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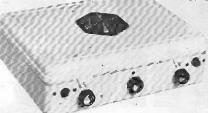
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#### ROAMER TEN

with VHF including air-craft, 10 Transistors. Latest 4" 2 watt Fer-



Laiest 4" 2 wast revrite Magnet Loudspeakers, 9 Tunable
Wavebands, Wil,
MW2, LW, SW1, SW2, SW3, Trawler Band, VHF
and Local Stations also Aircraft Rand, Built in
Ferrite Rod Aerial for MW/LW. Retractable, chrome
plated 7 section Telescopic Aerial, can be angled and
rotated for peak short wave and VHF listening. Push
Pull output using 600 mw Transistors, Car Aerial and
Tape Recording Bockets, 10 Transistors plus 3 Diodes.
Canged Tuning Condenser with VHF section.
Separate coll for Aircraft Band, Volume
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3 Timable wavebands.
M.W./L.W. and Trawler
Band. 7 stages, 5 transistors and 2 diodes,
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Wavebands, transistors and speaker as Pocket Pive. Larger Case with Red Speaker Grille and

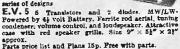
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E.V. 7 Case and looks as above. 7 Transistors and 3 diodes. Bix wavebands. MW/LW, Trawler Band, 6W1, 8W2, 8W3, powered by 9 volt battery. Path Pull output. Telescopic aerial for short waves. 3" loudspeaker. Parts price list and easy build plans 20p. Free with parts.

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TURNE CONTROL

Tunnble Wavebands: MW1, MW2, LW, SW1, SW2, SW3 and Trawler Band. Built in Ferrite Rod Aerial for MW and Trawler Band. Built in Ferrite Rod Aerial for MW and LW. Retractable chrome plated Telescopic aerial for Short Waves. Push pull ontput using 600m W transistors. Car aerial and Tape record cookets. Selectivity switch. 8 transistors plus 3 dlodes. Latest \*2 wast Ferrite Magnet Londepsakers. Air spaced gauged tuning condenser. Volume/on/on, tuning, wave change and tone controls. Attractive case in rich chestnut shads with gold blocking. Size 9 x 7 x 4in. approx. Easy to follow instructions and diagrams. Farts price list and plane 250 (FREE with parts).

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WITH V.H.F INCLUD. AIRCRAFT

9 Tunable wave-bands as Roamer

bands as Roamer
Ten, built in
ferrite rod serial for MW/LW. Retractable chrome
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Components include:
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8 TRANSISTORS and 3 DIODES

6 Tunable Wavebands; MW, LW.
8WJ, 8W2 8W3 and Trawier
Band. Sensitive ferrite rod aerial
for M.W. and L.W. Telescopic
aerial for Short Waves. 3in.
Speaker. 8 improved type transintors phas 3 diodes. Attractive case in black with red grille, dial and black
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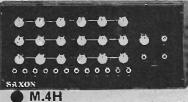
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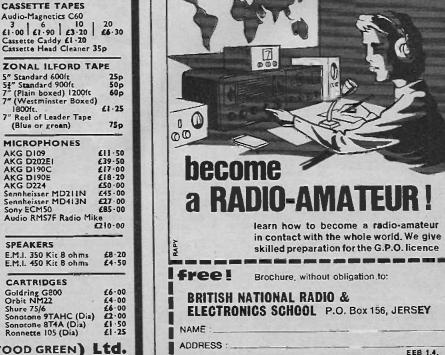


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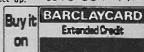
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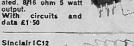


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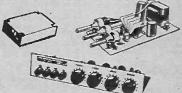
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	AA4	42-45	G8
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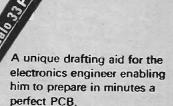
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Everyday Electronics, January 1974

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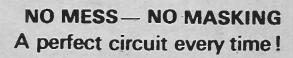
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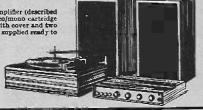
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3 watts per channel output

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\$ Speaker impedance 8 obms

\$ Meacures 175mm. D. x 152mm. W. x 50mm. H.

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The said in

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# The Sinclair Cambridge... no other calculator is so powerful and so compact.

# Complete kit-£24-95! (PLUS VAT)

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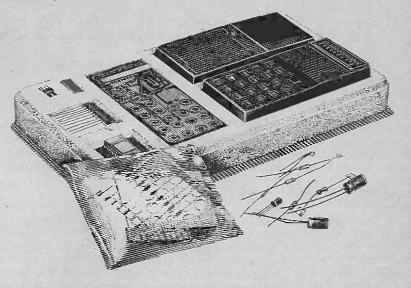
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Assembly time is about 3 hours.

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- 4. Thick-film resistor pack.
- Case mouldings, with buttons, window and light-up display in position.
- 6. Printed circuit board.
- 7. Keyboard panel.
- Electronic components pack (diodes, resistors, capacitors, transistor).
- Battery clips and on/off switch.
- 10. Soft wallet.



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How? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations like:

Logs Sines Cosines
Tangents Reciprocals nth roots
Currency Compound
conversion interest



Everyday Electronics, January 1974

Sinclair Radionics Ltd, London Road, St Ives, Huntingdonshire Reg. no: 699483 England VAT Reg. no: 213 8170 88 Why only Sinclair can make you this offer

The reason's simple: only Sinclair – Europe's largest electronic calculator manufacturer – have the necessary combination of skills and scale.

Sinclair Radionics are the makers of the Executive—the smallest electronic calculator in the world. In spite of being one of the more expensive of the small calculators, it was a runaway best-seller. The experience gained on the Executive has enabled us to design and produce the Cambridge at this remarkably low price.

But that in itself wouldn't be enough. Sinclair also have a very long experience of producing and marketing electronic kits. You may have used one, and you've almost certainly heard of them – the Sinclair Project 60 stereo modules.

It seemed only logical to combine the knowledge of do-it-yourself kits with the knowledge of small calculator technology.

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The Sinclair Cambridge is fully guaranteed. Return your kit within 10 days, and we'll refund your money without question. All parts are tested and checked before despatch—and we guarantee a correctly-assembled calculator for one year. Simply fill in the preferential order form below and slip it in the post today.

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Please send me	Name
a Sinclair Cambridge calculator kit at £24.95 — £2.50 VAT (Total: £27.45)	
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*I enclose cheque for £ , made out to Sinclair Radionics Ltd, and crossed.	
*Please debit my *Barclaycard/Access account. Account number	
*Delete as required.	PLEASE PRINT

# everyday electronics

## PROJECTS. THEORY....

#### **NATURAL RESOURCES**

The energy crisis has tempered the fulsome spending traditionally indulged in at this time of year. By strange irony, during the Christmas run-up period we have been compelled to think in terms of economising with our use of natural

In view of this rather alarming picture of shortages, real or impending, it is salutary to look at electronics. Considering the great contribution this technology makes in all areas of human affairs, the demands upon natural resources directly arising from the electronics industry are meagre in the extreme. Maybe it is significant in some sort of way that the heart of the normal electronics circuit is made of silicon-the most abundant element in the earth.

#### COMPONENT SHORTAGE

Yet, currently, shortages are being experienced in the field of electronic components, as elsewhere. But such shortages seem to arise mainly because of the overtaxing of production facilities rather than from any real shortage of basic raw materials.

Electronics is a science based industry, and highly advanced and elegant processes are necessary to transform base materials into components such as transistors and integrated circuits. The available skills and technical resources are often stretched to the limit by the increasing demands imposed by the world wide expansion in electronics in general. So inevitably

-shortages in particular lines occur from time to time. And this brings us to a particular case directly affecting Everyday Electronics readers which has recently come to light.

#### DISINTEGRATION

The Four-Band T.R.F. Receiver described in the November issue uses an integrated circuit as audio amplifier. This i.c. is a highly efficient device, and is capable of being used in many different applications. Not surprisingly therefore, it has become exceedingly popular and the demand at present exceeds supply. No doubt within a short time (perhaps even before these words appear in print) an adequate supply will once again be in circulation.

But if not, all is not lost. The Four-Band Receiver can be completed by substituting a "handmade" amplifier for the i.c. originally specified. Full details are given this month.

From i.c.'s to discretes—does this seem a move against the tide? We don't think so. Actually it is a matter of belt and braces. In this day of increasing integration it is a wise constructor who knows his discretes! In cases such as the one mentioned the constructor can be independent, roll his own, and forget that waiting queue.

Here's wishing all our readers a happy and shortage-free New Year.

fred Bennett

Our February issue will be published on Friday, January 18

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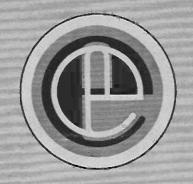
K. A. Woodruff

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# .EASY TO CONSTRUCT .SIMPLY EXPLAINED



VOL. 3 NO. 1

JANUARY 1974

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Publisher's Annual Subscription Rate, including postage to any part of the world, £2:35. International Giro facilities Account No. 5122007. State reason for payment "message to payee". Address to Everyday Electronics, Subscription Department, Carlton House, Great Queen Street, London, WC2E 9PR. Binders for volumes 1 and 2 (state which) and indexes for volume 1 available for 97p and 11p respectively, including postage, from Binding Department, at the above address.

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For more details see page 49

# VCO EFFECTS UNIT

#### BY C.EVANS

Add weird effects to drum solos or use this unit as an instrument or warning device on its own.

This unit has been designed to fulfill a number of requirements, the major one being a musical effects unit for use with most instruments. The unit is basically an audio preamplifier, a voltage controlled oscillator and a mixing network (Fig. 1).

If a guitar, organ, microphone or an oscillator is plugged into the a.c. input the output frequency will vary with the loudness of the input signal; at the same time the input signal can be mixed with the output. Using a microphone to pick up the sound of a drum kit the mixed output of drums and oscillator adds a new dimension to the basic sound. The unit can be easily turned on and off with a foot switch which allows the input to pass to the amplifier but disconnects the oscillator.

#### **OSCILLATOR CIRCUIT**

The circuit is basically a wide range audio oscillator. The oscillator overcomes two main problems found with other circuits:

- 1. It has a wide frequency range.
- 2. Power supply requirements are very simple.

The range of the oscillator covers approximately 10Hz to 10kHz, the output is a square wave.

The unit has two inputs, the d.c. input is used with potentiometers, l.d.r.s. etc. to control the oscillator and the a.c. input, which is used to control the oscillator from audio signals see Fig. 1.

#### CIRCUIT DESCRIPTION

The oscillator part of the circuit comprises TR5 and TR6 operating as a relaxation oscillator (Fig. 2). Usually, in a relaxation oscillator circuit C6 would be grounded to the negative supply line. In this circuit C6 is taken to the emitter of TR6 thereby increasing the frequency range. The overall frequency range is controlled by VR3, which also controls the mark to space ratio of the oscillator. The range may vary considerably with different makes of capacitors for C6 so to ensure the widest frequency range, various types of capacitors can be tried for C6.

Transistor TR4 acts as a voltage controlled

of the V.C.O. Effects
Unit.

PREAMP

OUTPUT TO AMPLIFIER

OUTPUT TO AMPL

£3.80 plus case

Everyday Electronics, January 1974

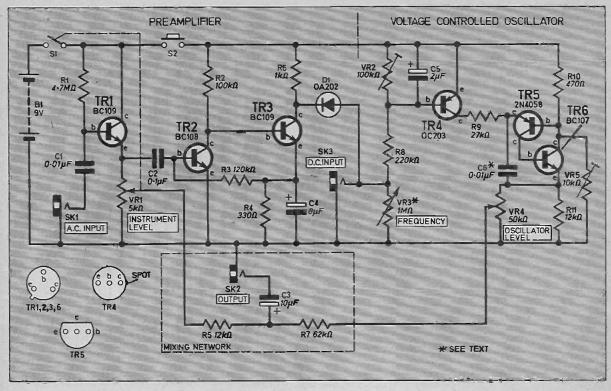


Fig. 2. Complete circuit diagram of the V.C.O. Effects Unit.

resistance between the supply and the emitter of TR5. Trimmer VR2, the bias resistor for TR4, is necessary because of differences in transistor gain, it is set for the lowest frequency required. The control voltage is fed to the base of TR4 via R8. The d.c. input jack SK3 and manual frequency control VR3 are also connected to R8. The output is taken from TR6 emitter via VR4, R7, C3 to the output jack SK2.

#### A.C. PREAMPLIFIER

Audio signals are fed through C1 to the base of emitter-follower TR1. The signal is then amplified by TR2 and TR3, some distortion occurs in these stages but since the signal is only used to control the oscillator this is not important. The output is taken from TR3 collector and rectified by D1, It is then fed to

## Components....

#### Resistors

 $4.7M\Omega$ R<sub>6</sub> 1kΩ R1  $62k\Omega$ R2 100kΩ R7  $220k\Omega$ R3 120kΩ R8 R9  $27k\Omega$  $330\Omega$ R10 470Ω  $12k\Omega$ R11 12kΩ All ±10% ¼W carbon

## SHOP TALK

#### Potentiometer

VR1 5kΩ log. with ganged switch

VR2 100kΩ skeleton preset

VR3 1MΩ lin. carbon (or 2MΩ see text)

VR4 50kΩ lin. carbon

VR5 10kΩ skeleton preset

#### Capacitors

C1 0·01μF C2 0·1μF C3 10µF elect. 12V

C4 8µF elect. 12V

C5 2µF elect. 12V

C6 0.01 µF

#### Semiconductors

D1 OA202 or similar silicon diode

TR1 BC109 silicon npn

TR2 BC108 silicon npn

TR3 BC109 silicon npn

TR4 OC203 silicon pnp

TR5 2N4058 silicon pnp

TR6 BC107 silicon npn

#### Miscellaneous

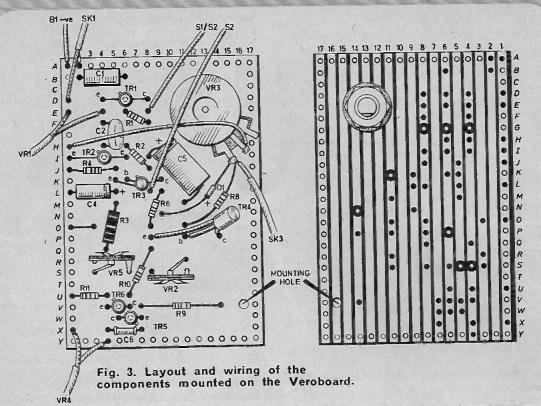
B1 9V PP6 battery and clips

SK1, 2, 3 jack sockets (3 off)

S2 s.p.s.t. foot switch

Vernier dial for VR3 (if required), knobs, Veroboard 0.15 inch matrix 25 holes x 17 strips, 4BA fixings, case (see text) connecting

wire and screened lead



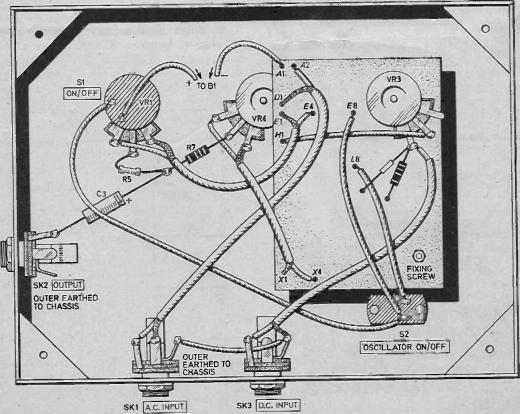


Fig. 4. Complete wiring of the V.C.O. Effects Unit.

TR4 base via R8, C5 filters out any a.c. reaching the base of TR4. The input signal and oscillator signal are mixed via VR1, R5, VR4, R7 and C3 and fed to the output jack SK2. The foot switch S2 switches off all of the circuit except TR1 and associated components. The battery on-off switch S1 is linked to VR1. Due to the gain of the preamplifier, a jack socket that grounds the input to the negative line when a.c. control is not in use, must be used. If the input is left open circuit it will pick up hum etc. and this will trigger the oscillator. The d.c. input jack socket must not be connected in this way.

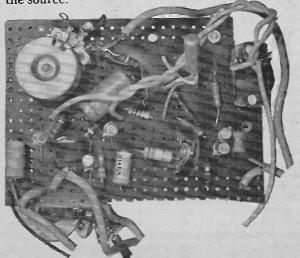
#### CONSTRUCTION

Component layout is not critical, the prototype was assembled on Veroboard (Fig. 3) although any type of assembly could be used. If a Vernier dial is used for the manual frequency control VR3 should be a 2 megohm linear potentiometer. This is because the Vernier dial will only turn the potentiometer through 180 degrees and if a 1 megohm potentiometer is used it will not travel the full length of its track.

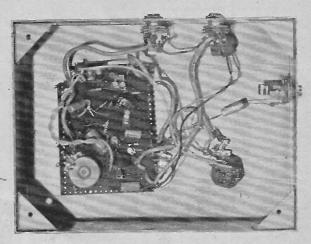
Once the Veroboard is complete it can be mounted in a case measuring approximately 200 by 150 by 60mm and wired to the remaining components as shown in Fig. 4.

#### SETTING UP

When the circuit is assembled plug the output into an amplifier. Set VR3 fully clockwise and VR5 midway along its track, switch on, the circuit should now be oscillating. Turn the slider of VR5 until the highest possible frequency is reached, VR3 should now sweep the oscillator over its entire range. If VR5 is turned too far oscillation will cease and the whole operation must be repeated. Trimmer VR2 should be set to provide the lowest required oscillation. If an audio source is connected to the a.c. input the oscillator frequency will follow the volume of the source.



Everyday Electronics, January 1974



If a Vernier dial is fitted the frequency can be finely adjusted and tuned to other instruments.

#### D. C. INPUT

simple organ.

The d.c. input can be used with a row of switches and potentiometers. It can then be played in a similar manner to an organ, bearing in mind that the oscillator is purely a melodic (one note at a time) instrument (Fig. 5).

An ORP12 l.d.r. (light dependent resistor) can be plugged into the d.c. input, by moving ones hands between the ORP12 and a light source the oscillator frequency can be controlled. By wavering ones hand the oscillator will have a vibrato tone. When used in this way the sound and method of control is similar to a theremin (Fig. 6).

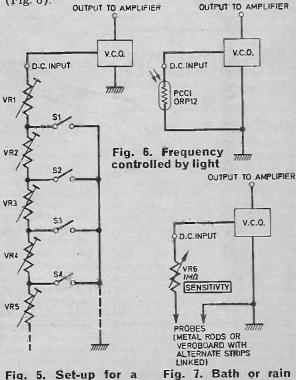
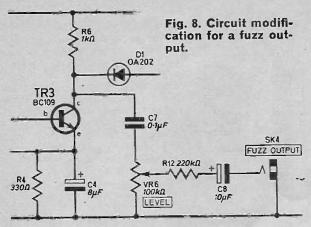


Fig. 7. Bath or rain alarm wiring.



The simplest method of control is to plug a lead in to the d.c. input and hold the ends of the lead with both hands. The frequency of oscillation is then determined by the body resistance and thus by how tightly the leads are held. The circuit can also be used as a bath/rain alarm. When the ends of the lead are placed in water the circuit will oscillate (Fig. 7).

The d.c. input can also be used as a sustain input. By plugging an electrolytic capacitor into the input and switching on the oscillator the capacitor will charge up and when the trigger is removed the capacitor will sustain the note for a time before it discharges. The value of capacitor can be anything from  $2\mu F$  to  $250\mu F$  depending on the sustain time required.

#### A.C. INPUT

The a.c. input is used to control the oscillator by audio signals such as electric guitar or microphone or another oscillator. The footswitch is used to switch on the oscillator signal.

If a switch is used in series with capacitor C3 and the capacitor is switched out of the circuit the a.c. signal will no longer be filtered and strange modulating effects will take place in the oscillator circuit.

#### CIRCUIT MODIFICATION

With an instrument plugged into the a.c. input a "fuzz" output can be taken from the collector of TR3 via an attenuating network (Fig. 8). The sound is not as harsh as a "Schmitt type fuzz" and gives good sustain on guitar notes.

When using an a.c. input a capacitor of between  $2\mu F$  and  $250\mu F$  can be plugged into the d.c. input to produce a siren effect, controlled by the loudness of the a.c. input. This is due to the capacitor taking time to charge and discharge.

#### CONCLUSION

The prototype oscillator has been in constant use for three months and there has been little drift in the oscillator frequency. When the oscillator is switched on by the footswitch there is a short delay before oscillation begins.

# Ruminations By Sensor

#### An Outside Broadcast

As I write, the wedding of Princess Anne and Mark Philips is being televised and transmitted to a potential 500 million viewers. By cable, microwave link and satellite, the pictures will be passed to Europe, Scandinavia, India, Australasia, America and Japan.

The picture quality, as judged on my old black and white set, is near perfection and demonstrates the high performance that the system can achieve when all resources are made available. The whole exercise must have been well planned and reflects great credit on all concerned, I am, of course talking about the television broadcast of the event and have no intention of entering into any

controversy concerning the event itself.

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The sheer scale of the operation is staggering, thirty cameras in the Abbey alone, each with its crew and associated equipment plus all those on the route between the Palace and the Abbey (plus one or two at Great Somerford)—and no apparent breakdowns! It says much for the reliability of the components.

There were also, I hear, a large number of colour television sets distributed around the Abbey so that guests could watch the ceremony along with the millions of viewers in their own homes throughout Britain and a great part of the world.

How many cathodes were emitting, how many collectors were collecting a replica of the original signal I just could not begin to estimate—perhaps around 8,000 million? Probably more I don't know. How many soldered joints were involved? I leave these conjectures to those who have a mind for such things!

#### Watts Up

The threat of power cuts is with us again and we face the prospect of a gloomy and chilly winter. Those fortunate enough to have an open fire and something to burn on it and an old fashioned hot water bottle can avoid the worst of it but my sympathy goes out to those who are solely dependant on electricity for cooking and heating. I always think at these times of the major difference between electronics and power engineers.

The electronics engineers, concerned with microvolts, milliwatts and milliamps and the power engineer with his megavars (mega volt-amps) and kilovolts. When the electronics man thinks big, his currents may be around five amperes, while the power engineer would consider that to be a leakage current! However, your electricity meter will faithfully measure very much less than five amps so don't think that you will get anything for nothing.

Everyday Electronics, January 1974



#### **Projects Past and Future**

Many thanks for a brilliant magazine. I have bought every copy so far. I have made several of your projects and found them very useful. I am very grateful for designs such as the Signal Injector and Audible Warning Alarm, as they fit my budget perfectly.

I wish to construct the Bit Saver in the December 1972 issue, but as yet I cannot find any advertisement for the 100mA diodes (would 300mA ones do)?

Secondly, have you any future plans for publishing a circuit for an amplifier of about 5 watts? I have already a three watt amplifier but now require an amp with a few watts more power.

Keep up the very good work.
P. A. Hawkins,
Innsworth, Gloucester.

Any 400V or higher diodes with a rating of at least 100mA will be suitable. Both the 400V and 100mA are minimum ratings, e.g. a 500V, 1A diode would be suitable.

We will probably be publishing more amplifier designs in future issues and we are sure one of them will meet your needs.

#### **Aquarium Thermostat**

We are going round in circles. We started with a good idea, then introduced an expensive meter. This leads you to say that we might as well have a thermometer in the tank, to which I reply: why not a bi-metallic strip?

The facts are simple, and I have made some tests. The normal heater current was 300mA at 240V. A pilot lamp (6.5V, 300mA) connected in series with the heater will carry a constant current of 300mA. If the heater is on, 6.5V appears across the lamp—but this link in the chain might also break.

If we run the lamp at half power by shunting it with a resistor, both the neon and the lamp should be on. If only the neon is on, the system has failed. To do this, use a shunt of 22 ohms at 2.5 watts minimum (because the lamp's running resistance is  $6.5 \pm 0.3 = 21.66$  ohms).

Simon St. J. Beer, West Byfleet, Surrey.

The original article was designed to do away with the inaccuracy and unreliability of the bi-metallic strip-it does this and performs the same function. The thermometer is necessary to set the temperature in the first place and will be necessary should the temperature be altered at a later date, so why not use it to check that the temperature is constant i.e. the heater has not failed. As far as we can see your monitoring system is quite good but if heaters other than 75W ones are used the lamp and resistor will need to be recalculated. Most aquarists have thermometers in their tanks but many require a accurate and reliable thermostat, we hope we have provided this.

#### Gas

I cannot praise you too highly for publishing the circuit of the Gas Alarm in the November issue of Everyday Electronics.

I have a 44,000 B.Th.U. output gas fired warm air furnace in my home which I never previously left switched on whilst my family was asleep for fear of carbon monoxide poisoning, despite generous provision for combustion air supply. Now we can all sleep soundly at night with a raucous alarm and automatic shut down control over the furnace.

As Mr. M. H. Keene says in his article, the uses of the Gas Alarm are only limited by imagination, and I am making a second one as a sophisticated "toy" to discover uses not sug-

gested in his article. The Gas Alarm is yet one more example of how forward looking is your magnificent magazine. Could I suggest another field in which I have never seen articles in any popular magazine and that is the subject of underwater sound.

You may be aware that many animals make underwater calls and those made by marine animals have been extensively studied due to their significance as background noise in submarine warfare. However, the study of the sounds made by freshwater fishes and insect larvae has been neglected and the amateur could make very valuable contributions to scientific knowledge in the sphere.

Many aquarium fishes make calls and there must be thousands of aquarists who would welcome a device that enabled them to listen in on their fish.

I know that a battery operated transistorised device is marketed in the U.S.A. and I have made such a device incorporating a modified crystal microphone insert with a preamplifier hooked up to a one-watt amplifier. This works well, and I have learnt a lot about acoustic impedance but I would like to see what one of your expert contributors could. come up with. Is there any chance of such an article being published in a future copy of E.E.? Peter Revell Hemel Hempstead

We will keep the subject in mind regarding a future project.



"That burglar alarm I made— its been stolen!"

Herts.



## LESSON 4 The Transistor

N order to extend our knowledge of electronics it is necessary to introduce a new and very important component, the transistor. This does not mean that we have finished with our earlier components, such as the resistor, capacitor and diode, but rather that the range of applications for these components can be widened by using the transistor in conjunction with them.

#### **PHYSICS**

A lot of articles have been written about the transistor and its associated physics but the author is of the opinion that this is not necessary in a first encounter with the device. In fact for a newcomer to the field of electronics a detailed study of transistor physics would be confusing and mask the inherent simplicity of the basic device behaviour.

In this series, we shall treat the transistor as an electronic component that can be bought for a few pence and we shall, at least initially, examine its operation from the point of view of a potential user rather than the device manufacturer.

This does not mean that the device physics are unimportant, for this is not the case. As the newcomer builds up his storehouse of knowledge he will acquire a deeper insight into the device operation. After all, the present day transistor, in discrete or integrated-circuit form, has reached its present level of sophistication as a result of intensive research and development over more than twenty years.

#### TRANSISTOR FAMILIES

A glance at some of the manufacturers catalogues or the advertisement pages of E.E. reveals an enormous array of transistor types and numbers. Fortunately they are all members of a few families and it is a well known fact that

the majority of general applications can be satisfied by the use of just a few of the many different types listed.

The BC107 transistor is a very popular and well known member of the family group known as bipolar transistors. The term bipolar stems from the fact that the device operation relies on current flow due to the action of both electrons and "missing" electrons. The latter are usually called holes. Members of this family are split into two groups depending on the voltage polarity or current direction that is used in normal operation.

The two groups are called npn and pnp. The letters n and p representing the type of semiconductor used in the various sections of the transistor and indicate that the material possesses either extra electrons (negative) or extra holes (positive). The BC107 is an npn transistor and the current symbol is shown in Fig 4.1 and on the Data Sheet.

The three sections or regions have leads connected to them and are identified by the

Fig. 4.1. (right) Symbol for an npn transistor.

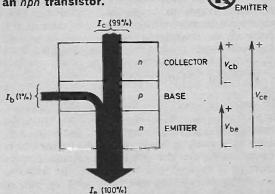


Fig. 4.2. Current flow diagram for an non transistor.

North Staffordshire Polytechnic (Any communications arising from the Teach-In '74 series must be addressed to Everyday Electronics, Fleetway House, Farringdon Street, London E.C.4)

COLLECTOR

names emitter, base and collector. These names are usually abbreviated to simply e, b and c. The arrow head on the emitter indicates the direction of conventional current flow when in normal use. A pnp type uses the same symbol but the arrow direction is reversed.

Another important family group contains the so called field effect devices and has several subdivisions. These need not concern us here and will be covered in a later part of the series.

Other more specialised devices such as the unijunction transistor, thyristor and triac are also available and have evolved mainly from applications involving the control of relatively large current or power levels.

#### BASIC TRANSISTOR OPERATION

This month we concentrate on the bipolar device family and in particular the BC107 npn transistor. All transistors behave as a form of electronic control valve whereby current in one part of a circuit can be made to change or depend in value on the current in another part of the circuit.

Consider the current flow diagram shown in Fig. 4.2 in which the width of the shaded arrow represents the amount of current flowing in a particular region of the *npn* transistor. If we take the total current leaving the emitter as 100 per cent we see that this is made up from the two currents entering at the base and collector. The base current is typically 1 per cent (1100th) of the total emitter current which means that the collector current accounts for the remaining 99 per cent as the total current entering the device must always equal the current leaving.

The base region of a modern transistor is very thin, typically a few millionths of a metre (called microns) and this is one of the main factors in ensuring that the base current is only a small fraction of the total emitter current. However, apart from this, the ratio of the base current to the emitter current is almost fixed and for the time being we shall assume this ratio to be perfectly constant for a given transistor sample.

The ratio does vary, however, between samples of the same transistor type. Thus one device may have a base current which is one per cent of the emitter current whilst a second sample of the same type may have a corresponding current ratio of only 12 per cent. Certain departures from this idealised relationship will be considered later.

To achieve current flow in the manner indicated in Fig. 4.2 the transistor must be connected into a circuit containing batteries and resistors in such a way that the voltage differences between the various regions are as shown. In a typical npn transistor the voltage between base and emitter,  $V_{be}$ , will be about +0.5 volts and will only vary slightly if the emitter current level is changed over quite a wide range.

The voltage between collector and base, however, shown as  $V_{\rm cb}$ , can have any value from about zero up to say  $+20{\rm V}$  or more. The actual voltage will be dependent on the external circuit conditions such as resistor values and battery voltage. In essence the voltage  $V_{\rm cb}$  will adjust itself to the conditions imposed by the Ohm's law requirements of the collector circuit. To see the implications of this let us examine the behaviour of the transistor when connected in a simple circuit such as Fig. 4.3.

If we assume that the voltage  $V_{be}$  is say +0.5V, the voltage across the resistor  $R_b$  must be (4.5-0.5) i.e. 4.0 volts. If  $R_b$  has a value of 1 megohm (a million ohms) the current flowing in  $R_b$  will be  $4\mu A$  and this is the current that enters the transistor via the base lead. If we further assume that the base current is exactly one per cent of the emitter current, for the transitions are said to the same current in the same current is exactly one per cent of the emitter current, for the transitions are said to the same current in the same current is exactly one per cent of the emitter current, for the transitions are said to the same current in the same current is exactly one per cent of the emitter current, for the transitions are said to the same current in the same current is exactly one per cent of the emitter current, for the transitions are said to the same current in the same current is exactly one per cent of the emitter current is exactly one per cent of the emitter current.

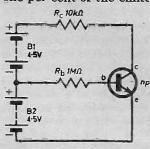
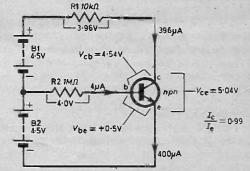


Fig. 4.3. (left) An npn transistor connected in a simple circuit.

Fig. 4.4. (below) Values calculated from Fig. 4.3.



sistor sample used, then we would expect  $I_e$  to be  $400\mu$ A and the corresponding collector current  $I_e$  to be  $396\mu$ A.

We now have sufficient information to work out the voltage  $V_{\rm cb}$ , since the voltage across the 10 kilohm collector resistor  $R_{\rm c}$  must be equal to  $I_{\rm c} \times R_{\rm e} = 0.396 ~({\rm mA}) \times 10 ~({\rm k}\Omega) = 3.96 ~{\rm volts}$ . To satisfy the voltage conditions round any circuit loop (Kirchhoff's law) we find that  $V_{\rm cb}$  must be equal to +4.54 volts. Fig. 4.4 shows the results of all our calculations for the given conditions. Readers should check these results and then satisfy themselves that the voltages around any closed loop "balance out" i.e. the voltage differences must add up to a value equal to the total battery e.m.f. acting in the chosen loop.

#### **ASSUMPTIONS**

In the above discussion we made two assumptions. The first of these was that  $V_{be}=0.5V$ 

approximately and this can be justified theoretically and measured using a practical circuit. (This is covered in this month's tests.) The second assumption was that the base current was exactly one per cent of the emitter current. These currents should be measured but as already mentioned the ratio does vary between samples of the same type.

The manufacturer controls the current ratio during the production of the transistor and usually gives a specification or data sheet which lists all the important parameters. These sheets are available for each transistor type and nowadays most manufacturers publish their data sheets in book form. The parameter that interests us here is the current gain and this can be measured in different ways. At one time it was common to quote the ratio of  $I_c/I_c$ , sometimes given the symbol z (alpha) and for our example this would be 0.99.

Since  $I_c$  is always less than  $I_c$  the parameter  $\alpha$  must always be less than unity. As circuits improved it became apparent that a more useful way of specifying the current gain would be to quote the ratio of  $I_c/I_b$ , and this ratio is sometimes given the symbol  $\beta$  (beta). These two forms give the same information in two different ways and it is possible to change from one method to the other quite easily.

For the case given our sample would have  $\beta = 0.99/0.01 = 99$  which simply tells us that the collector current is ninety-nine times the value of the base current irrespective of the actual current levels involved. (In fact the values of  $\alpha$  and  $\beta$  vary, both between samples and with emitter current level, but this latter effect will be ignored for the time being.)

#### TRANSISTOR EQUATIONS

Though not absolutely necessary it is very convenient to express some of the above details

in the form of simple equations as these will be useful in understanding the behaviour of the transistor in any given circuit. The "continuity of current" condition is expressed by:

$$I_{e} = I_{c} + I_{b} \tag{1}$$

whilst the devision of emitter current, between base and collector, can be written as:

$$I_{\rm C} = \alpha I_{\rm C}$$
 (2)

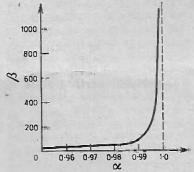
$$I_{\rm b} = (1 - \alpha) I_{\rm e}$$
 (3)

Dividing equation (2) by equation (3) gives a useful relationship, namely:

$$\frac{I_{\rm c}}{I_{\rm b}} = \frac{\alpha}{(1-\alpha)} = \beta \tag{4}$$

Since the value of  $\alpha$  is usually very close to unity, especially for present day transistors, the value of  $\beta$  varies over a wide range for quite small changes in  $\alpha$ . This is illustrated in Fig. 4.5.

Because the parameter a depends on the width of the very thin base region, the manufacturing problems involved in controlling this width force the manufacturer to quote a spread or range



0-95	19
- 98	49
0.99	99
0.995	199
0.999	999

Fig. 4.5. Variations in  $\beta$  for change in  $\alpha$ 

Table 4.1: Useful Transistor Parameters

Parameter Symbol	Meaning	Value for BC107
V <sub>ceo</sub> (max)	Maximum c/e voltage with base open circuit	+45V
I <sub>cM</sub> (max)	Maximum collector current (peak value)	200mA
V <sub>cbo</sub> (max)	Maximum c/b voltage with emitter open circuit	50V
Ic (max)	Maximum average collector current	100mA
V <sub>ebo</sub> (max)	Maximum e/b (reverse) voltage with collector open circuit	6V
P <sub>tot</sub> (max)	Maximum total power dissipation at specified temperature of 25°C (or less)	300mW for T <sub>ambient</sub> ≤ 25°C
V <sub>ce</sub> (sat)	Collector/emitter saturation voltage at specified current levels. Typical and maximum values may be quoted	Max. $600 \text{mV}$ at $I_c = 100 \text{mA}$ , $I_b = 5 \text{mA}$ (Typical $200 \text{mV}$ )
$f_{\epsilon}$	Transition frequency (a measure of transistor's usefulness at high frequencies)	300 MHz (Typical)
h <sub>FE</sub>	Static forward current ratio (similar to $\beta = I_c/I_b$ ). Test conditions usually quoted	240 (Typical) at $I_c=2$ mA, $V_{ce}=5$ V
hie	Small—signal gain (change of I <sub>c</sub> for unit change in I <sub>b</sub> )	$125 \longrightarrow 500 \text{ at}$ $I_c = 2\text{mA}, V_{ce} = 5\text{V}$
Icbo	Collector/base leakage current with emitter open circuit	15μA (max) at V <sub>cb</sub> 20V and junction temperature of 150°C

of values for  $\beta$ . This range may be as high as 5:1 (maximum to minimum) and for some types the transistors are colour coded to indicate that the current gain  $\beta$  lies within a specified range.

#### TRANSISTOR RATINGS

In addition to z and  $\beta$  other symbols are used and Table 4.1 lists some of these together with an indication of their meanings. It will be noticed that some of the symbols relate to maximum ratings of voltage, current and power and on no account should these be exceeded. Failure to observe this point can lead to permanent transistor damage or a change in the device characteristics.

Power dissipation in a transistor causes the temperature of the semiconducting material to rise and if this rise is excessive a process known as thermal runaway can occur. This results when the temperature rise itself causes increased dissipation and a regenerative build-up takes place. If the current is not limited by external resistance this thermal runaway will damage the transistor.

The emitter-base junction is particularly vulnerable since the current-voltage characteristic is very similar to that of a forward biased diode. Even with the large emitter currents that occur in power transistors the voltage between base and emitter,  $V_{\rm bc}$ , rarely exceeds about one volt. The variation of emitter current  $I_{\rm e}$  with  $V_{\rm be}$  is illustrated in Fig. 4.6. The curve could equally well represent the variation of base current if a different vertical scale is used to indicate the lower current levels. The curve shows that for a silicon transistor the current rises rapidly once  $V_{\rm be}$  exceeds about 0.5 volt.

If we connected a 4.5 volt battery directly across the base-emitter junction the transistor would be destroyed since the current would rise to an excessive level. When experimenting with transistors this point should be watched since the damage is not discernable from the outside. Always include a series resistance of say 1 kilohm to limit the current flow to a few milliamps. A simple method of checking transistors is covered in the experimental tests this month (Test 11).

## TRANSISTOR LEAD CONFIGURATIONS

Modern transistors are usually mounted in hermetically sealed metal cases or encapsulated in special epoxy material. The arrangement of the leads can take one of several forms as shown in Fig. 4.7 and in some of the metal cased types the case is electrically joined to the collector. This applies to the BC107 transistors used with the Tutor Board.

#### **MOUNTING FOR TUTOR BOARD**

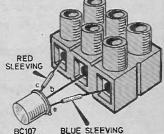
The BC107 transistors must be mounted using the 3-way connector blocks that were reserved for this purpose in Teach-in '74, Part 1. The leads are quite short and must be carefully spread out to match the connector spacing. They must not be allowed to touch the metal case of the transistor and as the lead-out wires are fairly thin the connector screws should be tightened carefully so that the wires are held firmly under the end of the screws. Excessive pressure will tend to fracture the leads.

The transistors should be left permanently mounted in these blocks and all other connections brought in on the opposite side of the block as required. The emitter and collector can be colour coded by using small spots of paint on the block, red for the collector and blue for the emitter. Alternatively, small lengths of plastic insulation can be slipped over the emitter and collector leads before mounting the transistor in the block. The general arrangement is shown in Fig. 4.8.

We are now in a position to carry out some simple tests.

Next month we shall continue our study of the transistor and introduce some simple circuit applications.

Fig. 4.8. Mounting of the BC107 in a connector block for use on the Tutor Board



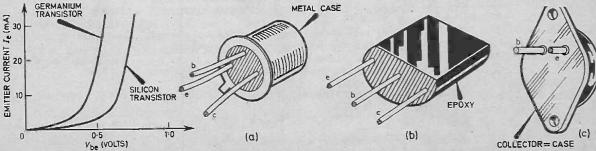


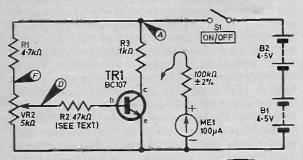
Fig. 4.6. Variation of emitter current with  $V_{\rm be}$ 

Fig. 4.7. Lead arrangements on some modern transistors.

#### TUTOR BOARD EXPERIMENTS

#### Test No. 11

The experimental work this month has been designed to demonstrate the main features of transistor operation as described in the article. The schematic circuit is shown in Fig. 4.9 and a suggested Tutor Board layout is given in Fig. 4.10. The 0-10V voltmeter circuit is required for this test and has the negative lead permanently connected to the emitter (e). Only one probe is required, for the positive lead, and this can be held in position when a measurement is made.



Before switching on check all wiring carefully. Remember that the metal case of the BC107 is electrically connected to the collector (internally).

When using the voltmeter avoid touching the metal probe with the fingers as this can give a leakage path and produce false readings if some other part of the hand touches another part of the circuit, such as the transistor case! When you are satisfied that all wiring is correct and firmly held in the connector blocks, set potentiometer VR2 fully anticlockwise so that the slider is at the end which is joined to e, and switch on the circuit.

Using the voltmeter probe check the total battery voltage  $V_{Ar}$  at point A, the collector voltage  $V_{ce}$  at point c and the voltages  $V_{Fe}$  and  $V_{Dr}$  at points F and D. If everything is operating correctly the readings will be approximately:

$$V_{Ar} = 9 \cdot 2 \text{ volts}$$

$$V_{ce} = 9 \cdot 2 \text{ volts}$$

$$V_{De} = 0 \cdot 0 \text{ volts}$$

$$V_{Fe} = 4 \cdot 8 \text{ volts}$$
typical values

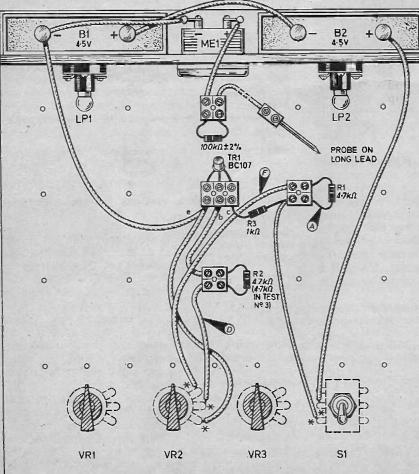


Fig. 4.9. (above, left) Schematic circuit diagram for Test No. 11.

Fig. 4.10. Layout on the Tutor Board for the circuit shown in Fig. 4.9.

\*= CROCODILE CLIPS

If  $V_{De}$  is not zero the potentiometer may be incorrectly wired or set at the wrong end. This condition would also give an incorrect value for  $V_{ce}$  which may be approximately zero under certain fault conditions.

If all is well, record the voltmeter readings in your log book and proceed with the rest of the experiments step by step. Try to understand what is happening at each stage before passing to the next test.

#### Test No. 12

Measure  $V_{\rm ce}$  with the probe at point c and slowly turn VR2 in a clockwise direction. Note that  $V_{\rm ce}$  does not change until VR2 has been turned through a few degrees. As VR2 is turned further clockwise  $V_{\rm ce}$  will fall until it becomes almost zero. By turning VR2 "to and fro" satisfy yourself that the voltage  $V_{\rm ce}$  can be made to rise, fall or swing about a given value anywhere in the range 0 to +9 volts approximately. Return VR2 to the fully anti-clockwise position.

#### Test No. 13

With the probe at point c turn VR2 clockwise until  $V_{\rm ce} = 8 \cdot 0$ V. Without disturbing VR2, transfer the probe to point D and record the voltage  $V_{\rm De}$  (about  $+0 \cdot 7$ V). Return the probe to point c and turn VR2 further clockwise until  $V_{\rm ce} = +1 \cdot 0$ V. Without disturbing VR2 measure  $V_{\rm De}$  again and record the new value. On the prototype this second reading for  $V_{\rm De}$  was  $+1 \cdot 4$  volts but the value obtained will depend on the current gain  $(\beta)$  of the transistor sample used. The results can be used to calculate the voltage gain of the circuit which is a "one-transistor" amplifier.

Voltage gain (between points c and D) =

$$\frac{\text{change in } V_{\text{Ce}}}{\text{change in } V_{\text{De}}} = \frac{(8-1)}{(1.4-0.7)} = \frac{7}{0.7} = 10$$

These results show that an increase in  $V_{De}$  of approximately 0.7 volts causes a decrease in  $V_{ce}$  of 7.0 volts. The collector voltage change is ten times larger than the change in  $V_{De}$  and is in the opposite sense since  $V_{ce}$  falls as  $V_{De}$  increases.

Because of the variation (or spread) in the parameter  $\beta$ , between transistor samples, the voltage gain obtained may be lower than 10. (For BC107 transistors the range will be about 2 to 10 in this circuit.) Restore VR2 to the fully anti-clockwise position.

#### Test No. 14

For this test we require a voltmeter covering a range of about 0-1 volt and this can be made up by connecting a 10 kilohm  $\pm 5$  per cent resistor in parallel with the 100 kilohm  $\pm 2$  per cent voltmeter resistor. The effective resistance of

10 kilohm in parallel with 100 kilohm is 9 09 kilohm which together with the additional series resistance of the 100 µA moving coil meter gives approximately the correct value for a 0-1V voltmeter (i.e. 10 kilohm). See Fig. 4.11.

With the batteries switched off, change the base resistor from 47 kilohm to 4.7 kilohm and replace the 1 kilohm collector resistor with a 100 ohm resistor connected in series with one of the 6V 60mA lamps. Check all wiring carefully before switching on Check that the lamp lights when VR2 is rotated clockwise. See Fig. 4.11.

Connect the positive probe of the 0-1V voltmeter to point b and slowly rotate VR2 clockwise until the lamp filament just begins to glow. Note the meter reading remembering that the full scale deflection now represents 1.0 volt, not 10V as previously. Continue to rotate VR2 whilst observing the meter reading. The change in meter reading will be relatively small even though the increasing light output shows that the collector current is still increasing.

This demonstrates that  $V_{be}$  is almost constant once the transistor is turned on. With the prototype Tutor Board the lamp started to glow at

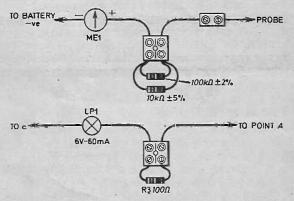


Fig. 4.11. Circuit alterations for use with Test No. 14.

 $V_{\rm be}{=}0.6{\rm V}$  and with the lamp fully on  $V_{\rm be}{=}0.72{\rm V}$ , an increase of only  $0.12{\rm V}{!}$  The voltage  $V_{\rm De}$  will change by more than this (as can be checked using the normal 0.10V voltmeter circuit) and rises to about  $+3.4{\rm V}$  when VR2 is fully clockwise.

Before dismantling this circuit return VR2 to the position at which the lamp just starts to glow whilst the 0-1V voltmeter probe is held on b. Observing the lamp, remove the voltmeter probe from b. The lamp light output increases considerably. Why does this happen?

When you have finished the experimental work dismantle the Tutor Board. Remember to remove the 10 kilohm resistor from the voltmeter circuit and to put the shorting lead on the meter terminals, for protection. Additional transistor experimental work will be given in Part 5.



# **PICKUPS**

By GORDON J. KING

This second and final part deals with sources of distortion and performance.

#### TRACING DISTORTION

The least error is deliberately arranged at the end of the record because it is here that another type of distortion increases, called *tracing distortion*. This results from the difference in shape of the cutting and replay styli such that the path traced by the replay stylus differs from that traced originally by the cutting stylus.

At the end of the record the modulation waveforms tend to compress in the groove since then the groove-stylus velocity is at its lowest. This makes it even more difficult for the replay stylus exactly to follow the modulation waveforms, hence the distortion rises. The same effect occurs when the frequency of the modulation rises at a given or increasing recording level.

#### TIP DIMENSIONS

Owing to its nature, therefore, it follows that the smaller the radius of the tip of the stylus the less will be the tracing distortion. This is in fact perfectly true to a large degree, but other factors tend to become involved.

In an endeavour to reduce tracing distortion, particularly at the inner diameters of a record, biradial or elliptical tips are being fitted to the better class of cartridge. The major axis of the tip is arranged to fall across the groove, thereby avoiding "bottoming" in the groove which can result in a high replay noise level, while the minor axis actually defines the modulation waveforms. Major and minor axes are commonly 0.7 and 0.3 thousandths of an inch.

Non-elliptical or non-biradial tips are spherical with radii of 0.7 and 0.5 thousandths of an inch. From the "definition" and least tracing distortion aspects, therefore, the elliptical or biradial tip is better than the 0.5 thousandths of an inch spherical, while the 0.5 thousandths of an inch spherical is better than the 0.7 thousandths of an inch spherical. The latter is really a "compromise" tip, suitable for playing early mono L.P.s (which carry a groove more suitable for a tip of 1 thousandth of an inch) without scraping up too much muck from the bottom of the groove, as well as the latest stereo records.



We must now return to the arm to examine a by-product effect of the head offset angle. Obviously, the stylus is kept in contact with the groove modulation by a downward force, commonly called the *tracking weight*, the value of which is dependent on the mechanical quality of the cartridge and arm partnership and on the level of the groove modulation. The stylus is thus subjected to a frictional drag in the groove, and because of the offset angle of the head a force is developed which tends to draw the arm towards the centre of the disc, see Fig. 7.

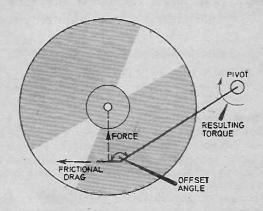


Fig. 7. Basic illustration of side-thrust (see text).

This is called side-thrust, and when the bearing friction of the arm is small it can be significant and thus cause the stylus to bear more heavily on the wall of the groove carrying the left channel than the other.

Because such imbalance can affect both the channel separation and the tracking performance, many arms are nowadays equipped with a scheme for combating the side-thrust. This is achieved merely by the application of an approximately equal force in the opposite direction provided by (i) a small weight dangling on a fine thread (SME, Audio-Technica), (ii) a spring arranged to introduce a countering torque at the pivot (Micro-Seiki), (iii) a system of permanent magnets (Decca).

The dangling weight idea on the SME 3009 short arm is shown in Fig. 8, while Fig. 9 shows the spring arrangement adopted by Micro-Seiki on the MA77/II arm, where the adjustment is provided by the small knob at

the bottom left of the base.

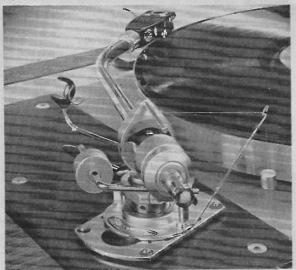


Fig. 8. The SME 3009 short arm showing dangling weight (side thrust correction) and counterbalancing and tracking weight system.

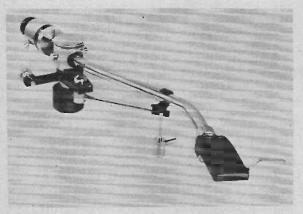


Fig. 9. Micro-Seiki MA77/II arm with spring arrangement for side thrust correction.

Since there is a likelihood of the side-thrust changing mildly with diminishing groove/stylus velocity, as the record plays out, and with changes in recording level, accurate correction over the entire disc is impossible. Nevertheless, the application of a nominal value of correction

can enhance the channel balance and separation and reduce the tracking weight by as much as 20 per cent in some cases.

The required nominal value will depend on the chosen tracking weight and the type and dimentions of the stylus tip, which is why it is adjustable on many arms.

#### OTHER ADJUSTMENTS

The arm must also embody a method for counterbalancing the weight of the shell-mounted cartridge (often by a sliding weight or weights at the end of the arm) and an adjustment for the tracking weight, either a small rider weight or a spring system.

The arm illustrated in Fig. 8 employs weights for counterbalancing and tracking, the latter sliding along the main part of the arm against

gramme calibration marks.

The arm in Fig. 9 also employs end weights for both functions.

Another arm fitment is an automatic or manually operated lifting and lowering device, such as shown on the Micro-Seiki MA77/II arm in Fig. 9, which is operated by the lever at the side.

We must now turn our attention to the chief pick-up parameters, of which there are three: (i) tracking ability, (ii) frequency response and (iii) channel separation.

#### TRACKING ABILITY

This refers to the least tracking weight required for the pick-up to handle modulation of a specific frequency and amplitude, usually translated to velocity, v, such that

 $v = 2\pi f A$ .

where f is the frequency in hertz and A the amplitude in centimetres of the modulation waveform.

Velocity is given in centimetres per second (cm/s), and because some of the latest discs have peak levels approaching 30cm/s at mid-spectrum, the pickup should be able to cater for such a velocity within its tracking weight range.

Sadly, few makers specify absolute tracking ability in this way (Shure being an exception by adopting the term 'trackability'). Most makers, though, specify the required tracking weight, sometimes in terms of minimum and maximum values.

One should not exceed the maximum, but whether the minimum weight will track modern records realistically will depend on the arm and side-thrust correction.

The tracking at high amplitudes is governed by the compliance of the cartridge. Compliance is the reciprocal of stiffness and is measured as the distance of millionths of a centimetre that the stylus is displaced by a force of 1 dyne (approximately equivalent to a force of 1 milligram). Modern cartridges boast vertical and lateral compliances of 20 x 10<sup>-2</sup> centimetres per dyne (cm/dyne) or better.

However, a high compliance cartridge does not necessarily imply a good tracking because the high frequency tracking ability is dependent on the effective mass at the stylus tip. When tracking high-frequency, high velocity modulation, the stylus tip can undergo an acceleration in excess of 1000g (g being Earth's gravitational pull). So by having a large tip mass, rapid change of motion will be impossible at a realistic tracking weight and without groove destruction. Top-flight cartridges have an effective tip mass of less than one milligram.

Tracking ability is also dependent on the mechanical damping built into the cartridge to tame overshoot and resonance effects, etc, thus the three factors of compliance, tip mass and damping combine to yield the tracking ability.

#### FREQUENCY RESPONSE

The output over the frequency spectrum should be free from violent changes if colouration of the reproduction is to be avoided; Fig. 10 shows the frequency response of a good quality cartridge. The slight undulations can be tolerated, but cartridges with violent changes in output within an octave are unsuitable for high quality reproduction.

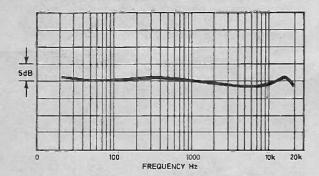


Fig. 10. Typical frequency response curve obtained with a good magnetic carfridge.

Magnetic pick-ups not uncommonly exhibit the "suck-out" around 5 to 8 kilohertz, while the mild rise at the bass end can be encouraged by the effective mass of the arm resonating with the compliance of the cartridge. It is thus necessary for a high compliance cartridge to be partnered with an arm of low effective mass.

Resonance, and thus a rise in output, occurs at the bass end because the resonant frequency is equal to  $\pi/2mC$ , where m is the effective mass of the arm and C the compliance of the cartridge. The resonant frequency is a little over 11 hertz when the compliance is  $20 \times 10^{-6}$  centimetres per dyne and the mass is 10 grammes.

If the resonance is too low the system will be unstable and if too high rumble from the motor and other acoustic effects may prove trouble-some.

#### CHANNEL SEPARATION

A separation curve compatible with the frequency response curve is shown in Fig. 11. Notice the high separation (almost 30 decibels (dB), equal to a voltage ratio of just over 31 to 1) at the middle of the spectrum.

At the bass and treble ends the separation normally falls off, but provided it holds around 10 decibels at 100 hertz and 10 kilohertz, with a maximum of at least 20 decibels at mid-spectrum, the stereo 'image' on replay should be reasonable.

Violent separation changes are sometimes noticed at the high treble due to stylus system resonances, and they often correlate with peaks and troughs in the response curve.

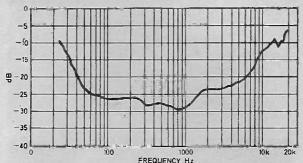


Fig. 11. Typical separation curve-magnetic pick-up.

#### **EQUALISATION AND LOADING**

Generally, magnetic cartridges are capable of better tracking, frequency response and separation than piezoelectric types. However, because the output from a magnetic is geared to velocity of modulation and because a modern disc is recorded with velocity rising with frequency, the output rises with frequency. This calls for equalisation at the amplifier input stage.

Actually, the recording is to the RIAA characteristics, with a velocity slope of 4 decibels per octave average (eg, almost constant amplitude). A reciprocal curve is required for equalisation, as shown in Fig. 12.

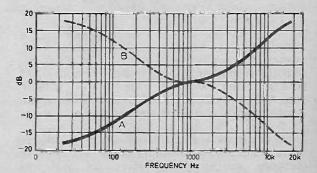


Fig. 12. Curves approximating the RIAA recording (A) characteristics and replay equalisation (B).

On the other hand, piezoelectric type cartridges give an output geared to the amplitude of the modulation, so the output is almost "flat" from an RIAA recording when the cartridge is loaded properly into the stipulated high resistance (about 2 megohms). Some piezoelectric species feature inbuilt equalisation to take into account the deviation from true constant amplitude recording.

It is possible to run a piezoelectric cartridge into an RIAA equalised input (eg. magnetic pick-

up).

The low value load here and the capacitance of the piezoelectric element result in a "tilt" in output so approximately simulating the velocity output of a magnetic cartridge. When running like this an input attenuator may be required to avoid the high piezoelectric output from overloading the RIAA equalised preamplifier.



A recent record deck from Scan-Dyna, type 1400.

#### **TURNTABLES**

We have already seen that the turntable must be responsible for the least wow and flutter. These are usually quoted as a percentage referred to an average frequency from a test record. One per cent is acceptable, but quality units might not produce much more than 0.1 per cent wow and flutter, depending on the method of measurement.

Another parameter is rumble. This arises from motor and bearing noises being transmitted through the turntable, motor board and disc to the pickup. It manifests like the low grumble of distant thunder or the movement of furniture in the room above!

As already noted, it can be emphasised by a critical pickup bass resonance. The slip-frequency of some drive motors is about 22 hertz, so if the resonance is close to that, rumble could be aggravated. Amplifiers often feature a high-pass filter to roll-off the sub-bass and hence the rumble signals. An unweighted value is about 40 decibels, but quality turntable units sometimes boast as high as 50 decibels (or higher when weighted), depending, again, on the test method.

Rotational speed should be adjustable to suit at least 3313 and 45 r.p.m. discs. If there is a likelihood of old 78's being played, then of course

the speed should be adjustable to this. Some turntable units also cater for 16 r.p.m. speech (talking book) discs.

Goldring-Lenco turntable units have a continuously variable drive. A motor board knob regulates the speed, and on some models the "standard" is indicated by a neon-illuminated stroboscope.

Recent models have "click" positions corresponding to the standard speeds. Fine speed control is useful for musicians and can avoid frustration when one is blessed (or otherwise!) with perfect pitch.



Photograph of a Goldring-Lenco turntable, type GL75 with variable speed control.

Speed change and variable control (when fitted) are related to the method of motor-to-turntable drive. The idler wheel type of drive, where the wheel picks up energy from the motor spindle (stepped to give speed changes) and couples it to the inside surface of the turntable, is still popular.

Belt drive is also being seen more these days. Here drive is coupled from the motor spindle or pulley (again stepped for speed change) to a larger diameter flange on the turntable or to a flywhel upon which the main turntable is placed (Micro-Seiki and Thorens respectively).

Automatic turntable are also liked in some quarters though rarely by the hi fi hierarchy for reasons of adjustment compromise and possible disc changes.

Motors commonly used for turntable drive are the small shaded pole variety, though sometimes a more "synchronous" device is adopted. When



The Connoisseur BD2 deck with arm; two speed belt driven unit.

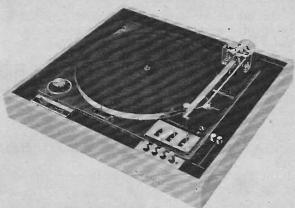
the mechanics are accurately balanced, the bearing friction low and the turntable mass high, it requires only a relatively small torque for constant speed drive.

#### THE FUTURE

The gramophone record will remain a long time yet the medium for high quality two-channel stereo and, seemingly, for the latest four-channel (quadraphony) reproduction. Discs are already available with the information of four channels in the single groove.

One scheme (Victor Company of Japan) incorporates four discrete channels of information by the use of frequency-modulation "multiplex" on a carrier frequency around 30 kilohertz, with sidebands towards 50 kilohertz.

Other schemes are based on the "matrixing" of ambient information relative to the normal left and right stereo channels, this being essen-



The Garrard QZ 100SC quadraphonic player system with built-in decoders. Can also be used for stereo or enhanced four channel modes.

tially a function of signal phasing by the encoding matrix. A reciprocal matrix at the reproducing end decodes the information into the original four channels.

It seems as though the magnetic pickup will retain its popularity, and species are available which respond up to 50 kilohertz (for the Victor discrete four-channel discs). Tracking weight is now down to one gramme (and less if you can handle it!).

To conclude, mention must be made of those cartridges which work on different principles, such as strain gauge (Miniconic), and photoelectric cartridges.

The magnetic family, incidentally, includes at least one make based on the ribbon principle—like a ribbon microphone.

There is certainly much more in record playing than meets the eye!

# TEACH-IN '74

#### QUESTION TIME ANSWERS

- 1. Electrons have a fixed negative charge.
- Current, in amperes, is a measure of the "rate of flow" of charge. One ampere equals one coulomb per second.
- 3. Current equals voltage divided by resistance.
- 4. Effective resistance is  $\frac{10 \times 22}{10 + 22} = \frac{220}{32} = 6.875$  kΩ.
  - For one watt power dissipation V<sup>2</sup>= 1000 and so V= 31·6 volts. The current is therefore 31·6 mA.
  - 6. Brown ( $\pm 1\%$ ), Gold ( $\pm 5\%$ ), Silver ( $\pm 10\%$ ).
  - 7. 270,000 ohms  $\pm$  5%.
  - 8. Providing the two battery voltages are the same the voltage difference will be zero for this method of connection.
  - 9. Capacitance increases.
- 10. Time constant is 220 mS. (i.e. 0.22 seconds).
- At the maximum working voltage of 100 V the energy will be 5 joules.

- 12. Resistor can be placed in either lead.
- 13. Cathode.
- 14. A reverse biased diode would give a voltage slightly less than the battery voltage. A good diode, in the forward bias direction would give a voltage reading of less than 1 volt.

An open circuit diode would give a voltage reading slightly less than the battery voltage due to the current taken by the voltmeter. A diode having appreciable leakage current in the reverse direction would also give a voltage reading less than the battery voltage. To distinguish between these last two cases it would be necessary to test the diode for both possible directions. If open circuit, the two readings will be the same. Hence both (b) or (c) could be correct.

- 15. 40mA when operating as a Zener.
- 16. Effective capacitance is  $^5\mu F$ .
- No. The "cold" resistance is lower than the operating resistance.

# A new series ...

# SEMICONDUCTOR PRIMER

By A.P. STEPHENSON

#### 1 . DEVELOPMENT OF THE TRANSISTOR

The transistor was invented on Christmas Eve 1947 in the Bell Telephone Laboratories U.S.A. The two scientists concerned were Bardeen and Brittain, working under the direction of Dr. Shockley.

The original experimental hookup was as Fig. 1.1. Two "catswhiskers" were pressing on a crystal of germanium, XI. It was noticed that if the current through ME1 was varied, the current through ME2 altered a slightly greater amount

This was the first time in history that amplification was achieved in a solid state device.

This device was named the point-contact transistor. Its creation launched an orgy of research throughout the world.

The original point-contact version was soon abandoned in favour of the junction transistor, which was essentially a sandwich of three semiconductor materials known as p-type which was doped germanium, rich in positive charge carriers called holes and n-type which was rich in electrons. The sandwich could be pnp or npn.

Silicon eventually displaced germanium, because of its much lower leakage current and its ability to withstand much higher temperatures (about 180°C instead of 75°C).

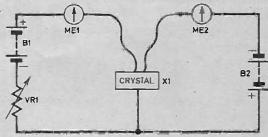


Fig. 1.1. The circuit used in the discovery of the transistor.

Manufacturing methods have continually improved, and the variety of techniques and sales gimmickry has now reached bewildering proportions.

The "in" type at present is the Planar Epitaxial as far as bipolar junction transistors are concerned. Bipolar means that the current is conducted through the device by two types of carriers, electrons and holes.

There is another entirely different type of transistor called the f.e.t. (Field Effect Transistor).

The transistor has triggered off the greatest technological revolution of all times.

#### 2 = THE SEMICONDUCTOR BARRIER POTENTIAL

Two slabs of material, one n-type and the other p-type, are joined together to form a pn junction diode.

The circuit symbol and the relation to p and n material is shown in Fig. 2.1.

The diode is an easy path for current in one direction only. In the other direction it is practically an open circuit.

If the applied voltages are as indicated in Fig. 2.1 the diode is said to be forward biased and will pass current. (This is easily remembered by noting that positive must go to p). When forward biased there is about 0.6 volts across a silicon diode, but about 0.2 volts, if germanium. Any attempt to push this voltage much higher will usually result in destruction of the device, because the current will rise rapidly.

. A graph, showing this behaviour, is given in Fig. 2.2.

These two voltages, 0.2 for germanium and 0.6 for silicon, are called the barrier potentials for the materials.

Note that current is small if voltage across diode is less than the barrier potential.

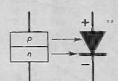


Fig. 2.1. The circuit symbol and relation to p and n type materials.

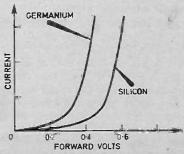
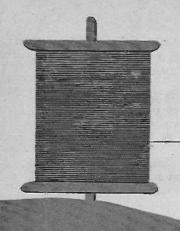


Fig. 2.2. Typical forward characteristics of silicon and germanium diodes.



# SEWING MACHINE

# SPEED CONTROL

BY J.A. BRETT

# **Enables finer speed control** with standard foot control.

This article describes a simple power controller for use on the domestic mains supply. It can handle up to 750 watts and be used to control the power fed to electrical appliances.

A very useful application, proved by the authors wife, is to use it with an electric sewing machine. Set at about half power it gives a finer speed adjustment with the standard foot control than can normally be obtained. A big advantage when machining intricate shapes in fine fabrics.

By reducing the power to electric motors as used in drills, food mixers and other appliances with series wound motors, the speed can be adjusted. The controller can also be used to dim lights provided they are conventional filament lamps, it will not work with fluorescent or other discharge lamps.

With the electric drill a well controlled speed reduction enables coil and transformer winding

to be attempted.

The circuit uses a triac which, although rated for a maximum current of 6 amperes, should not be allowed to run continuously at more than 3 amperes. The size of the heat sink and the fact that it is enclosed prohibit the sustained higher current use. On 240 volt a.c. mains supplies this gives a load rating up to approximately 750 watts, enough for most applications.

The circuit has been designed for the constructor with limited access to tools and uses, for the housing, a domestic MK Ivy base readily available from the local electrical contractor. With the exception of the triac the other components should be able to be supplied by the local electrical and radio shop. The triac can be obtained from several of the London based component houses by mail order.

#### CIRCUIT DESCRIPTION

The complete circuit diagram of the Sewing Machine Speed Control is shown in Fig. 1.

The actual power is controlled by a triac which is a semiconductor device similar to the controlled silicon rectifier (CSR) but with the ability to pass current in both directions. That is, once the gate terminal has been pulsed by a current pulse the device conducts current between the two main terminals until the end of that half cycle.

By altering the point in time during that half cycle when the gate is pulsed or "fired" the time current is allowed to pass is varied and hence the average power to the load is varied.

The firing pulse is produced by the partial discharge of the capacitor C1 into the gate. The voltage across the capacitor C1 rises to a high enough value to cause the neon lamp to strike, a comparatively high current then flows through the neon lamp into the gate of the triac until the voltage across the capacitor C1 falls to the extinguishing voltage of the neon lamp. The firing of the triac removes the source of charging current for the capacitor until the next half cycle.

The use of a neon lamp, has, in addition to being a low cost triggering device, the advantage of showing that the triac is being triggered also.



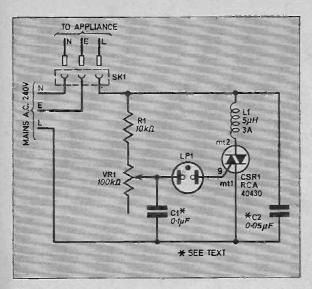


Fig. 1. The complete circuit diagram of the Sewing Machine Speed Control.

The point at which this triggering pulse occurs is determined by the rate by which the capacitor C1 is charged through the resistors R1 and VR1. With VR1 set to the minimum resistance, the capacitor C1 is charged at almost the same rate as the rate of rise of that half cycle of the mains supply.

As the typical striking voltage of the neon lamp is 90 volts, only a small percentage of the half cycle is not conducted through the triac. By increasing the value of the setting of VR1 the rate of charging C1 is lowered and hence the neon strikes later in the half cycle.

With VR1 set to the maximum resistance of 100 kilohms, a value of C1 is needed which is just too large to be charged to the neon striking voltage. The value required for this circuit lies between 0·1 and 0·15 microfarads and may be made up from a 0·1 microfarad capacitor in parallel with a lesser value determined on test of the finished unit. By selecting this apparently too large value capacitor, the neon will not strike and pulse the triac; hence the unit will be in a fully turned off condition.

Although the voltage across Cl does not rise to more than about 100 volts, the polarity reverses 50 times a second causing high stressing of the dielectric and a working voltage of at least 400 volts is needed. This is also the reason for specifying a 1200 volt d.c. rating for the interference suppression capacitor C2, if one with an a.c. rating of at least 350 volts is not used.

The small inductance L1 limits the rate of rise of current through the triac. This is most important when the triac is switching at half power, that is, switching on when the mains supply is at its peak value.

In addition to switching the maximum value of inrush current for the load, the triac has to

discharge the suppression capacitor C2. The triac junction will be destroyed if the rate of current is allowed to build up much in excess of 20 amperes per microsecond.

An inductance of about 5 microhenries will limit the rise in this circuit to a safe value. This value of inductance is typical of the TV interference suppression chokes sold in most radio and electrical shops.

The circuit with these suppression components does not appear to cause any TV interference as it has been used as a lamp dimmer alongside a working TV receiver.

# Components.

Resistor

R1  $10k\Omega \frac{1}{2}W$  carbon  $\pm 10\%$ 



#### Potentiometer

VR1 100kΩ ½W linear composition type

#### Capacitors

C1 0.1 µF 400V d.c. working

C2 0.05 400V a.c. or 1200V d.c. working plastic foil.

#### Semiconductor

CSR1 Triac 400V 6A type RCA 40430 or similar

#### Miscellaneous

SK1 MK Ivy mains socket

LP1 Panel or wire ended neon lamp

L1 Interference suppression choke 3A  $5\mu H$  Enclosure made from MK items: Ivy plate, base, divider; knob for VR1, insulated with internal retainer or deep set grub screw; aluminium 2 x 80 x 25mm (heat sink); 6BA nuts, bolts and solder tags.

#### CONSTRUCTION

The circuit is built up using point to point wiring as shown in Fig. 2.

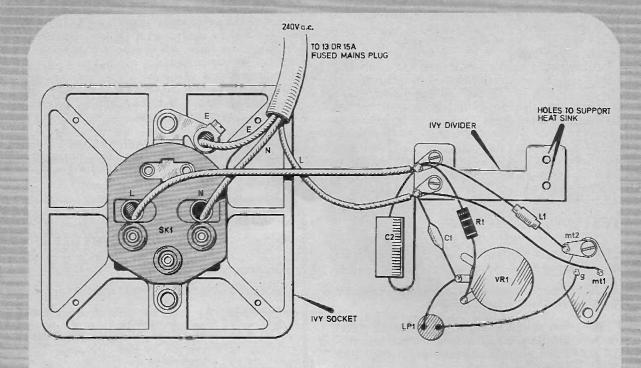
Begin by making up the heat sink as shown

in Fig. 3 and paint matt black.

The heat sink with mounted triac should be held in position inside the MK box, against the divider, as near to the side as possible, and then the drilling holes in the divider are marked out.

Drill these two holes and the two holes to take the 6BA terminal nuts and bolts at the other end of the divider, see Fig. 2. These two terminal nuts and bolts make the connection between the socket section and the control section. If the case shown is not used the triac should be insulated from the heat sink and the bolts insulated from each other and the case. The case should be earthed if metal.

Drill the blank cover plate centre hole and hole to suit the diameter of the neon lamp holder as shown in Fig. 4. If a neon lamp not mounted in a holder is used, drill the appropriate



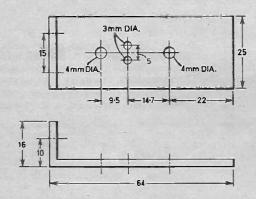
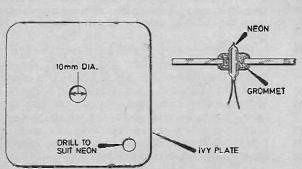


Fig. 2 (above). The wiring up diagram and layout of the components in the MK Ivy base.

Fig. 3 (left). Details of the heat sink for mounting CSR1. Use at least 1mm thick aluminium.



# SEWING MACHINE SPEED CONTROL

Fig. 4. Details of fixing the neon lamp.

hole to hold the neon in a grommet as shown in Fig. 4. Both the neon lamp and grommet should

be glued in position.

Mount the assembled heat sink to the divider plate and wire up the other components as shown in Fig. 2. Sleeve all component tails bearing in mind that the 0.1 µF capacitor at the C1 location may have to have a small value capacitor fitted in parallel later.

The whole assembly can now be fitted into the enclosure and the mains socket wired in. Finally fit the knob, ensuring that the grub screw is well below the surface if the type with an internal retaining spring is not available.

### TEST AND OPERATION

Connect a mains lamp load and switch on. Check that the output can be varied and that it will fall to zero. If the output will not fall to zero an additional small value capacitor, such as 0.022 microfarad or 0.05 microfarad should be fitted in parallel with C1.

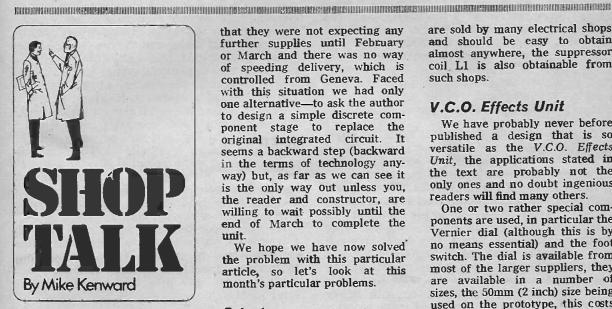
In use always check that the motor, lamp or other load is not short circuit as the average 3 amp fuse, which should be fitted to the mains plug, will not blow quickly enough to save the triac from permanent damage.

In use, the unit is plugged into the mains and the appliance to be "controlled" such as the sewing machine, via its foot pedal, is plugged

into the socket of the unit.

Clockwise rotation of the control knob increases the power (speed) to the appliance. The control knob should be adjusted in conjunction with the foot pedal-control to give much finer control than with the pedal alone.

Sewing machine shown on the front cover was kindly loaned by John Lewis.



Supply seems to be becoming non existent with regard to components. In November issue, we published the 4 Band T.R.F. Receiver and this design used a Motorola MFC 4000B integrated circuit amplifier. At the time this device was being advertised by many suppliers and all seemed to be well, however, by the time the issue was on sale virtually all stocks of the device had been sold and, after phoning all the Motorola appointed distributors-who supply the retailers-we could only find fifty of these devices in the whole of the British Isles, not nearly enough to meet readers'

What was even worse was the fact that the distributors told us that they were not expecting any further supplies until February or March and there was no way of speeding delivery, which is controlled from Geneva. Faced with this situation we had only one alternative-to ask the author to design a simple discrete component stage to replace the original integrated circuit. It seems a backward step (backward in the terms of technology anyway) but, as far as we can see it is the only way out unless you, the reader and constructor, are willing to wait possibly until the end of March to complete the unit.

We hope we have now solved the problem with this particular article, so let's look at this month's particular problems.

#### Fetset

The Fetset MW Receiver derives its name from the f.e.t. (field effect transistor) used in the first stage. This transistor and BC169C should both be readily available, as should the remainder of the components used in this project. The tuning capacitor can be almost any miniature variable type of about 250pF. The case must be plastic and there are a number of small ones available from the various retailers.

### Sewing Machine Speed Control

All components for the Sewing Machine Speed Control should be readily obtainable, the MK parts are sold by many electrical shops and should be easy to obtain almost anywhere, the suppressor coil L1 is also obtainable from such shops.

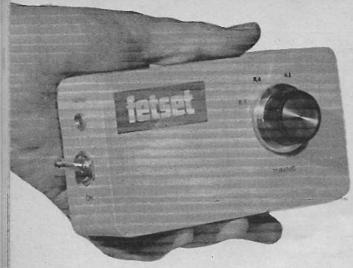
### V.C.O. Effects Unit

We have probably never before published a design that is so versatile as the V.C.O. Effects Unit, the applications stated in the text are probably not the only ones and no doubt ingenious readers will find many others.

One or two rather special components are used, in particular the Vernier dial (although this is by no means essential) and the foot switch. The dial is available from most of the larger suppliers, they are available in a number of sizes, the 50mm (2 inch) size being used on the prototype, this costs about 85p and this price was not included in the cost box.

The foot switch on the prototype is simply a heavy duty push on, push off pushbutton and is quite suitable. Henry's Radio show a rather more sophisticated foot-switch in their catalogue which is free standing and could be linked to the unit by a lead and plug, however this switch costs more than £1 and is not necessary unless the unit cannot be placed on the floor. The foot operation is only required when the unit is used as an effects box with drums or other instruments.

Other points to watch when buying for this unit, are the notes in the text referring to the jack sockets, and also the pot value if the Vernier drive is used.



# fetset mw receiver

A two transistor m.w. receiver using an f.e.t. for increased performance

# By R.A.PENFOLD

This receiver covers the m.w. band, and uses only two transistors, including one field effect type. The use of a f.e.t. (field effect transistor) gives the circuit a low noise level, and low current consumption. It also helps to give extremely sharp selectivity. While the set is quite compact, the prototype measuring 133 by 73 by 38mm, it has purposely not been miniaturised in order that construction should be very simple, and standard, readily available components can be used. The output is for a crystal earpiece.

As a regenerative detector is used, no alignment is required, and only one simple adjustment to optimise performance has to be made before the completed device is ready for use.

Apart from the normal B.B.C. stations, a few continental ones can be received at an adequate volume. After dark a larger number of continental stations can be received, including Radio Luxembourg which has been received very well in the south east of England.

The unit is very economical to run as the current consumption from the PP3 battery is only about 650 microamps. Even with heavy use this will give a battery life of many months.

# THE CIRCUIT

A circuit diagram of the receiver is shown in Fig. 1, TR1 is a field effect transistor, and

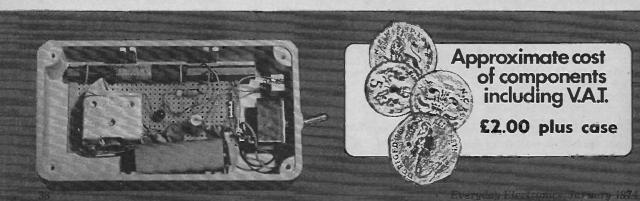
this type of component is very different from an ordinary bipolar transistor. An ordinary transistor has a very high resistance between its collector and emitter terminals unless a small forward bias is applied to its base, whereupon its resistance will drop, and it can be used for linear amplification. An f.e.t. however, has a relatively low impedance across its drain and source terminals (equivalent of the collector and emitter of a bipolar transistor), and it is necessary to give it a small reverse bias in order to bring it into linear operating conditions.

Referring to Fig. 1 it will be seen that the drain and source terminals of TR1 are connected as part of a potential divider network across the 9 volt supply. A small voltage will therefore appear at TR1 source. The gate of TR1 has to be held at earth potential so as to give the required reverse bias.

As the input impedance to the f.e.t. is extremely high, normally a very high value resistor would be used to fulfil this function. In this case though, the tuning coil, L1, has a dual function, and also acts as this biasing component.

#### REGENERATION

Coil L1, which is wound on a ferrite rod, forms the aerial, and the signals received by this are coupled into the gate of TR1. Capacitor C1 is the tuning capacitor, L2 is a regenerative feed-



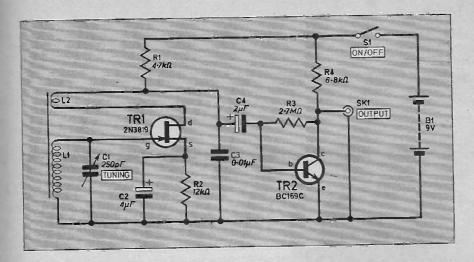


Fig. 1. Complete circuit diagram of the Fetset

back winding, and couples some of the amplified signal at TR1 drain back to the input of the circuit. This winding is adjusted to the point just below that at which the circuit breaks into oscillation. It is at this point that the maximum effective regeneration is applied, and the circuit is at its most sensitive.

In this particular application, TR1 is not biased into true linear operating conditions, as it is essential that it should amplify one half cycle of the r.f. (radio frequency) signal more than the other half in order to detect the signal, and produce an a.f. (audio frequency) output. The use of regeneration heightens this effect, and thus greatly increases the detectors efficiency. It also increases the r.f. gain of the circuit, and thus gives a large overall increase in sensitivity.

It is important that the type of regenerative circuit used gives a fairly even amount of feedback over the entire range of frequencies covered, so as to give the maximum sensitivity over the entire band. It is also important that the regeneration is not seriously affected by the drop in supply voltage caused by ageing of the battery. This circuit is very good in both these respects.

Capacitor C2 is the bypass capacitor for R2. The audio output of the detector is developed across R1, and C3 decouples the r.f. signal. The audio signal is fed to TR2 via C4.

Transistor TR2 forms a straightforward high gain audio amplifier stage, which has collector load resistor, R4, and base bias resistor, R3. The output is taken from TR2 collector, and is suitable for a crystal earpiece only. Switch S1 is the on/off switch.

# FERRITE AERIAL

The ferrite aerial is home made, and Fig. 2 illustrates the construction of this. The coil is wound on a 102mm by 14 inch diameter ferrite rod. If a rod of the correct length cannot be

obtained, the length can be cut from a longer piece. At the point at which the rod is to be cut, a deep V shaped groove is made around the circumference of the rod using a triangular file. The rod is then given a sharp tap with the edge of the file at this point to break it in two.

If the end of the rod is left a little rough, this does not really matter. Care should be taken when handling the rod, as these are very brittle, and can easily smash if accidentally dropped.

Coil L1 consists of 65 turns of 32 s.w.g. wire (enamelled or double cotton covered) wound in a single layer. In order to prevent the coil

# Components....

#### Resistors

R1 4·7kΩ R2 12kΩ

R3 2·7MΩ

R4 6.8kΩ

All 1W ± 10% carbon

SHOP TALK

#### Capacitors

C1 250pF (approx.) miniature variable

C2 4µF elect. 9V

C3 0.01 µF disc ceramic or Mullard C280 type

C4 2µF elect. 9V

#### **Transistors**

TR1 2N3819 or PN3819 f.e.t. n channel TR2 BC169C silicon npn

#### Miscellaneous

S1 s.p.s.t. toggle or slide switch

SK1 3.5mm jack socket

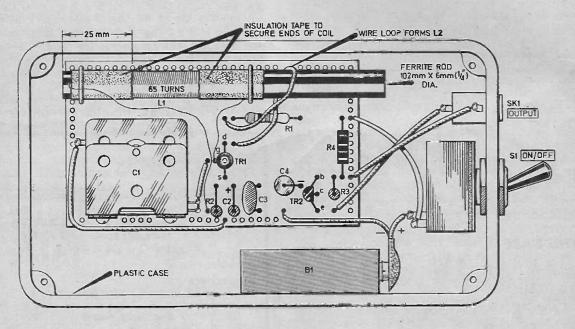
B1 9V PP3 battery and clip

Ferrite rod 103mm x ½ inch diameter, 32 s.w.g enamelled or double cotton covered copper wire (for L1), crystal earpiece, 0·1 inch matrix plain perforated Veroboard 90mm x 50mm, plastic case (see text) large diameter control knob, wire, fixing screws for C1 if needed.



# fetset mw receiver

Photograph of the completed Fetset, with earpiece.



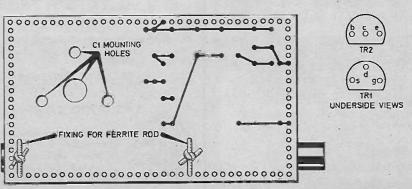


Fig. 2. Complete layout and wiring diagram of the Fetset

from unwinding, the lead out wires are taped to the rod using ordinary insulation tape (not Sellotape). Try to keep the winding reasonably neat, with the turns wound side by side, avoiding overlaps if possible. Ensure that the lead out wires are made sufficiently long (at least 80mm).

#### COMPONENT PANEL

Most of the wiring is on a 0·1 inch matrix perforated paxolin panel measuring 90mm x 50mm, Fig. 2 shows a diagram of the board.

The first task is to drill the mounting holes for Cl. Some variable capacitors require a single <sup>3</sup>8-inch diameter mounting hole, but others require a <sup>5</sup>15-inch diameter hole for the component's spindle, and three smaller holes for three 4BA countersunk fixing screws (not normally supplied with the component). The ferrite aerial is tied to the board by two loops of thin p.v.c. sleeving or string.

Next the small components are mounted on the board and wired together. These are mounted in the positions shown in the diagram, and their lead out wires are bent over at right angles and cut to length. The leads are then directly soldered to one another, this underside

wiring also being shown in Fig. 2.

Connections to C1, S1, SK1, etc., should be left until last. Three 50mm long insulated leads are connected to the board where the connections to S1, and SK1 are to be made. The connections to S1 and SK1 are not made until both these, and the component panel are mounted in the case.

Coil L2 consists of a 130mm length of single core p.v.c. insulated wire. This has a loop made in the middle, and this is slipped on, and pushed a little way onto, the ferrite rod. This in effect forms a single turn coil on the ferrite rod.

### THE CASE

The prototype receiver is housed in a commercially produced fibreglass case with a removable aluminium back. There are several plastic boxes of about this size available (130 x 73 x 38mm), any of which is suitable for this project. A metal case cannot be used as this would screen the aerial, and so prevent the receiver from working.

The general layout of the components inside the case is also shown in Fig. 2. A mounting hole is required for SK1, and S1. The front panel of the case is drilled with mounting holes for C1. The component panel is secured inside the case by being trapped between C1 and the front of the case, C1 in effect being used to bolt the

panel to the inside of the case.

### ADJUSTMENT

Once construction has been completed it is only necessary to adjust the reaction coil (L2)

for optimum results before the set is ready for use. With the earpiece connected and the receiver turned on, it should be possible to tune a few stations. If these are very weak, or none can be received at all, providing the set has been wired correctly, this means that L2 has incorrect phasing. To correct this, L2 is removed from the ferrite rod, twisted through 180 degrees, and then replaced on the rod.

For maximum sensitivity and selectivity, L2 is pushed as far onto the rod as possible without the set breaking into oscillation, at any setting of C1. When the set is oscillating there is a noticeable increase in background hiss, and a whistle will be heard as the set is tuned across

a station.

In practice it is probably best not to take L2 too close to the threshold of oscillation, as the tuning will be so sharp that it will be difficult to tune a station properly, and the audio quality may suffer. It should, however, be possible to find a setting for L2 which gives good sensitivity, selectivity, and audio quality, just below this setting.

It should be found that L2 is firmly held in place by being trapped between the ferrite rod and the component panel, but if any further fixing should be found necessary, a small strip of insulation tape can be used to secure it to the rod.

As a finishing touch a simple dial can be marked around the control knob of C1, showing the station positions. Should it be found that tuning is difficult the size of the knob can be increased.



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# AMPLIFIER FOR ...

# 4 BAND T.R.F. RECEIVER

BY F.G. RAYER



# A replacement amplifier for the circuit published in November 1973

THE 4 Band T.R.F. Receiver in the November 1973 issue used a small integrated circuit audio amplifier, the MFC4000B. In view of delays which may be encountered in obtaining this IC due to the fact that most suppliers have sold out and a new consignment is not due for some months, a suitable substitute amplifier is described here. Though particularly intended for this receiver, it can of course be used for other purposes where a small amplifier of this kind is required. The amplifier replaces the audio board originally used.

### CIRCUIT

The circuit is shown in Fig. 1, and both transistors are easily obtained, high gain types, VR1 is the volume control present in the original receiver, providing the required level of audio signals via capacitor C1 for the base of TR1. This is a high gain stage, stabilised by taking the base resistor R1 to the collector side of the load resistor R2.

The base of the second stage TR2 is capacitor coupled by C3. Working conditions in this stage are arranged for a collector current of about 15mA. This easily gives more than adequate headphone volume, while allowing modest volume reception with a loudspeaker, while not imposing a heavy drain for the PP9 type of 9V battery used.

Resistor R6 is the collector load for this stage, with audio output taken from C5, and this arrangement means that working conditions do not depend on the direct current resistance of the headphones or speaker which may be plugged into the output jack socket. It will be found that best results are obtained with medium impedance phones, or a speaker of about 75 ohms impedance, but other loads are satisfactory.

#### CIRCUIT BOARD

Both sides of the circuit board are shown in Fig. 2. It can be of the same size as originally used in the receiver, and input and other circuit connecting points are arranged in similar positions to those used with the original amplifier.

Two 6BA bolts secure tags which form the negative connecting points. Extra nuts are put on these bolts, and when the amplifier is finished they are locked to the chassis, with enough clearance to avoid any possible short circuit to the metal.

The polarity of the electrolytic capacitors should be noted when inserting these. The wire ends of components are bent over and soldered to the required points, excess being snipped off. Leads and joints are kept close against the insulated board. Transistor leads are arranged to come through the holes shown, and are soldered without unnecessary or prolonged heating.

### **EXTERNAL CONNECTIONS**

A lead from Cl passes to the wiper of the volume control VR1. If the amplifier is not being



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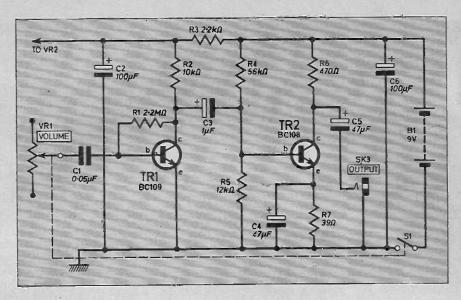


Fig. 1. Circuit of the new audio section for the 4 Band T.R.F. Receiver.

used with the receiver, but for some other purpose, connect the lower end of the volume control element to amplifier negative line.

A lead runs from positive of C2 to VR2, which is one of the regeneration controls of the receiver. If the amplifier is used alone for some

other purpose, no connection is required here.

Battery positive goes to positive of C6, and battery negative to the negative line, the on-off switch being included here.

Leads from C5 negative and the earth or chassis line run to the output jack. Connect the sleeve contact tag to "earth" or chassis, and the tip contact to C5.

SEE

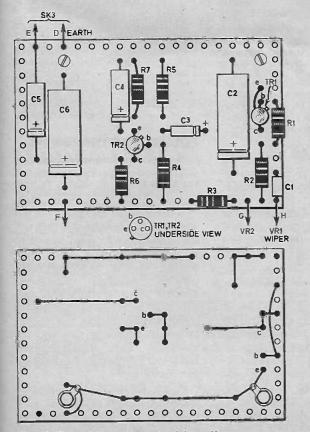


Fig. 2. Board layout and wiring diagram.

Components....

R	es	is	to	rs
---	----	----	----	----

R1 2·2MΩ R2 10kΩ\*

R3 2·2kΩ\*

R4 56kΩ\*

R5 12kΩ

R6 470Ω

R7 39Ω

All ¼W ±10% carbon

#### Capacitors

C1 0·05μF

C2 100µF elect. 10V\*

C3 1µF elect. 10V

C4  $47\mu$ F elect. 10V C5  $47\mu$ F elect. 10V

C6 100 F elect. 10V\*

### **Semiconductors**

TR1 BC 109 silicon npn

TR2 BC 108 silicon npn

#### Miscellanous

- \* Veroboard 75 x 51 mm, 0.15 inch matrix plain type, connecting wire.
- \* Items marked thus may already have been purchased for the original amplifier design and need not be reordered.



By GEORGE HYLTON

"On the one hand, one is told that the decibel rating is a comparative ratio figure with no fixed unit value, and on the other that a decibel is the smallest sound difference audible to the human ear. Can you help?"

Let's get on at the start of the line; in this case a telephone line. The inventor of the telephone was, you'll remember, Alexander Graham Bell.

Long afterwards, when telephone engineers wanted a unit to describe the way signals get attenuated as they travel down a line they decided to honour the inventor by using his name. Being economically minded (or perhaps just bad spellers) they knocked off the final "l" and called the unit the "bel". The bel (B) is inconveniently large for most purposes, so we chop each bel into ten decibels (dB).

Problem: if you pump one milliwatt of audio power into a telephone line and this gives a usable range of 10 miles, what range will you get by increasing the power to 100 milliwatts? Common sense says, 1,000 miles. Practical experience shows that the new range it very much less, about 17 miles!

evidently Common sense looked at the problem the wrong way. Let's try a different approach.

### RELATIVE LOSS

The power gets used up as the signals travel along the line. After a certain distance, half the power has gone. Suppose this distance is one mile. So if we start with 100 milliwatts, after one mile we have 50 milliwatts left. After two miles, we have 25 milliwatts, after three, 12.5 milliwatts, and so on, halving for each mile. Somewhere between six and seven miles down the line the power is reduced to one milliwatt.

We know that one milliwatt gives a range of 10 miles, so the range for 100 milliwatts is this plus the 6 to 7 miles it took to reduce the 100 milliwatts to one milliwatt. Total, between 16 and 17 miles.

#### **DECIBELS**

In terms of decibels, the telephone line had an attenuation of 3dB per mile. Decibels tell you at what rate something is decreasing (or increasing). A decrease of 3dB means a halving: a decrease of 30 per cent corresponds to 1.5dB.

In a telephone line, what declines is power. In electronics, we often want to work in voltage or current rather than power. Because power is proportional to voltage squared (doubling the voltage quadruples the power in a particular circuit), the decibel numbers come out differently for voltage and current comparisons than for power comparisons. Doubling the power gives a 3dB increase. Doubling the voltage gives a 6dB increase.

Why use decibels anyway? They are often used where it would be just as meaningful to use other ways of expressing gain or loss, it's true, but at times they are very convenient.

If a radio receiver has an r.f. gain of 10, an i.f. gain of 20,000, a detector efficiency of 50 per cent, and an audio gain of 400, the overall gain is 10 x 20,000 x 0.5 x 400. Whatever that comes to, it will be a large number with a lot of noughts at the end. In decibels, the gain is

20 + 86 - 6 + 52 = 152 dB

which looks a lot tidier. Note that you add the gains of the successive stages when working in decibels (and subtract the losses, which explains the minus 6, for the detector).

#### COMPARISON

Strictly speaking, decibels give only comparisons. They tell how many times weaker or more intense one signal is compared to another. But if you pick on an agreed signal power and call that "0dB", the "0" standing, not for zero power but for the agreed reference power, then you can make a decibel figure stand for an actual power.

In telephone engineering, 0dB is usually one milliwatt. On this basis, 100 milliwatts is

+20dB.

If the line halves the power every mile, you knock off 3dB per mile. So a power increase of 20dB (from one milliwatt to 100 milliwatts) gives a range increase of 20/3 miles which is 6.67 mile:

### LOUDNESS

In loudness measurements 0dB usually refers to the sound intensity which the average person can just hear-the "threshold of hearing". This varies with frequency, but at 1000Hz it's about a millionth of a millionth of a watt per square metre. A very loud sound is (almost painful) around 120dB on this basis, or one watt per square metre. If these figures sound low in relation to amplifier powers, rethat loudspeakers member have low efficiency, around one per cent!

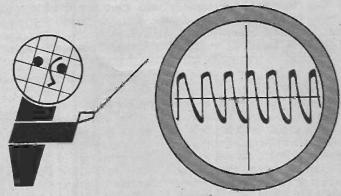
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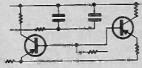
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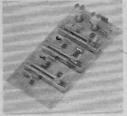
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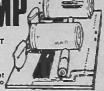
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4700µF	29p	470µF	10p			6.8µF	6+p	22µF	0 ip
		1000µF	Hp			15µF	6 p	68µF	[Op
6-3 VC	DLT	1500µF	20p	25 VC	LT	33µF	61p	100µF	Hp
33µF	61p	2200µF	24p	10µF	61p	47µF	61p	150µF	[3p
68µF	61P			22 <i>u</i> F	61p	100uF	9p	220µF	19p
150µF	6 p	16 VC	LT	47µF	61p	150µF	10p	330µF	22p
470µF	lip	15µF	6+p	100µF	8p	220µF	Hp	470µF	26p
680µF	13p	33uF	61p	150µF	8p	470µF	19p	1000µF	44p
1500µF	18p	68µF	6 p	220µF	10p	680µF	25p	100	
2200µF	18p	150µF	8p	470µF	13p	1000µF	25p		
3300µF	26p	220uF	9p	680µF	20p	2200µF	44p		
6800uF	40n	680uF	17p	1000uF	22p	3300µF	65p	1	

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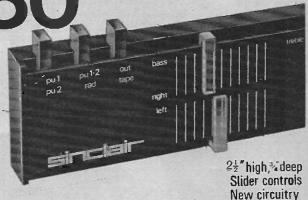
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TW 2% ELECTROSIC TRS.     Values available l-99 100+       Price watts Tolerance watts 1 0% 3·3m α-10m α E12 lp 0·8p       1 10% 3·3m α-10m α E12 lp 0·8p       1 2% 10 α-1m α E24 3·5p 3ρ       1 10% 1 2-3·9 α E12 lp 0·8p	MULLARD POLYESTER CAPACITORS C2%6 SERIES 400V: 0.001μF, 0.0015μF, 0.0022μF, 0.0022μF, 0.0033μF, 10.0024μF, 2½p. 0.0068μF, 0.012μF, 0.015μF, 0.0023μF, 10.047μF, 0.0068μF, 0.015μF, 4p. 0.15μF, 4p. 0.022μF, 0.033μF, 11p. 0.47μF, 13p. 160V: 0.01μF, 0.015μF, 0.022μF, 0.033μF, 0.022μF, 0.033μF, 0.022μF, 10p. 1.0μF, 13p. 1.0V: 0.01μF, 0.015μF, 0.022μF, 5p. 0.33μF, 6p. 0.47μF, 7½p. 0.68μF, 11p. 1.0μF, 13p.
DEVELOPMENT PACK 0.5 watc 5% lakra resistors 5 off each value 4.7 \( \Omega\$ to IM\( \Omega\$.\) E12 pack 325 resistors £2.40. E24 pack 650 rasistors £4.70.  POTENTIOMETERS Carbon track \$k\( \Omega\$ to 2M\( \Omega\$, log or linear (log \div W, lin \div W).  Single, 12p. Dual gang (stereo), 40p. Single D.P. switch, 24p.  SKELETON PRESET POTENTIOMETERS	ELECTROLYTIC CAPACITORS (µF/ν) 1/63, 1-5/63, 2-2/63, 3-3/63, 4-7/63, 6-8/40, 6-8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/163, 33/6-3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6-3, 68/16, 100/4, 100/10, 100/25, 150/6-3, 150/16, 220/4, 220/6-3, 220/16, 330/4, 6p. 47/63, 00/40, 150/25, 220/25, 330/10, 470/6-3, 7p. 68/63, 150/40, 220/40, 330/16, 1500/4, 10p. 470/10, 680/6-3, 11p. 100/63, 150/63, 220/63, 1000/10, 12p. 470/25, 680/16, 1500/6-3, 13p. 470/40, 680/25, 1000/10, 1500/10, 2200/6-3, 18p. 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6-3, 4700/4, 21p.  SOLID TANTALUM BEAD CAPACITORS  0-1µF 35V 22µF 16V 12p. 16V 33µF 10V 22µF 16V 12p. 25V 33µF 10V
Linear: 100, 250, 500 g and decades to SM Q. Horizontal or vertical P.C. mouncing (0-1 matrix).  Sub-miniature 0-1W, 50 each. Miniature 0-25W, 70 each.  TRANSISTORS  ACI07 15p AFI26 20p BFI15 25p OC42 12p 2N3707 12p ACI26 12p AFI39 32p BFI73 20p OC44 12p 2N3708 10p ACI27 15p AFI78 32p BFI77 28p OC45 12p 2N3709 10p ACI27 15p AFI88 40p BFI78 32p OC70 12p 2N3710 11p ACI31 12p BCI07 12p BFI89 32p OC70 12p 2N3711 11p ACI31 12p BCI07 12p BFI89 32p OC70 12p 2N3711 11p ACI32 12p BCI07 12p BFI89 32p OC71 12p 2N3711 11p ACI32 12p BCI07 12p BFI89 32p OC72 12p 2N3711 32p ACI32 12p BCI07 12p BFI89 32p OC72 12p 2N3711 32p ACI32 12p BCI07 12p BFI89 32p OC72 12p 2N3711 32p ACI32 12p BCI07 12p BFI89 32p OC72 12p 2N3711 32p ACI32 12p BCI07 12p BFI89 32p OC72 12p 2N3819 32p	O-47µF 35V   O-27µF 35V   O-2
AC176 15b 8C108 12b 8F181 32b CC81 12b 2N4062 12b CC87 22b 8C109 12b 8F181 32b CC81 12b 2N4062 12b CC87 22b 8C109 12b 8F195 14b 2N2646 60b 2N4289 20b AD140 30b 8C148 12b 8F195 14b 2N2646 60b 2N4289 20b AD140 45b 8C149 12b 8F197 15b 2N2904 20b 40360 35b AD149 45b 8C149 12b 8F197 2N2904 20b 40360 35b AD149 45b 8C149 12b 8F200 32b 2N2926 10b 40361 35b AD162 36b 8C158 14b 8F750 20b 2N3055 60b 40406 40b AF114 20b 8C159 14b 8F752 20b 2N3055 60b 40406 40b AF114 20b 8C159 14b 8F752 20b 2N3055 60b 40406 40b AF116 20b 8C159 14b 8F752 20b 2N3702 12b ZTX108 15b AF116 20b 8C187 22b 8U105 22b 2N3703 12b ZTX108 15b AF116 20b 8C187 22b 8U105 22b 2N3703 12b ZTX300 15b AF118 30b 8D131 75b 0C26 45b 2N3704 13b ZTX300 20b AF118 30b 8D133 75b 0C35 50b 2N3706 12b ZXX500 15b ZXX500 15b AF118 30b 8D133 75b 0C35 50b 2N3706 11b ZXX500 32b	17 x 3 (plain) —   82p   7 x 32 (plain) —   60p   17 x 22 (plain) —   60p   17 x 22 (plain) —   42p   24 x 5 (plain) —   12p   24 x 32 (plain) —   12p   1
WIRE WOUND POTS. 3W, 10, 25, 400mW 5% 3·3V to 30V, 12p.   S0 Ω and decades to 100k Ω. 35p.	2500µF 50V 58p 3200µF 16V 50p 5000µF 50V ET-10 HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT 0-01µF 10p 0-047µF 13p 0-12µF 20p 0-022µF 12p 0-1µF 13p 0-47µF 22p POLYSTYRENE: CAPACITORS 160V 2½% 10pF to 1,000µF E12 Series Values, 4p each.  SMOKE AND COMBUSTIBLE GAS DETECTOR—GDI The GDI is the world's first semiconductor that can convert a concentration of gas canable into an electrical ireal. The sensor decreases its electrical resistance when
SLIDER POTENTIOMETERS  B6mm x 9mm x 16mm, length of track 59mm.  SINGLE 10K, 25K, 100K log, or lin, 40p.  DUAL GANG, 10K + 10K etc. log, or lin, 60p.  KNOB FOR ABOVE, 12p.  FRONT PANEL, 65p.  18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.	it absorbs deoxidizing or combustible gases such as nydrogen, Laroun mollostome mathane, propane, alcohol, North Sea gas, as well as carbon-dust containing air of smoke. This decrease is usually large enough to be utilized without amplification full details and circuits are supplied with each detector. Detector GDI, £2. Kit of parts for detectors including GDI and P.C. board bu excluding case. Mains operated detector £5.20. 12 or 24V battery operated audible larm £7-30. As above for PP9 battery, £6-40.  PRINTED BOARD MARKER  77  Draw the planned circuit onto a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high
ALUMINIUM BOXES  AB7 22" x 51" x 15" 50p AB14 7" x 5" x 2±" 84p  AB8 4" x 4" x 14" 50p AB15 6" x 6" x 3" 108p  AB9 4" x 22" x 1 " 50p AB16 10" x 7" x 3" 122p  AB10 4" x 52" x 1 " 50p AB16 10" x 7" x 3" 122p  AB11 4" x 2±" x 2" 60p AB18 12" x 5" x 3" 108p  AB12 3" x 2" x 1" 44p AB19 12" x 8" x 3" 160p	BULGIN MAINS CONNECTORS  3 Pin 1½A Chassis Plug 10p 10p 12p 13p 12p 13p 13p 14p 14p 13p 13p 15p 15p 14p 15p 15p 14p 15p 15p 15p 15p 15p 15p 15p 15p 15p 15
HEATSINKS—REDPOINT 2W 24p 4W 45p TO5 Clip 5p TO1 Single 5p 3W 36p 6W 60p TO18 Clip 5p TO1 Double 8p  TRANSFORMERS All have 240V primary MT30/2 0-12-15-20-24-30V 2A £2-85 MT50/1 0-19-25-33-40-50V 1A £2-85 MT50/1 0-19-25-33-40-50V 1A £2-55 MT50/2 0-19-25-33-40-50V 2A £3-50 MT60/2 0-19-25-33-40-60V 1A £2-50 MT60/1 0-24-30-40-48-60V 1A £2-80 MT60/2 0-24-30-40-48-60V 1A £2-80 MT60/2 0-24-30-40-48-60V 1A £2-80 MT60/2 0-24-30-40-48-60V 1A £2-80 MT60/2 0-24-30-40-48-60V 1A £2-80	THERMISTORS  VA1005  VA1005  VA1026  I5p  VA1026  VA1033  I5p  VA10555  I5p  VA10665  I5p  VA1077  I5p  R53  41 -35  WAVECHANGE SWITCH 23p  I6 12W 3p 4W, 2p 2W, 2p 6W, 4p 3W  DIL Sockets 14 pin and 16 pin 16

Project 80

# the slimmest, most elegant hi-fi modules ever made

Living with hi-fi takes on new meaning with Project 80 modules. They can be assembled virtually anywhere, creating opportunities to install systems hitherto only dreamed about and never before made practical. Quality and reliability are everything you could wish for. Units are mounted by 6BA bolts at rear passing through drilled holes, cases are in black with white embellishment.



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Each channel has independent tone and volume slider controls enabling exceptionally good en-vironmental matching to be obtained. A virtual earth input stage forms part of the up-dated circuitry which includes generous overload margins. Clear instructions with template supplied.

R.R.P. £11.95 +£1-19



Size =  $260 \times 50 \times 20$ mm ( $10\frac{1}{3} \times 2 \times \frac{3}{4}$  ins) Inputs = Mag. P.U. 3mV RIAA corrected; Ceramic P.U. Radio, Tape S/N ratio - 60db Frequency range - 10Hz to 25KHz + 3dB Power requirements - 20 to 35 volts Outputs - 100mV + AB monitoring for tape Controls - Press button for tape, radio and P.U. Sliders for Volume. Bass and Troble.

# Project 80 FM tuner and stereo decoder

FM Tuner Size - 85 x 50 x 20mm Tuning range – 87.5 to 108 MHz Detector – I.C. balanced coincidence. AFC - Switchable One 26 transistor I.C. Twin dual varicap tuning Distortion 0.2% at 1 KHz for 30% modulation 4 pole ceramic filter in I.F. section Sensitivity - 4 microvolts for 30dB quieting

Output - 300mV for 75 KH

deviation

Decoder-With gallium arsenide tuning beacon and 19-transistor I.C. Size - 47 × 50 × 20mm

FM tuner £11.95 +£1-19 VAT.

Decoder £7.45 +0.45p

# Project 80 active filter unit



Size - 108 × 50 × 20mm (41 × 2 × 3 ins) Voltage gain - minus 0-2dB Frequency response - 36Hz to 22KHz. controls minimum Distortion - at 1 KHz 0.03% using 30V HF cut off (scratch) - 22KHz to 5-5KHz.

12dB/oct slope LF. cut off (rumble) - 28dB at 20Hz. 9dB/oct. slope

R.R.P £6.95 +0.69p

# Z.40 & Z.60 power amplifiers



Input sensitivity-100mV Output 15W RMS continuous 8 Ω (35V). Frequency response – 10Hz – 100KHz ±1dB Signal to noise ratio -Distortion - less than 0-1% at 10W into 8 Ω Powerrequirements-12-35 volts

Size - 55 × 80 × 20 mm

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Z60 Size - 55 x 98 x 20mm Input sensitivity -100-250mV Output-25W RMS8 Q

Distortion - typically 0-03% Frequency response -10Hz to more than 200KHz ±1dB S/N ratio-

better than 70dB

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PZ.8

The worlds most advanced unit in its class. It is a stabilised unit. Reentrant current limiting makes damage from overload or even direct shorting impossible, a principle never before incorporated in a commercially available constructor module. Normal working voltage (adjustable) 45V. R.R.P. £7-98 + 0-79p V.A.T.

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#### AUDIOTRONIC MODEL ATM.I

Top value 1000 o.p.v. pocket multimeter. pocket multimeter.
Ranges: 9/10/50/220/1000v.
AC and DV.
DV Current 0-1mA/100m/Ac
Resistance 0/150k ohms.
Decibels -10 to +22dB.
Slize 90 x 60 x 28mm.
Complete with test leads.
22-85. Post 15p.



S2-85. Post 15p.

RUSSIAN 22 RANGE MULTIMETER
Model U-37 10,000 c.p.v.
A first class versatile instrument inanufactured in
U.S.S.R. to the hichest
standards. Ranges: 25/10/
50/220/S500/1000 D.C. 25/
DGO Carrent 100wA/1/10/
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Complete with batteries,
test leads, instructions and sturdy steel carrying case. sturdy steel carrying case. 24-95. P. & P. 25p



HIOKI MODEL 700X
100.000 O.P.V. Overload
protection. Mirror scale.
-3/-d/1-2/1-6/3/6/12/30/60/
120/300/600/1200V DC
1-6/3/6/12/30/60/150/300/600
1200 V. A.C.
15/30/12/3/36/30/60/150/300mA
6/12 AMP. DC. 2K/200K/2
Mey/20 Meg ohm -20 to
+63dB. 214 95. P. & P. 20p

370 WTR MULTI-METER Features A.C. current ranges. 20,000 a.p.v. 0/-5/2-5/10/50/250/500 1000 V. DC. 0/2-5/10/50/250/500/1000 V AC 0/50/μΔ/1/10/100mA/1/10 Amp D.C.

0/100mA/1/10 Amp AC 0/5K/50K/500K/5 mcg/ 50





MODEL TE-300
30,000 0.P.V. Mirror scale, overload protection 0/-6/3/15/560/
300/1.200V. D.C. 0/6/36/12/0500/
1.200V. A.C. 0/30µA/6mA/
60mA/300mA/600mA/ 0/8K/
80VK508/K/8 mcg. ohm 20 to 80K/560K/8 meg. ohm -2 +63 db, £7-50, P. & P. 15p.



U4312 MULTIMETER





MODEL 500

MODEL 500
30,000 O.P.V. with over-load protection, mirror scale, of 9/43°54/0/20/100/260/500/000
1,000v. D.C. 0/2°5/10/26/
100/250/500/1,000v. A. (20/50/4/6/60/500mA. 12
amp. D.C. 0/50/4/6/6 Meg./
60 Meg Ω
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Leather Case £1.75



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MODEL C-7080 EN Giant 6° mirror scale. 20,000 o.p.v. 0 / 28 / 1 / 2-5 / 10 / 60 / 250 / 1000 / 5000 v. D.C. 0 / 2-5 / 1000 / 500 v. D.C. 0 / 2-5 / 10 / 1000 / 5000 v. A.C. 0 / 50 / A / 11 / 10 / 1000 m / 1 0 amp. D.C. 0 / 2 / 1 / 200 K / 20 mcg - 20 to 4 - 8 f od B. 23.95. Post 35p.

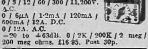


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**KAMODEN 72 200** 

RAMODEN 72. 200
MULTITESTER
High sensitivity tester.
200,000 o.p.v.v Overload pretection. Mirror scale. Ranges:
0/-06/-3/3/30/120/600/
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meg. -20 +62db. 217-50. P. & P. 25p. KAMODEN HM.350 TRANSISTOR TESTER

KAMODEN HM.350 TRA High quality instrument to test Reverse Leak current and DC current. Amplification factor of NPN, PNP, transistors, diodes, SCR's ets. 4" x 4" clear scale meter. Operates from internal batteries. Complete with instructions. leads and carrying handle. £12.50. Post 30p.



MODEL 449Å IN CIRCUIT TRAN-SISTOR TESTER Checks true A.C. beta in / out. Checks Loo. Checks diodes



LB3 TRANSISTOR TESTER &

Tests ICO and B. PNP / NPN. Operates from 9v battery. Com-plete with all in-structions, etc. 23-95. P. & P. 20p.



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Operates on two 1-5v batterics. Complete with all instructions, etc. £4-60.
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no. VOLIMETER

10 meg input 10 ranges:
001/-03/-1/-3/13/10/30/100/
300V. R.M.S. Seps.-12 Mc/s.
Decileis: -40 to +50dR.
Supplied brand new complete
with leads and instructions.
Operation 230V. A.C. \$17-50.

Carr. 25p.



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£2-50.



MODEL ATZOI DECADE ATTENŬATOR

Frequency range 0-200kHz. Attenuator 0-11l-lb. 0-ldb step. Impedance 600 ohms. Max. Input power 30dtum. Size 180×90×55m £12-50. Post 37p.



KAMODEN HM. 720B F.E.T. V.O.M. Input impedance 10 meg ohms. Banges: 0/25/11/25/10/50/ 250/1000V D. 0 0/25/10/50/ 0/25/10/ 0



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WOLTMETER
Battery operated, 11
meg input, 26 ranges.
Large 42" mirror scale.
Size 52" x 42" x 22".
DC VOLTS 0-3-1200V
AC VOLTS 3-300V
RMS, 8-0-800V P-P.
DC CURRENT -12-



DC CURRENT 12-12mA. Resistance up to 2000M ohm. Decibels -20 to + 51dB. Complete with leads/instructions. \$17.50. P. & P. 20p.

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RESISTANCE TESTER
Range 0-1000 Megohms, 500 Voit.
Battery operated.
Wide range clear
meter 44" x 4".
Complete with deluxe carrying case,
batteries, instructions, £18-95, Post 30p



Attractive 2-tone case 7 f" × 5" × 2". Price 217-50. Carr. 17p.



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TO-3 PORTABLE OSCILLOSCOPE

3in. tube. Y amp. Sensitivity
0-1v p-p/CM. Bandwidth
1-5 cpp 1-5 Mill. Input imp.
2 meg Ω 25pF X amp.
sensitivity 0-9v. p-p/CM.
Bandwidth 1-5cpa-800kHz.
Input imp. 2 meg Ω 20pP.
Time base. 6 ranges 10 cps
200 kHz. Synchronization.
Internal, External. Illuminated scale 140×215×330 mm. Weight 15ilb.
220/240v. A.C. Supplied brand new with handbook. 552 50. Carr. 50p.





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TE-16A TRANSISTORISED SIGNAL GENERATOR

5 ranges 400kHz-80mHz.
An inexpensive instrument for the handyman. Operates on 9v battery Wilde easy to read scale 800kHz modulation.

52 x 51 x 32im.
Complete with instructions and leads. 25 97. Post 25p.



: 8:

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

RANGE VOLT AMMETER
Sensitivity 330 obms/Volt
AC and DC. Accuracy
0.5% D.C. 1% AC. Scale
length 165mm. 0/500/75046/
1-5/3 / 7-5/16/30/75/
150/300/750mA/1-5/3/
7-5/34F DC 0/8/7-5/15/
20/75/150/300/750mA/
AMP AC 0/75/150/
300/760mV/1-5/3/
7-5/16/30/75/150/
300/760mV/1-5/3/
7-5/16/30/75/150/
300/760mV/1-5/3/
7-5/16/30/75/150/
300/750mV/1-5/3/
7-5/16/30/75/150/
300/750mV/1-5/3/
7-5/16/30/75/150/
300/750mV/1-5/3/
7-5/16/30/75/150/
300/750mV/1-5/3/
7-5/16/30/75/150/
300/750mV/1-5/3/
7-5/16/30/75/
300/750mV/1-5/3/
7-5/16/30/
300/750mV/1-5/3/
300

TMK MODEL TW-SOK

46 ranges. mirror scale, 50K/Vol. D.C. 5K/Vol. A.C. D.C.: Volis 125, 25, 1-25, 



# MODEL TE.15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscillator, Absorp-tion Wave Meter and Oscil-lating Detector. Frequency range 449Kcfs-280Mcfs in 6 colls. 500µA Meter, 9V battery operation. Size 180× 80 × 40mm. #15-00 Post 20n



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ARF-300 AF/RF SIGMA
All transistorised,
compact, fully portable, AF eine wave
18 Hz to 220 KHr.
AF square vave 18 Hz
to 100 KHz. Output
sine / square 10v.
P-P. RF 100 KHz to
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maximum. Operation
220/240v. AC. Complete with instructions
and leads. £23-95.
Poot 50p. and leads Post 50p.



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Sine: 20cps to 200 kc/s on 4 bands. Square: 20cps to 30 kc/s. Output impedance 5.000 chins; 200/250V. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £17-50, Cart. 374p.



#### 240° Wide Angle **ImA Meters**

MW 1-6 60mm square MW 1-8 80mm square P. & P. 15p.



#### POWER RHEOSTATS

High quality ceramic construction. Windings brodded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single bole fixing, jin. dia. shafts. Bulk quantities available.



ahle. 25 WATT. 10/25/50/100/250/500/1000 ohms. 21-15 P. & P. 10p. 50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. 21-62. P. & P. 10p. 100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 22-64. P. & P. 10p. 100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 22-64. P. & P. 10p.

AUTO TRANSFORMERS 0/115/250V. Step up or step dem down. Fully

1000 W 1500 W 1000 W 1000 W £2.35 P. & P. 18p £3.00 P. & P. 18p £4.00 P. & P. 23p £5.80 P. & P. 33p £8.25 P. & P. 38p £11.25 P. & P. 43p £19.00 P. & P. 21



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HF395	Aerial Amplifier for AM/FM
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500µA	42 60	50V. A.C 42 80
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	50-0-50µA	28-15	20V. D.C \$2 60
	100µA	48-15	50V. D.C 42-60
ŀ	100-0-100µA	48-10	150V. D.C. 42-60
	200µA	48 05	300V. D.C. #2 60
	500µA	42.75	15V. A.C 42-80
	500-0-500MA	42 60	50V. A.C 42 80
	lmA	42-50	150V. A.C #2 80
	5mA	42-60	300V. A.C 42-80
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	50mA	42-80	8 Meter 1mA 42-85
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		42 60	50mA A.C. * \$2-80
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	1 amp		TAGENT WILL BE AT
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Type MR.65. 31in. square fronts 22 50 42 60 42 60 42 60 42 60 42 60



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	_	20V. D.C	ES 24
		50V. D.C	42 60
		160V. D.C.	42-60
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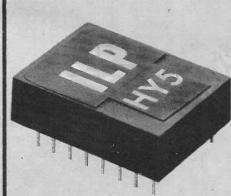
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Like the HYSO, the new HYS has no external components a has been redesigned to run off a split power-line with improvements in signal/noise, overload, capability & reduced distortion. The output has been increased to match the power module (Odb), and to share the same power supply.

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The combination of two HYSO's wharing a common power supply (PSUSO) are linked by a balance control to form a complete stereo system.

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OUTPUTS Tape 100mV. Main output, Odb (0.775volts)

ACTIVE TONE CONTROLS
Troble ± 12db at 10kHz
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	Price p	Type Price		Price p		Price p	BF182 44	MAT121	22	2G308	39	21/2192	39	2N3391A	18	2N4062	13
AC107	22	AD161 and	BC1:		BD131	55		MJE2955		2G309	39	2N2193	39	2N3392	16	2N4284	19
AC113	20	AD162(MP)	75 BC1		BD132	66	BF183 44			20339	22	2N2194	39	2N3393	16	2N4285	19
AC115	20	ADTI40	55 BCI:		BD133	72	BF184 28	MJE3055								2N4286	19
AC117K			27 BC1		BD135	44	BF185 33	MJE3440		2G339A	18	2N2217	24	2N 3394	16		
AC122	13		27   BC1		BD136	44	BF187 30	MPF102	46	20344	20	2N2218	22	2N3395	19	2N4287	19
AC125	19	AF116	27 BC1	7 20	BD137	50	BF188 44	MPF104	41	2G345	18	2N2219	22	2N3402	23	2N 4288	19
AC126	19	AF117	27 BC1	8 18	BD138	55	BF194 12	MPF105	41	20371	18	2N2220	24	2N3403	23	2N4289	19
AC127	20		39 BC1		BD139	61	BF195 13	OC19	39	2G371B	13	2N2221	22	2N3404	. 31	2N4290	19
AC128	20		38 BCI		BD140		BF196 16	OC20	70	2G373	19	2N2222	22	2N3405	46	2N4291	19
AC132	16	AF125	33 BC1		BD155		BF197 16	OC22	52	2G374	19	2N2368	19	2N3414	17	2N4292	19
AC134	16		31 BC1		BD175	66	BF200 50	OC23	54	2G377	33	2N2369	16	2N3415	17	2N4293	19
	16		31 BC1		BD176	66	BF222 £1.05	OC24	62	2G378	18	2N2369A	16	2N3416	31	2N5172	. 13
AC137	20		33 BC		BD177	72	BF257 50	OC25	42	20381	18	2N2411	27	2N3417	31	2N5294	60
AC141					BD178		BF258 68	OC26	32	2G382	18	2N2412	27	2N3525	83	2N5457	35
AC141K			55 BC1		BD179	77	BF259 94	OC28	55	2G401	33	2372646	52	2N3614	74	2N5458	35
AC142	20		55 BC1			- "	BF262 61	OC29	55	2G414	33	2N2711	23	2N3615	82	2N5459	44
AC142K			55 BC1		BD180				46	2G417	28	2N2712	28	2N3616	82	2N6211	75
AC151	17		55 BCT		BD185	72	BF263 61	OC35			39		23	2N3646	10	28301	-55
AC154	22		55 BC1		BD186	72	BF270 39	OC36	55	2N388		2N2714			13		-00
AC155	22	AF239	41 BC1		BD187	77	BF271 33	OC4J	22	2N388A	61	2N2904	19	2N3702		28302A	46
AC156	22	AL102	72 BCI		BD188	77	BF272 88	OC42	27	2N 404	22	2N2904A	23	2N3703	13	28302	40
AC157	27	AL103	72 BC1	B 21	BD189	83	BF273 39	OC44	17	2N404A	31	2N2905	23	2N3704	14	28303	81
AC165	22		28 BCI	9 21	BD190	83	BF274 39	OC45	14	2N524	46	2N2905A	23	2N3705	13	28304	77
AC166	22	ASY27	33 BC1		BD195	94	kFW10 66	OC70	11	2N527	54	2N2906	17	2N3706	13	28305	88
AC167	22		28 BC1		BD196		BFX29 30	0071	11	2N598	46	2N2906A	20	2N8707	14	28306	86
AC168	27	ASY29	28 BC1		BD197	89	BFX84 24	OC72	16	2N599	50	2N2907	22	2N3708	09	28307	88
AC169	16	A8¥50	28 BCI		BD198		BFX85 33	OC74	16	2NG96	14	2N2907A	24	2N3709	10	28321	62
AC176	22	A8Y5)	28 BC1		BD199		BFX86 24	OC75	17	2N697	15	2N2923	16	2N3710	10	28322	46
	27	ASY52	28 BC1		BD200		BFX87 27	OC76	17	2N698	27	2N2924	16	2N3711	10	28322A	46
AC177					BD205		BFX88 24	OC77	28	25699	39	2N2925	16	2N3819	31	28323	62
AC178	31								17	2N706	09		14	2N3820	55	28324	77
AC179	31	ASY55	28 BC1		BD206		BFY50 22 BFY51 22	OC81	17		10		12	2N3821	39	28325	77
AC180	22		28 BC1		BD207			OC81D		2N706A				2N3823	31	28326	77
AC180K	32	ASY57	28 BCL		BD208		BFY52 22	OC82	17	2N708	13		11				77
AC181	22	A8Y58	28 BC2	7 12	BDY2		BFY53 19	OC82D	17	2N711	33	2N2926(R)	11	2N3903	31	28327	
AC181K	32		28 BC2		BF115	27	BPX25 94	OC83	22 22	2N717	39		11	2N3904	33	28701	46
AC187	24	ASZ21	44 BC2	9 13	BF117	50	BSX 19 17	OC139	22	2N718	27	2N3010	77	2N 3905	81	40361	44
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AC188K			13 BC2		BF121	50	BSY26 17	OC170	28 28	28727	31	2N3054	51	2N4059	11		
ACY17	28		11 BC2		BF123	55	BSY27 17	OC171	28	2N743	22	2N3055	55	2N4060	13	1	
ACV18	22		17 BC2		BF125	50	BSY28 17	OC200	28	2N744	18	2N3391	16	2N4061	13		
ACY19	22		17 BC2		BF127	55	BSY29 17	OC201	31	2N914	16						
ACY20	22		17 BC3		BF152	61	BSY38 20	OC202	81	2N918	33		DIOI	ES AND R	ECTIL	TERS	
	22		20 BC3		BF153	50	BSY39 20	OC203	28	2N929	23	RITAA	9 1	BY133	23 1	OA70	. 8
ACY21					BP154	50	BSY40 31	OC204	28	2N930	23	-AA220	9	BY 164	55	OA79	8
ACY22	18					77	BSY41 31	OC205	39	2N1131	20	AA129	9	BYX38/30		0481	8
ACY27	20	BC119	33 BC4		BF155			OC309	44	2N1132	24		10	BYZ10	39	OA83	10
ACY28	21		88 BC4		BF156	53	B8Y95 14			2N1302	16		11	BYZII	33	OA90	7
ACY29	39		13. BCX		BF157	81	BSY95A 14	OCP71	48		16		11	BYZ12	33	OA91	-
ACY30	31		20 BCY	31 29	BP158	61	Bu105 £2.20	ORP12	48	2N1303				BYZIZ	28	QA95	
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AD161	39		II BD1		BF180			2G304	44	2N2160	66		18	0.47	8		
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7403	0.18	0.17	0.16	7453	0-18	0-17	0-16	74145	1.65	1-55	1-45
404	0.18	0.17	0-16	7454	0.18	0.17	0.16	74150	2.90	2.80	2.70
7405	0-18	0-17	0.18	7460	0.18	0.17	0.16	74151	1.10	1-05	1-00
1406	0.38	0.34	0.31	7470	0-32	0.29	0.27	74153	1.30	1.20	1.10
7407	0.39	0.84	0.31	7472	0.32	0-29	0.27	74154	1-98	1-90	1.75
7408	0.20	0-19	0.18	7473	0.41	0.39	0.35	74155	1-50	1.45	1-35
7409	0-20	0.19	0-18	7474	0.41	0.38	0.35	74156	1.50	1.45	1.35
7410	0-18	0.17	0-16	7475	0.50	0.48	0.48	74157	2.00	1-90	1.80
7411	0-28	0.27	0.26	7476	0.44	0.43	0.42	74160	2.10	2.00	1-90
7412	0.39	0.34	0.31	7480	0.74	0.71	0.84	74161	2.10	2.00	1.90
7413	0.32	0.31	0.30	7481	1.30	1.25	1.20	74162	4.40	4-15	3 - 85
416	0-48	0.44	0.42	7482	0-98	0.95	0.94	74163	4-40	4.15	3 - 85
7417	0.48	0-44	0.42	7483	1.20	1.15	1.05	74164	2 · 20	2.10	2.00
420	0-18	0-17	0.18	7484	1-10	1.05	1.00	74165	2.20	2-10	2.00
1422	0.55	0-53	0.50	7-185	3.50	3 - 30	3.30	74166	3-20	3.10	3 - 00
423	0 55	0.53	0.50	7486	0-35	0.34	0.33	74174	2.50	2.40	2-30
425	0.55	0.53	0.50	7489	4.00	8.75	3.50	74175	1-75	1.65	1.55
7426	0.50	0.46	0.44	7490	0-74	0.71	0.64	74176	1.85	1.75	1.65
1427	0.50	0-46	0.44	7491	1-10	1.05	1.00	74177	1.85	1.75	1.65
7428	0.55	0.53	0.50	7492	0.74	0.71	0.64	74180	1.50	1-40	1.30
430	0.18	0.17	0.16	7493	0.74	0.71	0-64	74151	\$.00	4.50	4-00
7432	0.50	0-46	0.44	7494	0.85	0.82	0.75	74182	2.00	1-90	1.75
433	0-75	0.73	0.70	7495	0-85	0.82	0.75	74184	3.20	3.10	3-00
437	0.70	0-88	0-65	7496	0.96	0-93	0.86	74190	2.15	2-10	2.00
438	0-70	0.68	0-65	74100	1.50	1.45	1-40	74191	2 - 15	2.10	2.00
440	0.18	0.17	0.18	74104	1.07	1.04	1.00	74192	2.15	2.10	2.00
441	0-74	0.71	0-64	74105	1.07	1.04	1-00	74193	2-15	2-10	2.00
442	0.74	0.71	0.64	74107	0.44	0.42	0-40	74194	2-98	2.86	2-75
443	1.20	1.15	1-10	74110	0.60	0-55	0.50	74195	2.00	1-95	1.90
444	1-20	1-15	1-10	74111	1.88	1.27	1.21	74196	1.95	1.90	1-85
445	1.98	1.95	1-90	74118	1.10	1.05	1.00	74197	1.95	1.90	1.85
446	1.20	1-15	1.10	74119	1-50	1.40	1.30	74198	B-00	4-75	4-50
3.30	1.10	1.07	1.05	74121	0.50	0.48	0.45	74199	5-00	4-75	4.50

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U1C02-12×7401
U1C02-12×7402
U1C04-12×7403
U1C04-12×7403
U1C04-12×7407
U1C10-6-6×7406
U1C06-6×7406
U1C06-12×7407
U1C10-12×7407
U1C10-12×7407 PAR MO. CONTABLE
UIC48-5-7446
UIC48-5-7448
UIC30-12-7451
UIC53-12-7451
UIC53-12-7451
UIC53-12-7454
UIC64-12-7464
UIC60-12-7464
UIC60-12-7464
UIC61-5-7470
UIC61-5-7470
UIC61-5-7470
UIC62-5-7480
UIC63-5-7481
UIC63-5-7481
UIC63-5-7481
UIC63-5-7483
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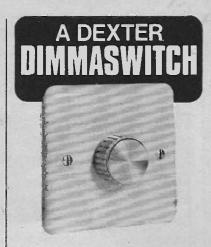
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