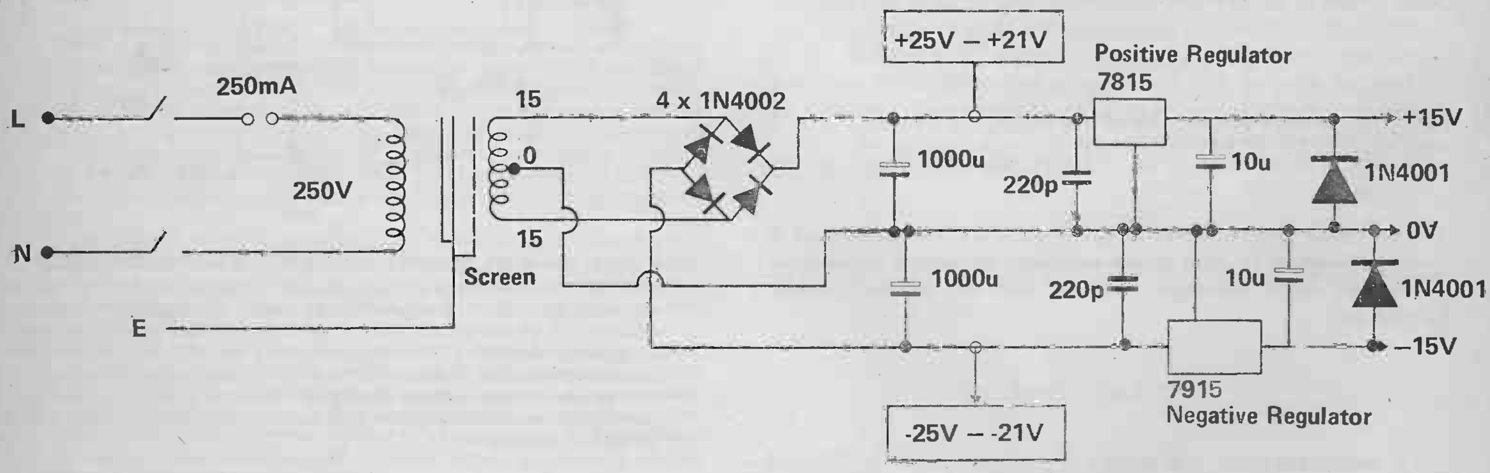


C)
The output current can be increased by using a bypass transistor. When the current flowing through the voltage regulator exceeds 100 mA (the voltage across the 5R6 being 560 mV), the bypass transistor begins to turn on. This transistor takes all currents in excess of 100 mA and yet the output still remains regulated. However a few extra components are needed to get current limiting in the transistor path.

D)
A high voltage unregulated supply can cause problems when using regulators. It may at times exceed the maximum voltage rating of the regulator. A simple voltage regulator D_z and Q1 can be used to overcome this problem. D_z should be chosen so that it is about 6V greater than the regulator output voltage. This technique has the added advantage that the power dissipated in the regulator is less (the rest being dissipated in Q1), and the regulator is presented with a semiregulated voltage, so the output will have less ripple.

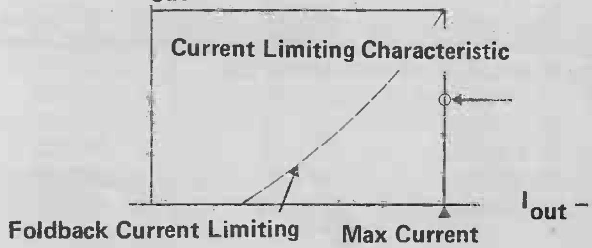
Dual Power Supply

The circuit shows a complete regulated dual power supply. The unregulated rails are obtained from a split secondary transformer, a bridge rectifier and two smoothing capacitors. A positive and a negative regulator have been used to generate the + and — rails. These regulators should be mounted on heat sinks and they should be insulated. The pin out of the negative regulator is different to that of the positive regulator. The two diodes at the output prevent latching up situations (on load) whereby one side starts up faster than the other and forcibly reverse biases it, preventing it from operating.

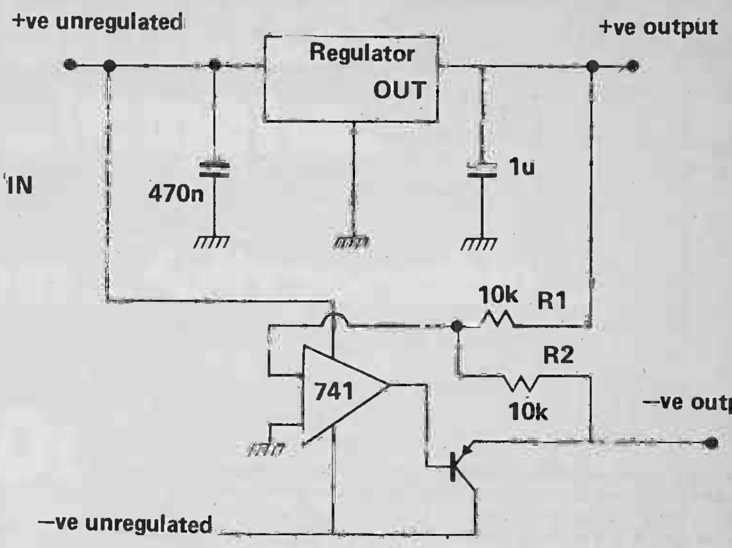


Tracking Regulator

Instead of using a negative voltage regulator to obtain the negative rail, an op amp and a power transistor can be used. The resistor ratio, R1, R2 determines the negative rail voltage. The negative rail is not, however, current limited. The internal current limiting of the regulator is shown. When the load current exceeds the current limit, the output voltage drops to almost 0V. This makes the regulator short circuit protected. Another type of current protection is known as 'FOLD BACK' current limiting (shown dotted). This serves to reduce the short circuit current. These devices protect the power supply from abuse. Another type of protection device is the overvoltage clamp, which



protects the 'non-power supply electronics' from an increase in the power supply voltage. These are two terminal heavy current devices which are placed across the power supply. When the supply voltage exceeds a certain level a thyristor is triggered on and clamps the rail to ground. This is intended to pop a fuse and so disconnect the faulty power supply (which is better than replacing a £1,000 worth of IC's).



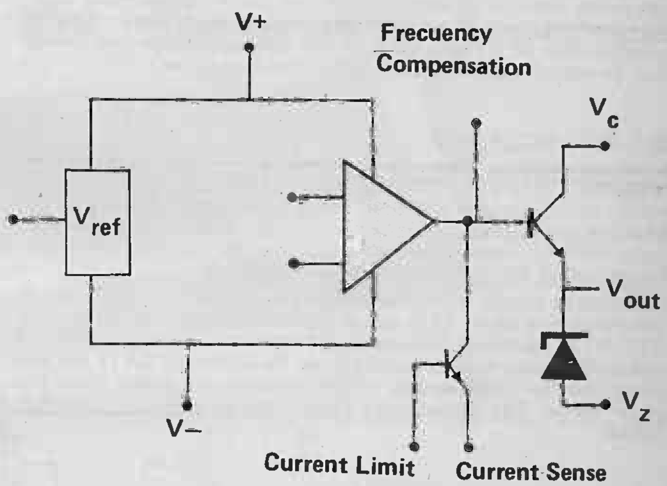
—ve output = —(+ve output × R2/R1)

With foldback the short circuit power dissapated in the regulator is less than that with current limiting.

723 Voltage Regulator

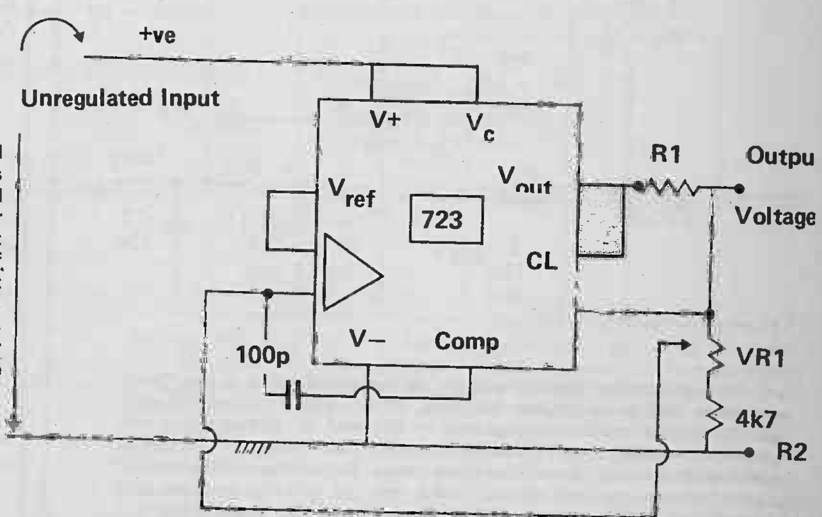
The 723 is an industry 'standard' device. Many manufacturers produce it and the device itself is versatile. It comes in a 10 pin TO5 can or a 14 DIL pack. The device contains a precision voltage reference, with a temperature coefficient of 50ppm/°C, an error amplifier, an internal transistor capable of handling 100 mA and a current limiting mechanism. By using a few external resitors, a capacitor and maybe an external power transistor, a wide variety of regulator designs can be realised.

Left is shown the block diagram of the 723 regulator. As pinouts vary depending upon package, no pin numbers are shown.



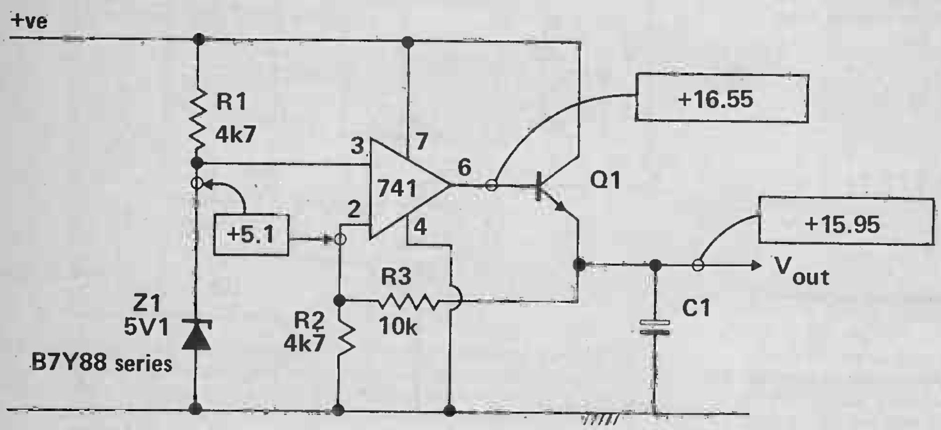
Adjustable Positive Voltage Regulator

By using a variable feedback path (RVI), a variable regulated output voltage can be generated. The voltage reference is connected to the non-inverting input of the error amplifier and the output voltage (via RVI), to the inverting input. The error amplifier drives the output transistor and hence the output voltage is controlled by the feedback voltage from VR1. A 100pf capacitor is used to stabilise the device. R1 is used as a current limit control. When the current through R1 (the load current), exceeds 100 mA a voltage of 560 mV is set up across it. This is just about sufficient to turn on the current limiting transistor which in turn shorts out the regulating transistor, causing the output voltage to collapse towards 0V.



Regulated Power Supply

Sometimes it is necessary to make a simple power supply using discrete components when a non-standard voltage is required.



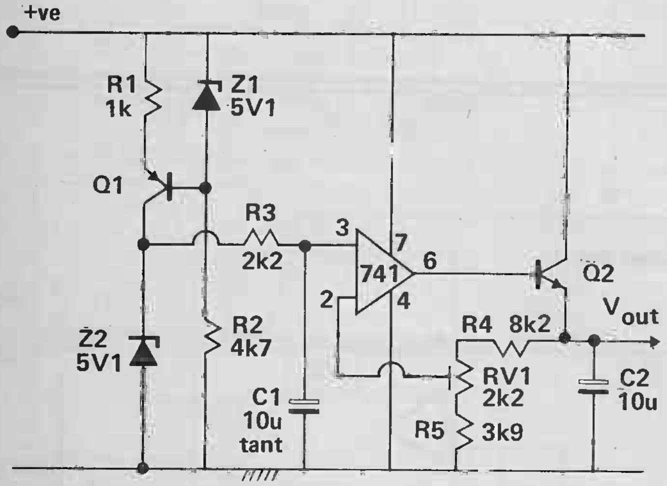
Left: Circuit diagram of discrete component PSU. Voltage measurements are taken with high impedance voltmeter.

The circuit shown uses all the basic elements of a voltage regulator, that is, a reference voltage Z1, an error amplifier and a series control Transistor Q1. The zener diode, Z1 sets up a reference voltage of 5V1. This diode has a temperature coefficient of —1.2mV/°C (a 5V6 zener is best at —0.2mV/°C). The resistor ratio of R3 and R2 sets the output voltage and the op amp provides the error correction (the regulation).

C1 is used to reduce the output impedance at high frequencies. The zener diode has a slope resistance of 76Ω, and so any fluctuations in the unregulated rail will be attenuated by the ratio of 76:7: 0.016
R1 4700
Therefore a 1 Vpp ripple will end up as 16 mVpp, but will be multiplied by the gain of the R3, R2 network to nearly 50mV.

Improved Regulated power supply

This power supply has various improvements over that shown. The reference zener Z2 is run at almost constant current by the R12, Q1 Z1 network. This makes Z2 much less sensitive to ripple and unregulated supply fluctuations. The filter R3 C1 (7 HZ low pass), further reduces any ripple voltage and noise from the zener diode. The preset VR1 allows the output voltage to be varied.

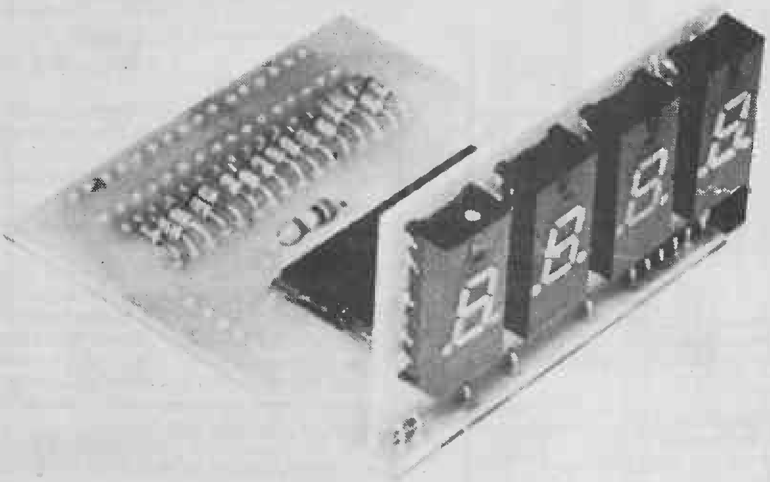


If a precision power supply is required then a precision voltage reference should be used. These can be obtained with temperature coefficients as low as 10ppm/°C. When using this level of stability, high stability resistors (TC=10ppm/°C), and a low drift op amp should be used. Also, to reduce mains carried interference (mainly sharp clicks due to electric motors and thyristors turning on), a mains filter should be used. This is a passive inductor capacitor low pass filter network which attenuates high frequency spikes and clicks.

ETI

DIGITAL MODULE

- *4 digit
- *up/down counting
- *drives LEDs directly
- *latch
- *presettable
- *second register
- *equal and zero outputs
- *DC to 2MHz
- *5V operation



SPECIFICATION

Number of digits	4
Readout	LED
Maximum frequency	2MHz
Input impedance	100k
Output drive	1 TTL load
Supply voltage	4.5 – 5.5V
Supply current	
low power mode	500µA
all eights	100mA

THE THREE DIGIT display we previously published has proved to be one of our most popular projects. We have used it in a number of projects and we know of several commercial companies using it in their own equipment.

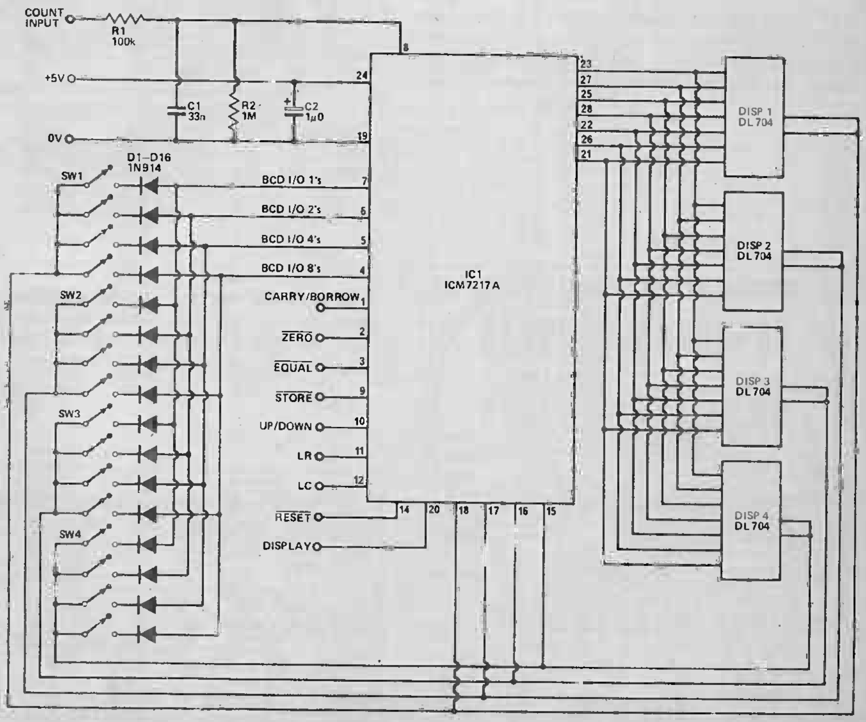
Many people have asked us for a 4 digit version and we have been looking round at ICs available. We have chosen this Intersil device because we believe it offers the best versatility at the moment. Apart from being a 4-digit counter-latch-decoder driver needing no external components except the displays, it also is an up-down counter and can be preset to any number. In addition, it has a separate register which also can be set to any number and comparators which give outputs when the counter is equal to the register and when it is zero — all in one IC!

Mod Build

The unit is built on two small PCBs which are connected together with short links of tinned copper wire. Be careful to orientate the IC correctly as it is expensive!

The preset system is designed to use a 4 digit BCD thumbwheel switch

Fig 1. Full circuit diagram of the counter module. The How It Works section for this is given overleaf — but as this is really a "How To Use It" section it don't matter — does it?



(closed = '1') but individual switches can be used if required. Input is in BCD, therefore the switches will have the weighted values 8, 4, 2 and 1. If the preset is not needed then the diodes can be left out. If a preset is needed, but always to a fixed number, links can be inserted to replace the "on" switches and the other diodes left out. ETI

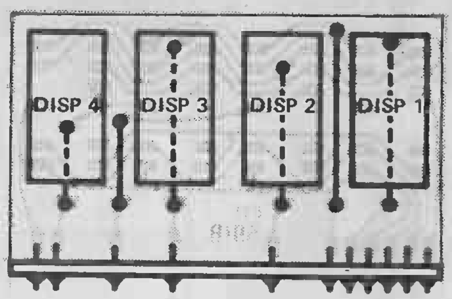


Fig. 2. The positioning of the displays and the links which must be installed before the displays.

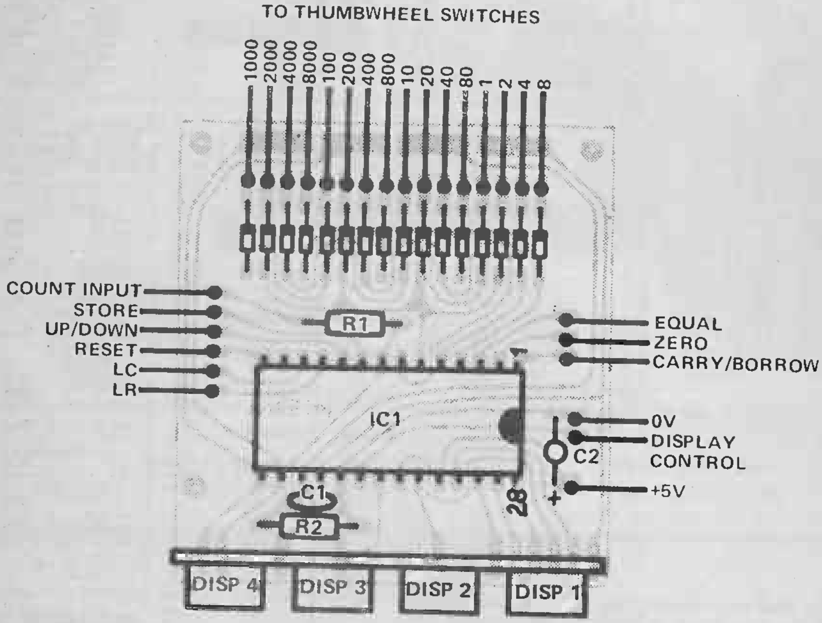
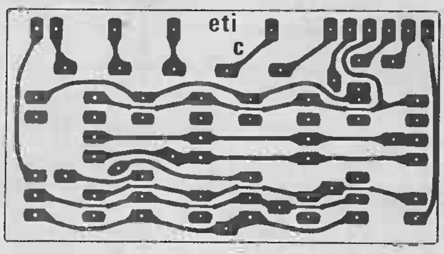
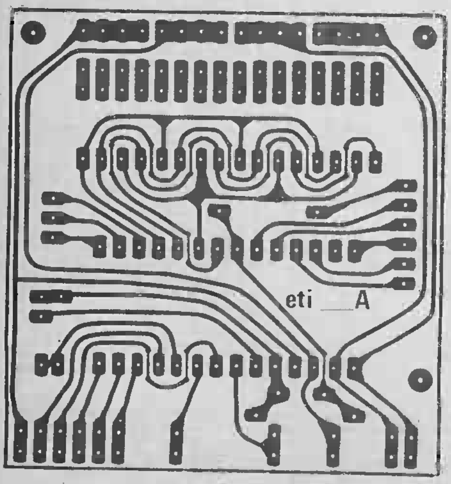
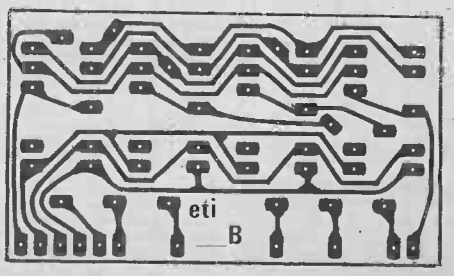


Fig. 3. The component overlay for the main board. The common connection from each of the thumbwheel switches goes to the track next to the other connections.





Full patterns for the digital module project. Shown full size. Board C — above — is to fit high brightness displays such as employed in our digital dial project.



HOW IT WORKS

Count Input — Pin 8

The counter is incremented or decremented on the leading edge of this input. A schmitt trigger is provided with a 500 mV hysteresis on a 2 V trigger point. For high speed operation, or operation from a digital output, delete R2 and C1 and short out R1. Maximum frequency of operation is about 2 MHz.

Up-Down — Pin 10

If this pin is left open or taken to +5 V the counter will be incremented by the count input. If it is taken to 0 V the counter will be decremented by the count input.

Reset — Pin 14

If this pin is left open or taken to +5 V the counter is free to be incremented or decremented. If it is taken to 0 V the counters will be reset to zero and held there until reset is taken high again.

Store — Pin 9

Ig this input is left open or taken to +5 V the latches are "closed" and the information which was in the counters at the time the store input went high will be remembered, decoded and displayed. The counters can be reset, incremented or decremented without affecting the display.

If it is taken to 0 V the counter contents will continuously be displayed for as long as this input is at 0 V. Any change in the counter contents will be shown on the display.

Load Counter — Pin 12

This is a 3 level input. If it is left open the counter works normally. If it is taken to +5 V the counter is loaded with the BCD data which is set on the thumbwheel switches. If the latch is open, this number will also be displayed. If this input is taken to 0 V the BCD I/O pins become high impedance. If a 3 level input is to be controlled by other logic outputs they must be tristate devices.

Load Register — Pin 11

This is also a 3 level input. If it is left open the counter works normally. If it is taken to +5 V the register is loaded with the BCD data. If taken to 0 V the circuit goes to a low power state with the multiplexing oscillator stopped, the display off and the BCD I/O pins in a high impedance state. The operation of the counter is unaffected except that there is no display.

BUYLINES

Since this project is based entirely upon the one chip—ICM 7217A — this is all there is to cause problems! Since it appears in most peoples catalogues we cannot foresee any trouble here. Displays can be any type really — but for outdoor work use high brightness types.

Display Control — Pin 20

This is also a 3 level input. If it is left open, leading edge blanking occurs. If all digits are zero then all are blanked. If it is connected to +5 V the display is completely blanked irrespective of the value. If taken to 0 V all digits are ON irrespective of value.

Scan — Pin 13

The internal multiplexing frequency is nominally 10 kHz giving a digit repetition rate of 2.5 kHz. With a 20 pF capacitor from this point to 0 V the frequency drops to 5 kHz and with 90 pF it is about 1 kHz.

BCD I/O — Pin 4-7

This is a multiplexed data port, normally an output which can drive 1 TTL load. It becomes an input when either LC or LR is at +5 V. Pin 7 is the least significant bit.

Digit Drives — Pins 15-18

These are used both to drive the LEDs and to provide data indicating which digit is being presented at the BCD I/O port. Pin 18 is the least significant digit.

Zero — Pin 2

If the value of the counter is zero this output will be at 0 V.

Equal — Pin 3

If the value of the counter is equal to the value of the register this output will be at 0 V.

Carry/Borrow — Pin 1

When the counter goes from 9999 to 0000 or from 0000 to 9999 a 500 ns positive pulse occurs on this output. This is connected to the count input of a second unit when an eight digit display is needed.

PARTS LIST

RESISTORS (all ½W 5%)

R1	100k
R2	1M

CAPACITORS

C1	33n polyester
C2	1u0 35V tantalum

SEMICONDUCTORS

IC1	ICM 7217A
D1—D16	1N914
DISPLAYS	DL704

A HISTORY OF ELECTRONICS IN MEDICINE

THE USE OF ELECTRICITY FOR medical purposes dates back to the Ancient Greeks who used the electric eel to treat various maladies. In 1759 Wesley collected case histories of the use of electricity. The first recorded use of electricity for treatment in a hospital in London was in 1767.

Not quite 200 years ago, in 1786 to be precise, Professor Luigi Galvani — an anatomist at the University of Bologna, Italy — discovered by chance that the muscles of a dead frog contracted under the influence of an electrical quantity.

He wrongly assumed that animal electricity stored within the muscle caused this to happen. It was, in fact, the result of dissimilar metals forming a primary electric cell which energised the nerves of the muscle. Volta of the University of Paris proved it and subsequently gave the world the voltaic battery, in 1800.

The contribution of these two men provided, in the simple primary cell, a workable basis for using electricity in practical ways not previously possible with the electro-static form of electricity. Galvani's work on "animal fluid" was amongst the earliest electro-medical studies. The apparatus he used was crude by today's standards — see Fig. 1.

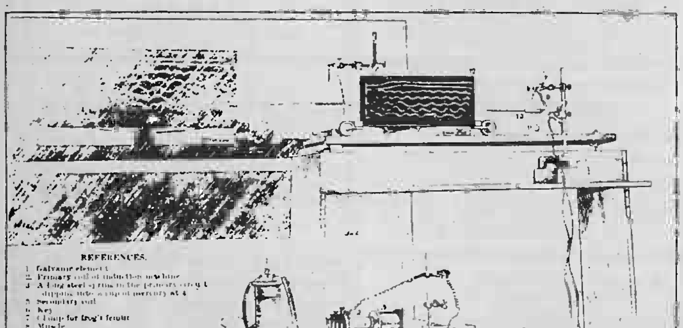


Fig. 2. Apparatus used by McKendrick to give lectures on life in motion to Royal Institution, London, audiences around 1890.

Fig. 1. Artist's idea of Galvani experimenting with frogs' legs in the 1780s. Note the friction electrostatic generator on the left and the Leyden jar on the right (Funk and Wagnells).

Body Electric?

Research into physiological electric quantities gradually became more sophisticated as the 19th century passed. This development, however, had to wait for suitable experimental inventions such as the electromagnetic galvanometer which became available in its crudest form around 1830. A typical laboratory electro-medical instrumentation set-up of the 1890s is shown in Fig 2. A smoked glass plate moved steadily across the end of a mechanical pen secured to the end of a frog's leg muscle. The muscle was energised by high-voltage generated from a vibration induction coil which was energised by a chromate primary single cell of the Grenet kind. Smoked screen recorders are still in use today in some medical research measurements, blood flow parameters being one example.

The sphygmometrograph (as a pulse measuring instrument was known in that time) was originated by Marey in 1860. A later design by Verdin is shown in Fig 3. Electronic method was little used in medicine in early times, as powerful electric signal amplification was not obtainable until the beginning of the 20th century —

Electricity has long been used for medical purposes, here's the story of the past and a look into the future. By Peter Sydenham.

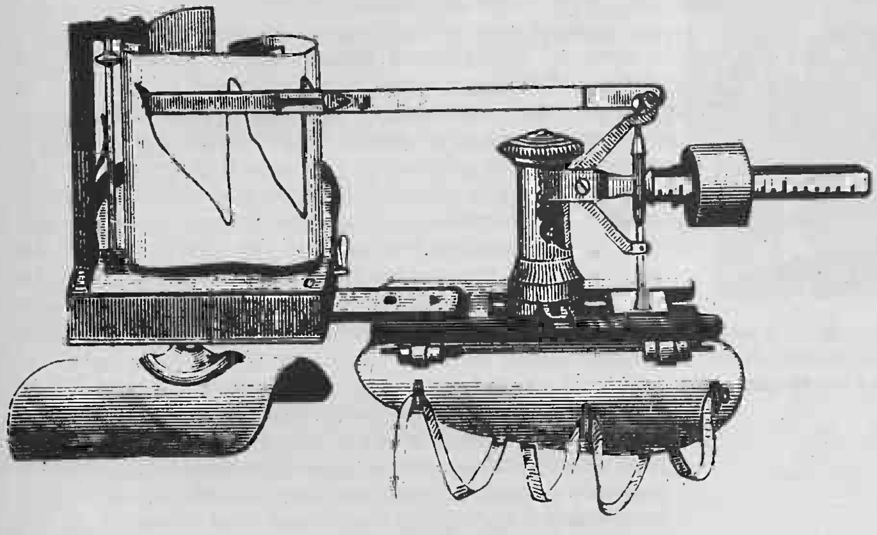


Fig. 3. Verdin's apparatus of the 1890s for recording action of the pulse.

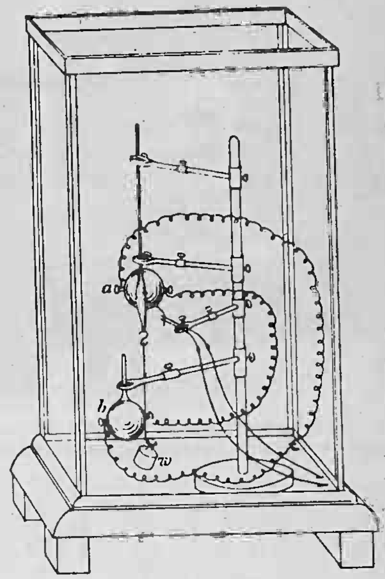


Fig. 4. Schematic of McKendrick's 1891 method for measuring heat generation in muscle.

when the thermionic valve was invented by Fleming (in 1904).

Figure 4 shows experimental equipment for measuring heat production of muscular contraction around 1880. Thermocouples, forming a thermopile, drive the crude galvanometer.

Ion Therapy

Another aspect of medicine where electricity is used is for therapeutic treatment. Since the very early 1800s output of the various kinds of electric current generator, namely the Faraday induction coil, the galvanic chemical battery, the sinewave rotating generator and the friction statical generator have been applied to appropriate parts of the body to provide a cure for all sorts of ailments.

X-ray equipment was born in 1895 when Roentgen discovered X-rays in a chance situation using photographic plates. There is probably no case in instrument history where application was more rapid. Edison, and others, had equipment in use in hospitals within months. Figure 5 shows contemporary American X-ray plant of 1899.

Measurement and recording of heart performance also began around 1900. Professor Einthoven of Holland devised a rapid response, high sensitivity detection instrument in 1903 — the string galvanometer. Soon after this was coupled to a photographic recording system, by the Cambridge Instrument Co., to produce an electrocardiograph. The first installation of this was made in 1909. By 1945 cardiographs were available in portable form. Figure 6 shows the interior of a 1930s Both Brothers portable electro-cardiograph invented and made in Adelaide, South Australia — possibly one of the first portable units devised anywhere. It used a loud speaker drive unit (right) to mark a rotating smoked disk. The record was viewed by the physician using an optical magnifier. Amplification to drive the stylus from skin electrode signals was obtained by thermionic tubes.

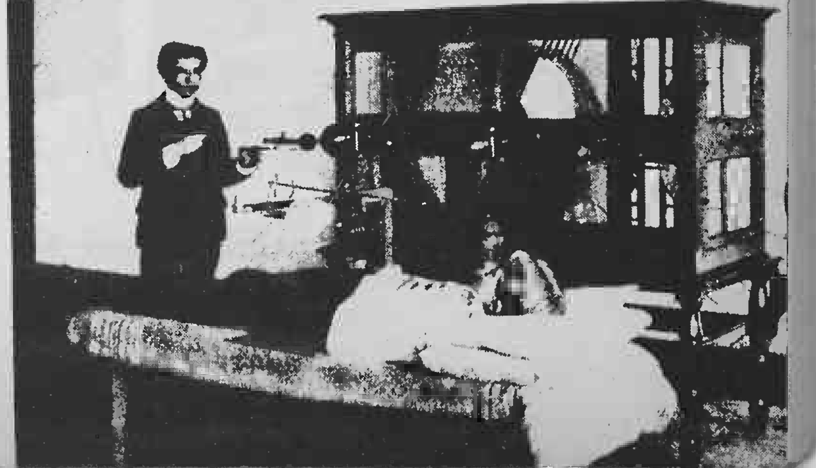
As with all disciplines, electronic method opened the door to new accomplishments. In medical electronics it happened from the 1920s onward. Equipment for researching physiology at Oxford University, in 1949 is shown in Fig 7 The unit, advanced for its time, incorporated amplifiers, a temperature control unit, stimulators to induce responses, a time base and a cathode ray tube display unit.

Electronic equipment used in medicine has come a long way during the past 50 years. This can be seen by comparing the apparatus pictured above, which covers the 1800s to 1930s period, with modern equipment such as that used in pathological testing and nuclear medicine.

Future

Against this background let me now suggest developments we can expect to experience over the next quarter century.

Fig. 5. Complete X-ray apparatus in use in America around 1900. Note the lack of safety devices and precautions.



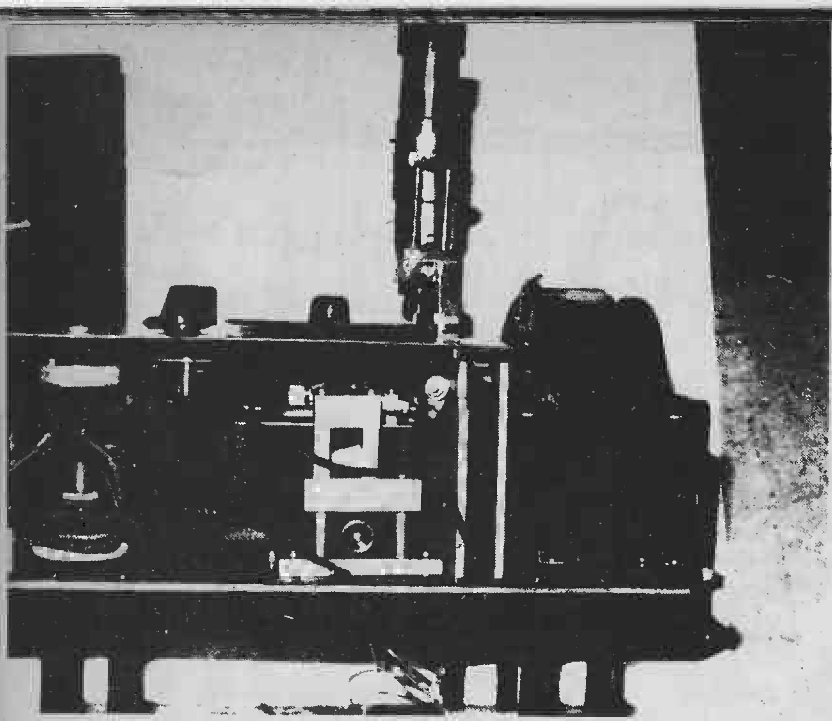


Fig. 6. Interior view of a Both portable electro-cardiograph machine made in Adelaide around 1930.

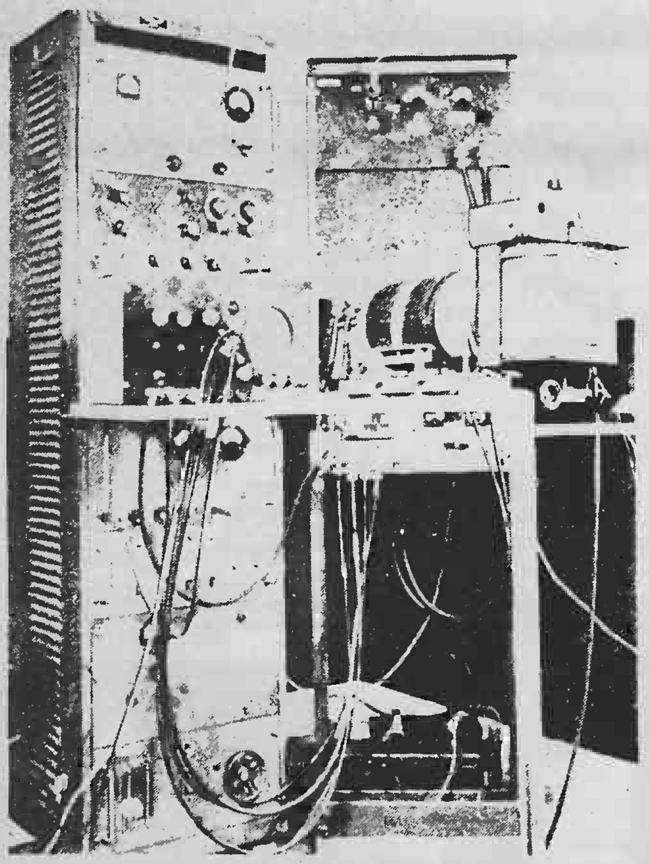


Fig. 7. E Electro-physiological research equipment used by Dickinson at Oxford University in 1949.

Monitoring

The largest proportion of electro-medical equipment is concerned with measurement; for detection of abnormal states. At present comparatively few of the incredibly great range of medical measurements needed can be made in situ on the body and without disturbing its functions. Samples of tissue, blood, urine, etc. are removed for analysis in the pathological laboratory. This process, although performed faster today than ever before, can still take several hours before a diagnosis is available to the physician in order that he or she can decide corrective action. Analysers now exist that handle many measurements of a sample entirely automatically once the sample is loaded into the analyser. But the sample must first be extracted from the body and then be transported to the machine, processes which consume time and in some circumstances alter the sample from its original state.

It is realistic to expect the transport step to be eliminated in the future with most local clinics having their own units for analysis of samples. The next stage in progress will come about by the invention of units that measure parameters such as blood count, albumin, etc, by contact externally to a suitable vein or artery. Direct measurement like this would also provide more accurate measurement as the blood would be in its normal working state. Furthermore, it would then be possible rapidly to optimize drug dosage and to investigate changes in parameters as they happen. The concept of in-situ measurement will apply to numerous other tests.

In special cases some people have already been equipped with sensors of critical body parameters. The outputs are telemetered to a remote observer. Examples of this are in space-medicine, in fitness studies and in a few heart disease cases.

Microbody

Considering the low-cost data processing power already available, and coupling this with inexpensive micro-miniature sensors we can expect to see developed in the future, it is possible that individuals will one day be able to obtain self-monitors that provide warning when body parameters exceed allowable limits.

Better measurements always leads to better control. As an example, respiratory tract problems, such as hay fever and asthma, are hard to combat effectively because of the lack of detailed data about each individual's characteristics in the various circumstances encountered. Not all people are allergic to the same pollens — we could benefit greatly if an easy way existed that determined the allergic pollens involved.

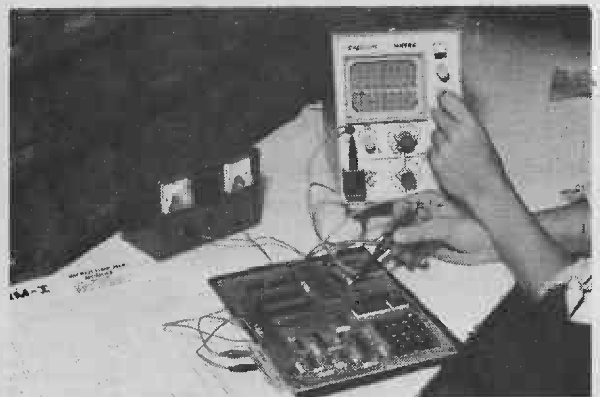
At present, a pollen count is usually taken by drawing the ambient air over a sticky surface for many minutes — hours sometimes. The surface is then observed with a microscope, the technician counting all pollen grains together to obtain the total pollen count. This process is now sometimes carried out using computer-controlled video TV camera systems, but the systems are still barely able to group the various kinds of pollen grain. (They are typically a micrometre in diameter or smaller — counts of a few grains per cubic metre can cause unwanted symptoms.)

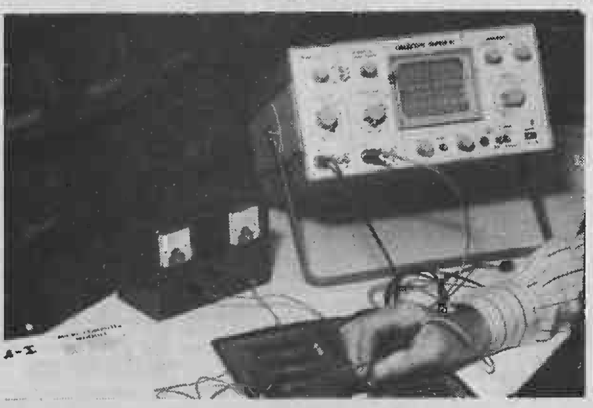
A development that could help is a sensor that provides a virtually instant count of the individual kinds of pollen grain present — a real-time sampling analyser.

news digest

FLEET OF FOOT?

For all us kiddies (anyone who isn't — please leave now) this is a good idea. Those nasty sneaky MPUs have invaded our nice little game of Battleships. Based on a TMS 1000 the unit contains enough RAM to hold the board as seen by both players, and make appropriate noises at time of defeat or victory or whatever. Nice explosion sound effects etc too. And what's more it's British designed — which is a distinct recommendation and selling well in America — which isn't. Price £29 or thereabouts. AID, 10 RATHBONE PLACE, LONDON W1P 2DN.





NOT A TRACE OF GREED

Two new oscilloscopes for the home constructor, from the Scopex stable. Called the Calscope 6 and Calscope 10 they are probably indicative of the fact the home market is of growing importance to manufacturers. Specs. below.

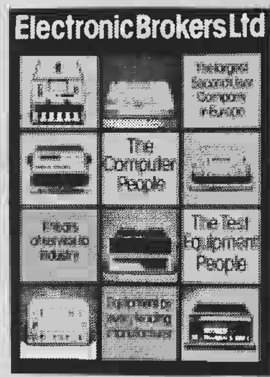
Calscope 6: — single trace: sensitivity range 50mV to 50V per cm/in 12 ranges: Bandwidth 6MHz: time base range 1 and to 100 ms per cm. Time base triggering is claimed to be particularly good. Price £162.

Calscope 10:— dual trace: 10mV sensitivity: bandwidth 10MHz (displayable across full screen size): time base range 200ns to 100 ms: accuracy 3% all ranges. Price £219.

Both available from Maplin and Marshall both of whom you should know already.

PEDIGREE CATS

Electronic Brokers — superb range of second hand hardware that should interest most small firms and not a few individuals. Much new equipment is also included, and although the cost is high at £1 to private individuals companies can get it free!



Not fair this world is it? ELECTRONIC BROKERS, 4a PANCRAS ROAD, LONDON NW1 2GB.

Ace Electronics — good range of components. Poorly produced catalogue but it is free, and adequate, and contains some nice little kits amongst other things worth sending for ACE MAILTRONIX TOOTAL STREET, WAKEFIELD, W. YORKS.

PUT THESE TO GOOD USE

Some new PUTs (at last), and in different packages too. The MEU21 and 2N6028 are intended for use in long internal timers and such and have low leakage (100nA max).

The MEU22 (and 2N6027) are general purpose types. All have specs of: 150nA peak point current (2N6028), low forward voltage (1V5 for 50mA I_{FWD}) and high pulse output voltage (6V minimum) MICRO ELECTRONICS LTD, YORK HOUSE, EMPIRE WAY, WEMBLEY, MIDDX.

With such a device the sufferer could test for the hostile situation *before* symptoms arise and take remedial action in time. Technologically such an instrument appears feasible. It is, however, cost and physical size that holds up its development and its practical everyday use at present.

A likely parallel already existing is the Coulter counter that analyses the size and number of cells in a blood sample. Blood-cell counting of several years ago required the blood to be smeared on a microscope slide and the cells counted by eye under a microscope. Today the machine makes the measurements in a few seconds by counting particles as they pass a small orifice — but it is neither portable nor inexpensive. Figure 8 shows a Coulter counter installation as used in the larger pathological laboratories.

Development of personal monitors will almost certainly pass first through a telemetry method in which a central computer processes the data, perhaps with the help of the trained physician to begin with. A direct self-contained method will then be developed in which the specific data processing requirements that have emerged from experience, are integrated into the unit.

Sensors

The human body is a vastly complicated chemical process plant. It has sensors feeding information to the brain for central processing. In turn, the brain sends signals to actuators — the muscles which cause the body to function and to do work. Nerves are the hardwired data channels for receiving and sending control information.

Slight deficiencies in the senses of sight and hearing have been aided using instruments — spectacles and hearing aids. The latter began as acoustic horns which provided sound pressure gain without active amplification. The advent of the telephone led to amplifierless hearing aids in the 1900's which used several mouthpieces coupled to the ear pieces (Fig 9). Then came electronic units which provided active signal gain from miniature thermionic tubes. Today we have integrated semi-conductor circuitry. We have still a way to go, however, before we are able to compensate for a failed action of the inner ear mechanism.

Vision, until very recently, was aided only by optical lens compensation. But this applies only where the eye is still largely operative as an optical-to-electrical transducer. Quite recently experiments have been reported in which a miniature video camera provides electronic signals that drive cells in the brain to provide illusion of sight. The method is still crude compared with the performance of natural process. Given time for research it seems reasonable to assume that quite compact and useful artificial eyes will soon be available for blind people. Bionic man is not so fantastic! Interestingly, once the bionic eye is developed it is an easy matter to provide greater than natural visual acuity and to offer sensitivity to other than the visible light band — infra-red for instance.

Providing electronic replacements for the sense of smell will most likely be a much later development. We know too little about the olfactory senses and have no really compact and cheap smell sensors at this time to expect great progress to occur in the near future.

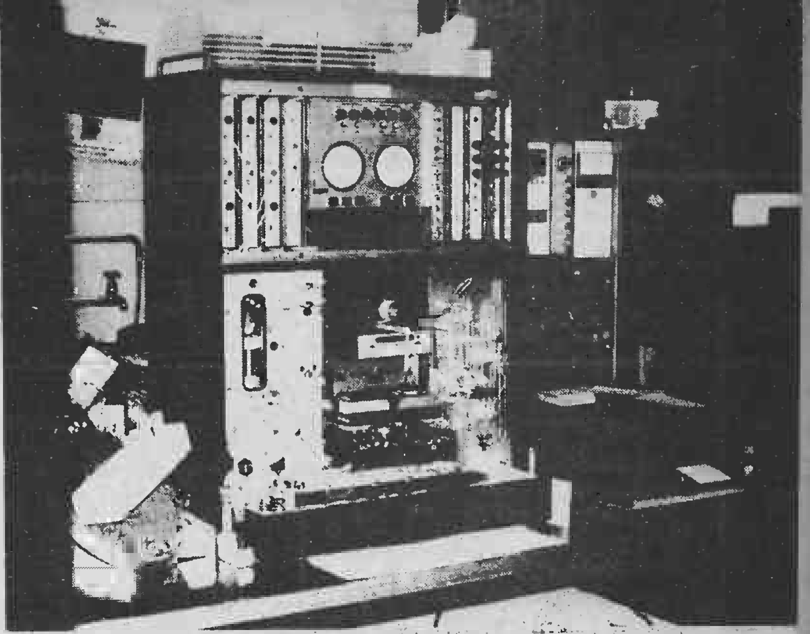


Fig. 8. Coulter counter unit of today that analyses blood sample particles providing a printout (IMUS, Adelaide).

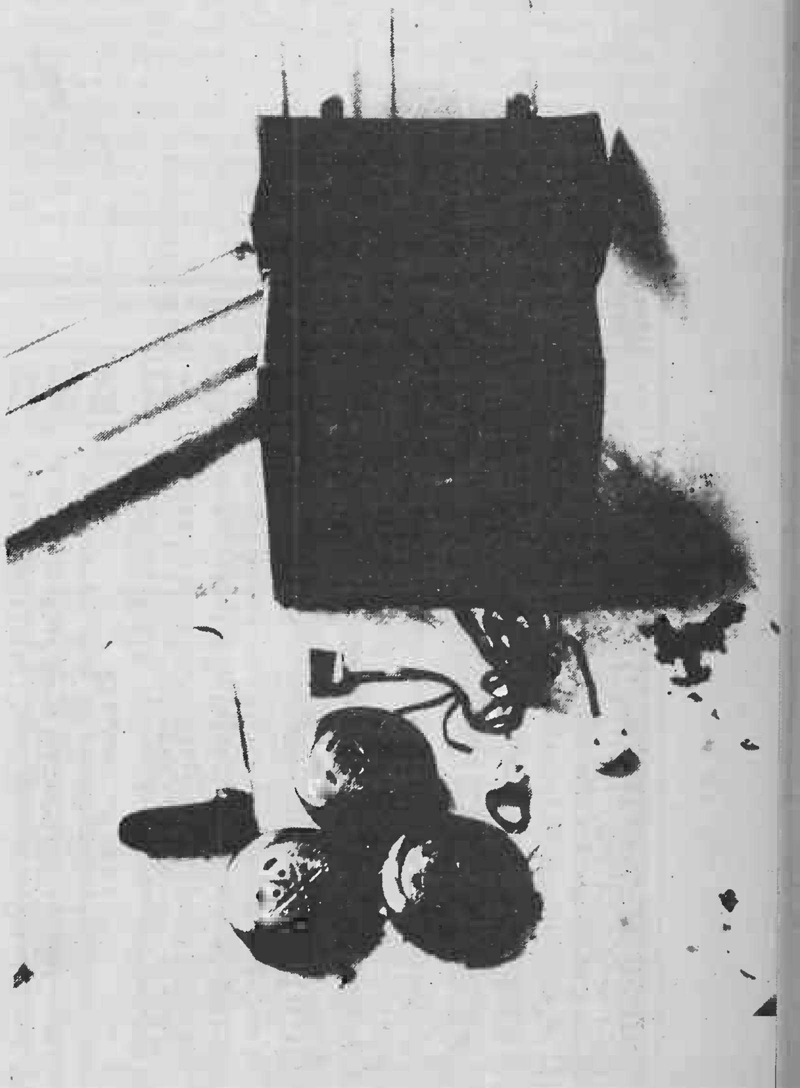


Fig. 9. 1900's hearing aid. The three receivers, which fit into the case, provide signal to the two earpieces. No active amplifier was involved. (Birdwood Mill Museum, S.A)

Animals, such as dogs, possess a sense of smell vastly much more sensitive than humans. Ants track each other by a scent trail! Yet man has not yet produced small and inexpensive chemical analysers (smell is a largely chemical process) that can meet the complex sensing requirements of smell detection.

Scanners

X-ray and nucleonic diagnostic methods have the valuable feature that certain internal structures of the body can be seen. But all such methods lack the spatial resolution we obtain by visual examination with the unaided eye or through a microscope. A nuclear radiation source set-up within the body privides a rather diffuse output picture. Resolution is improved by increasing the number of individual elements at the sensing stage. The gamma camera, for example, provides two-dimensional pictures using over thirty scintillometers connected in such a way as to provide many more picture elements. The latest development senses the body area by scanning multiple sensors thereby collecting yet more data in a given time. Sophisticated processing is then used to provide video screen outputs which contain much more useful information than ever before. Similar techniques apply to X-ray, nucleonic and ultrasonic signal transmission. Now that vastly more powerful data processing capability exists the future development will be to incorporate many more sensors of the same kind and make more effective use of three-dimensional data. Other variables, such as, say, thermal emission will also be incorporated along with systematic experience gained into the processing, all this to providing data conversion for a more meaningful measurement process.

Surgery

Electrical methods in surgery traditionally include endoscopes with which to see into inaccessible places and cauterizing probes for sealing blood flow, cutting and destroying cells where need be. The recent introduction of the laser as a cutting tool has most valuable properties. Selection of the appropriate wavelength decides which kind of body tissue will be cut. For example, it is possible to weld the retina of the eye through the pupil without need for surgery. The radiation is only absorbed by retinal material, the pupil and fluid of the eye ball being transparent to the wavelength used.

The selective property of narrow-band radiation will enable some highly precise surgical operations in the future. An operation might go as follows: a rigid framework holds the patient fixed with respect to an x-y-z translating pulsed laser operating head. Wired to the control unit of the translator are electrodes fixed to the body. These sense when low-power sensing pulses are energising the specific part of the body required to be operated upon. The unit scans until sensing signals (operated by a non-cutting wavelength source) verify the location of the beam. Once at such a point the laser is switched to full cutting power continuing to cut as the time-multiplexed sensing signals indicate position is satisfactory.

Looking back, electro-medical apparatus has only been with us for a mere 50 years. In the last 10 years of that time we developed inexpensive and very powerful data processing methods. The next 25 years are likely to unfold undreamed of aids to medicine many of which we would regard as miraculous if we heard about them today. ETI

DIGITAL DIAL

Most AM radio dials are pretty hopeless – especially portables and car radios. This application of our counter module can be a decided improvement.

WITH MODERN RADIOS which are designed to be operated anywhere in the world, the local station call signs are no longer marked on the dial. Instead the dial is marked with frequencies making it more universal. Unfortunately the scaling on many receivers leaves a little to be desired, with many car radios lucky to have 3 or 4 markings. The use of pushbutton selection helps but when a cassette is fitted or you are out of your local area there is still the problem of knowing to what station you are tuned.

This project gives a direct readout of the station being received allowing for easy identification and selection. The display is remote from the receiver allowing it to be mounted on the dashboard for easy viewing.

SPECIFICATION

Frequency range	500-1700kHz
Accuracy	∓ 5kHz
Sensor	pickup coil or direct connection
Power supply	7-20VDC @ 80mA or 240VAC
Display	4 digit LED

Design Features

This project is the first to employ our four digit module presented elsewhere in this issue. We will be using the module again over the next few months so don't lose track of it!

If this device is to be used outdoors i.e. in the car, it is recommended that high brightness displays, such as the Hewlett Packard HDSP 4133, be used. As these have a different pin-out a new display board is presented in this article.

The theory of operation is that we actually measure the frequency of the local oscillator in the radio and subtract the IF frequency. While we could have subtracted this using digital logic we chose to do it by resetting the display not to zero but to 9545 (10 000-455). The first 455 pulses in the timing period are then used getting to zero and in effect, only pulses after this are counted and displayed. This number can be loaded into the counter by selecting the appropriate diodes and using the "load counter" input instead of the reset line. The only difference is that as the data is entered into the counter serially the pulse used must be longer than 4 times the internal oscillator period. Also as the LC input is a three state input it cannot be driven by conventional two-state.

Out of Tune

We initially tried capacitive coupling onto the tuning capacitor of our portable radio (oscillator section!) but the loading detuned the set too much. We then tried a pickup coil and found enough signal with it in the correct place not to require any electrical connection to the set. With

►

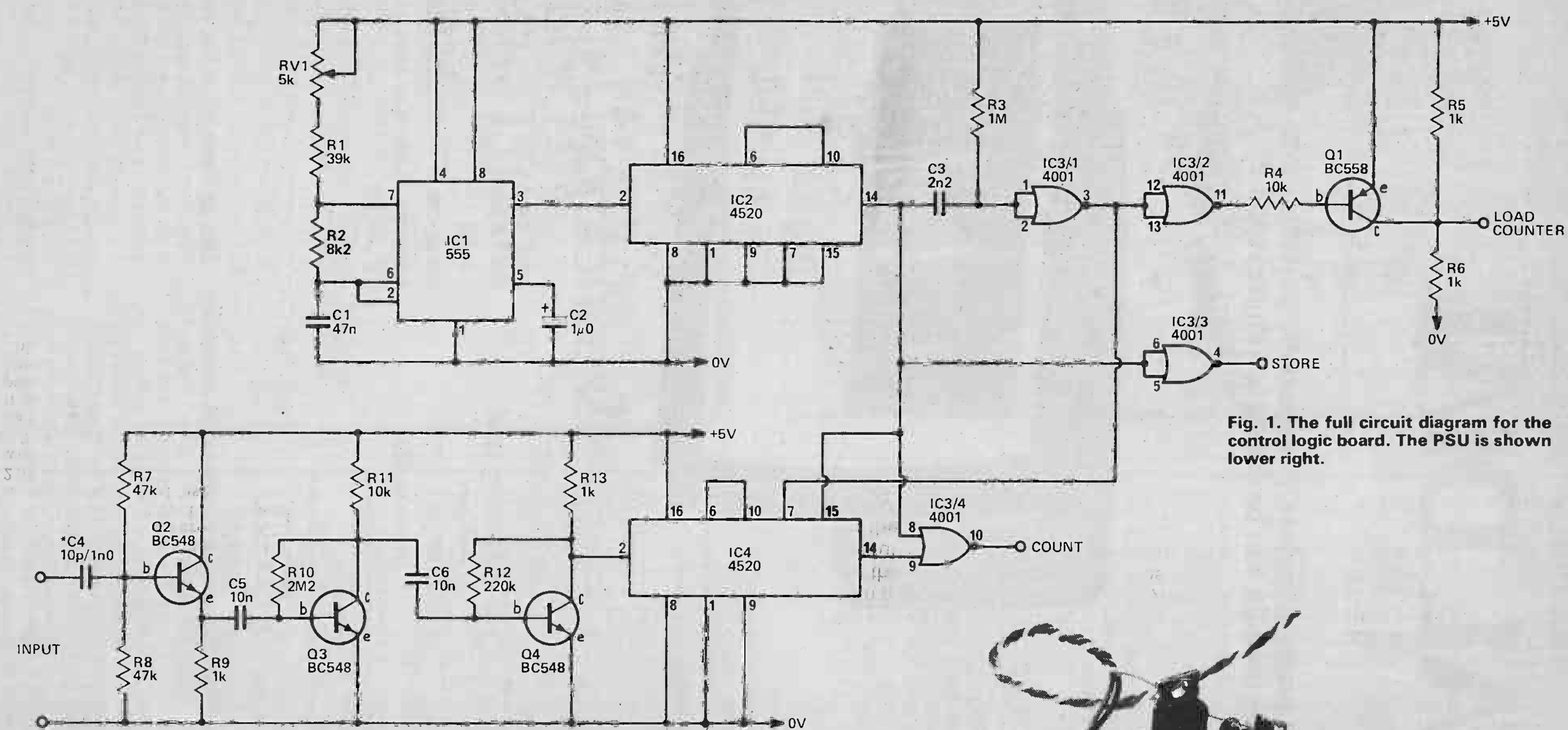
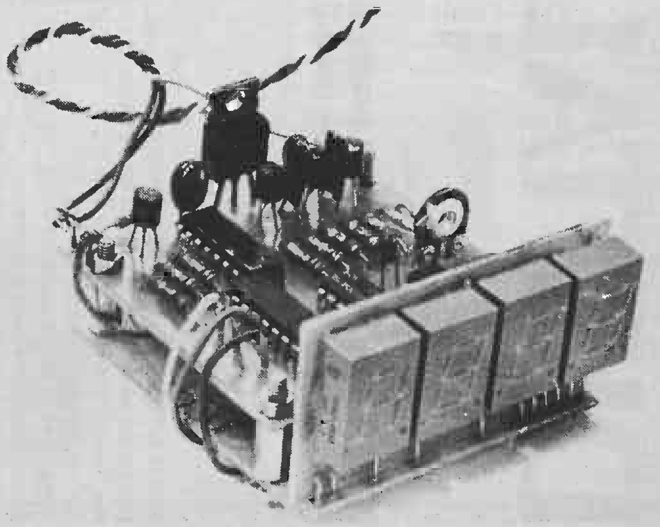


Fig. 1. The full circuit diagram for the control logic board. The PSU is shown lower right.



The photo to the right shows the module with the HP 5082-7663 displays. Suitable displays and their light outputs are given below.

Type	Colour	Size	Light output
HDSP 4133	yellow	10.9 mm	2100μCd @ 20mA
HDSP 3733	red	10.9 mm	1800μCd @ 20mA
5082-7663	yellow	10.9 mm	1500μCd @ 20mA
5082 -7653	red	10.9 mm	1720μCd @ 20mA
DL704	red	7.6 mm	320μCd @ 25mA

HOW IT WORKS

A signal from the local oscillator in the tuner is picked up either by a pickup coil or by direct connection to the set. It is then amplified by Q2-Q4 to give a square wave on the collector of Q4. The gain of this amplifier is about 250 (48 dB). The frequency of this signal will vary from around 1 MHz to about 2 MHz and this signal is then frequency divided by 256 (2^8) in IC4. This is used to clock the display module.

To measure the frequency we have to count the number of these pulses for 256/1000 seconds (256 because we divided the input by 256 and 1000 as we want a 1 kHz resolution). We used a 555 oscillator for the time base and its output is also divided by 256 (by IC2). This improves the stability of the time base by averaging out any short term variations in the 555 frequency.

The output of IC2 is a symmetrical square wave and when the output goes low a 1.5 ms wide pulse is generated by R3, C3 and IC3/1. This is inverted by IC3/2 which turns Q1 on for the 1.5 ms period. Two resistors are used to bias the output of Q1 to 2.5V to ensure that the three level input will work.

This pulse "loads" 9545 into the counters (in the display module). Counting now starts from this number and after 455 pulses it is passing through zero. 256 ms after the load pulse ended the output of IC2 goes high. This resets IC4 back to zero, inhibits any further clocking via IC3/4 and opens the latches via the strobe line allowing the total in the counter to be displayed. 257.5 ms later when the output of IC2 goes low again, the store is closed, the counter is once again preset to 9545 with the process starting again.

the car radio however the coils are shielded so well that reliable operation was not possible. However it was found that we could tap onto one side of the oscillator coil without affecting the operation.

We use a NE55 as the time base with its output being divided by 128 to improve stability. However if an accuracy of ± 5 kHz is to be maintained its frequency has to be better than ¼% and a polystyrene capacitor for C1 and 2% resistors for R1 and R2 are recommended.

Construction

The display board should be built according to the overlay in Fig. 4 which shows which diodes are required. Note that R1, 2 and C1 are not used in the display module and a link is used in place of R1.

The control card can now be assembled and wired to the display module. The two boards are mounted one above the other using 9.6 mm spacers. Check that these screws do not touch any tracks and insulate them if too close.

Depending on whether the unit is going to be used with a car radio or portable the values of C4 and C7 will vary. The pickup coil is made by winding about 80 turns of 0.25 mm enamelled wire onto a 25 mm long piece of 10 mm ferrite rod with the end terminated onto a twisted pair of plastic covered wires long enough to go between the radio and the position of the display. Do not use coaxial cable for this as the capacitance is too high.

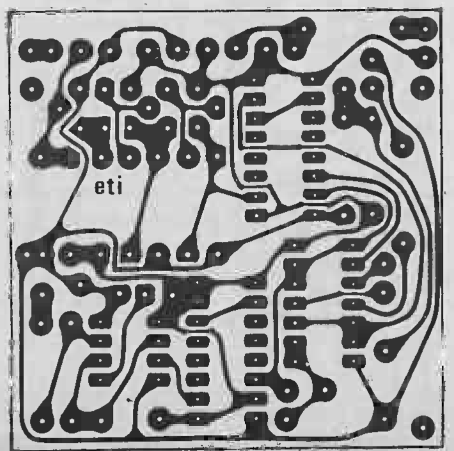
The case chosen has been left to the individual with our own being from a discarded digital clock. If you use the 240 V powered version be careful with the high voltage wiring. For the 12 V version the power can come from the radio via a twisted lead (3 wires).

When connecting into a car radio, tune the set to a local station and try the pickup wire on the terminals of the tuning coils in turn until one is found which will give a reading without moving it off station. Permanently connect to this point. With a portable radio try moving the pickup coil around the set, probably in line with the aerial coil, until the best results are obtained.

Calibration

Place the pickup coil in position such that reliable operation is obtained and tune to a known station (preferably near the top end of the dial). Now adjust RV1 until the digital dial agrees with that station. Check then with other stations.

Alternatively feed a known signal of between 1 and 2 MHz from an oscillator into the input and adjust RV1 until it reads 455 less than that frequency.



Right: full site foil patterns for the Digidial control board. Refer to the module article for details of those PCBs. Not shown here i.e. the two display boards and the third for high brightness seven segment types.

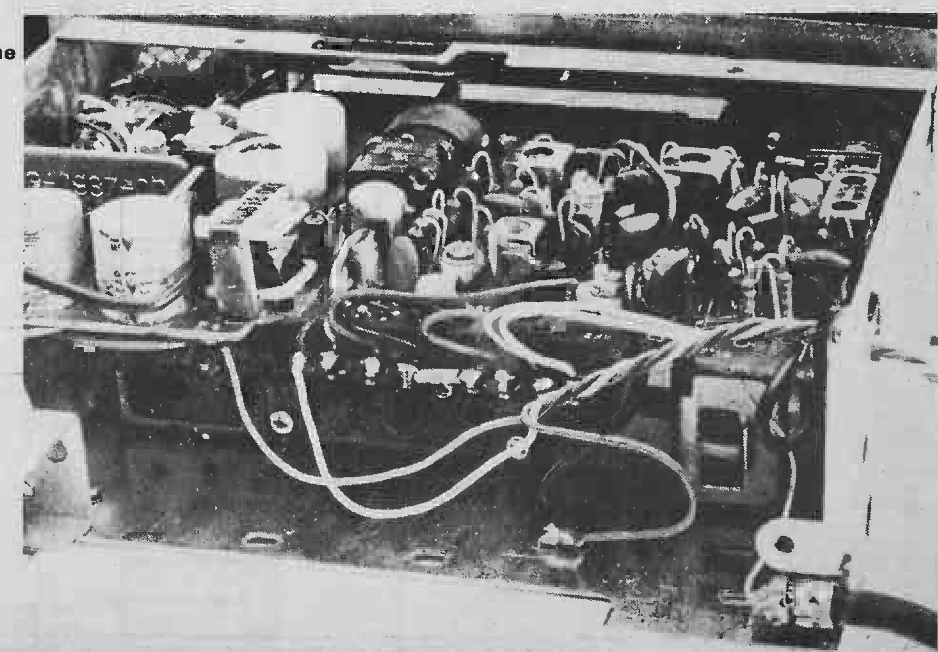
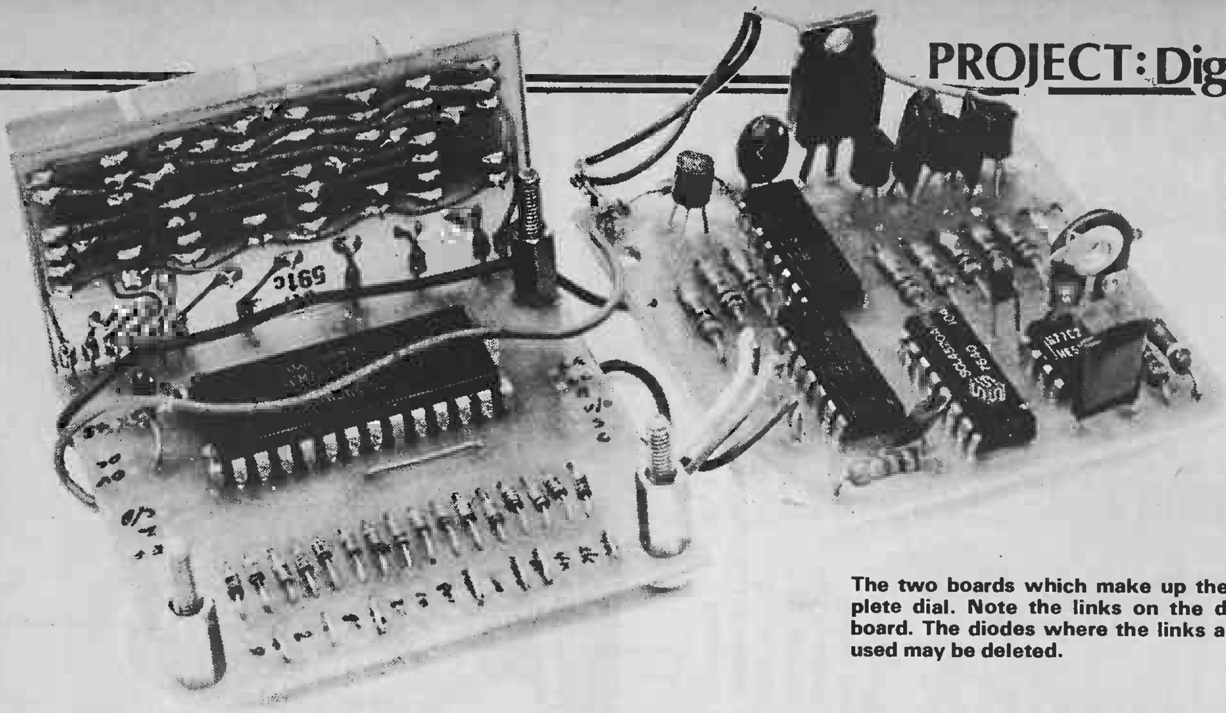
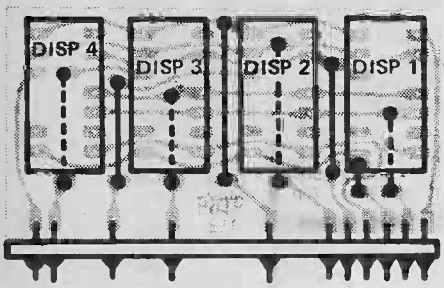


Photo showing where we tapped into the car radio.



The two boards which make up the complete dial. Note the links on the display board. The diodes where the links are not used may be deleted.



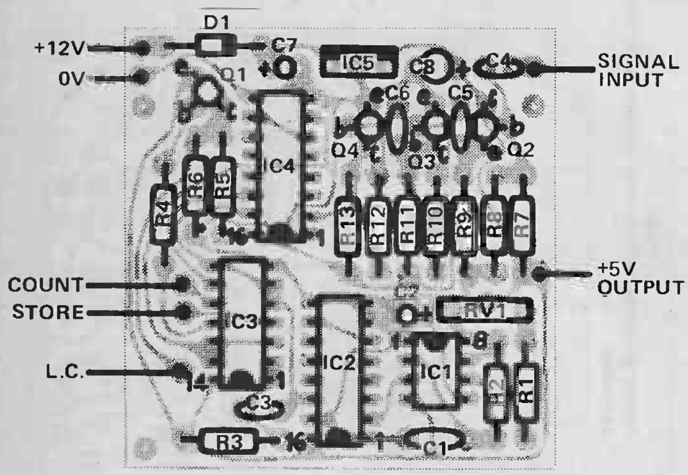


Fig 3(a) The overlay for the display board employing the high brightness displays. (b) Below that (left) the control board overlay.

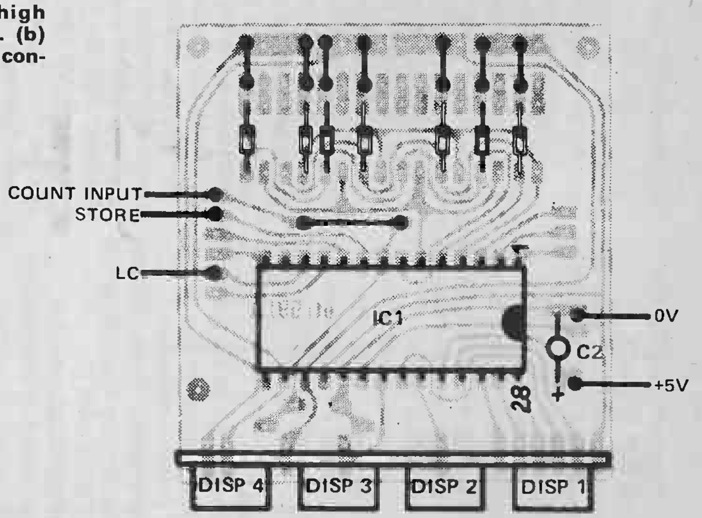


Fig. 4. The component overlay of the display module showing the diodes and links required.

PARTS LIST

RESISTORS	all ½W, 5%
R1	39k
R2	8k2
R3	1M
R4, 11	10k
R5, 6, 9, 13	1k
R7, 8	47k
R10	2M2
R12	220k
POTENTIOMETER	
RV1	5k trimmer
CAPACITORS	
C1	47n polystyrene
C2	1u0 tantalum
C3	2n2 polyester
*C4	10p ceramic
C5, 6	10n polyester
*C7	33u tantalum
C8	10u 25V electrolytic
SEMICONDUCTORS	
IC1	555
IC2	4520
IC3	4001
IC4	4520
IC5	7805
Q1	BC558
Q2-Q4	BC548
D1	1N4004
MISCELLANEOUS	
*Transformer 240V-12V6, 150 mA	

*For 12 V operation delete transformer. For 240 V version C7 should be 220u 25 V. For use with pickup coil increase C4 to 1n0.

BUYLINES

Any displays mentioned here are of course suitable and should be easily obtainable. The semiconductors are all available from Technomatic, or indeed from most other mail-order suppliers.

Power Supply

The unit can be powered by an AC or DC voltage of between 7 and 20 volts. If an AC voltage is used the capacitor C7 should be increased to 220 u. A 240 V to 12V6, 150 mA transformer is recommended. ETI

DATA SHEETS EXPLAINED

The data sheets which we publish regularly are very popular, but from time to time we receive requests for a fairly simple explanation of the terms and abbreviations which one finds in semiconductor device data sheets, and so here it is!

THE INFORMATION contained in semiconductor device data sheets is often grossly misunderstood. Great care must be taken to ensure that the exact meaning of a term or abbreviation is clear. As an example, we can quote the following conversation which actually occurred between two people who should both have known better.

A representative of a semiconductor distributor was showing data on a new power device to a lecturer. The lecturer said that the device data was wrong, since the maximum collector current was quoted as 12A and the maximum collector-emitter voltage (V_{CEO}) as 80V; this is a power level of 12 × 80 = 960W, but the maximum permissible dissipation quoted in the data sheet is only 90W. The representative could provide no answer!

The data was, of course, perfectly correct. The problem arose because neither of the people concerned had appreciated the exact meaning of V_{CEO} which signifies the collector-emitter voltage *with the base open circuited.* Under these conditions (with zero base current) the collector current will be very small and the power dissipation in the transistor will also be quite small. Thus there is a great deal of difference between V_{CE} (the collector-emitter voltage under any conditions) and V_{CEO} (the collector-emitter voltage with the base open circuited). If still more information is required, one must look into the SOAR (Safe Operating ARea) graph to ascertain the regions of the collector voltage/collector current curve where the device can be safely operated for limited or unlimited times.

This is a very simple example of the pitfalls one can encounter if one does not really understand the *exact* meanings of the terms and abbreviations used in data sheets. Such misunderstandings are very common, but not (we hope!) amongst the devices covered in our data sheets, since it is equally important that our readers understand the exact meanings of abbreviations used in data sheets on relatively simple devices such as ordinary diodes and transistors.

Letter Symbols

Three of the most important symbols used in semi-conductor device data sheets are V, I and P for voltage, current and power respectively. Various subscripts are added to these three letters to indicate the electrode(s) to which the symbol is being applied and possibly certain circuit conditions. Some of the most commonly used subscripts are listed below.

A	anode
AV	average
B	base
BO	breakover
BR	breakdown
C	collector
D	drain or delay
E	emitter
F	forward
G	gate
H	holding
I	input
J	junction
K	cathode
M	peak value of a quantity
O	open circuit or output
R	reverse or repetitive
S	source, short circuit, series or shield
T	in the on state (that is, triggered)
W	working
X	specified circuit
Z	impedance

Order of subscripts

In most cases more than one subscript is needed; the subscripts are usually placed in a definite order governed by the following rules:
The first subscript indicates the electrode at which the current or voltage is measured.
The second subscript denotes the reference terminal or circuit mode. (This subscript is often omitted if it is felt no ambiguity will arise.)
The letter O may be used as a third subscript to show that the electrode not indicated by any previous subscript is open circuited. Similarly the letter S can be used as a third subscript to show the third electrode is shorted to the reference electrode of the second subscript, whilst the letter R as a third subscript indicates that a specified resistance is connected between the third electrode and the reference electrode.
The supply voltage to a collector is indicated as V_{CC}, the second suffix being a repetition of the first in the case of supply voltages. Similarly, one often meets the symbol V_{DD} for the positive supply to a CMOS (or COS/MOS) device, this being the supply to the drain. The negative supply to CMOS devices is normally represented by the symbol V_{SS}.

It should now be clear why V_{CEO} is the steady collector emitter voltage with the base open circuited. Similarly I_{CER} is the collector cut off current with a specified resistance between the base and emitter. It is current with the base and emitter joined, since either the base or emitter can be used as the reference electrode without any change when they are joined.

The parameters of individual devices vary from one device to another of the same type number. The typical value of a parameter such as transistor current gain is often quoted in data sheets by the abbreviation 'typ' after the quantity, but minimum and maximum values are also often quoted. In economical devices no maximum and minimum values may be quoted. In the case of breakdown voltages the minimum value applicable to any device of that type number is usually quoted so that the circuit designer knows that he can apply that value of voltage without danger of the device junction breaking down.

The above discussion gives the general principles of the way in which the symbols for various parameters are chosen. It is not complete, since we have not yet covered such items as current gain of a transistor or thermal characteristics of a device. However, these and other quantities will be covered in the following tables.

Thermal characteristics

The symbols used for the following thermal quantities apply to all types of semiconductor device.

P_{tot}	total power dissipated within the device
T_{amb}	ambient temperature
T_c	temperature of the case of the device
T_j	temperature of the junction in the semiconductor material
T_{mb}	temperature of the mounting base of the device (= T_c)

▶

T_{stg} storage temperature
θ_h thermal resistance of heat sink. (Units. °C/W)
θ_i contact thermal resistance between the case of the device and the heat sink
$\theta_{j\text{-}amb}$ junction to ambient thermal resistance
$\theta_{j\text{-}c}$ junction to case thermal resistance

Symbols used mainly with diodes

C_d diode capacitance with reverse bias
C_f diode capacitance with forward bias
C_j capacitance of the junction itself
C_{min} minimum capacitance (which occurs at the rated breakdown voltage)
C_o diode capacitance at zero bias
f_{co} cut off frequency of a varactor diode
I_F total dc forward current
i_F instantaneous forward current
$I_{F(AV)}$ average forward current
I_{FM} peak forward current
I_{FRM} repetitive peak forward current
I_{FSM} non-repetitive peak forward current occurring under surge conditions
I_R continuous reverse leakage current
i_R instantaneous reverse leakage current
I_{RRM} repetitive peak reverse current
I_{RSM} non-repetitive peak reverse current
I_Z zener diode continuous operating current
I_{ZM} zener diode peak current
t_{on} turn on time
t_{off} turn off time
t_r rise time
t_{rr} reverse recovery time
t_s storage time
V_F steady forward voltage
v_F instantaneous forward voltage
V_R steady reverse voltage
v_R instantaneous value of the reverse voltage
V_{RM} peak reverse voltage
V_{RRM} repetitive peak reverse voltage
V_{RSM} non-repetitive peak reverse voltage (on surges)
V_Z zener diode working voltage

Symbols used mainly with transistors

C_{ob} transistor output capacitance in the grounded base circuit
C_{oe} transistor output capacitance in the grounded emitter circuit
f_T transition frequency or gain-bandwidth product in common emitter circuit
h_{FE} (h_{FB}, h_{FC}) current gain in the grounded emitter circuit (or in the grounded base or grounded collector circuit).
h_{fe} the increase in collector current divided by the small increase in the base current which produces it. (Small signal current gain.)
I_B, I_C or I_E the steady base, collector or emitter current.
$I_{B(AV)}$, $I_{C(AV)}$ or $I_{E(AV)}$ the average value of the base, collector or emitter current.
I_{CEX} collector cut-off current in a specified circuit
I_{CM}, I_{BM} or I_{EM} peak value of collector, base or emitter current
I_b, I_c or I_e rms value of the alternating component of the current
I_{bm}, I_{cm} or I_{em} peak value of the alternating component of the current
i_C, i_B or i_E instantaneous value of the total current
i_c, i_b or i_e instantaneous value of the alternating component of the current
I_{CBO} collector cut off current with the emitter open circuited
I_{CBS} or I_{CES} collector cut off current with emitter shorted to the base
I_{CEO} collector cut off current with the base open circuited
I_{CER} collector cut off current with a specified value of resistance between the base and the emitter
I_{EBO} emitter cut off current with the collector open circuited
$V_{BE(SAT)}$ base-emitter saturation voltage
$V_{(BR)}$ breakdown voltage
$V_{(BR)CBO}$ collector to base breakdown voltage with emitter open circuited
$V_{(BR)CEO}$ collector to emitter breakdown voltage with base open circuited
V_{CB} collector-base voltage
V_{CBO} collector to base voltage with emitter open circuited
V_{CC} collector supply voltage
V_{CE} collector to emitter voltage
V_{CEO} collector to emitter voltage with base open circuited
V_{ce} collector to emitter rms voltage
$V_{CE(SAT)}$ collector to emitter saturation voltage
V_{EB} emitter-base voltage
V_{EBO} emitter-base voltage with collector open circuited
V_{eb} emitter-base rms voltage

Symbols used mainly with FETS

I_D steady value of the drain current
I_{DSS} steady value of the drain current with the gate connected to the source
i_m peak drain current
I_G steady gate current
I_S steady source current
r_{DS} drain to source (or channel) resistance
V_{DS} steady drain to source voltage
V_{GS} steady gate to source voltage

Symbols used mainly with thyristors

I_{FRM} repetitive peak forward current.
I_{FSM} non-repetitive peak (surge) current
I_{GD} gate current which does not trigger the device
I_{GT} gate trigger current
I_{GO} gate turn off current
I_H holding current required to maintain conduction
I_R steady reverse leakage current
I_{RG} reverse gate current
I_{RRM} repetitive peak reverse current
I_{RSM} non-repetitive peak reverse current (in surge conditions)
I_T steady anode-cathode 'ON' state current
P_G gate power
t_{gt} gate controlled turn-on time
t_{gq} gate controlled turn-off time
$V_{(BO)}$ breakover voltage
V_D continuous off state voltage
V_{FG} forward gate voltage
V_{GT} gate trigger voltage
V_R steady reverse voltage

Operational amplifier terms

Bandwidth, Δf. The frequency at which the gain falls by a factor of 0.7 relative to the gain at low frequencies.
Common mode rejection ratio, CMMR. The gain when a signal is applied to one of the inputs of the amplifier divided by the gain when the signal is applied to both the inverting and non-inverting inputs. It is usually expressed in dB.
Frequency compensation. An operational amplifier requires a capacitor to enable it to be used in circuits which are stable over a wide frequency range. Internally compensated operational amplifiers have this capacitor fabricated on the silicon chip, but an external capacitor must be used with other types of operational amplifier which do not contain an internal capacitor.

Input bias current, I_{BIAS}. The mean value of the currents at the two inputs of an operational amplifier.
Input offset current, I_{OS}. The difference in the two currents to the inputs of an operational amplifier. Normally much smaller than the input bias current.
Input offset voltage, V_{OS}. The voltage which must be applied between the two input terminals to obtain zero voltage at the output.
Open loop voltage gain, A_{VOL}. The amplifier gain with no feedback applied.
Output resistance, R_O. The small signal resistance seen at the output when the output voltage is near zero.

Voltage regulator terms

Dropout voltage, V_{DO}. When the difference between the input and output voltages falls down below the dropout voltage, the device ceases to provide regulation.
Foldback current limiting. In regulators with foldback current limiting, the current will 'fold back' to a fairly small value when the output is shorted.
Line regulation. The change in the output voltage for a specified change in the input voltage.
Load regulation. The change in output voltage for a change in the load current at a constant chip temperature.
Quiescent current, I_Q. The current taken by the regulator device when it is not delivering any output current.
Ripple rejection. The ratio of the peak-to-peak ripple at the input of the regulator to that at the output. Normally expressed in dB.

Monolithic timer terms

Comparator input current. The mean current flowing in the comparator input connection during a timing cycle.
Timing capacitor, C_t. This capacitor is normally connected between the comparator input and ground. The time taken for it to charge controls the delay time.
Timing resistor, R_t. This is the resistor through which the timing capacitor charges.
Trigger current. The current flowing in the trigger input connection, at the specified trigger voltage.
Trigger voltage. The voltage required at the trigger pin to initiate a timing cycle.

Conclusions

Data sheets must be used intelligently and with much thought. Information on the conditions under which an entry in the data sheet is applicable is often stated in small print, but is of great importance. Data should always be thoroughly studied before a device is used for the first time, only then will you be able to fully understand the potential applications of the device.

Thus i_E is the instantaneous value of the total emitter current, i_e the instantaneous value of the alternating component of the emitter current, and $I_{E(AV)}$ the average (DC) value of the total emitter current. Other subscripts can be used in a similar way, I_F being the forward DC current with no signal, i_F the instantaneous forward current and I_{FM} the peak forward current.

ETI

TEMP STABILISED LOG CONVERTER

This design can be set up for either logarithmic or exponential operation and incorporates a neat heater circuit for temperature stability.

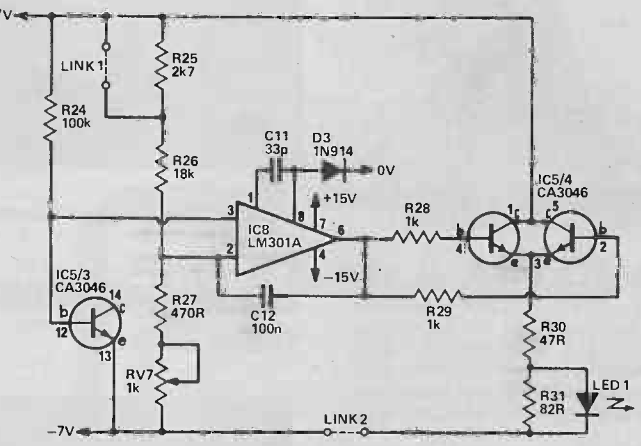
IN THE CONVENTIONAL musical scale, consecutive notes are not separated by the same frequency, but by the same ratio — the twelfth root of two. This is quite acceptable for most musical instrument manufacturers, except that in electronic music equipment it is easier to make oscillators which have an accurately linear frequency/control voltage characteristic. The keyboards of most music synthesizers give an output voltage of 1 V for each octave on the keyboard. This can easily be generated by a set of equal resistors between the contacts on each key and a voltage applied to each end (normally 5 V). However this means the oscillator is required to have an exponential frequency/control voltage response.

Trouble

This is where the trouble usually starts. An exponential converter is normally used which relies for its operation on the relationship between current and voltage in a silicon diode or transistor. However, unless temperature stabilisation is used the oscillator will not stay in tune for very long. With this unit the transistor used is heated to around 55° C and stabilised at this temperature, eliminating the problem of thermal drift.

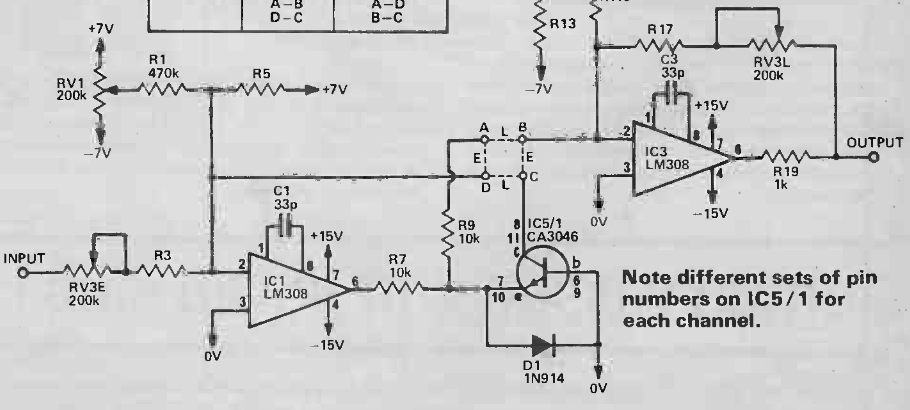
In the instrumentation field a lot of functions are displayed in dBs which are a logarithmic measurement. As this unit can be connected in either exp or log modes it is useful for this purpose also.

As the unit will normally be used with some other equipment, we have not described any mechanical housing.



Below: the circuit diagram of the converter section. One channel only is shown here, the second — identical — uses the even components numbers. Above: the oven circuitry.

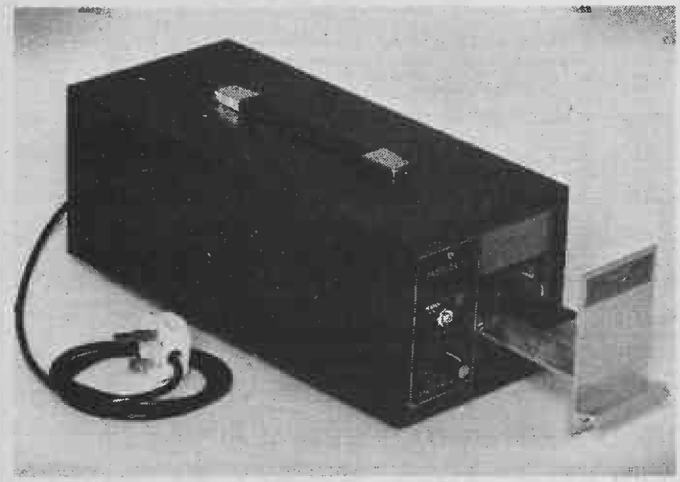
VALUES OF UNMARKED COMPONENTS	LOG	EXPONENTIAL
R3	33k	390k
R5	∞	150k
R13	∞	100k
R15	22k	470k
R17	390k	33k
RV3E	LINK	200k
RV3L	200k	LINK
LINKS REQUIRED		
	A–B D–C	A–D B–C



Note different sets of pin numbers on IC5/1 for each channel.

.... news digest......

PROM-IN-AID TIME



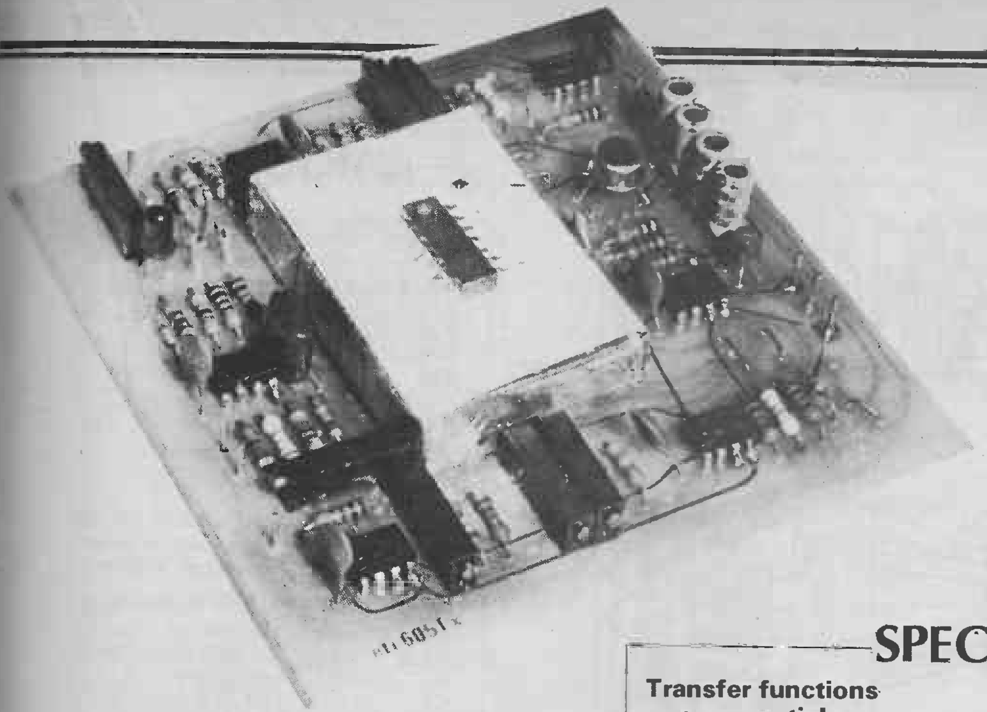
Micro-men take note. The Prombix 12 can wipe out twelve PROMs at once with variable erase time with safety interlock. Priced at £59.00 all inc. Should be of interest to small firms and rich enthusiasts.
GP INDUSTRIAL ELECTRONICS, SKARDON WORKS, SKARDON PLACE, NORTH HILL, PLYMOUTH PL4 8EZ.

GETTING INTO PRINT

A low cost printer is announced by Kimberley Business Records giving A low cost printer is announced by Kimberley Business Records giving good quality output. This will allow the expansion of many home systems into the extensive field of word processing, and God help you then! A standard lever operated typewriter mechanism has been used, driven by 240V solenoids.

Designed for parallel data input with handshake control, ASCII coding is accepted for the 88 characters available operating at a speed of 8 CAPS from a standard peripheral interface. It is supplied fully built and cased at £200 (including carriage and VAT). Alternatively as a print mechanism only, requiring all power other than 240V, case, and TTL logic to be added, the cost is £160.

KIMBERLEY BUSINESS RECORDS, 2, HARTINGTON ROAD, GOSPORT, HANTS, PO12 3AG.



The photo on the left shows the complete unit with the oven top removed to show IC5. Link 1 is made from a couple of valve socket pins in this prototype.

SPECIFICATION

Transfer functions	
exponential	V out = 0.15625 x 2Vin
log.	V out = Ln (Vin/0.15625)/Ln2
Useful dynamic range	50dB or 8 octaves
Oven temperature	approx. 55° C
Warm up time	about 2 minutes
Power supply	± 10 to ±15 volts

HOW IT WORKS

This unit relies on the fact that the collector current of a transistor is exponentially related to the base voltage.

In the log mode the collector of the transistor is linked back to the input of IC1. In this way the collector current is proportional to the input voltage and therefore the voltage on its emitter is logarithmically related to the input viltage. This voltage is then amplified and level shifted by IC3 to give the desired output.

In the exponential mode the 10k resistor R9 is linked back to the input of IC1 and the voltage on the emitter of the transistor is proportional to the input voltage; the collector current is exponentially related to the input voltage. This current is converted to a voltage by IC3.

All this works well provided the transistor is at a constant temperature. Compensation can be made by using other junctions and thermistors, however even the self-heating effect of the transistors can affect linearity. The transistors we have used are part of a transistor array IC which has three individual NPN transistors and a differential pair. We heat the chip up by dissipating heat in the differential pair while measuring the base-emitter voltage of one of the individual transistors. IC8 is used to compare this voltage to one set by the divider R25, 26, 27 and RV7. The base-emitter voltage is normally about 0.67 V at 20°C and drops about 2.2 mV per degree above this temperature. IC8 then stabilises the chip temperature to about 35°C above the temperature at which it was initially calibrated. As it warms up the current in the transistors will fall and when hot the voltage drop across R31 will be low enough that the LED will extinguish. The transistor array is housed in a polystyrene housing to conserve heat.

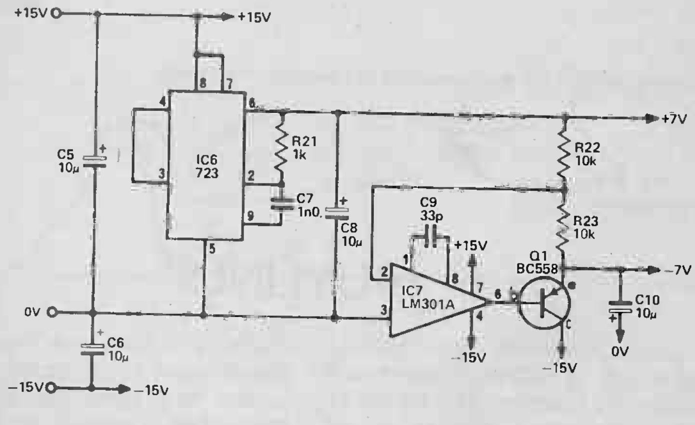
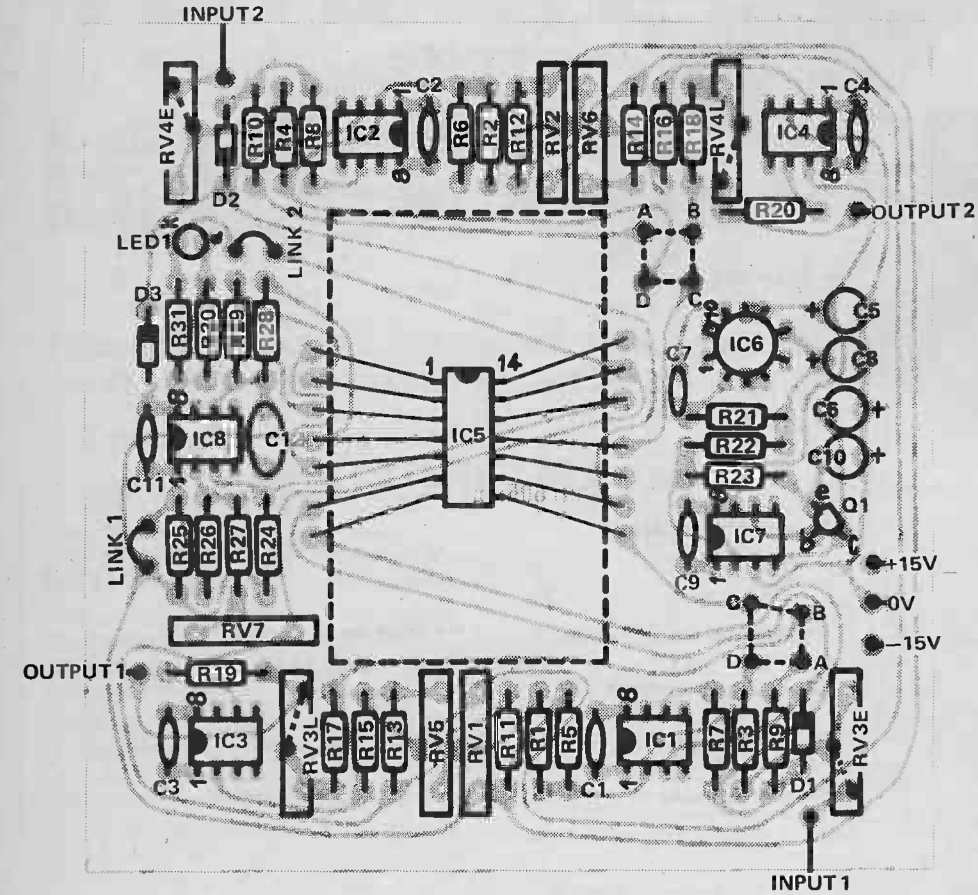


Fig. 1b. The power supply section which supplies the stable ± 7 V needed for the bias and adjustment controls.

The only difference between the assembly of this board and any other is the oven and the connections to the transistor array package. The oven is made out of two pieces of polystyrene about 55 x 35 x 12mm. The outside of the oven should be covered with aluminium foil to help reduce heat loss. The aluminium itself should be covered with a layer of adhesive tape where the leads can touch. A piece of thick paper should be used between the oven and the pcb to insulate the tracks.

Half Baked

The centre of the oven should be hollowed slightly to hold the IC (bend the leads out straight as shown in the photo; a hot soldering iron is the easiest method. Do not remove more than necessary. Now solder a 40 mm length of thin copper wire (a single strand of multistrand cable is best) to each pin, then with the base of the oven in position, sit the IC in the oven and connect the leads to the appropriate holes. If a small amount



Component overlay for the complete log converter project.

PARTS LIST

RESISTORS	all 2%, 5W
R1, 2	470k
R3—R6	see table 1
R7—R10, 22, 23	10k
R11, 12, 24	100k
R13—R18	see text
R19—R21, 28, 29	1k
R25	2k7
R26	18k
R27	470R
R30	47R
R31	82R
POTENTIOMETERS	
RV1—RV4	200k multiturn trimmer
RV5, 6	50k multiturn trimmer
RV7	1k multiturn trimmer
CAPACITORS	
C1—C4	33p ceramic
C5, 6	10u 25 V electrolytic
C7	1n0 polyster
C8	10u 25 V electrolytic
C9	33p ceramic
C10	10u 25 V electrolytic
C11	33p ceramic
C12	100n polyester
SEMICONDUCTORS	
IC1—IC4	LM308
IC5	CA3046
IC6	723
IC7, 8	LM301A
Q1	BC558
D1—D3	1N914
LED	T1L 209
MISCELLANEOUS	
PCB	
Polystyrene foam for oven	

BUYLINES

The project depends upon the CA 3046 device — near equivalents will probably **not** function. The CA 3046 itself is readily available — we found it in both the Marshalls and Stevenson catalogues when we looked for it! Initial reaction here had been that it would be difficult to obtain.

of epoxy cement is placed under the oven it will stay in position. Now fit the top of the oven and secure with a piece of adhesive tape until it has been checked out. It finally can be cemented with epoxy adhesive.

The potentiometer valuves chosen are a compromise between ease of adjustment and the ability to compensate different transistors. If the potentiometer does not have enough range then the series resistor will have to be varied. We have specified 2% resistors throughout to obtain a better temperature coefficient than is possible with conventional 5% resistors. It will not help to select out of normal 5% types.

Calibration

The equipment needed comprises an accurate digital voltmeter and a variable power supply with a fine voltage control. The + 7 V rail can be used for this with a mutli-turn potentiometer.

CALIBRATION TABLE

A	B
−3.00 V	19.5 mV
−2.00 V	39 mV
−1.00 V	78 mV
0.00 V	156 mV
+1.00 V	312 mV
+2.00 V	625 mV
+3.00 V	1.25 V
+4.00 V	2.50 V
+5.00 V	5.00 V
+6.00 V	10.00 V

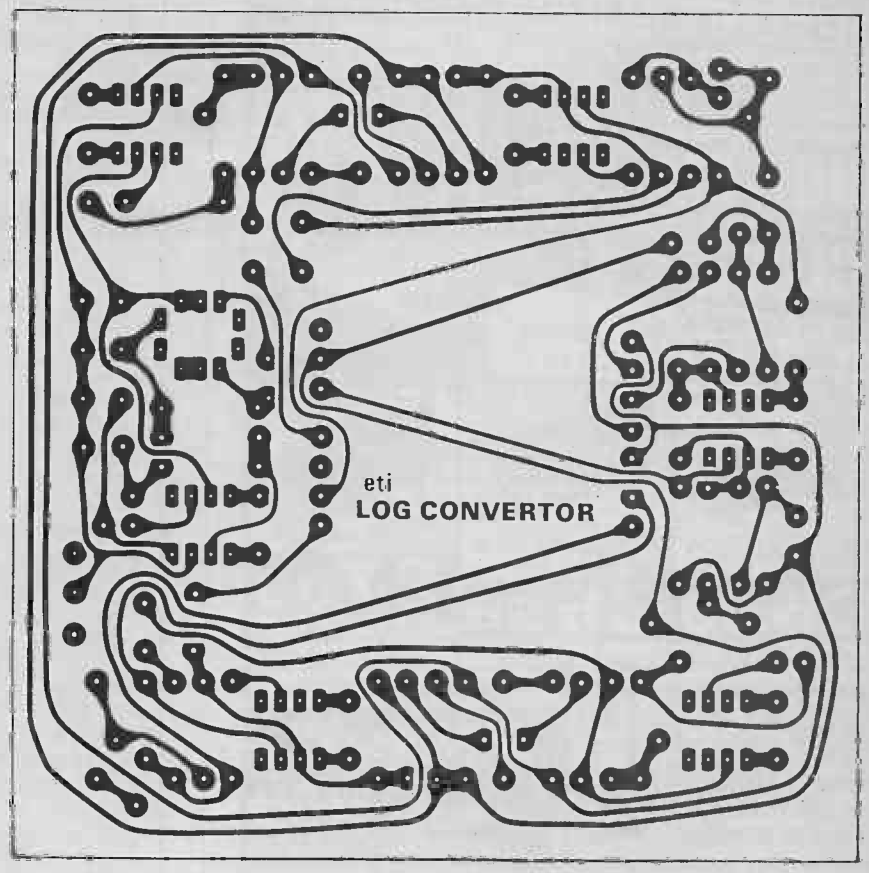
This table shows the relationship between the input and output. In the exponential model A is the input with B the output while in the log mode B is the input and A the output.

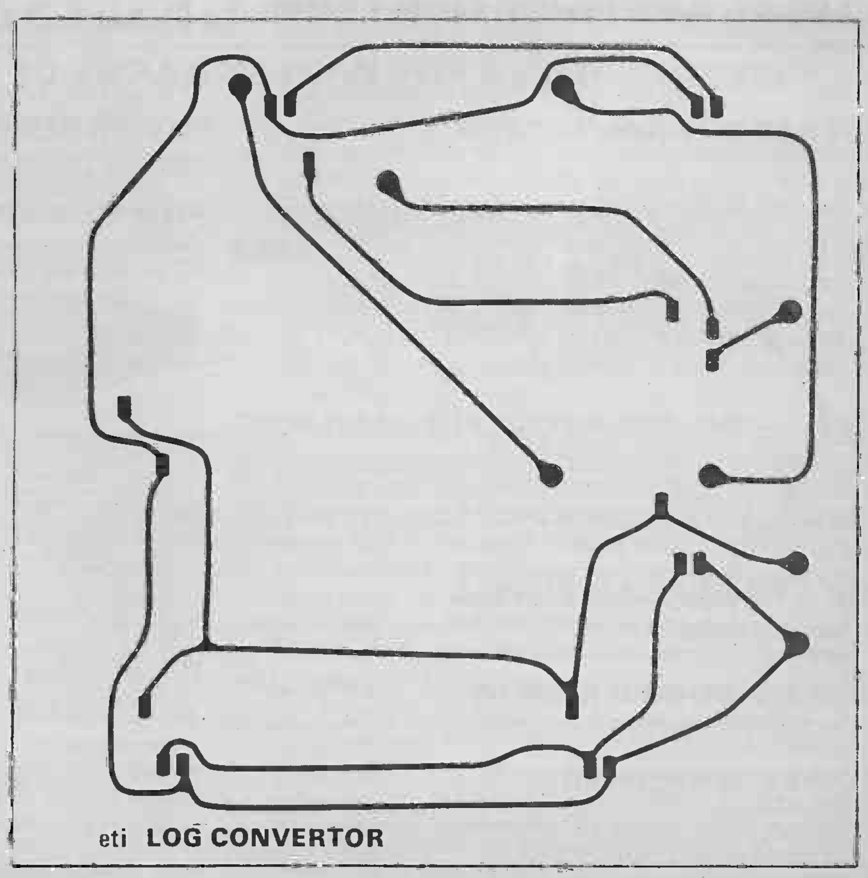
Oven Control
1. Before switching on, remove link 2 and fit link 1.
2. Switch on and monitor the voltage on the output of IC8 (pin 6).
3. Adjust RV7 until the voltage is about —5 V. The potentiometer is sensitive in this area but the actual voltage is not critical.
4. Remove link 1 and fit link 2. The LED should now come on for about two minutes before slowly going out. This indicates that the oven is stable.

Calibration of Log Mode
1. Set 0 V on the input.
2. Monitor the voltage on the junction. of R7 and R9.
3. Adjust RV1 to give a negative voltage on this point. Now adjust RV1 slowly until the voltage just switches positive.
4. Set 0.15625 V in the input.
5. Adjust RV5 to give 0 V output.
6. Set 5.00 V on the input.
7. Adjust RV3 to give 5.00 V output.
8. Set 1.25 V on the input and check the output voltage. It should be 3.00 V. If it is higher go back to step 4 except adjust RV5 to give —0.010 V and use RV1 to bring it back to zero. Continue with step 6. 7 and 8. If the output voltage at 1.25 V input is less than 3.00 V adjust RV5 to give +0.010 V instead of —0.010 V.

Continue until all three points are correct.

Calibration of Exponential Mode
1. Place a link between the junction of R7 and R9, and 0V.
2. Adjust RV5 to give 0.00 V output. Remove the link.
3. With 0.00 V input, adjust RV1 to give 0.15625 V output.
4. With 5.00 V input, adjust RV3E to give +5.00 volts output.
5. Check output voltage with 3.00 V input. It should be 1.25 V.
6. If high repeat steps 1-5 except output. If low, repeat steps 1-5 except adjust RV5 to give about 10mV output. ETI





Both sides of the PCB shown full size. On the top is the underside and the pattern beneath that is for the topside of the board.

microfile

This month dynamic Gary (mines a pint) Evans goes random, ROMs the seas as a pirate and plays strange games with a T.V., but still finds time to visit North London.

BEING CAUGHT PIRATING software could lead to all sorts of unpleasantness—boys in blue or more likely the boys in black (the legal eagles) looking for a large fee in some test case. At any rate copying, or rather being caught copying, software that someone, somewhere is willing to protect is something to avoid. It's for this reason that the guys at Transam — they who supply kits for the Triton — suffered a few nervous twitches when they heard that someone called Dobbs on the phone and he wanted to have a few words with them.

Now the BASIC that was used in the Triton has been around for some time. When development of the computer started we realised we could not undertake to write an 8080 interpreter from scratch and we looked around for something that was "in the public domain". The listing of an interpreter that appeared in Dr. Dobbs journal seemed to us to be just the thing we wanted — had we made a dreadful mistake.

Well gentle reader (I'm an Asimov fan) as it turned out we need not have worried at all. On picking up the phone, instead of some irate, distant American voice a softspoken northerner (north of England that is) greated the ear.

This Dobbs had nothing to do with publishing a software journal working — as it turned out — for British Rail. He wanted to order a Triton.

Relief all round — is there a Mr. Byte in the house. What the manufacturers produce today, industry uses the next day and we, the amateurs, use the day after that and what the manufacturers are producing now are 16 bit MPUs. Intel, Motorola, Zilog Texas — everybody seems to have caught the 16 bit bug.

The first small system for the Home Office to use a 16 bit beast is almost certain to be the long awaited, and much talked about, Texas machine. Just what overnight "quantum jump" in performance these 16 bit based systems are going to provide, remains to be seen — but at least we should have something with a bit more to offer in terms of throughput and facilities than the current crop of 8 bitters. At what cost penalty will become evident over the next year or so.

Dynamic RAMs are very cheap, are they not? A couple of systems in use in this country feature such devices — the TRS-80, although here any cost savings do not seem to be passed on to the end user, and the NASCOM.

The more extensive use of dynamic RAM in small systems is probably a hang over from the days when it was all anybody could do to get a dynamic memory card up and running. There is no doubt that a dynamic card can be a real pig to fault find. So many things have to happen at exactly the right time for the system to work at all. Unless some very sophisticated diagnostic equipment is available, it could prove almost impossible to decide what is wrong.

With the current crop of dynamic RAM controllers, however, hopefully there will be so little margin for error that we shall start to see nice cheap 4K and 16K memory expansion systems.

One example of a RAM controller that seems to do it all is the Intel 8202 — I have not yet managed to get a data sheet for this device but when I do I'll let you know just what it can do. In the meantime, if any of you have played around with dynamic devices, perhaps you'll let me know how you got on.

The North London Hobby Computer Club seems to be going from strength to strength. I was at their second meeting a while back and there was standing room only in the two rooms occupied by the club for demonstrating on the PET and the Triton. A continuing program of interesting talks and demonstrations is planned and if you live in North London, is recommended that you go along to the North London Poly in the Holloway Road and see what is going on for yourself.

Mine of Information Ltd is a company that is out to contest the high prices charged for many of the American microcomputer books brought over to this country. To quote from their literature "some worthwhile books are distributed by companies with exclusive European or British rights; there is a temptation to capitalize on the monopoly by increasing prices. In these circumstances MoI has to charge its customers more than is reasonable! MoI is taking action to contest the high prices. (When the choice of books is wider there will be no need to buy from such suppliers)."

A freshing attitude, as I can think of at least one outfit which must be making a mint from a number of exclusive titles sold at a high mark up. Some increase in cost from a straight $70 £ conversion is acceptable — to quote MoI again — "It means extra hassle and expense to bring books to Britain" — but not as much expense and hassle as some would have us believe.

I wish MoI luck in their campaign and if you would like their lists send an SAE to

Mine of Information Ltd
1 Francis Avenue
St. Albans
AL3 6BL

By the way members of the North London Computer Club get 10% off the prices in the list — yet another reason to pay a visit to the club. ▶

NEWS: Microfile

The trend in America at the moment, or at least one of the trends, is for the home computer and the TV games to meet in a sort of common ground. One example of such a product is the Bally Arcade "box". The machine features a calculator style keyboard with slot for a Bally cartridge as well as sockets into which a number of accessories can be plugged, these include the two hand controllers supplied with the basic machine.

The machine features a number of built in games including the excellent gunfight which many of you may have seen in the arcades over here. This game produces good high resolution graphics in colour as well as a repertoire of musical sounds.

By plugging a ROM cartridge into the font panel socket additional games can be played on the machine and if a BASIC cartridge is used the Arcade is converted to a computer running the familiar TINY BASIC as per the TRITON.

Z80 based, the Arcade is supported by 8k of ROM to store the resident games and 4K of RAM which acts mainly as a screen memory.

The Bally Arcade is not the only product to appear in this area. Magnavox has the "Dyssey 2" machine from Interacot and it's rumoured, Atari are ready to launch something into this market.

ETI

CLICK ELIMINATOR

The Cat Sat On The Mat: or was there one of your favourite records on the mat? Never mind — ETI steps in to rescue your valuable vinyl from those evil clicks and pops.

EVEN THE MOST fastidious of record collectors must have some records in his collection which during their career have picked up the odd scratch or two. Perhaps your record collection dates back to the time before you obtained that second mortgage, sold the wife or whatever, to get the latest in laser controlled fluid damped, tangential tracking phonograms, sorry record deck, and the previous system has left it's mark on these early platters.

In The Click Of Time

However the scratches got there, they are bound to be obtrusive on any reasonably Hi-Fi set up and even if you do not qualify for the title Hi-Fi purist — someone who listens, not to the music, but to the defects, real or imagined, in the Hi-Fi chain — the clicks will detract from your enjoyment.

Enter ETI — we can help. The click suppressor described here will remove or greatly reduce the audible transient sounds — nice phrase — resulting from scratches on a record's surface.

Design Decisions

When designing a click suppressor it is fairly obvious that we have to be able to tell the click from the cacophony as it were. Fortunately a click has several unique characteristics which set it apart from a music signal. For instance it will have very fast attack and delay times — even high frequency percussive sounds will delay slowly, although attack will be fast. A click will also be of a very short duration — again musical sounds are in general of a longer duration.

Once we have spotted our click, it is necessary to remove it. In our case we substitute a short period of silence — subjectively unnoticable — in place of the click.

As our click detection circuit requires a finite time in which to operate, we will also have to provide some sort of delay for the music signal within the system. Our circuit, and all the commercially available units, use a CCD delay line to provide this delay. It is the recent availability of this device that has made the click suppressor possible, or rather brought it within the financial reach of the constructor. ▶

Next month we will be giving the full details for building and setting up the Click Eliminator

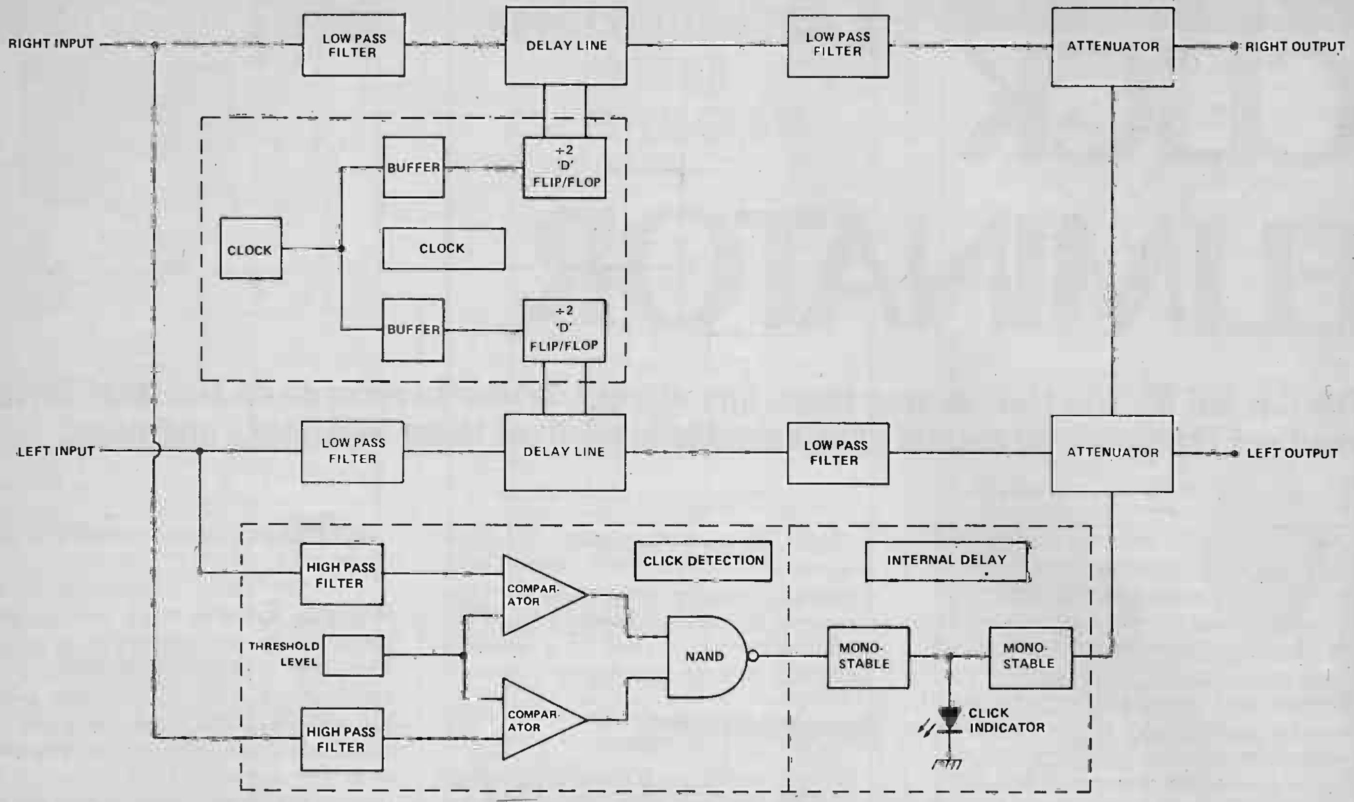


Fig. 1. Block diagram of the ETI click eliminator.

HOW IT WORKS

Overall operation of the circuit can best be understood by reference to the block diagram shown in fig 1. The signal from each of the inputs is fed both to a delay line, with associated low pass filters, and to the "Click Detection" block. This provides a negative going signal at it's output coincident with a click appearing on either input channel.

With the click identified, the next step is to remove it without affecting the subjective quality of the program material. The circuit operates by dramatically attenuating the signal passing through the unit for a brief period of time "Either Side" of the click.

If the attenuation is large enough and it's period accurately synchronised to the occurrence of the click, the effectiveness of the unit is dramatic. The loss of program material during this blanking period which might be thought to be as objectionable as the click itself, seems to produce little subjective disturbance.

It has been shown that periods of attenuation of this nature, up to 10ms, do not unduly disturb the signal, and the 2ms or so necessary to "straddle" a click goes entirely unnoticed.

It is necessary to incorporate a delay line within the circuit as a finite time is necessary for the click detection circuits to operate. The chain of events is shown in fig 2. The click is fed to the input of the delay line and at some time later will emerge from this device where it is passed to the attenuator. Meanwhile the click has been detected and activates two 555 timers acting as monostables. The first provides a click detection indicator for the front panel. As this returns to it's stable state, it triggers the second 555. It is this IC that causes the 570 IC to suppress the signal.

By careful selection of the timing components associated with the 555's, the signal is blanked during the time when the click is emerging from the delay line.

A detailed description of the various circuit blicks now follows.

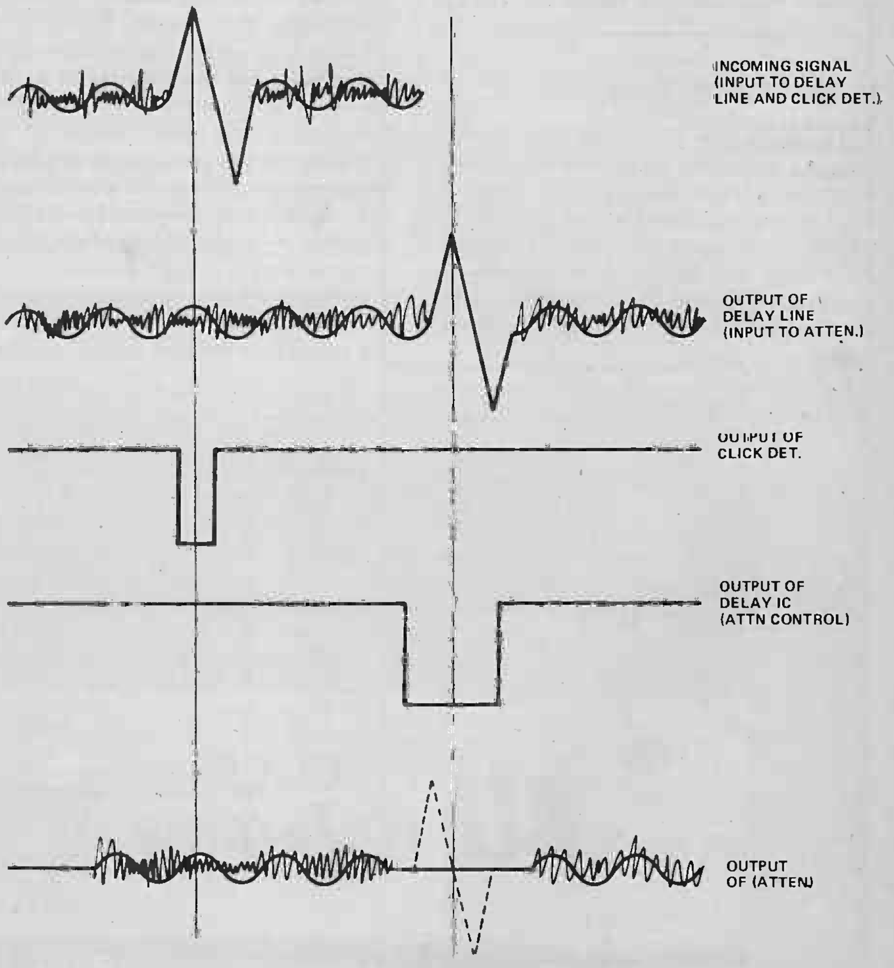
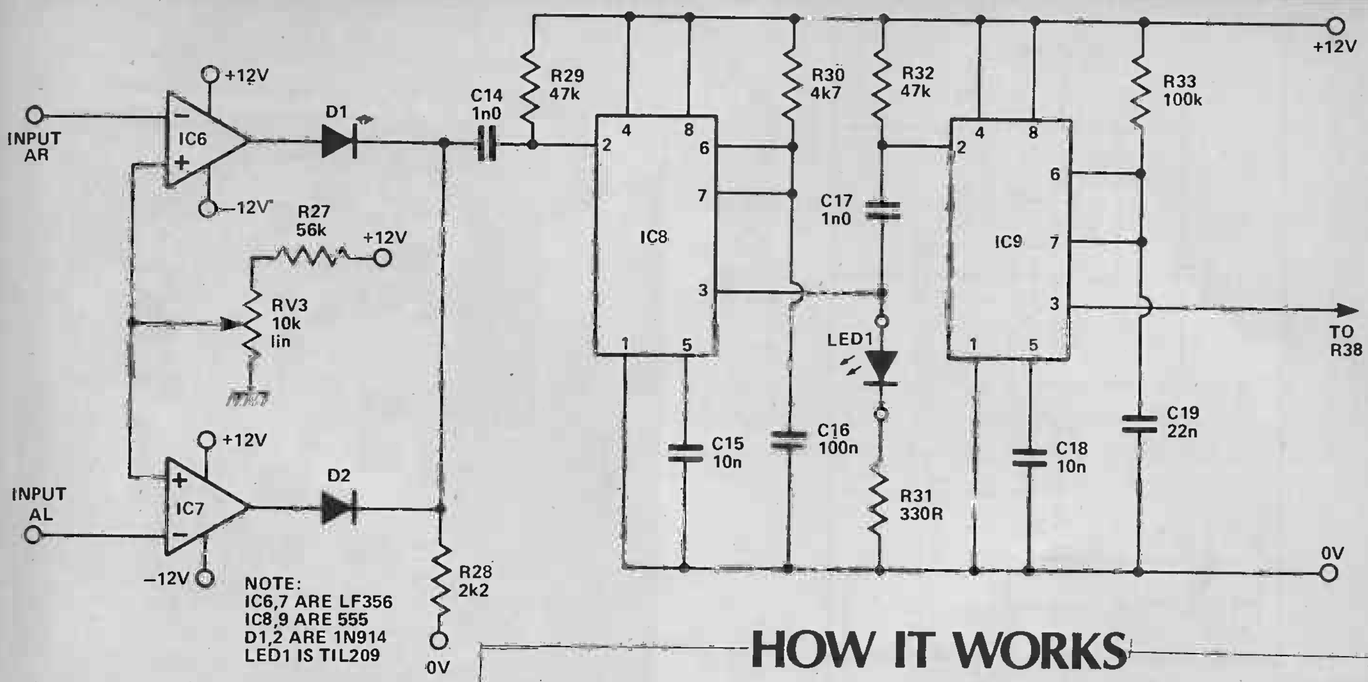
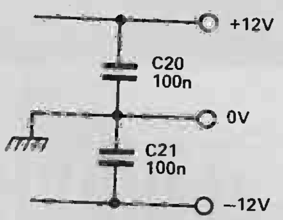


Fig. 2. Above are shown the waveforms that illustrate the action of the circuit when a click has been identified and is to be suppressed.





Second stage of the "click detection" circuitry.

HOW IT WORKS

CLICK DETECTOR AND ATTENUATOR CONTROL

Outputs from the low pass filters described above are passed to comparators IC6 and 7. The outputs of these IC's are usually high, but if the level at their inputs exceeds a level (set by RV3) they will go low. This control is set such that the comparator will operate only when a high amplitude click is passed to IC6 and IC7, the click being of greater amplitude than the program material.

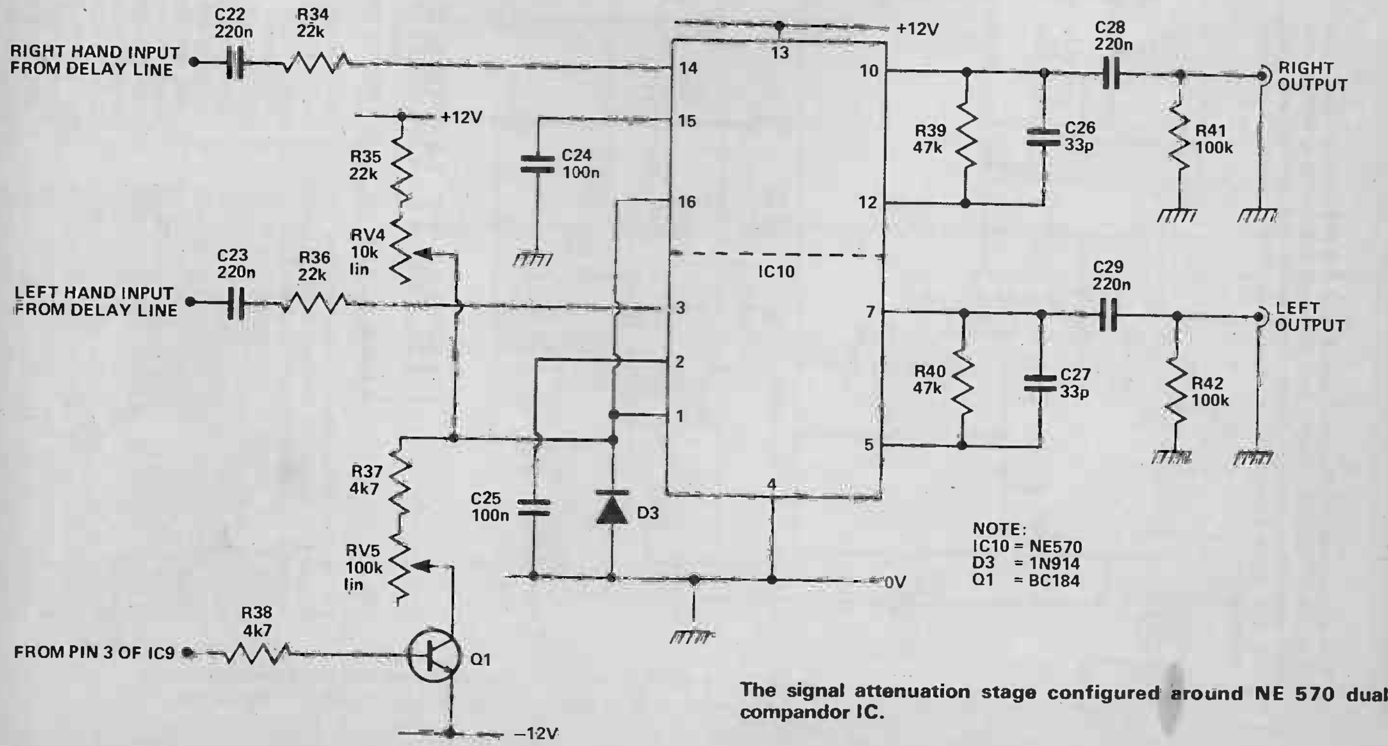
Another unique characteristic of a click is that it will appear on both channels simultaneously. We therefore pass the outputs of the comparator IC's to the NAND gate formed by D1, D2, and R28. The junction of these components and C14 will be high unless both the comparator outputs are low.

A negative going signal applied to IC8 via C14 will trigger this IC and illuminate LED 1 the click indicator LED. After X mS the IC's output will return to its stable state and in so doing will trigger IC9. This IC controls the attenuator and will suppress the program material during its astable state.

ATTENUATOR STAGE

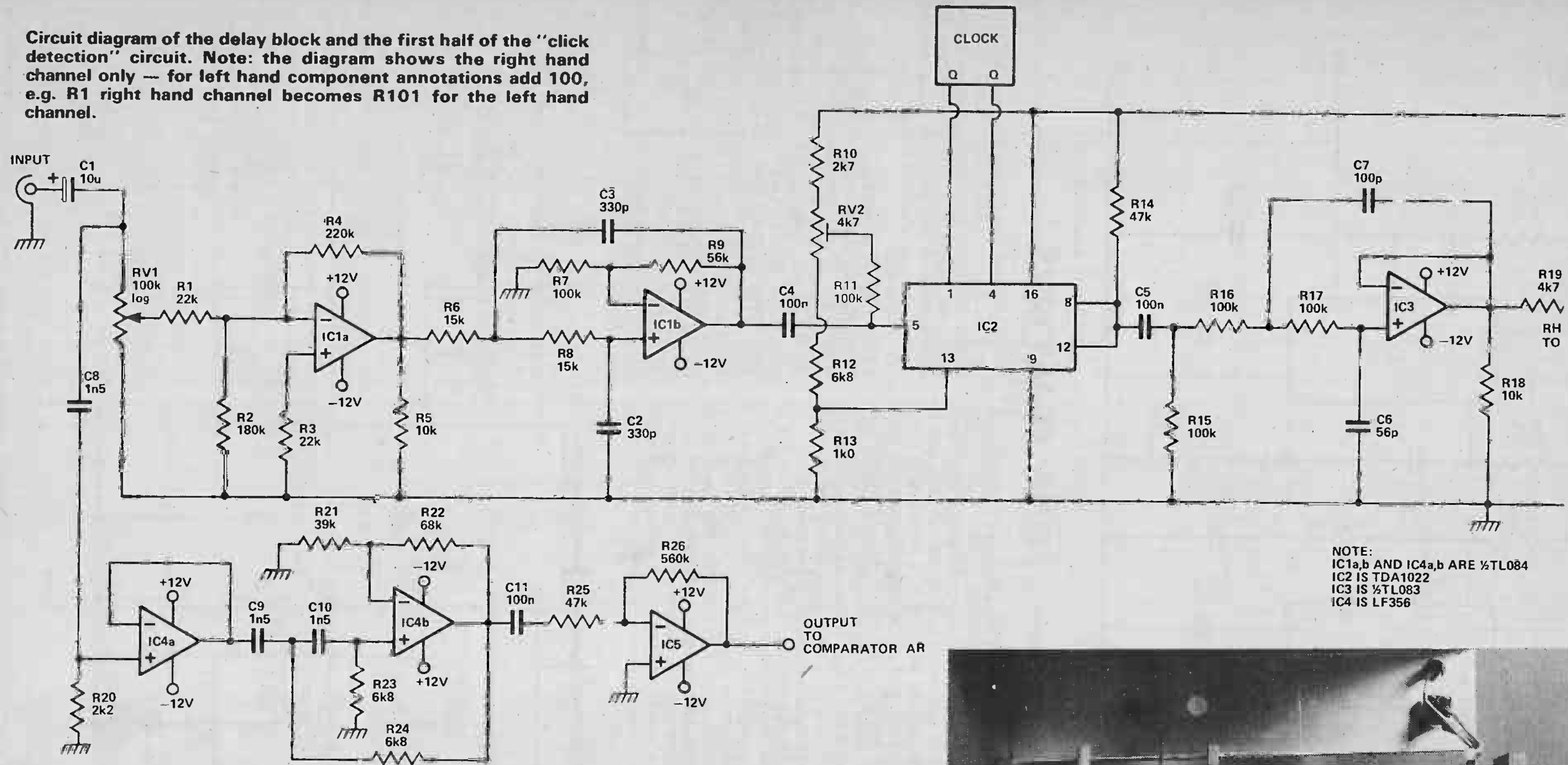
The attenuator is built around an NE570 dual compandor IC (see data sheet Oct 77 p.59). The inputs to the IC are at pins 14 and pin 3, the outputs — with suitable filters — are taken from pins 10 and 7. Gain control is achieved by robbing current from the NE570.

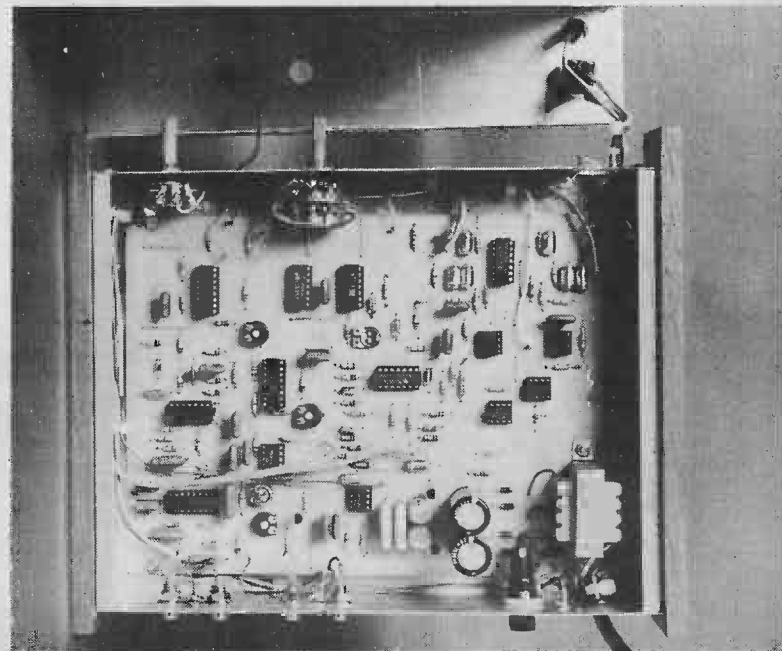
As the input to Q1 is taken high, the device will start to conduct and thus rob the NE570 of current, thus reducing the gain of the amplifier within the device. The control action is set up by RV4.



The signal attenuation stage configured around NE 570 dual compandor IC.

Circuit diagram of the delay block and the first half of the "click detection" circuit. Note: the diagram shows the right hand channel only — for left hand component annotations add 100, e.g. R1 right hand channel becomes R101 for the left hand channel.





HOW IT WORKS

DELAY LINE AND FIRST STAGE OF CLICK DETECTOR

The circuit block shown above forms one channel of the delay line and click detector circuitry (the other channel is identical).

The input signal is first passed to IC1a, which is configured as an inverting amplifier. The output from this stage is fed to IC1b and associated components. This stage forms a second order Butterworth filter with an upper 3dB point of about 18kHz. The stage also has a small amount of gain in its pass band.

This configuration ideally meets the drive requirements of the delay line, which suffers from an insertion loss, made up for by the passband gain and must have the maximum frequency applied to it limited to, in this case, the audio spectrum of frequencies. The reason for the frequency limit is that the maximum frequency fed to a delay line must not be greater than half the frequency of the clock signal superimposed on the output that might cause HF overload in subsequent stages.

The input of the delay line is pin 5, the filter section that forms the first stage of the click detector.

A click has a number of unique characteristics, one of which being that it is rich in HF energy — a result of its fast attack and delay time. The effect of passing the music signal through a low pass filter will be to highlight the high energy click amongst the generally low high frequency content of normal program material.

The low pass filter is once again built around a second order Butterworth stage. The signal is passed to this stage after a simple HF filter and buffer (IC4a). The output from the filter is amplified by inverting amplifier IC5 and fed to the second half of the clock signal used in controlling the device. If this precaution is not observed, the result is severe distortion.

The clock drive circuitry is described below.

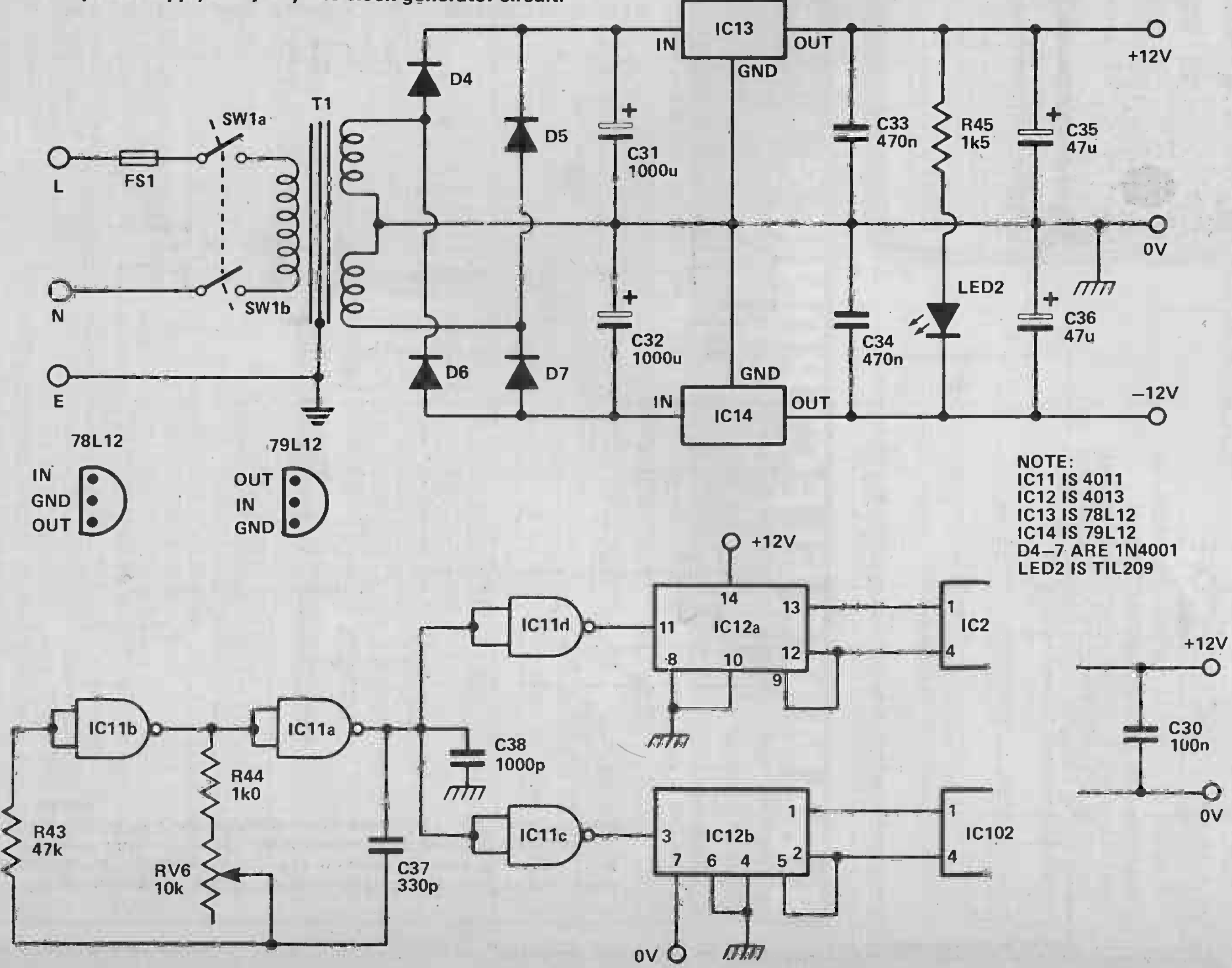
The input of the delay line kis pin 5, the resistor chain R10, R11, R12, R13 and RV2 is to hold pin 13 at 1V0 above ground, this ensures maximum dynamic range in the delay line, and to bias pin 5 for class A operation which minimises distortion.

The output from the delay line is taken, via C5, to another Butterworth filter, this stage being used to remove any high frequency click detector described below.

CLOCK AND POWER SUPPLY

Pins 1 and 4 of the delay line must be presented with 180° out of phase wave forms. The clock signal is generated by the CMOS oscillator based around IC11a and b, which after buffering is fed to the two D type flip-flops contained within IC12. The Q and Q outputs of this device provide the required 180° out of phase drive signals.

The power supply is a straightforward design based on two three-terminal regulators.



The power supply and delay line clock generator circuit.

PARTS LIST

RESISTORS

R1, 3, 34, 35, 36, 101, 103	22k
R2, 102	180k
R4, 104	220k
R5, 18, 105, 118	10k
R6, 8, 106, 108	15k
R7, 11, 15, 16, 17, 33, 38, 41, 42, 107, 111, 115, 116, 117	100k
R9, 27, 109	56k
R10, 110	2k7
R12, 23, 24, 112, 123, 124	6k8
R13, 44, 113	1k0
R14, 19, 25, 29, 32, 39, 40, 43, 114, 119, 125	47k
R20, 28, 120	2k2
R21, 121	39k
R22, 122	68k
R26, 126	560k
R30, 37	4k7
R31	330R

POTENTIOMETERS

RV1+101	100k log gang
RV2, 102	4k7 min. preset
RV3	10k
RV4, 6	10k min. preset
RV5	100k min. preset

CAPACITORS

C1, 101	10u 16V tantalum
C2, 3, 37, 102, 103	330p polystyrene
C4, 5, 11, 16, 20, 21, 24, 25, 30, 104, 105, 111	100n polyester
C6, 106	56p polystyrene
C7, 107	100p polystyrene
C8, 9, 10, 108, 109, 110	1n5 polystyrene
C12, 13, 35, 36	47u 16V electrolytic
C14, 17	1n0 polystyrene
C15, 18	10n polyester
C19	22n polyester
C22, 23, 28, 29	220n polyester
C26, 27	33p polystyrene
C31, 32	1000u 25V electrolytic
C33, 34	470n polyester

SEMICONDUCTORS

IC1, 4	TL084
IC2	TDA1022
IC3	TL083
IC5, 6, 7, 105	LF356
IC8, 9	555
IC10	NE570
IC11	4001
IC12	4013
IC13	78L12
IC14	79L12
Q1	BC108
D1, 2, 3	1N914
D4, 5, 6, 7	1N4001
LED1, 2	T1L209

MISCELLANEOUS

PCB as pattern, case (Maplin B3), phono sockets, fuse (500mA) plus holder, switch (DPDT), knobs to suit, cable etc.

.......news digest.......

POCKET ADVANTAGE

A wallet type machine with hold-on memory. The new TI 50 has two memories, some scientific features, some statistical features and will turn itself off after 15 minutes if you aren't using it. Up to 15 levels of parenthesis are allowed. There is even a 'battery low' indicator.

Available now, it will cost under £30 and be in most shops that sell this sort of thing.

SCREEN TEST

The UK is now Hong Kongs largest market for TV games. We absorbed 26% of their export in the field, some 523,506 items if you please, in the first eight months of this year. Germany finished second on 22% and the USA came third with 13%.

Somewhat of a surprise, and a shame, that we take more than the States of these items. I always thought we had more taste.

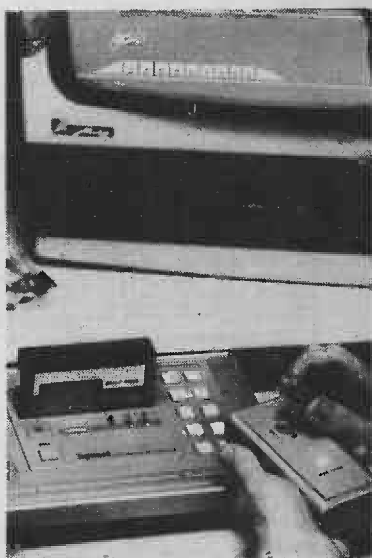
SHORTS

● Every Ready — now called Berec — have released four rechargable consumer batteries, in the HP2, HP11, HP7 and PP3 varieties. Chargers are also available. An undoubted reaction to the phenominal loss of dry cell power these days.

● Direct drive turntables yes. But direct drive MPUs? Also yes — now. The S2000 is a new release from AMI which can drive flourescent displays directly, with HT drive and 7-segment decoding on chip. Also on board 64 x 4 RAM and 1K ROM. Intended for low lost applications.

● Ingersoll — the tick tock people — are into electronics. They have released three TV games, three clock radios, two Door Chimes, and a portable micro cassette player. Photo shows one of their new TV games. It must be Christmas.

● Fairchild are making a big fuss about having their F16K Dynamic 16K RAMs available at last. Access times vary from 150 ns to 300 ns.



BORIS IN CHECK

There are quite a few chess machines lying around the shops these days, and this one has a reputation for being one of the best. Armed with his "Best of Spassky Volume 2" Ron Harris went to check it out.

BORIS is a multi-level chess machine with the disconcerting ability to comment on its opponent's (your) moves. The level of its analysis is set by the user who determines how long BORIS may consider its reply. Thus a tyro may set the machine to minimum time to begin with, and steadily advance the machine as he improves.

Present Arms

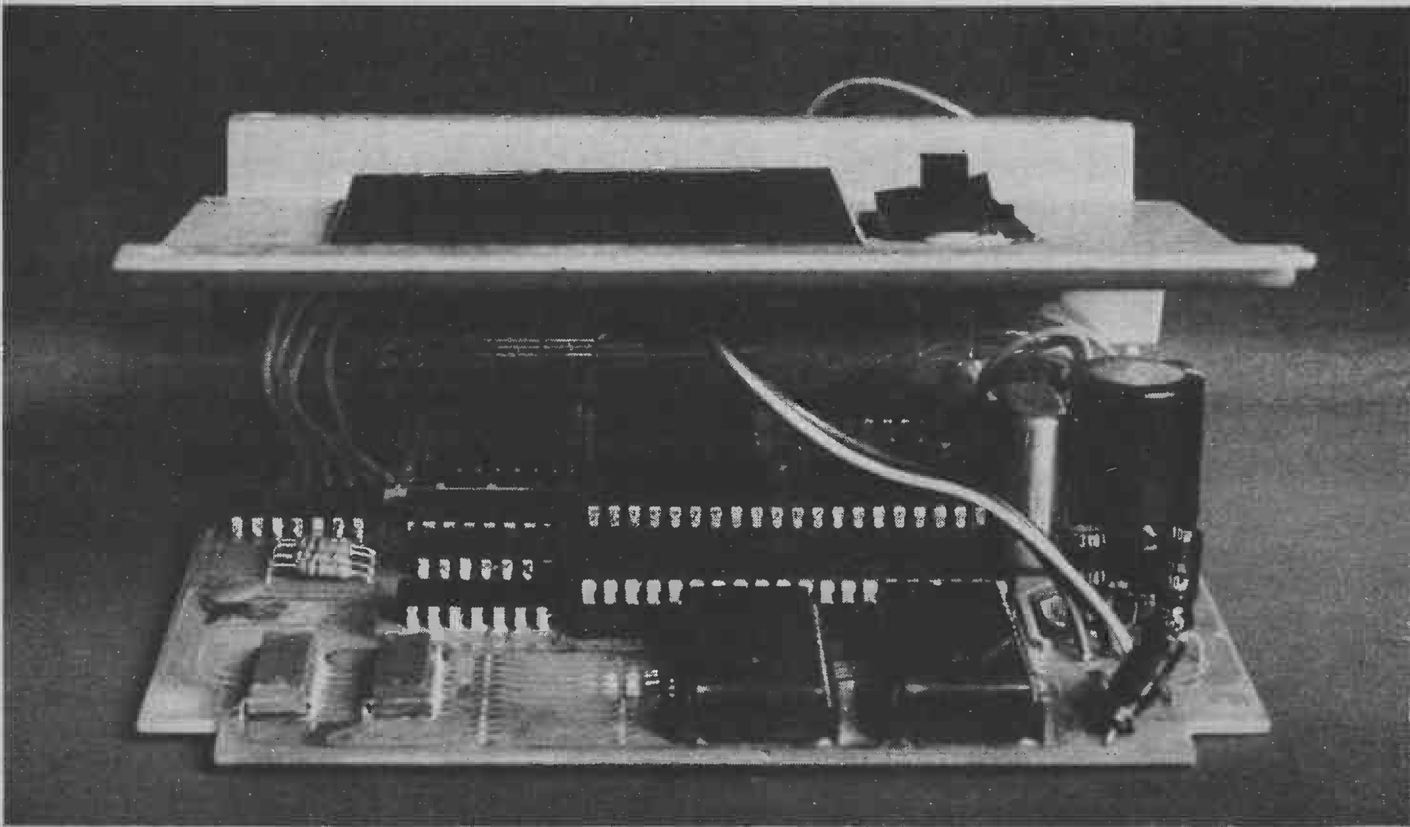
The presentation of the machine is excellent. The electronics consist of an F8 based system accessed by a 16 (multi-function) key array and interfaced to the outside world by a display consisting of eight alpha numeric devices. These are packed into a very smart wooden case which also holds the mains adaptor and chess pieces. A board is also provided, but is of a standard which suggests it is included out of duty rather than devotion. Alas, the chess pieces fall into this lamentable category also, but improvements are now being made by the importers, and the quality of replacements is much higher.

On the two units we were able to examine the mains adaptor terminates in a two pin American 'hi-fi' type of plug — which now fails BS of course. This is moulded into the adaptor body and makes life very awkward for the buyer. At first glance there is no way of getting mains into BORIS aside from wrapping wires around them. DANGEROUS. The importers *must* look into this very quickly. We are assured they are doing so — let us hope.

In the meanwhile I would advise purchasers to take a trip down to good ole Woolies and make off with one of their shaving adaptor plugs, into which BORIS's adaptor will neatly plug. 240V AC is a poor opening gambit in any game.

Getting Rooked . . . and Pawned And . . .

Using this machine is both simple and interesting. The keyboard sets up your move on the display — which is also showing elapsed time — and the ENTRY key presents it to BORIS for reply. ►



BORIS exposed to the world!

Once he's thinking about, the display flashes at 1 Hz, the timer counts down the time allotted to BORIS and the various moves he's cogitating appear on the display, settling finally at time 00 seconds. The display then counts down *your* time — but there's no penalty for not playing inside the time limits you've imposed on BORIS.

If for some reason (like cheating) you wish to alter the board at any time during a game, pressing RANK displays the contents of each row of the board using a very ingenious symbols set. The keyboard now creates or destroys pieces as required. Korchnoi could have done with *that* in his armoury. This makes correcting errors very easy.

Use of the RANK key while BORIS is having a think lets you watch the pieces moving around in his head(!?). Hypnotic.

Alpha-numeric Big Mouth

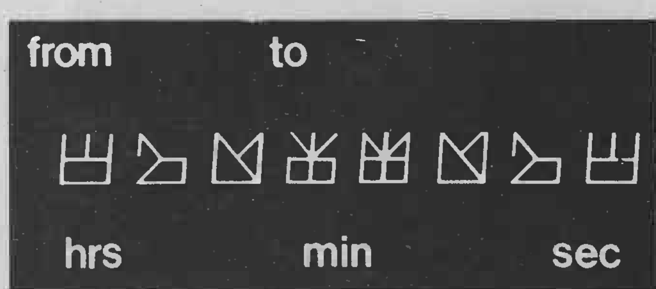
Undoubtedly the first thing to impress about BORIS has nothing to do with his chess abilities. It's his big mouth. Exactly how many comments his PROMs contains is anyone's guess — the importers Optimisation aren't saying — but we counted 47 in two evenings of chess, and I don't think we got them all!

The comments appear in the eight displays and are clocked along right to left at about 2Hz. At any position on the board the program limits BORIS to a shortlist of appropriate comments, and a 'random' choice is made amongst them — or indeed not to comment at all. Saying nothing is the most likely choice of all, which means that the sayings do not always appear and so do not become boring with repetition.

Play It Again BORIS

Once in play BORIS is a fair match for most people. On its basic level the machine plays a good beginner's game, and will find most things you leave lying around the board. Responses differ sufficiently even at this level to make 'psyching out' difficult. The biggest drawback of BORIS's chess is his passion for exchanging pieces.

Being cowards we started at this level to see what he could do. The first comment we got was 'AWFUL' to our opening move. Frightening! From here we kept increasing the time BORIS had to think about his answers. At five minutes he was winning consistently, and at two it's a long, long struggle to get him to lie down and die!



The symbols BORIS uses to identify the chess pieces. Shown here is the back rank of the white men. The black appear upside down so you can tell which men are which. Pawns appear as triangles.

Below: BORIS in play at the computer chess championship recently. He finished second to a private program.

We're only average chess players ourselves and so passed the infernal pawn-pusher onto a club standard player to get his comments.

On the longer response times, five minutes upwards, he considered BORIS a good opponent — and of course wouldn't admit how often he'd lost! Certainly everyone who had a game against him considered BORIS entertaining — the comments really do seem appropriate at times.

For example, in the middle of a game with BORIS hard pressed and the telephone ringing — I NEED LESS NOISE appears! Coincidence but fun all the same. One move away from being checkmated and he asks READY TO RESIGN? The classic must be after losing a queen to a knight fork — WHOOPS!

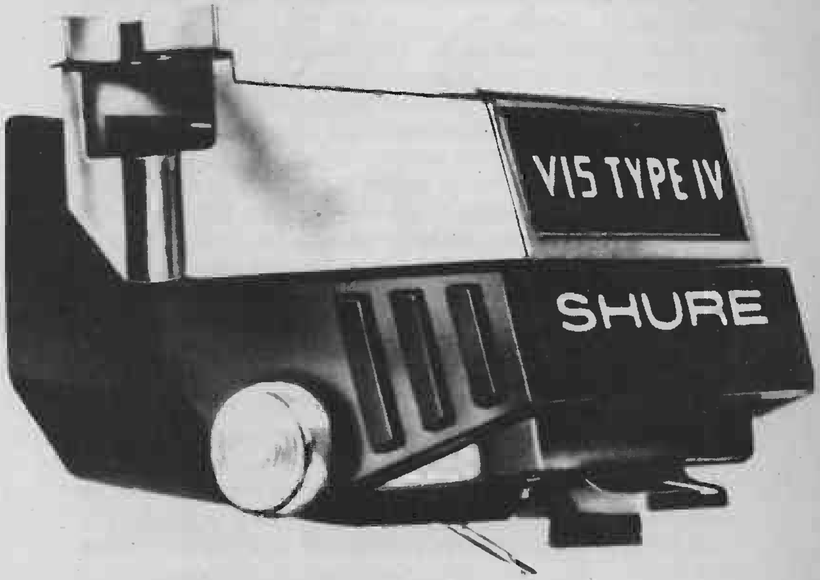
Conclusions

All in all then BORIS can be confidently recommended to anyone interested in the game of chess. It can play a good game, and entertain while doing so. It is very difficult indeed *not* to think of the machine containing an (evil) little elf — a grand master type elf — plotting against your every manoeuvre, and unleashing sarcastic comments where possible. A definite winner. ETI

Our thanks to Kramer and Co for their assistance in the preparation of this article — they lent us a BORIS! (They also supply to the public!)

audiophile

What would you say if we told you about a cartridge which has a totally new stylus shape, a new improved magnet structure and revolutionary two part cantilever system — and a new radically different method of controlling operating conditions? It is all true, and its been around a few months too! Ron Harris took his time getting to the V15 Mk.4 — but found it worth the wait!



IT HAS BEEN some time now since the launch of the V15 IV from Shure, and by now I hope all the fuss has died down. Never has a product been rumoured to appear for so long, and met with such polarised comment when it did. In the meanwhile since the release the cartridge has slowly gained ground, and now would appear to be highly regarded in all but the most partisan anti-moving-magnet circles.

Changes By Design

There is a lot in this design to interest the engineer, so let's consider that aspect first. The criteria to be met were to produce a cartridge which performed as close to perfection as possible under ideal conditions, and which went some way to creating those conditions.

The ambition I applaud!

Naturally these days computer analysis of just about anything numerically expressable was undertaken — and quite right too! Everything down to body size and mass were considered, and then more models set up to attempt to blend the whole design successfully. (I don't think it would be an outrageous suggestion to make that the SME Series III was used as the optimum arm in all these cavortings.

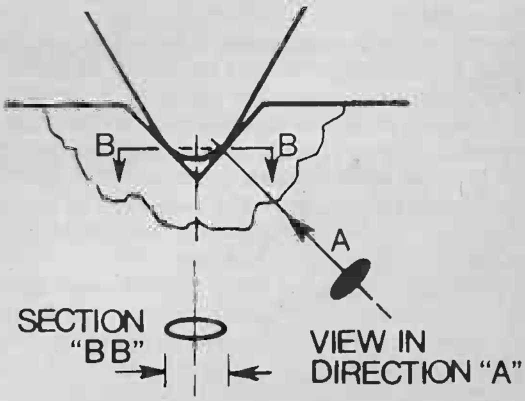
The new features to come out of of all this are a dynamic stabiliser — and it's *not* just a brush, a new cantilever assembly; a new stylus shape, and a static reduction system. In addition the effective mass of the dynamic system has been lowered significantly.

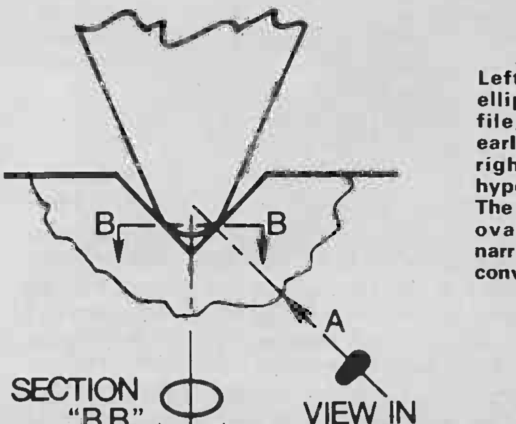
Tipped For Shape

Shure have decided, somewhat bravely, to go it alone and produce a new stylus profile. The reason is they wanted lower distortion but without sacrifice of low wear and trackability in the process.

Any design for a stylus *must* include consideration of such factors as the actual groove itself, tip mass, manufacturing cost, record wear etc etc.

As you can see from the diagram the end result of Shures endeavours is a long contact profile, basically a hyperbola from the front, termed a hyperelliptical design. Its actual contact radius is around 38 microns, while its tracing radius (parallel to groove tangent) is smaller than other types. The compromise does appear to offer advantage over other types, right enough.





Left: a conventional elliptical stylus profile, as used in the earlier V15/III, and right, the new hyperelliptical prfile. The "footprint" (black oval) is longer and narrower than in the conventional profile.

▶

Magnetic Heart

The cantilever assembly is always the first section to come under scrutiny whenever a cartridge is to be improved, (just shows what improvements *could* be made if you ask me!) and it has not escaped this time.

After much playing with computers and trading off advantages against system requirements, Shure put themselves some prototypes together and carted them off for listening tests. Measurements, mathematical models and ears later a telescopic two element design emerged as the overall best solution, and was duly adopted.

Part of the reason for this is vibration control — presumably to supress resonances excited by dynamic stresses — and this is assisted by an elastomer damping device. The earlier M24 featured something like this, but not so sophisticated apparently.

The magnet itself is of a new type, of lower mass but higher strength than its predecessors, allowing the cantilver unit mass as a whole to be lower. Taken together the improvements to the system are claimed to provide better high frequency tracking ability, and the shifting of the HF resonance to beyond 20 kHz.

Brush Up On Damping

Now down to the obvious bit — which I had to do last just to keep you reading. Static on records can be blamed for most of the ills besetting disc reproduction as it now stands. It attracts dust — and holds it — leading to quicker wear of both disc and stylus and higher replay noise.

There are umpteen devices on the market for clearing static charge, most of which resemble gas lighters. But Shure make the valid point that unless you know what polarity the charge is you're trying to clear, you've a 50-50 chance of making if worse by pumping ions at it.

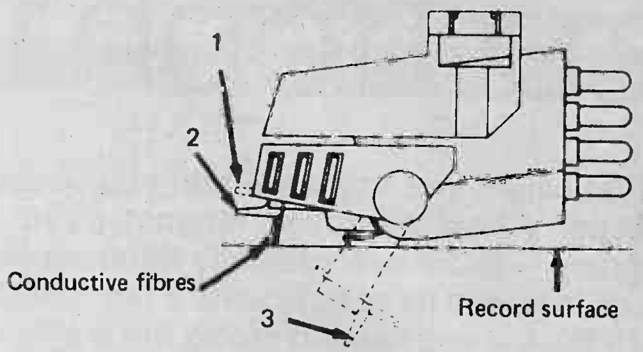
Another nasty well-known to LPs of all age groups is the warp. Warps come free with most records these days and provide such delights as variation in tracking angle, mis-tracking due to effective reduction of applied tracing force and overall disruption of the ideal conditions in which cartridges like to operate.

Damping applied at the arm pivots can help with this, but represent a compromise at best. It is better to have the control as close to the tip as possible. The dynamic stabiliser is designed to do exactly that. The carbon fibre brush is mounted to ride just ahead of the stylus, and is equipped with viscous damped pivots. These are designed to absorb the shock produced by a warp, be it gradual or sudden. The optimum distance between cartridge body and record is thus preserved.

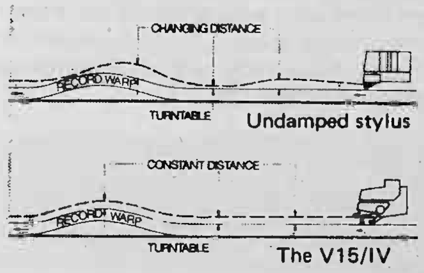
Bristling With Pride

That brush is made up of about 10,000 carbon fibre bristles, ten of which would fit nicely into a record groove. Since it is carbon fibre it is conductive and can leak static charges to system earth since it is connected to one channel earth. Shure's research has indicated too that local static charges can increase tracking force by attracting the cartridge to the LP!

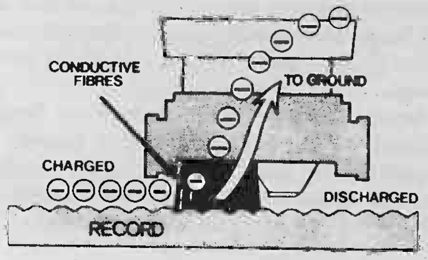
Sounds logical once someone tells you doesn't it? The brush does a good job shifting dust and muck out of the way too!



The outrigger carbon-fibre brush may be set in any one of three positions: 1) in the "Up" position. 2) the dynamic stabiliser in its operating position 3) set down as a guard.



The V15 Type IV's brush with damped pivot is said to aid the tracking of warped discs by matching stylus movement more closely to the motion of the arm



The carbon-fibre brush is in continuous contact with one of the earth pins and leaks static charges to earth.

Having A Fit

Setting up the V15 was very simple indeed. It's a shame to have to take it out of the box at all unfortunately, the packaging is superb indeed! Holding the body into the arm is done by screwing into a small metal block tapped for the bolts. Simpler than using fiddly nuts — if you'll pardon the expression — but probably more massive.

A close-up view of the stabiliser fitted to the V15 Mk-4, reposing in its guard position. The white line tells you where to line up the stylus when at play!

Because of the stabiliser, the stylus sees 0.5g less than is applied to the arm as a whole. This means that to get 1g tracking force, you set 1.5g. It can look confusing at first, and don't forget later and clip up the stabiliser, else the cantilever gets the lot!

Tracing Class

After brief experiments, all our tests were conducted with 1g applied to the stylus, as the V15 tracked anything at this weight, regardless of how torturous we made our torture tracks. I failed to catch it out even once. Foiled again. One to Shure.

In contrast to the Mk3 the new model is sensibly specified for capacitive loading, and is apparently as insensitive to these things as it can be. Using a Sony TA-88 preamp enabled me to vary the loading while the cartridge was playing — a reviewers delight! No adverse effects can be expected in normal use. Noise seems to be reduced too.

The stabiliser does offer real benefits as it definitely aids tracking and makes the system as a whole very tolerant of record 'flatness'. I tried the cartridge with and without pivot damping on the SME and would suggest it be used *with* damping — it somehow gains confidence that way!

Sound Stuff?

This is the bit where I lose some 'musical' friends no doubt, because whatever anyone may have said amid the initial rash of reviews you will not find a cartridge better at information retrieval than the V15 IV. Its sound is incredibibly detailed,a nd free from audible vices. It has a nice confidence about it altogether, and did not mis tracks — or mis-anything — even once.

The sound has an overall smoothness that is perhaps its most 'nameable' feature. The bass quality is good, although I have heard better. In the mid-range and treble the sound stands forward towards the listener presenting a good stable image with all the detail you could wish for, with no trace of hardness or brightness whatsoever.

Conclusions

So there it is — interesting and worth the wait for its appearance. Whether you like the sound of the V15 or not only you can tell, but if you're considering spending around £70 on a cartridge you'd be ill-advised to miss listening to it.

●

Main Trouble

One of the most oft repeated queries to Audiophile concerns the problem of mains borne clicks and pops appearing out of loudspeakers.

Unfortunately there is no immediate overall solution. The first thing to try is to move either the hi-fi or the appliance — usually a fridge — causing the clicks to another outlet.

If this doesn't work then there are several suppressors on the market, at varying prices, to deal with the trouble. The most expensive is the QED unit at about £10. It does work in most cases, but no more so than some others.

The cheapest such unit available is probably the RS mains suppressor. Your local component stockist should be able to order this for you, and fitting it is pretty simple. Its input comes from the mains, and its output feeds the hi-fi in question.

Otherwise

If none of this works then pretty obviously your problem is not mains borne. For radiated problems there's not much you can do except move things around. This is pretty rare though.

●

Change Of Load

Above is the Sony TA88E preamp I mentioned a couple of months ago. Next month I'll be going through the circuits of this device in detail, as it represents a job done very very properly. At £699 so it should. The effect of all this engineering on the sound proved to be interesting too.

ETI

A TECHNICAL MEMORANDUM

By Simian

DURING THE LAST FEW weeks some valuable research work has been incorporated into BSI and MIL standards, and this will greatly ease the specification of equipment. These standards help to combat a hitherto neglected environmental hazard; the users of equipment. A range of Standard Idiots (SIDs) has been defined, and these will be useful additions to any development laboratory.

Using Standard Idiots

Standard Idiots are useful both for acceptance testing of incoming equipment, and for developing foolproof electronics. The latter is of particular value to manufacturers producing consumer goods. In general the technique of using SIDs is very simple: it consists merely of letting them come into contact with the equipment to be tested. Any flaws will be quickly shown up.

SIDs locate ergonomic faults very rapidly. It is instructive to watch them at work sometimes. If something is weak, they will break it; if no-one in their *right* minds would dry-off a poodle in a microwave oven, they will do just that.

Almost all old-style quality-control testing can be abolished. If SIDs are allowed to get at all products before they leave the factory, it will be found that only the perfect get through. This reduces the number of complaints received from users, but the cost of disposing of the rejects (in bulk) can be rather high.

Types of Standard Idiot

Several specialist schools have been set up to train SIDs since these students are not well received at normal colleges. The coursework is intensive, and there are rigorous examinations to maintain standards. Over 600 people have received a Diploma in Idiocy (Dip. I) to date.

Many people have been found to have a natural aptitude for this work.

There are various grades of SID, ranging from the merely incompetent to those capable of sinking the Titanic, and there are many specialist fields:

(1) The 'non-technical' person (BS 91000-FOOL). This type normally panics when faced with more than two control knobs simultaneously. She (sometimes he) always mis-tunes radios, and would be hard put to it to recognise the difference between a watch and an oil refinery.

(2) Fiddler, or fidgeter (MIL-ID-99436/010). This type is rapidly becoming an industry standard; the real word is full of them. If, for example, there is a switch controlling a lamp, the fiddler will flick it on and off for hours until either if breaks, or he spots something more exciting to play with. He will also use calculators to divide numbers by zero or to find arcsin(-10).

(3) The Ph.D (MIL-ID-12345/678) never reads instruction manuals. 'Of course, it's obvious that this piece of equipment works like so . . .' It is only when clouds of blue smoke issue from a new £2,000 oscilloscope that he scuttles back to his desk to read in the unused handbook that this model is for 110V, not 240V.

Ph.Ds are often quite intelligent.

(4) Dismantler. A member of this species is guaranteed to dismember any piece of equipment which he owns or uses. However, it is very rare for the article ever to be re-assembled. (They are usually foxed by the new child-proof pill boxes).

There are a few other specialist categories: for example, the 'jonah', whose mere presence in a room is enough to make clocks stop and television sets neurotic; or the Standard Irishman with fourteen fingers.

Disadvantages

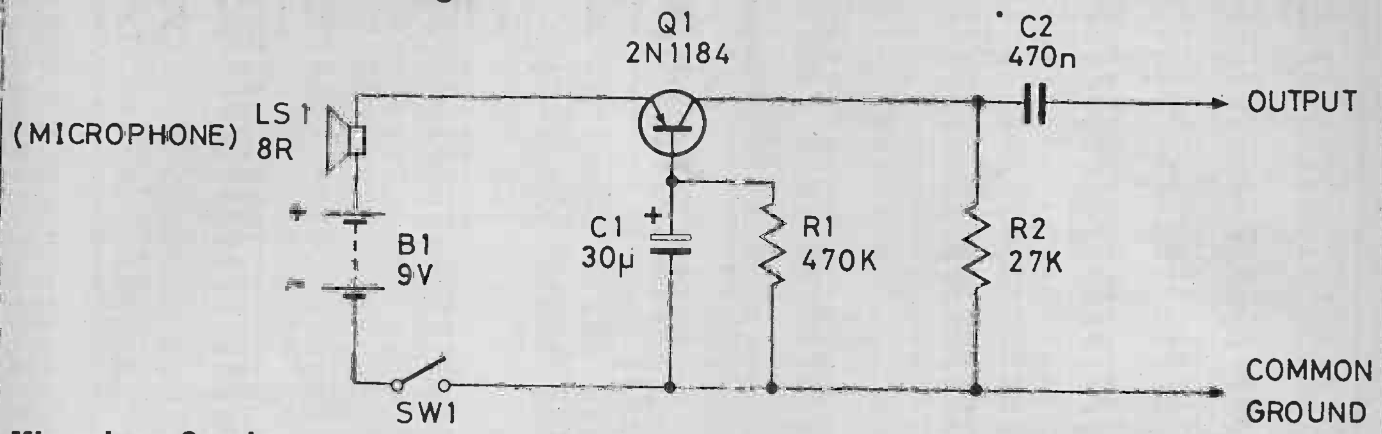
One major problem with SIDs is that of storage when they are not in use. Obviously they cannot be left to roam freely around the lab.! Normal work under these conditions is difficult. Even when they are stored in cupboards the voluble and plaintive cries of 'let me out' are disruptive.

There is another hazard which should not be overlooked: there have been a few unfortunate cases where standard idiots have been mistaken for engineers. Most of the companies where this has happened have now ceased trading.

Conclusions

Standard idiots, in their present form, can be useful development tools, but there are associated hazards; on no account should they be left alone to amuse themselves. The new specifications are a major advance in a naturally chaotic field and standard idiots are adding a new dimension to destructive testing. This technological advance is helping to provide jobs for those people whose natural talents previously made them unemployable.

ETI



Microphone Speaker

J. Smith

What do you do if you need a microphone in a hurry — the shops are closed and your friends are on holiday? Or you are just a little short of money? The answer is to build the following circuit from your odds and ends box. This circuit uses a small speaker as a microphone, one transistor and only four other parts, draws only about 2 mA of current from a 9 volt battery so an on/off switch is not really necessary.

The transistor shown is 2N1184 and is a PNP germanium medium power type but is not critical — try the ones you have first before buying this new type. The components too are not critical and the prototype was found to work OK with 20% variation in values. The output is high impedance and is fed into the mic input of a tape recorder or pick-up input of an amplifier.

Speed Alarm

D. Ian

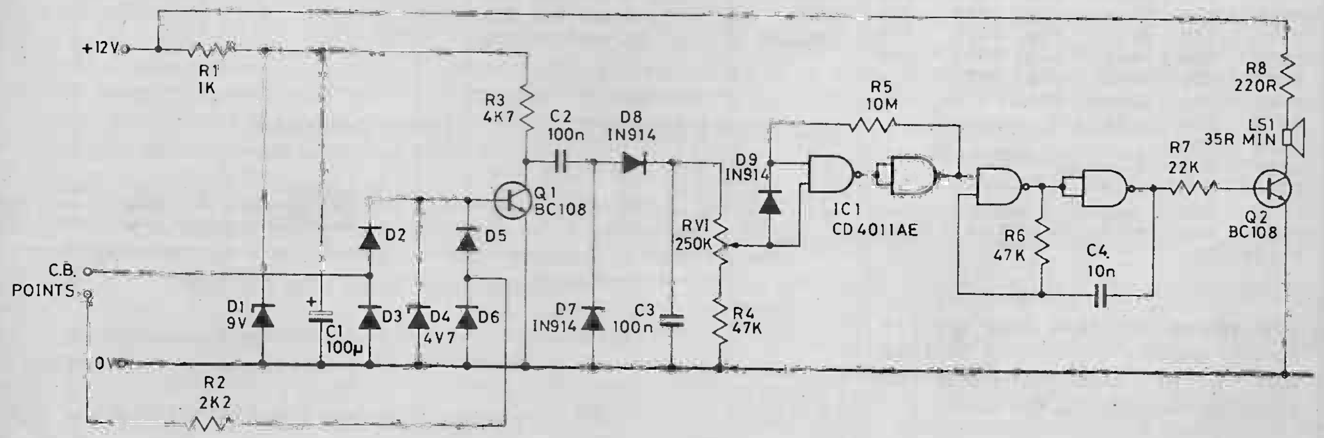
It is all too easy, during a long journey on a motorway, to allow one's speed to gradually creep beyond that point which the boys in blue take an unwelcome interest; this alarm gives an audible nudge whenever you drift over a pre-set speed.

Pulses from the distributor points (due to the ignition coil up to 400V may be developed as the points open) are passed through a current limiting resistor, rectified and clipped at 4V7. Via Q1 and the diode pump a DC voltage, which is proportional to engine revs, is presented to RV1; the sharp transfer characteristic of a CMOS gate, assisted by feedback, is used to enable the oscillator formed by the remaining half of the 4011.

At the pre-set 'speed' (revs) a non-ignorable tone emits from the speaker, and disappears as soon as the speed drops by three or four mph.

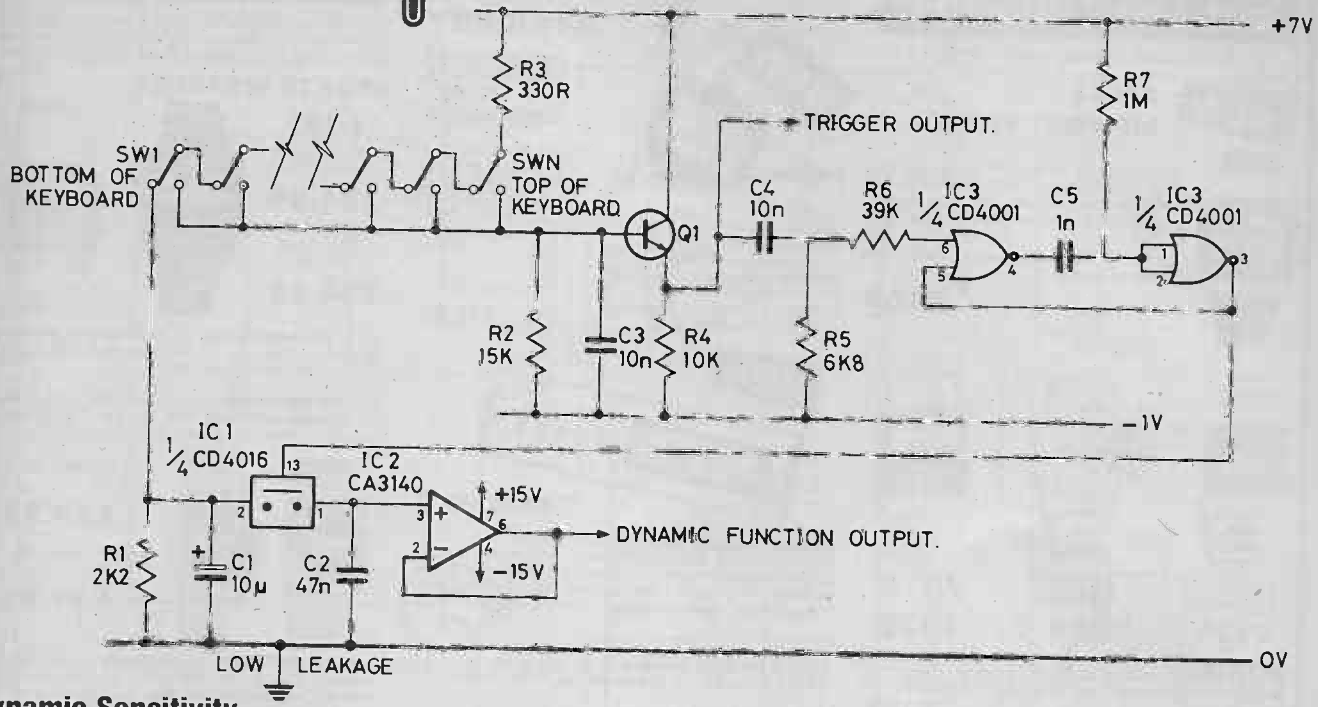
Calibration of Ca may be conducted with an accurate pulse generator remembering that, for a four stroke engine, frequency = revs per minute times the number of cylinders divided by 120; for a car with a specification of 17½ MPH per 1000 revs, in top gear, f = 133Hz at 70 MPH, 124Hz at 65 MPH (4000 RPM and 3714 RPM). The necessary frequency should be fed to Q1 and VR1 set so that the alarm is *just* off. Reliable switching occurs on the prototypes with a change of only 5Hz (150 RPM), ie less than 3 MPH for the above example.

Direct calibration 'on the road', while covering discrepancies due to tyre size, etc, will only be as good as the speedometer and obviously should be carried out by a passenger rather than the driver.



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.



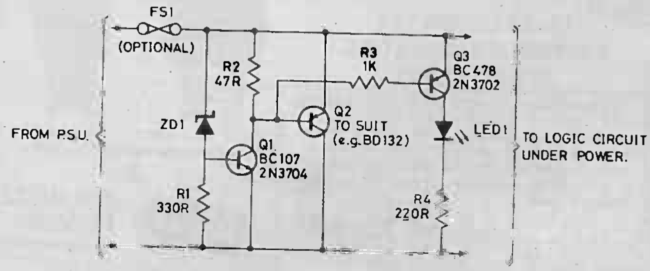
Dynamic Sensitivity

W. Stride

A dynamic function (touch sensitivity) greatly increases the flexibility of expression available to the player of a music synthesizer. This circuit achieves the dynamic function by measuring the change over time of the keyboard switches, and hence the velocity of the key depressed.

The circuit is basically composed of three parts; firstly an RC time-constant network (R_1 C_1) controlled by the keyboard switches, a buffer amplifier and monostable (Q_1 IC_3) and a sample/hold circuit (IC_1, C_2 IC_2).

Normally C_1 is kept charged up to +7 volts through the 'chain' of closed keyboard switches. When a key is depressed, the 'chain' is broken and C_1 discharges through R_1. As the key is further depressed, contact is made with the trigger busbar, TR_1 is turned on, and the monostable triggered. The monostable gives out a 1 millisecond pulse, which causes the analog switch (IC_1) to close allowing C_2 to charge up to the voltage on C_1 at that time. After this, the voltage is stored on C_2, the output being buffered by IC_2. Since the input impedance of IC is $\sim 1.5 \times 10^{12}$ ohms the delay time of C_2 is very long. An output is available from the emitter of TRQ1 to trigger envelope shapers etc. To make sure the response is the same all over the keyboard, the distance between the gold wires on all the contact assemblies should be made the same.



Overvoltage Protection for Logic

E. Parr

With the introduction of integrated circuit voltage regulators it is very easy to make power supplies for logic circuits. Unfortunately it is only easy to blast a board of TTL by letting the voltage rise above 7V as could happen if the common line came off a regulator IC or the sense lines came off a commercial power supply.

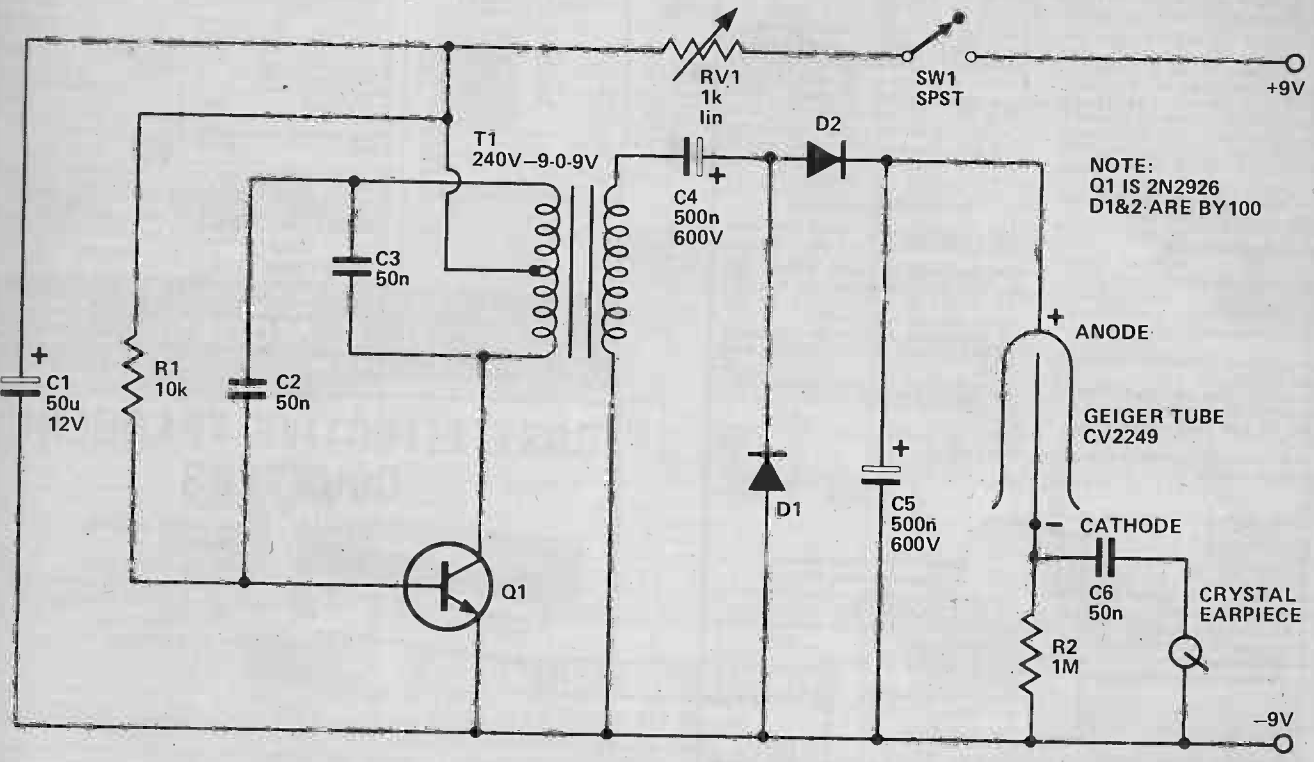
The described circuit was designed by the author as a "last ditch" defence after a disconnected sense line allowed a commercial 5V supply to rise to 9V and blast 50 TTL chips. The circuit is simple to add onto any power supply, and it is the author's intention to build it "on board" with any future system containing more than about 10 TTL chips.

Zener diode ZD1 senses the supply, and should the supply rise above 6V Q1 will turn on. In turn Q2 conducts clamping the rail.

Subsequent events depend on the source supply. It will either shut down, go into current limit or blow its supply fuse. None of these will damage the TTL chips.

The rating Q2 depends on the source supply, and whether it will be required to operate continuously in the event of failure. Its current rating obviously has to be in excess of the source supply. If the source supply is likely to sit down, LED1 should be added to indicate the circuit has operated.

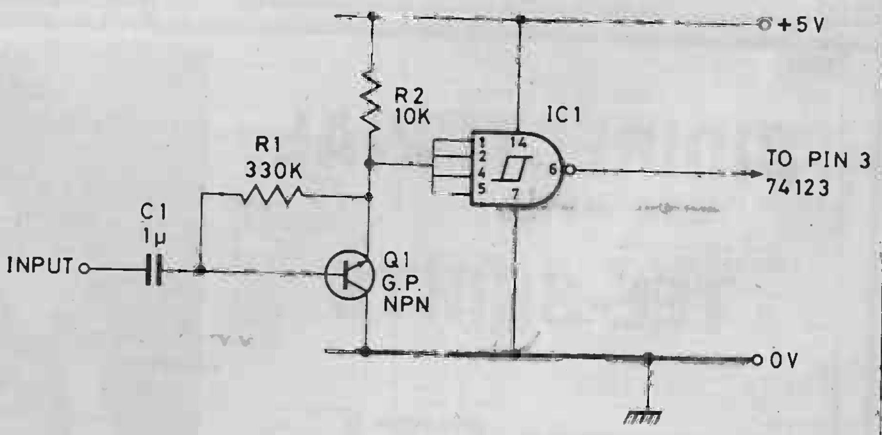
The circuit will operate in approximately 500 nS space, so it will also protect the logic from transient spikes which a normal regulator would not block.



Geiger Counter

A. Wheatley

Although the circuit is imexpensive and simple it is just as sensitive as many commercial devices. The important part is the geiger tube and this will probably cost about £1.90. It needs a high voltage supply which, in this case consists of Q1 and its associated components. The transformer is a low current 250V 9-0-9 and is connected in reverse. The secondary is connected into a Hartley oscillator, the base bias being provided by R1. RV1 is connected to control the voltage to the Geiger tube. A device to double the voltage is included because otherwise the voltage would still be insufficient to drive the tube. This comprises D1, D2, C4 and C5. This also rectifies it and smooths it. It is very important that C4 and especially C5 are of good quality and have low leakage. RV1 should be set so that each click heard is a nice clean one because over a certain voltage all that will be heard is a continuous buzz. The high voltage section is perfectly safe although if touched it will give a slight shock. This is unpleasant but quite harmless.



Cuts Above

B. Houseley

The circuit here is an improved version of the original cuts encoder. If Q1 is preceded by a high impedance buffer, quite low signal levels can be accommodated successfully — and still trigger the 74123. A 74C02 or a 7402 was found to trigger only unreliably in this circuit.

news digest................

WHEN THE COMPUTING and Control department of Imperial College decided that they needed a logic hardware teaching lab, they were faced with several alternatives. One was to teach all the students in each year to solder and then let them loose on a handfull of TTL and CMOS chips each. This would have meant a plethora of supply problems, technicians and even minor burns.

What they opted for instead was to use — you guessed it — a computer.

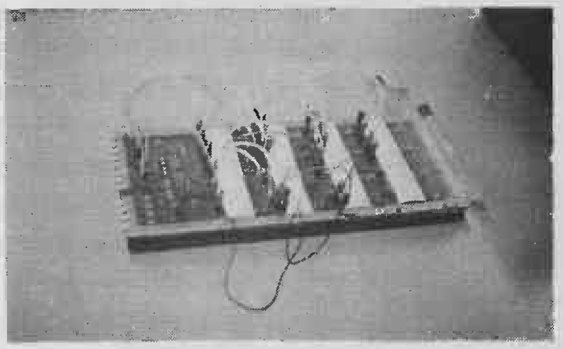
The setup works roughly like this: A computer terminal is situated in the centre of the 'lab' and is surrounded by 16 benches, each provided with an oscilloscope, a signal generator and other relevant test equipment and peripherals. Each bench also has a perspex case with several dozen sockets and LEDs in it. The student goes to the central console, tells the machine which bench he wishes to use and which logic elements he requires. He then goes to the bench and sticks labels on the perspex case. Each label is printed with the relevant logic symbol. By connecting patchcords between the sockets on the 'breadboard,' the student can build up a logic network. The LEDs indicate the state of the various outputs. Each of the boards also has various 'utilities' — several clocks, a random logic output and handswitches to provide inputs.

All of these functions are provided by the computer — the sockets all lead into it's bus and it is the computer which drives the LEDs. This means that not only is there no possibility of the students damaging ICs which would then have to be replaced, but also that any component can be 'synthesised' — the department has even designed an imaginary CPU for use with the system.

The computer also calculates propagation delays — the students learn the pitfalls of race hazards in digital systems. It is even possible to simulate faulty components — as a fault-finding exercise. Another system (experimental as yet) can pretend to be linear components as well. Clearly the teaching possibilities offered by such a system are tremendous — what price blobboards now?

— Phil Cohen

Martin Cripps telling the machine what it's supposed to be!



What the students see. The wires disappear into the table — some conjuring trick!

Our thanks to Roy Francis and Martin Cripps of Imperial College for their time and trouble.

LOUDSPEAKER PRINCIPLES

Every hi-fi must have not one but two. Loudspeakers are perhaps the weakest link in the precarious hi-fi chain. Many methods of improving the sound we hear have been tried. Few have succeeded well enough to reach production. Ron Harris explains the innermost secrets of those that made it!

ON PAPER most loudspeakers look to be terrible pieces of design. Distortion averaging 1%-2% — and what's worse varying with frequency. Efficiency only rarely exceeding 1% — so that the vast majority of those carefully nurtured, 0.002% THD amplifier watts pumped in down those non-inductive £10 a metre cables turn into nice, safe, un-musical heat!

The purpose of any loudspeaker is to convert an incoming complex electrical signal into compressions and rarefactions in the air—sound waves — which can be perceived as being as close to the original signal as possible. The different methods now being used to realise this end form the basis of this article.

What Is Left Undone

You will find references throughout this article to frequency divider — crossover — networks. Unfortunately there is too much to be said on that subject to allow a full and proper treatment of it within this article, and we shall return to it in a companion article later.

Forgive us our evasion.

Loudspeakers of whatever variety interact crucially with the surroundings they are used in — the living room, studio or whatever. When judging performance it is vital to remember this, and even moving a speaker around in a room can significantly alter performance. Some manufacturers are becoming sensitive to this themselves — notably AR — and are producing designs specially tailored to a particular location, or allowing adjustment of output to suit varied positioning (AR 10π, AR9).

Such adjustments are generally carried out within the crossover network, and alter the electrical inputs to the units to compensate for specific emphasis placed on certain frequencies — usually the bass — by the loudspeakers position.

And What Is Not

We have concentrated on the major fundamentally different systems in commercial use today, and tried to explain how they operate what their advantages are, and what are their drawbacks. Many minor variations have been left out simply through lack of space.

Forgive us our omissions.

The types covered are:

1. Moving coil — and methods of loading
2. Electrostatic
3. Isodynamic
4. Ribbon
5. Piezo-electric
6. Motional Feedback Control

MOVING COIL

This system dominates the field at present, and is certain to do so for the forseeable future. The principle is an exact reverse of the microphone principle, and takes its being from the fact that a wire carrying a current I in a magnetic field of flux density B will experience a force, F. where

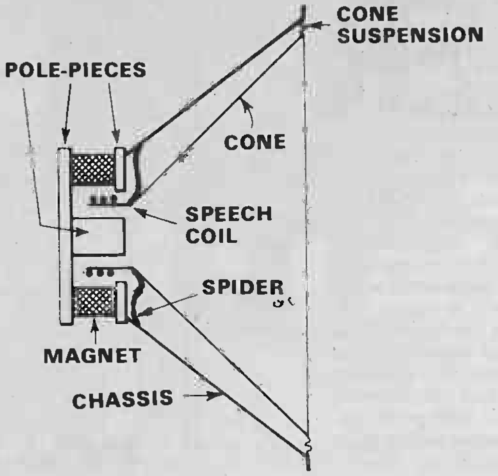
$$F = B.I.k \qquad k = \text{a const.}$$

A coil of wire carrying the audio is sited within an intense magnetic field, and is attached to a 'cone' as shown in the diagram. The cone is held in position by the edge suspension and 'spider'.

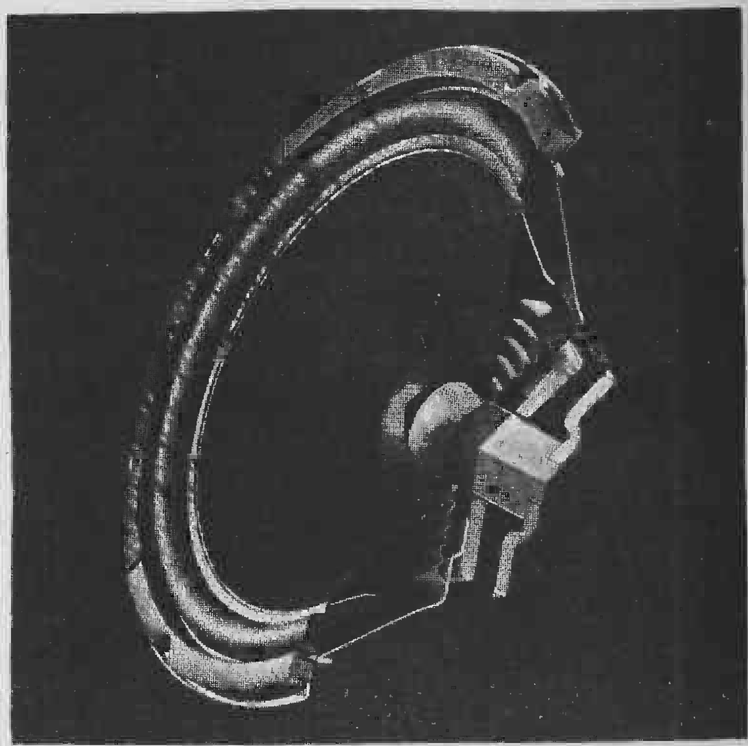
When a signal passes through the coil the force produced tries to push it out of the field in one direction or another, and this movement is transferred to the air by the movement of the cone. The suspension system provides a 'return-to-rest' force. This movement is related more or less linearly to the input as long as the coil remains within a constant field.

If it moves out, then the relationship will change, introducing non-linearity or distortion. For this reason large and powerful magnets are employed, which have as great a depth of field as possible.

Another solution is to use very long coils so that the number of turns of wire within the gap between the pole pieces remains relatively constant.



Basic schematic of moving coil loudspeaker. In practice the coil winding would be longer relative to the magnets, so that it did not move out of the field.

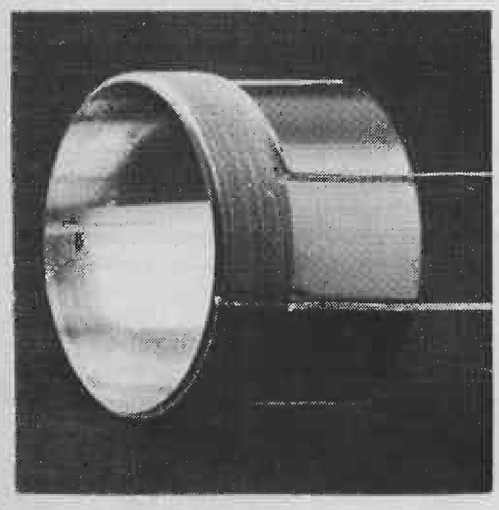


Cutaway photo of a moving coil unit — in this case a Bose driver. If you look carefully you should be able to identify the voice coil, magnet assembly, spider and cone assembly.

Heated Exchange

Heat is generated in the coil and must be conducted away, usually by the magnet assemblies and chassis. AR speakers now incorporate a heat conducting fluid which is present in the gap and the coil is immersed in this. Heat conduction is thus improved and power handling raised. The fluid also acts as a damper to aid movement control

The speaker chassis must be as rigid as possible, since the only reason the coil and cone move and it doesn't is that it weighs more! Any resonances present in the structure will act to transfer energy from the coil movement and hence distort the output.



Close-up of a voice coil. This is a machine wound unit belonging to a Bose driver. Note the winding is butted very close to the edge of the paper former, and the precise nature of the winding necessary for linearity.

Cone-ventional?

The greatest drawback of this system is the cone itself. This is usually either doped paper or Bexetrene — an erstwhile packing material someone fell over once! It should act as a piston to the air, with the entire surface moving together to produce the required air movement.

However, since it is driven only at the centre, unless the material is possessed of infinite rigidity(!) flexing or rippling will take place — once again deviating from the input signal. The larger the cone the worse the effect as the frequency rises, since the centre driven portion may well be oscillating with a period smaller than the time taken for the energy to be transmitted through the cone material to the outside edge.

Hence the centre of the cone leads the outside by a number of cycles, all of which appear as ripples in the cone. This is the reason for dividing up the incoming electrical signal, and for employing smaller coned drive units for higher, less energetic, frequencies.

To handle the high end of the audio spectrum, dome units have almost entirely replaced the coned variety, as they spread the sound more evenly, giving a better dispersion across the listening area. Also domes can be produced smaller, and a hemispherical dome, edge driven, will tend to act more as an integral surface than a centre driven cone.

Getting A Hangover

Since the cone has mass, and therefore inertia (Dr. Who excepted) it cannot respond instantaneously to changes in direction called for by changes in polarity of the electrical signal. This inability to get back in time is called 'overhang' and is another problem facing designers. To minimise it driver mass has to be as small as possible, while rigidity has to be as high as possible.

This has led over the years to many experiments with metal cones, mylar cones, polyester et etc etc. Anywhere other than bass units most of these have proved successful. ►

An integral part of a moving coil loudspeaker design is the method of housing the units, and thus putting an acoustic-loading upon the actual units. A brief discussion of the various methods is thus required at this point.

Housing Shortages

There are basically six methods of providing a home for drive units and at the same time augmenting its performance. These are:
(i) Finite Baffle
(ii) Acoustic Suspension (sometimes called Infinite Baffle)
(ii) Bass Reflex
(iv) Auxiliary Bass Radiator
(v) Transmission Line
(vi) Horn Loading
All of these apply primarily to moving coil units with the exception of horn loading which can be used to enhance efficiency of several types. In order then:—

Finite Baffle

Since the vibrating cone is emitting sound waves in both directions, unless prevented the two waves will interact causing cancellation and reduction in acoustic output. The effect is reduced by placing the speaker in the centre of a large solid board to make it difficult for a compression produced in front to cancel the rarefaction produced behind the speaker.

Obviously an infinitely large piece of wood prevents this entirely, but such things don't grow on (ANY) trees(!?) and so the finite baffle is an attempt to do the best that can be done.

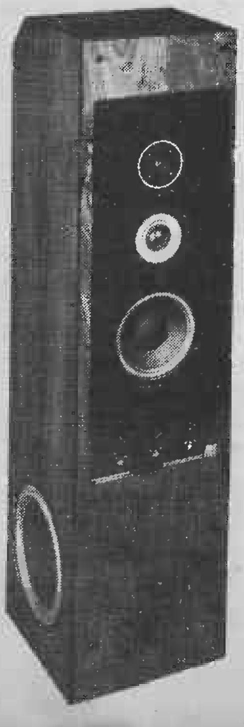
Once the sound wavelength approaches the baffle size destructive interference takes place and response rolls off.

This method is responsible for those hardened enthusiasts mounting their bass units flush into walls and sides of houses!

Sinclair marketed a finite baffle speaker some years ago but this seems to have ceased to be.

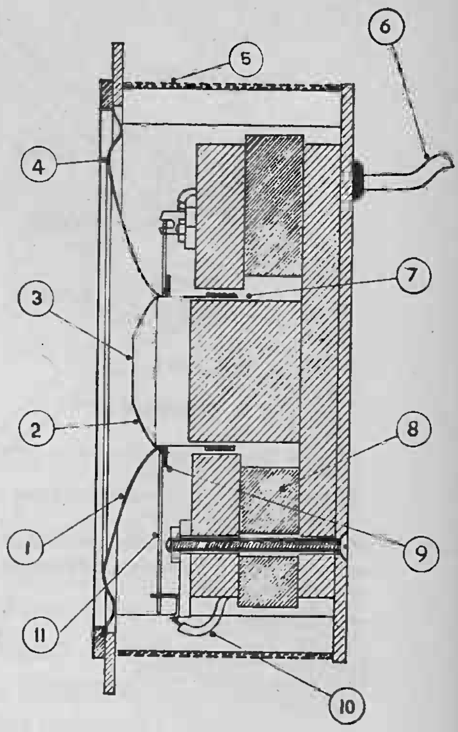
Acoustic Suspension

Here the rear radiation from the units is (hopefully) entirely suppressed by totally enclosing the unit in a box, and radiating through a hole in that box (sounds odd when phrased like that eh?).



The AR9. Coming from one of the 'founder' manufacturers it represents Acoustic Researches state of the art. The cabinet is treated around the baffle with absorbtion material to prevent diffraction and re-radiation effects that lesser enclosures suffer from. It also stands an endearing 53in high!

Schematic of a Jordan Watts driver module. Numbers refer to: 1. Metal cone contoured to hyperbolic law. 2. Phase correcting dome. 3. Resistive termination to dome centre. 4. Resistive termination to cone edge. 5. Acoustic damping. 6. Direct input signal cable. 7. Coil completely immersed in magnetic field. 8. High efficiency "Feroba" magnet. 9. Resistive termination at junction of cone, coil and suspension. 10. Connections to coil via suspension. 11. Silvered berylium copper suspension cantilevers.



Damping of the cone movement occurs due to the compliance of the trapped air, and the suspension system now consists of both the actual cone suspension plus the air load.

In order to preserve bass response the enclosure should be fairly large and hence present a good air load allowing high levels of energy to be applied. Bass units designed for this type of loading have a high cone mass and high compliance. In addition they are generally of the long voice coil variety. The air load then applies most of the restoring force required by the design. Efficiency is reduced since the cone mass is increased and compliance (total) is low.

Bass Reflex

The aim of this method is to raise efficiency at low frequencies and thus decrease the required enclosure size for a given bass output. This is accomplished by addition of a vent, or port, in the front panel of the enclosure. This allows a controlled movement of air between cabinet and room. The effect of careful design of vent dimensions and placement is to produce an effective addition to bass response below a certain frequency, such that the air moving out of the vent aids the air movement produced by the bass driver.

Above the operating frequency the vent has no effect on performance (they hope).

Auxiliary Bass Radiator

Basically a variation on the above principle, but with the vent 'plugged' with a driverless unit or suspended mass. This is tuned to provide antiphase radiation in the required frequency band. Above this band the unit acts like part of the enclosure wall. Perfected and practised by Celestion, and perhaps epitomised by the Ditton 66 design.