

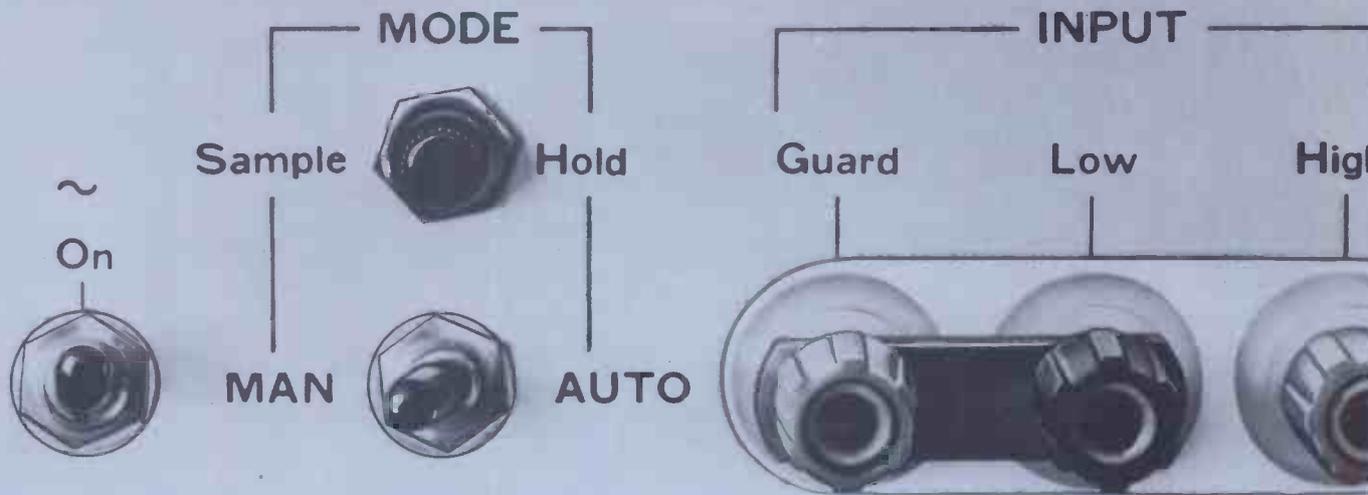
Wireless World

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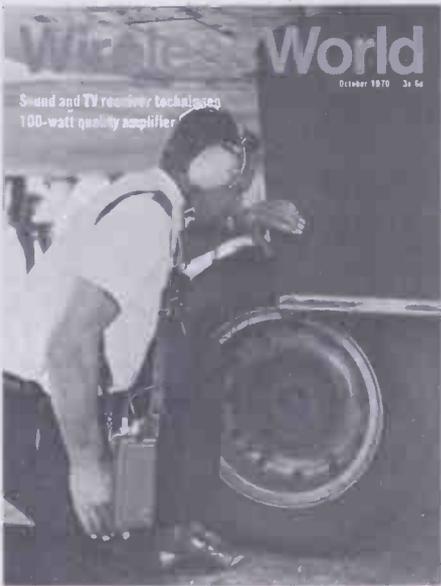
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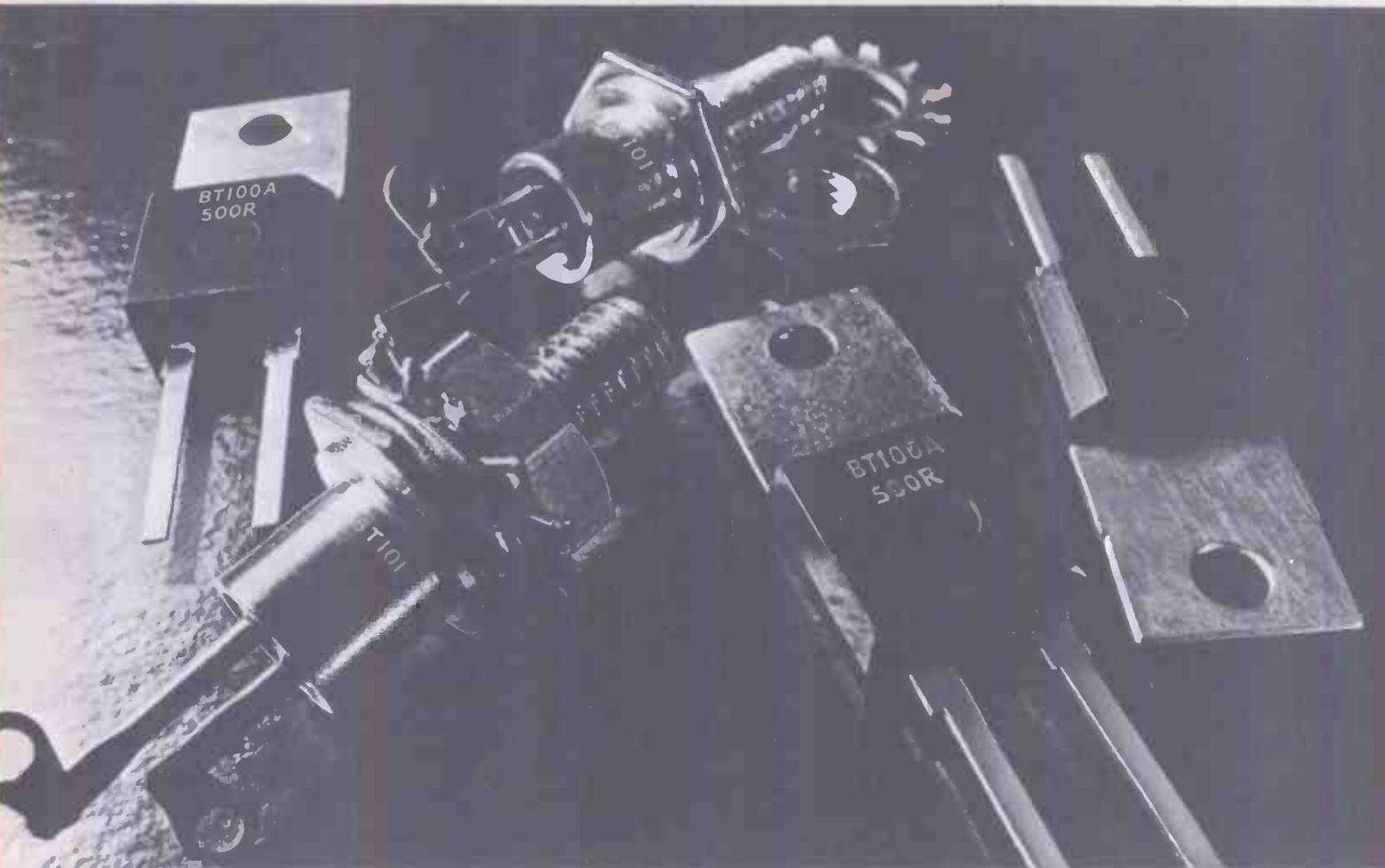


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How we made thyristors a commercial proposition for consumer products

Three years ago a Mullard design team was given the problem of developing thyristors for motor speed control in washing machines and drills. Thyristors offered important advantages over conventional power control methods, but at that time, production was confined to relatively expensive industrial devices. The high unit cost was essentially due to specialist production techniques.

Two Requirements The Mullard team set about designing inexpensive thyristors, together with triggering devices, for use on domestic mains supplies. Two current handling capabilities were identified as being necessary to meet the range of

applications—6.5A for washing machines and other heavy current loads, and 2A for drills and lighter loads.

Within six months two consumer type thyristors, BT101 and BT102, had been developed for 6.5A applications, and they were soon in mass production. Now these devices, in the TO-64 stud-mounted metal encapsulation, are well established.

Low-cost Plastic After further design work, a new *plastic* device, the BT100A, was introduced to meet the lower current requirements. Plastic power device technology is highly specialised, and only intensive effort over many years has resulted in the highly automated manufacturing techniques which ensure extremely good reliability.

Computer Testing To cope with the necessary high rate of production, computer techniques were introduced to record test results and to allow automatic grading. The testing cycle was significantly shortened by the use of high-current pulses for directly heating the thyristor crystal. This is one of the best automated methods of testing breakdown voltages at the highest junction temperatures.

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Wireless World

The Dehumanization of Broadcasting

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Karl Marx, were he alive today, might have written that famous aphorism of his as: "Television . . . is the opium of the people". The fact that television is an opiate is generally blamed on the programme producers: the broadcasting engineers are inclined to take a superior, professional attitude and disclaim any responsibility for the material that is passed through their channels. Indeed some engineers, particularly in America, treat the programmes with open contempt. (The slang word "canned" used for recorded programmes is an implicit grouping of the creations of art and intellect with beer, soup, baby-food and other mass-produced commodities of a sloppy nature.) But it is too easy for the engineers to shelter in their sectarianism. They must become more aware of the effects of their work, their aims and attitudes, on the quality of what is broadcast. These effects may be indirect but are nonetheless real.

Anyone who has worked in mass-production industries will know that there is a strong pressure on designers to fashion their goods not so much for the convenience of the human customers as for the convenience of the production machinery. This, of course, increases manufacturing efficiency. If the resulting goods are not exactly what the customer likes he can always be persuaded to think that they are, by clever advertising. Equally it is well known that people must be continuously pressurized into buying goods which they may not really need, in order to keep the manufacturing plant fully loaded and hence economic—and, incidentally, to avoid unemployment and loss of consumers. The engineer, of course, has a vested interest in the design, manufacture and operation of the production machinery.

A similar situation is now developing in broadcasting. The mental and spiritual "goods" are becoming subservient to the broadcasting machinery, which is designed and operated by engineers whose main purpose is to achieve the most efficient distribution of canned, pre-digested, brightly packaged, expertly timed, second-hand experience to a mass audience.

At all costs the broadcasting machinery must be made efficient—and this seemed to be the cry at the recent International Broadcasting Convention in London (see p.484), where one of the main themes was the application of automation to broadcasting. One American contributor proudly remarked that the on-line computer programme for his computer-controlled broadcasting system had been "developed and documented to the point where it can be used as a general purpose program for any industry such as planning the production of manufactured goods."

Automation is fine, in so far as it relieves people of monotonous work, reduces operating costs and improves the technical quality of the broadcast programmes. But experience from industry shows that it is also a means by which the human being is even more completely enmeshed and demoralized by the production machinery. He is not driving but being driven, as Charlie Chaplin showed in "Modern Times", and now his brain is involved as well as his reflexes.

Nevertheless, one speaker at the I.B.C., on being asked why he had expressed disquiet about too much automation in broadcasting, said "because it can be destructive of human initiative and art". This speaker was an engineer. So there is at least one man who understands that the true work of engineers is not simply the perpetuation of engineering.

Elements of Linear Microcircuits

1. What a linear microcircuit is, how it is made and packaged

by T. D. Towers*, M.B.E.

What are these microcircuits that have revolutionized circuit design? In widest terms, they are a sort of supercomponent consisting of a number of circuit elements inseparably associated in a small package. In the ultimate they reduce the equipment designer's job to just fitting together a few prefabricated circuit blocks instead of designing a large complex of separate discrete components. No longer need the electronics experimenter puzzle out the design of a two-transistor 'Ridler' d.c. coupled pair for his tape replay amplifier; he just buys a ready built microcircuit.

Linear and digital: the difference

There are two classes of microcircuits (often called integrated circuits or just i.c.s): digital and linear. Digitals are designed for on/off switching applications and provide the equipment designer with a range of complete logic elements, such as AND, OR, NAND, NOR gates, flip-flops and some extremely complex computer-type sub-systems. Linear i.c.s are for applications where the output is in some way proportional to the input, and they provide the designer with ready-made d.c., a.f., r.f. and wideband amplifiers.

Digital microcircuits became generally commercially available in the mid-1960s and have been exhaustively discussed in the technical press since then. Linear i.c.s did not become readily available until much later, and are only now finding wide use. This series of articles is aimed at the newcomer to the linear field.

Linear microcircuits can be 'multiple-purpose' or 'single-purpose'. Multiple-purpose units are gain-blocks which can be externally pin-programmed to perform a large variety of different circuit functions (usually by fitting different feedback networks). The archetype of these is the operational amplifier † or op. amp. This is a very high gain d.c.-coupled amplifier with a response which is completely defined by feedback. It was the earliest linear microcircuit to become generally available and is the best known,

Most circuit designers prefer single-purpose microcircuits, which are complete in themselves and do not need additional circuits designed around before they can be used (as is the case with multiple-purpose linear i.c.s). Fortunately, more and more single-purpose linear i.c.s are coming on the market, ranging from a simple package of a matched pair of transistors up to a complete 100-W audio power amplifier.

Early developments

Before we look at current methods of microcircuit manufacture, it is of interest to look back over the past three decades at the landmarks in their evolution. Up until World War II, the normal methods of assembling electronic equipment was to mount all the heavier components on some form of chassis, and then interconnect them with point-to-point wiring, either directly or via tag boards.

The first major move towards present-day microcircuits began with the miniature proximity fuses developed for the nose-caps of artillery shells in World War II. These radio-controlled fuses were closely packed assemblies using special valves, but the technique never spread into large scale commercial use because of the bulky valve needed for amplification.

The development of microelectronics really started with the invention of the transistor in 1948. This got rid of the large wasted vacuum space inside the valve, its inefficient heater and the need for a high anode voltage. Assemblies could now be

much smaller, but they were still only scaled-down versions of the old point-to-point inter-wiring of discrete components.

In the late 1940s, Sargrove in England started a move away from point-to-point wiring. He pioneered a development in which a radio receiver was built on a ceramic substrate ‡ on which resistors and intercomponent wirings were printed and fired rather than separately mounted. This was one of the earlier experiments in the integration of circuitry, but in spite of it, point-to-point wiring continued unopposed.

Later printed circuit boards (more correctly printed wiring boards) became a commercial reality, and this form of integrated wiring provided another big step towards commercial microelectronics.

The 1950s also saw many different approaches to miniaturization, apart from assembling conventional miniature components on a small printed circuit board. They gave rise to names like 'Cordwood', 'Tinkertoy', 'Micromodule' and '2D', which are now largely of historical interest only. Details can be found in books such as 'Microelectronics' by E. Keonjian. (McGraw Hill, 1963.)

All these forms of microminiature assemblies developed in the 1950s were more expensive than the standard printed circuit board and they were only used in equipment where cost was not the governing element, military equipment for instance.

Today's microcircuits

In 1958 a development occurred which changed the whole face of things. Kilby of Texas Instruments came up with an interconnected assembly of resistors and transistors made by diffusion in tiny silicon chips. The true monolithic silicon integrated circuit (s.i.c.) had been born. The first of these was a mesa-type r.t.l. (resistor transistor logic) bistable and it used only two chips interconnected by bonding wires in a single package.

In 1960 the celebrated Fairchild planar process for manufacturing transistors was developed which gave a strong impetus to

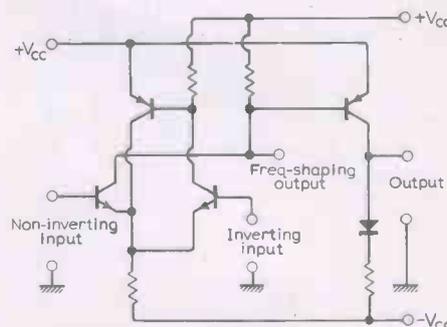


Fig. 1. Circuit of 1962 linear silicon integrated circuit (Texas Instruments SN521 operational amplifier).

*Newmarket Transistors Ltd.

†Operational amplifiers were dealt with at some length by G B. Clayton in a series of articles which appeared in the February to December issues of *Wireless World*.

‡Some details of this development are given in an article "Automatic Receiver Production" which appeared in the April 1947 issue of *Wireless World*.

the production of monolithic s.i.c.s. Early units were the easiest-to-make digital types such as the 1961 Texas Instruments Series-51 r.t.l. But linear s.i.c.s were not long in arriving. By 1962, the Texas Series-52 linear i.c.s were on the market. Typical of these was the SN521 general-purpose single-chip 62dB differential amplifier the circuit of which is given in Fig. 1.

In the linear field, however, the general use of linear s.i.c.s can be said to have started with the now well known Fairchild μ A709 op. amp. which came on the market in quantity in 1965. Since then there has been a proliferation of multiple-purpose linear amplifiers, particularly of the operational amplifier type.

But the linear s.i.c.s available by the mid-1960s did not get the immediate wide usage that their high technical specifications invited. This was partly because production was small and the cost was much higher than a designer could achieve by using conventional component circuitry. Also, run-of-the-mill circuit designers were not skilled at using wideband, high-gain operational amplifier blocks for general purpose circuitry. They would rather have had low-cost single-purpose units.

In this climate, significant developments began along different lines. Techniques developed for producing prefabricated assemblies of resistors, capacitors and interconnections by printing on ceramics (thick film) or vacuum evaporation on glass (thin film) were married to special miniature semiconductor devices suitable for attaching to such substrates. Out of this marriage came the hybrid active linear microcircuit, which had advantages over monolithics in some areas. The two main ones were that the hybrid could be fabricated economically in small batches and that single-purpose units could be made up readily.

By the end of the 1960s, many semiconductor manufacturers had gone into monolithic s.i.c.s. Cheap standard multiple-purpose linear i.c.s had become widely available, but there were not many standard single-purpose units around. You could get a special s.i.c. custom built, but you would have to use very large quantities for it to be economic. As a result, many custom hybrid houses had sprung up, using thick and thin film techniques, to serve the smaller-run equipment manufacturer who could not use the existing standard monoliths and was too small to have a special monolith built for him. Almost as a by-product, these hybrid houses also put on the market standard commercial single-purpose linears.

It is anybody's guess how the demand for linear microcircuits will divide itself up in the future between standard single-purpose, standard multiple-purpose, and custom-built units. One estimate is that in the 1970s linear applications will be met 50% by off-the-shelf single-purpose standards, 25% by multiple-purpose standards, and 25% by custom specials. As to how far the units will be monolithic and how far hybrid, again there is much

doubt. The chances are that most multiple-purpose standards will be monoliths, most custom units hybrid, and single-purpose units a mixture of monolithic and hybrid.

No reference has been made so far to m.o.s.t. (metal oxide semiconductor technique) microcircuits which use f.e.t.s (field effect transistors) instead of bipolar transistors as the basic circuit elements diffused into silicon chips. They are cheaper to produce than bipolar monoliths, and have already found wide use in low-cost digital applications. However, they are not as yet well suited directly to linear applications, and will not be discussed further here.

As to hybrid technologies, thin film is gradually being phased out for cost and technical reasons, and most hybrids are now thick film.

Monolithic silicon circuit manufacture

Manufacturing monolithic s.i.c.s is a highly complex business and many books have been produced on the subject. If you are seeking detailed information, you should consult one of the standard texts, such as Motorola's 'Integrated Circuits—Design Principle and Fabrication', edited by M. Warner (McGraw Hill, 1965). In this article we will give only a sketchy outline of how s.i.c.s are made.

The process starts with an ingot, usually about 250mm (10in) long and 25mm (1in) diameter, of highly refined single-crystal silicon, shown in Fig.2(a). The ingot is sawn up into thin slices of which one is shown at Fig.2(b), and the s.i.c.s are made in these slices.

As shown in the enlarged view of a single slice in Fig.2(c), a large number of identical circuits are formed in a regular pattern. Various techniques are used, such as high-temperature diffusion of impurity gases into the slice, selective surface etching of photoresist masking, formation of protective 'glass' (silicon oxide) surface layers, and deposition of metallic interconnections and lead bonding pads on the surface by vacuum evaporation (thin film) techniques. Depending on the area of the individual circuit in the pattern, a single slice typically produces anything from 200 and 2000 identical integrated circuits at the one time.

The slice is next scribed along the dividing lines between the circuits and broken up into individual units. A single circuit then finally appears as at Fig.2(d)—enlarged—in the shape of a square chip between 0.5mm (0.020in) and 1.25mm (0.050in) across with visible metallization on the surface.

This chip is packaged by bonding it face-up on a support such as the multi-lead TO-5 header shown in Fig.2(e), with the metallized bonding pads visible on the face. Connections are then made from the header leads to the pads by gold

§We normally regard m.o.s.t. as meaning metal oxide silicon transistor because this describes the structure of the device. That is a metal gate (aluminium) insulated from the drain/source silicon by a layer of silicon oxide. Ed.

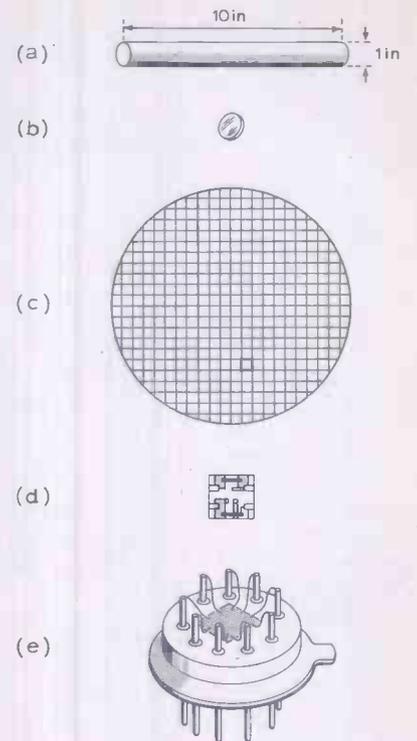


Fig. 2. Construction of silicon integrated circuits: (a) basic silicon crystal ingot from which process starts; (b) thin slice (wafer) cut from ingot; (c) enlarged view of slice after processing produces large number of identical circuits inside the silicon formed by repeated diffusion, oxidation, and selective etching with final evaporation of surface metallization for interconnections and bonding pads; (d) one of many single-circuit chips obtained by scribing and cracking the complete slice, and (e) individual circuit chip mounted on header with connections to header leads.

or aluminium wire about 0.025mm (0.001in) diameter. After being tested, the package is sealed. In the example shown, a metal top cap is fitted by welding round the rim.

From this necessarily brief summary, it should be evident that the basic element in a monolithic s.i.c. is a very small processed thin chip of silicon about the area of a grain of sugar. This makes it clear why high-power dissipation presents a major problem in s.i.c.s, because of the difficulty in getting the heat away from the tiny chip. Normally, temperatures inside the chip must be kept below about 150 to 180°C and because of its small size it is hard to dissipate much power without exceeding this limit. This also explains why most of the commonly available s.i.c.s have a power rating somewhere round 100 to 500mW (very much the same as a single transistor), and also why most of the high power linear microcircuits on the market tend to use the hybrid fabrication to be described below.

Thick film hybrid fabrication

The assembly of a thick film hybrid starts with a smooth ceramic (aluminium oxide) blank substrate, typically about 25mm

(lin) square and 0.375 to 0.875mm (0.015 to 0.035in) thick, as shown in Fig.3(a).

On to this ceramic (which is an insulator) a matrix of passive circuit elements is screen printed and fired, just like the decorations on a piece of pottery, as shown in Fig.3(b). This produces an identical pattern of resistors, capacitors, insulating layers and metal interconnection runs and bonding pads (the last for attaching discrete components and external leads) in each cell of the matrix.

The large substrate is then scribed along the cell dividing lines and cracked up into individual small circuit substrates. One of these is shown enlarged in Fig.3(c). The next step is to attach any subminiature discrete components required, such as the transistor shown in Fig.3(d), and the final substrate preparation is the attaching of external leads shown in Fig.3(e).

After being tested, the hybrid circuit is encapsulated in some form of protective package, as shown in Fig. 3(f). It can be seen that the dissipating semiconductors can be dispersed over a relatively wider area than is possible in an s.i.c. chip so

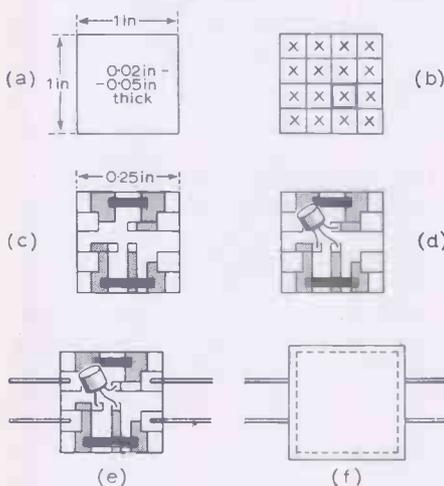


Fig. 3. Construction of thick-film hybrid microcircuits: (a) Starting ceramic substrate; (b) number of identical R, C and conductor networks printed and fired on substrate; (c) single circuit substrate scribed and cracked from complete multiple-unit substrate; (d) discrete components such as transistors attached to substrate. (e) Leadout wires attached; (f) circuit encapsulated in protective package.

higher power dissipation is possible. On the other hand, it must also be clear that the overall package size will tend to be larger for hybrids.

The packaging of a microcircuit is of importance not only because it is all that the user sees of the device, but also because it has such an important bearing on cost and reliability. For this reason, the rest of this article will be devoted to packaging aspects.

Microcircuit packaging; the problems

Just as with transistors, microcircuit packages are of two basic types, 'hermetic'

(metal or ceramic and glass) and 'non-hermetic' (plastic). Non-hermetic are much cheaper than hermetic, but have not yet reached the stage where they can be regarded as satisfactory in extremes of temperature and humidity. Thus in high reliability applications, hermetic packages are the rule. Initially only hermetic packages were accepted for professional use, but recently plastics have improved so much that they are creeping in for the less demanding applications.

In commercial linear microcircuits, you will therefore find three grades in the market: (a) *Entertainment or Consumer*, suitable for use from 0 to 70°C and in low humidity environments (and almost always non-hermetic), (b) *Industrial*, suitable for use from -20 to +100°C and in medium high humidity (mostly hermetic), and (c) *Military* for -55 to +125°C and high humidity environments (until now always hermetic).

Unfortunately for the user, package standardization for microcircuits is a long way off. We are not yet in the comforting climate of transistors where you can take the same JEDEC standard TO-5 outline device from several different manufacturers and find that the case sizes varied by only a few thousandths of an inch and that the standard emitter-base-collector numbering of leads round the can obtained in every case.

For linear microcircuits at the time of writing there are over 700 different shapes, sizes and lead configurations available. In this chaos of packages offered, however, some trends are beginning to make themselves clear.

Monolithic s.i.c. packages show more standardization than hybrids because they have been around longer. But packages which have reached some acceptance for monoliths have had to be severely modified to encompass the generally larger hybrid element.

With regard to outlines, packages fall into four main classes: (1) low-power packages with leads to be inserted through circuit boards and soldered on the copper side; (2) low-power packages designed to be mounted directly on the copper side with leads attached flat to the metallization by soldering or welding; (3) medium-power packages with integral heat sinks for printed circuit board mounting; and (4) high-power packages designed for attachment to substantial metal chassis or heat sinks.

Low-power through-board-mounting packages

The most common low-power through-board-mounting microcircuit package is the *dual-in-line*, abbreviated to d.i.l. for the hermetic version and d.i.p. for the non-hermetic or plastic version *b*. Fig.4(a) shows the main dimensions of the most

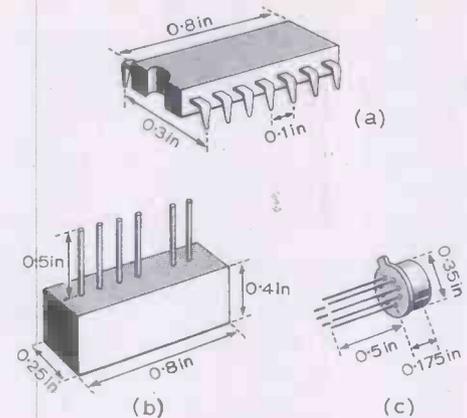


Fig. 4. Typical common low-power linear microcircuit packages for attachment to non-copperside of printed circuit board: (a) Dual-in-line; (b) single-in-line; (c) multilead TO-5.

common package, the 14-lead dual-in-line. Variants of the package may have anything from 4 to 24 leads or more. The interlead spacing of 2.54mm (0.1in) in the line of leads is standard (to allow conductor runs between the lead lands on the board). The inter-row spacing of 7.62mm (0.3in) is standard for monolithic s.i.c.s, but, for the generally larger hybrid, other spacings such as 15mm (0.6in) are common.

Dual-in-lines are not easy to unsolder from circuit boards for servicing, and there is growing up another package style for through-board mounting which is easier to unsolder. This is the *single-in-line*, of which an example will be found in Fig.4(b). This s.i.l. can be thought of as half of a dual-in-line with the leads straightened into the plane of the device. It too, like the d.i.l., tends to use lead spacings of 2.54mm (0.1in), and is more common in hybrids than monoliths.

Historically the earliest monoliths were developed by semiconductor manufacturers and it was natural that they should package them in modified transistor cases. Fig.4(c) gives an illustration of the multilead TO-5 which may have anything from six to twelve leads. Because of the close lead spacing and the difficulty of removal from a printed circuit board, it is now not very popular with designers.

Low-power copper-side mounting packages

In these days of double-sided printed circuit boards and the demand for space

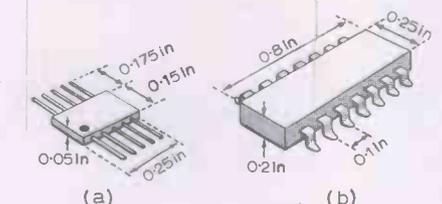


Fig. 5. Typical low-power linear microcircuit packages for attachment to copper side of printed circuit board: (a) Flat pack; (b) ready-to-reflow dual-in-line with preformed leads.

^b Although d.i.p. always means a plastic package, we often find that in the various manufacturer's data sheets we receive, d.i.l. is also used to describe plastic packages. If your application needs a hermetically sealed microcircuit always check the data sheet for the type of package material used. Ed.

saving, several packages have been developed for attaching to the copper side of the board. Two are fairly standard.

The flat pack shown in Fig.5(a) was developed by Texas Instruments for their early s.i.cs. With the general adoption of the dual-in-line package described earlier, users who wanted to mount them on the copper side of the board dressed their leads out flat as shown in Fig.5(b). This gave rise to the ready-to-reflow dual-in-line modification which manufacturers are now prepared to supply.

Medium-power microcircuit packages

The packages so far discussed usually cannot dissipate more than a few hundred milliwatts. Other packages had to be developed for higher powers, particularly in the linear field. These tend to fall into two main groups: (a) items designed for powers up to about 5W without any special substantial external heat sinking, and (b) high-power packages capable of dissipating up to 50 or 100W.

In the first, medium-power, category, several packages will be met with. Semiconductor manufacturers, accustomed to standard two-pin TO-3 outline power transistors, developed a multi-pin version of this outline, of which Fig.6(a) shows a typical example. On a printed circuit board this can dissipate up to about 2W (and on a substantial heatsink 10W).

Another transistor case used for medium-power microcircuits is the multilead TO-8 transistor package, of which Fig.6(b) is an example. This has twelve pins arranged in a square, but a sixteen-pin version is also available. This package can dissipate up to about 1W in free air and about 2.5W clipped to a substantial heat sink.

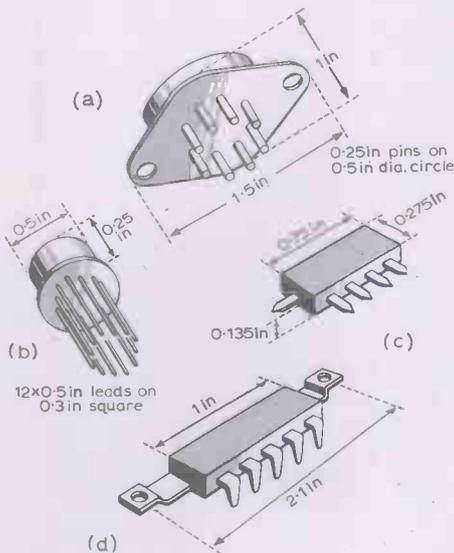


Fig. 6. Examples of medium-power linear microcircuit packages; (a) Modified multilead TO-3 power transistor package (2-5W); (b) modified multilead TO-8 intermediate power transistor package (1-2W); (c) modified dual-in-line with integral tongued heat sink (1W); (d) modified dual-in-line with integral heat sink for bolting to chassis (3W).

A different approach to a medium-power package is the integral heat sink. Fairly typical of this is the package sketched in Fig.6(c). This is really a dual-in-line with the leads dressed for reflow soldering and with a strip of metal inside extending from one end for better removal of heat from the chip. Permissible power dissipation can be increased by soldering the metal tongue to board metallization or some area of metal. Packages like these are typically capable of dissipations up to 1W.

The power dissipation capability of integral heat sink package can be extended by making provisions for bolting to a metal heat sink. One well known example of this is the chassis-mounting integral heat sink given at Fig.6(D). This package is used for a linear monolithic amplifier with a power output capability of 3W audio, which has been widely marketed in the United Kingdom. #

High-power microcircuit packages

Package design becomes a critical problem when we come to linear i.c.s. capable of handling more than a few watts, whether they be monolithic or hybrid. At the time of writing no standard packages have been evolved, but the main features to be expected in such packages can be seen in the illustrative example of Fig.7. This is a 50-W high-quality audio amplifier. In the casing outline at Fig.7(a), you can see that it is a fairly substantial package, 100 x 50 x 25mm (4 x 2 x 1in), with flanges for bolting to a chassis or heat sink. The terminals are stout pins issuing from one side of the package, to which connections can be made by soldering or by crimped-tag flying leads. The amplifier is of the quasi-complementary class-B type and the circuit used is shown in Fig.7(b). The main power-dissipating elements are the two output transistors. Some expertise is required to mount these in the package to ensure the most efficient removal of the heat—quite a problem when you realise that the power transistor chips are asked to dissipate internally 30W apiece.

Sockets for microcircuits

In the early days of transistors, when designers were a little uncertain how to handle them, it was common to fit sockets for them on printed circuit boards. We see the same development with microcircuits, and there is a lot to be said for it.

Sockets for standard dual-in-line, single-in-line and multilead TO-5 packages are nowadays fairly readily available from electronics distributors. Apart from distributors, some firms specialize in the supply of microcircuit sockets, such as Jermyn Industries in the U.K. and Augat or Barnes in the U.S.A. (with agents in the U.K.).

If you are buying microcircuit sockets, remember that they come in two types: "test" sockets specially designed for

#Plessey type SL403A.

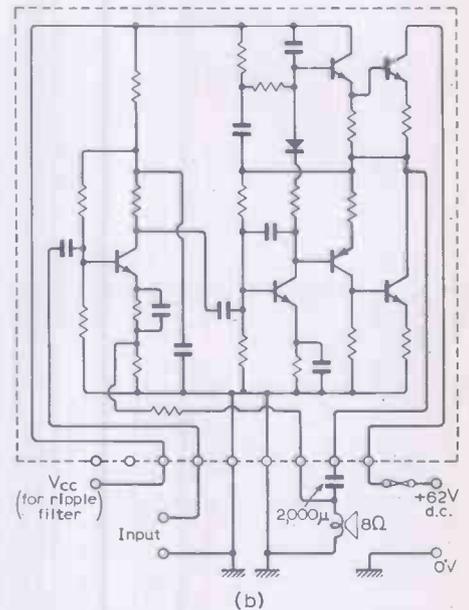
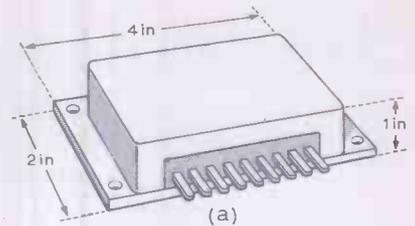


Fig. 7. Typical commercial example of high-power linear microcircuit (Sanken Electric SI-1050A, 50Watt Hi-fi power amplifier). (a) Package; (b) hybrid circuit.

continuous repetitive use, and "production" sockets for once (or occasionally twice) use in equipment. Obviously production sockets will be cheaper than the test type.

Availability of Linear Microcircuits

From this preliminary look at the linear microcircuit field, it should be evident that nowadays the designer can look to a large commercial armoury of such circuits around which to build his equipment. As later articles in this series will show, he will find linear i.c.s. for applications in frequencies from d.c. to 1,000MHz, powers from 0.1mW to 100W and gains from 0dB(x1) to 120dB (x1,000,000). The article next month will deal with what is commercially available in the way of linear i.c.s. and how to set about finding them.

Editor's Note. The arrival of the first integrated circuit from Texas Instruments in 1958, referred to by the author on p. 472, was foreshadowed by a report in *Wireless World* in 1957 (November issue, p. 516) dealing with early British work by the Royal Radar Establishment and Plessey. The title of our article, "Solid Circuits", later involved our reporter in some legal business with Texas, as this company subsequently used these words as a trade name for their devices.

Circuit Ideas

Loudspeaker transmit/receive switch

In low-power radio transceivers it is customary to use the receiver output stage as the modulator when transmitting, a switch being used to disconnect the loudspeaker. The following circuitry allows this switching to be accomplished remotely without the use of a mechanical relay, and has been used in a four-metre portable transceiver in which all send/receive switching is accomplished electronically. The basic circuit is shown in Fig. 1 and has a very much lower insertion loss than any diode or other system that was investigated. The power loss is only slight with a 3Ω loudspeaker and is unnoticeable with a 15Ω load. Almost any

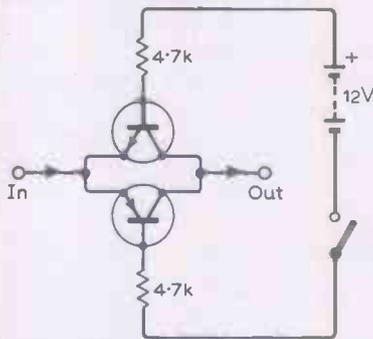


Fig. 1. Basic electronic switch.

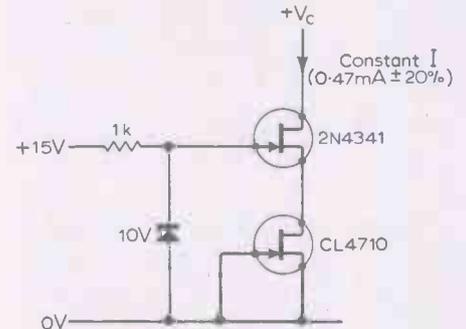
transistors can be used but silicon planar devices give the greatest attenuation when the gate is off. Because of the fairly low reverse emitter-base breakdown voltage ratings of such transistors (about 5 to 6 V), some breakthrough occurs if the input voltage swing is greater than 12 V pk-pk. When one side of the input or output is referred to one pole of the supply battery the circuit of Fig. 2 can be used. If only one switched h.t. supply is available, for example that for the transmitter, the modification shown in Fig. 3 can be used. The diode ensures that Tr_4 does not conduct when any audio peaks cause reverse breakdown current to flow into the base of Tr_2 .

D. A. TONG,
Kirkintilloch,
Dunbartonshire.

High-stability constant-current source

A convenient two-terminal constant-current source is a field-effect diode. Devices may be selected to have a temperature coefficient of less than $0.0005\%/^{\circ}\text{C}$. However, the voltage coefficient of such diodes is typically $0.05\%/V$. This means that voltage variations may lead to larger errors in the con-

stant current than temperature changes. A way of isolating the diode from voltage changes using an f.e.t. with its gate held at a constant voltage is shown. The f.e.t. should be chosen to have a low V_p consistent with an I_{DSS} which exceeds the current passed



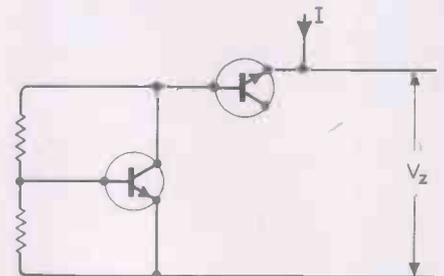
F.e.t. current source.

by the current limiting diode. A 2N4 340 or 2N4 341 is suitable for use with the CL4 710. The gate source voltage of a 2N4 341 changed less than 10% over a 30V change in V_c giving a current stability of $0.0005\%/V$ and $0.0005\%/^{\circ}\text{C}$.

J. A. ROBERTS and J. R. JONES,
Swansea.

Cheap voltage reference

The base-emitter diode of most silicon transistors can be reverse-biased and made to operate as a zener diode. At currents of about 1mA a positive coefficient of voltage with temperature is usually found



Temperature compensated 'zener' diode.

which is greater in magnitude than the negative temperature coefficient of the same diode when forward-biased. By operating a transistor in an 'amplified diode' arrangement the temperature coefficients of this diode and the zener can be made equal and opposite. With the two in series a very cheap temperature compensated zener diode can be produced which is the equal of most of the reference diodes available commercially for quite high prices. Using two 2N2484 transistors in a common heatsink a temperature coefficient of less than 10 p.p.m. over a ten degree temperature range can be achieved for 2mA current and 12V output. Resistors of the order of 10k have been used.

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New South Wales,
Australia.

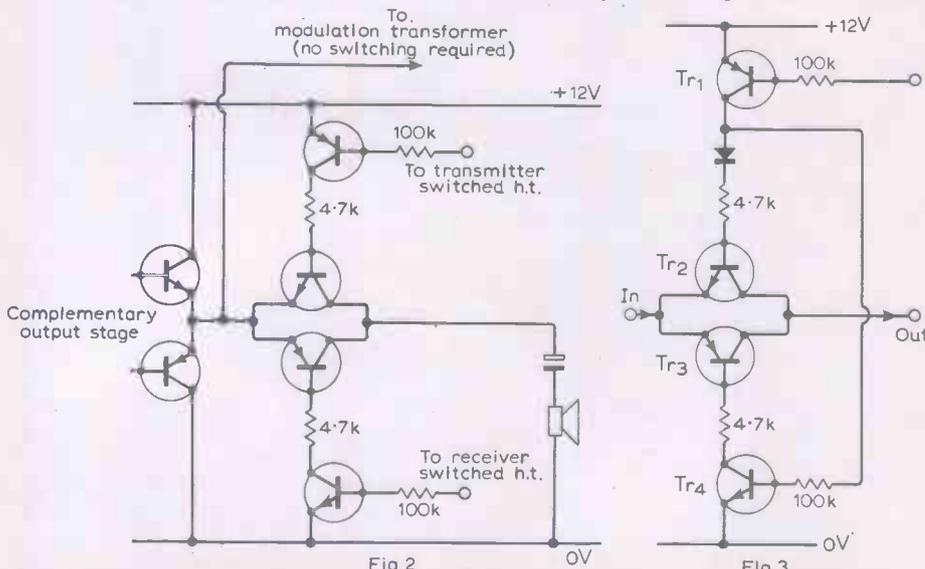


Fig. 2. Circuit for connection to two switched h.t. supplies. Fig. 3. Circuit arrangement for use with only one switched supply.

High-power Amplifier

A design with a bridge output stage delivering 100W into 8Ω

by Ian Hardcastle*, M.A., & Basil Lane

Regular readers of *Wireless World* will recollect an earlier article of ours describing a simple 15-W power amplifier†. This article takes the design several stages further to provide an output power of 100W.

In attempting to upgrade the original design (reproduced in Fig. 1) two alternatives could be adopted, either to use 8Ω speakers and raise the supply voltage or to use 4Ω speakers and accept a very high output current.

Table 1 lists the requirements in detail and from the data sheets of the output transistor range (TIP29A to TIP36A) it can be seen that the supply voltage equals the breakdown voltage in the case of the 4Ω version, and for the 8Ω version the supply rail is well above breakdown. In addition if we are to retain the same pre-driver the supply voltage is also well above the breakdown of the BC212L used. Any alternative device used as a pre-driver would represent a rise in cost as would be the case for the output transistors in the 4Ω version. Here the large peak current demands would necessitate the selection

* Texas Instruments Ltd.

† "Low-cost 15-W Amplifier", *Wireless World*, October 1969.

TABLE 1. Voltage and current requirements for 100 watt amplifier

load impedance	r.m.s. voltage	peak voltage	pk-pk voltage	r.m.s. current	peak current	power supply
8Ω	28.3V	40.1V	80.2V	3.53A	5.0A	90V
4Ω	20V	28.3V	56.6V	5A	7.06A	64V

of TIP35A/36A preceded by TIP29A/30A to give the base drive required by the output pair under peak output-current conditions. In turn, base drive for these devices, if derived from the existing pre-driver, would set a collector current requirement for this stage of around 20mA giving a power dissipation beyond the capability of the low cost small signal devices. In addition the stage gain would be reduced and by a chain reaction reduce the ratio of open loop to closed loop gain giving a high level of distortion. A way round this problem is to insert another set of drivers using a further pair of TIP29A/30A as shown in Fig. 2.

To ensure sufficient overall current gain around the quiescent point, resistors R_1 to R_4 are added to the configuration to increase the running current of the output

stage to a point where the devices have developed useful gain. Since a 4Ω load is being employed the load coupling capacitor must be large and its current rating must be greater than 5A.

Finally the use of the 64-V rail means that the transistors are operating at and beyond the limits of their voltage ratings making the production of such an amplifier a risky business. Furthermore, the unregulated supply previously specified would be unsuitable since its off-load voltage could well rise too far. A fresh look at the design is obviously required.

Argument for the bridge

At the sort of power levels under consideration we are stuck with the output current and voltage requirement already mentioned and any attempt at reducing this (with say an 8Ω load) will only result in a prohibitively high rail voltage to provide the large voltage swings required. The reason for this is that the use of the capacitor coupling arrangement to the load limits these voltages to peak values of + or - half the supply voltage. What is required is an arrangement that eliminates the coupling

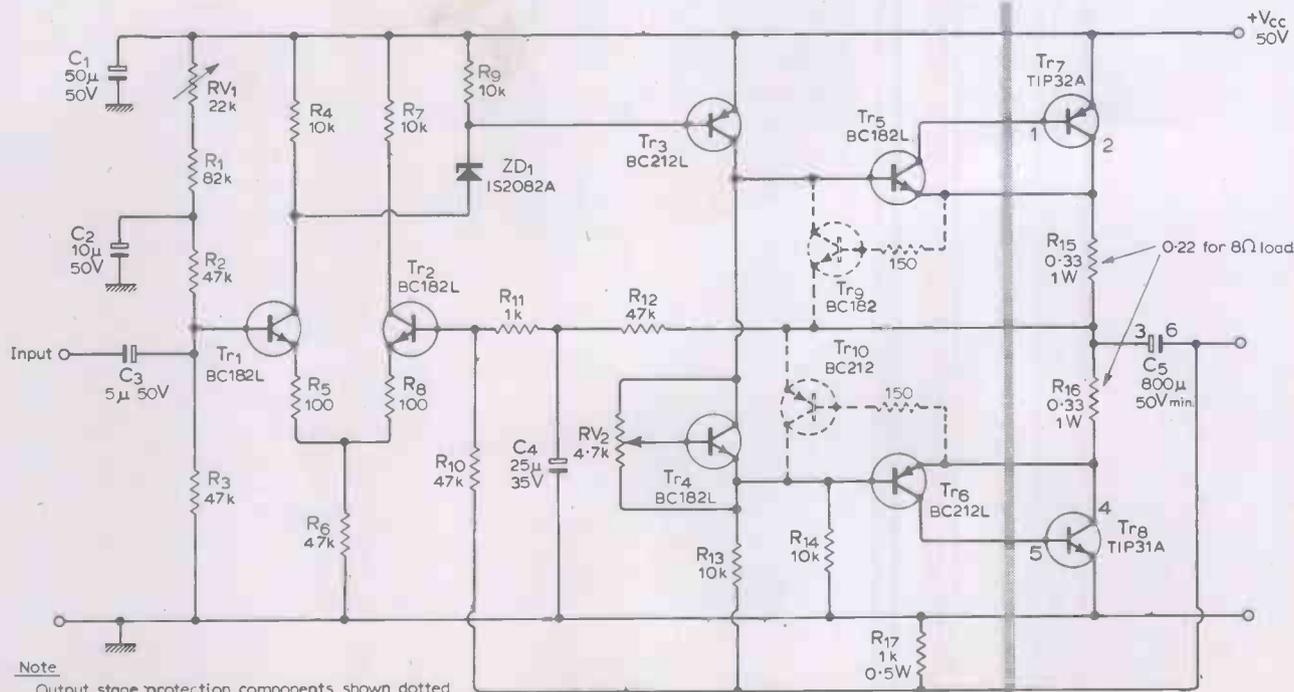


Fig. 1. Circuit of amplifier described in October 1969.

capacitor without incurring the penalty of d.c. flowing in the loads.

Fig. 3 shows such an arrangement, where four output transistors are arranged as a bridge with the load connected across the d.c. null. If an anti-phase signal is applied to this configuration, on peak positive signals Tr_1 and Tr_4 are turned hard on, Tr_2 and Tr_3 are hard off, causing the full supply voltage to appear across R_L . With a peak negative input, Tr_2 and Tr_3 are turned hard on, causing the full supply voltage to again appear across the load but in the opposite direction. Taking another look at Table 1, we see that an r.m.s. voltage of 28.3V is required to produce 100W in 8Ω .

With the arrangement shown in Fig. 3, each half of the output stage only has to swing half of the required voltage. In this instance 14.15V r.m.s., 20.05V peak, or 40.1V peak to peak. This now allows the rail voltage to be lowered to 50V enabling the same transistor families to be used in the output stage as were employed in the original 15-W design. In addition, if at any time the power output of the amplifier needs to be raised, the rail voltage can be raised to achieve it. For example an 8Ω load with 60-V supply would provide an output power of up to 175W. Alternatively for a 4Ω load power in excess of 350W should be obtained.

Fig. 4 shows a block schematic of the arrangement to be used in this instance together with a full circuit diagram in Fig. 5.

Considering one half

Referring to Fig. 5, the left-hand power amplifier will now be described, similar arguments being applicable to the right-hand amplifier. Readers will recognize the configuration of the output stage, which is similar to that of the early 15-W design. The transistors TIP35A and TIP36A would be suitable for use in this 100-W version, but at the moment they are considerably more expensive than the metal can versions, the 2N3715 and 2N3791. It is possible that at some time in the future the plastic encapsulated versions will become cheaper,

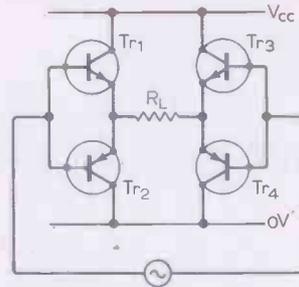


Fig. 3. Bridge output stage with the load across the d.c. null.

in which case they can be substituted without any modification. The latter transistors have a minimum current gain of 20 at 5A and hence a peak base current of 250mA is required. This is above the power dissipation capabilities of the smaller plastic encapsulated transistors which were previously used but the substitution of a pair of TIP29A and TIP30A will serve the same purpose without the need for heat sinks, since the demand is well within their free-air current and power ratings. The current gain at their peak collector current is at least 40, the peak base current required being about 5mA.

This particular type of transistor, when operated at low quiescent collector currents has a somewhat low current gain, and to obviate any difficulties likely to be encountered by variations in gain in such a situation, resistors R_{21} and R_{23} are used to shunt the base-emitter diode of the output transistors. Under quiescent conditions, the collector current of the drivers is now set at about 4.5mA giving them a current gain of around 100. A point not mentioned in the previous article dealing with the 15-W version, was the necessity for such resistors to be included to provide a path for the output transistors' collector-to-base leakage current.

Readers who have built the 15-W version, will find it advantageous to insert resistors in a similar position, of value $1k\Omega$.

Two additional functions are performed by these resistors in both designs; they ensure thermal stability of the output stage and by providing a path for collector-base

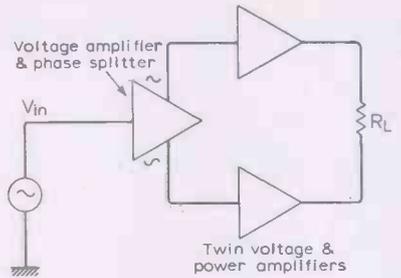


Fig. 4. Block diagram of circuit employed.

leakage, decrease the turn-off time of the transistors thus reducing high-frequency cross-over distortion and dissipation.

The familiar transistor-potentiometer biasing arrangement has been used again to supply the necessary inter-base voltage to the drivers, thus causing the output stage to operate in class AB, giving a nominal output quiescent current of 20 to 50mA. The pre-driver stage operates at a quiescent current of 10mA, this current being well within the current and power handling capabilities of the devices specified in the 15-W version. Referring to Fig. 1, the reader will see that a bootstrap resistor has been used as a constant-current sink, this resistor being connected between C_5 and Tr_4 . In this instance, at the cross-over point, the input impedance of the resistor tends to fall because the voltage on the collector of the driver transistor Tr_3 changes more than the output voltage, thus a voltage imbalance occurs at either end of the resistor and the bootstrapping fails. An alternative providing a more satisfactory constant-current sink, is to replace the resistor by an additional small signal transistor suitably biased from a constant-current source. Such an arrangement is shown in Fig. 6 where the transistor Tr_9 has a constant voltage at its base provided by a potential divider chain formed by the resistors R_{11} and R_{12} with diode D_1 . The voltage developed by D_1 approximately matches the base-emitter voltage of Tr_9 over a range of ambient temperatures and thus ensures that the voltage across resistor R_{19} and in turn the current sink provided by transistor Tr_9 , remains constant with changes in temperature. An improvement in the cross-over distortion figures (still present in spite of the output stage operating in class AB) is obtained, since the constant-current sink is no longer dependent upon feedback from the output mid point.

This arrangement has been used for the 100-W amplifier for the reasons discussed above, and also because there is no output capacitor to transfer the output voltage from the output mid-point down to the earth rail. To provide such a point suitable for the connection of a bootstrap resistor, an extra capacitor and resistor would have to be inserted. All in all a comparison of costs between providing the additional transistor, or providing the capacitor-resistor arrangement shows that they are about equal, but the improvement in performance from using the transistor constant-current sink more than sub-

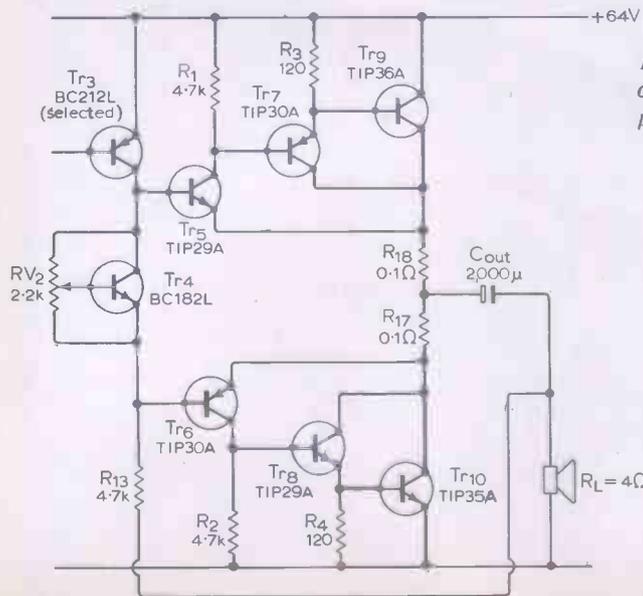


Fig. 2. Possible modification of Fig. 1 to obtain greater power.

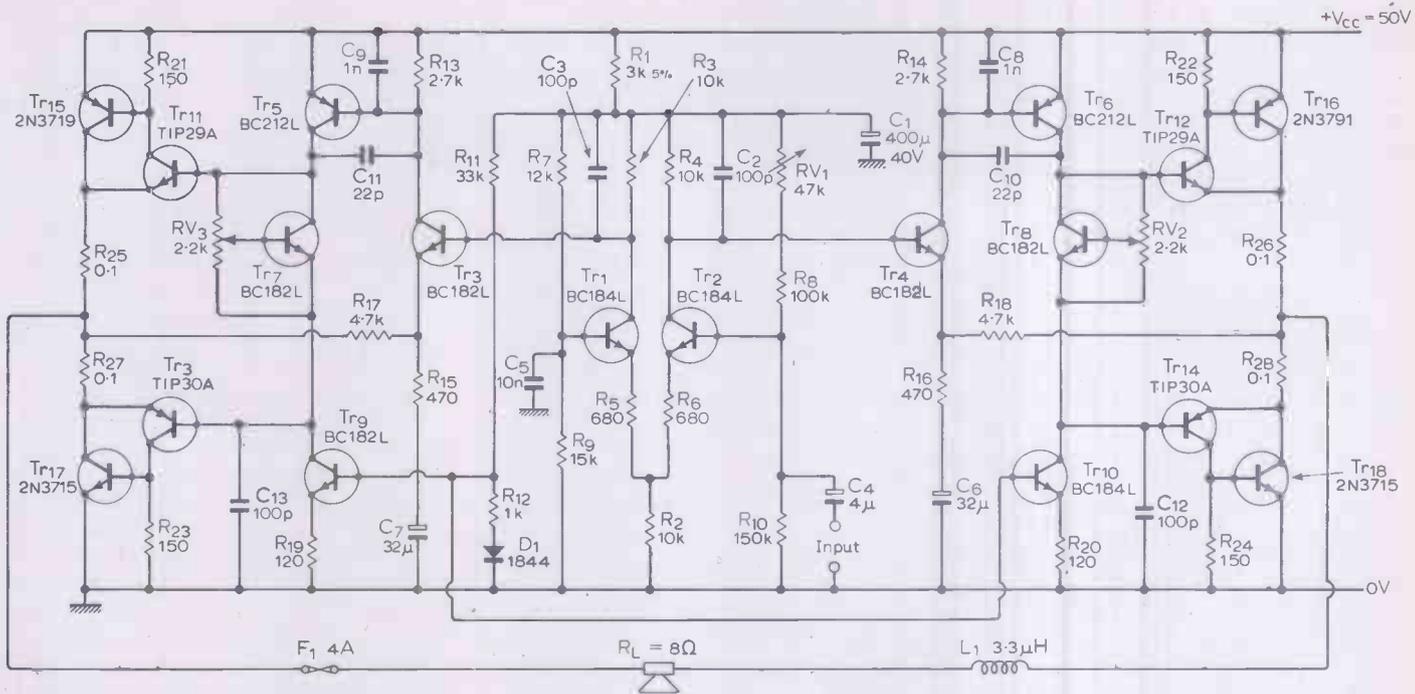


Fig. 5. Full circuit of 100-W amplifier. Resistors can be 10% types except R_1 .

stantiates any reason for its selection. Additionally, small signal transistors are far more readily available than the electrolytic capacitors at the time of writing and in the foreseeable future. Since our 100-W Figuration employs two identical power amplifiers, the cost of providing the constant potential divider chain for this additional transistor has been reduced by making use of the same bias chain for both amplifiers.

Input stage

To complete the power amplifiers, a different input stage is used from the version shown in Fig. 1. The long-tailed pair has been replaced by a single transistor with its collector connected directly to the base of Tr_5 , the base-emitter junction of which is partially shunted by R_{13} to reduce variation in the collector current of Tr_3 due to variations in the current gain of the driver transistor. Resistors R_{17} and R_{15} , together with capacitor C_7 provide an a.c. feedback path to the emitter of Tr_3 and set the somewhat low a.c. closed loop gain of 11. In our original article several benefits were claimed for using the long-tailed pair as an input stage. These included good stability of d.c. level of output mid-point, and high input impedance to the input and feedback circuits.

In the 100-W amplifier, the stability of the d.c. level of the two output mid-points is certainly worse than that of the 15-W amplifier. The reason for this is that changes of both the base-emitter voltage to Tr_3 and the current gain in Tr_5 will affect the d.c. output level. Under normal conditions the results of these changes due to temperature variations would be expected to be small, for example, a 20°C change will cause an output level shift of 40 mV and a change in gain of Tr_5 and Tr_6 from 60 to 300 will cause the output level shift of 400 mV. However, this is not really important since what we are interested in

is any changes of voltage across the load creating a d.c. unbalance in the bridge, because at all costs large direct currents must be prevented from flowing in the load. However such currents are unlikely to occur since any temperature change affecting the left hand power amplifier will similarly affect the right hand power amplifier. Such changes in both amplifiers would simply result in a similar shift of output mid point voltage at both ends of the load, resulting in a cancellation of effect and the preservation of bridge balance.

The high impedance feature of the feedback circuits in the original design has become unnecessary in the 100-W version, since the closed loop gain has been made small.

The advantage of having low value decoupling capacitors is retained since resistor R_{15} is relatively large (470Ω) and needs only a 32μF decoupling capacitor to give a low-frequency -3dB point at 10Hz—once again comparing favourably with the 15-W version. If this arrangement were used in a simple amplifier with a gain

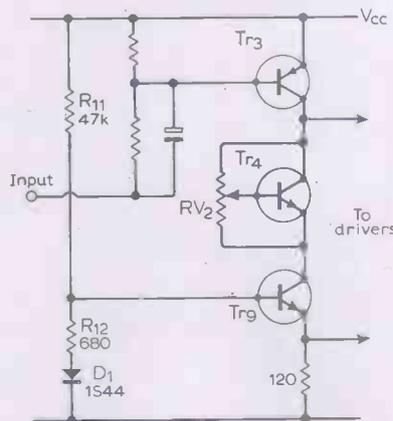


Fig. 6. Replacement of bootstrap resistor by transistor.

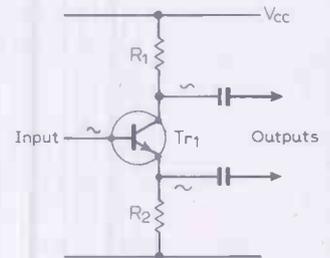


Fig. 7. Single-stage phase splitter.

of, say 100 where the feedback loop encompassed the whole amplifier, a capacitor of ten times this value would be required to give the same -3dB frequency. Despite the change of configuration from long tailed pair to single transistor the input impedance looking in at the base of Tr_3 is still high, due to the presence of the large in-phase feedback signal at the emitter. As the entire amplifier is d.c. coupled, the stability of the output mid-point voltage needs to be ensured by a d.c. reference provided at the base of Tr_3 . Two alternatives present themselves at this point.

(a) To provide an independent potential divider bias chain for Tr_3 and Tr_4 , the doubling up being necessary to allow compensation for individual variations in V_{BE} of these two transistors together with the potential drop tolerance in R_{17} and R_{18} .

(b) To make use of the d.c. level present at the output of the phase splitter as a reference.

The latter alternative represents a considerable simplification and has therefore been chosen.

Phase-splitter stage

Readers will note that the phase splitter used consists of a long-tailed pair formed by the transistors Tr_1 and Tr_2 . Other

alternatives could have been used, such as a single transistor with equal collector and emitter resistors (see Fig. 7) one phase being taken from each output electrode. The preference for the phase splitter was set by the following considerations:

1. Voltage gain is obtainable from a long tailed pair allowing a reduced voltage gain in the power amplifier and making a simpler design. In addition, a greater ratio of open to closed loop gain is obtained, giving lower distortion.

2. In the case of the single transistor, the impedance seen by each of the identical power amplifiers would be different since the collector output impedance of the phase splitter is higher than that of the emitter. The long-tailed pair shows no such disadvantage and provides identical drive conditions for both power amplifiers.

3. A single transistor phase splitter presents different d.c. levels at emitter and collector thus complicating the problem of direct connection to the input of the power amplifiers. In the case of the phase splitter using a long-tailed pair, connection is made to collectors at the same d.c. level for both power amplifiers.

An examination of Fig. 5 reveals that the bias arrangements for the two halves of the phase splitter are different. Resistors R_8 and R_{10} are of an order of ten times the value of R_7 and R_9 . One of the main reasons for this difference is that the input to the phase splitter is fed to the base of Tr_2 and it is necessary to preserve a high input impedance (to avoid loading the output of the pre-amplifier). The source impedance seen by transistor Tr_2 when taking noise into consideration will be low, since C_4 , the input coupling capacitor

and the impedance of the source acts as a de-coupling network across R_8 and R_{10} . Provision of a network of similar impedance at the base of Tr_1 would mean that the source impedance seen by Tr_1 would be too high for minimum noise output, and additionally, radiated interference would be easily picked up by this device. The values chosen for resistors R_7 and R_9 provide the optimum low-noise condition, capacitor C_5 being used to de-couple the bias chain at high frequencies to eliminate noise from radiation sources.

In most conventional long-tail pair arrangements efforts are made to see that both halves of the pair are balanced in their current, voltage, and impedance characteristics. In this way such an arrangement takes advantage of the inherent self-balancing of d.c. conditions available from such a configuration. Since in this version of the long-tailed pair we have an impedance imbalance at the base of each half of the long-tailed pair, gain changes in the transistors arising from temperature shifts is likely to result in a drift in the relative d.c. voltage levels of the two bases; this in turn appears at the output of the long-tailed pair and hence throws the power amplifiers into a state of imbalance. In practice, this effect is very small due to the selected high-gain characteristics of the transistors specified for Tr_1 and Tr_2 . As an example, if a minimum gain transistor's gain doubles due to any changes in temperature, a differential change in the base voltage of Tr_1 and Tr_2 of about $120\mu V$ can be expected. The resulting differential change in the output voltage of the whole amplifier is likely to be about 1.7 mV.

As already mentioned, the input impedance of the power amplifier is high and thus though it shunts the collector resistors of each half of the long-tailed pair this need not be considered when calculating the gain of the phase-splitter stage. Gain is calculated by the ratio of the collector resistors R_3 and R_4 to the emitter resistors R_5 and R_6 and produces a value of 15.3. Resistor R_1 is used to connect the complete phase-splitter stage to the positive rail. Since it is decoupled by C_1 , ripple and noise is prevented from appearing at the inputs of the power amplifiers. Since the power amplifiers themselves are fully hum-proofed, noise appearing at the output source is extremely low. One could argue that the de-coupling of R_1 is not strictly necessary, since any hum appearing at R_3 and R_4 will be in-phase and will thus appear at the output of each power amplifier still in phase, constituting a null in the load. This condition would only be true were the voltage gain of each power amplifier equal. In practice this is somewhat difficult to ensure, and anyway the cost of the additional decoupling is small ensuring low noise as well as incidentally improving the high-frequency stability of the amplifiers.

A further consideration in the selection of the value of the collector resistors in the phase splitter, was the requirement to provide the appropriate d.c. level to allow direct coupling into the power amplifiers. This voltage is 28.5V allowing the mean d.c. level of the power amplifier output mid-points to be set at approximately +26.2V. Since a 50V supply rail has been specified, one might expect this output mid-point voltage to be nearer 25V, however, the output voltage of the power amplifiers cannot swing as close to earth as it can to the positive rail because the emitters of the current-sink transistor Tr_5 and Tr_6 are set at 1.5V.

As has already been stated it is undesirable for differences in the d.c. mid-point voltage levels to occur because of the resultant large direct currents flowing in the load. Component tolerances tend to create such a situation which is to a large extent compensated for by adjustment of the base voltage of transistor Tr_2 using the potentiometer RV_1 . This potentiometer allows the adjustment of the output mid-point voltage in the right hand power amplifier to the same level of the output mid-point voltage of the left hand power amplifier.

If low-cost wide-tolerance resistors are used throughout the system it may be found that the adjustment of RV_1 is insufficient to correct any imbalance in the output mid-point voltage. In such an instance resistor R_7 should be reduced to $10k\Omega$ and a $4.4k\Omega$ potentiometer connected in series with it giving an additional adjustment to the left hand amplifier's output mid-point voltage.

High-frequency stability

Due to the high cut-off frequency of the transistors used throughout this design the whole amplifier has gain in the mega-

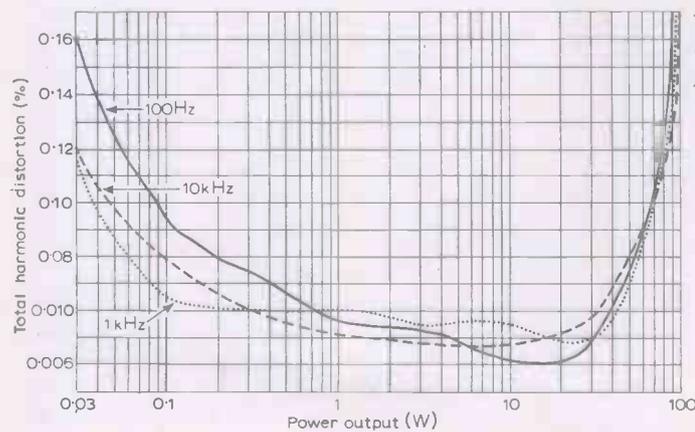


Fig. 8. Total harmonic distortion at different power levels.

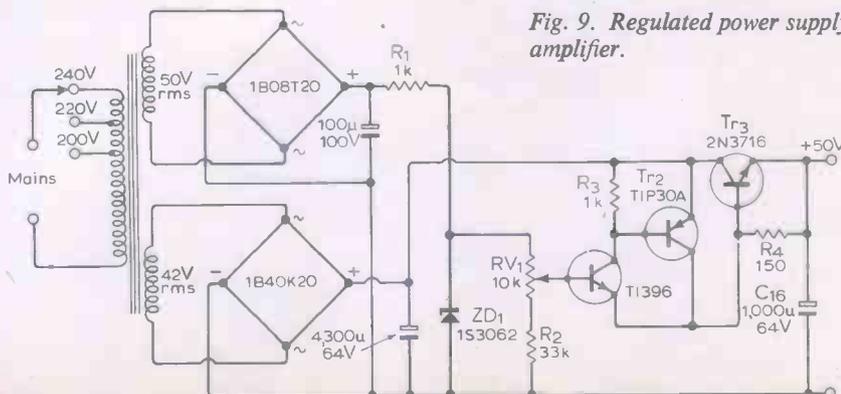


Fig. 9. Regulated power supply for amplifier.

hertz region and is therefore unstable. Where straight resistive loads are to be connected stability may be ensured by connecting 100 pF capacitors between the collector and base of Tr_5 and Tr_6 . However, if the load displays parallel capacitance the amplifier is again unstable and capacitors C_2 and C_3 have to be added and C_{10} and C_{11} increased to 330 pF. Unfortunately, although this stabilizes the amplifier, the maximum undistorted output frequency is limited to about 10kHz. Naturally this is undesirable and to alleviate the situation and extend the frequency response beyond 20kHz, capacitors C_8 , C_9 , C_{12} and C_{13} have to be added. In addition, a small inductor L_1 completes the stabilization arrangement. This inductor can be made by winding 25 turns of 26 s.w.g. enamelled copper wire in a single layer on a high value 1W resistor.

It may seem that rather a large number of components have been used to ensure the high frequency stability of the amplifier, but this situation has arisen as a result of the large open-loop gain of the amplifier and the large current and voltage swings involved. Distortion characteristics for the amplifier are shown as a graph in Fig. 8. The main performance figures are given in Table 2 and intermodulation distortion readings in Table 3.

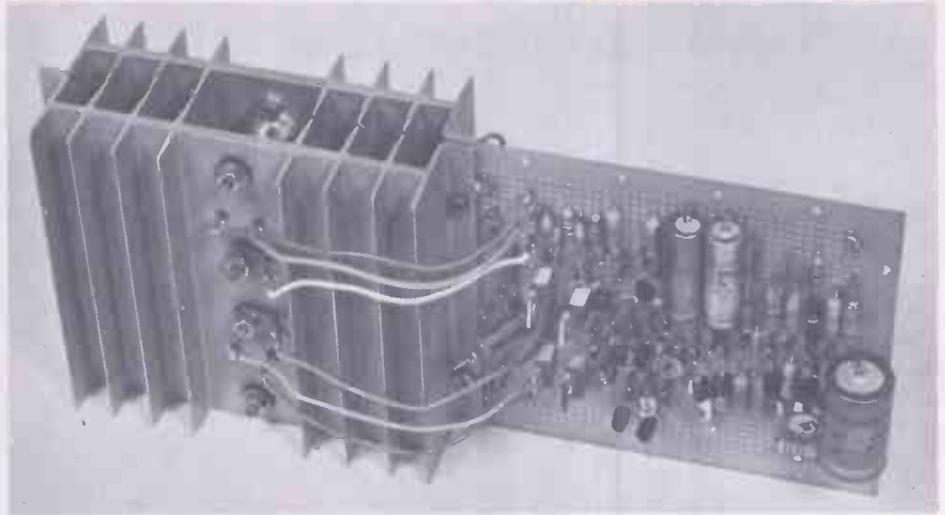
Construction

As is the case for the 15W amplifier described in our previous article the layout of this amplifier is not very critical. However, some simple rules should be observed in the layout of the output stages. Transistors Tr_{11} , Tr_{12} , Tr_{13} and Tr_{14} should be mounted as close as possible to one another on the circuit board.

Short wires should be used to connect these stages to the output transistors. If possible separate leads from the emitters of the n-p-n output transistors should be taken directly to the reservoir capacitor. Alternatively if the power supply and reservoir capacitor are not close to the power amplifiers these leads could be connected to the circuit board at one point close to the driver stages with the negative lead from the power supply. A similar arrangement should be made for the emitters of the p-n-p output transistors.

As one may expect from an amplifier of such an output there is considerable heat dissipation in the output transistors. In fact this amounts to about 25W, so efficient heat sinking should be employed. One heat sink should be used for each output pair.

A method of component layout employed in the prototype was to make use



A complete amplifier. The four electrolytic capacitors used in the circuit are small enough to be wired directly to the Lektrokit board.

of the plain perforated Lektrokit board.

To avoid the inevitable rage and frustration in the event of turning your amplifier on for the first time and seeing large black clouds of smoke rising, the following setting up rules should be closely observed:—

(1) Terminate the input with a 10k Ω resistor. Connect a voltmeter across the open circuit output terminals.

(2) Set RV_2 and RV_3 such that their wipers are at the end of their tracks connected to the collectors of Tr_7 and Tr_8 .

(3) Set the wiper of RV_1 at its mid-point.

(4) Connect a 3W 5k Ω rheostat and a 250mA meter in series with the positive supply lead. Set the rheostat to 5k Ω and connect the amplifier to its power supply.

(5) Turn the power supply on, and slowly reduce the resistance of the rheostat to zero. Should the current drawn exceed 150mA turn off and check the wiring.

(6) Connect a voltmeter across the output points and adjust RV_1 until the output voltage as read by the meter reads 0V (± 50 mV).

(7) Switch off. Disconnect the rheostat and current meter, and connect a suitable resistive load. Switch on and re-check the differential output voltage. Re-adjust as necessary and then switch off.

(8) Connect a 100mA current meter in series with the emitter of Tr_{15} . Switch on and adjust RV_3 until 50mA is indicated. Switch off.

(9) Move the meter connections to the emitter of Tr_{16} and switch on. Adjust RV_2 until the meter indicates 50mA. Switch off, and remove the meter.

(10) Switch on and re-check the d.c. differential output voltage. The amplifier is now ready to be used.

Overload protection

In an amplifier of this type, some form of protection is essential and the method shown in our earlier article is suitable for use here, though the number of items is doubled. In addition the fitting of fuse F_1 is regarded as imperative in view of

TABLE 3. Intermodulation Distortion

output frequencies & amplitudes				intermodulation distortion
Hz	V	Hz	V	(%)
1100	14.4	900	14.4	0.16
11k	14.4	9k	14.4	0.23
10k	24.0	1k	6.0	0.14
10k	6.0	1k	24.0	0.14
10k	24.0	120	6.0	0.15
10k	6.0	120	24.0	0.15
1k	24.0	120	6.0	0.135
1k	6.0	120	24.0	0.145

the fact that the output stage can still overheat under long-term overload conditions. The value of this fuse should be 4A.

Power supply

It is just feasible that an unregulated power unit could be used to supply this amplifier, but it is important that under no-load conditions the voltage does not rise above 60V and at full power it does not drop below 50V. Large currents are drawn from the supply making these requirements difficult to obtain and most readers may favour a regulated unit. A suitable design is given in Fig. 9, where the 50V winding (rated at about 10mA) provides a supply which when rectified and smoothed acts as a constant voltage source. Resistor R_1 acts as a constant current source for the zener diode ZD_1 and the parallel arrangement of RV_1 and R_2 in series provide a small measure of adjustment. Transistors Tr_1 and Tr_2 provide the necessary current gain to minimize the effect of the base current swing of Tr_3 on zener diode ZD_1 . The dissipation in Tr_{20} reaches a maximum of about 35W, and so it should be mounted on a heat sink having a thermal resistance of less than 3.5°C/W. The leads from C_{16} to the emitters of the four output transistors should be kept as short as possible.

The three electrolytic capacitors used in this power supply cannot be eliminated or safely reduced in size. Separate transformers can of course be used to provide the 50 and 42 volt secondaries.

TABLE 2. Performance Figures

power output	100W
power output (t.h.d. = 10%)	150W
frequency response (± 1 dB)	10Hz—20kHz
signal-noise ratio ($R_{source} = 600\Omega$)	89dB
signal-noise ratio ($R_{source} = 10k\Omega$)	84dB
input impedance at 1kHz	56k Ω
output impedance at 1kHz	0.08 Ω
nominal input voltage ($P_{out} = 100W @ 1kHz$)	180mV
power-supply current (at 100W & 1kHz)	3.5A r.m.s.

Avionics at Farnborough

Some impressions from the electronics show

Have you ever thought of all the things that occur when a modern aircraft is displaced slightly from its flight path by an air disturbance or for some other reason? As an airline passenger one is inclined to think only in terms of seating comfort and cabin service and to hope that the wings won't fall off or that engines won't pack up. It is interesting to look at the aircraft as a single unit, that is, to roll all the sub-systems into one.

The small disturbance mentioned above will cause a host of transducers of many types to give out a signal or to change their existing outputs. Innumerable gyros will measure the amount, rate and direction of the disturbance; accelerometers will measure the size and direction of the accelerations and decelerations involved in three dimensions; aneroid and other capsules will measure change in height, airspeed and rate of climb or dive; direction-finding aerials move slightly to stay aligned on the beacon they are tracking; doppler beats are generated proportional to the rate of the disturbance; flux valves measure the angle of the earth's magnetic field relative to the aircraft, and so on.

This flurry of signals is fed to a number of digital, analogue and hybrid computers. Trains of pulses are generated during the computations, analogue signals change in phase and amplitude in such a way as to describe the amount and direction of the displacement, scores of small motors turn to either drive pointers or to assist in the calculations by turning a shaft which mimics the aircraft's angle in a particular plane.

As a result of all these actions the gyro compass now indicates the new heading (true or magnetic) and updates all the navigation computers which will provide a read-out of position; the outputs of the accelerometers are changed into signals representing velocity and to distance flown in a given direction for the navigation system; the doppler radar will be giving an indication of ground speed and drift from which true track can be computed; and signals will be fed to limited authority motors in the flying control system to cause the hydraulics to apply control surface movement to limit the size of the displacement. With automatic control the automatic pilot will apply control surface movement, after taking into

account the flying characteristics of the particular aircraft, in such a way as to correct the displacement practically before it occurs. During even a disturbance these and many other actions occur. For instance, signals from different sources, but describing the same thing, are compared and an error signal may be generated to correct one of the sources.

Apart from these systems there is the radar blind-landing and communication equipment as well as the electrical, electronic, hydraulic, pneumatic and mechanical systems needed to control and monitor cabin pressurization, fuel management, undercarriage, flying controls, flaps, dive brakes, engines, temperatures, etc., etc.

All these systems have to be powered and the prime movers for this are of course the engines. The outputs of the engine-driven alternators have to be controlled in frequency and amplitude and distributed throughout the aircraft so a great deal of electrical equipment is required.

The preceding few paragraphs were presented so that the reader who is not familiar with aircraft systems could get some idea of how complex a modern aircraft is. Not all systems were mentioned and if a military aircraft had been taken as an example, instead of a civil one, the various weapon aiming systems would have increased the complexity by a very large factor.

Britain's avionic industry can design, develop and build all the systems necessary including the engines and the airframe for any aircraft that is technically feasible by today's standards if it had the money to do so. The only other countries to have such a complete capability are Russia and America.

This lead cannot be maintained unless the industry designs and builds aircraft and at present its hopes are placed on perilously few products. Topping the list is of course the Anglo-French *Concorde* which stands to win £4,000M worth of export orders if it comes up to its design performance. There is also the Anglo-French *Jaguar* and the European *Multi role combat aircraft* (MRCA) controlled by an Anglo, German, Italian company called Panavia. There is the successor to the BAC one-eleven, the three-eleven, which is a short/medium haul jet airliner capable of carrying about 250 passengers which could be ready by mid-1975. About £200M is needed by BAC to get this project off the ground. Also awaiting money and policy decisions are two vertical take-off airliner projects the Westland WE.01/02 which employs a helicopter principle and the Hawker Siddeley H.S.141, a modified Trident with jet powered vertical take-off. If the British aircraft industry is to stay with the leaders it must have the money even if the costs are offset to some extent by Anglo-European co-operation. The benefits for the country in terms of exports could be enormous.

Not only can the British aircraft industry build aircraft but, as was



Designed primarily for air traffic control use by Solartron the interface equipment shown allows a standard television tape recorder to be used to record radar data for subsequent analysis on a radar display.

exemplified by the static exhibition of Farnborough, our own electronics industry is fully capable of meeting all the demands likely to be made upon it for the equipment so essential to today's aerospace technology.

At the show Marconi introduced a new computer called Myriad-3 which is designed around t.t.l. logic and is intended for handling radar data.

Myriad-3 is a parallel binary fixed-point machine with single address operation having a word length of 24 bits with facilities for double-length working. Extensive input/output facilities are available in the form of optional plug-in modules. Most single-length instructions take about $3.2\mu\text{s}$ and the more complicated instructions, such as multiply, take around $11\mu\text{s}$. Storage capacity is up to 256,000 words and two types of store are available; a 32k word store with a 650ns cycle time and a 16k word store with a $1.6\mu\text{s}$ cycle time. Because the store timing is controlled from within the store unit, it is possible to have both types of store in a system, with the slower (and cheaper) store carrying less urgent information.

The basic machine comprises a number of modular 'building bricks'. The main units are the central processing unit, store units, power units, operators' control unit, programmers'/engineers' control unit and a highway extension unit. A master peripheral unit, designed to accept standard control modules, accommodates the input/output control circuits for peripheral devices.

Among the many demonstrations on the Min-tech stand was the use of glass fibre light guides in an experimental optical communications system employing a gallium arsenide diode as the light



A personal survival beacon, Sarbe 5, introduced by Burndept for military use. It allows two-way speech and a built-in test system.

source and an exhibit which showed how a c.r.t. and associated keyboard could be used on board an aircraft to communicate with a navigational digital computer.

Visitors to Farnborough were able to navigate their way round the airfield without moving from the Sperry pavilion. To do this, they went for a simulated run in a Land-Rover equipped with the Sperry Vehicle Navigator and Map Display which is currently being offered for airfield navigation duties.

The Land-Rover was driven in the normal way; the wheels revolving against a dynamometer to provide a speed input for a computer. Turning the steering wheel produced heading change inputs for the computer, in place of the gyro or flux-valve normally employed. A map display unit was mounted on the bonnet for the demonstration and the position of the vehicle was indicated by hair line cursors. A digital computer monitored the process.

The helicopter version of the Solartron Simfire seen at the exhibition is one of a family of direct fire weapon effects simulators developed as aids for combat training. The system has two basic roles. As a method of training helicopter pilots in making the best use of ground and cover to avoid ground fire; and as a means of assessing the vulnerability of helicopters to ground fire, for operational analysis purposes. A laser-beam projector is aimed by the operator at a helicopter target. When the operator 'fires', a stream of pulses is directed towards the target. Detectors on the helicopter receive the laser beam impulses and illuminate indicator lamps which show the pilot that he is under attack. The direction of the attack is indicated by a lamp to the pilot who can then take avoiding action. If the helicopter target is held in the centre of the beam for a period exceeding one second, the helicopter is 'killed'.

Texas Instruments, as part of their Klixon range, were showing what they describe as a solid-state vane switch—a contradiction of terms if ever there was one. The device is designed to sense when

a supply of cooling air is stopped or reduced in a piece of equipment. The sensing element is a positive temperature coefficient thermistor built into a probe.

Sperry were showing a c.r.t. display intended to replace a number of instrument panel dials. The c.r.t. displayed characters and symbols to give aircraft attitude, flight director information, altitude, airspeed and weapon aiming information either individually or as an integrated display.

Decca Navigator, who were rightly shouting about the recent order by America's Eastern Airlines for the Omnitrac Area Navigation System, were also displaying a new back-projection navigation display.

Elliott Automation Radar Systems introduced a new nose radar of advanced design capable of terrain following, mapping, ranging, and air-to-air operation in strike aircraft while Elliott Flight Automation had on display a digital automatic flight control system for civil use.

Ultra Electronics were displaying a personal radio location beacon designed to replace the larger beacon now in service with the armed forces. Called Sarah-B the beacon is capable of twin-frequency working and it is built using thin film circuit methods. It measures $110 \times 75 \times 25\text{mm}$ and weighs less than 20 oz. Sarah-B transmits a tone on the distress frequency of 243MHz and can be used for two-way communication over short ranges on 243 or 282MHz; battery life is in excess of 24hr.

That completes our quick glance at a small percentage of products that were on show at Britain's biennial avionics supermarket at Farnborough.

Among the new items introduced by E.M.I. was a video map generator (Type VM101) which is designed to be an inexpensive adjunct to radar simulators or for use with real time radar displays for simulating stationary or moving clutter. It will also produce a video map. Patterns are generated by a flying spot scanner.

Elliott's stand contained a vast assortment of equipment for both military and civil applications and the Digital Systems Department introduced an airborne display control unit. Facilities provided by this unit include alphanumerics, lines and circles with 10-bit angular and positional accuracy. Individual symbols can be made to flash or be made brighter, and several displays, each showing a different picture, can be driven simultaneously.

Plessey had an engine vibration monitor on show which was designed for *Concorde*. The system consists of eight piezo-electric transducers, one mounted on both the fore and aft bearings of each of the four engines. An eight-channel display of the flight deck gives immediate indication of increased vibration, often the first indication of serious engine trouble. Another item on the Plessey stand was a stall warning unit for use on the Hawker *Harrier*. Intended for use when the aircraft is hovering, the unit senses an incipient stall condition and warns the pilot by shaking the rudder bar.



This floating beacon manufactured by Burndept, which has already captured orders worth £50,000 from Norway, operates on a primary battery and transmits on both the civil and military aviation distress frequencies (121.5 and 243MHz) for a minimum of 48hrs at 0°C. It measures 670 x 85mm and weighs 2.89kg.

London Broadcasting Convention

Some developments in broadcasting seen at the September convention

With over 80 technical contributions the biennial International Broadcasting Convention in London in September attracted 1000 delegates. Most of the papers were about television—the big stride nearly a year ago when the U.K. passed out of the 405-line monochrome age into the 625-line colour age overshadowing developments in sound broadcasting.

Automation in broadcasting was one of the major themes of the convention and a good 25% of the papers dealt with some aspect of automatic control of equipment, ranging from closed loop servos for particular operations (e.g. automatic registration of colour-separation images in television cameras) to a vast data processing system using several digital computers that controls the whole of the NHK (Japan) broadcasting network and even encompasses the audience. All this is becoming necessary, apparently, because of the increasing scope and complexity of broadcasting operations and equipment—human control is beginning to prove inadequate—and, in turn, because of the excessive cost of training and using technicians for these operations. The subject has become so important, and the automation techniques are so varied and complicated, that we intend to make a special report on this aspect of the I.B.C., to be published in the November issue of *Wireless World*.

Satellite broadcasting has its problems, some of which have been discussed before. One, discussed by P. L. Mothersole, is that of mains isolation in television receivers; a problem when thinking in terms of adding a converter to receive satellite broadcasts (such an add-on unit would convert from f.m. to a.m. as well as frequency). But with a new receiver design a convenient way around this is to have an insulated winding on the line scanning transformer, at earth potential, providing the low-voltage supply that would be required for a converter. A possibility which Mr Mothersole foresaw is the use of a communal aerial and converter system. This would avoid mounting and aligning dish aerials in domestic installations, and could also help to keep cost down.

An interesting point touched on by J. Redmond, director of engineering, B.B.C., in his address was that of sound

broadcasting from satellites in the h.f. band. A study has shown this to be technically feasible in the 21 and 26MHz bands. The satellite would probably be in a low-altitude orbit in such a scheme, because of the high power needed from a geo-stationary satellite—of the order of tens of kilowatts. A power in the region of 1kW is thought feasible for a low-orbiting satellite, and no doubt folding aerials would not present undue difficulties. Snag is the expense of maintaining orbiting satellites and with the limited number of sets able to receive 21 and 26MHz broadcasting authorities might feel there would not be much return for an outlay which could be as high as £10M p.a.

Speech clipping is used to increase the average modulation level in transmitters without overmodulation by reducing the peak-to-average energy ratio in speech waveforms. Normally this is done at speech frequency and results in trapezoidal waveforms. As well as imposing a linear phase response on the modulator this means a much wider bandwidth is needed and also power supply requirements would need to be increased. To avoid modifying older modulators to cope with the clipped speech, frequency translation can be used to ease filtering. The problem is of course that some harmonics of low-frequency speech signals in the clipped waveform are still within the speech spectrum and can not be filtered out. By modulating the speech signal on to, say, a 20kHz carrier (suppressed) and then clipping, filtering is made easy. This is because the highest upper-sideband frequency will be at, say, 25kHz—well away from the lowest first harmonic at about 40kHz. The signal is then demodulated in a product detector. With this kind of system, Radio Liberty (Federal Republic of Germany) has produced a clipper with harmonic distortion of less than 1%, even with an overload of 16dBm.

Studio acoustics. The well-known technique of making models to predict acoustic properties of concert halls has been applied to studio design and fault correction by the B.B.C. Pioneered by Spandöck at the University of Munich, this is the first time it's been used with a good signal-to-noise ratio—at least

50dB—allowing models to be listened to seriously. This method imposes severe constraints on experimental apparatus, severity depending on the scaling factor. Not least of these is the problem of air absorption, and to get the sound attenuation right a relative humidity of 3% is needed. The usual way of doing this is with silica gel but it takes several weeks to achieve the required dryness. In the B.B.C. experiments H. D. Harwood and A. N. Burd have reduced drying time to half a day for the first drying and to 15 minutes for subsequent drying by using an artificial zeolite.

Using a scale model of a studio reverberation time in the model agreed with that in the studio to within $\pm 10\%$ throughout the whole frequency range, this difference being inaudible. The model was also a success subjectively in that addition of an 'orchestra', made from polystyrene backed with felt, to the model was clearly apparent in recordings made from the model. An unexpected change in *tonal quality* from the model occurred when this orchestra was added, as well as the expected change in reverberation time. On checking against recordings made in the real studio this change was also apparent and although there is no obvious theoretical explanation for this change the fact that the model predicted it is a very satisfying validation of the modelling technique.

Another interesting development in studio design is the realisation that reverberation time need not be independent of frequency. Absorbers needed to keep low-frequency reverberation time low (say 0.35s, the recommended value for talks studios) are expensive to make and install, bulky and make modifications difficult. Availability of a recently constructed studio with removable bass absorbers made experiments on how much bass r.t. could be increased possible. As a result of various subjective tests,† it's now recommended that r.t. can rise to 0.4s at 500Hz, 0.47s at 125Hz and 0.74s at 62.5Hz.

A discussion of new developments in television will be published in the November issue.

† Spring, N. F. & Randall, K. E. "Permissible bass rise in talks studios". *B.B.C. Engineering*, July 1970, pp.29-34.

Domestic Receivers

New techniques seen at the London trade shows

Television

The design of domestic receivers is a compound of two elements: the available market and the available technology. To be more precise, the sales people are not interested in the electronic contents of the box provided the complete product is attractive for renting (and, to a smaller extent, owning); technical features, whether real or cooked up, are seen merely as fodder for sales promotion campaigns. The engineers have at their disposal new devices and techniques and would like to use them to the full in elegant, tidy circuits, but, being restricted by cost, usually end up with a design which to them is an unsatisfactory compromise.

What the engineers have in the back of their minds, as a sort of *Volksfernsehempfänger*, is a flat box producing coloured pictures and containing nothing more than a few integrated circuits. We are certainly on the way towards this ultimate, leaving behind as we go valves, round tubes, monochrome pictures, hybrid circuitry, dual standards and discrete components. Meanwhile, in our present confused state of transition, there exist side by side monochrome and colour, hybrid and semi-conductor circuitry, dual-standard and single standard, picture tubes of different sizes and shapes, single chassis and modular construction, together with a variety of "furniture" styles and electronic circuit techniques which seem like tricks because they are individual to particular manufacturers and not yet standard. In this confused situation it is difficult to decide what is "typical".

To begin with the most obvious thing, the picture tube, the six main sizes available last year (19in, 20in, 22in, 23in, 24in and 25in) have now been supplemented by two more, 17in (monochrome) and 26in (colour). There are in addition the various portable battery sets with screen sizes of 12in and smaller. The range, however, is not as embarrassingly large as it seems, as the 19in and 23in monochrome tubes have been superseded by the 20in and 24in sizes respectively, and the 25in colour tube, though still being used in sets, is due to be replaced eventually by the 26in type. The 17in monochrome tube really takes the place of the 16in type that has been

widely used in transportable and small "second sets". Thus one sees a general up-grading in size all round. Monochrome tubes have deflection angles of 110°, colour tubes 90°; but colour tubes with deflection angles of 110° and, consequently, a few inches off their length, are available on the Continent and it is only a matter of time before they appear in British sets.

The distribution of valves, transistors and i.c.s in receiver circuitry varies considerably from maker to maker. British Radio Corporation and Rank Bush Murphy have all-transistor colour sets which are virtually the same as last year's designs, and a new transistor colour receiver has been introduced by Philips. In the hybrid receiver circuits, colour and monochrome, it is common practice to use valves for the line and field scanning oscillators, for the associated output stages and for the sound output, but there is some variability with other stages. In a Decca single-standard monochrome chassis, for example, valves are also used for the 1st and 2nd i.f. stages, video amplifier, sync separator and line pulse discriminator. This design is, however, very much up with the times in having an integrated circuit, the Motorola MC1351P, for the sound intercarrier i.f. amplifier and f.m. detector (followed by a transistor a.f. output stage). Some current monochrome sets are still all-valve designs except for the u.h.f. tuner. Generally speaking the U.K. manufacturers are not bothering to put design effort into producing all-transistor monochrome circuits, which will only be found in the small imported portable sets.

Integrated circuits, last year restricted to the intercarrier sound and colour decoding functions* have now blossomed out somewhat, and in the new Philips colour receiver mentioned above there are four: (1) intercarrier sound; (2) stabilization for the tuner; (3) video pre-amplification, line gated a.g.c., sync pulse separation, noise protection for a.g.c. and sync channels; and (4) PAL switch, identity circuit and colour-difference demodulators. These devices are available from Mullard under the general type-number prefix TAA. But the general

run of set makers is still rather wary about using i.c.s, mainly for the reason that, as distinct from the digital computer field, there is a lack of standardization and "second sourcing" in the manufacture and supply of devices.

Two noticeable trends in circuit design this year are the use of variable-capacitance diode tuning and the replacement of wound components by equivalent circuitry using transistors, resistors and capacitors. Variable-capacitance diode tuning on both u.h.f. and v.h.f. has been used fairly extensively for some time in Continental television tuners but this is the first time it has appeared in sets on the British market. Examples of the technique were seen in receivers by Philips, Ekco, ITT and Teleton. The reason why varicap diodes, as they are called, have not been used here is a technological one and not, as might be thought, because U.K. makers were slow to appreciate the advantage of diode tuning. It is to do with the way in which channels are allocated.

In the U.K., u.h.f. channels are assigned to transmitters in groups of four. In most cases the four channels are n , $n + 3$, $n + 6$ and $n + 10$, or n , $n + 4$, $n + 7$ and $n + 10$, n being the lowest channel number for each station. For example: the channels assigned to Emley Moor are 41 (n), 44 ($n + 3$), 47 ($n + 6$) and 51 ($n + 10$). Those assigned to Winter Hill are 55 (n), 59 ($n + 4$), 62 ($n + 7$) and 65 ($n + 10$).

It will be seen that in each case the highest channel is spaced 10 channels from the lowest, which means that with the 8-MHz channel spacing laid down by the European frequency plan the highest channel is 80MHz away from the lowest. Now, for a receiver tuned to the lowest channel, the highest channel becomes the image frequency. This is because the agreed vision i.f. is 39.5 MHz. If the oscillator is tuned "high" as is usually the case, the image frequency is 39.5 Hz "on the other side of" (above) the oscillator or 79 MHz above the wanted station.

This figure is only 1 MHz short of the 80 MHz separation between n and $n + 10$ and a signal radiating at $n + 10$ if allowed to enter the pass band of a receiver tuned to

*"Colour Receiver Integrated Circuit" *Wireless World*, August 1968, p.263.

n channel would beat with the oscillator and cause severe interference at i.f., unless measures were taken to eliminate or greatly attenuate signals at image frequency. In the case of an oscillator tuned "low" the wanted channel and image channel would be in reverse, i.e. $n + 10$ and n respectively. The presence of interference channels at image frequency is unavoidable because four of the forty-four available channels have to be allocated to several hundred stations, which necessitates the same channels being shared by many stations. The two stations quoted already share their channels with up to six others.

It is arranged for stations sharing channels to be sited geographically remote from each other, and mutual interference can also be alleviated by the use of directional aeri-als. Despite this, u.h.f. tuners have to be designed with specially selective r.f. circuits to reject signals outside the pass band, particularly those at image frequencies. By arrangement between BREMA (the association of set manufacturers) and the broadcasting authorities the specification for the magnitude of rejection or attenuation of image frequency signals is fixed at 53 dB. All makers try to achieve this.

Using valves and three variable tuned r.f. circuits controlled by a ganged capacitor,

53 dB image rejection is relatively easy to obtain over the u.h.f. bands. However, because of production spreads it is difficult to track the capacitance of four varicap diodes (three r.f. tuning and one oscillator) over the required frequencies to obtain the specified selectivity.

On the Continent, in Germany for instance, transmitter density is much less and the receiver i.f. is different (38.9 MHz vision), therefore the problem does not arise. The German specification for image rejection is 40 dB. This less stringent requirement allows the designer to use one less r.f. tuned circuit, and the incorporation of three varicap diodes instead of four, making tracking relatively easier.

In the varicap-diode tuner designed by Philips (Fig 1) the basic problem has been overcome in two ways. First, matched sets of five diodes with similar voltage/capacitance characteristics are selected for individual tuners. The fifth diode is employed to equalize the oscillator voltage over the tuning range. Secondly, a special image frequency rejection tuned circuit is built in. This is coupled to the aerial input inductor in the emitter of the r.f. amplifier transistor. It is automatically tuned to the image frequency as the aerial input is tuned to the wanted station.

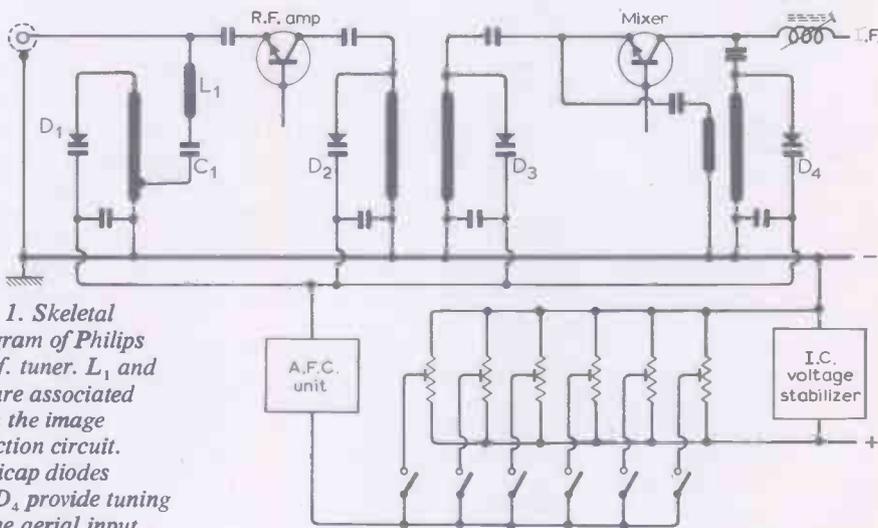
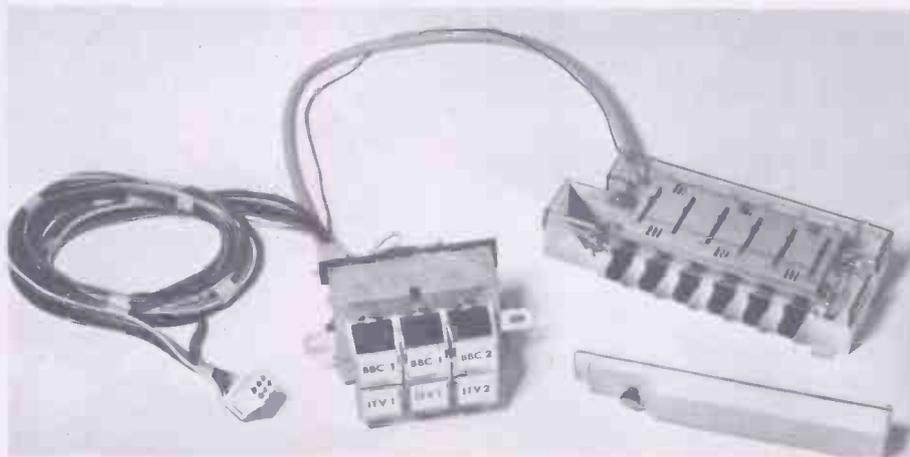


Fig. 1. Skeletal diagram of Philips u.h.f. tuner. L_1 and C_1 are associated with the image rejection circuit. Varicap diodes D_1 - D_4 provide tuning of the aerial input, bandpass primary and secondary, and oscillator respectively.



Push-button channel selector (left) and pre-set potentiometers (right) of the Philips varicap-diode tuner (Fig. 1), as used in the Philips G8 colour television receiver.

The big advantage to be had from using varicap diodes is, of course, that tuning is possible by means of a single simple potentiometer. The Philips receiver uses six preset potentiometers, each associated with a press-button switch, and so provides a six-programme station selector.

Two additional bonuses in the hands of the set designer are the smaller size of the tuner unit itself and the realization that the unit can be mounted anywhere in the cabinet. The press-buttons need be only simple switches remotely connected to the tuner via low-voltage wiring. In the Philips receiver the tuner unit is actually mounted on the i.f. printed panel and it appears in the unusual position in the centre of the chassis. The effort required to operate the "programme-change" buttons, as Philips call them, is surprisingly light when compared with mechanical systems.

The varicap diodes, being voltage-dependent devices, are susceptible to variations in supply voltage. Since any variation in supply voltage would have a serious effect on tuning accuracy it has been found necessary to stabilize, not only the receiver power supply, but also the voltage line feeding the tuner itself. The tuner incorporates a simple i.c. stabilizer (see above).

In order to take station tuning out of the viewer's hands and make it into a preset adjustment, the six tuning potentiometers are concealed by a plastics cover at the rear of the receiver. Any tendency for the tuning to drift during reception is counteracted by an a.f.c. circuit which provides the large pull-in range of 1-2 MHz either side of the correct tuning point. To prevent the receiver being "captured" by a strong transmission during programme changes the a.f.c. is cut while a button is pressed.

Avoidance of wound components was illustrated by a technique used in an ITT colour receiver, type CVC5, which is based on a Schaub Lorenz design that has been available in Germany for about a year. The circuit has R - Y and B - Y synchronous demodulators that dispense with the usual transformers needed to drive the electronic switching circuits (see for example, *W.W.* May 1969, p.223). The arrangement used is shown in Fig. 2. The demodulators proper function in the manner of a symmetrical phase discriminator. To one side of this is applied the subcarrier reference oscillation (for R - Y , via the 62pF capacitors; for B - Y , via the 560 Ω resistors), while to the other side is applied the signal voltage to be demodulated (at the common point of the 33pF capacitor in each case). At the common point of the 470 Ω resistors in each demodulator the demodulated colour signal appears without the reference oscillation because the reference oscillation is balanced out in the bridge network. As can be seen the R - Y demodulator is preceded by a transformerless PAL reversing switch which operates on the chrominance signal from the delay line, not on the reference oscillation.

It has become customary with transistor colour receiver circuits to use RGB drive to the c.r.t. cathodes, as this requires lower

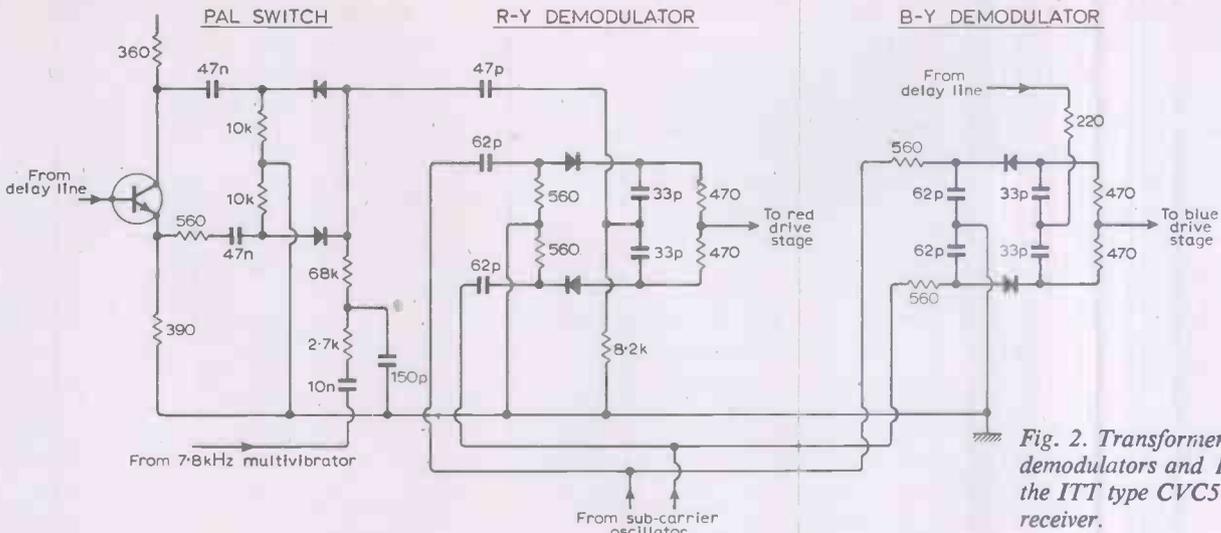


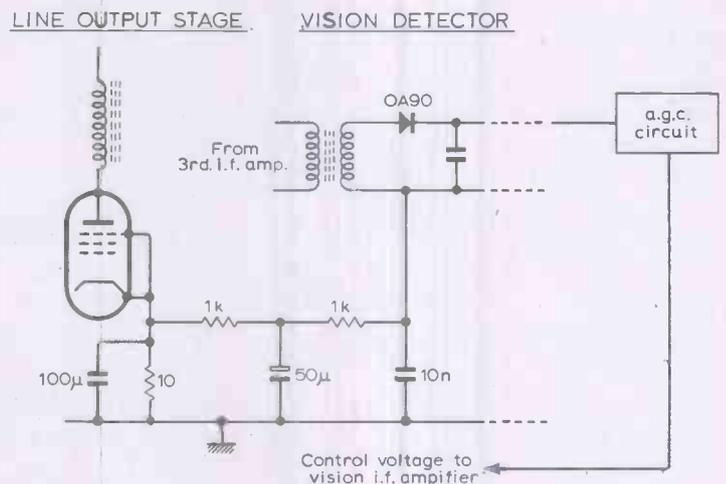
Fig. 2. Transformerless synchronous demodulators and PAL switch used in the ITT type CVCS colour television receiver.

voltage swings than do colour-difference signals, which are matrixed with the luminance signal by the c.r.t. In the new Philips set referred to above, for example, matrixing is carried out in the decoder i.c. (4) at low level and the RGB outputs receive several stages of amplification through separate channels before being applied to the c.r.t. cathodes. This method relies on accurate setting of the grey scale for good monochrome reception and for this reason the colour drive adjustments are preset at the factory.

Colour television sets usually include a circuit for preventing the beam current of the colour c.r.t. from rising above a certain upper limit, the purpose being to save the tube's shadow mask from becoming overheated and consequently distorted in shape. In any case the shadow mask carries the major part of the beam current, and with certain types of picture content the electrical energy converted into heat could become excessive. Normally the beam current limiting is arranged as a form of automatic brightness control, but during operation this causes an error in colour saturation and also a loss of detail in the darker parts of the picture. To avoid this undesirable side effect, Decca, in their latest colour receiver chassis, have designed the beam limiter as a form of automatic contrast control. Fig. 3 shows how it is arranged. A potential proportional to beam current is derived from the cathode of the line output valve and this is applied through the vision detector and other circuitry (not shown) to a video emitter follower and then to the a.g.c. circuit. The direct voltage from the a.g.c. circuit is fed back to bias the first vision i.f. amplifier transistor and so control i.f. gain in the normal manner, but is further controlled by the beam limiting circuit. Thus if the current through the line output valve starts to become excessive the effect is to reduce the amplitude of the i.f. signal and, consequently, reduce the drive to the c.r.t. and hence the beam current.

Numerous small u.h.f. television receivers from Japan were shown at the various trade shows we visited. Three new models from Standard included an all-transistor 3in portable, the SRV 307, employing 29

Fig. 3. System used for c.r.t. beam current limiting in the latest Decca colour receiver.



transistors and 23 diodes. This works from an internal supply of nine U11 cells or from a car battery. A mains adaptor is available. The weight, with batteries, is 2.4kg and the price is £77 4s 6d. The other two sets were the same price and were 7in and 12in mains/battery portables. Sanyo showed a 5in portable set, the 5TC1 weighing only 4kg with built in cadmium/nickel cells (12.5V). Using the batteries 16 hours of reception is possible: charging takes 4 hours. This set uses 25 transistors and 22 diodes, and costs £69 15s including a mains adaptor. The Toshiba 11 TBB is an 11in receiver selling at £79 10s. All these models gave clear stable pictures in the London service area with modest loop or telescopic aerials. The continuous tuning employed on these sets was easy but inter-station noise was considerable.

Teleton (European distributors for the 26-company Mitsubishi combine) still haven't produced the 12in colour portable that was rumoured in last year's survey. Other circuit features noted: The B & O Beovision 3200 colour set has a circuit which automatically cuts out the colour sub-carrier notch filter in the luminance channel when the set is receiving monochrome transmissions. This colour set also has the unusual features of a separate high-frequency loudspeaker, and bass and treble controls. In the ITT CVCS colour receiver the saturation and contrast controls are

mechanically ganged, and there are separate diode detectors for vision and intercarrier sound. The e.h.t. pulse winding on the line output transformer of the latest Decca colour chassis is underneath the primary winding instead of on top—a cost saving feature. Automatic line hold, dispensing with the usual manual control, is employed in the Philips and ITT colour receivers.

Sound receivers and reproducers

The mere appearance of integrated circuits in receivers is no longer a matter for surprise, but as the art of using i.c.s progresses makers may find alternative or novel uses. A case in point is the use of the TAD100 circuit in the new Dynatron amplifier and a.m./f.m. tuner (HFC91), announced earlier this year. This i.c. is intended as an i.f. amplifier, detector, local oscillator and a.f. pre-amplifier, but in the Dynatron circuit the stage normally used for audio amplification is used instead as a d.c. amplifier feeding an a.m. moving-coil tuning meter. (Same meter acts as tuning indicator on f.m. straight from the discriminator.)

This tuner incorporates diode tuning on v.h.f. for four circuits, two back-to-back diodes each, with three pre-set potentiometers and another linked to the tuning scale. The scale covers 88-100MHz, giving greater spread than with 108MHz top

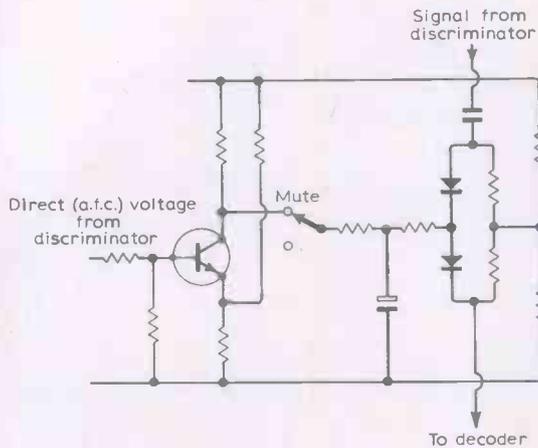


Fig. 4 (left). Interstation muting circuit in Dynatron tuner-amplifier. Tuner uses diode tuning, five integrated circuits and dual-gate f.e.t.s.

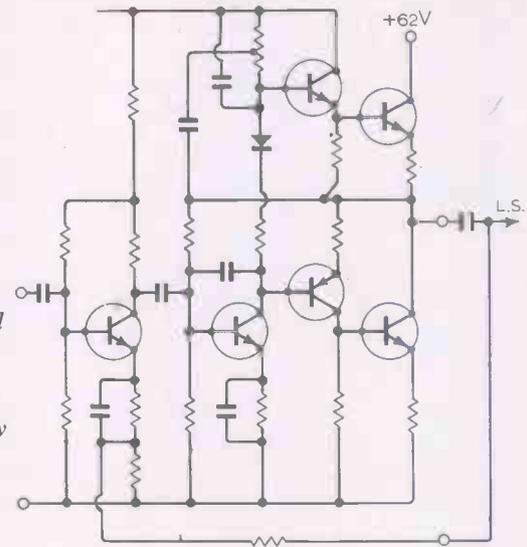


Fig. 5 (right). Hybrid thick-film high-power amplifier module made by Bendix is used in new Kellar amplifiers. Circuit shown gives r.m.s. output of 50 watts.

frequency, but the pre-set potentiometers extend to 108MHz, in anticipation of this model being sold in the U.S.A. and Canada. Supply voltage for the tuning circuits is regulated with a TAA550 i.c. between supply rail and ground. The three pre-set controls together with the displayed range allows a local station to be pre-set as well as the three national services, but we have seen some sets with four pre-set controls. (Incidentally, some local stations will be using 45° slant polarization with consequent benefits to car and 'picnic' radio reception—see p. 492.)

Interstation muting is achieved by switching back-to-back diodes in the signal path to the decoder from a d.c. amplifier following the discriminator (Fig. 4). Other features of this design are dual-gate f.e.t.s in the f.m. tuner, four i.c. Görler f.m.-i.f. amplifier, ceramic filter unit with the TAD100 a.m. i.f. amplifier, twin-T high- and low-pass filters and negative feedback tone controls in the pre-amplifier. Extensive use is made of BC148 transistors (11) with BC149s as low-noise input transistors. The audio amplifier is a conventional quasi-complementary circuit giving 45 + 45 watts into 3 ohms, or reduced powers into higher impedance loads, at low distortion (0.2%). It is typical of modern designs using silicon transistors which allow a high voltage supply with consequent high-power output. A thyristor overload protection switch reduces output to a safe level when safe operating limits of the transistors are exceeded, lighting an indicator lamp and reducing the supply voltage to the pre-amp emitter follower. Price of this tuner amplifier is £165.

A notable trend in this kind of quality tuner is the omission of a ferrite aerial for a.m. reception—or at least provision of a separate coil pack for an exterior aerial. This was also noted on the new B & O Beomaster 1600 which, apart from the addition of f.e.t.s and an f.m.-i.f. ceramic filter, is a re-styled version of the 1400. This new a.m./f.m. model, with a power output of 15 + 15 watts, and including two short-wave bands, costs £122. Another new a.m./f.m. tuner-amplifier from B & O is the Beomaster 1200. A new design, but along fairly conventional lines, it uses a cascode

f.e.t. input circuit and diode tuning. Sensitivity is better than that of the 1600 (1µV for 26dB s/n ratio f.m., 7µV for 3dB s/n ratio a.m.) and power output is 15 + 15 watts. Price £108.

Latest Teleton tuner-amplifiers (made by Mitsubishi) acknowledge the difficulty in seeing vertical tuning scales in 'low-line' models by using a horizontal scale—in one case both types are used.

The Dynatron stereo decoder is fairly typical of current practice. Designers seem to have settled on the balanced switching demodulator, this only partially demodulating the L-R signal of course. Correction to give 40dB separation is made in a common-mode amplifier (one transistor in each channel with emitters bridged with a resistor). The Dynatron circuit has the added luxury of twin-T filters in each channel to reduce sub-carrier level.

First commercial amplifiers using a hybrid thick-film integrated circuit for the power amplifier are designed by Stanley Kelly, joint managing director (with Sidney Larholt) of Kellar Electronics Ltd (Maryland Works, 9 Brydges Road, London, E15 1NA). One of the series of amplifiers is used in the new Kellar cassette tape recorders using the Dolby 'B' system for noise reduction above 2kHz. The system gives a signal-to-noise ratio improvement of 10-15dB (see p. 519). As well as using this system with the 25 + 25 watt cassette tape recorder, it will be available separately for reel-to-reel tape recorders (to be shown at the Audio Fair). We expect the Dolby 'B' system to appear in equipment from various makers later this year—Decca, Rank and Metrosound are rumoured to be working on this.

The hybrid thick-film module used by Kellar—a Bendix circuit originally designed for industrial applications—has made possible a low-cost 15 + 15 watt amplifier. Marketed under the name Nova by L. L. Electronics at £33 and with low distortion (about 0.2%) this could be the best value for money in terms of watts per £ at this power level. The circuit uses a conventional quasi-complementary output stage and complementary driver with discrete transistors on the thick-film circuit. Module measures 20 × 45 × 80mm. A slightly

larger 50-watt module is available, circuit is shown in Fig. 5, and will be used in an amplifier to be released shortly.

In designing the regulated power supplies for this amplifier, Stanley Kelly found that by using two series transistors (OC22s) each feeding one amplifier, instead of operating them in parallel, and arranging feedback from one side of a long-tailed pair circuit, he obtained a worthwhile increase in channel separation.

Another Nova Design, the 10 + 10 watt amplifier, currently using an AD161/2 output pair, is due for re-design around a Siemens TAA420 integrated circuit.

Another hybrid high-power amplifier is made by RCA (type TA7625) which operates from a split power supply and has a built-in limiting circuit.

Among the new tape recorders there is a profusion of cassette machines and medium quality reel-to-reel types. Three models from Sharp are of particular interest, having servo control of motor speed: a cassette recorder with slider controls for setting the recording level (model RD423, price £57 10s) and two 5in reel-to-reel recorders with switched speed change (model RD513, price £39, and its push-button-control counterpart, the RD514, price £42). In each of these recorders the d.c. drive motor is in the collector circuit of a control transistor, the base circuit of which is fed from a generator coupled to the motor shaft. Speed change from 3½ to 1½ i.p.s. is accomplished by a switched resistor change in the bias circuit.

Sanyo now have thirteen cassette recorder models available ranging in price from £19 15s to £99 15s—some of these have an f.m. radio too.

Along with several new tape recorders, ranging in price from £55 15s 7d to £157 14s, Grundig displayed the TK3200 three-speed battery recorder with a stick microphone priced at £178 3s. At 7½ i.p.s. the frequency response is said to be 40Hz to 16kHz and wow and flutter as 0.1%. Signal-to-noise ratio is claimed to be better than 48dB at 1½ i.p.s. Outputs are 500mV (into 15kΩ) with provision for driving an external 4Ω speaker with 2W or the internal speaker with 0.8W. This is a single channel recorder.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Mobile radio and amateur bands

I refer to the letter under the above heading which appeared in your September issue.

The second paragraph implies that some unofficial arrangement exists concerning the 70-MHz amateur band. The Electronic Engineering Association seems unaware that the amateur service has been allocated frequencies between 70 and 71 MHz since 1956. Indeed, recent issues of your journal have carried news of propagation experiments by amateurs using these frequencies. It is implicit by the terms of the Radio Regulations that where the amateur service is the secondary user then this is subject to non-interference with the primary service.

The last sentence of the third paragraph of your correspondent's letter shows a lack of knowledge of the occupancy of the 420-450 MHz band. There are, of course, a number of amateur television stations using frequencies in this band, but, in addition, there are a far greater number of stations occupying the band for experimental work in connection with moonbounce, meteor scatter and satellite communication. Stations operating under the terms of the Amateur (Sound) Licence B are present in large numbers on both the 2-m and 70-cm bands.

The final sentence of the E.E.A. letter mentions "amateur associations". I would point out that the Radio Society of Great Britain is the organization recognized by the Ministry of Posts and Telecommunications as representing the stations of the amateur service in the United Kingdom.

There are regular discussions between the Ministry and the R.S.G.B. concerning licensing matters and frequency allocations and we have no doubt that at the correct time the Society will be approached by the licensing authority.

J. A. SAXTON,
President,
Radio Society of Great Britain.

Crisis in microelectronics

Your September editorial draws attention to the difficulties of the integrated circuit industry, but the conclusion one should draw depends rather on one's standpoint. The

U.S. microelectronics industry obviously has excess production capacity for the foreseeable future, and the present marketing situation cannot be changed rapidly. Dr. F. E. Jones cites import duties as a reason for British companies not manufacturing in the Far East. From a quick enquiry I get the impression that duty on radio components entering Britain is at most 17% which is not decisive in comparison with price differentials quoted in your Editorial, and nil from Commonwealth territories. So why not use Hong Kong? In addition, I feel that more could be done to establish the facts about American manufacturing costs and selling prices, unless it is the desire of the British i.c. industry to befoe the issue. If American i.c.s which are packaged in the Far East are taken back into America on conditions which assume that the major part of the manufacture has taken place in America, then surely there is no doubt about the country of origin. But even if there is doubt about the country of origin in the manufacturing sense, it must be possible to establish the country in which the manufacturing company has its registered office. Before we worry too much about the difficulty of ascertaining the true country of origin, let us know at least the selling price in U.S.A.

If there is still a possibility of Britain joining the Common Market there might be a case for a European production facility. So far as concerns Britain as an isolated unit, however, the sensible thing might be to cut one's losses and abandon the whole of the British microelectronics industry as now understood. This sounds a rather staggering proposition, but surely the financial loss to be cut would be no greater than losses which have been cut on unsuccessful military development projects. When I say "the industry as now understood" I mean an industry producing logic units and simple linear amplifiers. These are the type of thing which can be bought cheaply from U.S.A., and so far as military strategy is concerned there could well be either a factory operating under licence or an assembly and encapsulation plant in Britain. But I doubt however whether this is a serious concern: one plane load of integrated circuits could be enough to last for some time—longer than a nuclear war!

On the other hand, I think that large scale integration should be pursued in this coun-

try because by their nature large-scale-integrated-circuit chips are usually tailor-made for a particular purpose. It is no novelty for an industry to cut down on the manufacture of a basic product in order to progress to more advanced products.

Another point is that we must not be mesmerized by the idea of integrated circuits using present techniques, which are essentially collections of junction semiconductor devices. There may be a big future for solid state devices which do not depend on junctions, and Britain might have the chance to take the lead in this field. The Gunn effect has already been put to extensive use. The DOFIC appears to have faded into obscurity after a brief appearance, but perhaps there may yet be possibilities of developing it further. There is also the acousto-electric amplifier based on the interaction of electrons and phonons in materials such as cadmium sulphide. These may well play a large part in the future of electronics and should not be overlooked in a moment of panic about the marketing of devices which although scientific marvels to the layman can now be manufactured as a matter of routine.

D. A. BELL,
The University of Hull.

Class AB amplifiers

I am grateful to Mr. Mitchell for his letter in the September issue concerning my class AB amplifier, but there are some points which he makes which, I feel, should not pass without challenge.

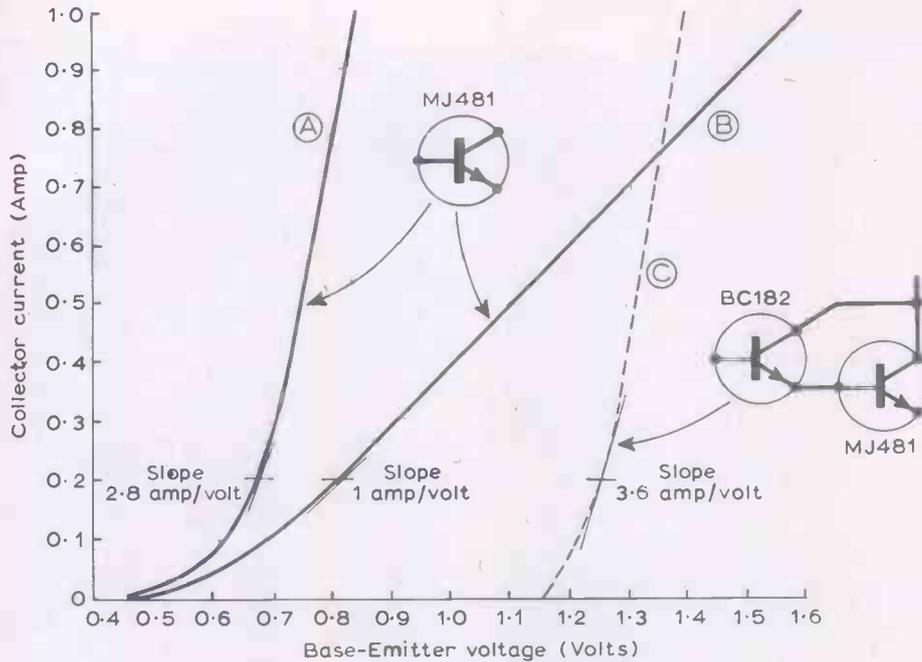
In particular he states that a Darlington pair output stage has a lower mutual conductance than the output transistor on its own. While, in theory, this could follow from the fact that the second transistor imposes an impedance in the emitter circuit of the first, this situation does not arise under any but near zero source impedance systems, as I have illustrated in the transfer characteristic graphs on the next page.

Curve A is the transfer characteristic of a simple (MJ481) transistor with a source (base input circuit) resistance of 10 ohms. Curve B shows the performance of the arrangement but with a source resistance of 100 ohms. Curve C is that of the same output transistor, but with an input Darlington configuration using a BC182 input transistor. There is no measurable difference in performance, in this configuration, with source resistances of 10, 100 or 1,000 ohms.

In the event, the slope of the Darlington pair, at 200 mA, which was my chosen quiescent current, is 3.6 amps/volt as compared with 2.8 amps/volt for the simple output transistor.

The presence of as little as 100 ohms input circuit resistance reduces this to 1 A/V, which confirms the point I made in my article, which was concerned, implicitly, with the circumstances which would exist in a practical design.

The second point on which I differ from Mr. Mitchell concerns the conditions of operation of a class A stage. I believe this classification should be restricted to systems in which each component of the output stage operates in its linear region over the



whole of its effective output swing. The mere fact that one or other of the output transistors is not completely cut off is not enough to satisfy this requirement.

Although I had not mentioned this point specifically in the article, the use of the amplifier in true class A does bring about a reduction in the distortion typically to below some 0.01%, at power levels below 15 watts, over the frequency range 100 Hz-5kHz, and the distortion content then decreases linearly with reduction in output signal magnitude.

My decision, in the design of the amplifier, to employ a variable resistor, as a source of bias, between the bases of the output transistors, rather than a more complex temperature compensation network was based partly on the convenience of adjustment of such a biasing system, as compared with, say, a string of diodes (two forward biased silicon diodes will, in fact, give almost the correct quiescent current, and this arrangement was used in some of the prototypes in use by friends) and partly on its lesser proneness to catastrophic failure than transistor "amplified diode" systems.

My curve B indicates the relative insensitivity of the single transistor output stage to variations in forward bias (and the choice of 200 mA quiescent current very much reduces thermal effects, even with an 8-ohm load!) as well as the excellent transfer linearity of such a system which contributes to the lower harmonic distortion figures obtainable with such an output stage in comparison with the more normal push-pull configurations.

Both Mr. Mitchell and Mr. Gibbs (letters, Aug. 1970) have taken me to task for my observation in the article that "the use of a complementary pair of emitter followers 'driven from a low source impedance' appeared to offer the best way of minimizing the several problems" described in the introduction.

The article in question was in fact written as one, rather lengthy, article which was divided in two for convenience

of publication, and this division, coupled with some editorial deletions, resulted in the observation above being given an unexpected degree of prominence. Since I was, at this stage, reviewing the thought processes which had led to the choice of this output stage configuration, it would have been better if I had continued "and this type of stage was therefore chosen as the starting point for this design".

In the event, both the preliminary calculations and the initial experiments indicated that it was neither practicable nor desirable, from the point of view of linearity of operation, that the output stage should have a low source impedance and the solution suggested by Mr. Mitchell in his letter, that of a relatively high driver impedance with a low inter-base impedance, was the configuration which had been adopted in the final design.

In reply to the letter from Messrs Smith and Walker in the September issue I would point out that the total harmonic distortion was quoted at 1000 Hz, because this is the recommendation of the B.S. and DIN specifications. The t.h.d. figures, at full output, at 100Hz and 10kHz, are typically 0.04% and 0.06% respectively. At low frequencies the harmonic distortion is mainly influenced by the impedances of the power supply bypass capacitor and the decoupling and 'bootstrap' capacitors, and an improvement can be made, if necessary, by increasing the value of these.

At high frequencies, the distortion content is mainly determined by the deliberate and necessary reduction in the open-loop gain, and feedback factor, required to maintain good reactive load stability, although the circuit layout and stray capacitances have some effect.

I apologise for the omission of the bandwidth limits for the noise figure measurements. These were effectively those imposed by the amplifier gain/frequency characteristics, as would be measured by a very wide bandwidth millivoltmeter. The use of a more restricted bandwidth, say 20Hz-20kHz, would allow an apparent

improvement in the specified noise figure. (It is, in fact, quite inaudible.) However, on looking through back numbers of *Wireless World* I find that other authors have been equally remiss in omitting measurement bandwidths when quoting noise levels. This point will, perhaps, be noted in the future.

I regret that the measurement parameter "square wave transfer distortion" was not accompanied by some further explanation. In practise, transfer distortion is measured by comparing electrically the waveforms at the input and output of the system under test, and then expressing the error arising in the transfer as a percentage of the input waveform, as measured on an r.m.s. calibrated voltmeter such as that used for conventional t.h.d. measurements. Any convenient waveform may be used for this purpose.

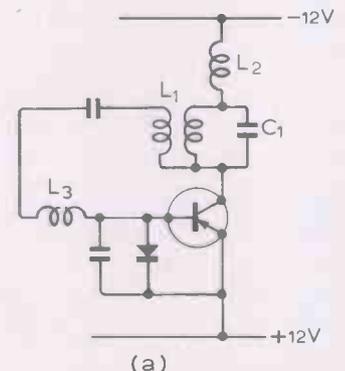
Typical values for transfer distortion with conventional audio amplifier designs using a 10kHz square wave and a resistive load range from 0.2% to 10%. Square-wave transfer errors as high as 30% are fairly common under reactive load conditions, and this, in conjunction with the relatively high distortion levels sometimes found at low volume levels, may account for much of the so-called 'transistor sound'. Unlike harmonic distortion, transfer distortion with reactive loads may worsen as the amount of negative feedback is increased.

J. L. LINSLEY HOOD,
Taunton,
Somerset.

Sine-wave power oscillator

The basic requirements for any circuit are that it should be comprehensible, designable and as simple as possible. The old rule, simplify and add lightness, still applies. Mr. Armer's circuit (August p.402) and his explanation, do not seem to satisfy this.

It is rather easier to examine this circuit if the earth point is moved: indeed it is probably easier to use it if a second variation is adopted. Fig. A shows the circuit rearrang-

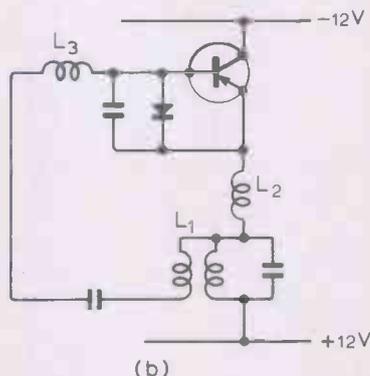


ed for conventional analysis, and Fig. B shows it with the collector of the transistor at an a.c. earth. In both circuits the tuning capacitor has been transferred to be in parallel with only the larger part-winding, simply to make the circuit look conventional.

Before discussing how it works, let us look at the numbers. L_1 is tapped to give

400 μ H in the one part, 200 μ H in the other. The total inductance is thus $200 \times (1 + \sqrt{2})^2 \mu$ H, or 1.16mH. This tunes with $C_1 = 0.05 \mu$ F to 21kHz. It would seem that the frequency is not determined, as Mr. Armer suggests, by L_1 and L_2 in parallel. They are, in fact, in series, to give the reactance plot shown in Fig. C.

The feedback path when neither the diode nor the base emitter junction are conducting very much is a low-pass half-section with a cut-off frequency of below 1kHz and an impedance of about 75 Ω . When either diode is conducting it reduces to an induc-

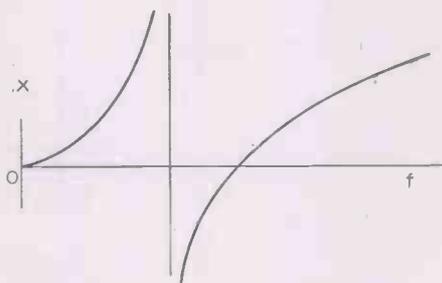


(b)

tance of about 180 Ω , to give a 90° phase shift.

The load for 13W must be in the region of 10 Ω . The reactance of C_1 is about 160 Ω , so that the Q of the circuit is very small indeed. Furthermore the value of $I_{dc}(L)^{\dagger}$ for the 400 μ H section would seem to require a ferrite core of some 30cm³ volume.

In a push-pull circuit L_2 would be identified as a constant current supply choke. Here its value is just low enough to avoid really awkward high voltages as the transistor is cut off, provided that the cut-off is



(c)

slow, and thus lossy. What Mr. Armer means by the statement that the base current controls the collector current while the transistor is saturated I cannot understand. The only way this can be done is by limiting emitter current and drawing much of it off into the base. But 2A base current?

Mr. Unsworth ("1000:1 Attenuator"—same page), in offering us an output of 0.768V, appears to neglect the fact that the 8 should be significant. He obtains his 0.7-0.8V across an R which is loaded by roughly 100 Ω . Thus if we look at the first step, nominally 0-0.1 we shall have, in fact, 0-0.099. Moreover, V_{out} must be loaded by something like 5000 Ω —I have not worked it out—if the system is to be plausible.

T. RODDAM,
London.

R.S.G.B. Exhibition

Where have all the experimenters gone?

Seduced by sales talk every one!

Not so long ago under the heading of "Components, Complaints and Complacency" we urged manufacturers to turn a sympathetic ear to the component needs of the home constructor. It would seem, however, that as far as the amateur radio enthusiast is concerned we should not have wasted the ink and the paper. There were only seven entries from the whole amateur radio fraternity for the home constructed equipment competition held at the recent R.S.G.B. Exhibition. A lamentable turnout.

Is it true that the ham of today does no more than gossip on the air while twiddling the spun aluminium knobs and peering at the gleaming Perspex dials of a shiny piece of commercially constructed equipment? If so the frequency bands allocated to amateurs are being wasted and should be re-allocated to a more deserving cause.

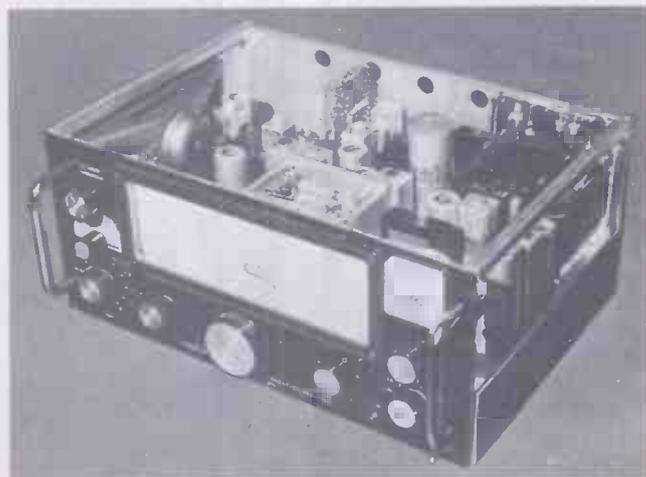
Today's home constructor has never had it so good. He can obtain at reasonable prices sophisticated components which were not even available to industry a few years ago. Is it that today's amateur does not want to risk his money on experiment? Or are the days of trial and error design over?

The winner of the Horace Freeman award for home constructed equipment this year was George Goldsmith, from Jersey, with a finely engineered communications receiver for the amateur bands. It employed both valves and semiconductors and incorporated three crystal filters. Sensitivity was 0.4 μ V for a 10dB signal-to-noise ratio. Other prizewinners were M. F. Taylor, of

Reading, with a 2-m transceiver and J. R. Jessop, of Pinner, with a linear amplifier. This year the John Rouse Trophy was not awarded as there was not a single entry from the under-16 age group, a necessary qualification for this award.

The exhibition itself is still affectionately known as the R.S.G.B. Exhibition, rather than by its somewhat pretentious title (International Radio Engineering and Communications Exhibition). This year it sprouted the additional title Radiocom 70 as well. Attendance was just over 7000; about 800 less than last year. This may have been due to the show being held in August instead of later in the year as in the past. We do not question the value of the exhibition which, as a meeting place for the electronics-radio fraternity, is almost second to none. It is patronized by all types of people from home constructors and amateurs to engineers and academics. It is a pity that working equipment demonstrations were so thin on the ground this year. There were many bargains in surplus equipment to be found even though one exhibitor admitted that the exhibition gave an opportunity to get rid of a "pile of junk".

The Ministry of Posts and Telecommunications had a display which illustrated how interference can spread in large urban areas and the problems incurred in tracing, measuring and suppressing it. This year the Radio and Space Research Station had a stand which showed the work they are doing in the field of propagation of radio waves over a very wide band of frequencies.



The communications receiver built by George Goldsmith which this year won the Horace Freeman Trophy. It has a hybrid circuit and operates on the amateur bands.

News of the Month

Ceramic stores for information displays

Some interesting work currently being carried out at Bell Labs in America has resulted in a sort of re-usable slide for projection purposes. Images stored on the slide can be erased and replaced with a new image at will. At the present stage of development the device, or 'ferpic' as Bell Labs call it, would only be suitable for use in displays of written text and figures which do not require to be quickly altered. Not a great deal of information has been released but it does not take a great deal of thought to see that if the speed can be increased and if the devices can be manufactured at reasonable cost the ferpic could have a bright future.

The material used in the construction of the ferpics was first announced by an American concern called the Sandia Corporation. The device is a sandwich. A very thin plate of fine-grained ferroelectric ceramic is coated with a photoconductive film which in turn has a system of transparent electrodes deposited on it. The whole is then bonded to a flexible transparent substrate.

The release from America which describes the operation of the device is

rather sketchy and it is not clear exactly how the device works. Quoting directly from the American statement; "To change the stored information in this simple structure, a new technique, called 'strain-biasing' was developed by Bell Lab scientists. The ferpic sandwich is flexed so as to stretch or strain the material.

"In an ordinary film slide an image is stored in the form of variations of transparency across the film. In a ferpic the image is stored as a variation of the 'Birefringence' of the ceramic plate, i.e., as a variation in the way the plate transmits polarized light.

"In one mode of operation, a scanned laser beam records an image on the photoconductive film—one picture element at a time as in a TV picture. A voltage applied to the transparent electrodes develops a field across the ceramic. When the field is removed, the image remains stored on the ceramic plate. The image stored in the ferpic device can be viewed by putting light polarizing sheets over it, or the image can be projected on a screen using polarized light in a conventional projection system.

"To erase the image, the entire structure is flooded with light in the presence of a

reversed electric field; the plate is then ready to store another image."

Bell Labs is exploring this device in the hope of obtaining efficient, low-cost solid-state information displays with features that are difficult to obtain in present display systems. Because the image store in the ferpic device can be projected, very large displays can be obtained. Also ferpic slides can retain images for a long time without electrical power, fading only slowly.

Slant polarization for local radio

Certain B.B.C. local radio stations will be using slant (45°) polarization instead of horizontal polarization. This follows successful tests by B.B.C. research department engineers in Kingswood and Nottingham areas†. Reception in cars and in the open air with vertical aerials will be improved through the effective increase in transmitter power equivalent to about 6—9dB, at least doubling signal strength on average. Hitherto, satisfactory reception with vertical aerials has been largely a matter of luck. As a consequence, horizontal roof aerials will give a reduced signal—about 70% or -3dB. If necessary, this could be recovered by slanting the aerial (clockwise by 45° when looking at the transmitter) but the national v.h.f. services, not using slant polarization, would suffer a loss.

Stations using slant polarization are: Manchester—95.1MHz; and early in 1971 Blackburn—96.4MHz; Derby—96.5MHz; Leicester—95.05—95.2MHz and Nottingham—94.8MHz.

B.B.C. make the point that some roof-level aerials may not be correctly oriented for the local station and some adjustment may be needed for best results.

Mullard's golden jubilee

As part of their Golden Jubilee celebrations Mullard Ltd. are to stage a 3-week public exhibition in the Electronics Centre of their London headquarters, Mullard House, Torrington Place, London, WC1E 7HD.

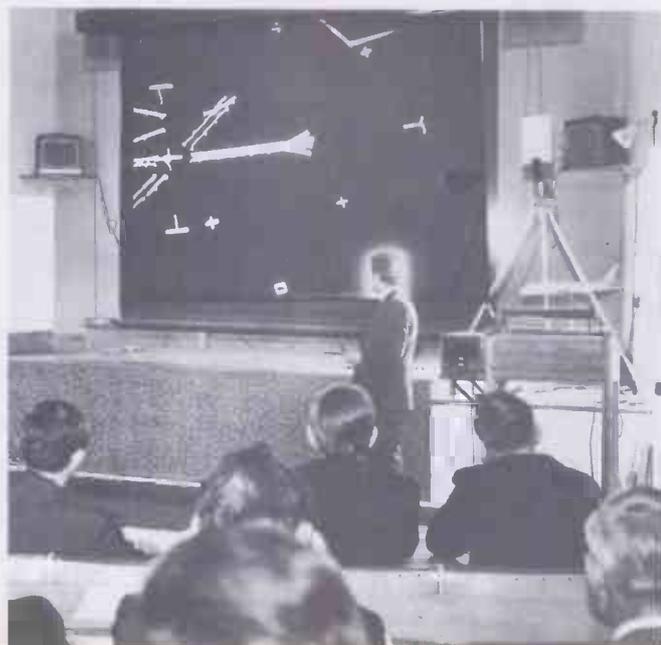
The exhibition will trace the history of electronics—linked with the company's own history—over the past 50 years.

The exhibition opens on October 5th, and will run until October 24th, opening every day (except Sundays) between 10.00 and 18.00 (21.00 on Thursdays). Admission will be free. Later, the exhibition, probably in a modified form, will tour Mullard establishments throughout the country.

The main window of the Electronics Centre will contain examples of vintage electronic equipment contrasted with their modern counterparts and supported by displays of Mullard components used in their manufacture.

Within the Centre one of the main attractions will be a radio transmitter built and operated by Mullard 'hams'. Some of the company's earliest valves will be used

†Spencer, J. G. Tests of mixed polarization for v.h.f. sound broadcasting. *B.B.C. Engineering*, July 1970, pp.4-12.



Representatives of the Services, Ministry of Defence and industry watching a demonstration of the Eidophor large-screen display system at the College of Air Traffic Control, Hurn Airport. This equipment was used by N.A.S.A. during Apollo 11 and 12 missions, and its pictures were re-transmitted by practically every TV network throughout the world.

in its construction. It is also hoped to show part of the original 2LO transmitter used by the B.B.C. for its first public broadcasts.

Another main feature will be entitled 'Mullard Through the Decades': This will show electronic products and their components of each era, beginning with the first Mullard high-power transmitting valve. Displays in the 'Today' section will feature many working exhibits including a microwave oven. Another section will provide a glimpse of some of the likely future applications of electronics. The exhibition will also include a section where visitors can test their skill and reflexes in various electronic games.

I.T.A. completes 405-line network

The coming into service of a local v.h.f. relay station at Newhaven, Sussex, on August 3rd marked the completion of the I.T.A. network of 405-line v.h.f. television transmitting stations. No further additions to this network, which operates solely in Band III, are currently envisaged. All I.T.A. station building plans are now concentrated on the rapid expansion of the new 625-line network of u.h.f. transmitters.

Since the original opening of the first I.T.A. Band III station at Croydon,

south-east London, on September 22nd, 1955, the 405-line network has expanded steadily and now comprises 47 transmitting stations, of which 20 are manned, and 27 remotely controlled. The network provides television coverage for approximately 98.7% of the population of the United Kingdom.

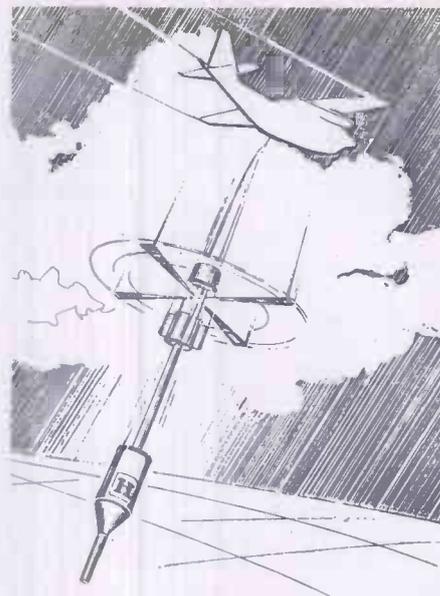
Want to use a satellite?

The National Aeronautics and Space Administration is offering the use of six satellites which have long since fulfilled their original task but are still operational.

The six spacecraft are: OGO-1 (Orbiting Geophysical Observatory), ten experiments still operational, highly elliptical orbit 111,000 by 39,000 miles, inclination 58°; OGO-3 similar orbit to above, 13 experiments operational; Explorer-31 (direct measurements explorer) with five operational experiments and Explorer-33 (Interplanetary monitoring probe) orbit 410,600 by 109,000 miles, orbit period 32 days; finally the orbiting solar observatory satellites OSO-3 and OSO-4 are also available.

Interested scientific bodies should contact Code SG N.A.S.A. Washington D.C. 20546.

As a matter of interest the oldest satellite still transmitting useful information is the Canadian Alouette-1 which was launched on September 29th 1962.



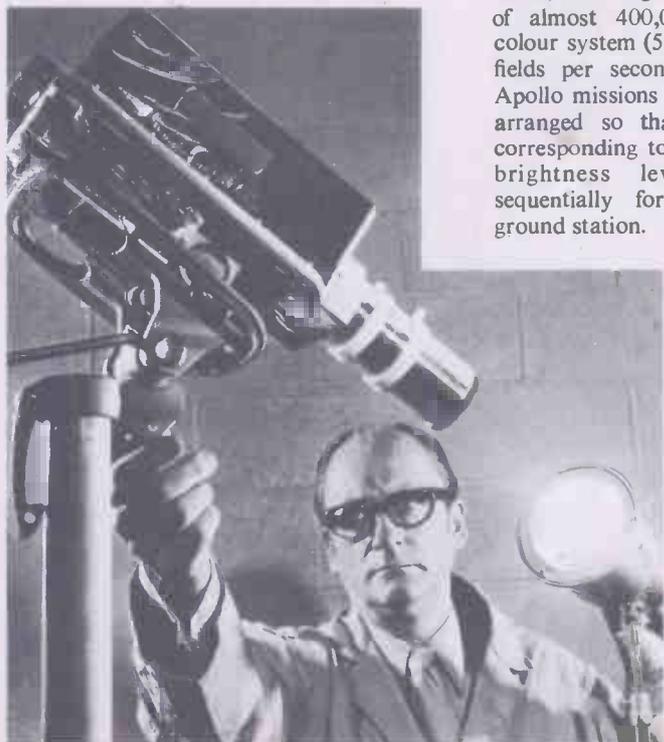
The sketch shows a device called EROWS (Expendable Remote Operating Weather Station). The eight-foot arrow-like structure implants itself in the ground after being dropped from an aircraft. The device is turned on remotely and it begins to transmit information on wind speed and direction, atmospheric pressure, temperature, humidity, precipitation and cloud cover. EROWS is being developed by Honeywell for the U.S. Air Force.

Apollo colour TV camera

Under a \$196,500 contract R.C.A. will deliver two colour television cameras to the National Aeronautics and Space Administration which can be used under

the extreme lighting conditions found on the moon. The cameras, which weigh ten pounds each, not only operate in dim lighting conditions but they can be pointed directly at the sun without sustaining any damage!

The cameras employ silicon intensifier tubes, the imaging surface being made up of almost 400,000 silicon diodes. The colour system (525 lines per frame and 60 fields per second) is as used in earlier Apollo missions with a colour filter wheel arranged so that monochrome pictures corresponding to the red, blue and green brightness levels are transmitted sequentially for recombination at the ground station.



A lamp, which simulates the brightness level of the sun, being pointed directly into the lens of the new Apollo TV camera.

European component standardization

A 'Harmonized System for Electronic Components' is being introduced in Western Europe in which a set of common specifications and quality assurances will remove all technical barriers to inter-country trading. The system is similar to, and fully compatible with, our own BS 9000.

Agreement has already been reached on all the major aspects of the Harmonized System and at the invitation of the Tripartite Committee for Standardization, the Comité Européen de Coordination des Normes Electrotechniques (CENEL), which comprises all E.F.T.A. and E.E.C. countries, has accepted overall responsibility for launching the system in these countries.

The responsibility for the quality assurance aspects of the Harmonized System is to be handled by an independent committee known as the Electronic Components Quality Assurance Committee (ECQAC). It is hoped that the system can be introduced on a world-wide basis later.

Radar base at Lahr

On August 18th Marconi handed over a radar base to Brigadier General R. E. Mooney who was acting on behalf of the No. 1 Canadian Air Group. The

station, at Lahr in West Germany, is situated on a rather difficult site being ringed with mountainous country and suffering a high annual rainfall. The base will provide air traffic control terminal services for the Canadian bases at Lahr and Soellingen. In emergency the base will provide the German airfield at Bremgarten with assistance. Air traffic problems in the area are complicated by the civil airports at Strasbourg and Basle which are not very far away.

The radar installation, which cost £425,000, consists of a type S654 surveillance radar together with a temporary aerial which will be replaced by a dual beam aerial next year, a secondary radar system and a central operations control room. Under the contract the Canadian Marconi Company, acting as sub-contractors, modified the existing precision approach radar for remote operation from the central control room.

Announcements

"Compendium of Degree Courses 1970", providing information about more than 279 sandwich, full-time and part-time courses, is available from the Council for National Academic Awards, 3 Devonshire Street, London W1N 2BA.

The following courses are to be held at Hendon College of Technology, London N.W.4. "Thyristor applications", six lectures commencing 15th October; "Electronics for non-electrical engineers", fourteen lectures commencing 13th October; "Construction and operation of digital computers", sixteen lectures commencing 15th October. Fees are £3, £6 and £8 respectively.

Two-day and three-day colour television training courses are being conducted at the Thames Hotel, Bridge Street, East Molesey, Surrey, by Electronic & Colour Television Training Ltd, of 180 St. Johns Road, Woking, Surrey. Fees 15gn and 20gn.

Coincident with next year's Electronic Components Show at Olympia (May 18-21) an Electronic Components Conference is to be held at the Royal Garden Hotel, Kensington, under the auspices of the Electronic Components Board.

Truvox Ltd, which became part of the Racal group with the acquisition of Controls & Communications Ltd, has ceased manufacture and their range of audio products will not be available in future. The service department will continue to operate from Hythe, Southampton, providing an advisory service, repairs and a supply of spare parts.

Philips and Brown Boveri.—An agreement has been reached between Philips' Telecommunicatie Industrie, of Hilversum, Holland, and Brown, Boveri & Company Ltd, of Baden, Switzerland, by which the two companies will co-operate in the manufacture and development of sound broadcast transmitters.

REMO is the brand name of a new company, Rectifier Modules International Ltd, of Remo House, Rye Street, Bishops Stortford, Herts. The range of products will begin with three basic types: e.h.t. rectifiers and modules, encapsulated rectifiers and rectifiers to meet British Post Office specifications.

Mobile Radio Communication

Congestion of bands: Proposals for improving the service

The number of private mobile radio licences in the U.K. which at present stands at about 85,000, is likely to double every five years according to figures given at a recent conference on mobile communications arranged by the Society of Electronic & Radio Technicians. Sectors of the frequency spectrum allocated to this mode of communication are already saturated and equipment manufacturers and users are desperately seeking means whereby they can increase the number of available channels.

Speaking before 130 delegates at the conference at Brunel University, Uxbridge, J. R. Brinkley, of S.T.C. suggested that one way out of the dilemma would be to extend the present u.h.f. mobile band (450-470 MHz) to 420-512 MHz. This would entail, at the top end of the extended band, sharing television channel 21 in Band IV. Channel 21 has been assigned to 15 B.B.C. TV transmitters including three high-power stations at Rowridge (I.o.W.) Divis (N. Ireland) and Sandy Heath. D. B. Balchin, from the Ministry of Posts and Telecommunications, pointed out that the TV band was fixed by international agreement. There would be great difficulty in sharing this band with mobile radio. Undeterred Mr. Brinkley asserted that frequency sharing with TV broadcasts had been successfully introduced in America in three densely populated areas. The situation in the U.S.A. is somewhat different to the U.K. in that densely populated areas in the U.S. are more widespread than in this country. These areas are each served by a large number of relatively low-power transmitters. Therefore there would be little likelihood of interference from a mobile operator sharing the frequency of a TV station located several hundreds of miles away, but unused in his own area. In the U.K. on the other hand, an attempt is made to saturate the whole island with television signals, with most of the area covered by 8 high-power transmitters.

Users as a whole, however, cannot be unaware that v.h.f. television Bands I and III may be phased out of use for the existing programmes and the two broadcasting organizations are expected to present a convincing case for retention of the v.h.f. bands for broadcasting before their charters come up for renewal in 1976. Otherwise industry will have its sights firmly fixed on this substantial sector of the frequency spectrum. The threat by mobile radio to amateur frequencies was pointed out in "World of

Amateur Radio", in the July issue.

The conference posed the question, whose need is greater, mobile radio or television? This is a choice which may not necessarily have to be made because several delegates spoke of new technologies, or the updating of old ones, which can provide a greater number of effective communicating channels within the existing frequency allocation. There is, for example, the possibility of reducing the u.h.f. channel spacing (currently 25kHz) to 12.5kHz. This would virtually double the number of available channels but an increase in noise would result from a reduction in deviation ratio.

Frequency modulation is in general used on u.h.f. but systems might be improved by changes in the modulation characteristic. E. W. Crompton of the Home Office (police and fire services) described work his department was currently carrying out on double sideband diminished carrier amplitude modulation (d.s.b.d.c.) which has the desirable feature of concentrating most of the transmitted energy in the sidebands and not in the carrier as with conventional a.m. and f.m. A more complex detector than the simple diode demodulator would be required¹ but the post detector circuits could be relatively simpler than in the conventional receiver. Delegates were played a tape recording of speech from the output of a d.s.b.d.c. receiver with a 1μV signal input. Noise was virtually absent but the intelligibility of the speech left much to be desired. Mr. Crompton postulated that more than one information channel could be accommodated in a single transmission by quadrature modulation of a subcarrier, in the same way that colour TV systems carry chrominance information, and the use of synchronous detection.

A system was described for dialling from a vehicle into a private telephone exchange and another for using the mobile radio as a data link. This latter can provide information on the location of up to 1000 vehicles by a hyperbolic system employing four fixed stations disposed round the vehicle movement area. By measuring the phase shift of a 2.7kHz audio tone and collecting 600-2700-band data in a small computer at the base terminal, the system is capable of giving the positions of up to 2000 vehicles per minute.

¹ Macario, R.C.V. "How Important is Detection?" *Wireless World*, April 1968.

Electronic Building Bricks

5. The electronic circuit

by James Franklin

In order to transmit and process information, say in a television set or a computer, we must provide means for moving the electrons which we are using to represent the information. In Part 3 we looked at the general nature of this movement—conduction. The medium most widely used for electron conduction is one in which the process can take place most freely—a metal—and which is also reasonably cheap, which means copper. A path for electron conduction is called a *circuit*, and the simplest form of electronic circuit is a continuous loop of wire as shown at Fig. 1. Almost all “electronic building bricks” are elaborations of this.

To cause the free electrons in a conducting path such as Fig. 1 to move,



Fig. 1. Basic electronic circuit, a continuous loop of wire or other conduction path for electrons.

one must apply a force to them. Two forces which will act on electrons are the electric field (e.g. the region of “attraction” surrounding a plastic comb which has been rubbed to make it pick up pieces of paper) and the magnetic field (e.g. the region of “attraction” surrounding a magnet). For circuits we use principally the electric field. In practice this field is produced by the rotating generator (to which we make connection through the electricity mains) and the dry battery. These, of course, are both devices for converting some other form of energy—mechanical in the generator, chemical in the battery—into electrical energy. Because the electric field they produce is a force used for moving electrons it is known in the context of circuits as an electro-motive force (e.m.f.). A strong electro-motive force will move more electrons in a given time than a weak electro-motive force.

The unit by which this force is measured is the volt* Thus in a given

circuit, 2 volts will move twice as many electrons in a given time (cause twice the current to flow) as 1 volt. There is a very precise scientific definition of the volt, but most people know from experience the relative strengths of different “voltages” by what can be “driven” by them— $4\frac{1}{2}$ volts from a torch battery, 9 volts from a transistor radio battery, 12 volts from a car battery, 240 volts from the electricity supply mains—and these give some practical idea of the e.m.f. presented by the volt. (Anything above about 50 volts will give you a nasty jolt!)

Fig. 2(a) shows how a source of e.m.f. is inserted into the Fig. 1 circuit to cause the free electrons in the metal to move. The insertion of the e.m.f. source breaks the loop of wire, but the electrons flow through the source, as indicated by the dotted lines. We may also insert some electronic component or device in the circuit, as indicated. The flow-rate of electrons (current) in the whole loop containing the e.m.f. source and the component can be measured by inserting a meter as shown at (b)—and, of course, to allow the current to continue to flow this meter must not break the circuit. Such a meter for measuring current will be calibrated in amperes (Part 3) or, for small currents, milliamperes (thousandths of an ampere)

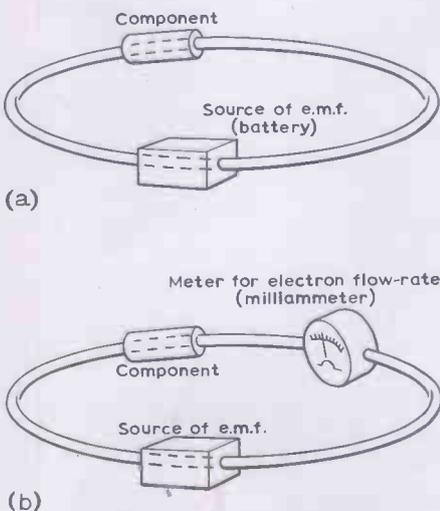


Fig. 2. The Fig. 1 loop with (a) a source of electro-motive force and an electronic component inserted; and with (b) a meter included to measure current.

or microamperes (millionths of an ampere).

As will be seen from other articles in *Wireless World*, circuits are normally drawn in a simplified form by the use of symbols. To draw the physical form of the wires and components, as was done in the early days of radio, would be extremely laborious for the more complex circuits, and in any case is unnecessary, except sometimes as an aid to the construction of equipment. All the essential information about the *functioning* of electronic circuits and systems—and this is what we are really interested in—can be given in the simplified, generalized form known as a theoretical circuit diagram (or just “circuit diagram”). Thus the simplified form of Fig. 2(b) is shown at Fig. 3. It will be seen

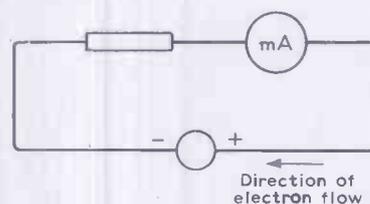


Fig. 3. Theoretical circuit diagram, using graphical symbols, representing the actual circuit shown in Fig. 2(b). (The rectangle symbolizes a particular type of component, to be explained later.)



Fig. 4. Graphical symbol for a source of electro-motive force giving an alternating current (a.c.).

that this takes no account of the physical size or shape of the wire, the source of e.m.f. or the meter. We have a generalized representation that could mean any type of conductor (e.g. areas of metal film), any type of e.m.f. source (battery, rotating generator, thermo-electric device, electrostatic machine) and any shape or size of meter. Thus with the removal of non-essentials, our attention is concentrated on the functional aspect.

It will be seen that diagram Fig. 3 contains some extra information, the + and - signs on the e.m.f. source. Without going into the full meaning of electrical “positive” and “negative”, it is sufficient to say at this point that these signs on this particular source indicate (a) the direction in which the electrons are made to move round the loop by the e.m.f. and (b) the fact that this direction is always the same. A source of e.m.f. producing such a uni-directional current is called a direct-current (d.c.) source—a practical example is a battery—and the positive side of this source is identified as that towards which the electrons travel.

Another type of e.m.f. source used in electronics causes the electrons to flow alternately in opposite directions. This type of flow is called alternating current (a.c.), and the theoretical circuit symbol used to represent an a.c. source—which might be a power-station generator or a laboratory testing instrument (oscillator)—is shown in Fig. 4.

* Named after Alessandro Volta, (1745-1827), Italian physicist and inventor of the electric battery, which was originally known as a Voltaic pile

Personalities

Professor A. L. Cullen, O.B.E., Ph.D., D.Sc. (Eng.), Pender professor of electrical engineering, University College, London, is to receive from the Paul Instrument Fund Committee the sum of £10,717 over three years for the construction of a wideband microwave impedance bridge of high accuracy, using a new and very precise absolute impedance standard. Professor Cullen, who graduated at Imperial College, London, in 1940 and was for six years at R.A.E. Farnborough, occupied the chair of electrical engineering at Sheffield University from 1955 until his appointment to University College in 1966.

George Millington, M.A., B.Sc., F.I.E.E., who recently retired from the Marconi Company, has been appointed consultant to the Directorate of Radio Technology of the Ministry of Posts and Telecommunications. Mr. Millington is well known for his studies of radio-wave-propagation phenomena and was at one time international vice-chairman of the C.C.I.R. study group investigating the problems of ground-wave propagation. A graduate of Clare College, Cambridge, he joined Marconi's in 1931 and headed the company's propagation section for many years.

W. F. Hawes has been appointed general manager for marketing by Pye Telecommunications Ltd. Mr. Hawes, who is 49, was formerly overseas marketing manager and succeeds **J. C. Turnbull** who has become managing director of the recently formed Pye Business Communications Ltd.

Alec Kravis, O.B.E., who is 51, has been appointed sales manager of the Radio Communications Division of Marconi Communication Systems Ltd. He has been with the Marconi Company since 1950 and was at one time project co-ordinator in Research Division for advanced communication and radar projects. In 1964 he was appointed project co-ordinator for space communication studies, and when Marconi

won the contract for the first British military satellite communication stations Mr. Kravis was made project manager. After the completion of this project he became manager of administration and technical services in the Research Division, and since 1967 has been in the Computer Division, as deputy manager.

Donald W. Morrison, B.A., who joined the Sprague organization earlier this year as special assistant to G. V. Tremblay the president of Sprague World Trade Corp., has been appointed managing director of Sprague Electric (U.K.) Ltd, of Yiewsley, Middx. From 1960 to 1967 Mr. Morrison was director of marketing and general manager for the Far East of A.M.F. International after which he spent two years as regional manager for Europe with the American Air Filter Co.

Alan Hall has joined Marconi Communication Systems Ltd as sales manager of the Specialized Components Division at Billericay, Essex. After studying at Sheffield University Mr. Hall, who is 45, served in the Royal Signals from 1945 to 1948. He worked as a sales engineer with Solartron Electronic Group and with Muirhead, then as assistant to the technical manager in the Electronic Component Division of Johnson Matthey at Burslem, and latterly as sales manager for Oxley



Alan Hall

Developments Co. Ltd, of Ulverston, Lancs, Mr. Hall is an amateur radio transmitter using the call G3UWA.

The appointment of **John S. Walker** as managing director is announced by Cosmocord Ltd, of Waltham Cross, Herts, manufacturers of Acos electro-acoustic products. Mr. Walker has been associated with the electronics industry for nearly 20 years. He was until recently with De La Rue Instruments, before which he spent 10 years with Texas Instruments Ltd, where he was in turn responsible for the application laboratories and for research and development.

Ernest M. Hickin recently joined Microwave Associates Ltd where he is now responsible for co-ordinating all the technical activities of the Luton-based subsidiary of Microwave Associates Inc., of Burlington, Mass. Mr. Hickin was previously for six years with GEC-AEI Telecommunications Ltd at Coventry as chief radio engineer, Transmission Division, having earlier been responsible for transmission research at the GEC Hirst Research Centre, Wembley. He is vice-chairman of the I.E.E. South Midland Electronics & Control Section.

J. D. Rhodes, B.Sc., Ph.D., an authority on microwave selective linear-phase filters, has been appointed design consultant to the Valve & Microwave Group of Ferranti Ltd at Dundee, Scotland. Dr. Rhodes, who is 26, is a lecturer in the Department of Electrical & Electronic Engineering at Leeds University, where he graduated and obtained his doctorate. He then spent one year as a post-doctorial fellow before going to work for Microwave Development Laboratories Inc., Natick, Mass., U.S.A. There he was engaged upon general research and development into microwave techniques with the emphasis on linear-phase and elliptic function filters. During 1969, Dr. Rhodes returned to Leeds to take up his present post at the University.

J. E. Diggins, M.B.E., who joined Racal in 1963 as an electronics engineer at Bracknell, is appointed deputy managing director of Racal-BCC Ltd, the largest company in the Racal group. In 1966 he headed a team of engineers whose task was to develop a new h.f. mobile radio-telephone. The project was so successful that a separate company was formed, named Racal-Mobilcal Ltd, and production transferred to a new factory in Reading. **E. T. Harrison** is managing director of Racal-BCC Ltd, in addition to being chairman and managing director of the

Group. Following Mr Diggins appointment **G. J. Lomer** has become general manager in addition to being technical director of Racal-Mobilcal Ltd. **D. C. Elsbury**, formerly chief inspector and quality assurance manager of Racal-BCC, Bracknell, becomes production director of Racal-Mobilcal and **E. Phillips**, formerly production manager of Racal-Mobilcal becomes chief inspector and quality assurance manager of Racal-BCC Ltd.

The appointment of **J. O. M. Jenkins, M.Sc.**, as applications engineer for digital integrated circuits is announced by Siliconix Ltd, of Swansea. After graduating in electrical engineering at the University of Swansea, Mr. Jenkins, who is 30, went to the Steel Company of Wales in 1961. In 1966 he relinquished his appointment to study for his Master's degree at Cranfield Institute of Technology following which he joined Mullard, Southampton, to work on the development of integrated circuits.

James A. Scott, appointed sales manager of K. W. Electronics Ltd., Dartford, Kent, was previously assistant to the sales manager of the radio navigational aids division of Standard Telephones & Cables Ltd. After studying at Oxford Technical College Mr. Scott, who is 41, joined the Scientific Civil Service at the Atomic Energy Research Establishment at Harwell. Following transfer to the Overseas Civil Service he held executive positions in the security services radio branch and in the civil aviation department in Kenya, until the independence of that country. He held an amateur radio call sign in Kenya, and now operates in this country with the call G3CMI.

J. R. Tillman, D.Sc., Ph.D., M.I.E.E., deputy director of research at the Post Office Telecommunications Headquarters, London, has been appointed a visiting professor in the Department of Electrical and Electronic Engineering of the City University, London. Dr. Tillman joined the Post Office Research Station in 1936 and was appointed deputy director of research there in 1965.

B. A. Paine, B.Sc., is appointed managing director of Booker Bowmar Ltd and its subsidiaries Reliance Controls Ltd and Bowmar Instruments Ltd. A graduate of California State Polytechnic College, Mr. Paine, who is 37, was, until his new appointment, operations manager with Spectral Electronics Corp., of Southern California. He succeeds **L. M. Butler** who has gone to California to become president and general manager of another Bowmar company.

Television Wobbulator

3. Construction and operation

by W. T. Cocking, F.I.E.E.

The whole equipment has been built into a standard case (Olson Type 75B) with the power supply assembled on the back panel ($4\frac{1}{2}$ in \times $11\frac{1}{8}$ in). This was mounted at one end on a hinge so that it could be opened out, but this proved to be quite unnecessary and would not be done in a second model. It is mentioned merely because the hinge may be evident in some photographs.

All other parts are mounted directly or indirectly on the front panel, which is of the same size as the back panel. Connection between the two is made by an 8-way cable terminated by an 8-way connector. Another identical connector is screwed beneath the box which contains the marker oscillator and the two joined together by short lengths of No. 16 wire. The cable is long enough to enable the front unit to be withdrawn from the case and turned over, and it can then be disconnected by slacking off eight screws.

In this way good screwed connections are obtained and, by using two connectors, there is no possibility of making wrong connections on rejoining them as there would be if wires were disconnected independently.

Components are not critical and an indication is given of a supplier of certain parts which have been used in the model described. Only one component is really important—the Motorola 1N5145—and this was obtained from Celdis Ltd. (37/39 Loverock Rd., Reading, Berks, RG3 1ED). The photographs show most of the constructional details. The marker oscillator is built on a piece of plain Veroboard with a 0.1-in matrix of holes and measuring $2\frac{1}{8}$ in by $2\frac{1}{8}$ in. The variable capacitor used (Home Radio type VC20, Jackson U101/SS, 25pF) is a split stator type of 25pF each half; only one half is used. It is screwed to the Veroboard, on which the other parts are mounted in the usual way. A long 6BA screw for mounting to the box is fixed in each corner of the board and nuts are run on, not only to fix the screws to the board but so that the spacing of the underside of the board from the case can be adjusted.

The screening case for it is a metal box measuring 3 in \times 3 in \times 2 in (Home Radio Z127). This must have four holes drilled in its bottom to take the four screws from the Veroboard. A $\frac{3}{8}$ -in hole must be drilled in



General view of the wobbulator showing all the external controls

one side as a clearance hole for the capacitor shaft extension and in the same side four 6BA holes for the screws by which the box is attached to the front panel. It is mounted with spacers so that the box lies 1 in behind the panel. It is desirable to tap the holes in the side, since this saves getting nuts on to the screws in rather awkward positions. An extension shaft of insulating material is used for the capacitor with the usual metal coupler inside the screening can.

Another hole in the bottom is fitted with a grommet to take two power-supply leads and the twisted pair for the r.f. output. One connector is screwed to that side of the can which is at the bottom when it is mounted on the front panel.

The main assembly is on a piece of plain Veroboard, again with a 0.1-in matrix of holes and measuring $3\frac{1}{2}$ in \times $6\frac{1}{8}$ in. It is held to the panel by brackets. The layout is not critical but all connections within a tuned circuit should be kept short.

Printed circuits do not lend themselves at all well to development work and instead we used plain Veroboard with Cir-Kit for "wiring", for it permits easy alteration. It proved very successful, and we retained it in the final model. Cir-Kit comprises copper strip and is available in widths of $\frac{1}{16}$ in and $\frac{1}{8}$ in. It is coated on one

side with an adhesive and a paper backing to prevent it from sticking together. A piece of the required length is cut off the roll, the backing paper is peeled off and it is placed on the board in the required position and pressed firmly down. The $\frac{1}{8}$ in was used only for the earth, 17V and 70V lines, the $\frac{1}{16}$ in being used for everything else.

It works very successfully as long as there is no push or pull on it which tends to separate it from the board. A component on the top of the board, therefore, should not be spaced from the board but should rest on it and its leads should be bent over flush with the board on the under side, so that the component and its leads tend to clamp the Cir-Kit strips to the board. It is wise to let a lead cross the copper strip and project a little on the other side. If it should be necessary to remove a component a knife blade can then be slipped under the projecting wire while the soldering iron is applied and the lead bent up without disturbing the copper strip.

The adhesive softens with heat and this can cause trouble when unsoldering a lead from a very small piece. It is then sometimes easiest to pull out the copper strip while it is hot and replace it with a new piece.

Connecting leads and any components on the under side of the boards should be

attached only at places where the leads from parts on the top of the board are providing a firm anchorage for the strip to the board. In other places, a connecting lead should be anchored to the board by enlarging two holes, passing the lead through one from bottom to top and then through the other from top to bottom.

It is worth while to check all components before mounting them, including semiconductors. Using the Model 8 Avometer on the ohms range most diodes and base-emitter junctions show from about $400\ \Omega$ to $2k\ \Omega$ in the forward direction and appear to be open-circuit in the reverse direction. Other ohmmeters may give very different resistance values, but as long as the resistance in the forward direction measures much less than in the reverse direction there is a presumption that all is well. This applies to zener diodes as well as ordinary types, and also to the varactor diode.

Setting-up

Until further notice the vision-sound switch is to be in the vision position. No i.f.

amplifier need be connected. Connect a voltmeter across R_{11} . Turn R_{22} for zero a.c. drive to Tr_3 . Check that as R_{20} is rotated the voltage across R_{11} can be varied from almost zero to 70V. Set R_{20} for about 20V.

Disconnect the voltmeter and connect the c.r.o. between earth and the junction of R_9 , R_{10} and D_3 . Turn up R_{22} to apply a.c. drive to Tr_3 . Use the linear timebase of the oscilloscope and synchronize it to the waveform (50Hz). The waveform should at first appear sinusoidal but, as the amplitude increases, it should more and more tend to very rounded positive half cycles with peaky negative half cycles. If the amplitude is too great or the bias on Tr_3 is wrong, or both, there will be flats on the bottoms of the negative half cycles. This occurs when D_3 conducts it and it shows that the safety circuit is functioning. Adjust R_{20} and R_{22} for the maximum possible amplitude of the waveform without overloading. This will be about 50V p-p.

It is important to realize that the oscilloscope is connected to a high impedance point (about $0.4\ M\Omega$) with the

result that unless the oscilloscope is of much higher impedance the voltage measured by it will be a good deal less than the true voltage. If R is the input resistance of the oscilloscope, the voltage indicated by it should be multiplied by $1 + 0.4/R$. We used an oscilloscope of $1M\Omega$ input resistance and measured on it a maximum of 38V p-p, making the true voltage 53V approximately.

Connect the c.r.o. to the "Output to c.r.o. Y-amp" socket and set its Y sensitivity to about 1V, or a little less, for full vertical deflection. Connect its X-input to "Output to c.r.o. X-amp" socket. Connect the signal generator to "Input from s.g.". The signal generator should have an open-circuit output impedance of $75\ \Omega$ and an open-circuit output of at least 200 mV. Set it at full output at 36.5MHz. Turn R_{56} to maximum. Set the internal marker oscillator control so that the variable capacitor vanes are fully unmeshed. Set the core of L_4 so that its top is a little below the top of the former.

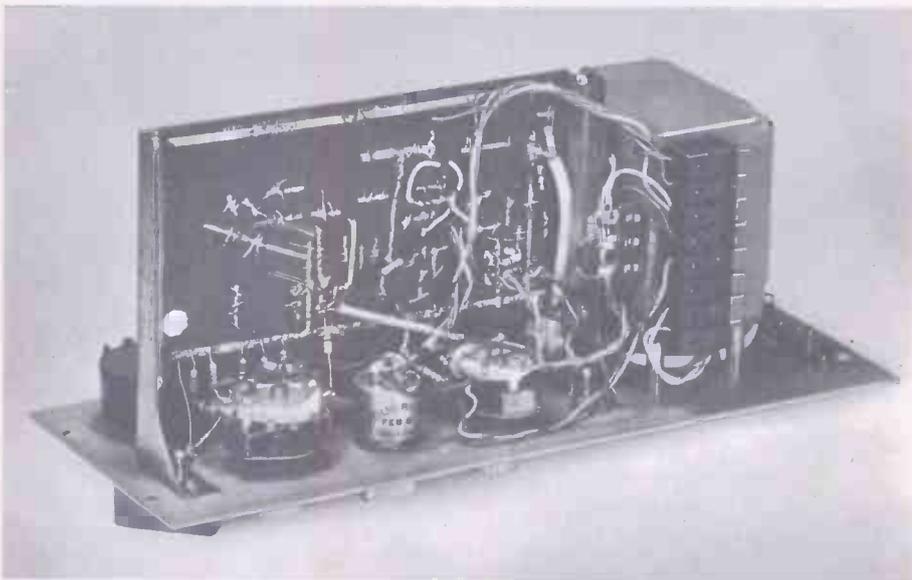
There may now be visible on the trace anything from none to three markers. If there are three the largest will usually be from the internal marker oscillator and the next from the signal generator. This may be checked by adjusting their controls independently; the markers will then move along the trace independently. The third marker is much smaller in amplitude and is always about half-way between the other two. Also it moves when either of the other markers is moved and in the same direction, but at half the rate. It arises because a frequency equal to the sum of the two marker frequencies is generated in the D_4 circuit and it beats with the second harmonic of the wobbly oscillator. Its frequency is precisely half way between the two marker frequencies and it is useful in adjusting for linearity, for this third marker should be precisely half way between the other two markers on the trace.

For the moment we are concerned only with the marker at 36.5MHz provided by the signal generator. If it is not visible adjust R_{20} to bring it on to the trace, and in any case adjust this control to bring this marker as nearly to the centre of the trace as possible.

Unless the phase adjustment is by chance set correctly, each marker will be double. Adjust "Phase" to make the markers on the forward and return sweeps coincide.

Check that increasing the marker frequency makes the marker move along the trace to the right. If it moves to the left, reverse the leads to one of the 7-V transformer secondaries.

Adjust the signal generator towards 30.5MHz while watching the trace. The marker may disappear from the left-hand end of the trace before this frequency is reached or it may not have reached the end at this frequency. In either case adjust R_{20} to bring the 30.5-MHz marker precisely to the end of the trace. This is when the end of the trace comes to the middle of the marker, so that only half of the marker is visible.



Upper part of the wobbulator unit.



Lower part of wobbulator.

Now turn the s.g. towards 42.5MHz. There are now several possibilities. The marker may disappear beyond the right-hand end of the trace at some frequency above 42.5MHz. If it does this readjust R_{20} and R_{22} so that when the s.g. is set in turn to 30.5MHz and 42.5MHz the marker is precisely on the left and right hand ends of the trace respectively.

If the marker stops before 42.5MHz is reached, it may still be possible to make it reach the end while still keeping 30.5MHz at the other end, just by adjustment of R_{20} and R_{22} . More likely, however, the third possibility will arise. This is that the marker will stop before 42.5MHz is reached but, while its left-hand half will be undistorted, its right-hand half will be drawn out into an oscillation for the rest of the trace. If this happens unscrew the core of L_1 , a little and repeat the process.

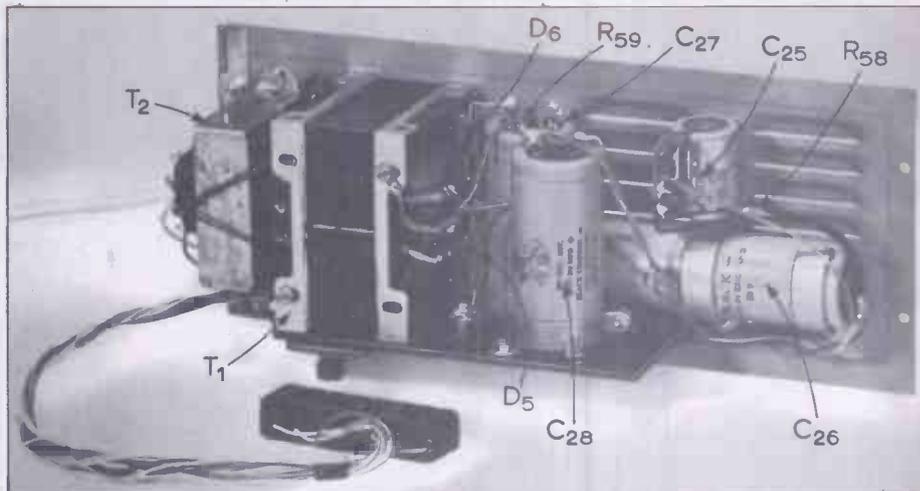
Having obtained a sweep covering 30.5MHz to 42.5MHz, calibrate the internal marker oscillator against the signal generator. It is sufficient to do this in 1-MHz steps. It is convenient to use the blank half of the dial with the slot of an adjacent screwhead as an indicator, and place a pencil mark on the dial for each calibration point.

Set the s.g. to the required frequency and turn the dial of the marker oscillator to superimpose its marker on that provided by the s.g. When the two are nearly equal in frequency a low-frequency oscillation will appear right across the trace and it will disappear at a very critical setting when the two are precisely equal. Mark this point on the dial, move the s.g. by 1MHz and repeat, and so on until the calibration has been completed.

The calibration is easily checked in this way at any time, and if the marker is needed at any frequency in between calibration points it can be set there by reference to the s.g. When the marker is calibrated, the setting up procedure is very much easier because a marker can be set at each end of the range, and it is unnecessary to be continually turning the signal generator from one end of the range to the other, possibly by a tedious slow-motion control.

Set the internal marker oscillator so that its marker is off the trace. Set the s.g. to 36.5MHz and adjust the core of L_4 for maximum amplitude of the marker. Check that the amplitude is about the same at 30.5MHz and 42.5MHz and is about 70% of that at 36.5MHz. Readjust the core if the amplitudes at the two ends are not almost the same. The adjustment is not critical.

The next step is to check the linearity. This is done with the aid of the third marker. Set the s.g. and the internal marker to 30.5MHz and 40.5MHz and see that they lie precisely on the two ends of the trace; slight readjustment of R_{20} and R_{22} may be needed because of temperature drift. Measure the distance of the small centre marker to each of the two end markers. The two distances should be the same. If they are not adjust the core of L_1 very slightly and readjust R_{20} and R_{22} , and measure the distances again. If the distances are more nearly equal continue



General view of the power supply unit.

adjusting the core in the same direction, each time readjusting R_{20} and R_{22} until they become equal. Of course, if the first adjustment to the core makes matters worse, it needs adjusting the other way.

As an example, it was found in one instance that the distance of the centre marker to the left was 35 arbitrary units, whereas the distance to the right was 32 units. About one turn only of the core was needed to bring the distances to equality.

The wobblator is now set up on vision and can be used with an i.f. amplifier to depict its response curve. Proper alignment of the vision amplifier with its trap circuits must be achieved before any attempt is made to align the inter-carrier sound channel.

There are certain traps for the unwary in doing this. The first is a short-circuit on the mains supply! Never for one moment forget that the normal television receiver is live to the mains. To avoid the risk of shock, damage to equipment and even to obtain proper operation of equipment, there is really no alternative but to use a double-wound 1:1 ratio mains transformer to feed the television set. It is certainly the only safe thing to do. Otherwise the i.f. strip must be removed from the set and operated from a separate power unit containing a transformer.

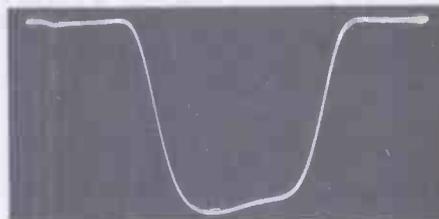
Most television sets are designed to operate with the video detector giving an output of 2V to 4V. Care should be taken to see that the peak-to-peak output with the wobblator is of this order. However, the input from the wobblator must never be so great that overloading occurs.

It is essential that the connection of the video output to the wobblator should not cause feedback in the i.f. amplifier. A well-screened lead is necessary and it is sometimes better to take the output from a video stage than from the detector itself. In the case of the *Wireless World* Colour Television Receiver it was found to be best, and certainly most convenient, to use the sync separator feed. This is a long screened cable which plugs into the sync separator board, and so it can just be unplugged and plugged into the wobblator.

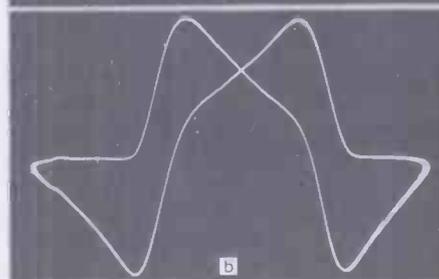
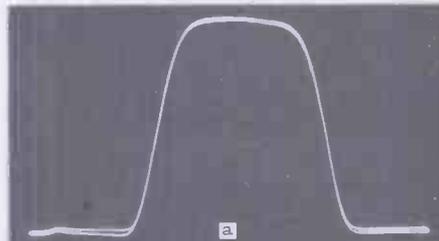
The r.f. output from the wobblator must be by coaxial cable and its length



Here the markers are at 34MHz and 40MHz and half way between them there is a very small marker at 37MHz. This arises from the sum of the main markers (74MHz) beating with the second harmonic of the wobbly oscillator.



Taking the output from the luminance delay line of the W.W. Colour Television Receiver results in an inverted trace.

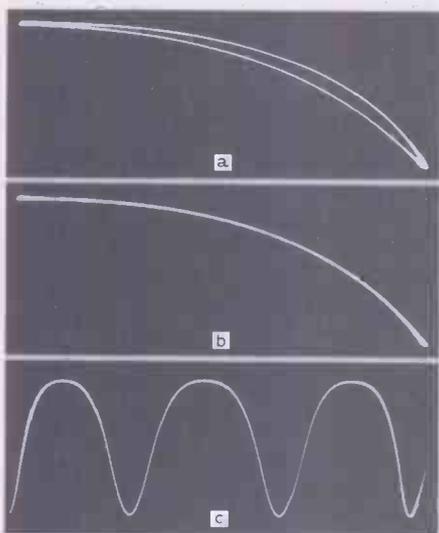


The normal input coupling time constant of the oscilloscope is 0.25 sec. These photographs show the result of reducing it, at (a) to 0.04 sec and at (b) to 0.001sec. Notice the double trace in the vertical direction in (a) and the gross distortion in (b).

should be as short as possible. It is not practicable to match the cable perfectly at each end. At mid-band only about 4ft. of cable is needed for a quarter-wave section. It is well, therefore, to arrange the apparatus so that the cable is no more than 2ft. long if possible. It is not often practicable to feed into the tuner of the television set, so that the first i.f. circuit, which is normally in the tuner, can be in circuit. It is useful, therefore, to have a dummy tuner built to the circuit of Fig. 1 to connect the wobulator to the i.f. strip. The cable from the dummy tuner to the i.f. strip must, of course, be the same length as that from the real tuner to the i.f. strip in the receiver.

Very often additional attenuation that is provided in the wobulator will be needed. This is conveniently obtained from Belling Lee coaxial attenuators, which are available with attenuations of 3, 6, 12, 18 dB; they plug into each other and to the normal cable plugs and sockets. It is particularly convenient to have three 6-dB (L729/6) types available. Whenever possible one should be between the wobulator cable and the dummy tuner. This is the point at which the cable has its greatest mismatch, because of the tuned circuit in the dummy tuner, and this mismatch is greatly reduced by introducing an attenuator at this point. Even when there is sufficient range on the internal attenuator, it may pay to include a 6-dB attenuator at the cable end, and use a step or two less internal attenuation.

For the sound channel the overall picture including the discriminator is obtained by feeding the a.f. output of the sound detector to the "Input from i.f. amplifier" socket. For the alignment of the early circuits, however, it is advisable to make up an a.m. detector to the circuit shown in Fig. 2 and to take the output



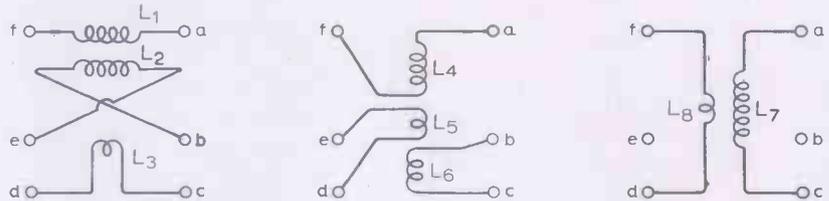
The voltage waveform at the collector of the BF177 wave shaper is shown in these photographs. At (a) the waveform is shown with a sinusoidal timebase and the double trace is due to phase shift caused by the connection of the oscilloscope. Adjusting the phase control removes this (b). The waveform with the more familiar linear timebase is shown at (c).

Coil data

Details of windings: L_1 10t; L_2 10t; L_3 1t; L_4 14t; L_5 1t; L_6 2t; L_7 10; and L_8 2t.

Formers are Neosid 722/1 with terminal bases 5027 and Neosid long screw cores 4 x 0.5 x 12.7. The former diameter is $\frac{3}{16}$ in. with an available winding length of $\frac{5}{8}$ in. Except L_2 , all coils are wound with No. 24 enamelled wire; L_2 is wound with No. 32.

In every case the start of the main winding is next to the base of the former and is the 'hot' end of the coil. All coupling coils, except L_2 , are adjacent to the main winding at the earthy end. L_1 and L_2 are bifilar. Wind L_1 first, close-wound with the start soldered to its pin. Leave the other end free. Solder the wire for L_2 to its start pin and wind it in



between the turns of L_1 . The turns of the latter will spread out to accommodate the wire and it will unwind very slightly. Terminate L_2 on its earthy pin and then L_1 on its earthy pin. Note that the "hot" and earthy pins of the two coils are not adjacent. It is important that the same ends of the two coils should be earthy. Reversed connections to one coil will prevent the proper frequency coverage from being obtained.

The pin spacing of the bases does not fit the hole spacing of Veroboard. It is advisable, therefore, to make a metal-template so that the Veroboard can be drilled in spite of the existing holes. The base is fixed to the board by putting small washers or loops of wire around four of the pins and soldering.

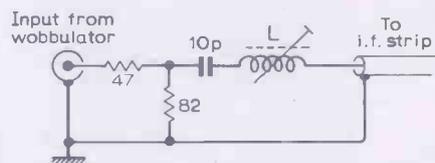


Fig. 1. Circuit of dummy tuner. The coil L can be 15 turns of No. 30 wire wound on a former like those used for the wobulator coils.



Fig. 2. Circuit for connection between earth and the last sound i.f. collector to view the overall response apart from the discriminator.

from this. It is connected to the collector of the last sound i.f. transistor, for instance.

To operate the wobulator on sound, set the vision-sound switch to sound. Set the s.g. to 39.5MHz, and then set the marker oscillator to zero beat with it. This can be done even if there is no visible marker on the trace, because near the proper setting the low-frequency beat between them extends over the whole trace. It is necessary to do this because the calibration of the marker oscillator does not hold when it is switched to sound. It produces 39.5MHz when it is set roughly to the 40.5-MHz calibration point. If one wishes one can put on a special 39.5-MHz point for sound, but it is so easy to set the marker against the s.g. that it seems unnecessary. The change occurs because there is a change of loading on the marker oscillator between the two positions of S_1 .

Turn the "Mid-band frequency control" R_{20} fully clockwise (if it is wired so that on vision a clockwise rotation shifts a response curve to the right) and then gradually back until the sound response curve appears. This is the correct one. If it is turned further another of less amplitude will appear, and if one goes on turning others will come into view, and there may even be several overlapping ones. The first and, usually, largest is the proper 6-MHz

inter-carrier beat between 39.5MHz and 33.5MHz in the vision i.f. detector. The second occurs between 39.5MHz and 36.5MHz, when the separation is 3MHz, and it is the second harmonic of this produced in the detector which passes through the sound i.f. amplifier. The others occur for separations of 2MHz, 1.5MHz, 1.2MHz, 1MHz and so on, with the third, fourth, fifth and sixth harmonics.

By adopting the above procedure the right setting is easily found and the spurious responses cause no trouble. Notice, however, that the proper response will not always be the largest. If the sound trap in the vision i.f. amplifier gives more attenuation than usual, the second response may be larger than the proper one.

On both vision and sound an increase of marker frequency moves the marker to the right. On vision a clockwise rotation of R_{20} moves the response curve to the right on the trace, but on sound it moves it to the left. This could be avoided by extra switch contacts to reverse the leads to R_{20} , but did not seem worth while. Temperature drift is normally to the left on vision and to the right on sound.

One thing must not be overlooked. It is usually necessary in some way to put out of action any a.g.c. system of the amplifier under test and the way of doing this will depend on the receiver design.

A YIG Radiometer and Temperature Controller

Solid-state device for temperatures of 100-250°C

by I. J. Kampel*

The radiation pyrometer or radiometer provides a convenient way of measuring surface temperature where more conventional sensing elements may not be employed. The system to be described also utilizes an experimental solid-state optical modulator—the YIG—and in so doing eliminates the bulky and inconvenient motorized chopper unit normally associated with such systems. Use of this new electro-optical component therefore answers the need for a sensing head requiring no maintenance, and provides a rugged, miniature solid-state construction.

All bodies emit electromagnetic radiation, the amount of radiant energy being dependent upon their temperature and emissivity. The maximum theoretical emission at any temperature is given by a black-body radiator, and the "emissivity" factor determines the ratio of emittance by a body to the emittance of a black-body at the same temperature.

The Stefan-Boltzman law states that the total spectral emittance of a black-body is directly proportional to the fourth power of its absolute temperature. The radiometer—or radiation pyrometer—utilizes this principle. Emitted radiation is measured, and this is then equated to source temperature. A control is normally provided to allow for emissivity factor corrections.

While the disadvantage of temperature measurement by radiometer lies in the need for approximate evaluation of source emissivity, the system does offer unique advantages over more conventional techniques. The infrared sensing element represents the perfect measuring transducer: it in no way affects the object being measured since it is non-contacting. This particular versatility also allows the remote measurement of moving bodies. As measurement is by means of a photoelectric as opposed to the more common thermoelectric principle, a fast response may be realized. Many control systems do not require an absolute temperature indication, and in such cases the controller may be used without prior determination of source emissivity.

For accuracy, and the convenience of a.c. amplification in radiometer systems, it is normal to chop the incoming radiation

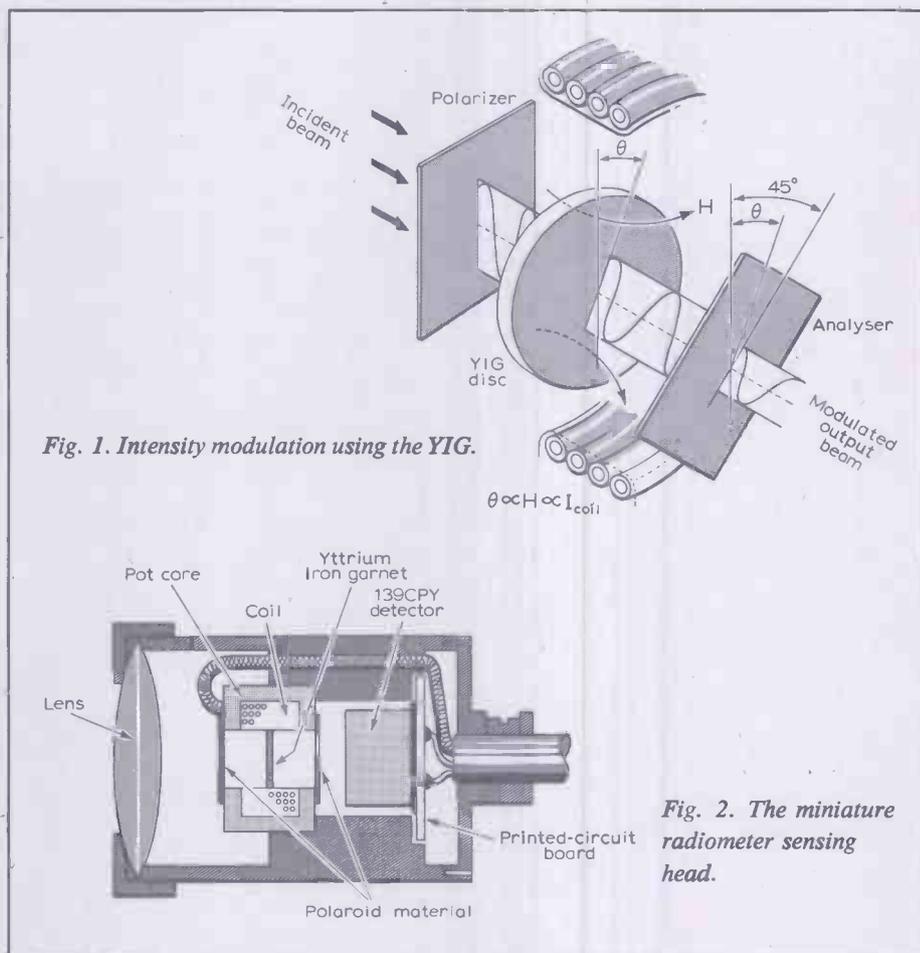


Fig. 1. Intensity modulation using the YIG.

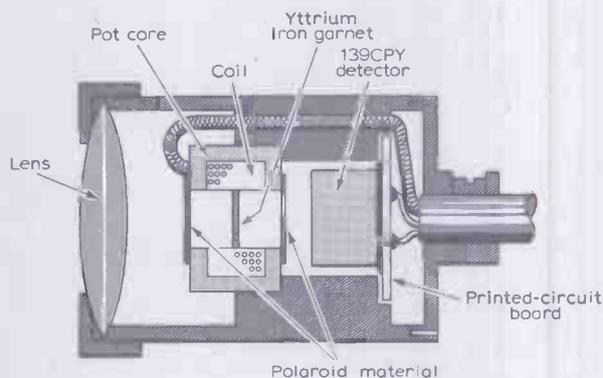


Fig. 2. The miniature radiometer sensing head.

with a rotating segmented chopper-disc. The size of such a disc with its associated driving motor has necessarily led to rather bulky sensing heads in previous equipments, however the YIG solid-state optical modulator removes such size restrictions. The total absence of all moving parts has also eliminated the need for servicing.

YIG Modulator

Unbalance in electron spin of inner orbital electrons induces a magnetic moment in a crystal of yttrium iron garnet (YIG); it is therefore said to be ferrimagnetic. Magnetic domains of identically orientated magnetic dipoles form and take up a natural alignment. These domains exhibit Faraday rotation; in the presence of a magnetic

field the plane of polarization of transmitted plane-polarized radiation is rotated through an angle proportional to the magnetic field strength. Faraday rotation is also proportional to path length through the material, and is inversely proportional to the wavelength of radiation.

The high transmission of YIG in the spectral range 1.1-4.5 μm is enhanced by the use of an anti-reflection coating. Its usefulness is limited by the rapid deterioration in Faraday rotation with increasing wavelength. The polarizing material normally employed in the modulator also limits the spectral response to about 2.3 μm . Lead sulphide is the most suitable detector material to employ in radiometric applications due to its similar spectral response characteristic.

*Mullard Ltd.

Current passing through a coil situated around the material provides the required magnetic field, with lines of flux lying parallel to the path of the traversing radiation. A square-wave current drive provides a suitable modulation of the plane of transmitted plane-polarized radiation, and by further passing this radiation through another polarizer—known as the analyser—an intensity modulation is derived. This principle is illustrated by Fig. 1.

A sectional diagram of the sensing head is shown in Fig. 2. Overall dimensions are 2cm diameter by 3cm length.

A glass lens is used to focus incident radiation on to the element of a 139CPY chemical lead sulphide detector. In the path of this radiation is situated an experimental YIG modulator; this was housed within a modified Ferroxcube transformer pot core which served to provide a low reluctance path for external flux, so minimizing direct electromagnetic pick-up at the detector. Polarizer and analyser are located on the outer faces of this housing.

The plane of polarization of the analyser is situated at 45° relative to the polarizer. This requires a ± 45° rotation of the plane-polarized radiation for full theoretical modulation, and this is approached by employing a true a.c. drive current in the YIG coil. A greater modulation depth for a given drive power may be achieved with this method than by any other.

System description

Output from the radiometer takes the form of a moving coil meter; output from the controller may either be a simple audible warning, or a change-over relay, but various operational modes may be selected to give this considerable flexibility.

A chemical lead sulphide detector was employed since this had a suitable spectral response, and was available in the small size of a TO-5 encapsulation. The system to be described is suitable for a black-body source temperature range of 100-250°C, covered by two ranges; the addition of higher temperature ranges would be straightforward. An emissivity control covering the range $e=0.1$ to $e=1.0$ was provided.

Two integrated circuits are used to modulate the YIG coil with a true a.c. square-wave current at a frequency of 400Hz as shown in Fig. 3. This frequency is sufficiently high to avoid mains pick-up problems, and low enough to allow optimum performance from a lead sulphide detector having a somewhat slow response.

A quadruple NAND gate (FJH131) is interconnected to form a square-wave generator, where external 1-μF capacitors set the periods as in a conventional multivibrator. Since the resistive component of the time-constant is contained within the integrated circuit, however, this is liable to production spreads and will introduce some spread in frequency. (See Fig. 3).

A dual buffer gate (FJH141) provides the required current drive to the YIG coil. The coil is d.c. coupled and driven in push-pull mode. The voltage amplitude from this

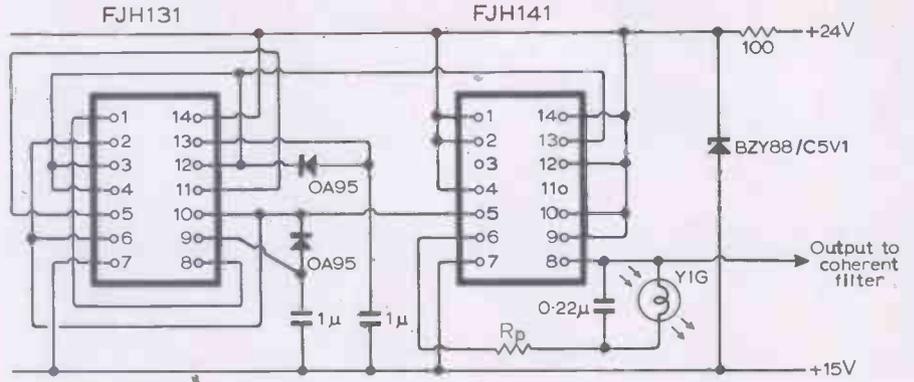


Fig. 3. Drive circuit for the YIG.

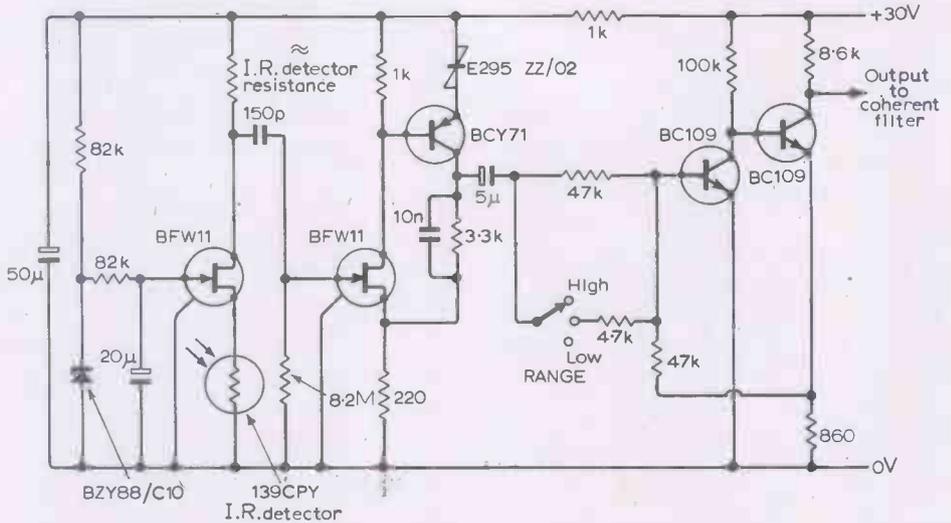


Fig. 4. Low-noise preamplifier circuit with compensatory detector bias.

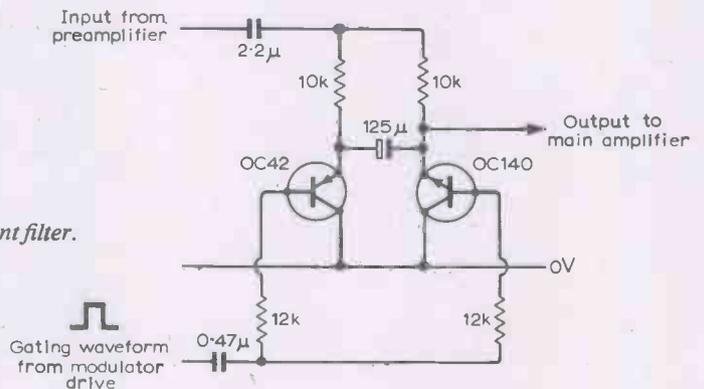


Fig. 5. A simple coherent filter.

integrated circuit is also dependent upon production tolerances, and R_p is adjusted on test to give a coil current of approximately 20mA (33-68Ω typical). A capacitor in parallel with the coil reduces the spike caused by fast current switching in the inductive load.

Modulator and detector leads should be adequately screened from one another in order to avoid pick-up problems.

Pre-amplifier Circuit

Detector resistance varies with ambient temperature. Since responsivity is approximately proportional to the square of this resistance, it is necessary to provide some correction. By biasing the detector in a constant voltage mode and utilizing the

signal current, the output obtained is inversely proportional to the square of detector resistance and a much improved temperature stability is achieved.

An f.e.t. is used to provide detector bias, and was found preferable to a transistor, introducing far less current noise than the latter. The complete circuit is shown in Fig. 4. Noise from the zener diode is eliminated by decoupling the gate of the f.e.t. A second f.e.t. is used in a compound arrangement with a transistor to provide initial gain; this is also a low noise configuration. A voltage-dependent resistor in the transistor emitter allows a greater drain resistance for improved loop gain. A further gain of 10 or 100 is provided by the following virtual-earth amplifier, the gain being selected by the range switch.

A simple coherent filter is formed from two complementary germanium transistors as shown in Fig. 5. These effectively form a dynamically synchronized narrow-bandwidth filter. A gating waveform is taken from the YIG drive circuit and applied to switch these transistors in anti-phase. The output from the pre-amplifier is fed into the circuit, and is used to charge the 125- μ F capacitor through one or another of the 10-k Ω resistors.

The two transistors are switched in synchronism with the signal, and earth alternate sides of the capacitor so that a d.c. charge builds up which is proportional to the signal waveform. Any noise or spurious signals present at frequencies other than the modulating frequency average to zero. An output is taken from one side of the charge capacitor for further a.c. amplification.

It is important to ensure a true 1:1 mark-space ratio for optimum performance from the coherent filter. It will be obvious that drift of the chopping frequency will in no way affect performance. The transistors are connected in an inverted manner to minimize leakage current and breakthrough of the gating signal.

An operational amplifier (TAA811) is used to provide a further stage of variable gain and an emissivity control. The configuration of Fig. 6 will provide a linear emissivity scale calibration between 0.1 and 1.0 provided that the potentiometer is truly linear (selection normally required). Voltage gain will be 100 at $e = 0.1$, and 10 at $e = 1.0$.

The radiometer section of the instrument terminates in a peak detector circuit and is shown in Fig. 7. The 1- μ F capacitor charges to a d.c. potential proportional to the signal amplitude. This is fed to a moving-coil meter and provides the temperature indication. The zener diode is a protective device for the meter.

The d.c. level on the charge capacitor is also monitored by the controller circuitry. Provision is made to switch the meter to a variable d.c. potential independent of the signal: this greatly facilitates initial adjustment of the controller.

Temperature controller

Totally independent adjustable maximum and minimum limits are provided, and either or both may be used. In the "basic" mode, if the meter pointer crosses either limit, the relay or audible warning switches on; hence the output does not distinguish

between maximum and minimum (although the meter indicator will). In the "cycle" mode, the relay or audible warning switches on when the pointer exceeds the maximum limit, and will remain on until the lower limit has been crossed.

Thus by using both limits in this mode, a cycling controller is available between preset temperatures. By using only one limit in this mode, a one-shot function is available provided that the initial state has been correctly set.

The input to the control circuit is taken directly from the output of the radiometer circuit, and responds either to a d.c. potential set by the signal waveform, or a potential manually set on the "meter-set"

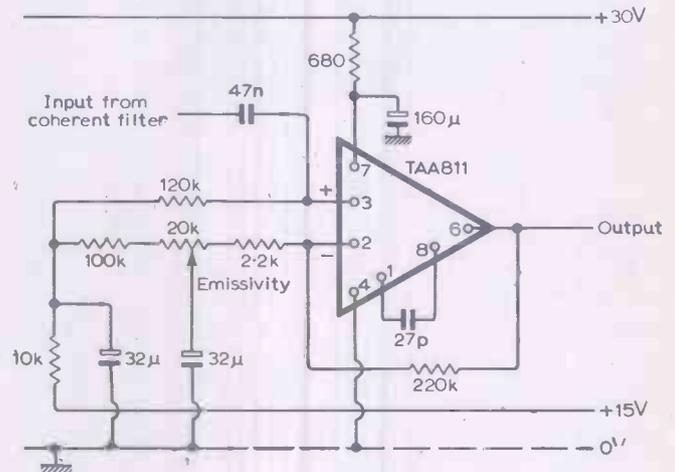


Fig. 6. Main amplifier with emissivity control.

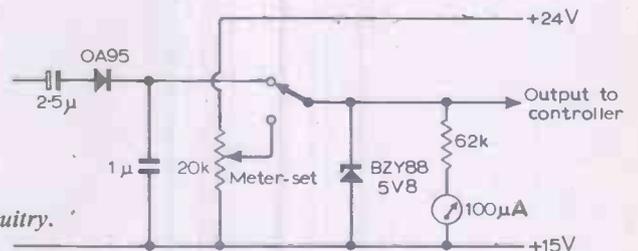


Fig. 7. Radiometer output circuitry.

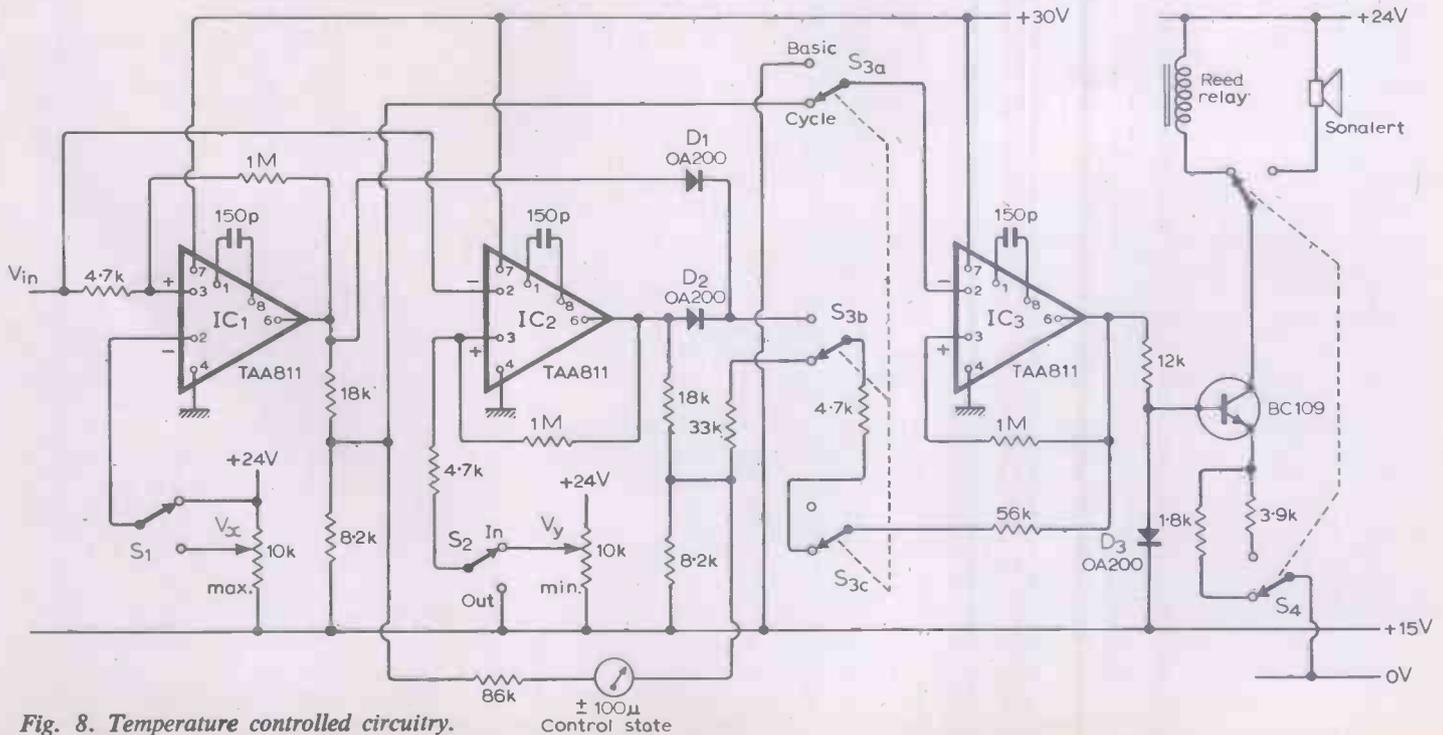


Fig. 8. Temperature controlled circuitry.



The picture shows the temperature of a silica tube being measured while undergoing a production process. The chopper and temperature sensor form the small unit held in the operator's left hand and pointed at the hot part of the silica tube.

control; the latter considerably eases the accurate setting of limits.

Two integrated circuits (IC_1 and IC_2 , Fig. 8) monitor the input voltage, and both their outputs will be at 0V until a limit has been crossed. When S_1 is closed the maximum limit is set by adjusting V_x to a suitable level. If V_{in} exceeds V_x then IC_1 output rapidly switches to +30V. When S_2 is closed, the minimum limit is set by adjusting V_y to a suitable level. If V_{in} falls below V_y then IC_2 output switches rapidly to +30V.

With S_3 in the "basic" position, the — input of IC_3 is referred to +15V. The output of IC_3 is normally at 0V. If either limit is crossed, the anode of either D_1 or D_2 will be taken to +30V, and the + input of IC_3 will follow; thus the output of IC_3 will then switch to +30V.

Hysteresis circuit

With S_3 in the "cycle" position, IC_3 forms a hysteresis circuit, and the output voltage will switch to +30V if IC_1 output goes +ve, and will remain there until the output of IC_2 goes +ve, whence it returns to 0V.

When the output of IC_3 switches to +30V, the base of the output transistor rises from 0V to a little above +15V, and either the audible warning or the control relay will operate. The choice is selected by S_4 .

A second small centre-zero meter ($\pm 100\mu A$) may be used to give a constant indication of the control state under all conditions. The pointer will be centred until a limit is crossed, and will deflect when a limit is crossed, the direction of deflection being indicative of maximum or minimum.

Olympia Audio Fair Lectures

The 1970 International Audio and Music Fair, to be held from 19th to 24th October at Olympia, London, differs from previous fairs of this kind (in this country) in that there will be a programme of "presentations" sponsored largely by the audio press. The full list is given below.

It will be seen that *Wireless World* is sponsoring five lecture-demonstrations. Each session will be given by a well-known *Wireless World* author, who will relate engineering principles and procedures to the performance actually given by items of audio equipment. The lecturers will be Arthur Bailey, Peter Baxandall, Jack Dinsdale, John Linsley Hood and Ted Jordan. Tickets for each of these sessions will be available at the *Wireless World* stand at the Fair on the day of the lecture.

Tuesday, 20th

2.0 Types of recorded sound quality

by John Crabbe (*Hi-Fi News*)

Different musical and acoustical balances to be found on modern recordings will be discussed and demonstrated.

4.0 The progression of electronic music synthesizers

by Dr. Robert A. Moog

The inventor of the Moog Synthesizer will demonstrate the instrument used for the famous "Switched on Bach" LP.

6.0 The heart of hi-fi

by J. Dinsdale (*Wireless World*)

The important features of modern amplifier circuitry and specifications will be explained and demonstrated.

8.0 Cassettes and cartridges

by W. Woyda (*Precision Tapes*)

Cassette and 8-track cartridge formats will be described in detail and several recently released recordings will be played in both media.

Wednesday, 21st

2.0 Power levels, distortion and the enjoyment of music

by P. J. Baxandall (*Wireless World*)

The inventor of the Baxandall tone control will discuss the technical requirements of hi-fi equipment and relate them to musical enjoyment.

4.0 How good is your gramophone?

by John Borwick (*The Gramophone*)

The lecturer will play a selection of records and suggest how these can be used to assess the performance of record reproducing equipment.

6.0 Both sides of the record

by Joan Coulson (EMI Records)

All kinds of music on record with glimpses behind the scenes.

8.0 The progression of electronic music synthesizers

by Dr. Robert A. Moog (See Tuesday)

Thursday, 22nd

2.0 From cylinders to 78s to today

by G. Child (formerly of Decca Records)

A short history of the gramophone record with a display of vintage players and examples of records old and new.

4.0 Audio facts and fallacies

by A. R. Bailey (*Wireless World*)

The well-known designer examines hi-fi ideas and terminology.

6.0 Personal appearance of Sir Arthur Bliss

The Master of the Queen's Musick will introduce excerpts from the first recording of his "Pastoral" and "Knot of Riddles" to be issued in October by Pye Records.

8.0 Stereo for beginners

by Clement Brown (*Hi-Fi Sound*)

A simple introduction to the subject of stereophonic recording and reproduction.

Friday, 23rd

2.0 Cassettes and cartridges

by W. Woyda (*Precision Tapes*)

(see Tuesday)

4.0 How good is your gramophone?

by John Borwick (*The Gramophone*)

(see Wednesday)

6.0 Little and good

by J. L. Linsley Hood (*Wireless World*)

An illustrated examination of the related subjects of power and quality in sound reproduction.

8.0 The funny side

by Donald Aldous (*Hi-Fi News & Record Review*)

A light-hearted look at the record repertoire—"in the groove, but out of the rut".

Saturday, 24th

2.0 Sound sense

by E. J. Jordan (*Wireless World*)

This well-known loudspeaker designer will talk about sound reproduction aims and play some recorded examples.

4.0 The funny side

by Donald Aldous (*Hi-Fi News & Record Review*) (see Friday)

6.0 Types of recorded sound quality

by John Crabbe (*Hi-Fi News*)

(see Tuesday)

8.0 Live pop recital

presented by *New Musical Express*

Throughout the Exhibition there will also be a programme of semi-technical films.

Active Filters

14. Bandpass types

by F. E. J. Girling* and E. F. Good*

It has already been shown that low-pass filters can be made up from one or more feedback loops containing integrators, simple lags, or a mixture of the two. The band-pass counterparts of both integrators and simple lags are tuned circuits tuned to the chosen centre frequency. Consequently band-pass filters may be made by substituting such tuned circuits for the lags and integrators of suitable low-pass models, and the method is described for synthesis by factors and for active-ladder synthesis. A brief discussion of stagger tuning is also given.

A symmetrical band-pass characteristic may be considered as a transform of a low-pass characteristic, and all the methods of design used for low-pass filters may be carried over into b-p filter design, the most important being (a) by factors, (b) as a ladder structure. The nature of the transformation has been described in Part 2; and if, for clarity, frequency for the l-p model is designated by the upper-case letter Ω , and for the b-p counterpart by the conventional ω , an algebraic statement of the transformation is

$$\Omega = \omega - \omega_0^2/\omega = \omega_0(\omega/\omega_0 - \omega_0/\omega) \quad (1)$$

This produces, Fig. 1, a b-p characteristic in which the bandwidth, $\omega_1 - \omega_2$, between any two points of equal amplitude, and of equal but opposite phase shift, is equal to Ω_1 , the bandwidth from zero to the corresponding point on the l-p characteristic. The b-p characteristic is centred on ω_0 in the sense that $\omega_0 = \sqrt{\omega_1\omega_2}$, i.e. $\omega_2 = \omega_0^2/\omega_1$.

Realisation by factors

Since resolution of a l-p characteristic into 1st- and 2nd-order factors provides a basis for the design of a l-p filter as a cascade of non-interacting simpler (i.e. lower-order) l-p sections, transformation of the l-p factors to b-p provides a basis for the design of the corresponding b-p filter as a cascade of non-interacting simpler b-p sections.

1. 1st-order

The frequency response function for 1st-order l-p response (a simple lag)

$$G(\Omega) = 1/(1 + j\Omega/T_0) \quad (2)$$

* Royal Radar Establishment.

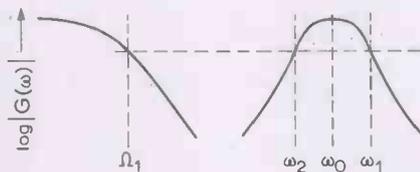


Fig. 1. Corresponding b-p and l-p responses: for any pair of points on the b-p curve and the corresponding point on the l-p curve $\omega_1 - \omega_2 = \Omega_1$ and $\omega_1\omega_2 = \omega_0^2$.

transforms into

$$G(\omega) = 1/\{1 + j\omega_0(\omega/\omega_0 - \omega_0/\omega)/\omega_c\}, \quad (3)$$

which may be simplified to

$$G(\omega) = 1/\{1 + jQ(\omega/\omega_0 - \omega_0/\omega)\} \quad (4)$$

where

$$Q = \omega_0/\omega_c \quad (5)$$

the well known definition.

In transfer-function form the functions are

$$G(p) = \frac{1}{1 + pT} \quad (\text{l-p}) \quad (6)$$

$$G(p) = \frac{1}{1 + Q\left(pT_0 + \frac{1}{pT_0}\right)} \quad (\text{b-p}) \quad (7)$$

which rearranges into

$$G(p) = \frac{pT_0/Q}{1 + pT_0/Q + p^2T_0^2} \quad (8)$$

the familiar form for "tuned-circuit" response. ($T_0 = 1/\omega_0$). The transformation may be considered, therefore, to consist in replacing pT , where $T = 1/\omega_c$, by

$$Q\left(pT_0 + \frac{1}{pT_0}\right) \quad (9)$$

Physically this means, for example, that a differentiator (say the capacitor of a Blumlein integrator) has an integrator placed in parallel with it.

2. 2nd-order

2nd-order l-p response may be defined

$$G(p) = 1/(1 + pT/q + p^2T^2) \quad (10)$$

When $q > \frac{1}{2}$ the response cannot be resolved into real 1st-order factors, and when $q > 1/\sqrt{2}$ the response shows a resonant hump or peak. The corresponding b-p res-

ponse is of the type associated with coupled tuned circuits.

2nd-order l-p response may be obtained from an integrator-and-lag loop, a two-lag loop, etc. The b-p transform of a simple lag is a single tuned circuit of finite Q and tuned to ω_0 (above), and it is a simple piece of reasoning† to show that the transform of an integrator is an infinite- Q tuned circuit, also tuned to ω_0 . It follows that 2nd-order b-p responses may be obtained from feedback loops containing two tuned circuits tuned to the required centre frequency.

Tuned circuits of finite Q are matched to the lags of the l-p model so that the same bandwidths are obtained, and the gain at ω_0 (the peak) is made equal to the gain of the l-p simple-lag circuits at zero frequency. Tuned circuits of infinite Q are matched to corresponding integrators in the l-p model by making the unity-gain bandwidth the same, Fig. 2.

In a b-p filter there is the possibility of a type of error which has no counterpart in the l-p model. There can clearly be no error in the position of zero frequency, but the centre frequencies of the constituent tuned circuits of a b-p filter can be misaligned both with respect to each other and with respect to the desired ω_0 . In a loop containing an infinite- Q tuned circuit and a damped tuned circuit misalignment causes the loop gains in the critical regions near the band limits (where the Nyquist plot comes nearest to the $-1, j0$ point, Fig. 3) to be different, with more phase shift on one side than on the other for points of equal magnitude of loop gain. This causes the response when the loop is closed to be unsymmetrical, showing more peaking on one side of the passband than on the other (i.e. show different equivalent values of q). Two tuned circuits of equal Q give a symmetrical response even when misaligned, Fig. 4, and consequently a symmetrical response with the feedback

† The integrator has infinite gain at zero frequency and a constant 90° phase lag; the infinite- Q tuned circuit has infinite gain at ω_0 , a constant 90° phase lag for $\omega > \omega_0$, and a constant 90° phase lead for $\omega < \omega_0$.

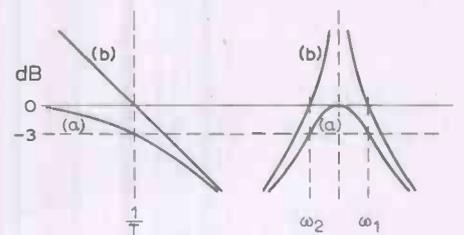


Fig. 2. Relationship between (a) a damped tuned circuit and a simple lag, (b) an infinite- Q tuned circuit and an integrator. For each pair $\omega_1 - \omega_2 = 1/T$.

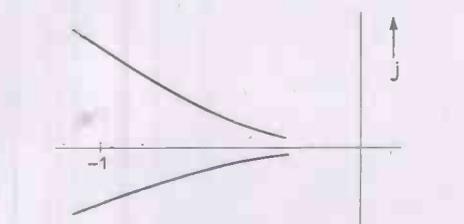


Fig. 3. Misalignment of tuned circuits of different Q gives an unsymmetrical loop response, which shows in the Nyquist plot.

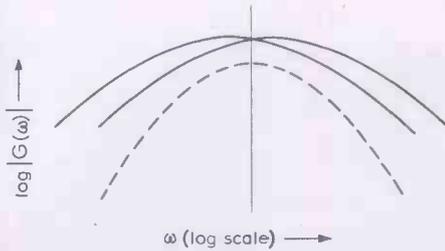


Fig. 4. Misalignment of two tuned circuits of equal Q gives a still symmetrical loop response.

loop closed—although bandwidth and shape factor (q) are affected. In practice there may be errors in Q as well as in centre frequency, but the effect of error is still likely to be more tolerable than in a loop containing one infinite- Q circuit. It appears, therefore, that the preferable 1-p model for a b-p filter is the loop with two equal lags.

The properties of such a loop have been considered in Part 4, and the important result obtained that closing the loop increases both q and bandwidth by the factor $\sqrt{(A_0 + 1)}$, where A_0 is the loop gain at zero frequency. For two equal lags the open-loop q is $\frac{1}{2}$. To obtain a closed-loop value of q , therefore,

$$\sqrt{(A_0 + 1)} = 2q \quad (11)$$

i.e. $A_0 = 4q^2 - 1; \quad (12)$

and for a closed-loop bandwidth $\omega_c = 1/T$, the open-loop bandwidth, which is also the bandwidth of the individual lags, must be $\omega_c/2q$, i.e. the time constant of the lags must be $2qT$. This is shown in Fig. 5(a).

Now the bandwidth of a tuned circuit = ω_0/Q . So for the tuned circuits of Fig. 5(b) to have the same bandwidth as the lags in Fig. 5(a)

$$\frac{\omega_0}{Q} = \frac{\omega_c}{2q} \quad (13)$$

i.e. $Q = 2q\omega_0/\omega_c. \quad (13)$

It is now convenient to define a measure of the relative sharpness or selectivity of a 2nd-order band-pass circuit,

$$Q_B = \omega_0/\omega_c. \quad (14)$$

This is comparable with the definition of Q for a single tuned circuit, although now ω_c is the nominal bandwidth equal to the corner frequency of the corresponding 2nd-order 1-p circuit, and the -3dB bandwidth only for the particular case of $q = 1/\sqrt{2}$.

Making this substitution in equn. (14) gives

$$Q = 2qQ_B \quad (15)$$

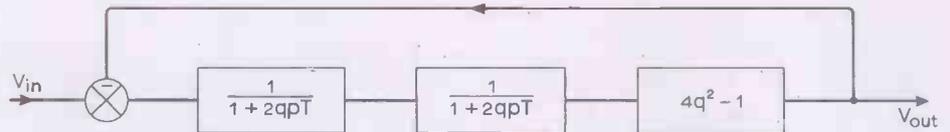
and substituting for Q in equn. (7) then gives for the transfer functions of the elementary tuned circuits of Fig. 5(b)

$$G(p) = \frac{1}{1 + 2qQ_B \left(pT_0 + \frac{1}{pT_0} \right)} \quad (16)$$

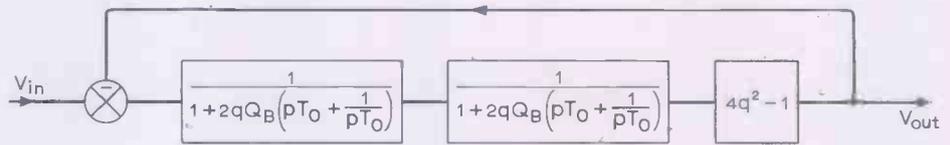
Comparison with the transfer functions of the simple lags of Fig. 5(a)

$$G(p) = \frac{1}{1 + 2qpT} \quad (17)$$

shows that the transformation may be con-



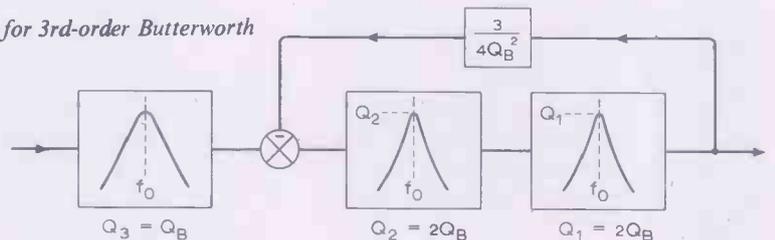
$$(a) \quad \frac{V_{out}}{V_{in}} = \frac{4q^2 - 1}{4q^2} \cdot \frac{1}{1 + \frac{1}{q} pT + p^2 T^2}$$



$$(b) \quad \frac{V_{out}}{V_{in}} = \frac{4q^2 - 1}{4q^2} \cdot \frac{1}{1 + \frac{1}{q} Q_B \left(pT_0 + \frac{1}{pT_0} \right) + Q_B^2 \left(pT_0 + \frac{1}{pT_0} \right)^2}$$

Fig. 5. A two-lag loop and its band-pass counterpart.

Fig. 6. Scheme for 3rd-order Butterworth filter.



sidered to be the replacement of pT , where $T = 1/\omega_c$, by

$$Q_B \left(pT_0 + \frac{1}{pT_0} \right). \quad (18)$$

Transfer functions for corresponding 1-p and b-p 2nd-order sections may therefore be written

$$\frac{1}{1 + \frac{1}{q} pT + p^2 T^2} \quad (1-p) \quad (19)$$

$$\frac{1}{1 + \frac{1}{q} Q_B \left(pT_0 + \frac{1}{pT_0} \right) + Q_B^2 \left(pT_0 + \frac{1}{pT_0} \right)^2} \quad (b-p) \quad (20)$$

though the method of synthesis just described does not depend on explicit statement of the b-p transfer function.

The rule for 1-p to b-p transformation given above, expression (18), is only apparently different from the rule given for 1st-order sections, expression (9). By dividing by $T (= 1/\omega_c)$ both reduce to the basic rule: i.e. p is replaced by

$$\frac{1}{T_0} \left(pT_0 + \frac{1}{pT_0} \right) \quad (21)$$

Equation (15) and the well known relationship expressed by equn. (5) provide the basic theory for the design of any symmetrical simple (all-pole) band-pass filter as a cascade of active 1st- and 2nd-order band-pass sections.

It is also worth noticing for future reference that because of the identity

$$\frac{pT_1}{D_1(p)} \times \frac{pT_2}{D_2(p)} = \frac{T_1}{T_2} \times \frac{1}{D_1(p)} \times \frac{p^2 T_2^2}{D_2(p)} \quad (22)$$



Fig. 7. The band-pass response has twice as many ripples as the low-pass response used as model.

where in the present case

$$D_1(p) = 1 + pT_1/Q_1 + p^2 T_1^2 \quad (23)$$

$$D_2(p) = 1 + pT_2/Q_2 + p^2 T_2^2 \quad (24)$$

two tuned circuits in tandem may be replaced by a low-pass circuit and a high-pass circuit also in tandem.

3. Higher-order filters

The general pattern for a higher-order filter realized as a cascade of sections designed as above is n tuned circuits all tuned to ω_0 and connected in $n/2$ feedback pairs, or when n is odd $(n-1)/2$ feedback pairs with one single tuned circuit. The feedback pairs form the 2nd-order sections, and the Q factors of the constituent tuned circuits and the degree of back coupling are chosen to give the required closed-loop bandwidth and q (shape factor). Similarly the Q s of any single tuned circuits (the 1st-order sections) are chosen to give the required bandwidth.

Butterworth filters are a special case, as the nominal bandwidth of each section is equal to the -3dB bandwidth of the complete filter. So $Q_{B1} = Q_{B2} = \dots = \omega_0/\omega_c$; and for n odd the Q factor of the single tuned circuit is also equal to ω_0/ω_c . But the q of each 2nd-order section is different, and, using equns (15) and (12), the Q factors of

the constituent tuned circuits and the loop gains must be calculated as follows:

$$Q_1 = 2q_1 Q_B, \text{ loop gain} = 4q_1^2 - 1,$$

$$Q_2 = 2q_2 Q_B, \text{ loop gain} = 4q_2^2 - 1, \text{ etc.}$$

Thus the block diagram for a 3rd-order Butterworth filter, which needs only one feedback pair (with $q = 1$), may be drawn as in Fig. 6. Values of q for up to $n = 10$ were given in Part 9, Table 6.

In general, however, both q and bandwidth will be different for each factor, as they are for the factors of an l-p filter, e.g. Table 8 of Part 9. The parameters q pass straight over into the band-pass design. The parameters T are inversely proportional to the nominal bandwidths of the factors (ω_c), and consequently directly proportional to the band-pass parameters Q_B (or Q for a 1st-order factor). As a b-p response repeats itself on the other side of ω_0 it will show twice as many ripples as the l-p response, e.g. Fig. 7.

1/nth octave filter

The bandwidth of a b-p filter is often specified as a fraction of an octave (2:1 frequency ratio), especially when it is one of a bank of filters required to divide a broad spectrum into a number of relatively narrow contiguous bands.

If the filters all have the same relative bandwidth, and the first one is centred on $\omega_0 = 1$, the n th filter will be centred on $\omega_0 = 2^n$, Fig. 8. Consequently

$$x^2 = 2^{\frac{1}{n}}, \tag{25}$$

$$\frac{1}{Q_B} = x - \frac{1}{x} = \frac{2^{\frac{1}{n}} - 1}{2^{\frac{1}{2n}}}, \tag{26}$$

from which the figures shown in Table 1 may be calculated. The last row corresponds to one filter for each note of the equally tempered scale. Sometimes of course, the relative bandwidth is made different from the spacing between adjacent filters. This is so for B.S. 1/3rd-octave filters, which have a band width much less than the pitch between centre frequencies.

From the first column of Table 1 the Q factors required of individual tuned circuits may be calculated via equn. (15). Thus for 3rd-order Butterworth response Q factors

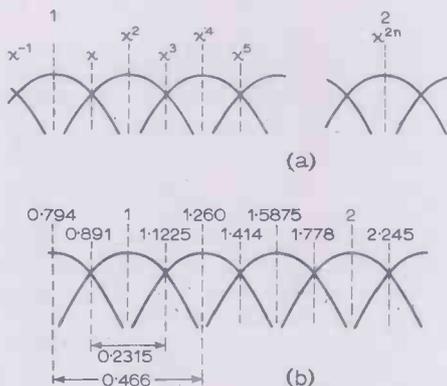


Fig. 8. (a) n filters to the octave, each with a band width of $1/n$ th of an octave. (b) Frequency relationships for $1/3$ rd-octave filters.

TABLE 1
1/nth-octave filters— Q_B against n

n	1	2	3	4	5	6	8	10	12
Q_B	1.414	2.87	4.32	5.76	7.21	8.65	11.55	14.47	17.3

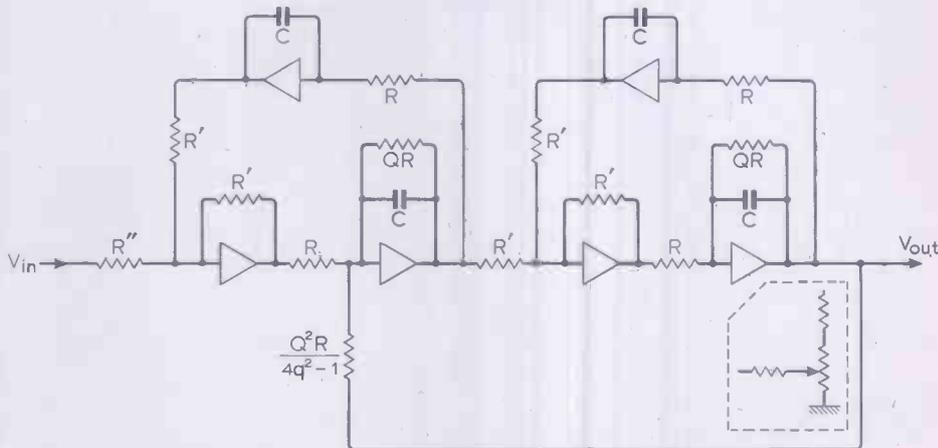


Fig. 9. 2nd-order band-pass filter using two-integrator loops.

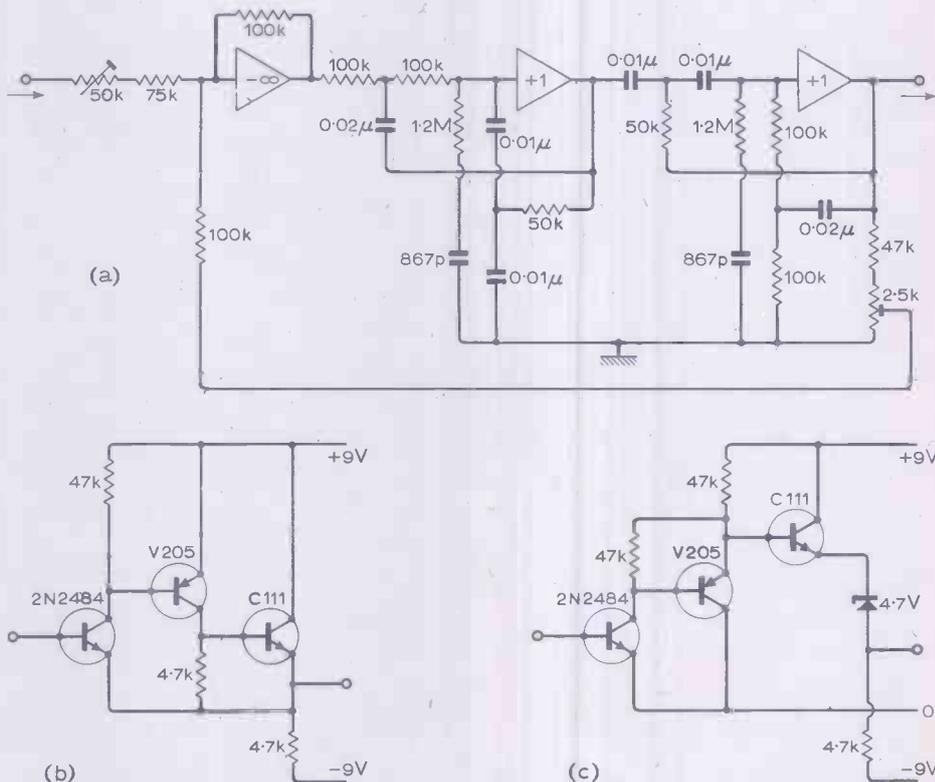


Fig. 10. (a) Schematic for $1/3$ rd-octave 2nd-order band-pass filter, centre frequency 159 Hz, peak gain 18 approx. (b) Enhanced emitter follower using three transistors. (c) Simple high-gain amplifier.

equal to $2Q_B$ are needed. This gives a guide to the type of circuit needed.

Circuits

The most powerful type of active tuned circuit is the two-integrator loop, especially when high Q is needed. In its ordinary form (Parts 7 and 8) the circuit uses three amplifiers, and two circuits may be put together as in Fig. 9 to form a feedback 2nd-order band-pass section. With the usual balance of component values shown each tuned circuit gives a peak gain of Q , not 1 as assumed in Fig. 5 for example. So the "gain" of the feedback path must be divided by Q^2 to

compensate, and unless Q is very low the feedback resistor may have an inconveniently high value. This can be avoided by using a resistor of moderate value fed from a potential divider as shown inset. It may also be helpful to make the feedback variable over a small range. This will allow some adjustment of bandwidth, although not without varying q simultaneously.

The ease with which both tuning and Q can be adjusted in a two-integrator loop can also be made use of. Thus each tuned circuit can be individually adjusted to the centre frequency, allowing components of relatively broad tolerance to be used, or perhaps the nearest preferred value. Similarly

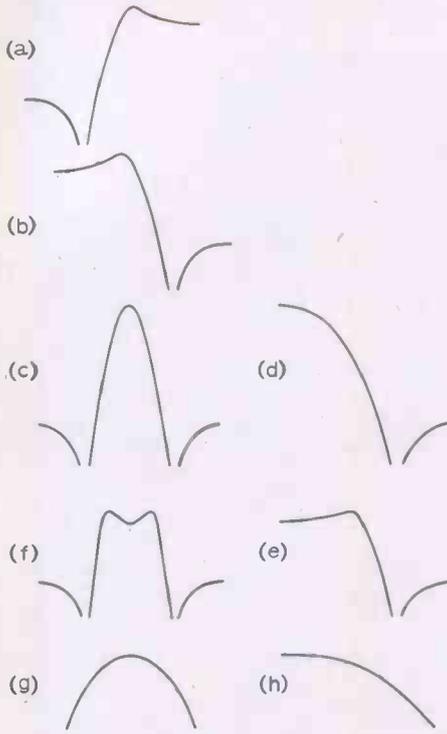


Fig. 11. Building up a 3rd-order b-p response. On the right, corresponding l-p responses.

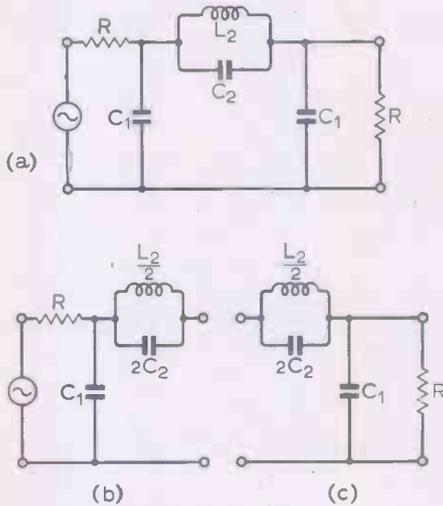


Fig. 12. Bisection of a symmetrical filter.

in a 3rd-order filter tilt in the passband can be corrected by adjusting the tuning of the single tuned circuit. If only a single resistor (or T) is varied, Q is varied with ω_0 , but for a small range of adjustment this is likely to be unimportant. In any case it is quite easy to adjust Q also.

Probably most active band-pass filters at the present time use a balanced parallel-tee network (see Parts 10 and 11). Fig. 10 shows a circuit for a 2nd-order filter which was designed for $\frac{1}{3}$ rd-octave bandwidth approximately. The tuned stages use the Sallen-and-Key type of connection and are arranged as low-pass \times high-pass, which also usefully multiplies the forward gain by Q^2 . An untuned input stage puts the necessary sign reversal into the loop, and allows adjustment of overall gain without affecting the tuned stages. Adjustment of the feedback is also provided, but if the required com-

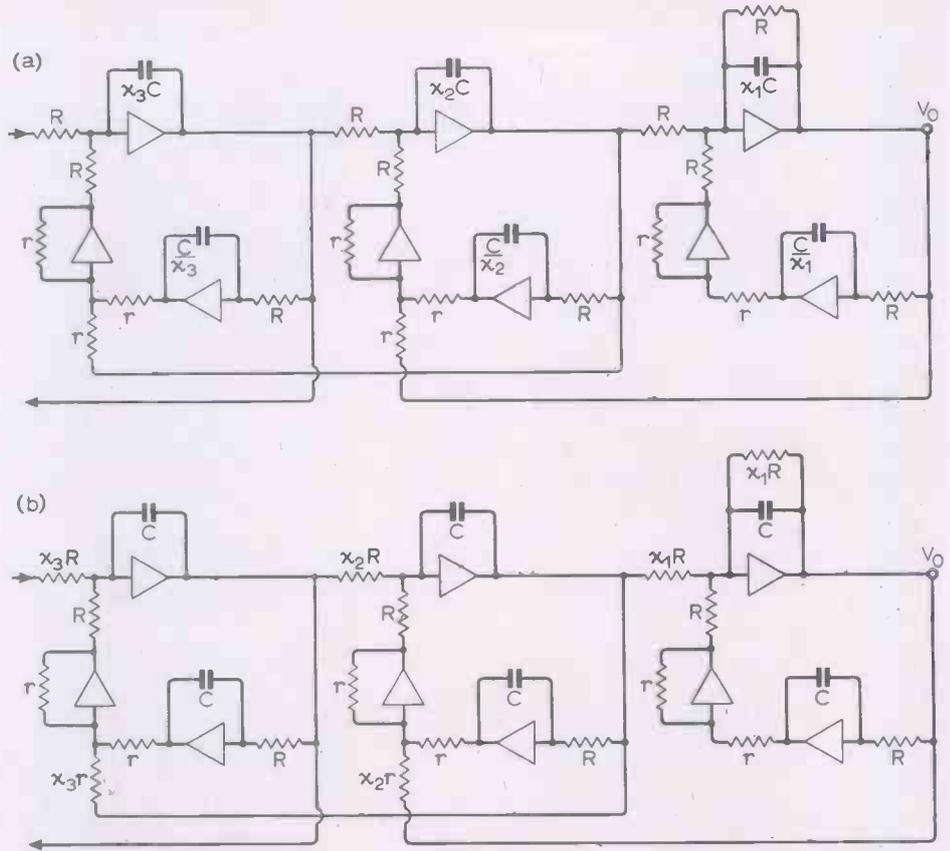


Fig. 13. As first derived the integrators of the elementary tuned circuits have different T_s (CR products). This can be corrected by making the changes shown in (b).

bination of bandwidth and q is not obtained the damping of one or both stages must be adjusted.

As the bandwidth is over 20% of the centre frequency, a reasonable tolerance on the time constant of the tees is $\pm 1\%$. To ensure that each twin tee is well balanced, however, so that the expected value of Q is obtained, it is advisable to make each up from matched pairs of components as explained in Part 11 (June). As a b-p system is not required to pass zero frequency, the amplifiers do not need to have low zero drift; and as Q is only moderate, the internal gain need not be very high. The amplifiers can, therefore, be quite simple—though they can be high-gain types provided they will give the required output at the highest frequency with low distortion.

The attenuation of a 2nd-order Butterworth filter is given by $(1+x^4)^{\frac{1}{2}}$, where $x = \text{actual bandwidth}/\text{3-dB bandwidth}$. So 20 dB is obtained at $x = 99^{\frac{1}{2}} = 3.155$; 40 dB at $x = 10$ approximately.

An advantage of the parallel-tee circuit is that zeros are easily added. Thus a 3rd-order b-p filter can be built up as in Fig. 11. The 2nd-order loop contains a 1-p and a h-p stage, and these are given zeros (a) and (b) by feeding a fraction of the input to the other tee (Part 11, Fig. 11) so that an open-loop response as (c) is obtained. If this is symmetrical it can be represented by the transfer function of the corresponding 1-p response (d) of the form

$$\frac{1+k^2p^2T^2}{1+pT/2+p^2T^2}$$

and the amount of feedback calculated which will give a 1-p response such as (e) and to the b-p circuit an "over-coupled" response

(f). The hole in the middle can then be "filled up" with a single tuned circuit (g) corresponding to a simple lag (h).

A suitable model is a 3rd-order Darlington filter, Fig. 12(a). Being a symmetrical network it can be divided into two halves with $Z_{out(1)} = Z_{in(2)}$, and its transfer function may be written down as $\frac{1}{2}$ the product of the transfer functions of the subnetworks so formed, Figs 12(b) and (c). These are:

$$\frac{1}{1+pC_1R} \cdot \frac{1+p^2L_2C_4}{1+pL_2/2R+p^2L_2(C_1+C_4)/2}$$

and can act directly as 1-p models for the single tuned circuit and the 2nd-order loop of the active b-p filter, the required bandwidths and q being obtained by comparing these transfer functions with transfer functions written in standard form, $1/(1+pT_1)$ and $(1+ap^2T_2^2)/(1+pT_2/q+p^2T_2^2)$.

Parallel-tee stages can be given variable tuning (Part 11); but this usually requires extra amplifiers, and the short-circuited-output time constants of the two tees must still be equal. So the practicability of a parallel-tee filter, or bank of filters, depends very much on the cost and difficulty of obtaining accurate components for the parallel-tee networks. As the price of gain comes down, therefore, the preference is likely to go to circuits which, while needing more amplifiers, have less severe requirements for passive components.

Active ladders

The first stage in preparing a design for a band-pass active ladder filter has already

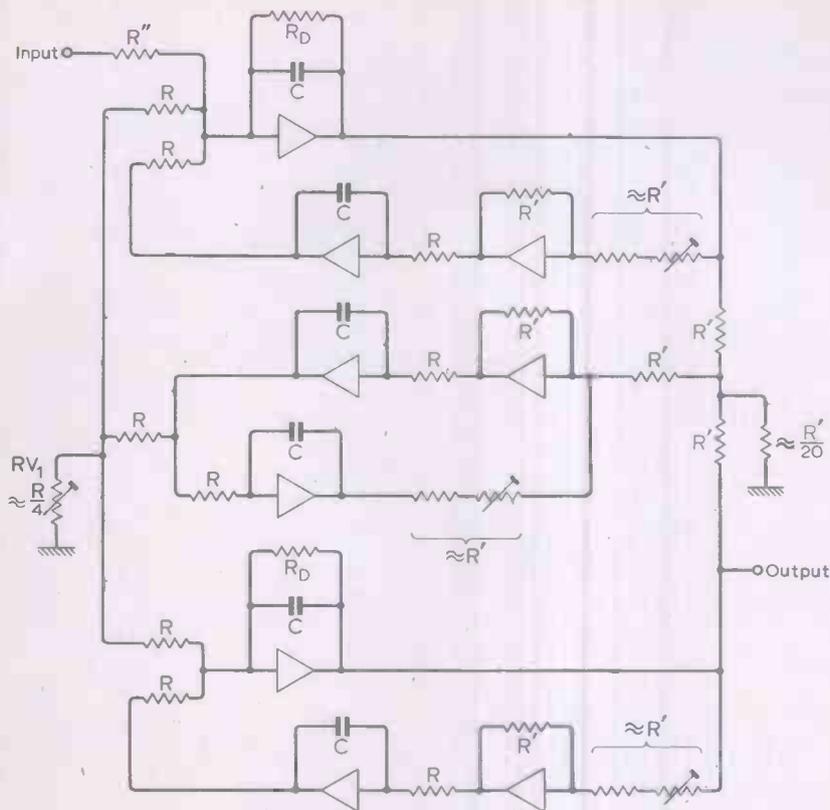
been given (Part 13, Fig. 17). But when the centre frequency is much greater than the bandwidth ($\omega_0 \gg \omega_c$), L_1/R , C_2R , L_3/R of diagram (b), where L_1 , C_2 , L_3 , come from the 1-p filter of equal bandwidth, are much greater than $C_1'R$, L_2'/R , $C_3'R$, where C_1' etc. are the reactances added to transform the 1-p filter to b-p. Thus, for example, for 5th-order Butterworth response with $\omega_c = 20$ Hz, $\omega_0 = 225$ Hz, $T_1 = T_5 = 4.92$ and $T_1' = T_5' = 0.1017$, $T_2 = T_4 = 12.88$ and $T_2' = T_4' = 0.03885$, $T_3 = 15.92$ and $T_3' = 0.03143$ (all in milliseconds). This is undesirable. As $T_0 = 1/\omega_0 = 0.707$ ms, the integrators of low T would work with voltage gains of up to twenty and more. So they would develop output voltages up to that number of times greater than the voltages at the outputs of the integrators feeding them, which is bad for dynamic range; and the elementary tuned circuits which they form with those integrators would be likely to have a lower Q factor than need be, since if the zero-frequency gains of the integrators are equal the best performance is obtained with T s equal.

This condition is obtained by making the T of each integrator = T_0 , and readjusting the linkages between the tuned circuits so that all loops have the same loop gains as before. If the T of one of the integrators in the forward path is changed from T_1 (say) to T_0 , the signal voltage at its output is multiplied by T_1/T_0 . The loop gain of the minor loop, the elementary tuned circuit, has simultaneously been restored to its former value by changing the T of the other integrator from T_1' to T_0 —and $T_1 T_1' = T_0^2 = 1/\omega_0^2$. Compensation in all other paths including the T_1 integrator is effected by introducing a multiplying factor T_0/T_1 , which may in practice mean multiplying one or more resistances by T_1/T_0 , Fig. 13.

The ratios T_0/T_1 , T_0/T_2 etc., although not in general equal, are all roughly equal to bandwidth/centre frequency, say $1/Q_B$; and the ratios T_0/T_1' , T_0/T_2' etc., roughly equal to Q_B . And, if more convenient, all the T s of the first set of integrators may be multiplied by $1/Q_B$, and all of the second set by Q_B , as this will bring them near enough together for the elementary tuned circuits to give good performance. The scaling factors to be introduced into the linkages between the tuned circuits will now all be $1/Q_B$. It will still be practicable to use the same value of C for all the integrators, by obtaining the required spread of T by variation of R .

After scaling, a filter with a relatively narrow pass band ($Q_B \gg 1$) is seen to consist of n two-integrator loops, where n is the order of the 1-p filter used as model, loosely coupled together. This points to a rough analogy between a coupled-tuned-circuit filter and a ladder b-p filter, in which the loose coupling needed for a relatively narrow bandwidth is obtained by making the reactances of the shunt branches much smaller than those of the series branches.

The analogy may be put to use in a 3rd-order b-p filter as shown in Fig. 14. RV_1 is placed so that the symmetry of the system is preserved and allows simultaneous adjustment of the loop gains of the two inter-



$C = 0.01\mu$, $R = R' - R'' = 100k$, $R_D = 16R$
Amplifiers type 741

Fig. 14. 3rd-order b-p filter with adjustable coupling.

meshing feedback loops. As it is increased from a low value the response changes from single-peaked, through a maximally flat response (Butterworth), to the overcoupled type of response, Fig. 15. Ideally the three peaks have equal height. This depends on the central tuned circuit having infinite Q . If it has appreciable damping the outer peaks are lower than the middle peak and may become only shoulders. Compensation can be made by applying to the central stage regeneration or positive feedback.

Other types of tuned circuit can be used in place of the two-integrator loops, provided the inside ones have high Q (approaching infinity). Thus Fig. 16 shows a 3rd-order filter using parallel-tee circuits. By making use of the identity expressed in eqn: (22), and by making the middle stage sign-inverting and the outer stages not, the feedback loops have been closed in the right sense, without the use of separate inverting or adding stages. So the filter is economical in amplifiers, using only one third as many as the previous circuit. But although the equally terminated structure is some help against the effects of mistuning, the Q factors of the tuned circuits are still very dependent on accurate balance in the twin-tee networks, and at least twice as many capacitors are needed.

Electronic tuning

An all-integrator circuit lends itself to electronic (voltage-controlled) tuning (Part 8, Fig. 11). The electronic switches are equivalent to accurately ganged potentiometers, and the effective T of each integrator in series with a switch varies inversely with the mark/period ratio.

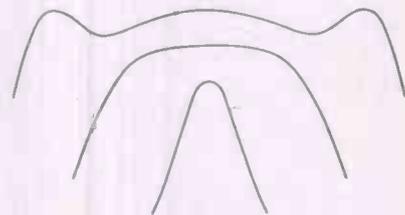


Fig. 15. Showing effect of increasing coupling in a 3rd-order b-p ladder filter.

In the passive band-pass model (Fig. 17(a) of Part 13) centre frequency is determined by the LC product of the elementary tuned circuits, $L_1 C_1' = C_2 L_2' = \text{etc.} = 1/\omega_0^2$. The bandwidth is given by only L_1/R , $C_2 R$, L_3/R , etc., L_1 , C_2 , L_3 , and R , being the components derived from the 1-p counterpart. If all reactances are multiplied by x , both $1/\omega_0$ and $1/\text{bandwidth}$ are multiplied by x ; so the frequency response curve is moved down the frequency scale and keeps the same ratio of bandwidth to centre frequency. By analogy with a single tuned circuit this may be called constant- Q tuning. Because of the linear relationship between x and $1/\omega_0$, it is quite easy in the active ladder to reduce ω_0 say ten times. But the tuning reduces the effective A (zero-frequency gain) of each integrator; so as the constant- Q nature of the tuning means that ideally the same Q factors are called for, some deterioration of the sharpness of the corners of the passband may be experienced.

If only the primed reactances are varied tuning is obtained with constant bandwidth. The centre frequency, $\omega_0 \propto 1/\sqrt{x}$; and, because of the constant bandwidth, the Q factors called for are proportional to ω_0 and therefore fall as ω_0 is reduced. It is likely,

* 1 Hz = 2π radians/second.

therefore, that the tuning range found practicable will be smaller, and that in compensation deterioration of bandshape at the lowest frequency will also be less.

Once again we are indebted to Dr R. L. Ford for showing that the versatility of the active filter does not end here and that it is possible to vary bandwidth independently of ω_0 . To do this it must be possible to increase the effective value of L_1, C_2, L_3 , etc., for transmission round the larger loops, while leaving the tuning of the minor loops unchanged. The switches are therefore placed as shown in Fig. 17. Operation of switches k_2 varies the bandwidth, operation of switches k_1 varies the centre frequency, operation of both sets simultaneously gives the constant- Q type of tuning. If zeros are introduced by adding linkages as described in Part 13, these also move under the action of the switches, as their positions also depend on the effective T s of the integrators.

Stagger tuning

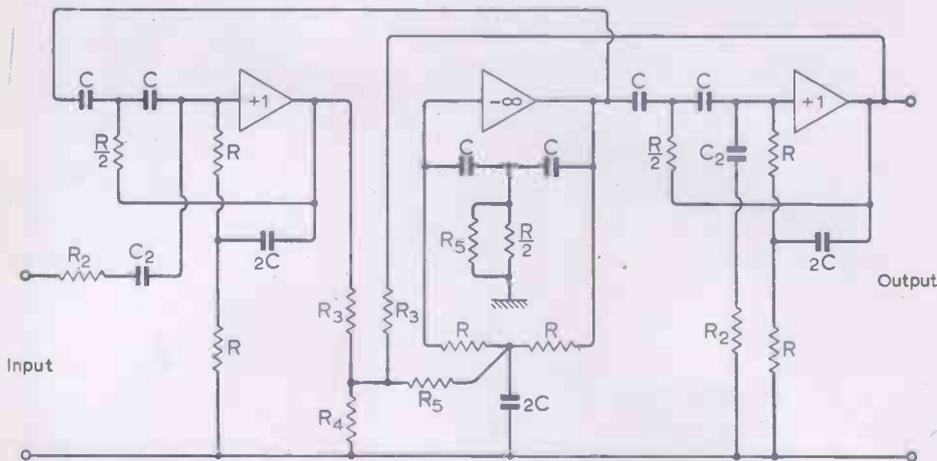
Consideration of symmetry shows that when two tuned circuits are staggered to give a 2nd-order b-p response they must be of equal Q , and that the centre frequency of the combined response is the geometric mean of the centre frequencies of the two factors. Hence the pole positions are as shown in Fig. 18, and the normalized responses may be written

$$G_1(\omega) = \frac{1}{1+jQ(\omega/x-x/\omega)} \quad (27)$$

$$G_2(\omega) = \frac{1}{1+jQ(\omega x-1/\omega x)} \quad (28)$$

The product gives an expression for the overall gain, and from this by substituting $\Omega = \omega - 1/\omega$, which is equn. (1) when $\omega_0 = 1$, the frequency-response function for the corresponding l-p response is obtained as

$$G(\Omega) = \frac{1}{1+Q^2\left(x-\frac{1}{x}\right)^2+jQ\left(x+\frac{1}{x}\right)\Omega-Q^2\Omega^2} \quad (29)$$



$C = 0.05\mu, R = 50k, C_2 = 1,250p, R_2 = 2.0M, R_3 = 27k, R_4 = 1.2k, R_5 = 470k$
Amplifiers type 741

Fig. 16. 3rd-order b-p active ladder filter using parallel-T circuits.

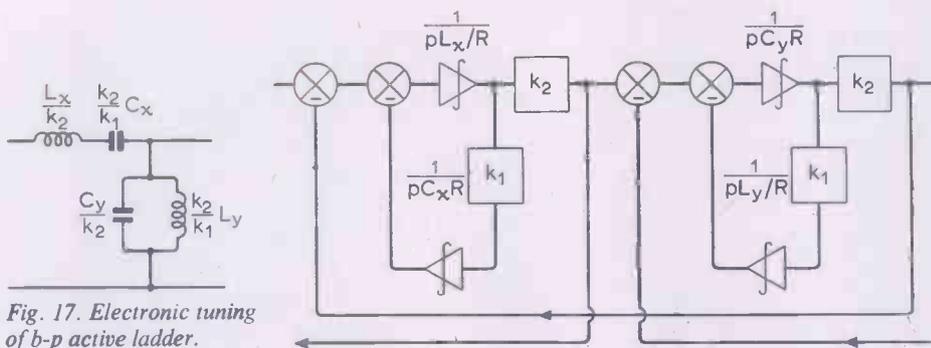


Fig. 17. Electronic tuning of b-p active ladder.

If S is defined by

$$x - 1/x = 1/S, \quad (30)$$

$$x + 1/x = 2\sqrt{1+1/4S^2} \quad (31)$$

So equn. (29) becomes

$$G(\Omega) = \frac{1}{1+Q^2/S^2+j2Q\sqrt{1+1/4S^2}\Omega-Q^2\Omega^2} \quad (32)$$

and comparison with

$$G(\Omega) = \frac{1}{1+j\Omega/q\omega_c-\Omega^2/\omega_c^2} \quad (33)$$

gives

$$q = \frac{1}{2} \sqrt{\frac{1+Q^2/S^2}{1+1/4S^2}} \quad (34)$$

$$\omega_c = \frac{1}{Q} \sqrt{1+\frac{Q^2}{S^2}} \quad (35)$$

So, for example, if $S = Q$, the bandwidth obtained is $\sqrt{2}/Q$, i.e. $\sqrt{2}$ times the bandwidth that the tuned circuits would have if not staggered.

For the general case where the overall response is centred on ω_0

$$\omega_c = \frac{\omega_0}{Q} \sqrt{1+Q^2/S^2} \quad (36)$$

Now ω_0/ω_c is the parameter Q_B . For brevity let $B = Q_B$. Equn. (36) may then be written

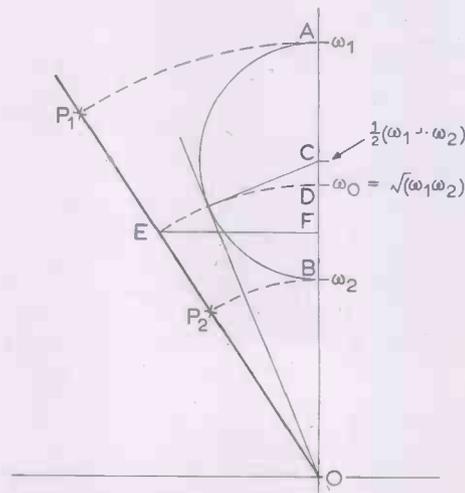


Fig. 18. Pole positions for 2nd-order band-pass response.

$$\frac{1}{B} = \frac{1}{Q} \sqrt{1+Q^2/S^2} \quad (37)$$

or
$$\frac{1}{B^2} = \frac{1}{Q^2} + \frac{1}{S^2} \quad (38)$$

Thus q , the shape factor, and $1/B$, the relative bandwidth, may be calculated for any combination of Q and S .

For relatively narrow bandwidths $1/4S^2 \ll 1$, so equn. (34) becomes

$$q = \frac{1}{2} \sqrt{1+Q^2/S^2} \quad (39)$$

and substitution in equn. (37) gives

$$Q = 2qB. \quad (40)$$

The above results may be used to analyse the performance of a h-p filter and a l-p filter in tandem, using the identity already given, equn. (22). Thus equn. (34) shows that for very great staggering ($4S^2 \ll 1$ and $S^2 \ll Q^2$) $q \rightarrow Q$; but that for $Q > \frac{1}{2}$, as S increases q falls, until for no stagger $q = \frac{1}{2}$.

Stagger tuning is not a good practical method of making a filter, as obtaining a flat pass band depends so much on balancing one slope against another (e.g. see Ref. 1, Fig. 10.16). But the analysis is of theoretical interest as it gives the resonant frequencies and Q factors of a b-p system.

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Current Generators

Some circuit techniques used to design discrete component and integrated circuit current generators

by B. L. Hart,* B.Sc., M.I.E.R.E.

Good approximations to voltage sources are commonplace in electronic circuits and are widely used in equipment design. Familiar examples are the low impedance d.c. power supply and the "follower" circuit in all its guises (cathode, emitter, etc.).

Less well known, but often very useful, are current source circuits or current generators. These are required in the measurement of semiconductor d.c. characteristics when a specified current is caused to flow between the terminals of a device and a breakdown voltage observed. Also a current source is required for the linear charging of a capacitor to produce an accurate linear sawtooth voltage waveform in timing applications. Such a scheme has the advantage over a conventional "Miller" circuit of producing no initial jump and not requiring a floating clamp.

Review of fundamentals

The first quadrant characteristics of an ideal controllable current generator are evident from Fig. 1(a); these are:

- (i) Infinite i.f. incremental resistance for $V \geq 0$.
- (ii) The d.c. current is dependent on only one chosen variable λ . This parameter could represent the effect of variation in a circuit resistance, current, voltage, charge, applied pressure, or radiation intensity, etc. The practical situation corresponding to Fig. 1(a) is shown, exaggerated for clarity, in Fig. 1(b). Curve (1) is now only approximately straight over a region between two arbitrarily defined points A and B being limited beyond these points by physical mechanisms such as voltage saturation and breakdown. The incremental output resistance at point P, $r_o [= (\delta I / \delta V)_\lambda]$ is not infinite and may be a function of λ and V , depending on the precise nature and spacing of the curves. Furthermore, λ may not represent only the effect of one variable. It is desirable that the variable at our disposal, e.g. resistance, is dominant, and that there is a relative insensitivity, calculable in magnitude, of set current I , and resistance r_o with respect to the other variable parameters. In most cases of practical interest the disturbing functions are temperature and rail voltage variation.

Before passing to specific circuit realizations and assessing to what extent they

succeed in satisfying the ideal criteria discussed above, it is worth noting that current generators may be simply paralleled. One easily-met requirement is that the common load resistance is much less than the r_o of each source.

Basic circuit schemes

One of the simplest and most frequently encountered current sources is that shown in Fig. 2(a), in which D_2 is a zener diode (preferably temperature-compensated) operating in the breakdown region.

Normally $V_Z \gg \delta_1, \delta_2$, and $\delta_1 \approx \delta_2$; hence if α = common-base current gain of Tr_1 , then for $BV_{CBO} > V \gg (V_Z + \delta_2)$,

$$I \approx \alpha V_Z / (R_E + R_V) \quad (1)$$

$$r_o \approx 1/h_{ob} = f(I) \quad (2)$$

Potentiometer R_V is the controlling variable. This may be manually operated or mechanically driven, or might represent an f.e.t. operated in the pre-pinch-off region. The main disturbing influences are variations of temperature (T), and change in V_1 . The latter produces a change in V_Z because of alteration in zener current; this may be reduced by replacing R_B by a similar current source using a p-n-p transistor. Since α and V_Z are weak functions of T , I is not sensibly dependent on this variable. Sometimes the lower limit of the voltage range is unacceptably high.

If a negative rail is available then the simple arrangement of Fig. 2(b) is useful. The stability of I is directly dependent on $-V_1$ for this configuration.

For the case where a negative rail voltage is not available the circuit of Fig. 3(a) may be used. This has been used by the author

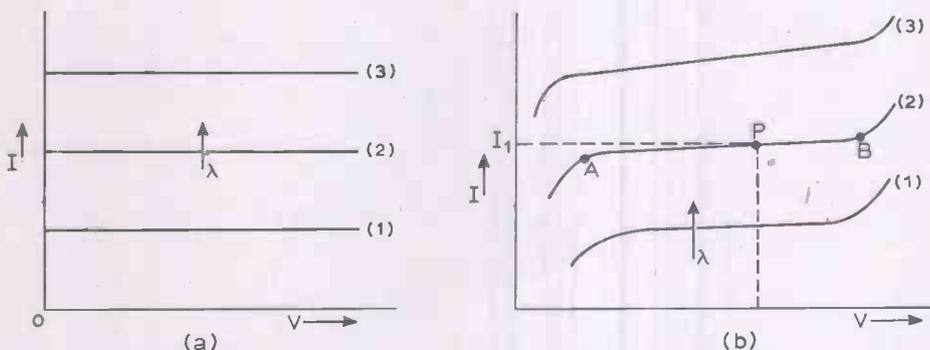


Fig. 1. (a) First quadrant characteristics of ideal current source. (b) Characteristics of practical current source.

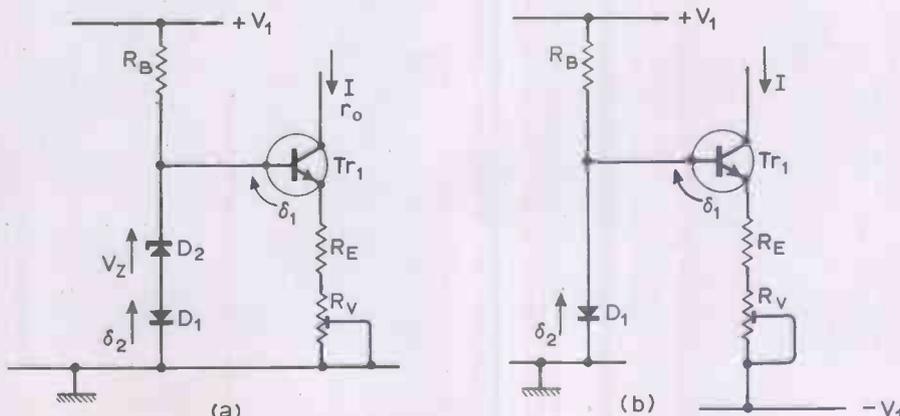


Fig. 2 (a) Popular current source circuit. (b) Current source using two rail supplies.

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to obtain the maximum input voltage range in a long-tailed pair differential comparator.

Tr_1 is a germanium transistor whilst D_1 is a silicon diode.

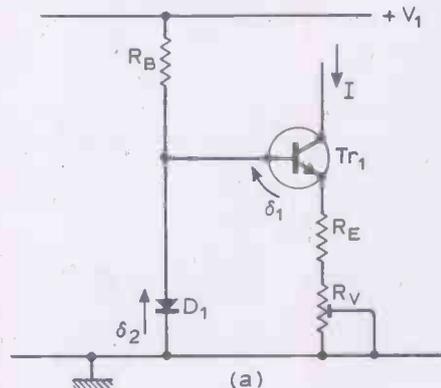
It follows that, for $V_u > V \gg \delta_2$, where V_u is the upper limit of the voltage range,

$$I = \alpha(\delta_2 - \delta_1)/(R_E + R_V) \quad (3)$$

$$1/h_{oe} < r_o < 1/h_{ob} \quad (4)$$

V_u , and the actual value of r_o both depend on $(R_E + R_V)$ and the incremental resistance of D_1 .

Assuming a logarithmic volt-amp. relationship for D_1 , a $\times 4$ change in V_1 causes a change in I of about 10% for $\delta_2 \approx 0.6$ V and $\delta_1 \approx 0.2$ V.



Because of the larger value of I_{CBO} for germanium transistors and the fact that $|d\delta_2/dT| \neq |d\delta_1/dT|$ there is an increased temperature sensitivity for this configuration compared with that of Fig. 2(a).

To obtain the output characteristics, shown in Fig. 3(b), on a curve tracer (Tektronix 575) R_B is removed and the rest of the circuit treated as a transistor—the emitter of which is the junction of D_1 and R_V —subject to base current drive in the common-emitter configuration. The logarithmic relationship between applied current and δ_2 causes two effects which are visible on the photograph.

In the first place the curves become al-

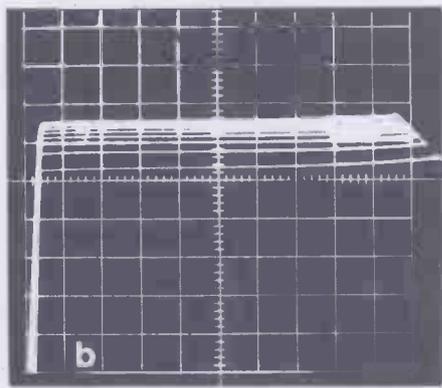


Fig. 3. (a) Useful alternative circuit to Fig. 2(a). (b) Output characteristics for circuit of Fig. 2(b). Scale: vertical 1 mA/div; horizontal 2 V/div. Steps 0.5 mA.

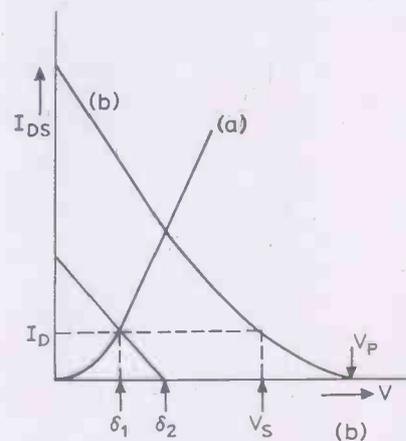
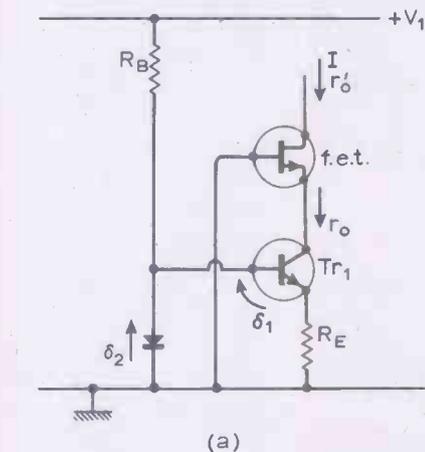


Fig. 4. (a) Improved form of circuit in Fig. 3(a). (b) Load line construction for 4(a).

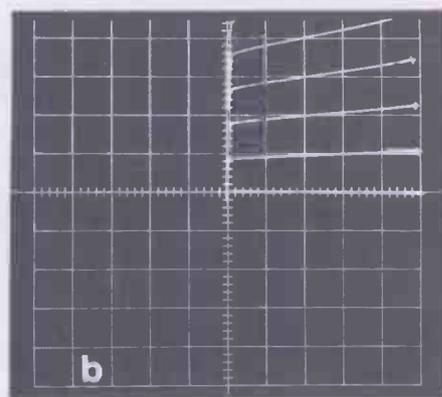
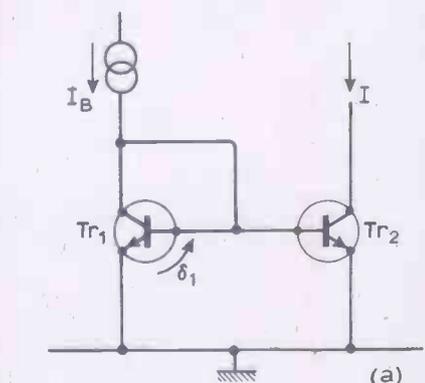


Fig. 5. (a) Integrated transistor pair in "current mirror" configuration. Emitter area ratio 1: m. (b) Current mirror characteristics using SL303A. Scales: vertical 1 mA/div; horizontal 2 V/div. Steps: 1 mA.

most parallel to the voltage axis at points successively shifted to the right by a small amount. This occurs because the saturation condition $V_{CB} = 0$ is a function of drive current.

Secondly, the characteristics are unequally spaced in the vertical direction.

In a practical circuit a selected value of R_B corresponds to a particular base current step. The vertical spacing thus gives a measure of the effect of R_B tolerance on circuit performance. For predictable behaviour it is arranged that $(V_1/R_B) \geq (I/\beta)$ where β = common emitter d.c. current gain of Tr_1 . The results were obtained using an OC139 for Tr_1 and a low cost 1N4148 for D_1 . R_V was set at a convenient value: in cases where R_V is dispensed with, a closer tolerance on a fixed I may be obtained by using a well-specified diode, such as the 1N3595, for D_1 .

If the magnitude of the minimum voltage across the terminals of the current source is not a problem the output resistance of the circuits in Figs. 2(a), 2(b) and 3(a) can be increased¹ by employing a field-effect operated in the common gate mode (see Fig. 4(a)). The output resistance is now r'_o where,

$$r'_o = r_{ds} + (\mu + 1)r_o \quad (5)$$

r_{ds} = incremental drain-source resistance of f.e.t.

μ = f.e.t. amplification factor.

For this scheme to be successful the f.e.t. must be a "normally-on" type working in the current saturation region.

A mathematical treatment of the d.c. circuit conditions is not difficult but a pictorial representation conveys the information most appropriate to a practical design. Curve (a) represents the base-emitter characteristic of Tr_1 . The load line for R_E intersects this at I_D, δ_1 . Curve (b) shows drain-source current, I_{DS} , as a function of source voltage. Since r_o is large relative to the impedance seen looking in at the source the actual source voltage, V_S , is found at the point on curve (b) corresponding to $I_{DS} = I_o$. Clearly it is required that $V_S > \delta_2$ if Tr_1 is not to saturate.

Exploitation of the matching principle

One result of modern monolithic i.c. technology is the close parameter matching and temperature tracking of components of the same type fabricated on the same semiconductor slice. This feature is widely exploited in circuit design, giving rise to some arrangements which would not normally be encountered when using discrete components.

In Fig. 5(a), two transistors Tr_1, Tr_2 , having an emitter area ratio 1: m respectively are made in close proximity on the same wafer. Tr_1 is given a collector-base strap in order to function as a diode. The circuit has been variously described as a "compound diode-transistor structure"² and "current mirror".

Ignoring base width modulation effects in Tr_2 and the difference in power dissipation in the two devices—both legitimate assumptions for small values of collector-

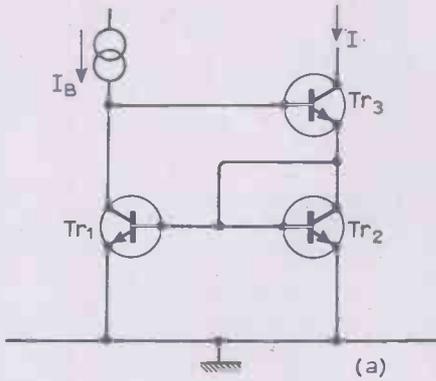
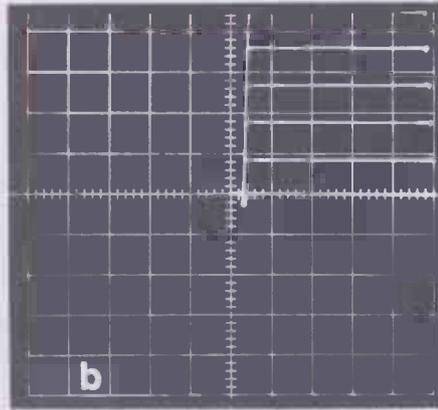


Fig. 6. (a) "Enhanced" current mirror circuit. (b) Characteristics of Fig. 5(a) using SL303A. Scales as in Fig. 5(b).



emitter voltage— it follows (see Appendix 1) that,

$$I = m\beta I_B / (m + \beta + 1) \quad (6(a))$$

or $I \approx m I_B \quad (6(b))$

for the usual case $\beta \gg 1$ and $m \leq 5$. The effective current gain of the combination is $\beta^* = I/I_B \approx m$. Gain precision has thus been obtained at the expense of gain magnitude—a familiar feature in feedback systems.

Equation 6(a) is true provided Tr_1 functions as a "well-behaved diode": in the present context this means a logarithmic current-voltage characteristic whatever the current level. Now the collector-base region of Tr_1 , is, in fact, < 0 by $\approx IR_{sat}$ where R_{sat} is the collector saturation resistance: it is thus necessary to use low R_{sat} devices, obtained for example by employing an n^+ buried layer technique, in order that equation 6(a) be valid.

Fig. 5(b) shows curve tracer results obtained using two matched devices of an SL303A (Plessey): in this case $m \approx 1$. Since m is a function of device geometry I is independent of T to a weak, calculable, extent. For the same approximations used in obtaining equation 6(b) from 6(a) it is simply shown that, at constant I_B ,

$$(1/I)(dI/dT) \approx (1/\beta^2)(d\beta/dT) \quad (7)$$

In fact the application of local heating to the T0-5 header (via a Thermoprobe) caused no noticeable shift in the characteristics on

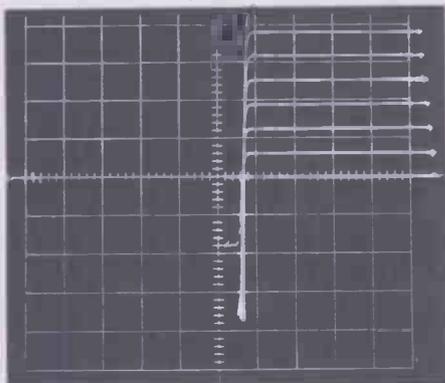


Fig. 7. Characteristics of Fig. 6(a) using sample X (Plessey). Scales: vertical 0.05 mA/div; horizontal 1 V/div. Steps: 0.1 A.

the scale used over a 50°C temp. range. However equation (7) must be used with caution since in a circuit I_B is not always fixed. If it is obtained by taking a resistor, R_B , from the collector of Tr_1 to a constant positive rail voltage, V_1 , then R_B and δ_1 both vary with T . This means that, in principle, by suitable choice of a discrete component R_B variation of I_B with T can be made to almost cancel variation of β with T . One shortcoming of the current mirror so far described is the noticeable output resistance at the collector of Tr_2 : this is not unexpected since as far as collector circuit of Tr_2 is concerned the transistor is connected in the common-emitter configuration with only a small incremental resistance between emitter and base.

At low current levels a resistance in the emitter lead of Tr_2 gives negative feedback and a consequent increased output impedance: for this case,³

$$R_E = (V_T/I) \log_e (I_B/I) \quad (8)$$

where $V_T =$ "thermal voltage" $= (KT/q)$.

This approach permits the design of current sources in the μA range: this avoids the necessity of large values of R and the resulting expensive use of chip area in monolithic circuits.

The technique is not really suitable at current levels of a few milliamps because R_E becomes very small; this means no significant output impedance improvement due to feedback, and a significant lack of precision in I .

High output impedances for currents in the milliamp range can be achieved by using the circuit of Fig. 6(a). This scheme—which might be termed the "enhanced current mirror"—is a modification of Fig. 5(a), and appears to have been first used by Wilson.⁴ Analysis, in Appendix 2, shows that if all the devices have equal emitter areas,

$$I = I_B / [1 + \{2/\beta(\beta + 2)\}] \quad (9)$$

Fig. 6(b), which should be compared with Fig. 5(b), shows the increased output resistance occurring in this circuit.

To obtain the trace an SL303A was used: this contains two matched transistors (Tr_1, Tr_2) suitable for use in a long-tailed pair and a third transistor (Tr_3) suitable for use in its current tail. Fig. (7) shows results

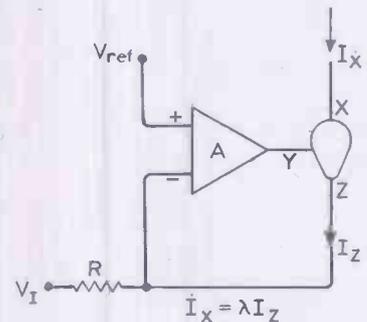
for a specially supplied device in which the area ratio of the matched transistors used in the circuit of Fig. 6(a) is 1 : 3.

Feedback amplifier schemes

Some of the limitations of the simple current generators so far considered may be overcome by using circuits having a large amount of negative feedback. This condition is easily met if plenty of gain is available. Such gain is readily and cheaply obtained with i.c. operational amplifiers. The input stages of these amplifiers will, incidentally, almost certainly contain a current-mirror type of current source functioning as an emitter or common-emitter load.

Fig. 8(a) shows the arrangement of a class of precision current generators in which a discrete active device is combined with an i.c. amplifier. The device—represented by the pear shaped symbol⁵—may, in principle, be any amplifying element with three electrodes. Terminals X, Y, Z are defined in Fig. 8(b) for the three types of unit most likely to be used. Control is effected between Y and Z and the output current, I_x , appears at terminal X.

It follows from established operational



(a)

	Thermionic valve	Bipolar transistor	Unipolar transistor
X	Anode	Collector	Drain
Y	Grid	Base	Gate
Z	Cathode	Emitter	Source

(b)

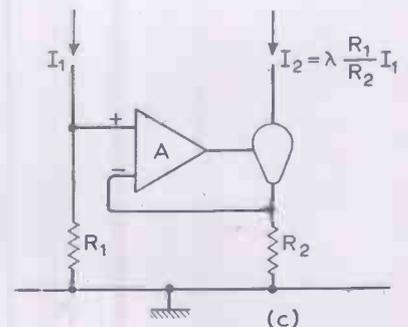


Fig. 8 (a) Current Source using 0 p. amp. and active device. (b) Terminal identification for general active device of 8(a). (c) Circuit for obtaining precise current ratio.

amplifier theory that if $A \gg 1$ and common-mode effects are neglected,

$$I_x \approx \lambda(V_{ref} - V_I)/R \quad (10)$$

The variables at our disposal for fixing I_x are thus V_I , V_{ref} , R . Suppose V_{ref} is considered as the "input". Then I_x increases with V_{ref} . Also, the current supplied by V_{ref} to the positive input is very low, being only the amplifier input bias current. The latter can be reduced to negligible proportions ($< 1\text{pA}$) if an f.e.t. input stage is employed. Fig. 8(c) indicates a method whereby a current I_2 may be made strictly proportional to I_1 . This follows from Fig. 8(a) by making $V_I = 0$ and $V_{ref} = I_1 R_1$. When V_I is regarded as the "input", I_x decreases with V_I and the current supplied by V_I is the output current (I_x).

To reduce the current demanded of V_I while at the same time maintaining the same I_x as before the circuit of Fig. 9 may be used. V_I now exerts control over the current furnished through additional resistor R_z connected to constant supply V_{ZZ} . $R' (> R)$ gives a reduced input current.

It must be noted that I_x is only as constant as the d.c. source(s) which define it. The effect of feedback is to increase the output resistance of the active device and to reduce the sensitivity of I_x to parameter variations in the active device due to ageing, replacement, etc. This is shown, for $V_I = 0$, by a more accurate expression for I_x , viz,

$$I_x \approx \lambda(AV_{ref} - V_{YZ})/(A+1)R \quad (11)$$

V_{YZ} is thus effectively reduced by a factor $1/(A+1)$.

The question arises as to whether it is better to use a bipolar transistor or an f.e.t. for the active device. This cannot be answered directly unless the requirements of the intended application are more closely specified. In some cases e.g. high current levels, a bipolar device is obligatory for current handling capability.

However, in making a choice the following points should be borne in mind. They apply to Fig. 8(a) for specified V_I , V_{ref} , R , and A .

1. It is the current in R that is "sensed" and kept constant by the feedback connection. Now with an f.e.t. $\lambda = 1$, so I_x is kept constant also. With a bipolar device $\lambda = \alpha$ (common-base current gain). Since α varies with T keeping the current in R constant will not ensure I_x 's constancy.

2. Errors due to V_{YZ} uncertainty will be

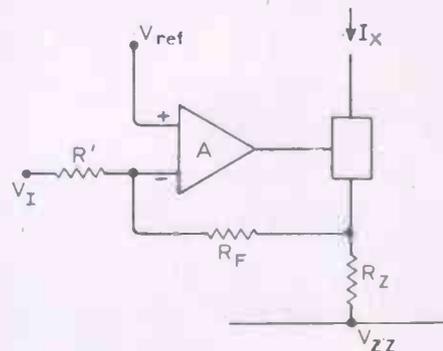


Fig. 9. Variation of Fig. 8(a) for reduced current from V_I .

slightly greater for an f.e.t. simply because V_{YZ} is in general much larger.

3. Because of the large impedance mismatch between the output of the amplifier and the input of the f.e.t. (operated at zero gate current) using an f.e.t. is likely to give marginally more voltage loop gain.

The extent to which the last two factors are troublesome is obviously dependent on the magnitude of A .

Appendix

1. "Current mirror" analysis

If, in Fig. 5(a), I_{E1} and I_{E2} are the emitter currents of Tr_1 , Tr_2 respectively, current addition at the commoned base terminal yields,

$$I_B = I_{E1} + \{I_{E2}/(1 + \beta)\} \quad A.1.$$

$$\text{but, } I_{E1} = I_{E2}/m \quad A.2.$$

$$\therefore I_{E2}[(1/m) + 1/(1 + \beta)] = I_B \quad A.3.$$

$$\text{now, } I = \alpha I_{E2} \quad A.4.$$

$$\text{hence } I = \alpha I_B / [(1/m) + 1/(1 + \beta)] \quad A.5.$$

or, rearranging

$$I = m\beta I_B / (m + \beta + 1) \quad A.6.$$

$$\text{and } (I/I_B) = \beta^* \approx m, \text{ for small "m" and } \beta \gg 1 \quad A.7.$$

2. "Enhanced current-mirror" analysis

If, in Fig. 6(a),

I_{C1} = collector current of Tr_1 ,

I_{E3} = emitter current of Tr_3

then from A.6 above, with $m = 1$,

$$I_{C1} = \{\beta/(\beta + 2)\} I_{E3} \quad A.8.$$

summing currents at the base of Tr_3 ,

$$I_B = I_{C1} + I_{E3}/(1 + \beta) \quad A.9.$$

$$\text{or, } I_B = I_{E3} \{ \beta/(\beta + 2) + 1/(1 + \beta) \} \quad A.10.$$

$$\text{now } I = \alpha I_{E3} \quad A.11.$$

$$I = \alpha I_B / \{ \beta/(\beta + 2) + 1/(1 + \beta) \} \quad A.12.$$

rearranging

$$I = I_B / [1 + \{2/\beta(\beta + 2)\}] \quad A.13.$$

This gives (I/I_B) closer to unity than A.6 with $m = 1$.

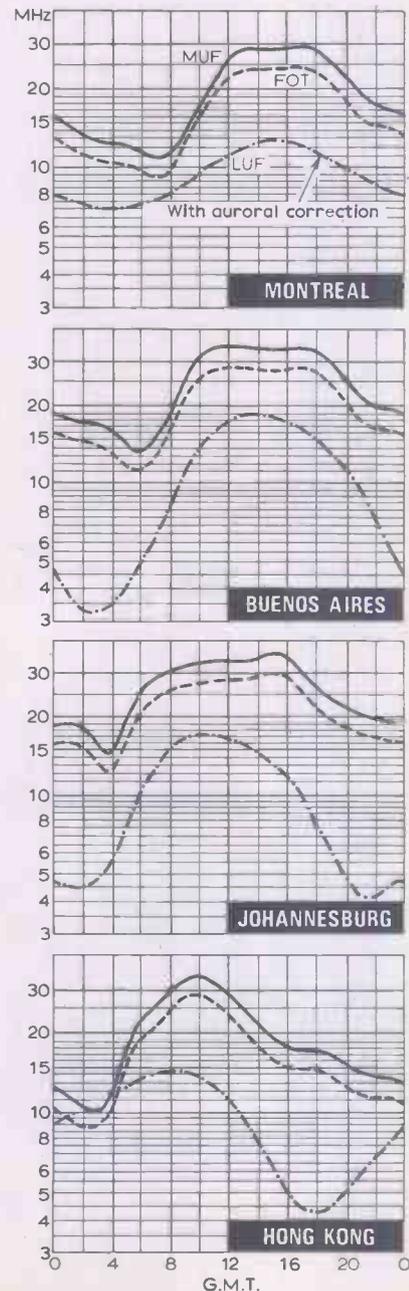
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H.F. Predictions— October

The curves show median standard MUF (frequency at which high- and low-angle ray paths coincide), optimum traffic frequency (MUF exceeded on 90% of days) and lowest usable frequency (LUF) for reception in the UK. LUF is the frequency above which the signal/noise ratio at receiver input exceeds a required value on 90% of days. The curves were drawn by Cable and Wireless Ltd for commercial telegraph operation using high power and directive aerials. Curves for a 50kW broadcast service would be very similar and rough estimates for other services can be made by increasing LUF 1.5MHz for each 10dB drop in e.r.p.

Day-to-day variations in height and density of ionospheric layers and hence deviations from chart values are greatest during equinox months around sunspot maximum as at present.



World of Amateur Radio

Amateur radio in Poland

The Polish amateur radio society Polski Związek Krotchofalowcow (PZK) is this year celebrating its 40th anniversary. A special jubilee meeting is being held on October 25th. Today there are 6000 members of PZK, about half of them licensed amateurs. Although the Polish authorities closed PZK in 1950, and then advised amateurs to join the official "League of friendship with the Army", the Polish amateurs re-established their own society in 1957 following internal changes in Poland in 1956. Current PZK activities include a journal, contests, QSL bureau, maintaining regional amateur measuring laboratories, running amateur radio courses and supplying emergency communications during floods or forest fires. Over 400 local radio clubs are in affiliation with PZK which, in 1963, became the first Iron Curtain country to re-join the International Amateur Radio Union. There are now over 2500 Class I licenses (h.f./v.h.f.), 450 Class II (v.h.f. only) and 400 club stations. Class I permits range from 20 watts (age 15 to 18), 50 watts (over 18), 250 watts (after 6 years) to 750 watts (on request after 10 years).

Long distances on MHz?

Two recent studies underline dramatically the potential of frequencies as high as 70 MHz to support long-distance ionospheric propagation at low-power. The Canadian amateur, Geoff Kennedy (VE2AI0), of Valois, Province of Quebec, has successfully received 70.275 MHz signals from the low-power TF3VHF beacon transmitter on Iceland, and is now striving to make a 50/70 MHz cross-band contact with the U.K. or continental Europe (he transmits on 50.055 MHz c.w.). The Canadian, already well-known for his intensive work on 50 and 70 MHz, believes there may be a connection between auroral, sporadic E and transequatorial (t.e.) modes of propagation.

This theory receives support from the results of an extended Japanese investigation into t.e. propagation on 32, 48 and 72 MHz over a 4850-km path from

Darwin, Australia, to Yamagawa, Japan (K. Tao *et al*, *Journal of the Radio Research Laboratories* [Japan] January 1970). This demonstrates that, even in years of low sunspot activity, t.e. propagation frequently extends, particularly in the evening-to-midnight equinoctial periods, to at least 72 MHz. It is noted that t.e. conditions appear to follow "spread F" occurrences and correlate with local sporadic E conditions. The Japanese team suggests that around 32 MHz there are two separate t.e. modes; one during daylight subject to a violent interference-type fading range of about 25 dB; and the night-time mode with a fading range of about 10 dB. The interest of propagation research workers in t.e. was aroused initially by long-distance amateur contacts across the equator in the 50-MHz band during the period 1947-51; this interesting "chordal hop" mode has since been confirmed by many professional and amateur studies—but there clearly remains much opportunity for further study of t.e. in the 28-, 50- (not available in the U.K.) and 70-MHz amateur bands.

Rise in Morse Test charges

From October 1st, Minpostel is increasing the fee for the Morse Test needed to obtain a U.K. Amateur (Sound) Licence A from ten shillings to £1. The Federal Communications Commission has recently raised the fees charged to U.S. amateurs (who for many years paid no licence fees) though these remain modest by European standards. The charge is now \$9 for new, renewed or upgraded operator licenses, but this covers five years. No fees are charged for Novice licences.

Trans-arctic expedition lecture

Radio communications played a vital role in the four-man polar crossing, led by Wally Herbert, in 1968-69. At an R.S.G.B. lecture on Monday, September 28th at 18.30 at the I.E.E., Savoy Place, London W.C.1, Squadron Leader Freddy Church (the expedition's base station operator), Dennis Collins (G2FLG) and Roly Shears (G8KW)—who

organized and operated the G7AE "weekend" stations—are to describe the expedition's communications system.

In Brief: The Mullard Jubilee Exhibition at Mullard House, Torrington Street, London W.C.1 (October 5th to 24th, excluding Sundays) is to feature an amateur station built and operated by Mullard radio amateurs and using some of the firm's earliest transmitting valves The Port Talbot R.S.G.B. group won the National Field Day shield with a score of 2386 points; Oxford and District Amateur Radio Society was the runner-up with 2174 points. The Bristol Trophy for the leading one-station entry goes to Cannock Chase society with 1633 points. . . . An unusual callsign—HG 100UA/D—has been frequently heard recently on h.f. bands; this is an exhibition station operating from various venues in Hungary to mark the centenary of the birth of Lenin Membership of the International Amateur Radio Club, with headquarters in Geneva, is now 394 A Scottish v.h.f. convention is being held at the Queen's Hotel, Dundee, on Sunday, October 11th. An afternoon programme of technical lectures will be followed by a dinner. Details from G. C. Somerville, GM3KYI 73 Balerno Street, Dundee A French biological study balloon, carrying beacon transmitters on 145.22 MHz (tone modulated) and 129.6 MHz (tone one-second pips) is to be launched in the Nancy area on Sunday, October 11th at 1400 G.M.T. and should reach maximum height about one hour later. Cardiac data on a rat will be telemetered on 27.4 MHz (reception reports to Georges Guinard, 15 Route de Villers, 54. Laxou).

PAT HAWKER, G3VA



This 28ft diameter dish was made by the Australian amateur VK3ATN for his moon-bounce experiments. The reflector uses half-inch mesh. Gain is 38dB at 1296MHz and 28dB at 432MHz. The photo was taken by L. A. Moxon (G6XN) during a recent visit.

October Meetings

Tickets are required for some meetings: readers are advised, therefore, to communicate with the society concerned

LONDON

1st. I.E.R.E.—“Some aspects of the design of a universal radar viewing unit” by R. W. Elbourn at 18.00 at 9 Bedford Sq., W.C.1.

1st. S.E.R.T.—“Design and performance of modern loudspeakers” by R. L. West at 19.00 at the Royal Commonwealth Society, Craven St., W.C.2.

7th. I.E.R.E.—“Solid state h.f. communications receiver” by B. M. Sosin at 18.00 at 9 Bedford Sq., W.C.1.

8th. I.E.E.—“Communication by glass fibre” by R. B. Dyott at 17.30 at Savoy Pl., W.C.2.

14th. I.E.R.E.—“The logistics of computer aided circuit design” by C. S. den Brinker at 18.00 at 9 Bedford Sq., W.C.1.

20th. I.E.E.—Colloquium on “Integrated circuits for consumer products” at Savoy Pl., W.C.2.

20th. I.E.E.—“Thyristor-bridge control systems analysis” by Dr. J. O. Flower and P. A. Hazell at 17.30 at Savoy Pl., W.C.2.

21st. R.Aero.Soc./I.E.E.—Discussion on the “The impact of modern avionics on safety” 18.00 at 4 Hamilton Pl., W.1.

21st. I.E.E.—“Technology and the Universities” by Professor John Brown the Electronics Division chairman at 17.30 at Savoy Pl., W.C.2.

21st. I.E.R.E.—“Continuing education for electronics engineers” by Dr. K. G. Stephens at 18.00 at 9 Bedford Sq., W.C.1.

22nd. I.E.E.—“A state-space approach to modular circuit synthesis” by Dr. A. W. Keen at 17.30 at Savoy Pl., W.C.2.

26th. I.E.E.—“The training of systems engineers—a systems problem” by Dr. I. Cochrane at 17.30 at Savoy Pl., W.C.2.

28th. I.E.E.—“An introduction to image analysis” by G. Gardner and Dr Gibbard at 18.00 at 9 Bedford Sq., W.C.1.

29th. I.E.E.—“Developments in soft magnetic materials and their uses” by Prof. J. E. Thompson at 17.30 at Savoy Pl., W.C.2.

29th. I.E.R.E.—“Space communications—the present and the future” by J. M. Brown at 18.00 at 9 Bedford Sq., W.C.1.

ABERDEEN

8th. I.E.R.E.—“High fidelity recording and reproduction at 19.30 at Robert Gordon's Inst. of Tech. Schoolhill.

29th. I.E.E./I.E.R.E.—“Medical electronics” by J. M. Neilson at 19.30 at Robert Gordon's Inst. of Technology.

BANGOR

20th. I.E.E.—“Electronic measurement in the automobile industry” by M. H. Westbrook at 19.30 at the School of Eng'g Science, University College.

BATH

14th. I.E.E./I.E.R.E.—“Review of marine radio development” by G. J. Macdonald and C. S. Burnham at 18.00 at the University.

BOLTON

15th. I.E.R.E.—“Coaxial-line cavity Gunn effect oscillators” by P. W. Crane at 19.15 at the Institute of Technology.

BRIGHTON

27th. I.E.E.—Colloquium on “Advances in automatic pattern recognition” at 14.30 at the Polytechnic.

BRISTOL

19th. I.E.E.—“Telecommunications—past, present and future” by J. S. Williams at 18.00 at Queen's Bldg. the University.

27th. I.E.E.T.E.—“Zinc-air batteries” by G. W. Walkiden at 19.30 at Royal Hotel, College Green.

CAMBRIDGE

15th. I.E.E.—“Design techniques for mobile and personal radio telephones” by P. A. Webster at 18.30 at the Eng'g Labs, Trumpington Street.

20th. I.E.E.—“Current electronic developments in the deep-sea fishing industry” by R. Bennett at 19.30 at the College of Arts & Technology.

CARDIFF

1st. S.E.R.T.—“The all-transistor colour chassis” by T. Ayscough at 19.30 at Llandaff Technical College, Western Avenue.

21st. I.E.E.T.E.—“Education and training of technicians” by Dr. H. L. Hazlegrave at 19.30 at the University of Wales Institute of Science & Technology, Cathays Park.

28th. S.E.R.T.—“Test equipment for colour receiver servicing” at 19.30 at Llandaff Technical College, Western Avenue.

CATTERICK

13th. I.E.E.—“The teaching of digital techniques” by D. Brown at 18.30 at the Camp.

CHATHAM

22nd. I.E.R.E.—“Thick film microelectronics” by A. F. Dyson at 19.00 at the Medway College of Technology.

CHELMSFORD

7th. I.E.E./I.E.R.E.—“The new Post Office research station at Martlesham” by C. F. Floyd at 18.30 at the King Edward VI Grammar School, Broomfield Rd.

DUNDEE

20th. I.E.E. Grads.—“Computer memory systems” by J. Crabb at 19.30 at the University.

ENFIELD

29th. I.E.E.—“Microelectronics” by E. T. Emms at 18.30 at the College of Technology.

FARNBOROUGH

13th. I.E.E.—“Electronics character recognition” by R. H. Britt at 18.30 at the Technical College.

GUILDFORD

6th. I.E.R.E.—“A computer for teaching” by V. F. Thomas at 19.00 at the Technical College.

HULL

29th. I.E.E.—“Review of electronics in cars” by W. F. Hill, at 18.30 at the Y.E.B.

LEICESTER

6th. I.E.R.E./C.E.I.—“How an engineer can take part in the total management of a company” by Dr. F. E. Jones at 19.00 at the University.

14th. I.E.E.T.E.—“Control systems, computer

simulation” by P. J. Lawton at 18.45 at the Hawthorn Bldg, the Polytechnic, The Newark.

LETCHEWORTH

21st. S.E.R.T.—“Art of computation” by C. Fleckney at 19.00 at ICL Engineering Training Centre, Icknield Way West.

LIVERPOOL

14th. I.E.R.E.—“Fast switching techniques as applied to automatic telephone exchange design” by J. Lewsley at 19.00 at the University, Dep. of Elec. Eng.

26th. I.E.E.—“The role of the polytechnics by G. Bulmer at 18.30 at the Polytechnic.

LOUGHBOROUGH

20th. I.E.E.—“Measuring the body's signals” by J. M. Ivson at 18.30 at Ed. Herbert Bldg, the University.

MALVERN

7th. I.E.R.E.—“Quasars—the most powerful transmitters in the Universe” by Dr. P. J. S. Williams at 19.00 at the Abbey Hotel.

MANCHESTER

12th. I.E.E.—“The polytechnics in perspective” by Sir Eric Richardson at 18.15 at Renold Bldg, U.M.I.S.T.

NEWCASTLE ON TYNE

7th. S.E.R.T.—“B.R.C. Colour TV 3000 power supplies” by K. R. Harris at 19.15 at Charles Trevelyan Technical College, Maple Terrace.

14th. I.E.R.E./I.P.P.S./R.T.S.—“Colour television” D. G. Packham at 18.00 at Tyne Tees Television Studios, City Road.

NEWPORT, I.O.W.

16th. I.E.R.E.—“The future of aircraft landing systems” by W. F. Winter at 19.00 at the Technical College.

23rd. I.E.E.—“Electronic performance testing of motor vehicles” by D. C. Freeman at 18.30 at the Technical College.

POOLE

20th. I.E.E. Grads.—“Integrated circuits in hi-fi systems” by B. A. Reed at 18.30 at the Technical College.

READING

6th. I.E.E.—“Review of electronic telephone switching” by D. J. Harding at 19.30 at the J. J. Thomson Lab., the University.

15th. I.E.R.E.—“Computer aided instruction” by Dr. D. G. Bate at 19.30 at the J. J. Thomson Laboratory, the University, Whiteknights Park.

ST. AUSTELL

6th. I.E.E.T.E.—“Communications satellite” by S. Pitham at 19.30 at the English Clays Loversing Pochin Ltd, Staff Restaurant, John Keay House.

SHEFFIELD

28th. I.E.E./I.E.R.E.—“Large scale integrated circuits” by C. S. den Brinker at 18.30 at the University.

SOUTHAMPTON

21st. I.E.E./I.E.R.E.—“Digital techniques in moving target indication” by I. C. Walker at 18.30 at the University.

SWINDON

6th. I.E.R.E.—“Thyristor engineering” by D. B. Corbyn at 18.15 at the College.

TAUNTON

13th. I.E.E.—“Television communications” by A. James at 19.45 at the Castle Hotel.

WEYMOUTH

22nd. I.E.E.—“Holography” by A. E. Ennos at 18.30 at the South Dorset Technical College.

WHITBY

13th. I.E.E.—“Radio astronomy” by I. W. Sheffield at 19.00 at Botham's Cafe, Skinner St.

WOLVERHAMPTON

6th. I.E.R.E.—“What the C.E.I. means to the professional engineer” by H. F. Schwarz and Sir Arnold Lindley at 19.15 at the Polytechnic.

New Products

M.O.S. Multiplex Switches

High-performance m.o.s. multiplex switches for communications are available in two ranges from Marconi-Elliott Microelectronics, one with leakage currents of 10nA and the other with leakages of the order of 0.1nA. Low-leakage types have been specially selected and are already used in a military message-switching application. Range includes single switches, with either high input or low 'on' resistance (M101, 103 and 106), dual switches, with either high input or low 'on' resistance (M203 or 206), dual pair used as multiplex switch and digital-analogue converter (M406), common-source sextet (M605), and triple pair digital-analogue converter (M606). Devices, all p-enhancement types, are made by the thick-oxide technique, used in high-voltage m.o.s. devices. Process allows increased oxide thickness by vapour deposition technique underneath non-active areas of aluminium conductors, thus avoiding spurious leakage. Marconi-Elliott Microelectronics Ltd, Witham, Essex.

WW319 for further details

Stabilized Power Supplies

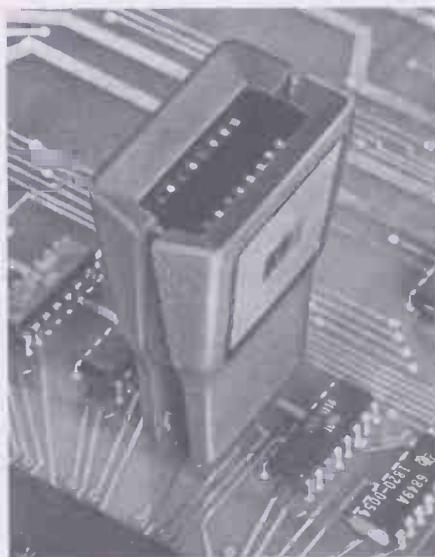
The Roband ECO range of stabilized power supplies provides outputs of up to 50V and 10A. All components are mounted on a single printed board. Stabilization is about 0.005% with ripple and noise typically 150µV pk-pk. A modified re-entrant current characteristic maintains protection of loads and supplies, while preventing lock-out on linear and non-linear loads. They can also be externally programmed and used as

constant current supplies. Protection against overvoltage, without spurious shut-down, is made possible by an optional addition. The units range in price from £20 to £49. Roband Electronics Ltd, Charlwood Works, Charlwood, Horley, Surrey.

WW312 for further details

Logic-state Indicator

Hewlett-Packard model 10528A Logic Clip fits on to t.t.l. or d.t.l. integrated-circuit packages and instantly displays the



logic states of all 14 or 16 pins. The clip has 16 light-emitting diodes, each of which follows voltage-level changes on one pin.

A lighted diode indicates a high logic state (+5V). The Logic Clip is self-contained. It requires no power connections or adjustments, drawing its power from the circuit being tested, and contains logic circuitry for locating the ground and +5V pins even if clipped on unsymmetrically. The buffered inputs put no more than one t.t.l. load on the circuit being tested. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks.

WW313 for further details

Highly Accurate Digital Voltmeter

Digital voltmeter DSV4 from International Electronics has an accuracy of $\pm 0.01\% \pm 1$ digit. Input resistance is $10M\Omega$ on all ranges. There are $12\frac{1}{2}$ readings per second. Calibration is automatic between each displayed heading and is effected by reference to a temperature compensated



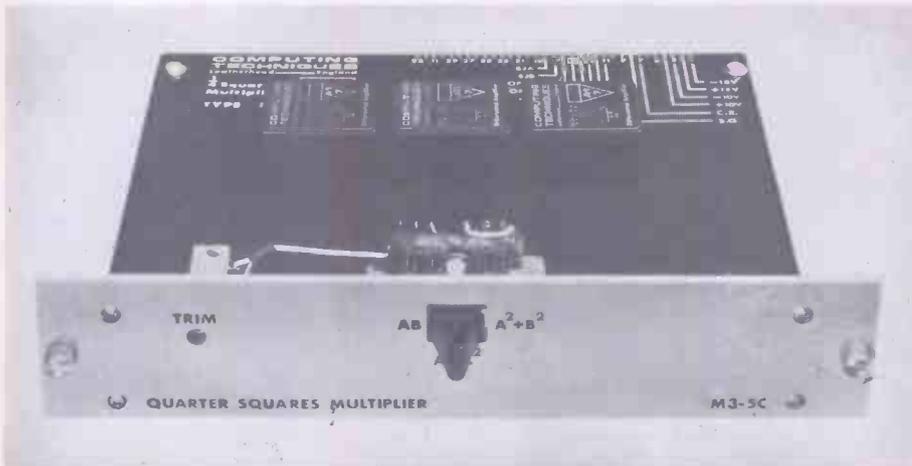
Weston standard cell. Zero offset current and voltage are automatically corrected between each reading. Series-mode rejection at mains supply frequency and its harmonics is greater than 85dB, and common-mode rejection 100dB at mains frequency and d.c. with $1k\Omega$ imbalance in the input leads. The price is £25. International Electronics Ltd, Ewood Bridge, Haslingden, Lancs.

WW303 for further details

Quarter Squares Multiplier

Quarter squares multiplier M3-5C from Computing Techniques obtains the product of two functions by implementing the relationship $XY = \frac{1}{4}(X+Y)^2 - (X-Y)^2$. Three built-in operational amplifiers perform the summing and inverting operations, while two function generators approximate the required parabolic transfer functions. Four-quadrant operation is provided. Using D1-2 amplifiers, the phase shift is less than 1° at 1kHz; this accuracy can be maintained up to 10kHz, and full power can be obtained up to 30kHz (with reduced accuracy) by using type F1-7 amplifiers. The required inputs are variable A, variable B and reference voltages; the input impedance is approximately $3k\Omega$. The available outputs, selected by miniature key switch, are $-AB$, $A^2 - B^2$ as a voltage and $A^2 + B^2$ as a current; multiplication accuracy is 2% f.s.d. The product output voltage is $AB/10$ and the output current is $\pm 5mA$ at $\pm 10V$. The multiplier is fitted with a standard





I.S.E.P. 33-way plug and is intended primarily for use with the Comtec analogue/hybrid computers Vidac 336 and Vidac 169. It may, however, be built into any analogue system operating on a machine unit of 10V. Computing Techniques Ltd, Westminster Bank Chambers, Bridge Street, Leatherhead, Surrey.

WW 330 for further details

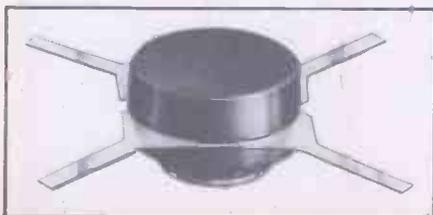
Opto-electronic Switch for T.T.L.

Light-activated integrated switches have been produced with outputs compatible with both transistor logic and relays. Devices can be used in many applications of light beams including punched card reading and are said to be cheaper than photocells. Included in the TO-18 can is an m.o.s. Schmitt trigger circuit integrated into the same silicon chip. Response can be up to 40kHz and switching threshold is variable over three orders of magnitude by an external RC time constant. Devices are available with either 12-15V or 24-30V operating voltage and logic value of 0 or 1 in the dark state. Price is £2 8s for 1-50 and £1 10s for 5000 up. Arrays of 40 and 60 diodes for character recognition, edge sensing, etc., are also announced by Integrated Photomatrix Ltd, Grove Trading Estate, Dorchester, Dorset.

WW 321 for further details

U.H.F. Transistor

The latest addition to the Mullard range of u.h.f. transistors is intended for use as a driver in mobile telecommunications equipment or as an output stage in pocket transmitters. Type BFW98G, it will deliver an output of 500mW at 470MHz when operating with a supply voltage of 13.8V

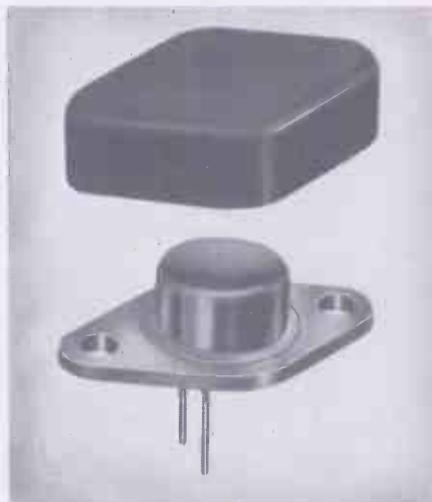


and a drive of 80mW. The transistor is an n-p-n silicon planar device in a new stripline package. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

WW304 for further details

Cover for Power Transistors

A cover designed for use with the TO-66 packaged devices is available from Jermyn. Designated the A22/2005, it is moulded in black Rilsan BMNP40 which is capable of



withstanding temperatures up to 113°C and provides electrical insulation up to 1000V. The cover has a lip to hold it in place, Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

WW308 for further details

Dynamic Shift Register

A 512-bit dynamic shift register, the MM5016, from National Semiconductor operates on a standard +5V and -12V power supply and is compatible with bipolar transistors. The device has a 600Hz guaranteed minimum operating frequency at 25°C and an input tap gives 500 or 512 bits. It is available in either TO-5 or dual-in-line packages. No pull-up or pull-down resistors are required on the input and output. Price is 50s for the TO-5 version in lots of 100 or more. U.K. distributors: Athena Semiconductor Marketing Co., Egham, Surrey; Electronic

Component Suppliers (Windsor) Ltd, Thames Avenue, Windsor, Berks; Farnell Electronic Components Ltd, Canal Road, Leeds LS12 2TU; and ITT Electronic Services, Edinburgh Way, Harlow, Essex.

WW 332 for further details

M.O.S. Adaptive Logic for Pattern Recognition

Adaptive logic gate, originally intended for use in pattern recognition experiments at Kent University, is now commercially available from Integrated Photomatrix. The m.o.s. gate (MC901) decodes all possible logic functions of the four binary inputs and sets one of the 16 internal bistable stores. Outputs of these stores are OR-gated to form the output. The adaptive gates can be connected into an array that will 'learn'. If, say, the array is controlling a system, feedback loops can be provided from the system to the array. The output of the array will be a function of the current input and, because of the memory stores, also a function of previous inputs and results as defined by the feedback loops. A particular input pattern does two things. First, it gates the output of one of the stores providing an output if that store contains a '1', second, it gates the input of the same store allowing it to set or reset depending on which of two input lines a 1µs pulse is applied. Two additional inputs allow all the stores to be reset. Available in dual in-line packages, price is £7 for 1-99 and £4 10s for 1000 up. Supply voltage is 27V. Integrated Photomatrix Ltd, Grove Trading Estate, Dorchester, Dorset.

WW 323 for further details

300-W Zener Diode

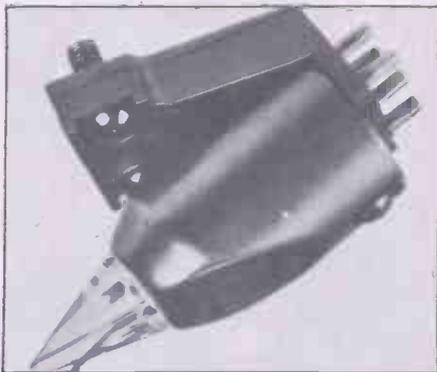
Type BZX86 zener diode from Mullard has a continuous power rating of 300W at a mounting base temperature of 65°C; and at an ambient temperature of 30°C it will withstand surges of 2kW. It is intended for use in preventing large electrical transients causing damage to equipment. It has a maximum diameter of 27mm and is 84mm



high. Zeners with voltages between 10 and 75V can be supplied. Mullard Ltd, Mullard House, Torrington Place, London W.C.1. WW 305 for further details

Pickup Cartridge

Aluminium stylus mounting is used on a new Bang & Olufsen medium-compliance magnetic pickup cartridge (model SP14).



The cartridge is included in a turntable unit to be released later this year, but is available separately.

response	15Hz-25kHz \pm 4dB 20Hz-16kHz \pm 2.5dB 40Hz-10kHz \pm 1.5dB
separation	> 20dB at 1kHz
channel difference	< 2dB
compliance	15×10^{-6} cm/dyne
effective stylus	
mass	1mg
stylus pressure	1.5-2.5g
output	1mV/cm/sec (typically 5mV)
impedance	47k Ω
stylus	15 μ m radius, spherical

Price £8 10s. Bang & Olufsen U.K. Ltd, Eastbrook Rd, Gloucester GL4 7DE. WW 322 for further details

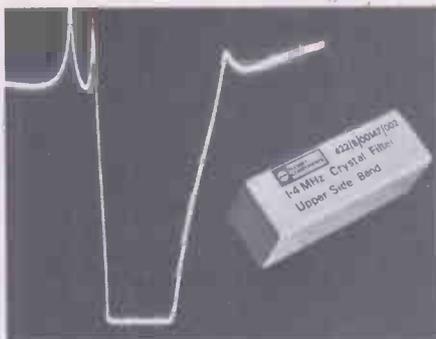
Monolithic Mica Capacitors

Using monolithic construction the MS611 series of capacitors available from WEL provides high stability over a wide frequency range. The units will operate over a temperature range -55 to $+100^\circ\text{C}$. Insulation resistance is about 10^5 megohms and $\tan d$ is better than 0.001 at 1 kHz and better than 0.002 at 1 MHz. The upper frequency limit is about 1 GHz. Voltage ratings up to 750V are provided and the standard E12 range of values at 1% tolerance is available from stock. Capacitance range is 10-10,000pF. WEL Components Ltd, 5, Loverock Road, Reading, Berks.

WW 327 for further details

Crystal Filters for Marine Communications

Plessey have introduced a new standard range of crystal filters for use in marine communications equipment employing an i.f. of 1.4MHz. Included in the standard



range are upper and lower sideband filters, and symmetrical filters for a.m. and c.w. applications. In each case, the design meets the selectivity requirements of the Post Office specifications, TSC105 or MPT1201. Operation is specified over the temperature range -10 to $+40^\circ\text{C}$, and each filter is sealed in a metal case measuring $76 \times 27.5 \times 26\text{mm}$. The new range is complemented by a 2.182MHz sideband filter which has been specially designed for use on emergency marine equipment, and a broad-band LC filter giving selectivity from 1.6MHz to 4.2MHz while rejecting 1.4MHz. Filter Unit, Plessey Components Group, Titchfield, Hants.

WW 334 for further details

1.5-MHz Recording Head

Gresham Recording Heads have produced a high-frequency analogue recording head for operation at 1.5MHz. The 14-channel wideband head-sets are made with a gap of only 25 μ -inches. They are designed for direct analogue recording at 1.5MHz on 1-in tape. The normal tape speed is 120 i.p.s. Gresham Recording Heads Ltd, Feltham Trading Estate, Feltham, Middx.

WW 328 for further details

Cassette Recorder with Dolby System

A new cassette tape-recorder unit, the Kellar DTA 50 available from Kellar Electronics, incorporates the Dolby 'B' noise reduction system, and is claimed to

give a performance as good as that obtained from gramophone records. The unit comprises a high-quality transport mechanism and a stereo amplifier capable of a continuous power output of 25W per channel. Ordinary cassette recordings can be played on the unit, but the Dolby circuit can be switched in to allow low-noise recordings to be made. The frequency response of the recorder is 40Hz to 12kHz \pm 3dB. The wow and flutter is given as 0.15% w.f.d. peak according to C.C.I.R. The use of the noise reduction system results in an increase of 5dB in the signal-to-noise ratio. Price £150. Kellar Electronics Ltd, Maryland Works, 9 Brydges Road, Stratford, London E.15. WW 324 for further details

10-turn Precision Pot.

Bourns have introduced a new $\frac{7}{8}$ in diameter, 10-turn, wirewound potentiometer with a glass-filled nylon housing and bushing, and a polycarbonate shaft with a screw-driver slot. Rotational life is guaranteed to 1 million shaft revolutions. The resistance range is 100 Ω to 100k Ω , and tolerance \pm 5%. Deviation from linearity is \pm 0.25% max. Maximum power dissipation is 2.0W at 25 $^\circ\text{C}$. The operating temperature range is -55 to $+105^\circ\text{C}$. Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.

WW311 for further details

Silicon Infra-red Light Detector

The MSP70 infra-red detector from MCP Electronics Semiconductor Division has, like its predecessors the MSP3 and MSP6, a black tubular housing 1in \times 0.25in. It will detect modulated infra-red up to 60kHz. MCP Electronics Ltd, Alperton, Wembley, Middlesex, HAO 4PE.

WW 335 for further details

D.C. Multimeter

Multimeter measuring direct current down to picoamperes can now be supplied by Wayne Kerr. Model M300, first seen on the





Wayne Kerr stand during the I.E.A. exhibition earlier this year, also measures direct voltage and resistance. Amplifier uses photochopper stabilization with 40-Hz switching to avoid beats with the 50-Hz supply. Instrument also features a small reverse scale for null detection, overload protection, one set-zero control for all ranges, a recorder output of 0.1mA at 1k Ω , and a hum rejection filter which rejects hum equivalent to 50 \times f.s.d.

current ranges	30pA—100mA in 20 ranges
accuracy	$\pm 1.5\%$
voltage	30 μ V—300V in 15 ranges
accuracy	$\pm 1\%$
resistance	10 Ω —1G Ω
accuracy	$\pm 2\%$ ($\pm 5\%$ 1G Ω range)
input Z	100M Ω
common mode rej.	120dB a.c. or d.c.
noise	< 1 μ V or 1pA r.m.s.
stability	$\pm 3\mu$ V, ± 3 pA
response time	< 1s (2s with filter)

Available for 110V operation. Price £150. Wayne Kerr Co. Ltd., New Malden, Surrey. WW317 for further details

Miniature Power Supply

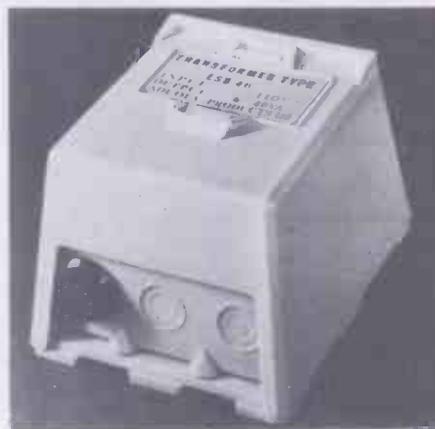
The PS5 supply from A.D.M. Electronics measures 70 \times 70 \times 180mm and provides up to 0.17A over the voltage range 0—15V. The PS5 design has been developed to eliminate damaging transient overshoot at turn-on and turn-off. The supply is fully protected against short circuits and overloads. The transient response is less than 5 μ s for a full load-current change and the regulation is claimed to be better



than 5000 to 1. On full load the ripple and noise do not exceed 500 μ V, reducing to less than 30 μ V for load currents below 50mA. A.D.M. Electronics, P.O. Box 3, Merthyr Tydfil, Glamorgan. WW310 for further details

Range of Transformers

A series of low-voltage, double-insulated transformers from Adcola has a primary-winding range of 110 to 380V and a secondary range of 6 to 115V. Ratings are 25, 40 or 60W. The casing is secured by



clips so dismantling for access to internal parts is quick and does not require the use of a screwdriver. Adcola Products Ltd, Adcola House, Gauden Road, London S.W.4. WW307 for further details

Monolithic Tuning Indicator

An integrated circuit tuning indicator is available from Motorola. The addition of a miniature lamp bulb turns the i.c. into an aid to the fine-tuning of f.m. radio and colour television receivers. In use type MC1335 tuning indicator is connected across the f.m. ratio detector. When the receiver is correctly tuned equal voltages appear across each half of the ratio detector centre-tapped coil causing the lamp to light. Unequal voltages turn the lamp off. The device is encased in an eight-lead dual-in-line plastic package and

requires a power supply of 20V. The price is 27s each in quantities of 100 or more. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx. WW309 for further details

V.H.F. Personal Radiotelephone

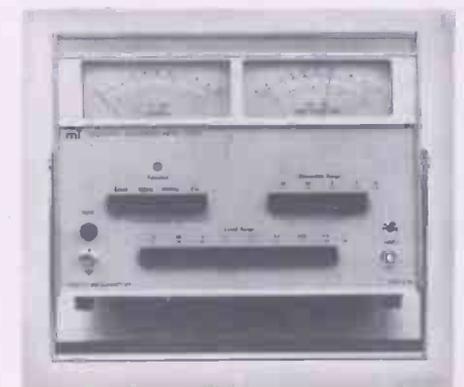
A v.h.f. personal radiotelephone consisting of a single lightweight unit suitable for emergency, public and private usage is available from Pye Telecommunications. It is known as the PF2FMB, and is equipped for three channel f.m. operation in the 68-88 and 148-174 MHz bands. It meets the Post



Office mobile specification and, with an adaptor, can be used in a car or other vehicle. Sockets on the top of the unit make connection with a small external loudspeaker/microphone unit, and an aerial. The unit can be clipped to the waist belt or carried in a specially designed case or harness slung from the shoulder with a flexible wire antenna fitted in the shoulder strap, its loudspeaker-microphone being clipped to the lapel. The whole unit, including battery, weighs only 28 oz. Power is from a single 15V rechargeable nickel-cadmium battery with a capacity of 200mAh, the unit incorporates a circuit to reduce battery drain when no signal is received. Pye Telecommunications Ltd, Newmarket Road, Cambridge. WW 331 for further details

Distortion Factor Meter

Push-button controls make this new distortion factor meter easy to use especially for measurements on production radio and TV receivers and audio equipment.



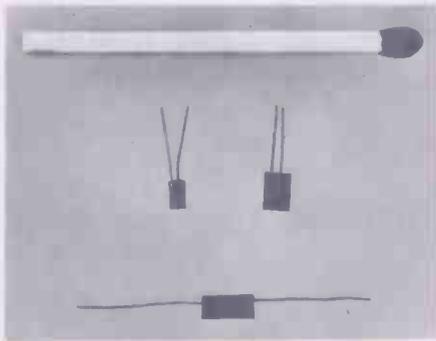
Meter, type TF2337, is complementary to the more elaborate Marconi Instruments TF2331 announced in 1964 and intended for development work. Level is set to give adequate meter deflection at either 400Hz or 1kHz and distortion factor read directly from the other meter. Provision is made for injection of external fundamental frequency in the range 30Hz-7kHz.

level ranges	10mV-30V in 8 ranges
accuracy (10mV range)	±5% f.s.d. (±10%)
distortion ranges	1-30% in 4 ranges
accuracy	±5% f.s.d.
input Z	100kΩ plus 50pF
fundamental rejection	56dB
frequencies	400Hz and 1kHz plus external facility

Available for 110V use. Price £230. Marconi Instruments Ltd, St. Albans, Herts. WW316 for further details

Small Tantalum Capacitors

The Kemet Micron range of small tantalum capacitors, from Union Carbide U.K., are available in either rectangular or cylindrical cases with radial or axial leads. The capacitance range is 0.001 to 220 μF, and voltage range 2 to 100V. Standard capacitance

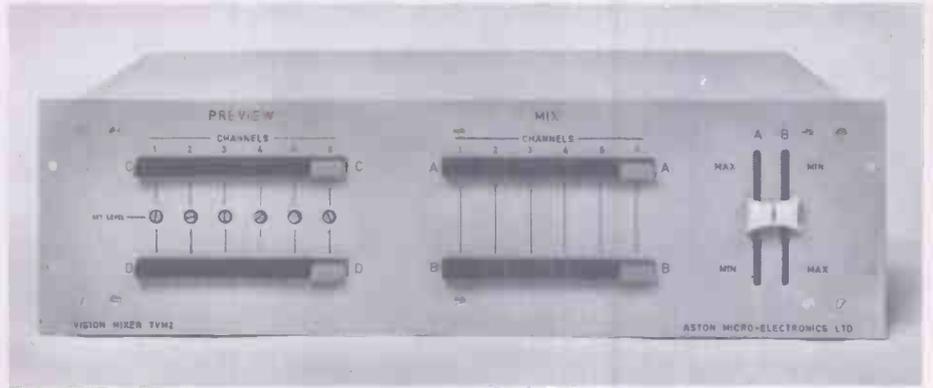


tolerances are ±20%, ±10% and ±5% and the operating temperature range is -55 to +125°C. The capacitors consist of very small tantalum anode assemblies with attached leads enclosed in insulated cases filled with epoxy resin. Union Carbide U.K. Ltd, 8 Grafton Street, London W1A 2LR.

WW302 for further details

Video Signal Mixer

From Aston Micro-Electronics Ltd we have received details of a vision mixer TVM2 for cutting, fading and mixing the pictures from five cameras and one video tape recorder. Two rows of button switches allow any two vision sources to be selected for viewing before transmission. Automatic interlocks prevent accidental mixing of the video tape recorder picture with pictures from the cameras. Although designed for monochrome systems, the 8MHz response of the TVM2 is adequate for colour television. It is claimed that PAL-encoded colour pictures can be mixed without



noticeable degradation of picture quality. Aston Micro-Electronics Ltd, Vapery Lane, Firbright, Woking, Surrey. WW314 for further details

requirement is half of these figures. Base is B13B and tube height is 26.5mm. Price is about £2 for 100 up. Hivac Ltd, Stonefield Way, South Ruislip, Middx. WW318 for further details

Wideband Test Oscillator

Model 4200 oscillator, manufactured by Krohn-hite and available from Omega Laboratories, provides a sine wave in the range 10Hz to 10MHz with 0.5W of power and 0.1% distortion. Frequency tuning is by means of a dial and six push buttons. Amplitude calibration of 0.2dB accuracy is obtained by an eight-position push-button attenuator calibrated in 10dB steps. A continuous output control combined with the attenuator provide 90dB of attenuation. Frequency accuracy is 2%. A fixed 1V output independent of the main output is also available. Price £235. Omega Laboratories Ltd, 59 Union Street, London S.E.1.

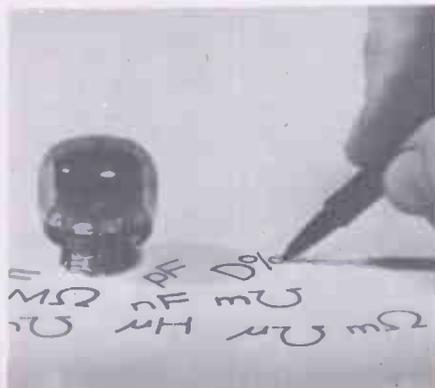
WW301 for further details

Units Symbol Numicator Tubes

End-viewing indicator tubes are now made by Hivac which display special symbols—units—in particular. Two tubes have the following symbols.

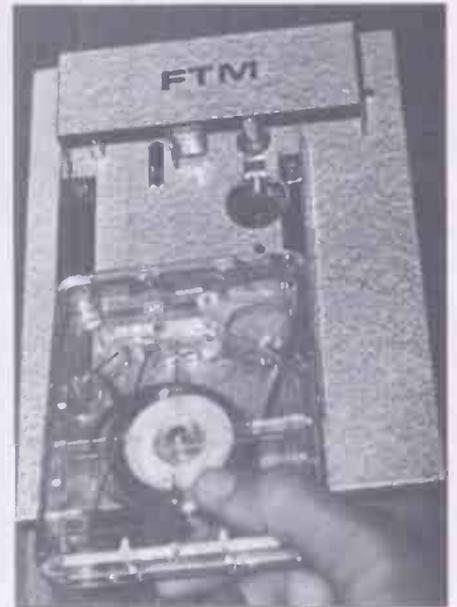
GR8M	GR81M
pF, nF, μF, mF	nΩ, μΩ, mΩ
μH, mH, H	Ω, kΩ, MΩ
%	D%, %

Both operate with minimum strike voltage of 170V and maintaining voltage of 140V. Minimum cathode current needed is 2mA with mean of 5mA and maximum peak current of 20mA. Because of the smaller area of the %, Ω and H symbols, current



Tape-transport Mechanism

Fitch Tape Mechanisms have developed and are now producing an endless-loop tape-transport mechanism using a new system of pinch wheel operation making tape stiction impossible even if the unit is



not actuated for long periods with the tape cartridge in the ready position. This mechanism, adaptable to all sizes of cartridge, can be battery or mains powered. It is fully automatic and can be remotely controlled. Fitch Tape Mechanisms, 7a Balham Grove, London S.W.12. WW 333 for further details

Corrections

"Miniature Tape Recorder" (August p. 413): The complete address for Hayden Laboratories Ltd, who market the Nagra SN recorder, is East House, Chiltern Avenue, Amersham, Bucks.

"Switching Diode" (September p. 463): The diodes illustrated are not the Mullard BAV 44 type described.

Literature Received

For further information on any item include the appropriate WW number on the reader reply card

ACTIVE DEVICES

A range of zener diodes and varistors manufactured by Schauer Semiconductors is described in literature obtainable from LST Electronic Components Ltd, 7 Coptfold Rd, Brentwood, Essex. The varistors consist of two matched semiconductor junctions and are suitable for meter protection, fractional voltage regulators, etc. WW401

From REL Equipment and Components Ltd, Components Division, Croft House, Bancroft, Hitchin, Herts, a catalogue devoted to semi-conductors, pot-cores, transformers, alkaline cells, capacitors and resistors WW402

We have received the following data sheets from Marconi-Elliott Microelectronics, Witham, Essex. M101, MO3. Single metal oxide silicon p-enhancement transistor, 3.5 to 6V threshold, 30V breakdown and 2nA max off leakage. WW403 M106. Single m.o.s.t. with low 'on' resistance (30 Ω), p-enhancement, $V_{DS} = -30V$ and $P_{max} = 350mW$ WW404 M206. Dual m.o.s.t. on a common substrate, similar to M106 WW405 M203, 406, 605. 30V m.o.s.t.s—203 is a pair without gate protection; 406 consists of two common-source pairs; and M605 is six common-source m.o.s.t.s in a d.i.l. package WW406

Integrated Photomatrix Ltd, Grove Trading Estate, Dorchester, have sent us a number of product data sheets.

IPL11. Light activated switch in TO-18 case consists of silicon planar diode and an m.o.s.t. i.c. for 28V operation WW407
IPL100. Similar to above for -12V operation WW408
IPL13. Light-to-frequency converter; planar diode and i.c. in TO-18 case, output 10Hz to 100kHz WW409
IPL14. Analogue light level sensor in TO-5 case WW410
HA14. Paper tape reader head. Planar diodes and i.c.s, no interface circuit required for driving t.t.l. or m.o.s. WW411
IPL20. 50 \times 1 light sensitive array. 50 silicon planar photodiodes and a 51-bit shift register on a chip WW412
IPL30/D. Position-sensitive photocell system. Gives X and Y output voltages proportional to the distance of a light spot from a central position. Accurate to better than 1 μm WW413
WCM22. Material width monitor WW414
IPL20R. 50 \times 1 Photodiode array driver. WW415
IPL15. Light activated switch WW416
MR103/4/5/6 A. 16-bit shift register; t.t.l. compatible m.o.s. WW417
MC901. Adaptive logic gate WW418
Price list WW419

We have received a 111-page brochure from British Brown-Boveri Ltd, Glen House, Stag Place, London S.W.1, called "Thyristors-Data and Diagrams" WW420

American Diodes Incorporated have just started a company in the U.K. called Diodes Ltd at Fairacres Estate, Dedworth Rd, Windsor, Berks. The following literature is available

Short-form catalogue WW421
Price list WW422

The 1970 catalogue of Electrovalue, 28 St. Judes Rd, Englefield Green, Egham, Surrey, lists a variety of semiconductor devices together with many other components, Price 2s.

PASSIVE COMPONENTS

We have received the following brochures from Tygadure, Littlebrough, Lancs.

Tygadure radio-frequency coaxial cables WW423
Tygaflor equipment wires WW424
Tygadure p.t.f.e. equipment wire, cable, sleeving, lacing cords and tapes, and glass braided yarn WW425

Engineering Bulletin No.7451 from Sprague is called "Beryllia-core silicone-coated Acrasil precision wirewound resistors". Sprague Electric (U.K.) Ltd, Sprague House, 159 High St, Yiewsley, West Drayton, Middlesex WW426

Swift Hardmans Wholesale Supply (S-O-T) Ltd, P.O. Box 23, Hardale House, Baillie St, Rochdale, Lancs, have produced a catalogue of Belling-Lee components (plugs, sockets, fuse holders and the like) they stock WW427

Precision miniature wirewound resistors with either radial or axial leads are the subject of a booklet available from Electrothermal Engineering Ltd, 270 Neville Rd, London E.7 WW428

B & R Relays Ltd, Temple Fields, Harlow, Essex, have produced a leaflet describing their D-range of relays which have contacts rated at 6A at 240V a.c. or 30V d.c. WW429

The following data sheets on components manufactured by the American Wilbrecht Company are available from J. H. Associates Ltd, 1 Church St, Bishop's Stortford, Herts.

Model 170-S potentiometer with switch WW431
Model 170-R potentiometer WW432
Model 100 variable resistor (2.54mm diameter) WW433
Model 2000 miniature slide switch WW434

APPLICATION NOTES

From Fairchild Semiconductor Ltd, Kingmaker House, Station Rd, New Barnet, Herts, a leaflet (No.6) describing the use of the $M\mu$ L4102 16-bit associative memory cell and the $M\mu$ L9035 64-bit read/write memory cell in a high-speed buffer memory system WW435

Application report B61 from WEL Components Ltd, 5 Loverock Rd, Reading, Berks, examines the construction of the triac and looks at its application in several circuits. The report includes notes on protection and working. Post and packing 2s.

Integrated Photomatrix Ltd, Grove Trading Estate, Dorchester, have produced an application note for the 50 \times 1 light sensitive array mentioned in the Active Devices section.

EQUIPMENT

REL Equipment and Components Ltd, Microwave and Electronics Division, Croft House, Bancroft, Hitchin, Herts, have issued a short-form catalogue which lists a comprehensive range of test equipment WW436

A logic trainer from Limrose Electronics which consists of 16-NAND/NOR gates, or five-switch input register and four indicator lamps is described in a leaflet CK1/02 from Limrose Electronics, Lymm, Cheshire WW437

EMI Electronics Ltd, Television Equipment Division, Hayes, Middlesex, have produced a 44-page booklet on monochrome closed-circuit television systems for educational purposes WW438

A Mullard booklet, 'Do-it-yourself stereo', price 5s, gives constructional (wood-working) details of several possible stereophonic record reproducing assemblies using amplifier and power-supply modules (Mullard 'Unilux') that can be wired up using only a screwdriver.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Oct. 14-16 Savoy Place
Earth Station Technology
(I.E.E., Savoy Place, London WC2R 0BL)

Oct. 19-24 Olympia
Audio & Music Fair
(C. Rex-Hassan, 42 Manchester St., London W.1.)

BRIGHTON

Oct. 13-15 Hotel Metropole
INTER/NEPCON
(P. G. Saville, 21 Victoria Rd., Surbiton, Surrey)

MANCHESTER

Sept. 28-Oct. 2 Belle Vue
Electronics, Instruments and Components Show
(Inst. Electronics, 659 Oldham Road, Balderstone, Rochdale, Lancs)

VERSEAS

Oct. 5-7 Argonne
Pattern Recognition
(Prof. S. S. Yau, Dept. of Electrical Eng., Northwestern University, Evanston, Illinois 60201)

Oct. 5-7 Rolla
Communications Conference
(J. R. Bretten, University of Missouri, 123 EE Bldg., Rolla, Missouri 65401)

Oct. 6-11 Ljubljana
Modern Electronics Exhibition
(Gospodarsko razstavisce, Ljubljana, Titova No. 50, Yugoslavia)

Oct. 7-9 Monticello
Circuit & Systems Theory
(G. Metz, University of Illinois, Urbana, Illinois 61801)

Oct. 12-16 Helsinki
British Engineering Week
(London Chamber of Commerce, 69 Cannon Street, London E.C.4)

Oct. 13-15 Los Angeles
Telemetering Conference
(International Foundation for Telemetering, 19730 Ventura Blvd., Woodland Hills, California 91364)

Oct. 14-16 Pittsburgh
Systems Science & Cybernetics
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Oct. 26-28 Washington
Electronics and Aerospace Systems
(Dr. R. Marsten, NASA Headquarters, Code SC, Washington D.C. 20546)

Oct. 28-30 Washington
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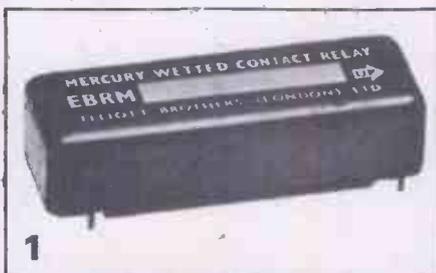
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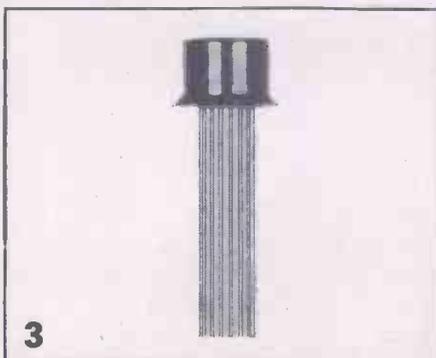
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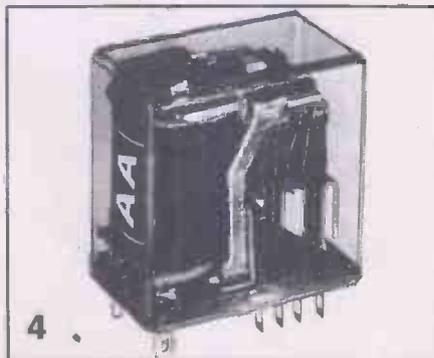
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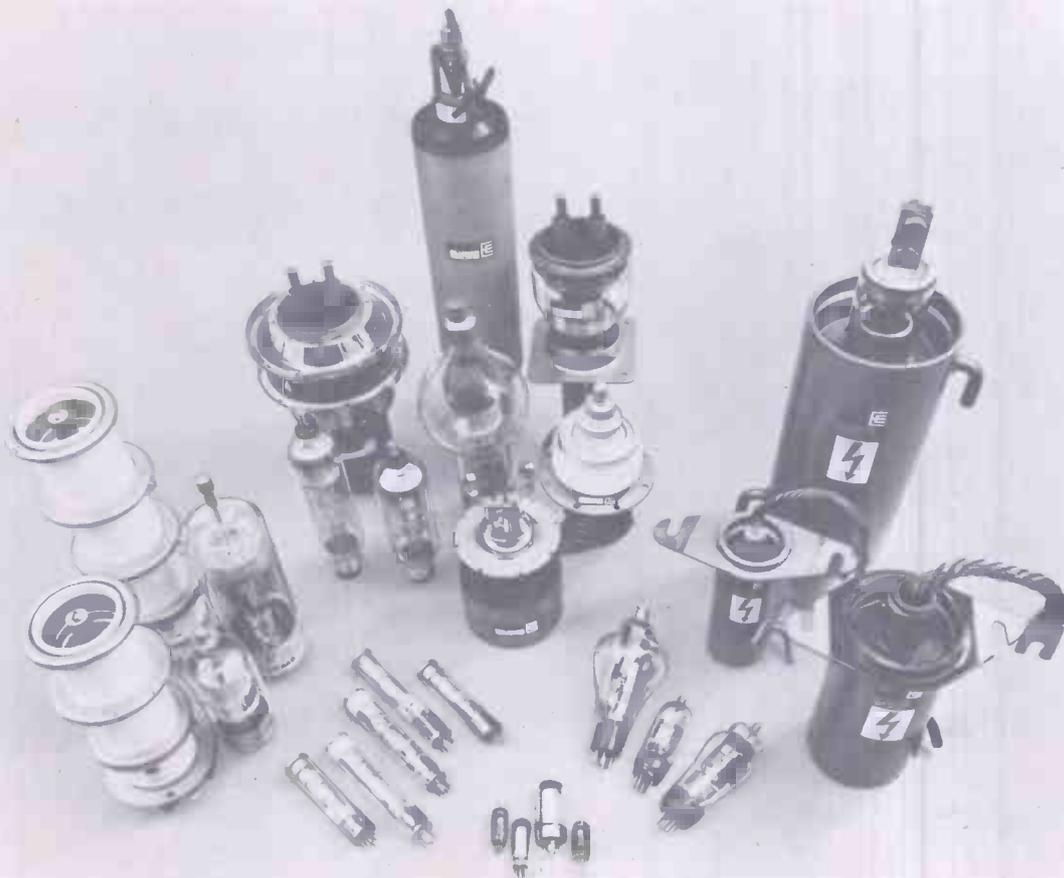
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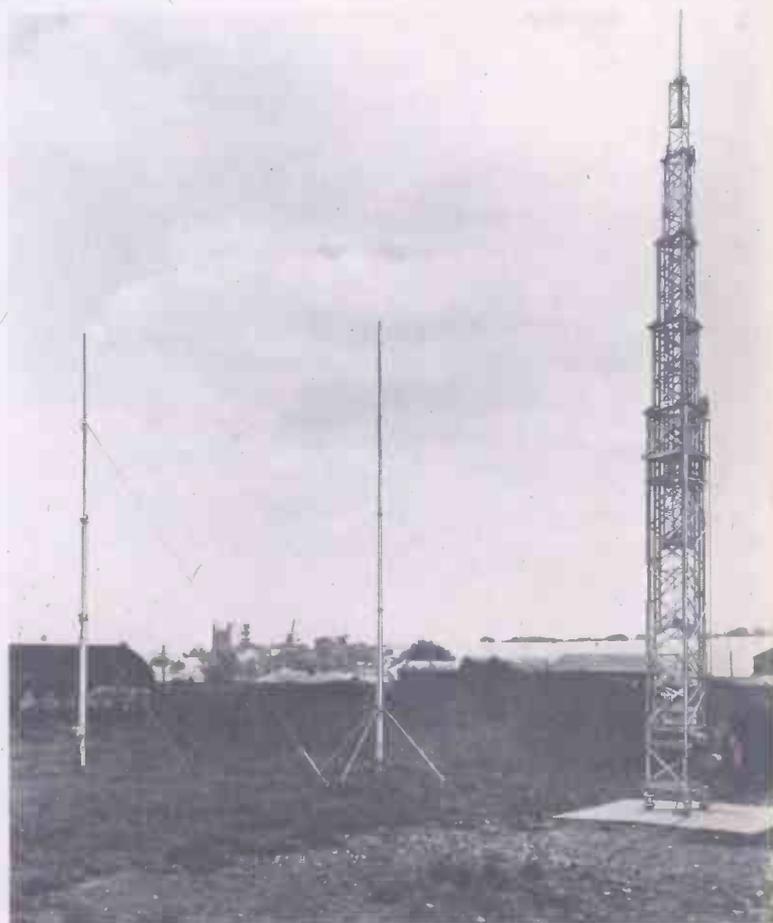
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Type	Energy input per flash max. (J)	Arc length (in.)	Bore diameter (mm)	Typical operating conditions			Trigger voltage (kV)
				Voltage (kV)	Series inductance (μ H)	*Flash rate	
XL615/4/3	400	3	4.0	2.5	400	1 per 30 sec.	12-16
XL615/7/3	600	3	7.0	2.5	400	1 per 15 sec.	12-16
XL615/9/4	1500	4	9.0	2.5	400	1 per 30 sec.	16-20
XL615/10/5.5	3500	5.5	10.0	2.5	400	1 per 60 sec.	16-20
XL615/10/6.5	5000	6.5	10.0	2.5	800	1 per 2 min.	20-25
XL615/10/12	9000	12	10.0	2.5	800	1 per 2 min.	25
XL615/13/6.5	10000	6.5	13.0	2.5	800	1 per 2 min.	25
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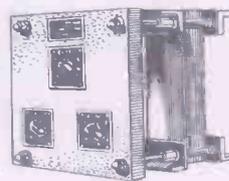
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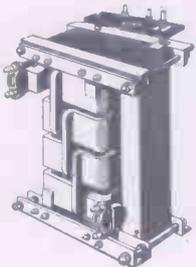
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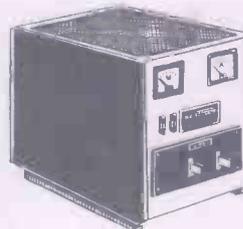
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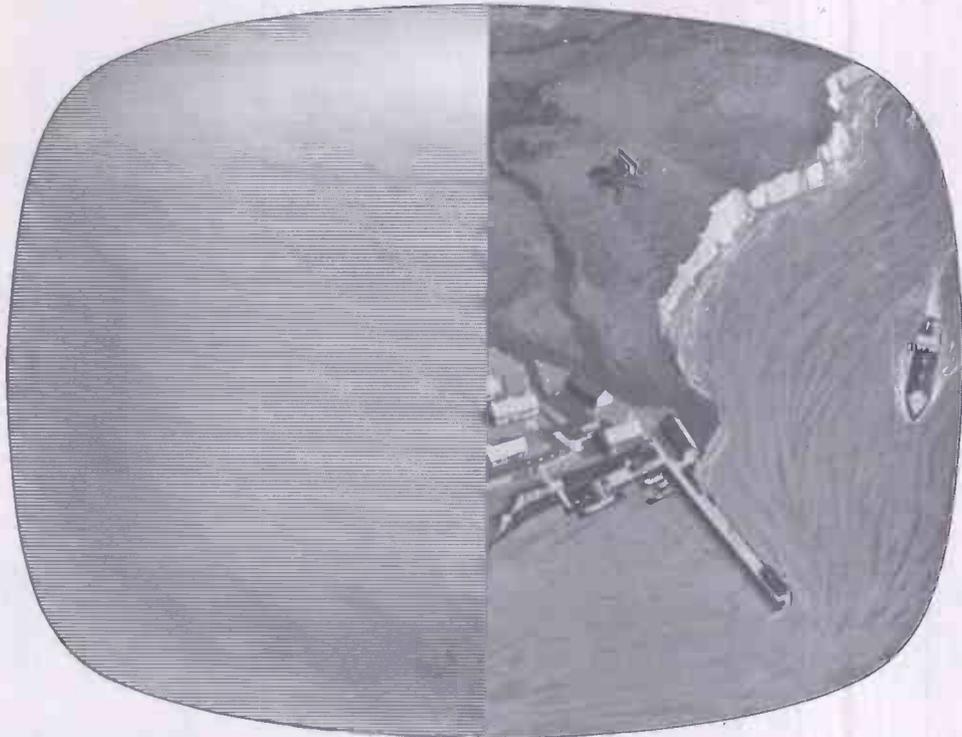
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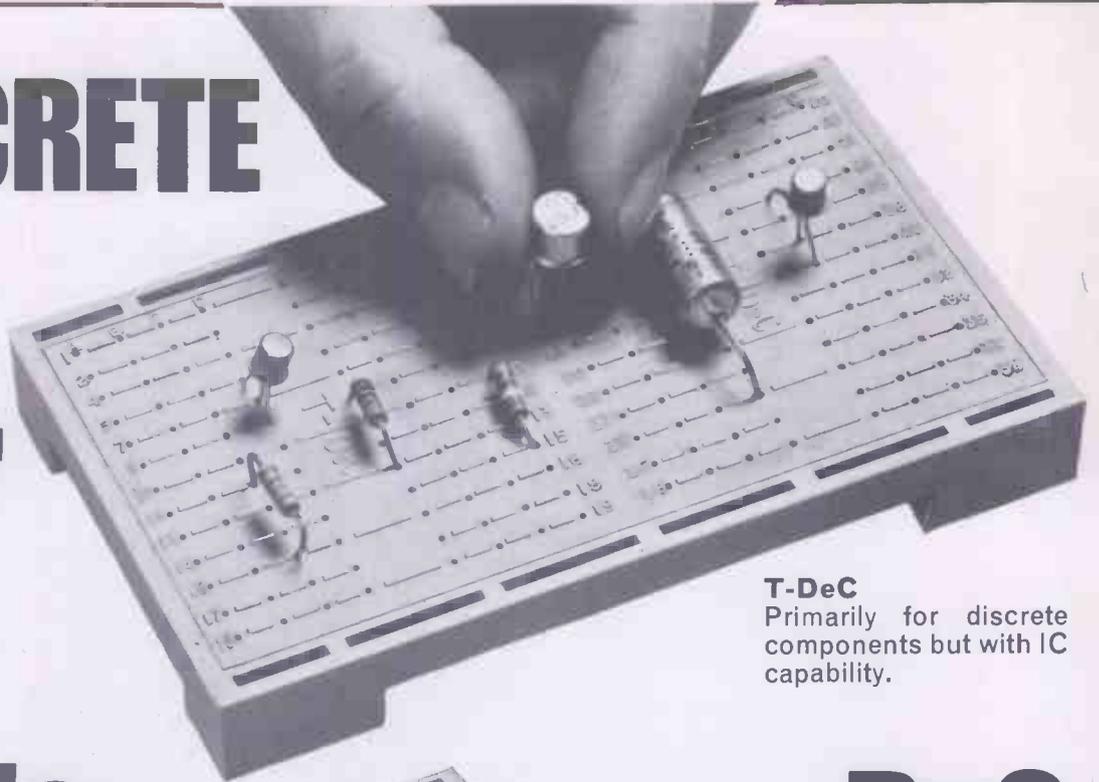
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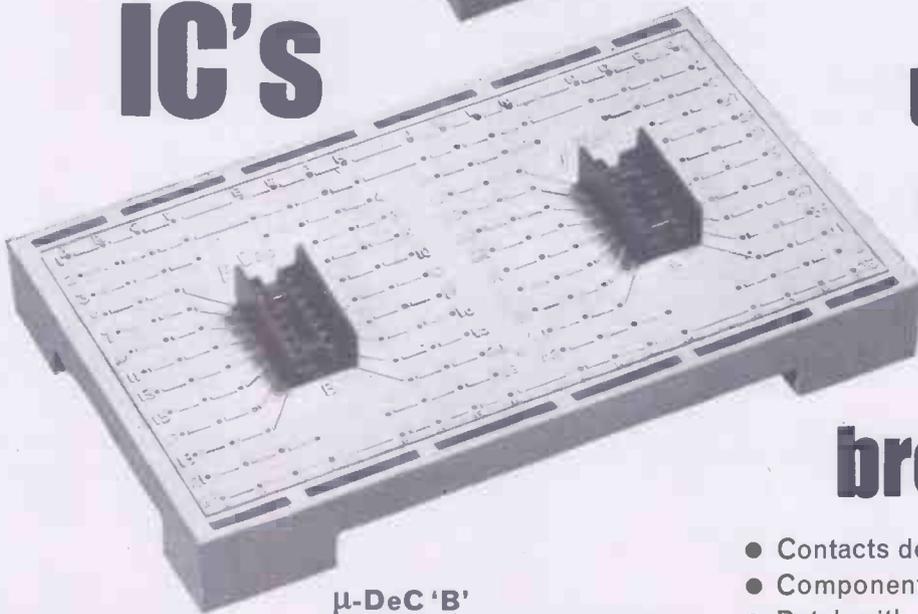
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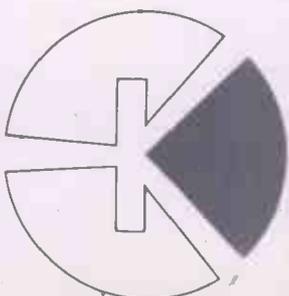
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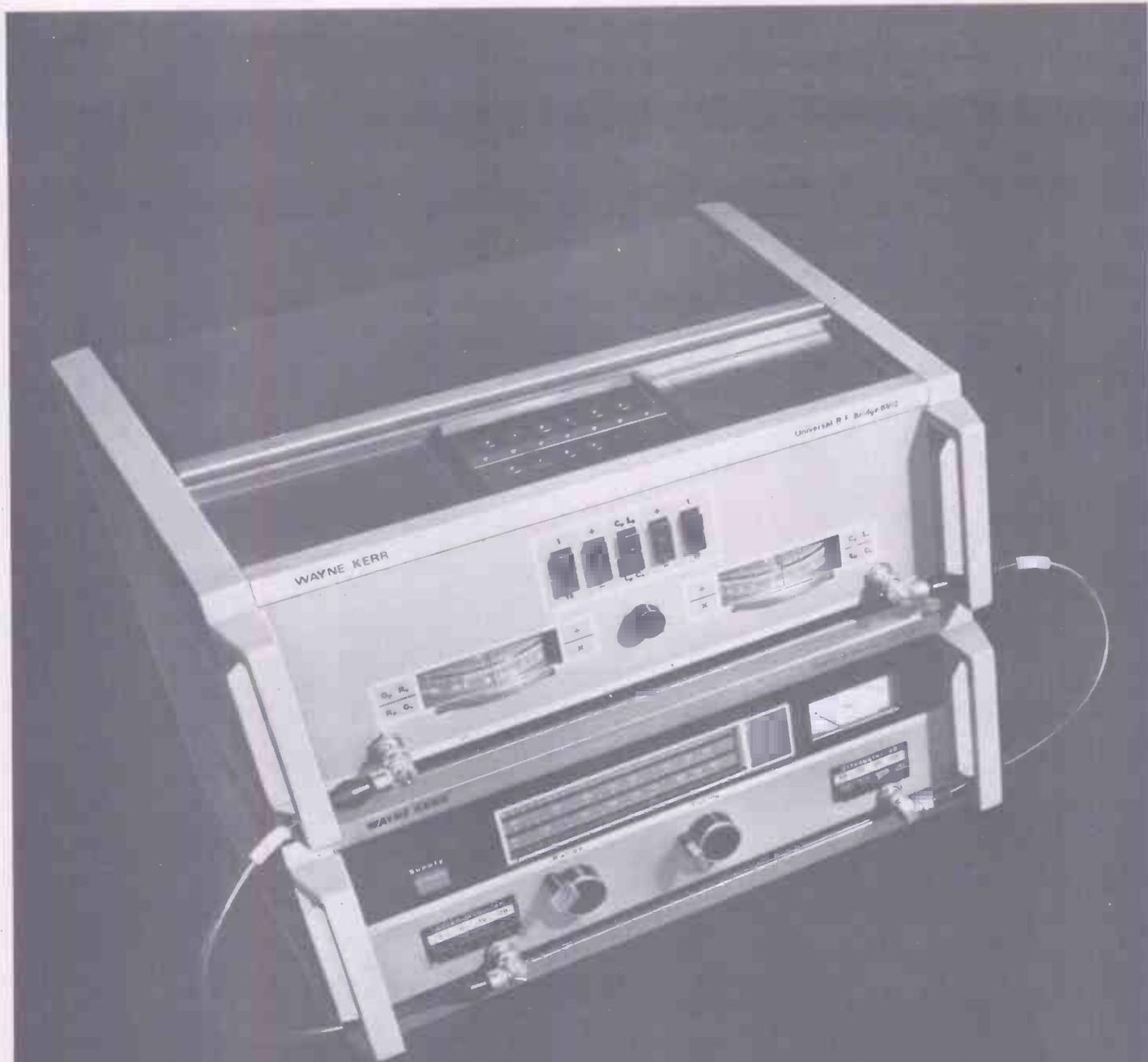
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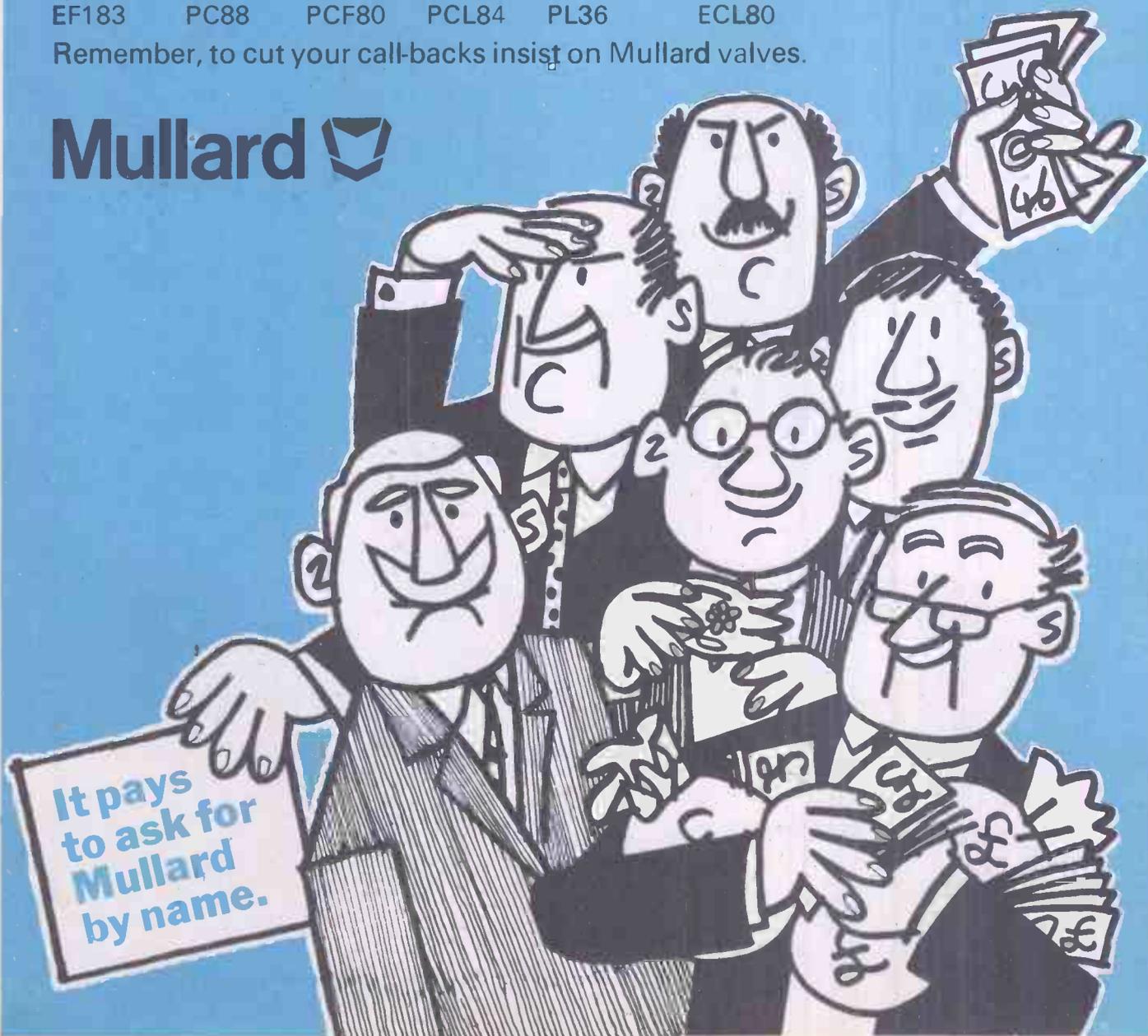
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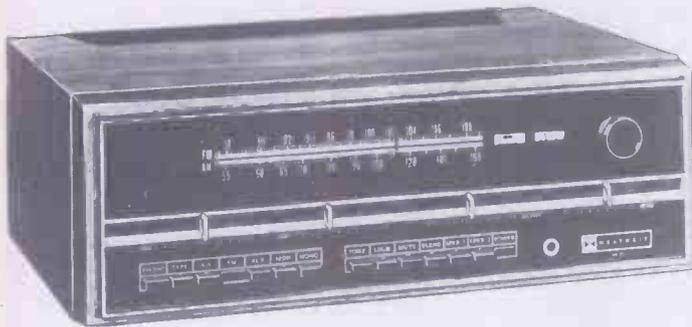
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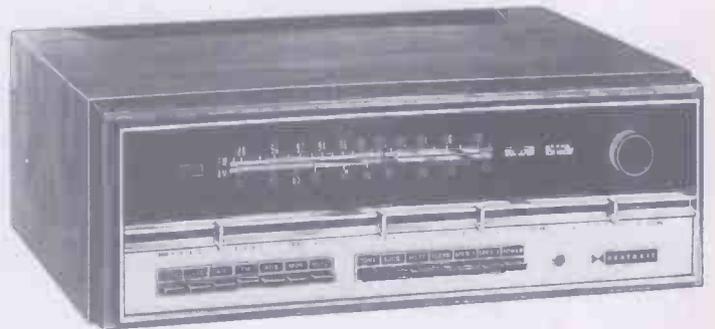
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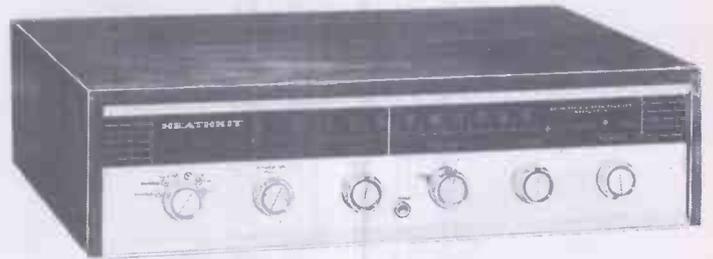
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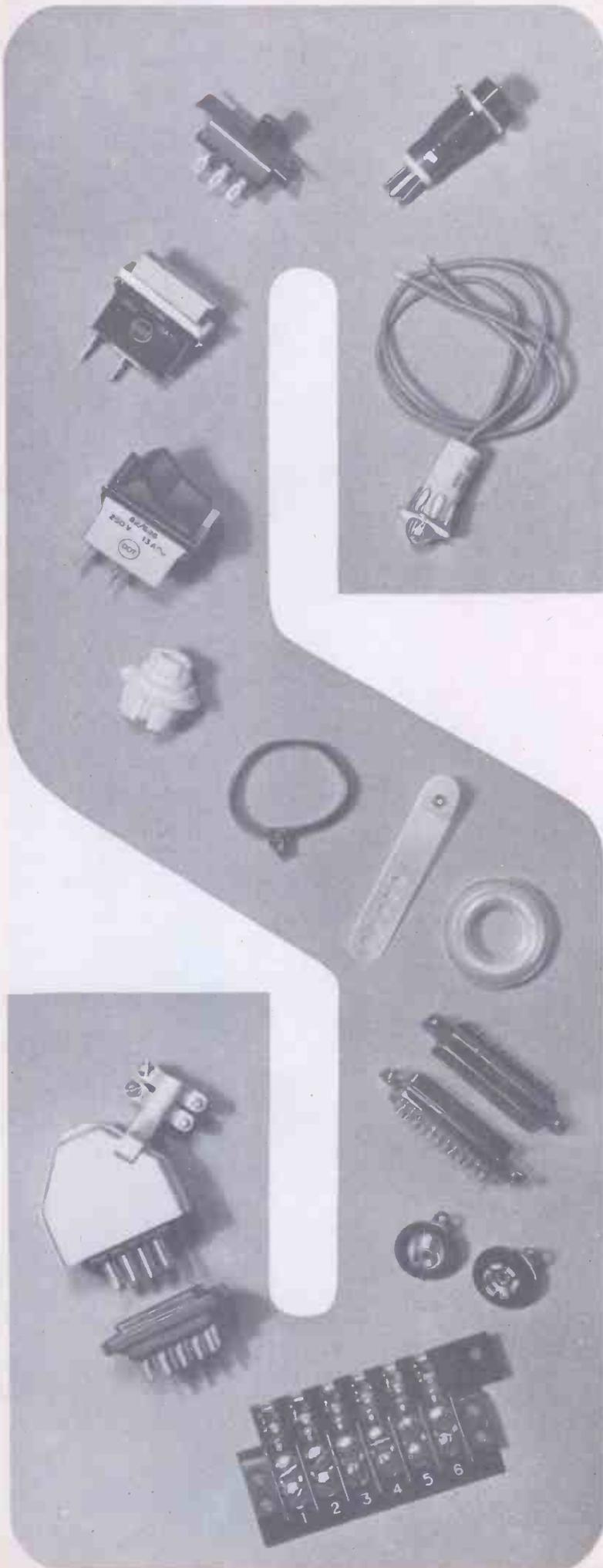
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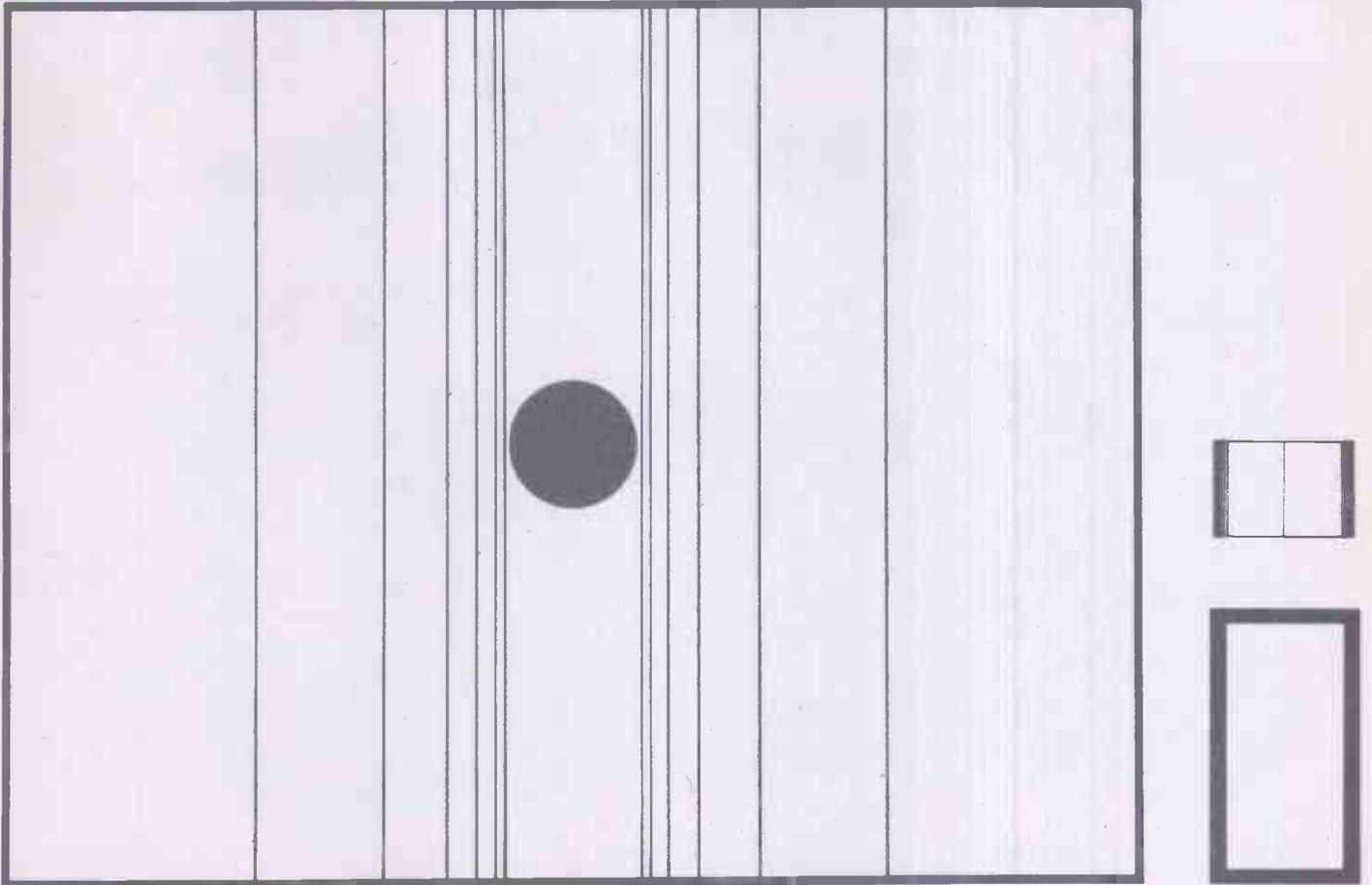
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Acoustic Research designed "Big Horn" to show the size of a horn-type speaker system that could match the bass response of the AR-3a.



a Big Horn; b AR-3a; c *Acoustics* by Beranek; all drawn to the same scale.

When the AR-3a is placed against a wall, its frequency response is flat to below 40 Hz, and continues even at lower frequencies with very low distortion. To design Big Horn, we turned to page 268 of the standard text, *Acoustics* by Leo Beranek*, to find the equation used to calculate the size of a horn with a cutoff frequency of 40 Hz.

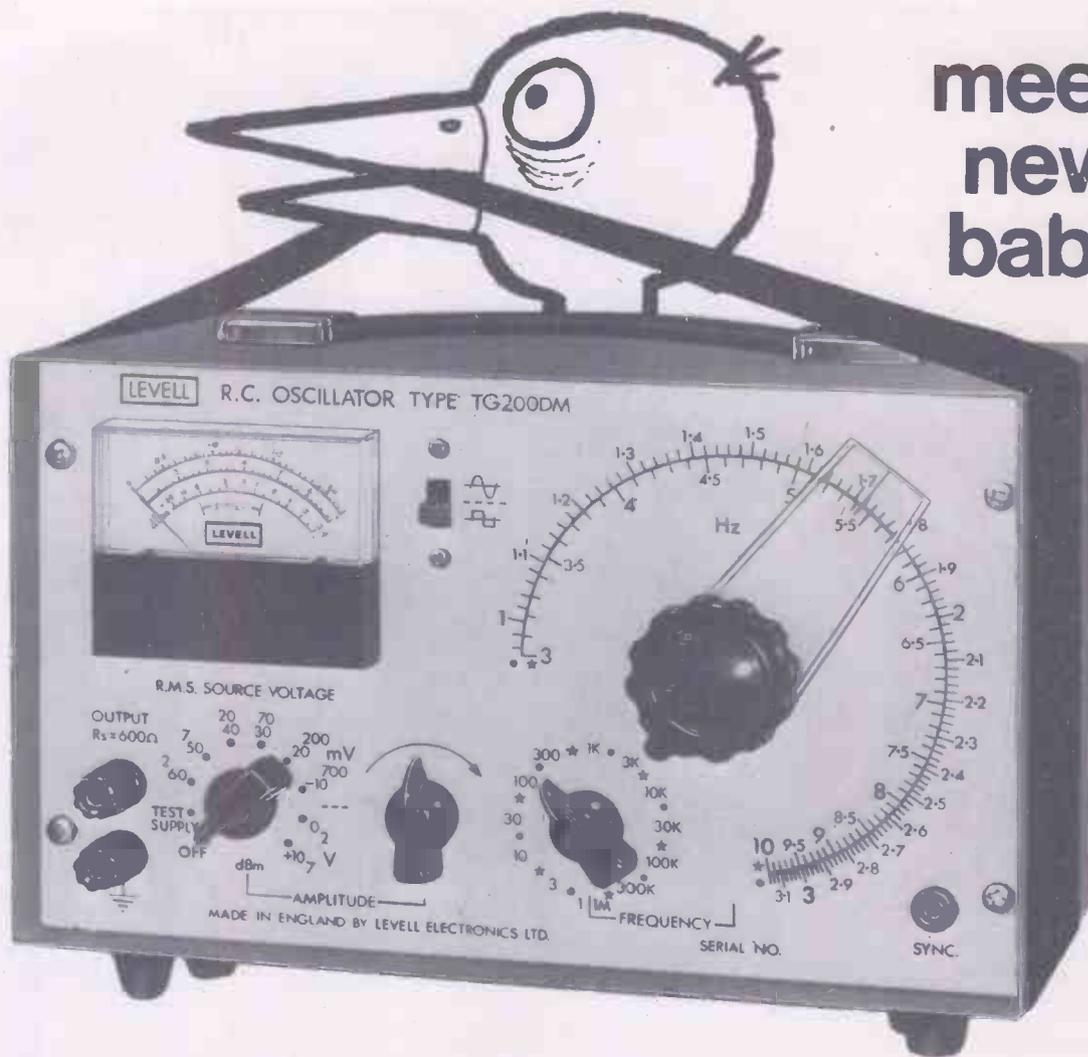
As shown in the scale drawing above, Big Horn is 7 feet high and 9 feet wide; its depth would have to be greater than either of these dimensions. A pair for stereo would take up slightly more space in a living room than two VW buses. Yet, played at the same loudness, the only audible difference between them and a pair of AR-3a systems would be the slightly rougher response of the Big Horns due to reflections inside them. Other than that, the Big Horns should sound excellent; they would simply be not quite as good, and much more costly than AR-3as.

The AR-3a speaker system is made by Acoustic Research and distributed in the U.K. by Bell & Howell.

Complete technical specifications of the AR-3a and other AR high fidelity products are available free on request.

*McGraw-Hill, \$14.50.





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7V r.m.s. Sine or Square from 1Hz to 1MHz

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AMPLITUDE STABILITY:	$< \pm 1\%$ variation with frequency up to 300kHz.
SQUARE WAVE OUTPUT:	7V peak reducible to $< 200\mu\text{V}$. Rise time $< 150\text{nS}$.
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SYNC. INPUT:	$\pm 1\%$ frequency lock range per volt r.m.s. input.
SIZE & WEIGHT:	7" high \times 10½" wide \times 5½" deep. 10 lbs.

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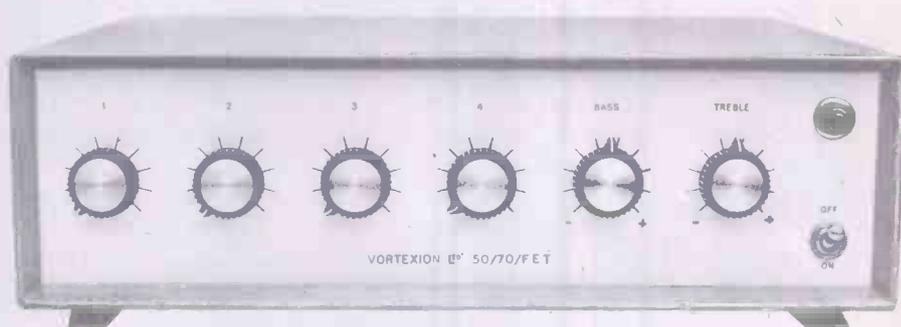
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THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms—15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

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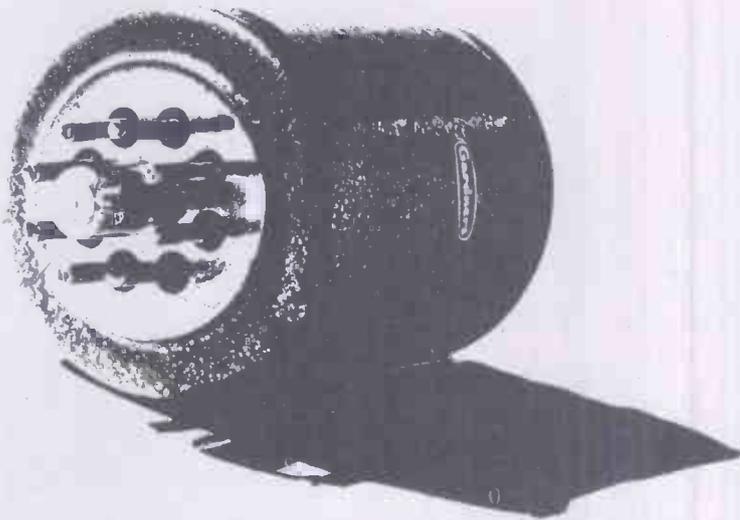
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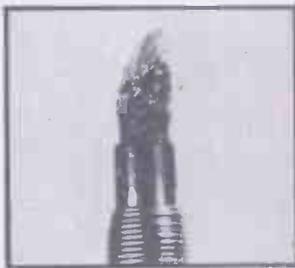
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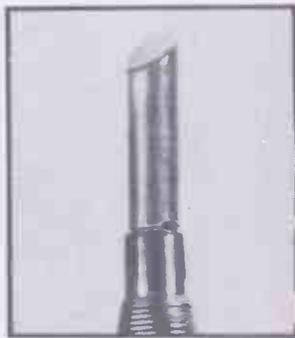
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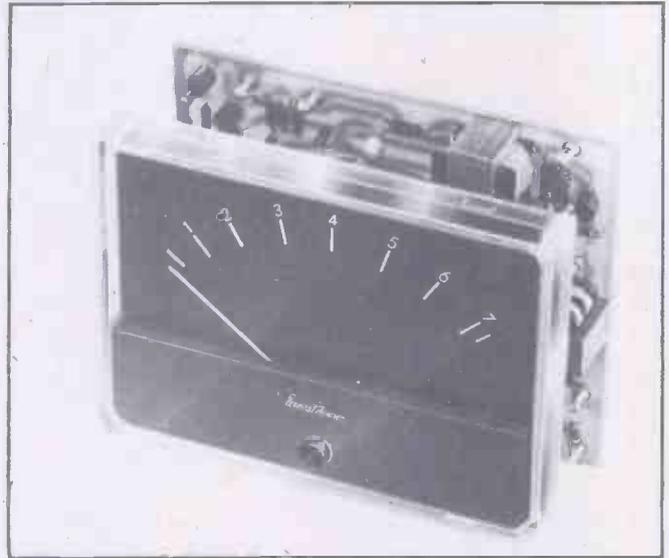
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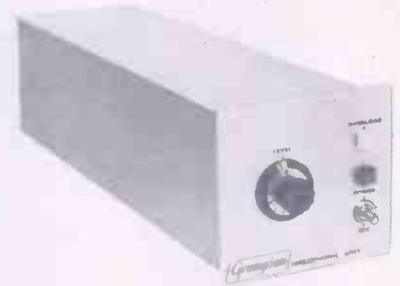
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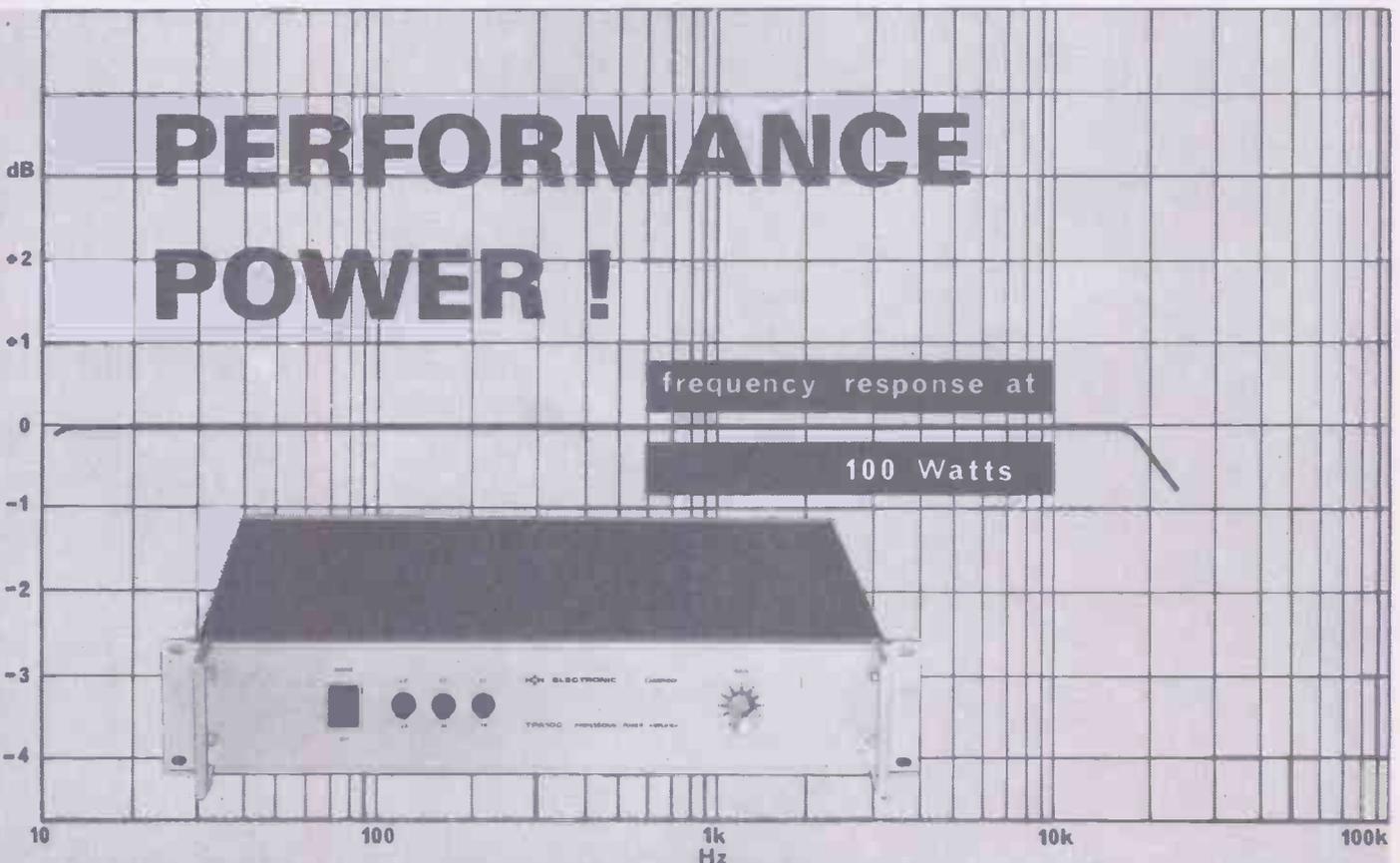
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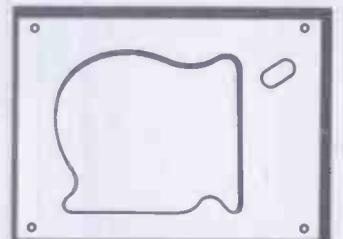
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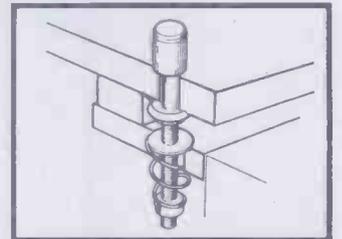


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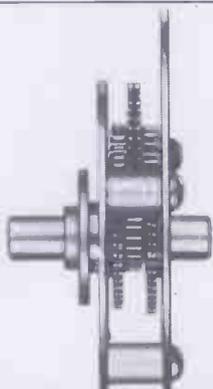
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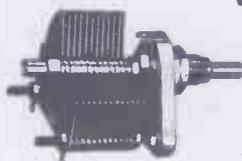
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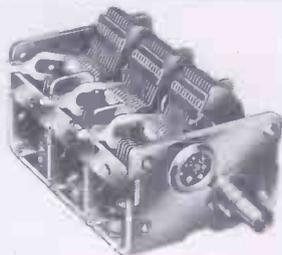
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P.20 2-GANG A.M.

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- ★ Gear ratio 3:1 or 1:1
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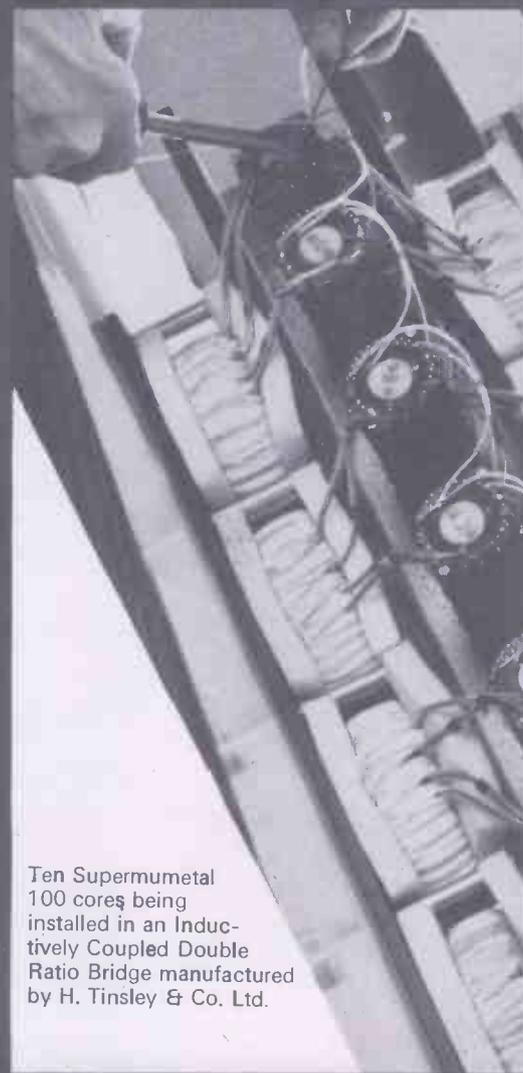
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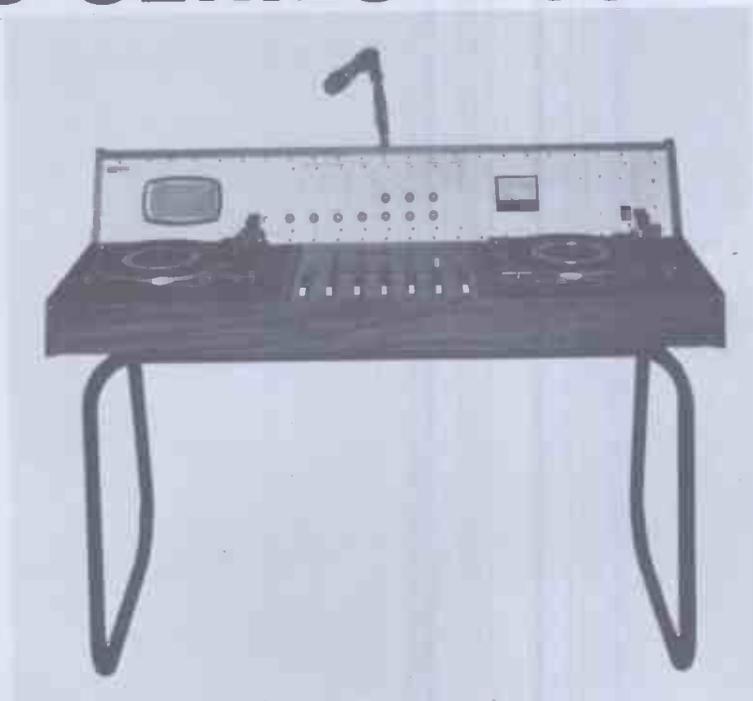
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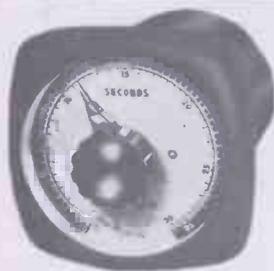
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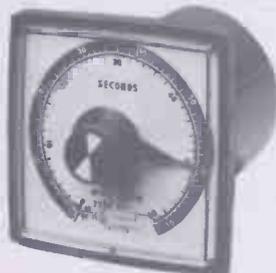


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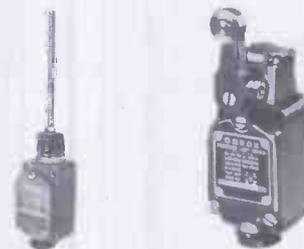
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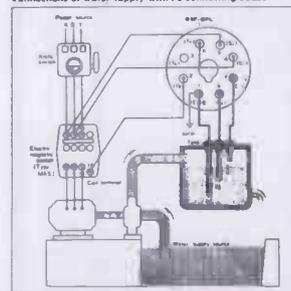
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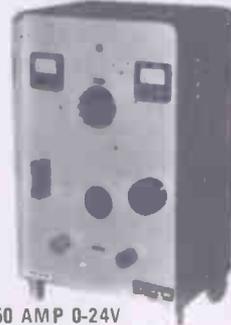
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<i>Five Decade</i>			
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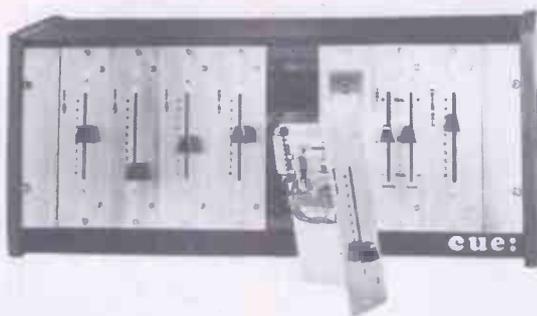
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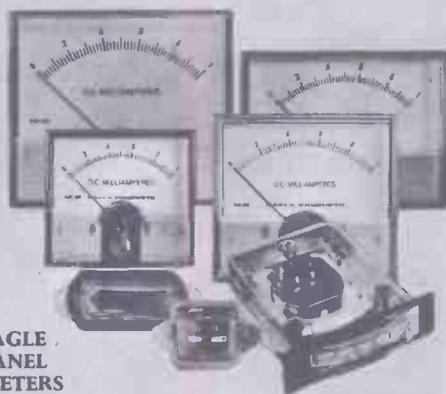
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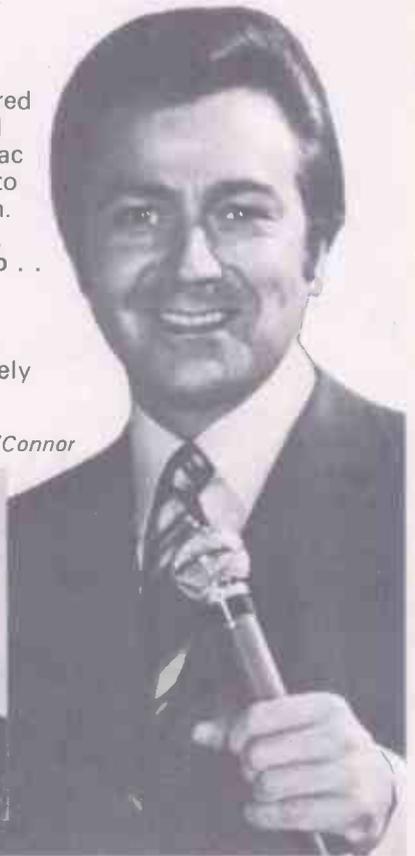
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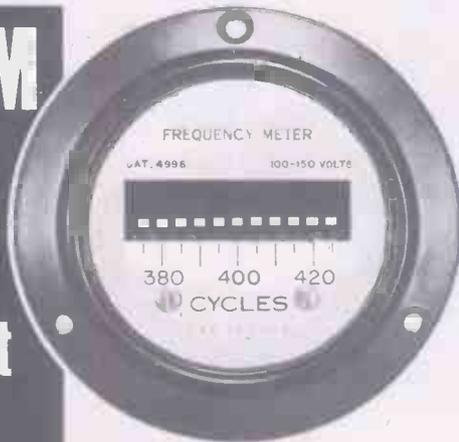
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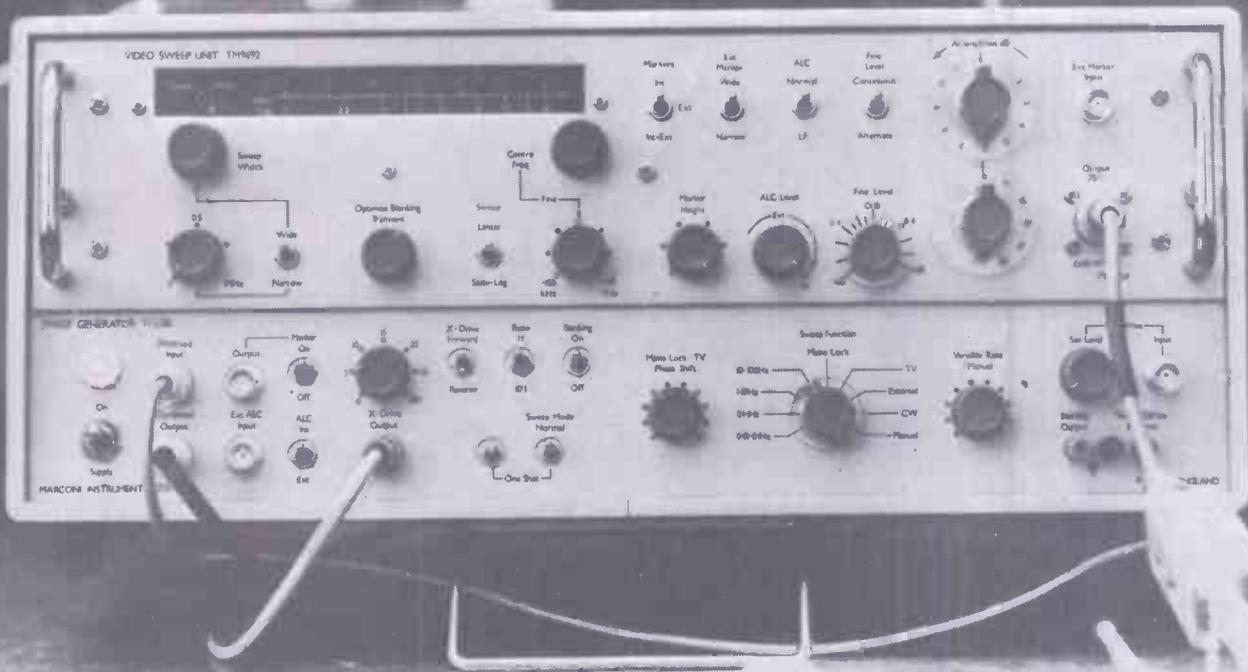
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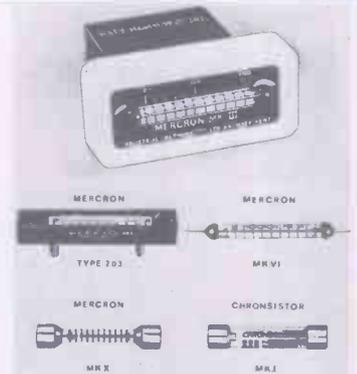
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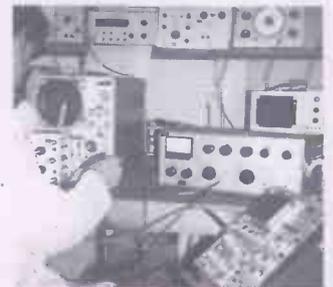


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plug it into your monitor system and it bridges 600Ω lines to drive your speakers.

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**or indeed any other impedance from 5 to 250 ohms.*

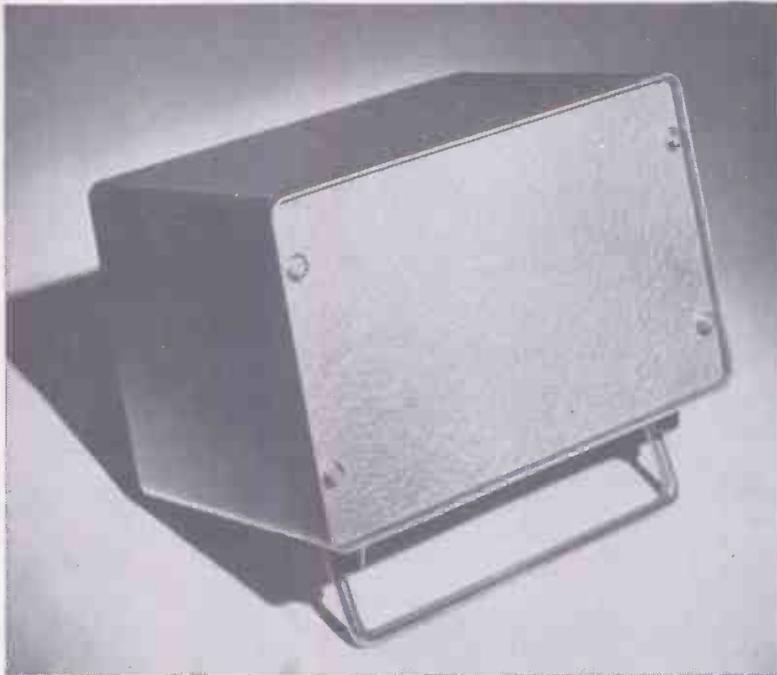


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Just what *is* this ABR, that makes such a vital difference to the 'DITTON 15'?

The "DITTON 15"

Now firmly established as a superb high-fidelity loudspeaker. Design features include the exclusive CELESTION ABR (auxiliary bass radiator), HF1300 treble unit—as used in B.B.C. Monitor Loudspeakers—and specially developed mid/bass unit. Low loss L/C crossover.

Power handling: 15 watts r.m.s.; 30 watts peak. Impedance 4–8 ohms.

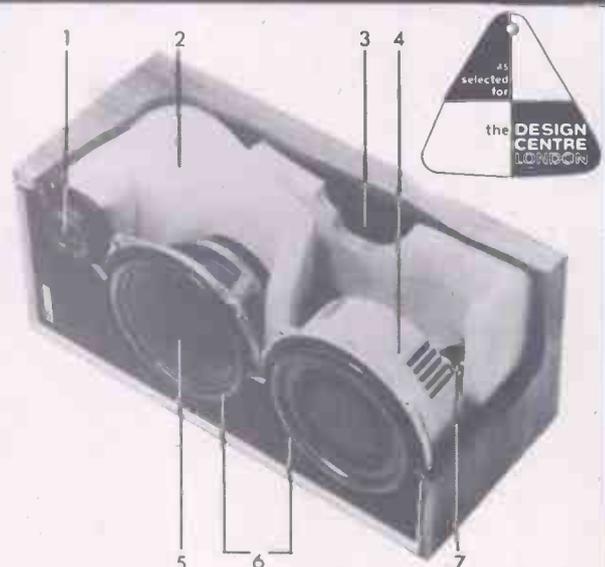
Dimensions: 21 in. x 9½ in. x 9¼ in.

Choice of finish: Teak or walnut.

Recommended Retail Price £29

1. Studio quality high frequency unit (HF1300 Mk. 2).
As used in B.B.C. Monitors.
2. Anechoic cellular foam wedge and lining eliminates standing waves.
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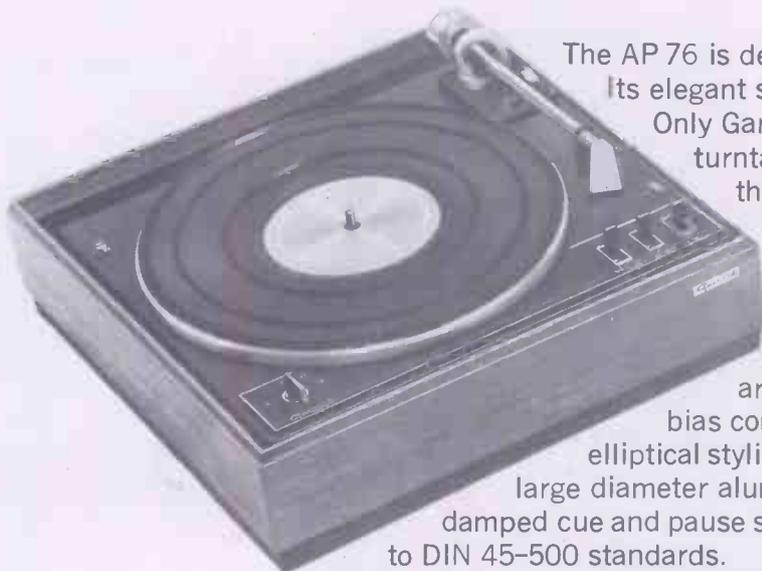
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Two new models from Garrard

The SP 25 MkIII a single play unit cleanly styled in black and silver with performance to DIN 45-500 will be even more popular than its predecessor the SP 25 MkII which dominates this market.

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Recommended retail price—£12.12.6. plus £3.1. 8. P.T.



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Garrard



a PLESSEY quality product



Garrard Engineering Limited, Newcastle St., Swindon, Wiltshire. Tel: Swindon (0793) 5381

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That's why you can be sure of top quality and real value for money from every Garrard model.

They give you a lot of choice too.

You'll find Garrard have something to suit every taste and every pocket. In fact Garrard is the only manufacturer that makes a complete range.

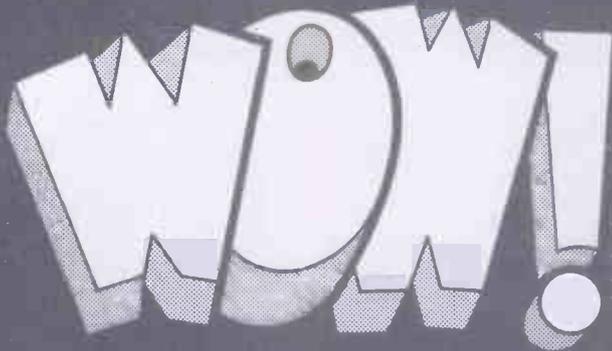
And now it's even better with the introduction of two superb new Hi Fi models – the SP 25 MkIII and AP 76.

Just look at these new Garrard models on the page opposite and see what they offer . . .

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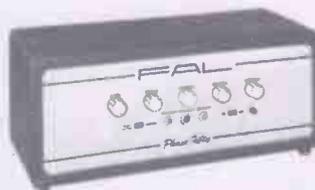
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29 Gns.
*Recommended
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For fast deliveries and full specifications, please contact:

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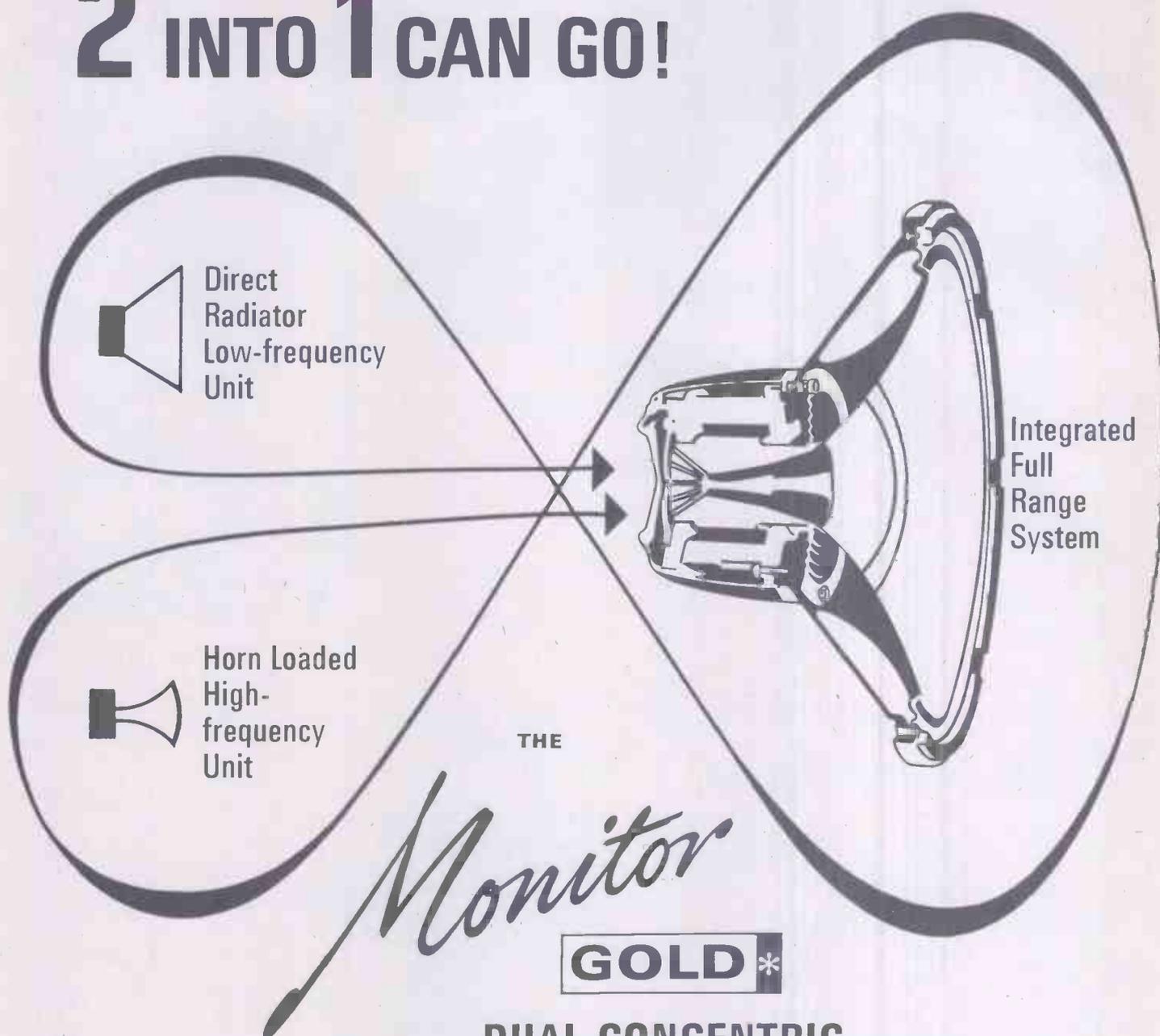
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... provides the perfect integrated source needed for stereo. The Monitor Gold is two separate transducers in a single assembly fed by a sophisticated cross-over and treble control network.

TECHNICAL SPECIFICATION

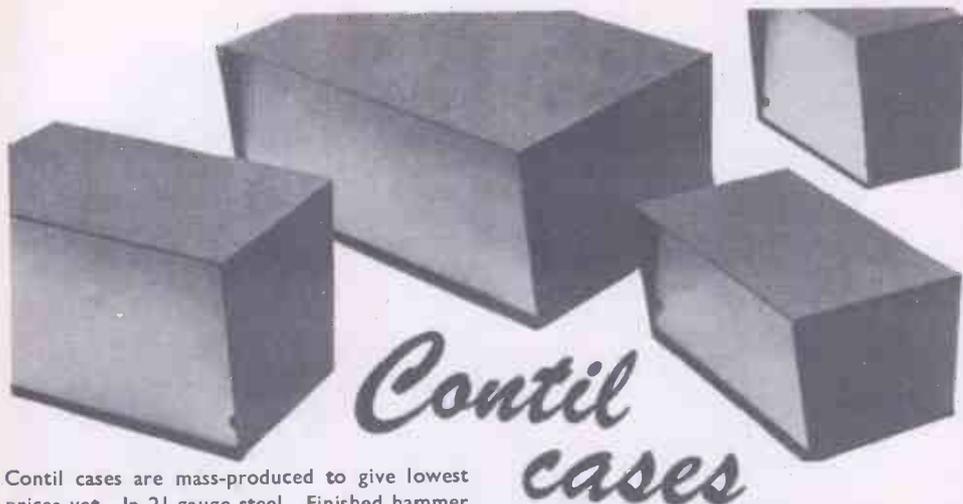
Frequency Response: 30-20,000 Hz. Power Handling Capacity: 15" 50 watts, 12" 30 watts. IHLZ 15 watts. Impedance: 8Ω nominal, 5Ω minimum.

The majority of Recording and T.V. Studios use TANNOY monitors



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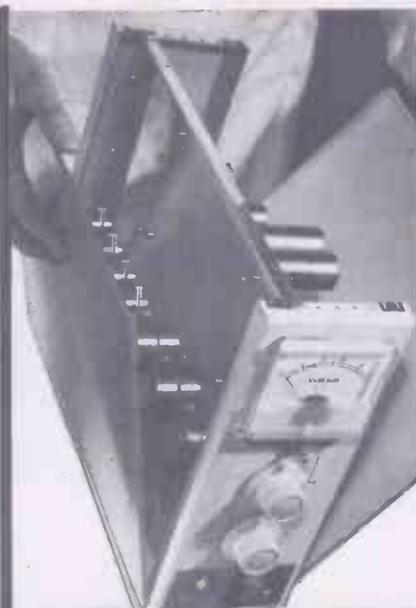
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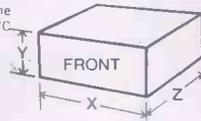
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191010	143/-	140/-	137/-	135/-	134/-	133/-	10/6
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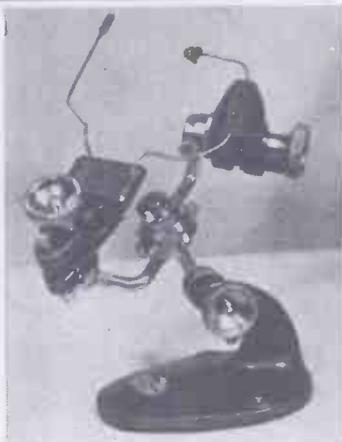
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R	9	10	13	89/-	6/-
S	13	3	13	73/-	6/-
T	13	7	13	89/-	6/-
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V	18	3	13	89/-	6/-
W	18	7	13	107/-	7/6
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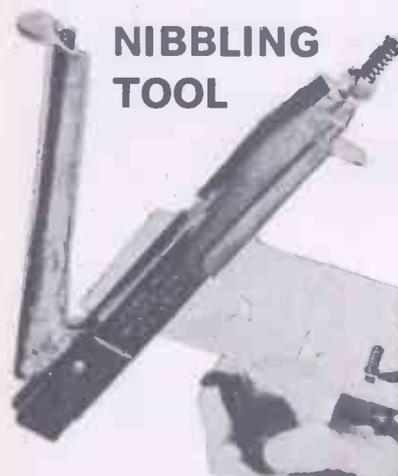
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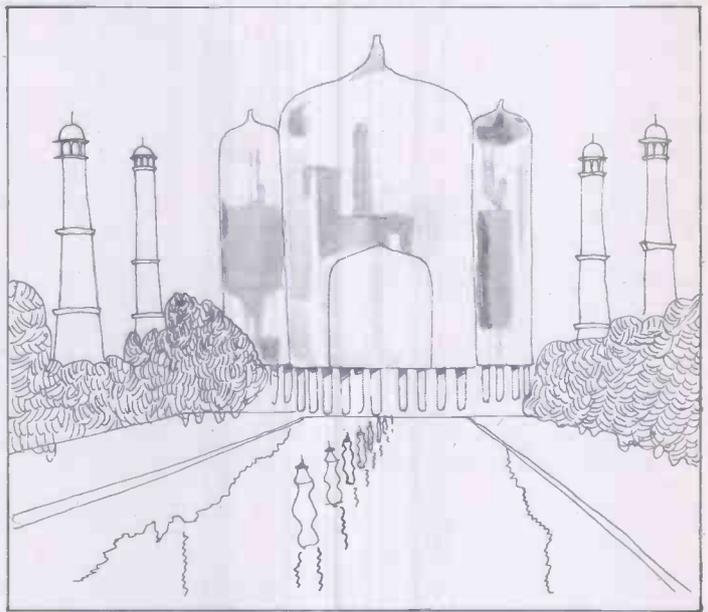
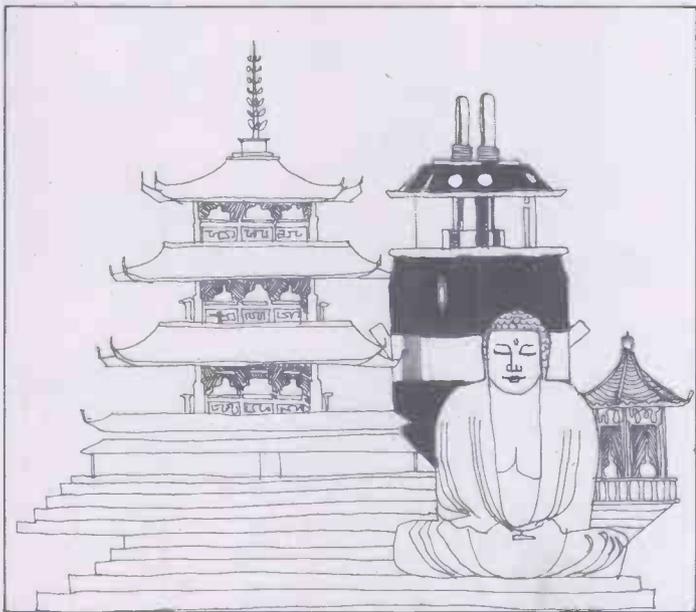
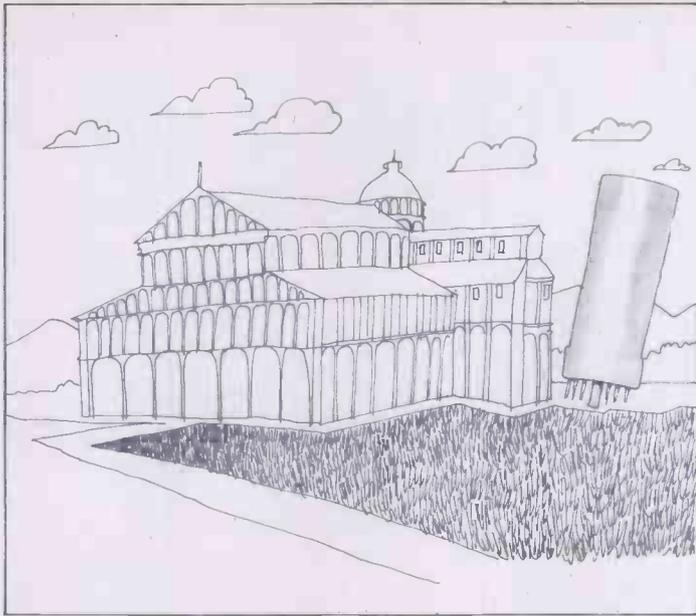
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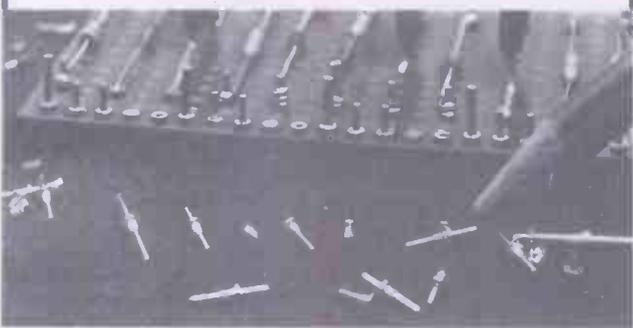
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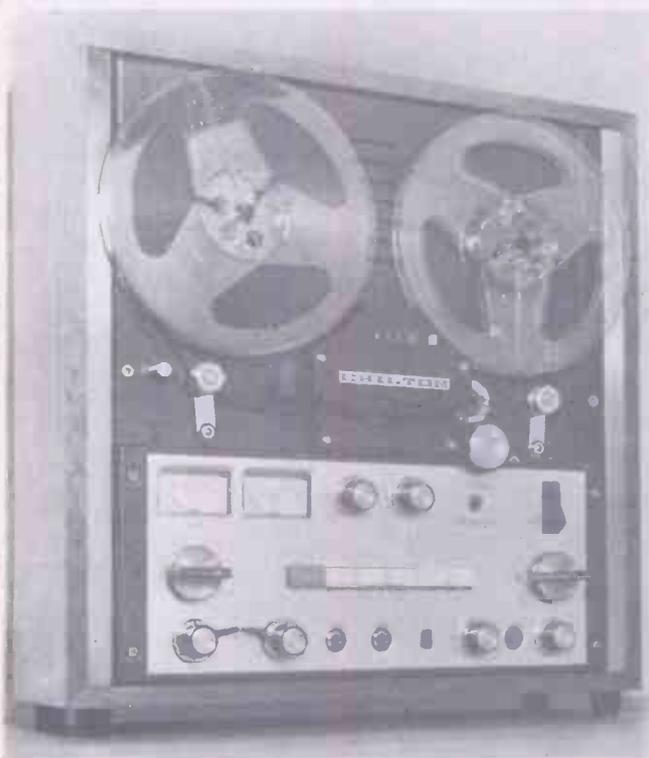
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But those same people had better start looking up. Now. Because that's where it's happening.

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Plus it's got a concealed control box housing

such sophisticated devices as Sansui's exclusive Acoustic Control for superior performance regardless of the listening environment.

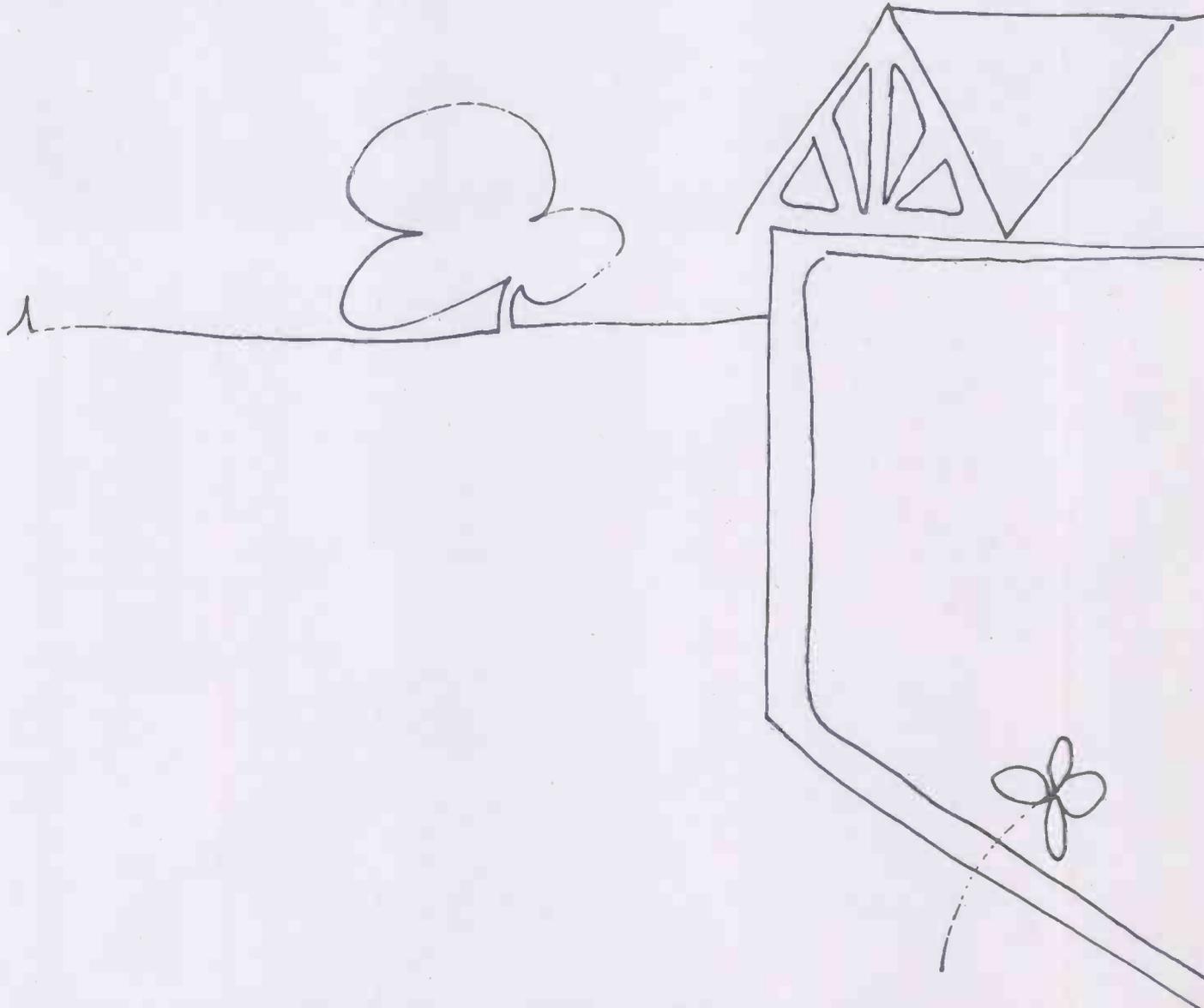
Things are looking up in speakers too. The newly-developed Sansui SL-7 system offers true high-fidelity sound for the first time ever in a slimline system, comes in lustrous pearl or natural wood and is suitable for wall mounting.

And for a peerless tape component, move up to the new Sansui 3-motor 4-head SD-7000, a 4-track, 2-channel deck with advanced relay/solenoid controlled tape transport system.

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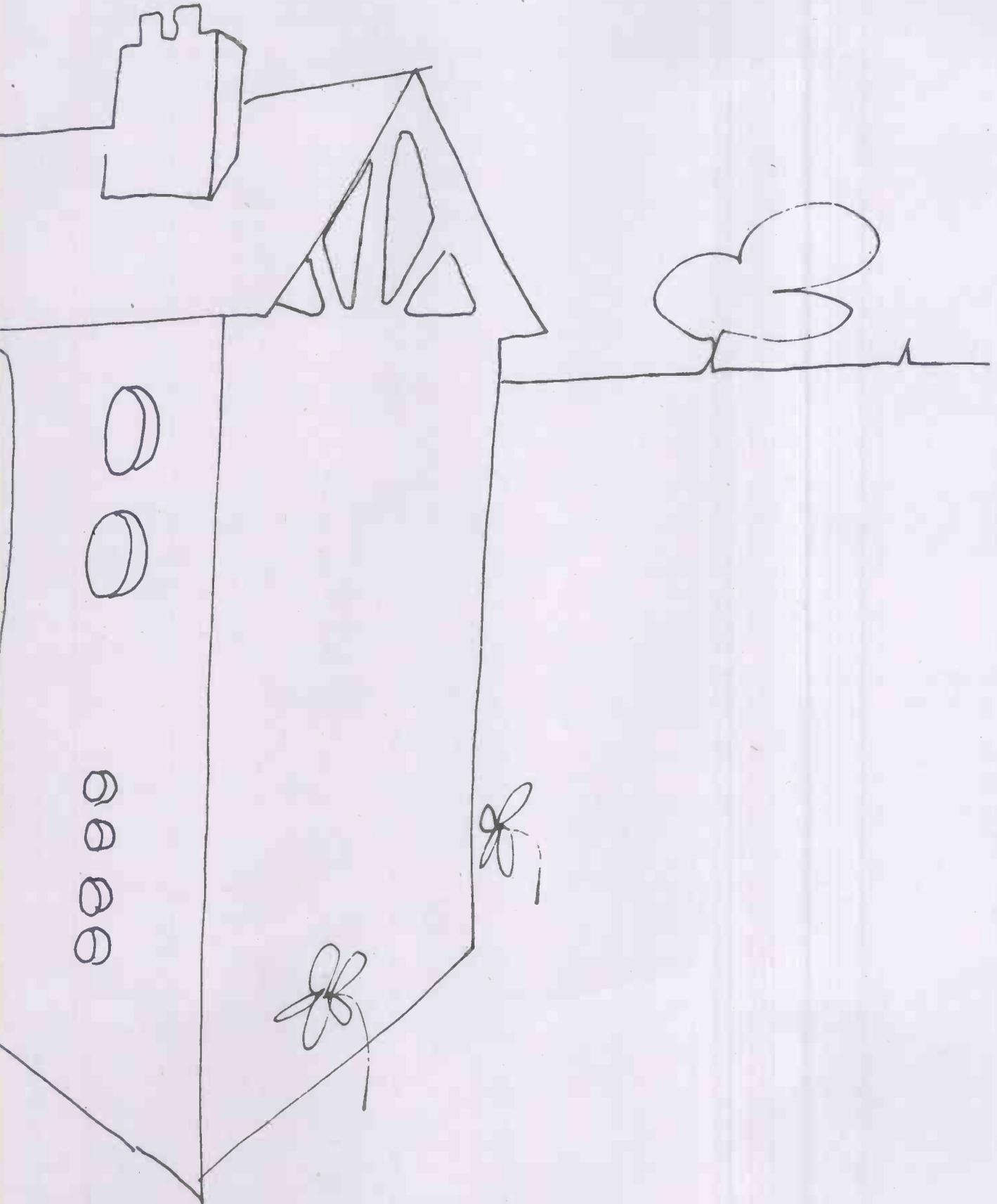
To the Ts the telly is law, opinion, reality, conversation, home—life itself.

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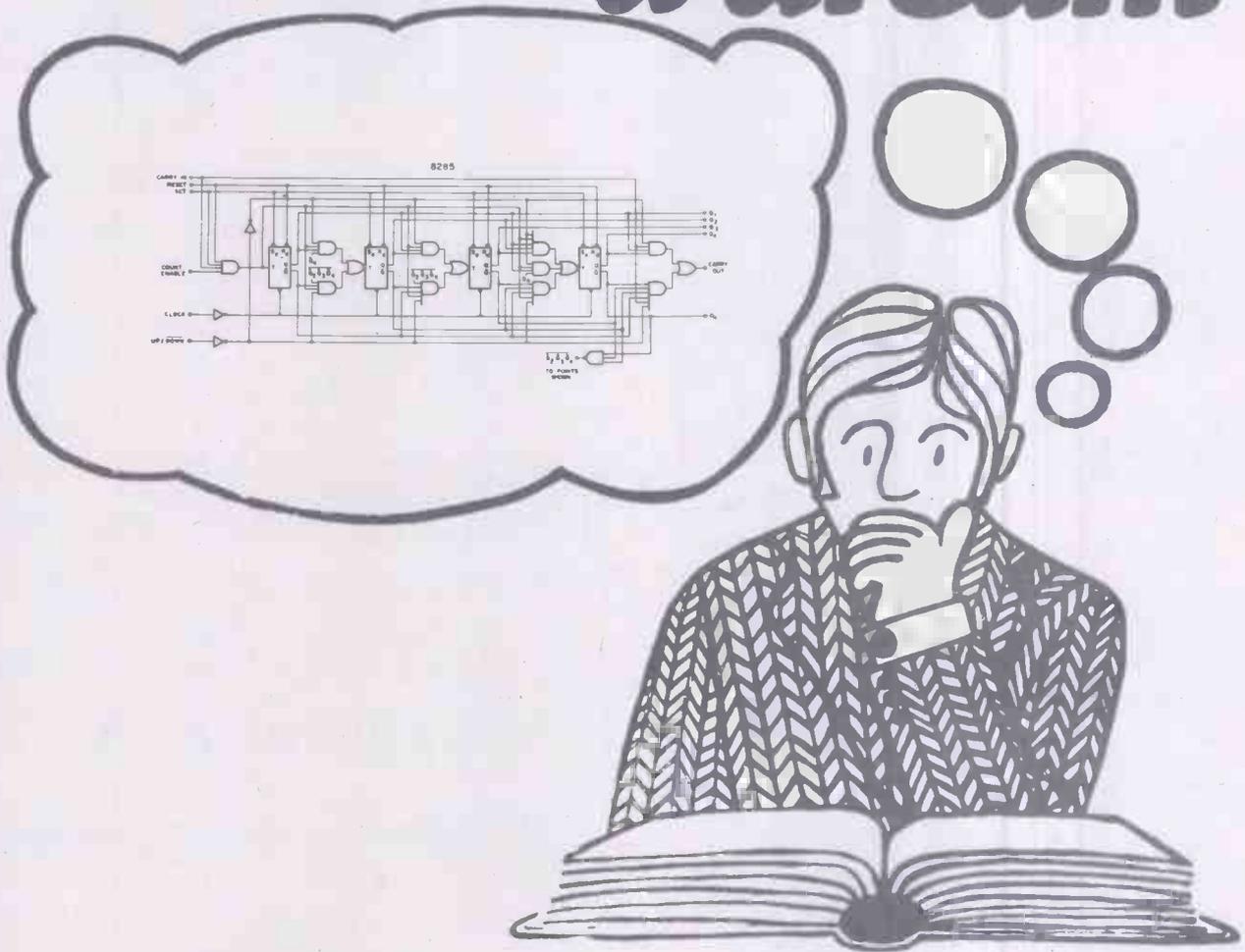
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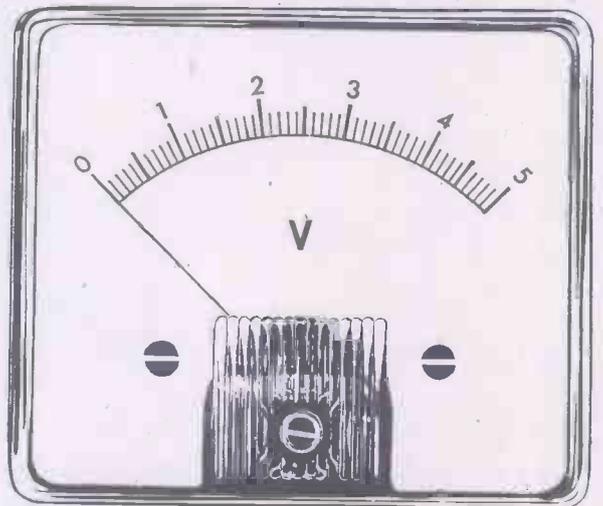
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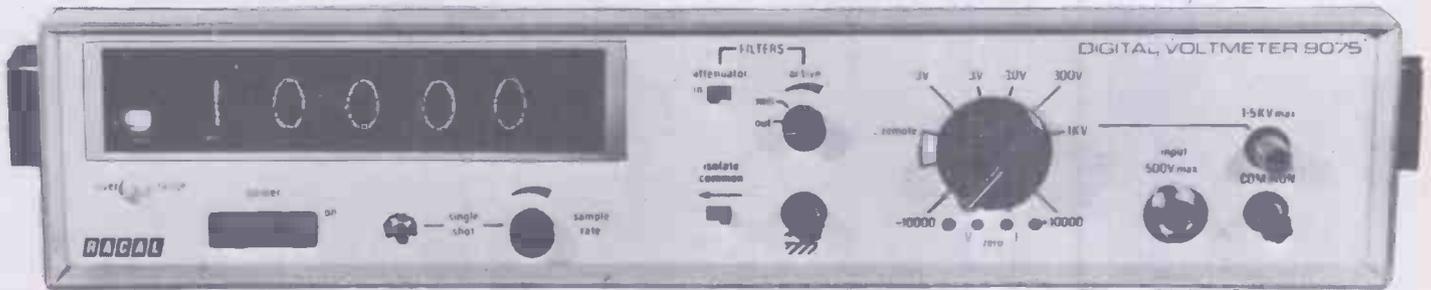
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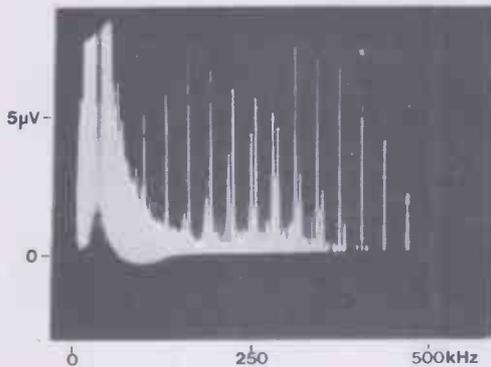


Well how much noise can a digital voltmeter make?

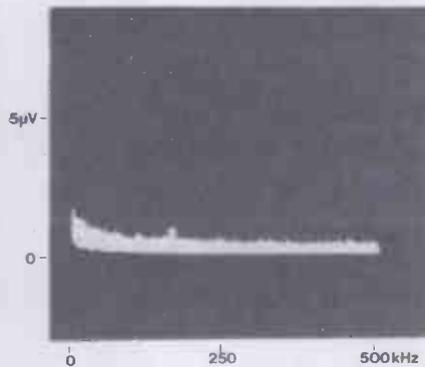
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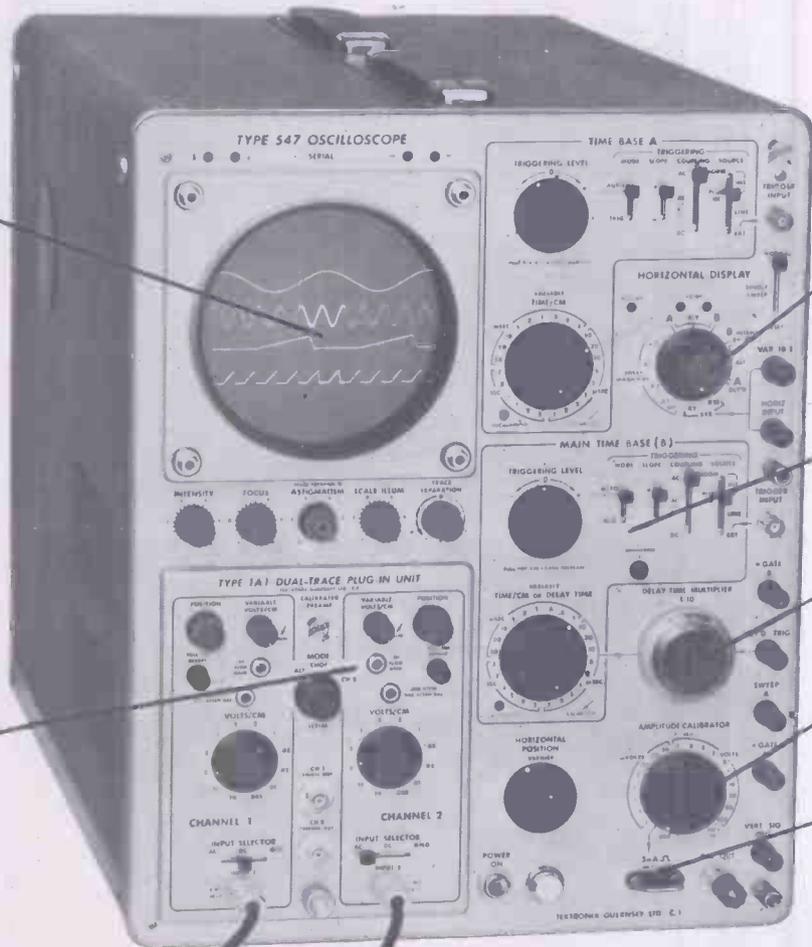
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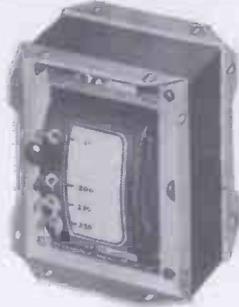


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PRIMARY 200-250V SECONDARY 12V AND/OR 24V						
111	0.5A	0-12V @ 0.25A x 2	3 x 2 1/2 x 1 1/2	12	14/10	13/9
213	1.0A	0-12V @ 0.5A x 2	3 1/2 x 2 x 2	1	17/6	16/2
71	2.0A	0-12V @ 1 Amp x 2	2 1/2 x 2 1/2 x 2 1/2	1	23/1	21/4
68	3.0A	0-12V @ 3 Amp	3 1/2 x 2 1/2 x 3 1/2	2	28/8	26/6
18	4.0A	0-12V @ 2 Amp x 2	3 1/2 x 2 1/2 x 2 1/2	2	31/4	29/11
85	5.0A	0-12V @ 5 Amp	4 x 3 x 3	3	36/11	34/1
70	6.0A	0-12V @ 6 Amp	4 x 3 x 3 1/2	3	39/-	36/1
108	8.0A	0-12V @ 4 Amp x 2	4 x 3 1/2 x 3 1/2	4	44/1	40/8
72	10.0A	0-12V @ 5 Amp x 2	3 1/2 x 4 1/2 x 4	6	3	51/3
17	16.0A	0-12V @ 8 Amp x 2	4 1/2 x 3 1/2 x 4	7	8	79/-
115	20.0A	0-12V @ 10 Amp x 2	4 1/2 x 4 1/2 x 4	11	13	100/6
187	30.0A	0-12V @ 15 Amp x 2	5 1/2 x 4 1/2 x 4 1/2	16	12	185/6

30 VOLT RANGE PRIMARY 200-250V—SECONDARY 30V						
Ref. No.	Current	Secondary Taps	Dimensions inches	Weight lbs. ozs.	Price	
112	0.5A	0-12-15-24-30V	3 1/2 x 2 1/2 x 1 1/2	1	4	17/6
79	1.0A	"	2 1/2 x 2 1/2 x 2 1/2	2	0	23/7
3	2.0A	"	3 1/2 x 2 1/2 x 3	3	2	31/10
20	3.0A	"	4 x 3 1/2 x 3 1/2	4	6	43/1
21	4.0A	"	4 x 3 1/2 x 3 1/2	6	0	51/3
51	5.0A	"	4 1/2 x 3 1/2 x 4	6	8	63/1
117	6.0A	"	4 1/2 x 3 1/2 x 4	7	8	75/10
88	8.0A	"	5 1/2 x 3 1/2 x 4 1/2	9	6	100/6
89	10.0A	"	5 1/2 x 4 x 4 1/2	12	2	124/1

50 VOLT RANGE PRIMARY 200-250V—SECONDARY 50V						
Ref. No.	Current	Secondary Taps	Dimensions inches	Weight lbs. ozs.	Price	
102	0.5A	0-19-25-33-40-50V	2 1/2 x 2 1/2 x 2 1/2	1	11	23/1
103	1.0A	"	3 1/2 x 2 1/2 x 2 1/2	2	10	33/10
104	2.0A	"	4 x 3 1/2 x 3 1/2	5	0	46/8
105	3.0A	"	4 x 4 x 3 1/2	6	0	63/7
106	4.0A	"	4 1/2 x 4 1/2 x 4	9	4	84/-
107	6.0A	"	4 1/2 x 4 1/2 x 4 1/2	12	4	124/1
118	8.0A	"	5 1/2 x 5 1/2 x 4 1/2	18	9	162/-
119	10.0A	"	6 1/2 x 4 1/2 x 6 1/2	19	12	203/-

60 VOLT RANGE PRIMARY 200-250V—SECONDARY 60V						
Ref. No.	Current	Secondary Taps	Dimensions inches	Weight lbs. ozs.	Price	
124	0.5A	0-24-30-40-48-60V	3 1/2 x 3 1/2 x 2 1/2	2	4	23/7
126	1.0A	"	3 1/2 x 3 x 3	3	0	32/10
127	2.0A	"	4 x 3 1/2 x 3 1/2	5	6	51/3
125	3.0A	"	4 1/2 x 3 1/2 x 4	7	0	75/10
123	4.0A	"	4 1/2 x 3 1/2 x 4 1/2	10	6	100/6
40	5.0A	"	5 1/2 x 5 x 5 1/2	13	4	121/-
120	6.0A	"	5 1/2 x 4 1/2 x 4 1/2	16	12	145/7
121	8.0A	"	5 1/2 x 5 1/2 x 4 1/2	20	3	192/8
122	10.0A	"	6 1/2 x 5 x 6 1/2	23	2	241/6
189	12.0A	"	5 1/2 x 6 1/2 x 6 1/2	31	0	289/6

MAINS ISOLATING RANGE PRIMARY 200-250V—SECONDARY 240V CENTRE TAPPED AND EARTH SHIELDED						
Ref. No.	Rating V.A.	For alternative 115 Volt Secondaries quote Ref. No.	Dimensions inches	Weight lbs. ozs.	Price	
100	60	191	4 x 3 1/2 x 3 1/2	4	10	37/5
61	100	192	4 x 3 1/2 x 3 1/2	9	12	45/7
30	200	193	4 1/2 x 4 x 4 1/2	9	12	45/7
62	250	194	3 1/2 x 5 x 4 1/2	12	4	100/11
55	350	195	5 1/2 x 5 1/2 x 4 1/2	17	6	137/4
63	500	196	6 1/2 x 4 1/2 x 6 1/2	27	0	194/8
96	750	197	5 1/2 x 6 1/2 x 6 1/2	31	0	277/8
92	1000	198	7 x 6 1/2 x 8 1/2	40	0	358/8
97	1250	199	7 x 7 x 8 1/2	47	0	440/8
128	2000	200	9 1/2 x 8 1/2 x 6	63	0	593/2
129	3000	201	8 1/2 x 8 1/2 x 8	84	0	927/7
190	6000	202	12 1/2 x 14 x 6 1/2	178	0	1,524/2

AUTO WOUND TRANSFORMERS						
Ref. No.	Current	Auto Taps	Dimensions inches	Weight lbs. oz.	Price	
113	20	0-115-210-240V	2 1/2 x 1 1/2 x 1 1/2	1	11	14/10
64	75	0-115-210-240V	2 1/2 x 2 1/2 x 2 1/2	1	14	28/8
4	150	0-115-200-220-240V	3 1/2 x 2 1/2 x 3	3	3	34/10
65	200	"	3 1/2 x 4 1/2 x 4	4	4	49/3
66	300	"	4 x 4 x 3 1/2	6	7	67/7
110	400	"	4 1/2 x 4 1/2 x 4	11	11	84/6
67	500	"	5 1/2 x 4 x 4 1/2	12	8	100/6
83	750	"	4 1/2 x 5 1/2 x 5 1/2	13	4	142/5
84	1000	"	4 1/2 x 5 1/2 x 5 1/2	16	6	182/5
93	1500	"	5 1/2 x 5 1/2 x 6 1/2	28	9	264/5
94	1750	"	5 1/2 x 6 1/2 x 6 1/2	31	12	297/3
95	2000	"	7 x 6 1/2 x 8 1/2	40	3	345/2
99	2500	"	6 1/2 x 6 1/2 x 8 1/2	44	4	407/11
73	3000	"	6 1/2 x 7 1/2 x 8 1/2	45	8	469/5

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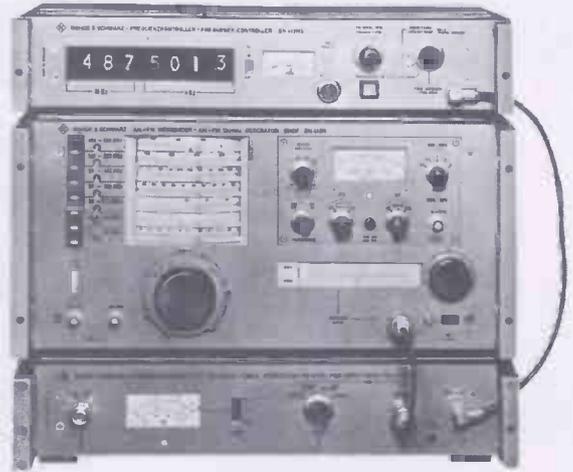
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FT-150 ADDITIONAL DATA TO ABOVE

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FT-500 ADDITIONAL DATA TO ABOVE

—TRANSMITTING POWER: SSB/CW=500W PEP INPUT, AM=200W INPUT, SENSITIVITY 0.5 V FOR 6db/SN STABILITY 100Hz, CRYSTAL FILTER 3.18KHz, ANTENNA π FILTER MATCHING 50 ... 100 Ω . WEIGHT 18kg. LENGTH 400 x HEIGHT 160 x DEPTH 350 mm.

FL-500 ADDITIONAL DATA TO ABOVE

—TRANSMITTING POWER: SSB/CW=240W PEP INPUT, AM=100W INPUT, STABILITY 100Hz, VOX RTTY BY EXTRA EXTENSION, TELEGRAPHIC bk CIRCUIT, ANTENNA MATCHING 50 ... 100 Ω . WEIGHT 15kg. LENGTH 370 x HEIGHT 160 x DEPTH 290 mm.

FR-500 ADDITIONAL DATA TO ABOVE

—SENSITIVITY 0.5 μ V FOR 10db/SN ADDITIONAL FREQUENCIES TO ABOVE 1.7 ... 2.3, 919 ... 10.5MHz 26.9 ... 27.5MHz FM WITH OPTIONAL EXTRA DEMODULATOR. WEIGHT 15kg. LENGTH 370 x HEIGHT 160 x DEPTH 290 mm.

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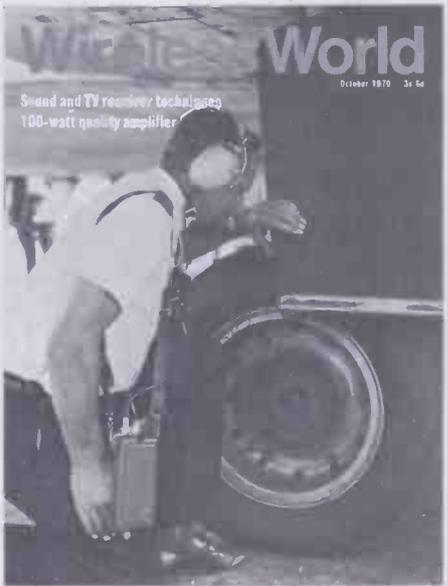
Electronics, Television, Radio, Audio

Sixtieth year of publication

October 1970

Volume 76 Number 1420

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Loudspeaker driver units. The fundamental parameters of moving-coil speakers will be examined and some new thinking introduced by Ted Jordan.

The first of a series of three articles on the design and construction of a high-quality tape recorder.

Details of an extra-versatile tone control.

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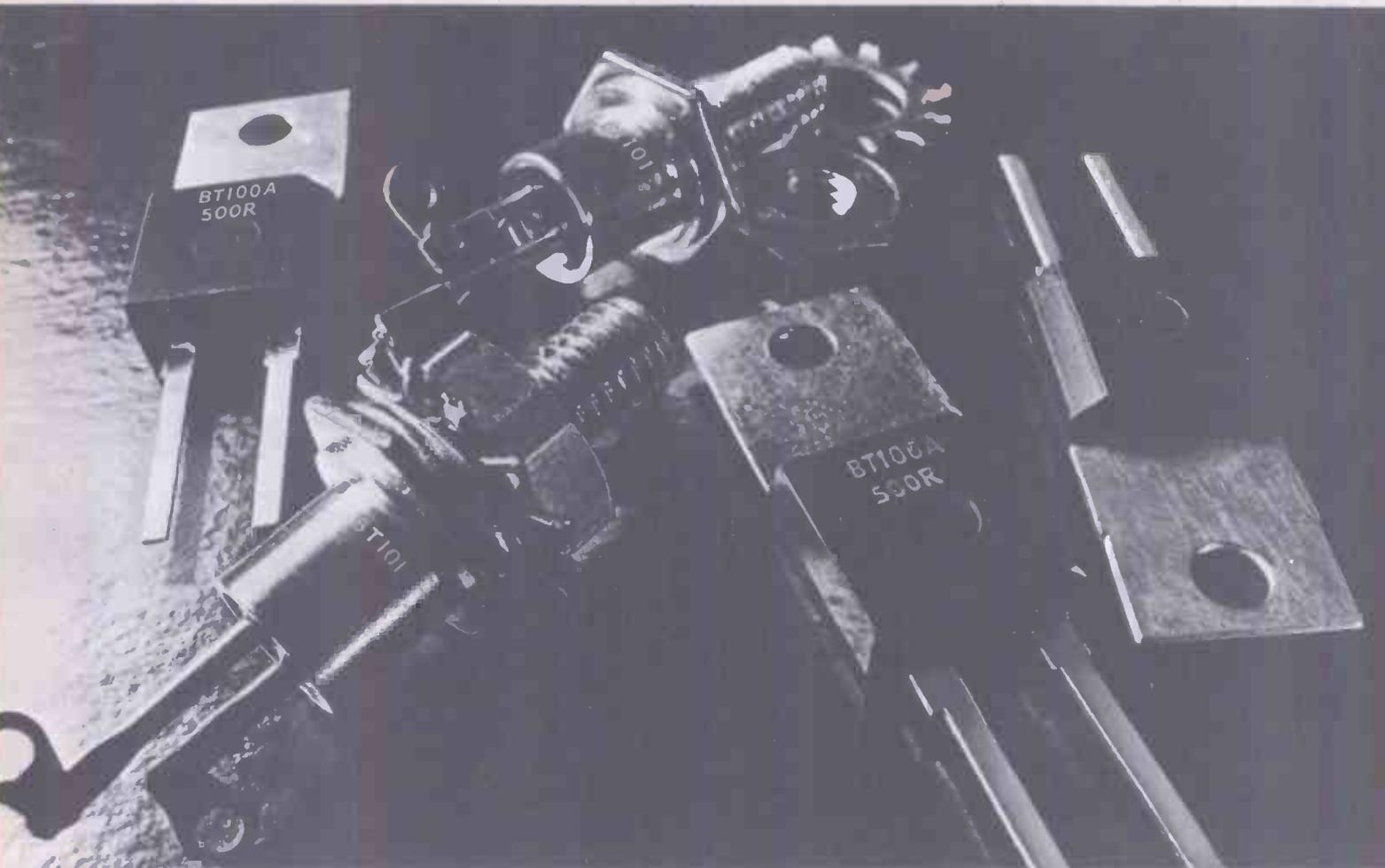


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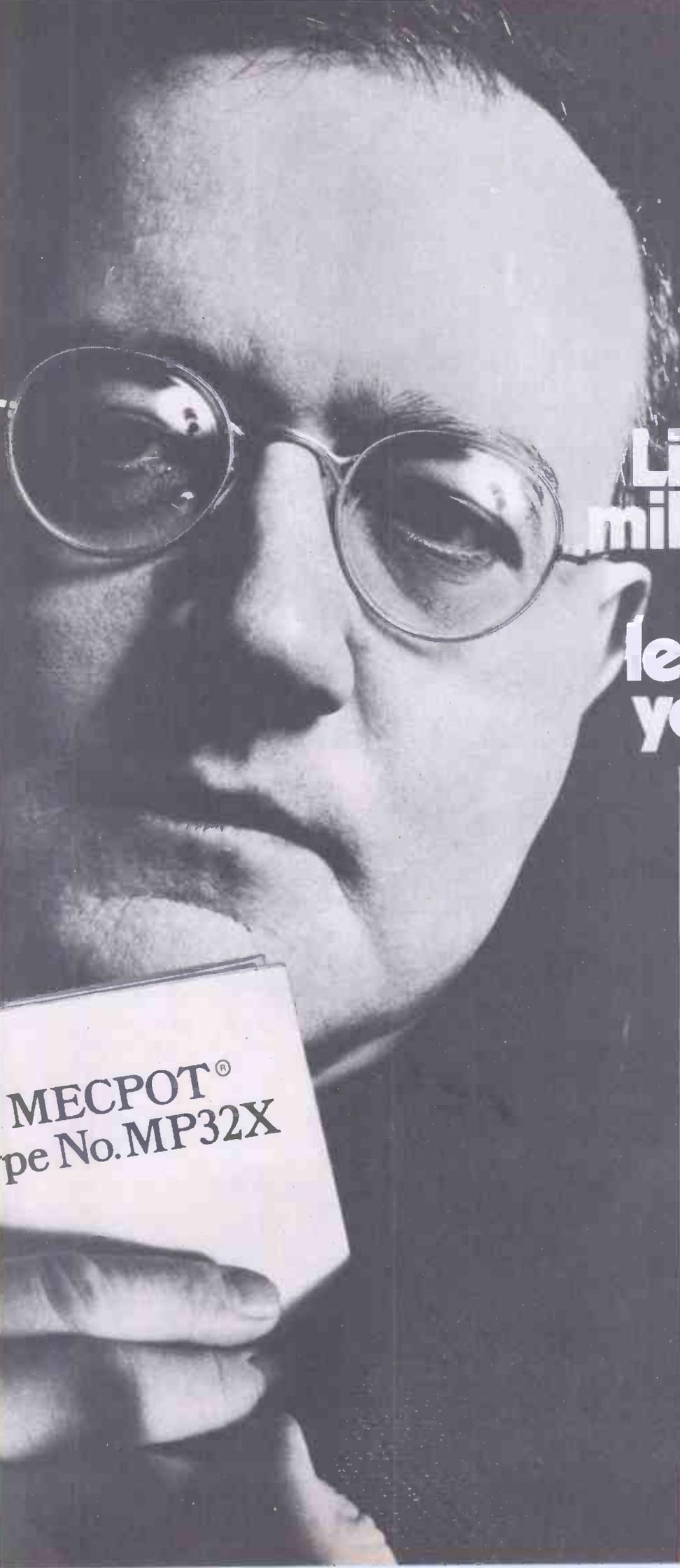
and of improving both the efficiency of power-control and the usefulness of the units controlled. They offer consumer product manufacturers smooth, continuous and efficient power control.

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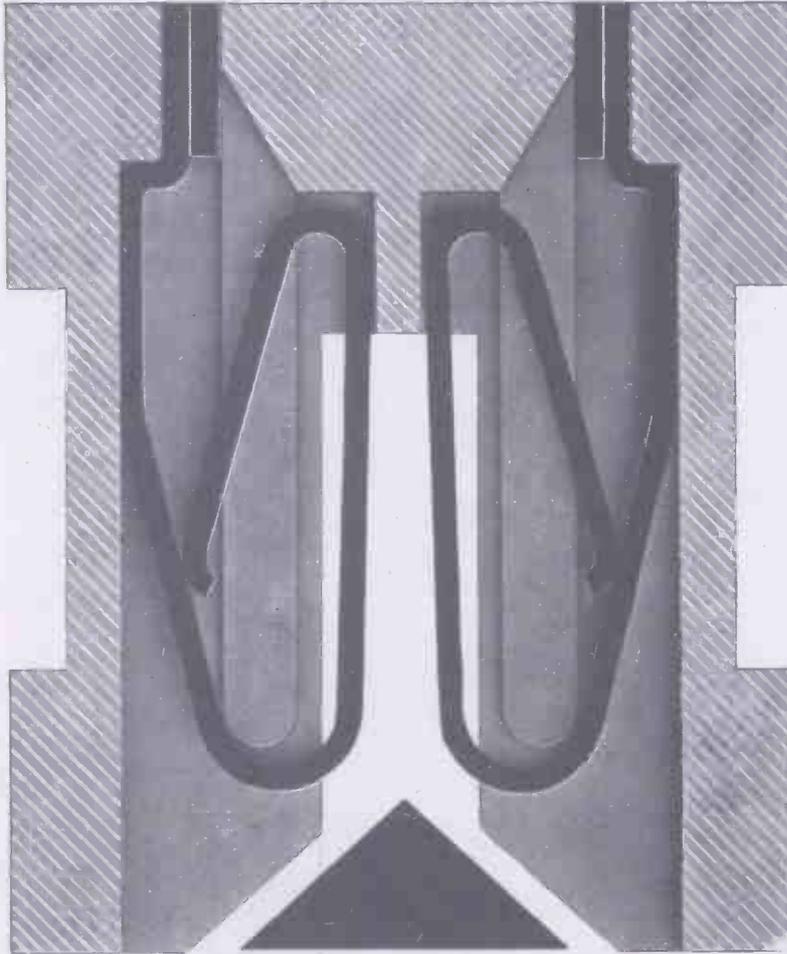
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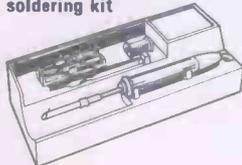


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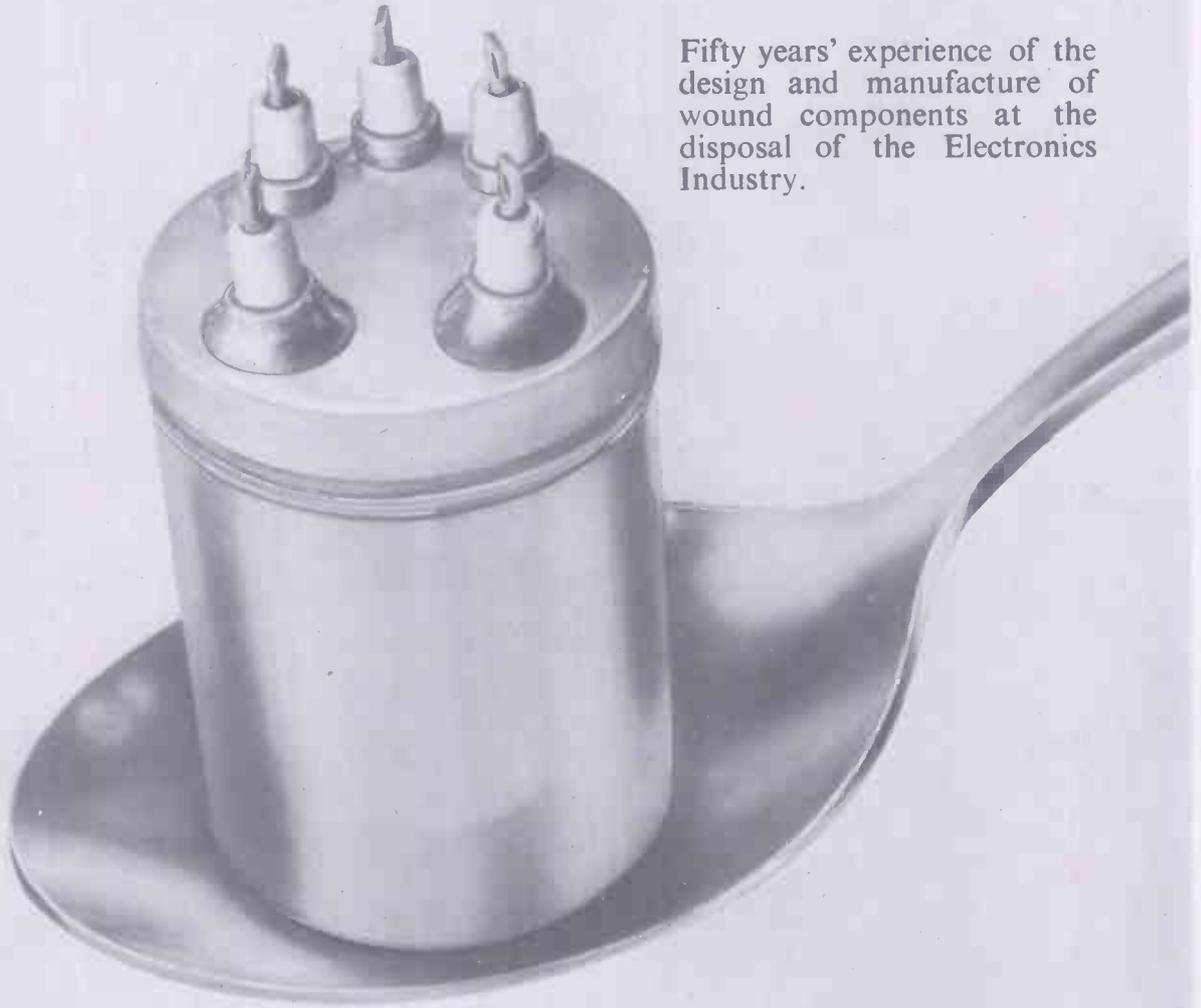
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There is an M in Decca

It stands for Motorola and you'll see it in the Decca single standard TV chassis. It's the mark of the Motorola quality and reliability that got radio on the road and helped to put men on the moon.

Motorola is one of the largest semiconductor manufacturers in the world. Its U.K. plant is at East Kilbride. Also in Europe there is a factory in France and another to be established in Germany, whilst the Company's European headquarters are in Geneva.

It's because Motorola understands quality and reliability that their equipment has provided the essential communication links (radio and TV) between the moon surface and earth.

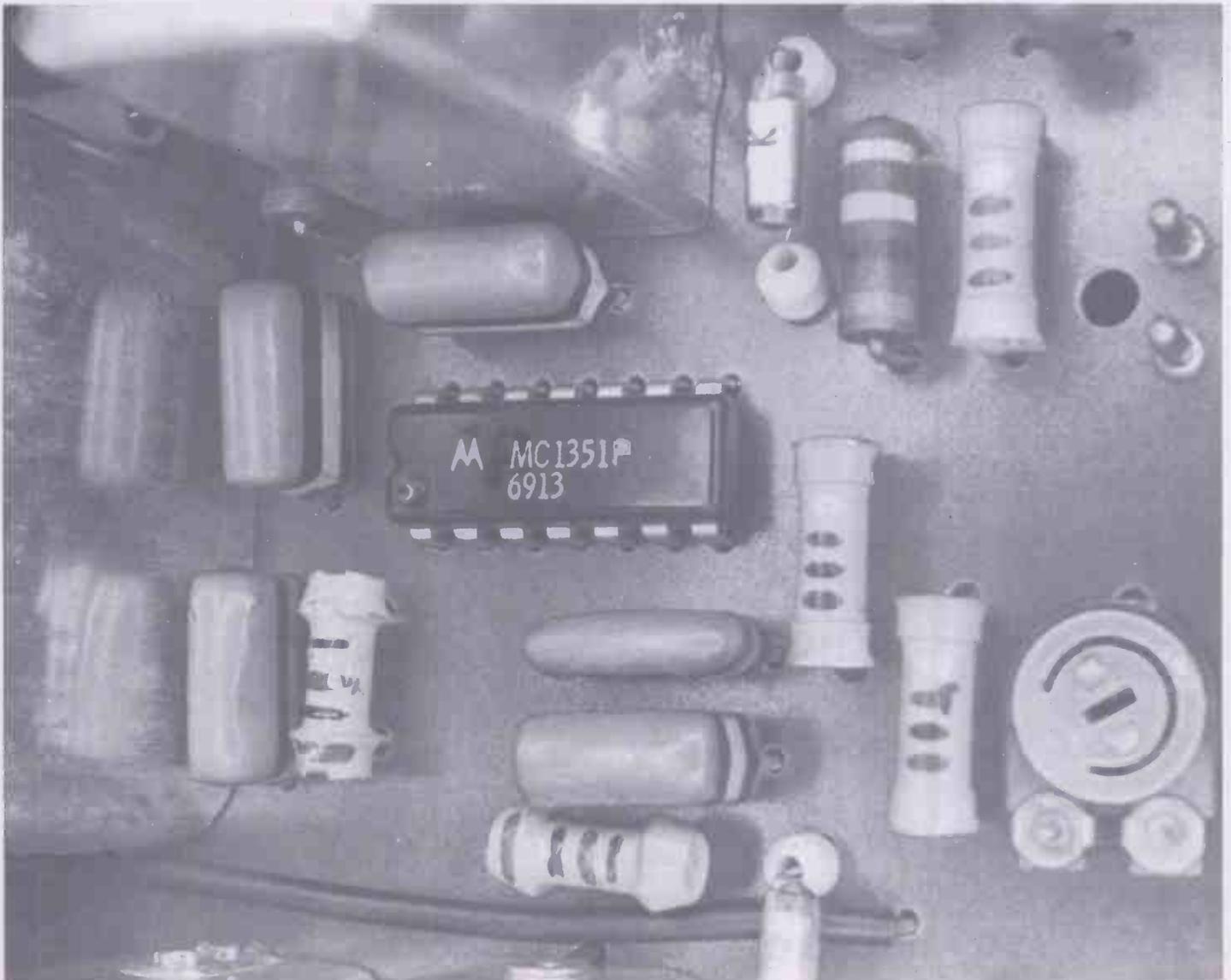
That too is why there is an M in Decca – it stands for reliability.

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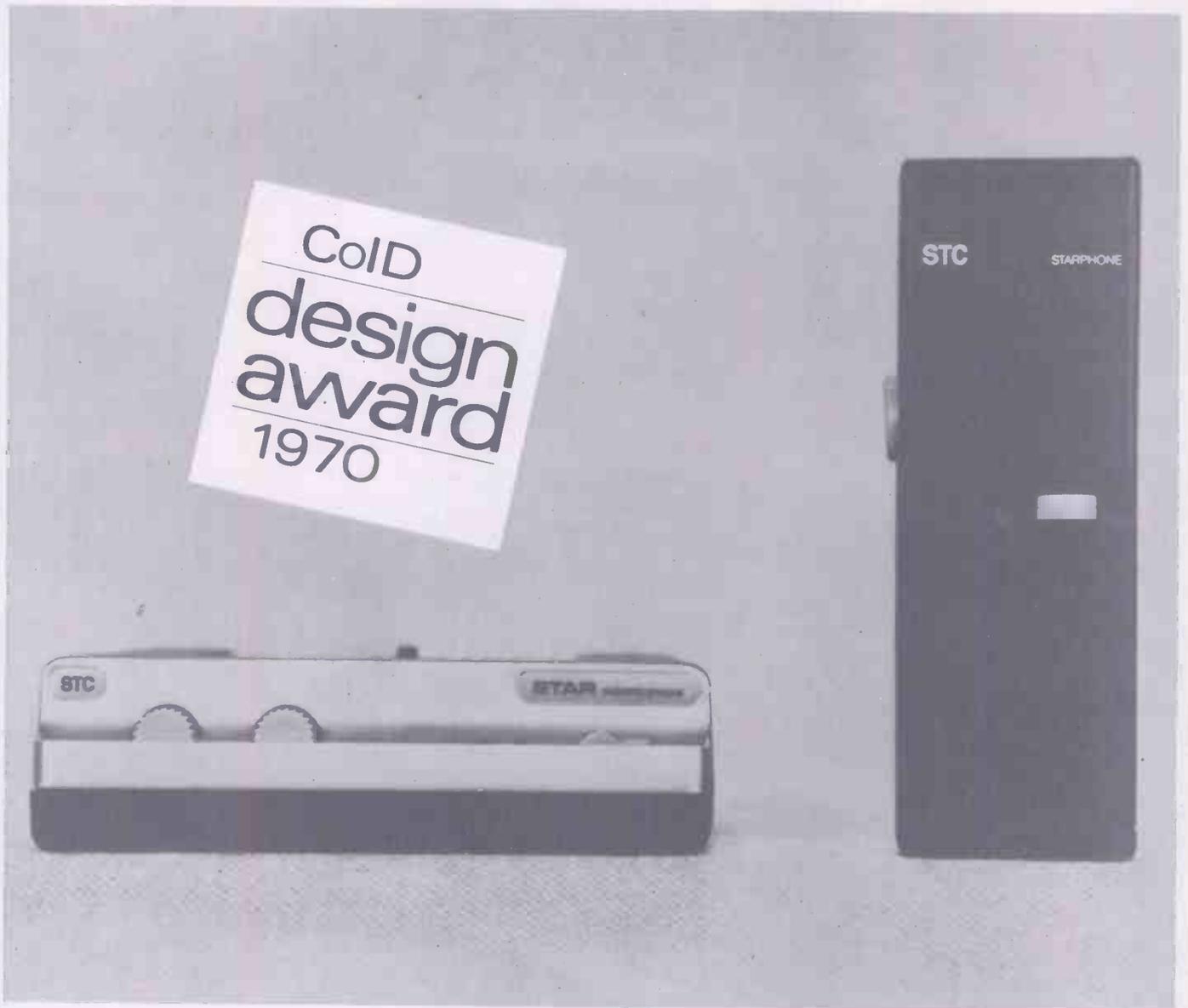


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STC is proud to announce that its entire range of Star equipment has received the award of the British Council of Industrial Design. Elegant and functional in design the Star Mobile Radiotelephone and Starphone Pocket Radiotelephone are milestones in the design of Radiotelephone products.

The rapid acceptance of Star Mobile Radiotelephones in the UK and in over 30 countries throughout the world is a forceful reminder of the importance of design in worldwide marketing success.

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volts and dual slope integration for noise rejection.

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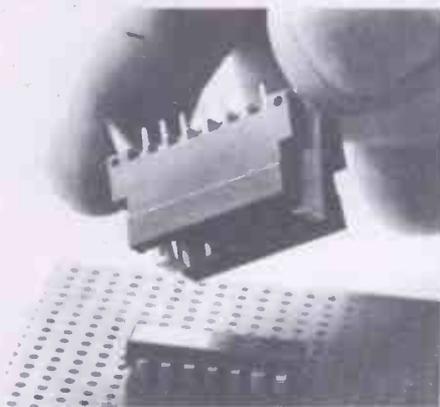
Electrosil's new Pick-a-Back connector, with the snap action, is the most advanced concept yet in D.I.P. testing. You can say goodbye to tedious test probes. Electrosil Pick-a-Backs are designed for D.I.L. packages mounted onto a P.C. board. Made specifically for testing and fault location, the connector will snap on to a D.I.L. package, obviating the need for test probes.

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● Gold plated beryllium copper contacts with wiping action for reliable contact. ● Four versions available to mate with all standard 14 pin and 16 pin D.I.P.s.

(Patent and Registered Designs applied for).



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Precision Electronic Components SIGNAL LAMPS

GENERAL PURPOSE MINIATURE AND NEON TYPES

List Number
D.805/W/S/Col.List Number
D.736/Col.List Number
D.674/1/Col.List Number
D.799/Col.List Number
D.805/Col.List Number
D.738/Col.List Number
D.22/Col.List Number
D.985/Col.List Number
D.926/Col.List Number
D.795/Col.List Number
D.925/Volta/Col.List Number
D.927/Volta/Col.

This fine selection of Miniature Signal Fittings includes models accepting L.E.S., S.8/8, and T.1. bulbs, together with types supplied complete with in-built neon lamps, the majority of which are fitted with the appropriate resistor for use on 110 or 250V supply. The plastic lenses on filament lamp models are available in five brilliant transparent or translucent colours, whilst the neon types are available with Red, Amber or Clear lenses and the normal 'pink' glow neon or with a clear lens and a green glow neon. The various lens and body styles give a wide choice to the designer engineer. Most models are panel mounting, fixing by rear nuts, spring washer or inbuilt spring clips, but D.965-966 is a NEW model developed for direct connection to a printed circuit assembly.

SMALL AND MEDIUM TYPES

List Number
D.656/Col.List Number
D.430/Col.List Number
D.9/1/M/Col.List Number
D.682/Col.List Number
D.590/M/Col.List Number
D.666/G/BLH/SBC/Col.List Number
D.666/G/MBC/Col.List Number
D.280/M/Col.List Number
D.230/Col.

Small and medium models accept filament lamps with M.E.S., M.B.C., C.E.S., S.E.S., and S.B.C. caps and are suitable for a wide variety of use in all types of equipment. In most cases, there is a choice of plastic or glass lenses, each type being available in five transparent or five translucent colours. Red, Amber, Blue, Green and Clear or White. Many models can also be supplied with a choice of a black moulded or chrome plated metal bezel, and/or a choice of lampholder. Fixing is normally by a rear nut to a single panel hole, with cable connection to screw terminals or solder tags. Bulb replacement is normally from both the front and rear.

HEAVY DUTY TYPES

List Number
D.818/G/Col.List Number
D.650/G/Col.List Number
D.945/G/Col.List Number
D.828/Col.

Heavy duty models accept E.S., or B.C. capped lamps and are of extremely robust construction for use on machine tools and heavy plant. Lenses are normally glass but are still available in the usual five transparent and translucent colours. The bodies are produced from heavy gauge metal or heavy duty plastics and fixing is normally by bolts rather than our usual rear-body-nut. In addition to our standard heavy duty models, we can also supply special services grades of signal fitting, all with J.S. numbering and approval and D.E.F. 5,000 etc. finishes. A full list of all Bulgin Signal Lamps is available on request—see below for the appropriate brochure number.

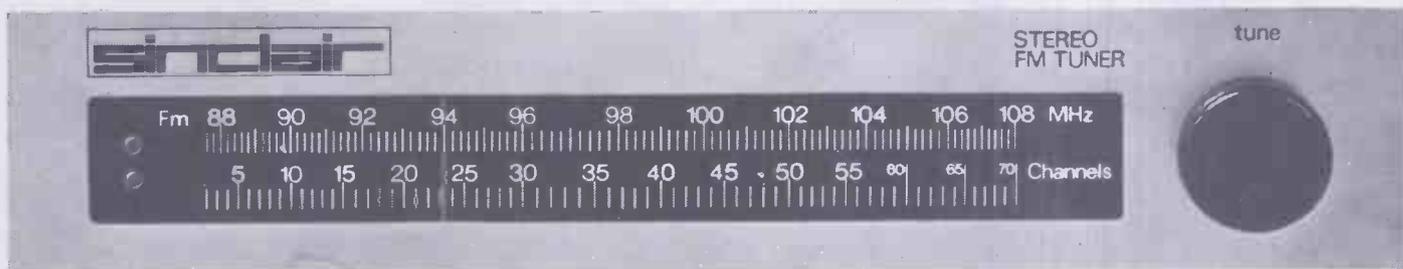
FOR DETAILS OF OUR COMPLETE RANGE OF SIGNAL LAMPS REQUEST BROCHURE 1502/C

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VARIETIES**

New for Project 60



the world's first high fidelity *phase lock loop* FM tuner

It has always been our policy at Sinclair Radionics to employ new and highly advanced circuitry in our products so that we can offer better performance at competitive prices. Our new F.M. tuner is the first in the World to use the phase lock loop principle. We have also incorporated such advanced features as varicap diodes for the tuning, printed circuit coils for the tuner and I.F. strip, A.G.C., A.F.C., an excellent squelch circuit to silence the tuner between stations, an Integrated Circuit stereo decoder and the option of remote control and push button switching.

The phase lock loop principle was first applied to receivers for reception from satellites because of the important improvements in signal to noise ratio that could be obtained by this technique. In addition there were the benefits of greatly improved selectivity and sensitivity. The Project 60 tuner, as the specifications show, is unsurpassed by any tuner now available yet we are able, because of the new circuitry, to sell the product at a fraction of the price.

From the high fidelity point of view this new circuit has the very important advantage of very much lower distortion than any other tuner known to us.

A voltage controlled oscillator (V.C.O.) in a phase lock loop tuner is kept in phase with the incoming signal by a phase comparator or detector which compares the two and feeds a control voltage to the oscillator. This control voltage is the audio output in the case of an F.M. signal. Since it is possible to design a V.C.O. which has an extremely linear voltage to frequency transfer characteristic excellent audio fidelity can be readily achieved. Furthermore, the oscillator can track a signal whilst completely rejecting a nearby stronger signal which would cause interference in a conventional receiver.

In use the tuner is especially attractive because the squelch circuit gives complete silence between stations and because fine tuning is accomplished automatically by the tuner. Accurate tuning is therefore ensured.

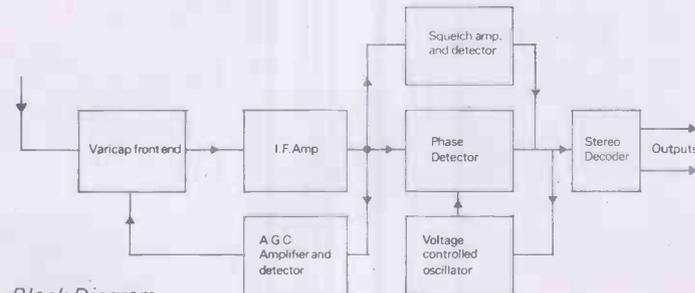
The use of an integrated circuit for the stereo decoder part of the circuit helps to give improved performance as it enables us to use a far more sophisticated circuit than would otherwise be possible. In particular stereo separation is excellent. Switching from mono to stereo is automatic and is indicated by a bulb.

The Project 60 tuner is supplied completely built and tested and ready

to be mounted into any cabinet you choose. It may be used with any high fidelity amplifier including of course the Project 60 amplifier systems. The remarkable selectivity and sensitivity will make it possible to receive stereo transmissions in many more areas and foreign broadcasts will also be received far more readily. It is worth remembering that the Project 60 tuner will operate well on only a few inches of wire in most areas should this be necessary.

Project 60 F.M. tuner specifications

Number of transistors	16 plus 20 in I.C.
Tuning range	87.5 to 108 MHz.
Capture ratio	1.5dB
Sensitivity	2 μ V for 30dB quieting 7 μ V for full limiting
Squelch level	20 μ V
A.F.C. range	\pm 200 KHz
Signal to noise ratio	>65dB
Total harmonic distortion	0.15% for 30% modulation
Stereo decoder operating level	2 μ V
Pilot tone suppression	30dB
Cross talk	40dB
I.F. frequency	10.7 MHz
Output voltage	2 x 150mV R.M.S.
Aerial Impedance	75 Ohms
Indicators	Mains on; Stereo on; tuning indicator



Block Diagram

Price: £25 built and tested. Post free.

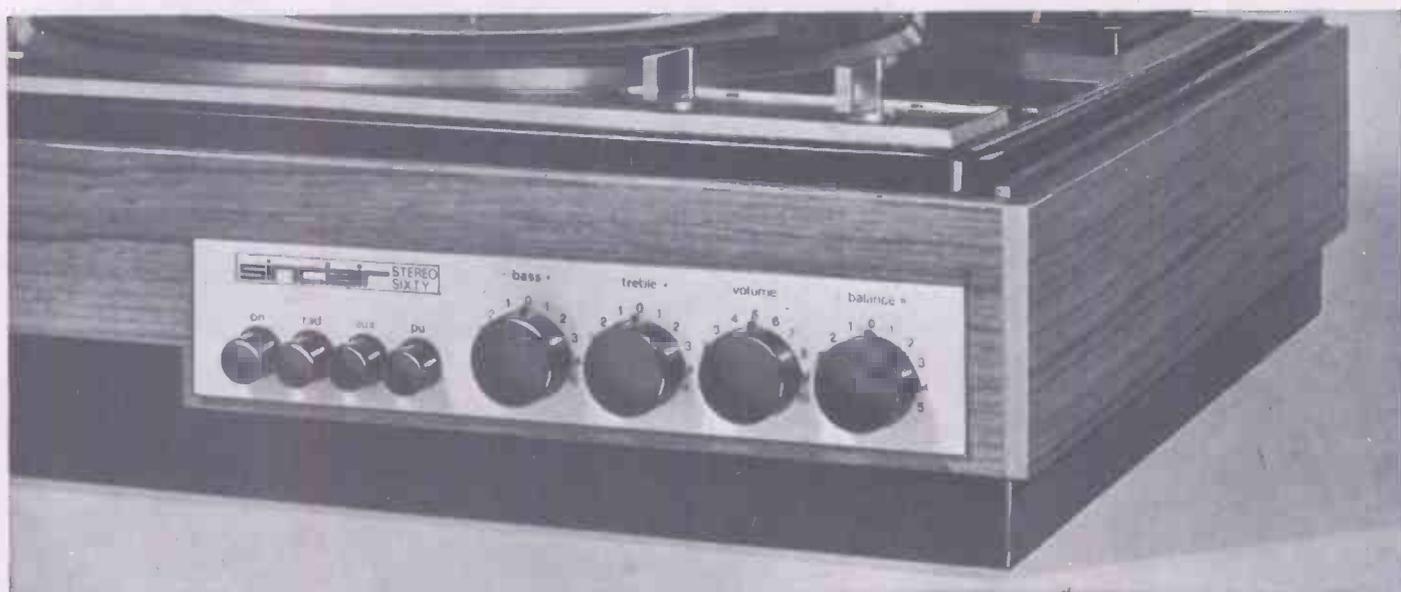
sinclair

Sinclair Radionics Ltd.

at the International Audio and Music Fair, Olympia, Stand

44

Project 60



Laboratory standard modular high fidelity

Sinclair Project 60 comprises a range of modules which connect together simply to form a compact stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance and now the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules are: 1. The Z.30 and Z.50 high gain power amplifiers. 2. The Stereo 60 preamplifier and control unit. 3. The Active Filter Unit. 4. 4 supply units—PZ.5; PZ.6; PZ.7 and PZ.8. In a normal domestic application, there will be no significant difference between PZ.5 or PZ.6 unless loudspeakers of very low efficiency are being used, in which case the PZ.6 will be required. For assemblies using two Z.50's there is the PZ.8 supply unit to ensure maximum performance from these amplifiers. No skill or experience are needed to build your system and the Project 60 manual gives all the instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as new additions are made to the range. A stereo F.M. tuner is next to come. These and all other modules introduced will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

System	The Units to use	In conjunction with	Your Project 60 Units will cost
A Car Radio	Z.30	Existing car radio, Sinclair Micromatic	89/6
B Simple battery powered record player	Z.30	Crystal pick-up, 12 V or more battery supply and volume control	89/6
C Mains powered record player	Z.30 and PZ.5	Crystal or ceramic P.U. Vol. control etc.	£9.9.0
D 20+20 watts RMS stereo amplifier for most needs	Two Z.30s, Stereo 60 and PZ.5	Crystal, ceramic or magnetic P.U., most dynamic speakers, FM tuner, etc.	£23.18.0
E 20+20 watts RMS stereo amplifier for use with low efficiency (high performance) speakers	Two Z.30s, Stereo 60 and PZ.6	High quality ceramic or mag. P.U., F.M. Tuner, Tape Deck, etc. All dynamic spkrs.	£26.18.0
F 40+40 watts RMS de-luxe stereo amplifier	Two Z.50s, Stereo 60 PZ.8 and mains transformer	As for E	£32.17.6
G Outdoor public address system	Z.50	Microphone, up to 4 P.A. speakers, 12V car battery with converter, or 45V d.c. controls	£5.9.6
H Indoor P.A	One Z.50, PZ.8 and mains transformer	Mic., guitar, heavy duty speakers etc., controls	£17.8.6
J High pass and low pass filters	AFU	D, E or F as above	£5.19.6
K Stereo F.M. tuner	To be released shortly		

How to assemble and use Project 60 modules to best advantage in the above and other applications will be found in the fully descriptive Project 60 manual included with Project 60 systems. This 48 page manual is available separately, price 2/6d including postage.

sinclair SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

Telephone 0223 52731

Z.30 & Z.50 POWER AMPLIFIERS

The Z.30 together with the Z.50 are both of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use the Z.30 or Z.50 power amplifiers in your Project 60 system will depend on personal preference, but they are the same physical size and may be used with other units in the Project 60 range equally well. For operating from mains, for the Z.30 use PZ.5 for most domestic requirements, or PZ.6 if you have very low efficiency loudspeakers. For Z.50, use the PZ.8 described below.

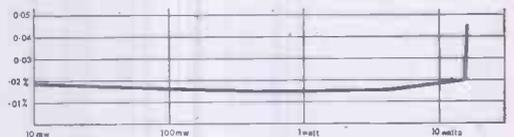
SPECIFICATIONS (*Z.50 units are interchangeable with Z.30s in all applications.*)

Power Outputs
 Z.30 15 watts R.M.S. into 8 ohms, using 35V: 20 watts R.M.S. into 3 ohms using 30 volts.
 Z.50 40 watts R.M.S. into 3 ohms from 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.
Frequency response 30 to 300,000 Hz \pm 1dB
Distortion 0.02% into 8 ohms
Signal to noise ratio better than 70 dB unweighted
Input sensitivity 250mV into 100 Kohms.
 For speakers from 3 to 15 ohms impedance
 Size 3½ x 2½ x ½ ins.

Z.30
 Built, tested and guaranteed with circuits and instructions manual **89/6**

Z.50
 Built, tested and guaranteed with circuits and instructions manual **109/6**

Curve shows power versus distortion for Z.30 and Z.50.



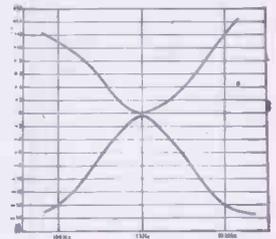
STEREO 60 Pre amp/Control Unit

Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS

- Input sensitivities - Radio - up to 3mV. Mag. p.u. - 3mV: correct to R.I.A.A. curve \pm 1dB: 20 to 25,000Hz. Ceramic p.u. - up to 3mV: up to 3mV.
- Output - 250mV.
- Signal-to-noise ratio - better than 70 dB.
- Channel matching - within 1 dB.
- Tone controls - TREBLE +15 to -15dB at 10kHz: BASS +15 to -15dB at 100Hz.
- Front panel - brushed aluminium with black knobs and controls.
- Size 8½ x 1½ x 4 ins.

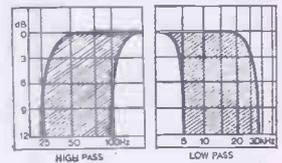
Built, tested and guaranteed **£9.19.6**



Curve to show bass and treble cut and boost.

ACTIVE FILTER UNIT

For use between Stereo 60 unit and two Z.30s or Z.50s, the Active Filter Unit matches the Stereo 60 in styling and is as easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The Sinclair A.F.U. is suitable also for use with any other amplifier system. Two stages of filtering are incorporated—rumble (high pass) and scratch (low pass). Supply voltage—15 to 35V. Current—3mA. H.F. cut-off (-3dB) variable from 28kHz to 5kHz. L.F. cut-off (-3dB) variable from 25Hz to 100Hz. Filter slope, both sections 12dB per octave. Distortion at 1kHz (35V supply) 0.02% at rated output.

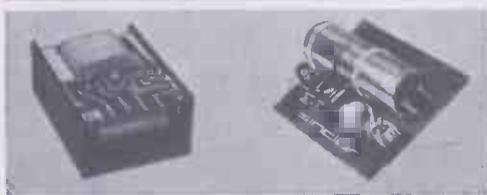
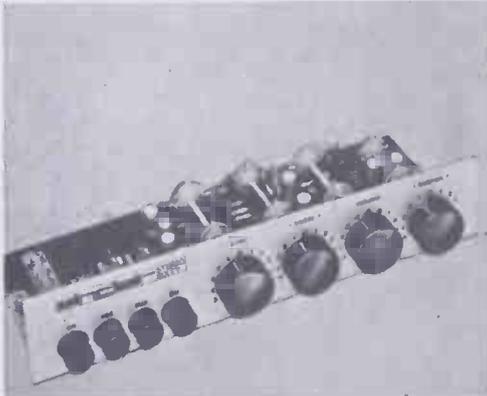
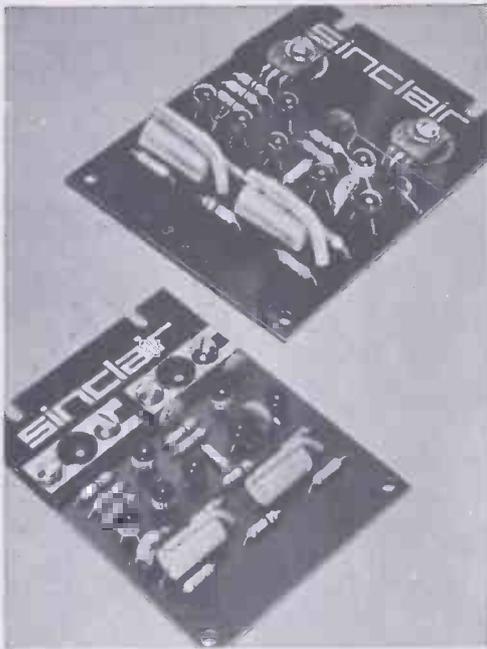


Built, tested and guaranteed **£5.19.6**

POWER SUPPLY UNITS

The units below are designed specially for use with the Project 60 system of your choice. Illustration shows PZ.5 power supply unit to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

- PZ-5 30 volts un stabilised **£4.19.6** PZ-8 45 volts stabilised (less mains transformers) **£5.19.6**
 PZ-6 35 volts stabilised **£7.19.6** PZ-8 mains transformer **£5.19.6**



GUARANTEE If within 3 months of purchasing Project 60 modules directly from us: you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail Air-mail charged at cost

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at the International Audio and Music Fair, Olympia Stand **44**

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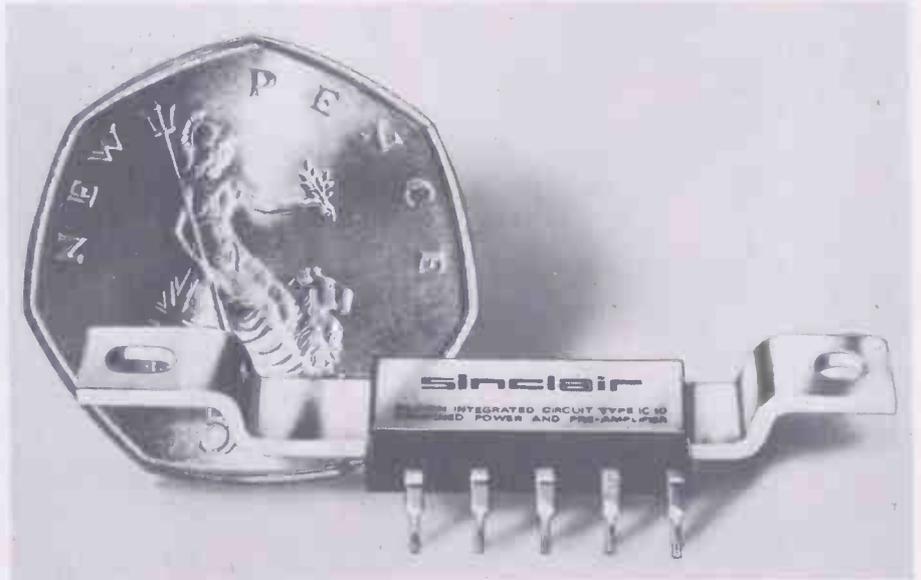
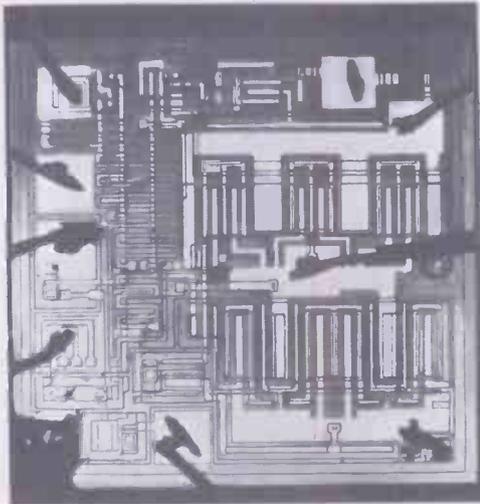
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for which I enclose cash/cheque money order

WW 10

Sinclair IC-10



the world's most advanced high fidelity amplifier

Specifications

Output: 10 Watts peak, 5 Watts R.M.S. continuous
 Frequency response: 5 Hz to 100 KHz \pm 1dB
 Total harmonic distortion: Less than 1% at full output.
 Load impedance: 3 to 15 ohms.
 Power gain: 110dB (100,000,000,000 times) total.
 Supply voltage: 8 to 18 volts.
 Size: 1 x 0.4 x 0.2 inches.
 Sensitivity: 5mV.
 Input impedance: Adjustable externally up to 2.5 M ohms.

Circuit Description

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

Applications

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a full guarantee on every IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

SINCLAIR

IC-10 with IC-10 manual 59/6
 Post free.

To: SINCLAIR RADIONICS LTD., 22 NEWMARKET RD., CAMBRIDGE

Please send

NAME

ADDRESS

for which I enclose cash/cheque
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WW10

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At the International Audio
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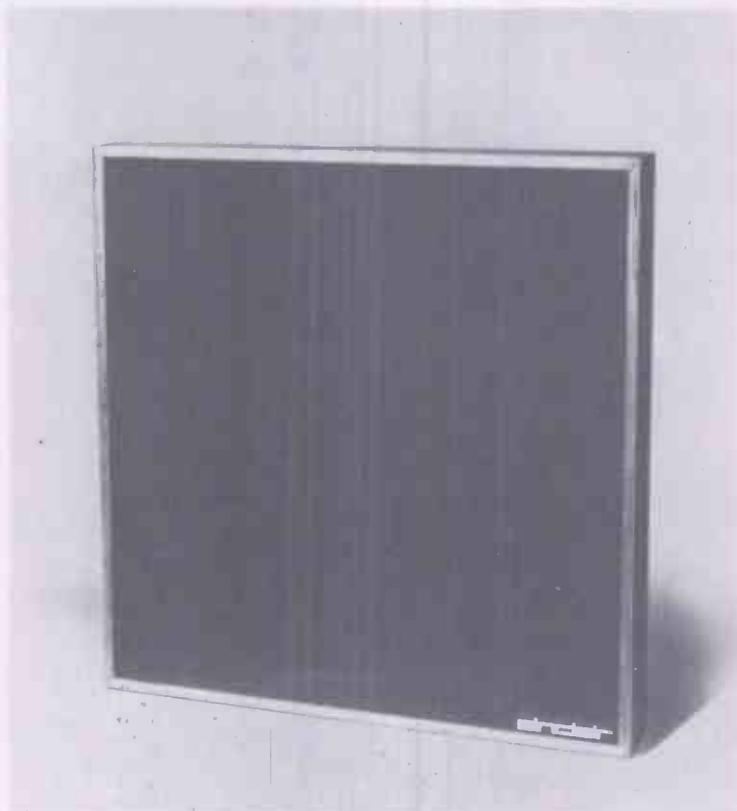
Q.16 High fidelity loudspeaker

Developed out of the revolutionary and much praised design of the original Sinclair Q.14 comes this more advanced version to meet the requirements of even greater numbers of high fidelity enthusiasts. The Q.16 employs the same well proven acoustic principles in which a special driver assembly is meticulously matched to the physical characteristics of the uniquely designed housing. In reviewing this exclusive Sinclair design, technical journals have been loud in their praise for it and it comfortably stands comparison with very much more expensive loudspeakers. The shape of the Q.16 enables it to be positioned and matched to its environment to much better effect than is the case with conventionally styled enclosures, and with its improved styling, the Q.16 presents an entirely new and attractive appearance. A solid teak surround is used with a special all-over cellular black foam front chosen as much for its appearance as for its ability to pass all audio frequencies unimpaired.

The Q.16 is compact and slim and is the ideal shelf-mounted speaker, and brings genuine high fidelity within reach of every music lover.

Specifications

Construction:	A sealed seamless sound or pressure chamber is used with internal baffle, all of materials carefully chosen to ensure freedom from spurious tone coloration.
Loading:	Up to 14 watts R.M.S.
Input impedance:	8 ohms.
Frequency response:	From 60 to 16,000Hz, as confirmed by independently plotted B & K curve.
Driver unit:	Specially designed high compliance unit having massive ceramic magnet of 11,000 gauss, aluminium speech coil and special cone suspension. Excellent transient response is achieved.
Size and styling:	9½" square on face x 4½" deep with neat pedestal base. Black all-over cellular foam front with natural solid teak surround.
Price:	£8 19 6.



Micromatic Britain's smallest radio

Considerably smaller than an ordinary box of matches, this is a multi-stage A.M. receiver meticulously designed to provide remarkable standards of selectivity, power and quality. Powerful A.G.C. is incorporated to counteract fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy at all times. Vernier type tuning plus the directional properties of the self-contained special ferrite rod aerial makes station separation very much easier than with many larger sets. The plug-in high fidelity type magnetic earpiece which matches exactly with the output of the Micromatic provides wonderful standards of reproduction both for speech and for music. Everything including the batteries is contained within the attractively designed case. Whether you build your Micromatic or buy it ready built and tested, you will find it as easy to take with you as your wristwatch, and dependable under the severest listening conditions.

Specifications

Size:	1½" x 1⅞" x ½" (46 x 33 x 13mm).
Weight including batteries:	1 oz. (28.35gm) approx.
Tuning:	Medium wave band with bandspread at higher frequency end.
Earpiece:	High-fidelity magnetic type.
Battery requirements:	Two Mallory Mercury Cells, type R.M. 675, for long working life.
Case:	Black plastic with anodised aluminium front panel, spun aluminium dial.
Controls:	Tuning dial, and on/off switching by means of earpiece plug.
Price:	Available in kit form complete with earpiece, case, instructions and supply of solder in fitted pack. 49/6. Ready built, tested and guaranteed. 59/6.



R.S.T. VALVE MAIL ORDER CO.

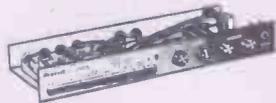
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BT89 87/-	EP37A 7/-	FL24 24/-	Z759 30/-	12AT6 4/9	2G427 9/6
C1C 20/-	EP39 8/-	FL25 25/-	Z800 20/-	12AT7 6/-	2N556 12/6
CBL31 18/-	EP41 10/-	FL27 27/6	Z801 30/-	12AU7 5/8	AC107 5/8
CH35 15/-	EP50 5/-	FL28 28/6	Z803U 15/-	12AX7 6/3	AC127 5/8
CV5 96/-	EP52 25/-	FL29 29/6	O A2 6/3	12BA6 6/3	AC128 4/8
CV74 80/-	EP80 4/8	FL292 5/2	OB2 6/-	12BB6 6/3	AC129 5/8
CV89 50/-	EP86 6/6	FL293 7/-	024 4/6	12E1 15/6	AC129 5/8
CV315 90/-	EP89 5/8	FL294 7/3	1B3GT 7/3	12KGT 7/1	AC129 5/8
CV354 110/-	EP91 3/8	FL295 7/6	12KSGT 8/1	AD134 5/-	AD134 5/-
CV370 800/-	EP92 2/6	FL296 9/8	2C39A 140/-	AD140 5/-	AD140 5/-
CV372 57/-	EP98 15/0	FL297 10/-	2C43 70/-	AD140 5/-	AD140 5/-
CV404 28	EP183 6/6	FL298 10/-	2D21 20/-	AD140 5/-	AD140 5/-
CV408 50/-	EP184 7/-	FL299 10/-	2E26 20/-	AD140 5/-	AD140 5/-
CV428 45/-	EPF80 21/-	FL300 10/-	2K25 180/-	AD140 5/-	AD140 5/-
CV429 350/-	EPF80 10/-	FL301 10/-	3A167M 80/-	AD140 5/-	AD140 5/-
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CV1144 60/-	EL33 12/8	FL303 10/-	27M1 72/6	AD140 5/-	AD140 5/-
CV1386 140/-	EL34 10/8	FL304 10/-	30C15 15/-	AD140 5/-	AD140 5/-
CV1622 180/-	EL36 9/8	FL305 10/-	30C17 15/-	AD140 5/-	AD140 5/-
CV1628 65/-	EL38 8/3	FL306 10/-	30F5 17/-	AD140 5/-	AD140 5/-
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CV2306 350/-	EL44 9/8	FL308 10/-	30L16 12/6	AD140 5/-	AD140 5/-
CV2312 35/-	EL48 4/9	FL309 10/-	30L17 17/-	AD140 5/-	AD140 5/-
CV4003 10/-	EL56 7/9	FL310 10/-	30P4 22/6	AD140 5/-	AD140 5/-
CV4004 10/-	EL58 8/3	FL311 10/-	30P9 15/-	AD140 5/-	AD140 5/-
CV4006 8/-	EL62 8/3	FL312 10/-	30P11 16/-	AD140 5/-	AD140 5/-
CV4008 18/-	EL66 8/3	FL313 10/-	30P13 18/8	AD140 5/-	AD140 5/-
CV4010 7/-	EL70 7/9	FL314 10/-	30P14 15/-	AD140 5/-	AD140 5/-
CV4012 7/-	EL74 8/3	FL315 10/-	30P15 15/-	AD140 5/-	AD140 5/-
CV4014 7/-	EL78 8/3	FL316 10/-	30P16 15/-	AD140 5/-	AD140 5/-
CV4016 10/-	EM34 18/-	FL317 10/-	30P17 15/-	AD140 5/-	AD140 5/-
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CV4025 7/-	EM81 12/6	FL319 10/-	30P19 15/-	AD140 5/-	AD140 5/-
CV4031 7/-	EM84 7/6	FL320 10/-	30P20 15/-	AD140 5/-	AD140 5/-
CV4033 7/-	EN32 25/-	FL321 10/-	30P21 15/-	AD140 5/-	AD140 5/-
CV4044 12/-	EN32 25/-	FL322 10/-	30P22 15/-	AD140 5/-	AD140 5/-
CV4045 10/-	EN32 25/-	FL323 10/-	30P23 15/-	AD140 5/-	AD140 5/-
CV4046 90/-	EN32 25/-	FL324 10/-	30P24 15/-	AD140 5/-	AD140 5/-
CV4048 12/6	EN32 25/-	FL325 10/-	30P25 15/-	AD140 5/-	AD140 5/-
CV4052 7/-	EN32 25/-	FL326 10/-	30P26 15/-	AD140 5/-	AD140 5/-
CV4054 7/-	EN32 25/-	FL327 10/-	30P27 15/-	AD140 5/-	AD140 5/-
CV4056 7/-	EN32 25/-	FL328 10/-	30P28 15/-	AD140 5/-	AD140 5/-
CV4058 7/-	EN32 25/-	FL329 10/-	30P29 15/-	AD140 5/-	AD140 5/-
CV4060 7/-	EN32 25/-	FL330 10/-	30P30 15/-	AD140 5/-	AD140 5/-
CV4062 7/-	EN32 25/-	FL331 10/-	30P31 15/-	AD140 5/-	AD140 5/-
CV4064 7/-	EN32 25/-	FL332 10/-	30P32 15/-	AD140 5/-	AD140 5/-
CV4066 7/-	EN32 25/-	FL333 10/-	30P33 15/-	AD140 5/-	AD140 5/-
CV4068 7/-	EN32 25/-	FL334 10/-	30P34 15/-	AD140 5/-	AD140 5/-
CV4070 7/-	EN32 25/-	FL335 10/-	30P35 15/-	AD140 5/-	AD140 5/-
CV4072 7/-	EN32 25/-	FL336 10/-	30P36 15/-	AD140 5/-	AD140 5/-
CV4074 7/-	EN32 25/-	FL337 10/-	30P37 15/-	AD140 5/-	AD140 5/-
CV4076 7/-	EN32 25/-	FL338 10/-	30P38 15/-	AD140 5/-	AD140 5/-
CV4078 7/-	EN32 25/-	FL339 10/-	30P39 15/-	AD140 5/-	AD140 5/-
CV4080 7/-	EN32 25/-	FL340 10/-	30P40 15/-	AD140 5/-	AD140 5/-
CV4082 7/-	EN32 25/-	FL341 10/-	30P41 15/-	AD140 5/-	AD140 5/-
CV4084 7/-	EN32 25/-	FL342 10/-	30P42 15/-	AD140 5/-	AD140 5/-
CV4086 7/-	EN32 25/-	FL343 10/-	30P43 15/-	AD140 5/-	AD140 5/-
CV4088 7/-	EN32 25/-	FL344 10/-	30P44 15/-	AD140 5/-	AD140 5/-
CV4090 7/-	EN32 25/-	FL345 10/-	30P45 15/-	AD140 5/-	AD140 5/-
CV4092 7/-	EN32 25/-	FL346 10/-	30P46 15/-	AD140 5/-	AD140 5/-
CV4094 7/-	EN32 25/-	FL347 10/-	30P47 15/-	AD140 5/-	AD140 5/-
CV4096 7/-	EN32 25/-	FL348 10/-	30P48 15/-	AD140 5/-	AD140 5/-
CV4098 7/-	EN32 25/-	FL349 10/-	30P49 15/-	AD140 5/-	AD140 5/-
CV4100 7/-	EN32 25/-	FL350 10/-	30P50 15/-	AD140 5/-	AD140 5/-
CV4102 7/-	EN32 25/-	FL351 10/-	30P51 15/-	AD140 5/-	AD140 5/-
CV4104 7/-	EN32 25/-	FL352 10/-	30P52 15/-	AD140 5/-	AD140 5/-
CV4106 7/-	EN32 25/-	FL353 10/-	30P53 15/-	AD140 5/-	AD140 5/-
CV4108 7/-	EN32 25/-	FL354 10/-	30P54 15/-	AD140 5/-	AD140 5/-
CV4110 7/-	EN32 25/-	FL355 10/-	30P55 15/-	AD140 5/-	AD140 5/-
CV4112 7/-	EN32 25/-	FL356 10/-	30P56 15/-	AD140 5/-	AD140 5/-
CV4114 7/-	EN32 25/-	FL357 10/-	30P57 15/-	AD140 5/-	AD140 5/-
CV4116 7/-	EN32 25/-	FL358 10/-	30P58 15/-	AD140 5/-	AD140 5/-
CV4118 7/-	EN32 25/-	FL359 10/-	30P59 15/-	AD140 5/-	AD140 5/-
CV4120 7/-	EN32 25/-	FL360 10/-	30P60 15/-	AD140 5/-	AD140 5/-
CV4122 7/-	EN32 25/-	FL361 10/-	30P61 15/-	AD140 5/-	AD140 5/-
CV4124 7/-	EN32 25/-	FL362 10/-	30P62 15/-	AD140 5/-	AD140 5/-
CV4126 7/-	EN32 25/-	FL363 10/-	30P63 15/-	AD140 5/-	AD140 5/-
CV4128 7/-	EN32 25/-	FL364 10/-	30P64 15/-	AD140 5/-	AD140 5/-
CV4130 7/-	EN32 25/-	FL365 10/-	30P65 15/-	AD140 5/-	AD140 5/-
CV4132 7/-	EN32 25/-	FL366 10/-	30P66 15/-	AD140 5/-	AD140 5/-
CV4134 7/-	EN32 25/-	FL367 10/-	30P67 15/-	AD140 5/-	AD140 5/-
CV4136 7/-	EN32 25/-	FL368 10/-	30P68 15/-	AD140 5/-	AD140 5/-
CV4138 7/-	EN32 25/-	FL369 10/-	30P69 15/-	AD140 5/-	AD140 5/-
CV4140 7/-	EN32 25/-	FL370 10/-	30P70 15/-	AD140 5/-	AD140 5/-
CV4142 7/-	EN32 25/-	FL371 10/-	30P71 15/-	AD140 5/-	AD140 5/-
CV4144 7/-	EN32 25/-	FL372 10/-	30P72 15/-	AD140 5/-	AD140 5/-
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CV4156 7/-	EN32 25/-	FL378 10/-	30P78 15/-	AD140 5/-	AD140 5/-
CV4158 7/-	EN32 25/-	FL379 10/-	30P79 15/-	AD140 5/-	AD140 5/-
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CV4162 7/-	EN32 25/-	FL381 10/-	30P81 15/-	AD140 5/-	AD140 5/-
CV4164 7/-	EN32 25/-	FL382 10/-	30P82 15/-	AD140 5/-	AD140 5/-
CV4166 7/-	EN32 25/-	FL383 10/-	30P83 15/-	AD140 5/-	AD140 5/-
CV4168 7/-	EN32 25/-	FL384 10/-	30P84 15/-	AD140 5/-	AD140 5/-
CV4170 7/-	EN32 25/-	FL385 10/-	30P85 15/-	AD140 5/-	AD140 5/-
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CV4174 7/-	EN32 25/-	FL387 10/-	30P87 15/-	AD140 5/-	AD140 5/-
CV4176 7/-	EN32 25/-	FL388 10/-	30P88 15/-	AD140 5/-	AD140 5/-
CV4178 7/-	EN32 25/-	FL389 10/-	30P89 15/-	AD140 5/-	AD140 5/-
CV4180 7/-	EN32 25/-	FL390 10/-	30P90 15/-	AD140 5/-	AD140 5/-
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CV4184 7/-	EN32 25/-	FL392 10/-	30P92 15/-	AD140 5/-	AD140 5/-
CV4186 7/-	EN32 25/-	FL393 10/-	30P93 15/-	AD140 5/-	AD140 5/-
CV4188 7/-	EN32 25/-	FL394 10/-	30P94 15/-	AD140 5/-	AD140 5/-
CV4190 7/-	EN32 25/-	FL395 10/-	30P95 15/-	AD140 5/-	AD140 5/-
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CV4194 7/-	EN32 25/-	FL397 10/-	30P97 15/-	AD140 5/-	AD140 5/-
CV4196 7/-	EN32 25/-	FL398 10/-	30P98 15/-	AD140 5/-	AD140 5/-
CV4198 7/-	EN32 25/-	FL399 10/-	30P99 15/-	AD140 5/-	AD140 5/-
CV4200 7/-	EN32 25/-	FL400 10/-	30P100 15/-	AD140 5/-	AD140 5/-
CV4202 7/-	EN32 25/-	FL401 10/-	30P101 15/-	AD140 5/-	AD140 5/-
CV4204 7/-	EN32 25/-	FL402 10/-	30P102 15/-	AD140 5/-	AD140 5/-
CV4206 7/-	EN32 25/-	FL403 10/-	30P103 15/-	AD140 5/-	AD140 5/-
CV4208 7/-	EN32 25/-	FL404 10/-	30P104 15/-	AD140 5/-	AD140 5/-
CV4210 7/-	EN32 25/-	FL405 10/-	30P105 15/-	AD140 5/-	AD140 5/-
CV4212 7/-	EN32 25/-	FL406 10/-	30P106 15/-	AD140 5/-	AD140 5/-
CV4214 7/-	EN32 25/-	FL407 10/-	30P107 15/-	AD140 5/-	AD140 5/-
CV4216 7/-	EN32 25/-	FL408 10/-	30P108 15/-	AD140 5/-	AD140 5/-
CV4218 7/-	EN32 25/-	FL409 10/-	30P109 15/-	AD140 5/-	AD140 5/-
CV4220 7/-	EN32 25/-	FL410 10/-	30P110 15/-	AD140 5/-	AD140 5/-
CV4222 7/-	EN32 25/-	FL411 10/-	30P111 15/-	AD140 5/-	AD140 5/-
CV4224 7/-	EN32 25/-	FL412 10/-	30P112 15/-	AD140 5/-	AD140 5/-
CV4226 7/-	EN32 25/-	FL413 10/-	30P113 15/-	AD140 5/-	AD140 5/-
CV4228 7/-	EN32 25/-	FL414 10/-	30P114 15/-	AD140 5/-	AD140 5/-
CV4230 7/-	EN32 25/-	FL415 10/-	30P115 15/-	AD140 5/-	AD140 5/-
CV4232 7/-	EN32 25/-	FL416 10/-	30P116 15/-	AD140 5/-	AD140 5/-
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IC STEREO



FET 154

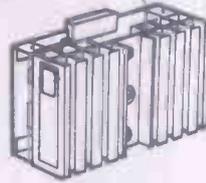


FET 9/4

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25 WATT & 50 WATT RMS SILICON AMPLIFIERS

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 - At full power—1dB 11c/s to 40 kc/s.
 - Response—1dB 11 c/s to 100 kc/s.
 - Rise time 2μ sec.
 - Short circuit proof plus limiting cct.
- PA 25 10 transistor all silicon differential input 400 mV sensitivity. 25 watts Rms into 8 ohms. Supplied with edge connector harness size $5'' \times 3'' \times 2''$.
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- MU 442. Power supply for one or two PA 25 or one PA 50. PA 25 £7.10.0. PA 50 £9.10.0. MU 442 £6
- All units. No soldering—just edge connectors and plugs.

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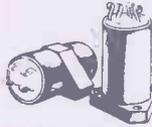
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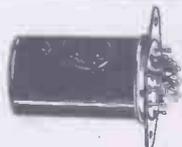
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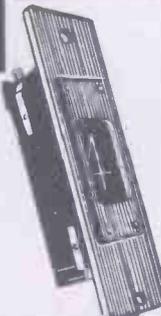


ATLAS MIDGET PANEL LAMPS unrivalled for indication purposes requiring a brilliant but tiny light source. Available with flange cap or wire ended in the following ratings: Capped: 6v. 1A and 12-14v. .08A. Uncapped: 4v. .25A., 6v. 1A., 6v. .2A. 24/- per dozen or boxes of 50 at £4 per box. **INDICATOR LAMP HOLDERS AND CAPS** for MIDGET PANEL LAMPS (as above) available red, green, blue, 2/6 each (complete) minimum order 4 units.



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THORN DIGITAL INDICATOR. A modular unit easily read through a wide angle of view even under bright lighting. 12 characters, 0 to 9, decimal point and minus sign. Characters 13/16" high on acrylic, edge-lit by 1 watt midget lamp. Front panel 4 1/2" x 1 1/8", depth overall 1", matt black finish. Supplied with 12 lamps. Choice of the following ratings—6v. 1A. or 12-14v. .08A. £4.0.0 each, spare lamps 24/- per dozen. Carr. Paid.



SPECIAL OFFER.—BRAND NEW ENGLISH ELECTRIC MAGNETRONS, TYPE 2155. NEW IN FACTORY SEALED TRANSIT PACKING. RECENT MANUFACTURE. SO ONLY AVAILABLE. £27.10.0. CARRIAGE PAID U.K.

VACTRIC. Precision D.C. motor and gear head. Motor type 11P101 (size 11) 28 volts operation. 5000 RPM Torque 120G.CM. 0.54 amp. Coupled to gear head, type 15H102 (size 15). Ratio 300-1. Max torque 10lbs/ins. Original makers packing. £20. Carr. Paid. Quantity discounts on application.



SYNCHROS—in original makers packing. Muirhead receiver 23/TR4b 400 HZ 115/90v. £8.10.0 Muirhead control transformer. 18CT4b. 400HZ. 90/IV per degree £8.10.0.

Sperry AC tachogenerator. Type 11MGGSL 400 HZ 115v. 0.5v/1000RPM. Lin. Range 0-600 RMP. £15.10.0.

Moore Reed synchro control differential transmitter VCDX18/27-4a. 400HZ. 90/90 volts. £8.10.0

Moore Reed synchro control transmitter. VCX 23-36-46. 400HZ. 115/90 volts. £8.10.0

Quantity discounts on application.

Muirhead—3 in. Synchro Magclip. Type E-19-E/1 110/50v. 50 HZ. Recent manufacture in original makers packing. £16 pair.

PULLIN MOTOR. Type PM1C. 28 Volts D.C. Original makers packing. £4.5.0. Carr. Paid.

SERVO POTENTIOMETERS Precision Line (USA). Size 15. 300 Ω ± 5% ± 5% LIN. Continuous track plat. Wipers set at 180°. 75/- each. Carr. Paid.

Penny & Giles. Size 15. 500 Ω. Type Q26201-72/1. Continuous track. 75/- each. Carr. Paid.

PRECISION POTENTIOMETER Beckman. Type AS.506. 10 turn. Tol ± 1%. LIN Tol ± .07%. 40K. Long Spindle. 60/- each. Carr. Paid.

S.T.C. Servo Potentiometer. Type B330 CT. 2500 Ω. 2 1/2" dia. x 1 1/2" deep. Completely copper encased. 45/- each.

PRECISION RESISTORS Electro-Thermal Precistor 2.4K ± 0.1% 10/- each. Shallcross 3400 Ω ± 0.5% 6/- each. Alma 141.46K ± 0.1% 10/- each. Alma 50K ± 0.05% 15/- each. RIL Type 2. 6.666K ± 0.01% 20/- each. RIL Type 9. 560 Ω ± 1% 2/6 each.

Painton Rotary Switch. Type 72 (to P.O. spec. RC1416). 3 pole, 3 position, 2 bank. Offered at less than half makers price at 32/6. Carr. paid.

New 75-0-75 Micro-ammeter by Sifam. 750 ohm movement, clear reading, 5 1/2 divisions x 1/2" plastic front, projection 1/2" (tapering forward). Size: 4 1/2" x 3 1/2", 57/6 each. Carr. Paid.



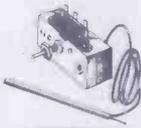
ERIE. Ceramicon capacitor. Type CHV41IP. 500 P.F. 30KV. Size 1.5 in. dia. x 1.44 in. long 15/- each. Carr. Paid.

SYLVANIA CIRCUIT BREAKERS gas filled providing a fast thermal response between 80° and 180°C. Will withstand pressures up to 2,000 lb. sq./in. rated 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures (degs. cent.) 80, 85, 95, 100, 105, 110, 120, 125, 130, 135, 140, 145, 150, 155, 160, 170, 175. 10/- each or 80/- per dozen. Carr. Paid.

CENTRIFUGAL BLOWER BY AIR CONTROL LTD. 240v. AC. 9" dia. 2,850 RPM. 1/10th HP. Ideal for organ blowing, powerful, low noise level. 1st class condition. Photo on request. £12.10.0. Carriage £1.

WE WELCOME OFFICIAL ORDERS FROM ESTABLISHED COMPANIES, EDUCATIONAL DEPTS., ETC.

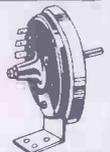
"TEDDINGTON" CONTROLS THERMO-STAT TYPE TBB.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. 17/6. Carr. Paid.



OMRON MICROSWITCH. Type VV—15—1A. Single c/o 10 amp. at 250v. 1 1/8" x 1/8" x 1/8". 30/- per dozen. Carr. Paid.

"HONEYWELL" MICROSWITCH.—Single and double bank, manual-push. Ideal for vending machines, etc. Each bank comprises a change-over rated 15 amps. 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. 1/8". Single 10/- each. Double 15/- each. Also few only 3 bank 20/- each. Carr. Paid.

"GOYEN" PRESSURE SWITCH.—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. 1/2 p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 1/8" dia. Projection 1/2". Overall size: dia. 3/8", depth 2" plus 1/4" (air tube). 25/- Carr. Paid.



"HONEYWELL" V3 SERIES.—Flush microswitch 10 amp. c/o. The side panel is insulated. End-plate size: 2" x 1/2". 30/- per doz. Carr. Paid.



"HONEYWELL" TYPE 23AC-NE—15 amp. change-over switch is fitted on angled metal mount with spring loaded plastic rod operating cam. 10/- each. Carr. Paid.



S.T.C. Midget Sealed Relay. Type 4190EC. 12v.-40 MA 170 Ω. Single H.D. make. 10/6 each. Carriage 2/-.

GARDNERS AUTO-TRANSFORMERS. 110/115/200/250v. 1500 watts. Weight 23lb. Few only. £10.10.0. P. & P. 25/-.

GARDNERS CASTLE SERIES. Isolation transformer type CAS 934. 240v. fused. Primary 24v. 4 1/2 amps. out. These units are constructed for outside use with fitted 5" mains lead and 3 socket outlet with plug supplied. Brand New. Makers price £7.18.6. Our price £4.15.0. P. & P. 15/-.

GARDNERS CHOKES

Type C237 20H 180MA	30/-	5/- P.P.
Type C570 0.05H 3.5A	35/-	5/- P.P.
Type C549 0.1H 2.5A	20/-	5/- P.P.
Type C271 5H 500MA	37/6	7/6 P.P.
Type C376 0.05H 7.5A	50/-	10/- P.P.
Type C527 0.5H 4A	50/-	10/- P.P.
Type SK7486 35MH 3A D.C.	30/4	5/- P.P.
Type F9719 25H 60MA	8/6	3/6 P.P.

PRECISION TRIMMER POTENTIOMETERS

Painton Bourns	Type 2005-1-502 5K Ω	12/-
Painton Bourns	Type 2005-1-03 10K Ω	12/-
Painton Bourns	Type 2005-1-501 500K Ω	12/-
Painton Bourns	Type 200-SI-503 50K Ω	12/-
Painton Bourns	Type 224P-1-202 2K Ω	12/-
Painton Bourns	Type 224S-1-102 1K Ω	12/-
Painton Bourns	Type 200S-1-203 20K Ω	12/-
Painton Bourns	Type 375-1-252 2.5K Ω	12/-
Ril	Type 321 10K Ω	12/-
Morganite	Type 80 1K Ω	12/-
Mec	Type 025 (Tubular) 200 Ω	12/-
Mec	Type T20P 50 Ω	12/-

All Carr. Paid.

Ernest Turner 5" x 4" 0-1 Ma. meter calibrated 0-10 in 50 divisions mirrored scale, handsome chrome escutcheon for flush mounting. A quality instrument. £4.5.0. Carr. paid.



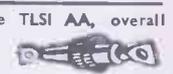
"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. 1/2" travel which can be increased to 1" by removing captive-end-plate. Overall size 2" x 2 1/2" x 2 1/2" high. 27/6. P. & P. 5/-.



New "Magnetic Devices" solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size 1 1/2" x 1 1/2" x 1". 20/- each. Carr. Paid.



K.L.G. Sealed Terminals. Type TLSI AA, overall length 1 1/16", box of 100, 25s. Type TLSI BB, overall length 1", box of 100, 35s. Carr. Paid.



Welwyn high value Resistors Type GA 36501. Values between 9.4 and 10.9 kilo-meg ± 1%, glass encapsulated 15/- Carr. Paid.

WELWYN RESISTORS.—Type H12. One value only. 1 kilo-meg ± 20%. 5/- each. (Min. order 2.) Carr. Paid.

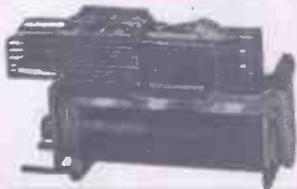
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P.O. TYPE 3000 AND 600
BUILT TO YOUR REQUIREMENTS - QUICK DELIVERY
COMPETITIVE PRICES-VARIOUS CONTACTS
DUST COVERS-QUOTATIONS BY RETURN



EQUIPMENT WIRE P.V.C. covered 80/- per 1000 yds. 7/0076, 1/024, 14/0048 type 1 and 2, all colours. 14/0076 type 11 Red and Natural £10 per 1,000 yds.

SUB-MINIATURE LAMPS. Flying leads 0.75 v., 50/- 100. **LEXER ROTARY SOLENOIDS AND CIRCUIT SELECTORS.** SIZE 5s. 4 pole, 11 way and off 110/-, 4 pole, 12 way 110/-, 24 pole, 11 way and off 210/-, 54 pole On/Off 130/-. **SOLENOIDS** type 3E in stock at 17/ 6each. **CERAMIC AND PAXOLIN WAPER SWITCHES** available from stock at keen prices, send for list. 24 way Double Pole Pax Wafer Switches 12/6 each, post 2/6. **P.O. STANDARD EQUIPMENT RACKS** 6s. U channel sizes drilled for 19in. panels heavy angle base, 15/-, cgs 20/-.

ONE HOLE FIXING SWITCHES
DOUBLE POLE ON/OFF Special Offer
 3 amp 250 volt A.C. 1 1/2 in. x 1 in. x 1 in. 30/- per dozen, 200/- per 100. Post 3/- per dozen, 6/- per 100.



AIR BLOWERS. 200/250v. A.C. cylindrical 7in. - 7in. suitable for intake or extraction. 1/50th hp. £10. 1/15th hp. £11. 1/10th hp. £14. Stockists of Stuart Turner Centrifugal Pumps. Nos. 9, 10 and 12. Details available.

GEARED MOTORS. 1 r.p.m. or 3 r.p.m. 4 watts very powerful, reversible 24v. A.C. 35/-, post 2/6, can be operated from 230v. with our 20/- Transformer. Post 5/-.

STANDARD LEVER KEYS, 3 POSITION
 4C lock/4C lock 17/6 each. 2C 2M non-lock/2C 2M non-lock 14/6 each. 4C non-lock/6C lock 20/- each.

ONE HOLE FIXING. Stop/4 C.O. non-locking 2 position 10/6. 6 C.O. lock/2 C.O. lock 3 position 17/6.

ROBUST AIRCRAFT PUSH 5C/898 of bakelite barrel type construction, with 1 1/2 in. square 4 hole fixing top with actual push below the level of a 1in. bakelite circle to prevent it being used accidentally. Samples 3/6 each, large quantities available.

ERICSSON CYLINDRICAL G.E.C. & S.T.C. SEALED & UNSEALED RELAYS IN STOCK, LIST AVAILABLE.

IN-LINE DIGITAL DISPLAY UNIT. 28 volts 5x4x1 1/2 in. five single Units each displaying 11 messages in letters, symbols and numbers, £25 complete.

CLOCKWORK MECHANISM. Precision made. Contacts making and breaking twice per second in sound-proof case with thermostat controlled heating. 12 or 24v. 18/6, post 6/-.

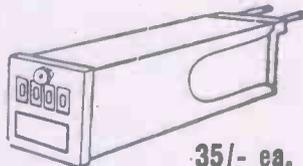
VACUUM GAUGES. 2 1/2 in. scaled. 0/30 inches of mercury, 20/- each, post 2/6.

PRESSURE GAUGES. 2 1/2 in., 60, 400 or 600 p.s.i., 23/- each. 4 in. flange 30, 60, 300 p.s.i., 37/6, 100 p.s.i. with 0/30ins. vac., 37/6, post 2/6.

AMAZING VALUE. 1/6th hp G.E.C. Fractional hp MOTOR 230/250v A.C., fitted with thermal protector with push button reset, ensures complete protection against overheating or burn-out, 1440 r.p.m. 1/2 in. shaft 1 1/2 in. long. Fully guaranteed 97/6, carriage 15/-.

HIGH SPEED COUNTERS

3 1/2 x 1 in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6v., 12v., 24v., 50v. or 100v.



35/- ea.

SUB-MINIATURE Microswitch Honeywell S.P.D.T. type 11 SMI TN 13 size 1/2 in. x 1/2 in. x 1/2 in. 6/6 each, or mounted in chassis 13/6, fours 18/-, and fives 22/6.

JACK PLUGS. 2 Point with screw-on cover, 2/6, post 9d. PO 201 on headphone cord 3/-, post 1/6.

PLUG-IN RELAYS. Lendex 4 change-over HD contacts 28v. D.C. with base and cover, 33/- each.

MAGNETIC COUNTERS. Veeדר Rotor with zero reset. 800 counts per minute, counting to 999,999. 110 volts A.C. or 110 volts D.C. 65/- each, post 3/-.

MINIATURE BUZZERS. 12 volts with tone adjuster, 7/6 each as illustrated. Quantity Rates.

RECTIFIER UNITS/BATTERY CHARGES-WESTALITE TYPE BC 3-3/15. Input 200/250 volts A.C., output up to 6 volts 15 amps D.C. Heavily damped 0/20 ammeter moving coil 2 1/2 in. reads true charging current, which is regulated by a four position rotary switch and sliding resistance. A ballast is fitted to smooth out mains variations. A.C. and D.C. fuses fitted. Size 1 7/8 x 1 3/8 x 1 1/2 in. designed to stand on bench or fit to a wall. £8.10.0. Carriage 20/-.

VARIABLE AUTO TRANSFORMER. Input 230 V. 2l amp. Output 57.5 to 230 V. in 16 switch steps. £25. **SINGLE FUSE HOLDERS.** Belling Lee L356 one hole fixing. 3/6 each.

METERS GUARANTEED. Complete list available.

Microamps 0/100 2 1/2 in. MC. 70/-
 Microamps 0/150 2 1/2 in. MC. 70/-
 Microamps 0/200 2 1/2 in. MCR. 80/-
 Milliamps 0/50 2 1/2 in. MC. 35/-
 Milliamps 0/500 3 1/2 in. MC. 34/-
 Amps 50-0-50 2 1/2 in. MC. 17/6
 Amps 0/5 2 1/2 in. MC. 42/6
 Volts 0/20 2 1/2 in. MC. 42/6
 Volts 0/40 2 1/2 in. MC. 42/6
 Volts 0/10 A.C. 3 1/2 in. MCR. 70/-

"VISCONOL-CATHODRAY" CONDENSERS. 1002 mfd. 15 kv, 9/-; .02 mfd. 10 kv, 10/-; .025 mfd. 2.5 kv, 3/-; .05 mfd. 5 kv, 9/-; 0.1 mfd 4 kv, 9/-; 6 kv, 17/6; 0.5 mfd. 2.5 kv, 17/6; 1 mfd, 17/6.

PORTABLE VOLTMETERS 30v moving coil DC precision sub standard grade 5in. mirror scale, in polished wood case £8.17.6, post 3/6; 160v moving iron AC/DC 6in. mirror scale in p. wood case £4.19.6, post 7/6.

CELL TESTING VOLTMETERS 3-0-3v. moving coil D.C. with leads and prods, in leather case 3in. scale 33/- ea., post 46

CAMBRIDGE PORTABLE MILLIAMMETER precision grade AC moving iron 7in. scale ranges-50, 100, 200, 500 and 1,000 mA, enclosed case £25, carriage 15/-.

BRIDGE MEGGER I. With resistance box and leads 1,000v., 0-100 megohms. Brand new and boxed. Usual price £189. Our price £60.

TRANSISTORS, DIODES, SCR'S ZENNERS, VALVES
 2N1305 2/6 25002 4/- ZT42 3/-
 2N1997 4/- 15131 1/- HX32 10KV 350mA 60/-
 2N1596 28/- ASZ20 4/- E66CC 10/-
 2N1613 3/- GET875 8/- EC88 3/6
 2N1671 4/- OC200 6/- Y30-30P 14/-
 2N698 4/- OC45 2/- I2BH7 6/-

OAZ242 5.6v regulator 3/6
 5X645 400 PIV 190 mA 10/-
 CG 4E/CV 448 80 PIV 30 mA 1/6
 CG50H 100 PIV 30 mA 1/6
 VR525 A-B 5.25v 0.4 Amps 9/-

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ELECTRONIC COMPONENTS

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369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339

RESISTORS:

Carbon 1/2W	100	10/-
1/3W	100	10/-
Wirewound, Multitapped	10	10/-
1-3W	20	10/-
5-7W	15	10/-
10W	10	10/-

PAPER CONDENSERS:

TV types, 500V	50	10/-
Miniature	100	10/-

ELECTROLYTIC CONDENSERS:

Mains radio/TV types	10	10/-
Transistor types	20	10/-
Mixed high/low voltage	15	10/-

POLYSTYRENE CONDENSERS

MULLARD POLYESTER CONDENSERS

SILVER MICA

WIRE-WOUND PRE-SET SLIDERS

VOLUME CONTROLS: Double, Mixed

NUTS AND BOLTS: Mixed lengths/types

8 B.A.	100	10/-
6 B.A.	100	10/-
4 B.A.	100	10/-
2 B.A.	100	10/-

METAL SPEAKER GRILLES: 7 1/2 in. x 3 1/2 in.

V.H.F./F.M. TUNERS: Need ECC85

VEROBOARD: Cutter +5 2 1/2 in. x 1 in. Bds.

TRANSISTORS:

P.N.P. Untested	50	10/-
N.P.N.	50	10/-
Light sensitive (OCP71)	5	10/-
Light sensitive diodes	10	10/-
OC44 Mullard. 1st grade	4	10/-
OC45 Mullard. 1st grade	4	10/-
OC22 Mullard. 1st grade	2	10/-
OC25 Mullard. 1st grade	2	10/-
2N378	4	10/-
ASY22	5	10/-
BY127 Rectifiers	4	10/-
1N4007 Rectifiers	4	10/-
STC3/4 200V	6	10/-
Unmarked 200V	10	10/-
Diodes. OA81	40	10/-

WIRE:

Solid core, insulated	yards 100	10/-
Stranded core, insulated	yards 50	10/-

SOLAR CELLS:

Selenium, large	2	10/-
small	3	10/-

COAX

Semi air spaced 15 yards	10/-
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CRYSTAL TAPE RECORDER MIKES

	1	10/-
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EARPIECES

No plug	6	10/-
With 2.5mm plug	4	10/-
With 3.5mm plug	4	10/-

FREE! FREE! FREE! ONE PACK EXTRA INCLUDING FREE WITH ORDERS VALUE £5. THREE PACKS EXTRA FOR £10 ORDERS.

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 2/-.

COMPUTER MULTI-CORE CABLES

12, 14/0076 copper cores, each one insulated by coloured P.V.C. then separately screened, the 12 metal braided cores laid together and P.V.C. sheathed overall making a cable just under 1/4 in. dia. but quite pliable. Price 7/6 per ft. Any length cut. Other sizes available 7 core 5/16 in., 6 core 4/16 in., 4 core 3/16 in.

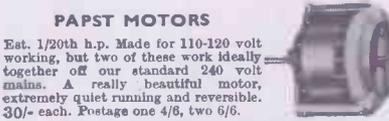
AC FAN

Small but very powerful mains motor with 5 in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 17/6, post 4/6. Mounts from back or front with 4BA screws.



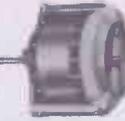
Double Leaf Contact

Very slight pressure closes both contacts. 1/3 each. 18/- doz. Plastic push-rod suitable for operating, 1/- each, 9/- doz.



PAPST MOTORS

Eat. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. 30/- each. Postage one 4/6, two 6/6.



2 SPEED REVERSIBLE TAPE MOTOR

230v. 50Hz. Capacitor start. Reversible. Normal construction. Size: 3/16 in. dia. x 2 1/2 in. deep. Approx. 1/40th h.p. 39/6 with Condenser, plus 4/6 post and insurance.

INSTRUMENT KNOBS

1/2 in. dia. head with 3/16 in. shank for flatted 1/16 in. spindle, 9d. each, 8/- dozen. Ditto but with metal disc, 1/- each, 11/- dozen.



MIDGET OUTPUT TRANSFORMER

Ratio 140 : 1. Size approx. 1 1/2 in. x 1/2 in. x 1/2 in., primary impedance 450Ω. Connection by flying leads. 4/6 each, 48/- doz.

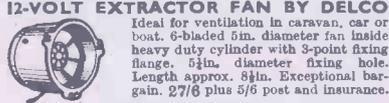
MIDGET OUTPUT TRANSFORMER

Ratio 80 : 1. Size approx. 1 1/2 in. x 1/2 in. x 1/2 in. Printed circuit board connection. 5/6 each, 23 doz.

CHART RECORDER MOTOR

Small (2 1/2 in. diameter approx.) instrument motor with fixing flange and spindle (1/2 in. long, 1/2 in. diameter); integral gearbox gives 1 rev. per 24 hours. 19/6.

IGNITION (E.H.T.) TRANSFORMER
Made by Parmeko Ltd. Primary 240v. 50 c.p.s. Secondary 5Kv at 23mA. Size approx. 4 1/2 in. x 3 1/2 in. x 2 1/2 in. thick. Price 29/6 + 4/6.



12-VOLT EXTRACTOR FAN BY DELCO
Ideal for ventilation in caravan, car or boat. 6-bladed 5 in. diameter fan inside heavy duty cylinder with 3-point fixing flange. 5 1/2 in. diameter fixing hole. Length approx. 8 1/2 in. Exceptional bargain. 27/6 plus 5/6 post and insurance.

4-PUSH SWITCH
Ideal to control fan heater, etc. 3 on switches and 1 off. Contacts rated at 15 amp on all switches. Price 4/6 each, 48/- dozen.

MAINS TRANSISTOR POWER PACK
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: EP1, FP3, PP4, PP6, PP7, PP9 and others. Kit complete with mains transformer, rectifier, smoothing and load resistor, condensers and instructions. Real snip at only 18/6, plus 3/6 postage.

3 DIGIT COUNTER
For Tape Recorder or other application, re-settable by depressing button. Price 5/6.

ISOLATION SWITCH
20 Amp D.P. 250 Volts. Ideal to control Water Heater or other appliance. Kit complete with Neon indicator shows when current is on. 4/6; 48/- per dozen.

LIGHT CELL
Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light. Epoxy resin sealed. Size approx. 1 1/2 in. dia. by 1/2 in. thick. Rated at 500 MW. wire ended. 8/6. Suit most circuits.

5A 3-PIN SWITCHED SOCKETS
An excellent opportunity to make that bench disc board you have needed or to attack up for future jobs. This month we offer 6 British made (Heraft) bakelite flush mounting shuttered switch sockets for only 10/- plus 3/6 post and insurance. (20 boxes post free.)

MOTOR WITH GEARBOX
Very powerful 7 r.p.m., operates from standard A.C. mains. 29/6, plus 3/6 P. & P.

230 VOLT SOLENOID
1/2 in. stroke. Size 2 1/2 in. x 2 in. x 1 1/2 in., 14/6, postage 2/6.

TRANSDUCER
Made by Aco, reference No. LD.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price 25. Our price 49/6. Brand new and unused.

THERMOSTAT
Continuously variable 30°-90°C. Has sensor bulb connected by 33in. of flexible tubing. On operation a 16 amp 250 volt switch is opened and in addition a plunger moves through approx. 1/2 in. This could be used to open valve on ventilator etc. 29/6 plus 4/6 p. & ins.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 x 18 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work. 39/6 less plug; 45/- with fitted 13 amp plug; 47/6 with fitted 15 amp plug, plus 4/6 P. & I.

STANDARD WAFER SWITCHES

Standard size 1 1/2 wafer—silver-plated 5-amp contact, standard 1/2 spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6
2 poles	6/6	6/6	6/6	6/6	6/6	6/6	6/6	10/6	10/6
3 poles	6/6	6/6	6/6	6/6	10/6	10/6	10/6	14/6	14/6
4 poles	6/6	6/6	6/6	10/6	10/6	10/6	10/6	18/6	18/6
5 poles	6/6	6/6	10/6	10/6	14/6	14/6	14/6	22/6	22/6
6 poles	6/6	10/6	10/6	10/6	14/6	14/6	14/6	26/6	26/6
7 poles	6/6	10/6	10/6	14/6	18/6	18/6	18/6	30/6	30/6
8 poles	10/6	10/6	10/6	14/6	18/6	18/6	18/6	34/6	34/6
9 poles	10/6	10/6	14/6	18/6	22/6	22/6	22/6	38/6	38/6
10 poles	10/6	10/6	14/6	18/6	22/6	22/6	22/6	42/6	42/6
11 poles	10/6	14/6	14/6	18/6	26/6	26/6	26/6	46/6	46/6
12 poles	10/6	14/6	14/6	18/6	26/6	26/6	26/6	50/6	50/6

VARIAC CONTROLLERS
With these you can vary the voltage applied to your circuit from zero to full mains without generating undue heat. One obvious application therefore is to dim lighting. We offer a range of these, ex-equipment but little used and in every way as good as new. Any not so, will be exchanged or cash refunded. 2 amp £4-19-6. 4 amp £6-19-6. 8 amp £9-10-0. Carriage extra.

THIS MONTH'S SNIP

MOTORIZED SWITCH
For Animated Signs etc.
This is motorised programmer switch, mains operated, with six 18 amp changeover contacts operated by triggers on a rotating drum. Six triggers will put switches up and another six triggers will put switches down. Also simple on/off operation or changeovers are possible. The triggers are exactly set by any position around the drum which is rotated by a one rev. per hour motor. (Motors with other speeds available.) A beautifully made precision switch which probably cost in excess of £20. Limited quantity only £9-15. each, post free.

TANGENTIAL HEATER UNIT
This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only need control switch. 79/6. 2kW. Model as above except 2 kilowatts 39/6. Postage and insurance 6/6. Don't miss this!

25 Amp Electrical Programmer
Learn in your sleep! Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5 1/2 x 3 1/2 x 2 1/2 in. Deep. Metal encased, glass fronted with chrome surround. Offered at 47/6 plus 3/6 postage and insurance.

INTEGRATED CIRCUITS
A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices 5s. upwards with circuits and technical data of each. Complete parcel only £21 post paid or list and all technical data.

RE-CHARGEABLE TORCH
Neat flat torch, fits unobtrusively in your pocket, contains 2 Nicad cells and built-in charger. Plugs into shaver adaptor and charges from our standard 200/240 volt mains. American made, sold originally at over 4 dollars. Our price only 19/6 each.

BARGAIN OF THE YEAR
MICROSONIC RADIOS
7 transistor Key chain Radio in very pretty case, size 2 1/4 x 2 1/4 x 1 1/4 in.—complete with soft leather zippered bag. Specification: Circuit: 7 transistors superheterodyne Frequency range: 530 to 1600 Kcs. Sensitivity: 5 μv/m. Intermediate frequency: 455 Kc/s. or 455 Kc/s. Power output: 40mW. Antenna: ferrite rod. Loud-speaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. 24/6 plus 2/6 post and insurance. Less batteries. Six for 27, post free.

HI FI BARGAIN
FULL F1 12-INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi loud and Rhythm Guitar and public address.
Flux Density 11,000 gauss—Total Flux 44,000 Maxwell—Power Handling 15 watts R.M.S.—Cone moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12 1/2 over mounting lugs—Baffle hole 1 1/2 in. Diam.—Mounting holes 4, holes 1/2 in. diam. on pitch circle, 1 1/2 in. diam.—Overall height 5 1/2 in. A 26 speaker offered for only £3-19-6 plus 7/6 p. & p. 12" 40w £29-19-6. Carr. 8/6. 15in. 25 watt £7-19-6 Carr. 10/6. 18in. 100 watt £19-10-0. Carriage, etc., 30/-.

PRINCESS AUTO CHANGER
The most amazing bargain ever! A brand new Auto change record player for less than the price of a single player... due to a frustrated export order we are able to offer the Balfour Princess 4 speed Autochanger—a really fine machine at about one-third of its regular price.
The Balfour has two unique features (1) A patented brush system which automatically cleans stylus after each record playing and (2) at shut off the pick-up locks itself into its recess—other features include pick-up height and stylus pressure adjustments, and motor suitable for our 230/240 or for 115v. continental mains.
Beautifully styled—this is a high class expensive instrument but you can purchase this month for only 59/6 plus 10/6 post and packing. One point, these changers have been to France and back and the vibrations of the journey, etc., may have loosened screws or otherwise put them out of adjustment. However, with each we supply a 16 page service manual and fault finding chart which is so detailed that if necessary you could completely re-build the changer. So this is truly a bargain that you will not want to miss.

Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

MAINS TRANSFORMERS

Note all these are first grade Transformers and all have normal 200/240 volt 50 cycle primary.
Mains Transformer Type No. 56786
Upright mounting, size 3 x 2 1/2 in. approximately. 2 secondaries one 25 volt 1 amp and the other 5.5 volt 1.5 amp. Earth screen between primary and secondaries—this transformer will power a 5-5 watt stereo amplifier (circuit diagram available, price 2/6). Suitable output transformer type 56787 described below. Our price 17/6. Plus 4/6 postage.

Mains Transformer Type No. 56783
Chassis mounting type, size approximately 3 x 2 1/2 x 3 in., 2 secondaries one 230 volt at 60 mA and other 6.3 volts 1.5 amp. Earth screen between primary and secondaries. This will power a 5 watt amplifier (circuit available 2/6). Matching-O.P.T. is 56734 described below. Price 16/6 plus 4/6 post.

Mains Transformer Type No. 56895
Upright mounting, size approximately 4 x 3 x 2 1/2 in. 2 secondaries 275-0-275 at 90 mA and 6.4 volts at 3.1 mA. There is a screen between primary and secondaries. This is a partner to output transformer 56694 described below. Price 19/6 plus 4/6 post.

OUTPUT TRANSFORMERS

O.P.T. ref. 56894
Chassis mounting—size 2 x 2 in. approximately 7 watts. A push pull transformer for matching 2/E14 or similar valves to 15 ohm Loud Speaker. 14/6 no extra for post if ordered with Transformer 56695. Circuit diagram of amplifier available, price 2/6.

O.P.T. ref. 56787
Upright mounting, size approximately 2 1/2 x 2 x 2 in. Matching impedance 60 ohms to 15 ohms. 5 watts output using transistor type AD140 (Circuit diagram available price 2/6). Price 8/6 each, no extra for postage if ordered with mains transformer type 56786.

O.P.T. ref. 525004
Chassis mounting, size approximately 2 x 2 1/2 x 2 in. Primary impedance 60 ohm, secondary impedance 3 ohm, otherwise this is as 56787. Price 8/6.

O.P.T. ref. 56734
Chassis mounting, size approximately 2 1/2 x 2 x 1 1/2 in. Primary 500 ohm centre tapped. Ratio 27/1. 5 watts output using twin ELL50 or similar. Price 12/6. No extra for postage if ordered with 56733.

HEAVY DUTY MAINS TRANSFORMER.
30V. 37A. Primary tapped 200/240 in 10v. steps. A really beautiful "C" core transformer. Made by Parmeko, impregnated and varnished. Weight approx. 50 lb., size approx. 8in. wide 6 1/2 in. deep and 8 1/2 in. high. Metal frame for free standing and fitted with E.S. screen. Probably priced £40-£50 from Parmeko. Ex equipment, but perfect, £17-10 each, plus carriage at cost.

50 CYCLE TO 60 CYCLE INVERTERS
For powering American instruments and other equipment made for 60 cycles 115 v. from 230/240 50 cycle mains. These units have an output of 115 volts A.C. and will handle a load of up to 100 watts. These are precision made and have a reed type frequency meter which vibrates when the frequency is exactly 60 c.p.s. Adjustment of the frequency is by a knob on control panel. Input by 3 core output from 3 pin socket. Original cost of this in excess of £60. A limited quantity available £17-10. each.

MAINS OPERATED CONTACTOR
230/240v. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2 1/2 x 2 in. 19/6 each.

SIMMERSTAD CONTROL SWITCH
Combined on-off switch and "heat on" regulator intended for automatic temperature regulation of electric hot plates up to 3kW. Official rating 15A 200-250V A.C. size 2 x 1 1/2 x 2 in. deep. Single hole fixing 12/6. Knob 4/6 extra.

AUTO-ELECTRIC CAR AERIAL
with dashboard control switch—fully extendable to 40in. or fully retractable. Suitable for 12v positive or negative earth. Supplied complete with fitting instructions and wired ready dashboard switch. £5-18-6 plus 6/- post and ins.

TOGGLE SWITCH
3 amp 250v. with fixing ring. 1/6 each 16/- doz.

MICRO SWITCH
5 amp. changeover contacts. 1/9 each 18/- doz. 15 amp model 2/- ea. or 21/- doz.

MINIATURE EAR PIECE
As used with imported pocket radios. 1/6 each 15/- doz.

15/20 AMP CONNECTORS
Polythene insulated 12-way strip. 2/6 each 24/- doz.

13 AMP FUSED SWITCH
Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type 3/6 each 30/- doz. Metal boxes for surface mounting 1/6 each 15/- doz.

13 AMP SPUR UNIT
By G.E.C. for connecting clock, etc., to ring main. Full-out fuse. Flush mounting. Cream. 2/6 each; 24/- doz.

MAINS MOTOR
Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 9/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

MINIATURE WAFER SWITCHES
2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each, 36/- dozen, your assortment.

MINIATURE SLIDE SWITCH
3 pole change-over. 3/- each 30/- doz.

ELECTRONICS (CROYDON) LTD
Dept. WW, 266 London Road, Croydon CRO-2TH
Also 102/3 Tamworth Road, Croydon

ELECTRONIC BROKERS LTD

HIGH STABILITY DC LABORATORY POWER SUPPLY UNIT

Type NOBATRON by Sorensen of U.S.A.

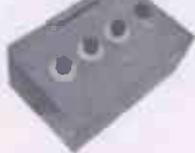
MODELS:

QRC-40—8A i/p 110-120V 50 Hz o/p 0-40V at 8 amps. £125.

DCR-40—10A i/p 200-240V 50 Hz o/p 0-40V at 10 amps. £160.

DCR-150—5A i/p 200-240V 50 Hz o/p 0-150V at 5 amps. £190.

These are modern slim line rack mounting units incorporating many desirable features such as overload protection etc. Carriage extra.



MUTUAL INDUCTANCE BOX TYPE R.7005

Specification Range: 0-11.100 mH in 0.002 mH divisions. Accuracy: $\pm(0.3 \times 0.012) \frac{\%}{M}$

where M = value of mutual inductance in mH set on the box. Frequency range: 0-2.5 Kc/s for all decades except X1 = 0-15 Kc/s. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary windings). Case: Polished teak. List price £65. Our price £17-10-0.

8 DIGIT UNIVERSAL COUNTER TIMER MODEL 1037-5

By well known American maker in excellent condition. Scale 99,999,999 with illuminated units annunciator and auto-positioned decimal point indication. Display width 7 in. Range: 0-50 MHz (D.C. Input); 10Hz-50 MHz (A.C. Input). Gate Time: 1 micro sec. to 10 sec. in decade steps. Accuracy: ± 1 count \pm time base accuracy. Sensitivity: 100mV, RMS. Attenuator: Stepped factors of 1, 10 and 100. Impedance: 100 K ohm per volt with overload protection. Dimensions: Height 5 1/2 in., Width 17 1/2 in., Depth 17 3/4 in. Weight: 42 lbs. Power Supply: 200-240V 50 Hz 125W. Price £450. Carriage extra.

HIGH GRADE COMPONENTS

OSCILLOSCOPE CAMERAS

Cossor Model 1431. Complete with motor, auto transformer and capacitor unit. Price.....£49.10.0 plus carriage
Langham Thompson 200 Type B. Price.....£25.0.0 plus carriage
New Telford Polaroid. Type 'A'. As illustrated.
Price.....£99.10.0 plus carriage
Viewing head to suit Type 'A' camera. Price.....£25.10.0 plus carriage



VOLSTATS

Type	I/P	Freq.	O/P	Load	Price
CV 25E	190/260	50	6	25 W.	£3.10.0
MT 161E	190/260	50	6	50 W.	£5.10.0
MT 161F	190/260	50	12	50 W.	£6.10.0
MTZ 161A	190/260	50	30	50 W.	£7.10.0
CV 500/27	50/130	50	85	4 Amp	£15.0.0
CV 50J	190/260	50	230	50 W.	£4.0.0
CV 150/98	110/220	50	230	150 W.	£8.10.0
MT 267A	190/260	50	230	250 W.	£10.10.0
MT 161ADA	190/260	40	230	50 W.	£4.0.0
MT 140A	190/260	50	230	150 W.	£7.0.0
MT 262XA	190/260	50	230	500 W.	£25.0.0
MT 140	190/260	50	230	150 W.	£8.10.0
MT 262A	190/260	50	230	500 W.	£25.0.0
30MB790	210/250	50	230	2.61 Amps	£25.0.0
CYH 60A	190/260	50	240	60 W.	£10.10.0
CV 50D	50/130	50	240	50 W.	£3.10.0
CV 1400A	190/260	50	240	1000 W.	£35.10.0
CYN 500H	190/260	50	220	500 W.	£35.0.0

GALVANOMETERS (PENCIL TYPE) SPECIFICATIONS

Adaptors available to suit all types of recorders, Low Frequency Types

Type No.	Natural Frequency Response $\pm 5\%$ c/s	Nominal Terminal Resistance in ohms	Galvanometer sensitivity for a 35mm optical path mA/cm	Price
EB/20	20	85	0.4 Micro A/cm	£33
EB/40	40	85	0.43 Micro A/cm	£33
EB/60	60	90	0.7 Micro A/cm	£33
EB/100	100	75	2.7 Micro A/cm	£33
EB/150	150	70	5 Micro A/cm	£33
EB/200	200	70	21 Micro A/cm	£33
EB/300	300	120	25 Micro A/cm	£33
EB/450	450	120	50 Micro A/cm	£33

High Frequency Types

Type	Natural Frequency	Nominal Terminal Resistance	Galvanometer sensitivity	Price
EB/1,000	1,000	90	0.46 MA/cm	£33
EB/1,400	1,400	85	0.8 MA/cm	£33
EB/1,800	1,800	85	0.9 MA/cm	£33
EB/2,200	2,200	85	1.9 MA/cm	£33
EB/2,500	2,500	42	4.9 MA/cm	£33
EB/3,300	2,300	45	6.3 MA/cm	£33
EB/4,000	4,000	45	7.2 MA/cm	£33
EB/5,000	5,000	45	13.3 MA/cm	£33
EB/8,000	8,000	45	22 MA/cm	£33
EB/10,000	10,000	45	26 MA/cm	£33
EB/20,000	20,000	90	85 MA/cm	£50

(No. 5) IMPEDANCE BRIDGE TYPE TF936

Measures L & C at 50 Hz, 1KHz or 10 KHz. Measures Z at D.C. AC Bridge volts monitored and variables. Automatic detector sensitivity control. Rugged pan-climatic construction. Measures L from 1 microH to 100H. C from 1 pF to 100 microF and resistance from 0.1 ohm to 100M ohm. Price.....£95 carriage extra.



BRAND NEW HIGH CAPACITY ELECTROLYTIC CAPACITORS at a fraction of original prices by MALLORY or SPRAGUE

Capacity In Microfarads	Working Voltage	Burge Voltage	Price
3,500	25	35	10/-
5,000	55	61	20/-
7,500	10	15	10/-
20,000	30	45	25/-
25,000	25	40	15/-
25,000	50	65	30/-

27,000	15	20	20/-
30,000	32	35	25/-
35,000	15	20	10/-
37,000	15	20	20/-
40,000	10	12	10/-
45,000	25	30	25/-
55,000	15	20	20/-
90,000	10	14	20/-

P. & P. 5/- on single item.

DELAY LINE

Type MON 2484 D 2 micro second 4K ohm. Length: 2 1/2 in. x 1/2 in. x 1/2 in. £1.10.0 P. & P. 3/-.

ACTUATOR

By English Electric. Type 4519 Mk. 1 D.C. Motor AE 1560 Mk. 1 28V 3A, 500 r.p.m. Intermittent rating. £16. P. & P. £1.

NEW MINIATURE RELAYS

Alma Read type NSC 32/B/1A, 650 ohm coil. £3. P. & P. 3/-
Smiths Micro-Relay type 14 PCB/7/R 28.5 m/A. £3. P. & P. 3/-

INDUSTRIAL LIGHT SWITCH

By Burndett. Model BE 290. Transistorised unit Relay o/p Sensing head uses Mullard DCP 71. Mains input. Dimensions 7 1/2 in. x 4 1/2 in. x 2 1/2 in. Weight: 4 1/2 lbs. £7.10.0 P. & P. 7/6.

PROGRAMME SWITCH

By Graseby Instruments. Model G1 408/5 consists of 4 Banks x 48 Way 1 Revolution in 239 sec. Supply 115V 400Hz £10. P. & P. 7/6.

TRANSISTOR AMPLIFIER

Type TA-1G by R. B. PULLIN. £5. P. & P. 5/-.

CODER SHAFT POSITION

By Datex Corporation. Type 4166-7003 "V" Scan Code National Binary Diode Pos. Diameter: 1 1/2 in. x 2 1/2 in. long. Servo Mounting. £15. P. & P. 5/-.

MULTILINE COMPARATOR

By Vanner. Type TB 89. Transistorised unit. As new condition. £5. P. & P. 5/-.

ANALOGUE-DIGITAL CONVERTER

By United Aircraft. Type 6-SPT-C. Model 13-BNRY-B. 13 Digit encoder Gray code. Length 3 in., diameter 1 1/2 in. Servo Type mounting. £15. P. & P. 7/6.

ACCELEROMETERS

Model LA 2 3C Potentiometric + or -10 G operating Voltage 30V. Nominal resistance 17.5K and Model LA 2 3C + or - 100G 34V. Ref. 20 K. Price £28. P. & P. 0/0

TYPE SE 55/A Range + or - 1G £28. P. & P. 0/0.
TYPE F by G.E.C. Up to 1,000 G. Ceramic type giving o/p of 23 mV. Supplied c/w technical leaflet. Weight 14.8 grammes. 2BA stud Mains supply.....Price £99.10.0
Many other types in stock

MAGNETIC AMPLIFIER

By Pullin/keartott. Type R603-1A and R601-1A-B. £6.10.0 P. & P. 6/-.

MOTORS

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-cz/in. Available in the following speeds and ranges: 240V 50 Hz, 18 r.p.m., 1 1/2 r.p.m., 1/5 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/80 r.p.m., 1/45 r.p.m.; 120V 50 Hz 1 1/2 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/20 r.p.m., 1/24 r.p.m., 1/30 r.p.m., 1/80 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 25/- each. P. & P. 3/-.

SYNCHRONOUS MOTORS

Model S 71 r.p.h. and 1/80 r.p.h. Self starting complete with gearing shaft 1/2 in. dia. 1/2 in. long, 200/250V 50 Hz. New condition Ex-Equipment. 40/- P. & P. 3/-.

DATA TRANSMISSION-SYNCHROS

A selection from our wide range

Type	Maker	Voltage	Hz	Price
Torque Receiver 11TR4s	Sperry	90/115v	400	7 10 0
Torque Receiver 11TR4s	Smith	26,12.3	400	7 10 0
Torque Receiver 11TR4s	Pullin	90/115v	400	7 10 0
Control Transformer 11CT4A	Muirhead	90v	400	9 10 0
Control Transformer 08CT4	Muirhead	26v	400	9 10 0
Control Transformer 11OT4a	Sperry	90v	400	9 10 0
Control Transformer 11OX4a	Pullin	26v	400	6 10 0
Control Transformer 11CX4	Ketay	115/90v	400	9 10 0
Torque Transmitter AC8/AE	Smith	115/90v	400	6 10 0
Torque Transmitter 11MD3	Muirhead	26v	400	9 10 0
Torque Transmitter 15M1B	Muirhead	115/90v	400	9 10 0

OARRIAGE EXTRA

HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 120V 60 Hz, 1/10 r.p.m., 30/- each. P. & P. 3/-.

HIGH PRECISION MAINS MOTOR 3 Phase-1 Phase

230V 50 Hz 1/8 h.p. continuously rated. Frequency range 5 c/s to 125 kc/s in five bands. Accuracy $\pm(1\% + 1 \text{ c/s})$. Sine wave distortion less than 1%. Output Sine wave continuously variable, 0 to 30V r.m.s. into 600Ω. Sine wave 0 to 1W into 5Ω. Square wave 0 to 30V pk-pk. Output impedance varies up to 5kΩ depending on output level setting. Rise and fall times 0 to 0.75μs maximum. Power requirements 100 to 130V and 200 to 260V, 40 to 60 c/s, 100W. Dimensions 19in. wide x 10in. high x 8 1/2in. deep. Weight 32 1/2lb. Rack mounting. Price £75 carriage extra.



GENERATORS

L.F. SIGNAL GENERATOR 9386

Frequency range 5 c/s to 125 kc/s in five bands. Accuracy $\pm(1\% + 1 \text{ c/s})$. Sine wave distortion less than 1%. Output Sine wave continuously variable, 0 to 30V r.m.s. into 600Ω. Sine wave 0 to 1W into 5Ω. Square wave 0 to 30V pk-pk. Output impedance varies up to 5kΩ depending on output level setting. Rise and fall times 0 to 0.75μs maximum. Power requirements 100 to 130V and 200 to 260V, 40 to 60 c/s, 100W. Dimensions 19in. wide x 10in. high x 8 1/2in. deep. Weight 32 1/2lb. Rack mounting. Price £75 carriage extra.

D.C. TACHOGENERATOR

Type 9c/106 16v. at 1000 r.p.m. Drive shaft dia. 3/16 in., 3/8 in. long. Price £16/10/0.



OSCILLATORS & SIGNAL GENERATORS

- (12) CRYSTAL CONTROLLED OSCILLATOR ETC. 16-LXU-62A Mk. II. 0-20 MHz. Sweep facilities. O/p attenuation 0-70 dB. Complete with power supply unit 14-LXU-52B. Price £85
- (104) NEW AUTOMATIC CYCLING OSCILLATOR. ACOS 1. P.YE. Range 5 Hz-5 KHz. Sweep mode 1 Ciry/min. O/p. 0-10V. Mains supply.....Price £99.10.0
- (108) LOW FREQUENCY DECADE OSCILLATOR D-838-A MURHEAD. Range 0.1 Hz-2.12 KHz. O/p 0-50V. Mains supply. Max. O/p 1W in 600Ω above 30 Hz.....Price £245
- (109) DECADE OSCILLATOR D-850-B. Range 1 Hz-111 KHz. Max. O/p 2W into 8KΩ above 20 Hz. O/p 0-150V.....Price £45
- (110) L.F. OSCILLATOR G 420 FURZEHILL. Range 1.4 Hz-15 KHz. Viewing CRT.....Price £15
- (113) R.C. OSCILLATOR AND AUTOMATIC FREQUENCY MONITOR-SMITHS. Oscillator range 10 Hz-100 KHz. Price £75
- (118) AUDIO FREQUENCY OSCILLATOR-PYE. Range 20Hz. O/p. 0-20V. Mains operated.....Price £215
- (149) GAUGE OSCILLATOR M 700L SOUTHERN INSTRUMENTS. Price £15
- (118) SIGNAL GENERATOR CT218. Range 85-300 MHz. O/p. Facilities include crystal calibrator, modulation.....Price £85
- (115) AUDIO FREQUENCY GENERATOR. Type J2. ADVANCE. Range 15 Hz-50 KHz. O/p. 0-40V.....Price £25
- (133) SIGNAL GENERATOR CT 480 SANDERS. Range 7 KHz-12 KHz. O/p. 0-±50V. Attenuation range -10 to +100 dB. Price £85
- (179) WOBULATOR GM 2877/02 PHILLIPS.....Price £65
- (142) NOISE GENERATOR CT 410 WAYNE KERR. Frequency Range: 15 Hz-160 MHz. Timer 0-8 mins. Diode current 0 dB. at 5mA to +13 dB at 100mA.....Price £50
- FM/AM SIGNAL GENERATOR. Type SG. 63D. ADVANCE. Range 4 MHz-100 MHz. O/p. 1 microV-100mV. Sweep facility and line FM deviation ± 100 KHz.....Price £55
- (105) SIGNAL GENERATOR Mod. 68A TAYLOR. Range 100 KHz-240 MHz. O/p. 0-10V R.F. O/p. and attenuation 0 to -80 dB in 4 steps.....Price £15
- A.C. MOTOR GENERATOR
Type G1005 Motor Spec. 6000 r.p.m. Torque 25gm/cm. Control winding 20v., 400Hz. Ref. Winding 26v., 400Hz. Generator Spec. Ref. Winding 26v., 400Hz. O/P 4v/1000 r.p.m. Length 2 in., dia. 1 in. Price £71/0/0 P. & P. 5/-



49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2. Cables: SELELECTRO TELEX NO. 267307

MEASURING INSTRUMENTS AND RECORDERS

METERS



- (R3) SINGLE PEN. DC MILLIAMMETER. 0-1mA. Chart width 3 1/2 in. Speed 1 in./hr. Alarm contacts, Mains power supply. Price £52.10.0
- (R4) SINGLE PEN. DC MILLIAMMETER. 0-1mA or 0-500 micro amp. Chart width 3 in. Speed 1 in. and 6 in./hr. Fitted alarm contacts. Terminal Resistance 400 ohms (0-1mA) 1.5K ohms (0-500 micro A). Mains power supply. Price £49.10.0
- (R24) SINGLE PEN. DC MILLIAMMETER. 0-2mA. Chart width 4 1/2 in. Speed 1 in. and 6 in./hr. and 1 in. and 6 in./min. Clockwork drive 8-day movement. Terminal Resistance 2,900 ohms. Price £30
- (R8) 2 PEN. DC MILLIAMMETER. 0-15mA. Chart width 8 in. Speed 6 in. and 12 in./hr. Mains supply. Price £75
- (R9) UNIVERSAL MULTIPoint. 1/24 point suitable quantities with slow rate of change. Chart width 12 in. Speed: 3 ranges, 6/1 ratio. Sensitivity 0-100°C based on 0-75mV FSD using Thermocouple pick up. Price £280
- (R10) NEW MULTIPoint RECORDER. 100-0-100mV. Chart width 6 1/2 in. Speed: 20 and 720 min./hr. Also available 0-100, 0-400°C using Thermocouple pick ups. Price £79.10.0
- (R11) CAMBRIDGE TEMPERATURE RECORDER SINGLE PEN. Circular Scale. Uses ether bulb and capillary tube. Range: 50-300°C. Chart dia. 1 1/2 in. (24-hr. markings). Mains supply. Price £25
- (R12) MERSTED TEMPERATURE RECORDER. Two Pen 0-200°C, c/w bulbs and capillary tubing. Mains supply. 24 hr. Chart dia. 1 1/2 in. Price £25
- (R13) HIDDEN Mk. II SERVOGRAPH. Single point fitted with turret head to enable conversion to 4 point. Uses capacitive sensing input. Chart dia. 1 1/2 in. Speed: 1 rev./hr. Sensitivity 50 micro Amp. Resistance 1,950 ohms. Mains supply. Price £25
- (R14) KENT Mk. II SINGLE POINT. Chart width 9 1/2 in. Speeds: 1 in., 2 in., 3 in./hr. Sensitivity approx. 10mV FSD. Various scales, k.e. 0-400°C, 0-1,000°C, -10 to +200°C, 0-100°C. Also available: Multipoint. General purpose slow response suitable Temperature, Humidity, etc. Response 33 secs. for FSD. Supply: 115V 50 Hz. 230V Autotransformer available. Price £49.10.0
- (R25) SINGLE PEN. DC MILLIAMMETER. 0-1mA. Chart width 4 1/2 in. Speed 3 in./hr. Mains supply. Price £29.10.0
- (R27) SINGLE PEN. DC MILLIAMMETER. 150mA OH damped movement. Chart width 7 in. Speed: 1 in./hr. Clockwork drive 8-day. Terminal Resistance 100 ohms. Price £29
- (R39) SINGLE POINT. DC MILLIAMMETER. 1/2-0-1mA. Chart width 2 in. Speed: 6 in./hr. Uses typewriter ribbon marker. Mains supply. Terminal Resistance 240 ohms. Price £25
- (R41) PHILLIPS 0-10mA CRYSTAL. DC. Chart width 5 in. Two-speed model. Mains supply. Price £25
- (R61) TWO PEN. DC MILLIAMMETER. 0-2mA. Chart width 8 in. Speed: 1 in./hr. Clockwork drive. Terminal Resistance 1,687 ohms. Price £25
- (R5) SINGLE PEN. SERVOWRITER MODEL FWS. Chart width 11 in. slow speed. Response time 24 secs. for FSD. Suitable Temperature, Humidity, etc. Price £75
- (R7) PORTABLE SINGLE AND FOUR PEN. Suitable recording quantities with high rate of change. Speeds: Single pen 60 in./min. and 240 in./min.; Four pen 1, 2, 4 and 16 cms./sec. Electric pens. Mains supply amplifiers to suit. Price £149
- (R56) SINGLE PEN. DC MILLIAMMETER. 0-5mA. Chart width 8 in. Speed: 1 in./hr. Mains supply. Price £30
- (R57) SINGLE PEN. DC MILLIAMMETER. 0-0.5mA. Chart width 8 in. Speed: 1 in. and 6 in./hr. Terminal Resistance 4,500 ohms. Price £35
- (58) SINGLE PEN. DC MILLIAMMETER. 0-2mA. Chart width 8 in. Speed: 1 in./hr. Mains supply. Price £20
- (R60) AC RECORDING WATTMETER MURDAY SYSTEM. Maximum current: 38 amps. Price £23
- (R34) CAMBRIDGE SINGLE PEN STRIP CHART RECORDER COMPLETE WITH CONTROL UNIT. A general purpose potentiometric recorder for quantities such as temperature, moisture, etc. Specifications: Chart width 8 ins. Chart speed 1/4, 1/2, 1, 2, 3, 6 in./min. Power supply 200/250V 50 Hz. Dimensions: Width 16 1/2 in., height 3 1/2 in., depth 10 1/2 in. Price £65
- (R35) ARKON PRESSURE RECORDER-SINGLE PEN TYPE 1000. Manufactured by Walker Crowther & Co. Ltd. Specifications: Range -0 to +6 in. w.g.; Chart width 7 ins.; Chart speed 1/4 in./hr.; Chart drive, synchronous motor, 200/250V 50 Hz. Dimensions: Width 18 1/2 in., height 2 1/2 in., depth 13 in. Price £75
- (R38) FOXBORO FLOW INDICATOR TYPE EC IMP. MAG FLOW DYNALOG MODEL M980B. Specifications: Range 0-40 litres/min. Curve uniform. Power supply 240V 50 Hz. Weight 82 lb. Dimensions: Width 14 1/2 in., height 17 in., depth 13 in. Price £235
- (R37) FOSTER STRIP CHART RECORDER TYPE 3490Y. Uses a six-colour half-inch ribbon and mechanical chopper principle to record data on a 6 in. chart. Specifications: Chart width 6 in.; Chart speed 1 1/2 cm./hr. Dimensions: Width 15 1/2 in., height 22 in., depth 13 in. Weight 60 lb. Price £90

- (1617) VIBRON ELECTROMETER. Mod. 33B. Electronic Inst. Range 0-10V. O/p. ± 1mA into 1.5 KΩ. Price £85
- (1514) pH METER. CAMBRIDGE. Price £12.10.0
- (1506) AC/DC VOLT METER. WINSTON ELECTRONIC. Voltage range -7.5 to 15V. Price £12.10.0
- (1608) FLUX METER TYPE 15A/AP. T.L.G. ELECTRIC. Range 96-12 gauge. In wooden case. Price £10
- (1604) VERNIER POTENTIOMETER. Type 4383. A. TINSLEY. Accuracy x .0001. Price £75
- (1513) WATTMETER. S 67. SANGAMO WESTON. Range 0-15W; 150-300V. 0.25-0.5A. Price £29.10.0
- (1110) WIDEBAND MILLIVOLTMETER. TF 1371 MARCONI. Range 3mV-300mV; -10 to +3 dB, complete with probe. Flat response 30 Hz-30 MHz. Reading μmVs. dB. Price £20
- (1121) PORTABLE POTENTIOMETER. Type L192826 CAMBRIDGE. Fitted with standard cell and thermometer. Price £45
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- (1123) SLIDE WIRE POTENTIOMETER. CAMBRIDGE. Voltage range 0.1-0.1 L.O. Fitted with Galvo. Key. Absolute voltage 0-1.7V in 18 steps. Price £35
- (1132) DECADE INDUCTOMETER. Type 230A. DAVE. Range 1 microH at 100 mH. in 40 steps. Price £25
- (1114) MILLIVOLTMETER. Type 264. AIRMEC. Range 0-900 mV. Complete with amplifiers and 75Ω probe. Price £20
- (1111) VALVE VOLTMETER. Type 712. AIRMEC. Range AC 0-150V; DC 0-500V. Price £25
- (1119) ABSORPTION WATTMETER A.F. No. 1 ME 4. Power Range. 200 microw-6W. Scaled in watts and dB. Impedance 2.5Ω-20KΩ. Price £15
- (1112) STANDARD FREQUENCY CHANGER. Type 203. AIRMEC. Range Volts 0-2.0V. Filters 100 KHz; 500 KHz; 1.1 MHz. Freq. 1 MHz-30MHz. Price £25
- (194) DYNAMOMETER. Type 3206. TINSLEY. Price £45
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- (192) PHASE METER. Type II. 1-3. McMICHAEL RADIO. 0-90° with reverse O/p. switching. Price £20
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- (112) R & Q METER. Type 299 XTE. SMITH. Reference and quadrature reading, also readings in radians: 0-360° head/lag phase reading. I/p 0-15V. Price £115
- (190) VALVE VOLTMETER. Type 6. MARCONI. Range 0-150V. Mains operated. Price £5.10.0
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- (143) VERNIER POTENTIOMETER-CAMBRIDGE. Accuracy 0.0001V. Standard Cell voltage selection. Price £55

AVO TRANSISTOR ANALYSER CT 446

A portable direct-reading instrument capable of giving accurate transistor measurements in the grounded emitter configuration. Battery power unit 1.5V to 10.5V in 5 steps. Base current 0-1 mA, 1-40 mA. Collector current 250 mA. Size: 151x94x5 ins. Weight with batteries: 15 lbs. Price £42.10.0. Carriage extra.



MINIRACK MULTICHANNEL OSCILLOGRAPH. MUR 12

The multichannel oscillograph is a 12 crt. oscilloscope with recording facilities. The instrument consists of two units. The trolley mounted recording unit comprising 12 crts. with their respective controls and a 120 mm. continuous feed camera. The electronic console contains the appropriate amplifiers, time marker, time base, and associated power supplies. Price and full details on application.



MINIATURE PRECISION POTENTIOMETERS BY BOURNS

New 10-turn precision potentiometers consisting of potentiometer, knob and readout dial in one extremely compact assembly. A very attractive unit finished in black plastic with white dial. Available in 100K, 20K, 5K, 1K, 10W. Resistance tolerance ± 5%. Accuracy correlation of dial reading to O/P 0.5%. Weight 0.6 oz., overall length 1 1/16 in., diameter 3/8 in. New price £7.15.0 each. Our price £4.10.0/P. & P. 2/6.



Amplifier X 0.1 to X 1000. Module A3 LF Amplifier X 0.1 to X 100. 2140/A1-B1 1000 V True RMS Converter. Price £175. 2140/A3-B3 200 V Mean (RMS CALIBRATED) Converter. Price £150.

NUMICATORS

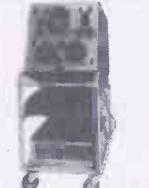
Cold cathode gas-filled, in-line 0-9 digital display tubes. Long life expectancy. Minimum striking voltage 180V. Slide reading type XN 13 and XN3 amber filter. Price 18/6 each. P. & P. 2/6.

CLOSED CIRCUIT TELEVISION SYSTEM

Consisting of a PARVIBOR Compact Camera fully transistorised printed circuitry. 625 lines. Dimensions: 11 x 2 1/2 x 7 ins. Weight 7 lb. AMPEX Video Monitor Type VM-9A. All solid state. Dimensions: Height 11 1/2 in., width 9 1/2 in., depth 6 in. Weight 14 lb SIEMENS Monitor Type IP 8008R. Two tripods and all interconnecting cables, c/w handbooks. This equipment is offered in excellent condition at a bargain price of £120. We can also offer a TV pattern generator by Video Circuits Model PC102 for checking out the above system, c/w handbook. Very good condition. Price £245

MICOVAC ELECTRONIC TEST METER

By E.I. Ltd. Model 22B this is a precision portable instrument with a wide range of facilities. D.C. volts, 0-2.4, 4.5, 24, 48, 240, 480, volts FSD with facility for zero measure. A.C. volts, similar range to D.C. with frequency coverage from 20 Hz-20 M Hz. Probe increases range from 10K Hz-200 M Hz. Resistance Ranges 0-1 K, 10 K, 100 K, 1 M ohm and 10 M ohms. Fitted with mains P.S.U. adaptor. Metal case. Price £40. Carriage extra.



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Marconi CA.109A. Spectrum Analyser. 3 to 30 M Hz. optional low frequency extension unit 100 Hz-3 M Hz. Display continuously variable up to 30 K Hz. Spectrum scan time variable from 0.1 to 30 secs. Long persistence CR tube. Complete with trolley and power supplies. Price £750.

PLATINUM RESISTANCE THERMOMETER PROBES

SOLARTRON Type NT 1198/8 and NT 1687. Accuracy ±1°C. Probes in stainless steel or in diameter. Temp. range NT 1198/8-50°C to +250°C. Price £12.10 each. p. & p. 3/6.

SET OF MEASURING INSTRUMENTS

Brand new high grade moving coil meters. Ideal auto-electric and other general D.C. applications. Supplied with 3 shunts in neat attaché type metal carrying case. Specifications: Voltmeter 0-15V, 0-150V, 0-450V. D.C. linear mirror scale 3mA FSD. Ammeter unshunted 7.5mA FSD. Used with 3 shunts to give ranges of 0-0.3A, 0-0.75A, 0-1.5A, 0-7.5A, 0-15A, 0-30A. The ammeter can also be used as a 0-75mV Voltmeter. Scale length 83 mm. Accuracy 1%. Case moulded plastic. Meter size 4 1/2 x 1 1/2 in. List price £30. Our price £5.19.6. P. & P. 30/.



FENLOW LOW FREQUENCY ANALYSER

0.5 Hz to 1 K Hz. Power density 0-10. Bandwidth switching range. .05: 0.3: 1.5: 7.5: 37.5 Hz. Price £275.

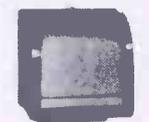
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Base B-9. Coil 6.3 v., 50-60 Hz. Proportion of time contacts are closed 45%. Also available 100 Hz and 400 Hz. Price £8/10.0. P. & P. 5/.



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20 and 40 channel Multiplex (Projecting Pattern) Recorder. Driven from a 24V supply. Chart width 9 in. Electro-magnetic pens. Voltage range 6-125V. Price £85.



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Goodmans Vibration Control Amplifier E501. Price £85
Goodmans Vibration Phase Shifter E 586. Price £59
Goodmans Power Oscillator 5V.A. Price £59.10
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by 20th Century Electronics
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600w. module. Ideally suitable for photoflood or speed controller, etc. Will mount into standard socket boxes. Our price 59/6. P. & P. 3/.



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Fully automatic dice gauging and sorting system, eliminates all manual operations. This instrument is of extreme interest to manufacturers of semi-conductors. It is offered in good condition at a quarter of its original list price. It is suitable for the sorting of germanium and silicon dice. The unit can sort up to 2,400 pieces an hour. Our price £450. Further information available on request. Complete with manual and spares.



All orders accepted subject to our trading conditions a copy of which may be inspected at our premises during trading hours or will be sent on application through the post.

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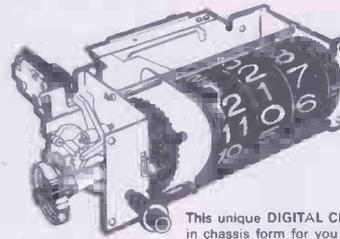
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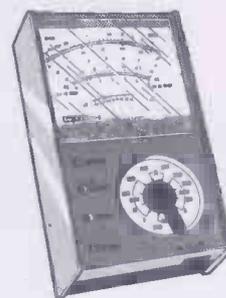
This unique DIGITAL CLOCK is now available EXCLUSIVELY FROM LASKY'S in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF, AUTO and AUTO ALARM, "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.

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The clock measures 4½W x 1½H x 3½D (overall from front of drum to back of switch). SPEC: 210/240V AC, 50Hz operation; switch rating 250V, 3A. Complete with instructions. HUNDREDS OF APPLICATIONS. COMPLETE WITH KNOBS

LASKY'S PRICE £6.19.6 P & P 3/6

SPECIAL QUOTATIONS FOR QUANTITIES



LASKY'S TM5

Another new look pocket multimeter from Lasky's providing top quality and value. The "slimline" impact resistant case—size 4½in. x 2½in. x 1½in., fitted with extra large 2½in. square meter. Readability is superior on all low ranges; making this an excellent instrument for servicing transistorised equipment. Recessed click stop selection switch. Ohms zero adjustment. Buff finish with crystal clear meter cover.

- DC/V: 3-15-150-300-1,200 at 5K ohms/V
- AC/V: 6-30-300-600 at 2.5K ohms/V
- DC Current 0-300mA 0-300mA
- Resistance: 0-10K ohms, 0-1M ohms
- Decibels: -10dB to 16dB
- Complete with test leads, battery and instructions

LASKY'S PRICE 49/6 P & P 2/6

LASKY'S TM1

The first of Lasky's new-look top value meters, the TM-1 is a really tiny pocket multimeter providing "big" meter accuracy and performance. Precision movement calibrated to ±3% of full scale. Click stop range selection switch. Beautifully designed and made impact resistant black case—with white and metallic red/green figuring. Ohms zero.

- DC/V: 0-10-50-250-1000 at 1K ohms/V
- AC/V: 0-10-50-250-1000 at 1K ohms/V
- DC CURRENT: 0-1mA, 100mA
- Resistance: 0-150K ohms
- Decibels: -10-22dB
- Complete with test leads, battery and instructions

Size only 3½in. x 2½in. x 1½in.

LASKY'S PRICE 39/6 P & P 2/6



TMK 200 METER KIT

This meter kit by TMK offers the unique opportunity of building a really first-class precision multimeter at a worthwhile saving in cost. The cabinet is supplied with the meter scale and movement mounted in position: the Model 200 also has the range selector in position. The highest quality components and 1% tolerance resistors are used throughout. Supplied complete with full constructional, circuit and operating instructions.

20,000 O.P.V. Multimeter. Features 24 measurement ranges with mirror scale. Large 3 x 2in. meter. Full scale accuracy. DCV and current: ±2% ACV: ±3%, resistance: ±3%. Special 0.6V DC range for transistor circuit measurements.

SPECIFICATION
 ●DCV: 0-0.6-6-30-120-600-1,200V at 20K/OPV. ●ACV: 0-6-30-120-600-1,200V at 10K/OPV. ●DC current: 0-0.6-6-600mA. ●Resistance: 0-10K-100K-1M-10M/ohms (58-580-5.8K-58K at mid-scale). ●Capacitance: 0.002-0.2µF (AC 6V range). ●Decibels: -20 to +63dB. ●Output: 0.05µF blocking capacitor. Uses two 1.5V (U7 type) batteries. Black bakelite cabinet—Size 5½ x 3½ x 1½in. Complete with test leads.

KIT PRICE ONLY 92/- P & P 3/6



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CRAMER TIMER 28V DC Sweep 1/100th sec & sweep 60 secs. 4" dial. Remote control stop/start reset £6.10.0.

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Omron/Schrack octal based plug-in relays. 2 pole c/o 5A, 6v only. Brand new. Boxed. 7/6 each.
G.E.C. 4 pole c/o 6/12v operation 180 ohms. Platinum contacts. Brand new. Boxed. 10/- each.

Miniature STC Plug in relays Plastic dust cover, 4 pole c/o 7.5-18 v. operation. 185 Ohms 8/- each. 6/- each per 100.

S.T.C. sealed 2 pole c/o, 2,500 ohms. (okay 24v) 2/6 ea.; 12v—7/- ea.
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EB800/01 27/-	EF91 14/-	PCF802 9/9	PCF802 9/9	VR150/30 35/-	5B255M 35/-	6AS6 6/-	6EA8 11/-	6E7 7/-	68VGT 6/3
EABC80 6/6	EF91 3/-	PCF805 14/6	PCF805 14/6	UABC80 7/-	5R4GY 10/6	6AT6 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
EAF42 10/6	EF92 7/6	PCF806 13/-	PCF806 13/-			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
EB1 2/-	EF95 5/-	PCF808 14/6	PCF808 14/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
EBC33 8/6	EF184 7/-	PCF200 14/-	PCF200 14/-			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
EBC41 10/6	EF1200 14/6	PCL81 14/-	PCL81 14/-			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC81 4/6	EL34 10/6	PCL82 7/6	PCL82 7/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
EBF80 7/6	EL41 11/6	PCL83 13/-	PCL83 13/-			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
EBF83 7/6	EL42 10/6	PCL84 8/6	PCL84 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC81 4/6	EL44 9/6	PCL85 8/6	PCL85 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC82 5/6	EL85 7/3	PCL86 8/6	PCL86 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC83 5/6	EL86 8/-	PCL87 8/6	PCL87 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC84 6/6	EL90 6/-	PCL88 8/6	PCL88 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC85 7/6	EL95 6/-	PCL89 8/6	PCL89 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC88 7/6	EL90 17/-	PCL90 10/6	PCL90 10/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC189 9/6	EM31 5/6	PCL91 10/6	PCL91 10/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC190 6/6	EM90 7/6	PCL92 10/6	PCL92 10/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC192 6/6	EM84 7/6	PCL93 10/6	PCL93 10/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECP83 15/6	EM87 11/-	PCL94 8/6	PCL94 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECP801 12/6	EM81 9/6	PCL95 8/6	PCL95 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECP802 12/6	EM81 9/6	PCL96 8/6	PCL96 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECH36 12/-	EZ41 8/6	PCL97 8/6	PCL97 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECH42 13/-	EZ80 5/-	PCL98 8/6	PCL98 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECH81 5/9	EZ81 5/-	PCL99 8/6	PCL99 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECH83 8/6	GZ34 10/6	PCL100 8/6	PCL100 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECH84 7/6	KT66 27/6	PCL101 8/6	PCL101 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECC200 12/6	KT88 3/6	PCL102 8/6	PCL102 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECL80 12/6	N78 25/-	PCL103 8/6	PCL103 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3
ECL80 12/6	OA2 6/-	PCL104 8/6	PCL104 8/6			6A76 4/6	6E7 7/-	6E23 15/-	68VGT 6/3

INTEGRATED CIRCUITS
MANY OTHERS IN STOCK

RCA
CA 3005 wide band R.F. Ampl. 300mW diss 27/-
CA 3012 wide band ampl. 150mW diss 22/-
CA 3020 Audio power ampl. 30/-
CA 3036 Audio pre-ampl. 19/-

STC
MIC 9301B Digital dual 4 input gates 86/-
MIC 709-1C Linear operational ampl. 190/-
MIC 9005D Highspeed flip-flop.... 54/-
Plessey, SL402A 2-5W 42/6 SL403A 3-5 52/6

VALVE VOLTMETER
TYPE TF 958
Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1.5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. £32.10.0.

SPECTRUM ANALYZER TYPE OA 199A
Frequency range 3-30MHz, Band width 6, 30 or 150MHz, Spectrum width 0-30kHz. Price on request.

SIGNAL GENERATOR TF 801D
10-485MHz, sine and pulse modulation 0.1 microvolt to 500mV output, price on application.

VIDEO OSCILLATOR TF 885A & 885A I
25Hz to 5MHz and 25Hz-12MHz respectively, fine and square wave output up to 31V £55 and £85 resp. Carriage 30/-.

AVO VALVE CHARACTERISTIC METER
complete with manual, £45 Carriage 30/-.

AVO SIGNAL GENERATOR CT 378, 2-450MHz. £38.10.0. Carriage 18/-.

AVO'S METERS
Model 48A complete with multiplier shunts, etc., in special fitted wooden case, £14.10.0.
Model 47A £12.
Carriage for each of above 7/6.

REDIFON
Twinplex combiner type AFS 13 £65
Twinplex converter type AFS 12 with P.S.W. £85
F.S.K. unit type GK 185A £58/10/0

SOLARTRON EQUIPMENT
Regulated and stabilised P.S.U. SRS 151A, 20 to 500V positive at 300mA in two ranges. Variable and fixed 170V negative output, £35. Carriage 20/-.
CD 711S.2. Double beam, DC to 7MHz scope, £85. Carriage 30/-.
CD 643.2. Single beam Laboratory Model, DC to 14MHz price upon application.
QD 910. Storage Oscilloscope, as new. Price on request.

SIGNAL GENERATOR TYPE CT 480, 7-12kHz in one range, square and pulse modulation and C.W. £65.

SIGNAL GENERATOR TYPE CT 478. As above but 1.3-4.2kHz in two ranges £55.

1 1/2 in. DIA. PANEL METERS, 7 1/2-15v —ideal for "Battery Condition" indicators for cars 15/6.

BOONTON Q METER TYPE 160A. Freq. range 50kHz to 75MHz, main capacitor 30 to 500pF. Vernier capacitor ±3pF; q range, 0-250 with 2.5x multiplier. £85 plus carriage.

NOISE GENERATOR CT 207. 100-600 M/c with built-in 8-minute timer. Complete with cables. £57.10.0.

TS 418 B/U SIGNAL GENERATOR, 400-1000MHz. £105. Carr. 30/-.

P. C. RADIO LTD.
170 GOLDHAWK RD., W.12
01-743 4946

SPECIAL OFFER TRANSISTORS, ZENER DIODES

OA5 2/6	OC58 8/6	IN43 4/-	3F100 12/6	AFY19 22/6	CRS1/40 12/6
OA10 2/6	OC44 4/6	IN70 4/-	3FR5 6/6	ASY26 5/6	CRS3/05 6/-
OA70 2/6	OC45 2/6	IN702-725 5/3	3N128 17/6	ASY28 5/6	CRS3/20 10/-
OA71 2/6	OC70 3/6	IN746A 7/3	3N139 35/-	ASY67 22/-	CRS3/30 11/6
OA73 1/6	OC71 2/6	series 5/3	3N140 19/6	BAW19 5/6	CRS25/025 15/-
OA74 2/6	OC72 4/6	IN821A 21/-	3N154 19/-	BC107 3/6	CRS3/40 12/6
OA79 1/9	OC73 11/-	IN823A 26/-	3N158 19/-	BC108 4/-	GET103 4/-
OA81 1/6	OC75 4/6	IN823A 26/-	6PR5 7/9	BC113 6/-	GET115 9/-
OA91 1/3	OC76 5/6	1844 3/6	12FR60 14/9	BC118 7/6	GET116 8/-
OA200 1/9	OC81 4/-	12MT5 7/6	10D1 3/4	BCY10 9/-	GEX66 15/-
OA202 2/6	OC81D 3/6	12MT10 6/9	40594 27/6	BCY72 7/9	NKT222 4/-
OA210 7/6	OC81DM 3/6	12T5 13/6	40598 27/6	BF115 5/-	NKT304 7/-
OA211 9/6	OC82 5/6	12T10 19/9	40638 29/-	BF173 6/-	SD918 5/3
OA220011/-	OC82DM 3/6	2G385 10/6	40668 27/-	BFY52 4/6	SD928 6/3
OA220110/-	OC83 4/6	2G403 10/6	40669 29/-	BFY52 4/6	SD988 6/6
OA2202 2/6	OC83B 3/6	IN807 22/-	AC126 4/6	B805 7/6	SD998 6/6
OA2206 8/6	OC84 5/6	IN4785 11/-	AC127 4/6	B8 9/1	2E14 17/6
OA2207 9/6	OC122 10/6	2N1304 6/-	AC128 4/6	B82 9/3	2E16GT 7/3
OA2208 7/6	OC139 6/6	2N1306 6/6	AC176 7/6	BY216 15/-	30C15 15/-
OA2213 6/6	OC140 8/6	2N1307 6/6	AC177 5/-	CRS1 10 5/6	30C18 15/-
OA2223 10/-	OC170 5/6	2N12147 17/6	ACY28 4/-	CRS1/20 9/6	Z Range
OC16 15/-	OC172 7/6	2N3053 6/6	AD149 11/-	CRS1/30	Zener diodes
OC22 8/6	OC200 6/-	2N3054 12/6	AD161 7/-	CRS1/35 11/6	All preferred voltage
OC25 7/6	OC201 7/6	2N3055 15/-	AD162 7/-	1W 3/8	1W 7/6
OC26 5/6	OC206 10/-	2N3730 25/-	AD177 4/9	1.5W 5/-	7W 7/6
OC28 12/6	IN21 3/6	2N3731 25/-	AF118 10/-		
OC29 15/-	IN21B 5/-	2N5109 41/-	AF139 10/-		
OC35 8/6	IN25 12/-	82303 10/-	AF178 12/6		
			AF186 9/-		

MANY OTHERS IN STOCK include Oathode Ray Tubes and Special Values. U.K. P. & P. up to 10/- 1/-; to £1 2/-; over £1 2/- in £, over £3 post free. C.O.D. 4/- extra.

PLEASE NOTE ALL EQUIPMENT ordered from us is completely overhauled mechanically and electrically in our own laboratories

MARCONI TEST EQUIPMENT

TF1041C VTVM A.C.
voltage range 300 MV to 300V in 7 ranges. 20 Hz-1500 MHz. D.C. voltage ranges 300 MV-1000V in 8 ranges. D.C. resistance 50 ohms to 500 Mohms. Price £62.10.0.

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz, R.F. output 2uV to 2V at 50 ohms 400 and 1000 Hz. Internal mod. Limited qty. only available. Full spec and price on request.

SIGNAL GENERATOR TF 801A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. £85. DITTO but 801A/I with additional high level output. £89. Both P. & P. 20/-, including necessary connectors, plugs, and instruction manual.

IMPEDANCE BRIDGE TYPE TF 936 (No. 5). Measures L & C at 80Hz, 1kHz, 10kHz. Ranges:—L: 1µH-100H. C: 1mF-100µF. R: 0.1ohms-100ohms. AC Bridge volts monitored and variable. Automatic detector sensitivity control. £105. Carriage 30/-.

F.M. DEVIATION METER TYPE TF934. Frequency range 2.5-100MHz. Can be used up to 500MHz. Deviation range 0-75kHz £67/10/0. Carriage 30/-.

29/41FT. AERIALS each consisting of ten 3ft., 3/16 in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, £4/10.0. P. & P. 10/-.

FIELD TELEPHONE TYPE "F". Housed in portable wooden cases. Excellent for communication in and outdoors for up to 10 miles. Pair including batteries, fully tested. £6.10.0, or with 220 yds field cable in drum £7.10.0.

BRADLEY PORTABLE ELECTRONIC MULTIMETER TYPE CT471B. This instrument operates from three 1.5V cells, is fully transistorised and measures A.C. and D.C. current, A.C. and D.C. voltage and D.C. resistance. Built-in battery check and calibration check. Full spec. and price on request.

As above but MODEL CT 471A manufactured by AVO, full spec and price on request.

4, 5 and 8 bank 25 way uniselectors, 24V, guaranteed perfect, £3.15.6; £4.10.0; £6.17.6 respectively.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

WEE MEGGERS. 250v £12.0.0.

GENERAL RADIO AMPLITUDE MODULATION MONITOR TYPE 1931A. £45 plus carriage.

230v, 3 pole, 10 amp plug in change over relays. 11 pin base, perspex cover. 25/- P. & P. 1/-.

PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy of ± 1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition. £75. Carriage 30/-.

HARNES "A" & "B" control units, junction boxes, headphones, microphones, etc.

FOR EXPORT ONLY
53 TRANSMITTERS. All spares available. COLLINS TCS. Complete installations and spare parts. R.C.A. TRANSMITTERS ET 4336. Complete installations and all spares. BC 610E & I TRANSMITTERS.

COLLINS TYPE 231D 5KW TRANSMITTERS. 10 channel, auto-tune and manual tuning. Complete with very comprehensive spares. Full specification and price on application.

Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R.21Q RECEIVERS with all necessary accessories.

PYE PTC 2002N A.M. Ranger Mobile Radio Telephone, brand new and complete, £45.

Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.

TELEPHONE ENQUIRIES relating to TEST EQUIPMENT should be made to 01-748 8006 Extension 23. To view TEST EQUIPMENT please phone for appointment

COLOMOR (ELECTRONICS) LTD.
170 Goldhawk Rd., London, W.12
Tel. 01-743 0899

LIQUID LEVEL DETECTOR. Detects even mildly conductive liquids, i.e. ether, etc. N.O./N.C. contacts. Falls to safe. £10 ea. S.a.e. literature.

MODULAR POWER SUPPLIES. Fully stabilised 8.5 to 9.5 volt. 10 amp. (12 x 6 x 4 in.) Brand new. Individual spec. with each unit. £10 ea.

RADIATION MONITORING EQUIPMENT. Portable and bench models (brand new) S.a.e. literature.

KLYSTRON POWER SUPPLY (Solartron AS562). £40. Carr. 50/-.

KLYSTRON POWER SUPPLY (Elliott PKU1). £100

120 AMP. AUTO TRANSFORMERS. 190-270v. 50 c/s (tapped every 5 volts). £50 ea. (Carr. by arrangement.)

801A SIGNAL GENERATOR. 10-300 mc/s in 4 bands. Ext. 50 c/s-10 Kc/s. Output 200 mV £80 ea. P.P. 25/-.

SPEAKERS

"E.M.I." 19x14 in. 50 watts. 8 ohm (14A/500A.) Four tweeters mounted across main axis. Separate "X-over" unit balances both bass and h.f. sections. 20 Hz. to 20,000 Hz. Bass unit flux 16,500 gss. A truly magnificent system £28. P.P. 50/-.

E.M.I. 13x8 in. with two tweeters and cross-over. 8 or 16 ohm. 75/-, P.P. 5/-.

"E.M.I." 6 1/2 in. Rd. 10 watt woofers. 8 ohm. 30/- ea. P.P. 2/8.

"FANE" 12 in. 20 watt. 15 ohm. (122/10A.) With integral tweeter. £8 ea. P.P. 7/8.

SPEAKER SYSTEM (20x10x10 in.) Made to Spec. from 1/2 in. board. Finished in black leathercloth. 13x8 in. speaker with twin tweeters complete with "X-over". 50 Hz. to 20,000 Hz. £7 10s. P.P. 10/-.

SPEAKER CABINET KIT. Above mentioned cabinet only. In kit form which you may assemble and cover to your own choice. 40/-, P.P. 5/-.

EXTRACTOR FANS/BLOWERS

"AIRMAX" 7 1/2 in. FAN. In aluminium diecast housing (9 in.). 240v. Brand new. £4 10s. P.P. 10/-.

"PLANNAIR" 5 1/2 in. FAN. (Type 5 PL 121-122.) Diecast housing. 240v. Brand new. £6. P.P. 10/-.

"SOLARTRON" TANGENTIAL BLOWERS. Overall size 15x5 1/2 x 3 1/2 in. Air outlet 12x1 1/2 in. 240v. Brand new. 50/- ea. P.P. 7/8.

BULK COMPONENT OFFER. Resistors/capacitors. All types and values. All new modern components. Over 500 pieces. £2. (Trial order 100 pieces 10/-) We are confident you will re-order.

HIGH SPEED MAGNETIC COUNTERS (4x1x1 in.) 4 digit. 24/48v. (state which), 6/8 ea. P.P. 1/-.



LEVEL METERS (1 1/2 x 1/2 in.). 200 micro-amp. Made in Germany. 18/- each.

SILICON PHOTOVOLTAIC CELLS (MS2BE) 550m.V. 35 ma. 30/- ea.

RELAYS H.D. 2 pole 3 way 10 amp. contacts. 12v.w. 7/6 ea.

LIGHTWEIGHT RELAYS (with dust-proof covers) 4 c/o contacts. 24v. 500 ohm 7/6 ea.

PRECISION CAPACITANCE JIGS. Beautifully made with Moore & Wright Micrometer Gauge. Type 1. 18.5 pf. 1,220 pf. £10 ea. Type 2 9.5 pf-11.5 pf. £6 ea.

POT CORES LA1/LA2/LA3. 10/- ea.

71 WAY PLUG & SOCKET (Painton Series 159). Gold plated contacts with hood & retaining clips. 30/- pair.

50 WAY PLUG & SOCKET (U.C.L. miniature). Gold plated contacts 20/- pair. 34 way version 18/- pair.

GO-AX RELAYS (magnetic devices) 1 change-over 12 v.v. 20/- ea.

COMPUTER BOARDS

4-OC23; 4-2N1091; 4-2G302; 4-OA10. 20/- ea.

8-OC42 (long leads); 15-OA47. 7/6 ea.

8-DA11A; 14-OA47. 5/- ea.

Bargain pack of 5 boards. Components too varied to enumerate. At least 100 transistors and diodes. £2 lot.

TRANSFORMERS

L.T. TRANSFORMERS (shrouded). Prim. 200/250v. Sec. 20/40/80v. 2 amp. 42/8. P.P. 7/6.

L.T. TRANSFORMERS. Prim. 200/250v. Sec. 20/40v. 1.5 amp. 30/-, P.P. 5/-.

"ADVANCE" CONSTANT VOLTAGE. Prim. 190/250v. ±15%. Sec. 115v. 2,250 watts. £18 ea. P.P. 50/-.

H.T. TRANSFORMERS. Prim. 200/240v. Sec. 300-0-300v. 80 ma. 6.3v. C.T. 2s. 30/- ea. P.P. 7/6.

350-0-350v. 60 M.A. 6.3v. C.T. 2s. 20/- ea. P.P. 5/-.

L.T. TRANSFORMER. Prim. 240v. Sec. 33-0-33v. 5 amp. 45/-, P.P. 10/-.

STEP DOWN TRANSFORMER. Prim. 200/240v. Sec. 115v. 100 watts. 20/- ea. P.P. 5/-.

L.T. TRANSFORMERS. Prim. 240v. Sec. 8/12/20/25v. 3.5 amp models 20/-; 5 amp model 28/-, P.P. 5/6.

L.T. TRANSFORMERS Prim. 240v. Sec. 14v. 1 amp 10/- ea. P.P. 2/6.

COPPER LAMINATE PRINTED CIRCUIT BOARD (8 1/2 x 5 1/2 x 1/16 in.), 2/6 sheet, 5 for 10/-, Also 11 x 8 1/2 in., 3/- ea., 4 for 10/-.

ELECTRIC SLOMETERS (1/-) 25 amp. L.R. 240v. A.C. 85/- ea. P.P. 5/-.

QUARTERLY ELECTRIC CHECK METERS, 40 amp 240v. A.C. 20/- ea. P.P. 5/-.

"LONG LIFE" ELECTROLYTICS (screw terminal). 25,000 u.f. 40v. (4 1/2 x 2 1/2 in.). 20/- ea. P.P. 2/6.

10,000 u.f. 75v. (4 1/2 x 2 1/2 in.). 17/6 ea. P.P. 2/6.

3,150 u.f. 40v. (4 1/2 x 1 1/2 in.). 18/- ea. P.P. 2/6.

EXECUTIVE "SIXTY" AMPLIFIER. (50 w. r.m.s. into 8 ohm.) British designed and built. True hi-fl performance. Built-in filters to protect speakers. Three independently mixed inputs. High-Low impedance. Mic. Crystal-Ceramic-Magnetic Cartridge, or aux. equipment. £85. P.P. 50/-, S.a.e. literature.

TELEPHONE DIALS (New) 20/- ea.

RELAYS (G.P.O. '3000'). All types. Brand new from 7/6 each. 10 up quotations only.

EXTENSION TELEPHONE (Type 706) Black or 2 tone Grey. 65/-, P.P. 5/-.

UNISELECTORS (Brand new) 25-way 75 ohm. 8 bank 1/2 wipe 65/-, 10 bank 1/2 wipe 75/-, Other types from 45/-.



REED RELAYS 4 make 9/12v. (1,000 ohm.) 12/6 ea. 2 make 7/6 ea. 1 make 5/- ea. Reed Switches (1 1/2 in.) 2/6 ea. £1 per doz.

SUB-MINIATURE REED RELAYS (1in. x 1/2 in.). Weight 1/2 oz. Type 1. 950 ohm, 3/9v. 1 make. 12/6 ea. Type 2 1800 ohm, 3/12v. 1 make. 18/- ea.

SILICON BRIDGES. 100 P.I.V. 1 amp. (1 1/2 x 1 1/2 in.). 8/6 ea.

PLUG-IN RELAYS. (Siemens-Varley) 4 c/o. 700 ohm. 10/- ea. complete with base. (Other make-ups and coils available.)

PATRICK & KINNIE

191 LONDON ROAD · ROMFORD · ESSEX
ROMFORD 44473 RM79DD

Imhoff die-cast instrument cases; finished stove enamel cream. 2 for 10/- (less lids), p.p. 2/6.

Miniature solenoid driven wafer switches, type-Ledex single pole, 7 pos., 3 wafers. Primarily used for channel switching in Radio-Telephones. Wafers may be substituted for any type. Solenoid voltage, 12 or 24V. Brand new, 30/- each, p.p. 2/6.

S.T.C. Crystal filters. Frequency 10.7 MHz., type 445/LQU. Price 85/- each.

Epicyclic slow-motion drives. 6 1/2-1 ratio. Brand new, 2 for 10/-, inc. p.p.

U.G. panel mounting VHF sockets type SO239 amphenol. Brand new, sealed, 2 for 10/-, inc. p.p.

Burndapt RF Plugs still available. These hard to find plugs are used on a multitude of equipment, especially Londe aerial c/o relays. Offered new ex. equipment, 2 for 10/-, inc. p.p.

Nife traction Batteries Nickel Iron. 1.2V. per cell rated at 180 A.H. Sold in crates of three cells or crates of five cells. £4 per cell. Guaranteed best buy.

Meters, new U.S.A. type, high quality panel mounting 2 1/2 ins. dia., matching pair—0-800V. DC., and Ampmeter scaled 0-10 Amps, 35/- the pair, plus 5/- carriage.

Auto electrical test sets. All you want for a complete check out on car electrical systems etc. Sold c/w all leads etc., housed in polished wooden case. ONLY £5 plus 10/- postage and packing.

Lucas car relays, 12V., one heavy duty make contact, rated at 5A. Terminated for push-fit connectors. Has many uses for auto-electrics such as spot-lights, horns, over-drives, head-lamp flash, etc., etc. 10/- each, inc. p.p.

Voltage and Current regulators—heavy duty rheostats—1 ohm rated at 10A. Brand new by famous manufacturer, 12/6 each. Also 1.5 ohm at 7A., 12/6, p.p. 1/6.

Lucas diode rectifiers—full wave bridge rectifier mounted on special heat-sink. 50V.-60V. operation rated at 50A. Has many uses for heavy duty charging plants, plating rectifiers, etc., etc. Per pair £8 (two complete bridge rectifiers), p.p. 7/6.

OSCILLOSCOPES

13A Hartley Double Beam as featured in last month's W/W complete with instructions, leads, etc., ready to work and good condition, price £22/10/-, p.p. 30/-.

Cosser Double Beam Type 1049, ideal cheap scope for Audio Work, etc., DC coupled bandwidth DC-450 KHz., ready to work in good condition, £25, p.p. 30/-.

Cosser type 1076 complete with 3 plug in units no-less than 38 controls, 60 BTG valves 50MHz bandwidth. For the man who has everything you can still impress your friends with this piece of electronic wizardry, cost over £1,000 complete, yours for £100, in good condition and working order, p.p. 40/-.

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JUPITER SERIES SWINGING CHOKES
 34H. 60M/A.-70H. 35M/A., 2-8kv., D.C. Wkg. 25/- P. & P. 6/-

LOW TENSION SMOOTHING CHOKES
 By Redcliffe. 100MH. 2 amps. 49/6. P. & P. 7/6. Swinging Type. 10MH. 6.5 amp-30 MH. 2 amps. 45/- P. & P. 7/6. Both types less than 1/2 ohm res. Hermetically sealed. Oil filled. Brand new. In makers cartons.

OIL FILLED BLOCK CAPACITORS
 All by famous makers. New and guaranteed. DC working voltage shown are at 60 degs C. 24 mfd. 350v. 15/- P. & P. 3/6. 12 mfd. 600 v. 12/6. P. & P. 3/6. 8 mfd. 2500v. 37/6. P. & P. 8/6. 8 mfd. 1500v. 17/6. P. & P. 6/6. 8 mfd. 500v. 7/6. P. & P. 2/6. 8 mfd. 350v. 5/- P. & P. 2/- 8 mfd. 200v. 3/6. P. & P. 2/- 4 + 3 mfd. 5/- P. & P. 2/- 4 mfd. 600v. 5/- P. & P. 2/- 4 mfd. 500v. 3/6. P. & P. 2/- 2 mfd. 2000v. 7/6. P. & P. 2/6. 2 mfd. 1500v. 6/- P. & P. 2/- 1 mfd. 600v. six for 9/- P. & P. 5/- 0.5 mfd. 2000v. 5/- P. & P. 2/- 0.25 mfd. 7000v. 17/6. P. & P. 5/- 0.25 mfd. 5000v. 12/6. P. & P. 3/6.

AC WKG CAPACITORS
 65 mfd. 550v. 45/- P. & P. 8/6. 60 mfd. 275v. 25/- P. & P. 6/6. 18 mfd. 300v. 18/- P. & P. 3/6. 5 mfd. 220v. 6/- P. & P. 2/- 60 mfd. 275v. 30/- P. & P. 6/6. 2 + 4 + 6 mfd. 400 v. 12/6. P. & P. 2/6. 0.125 mfd. 850v. 5/- P. & P. 1/6.

A.E.I. LIGHTING CAPACITORS
 12 mfd. 250v. A.C. wkg. 5/- P. & P. 2/6. 13 mfd. 250v. A.C. wkg. 2.85 mfd. 440v. wkg. tubular. 5/- P. & P. 2/-.

SPECIAL OFFER OF OIL FILLED CAPACITORS
 GEC. 8mfd. 600v. D.C. wkg. Six for 29/6. Carr. 7/6. Dubilier Nitrogol. 8 mfd. 350. D.C. wkg. Six for 25/- Carr. 7/6. T.C.C. Visconol. 2 mfd. 200v. D.C. wkg. Six for 12/6. P. & P. 3/6. T.C.C. Tubular. 200 mfd. electrolytic 200v. D.C. wkg. Size 4 1/2 in. by 2 1/2 in. dia. 7/6. P. & P. 2/6. 25000 mfd. 12v. D.C. wkg. tubular. 10/6. P. & P. 2/- 1250 mfd. 180v. D.C. wkg. 8/6. P. & P. 2/-.

AIR MINISTRY SLIDING RESISTORS
 Wire Wound single tube. 1 1/2 in. dia. 15/- P. & P. 3/6. 1 1/4 in. dia. 17/6. P. & P. 3/6. 57.2 2.8a. Adjustable metal clip type. 27/6. P. & P. 5/- 71.5 2.8a. Fixed type. 17/6. P. & P. 3/6. 1 1/4 in. dia. Fixed type. 7/6. P. & P. 2/6. 1004 1a. Single tube slider. 47/6. P. & P. 7/6. 30 1.5a. Right angle geared drive. 19/6. P. & P. 4/6. Colvern ceramic rheostats. 1500 0.18a. 7/6. P. & P. 2/6. 1500 0.1a. 5/- P. & P. 2/- 20K inst. pots 3 ins. dia. 6/6. P. & P. 2/6.

GPO 3000 TYPE RELAYS
 1K 0 1 CO 3M. 2K 0. 1 B. 2 heavy makes. 5K 0 1 CO 1M. 200 0 2M. 2 heavy makes. 75 0 3M. 1B. 1 CO. All at 6/- each. Post free.

WESTERSTRAND CLOCKWORK TIMERS

 Switch contacts. 15 amps., 250 volts A.C. Control knob can be set between 30 secs. and 6 mins. Brand new 17/6 P. & P. 2/6.

AMERICAN WILLARD
 Miniature accumulators 6v. 1.2 A.H. Size 1 1/2 x 4 ins. Wt. 5 1/2 oz. These batteries were designed for meteorological balloon transmitters. Easily filled with a hypodermic syringe. Self sealing. 7/6. P. & P. 1/6.

MINIATURE 24v. D.C. GEARED MOTORS
 500 rpm. Size 2 x 1 1/2 x 1 in. Length of spindle 1 in. dia. 1/2 in. 15/- P. & P. 2/-.

Samson's

(ELECTRONICS) LTD.
 9 & 10 CHAPEL ST., LONDON, N.W.1
 01-723-7851 01-262-512

CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS, FULLY SHROUDED (*excepted) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v

No.	Sec. Taps	Amps	Price	Corr.
1A	25-33-40-50	15	£10 10 0	12/6
1B	25-33-40-50	10	£7 12 6	9/6
1C	25-33-40-50	6	£6 15 0	9/6
1D	25-33-40-50	3	£4 0 0	7/6
2A	4-16-24-32	12	£7 2 6	8/6
2B	4-16-24-32	8	£5 7 6	8/6
2C	4-16-24-32	4	£3 12 6	7/6
2D	4-16-24-32	2	£2 7 0	5/-
3A*	25-30-35	40	£16 10 0	12/6
3B*	25-30-35	20	£10 5 0	10/6
3C*	25-30-35	10	£7 5 0	8/6
3E	25-30-35	5	£4 2 6	7/6
3F	25-30-35	2	£3 2 6	7/6
4A*	12-20-24	30	£13 0 0	12/6
4B	12-20-24	20	£8 5 0	9/6
4C	12-20-24	10	£4 5 0	8/6
4D	12-20-24	5	£3 12 6	7/6
5A	3-12-18	30	£9 12 6	9/6
5B	3-12-18	20	£7 2 6	8/6
5C	3-12-18	10	£4 5 0	7/6
5D	3-12-18	5	£2 17 6	6/6
6A	48-56-60	2	£3 12 6	6/6
6B	48-56-60	1	£2 12 6	6/6
7A	6-12	50	£10 7 6	10/6
7B	6-12	20	£6 2 6	8/6
7C	6-12	10	£3 17 6	7/6
7D	6-12	5	£2 15 0	6/6
8A	12-24	1	£1 12 6	6/6
9A	17-32	8	£6 5 0	8/6
10A*	6-3	2	£1 9 6	6/6
11A	6-3	15	£2 10 0	7/6
12A	30-25-0-25-30	2	£3 12 6	6/6

Note: By using the intermediate taps many other voltages can be obtained.
 Example: No. 1 7-8-10-15-17-25-33-40-50v.
 No. 2 4-8-12-16-20-24-32v.
 No. 5 3-6-9-12-15-18v.

AUTO TRANSFORMERS
 240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	Watts	Approx. Weight	Price	Corr.
1	80	2 1/2 lb	£1 19 6	5/6
2	150	4 lb	£2 12 6	6/6
3	300	6 1/2 lb	£3 12 6	6/6
4	500	8 1/2 lb	£5 2 6	8/6
5	1000	15 lb	£7 2 6	9/6
6	1500	25 lb	£9 15 0	10/6
7*	1750	28 lb	£14 15 0	12/6
8*	2250	30 lb	£17 17 6	15/-

* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

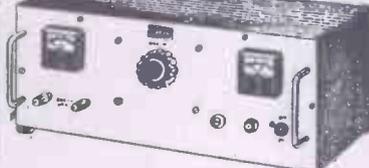
DOUBLE WOUND ISOLATION TRANSFORMERS
 240-240v. 240-110v. Up to 2 1/2 kva. Let us know your requirements.

ISOLATION TRANSFORMERS
 By Magestic Winding Co. Pri 240v. Sec. 240v. Centre tapped. 2kva. Mounted in strong metal case. Size 11 x 9 x 8 ins. Conservatively rated. £27.10.0. Carr. 30/-.

VARIABLE D.C. SUPPLY UNITS TYPE S.E.4

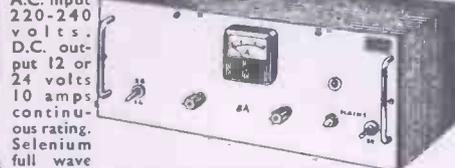
ISOLATION TRANSFORMERS
 By Magestic Winding Co. Pri 240v. Sec. 240v. Centre tapped. 2kva. Mounted in strong metal case. Size 11 x 9 x 8 ins. Conservatively rated. £27.10.0. Carr. 30/-.

VARIABLE D.C. SUPPLY UNITS TYPE S.E.4



0-48 volt 10 amps, continuous from 240 volts A.C. Silicon full wave bridge rectification, isolated transformer with Variac controlled primary. 3 in. scale voltmeter and ammeter. Neon Indicator. Housed in strong metal case. Size 17 x 17 x 6 1/2 in. £32.10.0. Carr. 15/-.

L.T. SUPPLY UNITS TYPE S.E.5



A.C. input 220-240 volts. D.C. output 12 or 24 volts 10 amps continuous rating. Selenium full wave bridge rectification. 3 in. scale ammeter, neon indicator. Housed in strong metal case. £17.10.0. Carr. 15/-.

SPECIAL OFFER OF PARMEKO NEPTUNE SERIES TRANSFORMERS ALL PRIMARIES TAPPED 115-230v.

Sec. 6-3v. CT 5a. 6-3v. CT 2a. 37/6. P. & P. 5/-
 Sec. 9-10v. 0-5a. 6-3v. 1-2a. 19/6. P. & P. 4/-
 Sec. 400-0-400v. 150 m/a. 50/- P. & P. 7/6
 Sec. 350-0-350v. 100 m/a. 3-6-12-18v. 5a. £3.19.6. P. & P. 8/6
 Sec. 6-3v. CT 5a. 6-3v. 1-2a. 27/6. P. & P. 5/-
 Sec. 6-3v. 1-8a. 6-3v. 1a. 17/6. P. & P. 3/6
 Sec. 29-5-32-5v. 32/6. P. & P. 5/-
 Sec. 4v. 0-5a. four tms. 15/- P. & P. 3/6
 Sec. 6-3v. CT 0-6a. 6-3v. 0-6a. 12/6. P. & P. 3/6
 Sec. 6-3v. 0-250v. 50 m/a. 6-3v. 1a. 22/6. P. & P. 4/6
 Pri. 200-240v. Sec. 250-0-250v. 60 m/a. 6-3v. 2a. 6-3v. 3a. 5v. 2-5a. 30/- P. & P. 7/6.

VARIABLE TRANSFORMERS
 Input 240v. output 0-260v. Large selection of new and reconditioned transformers available.

GARDNERS HT TRANSFORMERS ALL PRIMARIES TAPPED 200-250v.

Sec. 450-0-450v. 180 m/a. 6-3v. CT 4a. 6-3v. 1a. 5v. 2a. £4.15.0. Carr. 10/-
 Sec. tapped 350-360-370-380-390-400v. 350 m/a. 15v. 2a. 6-3v. 3a. X 3. 6-3v. 2a. 6-3v. 1a. Fully shrouded. £4.19.6 Carr. 8/6.
 Sec. 350-0-350v. 60 m/a. 4-6-3v. 4a. 4-5v. 2-5a. Fully shrouded. 27/6. P. & P. 5/-
 Sec. 500-0-500v. 80 m/a. 6-3v. 2a. 6-3v. 2a. 5v 2a. Fully shrouded. 47/6. P. & P. 5/-
 Sec. 63v. 1-6a. 24v. 0-8a. 6-3v. 1a. Open type. Table top connections. 65/- P. & P. 7/6.
 Sec. 12v. 1a. Twice open type T.T. connections. 17/6. P. & P. 3/6.
 Sec. 3-75v. 9a. 6-3v. 0-5a. Fully shrouded. 17/6. P. & P. 3/6.
 Sec. 7v. 5a. 6-4v. 4a. 6-4v. 2-2a. 6-4v. 2-2a. 5v 2-8a. 4v. 1a. Oil-filled potted type. 50/- Carr. 8/6.
 Sec. 370-390-410v. 6 m/a. Open 'C' core type. 12/6. P. & P. 2/6.
 Sec. 12v. 6a. and 15-6v. 1-5a. Fully shrouded. 57/6. P. & P. 7/6.
 Sec. tapped 20-40-700-760v. 50 m/a. 6-3v. 1-5a. Fully shrouded. 17/6. P. & P. 4/6.
 600 watts auto tapped 200-210-220-230-240-250v. Open type. T.T. connections. 45/- P. & P. 5/-.

GRESHAM HT TRANSFORMERS

Oil filled potted type. Pri 240v. sec. 475-0-475v. 220 m/a. 6-3v. 2a. 6-3v. 0-3a. 3 times. 5v. 2a. £4.5.0. Carr. 10/- P. & P. 3/6.
 sec. 375-0-375v. 200 m/a. 6-3v. 2-5a. 6-3v. 2-5a. 6-3v. 2a. 6-3v. 1-5a. 6-3v. 0-5a. 6-3v. 0-3a. 15v. 0-1a. 5v. 2a. £3.15.0. Carr. 10/-
 Pri 240v. sec. 800v. 120 m/a. 45/- P. & P. 7/6. Pri 200-240v. sec. 15v. 2-5a. and 13v. 6a. Vary conservatively rated. Open frame type. 50/- P. & P. 8/6.

REDCLIFFE HEAVY DUTY HT TRANSFORMERS

Pri 220-220-240v. sec. 635v. 1 amp twice. Suitable for high power audio equipment. Oil filled potted type. etc. £8.15.0. Carr. 15/-.

SPECIAL OFFER A.E.R. TRANSFORMERS

Pri 205, 225, 245v. sec. 300v. 37.5 m/a. twice. 4kv. D.C. wkg. 4v. 1a. 4v. 0.3a. 15/- P. & P. 6/6.
 Pri 200, 220, 240v. sec. tapped. 370, 390, 410v. 6 m/c. C. core. 10/- P. & P. 3/6.
 Pri 200, 220 240v. Sec. 350-0-350v. 25m/a. 6-3v. 1a. 6-3v. 0 6a. Sealed potted type. 15/- P. & P. 4/6.

ADVANCE C/V TRANSFORMERS

Type CV 15/95. Input 95-130v., 190-260v. Output 4v. rms + or -1%. 3 watts. Open frame type. 25/- P. & P. 5/-
 Type MT140. Input 190-260v. Output 230v. 150w. £5.15.0. Carr. 10/-
 Type MT161. Input 190-260v. Output 230v. rms. 60w. £3.15.0. Carr. 7/6.

BURGESS MICRO SWITCHES

Type MK 3BR/74. Norm closed or Norm open. 1/2 in. raised Press Button, 8/6 for three. P. & P. 2/6.

HONEYWELL 250v. 10A. A.C. Lever operated. Make or break (3 tags). Three for 12/6. P. & P. 2/-. Many other types available.

NEWMARK SYNCHRONOUS MOTORS

220-240v. 50 cycles, 3 watts 8 r.p.m. Overall size 2 x 2 x 2 ins. 10/6. P. & P. 1/6

LONDEX 220-240v. A.C. RELAYS
 Open frame type 12 heavy make contacts. 27/6. P. & P. 5/-

VENNER SYNCHRONOUS BIO-DIRECTIONAL MOTORS

220-240v. 50 cycles 40 r.p.m. automatically reverses when spindle stop is placed overall size 2 1/2 x 2 x 2 ins. Spindle length 1/2 in. dia. 1/16th. An ideal motor for display, giving a forward and reverse motion. 12/6. P. & P. 2/6.

A.C. 220-240v. Shaded Pole Motors. 1,500 r.p.m., double spindle. 0-9 in. and 0-6 in. overall. Size 3 x 3 1/2 x 2 in. As used in hot air blowers, new and boxed. 10/6. P. & P. 3/6.

A.E.I. Adjustable Thermostats. Type TS2, stem 6 in., 60 deg. C. contacts N.O., new and boxed. 27/6. P. & P. 3/6. 12 in. stem. 32/6. P. & P. 4/6.

RANCO REFRIGERATION THERMOSTATS

Type A.10. 100-250v. A.C. 1/2 h.p. 15/- P. & P. 2/-
 Type Q1. 100-150v. A.C. 1/2 h.p. 15/- P. & P. 2/-
 2 1/2 in. N.A.B. spoils for 1/2 in. tape. 10/6 each. P. & P. 4/6.

SCOTCH MAGNETIC TAPE

Type 3M 459 1/2 in. 3,600 feet. Supplied new in maker's cartons. List price £18.10.0. Our price £3.19.6. P. & P. 5/-.

LONDEX PLUG-IN RELAYS

Sealed type, 28v. D.C. Three heavy duty silver contacts. Size 2 x 2 x 1 in. Complete with base. 8/6. P. & P. 2/-.

SUNYK TANK THERMOSTATS

Type TQP. 250v. 15 amps NC. 5 amps NO. 190-70 deg. F. Length of stem 10 1/2 ins. 25/- P. & P. 5/-.

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GLOUCESTER ROAD, LITTLEHAMPTON, SUSSEX, Littlehampton 6743

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OB2	9/-	6BW6	14/3	6X4GT	5/-	20P3	18/-	985	2/-	DM71	7/6	ECL82	6/8	FW4/500	15/-	PCF87	16/3	R16	34/11	U45	15/8	2B323	10/-	BOV10	5/-	GET116	6/6	OC24	7/6	
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LAB	5/-	6C6	3/9	7B8	10/9	25A6G	5/9	6060	5/6	DY86/7	5/9	ECL85	11/-	GZ30	15/-	PCF802	9/-	R30	11/9	U50	5/8	AA123	3/6	BCY34	4/6	GET123	7/6	OC38	9/-	
LA7GT	7/8	6C9	14/8	7B7	7/-	25L6G	5/8	7193	10/6	EY502	9/6	ECL86	6/-	GZ32	9/-	PCF805	12/9	R52	7/8	U78	4/3	AC107	3/6	BCY39	4/6	GET872	18/-	OC35	7/6	
1C5	4/9	6C17	12/6	708	6/-	25Y5	6/-	7475	14/-	E507	34/-	ECLL800		GZ33	18/6	PCF806	11/9	RG1/240A	10/6	U107	18/3	AC113	5/-	BC107	4/6	GET873	3/6	OC36	7/6	
1D6	7/8	6CDBG	23/-	7F8	12/6	25Y6G	8/6	A1834	80/-	E85F	24/-			GZ34	10/-	PCF808	14/6		39/8	U181	12/6	AC114	8/-	BC108	3/6	GET88210/	OC38	5/6		
1D8	9/6	6CR6	7/-	7E7	5/6	25Z4G	9/-	A3134	19/6	E833	12/-	EP22	12/6	HARCO	8/6	PCL52	7/3	SP13C	12/6	U251	14/6	AO128	4/6	BC115	3/6	GET887	4/6	OC41	10/6	
1PD1	6/6	6CL6	1/8	7R7	13/-	25Z5	8/-	A3042	18/-	E180F	12/-	EP26	12/6	HL30	7/-	PCL83	10/-	SP42	12/6	U281	8/-	AO154	5/6	BC116	5/-	GET89	4/6	OC42	12/6	
1PD9	4/3	6CW4	12/-	7V7	5/-	25Z6G	8/6	AC044	23/6	E182C	22/6	EP37A	7/-	HL28DD5/-	4/-	PCL84	7/8	SP61	6/6	U282	8/3	AC156	4/6	BC118	4/6	GET896	4/6	OC45	2/-	
1G6	6/-	6D3	7/8	9BWB6	7/6	30C1	6/6	AC02PEN	11/6	E1148	10/6	EP39	5/-			EW3	5/6	PEN45DD	UBC41	9/-	VP2	10/6	AC176	11/6	BF188	6/6	GET897	4/6	OC46	3/6
1H6GT	7/-	6D6	3/-	9D7	15/6	30C15	13/-		19/6	E450	13/6	EP40	10/-	HL41DD	19/6	PCL86	8/6	TH4B	10/-	U301	11/-	AC157	5/6	BC211	3/6	GET897	4/6	OC46	3/6	
1L4	2/6	6F1	12/6	10C1	25/6	30C17	16/-	AC2PEN/		E476	13/6	EP41	10/-			PCL88	15/6	TH223	10/6	U329	14/6	AC165	5/6	BD119	9/-	GET897	4/6	OC65	22/6	
1LD5	7/6	6F8	12/6	10C2	10/-	30C18	12/6	DD	19/6	E4BC80	9/6	EP42	3/6	HL42DD9/-	19/6	PCL80	15/6	TH2620	19/6	U403	6/6	AC166	5/6	BF164	5/6	GET897	4/6	OC70	2/3	
1LN5	9/6	6F8G	5/-	10D1	9/6	30P5	15/6	AC6 PEN		E4C91	8/6	EP44	12/6	HN309	27/4	PCL801	13/9	UADBC80	8/6	U404	7/6	AC167	12/6	BF159	9/-	GET897	4/6	OC71	2/6	
1N6GT	7/9	6F12	3/3	10D2	14/7	30FL1	13/9		7/6	E4F42	10/-	EP43	6/6	HV22	10/6	PCL85	10/6	UAF42	10/3	U361	10/6	AC168	7/6	BF168	4/6	GET897	4/6	OC72	2/6	
1B5	5/6	6F13	3/8	10F1	15/-	30FL2	15/-	AC/PEN	(7)	E4B34	3/6	EP40	4/6	HV22A10/8	PC/L85	9/6	UB41	6/6	U4020	7/6	AC169	6/6	BF173	7/6	GET897	4/6	OC73	16/6		
1B4	4/9	6F14	15/-	10F9	9/6	30FL12	16/-		19/6	E4B41	4/6	EP43	9/6			PEN45DD	UBC41	9/-	VP2	10/6	AC176	11/6	BF188	6/6	GET897	4/6	OC74	9/6		
1B5	4/3	6F15	10/-	10F18	7/6	30FL14	14/6	AC/TH10/-		EB91	2/8	EP45	5/3	EW4360	5/6		15/-	UBC81	7/6	VP2B	9/6	AC177	5/6	BF181	8/6	GET897	4/6	OC75	2/6	
1U4	5/9	6F18	7/8	10LD11	10/-	30L1	12/6	AC/TP	19/6	EB41	2/8	EP46	5/3	IW4/500	6/6		15/-	UBC81	7/6	VP2B	9/6	AC177	5/6	BF181	8/6	GET897	4/6	OC76	2/6	
2D21	6/6	6F20	13/3	10P13	13/6	30L5	13/6	AL60	18/6	EB41	2/8	EP46	5/3			PEN46	4/6	UBF80	5/9	VP13C	7/6	AC177	5/6	BF185	8/6	GET897	4/6	OC76	2/6	
3A4	4/-	6F24	13/6	10P14	20/-	30L17	15/6	ARP	3/6	EB41	2/8	EP46	5/3	KT2	6/6			UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT100	7/8	OC78	3/6	
3A5	10/-	6F25	13/6	12A6	12/6	30P4	12/6	ATP4	2/3	EB41	2/8	EP46	5/3	KT3	3/8			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT101	8/8	OC78D	3/6
3B7	5/-	6F26	5/3	12AC6	7/6	30P4MR		AZ1	8/6	EBF80	6/9	EP97	10/6	KT4	20/-			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT120	7/8	OC79	8/6
3D6	3/6	6F28	14/-	12AD6	7/6	AZ1	3/6	EBF83	8/6	EP98	10/6	ME140014/9	PL662	KT6	17/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT121	8/8	OC81	2/6
3Q4	7/6	6G6G	15/-	12AE6	12/6	30P12	13/6	AZ1	10/6	EBF89	6/3	EP98	10/6	KT7	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT122	8/8	OC82	2/6
3Q6GT	8/6	6G6GT	3/-	12AT5	4/6	30P13	12/6	BL3	10/6	EBL21	12/6	EP84	6/6	KT8	3/8			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT123	8/8	OC83	4/6
3B4	5/9	6J6G	3/9	12AT7	3/9	30P11	13/6	CL3	18/6	EC53	18/6	EPF60	6/6	KT9	3/8			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT124	8/8	OC84	4/6
3V4	6/3	6J6	3/-	12AU6	4/9	30P13	15/6	CV6	10/6	EC54	10/6	EH90	7/6	KT10	3/8			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT125	8/8	OC85	4/6
5R4GY	10/6	6J7G	4/9	12AU7	4/6	30P14	15/6	CV888	2/6	EC70	4/9	EK90	4/9	KT11	3/8			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT126	8/8	OC86	4/6
5U4G	5/6	6J7GT	6/8	12AV6	5/6	30P15	15/6	CV10	10/6	EC86	12/6	EL32	3/6	KT12	3/8			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT127	8/8	OC87	4/6
5V4G	7/6	6K7G	2/-	12AX7	4/6	35A3	10/6	CV11	7/6	EC88	12/6	EL34	10/6	KT13	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT128	8/8	OC88	4/6
6Y3GT	5/6	6K7GT	4/8	12AY7	9/8	35A5	15/6	D63	5/6	EC92	6/6	EL37	17/3	KT14	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT129	8/8	OC89	4/6
5Z3	9/-	6K8G	4/-	12BA8	6/8	35D5	12/6	D77	2/3	EC33	15/6	EL41	11/-	KT15	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT130	8/8	OC90	4/6
5Z4G	7/-	6L1	19/6	12BE8	5/9	35L6GT	8/6	DAC32	7/6	EC32	4/6	EL42	10/6	KT16	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT131	8/8	OC91	4/6
6/30L2	12/-	6L6GT	7/9	12BH7	6/8	35W4	4/6	DAR91	4/3	EC33	3/6	EL41	10/6	KT17	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT132	8/8	OC92	4/6
6A8G	6/6	6L7GT	12/8	12E1	17/-	35Z3	10/6	DAR96	6/8	EC40	11/6	EL43	7/6	KT18	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT133	8/8	OC93	4/6
6AC7	3/-	6L18	6/-	12J7GT	6/6	35Z4GT	4/9	DCC90	10/6	EC81	3/9	EL84	4/9	KT19	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT134	8/8	OC94	4/6
6AG5	4/-	6L19	27/8	12K5	10/-	35Z5GT	6/6	DD4	10/6	EC92	4/6	EL85	8/6	KT20	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT135	8/8	OC95	4/6
6AK5	5/-	6LD20	9/6	12K7GT	6/8	35B2	7/6	DF33	7/9	EC83	4/6	EL86	8/6	KT21	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT136	8/8	OC96	4/6
6AK6	6/-	6N7GT	6/6	12Q7GT	5/6	50C5	6/3	DF91	2/9	EC84	6/3	EL91	4/6	KT22	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT137	8/8	OC97	4/6
6AL5	2/3	6P28	25/-	128A7GT		50CDD643/3	6/3	DF96	6/8	EC85	5/6	EL96	5/3	KT23	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT138	8/8	OC98	4/6
6AM4	18/6	6Q7G	8/6		8/6	50L6GT	9/-	DF97	10/-	EC86	8/6	EM80	7/6	KT24	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT139	8/8	OC99	4/6
6AM6	3/3	6Q7GT	8/6	128C7	5/6	72	6/8	DB63	6/8	EC88	7/6	EM81	7/6	KT25	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT140	8/8	OC100	4/6
6AQ5	5/6	6R7G	7/-	128D7	4/6	85A2	8/6	DH76	5/6	EC89	9/6	EM84	9/6	KT26	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT141	8/8	OC101	4/6
6AB6	20/-	6R7	11/-	128H7	3/6	85A3	8/6	DH77	4/6	EC90	12/6	EM87	7/6	KT27	12/6			PEN45DD	UBF89	8/9	VP23	5/6	AC178	3/8	BFY50	3/6	MAT142	8/8	OC102	4/6
6AT6	4/-	6S7GT	7/-	128J7	4/6	90AG	6/7/8	DH81	10/9	EC80	27/7	EY1	7/6	KT28	12/6			PEN45DD	UBF89	8/9	VP23</									

ELECTROVALUE

EVERYTHING BRAND NEW AND TO SPECIFICATION • LARGE STOCKS

BARGAINS IN NEW SEMI-CONDUCTORS

ALL POWER TYPES SUPPLIED WITH FREE INSULATING SETS

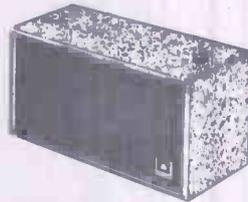
IN914	1/3	2N3706	3/3	40512	45/6	BC147	3/6	BFY51	4/3
IN3754	4/-	2N3707	4/-	40602	9/6	BC148	3/3	BSX20	3/9
IN4148	1/9	2N3708	3/-	AC107	14/6	BC149	3/6	BY164	10/-
IN5054	4/-	2N3709	3/-	AC126	6/6	BC153	10/-	BY238	3/6
IS940	1/-	2N3710	3/6	AC127	6/-	BC154	11/-	C106B1	14/6
2N696	5/6	2N3711	3/11	AC128	6/-	BC157	3/9	MC140	5/-
2N697	5/6	2N3731	24/-	AC176	11/-	BC158	3/6	M1480	21/-
2N706	2/9	2N3794	3/3	ACY22	3/9	BC159	3/9	M1481	27/-
2N1302	4/-	2N3819	8/6	ACY40	4/-	BC167	2/6	M1491	30/-
2N1303	4/-	2N3820	25/6	AD140	19/-	BC168	2/3	MPF102	7/6
2N1304	4/6	2N3904	7/6	AD142	14/3	BC169	2/6	NKT403	15/6
2N1305	4/6	2N3906	7/6	AD149	17/6	BC177	6/3	NKT405	15/-
2N1306	6/9	2N4058	5/3	AD161/AD162	16/-	BC178	5/8	OA47	1/9
2N1307	6/9	2N4059	4/-	(matched)	16/-	BC179	6/-	OA90	1/3
2N1308	8/9	2N4060	4/3	AF114	7/-	BC182L	4/3	OA91	1/3
2N1309	8/9	2N4061	4/3	AF115	7/-	BC183L	2/3	OA95	1/3
2N1613	6/-	2N4062	4/3	AF116	6/6	BC184L	2/6	OA99	3/-
2N1711	7/-	2N4284	3/3	AF117	6/6	BC186	8/6	OA200	1/11
2N2147	18/9	2N4286	3/3	AF124	7/6	BC212L	5/-	OA202	2/-
2N2218	9/3	2N4289	3/3	AF127	7/-	BC213L	5/-	OC71	5/6
2N2270	12/9	2N4291	3/3	AF139	9/6	BC214L	5/3	TIP31A	17/6
2N2484	13/6	2N4292	3/3	AF180	18/6	BCY70	5/6	TIP32A	23/9
2N2646	10/9	2N4410	4/9	AF239	9/9	BD121	18/-	TIS43	10/6
2N2904	11/-	2N5062	12/3	ASY26	6/6	BD123	24/3	ZTX300	3/6
2N2924	4/-	2N5163	5/-	ASY27	8/3	BD124	16/-	ZTX301	3/6
2N2925	4/6	2N5192	25/-	ASY28	6/6	BF167	8/6	ZTX302	4/6
2N2926	2/3	2N5195	28/3	BS041	15/-	BF178	10/6	ZTX303	4/6
2N3053	5/6	2N5457	9/9	BA102	9/-	BF180	12/-	ZTX304	6/9
2N3054	14/3	2N5458	9/9	BA115	4/-	BF194	7/-	ZTX500	5/-
2N3055	16/-	2N5459	9/9	BA130	4/6	BF195	7/6	ZTX501	5/-
2N3325	10/9	40250	14/3	BA145	5/6	BFX29	10/9	ZTX502	6/-
2N3663	11/6	40361	12/6	BC107	2/9	BFX84	7/5	ZTX503	5/-
2N3702	3/6	40362	16/-	BC108	2/6	BFX85	8/3	ZTX504	12/-
2N3703	3/3	40406	16/3	BC109	2/9	BFX87	8/6	ZTX530	5/5
2N3704	3/9	40408	14/6	BC125	12/-	BFX88	6/9	ZTX531	6/9
2N3705	3/5	40430	37/-	BC126	12/-	BFY50	4/6		

PEAK SOUND PRODUCTS ENGLEFIELD CABINET KITS



Build it
12+12
or
25+25

Stereo amplifier in modular kit form 12 watts per channel £38/9/-; 25 watts £50/15/-.
Cabinet kit only £6. These prices nett.
As recently reviewed in *Hi Fi Sound*.



BAXANDALL SPEAKER SYSTEM

Designed by Peter Baxandall. Superb reproduction for its size. Handles 10 watts with ease. Uses ELAC 15J, 59RM109 speaker unit. Kit £13/12/- nett; built £19/8/6 nett.

STEREO AMPLIFIER SA.10-10.



Developed from the very successful SA.8-B amplifier giving first-class stereo amplification featuring separate volume controls for each channel, bass and treble controls. 10 watts per channel into 5 to 8 Ω. Kit £19/7/6 nett; built £24/16/8 nett. Suitable 8 Ω wide range speakers available £13/15/- each nett.

MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500-700mV for full output into 8 Ω.

Power	Kit price including components	Suitable unreg. power supply kit
12W	168/- nett	92/-
25W	190/- nett	N/A
40W	210/- nett	115/1
70W	252/- nett	138/10

30 WATT BAILEY AMPLIFIER PACK

Special summer reduction (to Sept. 30th 1970 only)
Sensitivity 1.2V for full output into 8 Ω.
Transistors for one channel £7/5/6 list, £6 only nett.
Transistors for two channels £14/11/- list, £11 only nett.
Capacitors and resistors (metal oxide), 30/- per channel nett.
Complete unregulated power supply pack, 87/6 nett.

INTEGRATED CIRCUITS

PLESSEY SL403A 3 watts into 7.5 ohms. Data book supplied FREE when two of these units are purchased. Price per unit, nett 48/6.

SINCLAIR IC.10 as advertised, complete with instructions and applications manual 59/6 nett.
Components pack for stereo inc. mains transformer, controls, etc., nett £4/15/0.

S-DECs PUT AN END TO BIRDS NESTING

Components just plug in—saves time—allows re-use of components. S-Dec (70 points), 30/-.
Complete T-Dec, may be temperature-cycled (208 points), 50/- Also μ-Decs and IC carriers.

ELECTROVALUE CATALOGUE

48 pages and cover well printed and excellently illustrated. Thousands of items fully detailed. POST FREE 2/- Overseas, post free by surface mail, add 4/- If sent airmail.

COMPONENT DISCOUNTS
10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
(No discount on nett items)

POSTAGE AND PACKING
Free on orders over £2 Please add 1/6 if order is under.
Overseas orders welcome: carriage and insurance charged at cost.

RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
C	1/20W	5%	82Ω-220KΩ	E12	18	16	15
C	1/8W	5%	4.7Ω-330KΩ	E24	2-5	2	1-75
C	1/4W	10%	4.7Ω-10MΩ	E12	2-5	2	1-75
C	1/2W	5%	4.7Ω-10MΩ	E24	3	2-5	2-25
C	1W	10%	4.7Ω-10MΩ	E12	6	5	4-5
MO	1/2W	2%	10Ω-1MΩ	E24	9	8	7
WW	1W	10% ± 1/20Ω	0.22Ω-3.9Ω	E12		15d. all quantities	
WW	3W	5%	12Ω-10KΩ	E12		15d. all quantities	
WW	7W	5%	12Ω-10KΩ	E12		18d. all quantities	

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrofilm TR5, ultra low noise.
WW = wire wound, Plessey.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on resistor order.)

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

ZENER DIODES 5% full range E24 values: 400mW: 2.7V to 30V, 4/6 each; 1W: 6.8V to 82V, 9/- each; 1.5W: 4.7V to 75V, 12/- each.
Clip to increase 1.5W rating to 3 watts (type 266F, 9d).

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.

Single gang linear 220Ω to 2.2MΩ, 2/6; Single gang log, 4.7KΩ to 2.2MΩ, 2/6; Dual gang linear, 4.7kΩ to 2.2MΩ, 8/6; Dual gang log, 4.7KΩ to 2.2MΩ, 8/6; Log/antilog, 10K, 47K, 1MΩ only 8/6; Dual antilog, 10K only, 8/6. Any type with 1/2 A.D.P. mains switch, extra 2/3.
Please note: only decades of 10, 22 and 47 are available within ranges quoted.

CARBON SKELETON PRE-SETS
Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K, 4.7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M, 5M, 10MΩ. Vertical or horizontal mounting, 1/- each.

GOLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 250Ω, 500Ω, 1K, 1.5K, 2.5K, 5K, 10K, 15K, 25K, 50K, 5/6 each.

ENAMELLED COPPER WIRE even No. SWG only; 2 oz. reels: 16-22 SWG 4/3; 24-30 SWG 5/-; 32, 34 SWG, 5/6; 36, 38 SWG, 6/3.
4 oz. reels: 16-22 SWG only 7/6.

TYGAN SPEAKER MATERIAL
7 designs, 36 x 27 in. sheets, 31/6 sheet.
Pattern book, S.A.E. plus 6d. stamp.

MULLARD polyester C280 series
250V 20%: 0.01, 0.022, 0.033, 0.047 8d. each; 0.068, 0.1, 9d. each; 0.15, 11d., 0.22, 1/-, 10%; 0.33, 1/5; 0.47, 1/8; 0.68, 2/3; 1μF, 2/9; 1.5μF, 4/2; 2.2μF, 4/9

MULLARD SUB-MIN ELECTROLYTICS
C426 range, axial lead 1/3 each
Valves (μF/V): 0.64/64; 1/40; 1.6/25; 2.5/16; 2.5/64; 4/10; 4/40; 5/64; 6.4/6.4; 6.4/25; 8/4; 8/40; 10/2.5; 10/16; 10/64; 12.5/25; 16/40; 20/16; 20/64; 25/6.4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2.5; 50/6.4; 50/25; 50/40; 64/4; 64/10; 80/2.5; 80/16; 80/25; 100/6.4; 125/4; 125/10; 125/16; 160/2.5; 200/6.4; 200/10; 250/4; 320/2.5; 320/6.4; 400/4; 500/2.5.

LARGE CAPACITORS
High ripple current types: 1000/25, 5/6; 1000/50, 8/2; 1000/100, 16/3; 2000/25, 7/4; 2000/50, 11/4; 2000/100, 28/9; 2500/64, 15/5; 2500/70, 19/6; 5000/25, 12/6; 5000/50, 21/11; 5000/100, 38/3; 10000/15, 17/-; 10000/25, 24/6; 10000/50, 44/-; 10000/70, 61/-.

MEDIUM RANGE ELECTROLYTICS
Axial leads: 50/50, 1/9; 100/25, 1/9; 100/50, 2/6; 220/25, 2/3; 250/25, 2/6; 250/50, 3/9; 500/25, 3/9; 500/50, 4/6; 1000/25, 4/-; 1000/50, 6/-; 2000/25, 6/-.

SMALL ELECTROLYTICS
Axial leads: 4.7/10, 4.7/25, 5/50, 1/- each; 10/10, 10/25, 10/50, 33/10, 50/10, 1/- each; 22/25, 25/50, 47/25, 100/10, 220/10, 1/3 each.

ELECTROVALUE

DEPT. WW.10, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY,
Hours: 9-5.30, 1.0 p.m. Saturdays. Phone: Egham 8633 (STD 0784-3) Telex 264475

L.S.T. ELECTRONIC COMPONENTS LTD

= BETTER QUALITY, SERVICE, PRICES & LARGEST STOCKS

AA530 1/7 BAI11	6/- BFX13	5/- NKT103	6/- NKT243	12/- OC22	8/- 40312	9/6 2N1306	6/- 2N3702	2/6 2S019	19/6 EC401	5/-
AF123 3/2 BAX13	1/6 BFX29	8/2 NKT124	6/- NKT244	5/1 OC205	7/3 2N1307	6/- 2N3703	4/5 2N3704	2/5 2S020	20/- EC402	4/8
AC107 7/7 BC113	5/- BFX44	8/- NKT105	6/- NKT245	3/- OC24	10/- 40315	7/3 2N1308	6/- 2N3704	3/2 2S104	13/6 GET111	5/2
AC126 5/- BC116	8/- BFX84	5/2 NKT106	6/- NKT261	4/3 OC25	7/6 40316	9/3 2N1309	6/3 2N3705	2/8 2S301	8/6 GEX45/1	4/-
AC127 4/- BC118	7/6 BFX85	6/9 NKT107	6/- NKT262	4/3 OC26	6/6 40317	7/3 2N1613	4/6 2N3706	2/3 2S302	7/6 GJ3M	4/-
AC127Z 9/6 BC125	11/- BFX86	4/11 NKT108	6/- NKT263	4/8 OC28	12/- 40319	10/9 2N1711	5/- 2N3707	2/10 2S303	10/- OA5	3/8
AC128 4/- BC126	11/- BFX87	5/11 NKT109	6/- NKT264	4/3 OC29	15/- 40320	7/3 2N2147	16/3 2N3708	1/10 2S304	12/6 OA10	5/8
AC175 5/1 BC134	5/4 BFX88	5/3 NKT121	10/6 NKT265	5/6 OC35	10/- 40323	6/6 2N2148	12/6 2N3709	2/- 2S306	15/- OA47	1/8
AC187 6/- BC135	6/- BFX18	15/- NKT122	10/- NKT270	6/- OC36	12/6 40324	9/3 2N2160	12/6 2N3710	2/3 2S320	9/- OA70	1/8
AC188 6/- BC136	8/- BFX50	4/6 NKT123	9/6 NKT271	2/10 OC41	5/- 40326	7/3 2N2217	5/5 2N3711	2/6 2S321	6/- OA73	1/8
ACY17 5/9 BC137	8/6 BFX51	3/9 NKT124	6/5 NKT272	2/10 OC42	4/6 40329	4/9 2N2217A	11/4 2N3789	5/19 2S322	8/- OA79	1/8
ACY18 4/- BC138	12/- BFX52	4/6 NKT125	4/6 NKT273	3/8 OC43	4/6 40344	5/3 2N2218	6/5 2N3819	7/- 2S323	10/- OA81	1/8
ACY19 4/- BC140	13/3 BFX53	3/2 NKT126	4/- NKT274	2/10 OC44	3/- 40347	7/6 2N2218A	8/4 2N3820	18/9 2S301	8/6 OA85	1/8
ACY20 3/10 BC147	2/9 BFX90	13/6 NKT127	10/6 NKT275	3/4 OC45	3/- 40405	10/3 2N2219	7/2 2N3826	6/- 2S702	11/4 CT490	1/8
ACY21 3/10 BC148	3/3 BFX57	10/- NKT128	10/- NKT276	3/8 OC70	6/6 40360	8/6 2N2219A	10/- 2N3854	5/- 2S703	12/6 OA91	1/8
ACY22 3/9 BC149	3/- BFX58	5/6 NKT129	8/6 NKT279A	2/6 OC71	3/- 40361	9/6 2N2369	3/4 2N3854A	5/6 2S711	26/6 OA95	1/8
ACY23 3/6 BC154	12/- BFW59	5/- NKT135	6/1 NKT281	5/- OC72	4/6 40362	11/6 2N2369A	3/11 2N3855	5/6 2S712	34/6 OA200	2/-
ACY28 3/8 BC167	3/6 BFW60	4/6 NKT137	6/1 NKT301	18/- OC74	8/- 40370	6/- 2N2613	7/6 2N3855A	6/- 2S720	25/- OA202	2/-
ACY29 7/6 BC168	3/9 BLY47	31/3 NKT141	10/6 NKT302	12/5 OC75	4/6 40406	11/3 2N2614	4/- 2N3856	6/- 2S732	8/6 OA211	8/-
ACY30 7/6 BC169	3/9 BSX19	3/3 NKT142	10/- NKT303	17/6 OC76	3/- 40408	10/3 2N2646	8/- 2N3856A	6/- 2S733	5/11 OC81Z	11/-
ACY31 4/7 BC171	2/- BSX20	3/3 NKT143	9/6 NKT304	10/- OC77	8/- 40462	11/3 2N2904	8/10 2N3858	3/6 3NY128	CT441	12/6
ACY34 3/5 BC182L	2/3 BSX21	7/6 NKT144	8/- NKT351	10/- OC81	4/6 40467	16/6 2N2904A	9/9 2N3858A	6/- 3N140	15/3 TD716	12/-
ACY35 3/6 BC183L	1/10 BSX60	12/7 NKT151	6/- NKT352	17/6 OC81D	4/- 40468A	7/- 2N2905	12/11 2N3859	5/6 3N141	14/6 1B08T10	10/-
ACY36 3/9 BC184L	7/11 BSX61	7/11 NKT153	6/- NKT361	20/- OC82	5/- 40600	11/6 2N2905A	15/1 2N3859A	6/3 3N142	10/9 1N344A	10/-
ACY39 11/- BC121L	3/4 BSX76	4/- NKT154	6/- NKT362	20/- OC82D	3/- 40602	8/- 2N2906	8/10 2N3860	6/- 3N143	13/3 1N66	4/-
ACY40 3/10 BC192	10/- BSX77	6/- NKT161	6/- NKT401	14/6 OC83	4/6 1N3713	30/- 2N2906A	10/10 2N3866	25/- 3N152	17/3 1N64	4/-
ACY41 3/10 BC192	12/- BSX78	6/6 NKT162	6/- NKT402	15/- OC84	30/- 1N3717	30/- 2N2923	4/- 2N3877	9/- AA119	2/- 1N82A	9/6
ACY44 8/- BCY30	5/- BSY27	4/- NKT163	6/- NKT403	14/9 OC123	7/- 1S100	3/2 2N2924	4/- 2N3877A	9/6 AA111	2/- 1N87A	4/6
AD140 11/- BCY31	5/- BSY29	5/- NKT164	6/8 NKT404	11/- OC139	5/- 1S107	6/6 2N2925	3/6 2N3900	10/6 AA212	6/- 1N91	5/8
AD149 11/6 BCY32	10/- BSY32	5/- NKT165	6/- NKT405	11/- OC140	7/- 1S410	5/1 2N2926	2N3900A	11/6 AA213	2/6 1N914	3/6
AD161 7/6 BCY33	5/- NKT201	5/- NKT166	6/- NKT406	9/11 OC170	5/- 1S410R	5/1 Green	2/- 2N3903	7/- BA102	9/- 1N4002	1/6
AD162 7/6 BCY34	3/2 NKT202	5/- BSY35	6/- NKT420	28/11 OC171	6/- 2G302	3/9 2N2926	2N3904	7/- BA110	6/- 1N4003	2/-
AD171 12/6 BCY38	2/11 NKT204	6/- BSX78	6/- NKT451	9/11 OC176	7/6 2G339A	5/- Yellow	2/- 2N3905	7/6 BA111	6/- 1N4004	2/-
ADZ11 32/- BCY40	10/- BZ14	33/3 NKT205	6/- NKT452	9/6 OC201	9/6 2G371	3/- 2N2926	3/- 2N3906	7/6 BA112	18/- 1N4005	2/6
ADZ12 39/- BCY42	4/- BZ15	33/3 NKT206	6/- NKT453	6/6 OC202	12/6 2G371B	3/- Orange	2/- 2N4037	15/- BA114	3/- 1N4006	3/-
AF102 12/6 BCY43	4/- C111	18/- NKT208	6/- NKT454	4/8 OC203	7/6 2G374	5/- 2N2926	3/4 BA115	1/6 1N4007	4/-	
AF106 7/6 BCY54	7/6 C111E	12/- NKT210	4/2 NKT613F	5/2 OC204	8/- 2G381	5/- Brown	2/- 2N4059	5/- BA130	2/- 1N4148	1/6
AF114 5/- BCY70	3/10 C426	8/3 NKT211	3/9 NKT654F	4/2 OC205	9/- 2N174	16/- 2N3011	12/6 2N4059	5/- BAY31	3/6 1S44	1/6
AF115 5/- BCY71	7/8 CR1-051C	3/9 NKT212	3/9 NKT675	6/8 OC206	15/- 2N385A	15/- 2N3053	39/- 2N4061	4/6 BAY39	2/- ZTX107	2/7
AF116 5/- BCY72	3/2 CR1-401C	10/- NKT213	4/7 NKT676	5/- OC207	15/- 2N388A	4/6 2N3053	5/- 2N4062	4/6 BC107	2/6 ZTX108	2/7
AF117 5/- BCY87	86/9 D13T1	10/- NKT214	3/5 NKT677F	3/10 OC211	16/- 2N404	4/6 2N3054	12/6 2N4284	3/- BC108	2/6 ZTX109	2/7
AF118 8/10 BCZ11	7/6 FST3/8AF	5/- NKT215	3/7 NKT703	8/- ORP12	10/- 2N696	3/6 2N3055	15/- 2N4287	3/- BC109	2/6 ZTX300	2/7
AF121 6/- BDI19	1/6 GET16	12/6 NKT216	7/6 NKT713	3/10 ORP60	8/- 2N697	3/6 2N3133	6/- 2N4288	3/- BC115	6/6 ZTX301	2/8
AF124 5/6 BDI21	13/- GET102	6/- NKT217	9/- NKT717	5/10 ORP61	8/- 2N698	6/- 2N3135	6/- 2N4289	3/- BC117	9/- ZTX302	3/8
AF125 4/2 BDI23	16/8 GET103	5/- NKT218	6/- NKT734	4/11 OC233	3/6 2N706	2/4 2N3111	6/- 2N4290	3/- BC142	15/- ZTX303	3/8
AF126 3/6 BDI24	12/6 GET113	4/- NKT219	4/7 NKT736	6/2 P346A	3/9 2N706A	2/6 2N3235	28/6 2N4291	3/- BC143	15/- ZTX304	5/5
AF127 3/6 BDI20	20/8 MJ480	20/6 NKT221	7/- NKT773	3/7 RAS310AF	6/- 2N708	3/3 2N3234	27/6 2N4292	3/- BC145	15/- ZTX310	1/7
AF139 15/- BFI15	5/- MJ481	27/6 NKT222	6/- NKT774	6/- RAS508AF	15/- 2N709	8/6 2N3242	7/9 2N4871	6/9 BCY39	9/6 ZTX311	2/-
AF178 9/6 BFI52	13/6 MJ490	22/6 NKT223	5/- NKT0013	6/6 SIM	19/- 2N711	7/6 2N3391A	6/- 2N5027	10/6 BY100	4/- ZTX312	2/1
AF179 11/6 BFI54	5/- MJ491	29/6 NKT224	3/7 NKT10419	3/10 S4M	33/6 2N711A	7/6 2N3392	5/- 2N5028	11/6 BY127	4/- ZTX313	2/2
AF180 12/6 BFI59	15/- MPE102	8/6 NKT225	3/6 NKT10519	4/5 S72	9/9 2N743	4/6 2N3393	6/- 2N5029	9/6 BYX10	3/- ZTX314	2/3
AF186 8/- BFI63	9/- MPE103	7/6 NKT226	11/- NKT10339	4/7 T1407	9/8 2N744	6/- 2N3394	4/9 2N5030	8/6 BYX36/150	3/- ZTX315	6/1
AF239 7/6 BFI67	6/- MPE104	7/6 NKT227	9/6 NKT10439	5/5 TIC45	8/- 2N911	10/- 2N4002	5/6 2N5172	3/- BYX36/300	2/10 ZTX321	5/11
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ASV26 4/5 BFI79	12/6 NKT12	5/5 NKT231	6/- NKT13239	3/11 TIP31A	12/4 2N929	5/3 2N4044	5/6 2S001	10/- BYY23	26/3 ZTX341	3/7
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ASV29 2/6 BFI84	5/- NKT43	6/- NKT238	4/- NKT20329	6/8 V405A	9/3 2N1132	6/- 2N4046	15/- 2S004	15/- BYZ10	8/- ZTX501	3/1
ASZ21 7/6 BFI85	5/- NKT72	3/9 NKT239	4/- NKT20339	6/4 40250	10/9 2N1302	3/7 2N3525	21/9 2S005	15/- BYZ12	6/- ZTX502	3/8
AUY10 10/- BFI94	3/6 NKT73	3/7 NKT240	3/10 NKT35219	15/9 40309	9/6 2N1303	4/6 2N3528	19/- 2S006	15/- BYZ13	3/- ZTX503	3/1
B2M 32/6 BFI95	3/- NKT101	3/9 NKT241	9/- OC19	5/- 40310	9/- 2N1304	4/11 2N3606	5/6 2S017	15/- EA403	5/- ZTX504	7/4
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WITH MK II amplifier and magnetic cartridge £45 plus £2.10 P & P.

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High fidelity transistor stereo amplifier employing field effect transistors. With this feature & accompanying guaranteed specifications below, the Viscount F.E.T. vastly surpasses amplifiers costing far more.

Specification: Output per channel 10 watts r.m.s. Frequency bandwidth 20 Hz to 20 kHz ± 1 dB @ 1 watt.
Total distortion: @ 1 kHz @ 9 watts 0.5%.
Input sensitivities: CER. P.U. 100mV into 3 meg ohms. Tuner 100mV into 100K ohms. Tape 100mV into 100K ohms.

Overload Factor: Better than 26 dB.
Signal to noise ratio: 70 dB on all inputs (with vol. max).
Controls: 6 position selector switch (3 pos. stereo & 3 pos. mono). Separate Vol. controls for left & right channels. Bass ± 14 dB @ 60 Hz. Treble (with D.P.S. on/off) ± 12 dB @ 10 kHz. Tape Recording output sockets on each channel.

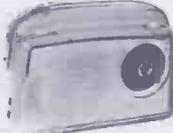
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 AC MAINS 200-250V
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 3 electronically mixed channels with 2 inputs per channel, enables the use of 6 separate instruments at the same time. The volume controls for each channel are located directly above the corresponding input sockets. **SENSITIVITIES AND INPUT IMPEDANCES.** Channels 1 & 2 4mV at 470K. These 2 channels (4 inputs) are suitable for microphone or guitars. Channels 3 & 4 300mV at 1m. Suitable for most high output instruments (gram. tuner, organ, etc.). Input sensitivity relative to 10w output. **TONE CONTROLS ARE COMMON TO ALL INPUTS.** Bass Boost + 12db at 60 Hz. Bass Cut—13db at 60 Hz. Treble Boost + 11db at 15 KHz. Treble Cut - 12db at 15 KHz. With bass and treble controls central - 3db points are 30 Hz and 20 KHz. **POWER OUTPUT:** For speech and music 50 watts rms. 100 watts peak. For sustained music 45 watts rms. 90 watts peak. For sine wave 38.5 watts rms. Nearly 80 watts peak. Total distortion at rated output 3.2% at 1KHz. Total distortion at 20 watts 0.15% at 1KHz. **NEGATIVE FEEDBACK 20dB at 1 KHz SIGNAL TO NOISE RATIO 60dB. MAINS VOLTAGES** adjustable from 200-250V. AC. 50-80 Hz. A protective fuse is located at the rear of unit. Output Impedance 3.8 and 15 ohms.

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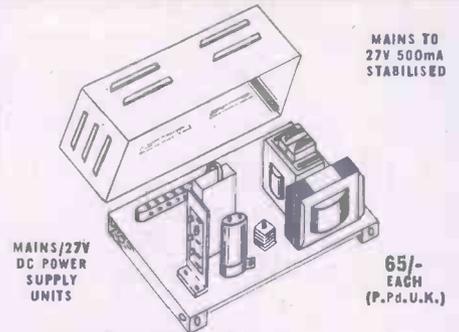
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 Range A 85-183 KHz Range E 1.83-3.94 MHz
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 " C 394-850 KHz " G 8.50-18.3 MHz
 " D 850-1.83 MHz " H 18.3-30 MHz

Crystal Check at 2 MHz and 100 KHz points.
 Deviation: 5 or 15 KHz on Range C; 10 or 30 KHz on range D; 30 or 90 KHz on ranges E, F, G and H. A.M. Modulation: 1,000, 1,600 or 3,000 Hz. Output voltage: 1μV-1V in 6 ranges and 1V-10V in 20 ranges. With provision for external modulation. In excellent condition. £65 each (carriage 30/-).

F.M./A.M. SIGNAL GENERATOR CT320
 As above but with additional L.F. range 35-85 KHz and less the 18.5-30 MHz range (Ranges A-H) and with additional mod. frequency 300 Hz. Deviation: 5 and 15 KHz, range D; 10 and 30 KHz range E; 30 and 90 Kz, F, G & H. In excellent condition. £65 each (carriage 30/-).

10 cm. SIGNAL GENERATOR SPERRY PT. No. 16116-0
 Modulated Microwave Generator covering the range 7.8 to 11 cm., with modulation frequency of 4-4 KC. The instrument may also be used as a CW Generator. The precision attenuator is calibrated 0-130 dB. Coaxial output. In excellent condition. £50 each (carriage 30/-).

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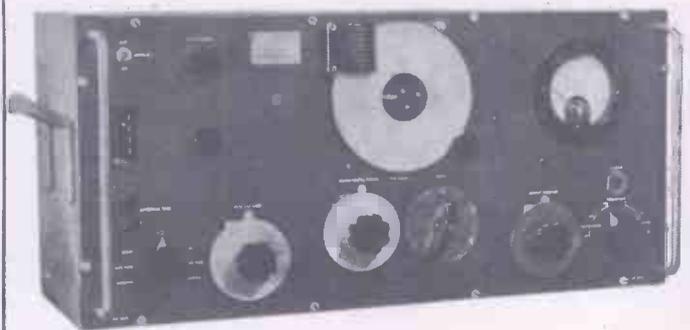
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* Available with Receiver only.

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(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

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RACAL EQUIPMENT: Frequency Meter type SA20: £35 each, carr. £1. Frequency Counter type SA21: £65 each, carr. 30/-. Converter Frequency Electronic VHF Type S.A.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, £40 each, carr. £1.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, £8/10/- each, 8/- post. 24 v D.C. input, 175 v D.C. @ 40mA output, 25/- each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., £7/10/- each, carr. 15/-. 40 mfd, 440 v A.C. wkg., £5 each, 10/- post. 30 mfd, 600 v wkg. D.C., £3/10/- each, post 10/- 15 mfd, 330 v A.C. wkg., 15/- each, post 5/-. 10 mfd, 1000 v, 12/8 each, post 2/6. 10 mfd, 600 v, 8/6 each, post 5/-. 8 mfd, 1200 v, 12/6 each, post 3/-. 8 mfd, 600 v, 8/6 each, post 2/6. 4 mfd, 3000 v wkg., £3 each, post 7/6. 2 mfd, 3000 v wkg., £2 each, post 7/6. 0.25 mfd, 2Kv, 4/- each, 1/6 post. 0.01 mfd. MICA 2.5 Kv. Price £1 for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. £3.15.0 each, 10/- post.

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COSSOR 1049 Mk. 111, £45 each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., £2 each, 6/- post. 12 Small American Relays, mixed types £2, post 4/-.

Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request 6d.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available 6d.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, £2/10/- each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 x 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 x 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19" W x 11" H x 14" D. (All connections at the rear). Excellent condition £8.10.0 each, Carr. £1.

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POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., £17/10/- each, 30/- carr. SMOOTHING UNITS suitable for above £7/10/- each, 15/- carr.

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CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω, with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New condition. Price 35/- each, post 5/-.

AUDIO OSCILLATOR 382/F: Input 115 v. A.C., 50 c/s, 20-200,000 c/s per sec. in 4 ranges. Cont. wave. Output 0-10 v. in 7 ranges. Power output 100 mW. Output impedance 1,000Ω. £27/10/- each, £1 carr.

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CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

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2N2221	5/6	2N4255	8/6	AF114	BF163	5/6	GET890	4/6	OC72	2/6
2N2222	5/6	2N4256	8/6	AF124	BF167	3/6	GET896	4/6	OC77	6/6
2N2287	21/6	2N4285	3/6	AF116	BF173	5/6	GET897	4/6	OC75	4/6
2N2297	6/6	2N4286	3/6	AF117	BF177	6/6	GET898	4/6	OC76	4/6
2N2368	3/6	2N4287	3/6	AF118	BF178	12/6	MAT100	6/6	OC77	6/6
2N2369	3/6	2N4288	3/6	AF119	BF179	14/6	MAT101	6/6	OC81	4/6
2N2369A	4/6	2N4289	3/6	AF124	BF180	7/6	MAT120	6/6	OC81B	4/6
2N2437	4/6	2N4290	3/6	AF181	BF181	4/6	MAT121	6/6	OC82	4/6
2N2483	5/6	2N4291	3/6	AF126	BF184	6/6	MJ400	21/6	OC84	5/-
2N2484	6/6	2N4292	2/6	AF127	BF185	6/6	MJ420	22/6	OC139	6/6
2N2539	4/6	2N5027	10/6	AF139	BF194	4/6	MJ421	22/6	OC140	6/6
2N2540	4/6	2N5028	11/6	AF178	BF195	5/6	MJ430	20/6	OC170	6/6
2N2613	7/6	2N5029	9/6	AF179	BF196	8/6	MJ440	19/6	OC171	6/6
2N2614	6/6	2N5030	8/6	AF180	BF197	8/6	MJ460	6/6	OC200	6/6
2N2646	11/6	2N5172	3/6	AF181	BF198	8/6	MJ481	25/-	OC201	9/6
2N2696	6/6	2N5174	10/6	AF239	BF200	10/6	MJ490	20/-	OC202	12/6
2N2711	6/-	2N5175	10/6	AF279	BF224	6/-	MJ491	27/6	OC203	8/6
2N2712	6/-	2N5176	9/-	AF280	BF225	6/-	MJ1800	43/6	OC204	8/6
2N2713	5/6	2N5232A	6/-	AF211	BF237	6/6	MJ340	12/6	OC205	8/6
2N2714	6/-	2N5245	18/6	ASV26	BFX12	17/6	MJ520	17/6	OC207	12/6
2N2865	12/6	2N5246	12/6	ASV27	BFX12	7/6	MJ521	17/6	OC271	8/6
2N2904	7/6	2N5249	13/6	ASV28	BFX13	4/6	MPFI02	8/6	ORP12	12/6
2N2904A	8/6	2N5265	65/-	ASV29	BFX29	5/6	HPFI03	7/6	ORP61	10/6
2N2905	8/6	2N5266	55/-	ASV36	BFX43	7/6	MPFI04	7/6	P346A	4/6
2N2905A	9/6	2N5267	52/6	ASV50	BFX44	7/6	MPFI05	7/6	TIS34	12/6
2N2906	6/6	2N5306	7/6	ASV51	BFX68	13/6	MPS338	6/6	TIS43	8/6
2N2907	8/6	2N5307	7/6	ASV54	BFX84	7/6	NKT0013	7/6	TIS44	2/6
2N2923	3/6	2N5308	7/6	ASV62	BFX85	7/6	NKT124	6/6	TIS45	3/6
2N2924	3/6	2N5309	12/6	ASV63	BFX87	6/6	NKT125	4/6	TIS46	3/6
2N2925	3/6	2N5310	8/6	ASV72	BFX89	5/-	NKT126	4/6	TIS47	3/6
2N2926	3/6	2N5311	8/6	ASV73	BFX89	5/-	NKT128	6/6	TIS48	3/6
Green	2/9	2N5355	5/6	ASV86	BFY10	12/6	NKT135	6/6	TIS49	3/6
Yellow	2/6	2N5356	5/6	ASZ20	BFY11	8/6	NKT210	6/6	TIS50	4/6
Orange	2/6	2N5365	9/6	ASZ21	BFY17	4/6	NKT211	4/6	TIS51	3/6
2N3011	6/-	2N5366	6/6	AUY10	BFY18	6/6	NKT212	4/6	TIS52	3/6
2N3014	6/6	2N5367	11/6	BC107	BFY19	6/6	NKT213	5/6	TIS53	6/6
2N3053	3/6	2N5457	1/6	BC108	BFY20	3/6	NKT214	4/6	TIS60	6/6
2N3054	3/11	25005	15/-	BC109	BFY21	3/6	NKT215	4/6	TIS61	6/6
2N3055	15/-	25020	3/6	BC113	BFY24	5/6	NKT216	7/6	TIP29A	13/6
2N3133	6/-	25102	6/6	BC114	BFY25	5/6	NKT217	9/6	TIP30A	15/6
2N3134	6/-	25103	6/6	BC115	BFY26	6/6	NKT219	5/6	TIP31A	19/6
2N3135	6/-	25104	6/6	BC116	BFY29	10/6	NKT223	5/6	TIP32A	19/6
2N3136	3/6	25501	6/6	BC16A	BFY30	10/6	NKT224	4/6	TZX107	3/6
2N3340	19/6	25502	5/6	BC118	BFY41	10/6	NKT225	4/6	ZTX108	3/6
2N3349	26/-	25503	5/6	BC121	BFY43	12/6	NKT229	4/6	ZTX109	3/6
2N3390	7/6	3N83	37/6	BC122	BFY50	4/6	NKT237	6/6	ZTX300	3/6
2N3391	4/6	3N128	14/-	BC125	BFY51	4/6	NKT238	5/-	ZTX301	3/6
2N3391A	6/6	3N140	15/3	BC126	BFY52	4/6	NKT240	5/6	ZTX302	4/6
2N3392	4/6	3N141	14/6	BC140	BFY53	4/6	NKT241	8/6	ZTX303	4/6
2N3393	4/6	3N142	11/6	BC147	BFY56A	11/6	NKT242	4/6	ZTX304	6/6
2N3394	4/6	3N143	13/6	BC148	BFY75	6/6	NKT243	12/6	ZTX500	4/6
2N3402	4/6	3N152	17/6	BC149	BFY76	8/6	NKT244	3/6	ZTX501	5/-

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1A	2/9	3/-	3/3	3/6	3/9	4/-	4/6	—	—
3A	3/-	—	—	4/6	—	6/-	—	—	—
6A	—	—	5/-	6/-	6/6	7/-	10/-	—	—
10A	—	10/6	11/6	13/-	15/6	17/6	19/6	25/-	32/-
17A	—	11/6</							

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN



An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kcs. Bandwidth 5.5 Mc/s. Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition. £22/10/- Carriage 30/-.

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Battery operated, fully transistorised. Sensitivity 100 MΩ/v. Measures A.C./D.C. voltages 12mV. to 1,200 V A.C./D.C. current 12μA. to 1.2 Amp. Resistance 12 ohm to 120 MΩ H.F. V.H.F. U.H.F. voltage with multiplier 4V. to 400V. up to 50 Mc/s. 40 mV. to 4V. up to 1,000 Mc/s. Offered in perfect condition. £55 each. Carr. 10/-.

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Small portable crystal controlled wavemeter. Size 7in. x 7in. x 4in. Frequency range 500 Kcs-10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 10mA and 12 V.D.C. 0.3A. Excellent condition. 89/8. Carr. 7/8.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kcs. Output 5k or 500 ohms. 200/250 v. A.C. Offered in excellent condition. £12/10/- Carriage 10/-.

CLASS D. WAVEMETERS



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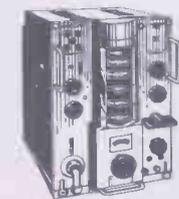


Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporated level meter, precision attenuator 1μV-100mV. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8 1/2 x 9in. Supplied in brand new condition complete with all connectors, fully tested. £45. Carr. 20/-.

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High quality 97 range instrument which measures A.C. and D.C. Voltage, Current, Resistance and Power Output Ranges D.C. volts 250 mV-10,000v. (10 meg Ω-110 meg Ω input). D.C. current 100μA-25 amps. Ohms. 0-1,000 meg Ω. A.C. volt 100mv-250v (with R.F. measuring head up to 250 Mc/s) A.C. current 10μA-25 amps. Power output 50 micro-watts-5 watts. Operation 0/110/200/250V. A.C. Supplied in perfect condition complete with circuit lead and R.F. probe. £25. Carr. 15/-.

ADMIRALTY B.40 RECEIVERS



High quality 10 valve receiver manufactured by Murphy. Coverage 5 bands 650 Kcs-30 Mc/s. L.F. 500Kcs. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19 1/2 x 13 1/2 x 16in. Weight 114lb. Offered-in good working condition. £22/10/0, carr. 30/- With circuit diagrams. Also available 84 L.F. version of above. 16 Kcs-700 Kcs. £17/10/- Carr. 30/-.

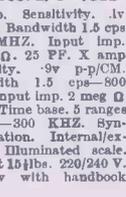
TO-2 PORTABLE OSCILLOSCOPE

A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 Cps-1 MHz. Input Imp. 2 meg Ω. 25 PF. Illuminated scale. 2 tube. 115 x 180 x 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22/10/- Carr. 10/-.



TO-3 PORTABLE OSCILLOSCOPE, 3" TUBE

Y amp. Sensitivity. 4v p-p/CM. Bandwidth 1.5 cps-1.5 MHz. Input Imp. 2 meg Ω. 25 PF. X amp sensitivity. .9v p-p/CM. bandwidth 1.5 cps-800 KHz. Input Imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps-500 KHz. Synchronisation. Internal/external. Illuminated scale. 140 x 215 x 330 mm. Weight 16lbs. 220/240 V. A.C. Supplied brand new with handbook £37.10.0 Carr. 10/-.



SEW PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES, ETC.
● LOW COST ● QUICK DELIVERY ● OVER 200 RANGES IN STOCK ● OTHER RANGES TO ORDER

NEW "SEW" DESIGNS! CLEAR PLASTIC METERS BAKELITE PANEL METERS



TYPE SW.100
100 x 80 mm.

500μA	89/8
50-0-500μA	87/8
100μA	87/8
100-0-100μA	85/-
500μA	82/8
1mA	82/8
1mA	59/8

20V. D.C.	59/8
100mA	52/-
300V. D.C.	59/8
1 amp. D.C.	59/8
5 amp. D.C.	59/8
300V. A.C.	59/8
VU Meter	75/-

TYPE S-80
80 mm. square fronts

500μA	82/8
50-0-500μA	59/8
100μA	59/8
100-0-100μA	57/8
500μA	52/8
1mA	49/8
20V. D.C.	49/8



50V. D.C.	49/8
300V. D.C.	49/8
1 amp. D.C.	49/8
5 amp. D.C.	49/8
300V. A.C.	52/8
VU Meter	57/8

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4 1/2in. x 4 1/2in. fronts.



500μA	72/-
50-0-500μA	62/-
100μA	62/-
100-0-100μA	62/-
200μA	57/8
500μA	55/-
500-0-500μA	52/-
1mA	52/-
1-0-1mA	52/-
5mA	52/-

10mA	52/-
50mA	52/-
100mA	52/-
500mA	52/-
1 amp.	52/-
5 amp.	52/-
30 amp.	52/-
20V. D.C.	52/-
50V. D.C.	52/-
150V. D.C.	52/-
300V. D.C.	52/-
15V. A.C.	52/-
300V. A.C.	52/-
8 Meter 1mA	57/8
VU meter	72/-
1 amp. A.C.*	52/-
5 amp. A.C.*	52/-
10 amp. A.C.*	52/-
20 amp. A.C.*	52/-
30 amp. A.C.*	52/-

Type MR.38P. 1 21/32in. square fronts.



500μA	40/-
50-0-500μA	37/8
100μA	37/8
100-0-100μA	35/-
200μA	35/-
500μA	30/-
500-0-500μA	27/8
1mA	27/8
1-0-1mA	27/8
5mA	27/8
10mA	27/8
20mA	27/8
50mA	27/8
100mA	27/8
150mA	27/8

200mA	27/8
300mA	27/8
500mA	27/8
1 amp.	27/8
2 amp.	27/8
5 amp.	27/8
10 amp.	27/8
3V. D.C.	27/8
10V. D.C.	27/8
15V. D.C.	27/8
20V. D.C.	27/8
100V. D.C.	27/8
150V. D.C.	27/8
300V. D.C.	27/8
500V. D.C.	27/8
750V. D.C.	27/8
15V. A.C.	27/8
50V. A.C.	27/8
150V. A.C.	27/8
300V. A.C.	27/8
500V. A.C.	27/8
8 Meter 1mA	32/-
VU meter	42/-

Type MR.52P. 2 1/2in. square fronts

500μA	62/-
50-0-500μA	52/-
100μA	52/-
100-0-100μA	47/8
500μA	45/-
1mA	40/-
5mA	40/-
10mA	40/-
50mA	40/-
100mA	40/-
500mA	40/-
1 amp.	40/-
5 amp.	40/-

10V. D.C.	40/-
20V. D.C.	40/-
50V. D.C.	40/-
300V. D.C.	40/-
15V. A.C.	40/-
300V. A.C.	40/-
8 Meter 1mA	42/-
VU Meter	62/-
1 amp. A.C.*	40/-
5 amp. A.C.*	40/-
10 amp. A.C.*	40/-
20 amp. A.C.*	40/-
30 amp. A.C.*	40/-

Type MR.45P. 2in. square fronts.

500μA	45/-
50-0-500μA	42/-
100μA	42/-
100-0-100μA	37/8
200μA	37/8
500μA	30/-
500-0-500μA	30/-
1mA	30/-
5mA	30/-
10mA	30/-
50mA	30/-
100mA	30/-
500mA	30/-
1 amp.	30/-

5 amp.	30/-
10V. D.C.	30/-
20V. D.C.	30/-
50V. D.C.	30/-
300V. D.C.	30/-
15V. A.C.	30/-
300V. A.C.	30/-
8 Meter 1mA	37/8
VU meter	45/-
1 amp. A.C.*	30/-
5 amp. A.C.*	30/-
10 amp. A.C.*	30/-
20 amp. A.C.*	30/-
30 amp. A.C.*	30/-

"SEW" BAKELITE PANEL METERS

Type MR.65. 3 1/2in. square fronts.



250μA	70/-
50-0-500μA	47/8
100μA	45/-
100-0-100μA	45/-
500μA	45/-
1mA	35/-
1-0-1mA	35/-
5mA	35/-
50mA	35/-
100mA	35/-

500mA	35/-
1 amp.	35/-
5 amp.	35/-
15 amp.	35/-
30 amp.	35/-
50 amp.	35/-
5V. D.C.	35/-
10V. D.C.	35/-
20V. D.C.	35/-
50V. D.C.	35/-
300V. D.C.	35/-
30V. A.C.*	35/-
50V. A.C.*	35/-
150V. A.C.*	35/-
300V. A.C.*	35/-
500mA A.C.*	35/-
1 amp. A.C.*	35/-
5 amp. A.C.*	35/-
10 amp. A.C.*	35/-
20 amp. A.C.*	35/-
30 amp. A.C.*	35/-
50 amp. A.C.*	35/-
VU meter	62/-

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Type PE.70. 3 17/32in. x 1 15/32in. x 2 1/2in. deep.



500μA	60/-
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100μA	57/8
100-0-100μA	55/-
200μA	55/-
500μA	52/-
1mA	47/8
300V. A.C.	47/8
VU meter	65/-

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High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brass wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, 1/2in. dia. shafts. Bulk quantities available.
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100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 27/6. P. & P. 1/6.



FTC-401 TRANSISTOR TESTER



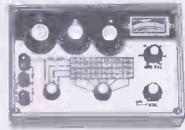
Full capabilities for measuring A, B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. £6.19.6 & 3/- P. & P.

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A new portable bridge offering excellent range and accuracy at low cost. Ranges: B. 10-11.1 MEG Ω. 6 Ranges ± 1%. L. 1μH-111 HEN-RIES. 6 Ranges -2%. C. 10PF± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000-1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CFS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7 1/2" x 5" x 2". £20. P. & P. 5/-.



COSOR 1049 DOUBLE BEAM OSCILLOSCOPES

D.C. coupled. Band width 1 Kcs. Perfect order. £25. Carr. 30/-.

TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kcs-250 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. £15.

P. & P. 7/6. S.A.E. for details.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 Kcs. on 4 bands. Square 20 cps to 30 Kcs. Output impedance 5,000 ohms, 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £16.10.0 Carr. 7/6.

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Incorporated in Radio Altitude Indicator ID-14APN. Ideal for rev. counter etc. 15/6. P. & P. 3/-.

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Accurate wide range signal generator covering 120 Kcs-500 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator, audio output. 3Xal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 7/6. Size 140 x 215 x 170 mm.

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Full range of facilities for testing PNP or NPN transistors in or out of circuit. £37.10.0. Carriage 10/- per item.

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0-40 Kcs/s. £20. Carr. 30/-.

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2N697	4/-	AF139	6/-	NKT224	5/8	6AL5	3/3
2N698	5/-	AF178	11/-	NKT241	5/8	6AM6	4/8
2N708	3/-	AF180	10/8	NKT261	4/-	6A85	6/-
2N706A	2/8	AF181	8/8	NKT271	4/-	6AT6	5/-
2N708	3/-	AF186	9/-	NKT272	4/-	6AU6	5/-
2N914	3/8	AF239	8/8	NKT274	4/-	6AV6	6/8
2N916	3/8	AS27	7/8	NKT275	4/-	6BA6	4/8
2N918	6/-	AS28	5/8	NKT278	3/8	6BE6	5/-
2N929	4/8	AS27	5/8	NKT403	15/-	6BH6	8/8
2N930	5/8	AUY10	30/-	NKT404	12/8	6BQ7A	7/8
2N1131	5/8	BAY31	1/8	NKT405	15/-	6BR7	17/-
2N1132	6/8	BC107	3/-	NKT773	3/-	6BR8	12/8
2N1302	3/8	BC108	3/-	NKT10439	7/8	6BW6	18/8
2N1303	3/8	BC109	3/-	OA5	2/8	6BZ6	6/8
2N1304	4/8	BC113	10/8	OA10	2/8	6C4	6/-
2N1305	4/8	BC116	12/8	OA47	1/8	6CD6	23/-
2N1306	5/8	BC126	11/-	OA70	1/8	6CL6	10/-
2N1307	5/8	BC126	11/-	OA79	1/8	6CZ4	12/8
2N1308	6/-	BC147	3/8	OA81	1/8	6F6G	5/-
2N1309	6/-	BC148	3/-	OA85	1/8	6FL3	7/-
2N1711	5/-	BC149	3/8	OA90	1/8	6FL4	12/-
2N1889	6/8	BC167	3/8	OA91	1/8	6FL5	11/-
2N1893	8/8	BC172	3/8	OA95	1/8	6FL8	5/-
2N2147	14/8	BC177	7/8	OA200	2/-	6G2	9/-
2N2160	11/8	BC186	7/8	OA202	1/-	6J3	3/8
2N2193	9/8	BC182L	4/-	OA210	3/8	6J5	3/8
2N2217	5/8	BC184L	4/-	OC19	8/8	6K8G	6/-
2N2218	6/8	BC186	4/8	OC20	15/-	6L6GT	9/-
2N2219	6/8	BC186	4/8	OC22	10/-	6LD20	6/8
2N2368	3/8	BC191	5/8	OC23	10/-	6M2	6/8
2N2369	3/8	BC197	3/8	OC24	11/8	6N47	7/8
2N2389A	4/-	BC198	3/8	OC25	10/-	6N7	7/8
2N2484	6/8	BC198	3/8	OC26	8/8	6N8	6/8
2N2613	7/-	BC198	3/8	OC28	10/-	6N7	7/8
2N2646	11/8	BC212L	4/8	OC29	12/8	6N7	7/8
2N2923	3/8	BC218L	4/8	OC35	8/-	6N7	7/8
2N2924	3/8	BC218L	4/8	OC36	12/8	6N7	7/8
2N2925	3/8	BC218L	4/8	OC37	8/8	6N7	7/8
2N2926	2/8	BC218L	4/8	OC38	12/8	6N7	7/8
2N2926Y	2/8	BC218L	4/8	OC39	12/8	6N7	7/8
2N2926Z	2/8	BC218L	4/8	OC40	12/8	6N7	7/8
2N3053	2/8	BC218L	4/8	OC41	12/8	6N7	7/8
2N3054	11/-	BC218L	4/8	OC42	5/-	6N7	7/8
2N3055	15/-	BC218L	4/8	OC43	5/-	6N7	7/8
2N3055A	15/-	BC218L	4/8	OC44	5/-	6N7	7/8
2N3416	7/8	BC218L	4/8	OC45	5/-	6N7	7/8
2N3702	3/8	BD121	13/-	OC46	3/-	6N7	7/8
2N3670	17/8	BD123	16/8	OC47	3/-	6N7	7/8
2N3703	4/8	BD124	12/-	OC48	3/-	6N7	7/8
2N3704	4/8	BF115	5/-	OC49	3/-	6N7	7/8
2N3705	4/8	BF117	9/8	OC71	2/8	6N7	7/8
2N3706	4/8	BF167	5/-	OC72	2/8	6N7	7/8
2N3707	4/8	BF173	6/8	OC73	5/8	6N7	7/8
2N3708	3/8	BF180	7/8	OC74	6/8	6N7	7/8
2N3709	3/8	BF181	6/8	OC75	4/8	6N7	7/8
2N3710	4/-	BF182	6/8	OC76	4/8	6N7	7/8
2N3711	4/-	BF184	6/8	OC77	6/8	6N7	7/8
2N3819	7/-	BF185	8/8	OC78	4/8	6N7	7/8
2N3903	7/-	BF194	4/8	OC81	4/8	6N7	7/8
2N3904	7/-	BF195	5/8	OC81D	4/8	6N7	7/8
2N3905	7/8	BF200	10/8	OC83	5/-	6N7	7/8
2N3906	7/8	BF224	6/-	OC84	5/-	6N7	7/8
2N4058	5/8	BF225	6/-	OC139	6/8	6N7	7/8
2N4059	5/8	BF244	9/8	OC140	6/8	6N7	7/8
2N4061	4/8	BFX12	4/8	OC169	4/8	6N7	7/8
2N4062	4/8	BFX13	4/8	OC170	6/-	6N7	7/8
2N4286	3/8	BFX29	7/8	OC171	6/-	6N7	7/8
2N4287	3/8	BFX30	9/-	OC200	6/8	6N7	7/8
2N4288	3/8	BFX44	7/8	OC201	9/8	6N7	7/8
2N4289	3/8	BFX45	7/8	OC202	12/8	6N7	7/8
2N4290	3/8	BFX86	6/-	OC203	8/8	6N7	7/8
2N4291	3/8	BFX87	6/-	OC204	8/8	6N7	7/8
2N4292	2/8	BFX88	5/-	OC205	8/8	6N7	7/8
2N5354	5/8	BFY18	6/8	OC207	12/8	6N7	7/8
2N5355	5/8	BFY20	12/8	OCPT1	8/8	6N7	7/8
28102	6/8	BFY50	4/8	ORF12	10/-	6N7	7/8
28103	6/8	BFY51	4/8	ORP90	10/-	6N7	7/8
28104	6/8	BFY52	4/8	P346A	4/8	6N7	7/8
40250	10/-	BFY90	13/8	PL4001	2/8	6N7	7/8
40361	12/8	BSX19	3/8	PL4002	3/8	6N7	7/8
40362	13/8	BSX20	3/8	PL4003	3/8	6N7	7/8
AC107	6/-	BSX21	7/8	PL4004	3/8	6N7	7/8
AC126	4/-	BSX26	3/8	PL4005	3/8	6N7	7/8
AC127	5/-	BSY26	3/8	PL4006	3/8	6N7	7/8
AC128	4/-	BSY27	3/8	PL4007	4/8	6N7	7/8
AC154	4/8	BSY28	3/8	T1843	8/-	6N7	7/8
AC176	5/8	BSY32	4/8	T1844	2/8	6N7	7/8
AC187	12/8	BSY38	4/8	T1845	3/8	6N7	7/8
AC188	7/8	BSY39	4/8	T1846	3/8	6N7	7/8
AOY17	5/8	BSY51	6/8	T1846	3/8	6N7	7/8

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10% on 12+ any one type
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Large quantity discounts on application. Postage: Semi Conductors 1/6; Valves 3/-.

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400mw. (3.3 to 33v)	1.5 watt (2.4 to 200v)	10 watt (3.9 to 100v)
3/-	4/-	5/-

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1 AMP 50PIV 5/-;	100PIV 5/8;	200PIV 7/8;
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SPECIAL OFFERS

GOLDRING GL69/2 fitted Goldring G800 cartridge complete with de luxe base and cover. Total list price £50.16.0. **OUR PRICE £29.** Carr. 20/-

GARRARD SP25 Mk II fitted Goldring G800 cartridge and wooden plinth with perspex cover. Total list price £35. **OUR PRICE £20.19.6.** Carr. 10/-

HALF PRICE OFFER! SINCLAIR STEREO 25

Hi Fi solid state pre-amplifier and control unit incorporating treble, bass, volume and balance controls. Switched input for p.a. (magnetic and ceramic), mike and radio. Will also accept tape head. Operates from 9V-12V battery (20V. max. 7.5mA). Frequency response 26Hz-30KHz ± 1 db. Noise level better than -50db on all inputs. Principally designed for use with Z12 Amplifier but full instructions are supplied to enable it to be used with any amplifier. Size 6 1/2 x 2 1/2 x 2 1/2. Overall plus knobs. Brushed and polished aluminium front panel with matching knobs. Supplied brand new and guaranteed, with full instructions. Original price £9.19.6. **OUR PRICE £4.19.6.** P. & P. 3/-.

SINCLAIR EQUIPMENT

Project 60. Package Offers

2 x Z30 amplifier, stereo 60 pre-amp, P25 power supply. £19.0.0. Carr. 7/8. Or with P28 power supply. £21.0.0. Carr. 7/8. 2 x Z30 amplifier, stereo 60 pre-amp, P28 power supply. £21.10.0. Carr. 7/8. Transformer 4 PZ4. 59/6 extra. Add to any of the above £4.17.8 for active filter unit and £16.0.0 for a pair of Q16 speakers. All other Sinclair products in stock: 2 x 2000 amplifier. £23.0.0. Carr. 7/8. Neoteric amplifier £46.0.0. Carr. 7/8.

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Popular solid state hi-fi amplifier incorporating 15 semi-conductors. Output 6 watts r.m.s. Inputs for magnetic ceramic, tuner and aux. Stereo phone socket and tape output. Controls: Volume, balance, bass, treble. Oiled Walnut case with brushed aluminium front panel. **SPECIAL PRICE £20.** Carr. 7/8.

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Top quality in plastic library boxes.

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Wonderful value and excellent performance combined. Adjustable head-band. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. **ONLY 47/6** P. & P. 2/6.

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5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. x 4in. C.R.T. Calibrated triggered sweep from 2 μsec. to 100 mill-sec. per cm. Free running time base 50cs/1mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87. Carr. paid.



MARCONI CT44 TF956 AF ABSORPTION WATTMETER
1 μ/watt to 6 watts.
£20. Carr. 20/-.



TE111 DECADE RESISTANCE ATTENUATOR
Variable range 0-111 db. Connections Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db x 10) + (1 db x 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (-3db). Accuracy: 0.05 db. + indication db x 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27/10/-, P. & P. 5/-.



BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR
Sine 18-200,000 Hz. Square 18-50,000 Hz. Output max. +10 db (10 K ohms). Operation internal batteries. Attractive 2-tone case 7 1/2 in. x 5 in. x 2 in. Price £17/10/0 Carr. 3/6



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5 Ranges 400 KHZ-20 MHz. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5 1/2" x 5 1/2" x 3 1/2". Complete with instructions and leads. £7/10/6. P/P 4/-.



BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR
New high-quality portable instrument. Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 db (10 K ohms). Operation 220/240 v. A.C. Size 215 mm x 150 mm x 120 mm. Price £27/10/0 Carr. 5/-.



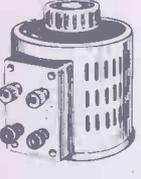
T.E.40 HIGH SENSITIVITY A.C. VOLTMETER
10 meg. input 10 ranges: .01/.05/1/3/10/30/100/300 v. B.M.S. 4 cps. 1.2 Mc/s. Decibels -40 to +50 db. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/-, Carr. 5/-.



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High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/-. Additional Probes available: B.F. 35/- H.V. 42/6.



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MULTIMETERS for EVERY purpose!

TECH PT-34. 1,000 O.P.V. 0/10/80/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K. 39/6 P. & P. 2/6.



MODEL TE-200 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000 V.D.C. 0/5/30/120/600/1,200 v. A.C. 0/50 μA/250 mA. 0/60K/6 meg. + 20 to + 62 db. 75/- P. & P. 3/-.



MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30 μA/3/30/300mA. 0/16K/160K/1.6M/16 MEG. £5/10/0 P. & P. 3/-.



TMK MODEL TW-50K 48 ranges, mirror scale. 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1000V. D.C. Current: 25, 50 μA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance 10K, 100K, 1 MEG, 10 MEG. Decibels: -20 to +81.5 db. £8/17/6. P. & P. 3/6.



TE-900 20,000 VOLT GIANT MULTIMETER. Mirror scale and overload protection. 6 in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50 μA/0/10/100/500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. £15 P. & P. 6/-.



MODEL 5025 57 Ranges, Giant 8 1/2 in. Mefer, Polarity Reverse Switch. Sensitivity: 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 100, 100K, 1MEG, 10MEG Decibels: -20 to + 85 db. £12/10/0. P. & P. 3/6.



LAFAYETTE HA-600 SOLID STATE RECEIVER
General coverage 150-400 kc/s, 550kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, 8 Meter, Bandspread, RF Gain. 15" x 9 1/2" x 8 1/2". 18 lb. 220/240V AC or 12v DC. Brand new with instructions. £45 Carrage 10/-.



RCA COMMUNICATIONS RECEIVER AR88D
Brand new. 6 bands 535kc/s - 32mc/s. Fully tested and checked. 110-250V AC. £85 Carr. £2.



HONOR TE10A. 20 kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50 μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. -20 to + 22 db. 10-0, 100 mfd. 0.100-0.1 mfd. 69/6. P. & P. 3/-.



MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30 μA/6mA/60 mA/300mA/600mA. 0/8K/80K/800K/8 meg. -20 to + 63 db. £5/19/6 P. & P. 3/-.



MODEL TE-90 50,000 O.P.V. Mirror scale, overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200 v. D.C. 0/3/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG. -20 to + 63 db. £7/10/0. P. & P. 3/-.



TMK MODEL TW-300CB FEATURES RESETTING OVERLOAD BUTTON. Sensitivity: 20K Ω/Volt D.C. 5K Ω/Volt A.C. D.C. Volts: 0-0.5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 0-2.5, 10, 50, 250, 1,000V. D.C. Currents: 0-0.05, 0.5, 5, 50, 500mA. -10 amp. Resistance: 0-5K, 50K, 0-500K. 5 MEG. Decibels: -20 to + 52db. £11/10/0. P. & P. 3/6.



MODEL A8-100D. 100K Ω/Volt 5 in. mirror scale. Built-in meter protection 0/3/12/60/120/300/600 1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10 μA/5/60/300MA/12 Amp. 0/2K/200K/2M/200M. -20 to + 17 db. £12/10/0. P. & P. 3/6



TMK LAB TESTER 100,000 O.P.V. 6 1/2 in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 OPV D.C. 5 /Volt A.C. D.C. Volts: .5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100 μA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG. Decibels: -10 to + 49 db. Plastic Case with carrying handle. Size 7 1/2" x 6 1/2" x 3 1/2". £18/18/0. P. & P. 5/-.



LAFAYETTE HA-800 SOLID STATE AMATEUR COMMUNICATION RECEIVER
3.5 - 4, 7 - 7.3, 14 - 14.35, 21 - 21.45, 28 - 29.7, 50 - 54 mc/s. Dual conversion, 2 mech. filters, product detector, variable BFO, 8 Meter, 100kc/s callibrator. 220/240V AC or 12v DC. 15" x 9 1/2" x 8 1/2". 18 lb. Brand new with instructions. £57/10/0. Carr. Pald. (100kc/s Crystal 39/6 extra).



LAFAYETTE PF60 VHF FM RECEIVER
Solid State. 152 - 174mc/s. Fully tuneable or crystal controlled (not supplied). Built in Speaker. Squelch and Volume Controls. 220/240V AC or 12v DC. Brand new with instructions. £37/10/0. Carr. 10/-.



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UNR 30 RECEIVER
4 Bands covering 550kc/s - 30mc/s. B.F.O. Built in Speaker 220/240V AC. Brand new with instructions. £13/13/0. Carr. 7/6.



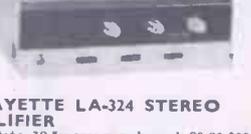
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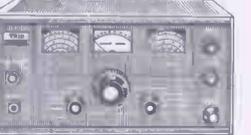
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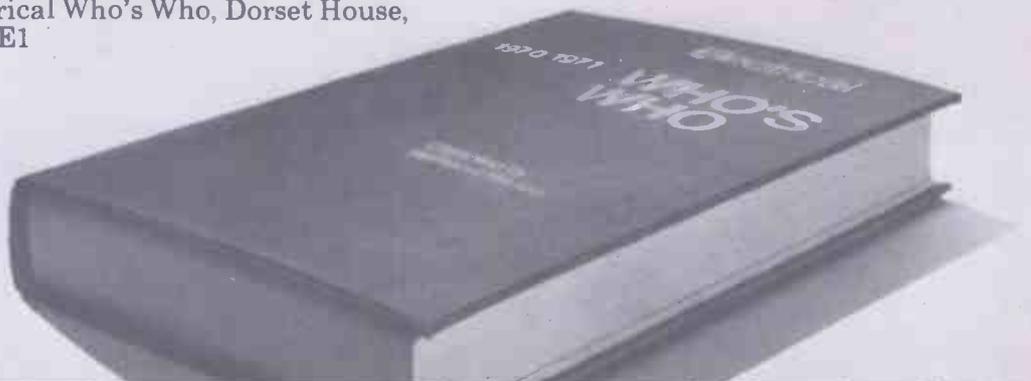
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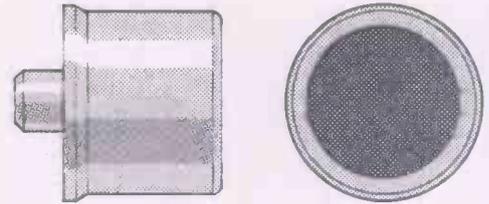
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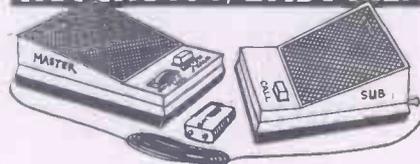
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Solve your communication problems with this new 4-Station Transistor Intercom system (1 master and 3 subs), in de luxe plastic cabinets for desk or wall mounting. Call/talk/listen from Master to Subs and Subs to Master. Operates on one 9 v. battery. On/off switch. Volume control. Ideally suitable to modernise Office, Factory, Workshop, Warehouse, Hospital, Shop, etc., for instant inter-departmental contacts. Complete with 3 connecting wires, each 66ft. and other accessories. Nothing else to buy. P. & P. 7/6 in U.K.

INTERCOM/BABY ALARM



OUR PRICE ONLY
3 gns.

A top quality DE-LUXE transistorised intercom consists of MASTER and SUB for desk/wall mounting. Call, talk or listen from either unit. On/Off switch, volume control. Ideally suitable as "BABY SITTER" or Door Phone. A boon for spastics and invalids. Useful in the home, surgery or business for instant 2-way conversations, effective range 300ft. Unsurpassed in QUALITY AND PERFORMANCE. Complete with 66ft. connecting lead. Battery 2/6 extra. P. & P. 4/6. Price Refund if not satisfied in 7 days.

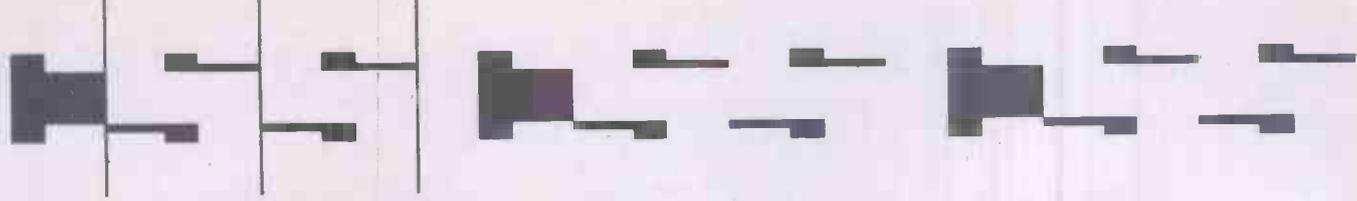
Transistor TELEPHONE AMPLIFIER



59/6

Why not increase efficiency of Office, Shop and Warehouse with this incredible De-Luxe Portable Transistor TELEPHONE AMPLIFIER which enables you to take down long telephone messages or converse without holding the handset. A useful office aid. A must for every telephone user. Useful for hard of hearing persons. On/off switch. Volume Control. Operates on one 9 v. battery which lasts for months. Ready to operate. P. & P. 3/6 in U.K. Add 2/6 for Battery.

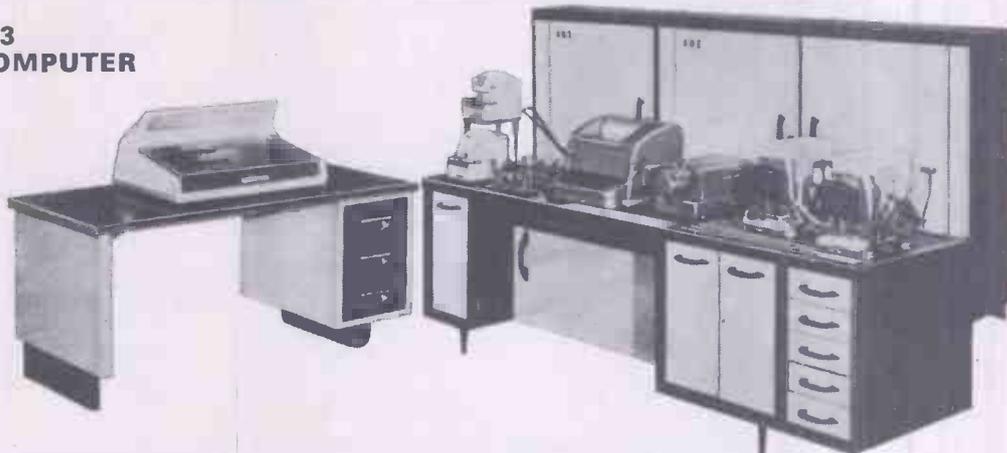
Full price refunded if returned in 7 days.



COMPUTER SALES AND SERVICES

49-53 PANCRAS RD., LONDON, N.W.1. Tel: 01-278 5571 Telex No. 267307
(low cost computers and peripherals)

ELLIOTT 803 DIGITAL COMPUTER



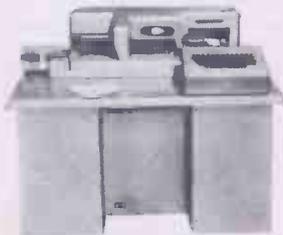
This is a well proved solid state digital computer, with well over 200 systems sold in the UK and abroad. Reliability has been proved by long periods of operation. It has many advantages, such as low running costs, compact design, automatic programming, extensive libraries of programmes available and a wide variety of Input and output devices and auxilliary equipment can be coupled making this system suitable for use in all classes of work.

Typical Configuration:

Central Processor with 4096 Core Store. Type 3 Paper Tape Station. One Tape Reader 500 characters per sec. (Elliott TS/93). One Tape Punch 100 characters per sec. (Teletype BRPE E11). Keyboard console and associated desk. Creed Teleprinter. Automatic Floating Point Unit.

PART USED COMPUTERS AVAILABLE SHORTLY

ICL 1500; PDP 8I; IBM 1440; IBM 1401; SDS 930; ELLIOTT 803; EMIDEC 1100; HONEYWELL 200; NCR 400.



ICT HOLLERITH

Type 029.80 column Punch

A well-proven electro-mechanical card punch, with duplicating, spacing, and skipping facilities. Two types of keyboard are available for this model Alpha/Numeric and Alphabetic. The alphabetic largely resembles a typewriter keyboard, enables alpha punching by the operation of one key. Supplies 110v. D.C. mains for card feed motor. **FEATURES:** Motor cut-out switch for clearing card jams. Stop Lever for stopping card at the 80th column. Also available H129 card verifiers.

MAGNETIC TAPE



COMPUTER QUALITY 1/2" MAGNETIC TAPE CERTIFIED 550 B.P.1. 800 B.P.1. ON 2,400-ft. REELS. GUARANTEED REPLACEMENT IF FAULTED. £8.10.0

- 3/4 in. Highest grade 2,400 ft. £3. 0.0
- 1/2 in. 10 1/2 in. dia. spool and cassette £1.10.0
- 1/2 in. 8 1/2 in. dia. spool and cassette £1.10.0
- 1 in. metal 10 1/2 in. dia. spool and cassette £2.10.0
- 1/2 in. N.A.B. centres 10 1/2 in. spool only £1. 0.0



ENGLISH ELECTRIC LEO

Lector Automatic Document Reader

A photo electric document reader sensing contrast between marks and background, transposing on to 7 or 8 channel paper tape. Suitable for transcribing order forms, meter reading sheets, stock control forms and market research returns, etc.

TAPE READERS

Photo Electric Readers for all colour paper tapes up to 1 in. ICL Type 2640 (250 cps); Elliott T2/94 (250 cps); Elliott D4/42 (500-1,000 cps). Available with full warranty.



8100 DOCUMENT READER

A low cost, single pocket machine with reject outstacking facilities. Permits data entry into the computer direct from source documents. Handles up to 1,200 documents per minute and is suitable for use with a wide variety of character recognition systems and optical mark reading employing computer printing and/or manual data entry.

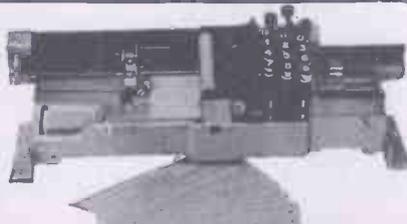


COMPLETE AIR CONDITIONING SYSTEM AVAILABLE BY WORTHINGTON U.S.A. COST OVER £8K WHEN NEW. P.O.A.

FRIDEN FLEXOWRITERS



Flexowriter programmable automatic writing machine for automatic letter writing, Data preparation work, invoice format paper work, edge punching cards, cutting continuous cards, preparing unit cards, preparing stub cards, reading edge punched cards, reading/copying punched tape. Price from £175.



REFURBISHED HAND PUNCHES—80 COLUMN

The Punch

is a table-mounted model punch. For the Serial Punching of alpha-numeric Data, Alpha or Multi Hole Punching is made by depressing two or more keys simultaneously. Also available refurbished ICT 103 80 col. verifiers. With full warranty.

SERVICE TRADING CO



**INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.**

BRAND NEW. Keenest prices in the country. All types (and spares) from 1/3 to 50 amp. available from stock.

0-260 v. at 1 amp.....	£5 10 0
0-260 v. at 2.5 amps....	£6 15 0
0-260 v. at 5 amps.....	£9 15 0
0-260 v. at 8 amps.....	£14 10 0
0-260 v. at 10 amps.....	£18 10 0
0-260 v. at 12 amps.....	£21 0 0
0-260 v. at 15 amps.....	£25 0 0
0-260 v. at 20 amps.....	£37 0 0
0-260 v. at 37.5 amps....	£72 0 0
0-260 v. at 50 amps.....	£92 0 0

8 AMP

1 AMP

OPEN TYPE (Panel mounting). 1/3 amp. £3.18.6
1 amp £5.10. 2 1/2 amp. £6.12.6. P. & P.7/6.

RING TRANSFORMER

Functional Versatile Educational

This multi-purpose Auto Transformer, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT.100 V.A. Model the output could be wound to give 8V. @ 12Amp., 4V. @ 25Amp. or 2V. @ 50Amp., etc. Price: RT.100VA 3.18 turns per volt, £2 5 0 +3/6 p. and p. RT.300VA 2.27 turns per volt, £4 4 0 +5/6 p. and p. RT.1KVA 1.82 turns per volt, £6 10 0 +6/6 p. and p. RT.2KVA 1.5 turns per volt, £10 0 0 +9/6 p. and p. RT.3KVA 1.5 turns per volt, £14 0 0 +10/- p. & p.

L.T. TRANSFORMERS

All primaries 220-240 volts.	Type No.	Sec. Taps	Price	Carr.
1	12 v. at 5A		£1 17 6	5/6
2	30, 32, 34, 36 v. at 5 amps.		£4 13 6	6/-
3	30, 40, 50 v. at 5 amps.		£6 17 6	6/6
4	10, 17, 18 v. at 10 amps.		£4 19 0	4/6
5	6, 12 v. at 20 amps.		£6 8 6	6/6
6	17, 18, 20 v. at 20 amps.		£7 5 6	6/6
7	6, 12, 20 v. at 20 amps.		£6 17 6	7/6
8	24 v. at 10 amps.		£5 4 6	5/6
9	4, 6, 24, 32 v. at 12 amps.		£7 3 0	6/6

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/12/6 each. P. & P. 4/6. 500 watt type £5/2/6 each. P. & P. 6/6. 1,000 watt type £7/2/6 each. P. & P. 7/6.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photo-cell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. ORP. 12 and Circuit 12/6 post paid.

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 1 make, 1 break, H.D. contacts. Price inc. circuit 47/6, plus 2/6 P. & P.

LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.

SOLID STATE INTERVAL TIMER

24-30v. D.C. operation. Stabilised uni-junction Timer and S.C.R. (30v. 1amp.), encapsulated in metal core. Timing interval adjustable from a fraction of a second to several minutes by means of external resistor or pot. By adding a 24v. Relay many other complex timing Functions are possible. Price: 1/6 incl. circuit, p. & p. 2/6. Suitable relay 9/6. P. & P. 1/6.

230/240V A.C. 10 RPM MOTOR

(Non Reversible)

Extremely powerful. Continuously rated. Offered at the low price of 35/- post paid.



INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 2/- each.

'AVO' MODEL 48A

Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp. and 480 Amp. A.C. Transformer for 60 Amp. and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. £15/0/0, P. & P. 10/-



POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous

Enamel, heavy duty brush assembly designed for continuous duty. AVAILABLE FROM STOCK IN THE FOLLOWING II VALUES: 100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm .7a., 500 ohm .45a., 1k ohm 280mA., 1.5k ohm 230mA., 2.5k ohm .2a., 5k ohm 140mA., Diameter 3 1/2 in. Shaft length 3 in. dia. 3/8 in., 27/8. P. & P. 1/6. 50 WATT 1/5/10/25/50/100/250/500/1K/1.5K/2.5K/5K ohm. All at 21/-, P. & P. 1/6. 25 WATT 10/25/50/100/250/500/1K/1.5K/2.5K ohm. All at 14/6, P. & P. 1/6. Black Silver Skirted knob calibrated in Nos. 1-9. 1 1/2 in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

MOTOROLA MACII/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price 21/- plus 1/6 P. & P.

T.M.C. ILLUMINATED LATCHING PUSH BUTTON

KEY SWITCH No. S525594

LOCK 4 c/o

Complete with mounting bracket, Push Knob and Lenses (GREEN, AMBER, RED or CLEAR — state colour preference). PRICE 14/6 each excluding bulb, Post Paid. Discount for quantities of 200 or over.

STROBE! STROBE! STROBE!

THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION. The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.

EXPERIMENTERS "ECONOMY" KIT Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Uni-junction Xenon Tube + instructions £5.50 plus 5/- P. & P.

NEW INDUSTRIAL KIT Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor Adjustable 1-80 f.p.s. Price 9 gns. 7/6 P. & P.

HY-LIGHT STROBE This strobe has been designed for use in large rooms, halls and the photographic field, and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 1-30 (p.s. Light output approx. 4 ioules. Price £10.17.6. P. & P. 7/6.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 10/6 and 2/6 P. & P. or post paid with kits.

ELECTRONIC ORGAN KIT

Ideal present for Electronically minded boy. Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, using two penlite 1 1/2 v. batteries. Complete set of parts including speaker, etc., together with full instructions and 10 tunes. Have all the pleasure of building this instrument and finish with a functional, instructive gift for any boy or girl. Price £3.0.0. P. & P. 4/6.

BODINE TYPE N.C.1 GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. Reversible 1/70th h.p., 50 cycle .38 amp. (Type 2) 28 r.p.m. torque 20 lb. in. reversible 1/80th h.p., 50 cycle .28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for 230/240v A.C. input. Price, either type £3.3.0 plus 6/6 P. & P. or less transformer £2.2.6 plus 4/6. P. & P. These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc. etc.



MINIATURE UNISELECTOR

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

UNISELECTOR SWITCHES NEW

4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £5.17.6, plus 2/6 P. & P.

6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £6.10.0, plus 2/6 P. & P.

8-BANK 25-WAY FULL WIPER 24 v. D.C. operation, £7.12.6, plus 4/- P. & P.

RELAYS NEW SIEMENS PLESSEY, etc.

COIL	WORKING D.C. VOLT CONTACTS	PRICE
52	6-9 6M	12/6
230	6-12 2 c/o	12/6
280	6-12 2 c/o incl. base	14/6
700	16-24 4M 2B incl. base	12/6
1250	36-45 6M	12/6
2500	36-45 6M	12/6
5800	80-85 4 c/o	12/6
9000	40-70 2 c/o incl. base	10/-

H.D. = Heavy Duty POST PAID

MINIATURE RELAYS

9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in. x 1/2 x 1/4 in. Price 11/6 Post paid.

30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1 x 1/2 x 1/4 in. 8/6 post paid.

SPECIAL OFFER

Relay 18/24 v. D.C. 2 c/o 3 amp contacts. 400 ohm coil. NEW. 9/6 P. & P. 1/6 or 3 for 30/- post paid.

RECHARGEABLE NICKEL CAD. BATTERY CELLS.

2 x 1.2 v. 250 MA/HR Nickel Cad. Cells, connected to give 2.4 v., at 25 milliamp/10 hour rate, complete with 200/250 v. A.C. charger, unused. Price 9/6 each plus 1/6 p. & p. or 2 units for £1 post paid.

COMPLETE NI. CAD. BATTERY OUT-FIT (EX W.D.)

2 metal carrying cases each containing 10 x 1.2 volt 7AH (12v) batteries, also 10 x 1.2v 22 AH (12v) batteries (40 batteries in all). 1 Dual voltage, dual meter, thyristor controlled charging unit. Designed for charging the 7AH and 22AH batteries simultaneously. Input voltage can be adjusted between 100-250v A.C. Built to ministry specification. Ideal power supply for field work. Offered at fraction of makers price. 2 sets of batteries, 1 charging unit. The set £45 c. & p. 30/-.

NICKEL CADMIUM BATTERY

1.2 v. 35 AH. Size 8 1/2 high x 3 x 1 1/4. 30/- each, plus 4/- P. & P. Sintered Cadmium Type 1.2 v. 7AH. Size: height 3 1/2 in., width 2 1/2 in. x 1 1/2 in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

NEW MODEL HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. 45/- plus 3/6d. p. & p.

SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2 1/2 lb. £4/12/6 post paid.

VENNER ELECTRIC TIME SWITCH

200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 10amp. £2/15/0, 15amp. £3/5/0, 20amp. £3/15/0. Also available with Solar Dial ON at dusk, OFF at dawn.

INSULATION TESTERS (NEW)

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size 1.8 in. W.4 in. H.6 in., weight 6lb., 500 VOLTS, 500 megohms £28 carriage paid. 1,000 VOLTS, 1,000 megohms, £34 carriage paid.

ALL MAIL ORDERS. ALSO CALLERS AT:

57 BRIDGMAN ROAD, LONDON, W.4. Phone: 995 1560 Closed Saturdays.

SERVICE TRADING CO.

SHOWROOMS NOW OPEN AMPLE PARKING

PERSONAL CALLERS ONLY

9 LITTLE NEWPORT STREET, LONDON, W.C.2. Tel.: GER 0576

AERO SERVICES LTD



DETECTOR DIODES.

AA112	15V	8mA	0.05	OA70	22.5V	50mA	0.10
AA120	1V	8.5mA	0.05	OA79	30V	35mA	0.10
*D223	50V	50mA	0.10	OA81	115V	60mA	0.08
*D223A	100V	50mA	0.10	OA85	115V	150mA	0.07
*D223B	150V	50mA	0.12	OA86	60V	35mA	0.15
OA5	100V	115mA	0.15	OA90	20V	40mA	0.10
OA5	60V	115mA	0.20	OA91	90V	50mA	0.10
OA10	30V	220mA	0.50	OA95	90V	50mA	0.10
OA47	25V	110mA	0.10				

* Silicon—all others are germanium.

EPOXY WIRE ENDED HALF-WAVE SILICON RECTIFIERS

DD000	50 p.i.v.	500mA	(45A)	0.15
DD006	400 p.i.v.	500mA	(45A)	0.25
BT127	600 p.i.v.	1A	(25A)	0.15
DD058	800 p.i.v.	500mA	(25A)	0.35
1N5399	1000 p.i.v.	1A	(50A)	0.25
1N5408	1000 p.i.v.	3A	(200A)	0.50

Figures in brackets refer to max. charge current.

E.H.T. SILICON CARTRIDGE TYPE RECTIFIER TYPE H532

10,000 p.i.v. at 350mA DC max. Max. range current 30 Amps £7.00

SPECIAL OFFER OF TRANSISTORS

(minimum order 24 per type) 2N2923, 2N2924, 2N3392, 2N3415 at £1.80 per 24 pieces, post paid.

WHEN ORDERING BY POST PLEASE ADD 0.124 (2/6) IN £ FOR HANDLING AND POSTAGE. NO C.O.D. ORDERS ACCEPTED. ALL MAIL ORDERS MUST BE SENT TO HEAD OFFICE AND NOT TO RETAIL SHOP.

INTEGRATED CIRCUIT AMPLIFIERS

CA3005	RF amplifier, 100mc/s bandwidth	1.35
CA3012	Wide Band Amplifier for IF applications	1.10
CA3020	550mV Audio Amplifier	1.50
CA3036	Two super-alpha pairs for stereo pick-up systems	0.95
CA3052	Latest addition to RCA range. Four-in-one amplifier	2.10
PA222	1.2 watt Audio Amplifier	3.25
PA234	1 watt Audio Amplifier	1.30
PA237	2 watts Audio Amplifier	2.00
MC1709G	G.P. operational Amplifier	1.15
TAA263	3-stage direct coupled Amplifier	0.75
TAA293	3-stage direct coupled Amplifier	1.00
TAA320	MOST input + bi-polar stage	0.65
TAD100	All active components required to construct an AM receiver	2.25
SL403A	3 watts Audio Amplifier	2.40

ZENER DIODES

BZY88 series, from 3.3V to 9.1V ± 5% 400mW . . . 0.17 each
 BZY94 series, from 10.0V to 12.0V ± 5% 400mW . . . 0.20 each
 D814 series, from 7.5V to 13.0V ± 10% 340mW . . . 0.15 each
 D815 series, from 4.7V to 18.0V ± 10% 8 Watts . . . 0.35 each
 D816 series, from 22V to 47V ± 10% 5 Watts . . . 0.35 each
 D817 series, from 56V to 100V ± 10% 5 Watts . . . 0.35 each

Outline: BZY series—miniature—wire ended
 D814—'Top Hat' type
 D815-D817—stud mounted, supplied complete with hardware
 Please state voltage required—nearest standard voltage will be supplied.

TWO NEW OSCILLOSCOPES FROM RUSSIA



CI-5 SINGLE BEAM OSCILLOSCOPE

10 mc/s passband, triggered sweep from 1 μ sec. to 3 milli-sec. Free running time base from 20 c/s to 200 kc/s. Built-in time marker and amplitude calibrator, 3-in. cathode ray tube with telescopic viewing hood. £39.00

CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s passband. Separate Y1 and Y2 amplifiers, rectangular 5 in. x 4 in. cathode ray tube. Calibrated triggered sweep from 0.2 μ sec. to 100 milli-sec. per cm. Free running time base 50 c/s to 1 mc/s. Built-in time base calibration and amplitude calibrator . . . £87.50
 Full details on request. Full servicing facilities and spares available.



OUR NEW CATALOGUE 1970/1971 IS NOW READY. PLEASE SEND S.A.E. FOR YOUR FREE COPY.

OA2	0.38	6U4G	0.33	6BR8	0.65	
OA3	0.45	6U4GB	0.42	6BR7	1.30	
OA4	1.15	6V4G	0.42	6BW6	0.85	
OB2	0.35	6W4GT		6B7	0.70	
OB3	0.60			6BK6	0.25	
OC2	1.00	5X8	0.50	6B3XGT		
OC3	0.38	5Y3GT	0.32		0.75	
OD3	0.35	5Z3	0.50	6B26	0.35	
LA3	0.30	5Z4G	0.40	6C4	0.33	
LA5GT	0.32	6AR6	0.75	6CB6	0.30	
1B3GT	0.35	6AR6	0.35	6CD6GA		
1B24	4.00	6AB4	0.35	1.15	68J7	0.40
1CG5T	0.35	6AC7	0.25	0.60	68K7	0.35
1G4GT	0.45	6AP4A	0.50	0.60	68L7GT	
1G6GT	0.40	6AG5	0.22	0.60	12A V7	0.70
1G5GT	0.42	6AG7	0.40	0.60	12BA4	0.55
1L4	0.20	6AR6	0.50	0.60	12BA5	0.35
1N5GT	0.48	6AJ8	0.30	0.60	12BA7	0.35
1Q5GT	0.50	6AK5	0.30	0.60	12BE6	0.35
1R4	0.35	6AK6	0.40	0.60	12BH7	0.40
1R5	0.35			0.60	12BY7	0.55
1R4	0.27	6AK6	0.57	0.60	12C8	0.35
1R5	0.25	6AL3	0.43	0.60	12E1	1.35
1T4	0.25	6AL5	0.20	0.60	12H6	0.30
1T6GT	0.45	6AM5	0.32	0.60	12J7GT	0.25
1U4	0.27	6AM6	0.33	0.60	12K7G	0.45
1V5	0.50	6AN8	0.50	0.60	12J7GT	0.25
1V2	0.45	6AQ5	0.35	0.60	12K7G	0.45
1X2B	0.40	6AQ6	0.55	0.60	12K5	0.40
2A3	0.40	6AR5	0.35	0.60	12K7G	0.45
2C26A	0.50	6AR6	0.40	0.60	12K7G	0.45
2C39A	7.00	6AR5	0.35	0.60	12K8	0.50
2C40	3.50	6AR6	0.37	0.60	12K8	0.50
2C51	0.45	6AR7G	0.60	0.60	12K8	0.50
2C63	4.50	6AT6	0.30	0.60	12K8	0.50
2C74A	0.55	6AT6	0.30	0.60	12K8	0.50
2D21	0.35	6AV5GT	0.45	0.60	12K8	0.50
2E24	2.55		0.70	0.60	12K8	0.50
2E26	1.50	6AV6	0.30	0.60	12K8	0.50
2K25	8.00	6AW8A	0.60	0.60	12K8	0.50
2X2	0.30		0.55	0.60	12K8	0.50
3A4	0.35	6AX4GT	0.34	0.60	12K8	0.50
3B4	0.60		0.45	0.60	12K8	0.50
3B28	2.15	6AX5GT	0.67	0.60	12K8	0.50
3B1	2.75		0.65	0.60	12K8	0.50
3D6	0.20	6B4G	1.00	0.60	12K8	0.50
3D21A	2.00	6B6G	0.50	0.60	12K8	0.50
3Q4	0.40	6B6G	0.50	0.60	12K8	0.50
3Q5GT	0.45	6B6A	0.25	0.60	12K8	0.50
384	0.35	6BE6	0.30	0.60	12K8	0.50
3V4	0.45	6BF5	0.30	0.60	12K8	0.50
4-128A	8.00	6BF6	0.50	0.60	12K8	0.50
4-400A		6BR6	0.45	0.60	12K8	0.50
4B32	4.00	6BK4B	0.65	0.60	12K8	0.50
4HA5	0.48		1.20	0.60	12K8	0.50
4THA	0.45	6BK7A	0.62	0.60	12K8	0.50
5AR4	0.60		0.55	0.60	12K8	0.50
5B/254M		6BL7GT	0.67	0.60	12K8	0.50
5B/255M			0.85	0.60	12K8	0.50
5B/255M		6BN6	0.40	0.60	12K8	0.50
5B/255M		6BQ5	0.25	0.60	12K8	0.50
5CP1	5.00	6BQ6GT	0.67	0.60	12K8	0.50
5D21	5.00		0.65	0.60	12K8	0.50
5R4GY		6BQ7A	0.40	0.60	12K8	0.50
	0.60	6BR7	0.85	0.60	12K8	0.50

FULLY GUARANTEED



FIRST QUALITY VALVES

30FL1	0.70	328A	2.00	CBL1	0.80	EA52	4.50	ECL86	0.40	EM87	0.55	KT36	1.00
30FL12	0.93	329A	1.15	CB13	0.90	EABCS0		ECLL900		EN10	4.00	KT44	0.50
30FL14		715B	2.50	CL4	0.60		0.35	EF9	0.50	EN32	1.50	KT66	1.70
30FL14	0.75	715C	5.00	CL33	1.00	EAF42	0.55	EF93A	0.60	EN31	0.35	KT71	0.50
30L1	0.40			DAF41	0.50	EAF801		EF93	0.40	EY51	0.40	KT76	0.40
30L15	0.35			DAF91	0.25	EB34	0.20	EP40	0.50	EY80	0.45	KT85	1.75
30P17	0.80			DAP90	0.50	EB91	0.20	EP41	0.65	EY81	0.40	KTW63	
30P12	0.80			DAP96	0.42	EB34	0.50	EP42	0.70	EY83	0.55		
30P19	0.80			DC90	0.45	EBC41	0.55	EP80	0.25	EY84	0.55	ME91	0.45
30P11	0.70			DF91	0.25	EBC81	0.30	EP83	0.55	EY86	0.40	MH4	0.50
30P13				DF92	0.20	EBC90	0.30	EP86	0.35	EY87	0.43	ML4	0.45
30P14	0.93			DF96	0.42	EBC91	0.30	EP86	0.30	EY88	0.43	ML6	0.40
				DH76	0.35	EBF80	0.40	EP89	0.28	EZ35	0.35	MPENT	
				DH81	0.60	EBF83	0.40	EP91	0.33	EZ40	0.45		0.50
				DH101	0.55	EBF89	0.30	EP92	0.40	EZ41	0.45		0.50
				DK40	0.55	EC53	0.50	EP93	0.25	EZ60	0.25	MU12/14	
				DK91	0.35	EC86	0.60	EP94	0.25	EZ81	0.28		0.60
				DK96	0.42	EC88	0.60	EP95	0.30	EZ90	0.30	N78	1.15
				DL66	1.25	EC92	0.35	EP97	0.65	FG17	4.50	NSP1	3.50
				DL68	0.65	EC93	0.50	EP98	0.65	FW4/500		NSP2	4.00
				DL69	1.75	EC8010		EP183	0.30	PABCS0		PL33	0.35
				DL91	0.27		2.25	EP184	0.35	FW4/800		PL36	0.55
				DL92	0.35	EC34	0.40	EP800	0.75	PC86	0.60	PL38	0.50
				DL94	0.45	EC40	0.60	EP804	1.50	PC89	0.60	PL42	0.45
				DL96	0.42	EC70	0.85	EP811	0.75	PC88	0.40	PL43	0.45
				DL98	0.40	EC81	0.33	EP812	0.80	PC88	0.50	PL44	0.40
				DL99	0.25	EC82	0.30	EP813	0.75	PC88	0.55	PL44	0.40
				DL99	0.25	EC83	0.30	EP814	0.75	PC88	0.60	PL45	0.40
				DL99	0.25	EC84	0.30	EP815	0.75	PC88	0.65	PL46	0.40
				DL99	0.25	EC85	0.30	EP816	0.75	PC88	0.70	PL47	0.40
				DL99	0.25	EC86	0.30	EP817	0.75	PC88	0.75	PL48	0.40
				DL99	0.25	EC87	0.30	EP818	0.75	PC88	0.80	PL49	0.40
				DL99	0.25	EC88	0.30	EP819	0.75	PC88	0.85	PL50	0.40
				DL99	0.25	EC89	0.30	EP820	0.75	PC88	0.90	PL51	0.40
				DL99	0.25	EC90	0.30	EP821	0.75	PC88	0.95	PL52	0.40
				DL99	0.25	EC91	0.30	EP822	0.75	PC88	1.00	PL53	0.40
				DL99	0.25	EC92	0.30	EP823	0.75	PC88	1.05	PL54	0.40
				DL99	0.25	EC93	0.30	EP824	0.75	PC88	1.10	PL55	0.40
				DL99	0.25	EC94	0.30	EP825	0.75	PC88	1.15	PL56	0.40
				DL99	0.25	EC95	0.30	EP826	0.75	PC88	1.20	PL57	0.40
				DL99	0.25	EC96	0.30	EP827	0.75	PC88	1.25	PL58	0.40
				DL99	0.25	EC97	0.30	EP828	0.75	PC88	1.30	PL59	0.40
				DL99	0.25	EC98	0.30	EP829	0.75	PC88	1.35	PL60	0.40
				DL99	0.25	EC99	0.30	EP830	0.75	PC88	1.40	PL61	0.40

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £7 per single col. inch.

LINE advertisements (run-on): 8/- per line (approx. 7 words), minimum two lines.

Where an advertisement includes a box number (count as 2 words) there is an additional charge of 5/-
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.

BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to
THURSDAY, 12 p.m., 8th OCT.,
for the **NOVEMBER** issue,
subject to space being available.

Sea-going Radio Officers can now make sure of a shore job and good pay.

If you'd like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £965—£1,215, depending on age, with annual rises up to £1,650 (salaries are under review) and good prospects of promotion to higher posts.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General, or the Ministry of Posts and

Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to:—

The Inspector of Wireless Telegraphy,
External Telecommunications Services,
Wireless Telegraph Section (ww),
Union House,
St. Martins-le-Grand,
London, E.C.1.

Post Office
Telecommunications

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**GET
AHEAD
WITH
SIEMENS**

Siemens, one of Europe's major growth companies, is expanding fast in Britain.

Spearheading this expansion is our electronics business, and so we are always in need of able and ambitious engineers, sales and service men. Even if your specific assignment isn't listed here, therefore, you are invited to send a brief curriculum vitae. We may have precisely the opportunity for career development you are looking for.

SERVICE ENGINEER

We urgently need a Service Engineer to work on high-quality telecommunications test equipment. This is an important assignment: the successful applicant will have had extensive experience of servicing and calibrating this type of equipment. HNC is desirable, but appropriate experience is more important. The job is based in Croydon, and an attractive salary will be negotiated.

INTERNAL TECHNICAL SALES ENGINEER

(Electronic Components)

A man with a sound technical background in electronic components (min. O.N.C.) is required in our Croydon office. The job entails solving customers' technical problems (frequently by telephone) and liaising between our engineers and works. The successful applicant will be capable of working well under

pressure. An attractive salary will be negotiated, appropriate to age and qualifications.

Write to the Personnel Officer at this address:

**Siemens (U.K.) Limited,
Great West House,
Great West Road,
Brentford,
Middx.**

Tel: 01-568 9133


SIEMENS



788

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1971 and subsequent years.

Specialist training courses lasting approximately 8 months are held at intervals. Applications are now invited for the course starting in September 1971.

Salary Scales

During training with free accommodation provided at the Training School:

Age 21	£848 per annum
" 22	£906 "
" 23	£943 "
" 24	£981 "
" 25 and over	£1,023 "

On successful completion of course:

Age 21	£1,023 per annum
" 22	£1,087 "
" 23	£1,150 "
" 24	£1,214 "
" 25 (highest age point)	£1,288 "

then by 6 annual increments to a maximum of £1,749 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must be United Kingdom residents, normally under 35 years of age at start of training course, and must have at least 2 years' operating experience or PMG qualifications. Preference given to those who also have GCE 'O' level or similar qualifications.

Interviews will be arranged throughout 1971.

Application forms and further particulars from: **Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ.**

Tel: Cheltenham 21491 Ext. 2270

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DIEHL CALCULATING SYSTEMS

require additional

ELECTRONIC AND ELECTRO-MECHANICAL ENGINEERS

to maintain a range of electronic/electro-mechanical printing calculating systems in London and the Home Counties. The range includes the Diehl Combitron Desk Computer, Punch tape input/output equipment, and interfacing equipment.

Full training will be given to successful applicants who should have either technical background to ONC/HNC level, City and Guilds or Radio/Radar experience in the forces.

Realistic salaries which will be related directly to experience and capabilities. Transport will be provided. Please send full details of experience to:

**Service Manager,
Calculating Systems Ltd.,
Pyramid House,
956 High Road, Finchley, N.12.**

801



Management Consultants
in Human Resources

17 Stratton Street London W1

Design Engineers

South Africa

TV and Radio

for a well established company having a substantial share of the local markets for radio, radiogram, record player and hi-fi equipment, and now moving into the manufacture of domestic television receivers. These are three new posts to deal with specialist design needs, as follows:

Design Engineer

Car/Portable Radio

to initiate and develop designs and circuits for the mass production of FM/AM radio receivers. Reporting to the Technical Manager he will be responsible for optimising designs by the application of transistor circuitry: he will be supported by drawing office staff and facilities. Candidates should be qualified at HNC level in electrical engineering or electronics and have at least 5 years' experience in circuit and component design of radio receivers. Reference ZH.1759.

Design Engineer

TV Receivers

to initiate and develop designs and circuits for domestic television receivers for both black and white and colour. Reporting to the Technical Manager he will be responsible for the complete electronic designs of sets to meet local systems. He will be supported by drawing office staff and facilities. Candidates should be qualified at HNC level in electrical engineering or electronics and have at least 5 years' experience in designing television or associated electronic equipment. Reference ZH.1760.

Industrial Designer

Entertainment Equipment

To co-operate with technical designers in the final designs of radio, TV and similar equipment to suit market trends and local production methods. In this post technical qualifications are less important than the proved ability to modify and dress technical designs to meet sales requirements without degrading their technical performance. Candidates must have at least 5 years' experience as industrial designers in the light electrical appliances or electronics industries. Reference ZH.1761.

For all three posts the starting salary is negotiable up to £3,000. Free life insurance, contributory provident fund and medical aid scheme. Appointed candidates will be expected to emigrate to South Africa with the assisted passage scheme. Telephone or write to P. H. L. Thomas quoting the appropriate reference.



The MSL Consultant has analysed each appointment

Further information will be sent if you provide your name and address by telephoning 01-629 1844 or writing to the consultant quoting the reference. Your enquiry will be in confidence.

812

If you're a telecommunications man and match up to the qualifications below cut yourself into a slice of Britain's future



Become a

Radio Technician

in the fast-growing world of Air Traffic Control

Please send me an application form and details of how I can join the fascinating world of Air Traffic Control Telecommunications.

Name

Address

Not applicable to residents outside the United Kingdom www/£2

To: A J Edwards, C Eng, MIEE,
The Adelphi, Room 705, John Adam Street, London WC2
marking your envelope 'Recruitment'

Sending this coupon could be your first step to a job that's growing in importance every year.

The National Air Traffic Control Service needs Radio Technicians to install and maintain the vital electronic aids that help control Britain's ever-increasing air traffic.

This is the kind of work that requires not only highly specialised technical skills but also a well developed sense of responsibility, and candidates must be prepared to undergo a rigorous selection process. Those who succeed are assured a steadily developing career of unusual interest and challenge. Starting salary varies from £1044 (at 19) to £1373 (at 25 or over) : scale maximum £1590 (higher rates at Heathrow). There is a good annual leave allowance and a non-contributory pension for established staff.

You must be 19 or over, with at least one year's practical experience in telecommunications, ('ONC' or 'C and G' qualifications preferred).

NATCS

National Air Traffic Control Service

Work as a RADIO TECHNICIAN attached to Scotland Yard

You'd be based at one of the Metropolitan Police Wireless Stations. Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment, which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale: £1,161 (age 21), rising by increases to £1,590 plus a London Weighting Allowance. Promotion to Telecommunication Technical Officer will bring you more.

For full details of this worthwhile and unusual job, write to: Metropolitan Police, Room 733 (RT), New Scotland Yard, Broadway, London, S.W.1.

656

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,350 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to Assistant Personnel Officer NCR, 1,000 North Circular Road, London, NW2 quoting publication and month of issue.

Plan your future with



RADIO TECHNICAL OFFICERS

Earnings in excess of £2,000 p.a.

The P.L.A. operate a wide telecommunications network from Tower Pier to the outer Thames Estuary, and vacancies exist at the King George V Dock for Radio Technical Officers to maintain the equipment at maximum efficiency.

To ensure adequate coverage, a shift system is operated.

Salary scale: £1,400-£1,520 p.a.

Plus pay supplement: £160 p.a.

Plus allowance for week-end and public holiday working: £275 p.a.

Payment at enhanced rates for overtime working when required.

Earnings in excess of £2,000 p.a. are possible.

Minimum qualifications:—O.N.C. Electrical Engineering

or City & Guilds Intermediate Certificate

in Telecommunications Engineering

plus Radio II

or equivalent Service qualifications.

Applicants should have at least 5 years' experience in semi-conductors and in at least two of the following fields:—

V.H.F. and U.H.F. Radio

Radar and Microwave Links

Telemetry and Digital

Teleprinters and Message Switching.

Application forms may be obtained from:—

The Chief Engineer (Personnel),

Port of London Authority,

P.O. Box 242, Trinity Square,

London, E.C. 3P 3 BX



PORT OF LONDON
AUTHORITY

One of the subsidiaries of a large international trading organisation operating in East Africa, requires the services of an:

X-RAY SERVICE ENGINEER (to be stationed in Nairobi, Kenya)

Candidates for this position must be prepared to travel extensively and have a thorough and practical experience with the installation and maintenance of:

X-RAY EQUIPMENT, ELECTRO MEDICAL and HOSPITAL EQUIPMENT

A working knowledge of Electronic Calculators will be an added advantage.

The successful applicant will be on contract for a tour of three years in the first instance with three months paid overseas leave. Salary will be dependant on experience and qualifications in the scale of K.£1,800—K.£2,100 with an annual bonus payment. Terms include annual local leave, free housing, medical scheme, company's pension fund and car, children and education allowances.

Written applications, giving full details of education, qualifications, age and experience should be forwarded to:

TOM MANAGEMENT LTD
P.O. Box 12186
NAIROBI, Kenya

Interviews for this position will be arranged in the United Kingdom or The Netherlands 791

REUTERS

DP AND DATA TRANSMISSION SERVICE ENGINEERS

News is our business at Reuters—we gather it from all over the world, sift it, edit it, and then get it to our thousands of subscribers just as fast as we can, twenty-four hours a day, every day of the year. We couldn't begin to cope without sophisticated data handling systems and computers. We are dependent on our communications and need more data processing or data transmission engineers to service our equipment comprising the following:

- PDP8 electronic message switching systems.
- STOCKMASTER and electronic brokerage systems, including remote display terminals.
- Reuters international data transmission systems
- Peripheral and ancillary equipment.

Qualifications. Preferably HNC, or equivalent, in relevant subjects. Consideration will also be given to Retiring Service personnel with Service qualifications, or engineers without formal qualifications but trained by a leading computer or communications company.

Experience. Two years or more in the maintenance of digital equipment—Processing, Retrieval or Data Transmission. Preference will be given to applicants who have experience in all three areas of operation.

Salary and Conditions. Starting salary will depend on experience and ability, and holidays and general conditions of employment are among the best in industry. Some vacancies will require shift working on a two shift system which operates from 8-4 and 2-10 alternate weeks. These positions are at our Head Office in London and for those applicants who measure up to our requirements we can promise an interesting and busy life where rewards will match performance.

Write or telephone for an application form, to:

Brian Heywood,
REUTERS Limited,
85 Fleet Street, London, EC4
Telephone: 01-353 6060

Communications Technicians

Home and Overseas

The Diplomatic Wireless Service requires men capable of working without supervision for the installation, modification, maintenance and operation of (a) radio transmitters and receivers, remotely tuned aerial systems, teleprinters and voice frequency telegraph equipment over a worldwide network, or (b) very high power transmitters, receiving equipment, tape-recorders, generating plant, etc., at several high power broadcasting stations, or (c) a wide variety of telephone subscribers' apparatus, machine telegraph and other specialised equipment, or (d) microwave receivers, associated test equipment, recorders and audio amplifiers, or (e) machine telegraph and electronic ancillaries.

Initial appointment will normally be at Hanslope Park (Bucks), or Crowborough (Sussex) or in London, but successful candidates must be prepared to serve anywhere in the United Kingdom or overseas.

QUALIFICATIONS: ONC in Engineering, including a pass in Electrical Engineering, or equivalent standard of technical education; and at least 5 years' appropriate training and experience.

SALARY (National): £1,224 (at 21) to £1,352 (at 23) to £1,643 (at 28 or over on entry), rising to £1,839, with prospects of increases to £2,730 on promotion. (London rates are £75 or £125 more). Non-contributory pension.

For full details and an application form (to be returned by 8 October, 1970), write to Civil Service Commission, Alencon Link, Basingstoke, Hants, quoting S/7554/70

775

MEDICAL ENGINEERING IN HOSPITALS MEDICAL ELECTRONICS TECHNICIAN

required in the Northampton Group of Hospitals to service, repair and calibrate a wide range of electronic equipment used in hospitals for medical, surgical and engineering purposes.

Candidates should have good practical experience in radio/telecommunications, pulse generation, automatic control systems or electro-medical equipment. Possession of HNC or HND in electronics or a comparable qualification would be an advantage.

Opportunities for further study and training available. Salary scale: £1,356—£1,764 p.a.

If you are interested in receiving further details of this opportunity, please write to the Group Secretary, Northampton & District Hospital Management Committee, General Hospital, Northampton, NN1 5BD.

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UNIVERSITY OF LANCASTER ELECTRONICS TECHNICIAN

The Department of Engineering invites applications from suitably qualified persons for a post as **Laboratory Electronics Technician** who must be experienced in solid state electronics and instrumentation; duties will include assisting in the design and making of new equipment for teaching or research and the maintenance of laboratory equipment.

Application forms (returnable by October 3, 1970) and further information available from the Staff Officer, University of Lancaster, Bailrigg, Lancaster. 802

JUNIOR TECHNICIAN

required at our Hampstead Laboratories, Holly Hill, N.W.3. Suitable for applicant in early 20's with some experience of workshop practice and an interest in electronic instrumentation. Minimum qualifications 4 G.C.E. 'O' Levels to include English, Maths and a Science subject. Salary according to age on scale £706 to £1,144 p.a. Please apply quoting our reference WW 62/1 to: Miss A. Furber, National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7. Tel.: 959 3666.

758

West Sussex County Council INDUSTRIAL TRAINING CENTRE, CRAWLEY

TRAINING INSTRUCTOR

Qualified applicant required to instruct Electrical Craft and Technician Engineer apprentices during first two years of apprenticeship. Good qualifications and experience in electronics are essential.

Salary scale:

£1,362—£1,902—£2,052 per annum

Further particulars and application form from: **Head of Centre, Industrial Training Centre, College Road, Crawley.** Completed form to that address within 14 days of the appearance of this advertisement. 794

Installation Design Draughtsmen

This senior appointment (with appropriate salary) involves responsibility for preparing radio station installation plans and supporting lists of installation materials.

Resulting from expansion of Pye Telecom Radio Systems business, the position demands considerable experience. Probably in your early 30's and having served a workshop apprenticeship, you should have as a minimum O.N.C. or equivalent in mechanical engineering. You'll need in addition a sound background in the mechanical design of light electronic or electrical equipment, preferably in the telecommunications industry; ability to read architectural drawings as applicable to installation design; familiarity with industrial procedures; and awareness of the market position for the supply of proprietary equipment used in large radio installations.

Please write, including details of your previous career to: Mr. M. W. Timmins, Senior Personnel Officer,



Pye Telecommunications Ltd



Newmarket Road, Cambridge, CB5 8PD
Telephone: Cambridge 61222

793

Design / Development Engineers

-come and make our products obsolete.

Today's new developments at Pye Telecom will be old hat within 5 years. That's the attitude which has put this company on top of the radio-telephone manufacturing league.

Now Pye Telecom are hotting the pace up further still. With massive expansion. And, hopefully, your help. You will be in the midst of exciting innovations—new products, new techniques, new components. Everything your work demands will be there—including computers for use as design aids and on-line Europe-wide research facilities.

In return for your talents . . . rewards, promotion opportunities and conditions of service which match the very best in industry today. There's a choice of 2 pleasant locations—Cambridge or Southend—and relocation expenses will naturally be company paid.

So how about it? You'll need an electronics degree or equivalent, circuitry experience, and preferably 2/3 years of VHF/UHF radio-telephone design experience. It will help, alternatively to have experience in other fields such as radar broadcasting or television.

Please phone for an application form or write giving full details of your experience and salary requirements to:
Mike Timmins, Senior Personnel Officer,



Pye Telecommunications Ltd 
Newmarket Road, Cambridge, CB5 8PD.
Tel: Cambridge 61222

811

Electronic Video Recording

EVR is being jointly developed by a consortium of CIBA, the international chemical group, ICI and CBS of America; Ilford is a member of the CIBA group, and we

now require the following additional staff for this project at Basildon in Essex:

SENIOR AUDIO ENGINEER and AUDIO ENGINEER

for the operation and maintenance of high quality magnetic and optical sound equipment.

A good theoretical knowledge and practical experience of audio recording and reproduction is essential. Candidates should also have experience of interlock system, multiple track recording, frequency modulation, audio dubbing facilities, compression, expansion and frequency equalisation equipment, measurement of distortion, wow and flutter and all other parameters in an audio system. An appropriate qualification would be an advantage.

Applicants for the above position must be prepared to work on shifts in due course. Commencing salaries will be in the range £1800 to £2500, according to qualifications and experience. We

operate a contributory pension scheme, free life assurance and sickness schemes. Assistance will be given with relocation expenses where appropriate.

Applications, quoting reference ZH.39, giving details of qualifications and career to date, should be addressed to:
The Personnel Manager, Ilford Limited, Christopher Martin Road, BASILDON, Essex.



ILFORD



Electronic Video Recording

EVR is being jointly developed by a consortium of CIBA, the international chemical group, ICI and CBS of

America; Ilford is a member of the CIBA group. The EVR Unit at Basildon in Essex requires a:

SHIFT CONTROL ENGINEER

to be responsible for the supervision of the overall operation of the video tape and sound transfer facilities on a shift basis.

The successful applicant will preferably have experience of video tape recording and editing, telecine operation, tele-recording and film characteristics, optical and magnetic sound transfer, vision and sound mixing apparatus and the control of staff in a senior television engineering capacity.

Applicants must be prepared to work on shifts in due course.

Commencing salary will be negotiable in line with experience.

Assistance will be given with relocation expenses where appropriate and rented accommodation can be arranged under the Basildon New Town scheme.

We operate a contributory pension scheme, free life assurance and sickness schemes.

Applications, quoting reference ZH.42, giving details of qualifications and career to date, should be addressed to:

The Personnel Manager, Ilford Limited, Christopher Martin Road, BASILDON, Essex.



ILFORD



748

SENIOR TEST ENGINEERS

The leading U.K. Manufacturers of high grade T.V. monitors and ancillary T.V. studio equipment require Senior Test Engineers for their rapidly expanding test department. Situated in the Berkshire town of MAIDENHEAD the company offers pleasant working conditions, good salaries, and a friendly environment.

Duties will cover the testing and troubleshooting of our complete range of equipment. Previous experience on television equipment is not essential but candidates must have a thorough knowledge of electronics and testing procedures.

Reply to:

PROWEST ELECTRONICS LTD.,

Boyn Valley Road, Maidenhead, Berks.

Telephone: Maidenhead 29612

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TELECOMMUNICATIONS ENGINEERS WEST AFRICA

Qualified Telecommunications Engineers are required for servicing and maintenance of radiotelephone equipment and associated items in tropical West Africa.

Qualifications: HNC or higher.

Contract: One year plus leave extensible.

Salary: According to age, experience and qualifications.

Commencing at not less than equivalent £2000 sterling.

Free accommodation and passages. Preference for bachelors with tropical experience but not essential.

Interested? Apply for application form to:

C.O.D.E.C.O.

2b-Sussex Road - New Malden - Surrey

635

Calling

Electronic Fault Finders & Inspectors

Our electronic paging equipment is in increasing world-wide demand—we need to call on more people with experience of printed circuit work to test and service this equipment NOW.

Bring your experience to us—of course the rates of pay and overtime opportunities are good but we offer that much more. . . job satisfaction, security, a future with a pace-setting Company.

We've called you—now take this opportunity and contact



The Personnel Manager.

Multitone Electric Co. Ltd.

10-28, Underwood Street,

London, N.1.

Tel: 01-253 8022.



THE UNIVERSITY OF LEEDS

Applications are invited for posts in the following Department: PHYSICS

(i) EXPERIMENTAL OFFICER/ SENIOR EXPERIMENTAL OFFICER

The successful applicant will be responsible for the design of a wide range of electronic apparatus covering DC and pulse amplifiers and digital recording systems. Minimum qualification: Degree in Physics or Electrical Engineering, together with appropriate experience. A well-equipped laboratory is available. Reference number 22/6/C1.

(ii) RESEARCH FELLOW/ RESEARCH ASSISTANT

Applicants should have a Ph.D. or appropriate research experience and should be interested in applying their knowledge and experience to the analysis and interpretation of data from the Haverah Park Extensive Air Shower Array. This Array has now been running for ten years and is yielding results on primary cosmic ray particles with energies in excess of 10¹⁷eV. The post will be tenable for two years. Reference number 22/7/C1. SALARY SCALES: Experimental Officer/Senior Experimental Officer: £995-£2,235; Research Fellow/Research Assistant: £900-£1,600. Applications (2 copies) stating age, qualifications and experience and naming three referees, should be sent to the Registrar, The University of Leeds, Leeds LS2 9JT. Please quote appropriate reference number.

CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following

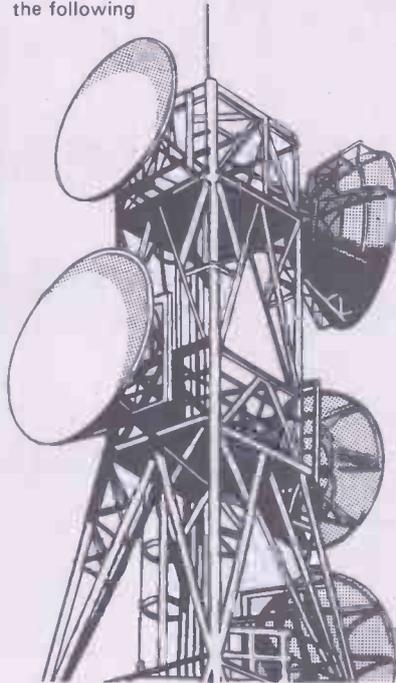
Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.



Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

STC

91

RADIO SPECIALIST

POLICE DEPARTMENT ZAMBIA

- ★ Salary £2,310 to £2,590 according to experience
- ★ Low Taxation
- ★ Contract of 36 months
- ★ 25% Tax Free Gratuity
- ★ Educational Allowances
- ★ Subsidised Housing

Duties will involve the maintenance and installation of police radio equipment throughout Zambia, travelling by road and air.

The equipment includes modern low and medium power H.F. equipment, S.S.B. equipment and V.H.F. equipment including multiplex links. Knowledge of maintenance of teleprinters, diesel and petrol generators preferred.

Candidates, who will serve in the rank of Inspector of Police (non-uniformed), must have completed a five year apprenticeship or hold a service trade certificate or equivalent qualification and have at least six years post qualification experience.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2Z/61274/WF



Communications Technician Libya

For installation and maintenance work on all types of equipment including UHF/VHF, teleprinter, and telephone exchange. This is a bachelor posting with 17 days home leave after each 45 days and very generous terms and conditions.

Candidates should possess a minimum of City and Guilds Telecommunications Certificate PL 49 or equivalent, and have experience of telephone and teleprinter equipment.

Please write briefly quoting reference ZH166, to:

P. J. Moritanjees, Recruiting Officer, The British Petroleum Company Limited, Britannic House, Moor Lane, London, EC2Y 9BU.

809

ELECTRONIC SERVICE ENGINEER

Required to assist in the Servicing, Maintenance and Development of electronic and electro-magnetic equipment in the Printing industry.

Although formal technical qualifications are not vital, applicants must have a wide experience in press register and drive controls, complex relay logic, computer peripheral equipment, etc. The position also necessitates light mechanical work.

It is intended that the engineer will be engaged on shift duties.

Salary by negotiation.

Apply in writing to:—

**PERSONNEL OFFICER
HAZELLS OFFSET LIMITED,
Leigh Road, SLOUGH, Bucks.**



Member of The British Printing Corporation Limited

Metropolitan Police Office

TELECOMMUNICATIONS TECHNICIANS

Five posts in the Lines Section of the Telecommunications Branch at New Scotland Yard involving co-ordination and planning in connection with the provision, development and maintenance of line communications and associated equipment.

Candidates (men or women) should normally be aged at least 23. They must have ONC in Engineering, including a pass in Electrical Engineering, or have attained an equivalent standard of technical education, and at least 5 years' appropriate training and experience.

SALARY: £1,477 (at age 23)—£1,768 (at 28 or over on entry); rising to £1,964. Promotion prospects. Non-contributory pension.

For full details and an application form (to be returned by 8 October 1970), write to Civil Service Commission, Alencon Link, Basingstoke, Hants. quoting S/7544/70.

774

CIRCUIT DESIGNERS

Required for Television and Communication Development, dealing with broad spectrum of circuit techniques embracing solid-state technology from discrete components to L.F.I.

The positions are with the engineering designs subsidiary of a leading television organisation, preferred qualifications are B.Sc., H.N.D. or H.N.C. and the membership of an appropriate professional body. Company insurance and pension scheme, three weeks leave, salary which is competitive with comparable industry levels, will be paid.

Reply to the:

**Managing Director,
DYNAMIC TECHNOLOGY LIMITED,
Station House, Harrow Road,
Wembley, Middlesex.**

785

UNIVERSITY OF ST. ANDREWS Department of Psychology

Applications are invited for the post of CHIEF TECHNICIAN

in the Department of Psychology tenable for three years in the first instance. The person appointed should hold a Higher National Certificate or its equivalent and possess special skills in the design and construction of electronic control apparatus. Salary scale £1676 to £1909; starting salary according to qualifications and experience. Pension scheme. Applications, with the names of two referees, should be lodged not later than 15 October, 1970, with the

**Secretary of the University
College Gate, St. Andrews**
from whom further particulars may be obtained.

789

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67]

A PPLICATIONS are invited for the post of electronics technician in the Department of Psychology. Candidates should have or be completing Final City and Guilds in Electronic Servicing, or an equivalent qualification. Candidates with ET4 or O.N.C. and with special experience in electronics will be considered. Familiarity with electrophysiological equipment or interest in or experience with small computers would be an advantage. The salary will be on the scale £935-£1,303 per annum. The initial point of entry will depend on qualifications and experience. Apply in writing, quoting ref. T24, to Assistant Bursar (Personnel), University of Reading, Whiteknights, Reading, Berkshire. [757]

ARE YOU INTERESTED IN HI FI? If so, and you have some experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 92 Tottenham Court Road, London, W.1. Tel. 01-387 7467/8. [21]

A SENIOR Transformer/Rectifier design Engineer is required for varied and interesting projects associated with equipment up to 150kVA/KW. We are an expanding Company of Manufacturing Electrical Engineers located in South Herts, Box W.W. 97 Wireless World. [779]

CANADA. Thousand Islands Tourist Region. TV engineer for expanding, modern service department. Starting salary \$5,200-\$5,500. Write, Atkinson Sheridan Service Co., 139 King St. W., Brockville, Ontario, or phone 613-342-3873. [779]

ELECTRONIC ASSEMBLY and wiring accepted by manufacturing workshop, phone Workshop Manager, Pan Wholesale Ltd., 33-37 Wardour Street, W.1. Phone 01-437 3733. [764]

ELECTRONICS TECHNICIAN required in Department of Medicine. Work involves development and maintenance of respiratory instrumentation in Clinical and Physiology sections of group. Experience in Analog and digital techniques desirable. Salary range £1,235-£1,535 per annum. Applications to Secretary, Royal Postgraduate Medical School, Ducane Road, London, W.12, quoting ref. 2/444. [763]

JUNIOR ELECTRONICS TECHNICIAN required for construction and repair of electronic instruments and maintenance of a Linear Accelerator. G.C.E. "O" level in Physics and Maths required; "A" levels or O.N.C. an advantage. Day release for further study is possible. Salary according to age and experience. Apply with full details to the Director, Medical Research Council Cyclotron Unit, Hammersmith Hospital, London, W.12. [778]

Electronic Video Recording

EVR is being jointly developed by a consortium of CIBA, the international chemical group, ICI and CBS of

America; Ilford is a member of the CIBA group and our plant at Basildon, Essex, requires a:

TECHNICAL ASSISTANT

for the operation and maintenance of Television and Audio Equipment

A good knowledge of radio and television theory together with some practical experience in television engineering or allied fields is essential. HNC or equivalent would be an advantage.

Commencing salary will be from £1300 according to qualifications and experience. We operate a contributory pension scheme, free life assurance and sickness schemes.

Applications, quoting reference ZH.40, giving details of qualifications and career to date, should be addressed to:

The Personnel Manager, Ilford Limited, Christopher Martin Road, BASILDON, Essex.



ILFORD



750

DEVELOPMENT ENGINEER

Urgently required—a dynamic young Development Engineer to join a design team working on H.F. Single Side Band Transceivers. Must be thoroughly familiar with the application of integrated circuits, field effect transistors and other state-of-the-art techniques. Attractive salary, Staff Pension Scheme, Canteen facilities, etc. Please apply giving a summary of your experience in this field of activity to **The Personnel Manager, Labgear Ltd., Cromwell Road, Cambridge. Tel. No. Cambridge 47301.**

760

Applications are invited from qualified candidates for the following post in the Electronics Department at Poole General Hospital:

ELECTRONICS TECHNICIAN III

Qualifications: O.N.C., H.N.C., City & Guilds or equivalent.

Salary: £1,180 x 8 increments to £1,500 per annum.

The Department will be primarily concerned with the installation, testing and maintenance of an extensive range of diagnostic/therapeutic and allied electronic equipment, and ultimately with research and development of bio-medical equipment in consultation with medical staff.

The position offers adequate scope for initiative and career progression, including the possibility of assistance with further training.

Applications, giving full details, including qualifications, experience and the names and addresses of two referees, to the Hospital Secretary, Poole General Hospital, Poole, Dorset.

761

Supervisory Systems Technicians

A progressive, well-paid career could be yours, in our expanding Systems Design Department. We have vacancies at junior and intermediate levels, with opportunities for promotion to Engineer grades, for technicians who have experience of industrial instrumentation or digital electronics and the ability to work on detail logic design.

Applicants should have, or be studying for, a City & Guilds, ONC or HNC qualification in electronic engineering.

Write or telephone D. J. W. Barker, Training & Recruitment Officer, for a full job specification and application form.



Serck Controls
systems division

Queensway, Leamington Spa, Warwickshire
Tel: Leamington Spa 27030.

A member of the Serck Group

806

GEC-Marconi Electronics

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON QUALIFIED OR NOT!

VACANCIES exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits.

RE-LOCATION EXPENSES available in many instances.

CONDITIONS excellent; free life assurance, pension schemes, canteen, social club.

37½-hour, 5-day, office-hours week.

WRITE or phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required, quoting WW 6



MARCONI INSTRUMENTS LIMITED,
Longacres, St. Albans, Herts.
Tel: St. Albans 59292
Luton Airport, Luton, Beds.
Tel: Luton 31441.

A GEC-Marconi Electronics Company



676

Telecommunications Engineer
Up to £2,438

The Meteorological Office is looking for an engineer to work at its headquarters in Bracknell, Berks, on the planning, provisioning and installation of landline and radio telecommunications systems. These systems transmit data and analogue/digital facsimile, some of the input being received via satellites and the output being fed into computers. The work is varied, interesting and involves the use of the most modern techniques.

Applicants must have satisfied the training and examination requirements of an appropriate Institution (or be Corporate Members) or hold a degree in engineering or physics. Some relevant experience expected.

STARTING SALARY: up to £2,438 according to qualifications and experience. Non-contributory pension.

Write to Civil Service Commission, Alencon Link, Basingstoke, Hants, for application form, quoting S/7546/70. Closing date 8 October, 1970.

773

WE KNOW YOU WANT A BETTER JOB
and what is more **WE WILL HELP YOU FIND IT.**



Experienced engineers in Design and Development, Systems Test, Technical Sales, Production Engineering, Field Service or Technical Writing should

Contact Electronics Appointments Ltd.
and we will help you.

Our placement service is professional, specialised and completely confidential. We are in consultation with over 800 companies on all aspects of electronics engineering. Phone or write at any time quoting WW 101.

NORMAN HOUSE · 105/109 STRAND · LONDON · W.C.2
TEL: 01-836 5557

554

MAINTENANCE ENGINEER required for major recording studio in London. Preferably experienced in setting up and maintaining professional equipment, but applicant with a suitable background considered. Please apply in writing to Mr. P. Godwin, Pye Studios, A.T.V. House, Gt. Cumberland Place, London, W.1. [759]

MEDICAL PHYSICS TECHNICIAN III required in the Artificial Kidney Unit at St. James's Hospital. Main responsibilities will be to maintain electrical/electronic equipment associated with hospital and home dialysis. Salary and conditions of service in accordance with appropriate Whitley Council recommendations. Applications stating age, experience and qualifications together with the names of two referees to the Group Secretary, St. James's Hospital, Leeds LS9 7TF. [796]

PLYMOUTH POLYTECHNIC, DEPARTMENT OF CIVIL, MECHANICAL AND PRODUCTION ENGINEERING. Required, Technician Grade III to maintain, service and assemble electronic instrumentation and equipment. Candidates must possess Final City and Guilds or equivalent qualifications and have had appropriate Industrial Experience. Would probably suit Ex-Servicemen with appropriate experience. Particulars and forms of application (s.a.e.) from Clerk to the Governors, Education Department, Municipal Offices, Plymouth, PL1 2EW, to whom they should be returned within 10 days. [816]

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26]

SENIOR TECHNICIAN/TECHNICIAN required for the construction, development and surveying of an interesting variety of electronic apparatus in modern chemistry teaching and research laboratories. Salary in ranges £1,248-£1,556 p.a. and £905-£1,273 p.a. according to age and experience, plus London Weighting £125 p.a. and possible £30 or £50 p.a. qualification allowance. Five-day week. Four/five weeks annual leave. Pension scheme. Letters only to Registrar (C/T/ST), Queen Mary College (University of London), Mile End Road, London, E1 4NS, stating which post applied for, age, past and present experience, any qualifications. [756]

TECHNICAL OFFICER in ELECTRONICS required for the design and development of solid state circuitry involved in the development and use of a cyclotron for medical research. Applicants should have a Pass Degree or HNC, and experience in the use of integrated circuits, switching circuits, or data handling techniques. Age under 35. Salary in range £1,723-£2,057 + £90 L.W. Apply to Director, Medical Research Council Cyclotron Unit, Hammersmith Hospital, London, W.12. [777]

THE UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY. TECHNICIAN OR SENIOR TECHNICIAN (ELECTRONICS). REF. OPT/237/AO required in the Department of Ophthalmic Optics. The successful candidate will be required to maintain, and occasionally design and build, electronic and other research equipment. Current research with the Department includes studies and applied optics and neurophysiological behavioural work on visual perception. Salary Grades: Technicians, £905-£1,273 per annum; Senior Technicians, £1,248-£1,556 per annum. (Additions of £30 and £50 in each grade for educational qualifications. Commencing grade and salary will be dependent upon qualifications and experience.) Requests for application forms, quoting above Reference, should be made to the Registrar, U.M.I.S.T., Sackville Street, Manchester M60 1QD. Completed forms to be returned by 5th October, 1970. [792]

TV RETAIL BUSINESS of the highest standing, established over 40 years N.W. London. Owner requires **PERSONAL ASSISTANT** with servicing experience. Good position and prospects for keen and capable man. State age and details of experience. Box W.W. 537 Wireless World.

WIRELESS Technicians. There are vacancies at the Home Office Wireless Depots throughout England and Wales for Wireless Technicians to assist with the installation and maintenance of VHF and UHF Systems. Pay—£1,161 (at age 21) rising to £1,590 p.a., 5-day, 40-hour week with overtime payable and 3 weeks paid holiday a year. Good Promotion Prospects. **QUALIFICATIONS**—City and Guilds Intermediate Telecommunications Certificate or equivalent, or good experience in Telecommunications. For further details write to: Directorate of Telecommunications, Home Office, 60 Rochester Row, London, S.W.1. [804]

X-RAY TUBE ENGINEER OR TECHNICIAN for X-ray tube plant in important country in SOUTH AMERICA. Candidate must have minimum of 7 years' experience in production of fixed and rotating anode x-ray tubes. No language requirement. Salary will be minimum £4,000 annually plus use of car and other benefits. Outstanding opportunity for right person. Write full details to "XRay Tubes," Box No. 762, Wireless World.

ARTICLES FOR SALE

AVO Mk. 4 Valve Characteristic Meter, mint condition, £95 o.n.o. Wanted, modern Pye Radio-telephone Equipment.—Austen, 1 Valebridge Road, Burgess Hill, 3409 (day). [754]

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. X 2½ in. X any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76]

EPSYLON closed circuit TV channel VC10T transistor Vidicon camera control power unit, two monitors, any reasonable offer considered. 01-892-4076.

HI-FI EQUIPMENT—Radio Tape Recorders, complete systems supplied and installed. Spares & components. Radio and T.V. valves. First class repair service. Telephone Farnborough (Hants) 42590/49101. [705]

MUSICAL MIRACLES. Send S.A.E. for details of Cymbals and Drum Modules, versatile independent bass pedal unit for organs, pianos or solo, musical novelties, waa-waa kits (49/3). Also bargain components list reed switches etc. D.E.W. Ltd., 254 Ringwood Road, Ferndown, Dorset. [95]

Electronic Video Recording

EVR is being jointly developed by a consortium of CIBA, the international chemical group, ICI and CBS of

America; Ilford is a member of the CIBA group. The EVR Unit at Basildon in Essex now requires additional:

VTR ENGINEERS

They must possess operational and maintenance experience of 2" quadruplex video tape recorders and have a thorough knowledge of colour television principles.

Applicants must be prepared to work on shifts in due course. Commencing salaries will be negotiable according to qualifications and experience. Assistance will be given with relocation expenses where appropriate. Rented accommodation can be arranged under the Basildon New Town scheme. We operate a contributory pension scheme, free life assurance and sickness schemes.

Applications, quoting reference ZH.41, giving details of qualifications and career to date, should be addressed to: The Personnel Manager, Ilford Limited, Christopher Martin Road, BASILDON, Essex.



ILFORD



749

AGRICULTURAL RESEARCH COUNCIL

Food Research Institute

Electronics technician required. The work is concerned with the construction and testing of electronic equipment together with some maintenance of existing instrumentation.

Applicants should have served an apprenticeship and possess a good theoretical and practical electronic background together with some workshop experience. An O.N.C. in electronics will be an advantage.

Salary on Technical Works Grade III, starting salary according to age, from £1,092 to £1,442 at age 28, rising by annual increments to a maximum of £1,643.

Optional contributory superannuation scheme.

Application forms from Secretary, Food Research Institute, Colney Lane, Norwich, NOR 70F, quoting 70/18.

805

JUNIOR TECHNICIAN

required at our Hampstead Laboratories, Holly Hill, N.W.3. Suitable for applicant in early 20's with some experience of workshop practice and interest in electronic instrumentation. Minimum qualifications 4 G.C.E. 'O' Levels to include English, Maths and a science subject.

Salary according to age on scale £706 to £1,144 p.a.

Please apply quoting our reference WW64/1 to:

Miss A. Furber,
NATIONAL INSTITUTE for
MEDICAL RESEARCH,
The Ridgeway, Mill Hill, London, N.W.7.
Telephone: 959 3666

784

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

Tenders are invited for the Supply of Close Circuit Television Equipment for the Brighton Polytechnic (Technology).

Forms of Tender are available from the Director of Education, 54 Old Steine, Brighton, BN1 1EQ.

803

Test Technicians

Our test department is expanding. It is responsible for the testing of magnetic storage devices, high-speed printers, punched-card and paper-tape equipment.

For people with experience in electronics, opportunities exist immediately. Further vacancies will arise over the next few months. Training will be given to those who do not have previous computer experience.

Applicants must have worked on the testing, maintenance or repair of electronic equipment, and preference will be given to those qualified to ONC (Elect.) or C & G Final.

Locations: Kidsgrove and Winsford. Both are situated in rural surroundings bordering on the Cheshire Plain. Housing is available at attractive prices, and assistance with mortgage can be arranged.

Write giving details of age, qualifications, and experience, to: Brian Buckley, Personnel Manager, International Computers Limited, Kidsgrove, Stoke-on-Trent, quoting reference WW498M.

International Computers

ICL

Radio and Electronic Engineers

for Air Traffic Control Systems

The National Air Traffic Control Service requires radio and electronic engineers to work on sophisticated electronic systems custom built to meet highly specialised operational requirements.

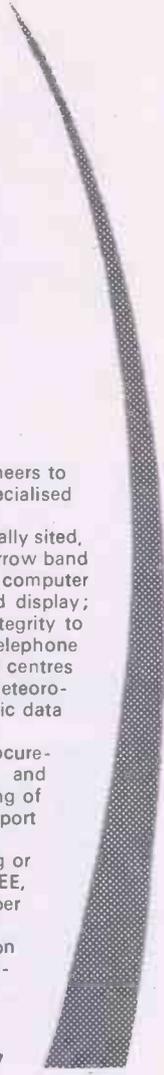
These systems include primary and secondary surveillance radars, strategically sited, which send automatically a continuous stream of data over wide band or narrow band links to Air Traffic Control Centres for processing and display; modern computer based installations now being introduced to speed up data extraction and display; radio aids to en-route navigation; instrument landing systems of high integrity to facilitate automatic approach and landing at major airfields; advanced radiotelephone networks linking pilots and air traffic controllers; automatic telegraph relay centres for passing messages about the movements of aircraft and for handling meteorological information; closed circuit television installations and other automatic data transfer systems.

Engineers help in systems planning, work on equipment specification, procurement and evaluation, and on installation planning, maintenance policy and direction. They may also be required to take part in the day-to-day running of the organisation in the field, for example, at an air traffic control centre, an airport or at a signals centre.

Qualifications: 1st or 2nd class honours degree in Electrical Engineering or Physics, or have passed or obtained exemption from the examinations for MIEE, MIERE, or AFRAeS. You should be aged between 23 and 35 on 31st December 1970 (extensions if you are ex-H.M. Forces or Overseas Civil Service).

Starting salary can be as high as £2,425, (Inner London) depending on qualifications and experience. Prospects of promotion within 3 years are outstanding.

For more details and an application form, (which must be returned by 8th October 1970) write to: The Civil Service Commission, Alencon Link, Basingstoke, Hants., quoting ref. no. S/85/ASO/787



FOR SALE

- TF 762C V.H.F. Generator £65 p.p. 30/-
 - TF 726C V.H.F. Signal Generator £55 p.p. 30/-
 - TF 937 (CT 218) Signal Generator 85 kcs-30 mcs £70 p.p. 30/-
 - CT 378 9-225 mcs Avo Signal Generator £35 p.p. 15/-
 - TF 373C Marconi Impedance Bridge £35 p.p. 15/-
 - BC 221 Frequency Meter with S.P. A.C. £30 p.p. 20/-
 - CD 513 Solartron Oscilloscope £35 p.p. 25/-
 - 13A D.B. Hartley Oscilloscope Perfect £25 p.p. 30/-
 - 1035 Mk. II D.B. Cossor Oscilloscope £25 p.p. 25/-
 - 103 Scope only £10 p.p. 25/-
 - CB 300 15 kcs-25 mcs 8 bands Marconi Receiver £28 p.p. 40/-
 - B.28 60 kcs-30 mcs 6 Bands Communication Receiver £30 p.p. 40/-
 - B.40 650 kcs-30.5 mcs Murphy Communication Receiver £15 p.p. 25/-
 - SP 600 TX T Model Hammerlund £65 p.p. 50/-
 - R 209 1-20 mcs AM/FM Receiver £12.10 p.p. 17/6
 - 836A 28-145 mcs AM/FM Hallcraft Receiver £35 p.p. 50/-
 - TR 1620 116-145 mcs Aircraft Transceiver £8 p.p. 20/-
 - 24 v. op. £3 p.p. 20/-
 - 19 Sets 1.8-8 mcs Transceiver £3 p.p. 20/-
 - 88 Walkie Talkie Sets E. K. Cole £4.10 p.p. 15/-
 - 91 Mk. II Transceiver £2 p.p. 15/-
 - Collins TCS Transceiver 1.5-12 mcs £25 p.p. 40/-
 - Pye Hand Loud Halls £5 p.p. 15/-
 - 6 Pole Double throw 5 amp contacts 200 ohms. 1 in. dia. Seales 5/6d. p.p. 2/-
 - Nylon Block suitable for bearings, etc. 4 in. dia. per 1 in. run 5/6d.
 - Schomandl Frequency Decade ND5 and Precision Decade NDE 1 (2) 0.1 kcs to 31 mcs. As New Offers.
 - QD 910 Solartron Storage Oscilloscope As New Offers.
 - Top Loading Scales 10 lbs. in 1 oz. divs. 25/- p.p. 5/-
- EASTLAKE ELECTRONICS**
EASTLAKE, BOGNOR REGIS BOGNOR 25606
797

INTEGRATED CIRCUIT AUDIO AMPLIFIER KIT

Power output:—3 Watts R.M.S. per channel.
 Sensitivity:—160 mv. input for 3 watts output.
 Output load:—7.5 to 15. Frequency response —15 Hz to 50 KHz (3db down). Treble cut and boost —18 db to +12 db. Bass cut and boost —14 db to +12 db. Noise level —80 db. max. (referred to 3 watts output). Hum —70 db. max. (referred to 3 watts output). Crosstalk —40 db. Distortion at 3 watts output 1% max. (Total harmonic).

Price of kit of parts and full constructional details £15.

TELEVISION CITY.
 Dept. WW1, 50, Richmond Road, Kingston, Surrey.

Tel. 01-546 3961 (100 yds. from Station).
 Daily 9.30-5.30; Friday 9.30-7; Closed Monday.

We offer A TAPE RECORDER ENGINEER

the opportunity of working in an up-to-date service department on Uher recording equipment. The applicant should be familiar with the latest transistorised circuitry as well as being able to carry out mechanical work on such equipment.

We offer a good salary, non-contributory pension scheme, subsidised canteen facilities and some free local transport.

If you are interested, please write giving brief details about your qualifications and experience to:

The Personnel Officer, **BOSCH LIMITED, Rhodes Way, Watford, Herts.**
 770

ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

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offer

ENAMELLED COPPER WIRE

S.W.G.	½ lb.	¼ lb.	1 lb.
18-29	6.3d.	11.0d.	16.0d.
30-35	7.0d.	11.6d.	16.9d.
36-40	8.9d.	13.6d.	22.0d.
41-45	11.3d.	17.6d.	27.6d.

S.W.G.'s 24, 30, 38 and 40
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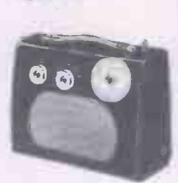
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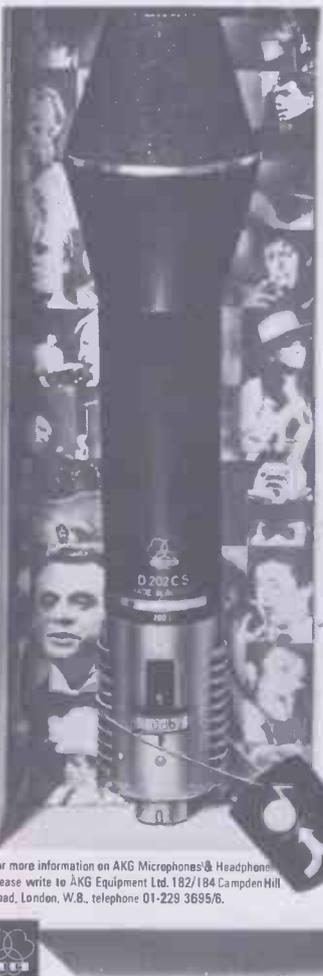
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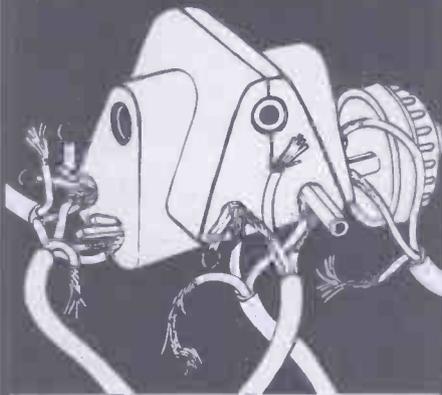
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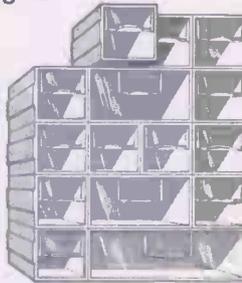
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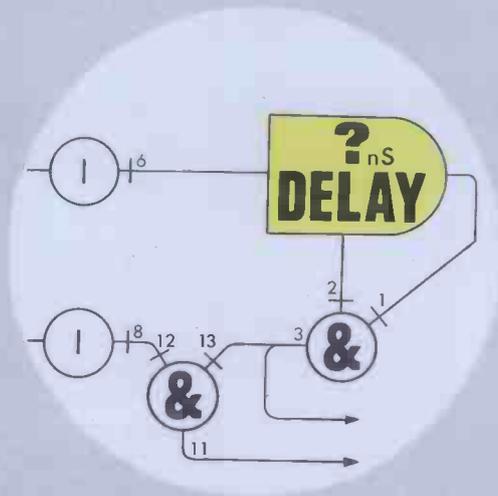
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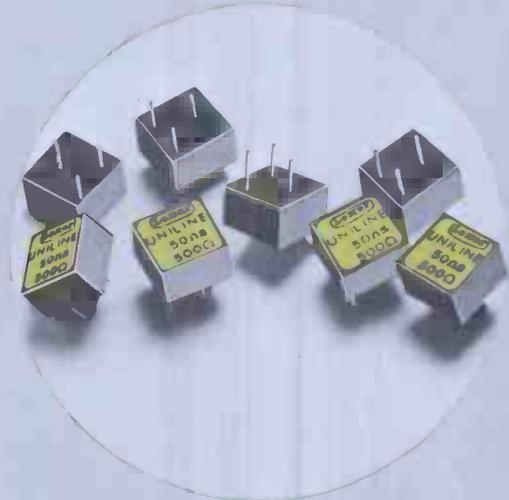
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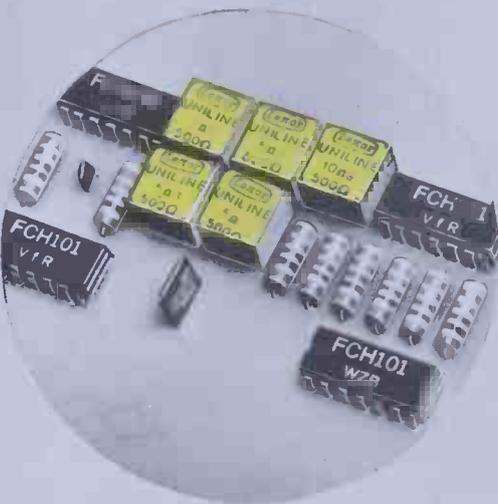
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