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# Wireless World

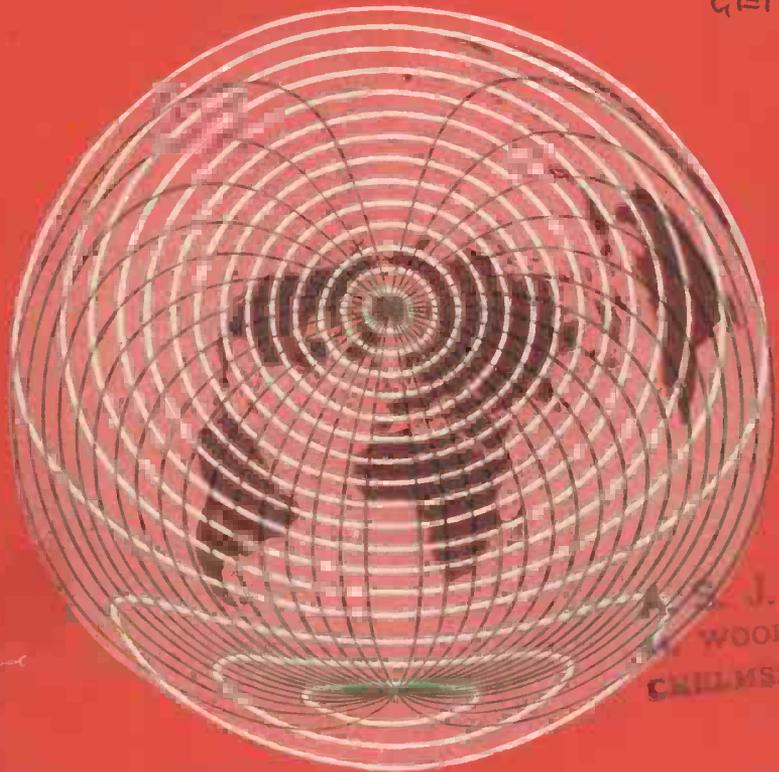
PAGE 98 MULLARD ADVT. AUTO-KEYING CIRCUIT TRANSISTORS.

## ELECTRONICS

### Radio · Television

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ELECTRONICS, RADIO, TELEVISION

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- |     |   |                            |
|-----|---|----------------------------|
| 255 | Editorial Comment                         |                            |
| 256 | Ferroelectrics—1                          | By <i>J. C. Burfoot</i>    |
| 260 | Improved Audio Input Circuit              | By <i>R. C. Marshall</i>   |
| 262 | Sporadic 'E' and the F <sub>2</sub> Layer | By <i>T. W. Bennington</i> |
| 264 | Simple Oscilloscope Camera                | By <i>A. J. Key</i>        |
| 266 | World of Wireless                         |                            |
| 267 | Personalities                             |                            |
| 269 | Pickup Arm Design                         | By <i>J. Walton</i>        |
| 272 | Displaying Valve Characteristics          | By <i>R. G. Christian</i>  |
| 274 | Feedback Amplifiers as Filters            | By <i>Thomas Roddam</i>    |
| 276 | Elements of Electronic Circuits—3         | By <i>J. M. Peters</i>     |
| 279 | Magnetic Matrix Stores                    | By <i>W. A. Cole</i>       |
| 283 | Letters to the Editor                     |                            |
| 285 | R.H.F.                                    | By " <i>Cathode Ray</i> "  |
| 289 | Electronics and the Phonetician           | By <i>H. J. F. Crabbe</i>  |
| 294 | Technical Notebook                        |                            |
| 296 | Manufacturers' Products                   |                            |
| 299 | New Marine Radar                          |                            |
| 300 | News from the Industry                    |                            |
| 302 | Random Radiations                         | By " <i>Diallist</i> "     |
| 304 | Unbiased                                  | By " <i>Free Grid</i> "    |

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# Transistor

# Automatic-keying Circuit



Various modulation arrangements can be used with the 500kc/s marine-distress transmitter (see previous advertisement). For c.w. operation a morse key can be connected in series with the base winding of the modulator transistor, together with an r.f. choke and a bypass capacitor to prevent r.f. voltages floating across the key.

Low-power modulation is used for radio telephony. The modulator transistor is biased into Class C operation, using a parallel CR combination, to a point where the output of the transmitter falls to half its normal value, and an a.f. signal is applied across the bias resistor.

The circuit shown here is for an automatic-keying device which generates the distress signal. A time interval of 0.1 sec was chosen for the duration of a dot and for the interval between successive dots or dashes. The duration of a dash is then 0.3 sec.

Transistors Tr1 and Tr2 form the dot multivibrator and the Tr2, Tr3 combination is the dash multivibrator. As the spacing between dots is the same as the spacing between dashes, no gate is required for mixing and so the output can be taken from the collector of Tr2, the common transistor. To square-off the waveform of this output an emitter follower Tr4 is added. The output from Tr2 is inverted by Tr13 to the negative-going pulses required for keying the transmitter. A positive line is provided for the combined multivibrator by connecting the three emitters to a suitably decoupled resistor R2. This ensures that the appropriate transistor (Tr1 or Tr3) is definitely cut off by the sequence multivibrator which acts as an on-off switch in the base leads of Tr1 and Tr3.

This multivibrator consists of transistors Tr6 and Tr7, which conduct alternately, switching the supply voltages across the base resistor R7 and R6 respectively. When Tr6 is on, Tr5 is off and the voltage across R9 (approximately  $V_{cc}$ ) appears across R7, the base resistor of Tr1, and three dots are generated. The timing of this sequence is mainly governed by the combination C9R11.

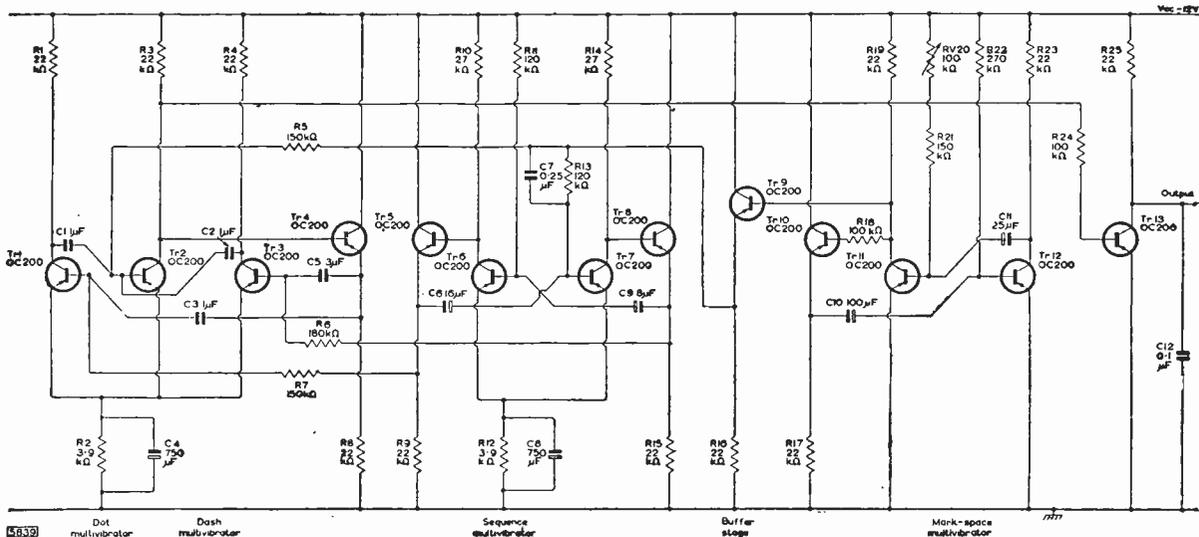
The capacitor C7 reduces the switch-on time of transistor Tr7. If it is omitted, the inhibiting signal from Tr7 does not reach the dash multivibrator soon enough and a spurious

dash precedes the dot-dash sequence. When Tr7 is on, Tr8 is off, the supply voltage appears across R6, and Tr3 generates three dashes. Transistors Tr5 and Tr8 are emitter followers which square-off the collector waveforms from Tr6 and Tr7. The sequence multivibrator is in turn controlled by the mark-space multivibrator by connecting R13, the base-feed resistor to Tr7, across the emitter load of Tr9. The mark-space multivibrator is the only free-running one in the whole circuit. It controls the whole automatic timing circuit. Tr10 is an emitter follower which squares-off the collector waveform of Tr11. A buffer stage, Tr9, is required to reduce interaction between the mark-space multivibrator and the previous stage.

The resistor R18, in the base lead of Tr10, is necessary to prevent pulses, fed back from the sequence and dot-dash multivibrators, triggering the mark-space multivibrator. It also reduces the voltage developed across the emitter resistor, R17, thereby reducing the on-period of Tr11. This time can be easily adjusted because it is the off-period for the complete timing circuit. If R22 is 270kΩ and C10 is 100 μF, the space period between signals is about 15 sec.

Some of the timing components need careful selection; all the resistors for these circuits should be of high stability, and the capacitors should have low leakage currents. These capacitors should preferably be metallised paper types (C1, C2, C3, C5, C7, C12), and tantalum electrolytic for the others. All the transistors operate at less than 500μA per stage; the total current drain from a 12V battery is about 4mA. The circuit operates satisfactorily with supplies down to about 10V, and over a range of temperature from 0 to 60°C. Taking into account the on-off power ratio of the combination of transmitter and keying circuit, a life of 50 hours can be expected from a 4 ampere-hour accumulator.

It cannot be emphasised too strongly that indiscriminate transmission of the international distress signal, whether licensed or not, is very undesirable. However, the principles of the design described can be used for the automatic keying of any morse signal, such as a call sign, by suitable adjustment of the timing components.



## Monodic Sound

THE current interest in stereophony, one might almost describe it as an obsession, has brought with it many headaches, not the least of which has been caused by the difficulty of finding a terse word to describe the other kind of sound reproduction—the one we used to enjoy before two-channel stereophony became a commercial proposition.

Most of the proposals to date have not been entirely satisfactory: some have been plainly ludicrous—"monaural" and "monophonic," for instance.

No normal person would dream of listening to free-field sound from whatever source or sources except with two ears, and it is useless to argue that the sound might have been picked up by a single microphone, for in that case a better term would be "monomicrophonic."

As for "monophonic," this calls to mind only tuning notes, test oscillators and other uninteresting laboratory noises; certainly not the rich polyphonic sounds of music and well modulated voices which often come through reasonably well even on "non-stereophonic" equipment. Let us therefore dismiss "monophonic" as an abortive attempt by the stereophonists to denigrate a system of high-quality sound reproduction of which we have by no means heard the last.

Thinking of why "monaural" and "monophonic" should sound so funny and out of context we chanced to remember a pedagogic dissertation on the origins of humour in which a high place was given to "the juxtaposition of the incongruous." False comparison, inadequate antithesis—here surely are the root causes of our trouble. "Monaural" is the antithesis of "binaural" which, by common consent, refers either to the normal act of hearing or to a system using headphones separately excited by independent reproducing channels. "Mono" should not be associated with "phonic" because the first part describes the channel of transmission whereas the second refers to the nature of the information conveyed. With "stereophonic" we are on firmer ground, because not only does it pass muster by referring exclusively to the quality of the sound, but it is now so well established that no etymological argument is likely to displace it. Therefore all we have to do is to find the Greek antonym for "stereo"—or do we?

The opposite of solid is plane or flat, and good single-channel sound reproduction is far from being that. By the judicious use of reverberation

and by varying distances from the microphone the skilful broadcaster or recording technician can convey the impression of spaciousness in depth. In fact the best results could justly be described as "single-channel front-to-back stereophony." True, the use of two or more channels gives width in addition to depth, so one might call it "second-order stereophony" to distinguish it from the "first-order stereophony" which we sometimes get from single channel.

Both systems have their strength and weakness. Obviously multichannel stereophony is best suited to orchestral and choral music, especially when this is written with antiphonal effects in mind; and single-channel "stereophony" should be best for solo instruments and voices with a subsidiary orchestral accompaniment. It is technically difficult to centre the virtual image of a voice, so that it seems to come from a point midway between two loudspeakers, but it can be done as Mr. Briggs demonstrated recently in the Festival Hall in London. The audience by a show of hands preferred two-channel stereophonic reproduction of the soprano voice to a single-channel recording, admittedly of a different singer but by the same recording company. Other experiences have shown that either system can beat the other at its own game when it is at the top of its form and the other is not. At the present stage of development it is therefore unsafe to try to draw a distinction based solely on the criterion of performance. ☉

Until recently this journal has favoured the term "single-channel" for non-stereophonic systems, but since the B.B.C.'s revival of interest in stereophonic broadcasting the possibility that two audio channels may eventually be broadcast over a single radio channel introduces an element of ambiguity. Radio people can with some justification lay a prior claim to the use of the term channel and we see no reason why they should not keep it if they will allow us the use of "monodic" (suggested on p. 304 of this issue by our sometimes unruly but often inspired contributor "Free Grid") to describe the audio-frequency part of the chain. It is self-consistent in describing the system without reference to the nature of the information conveyed, and it enables us to make free and confident use of the contraction "mono" in the knowledge that if challenged to explain what it stands for we shall be spared the embarrassment of trying to justify "monophonic" or "monaural."

# FERROELECTRICS

## I.—THE PHYSICS OF A SINGLE DOMAIN

By J. C. BURFOOT,\* Ph.D.

THE prominent property of a ferroelectric is that it has a spontaneous polarization  $P_r$ , analogous to ferromagnetic remanence, and that this polarization can be reversed by applying an opposing electric field  $E$  stronger than the coercive field  $E_c$  (Fig. 1). The name "ferroelectricity" was coined because of this similarity; there is no connection with "iron." The discovery of ferroelectrics is very much more recent than that of ferromagnetics. Weber's theory of magnetic substances in the middle of last century and Ewing's later extensions had led already in 1907 to the Weiss domain theory; the discovery of ferroelectricity in Rochelle salt was not made until 1921 (Valasek). Inevitably, progress in understanding the phenomenon has been more rapid, leaning on analogy with the magnetics. However, a closer look shows that the differences are at least as striking as the similarities, as I shall show in these articles.

About thirteen groups of ferroelectric materials are now known, and new ferroelectrics are being added constantly to the list. The physics of a ferroelectric material is most easily approached in terms of a single good crystal which is all one domain, though such a state may be difficult to maintain in practice; this first article deals with this topic. Later I shall consider the effect of multi-domain structures on these basic properties, and then the even more complicated nature of polycrystalline materials. Ferroelectrics have been used for many years, usually in the form of ceramics, in a great number of piezoelectric devices and transducers, and in capacitors. After considering these, I shall examine work carried out in the last decade on the "dielectric amplifier" and associated modulation devices, and towards uses in digital computers, for storage and switching purposes.

**Single Domains.**—In view of the historical lag, it is not surprising that understanding of the basic phenomena is considerably less well advanced than in magnetics. But it seems too that the underlying facts are genuinely less simple. For it is possible to describe ferromagnetism by treating each atom as though it were an elementary magnet. Then the complications of alignment and domain formation are described in terms of those external properties of magnets which have been known since William Gilbert's study of them about 1600: (1) a magnet produces a dipole magnetic field in its neighbourhood, and (2) a magnet aligns itself with a magnetic field if it is free to do so; interactions between magnets are described in terms of these two facts. At first sight this looks like describing ferromagnetism in terms of ferromagnets. But in fact the magnetic moment, or strength, of our elementary magnets undergoes no change in a field, and it is precisely such changes which are of interest (Fig. 1(a)) and

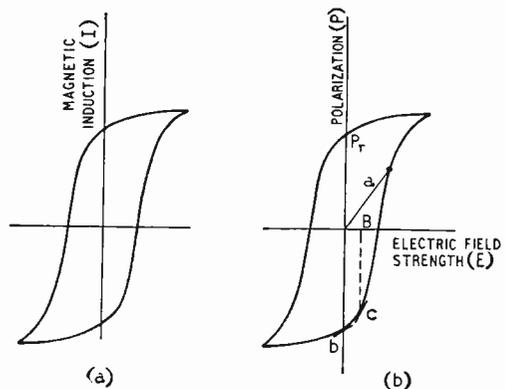
which we succeed in describing, in materials, in terms of our conception of the atom as a *permanent* dipole.

In ferroelectrics, permanent (electric) dipoles also occur, but one cannot usually identify a particular atom with the dipole, and certainly not a particular electron, as in magnetics. The "spinning" electron responsible for ferromagnetism is inside the atom, screened electrically from neighbouring atoms. But for ferroelectricity, the various structures which cause it are intimately associated with the bonds *between* atoms, so that even in the relatively simple crystalline form of solids it is difficult to find any conception of microscopic subdivision which will effectively isolate the essential dipoles. The complication is increased because the cohesive forces holding matter together are largely electrical in nature.

Three elementary magnets, the atoms of iron, cobalt, and nickel, largely account for ferromagnetics; but in ferroelectrics there are many possible elementary dipoles, and the same unit may behave quite differently in different materials. In many cases the unit involved is not yet known for certain. Also, *induced* dipoles become important in ferroelectrics; the polarizability of a molecule may well determine whether the material containing it is ferroelectric. Polarizability is the extent to which a particular atom or molecule can be given a dipole moment by an electric field.

**Permanent Dipoles.**—An electric dipole is a body which is electrically neutral, but with the effective centres of its positive and negative charges not at the same place. There is no reason to suppose that either of these charges is concentrated at a point, but it is sometimes convenient to think of the dipole as made up of two equal charges,  $+q$  and  $-q$ , fixed at a

Fig. 1. Magnetic and electric hysteresis loops. The inductions are respectively  $B=H+4\pi I$  and  $D=E+4\pi P$ , or in these materials, to a good approximation,  $B=4\pi I$  and  $D=4\pi P$ .



\* Queen Mary College, London University.

separation  $2d$ , and then we define the electric dipole moment as  $p = 2dq$ . The axis of the dipole is the line joining the charges. If a molecule or a crystal cell in a crystalline solid behaves like a permanent dipole whose axis can be turned into any direction or into any one of a number of particular directions, spontaneous polarization might result from alignment of these dipoles in strings head-to-tail in some particular direction, and alignment of the neighbouring strings in the same sense. If the alignment is complete, and there are  $N$  dipoles in a unit volume, then  $P = Np$ . Such an alignment may have been caused initially by the application of a suitable external electric field  $E$ , subsequently removed. But it is retained by the *internal* fields due to the dipoles themselves. It is believed that such internal fields are very much greater than any practical value of applied  $E$ , and they are very important to an understanding of ferroelectricity. For at any reasonable temperature, random thermal motions, which we have ignored above, spoil the alignment (so that many  $p$  are in wrong directions) unless there is some field  $F$  to counteract it; this field can be the internal field. The way  $P$  falls off if  $F$  is too small is shown in Fig. 2(a).

**Induced Dipoles.**—The above ideas are common to both ferromagnetism and ferroelectricity, though the reasons for the existence of  $p$  are very different in the two cases. But now turn your attention from permanent dipoles to the possibility of induced dipoles. That is, consider material in which the positive and negative centres of the units do coincide. The function of the field  $F$  is to separate them, against the influence of the forces holding the unit together. And now we meet the following curious possibility. Because polarization produces internal fields, it is possible for a material containing no permanent dipole to exhibit a polarization. The polarization creates the field and the field creates the polarization—it is only necessary that the polarizability should be “large enough”; equation (2) below puts this condition more precisely.

In a small field  $F$ , the strength of dipole induced,  $p_i$ , will be proportional to  $F$ ,

$$p_i = \alpha F \quad \dots \quad (1)$$

but in larger fields,  $p_i$  approaches some maximum value set by the structure and cohesion of the unit. This is known as “saturation.” See Fig. 2(b).  $\alpha$  is the polarizability. It is clear from Figs. 2(a) and (b) that the effects of permanent and induced dipoles will be similar, though the values and temperature dependences will be different. Probably both types of effect occur.

It is worth while to compare the induced dipolar effects that can occur in magnetic materials. Our electric induced dipoles may be due to relative movements, in the field  $F$ , of atoms carrying positive and negative charges (“atomic” or “ionic” polarization), or to displacements of the electrons of an atom relative to the positive nucleus of the atom (“electronic” polarization); in either case, the dipole produced is directed with the field rather than against it, so that the susceptibility  $I/H$  is positive, and we may even have a ferroelectric if the co-operative effect is large enough. In magnetics, induced dipolar effects are due to precessions of electron forbits about the field direction, and the

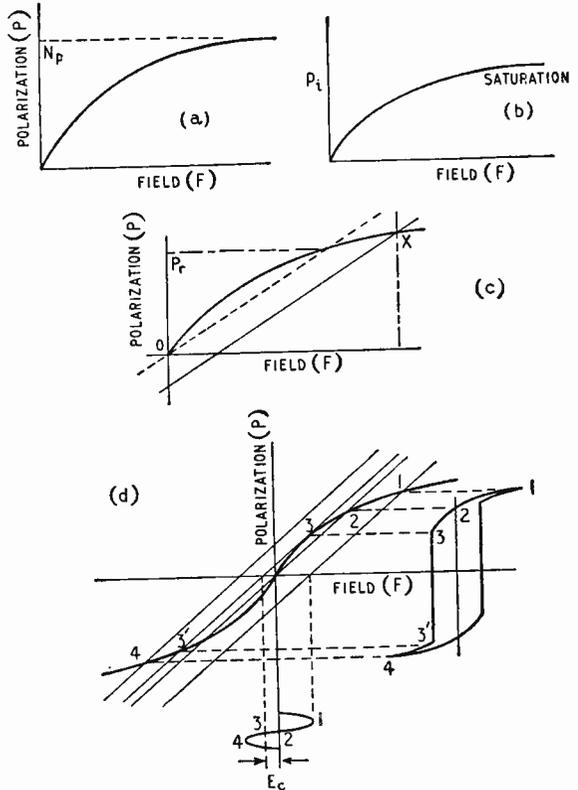


Fig. 2. Polarization and field curves. In Fig. 2 (a),  $P = Np \left( \coth \frac{pF}{kT} - \frac{kT}{pF} \right)$  for free dipoles; near 0, this is  $P \approx Np \left( \frac{pF}{3kT} \right)$ .  $k = 1.381 \cdot 10^{-16}$  erg/deg.

laws of magnetic induction are such that the result must oppose the applied field. So the associated susceptibility is negative, and materials in which this effect predominates are called diamagnetics rather than paramagnetics; such materials try to move away from, rather than towards, regions of high-field.

Two points of contrast with magnetics result: (1) In electric materials we cannot distinguish permanent from induced dipoles by the mere sign of a force; the terms dia-electric and para-electric are hardly in use, in fact. (2) In ferroelectrics we cannot be certain that permanent dipoles underlie the phenomenon, for here induced dipolar effects do have the right sign to allow co-operative effects.

**Spontaneous Polarization**—Fig. 2 will not explain why spontaneous polarization remains when  $E = 0$  unless we can identify the value of  $F$  when  $E$  is removed. To do this, let us first imagine that we do apply  $E$  (which we shall later remove) and describe the behaviour of  $F$  and  $P$  on the same Fig. 2. This is done by the full straight line  $F = E + \beta P$  in Fig. 2(c). That is, the extra field at a point inside the material, due to the overall polarization  $P$  of the surrounding material, is written as  $\beta P$  where  $\beta$  represents the strength of the co-operation. In ferromagnetics, exchange forces make  $\beta$  very large indeed, perhaps 10,000, but in ferroelectrics it is of order 1. The two full curves in Fig. 2(c) represent the two parts of the statement

† Not to be confused with electron spins.

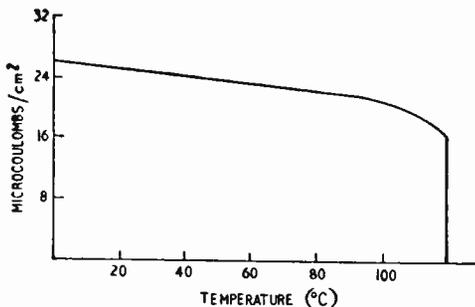


Fig. 3. Spontaneous polarization in a single domain of barium titanate, in microcoulombs per cm<sup>2</sup>.

“polarization creates (some of the) field, and field creates polarization.” The only state that satisfies both conditions at once is at the intersection X, which therefore determines F for that value of E. Now the effect of removing E is to slide the straight line towards the left to the dashed position, and P<sub>r</sub> then gives the value of the spontaneous polarization.

On the same figure can be seen circumstances under which P<sub>r</sub> will be zero, so that the material is no longer ferroelectric. This happens if the slope of the curve at 0, which we can get from P = Np<sub>i</sub> and p<sub>i</sub> = αF. That is, the condition for ferroelectricity is that Nα should be greater than 1/β or

$$\alpha > 1/N\beta \dots \dots \dots (2)$$

**Temperature Variations.**—Now in fact if the temperature is raised above some transition temperature T<sub>0</sub>, P<sub>r</sub> again will be zero in the same way. It is most readily seen for the permanent dipoles, for which T<sub>0</sub> is the temperature at which the thermal disordering overcomes the co-operation. For it is possible (but see next paragraph) to think of orientation of permanent dipoles in terms of a fictitious polarizability.

$$\alpha' = \frac{p^2}{3kT} \dots \dots \dots (3)$$

Then the slope of the curve at 0 is Nα', and unless this is greater than the slope 1/β, P<sub>r</sub> will be zero. That is, for ferroelectricity we need the equivalent of equation (2), Nα' > 1/β, which is now

$$\frac{Np^2}{3kT} > \frac{1}{\beta} \text{ or } T < \frac{N\beta p^2}{3k} \text{ Thus the transition}$$

temperature is

$$T_0 = \frac{N\beta p^2}{3k} \dots \dots \dots (4)$$

In the case of induced dipoles, the equation (2) shows no temperature dependence, and it must be supposed that the polarizability α decreases as the temperature rises, until equation (2) is no longer satisfied. Fig. 3 shows the way P falls off, for barium titanate.

Equation (3) is based on the idea of a dipole free to rotate, and is not strictly correct, first because an electric dipole is probably not free, and second because for rotatable dipoles our treatment of F is not quite correct. However, the equation will serve our purposes. Electric dipoles may be able to jump fairly freely between a number of alternative positions, and expressions for P have been worked out similar to those in the caption of Fig. 2(a).

When alignment is not complete, P is less than Np, say Np', and the caption shows that near the origin, this p' is  $p' = \frac{p^2}{3kT} F$ , which by comparison

with equation (1) gives equation (3). In these expressions, T is measured on the Kelvin temperature scale, so that T°K means t°C where T = t + 273.

**Hysteresis.**—The hysteresis loop of Fig. 1(b) can be seen on an oscilloscope by applying a.c. across two capacitors in series, one of which (A) has the ferroelectric for dielectric. The spontaneous polarization induces charge on the plates of A. When P changes, some of the induced charge is liberated, and, passing to the ordinary small linear capacitor, is displayed as a proportional voltage on the Y plates of the oscilloscope. The applied a.c. is connected to the X plates. In working with ferroelectrics, the plates or electrodes must be in exceedingly intimate contact with the material, because the dielectric constant is very high, say 5,000 in some cases. So an unsuspected air capacitor, only d/5,000 thick in series, halves the applied field, and in large-signal work will grossly distort the results. Evaporated electrodes or liquid electrodes are used. Notice that, just as in magnetics, the area of the hysteresis loop represents an energy loss per cycle, which we shall later have to take into account.

It seems that now we can explain the hysteresis loop, though we shall see later (see section on “Domains”) that this is deceptive. Fig. 2(d) shows an extended version of 2(c), in which four stages of a

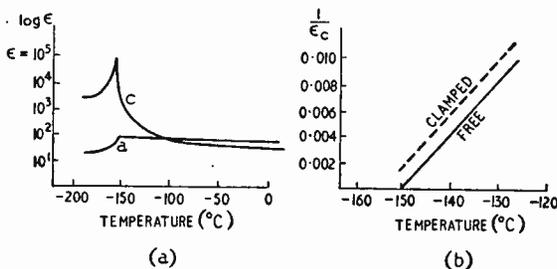


Fig. 4. Dielectric constants of potassium dihydrogen phosphate (divide e.s.u. by 900,000 to get μF.cm<sup>-1</sup>). The c direction is the ferroelectric axis.

cycle of an alternating E are shown (1, 2, 3, 4). At some moments, three intersections of the graphs occur. Some will be unstable. I shall not discuss this, since domains will modify the results.

**Thermodynamics.**—Our subject matter is to be largely the dielectric and piezo-electric values in these ferroelectric materials, many of which values are anomalous, i.e. are unusually large or unusually small and show large variations as the temperature changes. These properties relate S, X, P and E, where X is a mechanical stress applied to the material and S is its relative change of size. The magnitude of a change of P in response to an applied E is represented by † the dielectric constant ε; change of S in response to X is elastic compliance; the other four possible relationships are all exhibitions of

† See caption of Fig. 1. Permittivity D/E or dielectric constant is  $1 + 4\pi\eta$  where η is the susceptibility P/E. But in ferroelectrics P is so large that  $\epsilon \approx 4\pi\eta$  (or  $\epsilon \approx \eta$  in m.k.s. units) so that it is common to use the terms almost synonymously.

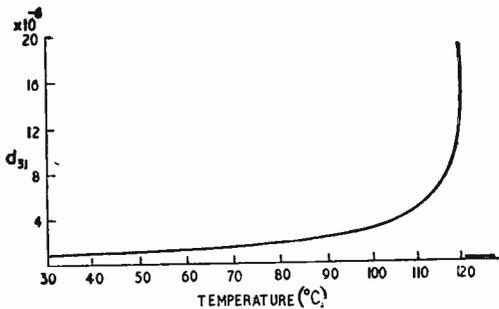


Fig. 5. One of the piezoelectric coefficients of a single-domain barium titanate crystal.

piezoelectricity, either "direct" (electrical changes caused by mechanical changes) or "converse" (mechanical changes caused by electrical), and it can be shown that they are equal in pairs; for example I shall use  $d$  to indicate the value of the response of P to X (a "direct" effect), which is equal to the response of S to E (a "converse" effect).

Any one of these values may appear to be very different, in ferroelectrics, depending on the conditions of measurement. For example, one may measure a property "at constant E", i.e. with opposite faces of the material connected together through a low impedance rather than open circuited. Or  $\epsilon$  may be measured "at constant S", i.e. with the material "clamped" rather than "free". But clamping may not be intentional. It will occur to some extent if there are domains present which restrict one another's expansions under field, and even without domains, clamping will occur if measurements are made by fields whose frequency is above the mechanical resonance frequency of the piece of material, so that inertia prevents the rapid expansions. This resonance frequency alters with the size and shape of the piece.

So in practice one must specify rather carefully all the conditions of measurement, and the formal methods of thermo-dynamics state the relationships between them and give the equalities above, and also show that if we can explain one or two of the anomalies, the rest may be deduced. Therefore I shall not explore all the inter-relations whose complexities I have hinted at, but shall content myself with a short examination of  $\epsilon$  and  $d$ .

**Dielectric Constant.**—The d.c. dielectric constant is the slope of a line such as  $a$  in Fig. 1(b), but usually of more interest is the incremental a.c. constant  $\epsilon_{ac}$  defined, for example, when  $P=P_r$ , by the slope  $b$ . Lag effects make a slender ellipse of this line and cause losses, just as in ordinary dielectrics. If there is a bias  $B$  applied in addition to the small measuring field, the defining slope is  $c$ , and this alteration with bias is important in applications such as modulating devices. If the applied a.c. amplitude  $E_m$  is large, it is clear that the changes of  $P$  do not vary linearly with  $E$ . If  $E_m$  exceeds  $E_c$ , the loop is

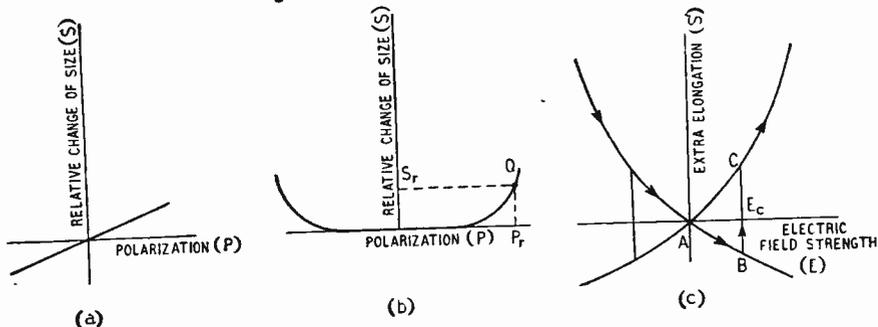


Fig. 6. Piezoelectricity in ferroelectrics.

traversed, and the apparent  $\epsilon$  is an overall value, not very different from  $P_r/E_c$ , say  $0.025 \mu\text{F.cm}^{-1}$  for barium titanate crystals. In this case also, there is a large loss specific to ferroelectrics, equal to the loop area, of order 1 mW per cu.mm at 50 c/s.  $\epsilon$  varies not only with  $B$ , and with  $E_m$ , but also with frequency  $\omega/2\pi$ , and with temperature  $T$ . In addition, it is different when measured by a.c. in different directions (anisotropy), and when measured free or clamped, as discussed above. Fig. 4 illustrates several of these points.  $\epsilon$  reaches values 1,000 times greater than in normal dielectrics.

Above  $T_0$  the ferroelectricity disappears. The polarizability is no longer large enough to maintain the spontaneous polarization in zero field, but it is apparent that its value is still large, for the effect on  $P$  of an applied field still results in an anomalously large  $\epsilon$ . Above  $T_0$ ,  $\epsilon$  falls off, unlike most normal dielectrics, in which it rises. In many cases it falls off in such a way that its reciprocal (or strictly, that of  $\eta$ ) is a straight line (Fig. 4(b)). This is known as a Curie-Weiss law. In equation (3) the polarizability varies as  $1/T$ , or, say,  $N\chi' = C/T$ , where I write  $C$  for the constant  $Np^2/3k$ . Then the earlier equations  $P = N\chi'F$  and  $F = E + \beta P$  show that

$$\frac{E}{P} = \frac{T - \beta C}{C} \quad \text{This is a Curie-Weiss law,}$$

$$\frac{1}{\eta} = \frac{T - T_c}{C} \quad \dots \quad \dots \quad \dots \quad \dots \quad (5)$$

The constants  $T_c$  and  $C$  are known as the Curie temperature and the Curie constant. A similar derivation can be made in other cases where  $\chi$  is proportional to  $1/T$ . In this case based on equation (3) we see that  $T_c = \beta C$ , which from equation (4) is  $T_c = T_0$ . That is, as  $T$  falls, in the non-ferroelectric temperature region, towards the transition temperature  $T_0$ ,  $\eta$  and  $\epsilon$  rise towards a value which in principle is infinite at the transition temperature. In some ferroelectrics,  $T_c$  is several degrees below  $T_0$  (though still  $T_0$  is often  $\epsilon$  reaches a high value, it falls again in the ferroelectric region, either sharply, or more gradually as in Fig. 4(a). Now the spontaneous saturation of  $P$  has left relatively little possibility of extra polarization being acquired under an applied field to show up as a high  $\epsilon$  value.

The mechanisms responsible for  $\epsilon$  under small voltages are not necessarily the same as those acting when voltages are large enough, below  $T_0$ , to reverse  $P$  and cause a hysteresis loop. But where the values are anomalously large, it is probable that there is much in common.  $P$  has taken up one direction,

so it is not surprising that  $\epsilon$  is very different in that direction. It is usually larger in the direction of P in materials where the cross-directions are not available as alternative easy directions for P.

**Piezoelectric Constants.**—Fig. 5 shows the anomaly of one of the  $d$  values of barium titanate, associated with its dielectric anomaly. The  $d$  states the fractional elongation S resulting from a small field E; another piezo-coefficient  $b$  states the S resulting from a small polarization P. Several  $d$  values (and several  $b$ , etc.) are needed to describe the piezoelectricity of any crystal, e.g. a field in direction  $c$  may cause elongation in that direction and also shear effects in cross-directions. For simplicity I shall write only of the former, though in fact Fig. 5 is a cross-coefficient. Many piezoelectric materials are known and used, which are not ferroelectric, e.g. quartz. Ten of the 32 symmetry classes of crystalline solids, being centrosymmetric, cannot be piezoelectrics, and one other is not. Fig. 6(a) is drawn for an ordinary non-ferroelectric dielectric which happens to be piezoelectric; the slope is the coefficient  $b$ . Fig. 6(b) shows a non-piezoelectric; its slope is zero (for small P). But it is electrostrictive for larger values, and this we may approximate by  $S \propto P^2$ ; such a curve could be found for most materials, and a similar one on an S-E plot, provided breakdown does not first occur.

All ferroelectrics are piezoelectric in the temperature range below  $T_0$  where they remain ferroelectric. It is convenient to divide them into two groups, A and B respectively, according to whether or not they are also piezoelectric above  $T_0$ . Group A we might describe as inherently piezoelectric, though in fact the ferroelectricity profoundly modifies  $d$ ; this group includes Rochelle salt and potassium dihydrogen phosphate. I shall discuss group B, in which all the piezoelectricity is, in a sense, given to the crystal by the ferroelectricity; barium titanate is an example.

It is a harmless simplification now to think of S as resulting from two steps: the applied E produces P and this P would produce S if "inherent  $b$ " existed or if P were large enough to show the electrostrictive region. But in group B, this region is reached without any applied E because of the spontaneous  $P_r$ . So the working point is at Q (Fig. 6(b)), showing that the crystal has also a spontaneous deformation  $S_r$ . For example, the cell of barium titanate, which is cubic above  $T_0$ , is 1% larger in the direction of P, below  $T_0$ . In a good crystal plate, this "c axis" is directed through the thickness of the plate. Now if an external E is applied, the extra P drives the point Q up the curve, producing extra elongation  $S'$ . So the effective piezo-coefficient  $d$  is  $S'/E$ , i.e. it is related to the slope of the curve at Q. The nature of this response is thus seen to be different from that of quartz, for example, Fig. 6(a). Because  $P_r$  is large the effect can be large. The effect plotted against E instead of against P is a butterfly loop traversed as shown in Fig. 6(c). From A to B, E opposes  $P_r$  but does not reverse it till  $E_c$  is reached. Reversal reaches C and thus at that point the effective  $d$  is changed in sign.

**ACKNOWLEDGMENTS:** Fig. 4(a) has been drawn from a paper by G. Busch in *Helv. Phys. Acta*, 11, 269, 1938; Fig 4(b) from a paper by H. Baumgartner in *Helv. Phys. Acta*, 24, 326, 1951; and Fig. 5 from a paper by E. J. Huijbregtse, M. E. Drougard and D. R. Young in *Phys. Rev.*, 98, 1562, 1955.

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(to be continued)

## Improved Audio Input Circuit

Use of Input Alternator Resistors at the Source

By R. C. MARSHALL, B.A., Grad.I.E.E.

**D**OMESTIC audio equipment must now accept inputs from an a.m. radio, f.m. radio, gramophone or tape recorder. Usually these inputs are selected by a switch, which is connected to the various sources by screened cables 2 to 5ft long with a capacitance of 50 to 150pF. Taking the latter case of 150pF, for a loss of 3dB at 20kc/s, which is an acceptable limit for one element in a high-fidelity system, the output resistance of the unit driving the cable is limited to 50k $\Omega$ . This is inconveniently low.

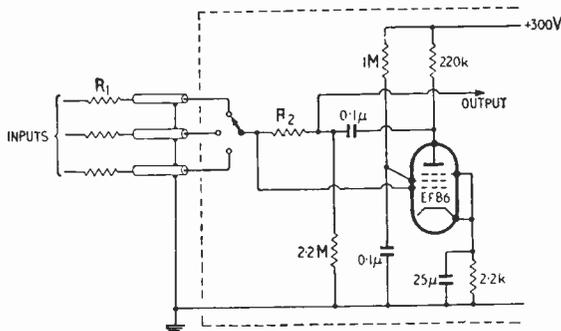
Furthermore the various inputs are at different levels, and attenuators in the control unit or alternatively an anode follower with different input resistors adjust the overall gains to the required values. These adjustments are rarely correct, as details of the sources are not accurately known when the control unit is built.

It has been shown<sup>1</sup> that the anode follower or see-saw can be used to counteract the effect of cable capacitance by placing the input resistor at the source end of the cable, as in the circuit diagram.

This is convenient also as the resistor can then be adjusted to suit the source without affecting the control unit. Some experimental figures obtained with this arrangement are given in the tables. Overall gain and permissible cable capacitances are given for a range of values of the source resistor  $R_1$ . It can be seen that for  $R_2=4.7M\Omega$  a 30dB range of gains can be obtained with input resistors

TABLE 1

$R_1$ (K $\Omega$ )	Gain(dB)	Capacity (pF) for -3dB at 20kc/s	Load capacity = 50 pF	
			Maximum Height of peak (dB)	Capacity (pF) for -3dB at 20kc/s
47	31	750	1	920
100	26	690	1	870
220	19.5	650	1.5	830
470	13	630	1.5	800
1000	6.5	610	1.5	790
2200	0	600	2	790



Improved input selector. The grid resistor of the following stage should be  $1M\Omega$ .

varying from  $220k\Omega$  to  $8.2M\Omega$ , with adequate frequency response. The corresponding input resistance values in Table I are roughly half those in Table II, so that a proportionately larger capacitance is possible. The bandwidth does not vary with the overall gain provided that there is appreciable feedback, and is theoretically equal to  $A/2\pi R_2 C$  c/s, where A is the open loop gain, in this case 170 times (measured), and C the cable capacity. This gives a figure in good agreement with the experimental results. The overall gain of the stage is approximately  $R_2/R_1$ . An analysis of this circuit, and bibliography, has already appeared in *Wireless World*<sup>2</sup>.

If the capacity of the lead is appreciable, a wider bandwidth is obtained and a "hump" in the

$R_1$ (K $\Omega$ )	Gain (dB)	Capacity (pF)
47	36	450
100	31.5	330
220	25.5	280
470	19.5	270
1,000	13.5	260
2,200	6.5	260
4,700	0	260
8,200	-5	260

$R_1$ (K $\Omega$ )	Gain (dB)	Capacity (pF)
47	25	1,300
100	19.5	1,150
220	12.5	1,100
470	6	1,100
1,000	0	1,100
2,200	-6	1,100

response may occur. This is characteristic of a feedback amplifier containing two lag circuits. For a 50pF load, the maximum rise for any cable capacity, and the cable capacity for 3dB loss at 20kc/s are given in the last two columns of Table I. The other measurements were taken with negligible load capacity.

#### REFERENCES

- 1 T. G. Clarke, "An Electronic Transformer," *Electronic Engineering*, Sept. 1958, p. 545.
- 2 P. J. Baxandall, "Negative Feedback Tone Control," *Wireless World*, Oct. 1952, p. 402.

## V.O.R. AIRWAYS BEACON

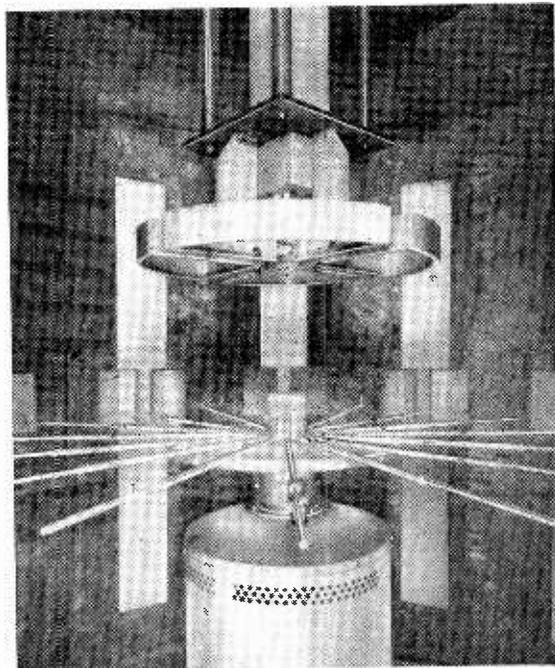
THE Marconi Omni-directional Radio Range Beacon (V.O.R.),\* with which the U.K. airways are to be equipped, operates on a spot radio frequency in the 112 to 118-Mc/s v.h.f. band and with a power output of 200 watts. The V.O.R. beacon transmits two signals on a single radio frequency, one modulated at 30 c/s. One has a constant phase throughout  $360^\circ$  of azimuth (the reference signal) whilst the other (the variable signal) has a phase which varies with azimuth. The former is radiated from an omni-directional aerial and the latter from a rotating loop and exciter system which produces a figure-of-eight radiation field. After detection in the receiver the latter produces a 30-c/s sinusoidal voltage.

Usually the system is arranged so that the phase of the rotating field pattern coincides with that of the reference signal's pattern, after demodulation, when the former passes through magnetic north, or zero degrees. At all other points in azimuth the positive maximum of the variable signal will be reached after the positive maximum of the reference signal. The fraction of the cycle between these two maxima at any point in azimuth gives the relative bearing of that point.

In the aircraft receiver the received signals are fed to a computer unit which compares the phases and displays the difference as a bearing to or from the V.O.R. ground beacon. Usually it is the magnetic bearing from the aircraft to the ground beacon. It is also possible to include a centre-zero meter which shows the aircraft's position to right or to left of a manually selected bearing. The latter provides facilities for track flying along a desired bearing to or from a V.O.R. beacon.

Marconi V.O.R. beacons also radiate a 1020-c/s tone signal keyed by a simple code sender at about 7 w.p.m. which is repeated every 30 seconds for beacon identification.

\* *Wireless World*, Feb. 1959, p. 98.



The aerial system of the Marconi V.O.R. installed in an aerial tower. Above is the omni-directional radiator with the figure-of-eight exciter below it.

# Sporadic E and the F<sub>2</sub> Layer

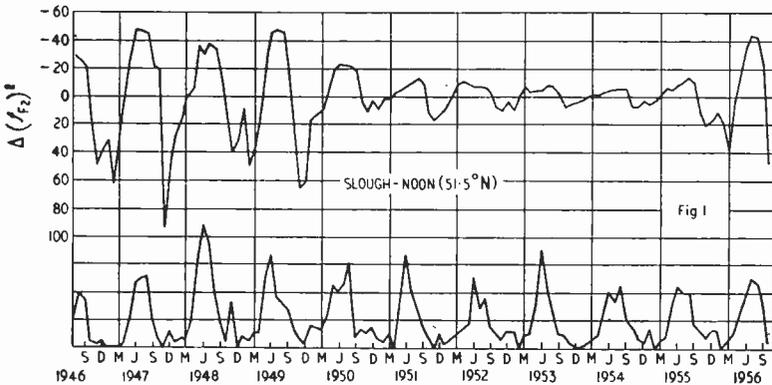
By T. W. BENNINGTON\*

ONE of the most mystifying of ionospheric phenomena is that of sporadic E. This is the name given to the relatively intense ionization "clouds" or "patches" which appear, in a sporadic manner, within the normal E layer. In the temperate and tropical zones this is largely a daytime phenomenon, and, though of a sporadic character, it has well defined seasonal variations which are rather more complex than is often supposed.

Speaking only of the sporadic E which appears in these zones, and leaving out that known as "auroral sporadic E," we may say that its cause, and the source from which its ionization comes, is at present unknown.

over, it had, in the southern hemisphere, a fluctuation of such different form from that in the northern hemisphere as to be more in the nature of a pronounced biannual fluctuation, then it might be supposed that the two phenomena were, in some way, interrelated.

It was remembered that the ionization of the F<sub>2</sub> layer does have an annual fluctuation of different form as between the two hemispheres, and it was desired, therefore, to compare this with that of the sporadic E. Accordingly the noon monthly mean critical frequency values  $f_{F2}$  for Slough and Christchurch were read off for the years in question, and  $(f_{F2})^2$  (to which the ionization of the layer is proportional) obtained. Since the sporadic E figures do not show any systematic variation with the sunspot number, it was desired to remove from the  $(f_{F2})^2$  values the secular effect due to the sunspot cycle, leaving only the seasonal fluctuations. In order to do this the twelve-month running mean value of  $(f_{F2})^2$  for each month (representing the sunspot cycle variation) was subtracted from the monthly value, and the result was called  $\Delta(f_{F2})^2$ . It is to be noted that, though the secular variation is thus removed, the seasonal variations themselves still vary in amplitude over the sunspot cycle.

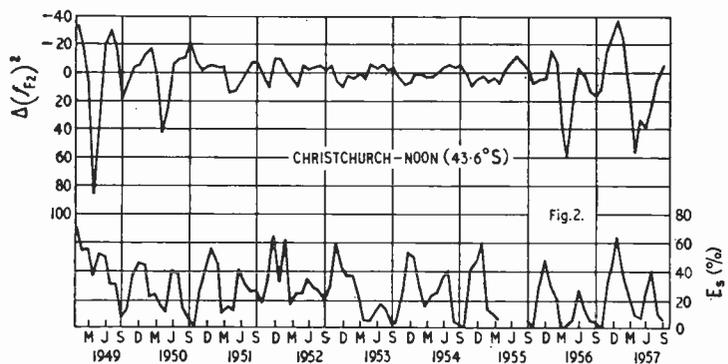


Several different types of sporadic E are, in fact, observed. Among the possible causative phenomena which have, up to now, been suggested, are meteors, thunder clouds in the troposphere, corpuscles from the sun and ionospheric current effects; but none of these possibilities has the nature of a proven fact.

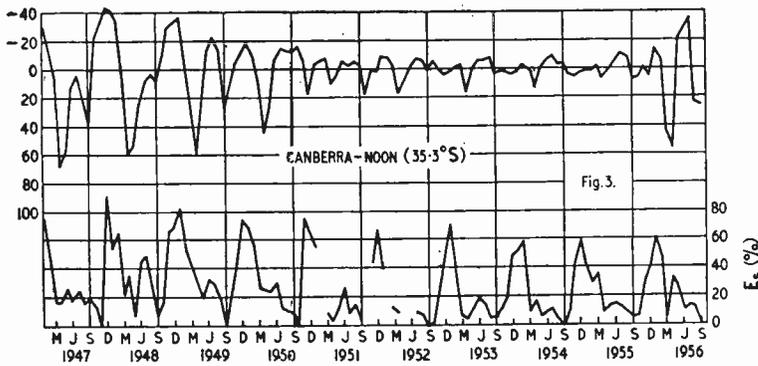
In the bottom curve of Fig. 1 are plotted the monthly values for the percentage of the total time when sporadic E with a critical frequency greater than 5Mc/s was observed at noon at Slough. The curve shows a large peak in the incidence of sporadic E centred approximately on June, i.e. near the summer solstice but it also shows a small but well defined secondary peak occurring year by year round about December. In the bottom curve of Fig. 2 similar data are plotted for Christchurch, New Zealand, a station having a somewhat similar latitude to that of Slough but in the southern hemisphere. We notice a striking difference in the curve as compared with that for Slough in that the secondary peak occurring in local winter (around June) is much larger, in fact often of amplitude almost equal to that for local summer (around December), producing, in fact, the effect of a biannual peak.

Returning to Fig. 1 it may be remarked that, to correlate the main peak with any other ionospheric phenomenon would indicate nothing much beyond the fact that they were both summertime phenomena. But if it could be shown that any other phenomenon also had a small winter fluctuation, and if, more-

The Slough values of  $\Delta(f_{F2})^2$  for noon are plotted in the top curve of Fig. 1, being inverted with respect to the sporadic E values, so that troughs in the  $\Delta(f_{F2})^2$  values appear as peaks in the curve. It is seen that, in addition to the regular summer trough in  $\Delta(f_{F2})^2$  corresponding to the main sporadic E peak, there is a small but definite trough in six of the winter periods shown, corresponding approximately in time with the secondary peak in the sporadic E. Furthermore, in several of the years when no definite trough in  $\Delta(f_{F2})^2$  appears, there is strong evidence of one which is masked by a subsequent further  $\Delta(f_{F2})^2$  variation. It is true that the secondary trough in  $\Delta(f_{F2})^2$  does not always correspond *exactly* in time with the secondary peak in sporadic E, but the troughs and peaks in each are near enough to appear to be significantly connected. The  $\Delta(f_{F2})^2$  troughs tend in fact to lag on the sporadic E peaks.



\* Research Department, British Broadcasting Corporation.



In the top curve of Fig. 2 the  $\Delta(f_{F2})^2$  values for Christchurch are plotted, and it is evident that the fluctuations are of a different character from those shown in the top curve of Fig. 1. In fact the curve shows, in general, a strong tendency for a biannual trough, which troughs appear to be connected with the peaks of the bottom curve. It is seen, in fact, that the major peak in the sporadic E curve is connected more often with a smaller trough in the  $\Delta(f_{F2})^2$  curve than is the secondary sporadic E peak. (During a few months of 1955 no measurements were available for Christchurch but it was possible to estimate the  $(f_{F2})^2$  values by interpolation; this was not possible for the sporadic E.)

It is convenient, in order clearly to distinguish the annual variation, to regard each year as starting at the vernal equinox in both hemispheres, and the vertical lines in the graphs are used to divide the time into years in this way.

Similar results can be obtained for stations in other latitudes. Consider, for example, Fig. 3, in which the values of sporadic E percentage time and of  $\Delta(f_{F2})^2$  for Canberra are plotted. There are several breaks in the data but the general features can be clearly seen. The secondary peak in sporadic E is less prominent than is the case for Christchurch, but it appears to be connected with one of the biannual troughs (often the major one) in  $\Delta(f_{F2})^2$ .

In Fig. 4 similar data are plotted for White Sands, a station in the northern hemisphere with a lower latitude than that of Slough. Here the winter peaks in sporadic E are much larger than those for Slough (in fact they are sometimes of greater amplitude than the summer peaks). Correspondingly, the winter troughs in  $\Delta(f_{F2})^2$  are much more pronounced than in the case of Slough, and the similarity between the peaks and troughs of the two curves of Fig. 4 is, all things considered, quite pronounced.

There is one further phenomenon which furnishes evidence of a like nature to that shown in the graphs. If one examines the sporadic E data for local noon for a station near the magnetic equator (such as Huancayo, Peru or Ibadan, Nigeria) it is found that sporadic E with critical frequency greater than 5Mc/s is present for from 90 to 98% of the total time during every month of the year. This effect is found to prevail in a narrow belt along the magnetic equator and within that belt a trough is found to exist in the geographical distribution of  $(f_{F2})^2$ . In other words the highest values of  $(f_{F2})^2$  exist, at noon, a few degrees to the north

and south of the magnetic equator, and nearer to the equator, and coincident with a permanent region of sporadic E, the  $F_2$  ionization is depleted.

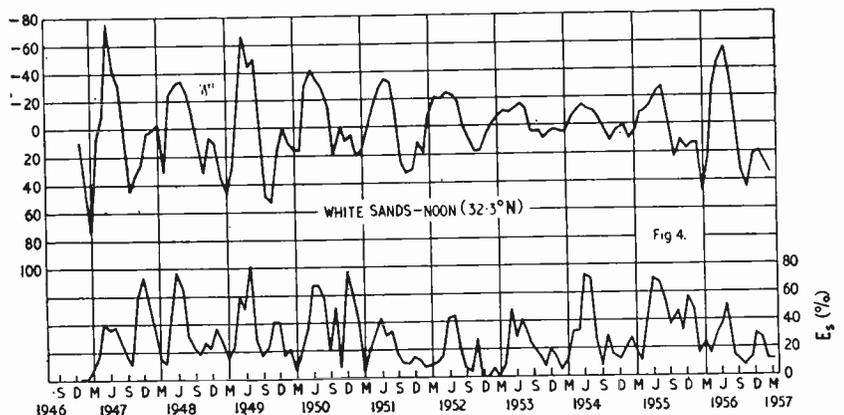
All the above facts seem to indicate that where intense sporadic E exists for a high percentage of the time, as at noon in local summer and at noon on the magnetic equator throughout the year, the  $F_2$  ionization is depleted. Further, that when there occur, in both hemispheres, secondary increases in the percentage time for intense sporadic E, as at noon in local winter, the  $F_2$  ionization is again depleted, and the magnitude of the

depletion corresponds approximately to the increase in the incidence of sporadic E. These facts may account, in some part, for the anomalous seasonal behaviour of the daytime  $F_2$ .

The above facts seem to suggest that the dense ionization which appears in the E layer, and is called sporadic E, comes in fact from the  $F_2$  layer, and that its occurrence leads to a depletion of the  $F_2$  ionization in all cases. This might occur by reason of some sort of "subsidence" or downward drift of ionization from the  $F_2$  into the E. The difficulty is to see, if this be so, how the sporadic E would have the "thin layer" characteristics which it does, in fact, usually display. Even so there appears to be the possibility that, above the thin sporadic E layer, phenomena such as a downward drift may be occurring but are not easily observable by ionospheric measurement techniques. As was first reported by Appleton and others in 1939†, a kind of downward drift is often observed during the formation of sporadic E. The ionization in these cases is first observed at the height of the  $F_1$  layer and, during the course of several hours, it decreases in height and increases in critical frequency until the normal E layer height is reached. What physical process could occasion such a downward drift, and cause it to occur only sporadically, is a subject for speculation. But the facts mentioned here, and the evidence of the graphs, do suggest that sporadic E may come from the  $F_2$  layer.

A further possibility is that the coincident biannual peaks in the sporadic E and troughs in the  $F_2$ -layer ionization are both due to some common cause of extra-ionospheric origin, though it is difficult to see how any ionizing agency could produce such effects. A more likely possibility would seem to be the presence of an ionospheric current, capable of causing interaction between the two layers.

†Appleton, E. V., Naismith, R. and Ingram, L. J., "The Critical-Frequency Method of Measuring Upper-Atmospheric Ionization". *Proc. Phys. Soc.*, Vol. 51, pp. 90-91, January 1939.



# Simple Oscilloscope Camera

Using Printing Paper to Record Stationary Traces

By A. J. KEY, B.Sc. (Eng.), Grad. I.E.E.

ONE often requires a record of a steady oscilloscope trace. As students, I remember, we used to trace the waveform on tissue paper obtained from a local plentiful supply, but the only merit of this method was cheapness. The alternative, an oscilloscope camera complete with shutter, film and driving motor, is an expensive improvement. I had thought of a contact printing process, which would involve holding contact paper against the tube face, but of course this would result in only a very blurred image. Some sort of focusing device is necessary; in fact a simple camera using printing paper as the film.

The camera and method of mounting the lens are shown in Fig. 1. The body of the camera is made from aluminium sheet rolled into a  $2\frac{1}{2}$ -inch diameter tube, to suit, of course, a  $2\frac{1}{2}$ -inch screen

c.r.t. The length of the tube depends upon the focal length of an available lens and the required image size. The minimum length of the tube would be  $4\times$  focal length of the lens, giving a magnification of unity. However, in the interests of image brightness, it is as well to use a magnification of  $\frac{1}{2}$ . This requires a camera length of  $4\frac{1}{2}\times$  focal length of the lens, as is shown in the appendix.

The front end plate (also made from aluminium sheet) has a circular window, slightly smaller in diameter than the aluminium tube, but fixture to the tube can be made easier if three tabs are cut and bent away from the sheet before cutting the window. These tabs then fit into the tube, which fits flush with the end plate. The rear end plate has a rectangular window slightly smaller than the printing paper size. It can be fitted to the tube

with four aluminium brackets, but the screw heads on the rear face of this end plate must be countersunk to enable the paper to lie flat upon the end plate. The backing plate is a plain piece of aluminium sheet which holds the printing paper during exposure against the window of the rear end plate, by being clamped to it with a pair of bulldog clips.

The lens is held by two rubber rings clamped between two aluminium "washers." These washers fit the inside of the tube, leaving a small clearance, and have apertures slightly smaller than the diameter of the lens. The washers are held together, sandwiching the lens between them, by three clamping screws. One of the washers has three tabs cut and bent from its edge to take the three 6 B.A. screws which project through axial slots in the tube. The lens assembly can then be moved nearer

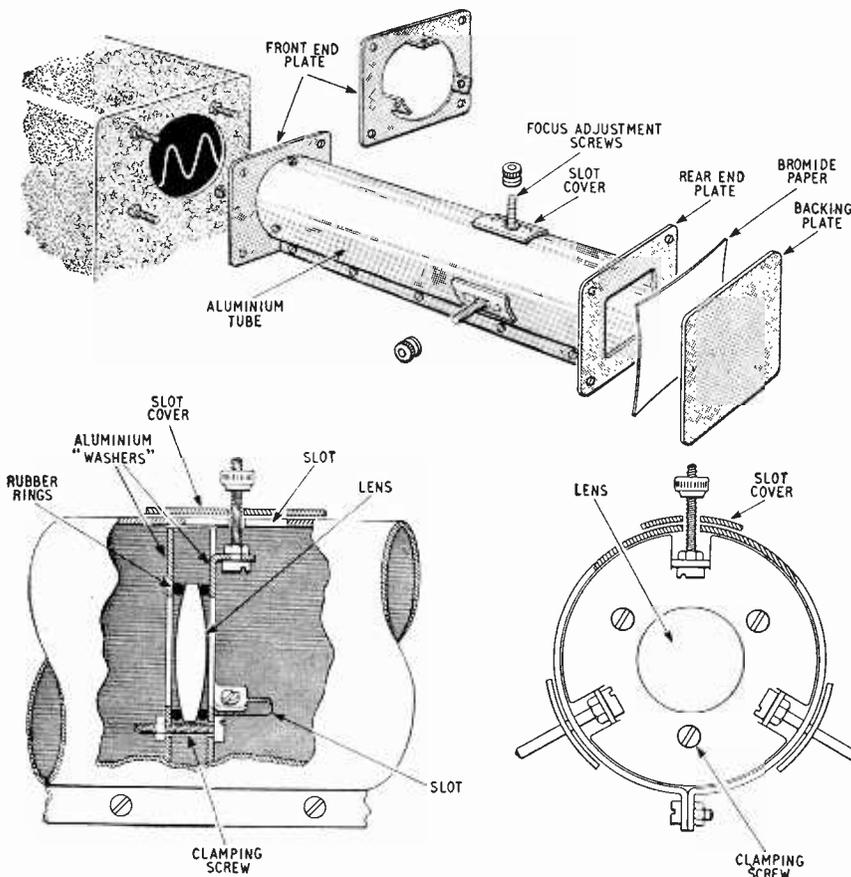


Fig. 1. Construction of the camera tube and lens mounting system.

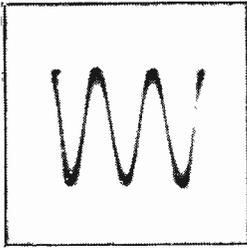


Fig. 2. Example of a 1,000-c/s sine wave recorded by the camera.

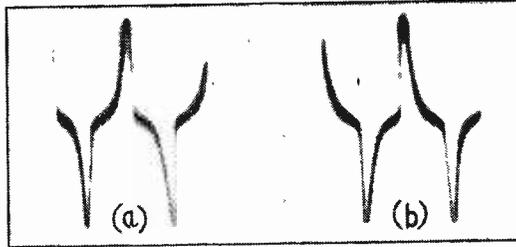


Fig. 3. (a) Mirror image obtained of a differentiated square wave with a forward-running timebase, (b) the same wave with a backward-running timebase.

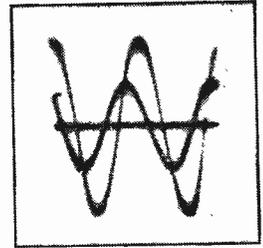


Fig. 4. Superimposition of two sine waves to show phase difference.

to or away from the screen to enable focusing adjustments to be made. Three sliding covers fit over the slots to prevent light ingress into the tube and the whole assembly is clamped by three 6 B.A. terminals. Although this may seem a rather complicated assembly, in practice it is very easy to make, requiring no tools other than a drill, a file and a pair of scissors. Finally, the inside of the tube is coated with a black matt paint (made actually from soot and nail varnish).

### Requirements for the Lens

The choice of lens will depend largely upon those available. In the interests of a bright image, the diameter (aperture) of the lens should be as large as possible, but if the lens is uncorrected for spherical aberration, a certain amount of blurring of the image will occur. The object lens from an old telescope is ideal. It will have a rather large focal length, making the camera rather long, but the spherical aberration will be reduced. If a simple uncorrected lens is used it should have a long focal length for this reason.

Contact paper does not appear to be sensitive enough; bromide paper is far better, using a reasonable brightness level. Two to three minutes' exposure, followed by two minutes' development and subsequent fixing, gave the results shown in Fig. 2 for a 1,000-c/s sine wave. As long as the paper is fitted into the camera in darkness, the exposure can be made in reasonable light conditions in the laboratory when the camera is fitted on to the oscilloscope. If trouble is experienced with fogging of the paper, draping a black cloth over the camera during exposure should cure the trouble. Synchronization must be used, of course, but the occasional jump does not affect the image.

The image produced will be a black trace on a white background, which is convenient when adding comments and making measurements. One snag, however, is that the image is a mirror-image (see Fig. 3(a), the trace of a differentiated square wave). This can be overcome by either reversing the X plates (thereby reversing the timebase) or reversing the Y plates (inverting the image) whichever is the more convenient. Luckily, on my oscilloscope, reversal of the X plates could easily be accomplished by a modification to the X selector switch. Otherwise, a double-pole double-throw switch could be fitted for this purpose. Fig. 3(b) is a trace obtained with a backward running timebase.

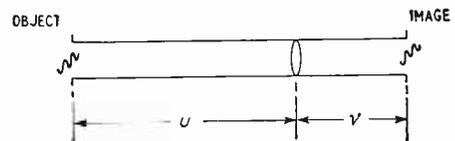
These results were given by a green trace cathode ray tube and bromide paper, WFL.2D. It may be that other printing paper is more sensitive to green

light and that other colour traces require other grades of paper.

The system is quite useful for measurement of phase differences. Normally one needs a double beam oscilloscope for this, but even then the thickness of the tube face and lack of a zero line make the measurement only approximate. Suppose one wishes to measure the phase difference between two voltages occurring at points A and B in a circuit. The oscilloscope is synchronized from the voltage at A and an exposure is made for two minutes to the trace of this voltage. Another exposure, to the waveform of the voltage at B, is now made, retaining the synchronization from A. Finally, an exposure is made to the undeflected trace to obtain a zero line. The result for two sine waves is shown in Fig. 4. Of course, any number of waveforms may be superimposed in this manner.

The cost of each exposure is negligible. Cutting sheets of 3½in × 4½in bromide paper into four makes each print about ¼d. The developer and fixer can be made up from powder and stored for two or three months.

### APPENDIX



Putting  $u$  and  $v$  as positive distances, for a double convex lens

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \text{ where } f \text{ is the focal length of the lens}$$

$$\text{Magnification } M = \frac{v}{u}$$

$$\text{therefore } \frac{1}{f} = \frac{1}{u} + \frac{1}{Mu}$$

$$\text{From which } u = \left(1 + \frac{1}{M}\right) \cdot f$$

$$\begin{aligned} \text{Total length} &= u + v \\ &= \left(1 + \frac{1}{M}\right) \cdot f + M \left(1 + \frac{1}{M}\right) \cdot f \\ &= \left(2 + M + \frac{1}{M}\right) \cdot f \end{aligned}$$

Thus if magnification is  $\times 1$ , total length =  $4f$

If magnification is  $\times \frac{1}{2}$ , total length =  $4.5f$

# WORLD OF WIRELESS

## Medical Electronics Conference

OVER 120 papers on the application of electronic techniques to medicine will be presented by experts from 18 countries at the Second International Conference on Medical Electronics to be held in the new U.N.E.S.C.O. headquarters in Paris from 24th to 27th June. A commercial exhibition of electro-medical equipment will be held in the building at the same time. Subjects of the conference papers range from the measurement and telemetering of physiological data during space flight to the control of artificial limbs by muscle action potentials; from "radio pills," which are swallowed and transmit physiological data from inside the body, to the use of electronic computers for statistical methods of diagnosis. Registrations for the conference can still be arranged through the treasurer, B. Shackel, E.M.I. Electronics, Ltd., Feltham, Middlesex.

## MSF Standard Frequencies

IN calculating the frequencies of the 60-kc/s transmissions from the Rugby station MSF in terms of the caesium resonant frequency a value of  $9,192,631,770 \pm 20c/s$  will be assumed instead of the former value of  $9,192,631,830c/s$ . The change is the result of the adoption of Ephemeris Time (ET) instead of corrected Universal Time (UT2). From March, 1959, corrections will be measured to

$\pm 1$  part in  $10^{10}$  and the results will be published monthly, as usual, in our sister journal *Electronic & Radio Engineer*. For a detailed discussion of the background to the changes readers are referred to *E. & R.E.* for March, p. 117.

## Receiver Production & Sales

THE total turnover of the domestic receiver side of the radio industry during 1958 was just over £90M; about £3M more than in 1957. Of this total £3.4M worth of receivers was sold overseas. The export of sound receivers dropped from £2.89M in 1956 to £2.12M last year, while the overseas sales of television receivers rose from £462,000 to £914,000 during the same period and radio-gramophones from £271,000 to £399,000. The largest market for domestic equipment was Sweden, who purchased £329,809 worth, of which £293,983 was for television receivers. Well over a fourth of the value of radio-gramophone exports went to the U.S.A. These figures are culled from the statistics section of the annual report of the British Radio Equipment Manufacturers' Association.

During 1958 the popularity of the 17-in television screen continued to increase; accounting for approximately 83 per cent of all home sales—an increase of 11 per cent during the year. The percentage of models with 21-in tubes fell from 8 to 5 and those with 14-in tubes from 20 to 12 during the year.

## Dip. Tech.

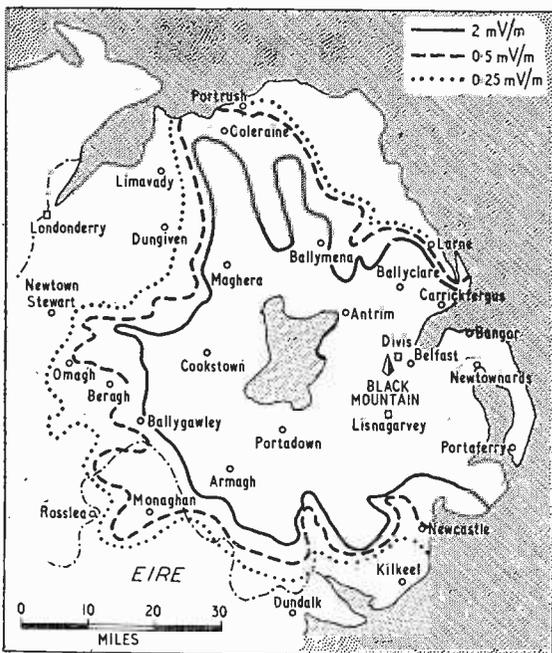
THE number of students taking advance courses leading to the award of the Diploma in Technology has increased more than two-and-a-half times during the past eighteen months. The second report of the National Council for Technological Awards published on April 23rd records that 2,518 students, including 52 women, are now following 66 diploma courses at 20 colleges.

Lord Hives, chairman of the Council, in paying his tribute to industry in a foreword to the report, refers to the fact that 82% of the 2,323 students following sandwich courses leading to the Diploma in Technology have their fees paid by their employers.

In addition to the 66 courses (53 of which are sandwich type) referred to above, the Council has recently approved a further 21 and all the 87 courses are included in the latest list (No. 10) available from the Council at 9, Cavendish Square, London, W.1.

## "Trader Year Book"

FIRST published in 1925 the "Wireless and Electrical Trader Year Book" has become the *vade mecum* for the radio trade. A few of the features of the 1959 edition are:—condensed specifications of nearly 250 current television receivers and over 400 sound receivers; tables of television tuning frequencies (giving i.f.s of superhet receivers and sideband characteristics of both superhet and t.r.f. models) and also the i.f.s of sound receivers issued since 1946. It is also a valuable book of reference for trade names and manufacturers' addresses. The 416-page volume, issued by the Trader Publishing Co., costs 12s 6d.



I.T.A. IN N. IRELAND.—Estimated service area of the new I.T.A. transmitter on Black Mountain, near Belfast. The station will radiate in channel 9 using horizontal polarization. The directional aerial atop the 700-ft mast, giving a height of nearly 1,700-ft above sea level, will have an e.r.p. varying from 20kW to 100kW. Full-power test transmissions are planned to begin in August.

**Television Society Premiums** have been awarded for outstanding papers read before the London meetings in 1957/58. For his paper "Transistors in Television Receivers," B. R. Overton, head of the television division of Mullard Research Laboratories, receives the *Wireless World* premium. The E.M.I. premium goes to Dr. R. Theile (Institut für Rundfunktechnik) for "Recent Investigations into the Operation of Image Orthicon Camera Tubes"; the *Electronic Engineering* premium to Dr. J. C. Parr (formerly Kelvin & Hughes) for "Some Aspects of Waveguide Technique"; the Pye premium to L. J. Griffen (Kolster Brandes) for "Dressing Television: Cabinet Design"; the Mervyn premium to K. H. Smith (Siemens Edison Swan) for "Performance of Television Receiver Turret Tuners"; and the Mullard premium to J. Polonsky (Compagnie Générale de T.S.F.) for "A French Portable Television Camera."

**Television Society Council.**—New members elected at the annual general meeting on May 8th, to fill the four vacancies on the council of the Television Society are: Dr. A. J. Biggs (G.E.C. Research); G. G. Gouriet (Wayne Kerr); B. R. Overton (Mullard Research); and Dr. J. D. McGee (Imperial College).

**B.R.E.M.A.**—The member firms of the British Radio Equipment Manufacturers' Association forming the new Council of the Association (with the firms' representatives in parentheses) are: A. J. Balcombe (E. K. Balcombe); Bush Radio (G. Darnley-Smith); E. K. Cole (G. W. Godfrey); Ferguson Radio Corp. (F. T. Holmes); G.E.C. (M. M. Macqueen); Gramophone Co. (F. W. Perks); Kolster-Brandes (L. R. Tyne); Philips Electrical (A. L. Sutherland); Radio & Allied Industries (Bentley Jones); Trix Electrical (D. A. Lyons); Ultra Electric (E. E. Rosen); and Roberts Radio (H. Roberts). F. W. Perks and A. L. Sutherland have been re-elected chairman and vice-chairman respectively.

**Outward Form.**—An international cabinet-styling exhibition is again being arranged by B.R.E.M.A. It will be held from October 6th to 8th and will this year occupy both the North and South Halls of the Victoria Halls, Bloomsbury Square, London, W.C.1. Manufacturers of metal embellishments, plastics materials, glassware, fabrics, ornamental controls and aerials are being invited to participate in this "stockroom" exhibition.

**University Scholarships.**—Over 500 applications were received for the second series of 20 university scholarships offered by the English Electric Co. The scholarships, worth £450 a year, cover a three-year course at a university to study for an honours degree. Commenting on the applications, E. R. L. Lewis, Controller of Education in the English Electric group of companies, stated that the standard of entry was very high. About one-third of the entrants were interviewed, from these 40 were invited to attend a two-day residential selection board, and from these the 20 recipients were chosen.

Plastics materials are used so extensively in the radio industry that we make no apology for drawing readers' attention to the International Plastics Exhibition to be held at Olympia, London, from June 17th to 27th. Over 300 U.K. and overseas manufacturers of plastics materials and finished products and machinery are exhibiting at the show which is organized by *British Plastics*. A three-day convention (June 22nd to 24th) is being held in conjunction with the exhibition. Admission tickets to both the exhibition and convention are obtainable free from *British Plastics*, Dorset House, Stamford Street, London, S.E.1.

**Institution of Electronics** is offering four new premiums for papers published in the proceedings of the Institution, which is issued quarterly. They vary in value from 15 to 25 guineas.

**"Transipack" Convertors.**—The two semiconductor h.t. units described on page 248 in the May issue weigh 1 lb 2 oz and 1 lb 15 oz respectively and not 11 lb as stated.

**Manchester Electronics Exhibition.**—The 14th Annual Electronics Exhibition and Convention of the Institution of Electronics will be held at the Manchester College of Science and Technology from July 9th to 15th. There will be two main sections in the exhibition; one for manufacturers and the other covering scientific and industrial research. Further particulars of the exhibition and the associated convention are obtainable from W. Birtwistle, 78, Shaw Road, Rochdale, Lancs., from whom complimentary tickets may also be obtained.

**Industrial Electronics.**—From May 26th to 29th at the Rutherford College of Technology, Newcastle-upon-Tyne, Farnell Instruments Ltd., of Wetherby, Yorks., are holding their third industrial electronics exhibition. It will open daily at 10.0 and close at 5.30 on the first and last days and 7.0 on the two intervening days.

**Receiving Licences.**—During March the number of combined television and sound licences throughout the U.K. increased by 102,495, bringing the total to 9,255,422. Sound only licences totalled 5,480,991 including 376,053 for sets fitted in cars.

**I.R.C.M.S.**—The duplicated bulletin of the International Radio Controlled Models Society is now available to non-members from N. R. Armstrong, 3 Lilburn Gardens, Newcastle on Tyne 3 (price 2s 10d). The bulletin includes not only reports on the groups operating in different parts of the country, but also useful notes on radio control techniques.

**Radio Control.**—The annual contest of radio-controlled model boats, cars, etc., organized by the I.R.C.M.S., will be held on August 2nd and 3rd in East Park, Kingston-upon-Hull. Entry forms and copies of rules are obtainable from B. E. Veal, 33 Steynburg Street, Newbridge Road, Hull, Yorks.

**Essay Competition.**—To encourage and promote improved and more effective reports of scientific and technical work the Waverley Gold Medal Essay Competition is again being sponsored by *Research*. Details of the competition, entries for which must be received by July 31st, are obtainable from the Editor of *Research*, 4 and 5 Bell Yard, London, W.C.2.

## Personalities

A. H. W. Beck, B.Sc.(Eng.), A.M.I.E.E., who was for some years in charge of the Vacuum Physics Division of Standard Telecommunications Laboratories at Enfield before joining the staff of the Engineering Department of Cambridge University last year, has been elected a Fellow of the American Institute of Radio Engineers "for contributions to the development of the thermionic valve." After graduating at University College, London, and undertaking a year's post-graduate work on secondary electron emission, he joined the research staff of Henry Hughes & Sons in 1937. He was at the Admiralty Signals Establishment extension at Bristol during the war, after which he returned to Hughes, where he stayed until 1947, when he joined Standard Telephones and Cables. He has twice received a technical writing premium from the Radio Industry Council.

R. S. Medlock, B.Sc., A.R.I.C., A.M.I.E.E., technical and home sales director of George Kent Ltd., of Luton, Beds., is the new president of the Society of Instrument Technology. He joined the company in 1935 and was chief research and development engineer for five years before assuming his present position in 1956. He is a past chairman of the control section of the Society. He succeeds J. F. Coales, O.B.E., M.A., M.I.E.E., reader in control engineering at Cambridge University, whose presidential address at the conclusion of his term of office dealt with the education of instrument technologists and control engineers.

**Air Commodore W. C. Cooper, C.B.E., M.A., M.I.E.E., M.Brit.I.R.E.:** has had conferred on him by the City and Guilds of London Institute the Insignia Award in Technology (C.G.I.A.). Five of these awards are made each year in various branches of industry to "persons of distinction in recognition of their outstanding achievements in technology." He joined the R.A.F. in 1922 at the age of 16, was gazetted in 1926 and after taking a Specialist Officers' Signals Course at Cranwell he went to Cambridge University for the engineering tripos course. When he retired from the R.A.F. in 1946 he was Director of Communications, Research and Development in the Ministry of Aircraft Production. He then joined Ericsson Telephones as factory manager at Beeston, Notts., and in 1957 became chairman and managing director of Manlove, Alliott and Co., of Nottingham, who are engaged in the development of process control equipment.

**Herman Baker,** for the past six years Far East Regional Manager for Marconi's, has been appointed managing director of Marconi (South Africa) Ltd. He joined the company in 1930 as a student apprentice and on completion of his technical training remained in the Test Department until the outbreak of the war, during which he served in the Royal Artillery, attaining the rank of Major. Since 1951 he has been responsible for the company's activities in the Far East and took charge of a large-scale survey for the establishment of the main Malayan v.h.f. multi-channel telecommunications trunk routes.

**Donald G. Fink,** formerly editor of *Electronics*, has been appointed director of the research division of the Philco Corporation, which he joined in 1952. He was a member of the editorial staff of *Electronics* from 1933, except for a period during the war when he was granted leave of absence to join the Radiation Laboratory of M.I.T. where he subsequently became head of the Loran division. He was president of the I.R.E. for 1958.

**H. de A. Donisthorpe** has retired from the G.E.C., which he joined in 1926. He had been for some years deputy manager of the company's Valve and Electronics Department. He was for 11 years chairman of the Radio Industries Club prior to being elected president for the year 1948/49.

**G. E. Spark** is joining the Garrard Engineering and Manufacturing Company as sales manager of the division being formed to market the tape deck to be introduced by the company. Mr. Spark, who is chairman of Audio Fairs Ltd., was previously with M.S.S. Recording Co.

**D. W. Rippin** has resigned his position as export manager of Belling & Lee to emigrate to Canada where he is joining the Astral Electric Company, of Toronto, who are Belling & Lee's Canadian agents. **J. E. Bailey, B.Sc.(Elec. Eng.),** who has been with Belling & Lee for two years, succeeds him as export manager. After graduating at Manchester University in 1948, Mr. Bailey joined the Navy for two years and was commissioned in the electrical branch. He then joined Marconi's as a graduate apprentice and subsequently worked on airborne and marine radar equipment. From 1954 to 1956 he was with Decca Radar.

**M. T. Elvy, A.M.Brit.I.R.E.,** has been appointed joint manager and chief engineer of the R.F. Heating Division of Pye, Ltd., Cambridge. He was formerly chief engineer of the Industrial Electronics Laboratory of Radifon, Ltd.

**D. C. F. Bartlett, B.Sc.(Eng.),** has been appointed a director of Alma Components Limited, manufacturers of precision wirewound resistors. He was formerly on the commercial manager's staff in the Components Group of Standard Telephones and Cables.

**E. R. Deighton,** recently appointed Assistant Superintendent Engineer, Television (Regions and Outside Broadcasts) by the B.B.C., has been assistant to the Controller, Television Service Engineering, since 1953. He joined the B.B.C. television service at the Alexandra Palace station in 1936. He succeeds **W. D. Richardson, Assoc.I.E.E.,** who is retiring after nearly 30 years' service.

**G. D. Cook, A.M.I.E.E.,** is appointed by the B.B.C. Engineer-in-Charge (Television), Manchester, in succession to **V. G. Hawkeswood,** who, as announced in our February issue, has joined Southern Television. Mr. Cook joined the Corporation in 1946 and has been assistant to the Superintendent Engineer Television (Regions and Outside Broadcasts) since 1955.

**J. J. S. Smith, A.M.I.E.E.,** works manager of British Communications Corporation, Ltd., was recently appointed to the board of directors.

## OUR AUTHORS

**J. C. Burfoot, Ph.D.,** contributor of the article on ferroelectrics in this issue, is a lecturer at Queen Mary College, University of London. Educated at Christ's College, Cambridge, he obtained first-class honours in his tripos in 1949 after an interval of three years as a Signals Officer in the R.A.F. His doctoral thesis at Cambridge and subsequent research at Aberdeen University were on aberrations in electron lenses. Since 1955 Dr. Burfoot has been investigating ferroelectricity and computers.

**R. G. Christian, A.M.Brit.I.R.E., Grad.I.E.E.,** who describes in this issue a circuit for displaying valve anode curves and their axes on a c.r. tube, is a teacher at the College of Technology, Liverpool. Before joining the staff at the College in 1954 he was for three years in industry. From 1946-48 Mr. Christian was in the Royal Army Educational Corps following which he was for three years a student at the Regent Street Polytechnic. He operates amateur station G3GKS.

**W. A. Cole, B.Sc.,** author of the article on magnetic matrix stores, served with the R.A.F. as a Flight Lt. on ground radar during the war. Subsequently he attended London University, where he obtained a special physics degree. In 1951 he joined Mullard Research Laboratories, Salfords, eventually taking charge of a group working on magnetic storage devices. Recently, he transferred to the component division at Mullard House.

**Jean Walton,** who recently contributed an article on pickup design, discusses the design of a pickup arm in this issue. Miss Walton, who has had twelve years' experience in the development of audio equipment, has been with Cosmocord for the past 18 months.

## OBITUARY

**Sir Stanley Angwin, K.C.M.G., K.B.E., D.S.O., M.C.,** who died on April 21st, aged 75, was for eight years engineer-in-chief of the Post Office before being appointed chairman of Cable and Wireless, Ltd., on the Government's acquisition of the company in 1947. He resigned in 1951 to become chairman of the Commonwealth Telecommunications Board, from which he retired in 1956. Sir Stanley joined the Post Office engineering department in 1906. "In recognition of his outstanding life's work in the field of telecommunication, both national and international," the I.E.E. granted him honorary membership in 1956. Three years earlier he had received the Institution's Faraday Medal. He was for some years a member of the Radio Research Board of the D.S.I.R. and was appointed chairman in 1947.

# Pickup Arm Design

By I. WALTON\*

## Requirements for Low Tracking Weight and Immunity from Vibration

**T**HE following considerations arose in the course of the design of the 1-gm pickup described recently in *Wireless World* (April issue, p. 182). A general reassessment of arm design was found necessary since most arms now available were designed when tracking weights were in the region of 5 to 10 gm, and side thrusts (intentional and otherwise) of about 1 gm seem to be quite common even after careful levelling.

The requirements for a suitable arm are that under operating conditions there should be:—

(1) *Low side thrust.* Side thrust may be produced by (a) pivot system friction, (b) an unlevel base, (c) the torque resulting from the head angular offset and friction between the stylus and both plain and modulated grooves, and (d) the "lateral" inertia of the arm acted upon by any eccentricities in both the disc and turntable. For 1-gm tracking, the total side thrust should be under 0.1 gm.

(2) *Constant and correct vertical stylus force.* This force is affected by (a) the "vertical" inertia of the arm acted upon by any warps in the disc and turntable, (b) friction of the "vertical" pivot system and (c) stability of vertical balance. This stability is determined by the distribution of mass above and below the vertical pivot, and any spring counterbalance which may be used.

(3) *Immunity from vibrations.* Such vibrations can be internal (rumble, etc.) or external. Excitation

in any direction at the stylus or pickup base or both together should not produce undue vertical or lateral pressures at the stylus tip. Internal excitations are limited by disc and record player standards, whereas external excitation varies with the rigidity of the user's floor!

(4) *Facility of use.* There should be no need for weighing machines, spirit levels, etc.

There appears to be some scope for arm development to fulfil these requirements, and to this end

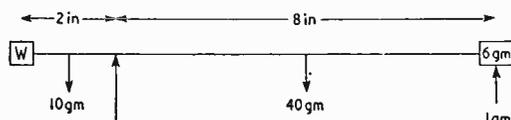


Fig. 2 Dimensions and weights in a typical single-pivot system.

the various principles of construction were reduced to the following:—

(a) Single pivot (including vertical pivots directly over lateral) as in Fig. 1(a).

(b) Axle and pivot (vertical pivots offset from lateral) as in Fig. 1(b), and

(c) Spring counterbalance as in Fig. 1(c).

**Low Side Thrust.**—As a result of measurements made on existing arms, low side thrust became the first consideration. It can be seen that friction at the lateral pivot is an almost constant minimum only in the case of the single-pivot system, since extra thrust on the side of the essential axle part in the other two principles of construction gives extra friction according to the balance moment required. An example will emphasize this point.

Consider a pickup to track at 1 gm with a head mass of 6 gm at a distance of 8 in from the lateral pivot. The three principles of construction then give the following results:—

(1) *Single pivot as in Fig. 2.*

Taking moments about the pivot we have:—  
 $(W \times 2) + (10 \times 1) = (40 \times 4) + (5 \times 8)$

$$\therefore W = 95 \text{ gm}$$

$$\therefore \text{Total weight on pivot} \\ = 95 + 10 + 40 + 5 \\ = 150 \text{ gm}$$

$$\therefore \text{To a first approximation, frictional force at pivot} \\ = 150 \times \mu \text{ gm}$$

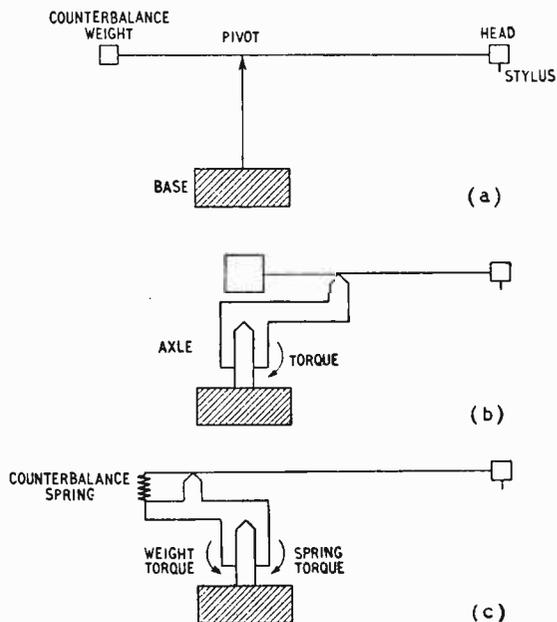
where  $\mu$  is the coefficient of friction. If  $\mu = 0.2$  and the pivot tip has a radius of 0.02 in then, taking moments about the pivot, Maximum side thrust at stylus

$$= 150 \times 0.2 \times \frac{0.02}{8} \\ = 0.075 \text{ gm}$$

(2) *Offset pivots as in Fig. 3.*

With a 2-in offset and 2-in axle we have, taking

Fig. 1 Basic principles of pickup arm construction:— (a) single pivot, (b) offset pivots with axle and weight counterbalance, and (c) offset pivots with axle and spring counterbalance.



\* Cosmocord Ltd.

moments about the vertical pivot  
 $(W \times 2) + (10 \times 1) = (30 \times 3) + (5 \times 6)$   
 $\therefore W = 55 \text{ gm}$

$\therefore$  Moment about axle  
 $= (55 + 10 + 30 + 5) \times 2 + (10 \times 1)$   
 $= 210 \text{ gm-in}$

$\therefore$  To a first approximation, frictional force at extreme lower end of an axle even as unusually long as 2-in

$$= \frac{210 \times \mu}{2} \text{ gm}$$

If  $\mu = 0.2$  as before, and the axle has a diameter of  $\frac{1}{8}$  in then,

$$\text{Side thrust at stylus} = 105 \times 0.2 \times \frac{0.0625}{8}$$

$$= 0.164 \text{ gm}$$

To this must be added the side thrust due to friction at the pivot at the top of the axle. If the pivot tip has a radius of 0.02 in then, from a calculation similar to that with a single pivot,

$$\text{Extra side thrust at stylus} = (55 + 10 + 30 + 5 + 10) \times 0.2 \times \frac{0.02}{8}$$

$$= 0.055 \text{ gm}$$

$\therefore$  Total side thrust at stylus  
 $= 0.22 \text{ gm}$

### (3) Spring counterbalance.

This can be arranged to have the same friction as the single pivot by countering the moment of the weight about the axle by the spring torque, using a rearward offset of the vertical pivot (see Fig. 1(c)). This, of course, is for only one value of the tracking weight.

The idea of using pivot friction to counter the side thrust caused by pickup head angular offset and friction between the stylus and groove was dismissed, since this thrust not only varies with the tracking weight required, but also with the recorded modulation as well as with the tracking error. It was thought that a considerable reduction in the side thrust would occur when tracking within the elastic limit of the record, because of reduced friction between the stylus and groove.

If British Standard 1928:1955, giving the allowable eccentricity of discs and turntables is taken as a basis, it can be shown that a pickup arm tracking a micro-groove disc may find itself at rest occasionally. Thus it is clear that static as well as sliding friction must be taken into account in the lateral pivot. A figure of 0.05 gm static frictional force was designed for, and even lower values were attained in practice.

The worst feature of the two offset pivot systems is the extra necessity for levelling the arm base. If this is not done, the laterally unbalanced moment of the whole weight of the whole arm may produce a side thrust proportional to the sine of the angle of arm base tilt. Again the spring system could be elaborated to avoid this, but only conveniently for one value of the tracking weight. In a true self-levelling, single-pivot system (i.e., one in which the arm can freely rotate about the pivot in any direction) the side thrust is only equal to the actual stylus force multiplied by the sine of the angle of turntable tilt. Considering 1-gm trackers, a  $2\frac{1}{2}^\circ$  tilt produces a side thrust of 0.044 gm for a true single pivot, and  $0.044 \times \frac{1}{8} (6 \times 8 + 40 \times 4 + 10 \times 1) = 1.2 \text{ gm}$  for example for the offset pivot case of Fig. 3.

If the effective stylus force is momentarily reduced by vibration or excessive modulation to less than the side thrust, then the stylus will ride up out of the groove. With an unlevelled offset system, due to the out-of-balance side thrust, the stylus will then skate with increasing momentum and destructive power across the record. With a true single-pivot system, owing to its "self-levelling" properties, the side thrust due to an unlevel turntable is only proportional to the contact force between the stylus and groove and thus falls to zero if the stylus leaves the groove. In fact the developed pickup, which incorporates a true single pivot, will not skate across the record under the most adverse conditions even at very low tracking weights.

Again consulting British Standard 1928:1955, it can be deduced that the combined allowable eccentricity of disc (0.002 in) and transcription turntable (0.001 in) will produce a lateral acceleration of  $(2\pi \times 33\frac{1}{2} \div 60)^2 \times 0.0015 \times 2.54 = 0.045 \text{ cm/sec}^2$ , with a proportionate side thrust at the stylus tip according to the inertia of the arm about its lateral pivot. In this respect the advantage is with an offset pivot, but the reduction of side thrust with an offset rather than a single pivot is only about 30% comparatively, and absolutely the reduction is very small, being in this case only of the order of a few tenths of a milligram. For example, the equivalent effective head masses in the cases of the offset pivot of Fig. 3 and single pivot of Fig. 2 are 20 and 26 gm respectively, and at an

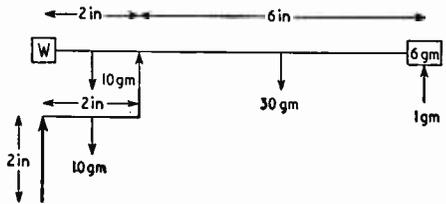


Fig. 3 Dimensions and weights in a typical offset-pivot system with axle and counterweight. The distance of the pickup head from the lateral pivot is the same as in Fig. 2.

acceleration of  $0.045 \text{ cm/sec}^2$  these masses produce side thrusts of 0.9 and 1.2 mgm respectively.

**Constant Vertical Stylus Force.**—It is when considering the constancy of the vertical force on the stylus as determined by the disc flatness and vertical inertia of the arm that the only basic advantage of the spring system arises. Again the gain is comparatively small, being only a 50% change at most, for the inertia can ideally only be halved by the elimination of the counterweight.

A vertical offset between the disc and vertical pivot centre can cause friction between the stylus and groove to alter the stylus pressure, and an integration of the extra frictional impulses due to groove modulation can then cause temporary changes in the stylus pressure.

The worst feature found on most arms is the difficulty of adjusting the pressure on fixed vertical pivots accurately enough to keep the pivot friction within a reasonable limit. Self-adjusting spring-loaded pivots should be used.

Where the centre of gravity of the arm is below that of its vertical pivots, "weighing" of the stylus force may be quite inaccurate if the arm is not in its usual playing position. Both this and the spring system must be weighed at disc level.

(Continued on page 271)

**Immunity from Vibrations.**—Let us consider the simplest example of vibration transmitted to the pickup base from the motor board when the pickup base moves vertically or laterally as one with the turntable spindle. Then, in the case of the spring-counterbalance system for vertical movement and both

offset systems for lateral movement, due to the unbalanced inertia of the arm, an enormously greater variation in the force at the stylus tip is produced than with a balanced single-pivot system. In a single-pivot system with its centre of gravity below the pivot as is required for stability, longitudinal movement (along the arm length) can produce small variations in the stylus pressure.

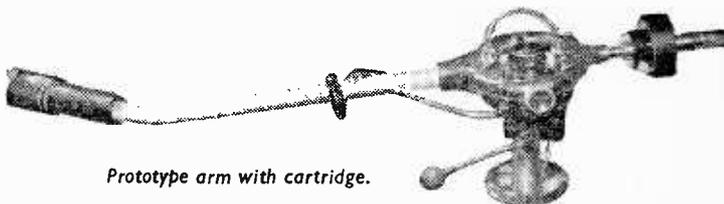
If the pickup base moves while the turntable spindle remains fixed the advantage is with the unbalanced inertia systems, at least for small accelerations, since in a balanced system the stylus tends to move more with the pickup base. The problem of small movements of the pickup base in this way (for example internal vibrations) can be better tackled with elastic washers between the base and motor board. Large rotational movements of the base while the turntable spindle remains fixed hardly ever occur in practice.

The previously discussed advantages and disadvantages of the three principles of arm construction when acted upon by disc and turntable eccentricities and warps also apply to externally applied similar lateral and vertical motions of the turntable spindle relative to the pickup base.

Thus, considering all the requirements for a suitable arm, the single-pivot system appears to offer by far the most attractive prospects, and these were developed as follows.

**Single-pivot System.**—A true single-pivot system with rotational freedom in any direction is used. The fact that the angle of the stylus in relation to a tilted turntable in such a self-levelling system might minutely affect the separation and balance of a stereophonic pickup was considered to be less significant than the advantage gained of more equal pressures on the groove walls due to the reduction of side thrusts.

If the sideways balance is to be stable the arm must have its centre of gravity below the pivot. A



Prototype arm with cartridge.

stabilizing weight below the pivot was therefore added (see Fig. 4). This weight was kept to the minimum required to provide sufficient torsional inertia for a maximum force of 5 gm at the stylus. Keeping the stabilizing weight as small as possible also ensures the minimum possible movement from sideways vibration at the base.

To absorb any such resonant motion which could occur at the single pivot, this was designed both to retain a damping medium by capillary action and also to alternately push out and "suck in" the medium if the stabilizing weight swings from side to side (see Fig. 4).

To make accurate vertical balancing easy, and to eliminate sensitivity to longitudinal vibrations, the stabilizing weight was "uncoupled" by two pivots for vertical movement on opposite sides of the single pivot. The vertical pivots were spring-loaded to ensure correct pressure.

Sideways balance of the head offset is obtained in this design by adjustment of the lateral positions of the vertical pivots about the single pivot. Alternatively the pickup heads themselves could be made to provide sideways balance by suitable distribution of their mass in relation to stylus and arm, or an asymmetrical counterweight could be used. These alternative schemes were abandoned to ease the design and adjustment problems respectively.

If the linear offset of the arm is kept large, then due to the extra freedom of sideways balance, some of the vertical motion of the arm due to disc warping, etc., will be converted into rotational motion about the single pivot. If the rotational inertia is kept as low as possible, then this effect will play its maximum part in reducing stylus pressure variations. In fact the developed arm can be seen to rotate if the turntable is lifted suddenly whilst playing. An otherwise completely balanced system with spring pressure to provide the stylus force cannot conveniently make use of this principle.

In the case of the counterweight a compromise must be made between a long cylindrical shape which gives the minimum possible rotational inertia about the arm length as is required by the considerations of the last paragraph, and a thin disc shape which gives the maximum range of stylus pressures over the restricted length of movement available in a record player cabinet. Thus the optimum shape is approximately a cylinder whose height is equal to its diameter.

Calculation of both bending and torsion of a tubular arm shows that extremely large diameters are required to put all arm resonances above the audio range. It would therefore be desirable to have sufficient lateral and torsional inertia in the head alone if arm resonances are to be minimized. If the pickup is a one-gram tracker with a compliance of  $15 \times 10^{-6}$  cm/dyne, and the bass resonance is required to be 15 c/s, then, to inhibit the lateral arm resonances, the total mass of the head should be  $(15^2 \times 4\pi^2 \times 15 \times 10^{-6})^{-1} = 7.5$  gm. Likewise,

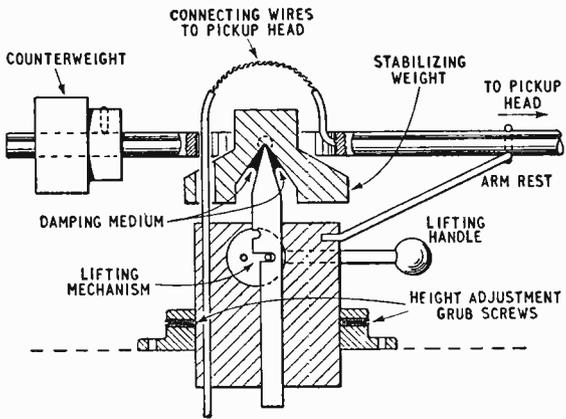


Fig. 4 Side-view sectional sketch of part of prototype arm showing stabilizing weight, damping medium, connecting wires and lifting mechanism.

considering that the compliance is usually inversely proportional to the tracking weight, about 40 gm would be required for a 5-gm tracker. Accurate vertical pressures are ensured by balancing the arm and then inserting a calibrated pellet into the head.

The biggest problem was now that of the electrical connections. Various schemes were considered and rejected, and it was finally decided that a controllable torsion was preferable to the possibility of unseen foulings and erratic behaviour. Thus the connecting leads are brought visibly over the top of the pivot to an exit tube at the rear (see Fig. 4). By this arrangement, as the arm moves, the wires flex at only one

point instead of two as in the more usual arrangement with the flexing portion of the wire all on the same side of the lateral pivot.

A raising and lowering mechanism was thought desirable, and this is incorporated in the arm base (see Fig. 4) to lower the arm gently on to the disc. By altering the sideways balance, this lowering mechanism can be used to move the stylus between 5 microgrooves ahead and 10 microgrooves behind its previous position to an accuracy of  $\pm 3$  microgrooves or better.

The arm produced has a measured side thrust of 0.02 gm and vertical friction of 0.05 gm. It should be eminently suitable for tracking down to 0.2 gm.

## Displaying Valve Characteristics

Cathode-Ray Tube System for Presenting Anode Curves with Their Axes

By R. G. CHRISTIAN,\* A.M.Brit.I.R.E., Grad. I.E.E.

A METHOD of displaying valve characteristics on a single-beam cathode-ray tube has been described by Buckingham and Price<sup>1</sup>. The result is a trace representing the anode-current/anode-voltage curve of the valve for a given grid bias plotted on a screen without axes. Since valve characteristics were required to be demonstrated in a convincing manner to engineering students it was felt that the addition

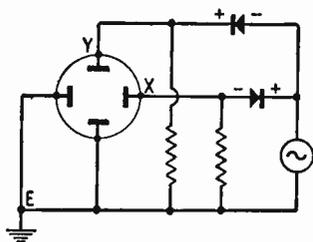


Fig. 1. Basic circuit for generating the X and Y axes for the display.

of axes was essential. A further disadvantage of the method referred to above was the use of both d.c. and a.c. to feed the valve. In the apparatus to be described the valve characteristic is presented in the same way as it would be shown on a blackboard during lectures, and the circuit is simple and compact.

One beam of a dual-beam c.r.t. is used to trace the axes. The deflection voltage for the X axis is obtained by means of a half-wave rectifier so that the axis is only traced during one half-cycle. On the other half-cycle a similar half-wave rectifier, connected in the reverse direction, produces a half-wave pulse which deflects the spot in the Y direction. The basic circuit to produce the axes is shown in Fig. 1.

The valve whose characteristics are to be displayed is fed by a.c. and conducts on one half-cycle only. The anode current produces a half-wave pulse across an anode resistor and this is fed to the second Y plate. It was found that a large anode resistor had to be used in practice in order to obtain suffi-

cient Y scan for the second beam, which traces the valve characteristic. The X scan, which represents anode voltage, is supplied by the same half-wave rectifier which deflects the first beam to write the X axis. The basic circuit for displaying the characteristics is shown in Fig. 2, from which it will be seen that the X plate section is the same as that in Fig. 1.

It will be seen that the scan voltage used to represent the anode voltage is, in fact, the sum of the voltages across both the valve and the anode resistor. The error is small only if the anode resistor is small, which is not so in this case. There would be no error if the anode was used as a common earth reference but since the purpose of the circuit was to demonstrate the approximate shape of the valve characteristics it was not considered to be of importance. If accurate characteristics are required the X scan voltage must be that developed between anode and cathode of the valve.

The circuits of Figs. 1 and 2 are combined in the

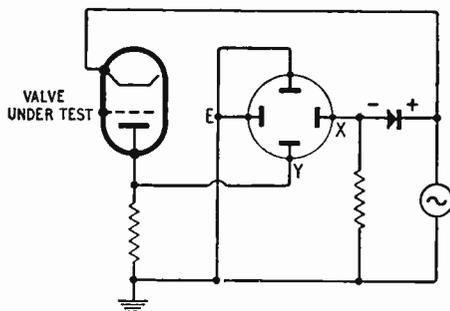
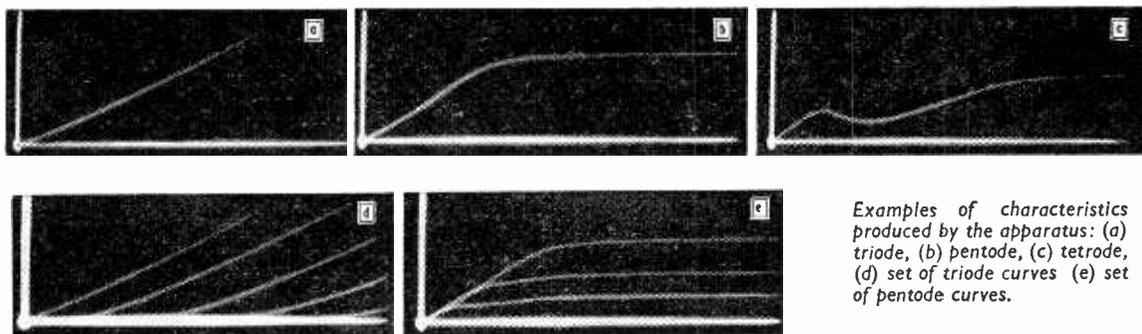


Fig. 2. Basic circuit for obtaining the anode characteristics of the valve.

practical circuit of Fig. 3 which also includes d.c. supplies to the screen and control grids of the pentode under test, the control-grid bias being variable in the negative direction. The screen and control grid must be supplied by steady d.c., which accounts for the inclusion of the two capacitance-resistance smoothing circuits. This will be apparent

\* Liverpool College of Technology.

<sup>1</sup> H. Buckingham and E. M. Price, "Principles of Electrical Measurements" (English Universities Press, 1955), page 304.



if the effect of supplying the screen grid with half-wave pulses is considered, since the resulting variation in screen-grid potential would follow that in anode potential and a triode characteristic would result.

All the supplies are obtained from a transformer with two simple secondaries, one for the scan and bias voltages, and one for the three valve heaters. The component values are not critical and those indicated happened to be available at the time. The valve under test is an EF36, with which it was possible to demonstrate triode, tetrode and pentode curves quite satisfactorily, the change-over being carried out by switching. When the switches, which are ganged, are set to position 1, the screen grid is connected to anode, the suppressor grid to cathode, and the valve behaves as a triode. On position 2, both screen and suppressor grids are connected to the screen supply and the valve operates as a tetrode; while on position 3, the suppressor is connected to cathode and the valve operates normally as a pentode. The photographs show the results obtained with various values of grid bias and for different connections.

The possibility of showing a family of curves is interesting and is easily effected in the case of two curves by feeding the output from a square-wave generator into the control grid. The amplitude of the generator output controls the spacing between the curves, the bias control being kept operative so that both curves may be shifted simultaneously.

In attempting to demonstrate more than one pentode or one tetrode curve it was found that the return of the trace was along a different path from the initial scan, producing an effect reminiscent of a hysteresis loop. No satisfactory explanation has so far been developed, neither has any attempt been made to overcome the difficulty, since it was felt that the circuit did all that was required of it, at least for the present. It would probably be possible, with suitable electronic switching, to produce more than two curves. Two possible methods would seem to be either the use of a stepped waveform applied to the grid or the use of an electronic switch to select different fixed values of grid bias. In the equipment described, however, no attempt was made to do this, since it was desired that the circuit should be as simple as possible.

The families of curves shown in the photographs were obtained by means of multiple exposure, which, while suitable for recording, is of no use from the point of view of live demonstration, which is the object of the apparatus. In this connection it is emphasized that the only purpose of the demonstration is to show practically and rapidly the general shape of the characteristics of triodes, tetrodes and pentodes and the effect of variation of control grid bias.

Thanks are due to V. Attwood for carrying out the practical work, for incorporating some of his own ideas into the circuit, and for taking the photographs.

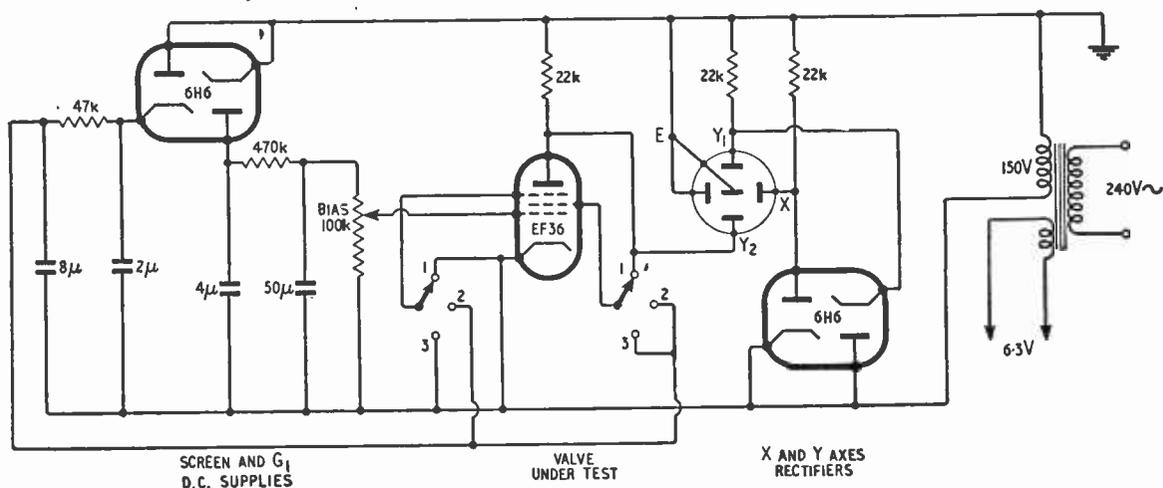


Fig. 3. Practical circuit for display of characteristics and axes. Direct-current supplies are included for the grids of the pentode test valve.

# Feedback Amplifiers as Filters

Application of Familiar Principles to Feedback-synthesized Filters

By THOMAS RODDAM

**I**N the course of a study of a rather simple feedback amplifier recently I found myself confronted by some equations which looked familiar, though not in this context. Generally, of course, one does not do very much mathematics when designing feedback amplifiers: at any rate, I don't, because the amplitude and phase response plots, together with the filter  $\mu\beta$  effect calculator, provide all the information needed for the usual task of making it flat, making it stable. As every schoolboy knows, quite a lot has been written on the design of particular feedback circuits with particular shapes of end characteristic but all the articles I can remember are of the kind which describe a circuit for a special job. As some hardened readers may know, I like to make one lot of analysis serve as many purposes as possible, even though this reduces the amount I can write on a given topic and thus gives more hope to the wolf which hovers outside my door, my door and everyman's.

The general feedback amplifier is shown in its old familiar form in Fig. 1. As that abominable

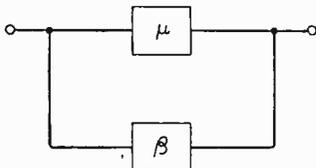


Fig. 1. The general feedback amplifier.

schoolboy of Macaulay's will point out, the gain of the whole system is:—

$$\mu_t = \mu / (1 + \mu\beta) \dots \dots \dots (1)$$

We know that in a practical configuration with negative feedback both  $\mu$  and  $\beta$  will have the same sign so we need not indulge ourselves in the academic practice of writing  $(1 - \mu\beta)$  and then making  $\beta$  negative. Sooner or later we shall be taking logarithms, to get ourselves into decibels, and as  $\log \mu$  is the same as  $-\log 1/\mu$ , we can rewrite Eqn. 1:—

$$1/\mu_t = (1 + \mu\beta) / \mu = 1/\mu + \beta \dots \dots (2)$$

This very simple equation is our starting point, for the behaviour of  $1/\mu_t$ , or  $-\log(1/\mu_t)$  if you like, is the response of the feedback amplifier. As you see, it depends on two factors,  $\mu$ , or  $1/\mu$ , and  $\beta$ . Usually we say cheerfully that  $\beta$  is much bigger than  $1/\mu$ , so the response is dominated by  $\beta$ , but of course this is no longer true at the edges of the working range when all kinds of things may happen. In many applications we manage to keep this region well away from the band which contains our signal and then our only interest is in the stability conditions which amount, more or less, to determining the phase of  $\mu\beta$  when  $\mu\beta = 1$ . Stability is a bit more complex than that, but it is true that usually we are so preoccupied with stability that we don't worry about the shape of the  $\mu_t$  response in this region.

Suppose now that the amplifier—we might even call it the  $\mu$ -amplifier to show that we mean the upper box in Fig. 1—has only one stage and it is completely dominated by a single shunt capacitance. The response will then be that of the simple network shown in Fig. 2. We can easily see that we have:—

$$\begin{aligned} 1/\mu &= (1/\mu_o) (1 + j\omega CR) \\ &= (1/\mu_o) (1 + j\omega/\omega_o) = (1/\mu_o) (1 + j\Omega) \end{aligned} \quad (3)$$

where  $\omega_o CR = 1$  and  $\Omega = \omega/\omega_o$ .

Suppose, too, that  $\beta$  is just a constant, that the  $\beta$ -network is made up of pure resistance elements. Then we have:—

$$\begin{aligned} 1/\mu_t &= 1/\mu + \beta = (1/\mu_o) (1 + j\Omega) + \beta = (1/\mu_o + \beta) \\ &\quad + j\Omega/\mu_o \\ &= (1/\mu_o + \beta) (1 + j\Omega/(1 + \mu_o\beta)) \\ &= (1/\mu_o + \beta) (1 + j\omega/\omega_o [1 + \mu_o\beta]) \dots \dots (4) \end{aligned}$$

I have churned through the transformation in the string of Eqn. 4 in order to arrive at that last expression: next time I shall leave out some of the steps. The final form is the product of two factors which we can call the gain factor  $(1/\mu_o + \beta)$  and the shape factor (which needs a line of its own). The gain factor is just what we expect and I do not propose to say anything more about it. The shape factor is rather interesting because if we write  $\omega_o' = \omega_o (1 + \mu_o\beta)$  and  $\omega/\omega_o' = \Omega'$  the shape factor becomes  $(1 + j\Omega')$ .

This is exactly the same form as we had for the basic  $\mu$ -amplifier in Eqn. 3, except that whereas for the basic amplifier the response was 3dB down at  $\omega = \omega_o$  the new response is 3dB down at  $\omega = \omega_o'$  and  $\omega_o' = \omega_o (1 + \mu_o\beta) = (1 + \mu_o\beta) (1/CR)$ .

It is easy to see that this sort of result should be expected. There is only one element, the C, in the whole system which can do anything to the frequency characteristic and the overall behaviour must therefore contrive to be what I find is convenient to call a first-order response. This result also contains the information that, for a first-order system anyway, the use of negative feedback does nothing to improve, or degrade, the gain-bandwidth product. There is a straight trade of gain for bandwidth which does not depend on a particular definition of bandwidth, because the shape is unaltered. What is more, if you can think of a suitable circuit configuration, the feedback can be positive without altering the terms of trade. From this we can go on to say that if we use enough positive feedback to make the gain infinite the bandwidth must be zero. Do you care? Well, if we replace the capacitance by a series inductance-capacitance pair and replace  $\omega$  by  $\Omega = (\omega/\omega_o - \omega_o/\omega)\omega_o$  we move the frequency at which we have infinite gain and zero bandwidth up from  $\omega = 0$  to  $\Omega = 0$  or  $\omega = \omega_o$ . This is the basis of the simple oscillator and the simple Q-enhancer.

Let us get back to the main line of our discussion and now consider the possibilities of second-order circuits. The term "second-order circuits" is a

rather formal way of saying circuits with two reactances in them. There are general possibilities here. The second frequency-dependent term can be added in the feedback network, as an isolated term in the  $\mu$ -amplifier or as a coupled term in the  $\mu$ -amplifier. One special form we can throw away immediately, especially as it's only an approximation, is when  $\beta$  and  $1/\mu$  have the same shape term  $(1 + jk\omega)$ , although with different values of  $k$ . This rapidly reduces to a single factor, so we are back in the first-order class.

The most ordinary form we can take seriously is the form we find with a two-stage  $\mu$ -amplifier when each stage has a network of the kind shown in Fig. 2. If one network has components  $C_1R_1$ , and  $\omega_1 = 1/C_1R_1$ , the other giving  $\omega_2 = 1/C_2R_2$ , we can see that:—

$$1/\mu = (1/\mu_0) (1 + j\omega/\omega_1) (1 + j\omega/\omega_2) \quad \dots (5)$$

and therefore

$$1/\mu_f = (1/\mu_0) (1 + j\omega/\omega_1) (1 + j\omega/\omega_2) + \beta \quad \dots (6)$$

We must, I am afraid, expand this and the most convenient form is, at first:—

$$1/\mu_f = (1/\mu_0 + \beta) [1 + jk\omega (1/\omega_1 + 1/\omega_2) - k\omega^2/\omega_1\omega_2],$$

where

$$k = (1/\mu_0)/(1/\mu_0 + \beta) = 1/(1 + \mu_0\beta).$$

We may now concern ourselves only with the shape factor, the expression:—

$$1 + jk\omega (1/\omega_1 + 1/\omega_2) - \omega^2 k/\omega_1\omega_2$$

This is the simple second-order characteristic and if we call it  $S$  we need only devote ourselves to:—

$$|S|^2 = 1 + \left\{ k^2 \left[ \frac{(\omega_1 + \omega_2)^2}{\omega_1\omega_2} \right] - 2k/\omega_1\omega_2 \right\} \frac{\omega^2}{\omega^2 + k^2\omega^4/\omega_1^2\omega_2^2} \quad \dots (7)$$

The term in this which is of chief interest, as I showed in "Filters Without Fears"\*, is the term in  $\omega^2$ . If the coefficient of  $\omega^2$  is zero we have the Butterworth or maximal flatness response: if it is negative the response is of the Tchebycheff, or humped, type. Readers of "Filters Without Fears" will remember that it is not always possible to make expressions of this form give the Tchebycheff type of response because the coefficient of  $\omega^2$  may be obstinately positive. Here, however, we can do a quick check by putting  $\omega_1 = \omega_2 = 1$  so that the coefficient of  $\omega^2$  becomes just  $4k^2 - 2k = 2k(2k - 1)$ . Thus if we make  $k = 0.5$ , or  $\mu_0\beta = 1$ , we shall get the neat, square Butterworth response, while any more feedback, making  $k < 0.5$ , will give us a bump before the response falls away. This is exactly what our experience with feedback amplifiers leads us to expect. Our experience also tells us that if  $\omega_1 \neq \omega_2$  we need more feedback, or a smaller value of  $k$ , before we reach this happy state. Sometimes we know that we want  $k$  to have a particular value,

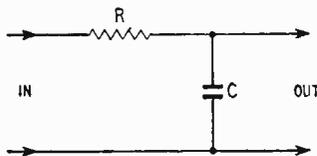


Fig. 2. The simplest frequency-response determining network for a forward path.

say 1/10, or 20dB of feedback. If we also want a Butterworth response we can put the coefficient of  $\omega^2$  equal to zero and solve for  $\omega_1/\omega_2$ . I have done

\*Wireless World, Vol. 60 (1954), pp. 367, 445, 561 and 603; (August, September, November and December.)

this on a separate piece of paper, to save filling the page with algebra, and the result is:—

$$\omega_1/\omega_2 = (1/k) [(1 - k) \pm \sqrt{1 - 2k}] \quad \dots (8)$$

We also know that the response is 3dB down at some value of  $\omega = \omega_0$  where  $k^2\omega_0^4/\omega_1^2\omega_2^2 = 1$  so that

$$\omega_1\omega_2 = 1/k\omega_0^2 \quad \dots (9)$$

The two equations, (8) and (9), enable us to fix the values of  $\omega_1$  and  $\omega_2$ .

All this analysis, of course, applies equally well if we perform the simple frequency transformations on it, so that although this is the ordinary low-pass filter case, the same pattern appears for the high-pass

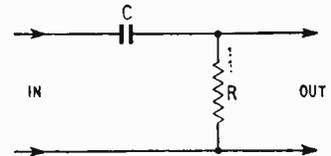


Fig. 3. The simplest frequency-response determining network for a feedback path.

and band-pass cases. I have been into all that before and you can look it up.

A difficulty which occurs in using amplifiers as filters is that  $\mu_0$  may vary. Obviously the response will vary too and there will be two effects. The coefficient of  $\omega^2$  will no longer be what you hoped, which for the calculation we have just done is zero, and the coefficient of  $\omega^4$  will also change, moving the asymptotic 12dB/octave cut-off. When  $k$  is small it is also very close to  $1/\mu_0\beta$  and a 6dB change of  $\mu_0$  will move the asymptotic line by a factor of  $\sqrt{2}$ , which is a rather large variation. Feedback amplifiers of this kind which are designed as filters must therefore have the gain of the  $\mu$ -amplifier held constant by some means. One obvious solution is a fair amount of feedback in each cathode or emitter circuit. This is just another example of the fact that you cannot get anything free: if the feedback is used up in one function it cannot play its full part in another.

The other important way of introducing a second frequency dependent element is to put it into the feedback network. Since the basic type of filter we are considering is the low-pass filter the obvious form of feedback network to use is that shown in Fig. 3. For this the response will be:—

$$V_{out}/V_{in} = j\omega CR / (1 + j\omega CR) = (j\omega/\omega_2) / (1 + j\omega/\omega_2).$$

Then the feedback term  $\beta$  can be taken as:—

$$\beta_0 (j\omega/\omega_2) / (1 + j\omega/\omega_2)$$

and the overall performance with a single Fig. 2 network in the  $\mu$ -amplifier becomes:—

$$1/\mu = (1/\mu_0) (1 + j\omega/\omega_1) + \beta_0 (j\omega/\omega_2) / (1 + j\omega/\omega_2).$$

Without going into any details we can see that the shape of the response is going to depend on an expression of the form:—

$$(1 + ja\omega - b\omega^2) / (1 + jc\omega).$$

This is a system having a first-order cut-off, only 6dB/octave, but it is complicated in the region of the transition from flatness to asymptote as you can see. The easiest way of analysing it is to notice that when we go over to decibels we have the difference between the decibels corresponding to the numerator and the decibels corresponding to the denominator. The one is a second-order expression.

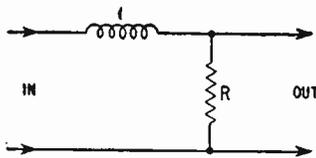


Fig. 4. Another first-order low-pass network.

of the form we discussed immediately above, while the other is an ordinary first-order expression.

I do not want to go into any more detail on designing these circuits because you can look up some specific designs in the literature, or work out your own problem for yourself. The really important thing is to go back to Eqn. 2 again:—

$$1/\mu_t = 1/\mu + \beta.$$

We can reasonably guess that this will be simplest if all the frequency dependent factors are in the  $\mu$  term, as we discovered in the examples. Suppose, then, that we have:—

$$1/\mu = (1/\mu_o) (1 + jf_1(\omega) + f_2(\omega))$$

and immediately

$$1/\mu_t = (1/\mu_o + \beta) [1 + jf_1(\omega)/(1 + \mu_o\beta) + f_2(\omega)/(1 + \mu_o\beta)]$$

When this is converted into the standard  $(1/\mu_t)^2$  form the coefficients of  $\omega^{2n}$  will contain factors which depend on  $(1 + \mu_o\beta)$ . This is of the nature of an interaction parameter, and, as we have seen, it plays an important part in fixing the shape of the response. If we consider a system in which the network of Fig. 4 is in tandem with that of Fig. 2; but in which a buffer amplifier is used between the two, the shape of the overall response will be expressed by an expression of the form:—

$$(1 + j\omega/\omega_1) (1 + j\omega/\omega_2).$$

This has a very limited range of shapes and at the best provides an extremely rounded cut-off. By rearranging the network elements so that the L and C are adjoining we know that we can get a more general second-order filter characteristic. The reason is that L and C can interchange their stored energy and it is this interaction between them which provides us with the one extra generality. In just the same way, in the feedback amplifier the  $(1 + \mu_o\beta)$  term represents the return to the first reactance network of energy which has passed through the second reactance network. One network can, as it were, see the other. Another way of looking at it is to regard it as a special form of coupling between the two networks. In band-pass filters this view gives us the possibility of three kinds of coupling: inductive, which falls with frequency; capacitive, which rises with frequency; and feedback, which in its basic form is independent of frequency.

The use of feedback as an energy interchange medium is of especial importance when the frequencies involved are low. By using feedback we store energy in a capacitor to return it to a capacitor; whereas without feedback we could only get the required interaction by using inductance—and large inductances for low frequencies are not easy to realise without excessive losses.

This short survey has, I hope, been enough to show that the kind of response you can get from a feedback amplifier is the same as that you can get from a conventional filter and that the algebra is consequently the same. It is always, to my mind, agreeable to find that one only need do the basic work once.

# Elements of Electronic Circuits

## 3 — Amplitude Limiting

By J. M. PETERS, B.Sc.(Eng.), A.M.I.E.E., A.M.Brit.I.R.E

IN order to eliminate unwanted fluctuation in the peaks of a waveform, or perhaps to discriminate between wanted or unwanted pulses, it is often necessary to limit the positive or negative excursions of such a wave. A further possible use is the derivation of rectangular pulses from a sinusoidal input. A common method of achieving amplitude limiting is by overloading a valve amplifier so that the peaks of the input are cut off by the flat regions of the dynamic characteristics. It is, therefore, possible to limit both the positive and the negative excursions by suitably biasing the amplifier.

In grid limiting the grid-cathode portion of the valve is operated as a diode. Grid current flows during the positive half cycles of the input wave, and if a resistor of the correct value is inserted in series with the grid the major part of the positive excursion of the input is developed across it instead of between grid and cathode. The positive-going anode current is thereby limited, as is also, of course, the negative-going anode voltage. This action is more fully explained later.

**Simple Limiting.**—As the diode provides the commonest example of amplitude limiting we will examine the simplest case first, i.e., with a sine-wave input. In the following circuits it is assumed that

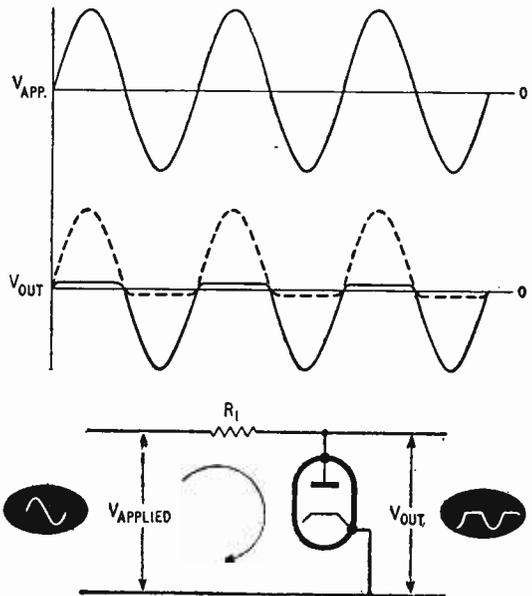


Fig. 1

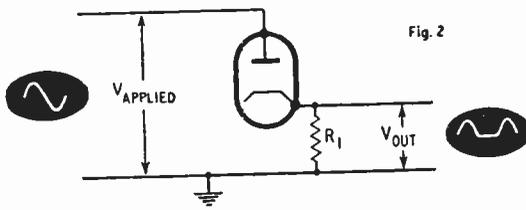
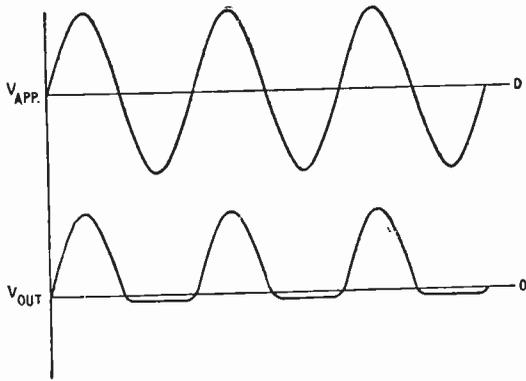


Fig. 2

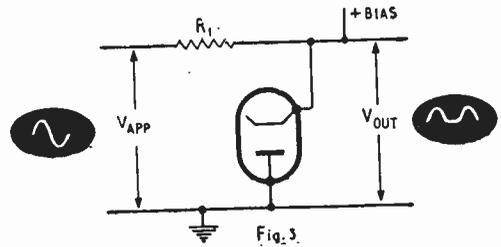


Fig. 3

the series resistor  $R_1$  is large compared with the resistance of the valve  $R_{ak}$  (not  $R_a$  but  $V_{ak}/I_a$ ) when the valve is conducting and small compared with the impedance of the valve when it is not. In Fig. 1, during the positive half cycles the voltage across the diode is limited. During the negative half cycles the voltage across  $R_1$  is limited (shown dotted). It follows, therefore, that if we wish to limit the negative peaks we take our output from across  $R_1$ . In Fig. 2  $R_1$  is shown in the cathode circuit of the diode as an alternative position. Fig. 3 shows an alternative way of limiting negative peaks, by reversing the diode shown in Fig. 1. If we choose to bias the diode it will then not conduct until the input voltage exceeds the bias voltage; in other words, we have shifted the level at which the limiting action commences (Fig. 4). Similar reasoning will show that it is possible to extend this action to positive peak limiting.

**Parallel Diode with Applied Square Wave.**—The limiting action on a square wave (Fig. 5) is similar to that shown for the sine wave. The loss of voltage during the non-conducting period of the diode is determined by the load current and the value of  $R_1$ .

It will be noted that the shape of the limited waveform is similar to the shape of an identical input after "clamping," i.e., the occurrence of d.c. restoration. The difference lies in the action of the CR coupling circuit immediately preceding the input (which for clarity is not shown in Fig. 5). The bias produced by choosing the correct time constant for the associated CR circuit is a necessary part of the action of a "clamping" circuit device, whereas

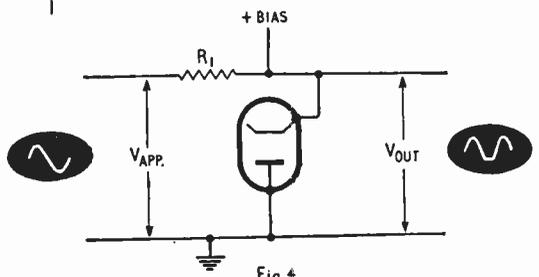
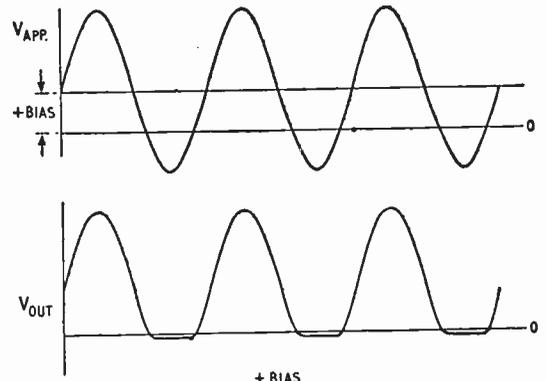
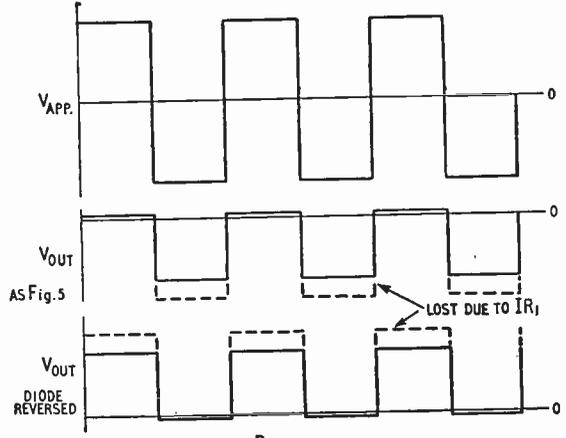


Fig. 4



AS Fig. 5

LOST DUE TO  $IR_1$

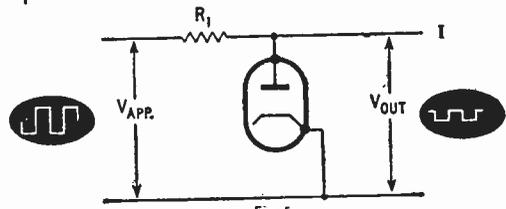


Fig. 5

in limiting the CR coupling circuit time constant must be chosen so that no slide-back occurs.

**Limiting Using Two Diodes.**—If two diodes are coupled as shown in Fig. 6 and provided with bias voltages X and Y, it is possible to limit the applied waveform at the same time as permitting it to continue to alternate about zero. Limiting of the positive excursion by diode  $D_1$  will not take place until the positive-going input exceeds the positive bias X. Similarly the limiting of the negative excursion by diode  $D_2$  will not take place until the negative-going input exceeds the negative bias Y. The amount of bias determines the limit of the positive and negative excursions.

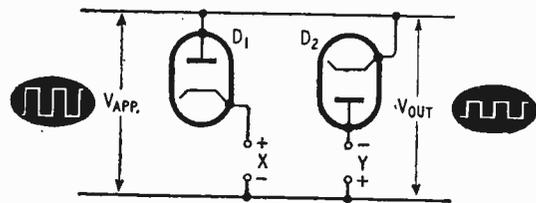
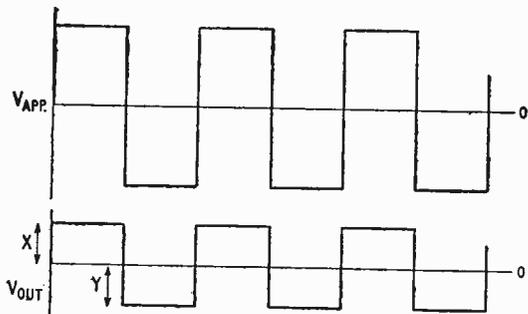


Fig. 6

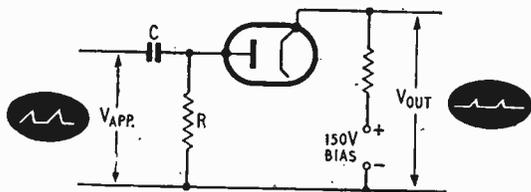
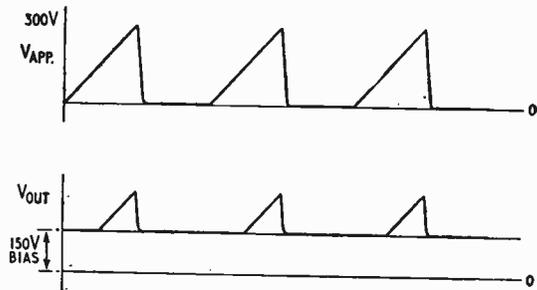


Fig. 7

**Series Limiting.**—Here the diode is used as a “biased switch” in series with the applied wave. As an example let us consider the action of a sawtooth waveform applied to the circuit in Fig. 7. The diode is biased to 150V while the amplitude of the sawtooth wave is assumed to be 300V. All the time the applied wave is less than 150V the diode is non-conducting; the “switch” is, therefore, “open.” When the anode voltage of the diode exceeds 150V the diode conducts, the “switch” is “closed” and the output voltage follows the input.

**Grid Limiting.**—As has been stated earlier, both positive and negative peak limiting can be achieved by driving an amplifier into the flat regions of the dynamic characteristic. So far as negative peak limiting is concerned, the point at which it occurs is determined by the cut-off bias and the amount of bias applied to the amplifier (see Fig. 8).

To obtain positive peak limiting a large amplifier load resistance is necessary so that  $I_a$  reaches the upper bend condition at relatively low grid voltage swings. Owing to this and to the undesirability

of driving the valve far into the grid current region, grid limiting is often resorted to for restricting the positive voltage excursions.

Let us assume that a sine wave is applied to the circuit shown in Fig. 9. During the positive half cycle of input grid current  $I_g$  flows and the grid-cathode resistance  $R_{gk}$  drops to a low value. As  $R$  is large compared with  $R_{gk}$  when the valve is conducting, most of the applied voltage is developed across it ( $I_g R$ ) and a negligible amount across  $R_{gk}$ .

During the negative half cycle of input no grid current flows and the input is applied directly between grid and cathode. However, the negative swing drives the grid beyond cut-off. The resultant  $V_a$  waveform is, therefore, approximately square on both positive and negative excursions.

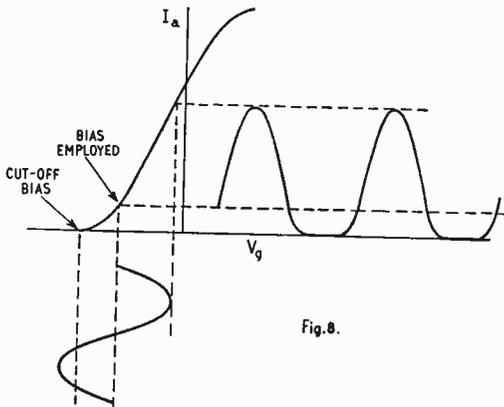


Fig. 8

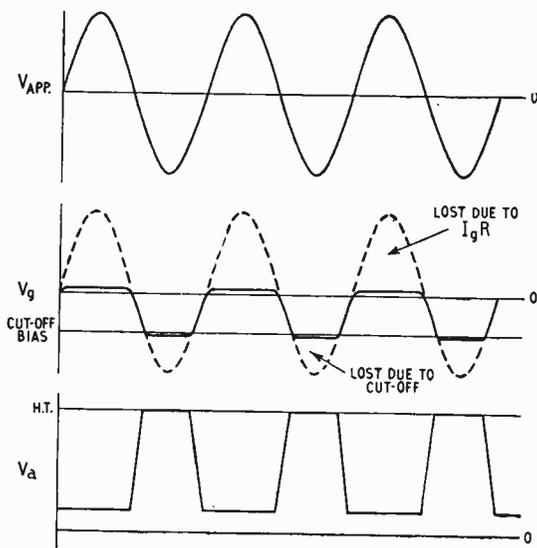
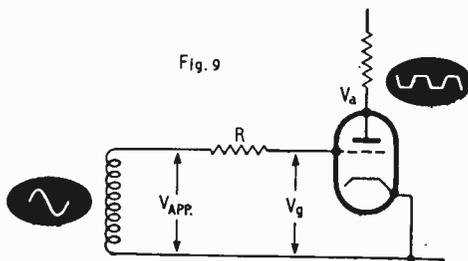


Fig. 9



# Magnetic Matrix Stores

COMPUTER STORAGE SYSTEMS BASED ON FERRITES

WITH RECTANGULAR HYSTERESIS LOOPS

By W. A. COLE,\* B.Sc.

ANY computer, whether human, mechanical, electro-mechanical or electronic, requires a memory, or storage system, in which to store the numbers involved in the calculation, the operations to be performed on the numbers, the intermediate answers and the final answers. The storage system may be simply a pencil and paper used by a person doing arithmetic; or it may consist of some combination of punched cards, punched tape, magnetic tape, magnetic drums, delay lines, cathode-ray tubes, valves, transistors, magnetic cores, etc., with a storage capacity of up to several million numerical digits in the case of a large scale electronic computer.

The speed at which an electronic computer can complete a problem, once the required information and instructions have been supplied to it, is governed by two things: the speed at which it can do individual arithmetical operations, and the speed at which it can obtain the next piece of information or instruction from the store. The time taken by many machines to perform the addition or multiplication of two numbers, each consisting of many digits, is measured in microseconds. It is obviously desirable that a machine of this speed should also be able to obtain information from its store in a few microseconds. If the access time to the store was even as long as a millisecond then the arithmetic units of the machine would spend the greater part of their lives waiting for something to do.

## Wide Applications

Seven years ago the first magnetic ferrites to have substantially rectangular hysteresis loops were produced in the U.S.A. Since then the application of these materials to high-speed digital storage systems has been so successful that there is hardly any large, fast, electronic computer under development any-

\* Mullard, Ltd

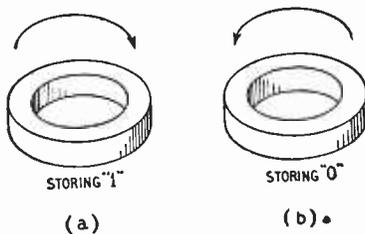
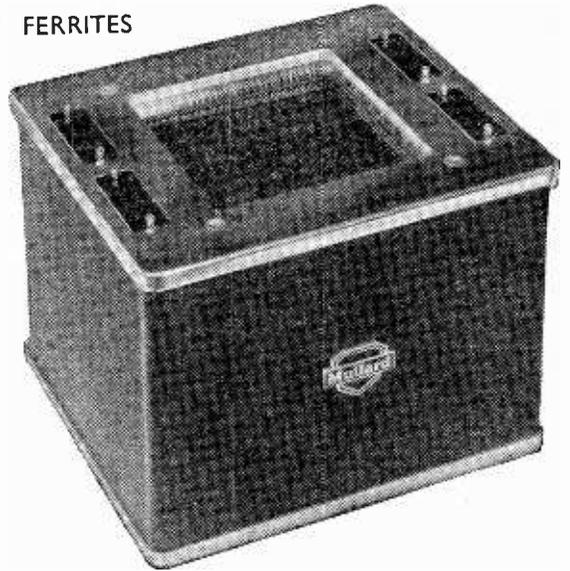


Fig. 1. Method of storing information by remanent magnetism in ferrite rings. (a) clockwise magnetization and (b) anticlockwise magnetization.



A stack of 20 matrix storage planes in practical form for use in a computer. The capacity is 81920 digits.

where in the world which does not incorporate a magnetic matrix store. The capacity of these stores varies from a few thousand to a few million binary digits, and the cycle time, that is, the time to select an address,† read the information stored and rewrite information into the address, is usually in the range from five to fifteen microseconds.

In a magnetic store the individual memory cells consist of tiny ferrite rings of less than one-tenth of an inch diameter linked by an array of insulated enamelled wires. Each ring is capable of storing one digit or piece of information, but in common with most devices used in computers, a magnetic memory works with numbers expressed in the binary system. In the decimal system, with which everyone is familiar, there are ten digits, namely 0 to 9, and a number 4275, reading from right to left, means  $(5 \times 1) + (7 \times 10) + (2 \times 10 \times 10) + (4 \times 10 \times 10 \times 10)$ . In the binary system there are only two digits, 0 and 1, and a number 1101, again reading from right to left, means  $(1 \times 1) + (0 \times 2) + (1 \times 2 \times 2) + (1 \times 2 \times 2 \times 2)$ . This is much easier to represent, as nature provides many devices with two stable states but it is difficult to find anything with ten discrete stable conditions.

The ferrite rings store the information in the form of the remanent magnetization, which simply means that if the ring is left magnetized in a clockwise sense, as in Fig. 1 (a), it is storing a digit "1," say, and if it is left magnetized in the opposite sense as in Fig. 1 (b), it is storing a digit "0."

Fig. 2 shows a typical hysteresis loop of Ferroxcube Type D ferrite. When a magnetizing field of amplitude  $+H_m$  is applied to the ring-shaped core, the resulting flux density will be  $B_m$  and when the

† Addresses are places in the store where items of information are held, and are usually identified by numbers like houses in a street.

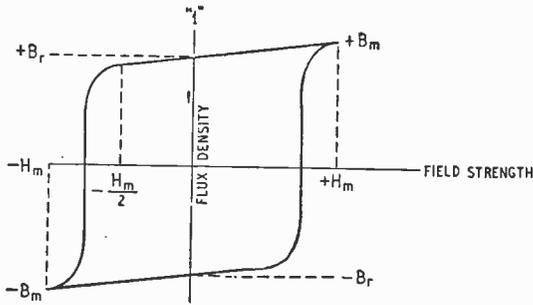
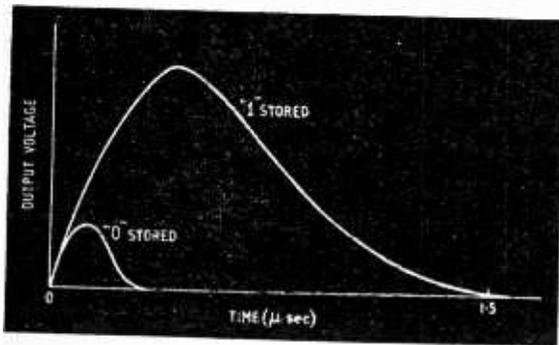


Fig. 2. Rectangular hysteresis loop, flux density against field strength, of a ferrite material.

field is reduced to zero the flux density will decrease to  $B_r$ . If a field of  $-H_m$  is now applied there will be a change of flux density of  $(B_m + B_r)$  and the flux density will be  $-B_r$  when the field is removed. A further application of a field of  $-H_m$  will produce a flux change of only  $(B_m - B_r)$ . Thus the polarity of the remanent magnetization can be readily determined by measuring the change of flux density, or the e.m.f. induced in an output winding on the core, when the core is subjected to a magnetizing pulse of amplitude  $-H_m$ . The output voltages induced in the two cases are shown in Fig. 3.

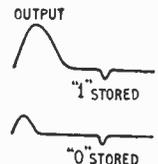
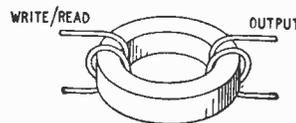
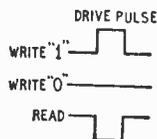
Fig. 4 shows a single binary storage cell comprising a core with two windings. A digit "1" is written into the cell by applying a positive current pulse to the write/read winding. The information is read by applying a negative current pulse to the write/read winding. Since the cell is always left in the "0" state after a read pulse no pulse is required to write a further "0" into the cell. The reading process necessarily destroys the information stored in the cell; therefore it is necessary to rewrite the information if it is required to retain it.

A store with a capacity of 1024 digits would require 1024 cores, and have 1024 inputs and 1024 outputs, although a single common output winding could be used if the information were required one digit at a time. The selection of 1 in 1024 inputs is a difficult problem and the magnetic matrix store, as first suggested by Forrester in 1951, greatly simplifies this problem by making further use of the rectangular form of the hysteresis loop.



Above: Fig. 3. Output voltages obtained from a core when the polarities of remanent magnetization are different.

Right: Fig. 4. Binary storage cell consisting of ferrite core with two windings.



If a ring core in the "1" state with remanent flux density  $+B_r$ , is subjected to a magnetizing pulse of amplitude  $-H_m/2$  the flux density falls to  $B_1$  and returns to  $B_2$  when the pulse is removed. Repeated applications of pulses of  $-H_m/2$  take the core around a closed minor loop and there is no further reduction in the remanent flux density. Thus the ring core has the ability to discriminate between pulses of amplitude  $H_m$  and  $H_m/2$ . The larger pulse is sufficient to change the direction of magnetization of the core whilst the smaller produces only a negligible change.

Fig. 5 shows 16 rings assembled in a  $4 \times 4$  matrix. Each core is threaded by one horizontal and one vertical wire. To switch a given core from one state to the other, current pulses of amplitude  $I_m/2$  corresponding to a magnetizing field of  $H_m/2$  are simultaneously applied to the horizontal and vertical wires linking that core. The selected core is thus subjected to a field of  $H_m$  and will be switched while the other cores linked by the energized wires will only experience a field of  $H_m/2$  and are not affected. The addressing problem is then reduced to selecting 1 in 4 and 1 in 4 wires to gain access to 1 in 16 cores. If 1024 cores are assembled in this way as a  $32 \times 32$  matrix, only 1 in 32 and 1 in 32 wires need be selected to gain access to 1 in 1024 cores.

### Output Winding

Since only one core can be switched at one time, the output winding can be common to all cores. It takes the form of a single conductor linking all cores and is so arranged that the mutual inductance between it and any drive wire approaches zero. The output wire is also arranged to link half the partially energized cores in one sense and half in the other so that the small signals from these cores tend to cancel one another.

It is obviously much simpler to assemble such an array of cores if the windings are restricted to single conductors rather than multi-turn windings. This is possible if the cores are made sufficiently small so that the current pulses required are kept to amplitudes which can readily be obtained from valve or transistor circuits. The most commonly used memory cores have an outside diameter of 0.08in and inside diameter of 0.05in and are 0.025in thick, but during the last two years cores of only 0.05in outside diameter, 0.03in inside diameter and only 0.015in thick have become commercially available, and in many cases these smaller cores are more suitable for use with transistor drive circuits.

The switching time  $T$  of the ferrites, that is the time for the reversal of the magnetic flux, is given by  $T(H_m - H_0) = \text{constant}$ , where  $H_m$  is the applied field and  $H_0$  is the maximum field for which no switching occurs. For a material with an ideally rectangular hysteresis loop  $H_0$  would be equivalent to the coercive force of the material. Under the conditions of use in a coincident current matrix system the value of  $H_m$  is limited to approximately  $1.7H_0$  so that the

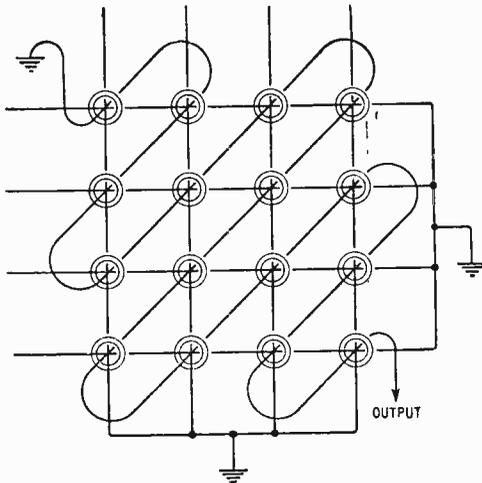


Fig. 5. A matrix store formed by 16 cores with threaded vertical and horizontal wires.

switching time is determined by the coercive force of the material, and a material of high coercive force will give a fast switching time and vice versa. For example, 0.08in cores in Ferroxcube D2 material require a drive of 700mA-turns to give a switching time of 1.5 microsecond and an output of 100mV per turn, while similar size cores in Ferroxcube D3 require 450mA-turns to give a switching time of 2.5 microseconds and an output of 60mV.

In many computers it is necessary to have access to all the digits of a number at the same time. This can readily be achieved by taking as many planes as there are digits in the numbers to be stored and connecting them electrically in series as shown in Fig. 6. Each plane would contain as many cores as there are words to be stored. When a particular pair of horizontal and vertical wires is energized the core linked by those wires in each plane is subjected to a pulse sufficient to switch it. Thus to read the information stored in a particular set of cores linked by the horizontal wire number  $x$ , and the vertical wire number  $y$ , positive current pulses are applied to these two wires. Each matrix plane has its own output winding and the information stored in the selected core in each plane appears as a voltage on the output wire of the plane, a large voltage for "1" and a small voltage for "0". To rewrite the information back into the cores the polarity of the current pulses is reversed. But this alone is insufficient since it would switch all the cores selected to the "1" state. Each plane, therefore, has an additional wire which links all the cores in that plane in the same sense. If a pulse of the same amplitude but of opposite polarity to the writing pulses is applied to this wire in a particular plane for the duration of the writing pulses, the selected core will remain in the zero state since the extra pulse inhibits the switching of the core. If no pulse is applied to this wire during the writing pulses then the selected core is switched to the "1" state.

As has been previously stated, in the coincident current system so far described, the signal appearing on the output wire is not only due to the flux change in the selected core but to the flux changes in the other cores on the selected row and column drive wires. Although the output from any one of these cores is very small, the sum of these outputs

can well be several times that of the selected core. To overcome this, the output wire is arranged to thread half the cores in each row and column in one sense and half in the other so that the unwanted outputs tend to cancel. As a result of this wiring arrangement the polarity of the output of the selected core depends upon its position in the matrix plane.

### Word Address Store

The word address matrix store used in the EDSAC II computer constructed by the Mathematical Laboratory of Cambridge University avoids the problem of unwanted outputs from half-selected cores by arranging the wiring so that there are no half-selected cores. The matrix consists of a single electrical plane with as many columns as there are words and as many rows as there are digits per word, as shown in Fig. 7. Thus one word is stored in the cores in one column and during the reading process the read drive pulse is applied to the selected column wire and the outputs appear on the row wires. In this way there is no output from any core other than the selected cores and the output circuit has only to discriminate between the largest "0" output and the smallest "1" output from any core. In addition the read pulse can be larger than that permissible in a coincident current read system, resulting in a larger and faster output from the selected core. To write information a half-amplitude write pulse is applied to the column wire, which, by itself, is too small to switch any cores. An additional half-amplitude write pulse is applied

‡ A "word" in computer terminology is a group of binary digits which can be either a number or an instruction.

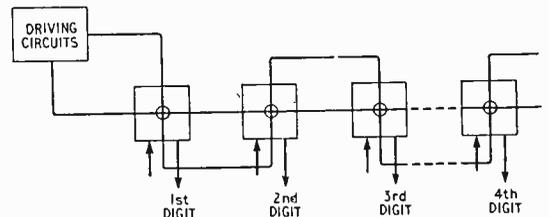


Fig. 6. Arrangement of matrix storage planes to give simultaneous access to all digits of a number.

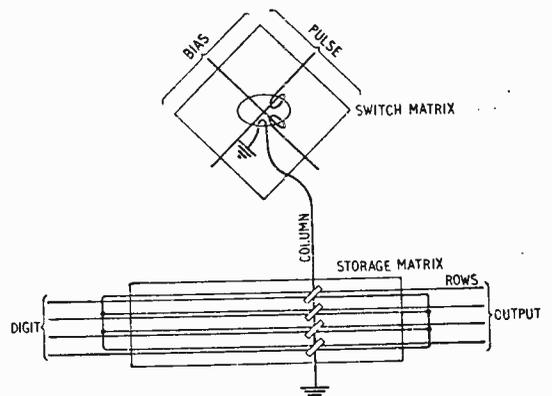
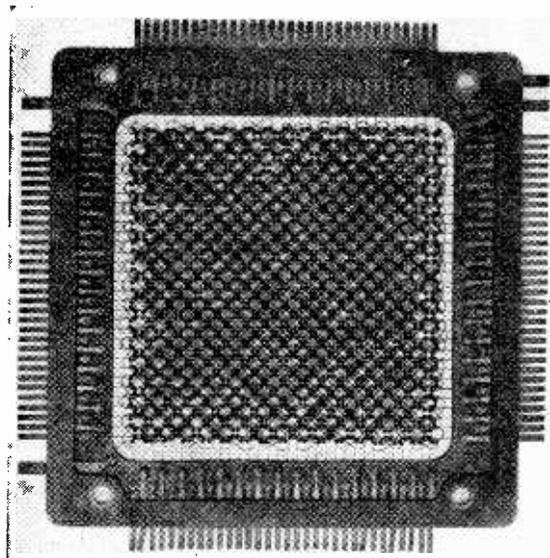


Fig. 7. Word address system with switch matrix.



Typical 32 x 32 matrix storage plane.

to the row wires which thread those cores which are required to store a digit "1."

The read pulses and the half write pulses applied to the store column wires are obtained via biased switch cores arranged in the form of a matrix. Each switch core has an output winding linking one column of the store matrix. To read the information from a given column of the store matrix the bias is removed from the appropriate row and a pulse is applied to the selected column of the switch matrix which switches the selected switch core and induces a read pulse in its output winding. When the bias is re-applied the switch core returns to its biased state and a half write pulse is induced.

In 1956 Rajchman of R.C.A. produced a modification of the core matrix store which uses ferrite plates 0.8in square containing 256 holes of 0.02in diameter. The areas of ferrite around the holes behave in much the same way as the separate ring cores of a conventional matrix store. The surface of the ferrite is metal-plated in such a way as to provide a conductor linking all the holes. This is equivalent to the "row winding" in the Cambridge University word address system. The plates are stacked one above the other and the column windings consist of straight wires threaded vertically through the equivalent holes in each plate as shown in Fig. 8. Two holes are required for each digit to be stored and a third hole is used as the switch core. Thus a store with a capacity of 256 words, each of 20 digits, would require 60 plates.

The two holes associated with one digit are equivalent holes in adjacent plates. The reading process leaves the material in the vicinity of both holes magnetized in the clockwise state, say. A digit "1" or a digit "0" is written in by applying a half-amplitude write pulse to the "column winding" threading both the holes, plus a half-amplitude write pulse to the plated conductor threading the upper hole or the lower hole respectively. Thus when the read pulse is applied the material around one or other of the holes is switched back to the clockwise state and the store presents an impedance which

does not depend upon the information stored. During the read process the plated conductors of the two plates concerned are connected in series opposition so that a "1" output appears as a positive pulse and a "0" output as a negative pulse.

### High Speed System

Quarterly of Mullard Research Laboratories has recently produced a ferrite store with a cycle time of less than one microsecond. This employs two cores per bit, wired in a manner similar to the Rajchman system. In this fast store, however, the flux swing in the cores is limited to approximately 50% of the possible total by limiting the duration of the drive pulses. The two cores used to store a single digit are linked in the same direction by a drive wire and in opposite directions by the digit and output wires as shown in Fig. 9.

After a read process both cores are left in the same state. The main writing pulse is of large amplitude and fast rise time, but of short duration, so that the cores begin to switch rapidly, but the switching is incomplete. A digit pulse of the order of 10% of the amplitude of the drive pulse is applied at the same time as the writing pulse so that one core will undergo a larger flux change than the other. The reading pulse is of similar form but of opposite polarity to the writing pulse and returns both cores to their original states. The core which has experienced the larger flux change will give the larger output so that the polarity of the resultant signal appearing on the output wire will depend upon the polarity of the previously applied digit pulse.

Experiments have shown that a cycle time of less than one microsecond is possible using 0.05in diameter cores in a low coercive force ferrite, with writing pulses of approximately 500mA-turns and 0.1 microsecond duration.

To sum up, magnetic matrix storage systems have

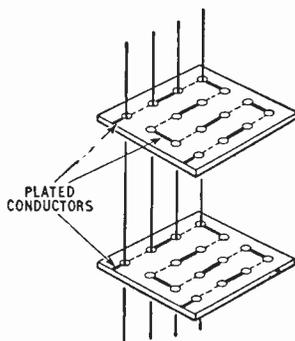
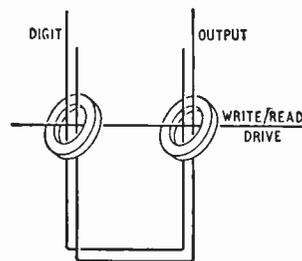


Fig. 8. Matrix store made up of perforated ferrite plates.

Fig. 9. High speed storage system based on two cores per digit.



the following advantages over most other forms of storage devices:—

1. Very short access time.
2. Information stored in any position in the store is available in the same short time.
3. Long life.
4. No moving parts.
5. Information stored indefinitely.
6. No regeneration of information required.
7. No energy required except to insert or extract information.

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## LETTERS TO THE EDITOR

*The Editor does not necessarily endorse the opinions expressed by his correspondents*

### Long Distance V.H.F. Reception

I AM not surprised that Mr. Terry (May issue) obtains more frequent sporadic-E propagation in Tangier than we do at Tatsfield. I would rather have expected this, but the fact that his peak year was 1957 is more difficult to explain. Also, over the shorter distance paths in the order of 1,500 km or less, there is difficulty in deciding whether the mode of propagation is sporadic-E or tropospheric. In v.h.f. Band II, it is assumed that reception must invariably be by the tropospheric mode since the highest critical frequency for sporadic-E seems too low for the refraction of signals as high as 90 Mc/s.

Tatsfield.

H. V. GRIFFITHS.

### Masers and Caesium Resonators

"CATHODE RAY" appears to be keen on rhymes. How does he like the following?

In March, seven seven nought was taught,  
 It used to end in eight three nought.  
 And when a caesium beam is bent  
 It's by magnetic gradient.

Harrow-on-the-Hill.

F. G. CLIFFORD.

*The author replies:*

Not being in a poetic mood I will prosily thank Mr. Clifford for pointing out the revised figure for the frequency of the caesium clock. His specifying of it by the last three figures reminds me of the similar R.A.F. practice with regard to personal numbers. When, in accordance with this customary method of identification at pay parade, the N.C.O. demanded of the new recruit: "Last three?" He received the proud reply: "Ted, Margie and Baby!"

Since my account of the magnetic deflection of the caesium beam was not precise, it is as well to have Mr. Clifford's reminder that it is the non-uniformity of the field that deflects the atoms.

"CATHODE RAY."

### Printed Circuits

LAYING aside for the moment all reference to the difficulty of tracing circuits and identifying components, it seems to me that most correspondents have missed the most vital factor in connection with these gadgets. Quality! We of the service profession encounter all makes and kinds of sets: after enough experience with them, we can begin to separate the electronic sheep from the goats. There are certain sets on the American market, using PC boards, which give very little trouble

with the PC boards themselves: a shining example of these is Westinghouse: so far, in three years, not a single case of true PC defects. On the other hand, two of our very largest manufacturers (who shall be nameless because I don't want to open any packages which tick!) persist in utilizing PC assemblies which, to me, are entirely too cheaply built. The phenolic board itself is quite thin, and the "printing" is very, very thin. This leads to the inevitable thermal difficulties; the semi-rigid mounting of the boards causes breakage, and the hair is then firmly deposited in the butter, as far as the serviceman is concerned.

So, insofar as the serviceman is concerned, one major objection could be overcome by making the boards "just a little bit better," as one of our more obnoxious TV commercials puts it. If the perspiring technician were fairly certain that he had only "normal" part-failures to cope with he would not view the apparatus with such a jaundiced eye.

Mena,

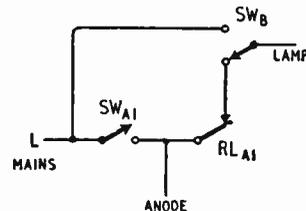
Arkansas, U.S.A.

JACK DARR.

### Inexpensive Photographic Timer

I SHOULD like to suggest one or two improvements to Mr. J. H. Jowett's photographic timer (p. 385, August 1958 issue). With the time setting controls on zero the grid follows the cathode and the cathode load is shunted by  $R_s$ . If now  $SW_B$  is closed for focusing, say, the mains potential is applied to the valve anode via the normally closed contact of relay  $RL_{A1}$  and the latter will buzz under self-interruption.

This fault is easily corrected by using a switch for



$SW_B$  having a changeover set connected as shown in the diagram.

The use of a normally closed contact to light a mains voltage lamp of possibly 100 watts or more in such a timing circuit is bad because the current rise in the winding causes the contact pressure to be progressively

reduced to zero, at which point the relay operates. The least vibration, under these low-pressure conditions can result in serious burning of the contacts as well as modifying the lamp output.

A better arrangement is to employ a make contact of RL<sub>A</sub> to operate a relief relay on a local circuit, the latter relay carrying a normally closed contact suited to the load it serves, the contacts being preferably of Elkonite or similar material.

Although the type of relay used for RL<sub>A</sub> is not specified in the description, its winding resistance leads me to think that it is probably one of the Siemen's high-speed relays readily available on the surplus market. This type of relay is admirable for use in this way if a relief relay is added as described above, the high-speed relay being easily adjustable to operate on 3.5mA as its normal test operate figure is about 4.5mA. Its contacts, however, though of platinum, are not insulated for mains voltage and the relief relay should preferably be chosen for a lower voltage.

If a small transformer is used to supply 12.6 volts for the valve heater, this supply could be used for operating the relief relay with a simple 4-plate selenium bridge rectifier.

New Barnet, Herts. H. d'ASSIS FONSECA.

*The author replies:*

Mr. H. d'Assis Fonseca's suggestion for modification of the "focus" switching arrangements is excellent and there is no reason why this should not be used. In practice, however, the conditions under which relay buzzing can occur are seldom realized, as the controls are set to a definite value during use.

The Siemens high-speed relay mentioned has in fact been used with the contacts directly connected to the mains and appears to withstand the ordeal satisfactorily; no deterioration of the contacts has occurred over a period of two years' use. A back-up relay (as mentioned in the original article) would obviously increase contact life, but at the expense of the simplicity achieved in the original circuit. J. H. JOWETT.

### TV Test Programmes

CANNOT the B.B.C. be prevailed upon to show "Test Card C" throughout their television test transmissions instead of interspersing tantalizingly brief glimpses of it between what appear to be someone's holiday snap-

shots (which are useless for setting-up purposes)? Perhaps things are better during the week: my experience is confined to Saturday mornings.

One wonders whether there is any supervision of what is transmitted during these periods, as recently a caption announcing a stereophonic transmission was kept on the screen for several minutes after the stereophonic experiment had ceased.

Incidentally, the pernicious practice of showing pictures instead of the test card has now spread to the I.T.A. Is this a further ramification of the plot (exposed by L. W. Turner in your last issue) to drive service technicians mad?

Surbiton, Surrey

E. MANSFIELD

### All-purpose Receivers?

IS it not neglectful of television manufacturers not to provide "pickup" and "extension loudspeaker" sockets on the combined TV/v.h.f. receivers they now produce? Such a set may well be the only source of radio and a.f. amplification (e.g., for record turntables) in some homes, and it is asking rather too much of the customer to buy a costly television-cum-radio set, only to find that he has also to buy another small radio or a.f. amplifier in order to enjoy his records or recording facilities. Lots of a.c./d.c. radio sets have these facilities provided, so why not a.c./d.c. television/radio receivers as well.

Paisley.

J. D. HAWORTH.

### Mc/s and Mc/ms

I DO have objections to the unwieldy abbreviation Mc/ms for 1000 Mc/s, proposed by "Free Grid" in your February issue.

Isn't there an internationally agreed abbreviation for 1000? That is "k", so that the abbreviation would be kMc/s, that is kilomegacycles per second instead of megacycles per millisecond.

More than that, if the British would use the equally internationally agreed (was it at Scheveningen in 1935?) abbreviation Hz for c/s, 1000 Mc/s would simply become kHz.

Voice crying in the wilderness, however! The position of the British in the matter of measure units is quite hopeless!

Rome, Italy.

ALDO SUGLIA.

## NATIONAL GRAMOPHONE CONFERENCE

**M**ANY of those present at the 1959 Conference in April at High Leigh, Hoddesdon, organized by the National Federation of Gramophone Societies, took part in the first gathering 21 years ago, as the chairman, Mr. W. W. Johnson, reminded his audience at the opening session.

The visitors had little time to relax as, from the Friday evening until the Sunday night, 11 sessions were presented by some eminent names in the audio world, in addition to excellent record recitals by the four companies, EMI, Decca, Philips and DGG. Always sure of a warm reception, the president, Sir Adrian Boult, who had just celebrated his 70th birthday, answered musical questions informally for two hours to the delight of his audience.

A welcome innovation at this year's Conference was an exhibition illustrating the history of recorded music from its beginnings to the advent of electrical recording around 1925, presented by Frank Morgan and G. Frow and other members of the Dulwich and Forest Hill Gramophone Society. Altogether 25 veteran machines were exhibited, and in most cases demonstrated. The technical highlight of the week-end was the daring experiment by F. H. Hugh Brittain, with colleagues of the G.E.C. Research Laboratories, in which he juxta-

posed "live" music with its reproduced counterpart. A specially composed "Sonata" by Eric Hughes (G.E.C.) for piano, drums, flute, clarinet and double-bass, was performed in front of the large audience, faced by two widely separated "Periphonic" loudspeaker enclosures (fitted with metal-cone bass units and two "Presence" units). The playback (from a Brenell deck) was started in synchronism with the performing musicians and then, one by one, in the manner of the players in the famous Haydn "Farewell" Symphony, they dropped out, to be replaced by their previously recorded tape facsimiles substantially without any significant change in the quality or continuity. From a central listening position, at one point, the image of the drums did seem to wander slightly, which Mr. Brittain explained was caused by an inadvertent change in the level of one of the recording microphones. The original recording was made by Allen Stagg, of I.B.C. Studios, London.

The many problems encountered (from correcting mains voltage to obtain correct pitch on playback and locating the speakers in the room) can easily be appreciated, and Mr. Brittain is to be congratulated on this unusual demonstration.—D. W. A.



cipline of the engineer, who trains them to amplify, and even to maintain continuous oscillation by positive feedback.

It looks as if we practitioners in electronics (if you prefer a more genteel British title) will have to be seeing a lot more of the physicists' point of view. We have been seeing quite a lot of it already if we have troubled to look into what goes on inside crystal diodes and transistors. Even if we have no intention of crossing over their boundary into the infra-red it will do us no harm to take a look at that neighbouring territory.

First, we shall have to consider nomenclature. The physicists' unit of wavelength, the micron, is denoted by the symbol—oh dear, yes!— $\mu$ . Being equal to 0.001mm, as regards magnitude it is quite convenient for the infra-red band, which begins at about  $0.75\mu$  and ends (if my arbitrary 1mm is accepted) at  $1,000\mu$ . But as we already use  $\mu$  for at least three things it is not the happiest choice for us. Millimetres are too large, and angstroms are too small. I doubt whether frequencies in MMc/s will be popular with physicists, but frequencies do at least have the merit of being unambiguous (provided that one is not travelling at high speed relative to the source of the waves), whereas wavelength depends largely on what the waves are travelling through.

And what will our authorities do who have, to date, ordained the use of the terms v.h.f. (very high frequencies), u.h.f. (ultra high frequencies), s.h.f. (super high frequencies) and e.h.f. (extremely high frequencies)? Seeing that the next step breaks through into the infra-red, and "infra-red" means "not quite red" or "reddish," and "ruddy" is defined as "reddish," there may perhaps be something to be said for r.h.f. (ruddy high frequencies).

The whole infra-red band stretches from our own boundary, say 1mm or  $1,000\mu$  or 300 Gc/s or 0.3 MMc/s, to a frequency rather more than a thousand times greater— $0.75\mu$  or 400 MMc/s, where visible light begins at the red end (Fig. 2).

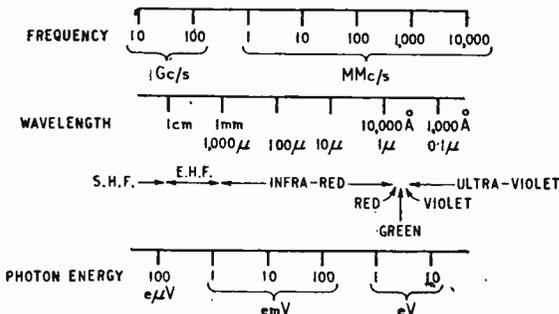


Fig. 2. Enlarged view of the part of Fig. 1 concerned with the infra-red band and its neighbours.

Historically one must begin at that (to us) far end. Sir William Herschel, the famous astronomer, investigated it 160 years ago and found that the invisible rays from the sun, beyond the red end of the light spectrum, were even more effective in heating than any of the visible ones. His detectors were pretty crude by present standards—just ordinary thermometers. Since then, the story has been very largely a search for better detectors. The problem of signal generators, which has always been so

present with radio engineers, hardly arose at first, since any hot body will do. However, we may be a bit hazy about this part of it, so let us begin there.

Everything above the absolute zero of temperature ( $-273^{\circ}\text{C}$  or  $0^{\circ}\text{K}$ ) has its atoms and their component parts in a state of vibration, the intensity of which increases with the temperature. Any movement of mass means mechanical energy. This is obvious if the mass is something visibly large that hits us, but if it is of only atomic size we don't feel it in the same way. If, however, the atomic vibration of something we touch is enough to impart such strong vibrations to our skin and underlying flesh that physical and chemical changes (i.e., rearrangements of the atomic structure) are caused therein, we rapidly withdraw the affected part, remarking (possibly with embellishments) that that thing is hot.

Not only does heat increase the intensity of vibration (temperature) of cooler things in contact; it radiates heat energy to the surroundings, even across empty space. If other things in the room are cooler, it receives less radiation from them than it gives out, so its temperature falls and theirs rises, until all are at the same temperature—unless, of course, heat is being generated somewhere by release of energy, say by the atomic rearrangements we call burning.

## Temperature Frequencies

A very important question is how the intensity of heat radiation varies with frequency. In practical situations it is nearly always complicated by some degree of selectivity; for instance, a glass window acts as a filter by passing the higher heat frequencies but not the very low ones now being explored; and the gases in the atmosphere absorb radiation at certain frequencies with quite sharp selectivity. So for basic study one assumes complete absence of selectivity, in what is called "black-body" radiation (because it would happen with a theoretically perfect black surface).

Using statistical methods of calculation—the only way possible with systems containing such unimaginable numbers of moving parts—the physicists calculated how radiation from a black body at a given temperature would be distributed as regards frequency. Unfortunately, the differences between the calculation and the results of actual experiments were too great to laugh off as "experimental error," and it was not until 60 years ago when Planck put forward his revolutionary quantum theory that the two could be reconciled. Fig. 3 shows a few calculated frequency characteristics for different temperatures, which are well supported by experiment.

One important feature of these curves is that maximum energy is radiated at a frequency which is directly proportional to the temperature\*. Another is that a higher temperature gives more radiation—very much more!—at all frequencies.

So you can see the difficulty in generating a strong signal at very low infra-red frequencies. If the temperature is lowered to place the maximum there, the intensity is too weak to be any good at all. For example, for our 1-mm waves the temperature for peak signal would be  $3^{\circ}\text{K}$ , or  $-270^{\circ}\text{C}$ ! The output here is negligible and would be entirely buried under interference from surroundings at higher temperatures. Raising the temperature brings the

\* The peak frequency in MMc/s is approximately one-tenth the temperature in  $^{\circ}\text{K}$  ( $=^{\circ}\text{C}+273$ ).

peak farther away, but it does nevertheless increase the low-frequency strength, though very slightly for an enormous increase in total energy output. At 2,000°K (a bright white heat) the intensity at 1mm is eight thousand million times less than at the peak wavelength (0.00144 mm).

All this applies to the theoretical entirely aperiodic black (?) body. In practical radiators the frequency characteristic is modified. For low infra-red frequencies (below 15 MMc/s) a favoured source is a heated silicon carbide rod called a Glowbar. Another much used "signal generator" is the formerly famous Welsbach gas mantle, which emits strongly in the low-frequency infra-red as well as in the visible band.

That glass lenses are effective for infra-red radiation from the sun was seen by us all at an early age when we used them to set fire to pieces of paper or to make our unsuspecting neighbour in school jump and attract the unfavourable notice of the teacher. But their transparency extends to less than four times the longest visible wavelength. Beyond that, crystals of such halogen compounds as common salt are effective; but below 10 MMc/s there is a band where no materials are sufficiently transparent for (say) spectroscopes, and mirrors and gratings have to be substituted for lenses and prisms.

Coming to detectors, we realize that for serious scientific work our jumping schoolmate lacked both sensitivity and precision. Even Herschel's thermometers were limited to the near-visible infra-red, by opacity of the glass and poor sensitivity. Both these types of detector are examples of one of the two fundamental classes—thermodetectors, as distinct from photodetectors. That is to say, their indications depend on some indirect result of the heat, such as muscular or vocal activity, or thermal expansion. One has to wait until the detector material has heated up for such indications to occur, so even if the material to be heated is made very small it can hardly be expected to respond within microseconds—as is sometimes desirable.

On the other hand thermodetectors are not inherently frequency-selective, so can be used throughout the band, provided they are sensitive enough to respond to the weak low-frequency end, and are not limited by features such as glass.

### Thermodetector Principles

After thermometers came the first really effective thermodetector—the thermocouple; still, in greatly improved form, much used. The early thermocouples were just junctions between metals, which, when heated, give rise to a small e.m.f. Modern thermocouples are made from special semiconductor alloys and can detect as little as 0.0001 microwatt per square millimetre of absorbing surface.

An alternative is the bolometer, which responds to heat by varying its resistance. Bolometers originally used very fine metal wire, but nowadays the thermistor with its vastly greater temperature coefficient is far more sensitive, and faster in response.

A more recent thermodetector (second world war) is the Golyay cell, in which the heat expands a small volume of gas, causing movement which is mechanically magnified. Rather surprisingly, this is quite sensitive and quicker in response (a few milliseconds).

An even more improbable thermodetector is the evaporograph, in which the received radiation causes a thin film of oil to evaporate, and the changes in thickness are shown up by an optical device. Although not so sensitive, it has the advantage that the distribution of heat over a surface can be observed as a "picture," rather analogously to the action of a television camera screen as regards light.

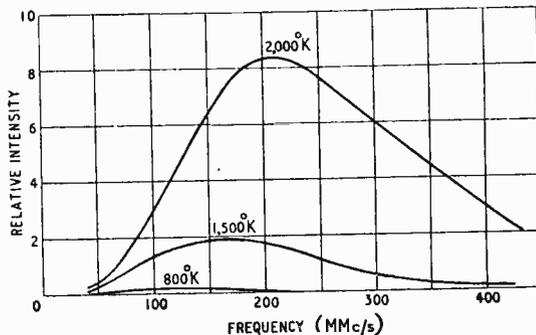


Fig. 3. Distribution of heat radiation as regards frequency, from a perfectly aperiodic radiator ("black body"), at three different temperatures.

Detectors of the other main class are called photodetectors. This is not to suggest that they respond only to light, but because the packets or quanta of radiation—which are called photons whatever their wave frequency—produce an immediate effect by their action on the electrons in the detector. Because the energy of the photons is exactly proportional to the frequency, and electrons usually need a certain minimum injection of energy for any response at all, photodetectors are more or less limited to the high-frequency end. If the frequency is too low for a quantum to reach this minimum, it doesn't make any difference how much radiation is available. Billions of peashooters are no substitute for one anti-tank gun, if one wants to make an impression on an armoured vehicle.

The first kind of photodetector was photographic plate or film, in which the photons make instant chemical changes in the coating. The fact that the ordinary kinds (non-pan) can be developed by red light shows that they fail to respond to visible red frequencies, let alone the infra-red. Panchromatic film is specially sensitized to cover the whole visible range, and in infra-red film the principle is extended to still lower frequencies; but even now the extension is quite small. However, by using filters to cut out the visible light—more subject to scattering by haze—one can, among other things, take extensive land photographs from high-flying aircraft when ordinary photography would fail.

Another line of attack is to extend the range of emissive photoelectric cells. (For a review of photo-cells, see August, 1958 issue.) Most surfaces need to be hit by quanta of at least several electron volts to give their electrons enough energy to kick some of them right out. So their response is mainly to ultra-violet or, at most, light near the violet end. But special surfaces, such as caesium on silver, yield up to less violent photons, over the whole visible range and even into the infra-red.

Like photographic materials, photo-emission can

be applied to picture-making. If an infra-red image is shone on to an emissive surface, and the emitted electrons are drawn forward by a positive-going field, at the same time being kept in formation by suitable focusing fields, they can be projected on to a fluorescent screen with sufficient violence to make it glow, thereby reproducing the picture visibly. The difference between this image converter (as it is called) and a television tube is that all the screen is being bombarded all the time, instead of sequentially by a fine beam of electrons. The technique had obvious uses during the war for "seeing in the dark," and there are also scientific applications.

### Semiconductor Cells

The other kinds of photoelectric cells—photo-voltaic and photoconductive—don't lend themselves to simultaneous picture formation, but only detection; on the other hand some of them work to considerably lower frequencies, though nothing like as far as the thermometers, which (with an exception to be noted later) are the only kinds available for two out of the three infra-red frequency decades. The interesting thing about them from our point of view is that they make use of semiconductors.

Of the two kinds, the photovoltaic have not so far proved themselves very useful, so I will mention only photoconductive types.

Most of them use semiconductor *compounds*, which are less familiar to students of transistors than the semiconductor elements, germanium and silicon. Here again the second war was a great stimulus to development. The German "lightspeaker" used thallium sulphide cells to receive a speech-modulated infra-red beam for secret communications. In another field of application, competition was keen to increase the sensitivity of detectors, with the object of locating the enemy's aircraft (by the heat of its engines) before he located yours.

Other compounds used are the sulphide, selenide and telluride of lead. Some of them are extraordinarily sensitive, and also quick acting—e.g., less

than 100 microseconds. A commercial lead sulphide cell, without benefit of concentrating or focusing devices, or cooling for the cell, is said to detect the heat from an ordinary soldering iron at 100 yards. For the highest sensitivity, however, cooling by liquid air or even liquid helium is needed; the idea being to reduce self-generated noise. With a suitable mirror the range from the same source can be increased to about 10 miles.

And now we have indium antimonide, which is less sensitive but far faster.

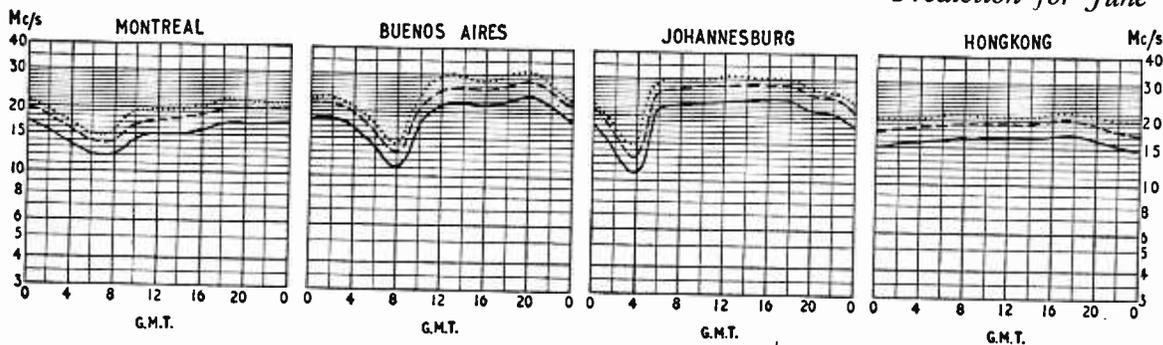
The low frequency limits of these are all higher than 36 MMc/s. If, however, we can remember our basic transistor physics we will know that the usual intentional impurities in germanium and silicon provide very small energy gaps—about 0.01 electron-volt, corresponding to quanta with a radiation frequency as low as 2.4 MMc/s or wavelength 0.125 mm. It is because the heat energy of the surroundings at ordinary temperatures is sufficient to excite nearly all the impurity electrons that transistor materials conduct. That state of affairs would obviously be no use for detecting infra-red radiation, any more than a coconut shy would be a fair test of marksmanship if all the coconuts had already been knocked off by swarms of small boys. So the detector material has to be cooled to a temperature at which most of the impurity electrons are unexcited, by keeping it in liquid helium—say 4°K.

Although r.h.f. can certainly be used for communication (and radar), as we have seen, perhaps the most important applications are in research concerning molecular structure, by infra-red spectroscopy. That is far too big a subject to embark on at this stage, and anyway rather off our beat, but perhaps if the maser is still in mind (April issue) it will give just a little clue to the sort of thing.

If anyone wants to know a lot more about all this, I can recommend the script of the Kelvin lecture on the subject by Dr. G. B. B. M. Sutherland (to whom I am indebted for much of the foregoing information), published in *Proc. I.E.E.*, Part B, July 1958.

## SHORT-WAVE CONDITIONS

Prediction for June



THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during June.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

- ..... FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME
- PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY
- FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

# Electronics and the Phonetician

Speech Analysis and Synthesis

By H. J. F. CRABBE

**M**ODERN experimental phonetics is rapidly becoming an all-embracing subject which endeavours to comprehend the working of the human speech mechanism as a whole. Speech is an immensely complex phenomenon, involving linguistics, mental processes both conscious and unconscious, brain, nervous system, vocal tract, sound waves, and the hearing and understanding mechanism of the listener. The attempt to understand the nature of speech in this dynamic sense involves much research and some controversy, and it is becoming increasingly useful to construct electronic models of parts of the speech mechanism. Also the investigation of the acoustical aspects of speech involves a variety of electrical measuring instruments.

As a result, a stranger, coming by chance into a modern phonetics laboratory, might be forgiven for thinking himself in a department of physics or electrical engineering. Gramophones and tape recorders, still the everyday tools of the phonetician, are augmented by a range of electronic apparatus of considerable complexity. It is the purpose of this article to describe some of the devices and techniques used in this field, from the point of view of the electronic technician.

**Nature of the Vocal Mechanism.**—One of the more limited aims of the phonetician is to achieve a more detailed understanding of the acoustics of speech<sup>1</sup>, so it will be convenient to start with a brief description of the basic vocal machinery.

Most readers of *Wireless World* will be acquainted with the useful practice of producing electrical analogues of simple acoustic devices, such as loudspeaker enclosures, and it is a natural first step to produce a similar model of the human vocal tract. However, the resulting circuit would be rather complex in its entirety, since nearly every element is continuously variable, so we must content ourselves with a simplified version (Fig. 1). Here it will be seen that the output of a tone generator of variable frequency and amplitude is fed to a load via a number of tuned circuits of variable Q and resonant frequency. Also "white noise" can be fed to this same point, either directly or via the above resonators. Finally, these resonant circuits can be excited by single transient pulses of various widths.

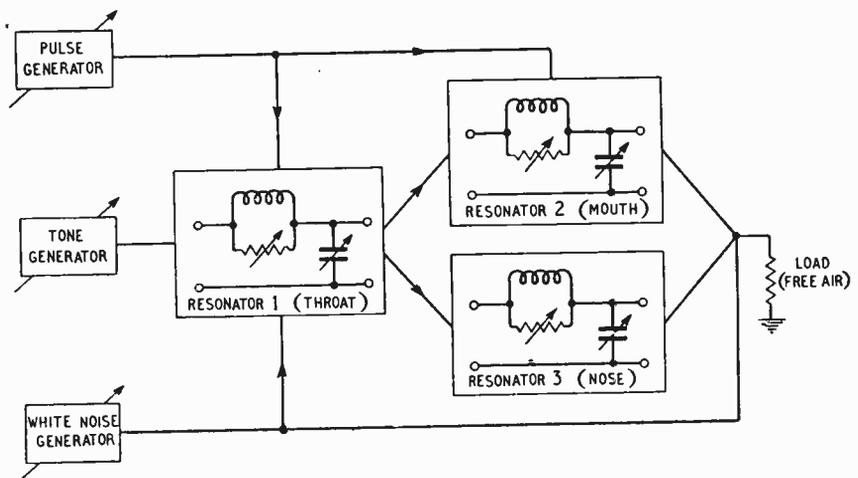
The tone generator has a spiky waveform rich in

harmonics, and is equivalent to the larynx, which contains the vocal chords. The larynx interrupts the flow of air from the lungs, thereby producing a note whose loudness and pitch can be controlled at will. This signal first passes through the pharynx or throat cavity resonator, and then via the mouth and nasal passages into the radiation resistance of free air. Continual unconscious adjustments of these three cavities take place during speech, and the various vowel sounds which we recognize are determined by the groups of harmonics or formants which are passed as a result. The "white noise" simulates the various high-frequency hissing sounds, or fricatives, which can be produced at the back of the throat or between the teeth and lips. It is interesting to note how the "white noise" becomes "coloured" on passing through the throat and mouth, in much the same manner as 78 r.p.m. record surface noise is coarsened by a resonant loudspeaker system. The sounds (sh), (s), (th) and (f) bring the point of hiss injection progressively further forward in our circuit, with a corresponding reduction of dependence on the shape of the mouth cavity for the final sound quality. The pulse generation corresponds to the production of various transient or plosive sounds such as (k), (t) and (p), which are essentially short bursts of energy.

These processes, functioning in continuous and rapid succession with frequent complex transitions which almost defy analysis, constitute the raw material of phonetics from the acoustic point of view.

**Speech Analysers.**—Phoneticians spend much of their time filling in the details of the above picture, and to do this various analysing devices are necessary. The most useful of these is the sound spectro-

Fig. 1 Electrical analogue of the human speaking mechanism.



graph known in one commercial form as the Sonagraph, which provides a three dimensional visual display of sound patterns on electro-sensitive paper. A typical sonagram is reproduced in Fig. 2. The time and frequency dimensions are plotted horizontally and vertically respectively, and intensity is indicated by the density of the trace. The sound depicted is the word "master" and the characteristic formants of the two vowels are clearly displayed, with the (s) and (t) as long and short bursts of high frequency noise. Only the (m) remains obscure, and many consonants are very difficult to define acoustically, as they appear to depend for their intelligibility almost entirely on the subjective interpretation of the listener and the linguistic context.

Machines which produce a display of this sort (see Fig. 3) will usually only handle a limited quantity of material at one time. The words to be analysed are recorded on a magnetic drum and then replayed at a higher speed. Each revolution of the recording causes the writing pen to traverse the paper in the time dimension, while the signal from the replay head passes through a tuned filter, whose output amplitude is used to control the density of the trace. A lead screw causes the pen to move slowly up the paper on the frequency ordinate, at the same time changing the resonant frequency of the filter by moving the slider of the potentiometer. So each time the recording is scanned the writing pen draws a trace corresponding to the sound energy at a particular frequency and slowly a complete picture is built up. This means that it takes several minutes to analyse a sound passage lasting only a few seconds, and it is one of the aims of technicians in this field to design an instantaneous sonagraph which will produce a continuous analysis of material fed straight in from a microphone or tape recorder. To do this it is necessary either to scan the paper in the frequency dimension with very great rapidity, which is difficult both electrically and mechanically, or to produce a large number of traces simultaneously in the time dimension. At the resolution of Fig. 2 this latter would need fifty or more lines to the inch, which is not achievable with actual writing pens. One solution is to produce the display

Fig. 2. Sonagram of the word "master" illustrating the differing ways in which energy (indicated by the density of the trace) is distributed in the three types of consonant and two vowels.

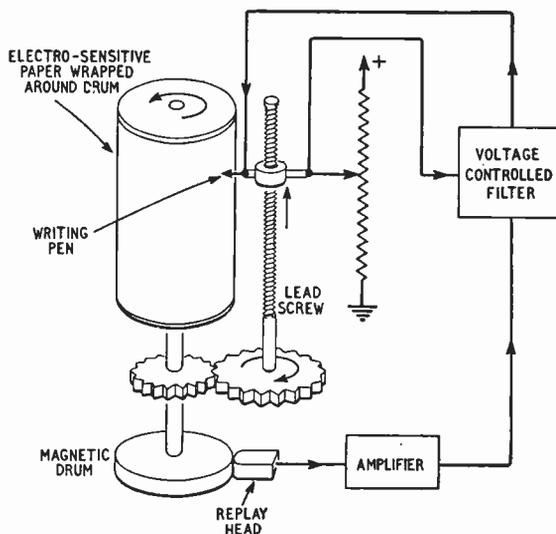
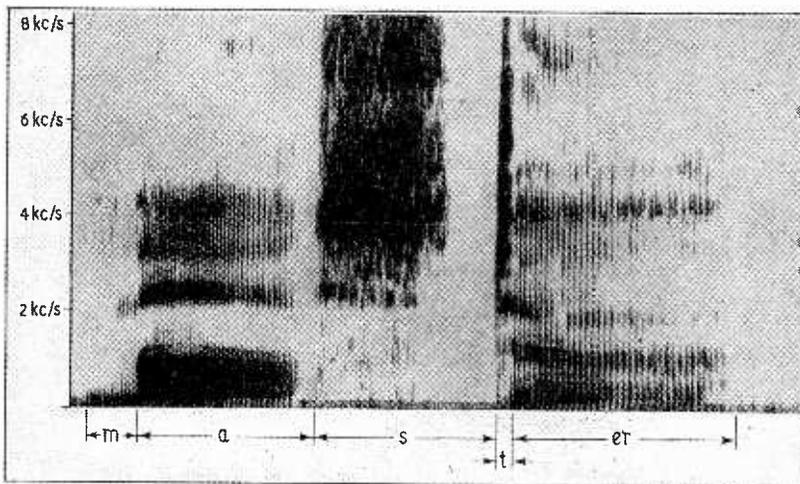


Fig. 3. Essential features of a Sonagraph type of sound analyser. The magnetic recording and the drum carrying the paper rotate together with the lead screw, altering the input to the voltage-controlled filter and causing the writing pen to move slowly up the paper as the analysis proceeds.

on a c.r.t. and to photograph it continuously on moving film. Recording papers sensitive to various forms of excitation are now becoming available, but so far there is some practical objection to each for this application, so the matter remains one for continued research.

In addition to waveform analysis of the individual sounds of speech, it is sometimes interesting to investigate the general distribution of energy against frequency in various languages or dialects. By this method it may be possible to establish some general correlations between particular languages and their acoustic spectra. It is easy to imagine for instance that the excess of fricatives in German, or nasal sounds in French, would produce corresponding peaks in the response curves. The results would be largely statistical, however, since many speakers would have to be examined to swamp the effects of individual characteristics.

The problem here from the electronic point of view is to produce an integrator which will indicate the energy sum of a given length of recorded material at a large number of spot frequencies. A normal narrow-band filter of variable frequency may be used for the latter, but the integrator itself has to meet somewhat stringent requirements. Periods of silence play an important part in speech, and it is essential to achieve an extremely low noise level and rate of drift

during these. Also the device must be linear over an input range of at least 40 dB. A Miller type of circuit cannot be made to perform this well, and one solution is to revert to the simplest of all integrators: a plain R and C. In this arrangement the a.c. input is amplified up to several thousand volts peak and rectified by an e.h.t. diode. The resulting d.c. is applied to the integrating condenser via a chain of high stability resistors, and the voltage across the condenser is measured by a long-tail pair in a starvation circuit to eliminate grid current. This scheme reduces drift and leakage to a minimum, and linearity is maintained by restricting the charge on the condenser to one per cent of the maximum applied voltage. On the completion of each charging period a Schmitt trigger circuit is used to register one digit on an electro-mechanical clock and to discharge the condenser ready for the next cycle. The instantaneous integral at any moment during a cycle is also indicated on a voltmeter, thus ensuring an accuracy of at least two figures on even very short speech passages.

An interesting "extra-phonetic" application of this type of analysis would be to discover the spectra of various commercial disc recordings of the same piece of music; also to study the high frequency attenuation resulting from record wear, which at the moment is a matter of subjective guesswork on all but pure tone test records.

**Speech Typewriter.**—A type of analyser which has a more dramatic and popular appeal than those discussed so far is one that converts the spoken word straight into a typewritten script; a sort of ideal shorthand typist. Several attempts have been made to produce such a machine and one of particularly advanced design<sup>2, 3, 4, 5, 6, 7</sup> is in use at the Department of Phonetics, University College, London.

Reference to the diagram (Fig. 4) shows that the speech input is fed to a bank of filters, the outputs of which are rectified. Thus a number of d.c. voltages are obtained which vary continuously according to the sounds uttered. Ideally, for most speech units, or phonemes, there are at least two frequencies at which major concentrations of energy appear, corresponding to the formants mentioned earlier, and at each of these frequencies there will be an associated rectified filter output. For each sound in the machine's vocabulary the appropriate two voltages are multiplied together in a valve multiplier circuit, and at any particular instant one multiplication product will be greater than all the others and will represent the phoneme being spoken. This instantaneous "winner" is selected by a maximum detector circuit and used to operate a key on an electric typewriter.

So, as the voltage maxima shift from one pair of filters to another during the course of a word, the appropriate keys of the typewriter are depressed in sequence. This method of phoneme detection is not suitable for some fricative and plosive sounds, which have similar spectra, so with these the machine makes its decisions according to the duration and/or amplitude of the signal. To achieve this a number of flip-flop timing circuits are triggered at the commencement of any hiss energy, and their operating times made to correspond to the length of the sound to be recognized. When the sound ends, the circuit within whose time band it comes causes the appropriate character to be typed. Similarly, differences of amplitude can be detected by Schmitt trigger circuits. The spaces between words are detected by a separate circuit, which examines the speech input and records a space when the signal disappears for more than a specified minimum time.

This basic instrument as it stands is not very efficient, and makes many mistakes, due largely to the extreme inconsistency of speech, which seldom lives up to the hypothetical acoustic pattern. Humans are able to recognize words with comparative ease, despite extremes of dialect or frequency distortion which would completely baffle a purely physical analyser. This is made possible by our knowledge of the language and of the probable occurrence of particular combinations of phonemes and words. We draw on this information unconsciously when listening to speech and thus extract a meaning from a jumble of sounds, as noted by Cherry recently in *Wireless World*<sup>8</sup>.

The blocks marked MEMORY and LINGUISTIC KNOWLEDGE in Fig. 4 represents circuits which

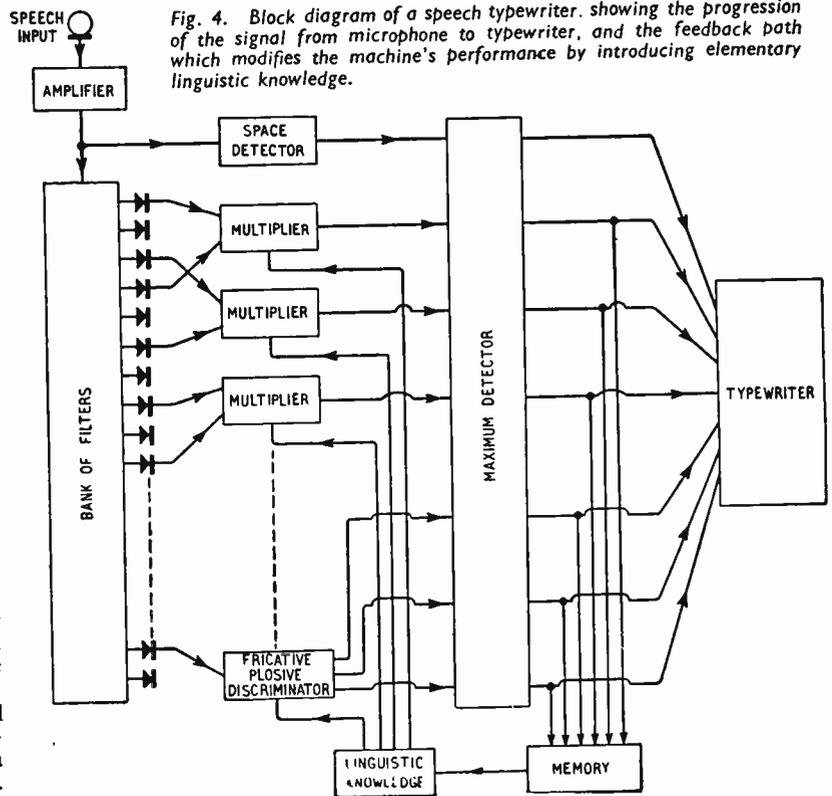


Fig. 4. Block diagram of a speech typewriter, showing the progression of the signal from microphone to typewriter, and the feedback path which modifies the machine's performance by introducing elementary linguistic knowledge.

attempt to simulate this especially mental part of the speech-recognizing process, though at a very elementary level. The linguistic knowledge takes the form of a matrix of potentiometers on which are set voltages corresponding to the probabilities of any sound following any other sound in the machine's vocabulary. As a particular character, say (m), is typed, so the machine "remembers" what the sound was by operating a self-holding relay. At the same time a voltage is applied to a column of potentiometers in the matrix appropriate to sounds following (m). The circuits used to multiply the pairs of rectified filter outputs are actually three-stage devices, the third inputs to which come from these potentiometers. This means that the next character to be typed will depend on three voltages, two derived from a frequency analysis of the input waveform, and one indicating the probability of following the previous sound. Thus the recognition of every succeeding sound is affected by the machine's knowledge of which phoneme is most likely to follow the one already identified, and of those which are impossible in that position.

This very simple one-stage memory arrangement greatly improves the performance of the apparatus and makes it noticeably less dependent on one particular speaking voice. The complete instrument, which is shown in the photograph, will correctly type 44% of words and 72% of individual sounds; and though it is limited to a vocabulary of 13 phonemes for the present, this is a third of all English sounds and provides the material for several hundred words. An extension of the principle of built-in linguistic knowledge to enable the machine to assess the sequential probabilities of sounds on the basis of the previous two or three characters would greatly improve the performance, but would involve the use of a large computer.

It would be unrealistic to hope that such a

machine could ever work perfectly with an unrestricted vocabulary, but it may be possible to achieve a reliable response to an agreed and limited range of words, such as telephone numbers or similar messages where the spoken word needs to be converted into a series of coded impulses. An instrument which could break down a complex speech wave to the forty phonemic units used in English would achieve an immense reduction of the bandwidths needed in communication channels, and if made to drive a corresponding synthesizer at the receiving end, it would provide a valuable advance in analysis-synthesis telephony methods".

**Speech Synthesizers.**—This brings us to synthesizers, which in one form or another have been in use now for some years<sup>10</sup>. Certain general principles of design have been established, though detailed circuit arrangements vary widely. It is convenient to make such a system in two functionally separate parts; one being a control circuit which will produce a succession of switching voltages of proper duration and sequence, and the other a generating circuit similar to Fig. 1, the output of which feeds a loudspeaker. In many synthesizers the control voltages are derived from a set of shaped patterns which are scanned in various ways. A design using a different method of control is in use at University College, and its basic layout is shown in Fig. 5.

The sequence timer consists of a series of ten flip-flop circuits which trigger each other in succession. The operating time of each one can be adjusted separately, and each on period corresponds to the duration of one speech unit in a short sentence. Associated with each time unit is a column of potentiometers on a control panel (only one of the ten columns is shown in Fig. 5) and when a particular sound in the sequence has been reached, the appropriate column is energized with a d.c. voltage and a set of signals sent into the generating half of the synthesizer. The form of these signals is preset according to the type of sound to be produced, and the various parameters which can be varied are marked on the control panel (see Fig. 5). The larynx tone generator is an oscillator rich in

harmonics, the fundamental frequency of which can be varied over the normal range of fundamental speech tones by means of a d.c. voltage. The formant filters are simply tuned circuits of an appropriate bandwidth, whose centre frequency can also be varied by means of a d.c. voltage. The amplitude of signal fed to each filter is determined by the gate units, and these will pass anything from full level to zero, depending on the applied voltage. The hiss generator produces continuous noise with a suitable spectrum.

If, for instance, one  
(Continued on p. 293)

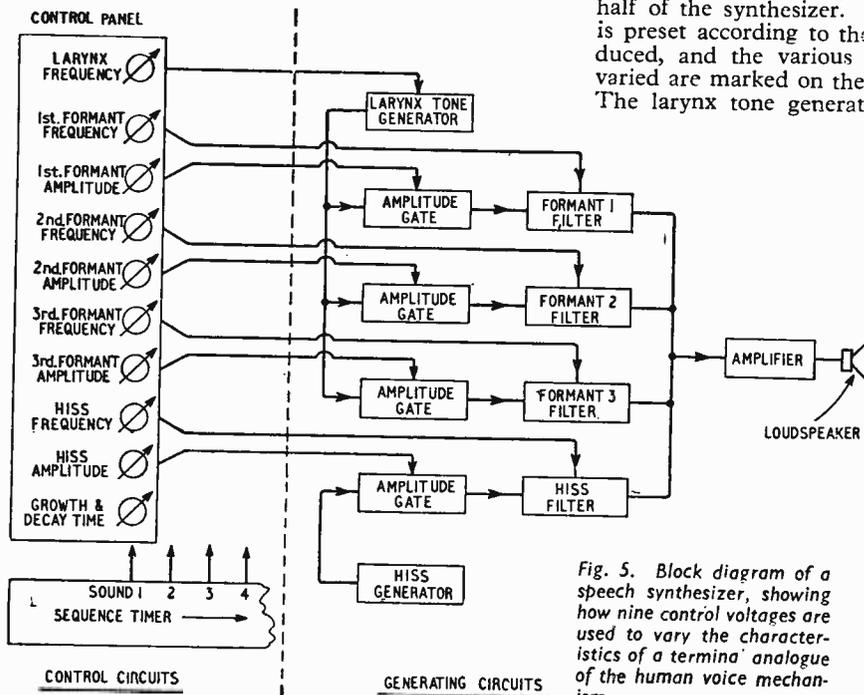


Fig. 5. Block diagram of a speech synthesizer, showing how nine control voltages are used to vary the characteristics of a terminal analogue of the human voice mechanism.

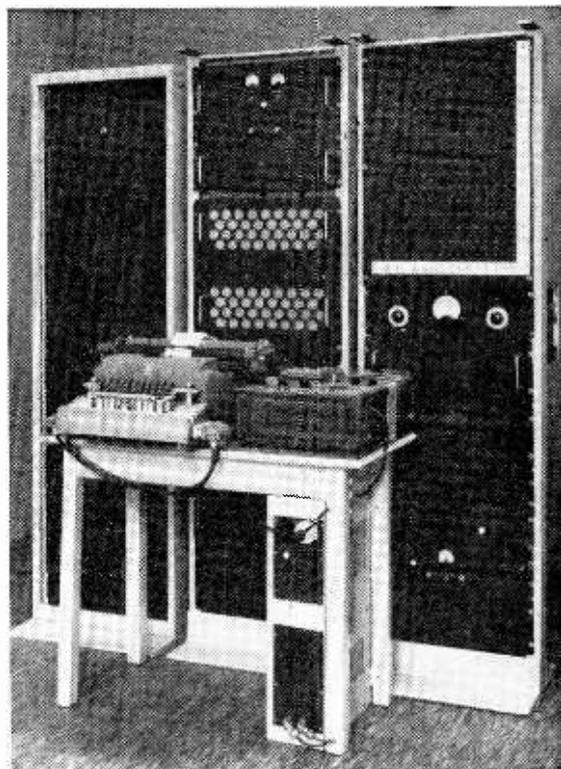
wished to generate the sound (ee) as spoken by the average male, then reference to published data<sup>11, 12</sup> shows that the larynx frequency will be 136 c/s and the three formants will be at 270, 2300 and 3000 c/s respectively. Also their relative amplitudes will be 0, -20 and -24 dB. Thus, by setting seven knobs, the sound can be synthesized in a few moments. The rate of change of the amplitude and frequency of the sound can be set by a variable time constant circuit, but the requirements here depend on what precedes and follows the phoneme in question. If a fricative sound is required, then here again the amplitude and frequency content of the hiss signal can be adjusted in a similar manner. For plosives, short bursts of hiss will normally produce satisfactory results.

Although for economic reasons the machine is restricted to sequences of ten sounds, it can still pronounce short meaningful sentences like "How are you, baby?" and "Where are you, Sir?". As a tool for research it is very valuable, both for testing data derived from speech analysis and for determining the minimum information necessary to define speech sounds<sup>13</sup>.

**Interfering with Speech.**—In the course of their investigations, phoneticians sometimes find it convenient to have independent control of the fundamental pitch, or larynx tone, in a continuous speech pattern, while leaving the other parameters unaltered. One way of achieving this is to adapt an instrument sometimes used in telephone systems and called a Vocoder<sup>14</sup>. This consists essentially of an analyser rather like the filter and rectifier part of the speech typewriter described previously, feeding a number of slowly varying control voltages through a communication channel to a corresponding synthesizer. The transmitted information relates to the changing distribution of energy in the spectrum. This is a less fundamental process than is involved in locating the actual phonemes, so the consequent reduction in bandwidth is not so great.

At a suitable point in the Vocoder an electrical signal corresponding to the instantaneous pitch can be intercepted and replaced by an artificial one under the control of the experimenter. Thus a speaker can talk into the system and, regardless of his own intonation, the output will vary in pitch according to the turn of a knob or the depression of key switches. The uninitiated might imagine from this that one could recite "John Brown's Body" into the microphone and produce an output of the same voice singing the same words. Alas, this easy conversion of soap-box orators into budding Carusos is not to be had! The characteristic formants associated with vowel sounds are, in singing, accompanied and even masked by others which are absent in ordinary speech<sup>15</sup>; so the result of this arrangement would be to produce a singing voice of very unnatural tone quality.

However, there is a useful application of this pitch control, as psychologists sometimes need to investigate the influence of intonation on the emotive content of words or sentences. For this a recording is made of a suitable sentence, and a number of painted patterns are produced corresponding to changes of pitch in various words or parts of words in the sentence. Each pattern is then scanned by a cathode-ray following device to produce an equivalent pitch control voltage in synchronism with the replayed recording. By this method the investigator



View of the complete speech typewriter outlined in Fig. 4. The control table carries the input material on recorded tape and also the typewriter. The racks from left to right contain the filters and rectifiers, multipliers and maximum detector, and memory and linguistic knowledge circuits respectively.

ensures that *only* the pitch is changed, which is important if listeners who are asked to assess the meaning or emotional content of an utterance are not to be misled by other variables introduced by a live speaker.

Another interesting way of interfering with speech is to upset the feedback loops in the human nervous system while the subject is speaking. This has become a very popular joke, and no doubt many *Wireless World* readers have submitted to it in the B.B.C. studios at the Radio Show in previous years. The voice is simply amplified, delayed by about one-quarter of a second on a tape loop, and fed back to the speaker's ears at high level via a pair of headphones. We normally unconsciously correct our speech as we go, but by this method we correct according to the wrong information and are reduced to a stuttering gibberish. Only the deaf can survive this experiment without loss of pride, as no amount of concentration will enable one to speak normally. Because of this it is a fairly reliable method of discovering whether a suspected malingerer is really deaf.

This short survey, based on the work of one University Phonetics Department, does not claim to be exhaustive. No doubt many gadgets and techniques of importance have been omitted, and the Americans particularly, with their vast laboratories, can afford a tolerant smile. However, if Shaw's

Professor Higgins could see us he would certainly find much to admire; the crude acoustic devices of an earlier age have now been completely superseded by the electronic approach, to the advantage of all.

The author would like to thank Professor D. B. Fry for permission to publish many of the above details. It should be noted that authorship of this article does not imply responsibility for the design of any of the items mentioned, which are the product of a technical team. Particular credit should go to Mr. P. Denes, M.Sc., A.M.I.E.E., who is in charge of the Phonetics Laboratory, and to the writer's colleague Mr. J. E. West. Some of the work described in this article has been financed by the U.S. Air Force under Contract No. AF61 (514)—1176.

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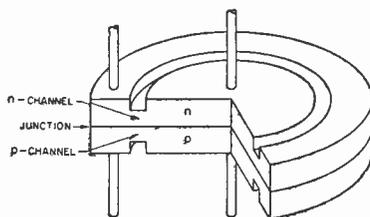
<sup>15</sup> D. B. Fry and L. Manén, "Basis for the Acoustical Study of Singing", *J. Acous. Soc. Amer.*, Vol. 29, p. 690 (1957).



**Aluminium-Backed Polyester Magnetic Tape** for high-speed video recording or computer applications has been produced by the M.S.S. Recording Company. At high speeds a considerable static charge can build up on the normal polyester backing. This has been avoided by M.S.S. by spraying a very thin ( $10^{-3}$ in) coating of aluminium on the back of the polyester to produce a low resistance ( $\approx 50\Omega/\text{ft}$  for  $\frac{1}{4}$ -in tape). At slower speeds it is sufficient to treat the polyester with an anti-static agent, as is normally done with tape for audio recording.

**Field Effect Tetrode** is a new experimental four-terminal semiconductor device recently produced at Bell Telephone Laboratories. It is said to be capable of operating as a transformer, a gyrator, an isolator, or as a non-distorting modulator. The tetrode consists of a disc of semiconductor material with a diffused junction. A circular trench is cut and etched into each face of the disc, to within about 1 mil of the junction on either side. Two leads

are then attached to each face, one inside the trench and the other outside (see diagram). When a voltage is applied across the junction, the thickness of the depletion layer adjacent to it is increased or decreased, depending on the direction of the biasing voltage. This in turn increases or decreases the resistance of each "channel" between the bottom of the trench and the junction. One of the most important applications, according to Bell Telephones, may be as a distortionless modulator, or electronically controlled resistor for large signals. In this use, a relatively low frequency control



voltage varies the width of the depletion layer, and thereby the resistance of the device. Simple capacitors can act as high-pass filters to isolate the control voltage from the signal if the frequency ratio is maintained at a high level. The signal voltage does not appear across the junction and has no effect on the depletion layer. Consequently it can be magnitudes higher than the control voltage, without being distorted by self-modulation. For the same reason, it is not limited by junction capacitance.

**High-Speed Counting Tube**, capable of operating at pulse rates up to 1Mc/s has just been introduced by Mullard. Designated the ET51, it is actually a trochotron decimal stepping tube. As distinct from the Dekatron glow-discharge type of counter, the trochotron is a vacuum device depending on the deflection of an electron beam. It makes use of crossed electric and magnetic fields to form the beam between a thermionic cathode and any of ten groups of three electrodes mounted radially about the cathode. The electric field is provided by the inter-electrode potentials within the tube and the magnetic field by a cylindrical permanent magnet fitted externally around the glass envelope. Each group of electrodes consists of a "spade," which forms and locks the beam in position, a target, which makes the beam available as a constant current output, and a grid, for switching the beam from one spade to the next. When power is first applied, all spades will be equally positive with respect to cathode and,

due to the action of the magnetic field in preventing electrons reaching the electrode-groups, the tube will be in a cut-off condition, with no beam formed. If, however, the potential of any spade is reduced, by means of a high-speed pulse or a d.c. voltage, the beam will form on the electrode group associated with that spade, and an output will appear on the corresponding target. Once formed, the beam is held in this position by a combination of the spade series resistance and spade current until it is stepped to the next position by lowering the voltage on

speed of  $3\frac{1}{2}$  in/sec, a loop 80ft long has been successfully stored.

**Fourier Transform Analogue Generator**, developed as a specialized research tool by the B.B.C., is shown below. With this instrument any function can be set up in graphical

*Electronics* for 30th January, 1959, is said to be very sensitive and has the advantage of eliminating contacts to the semiconductor, which are normally a source of noise in conventional infra-red detectors.

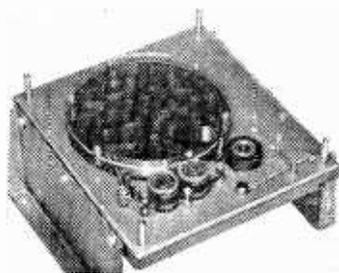
**Brazing Under Vacuum**, at temperatures up to  $1100^{\circ}\text{C}$ , was one of the requirements which had to be provided for by Edwards High Vacuum recently when designing a pumping plant for ceramic disc valves. At such high temperatures it was impossible to use normal sealing techniques, and metal seals had to be employed. At the same time the vacuum had to be extremely high because getters cannot be used in ceramic valves as they are in conventional glass valves. The pumping plant finally built by Edwards has a water-cooled vacuum chamber made of mild steel, inside which six ceramic valves can be moved round on a rotary work table. Movement is transmitted from outside the chamber to the work table via flexible metal bellows, to obviate the need for organic sealing gaskets. Similar metal bellows are used for raising and lowering the small brazing furnace, inside the chamber, on to each valve station in turn. Sealing between the cylindrical vacuum chamber and its baseplate is done by indium wire.

**Mechanical Separation of Stereo Pickup Movements** in two directions at  $90^{\circ}$  by a simple method was described recently by S. Kelly. A flat strip and a cantilever link carrying the stylus at one end are joined together at right angles to form a cross as in the illustration. The flat



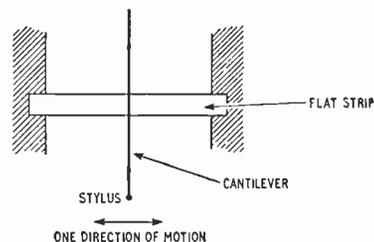
the associated switching grid. Since only the grid in its immediate vicinity will affect the beam, the grids are connected internally in two groups; the odd-numbered grids in one, the even-numbered in the other. This makes it possible to use a d.c. input for switching and still obtain single position stepping, thus avoiding the necessity for a pulse of critical width. The output characteristic of the trochotron is similar to that of a pentode valve, and in the ET51 over 80% of the beam current appears in the output, the remainder being used to form and lock the beam.

**Tape Cassette** consisting simply of a hollow cylindrical "pill-box" several inches in diameter but only slightly taller than the tape width has been devised for use in the Gate Electronics Continuous Tape Deck. Two narrow corridors protruding from the circular edge of the pill-box guide the tape in and out and keep its width parallel to the pill-box's height. Inside the pill-box the tape curls itself randomly into S-shaped lengths as may be seen from the photograph taken through the perspex end. With a  $4\frac{1}{8}$ -in diameter pill-box and a tape



form by adjustment of potentiometer sliders on a calibrated panel and the resultant Fourier transform displayed on an oscilloscope. Each potentiometer is connected to one of twenty harmonically-related sinusoidal voltages, and the voltages on all the sliders are combined to form the signal which represents the Fourier transform. The equipment was developed for a programme of research work on lenses as a means of avoiding the tedious calculations which would otherwise be necessary to obtain Fourier transforms.

**Microwave Infra-Red Detector** recently developed by the GB Electronics Corporation in America makes use of r.f. energy, propagated in a waveguide system, to detect the changes which occur in semiconductor material when infra-red or other radiation is directed on to it. The resistance and dielectric constant of the semiconductor (a germanium crystal) are affected by the incident radiation, and these produce changes in the phase and amplitude of a wave reflected from a tuned cavity. Indication of these phase and amplitude changes is obtained by combining the wave in phase opposition with a corresponding wave reflected from an identical tuned cavity (also containing a germanium crystal but not irradiated). Normally cancellation occurs, but when the semiconductor causes phase and amplitude changes in the first wave an unbalance signal is produced. The system, described in



strip is also fixed at both ends and runs parallel to one of the two directions of motion. Motion in this direction at the stylus end of the cantilever then causes this end of the cantilever to hinge about its joint to the strip so that the motion is *not* transferred to the other end of the cantilever. Motion at the stylus end of the cantilever in the other direction (at right angles to the paper in the illustration) causes the strip to twist and the motion is transferred to the other end of the cantilever.

**New Units** introduced by the Los Alamos Laboratory of California University, according to an advertisement in the April issue of *Astronautics*, include the Babe (20keV), Shake ( $10^{-3}$ sec), Jerk ( $10^{-10}$ ergs) and Zerk ( $10^{23}$ ergs).

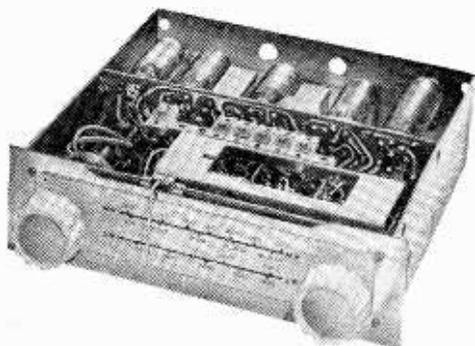
# Manufacturers' Products

## NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

### Hybrid Car Radio

A SET of parts for the construction of a "hybrid" 12V car radio receiver is now available from Mayra Electronics Ltd., 551, Holloway Road, London, N.19.

The receiver (to a S.T.C. circuit) uses five Brimar valves—two 12AC6, 12AD6, 12AE6, 12K5 and a Pye V15/10P transistor for the a.f. output stage. It is a superhet with an r.f. stage, which accounts for the excellent sensitivity and a.g.c. characteristic. Permeability tuning is employed, covering the medium and long wavebands and a printed-wiring panel for the receiver proper ensures consistent results. The output transistor is mounted on a heat sink on the back of the loud-



Mayra Electronic hybrid car radio receiver (case removed).

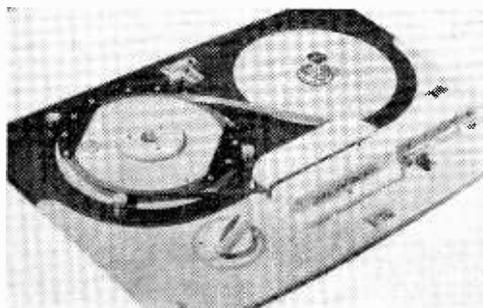
speaker and the heat sink is insulated from the circuit. Battery consumption is 1.5A at 12V.

The complete set of parts including the receiver case, loudspeaker, knobs and dial trim costs £13 10s.

### Tape Loop Cassette

FOR speeds of 15in/sec or less, up to 200 ft of tape can be wound in an endless loop on the "Brittape" cassette. This cassette is bolted over one of the spool spindles of the deck, and it can be used with most tape recorders which can take 7-in or larger-diameter spools. In the cassette the tape is wound on a central freely rotating 5-in diameter spindle and, when in motion, unwinds from the inside and winds in from the outside. To allow this motion, the tape must be wound on the cassette clockwise or anticlockwise (from the inside out when viewed from the top) according as the direction of tape

"Brittape" endless loop tape cassette.

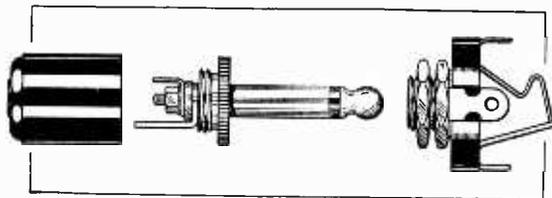


travel is from left to right, or, as in the illustration with the Regentone recorder, from right to left. The direction of travel for the 200 ft of tape usually supplied with the cassette must thus be specified when ordering. The cassette costs £6 12s 9d with tape and £6 6s without. The address of the manufacturer is Guy's Calculating Machines, Ltd., Truro Road, Wood Green, London, N.22.

### Miniature Plug and Jack

THE new Bulgin P519 plug and J30 jack are designed for use in modern miniaturized equipments and their small size makes them particularly suitable for this purpose. The plug is the familiar "concentric" type with a shank measuring  $\frac{7}{16}$ in in diameter. It has a  $\frac{1}{2}$ in diameter phenolic screw-on cap and with the plug seated this projects about  $\frac{7}{16}$ in from the panel.

Phenolic insulation is used for the jack which is fitted with a  $\frac{7}{16}$ in diameter fixing bush which fits metal panels up to  $\frac{1}{8}$ in thick. The fixing bush is also the contact for



Bulgin miniature P519 plug and J30 jack.

the shank of the plug and this will normally be "earthy." Two spring contacts are provided, one for the tip of the plug and another which mates with this spring when the plug is withdrawn. Maximum ratings are: current 1A, voltage 50, loading 10W. Test voltage is 250.

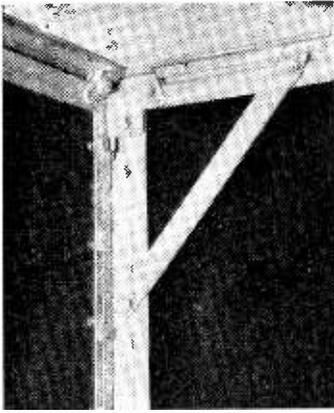
The makers are A. F. Bulgin and Co., Ltd., Bye Pass Road, Barking, Essex, and the prices are 2s 6d for the plug and 3s for the jack.

### New Rack-mounting Principle

THE convenience afforded by the 19-in Post Office rack has made it an almost-standard form of mounting for electronic equipment; but it does suffer from several disadvantages—these being mainly cost, due to the number of tapped holes necessary, and the difficulty of excluding dust from the apparatus or providing forced-air cooling.

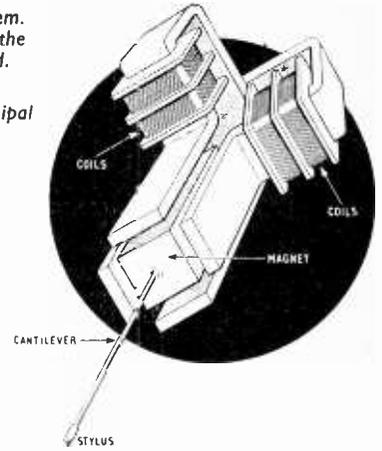
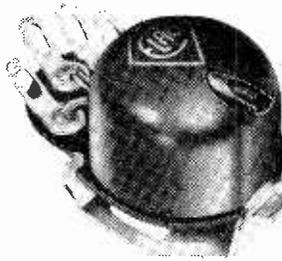
The new Widney-Dorlec rack-mounting system (also see R.E.C.M.F. review, May issue, p. 216) represents an effort to overcome the major disadvantages and, at the same time, it increases considerably the scope of the prefabricated cabinet system. The tapped-hole problem is overcome by the use of a pressed metal strip which holds against the front member of the cabinet at  $1\frac{1}{2}$ in spacing, rectangular nuts providing two threaded holes on  $\frac{1}{2}$ in centres: these are used only where they are required for the mounting of units. Holes in the cabinet-frame strip are drilled using the backing strip as a guide and any desired thread may be fitted by using the appropriate nut: the nut may be retained, if necessary, by a screw passed into it from the rear, through the stamped strip.

This system can naturally be used with any suitable Widney-Dorlec assembly; but the new "cubicle" cabinet for which it was designed offers some advantages. If units are mounted with their front panels exposed, the



Left: View from inside of cabinet of new system. Note that it is necessary to drill holes in the front member only where they are required.

Illustration and (right) sketch of principal parts of Elac stereo pickup cartridge.



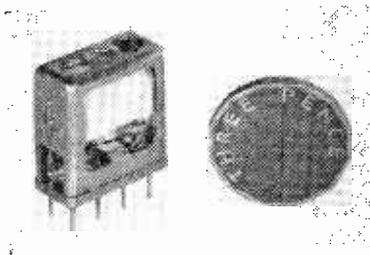
cubicle doors give side access to the chassis; however, by turning the cabinet through 90° and fitting ready-drilled bearers running from front to back equipment may be mounted so that the door closes on the front panels, still using the rectangular nut mechanism for securing the units. The makers are:—Hallam, Sleight & Cheston, Ltd., Oldfield Road, Maidenhead, Berks.

### Sub-miniature Relays

A hermetically sealed, miniature relay which measures 0.875in × 0.8in × 0.396in and weighs only 0.52oz is now obtainable from C. P. Clare Ltd., 70 Dudden Hill Lane, London, N.W.10. This is the Clare Type "F" relay, and is made under licence from the C. P. Clare Co. of Chicago, U.S.A.

Type "F" is a 2-pole 2-way relay with contacts rated at 3A at 28 volts d.c. or 115 volts a.c., the nominal operating power being 250mW. The "make" time is 3.5 msec and the "fall-out" time 1.5 msec. A balanced armature form of construction is adopted and the relay is claimed to withstand considerable shock and vibration.

The relay is designed especially for use in printed



Clare Type "F" relay with a 3d coin outline for comparison of size. Cover cut away to show internal assembly.

circuits and the glass-to-metal seal contact tags are spaced 0.2in apart in two rows also 0.2in apart.

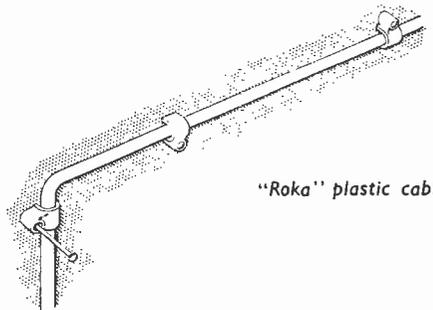
### Two Stereo Pickups

IN both the Elac stereo pickups types STS200D and STS300D there is a gap at each side of the square cross-section magnet so that a balanced system with two pairs of gaps is formed (see sketch). The compliance at the  $0.7 \times 10^{-6}$ in radius diamond tip is stated to be 4.1 × 10<sup>-6</sup>cm/dyne for both these pickups, and they each produce about 4% intermodulation distortion for recorded lateral velocities less than about 22cm/sec (using 400 and 4,000c/s with an amplitude ratio of 4 to 1,

and a tracking weight of 5gm). The crosstalk for the STS200D is given as about -20dB at frequencies up to 5kc/s, rising to -10dB at 10kc/s: the crosstalk for the STS300D is about 4dB less than these figures. The effective mass at the stylus tip is stated to be 2.5mgm for the STS200D and 2.16mgm for the STS300D. The STS200D costs £17 17s 7d and the STS300D £27 12s 10d, both these pickups being distributed in this country by Thermionic Products (Electronics) Ltd., Hythe, Southampton.

### Plastic Cable Clip

THE illustration shows a novel plastic cable clip of German design made of tough polystyrene. It is admirably suited for fixing television coaxial down leads and



"Roka" plastic cable clip.

extension-point cables, also the wiring to extension loudspeakers, to walls or wood surrounds.

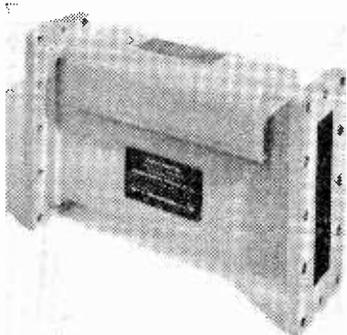
Known as "Roka" plastic clips, they embody a captive hardened-steel nail, a feature which greatly facilitates fixing the clip in awkward places.

Clips are available for cables of from  $\frac{1}{8}$ in to  $\frac{3}{8}$ in diameter, and prices vary with size. For example, clips for a  $\frac{1}{8}$ -in diameter cable cost 2s 5d a hundred, while for  $\frac{1}{4}$ -in cable the price is 4s 3d a hundred.

Further details can be obtained from Perihel Ltd., 146 New Cavendish Street, London, W.1.

### Ferrite Isolators

ABOUT 30dB isolation at any selected frequency in three ranges (1.8 to 2.3, 3.3 to 5.5 and 8.1 to 12.5kMc/s) falling to about 20dB 5% away from the selected frequency, is provided by a new range of isolators introduced by Marconi's. The power handling capacity is 80W for isolators in the 8.1 to 12.5kMc/s range and 20W for those in the other two ranges. The cost of



Typical ferrite isolator (centre frequency 2kMc/s) in the new Marconi range.

each isolator is £45 or £50 depending on the frequency range, and they are manufactured by Marconi's Wireless Telegraph Co., Ltd., of Chelmsford, Essex.

### Multi-range Meter

IN the new Taylor model 100A a sensitivity of  $100,000\Omega/V$  on the d.c. ranges has been achieved by using an  $8\mu A$  centre-pole movement. This movement can withstand a momentary overload of 100 times and a cut-out is incorporated, whose operating time and current have been used to determine the rating of all the meter resistors. Those resistors across which the voltage drop is measured on the ohms ranges are protected against the application of a.c. by a rectifier which produces a d.c. current to operate the meter cut-out, but

which does not conduct when the internal battery is connected on the ohms ranges. All the d.c. and a.c. range scales are coincident except for the most sensitive a.c. range (10V f.s.d.), thus avoiding most of the confusion produced by offset a.c. calibrations. This has been achieved by using a "half-bridge" rectifier on the a.c. ranges with selected loading resistors (the two resistors which replace two of the rectifiers in the full bridge). A double-section half-wave rectifier cannot be used, for on application of d.c. of incorrect polarity to one of the a.c. ranges, one section of the rectifier would short circuit the meter and render the cut-out inoperative.

Another useful facility is a push-button for interchanging the connections to the meter so that inputs of the incorrect polarity can be measured without reversing the connecting leads. The 8 internal d.c. voltage ranges on this meter extend from 0.5V to 2.5kV f.s.d. and an external adaptor (available at extra cost) containing a  $2.25M\Omega$  resistor enables measurements to be extended up to 25kV f.s.d. The current ranges extend from  $10\mu A$  to 10A d.c. f.s.d., and the ohms ranges from  $20\Omega$  to  $2M\Omega$  centre scale. Decibel and output ranges are also provided. This meter costs £31 10s and is manufactured by Taylor Electrical Instruments Ltd., of Montrose Avenue, Slough.



Taylor multi-range meter model 100A with  $100,000\Omega/V$  sensitivity on d.c. ranges.

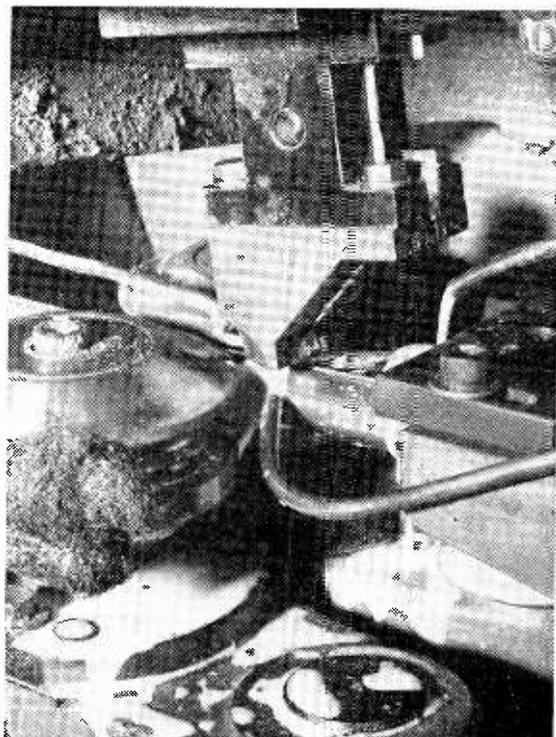
## High-Speed Tube Production

### Continuous Seam Welding with R.F. Current

A MACHINE recently imported from America by Elm Engineering Ltd (one of the Antiference group of companies) is capable of welding together the edges of rolled-aluminium or rolled-aluminium-alloy tube at speeds up to 400 ft/min.

Aluminium strip is formed into tube by passing it through a series of rollers, each of which imparts an increased degree of curvature to the strip until it forms a tube with a split in it corresponding to the edges of the original flat strip. About 50kW of r.f. power at 450kc/s is applied to the edges of the split by two copper shoes and then the tube passes through another pair of rollers which force the edges together. As the r.f. current is discouraged from taking the "long" path round the circumference of the tube by a ferrous core, an intense heating effect, resulting in the melting of the edges is produced at the join. The squeezing action of the rollers expels nearly all the molten material giving a weld with only a small section of grain structure differing from that of the rest of the tube. After the welding process the expelled material over the weld is removed and the tube passes through a further set of rollers to bring it finally to size. The machine accepts strip of 14 to 22 s.w.g., can produce tubes of outside diameter  $\frac{1}{2}$ in to  $1\frac{1}{2}$ in and can weld metals other than aluminium and its alloys.

The welding process is known as the "Thermatool" process and it was developed, and the machine made, by the New Rochelle Tool Corporation, New York, U.S.A.



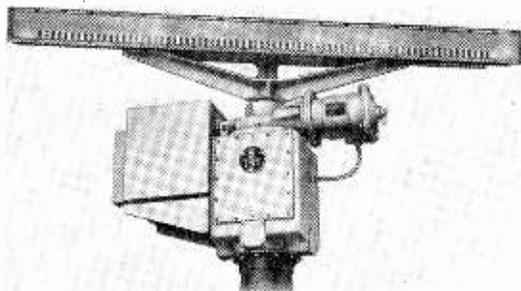
"Thermatool" tube-welding process in operation. Tube moves from right to left; picking up r.f. from copper shoes.

# NEW MARINE RADAR

## Details of the B.T.H. "Escort" Motion-Stabilized Equipment

ONE of the problems associated with the use of radar and similar complex electronic devices is that the large number of controls provided usually scares away the non-technical user, or leads to inefficient operation of the equipment. In an effort to overcome this problem B.T.H. in their new "Escort" 3-cm, motion-stabilized marine radar, have reduced the number of "user controls" to the absolute minimum—four relating to the motion-stabilized display, such as tide speed and direction; four for actually using the display (bearing graticule, range scale, etc.) which are mounted on the front panel, and eight subsidiary controls, e.g., marker brightness, i.f. gain, anti-clutter, etc. These last eight controls are mounted on the sides of the indicator unit and each has a differently-shaped knob for immediate and easy identification by touch.

The radar follows the general lines of any modern marine radar with a stabilized display (called "Chart Plan" by B.T.H.) but many small "convenience features" provide for ease of handling; for instance the bearing marker is differentiated from the heading marker by starting it from the continuously-variable range ring. This marker "paints" each time the radial scan



Aerial system of "Escort" radar. No parts other than turning gear and echo box are mounted with the aerial, so easing servicing problems.

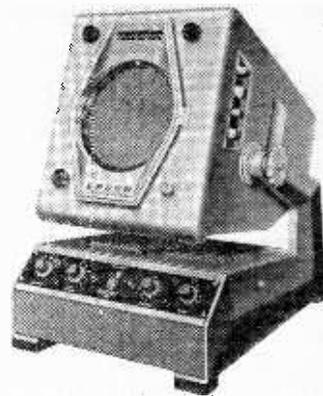
passes over its position: normally the resetting of the marker occupies several revolutions of the aerial; but in the "Escort" the whole procedure is much simplified by ganging the electronic bearing-marker angular control to the parallel-ruled c.r.t. graticule. Thus it is necessary only to line up the graticule to line up the bearing marker; also a control knob and a scale are dispensed with, for the graticule has a scale calibrated in degrees round its edge. Another feature which should prove most useful is that, on switching from a "ship's-head-up" display to the compass-stabilized "north-up" display no manual realignment of heading and course markers is necessary—this is done automatically.

Five malfunction indicator lamps are fitted just below the c.r.t.—these automatically indicate an abnormal condition of the equipment. Another feature is that an echo box is joined permanently to the waveguide; but it is "disconnected" normally by a ferrite isolator: switching-in this provides a very quick check that the equipment is operating, a fact which need not necessarily be apparent in the absence of echoes.

The slotted-waveguide aerial, fairly high p.r.f. (1200/sec) and short minimum pulse-length (0.12 $\mu$ sec) combine to provide a high-definition picture on the 12-in c.r.t. and the 45kW transmitter peak-power output ensures that the smallest scale of 48 nautical miles can be used effectively. The power input required is 1.3kW and, as a motor-generator with an electronic voltage

regulator is used to supply the equipment practically any ship's mains can be used. The "Escort" weighs about 1,000 lbs in all and the cost is in the region of £3,000, excluding waveguide, cabling and installation.

Display and "Chart-Plan" control unit of B.T.H. "Escort" marine radar. Controls (such as local oscillator tuning) which should not need resetting during operation are concealed by drop-flap below "Chart-Plan" control knobs.



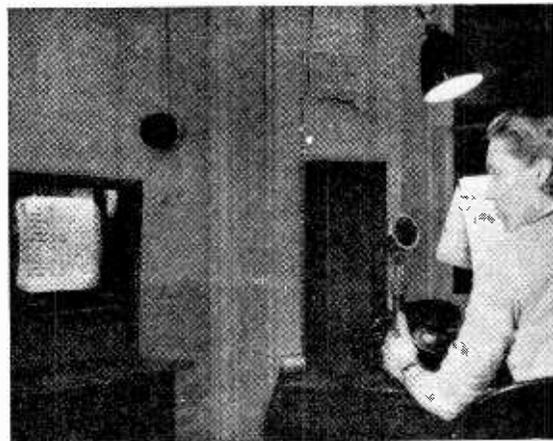
## Data-Handling at King's Cross

AT a main-line railway station information concerning the running of trains has to be passed from its source (the signal box) to several other people such as the enquiry-office staff, the station announcer and the arrival-indicator operators. In the past this has been done by telephone, which suffers from the disadvantages of demanding the whole attention of the users and of providing a considerable risk of cumulative errors.

In an effort to improve efficiency British Railways have arranged with Decca Radar Ltd. to install the Deccafax\* system at King's Cross terminal station for a trial period.

The flying-spot transmitter unit is housed in the signal box and information is written on a prepared transparency. At the receiving units a change in the information recorded is announced by the ringing of a bell. Apart from reducing the work in the signal box to the writing-in of times as they are received from stations down the line, the information is presented for as long as it is required and in such a way that it is possible to gain an overall picture of train movements into the station. The system uses the 405-line, 50-frame, positive-modulation standard and the video signal is carried on coaxial cable at a level of about 1½V.

\* *Wireless World*, October 1957, p. 470.



Station announcer at King's Cross reads details from Deccafax screen.

# News from the Industry

**Relay Exchanges Ltd.**—The annual report of Relay Exchanges for 1958 reveals that the group's total assets are now over £12M, compared with £7.6M at the end of the previous year. The value of television and sound receivers installed in subscribers' homes accounts for over £9M of the assets. During last year the group, which includes the Rentaset companies, acquired the whole of the share capital of Goodmans Industries. After providing for taxation, the group's profit for 1958 was £391,276 against £236,288 the previous year.

**T.C.C.**—In his statement at the annual general meeting of the Telegraph Condenser Company the chairman, D. W. Aldridge, announced a net profit for 1958, after providing for taxation, of £187,486 compared with £131,257 the previous year. T.C.C.'s wholly owned subsidiary, the United Insulator Company, has since April last year operated as a division of the parent company.

**Ferranti's** wholly owned Canadian subsidiary, Ferranti-Packard Electric Ltd., has developed an electronic seat reservation system which is being installed for Trans-Canada Airlines. The system uses a device known as a Transactor which is installed at each TCA booking office across Canada, and is used to send information to, and receive answers from, a central computer. The equipment will be available in this country and on the continent through Ferranti Ltd.

**I.C.T.**—International Computers and Tabulators Ltd. has formed a subsidiary, I.C.T. G.m.b.H., with headquarters in Düsseldorf. It will take over the existing business in Western Germany conducted through the Düsseldorf office of Powers-Samas Accounting Machines (Sales) Ltd. It is planned to open branch offices in Berlin, Hamburg, Hanover, Munich, Nürnberg and Stuttgart.

**Plessey International Ltd.** has set up a German manufacturing company to be known as Plessey Maschinen Elemente G.m.b.H. It will operate from Neuss, near Düsseldorf.

**Elliott - Automation Ltd.** has established a new subsidiary, The Swartwout Co. Ltd., to manufacture and sell the electronic control systems developed by the Swartwout Company, of Cleveland, Ohio. Two years ago, Elliotts entered into an agreement with the American Swartwout Company to handle their products in this country.

**S. N. Shure**, president and founder of Shure Brothers, Inc., of Evanston, Ill., manufacturers of microphones, pickups and recording heads, is arriving in this country on May 31st to investigate the possibility of establishing a factory here. Engineers and manufacturers interested in discussing such a project are invited to leave their names and addresses at the office of the Commercial Attaché at the American Embassy, London.

**Audio Fidelity** gramophone records, produced in the U.S.A. by Audio Fidelity Inc., are now being made available in this country through its recently formed subsidiary, Audio Fidelity (England) Ltd., of 44 Crawford Street, London, W.1. The distribution of these records in London, East Anglia and South-East England is being handled by Scientific and Technical Developments, of Melbourne Works, Wallington, Surrey.

**Ketay Ltd.**, manufacturers of synchros, resolvers, tachometer generators and other servo components, are now a Design Approved Manufacturer under the Ministry of Supply Instrument and Electrical Equipment Design Approval Scheme. The company is owned jointly by the Plessey Co., of Ilford, and Norden-Ketay Corp., of New York. Four Ketay synchros have been granted Certificates of Technical Approval by the Royal Aircraft Establishment.

**Southern Instruments Ltd.**, of Camberley, Surrey, has made an arrangement with the Ampex Corporation of America and its U.K. subsidiary, Ampex Electronics Limited, for the manufacture and marketing of Ampex tape instrumentation equipment in Great Britain.

**Winston Electronics'** production during the year ended in February exceeded £500,000. F. W. Reynolds, the managing director, recalls that the first year's output (1950/51) was £15,000.

**Pye** closed-circuit television equipment, including a new lightweight cylindrical camera, has been installed in the Conservative Party's television studio in London. The studio is employed mainly for the training of M.P.s and candidates in the use of the medium.

**Leland Instruments'** old address was given in the note on the Leroux measuring relays on p. 247 of our last issue. They are now at Abbey House, Victoria Street, London, S.W.1. (Tel.: Abbey 3585.)

**Tube rebuilding** service operated by C.R.T. Ltd., of Baldock, Herts, is to be known as C.R.T.'s TV Tube Exchange Service. The reduced prices recently introduced by C.R.T. Ltd. take into account the supply by dealers of an old tube for re-gunning.

**Mayra Electronics Ltd.**, manufacturers of Maykit car radio kits, have moved from North London to 118, Brighton Road, Purley, Surrey (Tel.: Bywood 1263). The newly appointed general manager is Maurice Reed.



FIFTEEN closed-circuit television channels in the new rolling mill of the Steel Company of Wales at Port Talbot provide a composite view of about 700ft of railway track. This installation by Marconi's is for the remote observation of the conveyance of red-hot steel ingots from the soaking pits to the rolling mill.

**Mullard.**—Two new laboratory blocks are being built on a site adjacent to the existing buildings of Mullard Research Laboratories at Salfords, Nr. Redhill, Surrey. An extra 45,000 square feet of floor space will be provided by the new buildings. They will house the electronics, telecommunications, transistor applications and television laboratories. The company is also to build a new factory on a site next to their existing cathode-ray tube factory at Simonstone, Lancs. It will produce glass for the production of tubes, which is at present purchased as pre-fabricated parts.

**Marconi's** are to supply the Post Office with the equipment for a wide-band u.h.f./s.h.f. radio link between Birmingham and Norwich. The twin-path bi-directional link will carry the B.B.C. television programmes between the two cities and serve *en route* the transmitter being built at Peterborough. The equipment at these three centres and at the three repeater stations will employ English Electric Valve Company's travelling-wave tubes.

**E.M.I.** colour television equipment was used to enable a large audience at a recent Anatomical Society symposium in University College, London, to see, on a 4-ft by 3-ft screen, experiments being carried out under an electron microscope. The demonstration was arranged by Smith, Kline and French Laboratories Ltd.

**Ekco** airborne search radar has been ordered by British European Airways for six de Havilland Comet 4Bs now being built. B.E.A.'s flight of Comet 4s is already fitted with Ekco radar.

**Siemens Edison Swan** supplied the marine radio equipment for the recently opened radio officers training school in the College of Technology, Belfast.

## EXPORT NEWS

**Iran.**—The v.h.f. multi-channel radiotelephone/telegraph system installed by Marconi's along the National Iranian Oil Company's 600-mile pipeline from Abadan to Teheran is to be extended. The extension, which will link five new booster pumping stations with the main v.h.f. installation, calls for the supply of 20 multi-channel equipments together with aerial towers. The carrier equipment is being supplied by the Telephone Manufacturing Co.

**Radiotelephones.**—Pye Telecommunications have been awarded a contract by the Iranian Oil Operating Companies to install a 12-channel radio communications system between Kharg Island in the Persian Gulf and the oilfields at Gachsaran and Agha Jari, a distance of 160 miles.

**Multi-channel Radio Link.**—The Posts and Telegraphs Administration of Finland has placed a contract with Marconi's for the supply of s.h.f. radio terminals and repeaters for a single-path 600-channel two-way radiotelephone link between Pori and Tampere, a distance of 65 miles.

**Computer for Australia.**—An EMIAC II two-module analogue computer has been ordered from E.M.I. Electronics, Ltd., for installation in the Australian Government Aircraft Factory at Melbourne.

**Film scanning equipment** for a new commercial television station in Brisbane, Australia, which is scheduled to be opened later this year, has been ordered from E.M.I. Electronics.

**Navigational Equipment.**—Two Decca Navigator chains are to be erected in the Persian Gulf. It is planned that these chains will be brought into operation at the end of this year.

**Radar Simulator.**—The Royal Swedish Air Board has purchased a Solartron ten-target early-warning and height-finding radar simulator for the country's Air Force.

**I.L.S.**—The government of the Belgian Congo has ordered the Pye Instrument Landing System for Elizabethville and Leopoldville airports.

**Telecommunication measuring equipment** valued at \$200,000 has been ordered by the Canadian Department of Defence Production from Marconi Instruments through the Canadian Marconi Co. In all, nearly 200 instruments, including signal generators, portable frequency meters, oscilloscopes, wave analysers and transmission test sets are to be supplied.

**Radar.**—Seven double-ended ferry boats operating between Brooklyn and Staten Island, New York, are to be fitted with Decca Type D303 radar. Each boat will carry two radar sets.

**Airborne search radar** with Doppler drift measuring equipment is being supplied by Ekco Electronics for the Viscount fleet of Kuwait Airways.

**Valves and C.R. Tubes.**—As part of a drive to extend their sales of valves and tubes in North America, the M.O. Valve Co. has seconded F. T. C. Dixon to their agents, British Industries Corporation, of New York. Mr. Dixon was previously in charge of cathode-ray tube sales at the company's Hammersmith works.

**Honduras.**—Agencia René Sempé, of Apartado 219, Tegucigalpa, wish to represent a U.K. manufacturer of television receivers. A television service operating on the American 525-line standard is starting shortly.

# New Trix Ribbon Microphone

Now smaller, this much acknowledged microphone gives unequalled performance and its directional qualities minimise feedback effects. The frequency response and sensitivity have also been improved.

This model—G7823—has its head tilted for easy use. It's normally supplied with low impedance output (30 ohms) but is also available with high if required. The microphone is complete with screened connector, with locking ring, which fits directly to stand or base. If wanted, a switch adaptor can be used.



*Finish Satin Chrome  
Dimensions (without  
connector)*

*Height 3 1/4 in. (9 cms.)*

*Diameter 1 1/8 in. (35 mm.)*

*Weight 7 1/2 oz. (215 grams)*

THE TRIX ELECTRICAL CO. LTD.

# TRIX

1-5 MAPLE PLACE, LONDON, W.1.  
Tel: MUSem 5817 (6 lines). Cables &  
Grams: Trixradio. Wesdo. London.

DHB, 63:4

# RANDOM RADIATIONS

By "DIALLIST"

## Improving East Anglian TV

TO those who live in East Anglia it is good news that a two-way radio link between Tacolneston and Birmingham is to be built. At present the Norwich station receives its television programmes by direct pick-up of the Crystal Palace transmissions at a receiving station near Bury St. Edmunds, whence it is routed by a radio link to Norwich. Reception can be very good over a wide part of the area and it's much improved since Tacolneston's e.r.p. was raised. But one big disadvantage of a long-distance pick-up system is that it is apt to gather in other things besides the wanted signal. And once received interference has willy-nilly to be relayed. The result has been that under certain conditions pictures have been no better than fair to moderate. I'll willingly admit that interference bad enough to spoil the picture has been but rarely in evidence lately. But one is sometimes conscious that the picture, though worth looking at, ought to be better than it is. I understand that even after the introduction of the new link Tacolneston will still have to rely for some time on the direct pick-up of a main station but this time it's Sutton Coldfield. However, this will be dispensed with when the radio links have been completed. When the I.T.A. station at Mendlesham, with its huge mast and high e.r.p. gets going, too, East Anglia should find itself very well served by television.

## Peterborough, Too

In addition to linking Tacolneston with Birmingham, the proposed link will serve *en route* the B.B.C. station being built at Morborne Hill, near Peterborough. The project will be carried out in two stages. At the end of this year a u.h.f. twin-path one-way link will be installed between Norwich and Peterborough where a B.B.C. receiving point will pick up the Sutton Coldfield programmes which will then be sent along the link to the Tacolneston station. The final installation will consist of a twin-path bi-directional link over the whole distance with three intermediate repeater stations. At Peterborough back-to-back terminals will be em-

ployed which provide complete modems (modulation/demodulation facilities) making it possible to extract a programme at that point to feed the new transmitter or to feed in a broadcast originating in the Peterborough area.

## A New Use for Radar

READERS who were concerned with p.p.i. radar receivers at the beginning of the war may remember those mysterious, large illuminated patches which sometimes appeared on the screen, usually at night-time. They were specially in evidence during the spring and autumn months and often covered large areas of the screen. It was established that they weren't due to high flights of aircraft and some wag suggested that they must be echoes from flocks of angels winging their way over the sky. The name "angels" stuck. It was eventually established by using powerful telescopes on clear, moonlit nights that the fliers were not 'planes or angels, but birds. In spring and autumn birds migrate in vast numbers, and so dense are the flocks that they give rise to good radar echoes. For some little time now both p.p.i. tube and height-range radar have been in use for studying bird migration and quite remarkable results have been ob-

tained. The big snag is that individual species can't be identified—there's no ornithological equivalent of i.f.f.—but it's often possible to deduce the identity from the height, speed and size of the flocks, from the direction they are taking and from the fact that birds have previously been seen massing for migration in this place or that, or that tired incoming migrants are seen in certain areas on the following day.

## Transatlantic Television?

ALMOST the whole continent of Europe either is or can be linked up for television purposes and we get some very good and interesting programmes from distant parts via our cross-Channel link. What so many people would like to see realized is transatlantic television. The Americans already operate radio-links for their forces in Europe; but these are used for sound only, for so far it hasn't been possible to utilize channels wide enough for TV. There seem to be two possible ways in which it might be done. When the whole of France was served with views of the Fourteenth of July Ceremonies taking place in Algiers, the method successfully used to span the Mediterranean was to employ a circling aeroplane as a relay station.



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A chain of aeroplanes circling over the Atlantic seems a possibility—though only just, for weather conditions might make station-keeping very difficult and it would at times be a risky business. But I don't see why, if the money were available, ships shouldn't be used with captive balloons to extend their effective horizon. They would remain in their allotted positions, as the weather ships now do, picking up transmissions and relaying them on. I'm sure that transatlantic television will be a commonplace occurrence one day. May that day come soon!

### It All Helps

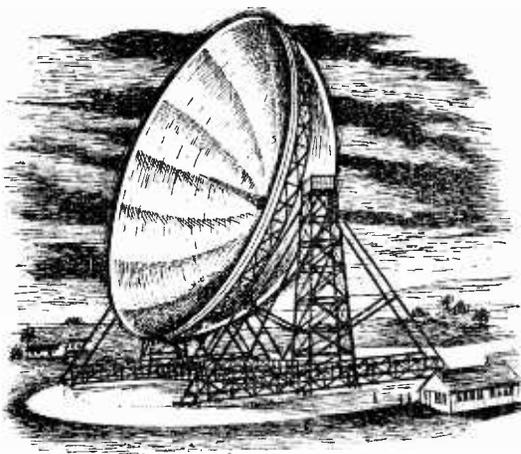
REDUCTIONS in taxation are always welcome, and I'm sure that all radio folk—manufacturers and their customers alike—were delighted by the lowering of the rates of purchase tax. This has made it possible to bring down the prices of sound and TV sets quite a bit, and it should make for increased business. Better still, to my way of thinking, is the removal altogether of purchase tax on replacement c.r. tubes. Before the budget announcement the position as regards rebuilt tubes was rather a queer one: if you got your own c.r.t. back duly renovated, it wasn't liable to tax. But should you receive one that had been someone else's, then the tax could be slapped on. Such a weird state of affairs must have meant a lot of extra work and expense in the way of checks and inspections, which couldn't have done anybody much good.

### A Record to End All Records?

WRITING from Worcester Park in Surrey, a reader tells me that he has a Marconiphone Type 702 television receiver, which was made in 1938 or '39 and is still giving good reception for about five hours every day on the screen of its original tube. When bought second-hand in 1949 it had a number of faulty capacitors, the e.h.t. transformer was out of action and one valve was dud. Otherwise it was, as my correspondent puts it, in mint condition. It has given consistently good service since, and despite its 20 or 21 years, it shows no signs of deterioration. My correspondent's only 'plaint is that with its 1/2-in steel chassis and plywood cabinet the set needs two strong men to lift it! By the way, the serial number of the cathode-ray tube is D26019, in case makers care to check its age.

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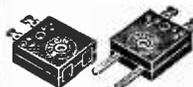
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## Homostereo and All That

IN its early days, the B.B.C. had a well-deserved reputation of being a centre of learning and culture, and those members of the staff—other than engineers—who were not alumni of Oxford or Cambridge were apt to be looked at askance; in fact it was rumoured that even the “hewers of wood and drawers of water” were Cambridge poll men.

All that is past history, however, and today things are vastly different as can readily be seen by the B.B.C.'s patronage of a dreadful word like “monophonic” to designate single-channel reproduction as distinct from its stereophonic counterpart.

The utmost that can be said in favour of monophonic is that it is somewhat less offensive than monaural; this latter word implies reproduction which is, in some way, specially adapted for those who have the misfortune to be totally deaf in one ear. The word monophonic is, however, not very much better. To my mind, monophonic reproduction—which means one-sound reproduction—conveys the idea of a solo performance on, say, a triangle or big drum.

Many people who ought to know better are woefully ignorant of the precise meaning of words. I once knew a Cambridge man who didn't know the difference between an exhibitor and an exhibitionist; now and again, of course, the former is also the latter. At any rate, I do not hesitate to suggest that the correct word for single-channel reproduction is “monodic”\*; it is surely *le mot juste* for it does literally mean single-channel. But I don't want you to think that I want to displace the familiar word stereophonic in favour of stereodic; obviously stereophonic—solid sounding—is the correct word.

The only possible objection that could be raised is that the word monodic with its meaning of single-channel may be needed one day to describe stereophonic broadcasting on a single radio channel.

There is, however, a far better word to describe such a system of broadcasting, and to emphasize the fact that the two “stereo” channels are sharing the same radio channel; obviously the word is “homodic”—same channel. This would convey an unmistakable meaning. In actual practice I do not doubt that this system will come to be known by the name of “homostereo broadcasting” to distinguish it from ordinary stereo broadcasting on two radio

channels which might be called “heterostereo.” May we expect that the Yanks, just to be different, will fuse Latin and Greek and call it “solo stereocasting”?

## Better Audio Fare.

IT is said that a rolling stone gathers no moss, but that is certainly not true of the Audio Fair of two months ago which again had a new home this year—the third in its brief history—and was as crowded as ever. Maybe, however, its organizers moved it away from the Strand area this year so that it should not gather so much Moss, with a capital M, in the form of waiter's dress, a subterfuge adopted in previous years by visitors unable to obtain an invitation card.

Even this year I was surprised at the extraordinary interest shown by the large catering staff of the hotel in which the Fair was held.

The highlight of the show was, as



Extraordinary interest

might be expected, stereophonic reproduction which is still a nine days' wonder. I was glad to see that the over-dramatized juggling with railway trains and suchlike things—which were a feature of the Audio Hall at last year's Radio Show—had been, to a large extent, abandoned, but I did not find the audio fare provided in the demonstration rooms very convincing.

This was largely due to the limitations of space in an hotel bedroom. They may be roughly the size of an average living room, but certainly do not simulate the listening conditions of the home. As I explained to one exhibitor who tried to convince me to the contrary, even if he usually packs a dozen or more perspiring people in one half of his living room,

I certainly do not, and nor do most ordinary people.

The arrangements in most of the demonstration rooms seemed to me to be such that only one or two of the audience were in a suitable position to perceive a stereophonic effect.

I think it would be far better if the exhibition authorities revised the order of things, and gave a separate bedroom to each manufacturer for his stand, and turned the exhibition hall into a properly fitted-up demonstration theatre. Each manufacturer could be allotted a certain period of the day for demonstrating his apparatus.

## Why Psi?

LAST December I was talking about  $\psi$  (psi) waves, and I said that this symbol was probably used because it was the first letter of the word “psyche,” which, among other things, means the basis of all things. I was ignorant at that time that “psi” was also used to describe such things as telepathy and other kinds of E.S.P. (extra-sensory perception), as well as ghost-hunting.

According to a book review I recently read under the title of “The Pursuit of Psi,” it seems as if  $\psi$  is the label applied to anything we know little about. I still think that the symbol “psi” is short for “psyche” but I am certainly not sure. So if any of you classical “scolards” can help to lighten my darkness I shall be very grateful. I have a vague idea that  $\psi$  may be the initial letter of a word unknown to me or even to our old friends Liddell and Scott.

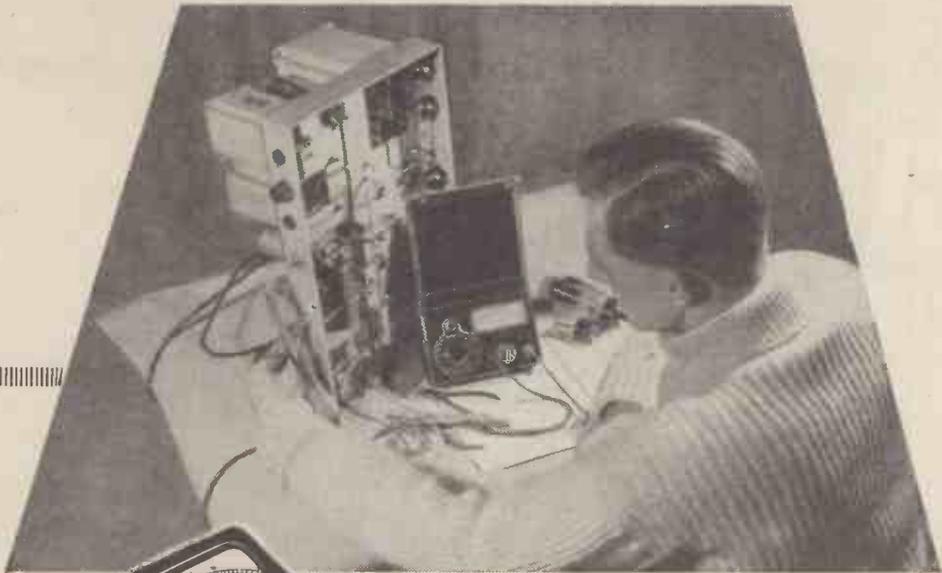
Talking of psi reminds me of what may be an instance of it. I recently heard from somebody who is well known in the world of audio technology. He was asked to help in down strange noises heard by two aged ladies which were inaudible to others.

On the face of it, one would say that the two ladies were suffering from aural hallucinations, but their doctor gives them a clean bill of health and says that all the usual causes of “hearing things” are absent. The recording apparatus is quite deaf to these sounds, and it has been suggested that the ladies may be able to hear frequencies which are lower than those normally audible.

Personally I wonder if they “hear” the noises telepathically and wrongly think they are coming in through their ears. I am hard at work to see if I can devise something to record telepathy.

\* A contraction of *monos* (one or single) and *hadros* (a way, path or channel). In such combinations the “h” is usually dropped, e.g., electrode.

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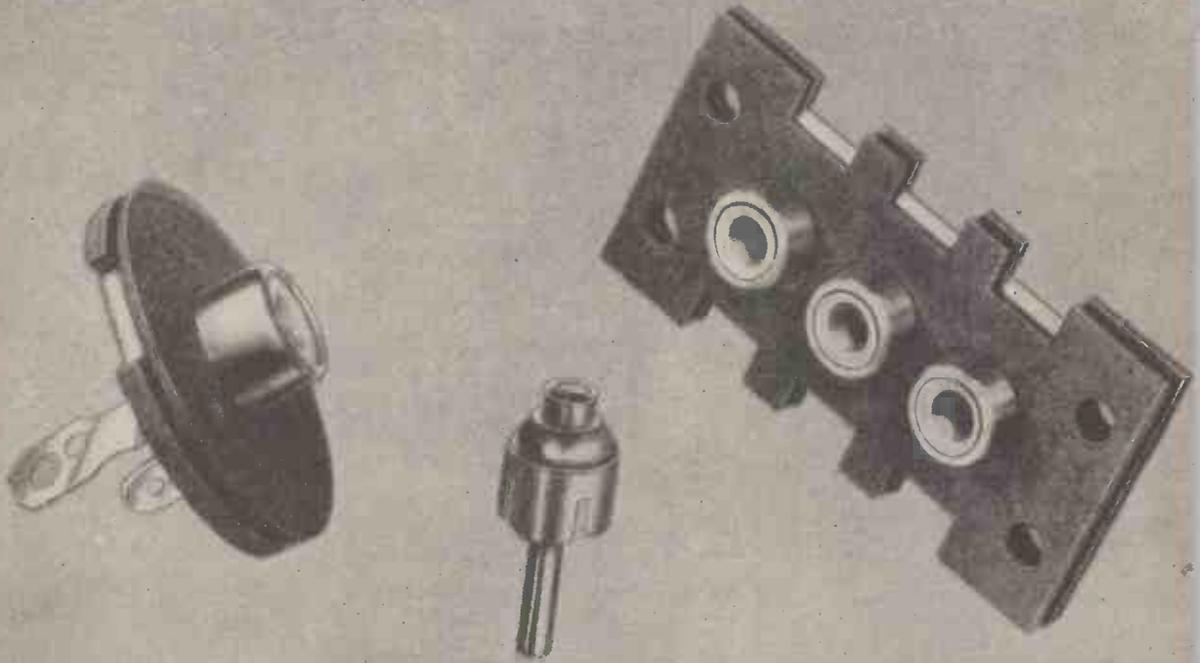
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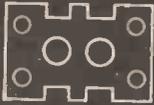
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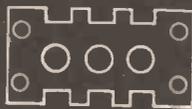
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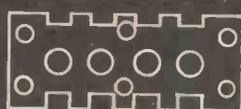
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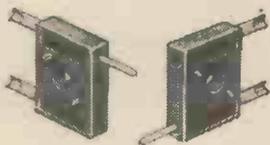
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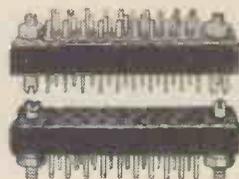
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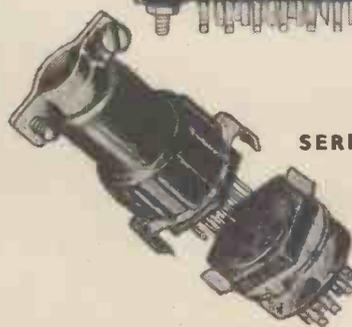
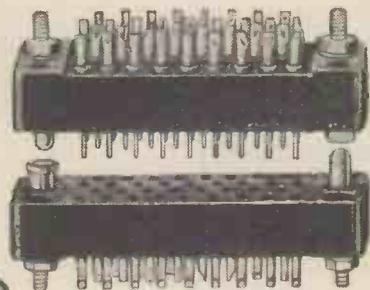
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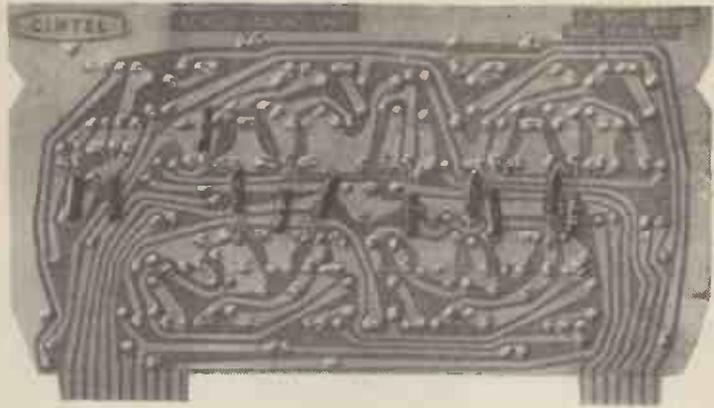


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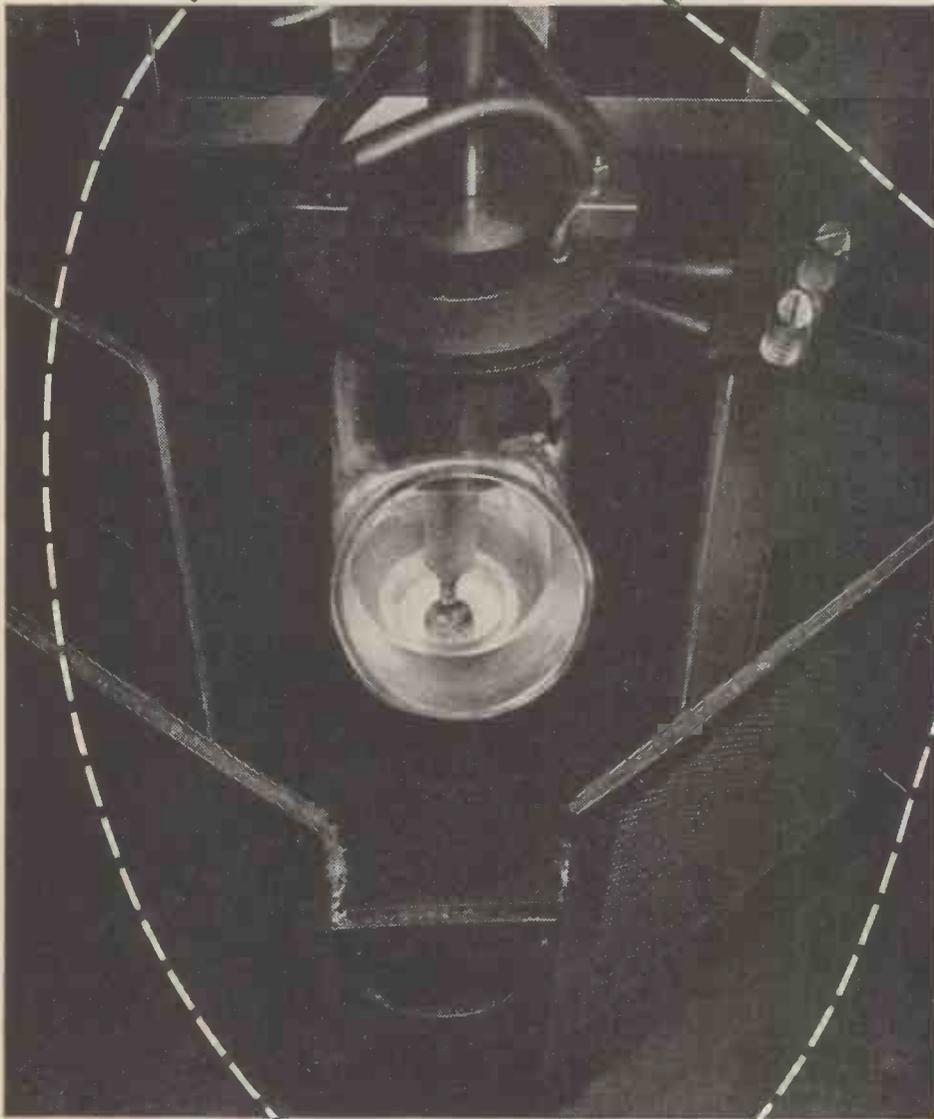
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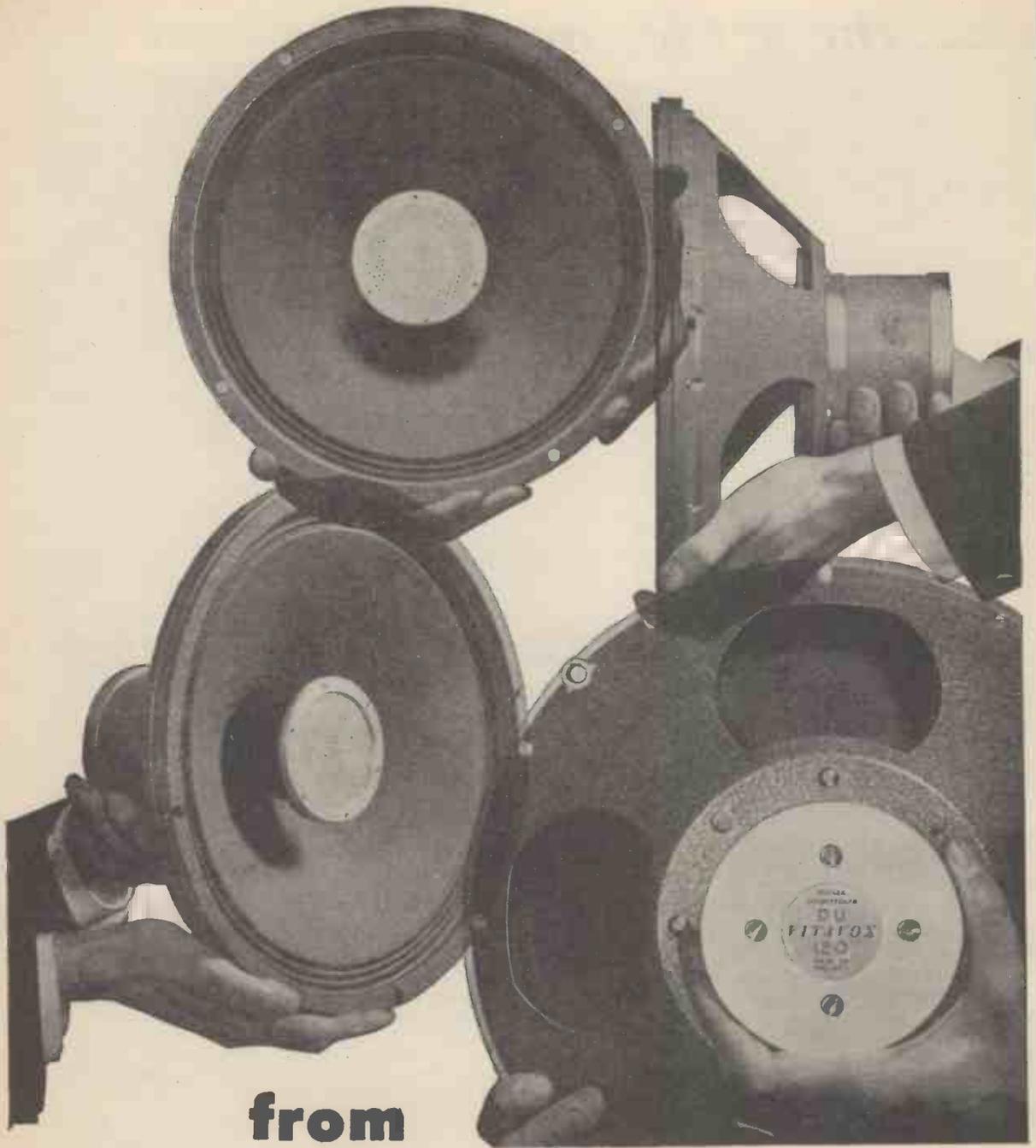
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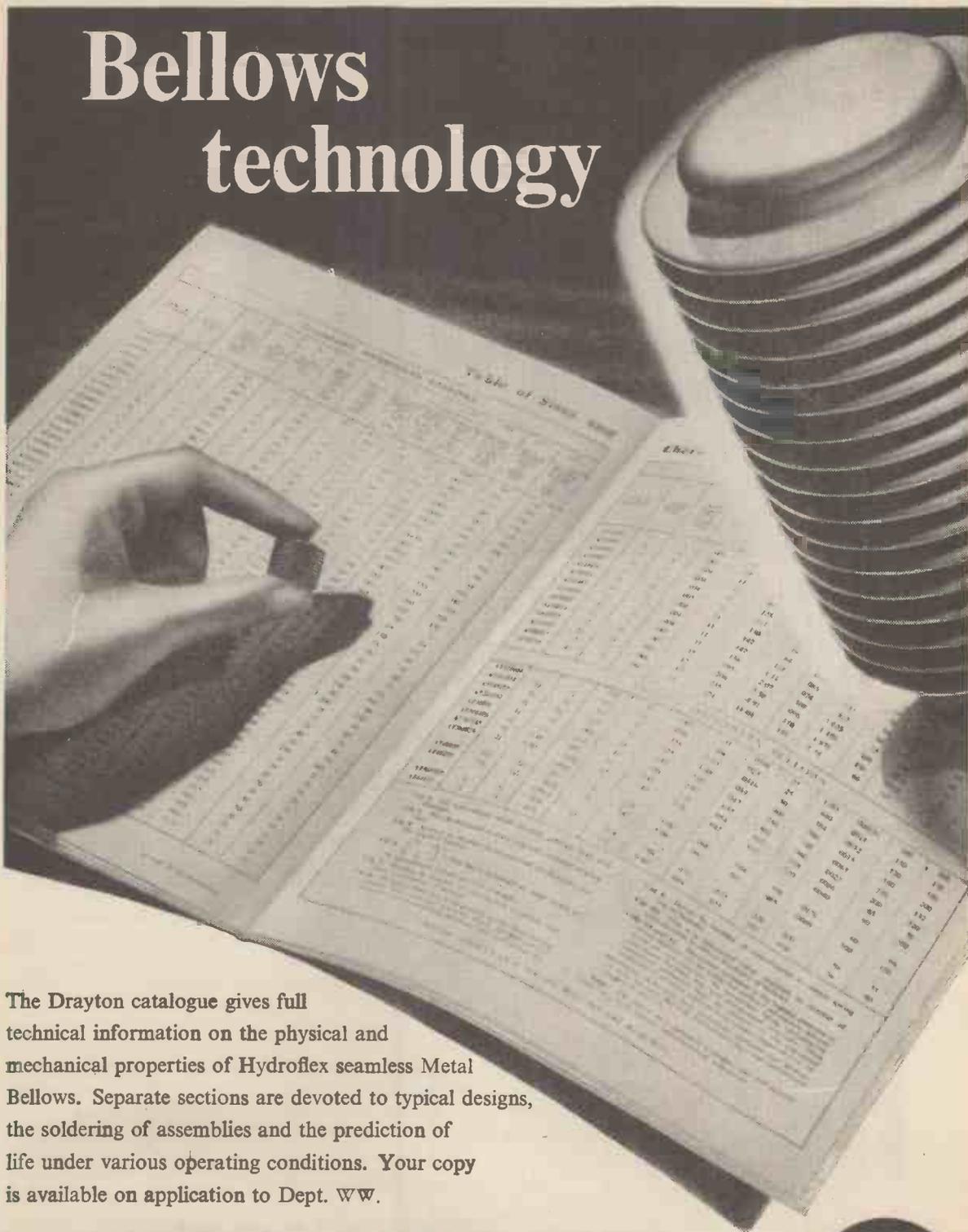
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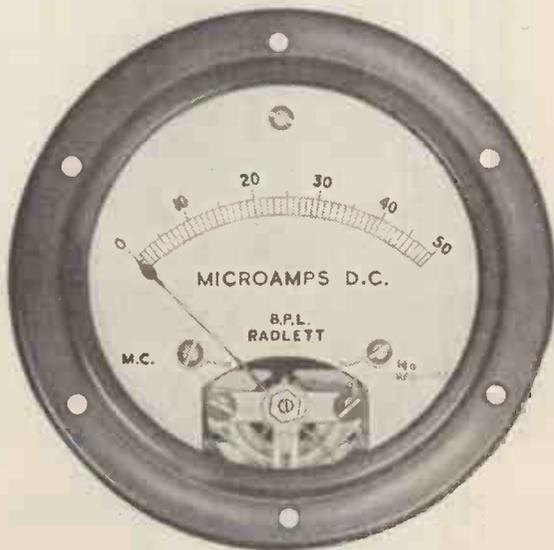
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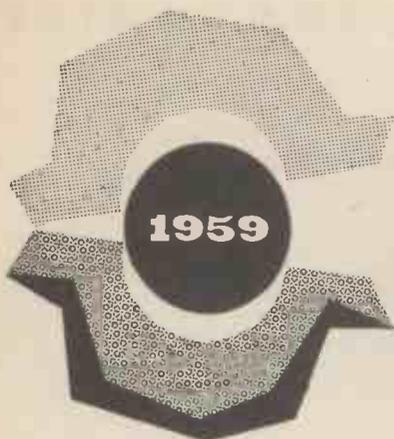
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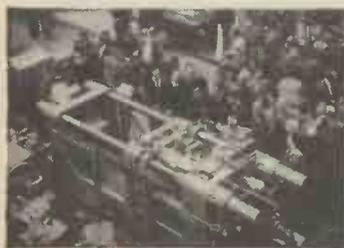
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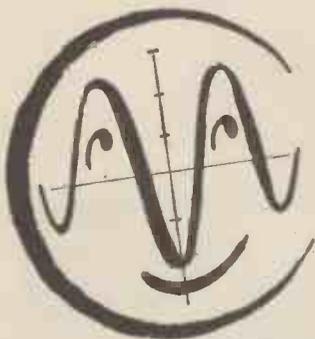
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COSSOR HOUSE, P.O. BOX 64, HIGHBURY GROVE, LONDON, N.5.

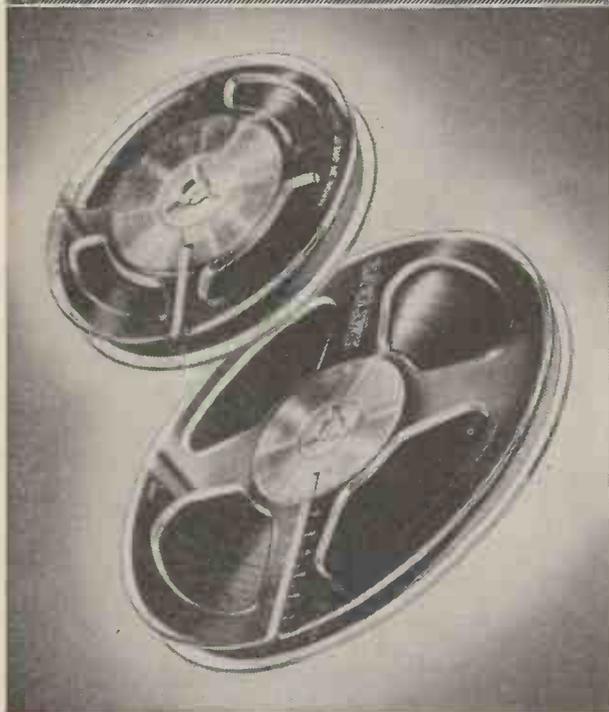
Telephone: CANonbury 1234 (33 lines).

Telegrams: Cossor, Northone, London.

Cables: Cossor, London.

Codes: Bentley's Second.  
TA5/CI.20

# Emitape



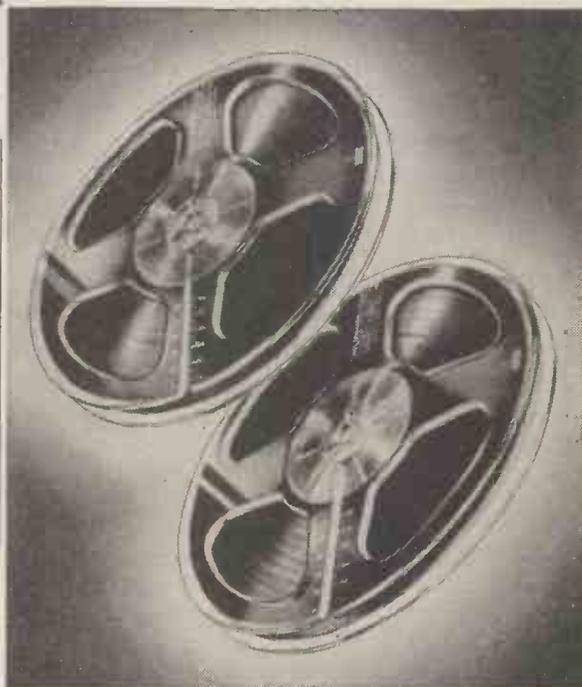
**the magnetic recording  
tape with the highest  
technical standards**

- \* High sensitivity
- \* Low noise level
- \* Low 'print through' factor
- \* Anti-static
- \* Freedom from curl and stretch

**"88"** GENERAL PURPOSE

**"99"** LONG PLAY

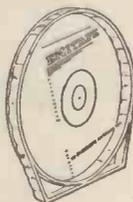
Type No.	Title	Size	Length approx.	Price in EMICASE	Price without EMICASE
88/3	"Message"	3" dia.	175'	—	7 6
99/3		3" dia.	250'	—	9 6
88/3N		3½" dia.	175'	—	7 6
99/3N		3½" dia.	250'	—	9 6
88/6	"Junior"	5" dia.	600'	£1 3 6	£1 1 0
99/9		5" dia.	850'	£1 10 6	£1 8 0
88/9	"Continental"	5¾" dia.	850'	£1 10 6	£1 8 0
99/12		5¾" dia.	1200'	£1 17 6	£1 15 0
88/12	"Standard"	7" dia.	1200'	£1 17 6	£1 15 0
99/18		7" dia.	1800'	£2 12 6	£2 10 0
88/18	"Professional"	8½" dia.	1750'	—	£2 17 6
99/24		8½" dia.	2400'	—	£3 12 6



## Emicase

now available separately!

the polystyrene container that solves tape storage problems, protects spools from dust and allows easy identification of leader tapes.



7" - 4s. 0d; 5¾" - 3s. 6d; 5" - 3s. 6d.

**E.M.I SALES & SERVICE LTD**  
(Recording Materials Division)  
HAYES . MIDDLESEX  
Tel: SOUTHall 2468

No. 15



## Eddy-Current Brake Effect

Advertisements in this series deal with general design considerations. If you require more specific information on the use of permanent magnets, please send your enquiry to the address below, mentioning the Design Advisory Service.

Permanent magnets are widely used to provide the field required in eddy-current braking systems.

Typical applications include integrating meters, speedometers, balance damping pots and timers, etc.

Braking effect is produced by the movement of a conductor in a magnetic field generating eddy-currents. Annealed copper of resistivity approximately  $1.6\mu\Omega/\text{cm}^3$  or aluminium of resistivity approximately  $2.8\mu\Omega/\text{cm}^3$  are the metals normally used. The braking effect on a disc rotating in a magnetic field, as illustrated in the diagram, can be calculated if the dimensions, speed and resistivity of the disc, and the magnetic field configuration are known.

$$\text{Damping torque} = \frac{B^2 \cdot A \cdot t \cdot \omega \cdot r^2}{\rho \cdot k \cdot 10^9} \text{ dyne. cm.}$$

where  $B$  = flux density being cut by the disc in gauss

$A$  = area of magnetic field in cm. ( $d \times w$ )

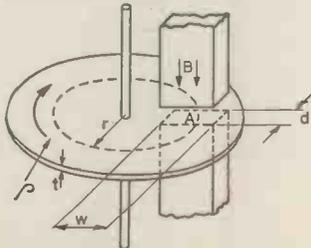
$\omega$  = angular velocity of the disc in radians per sec.

$t$  = thickness of the disc in cm.

$r$  = effective radius of the disc in cm.

$\rho$  = resistivity of the disc.

$k$  = a constant related to the length of eddy-current paths, and usually lies in the region of 2-3.



In an eddy current braking system as illustrated above, the maximum braking occurs when the broad edge of the magnet poles are presented to the direction of movement of the disc.

Magnet systems of this type give an adjustable braking effect by merely rotating the magnet system as a whole and an infinite variation of braking adjustment can be obtained without the risk of mechanical or magnetic instability.

### Kilowatt Hour Meters

The performance and accuracy of Kilowatt Hour meters depends finally on the stability of the permanent magnet used for braking. The importance of this magnet and the fact that the accuracy of the meter depends on the square of the flux den-

sity maintained by the magnet is not fully discussed here.

Probably the best type of design is one using two Ticonal 'G' magnets arranged one on each side of the rotating disc, or one magnet and a specially designed yoke leaving sufficient clearance to allow for all normal contingencies of movement and wear during the life of the meter.

This system has the great advantage that it will tend to give uniform flux distribution in the gap, resulting in constant braking effect, since if the rotating disc moves due to sudden application of load, jewel wear, or any other cause, the braking effect tends to remain constant.

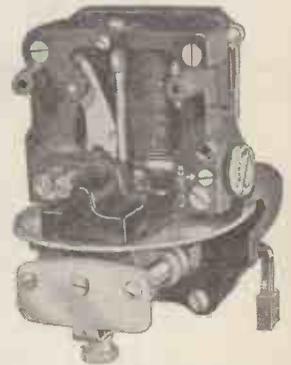


Illustration of Watt Hour Braking System — by courtesy of Ferranti Limited.

### Speedometers and Tachometers

The indication on most of these types of instruments is obtained by eddy-current braking or drag effect. A typical design of this type is where a cylindrical magnet magnetised diametrically, rotates in an aluminium or copper cup with a pointer which is free to rotate against a return spring.

### Balances and Weighing Machines

In order to make fast and accurate measurements of weight, weighing machines need a high degree of frictionless damping.

In applications of this nature where a high and adjustable degree of frictionless damping is required, permanent magnet eddy-current damping gives the necessary control.

### Timers

There is a wide variety of timing mechanisms used in industry for purposes such as welding, exposure measurement and other fairly short duration process timing.

Considerable advantages can be gained in many of these devices by using permanent magnet eddy-current braking. The resultant assemblies give uniform and reliable timing, avoid friction and are comparatively unaffected by temperature. Magnetic damping devices are replacing oil or air-filled 'dash pots' in equipment where accuracy and reliability is important.

If you wish to receive reprints of this advertisement and others in this series write to the address below:

# Mullard

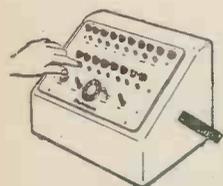


'TICONAL' PERMANENT MAGNETS  
'MAGNADUR' CERAMIC MAGNETS  
FERROXCUBE MAGNETIC CORES

THAT ELUSIVE WORKS MANAGER . . .

# found

in 10 seconds



NO LOUDSPEAKERS, BELLS or  
FLASHING LIGHTS

only the man who's wanted knows and replies.

Selective Induction is saving time, money and worry in Offices, Factories, Hospitals, Hotels, Departmental Stores etc., all over the Country. All key personnel carry small transistorised receivers bearing a number. When they are wanted their numbered key is pressed on a small transmitter. Immediately they must respond to the URGENT 'PEEP PEEP' in their pockets which summons them and them alone to ACTION! A verbal message can be transmitted if desired.

- Covers areas indoors or out, up to 10,000,000 sq. ft.
- Designed for the man who cannot afford to be tied to his office.
- Equally suitable for large or small concerns.
- Low purchase price—virtually no indoor wiring—low rental terms.

Write or 'phone for further particulars — WE CAN BE FOUND IN TEN SECONDS

# personal call

(the 'Peep Peep' in the Pocket)



THE ONLY STAFF LOCATION SYSTEM WORTH INSTALLING

MULTITONE ELECTRIC COMPANY LIMITED  
12/20 UNDERWOOD STREET LONDON N.1. TELEPHONE: CLERKENWELL 8022





From **I.C.I. AMMONIA—**  
**Nitrogen and Hydrogen**  
**for Industry**

I.C.I. Ammonia provides industry with a cheap and reliable source of pure nitrogen and hydrogen. And I.C.I. gas generating plants are available to convert ammonia into a wide range of nitrogen/hydrogen gas mixtures.

**Anhydrous Ammonia**

with a guaranteed minimum purity of 99.98%, to meet more exacting requirements, is offered in bulk and in a wide range of cylinder sizes.

**HYDROGEN**  
**NITROGEN**

**Liquefied Ammonia** (*Industrial Quality*), a cheaper grade, is available in bulk and in two-ton containers for the larger consumer, and makes possible substantial economies in gas costs.

*A bulk delivery of 10 tons of ammonia provides over 1½ million cu. ft of nitrogen.*

*Full information on request*

**IMPERIAL CHEMICAL INDUSTRIES LIMITED,**  
**LONDON, S.W.1.**



**YOUR EYE**

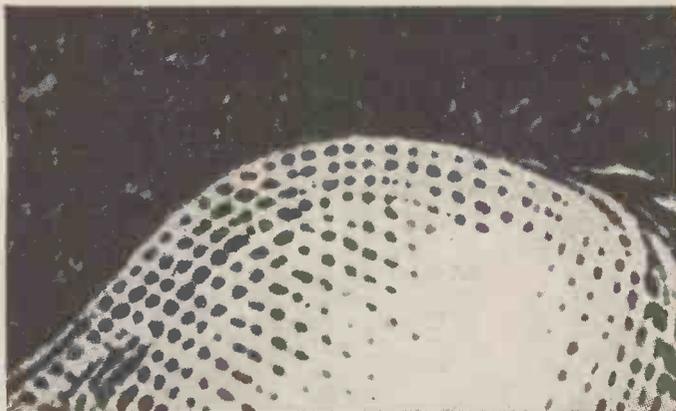
says "That's a gay new box. Ah, 'scotch' Brand Magnetic Tape. Eye can tell there's quality inside, just as everybody says."

**YOUR EAR**

says "This 'scotch' Brand Tape certainly lives up to its reputation. It sounds perfect to me, and I'm an ear for music."

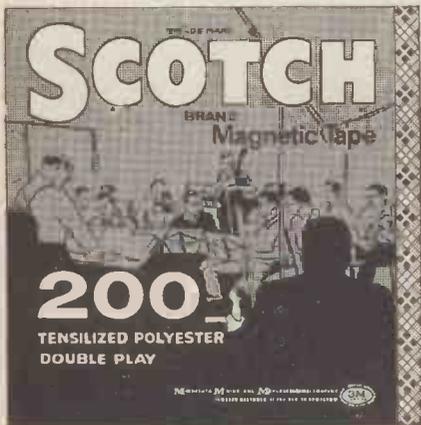
**YOUR COMMON-SENSE**

says "The quality suits the sound engineer—the exclusive silicone 'dry lubrication' minimises wear on magnetic heads—the price suits the pocket—well, it's 'scotch' Brand for me every time!"



**200 DOUBLE-PLAY**

Tensilized Polyester is the wonderful new 'scotch' Brand Magnetic Tape. It's extra strong, and gives you double the playing time! Resists stretching. Keeps its high quality of reproduction year after year!



Ask your supplier for the ingenious PLAYING-TIME CALCULATOR—it's free! Or write to our Head Office.

THE B.B.C. USE

TRADE MARK  
**SCOTCH**  
BRAND

MAGNETIC TAPE



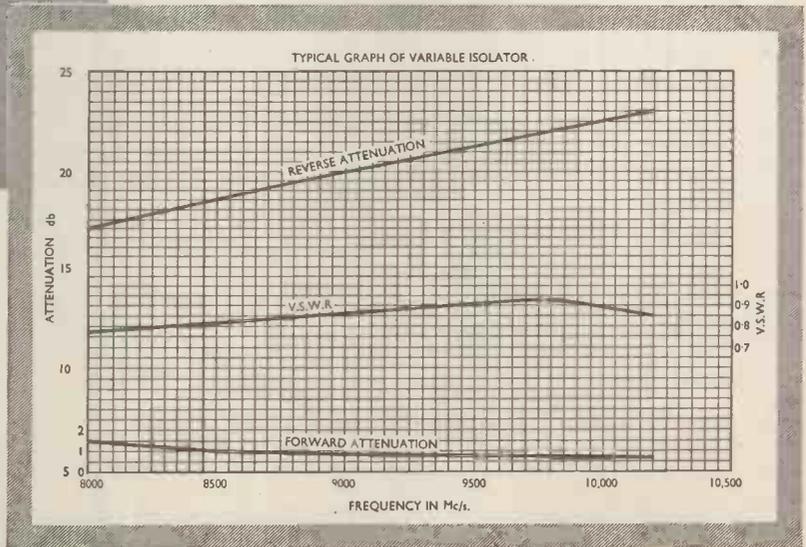
MINNESOTA MINING AND MANUFACTURING CO. LTD.

Tape and Electrical Products Division.  
Head Office: 3M House, Wigmore Street, London, W.1.  
And at Birmingham · Manchester · Glasgow

# Isolation at Microwaves

## L324 X-band isolator

This isolator is a ferrite loaded waveguide component with unidirectional characteristics designed to isolate an X-band microwave source from reflections caused by mismatch. It is a versatile component suitable for incorporation in equipment or for use as a laboratory aid. It is tunable for peak performance over X-band.



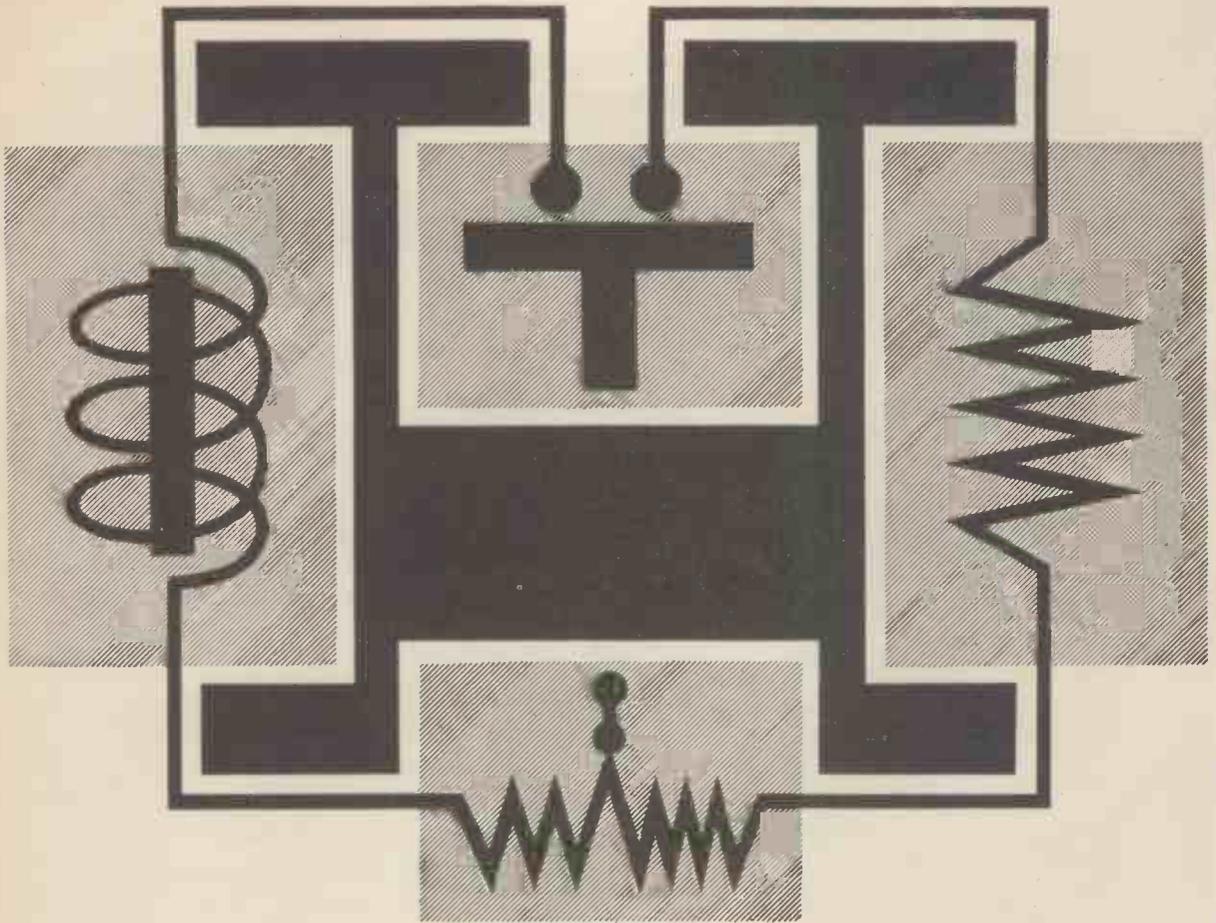
For information on other microwave components including circulators, co-axial mixers, switches, folded tees, etc., write to the address below.

ME638a

A PRODUCT OF  
**MULLARD EQUIPMENT LIMITED**

A COMPANY OF THE MULLARD GROUP

MULLARD HOUSE · TORRINGTON PLACE  
LONDON · W.C.1 · TELEPHONE: LANGham 6633



## The modern potting material

For the potting of capacitors, chokes, delay lines or similar components where protection against mechanical shock, vibration, moisture or corrosion is essential,

'Epikote' resins have proved exceptionally efficient.

They adhere strongly to most materials, with minimum shrinkage on cure, are tough, withstand thermal cycling, and possess excellent electrical properties over a wide temperature range.

Ask now for fuller details of how 'Epikote' resins can solve your potting problems. (Please quote No. EE.6.)

# EPIKOTE

## EPOXY RESINS



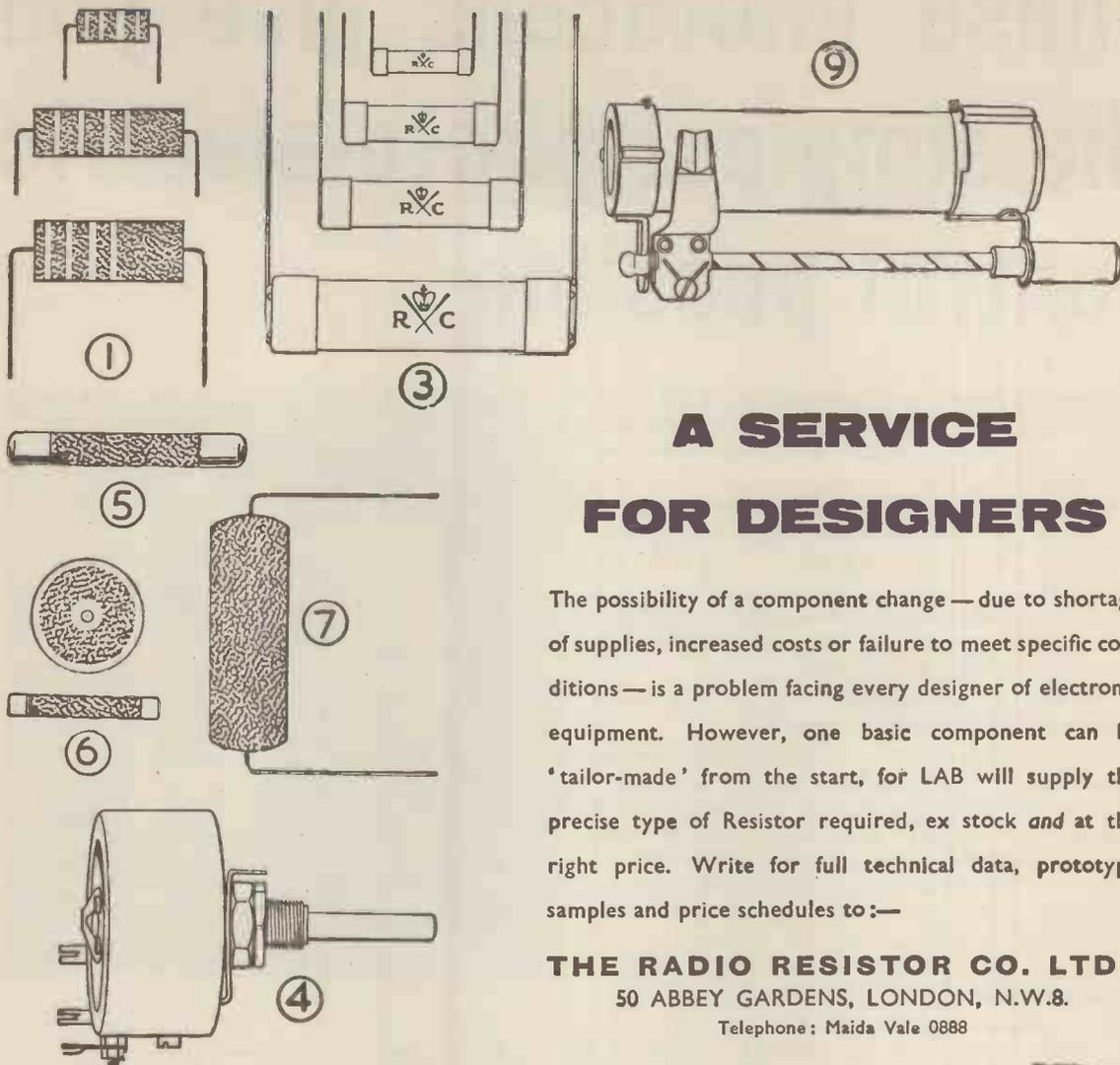
**SHELL CHEMICAL COMPANY LIMITED**

*In association with Petrochemicals Limited and Styrene Products Limited*

*Divisional Offices:*

LONDON	105-9, Strand, W.C.2. Tel: Temple Bar 4455.
MANCHESTER	144-6, Deansgate 3. Tel: Deansgate 2411.
BIRMINGHAM	14-20, Corporation Street, 2. Tel: Midland 6954.
GLASGOW	124, St. Vincent Street, C.2. Tel: Central 9561.
BELFAST	16-20, Rosemary Street. Tel: Belfast 26094.
DUBLIN	33-34, Westmoreland Street. Tel: Dublin 72114.

\*SHELL" and "EPIKOTE" are Registered Trade Marks.



## A SERVICE FOR DESIGNERS

The possibility of a component change — due to shortage of supplies, increased costs or failure to meet specific conditions — is a problem facing every designer of electronic equipment. However, one basic component can be 'tailor-made' from the start, for LAB will supply the precise type of Resistor required, ex stock and at the right price. Write for full technical data, prototype samples and price schedules to:—

**THE RADIO RESISTOR CO. LTD.,**  
 50 ABBEY GARDENS, LONDON, N.W.8.  
 Telephone: Maida Vale 0888

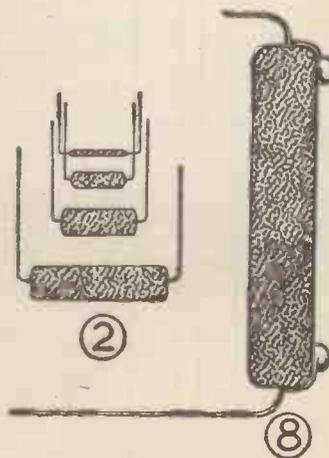
CARBON	WATTS	OHMIC RANGE	TOLERANCES ±
1. Solid	½ 1 & 2	10—10M	5% & 10%
2. Cracked	1/30—20	1—500M	5% & 10%
3. * High Stability	1/10—3	1—50M	0.5% 1% 2% 5%
4. Variable	½	5K—2M	—
5. V. High Resistance	½—3	50M—10 <sup>13</sup>	5% & 10%
6. V.H.F. (Rods & Discs)	1/10—1	10—1K	1% & 2%
WIREWOUND			
4. Rheostats	4—500	10—80K	—
9. Sliders	3—15	10—16K	—
8. Vitreous	3—500	1—150K	1% 2% 5%
7. Cemented	1—15	1—25K	5% & 10%

\* The ubiquitous blue (1%) grey (2%) "HISTABS"

**Do you KNOW**

THAT the Sub-miniature 1/30th watt unit (2) is probably the smallest production Resistor made.

THAT almost non-inductive Resistors in cracked carbon are available up to 20 watts rating.



# These photocells give you the simplest photo-electric control possible

Photo-electric control with the Mullard ORP11 and ORP90 cadmium sulphide cells is the simplest possible because a photocell and relay form the complete circuit.

The unusual combination of high current capacity and extreme sensitivity of these Mullard cells enables robust relays to be operated direct—amplifiers are unnecessary.

Both cells can be operated from either a.c. or d.c. supplies, they are inherently rugged and have a wide range of applications in industry.

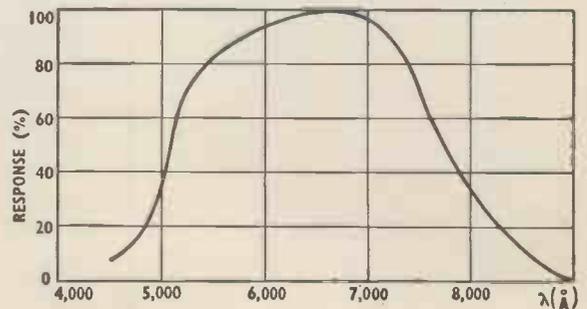
The usable response extends through the entire visible spectrum to the near infra-red.

The ORP11 differs from the ORP90 chiefly in being "end-viewing" and having a somewhat smaller photocathode area. This type of photocell is made available to simplify mounting problems encountered in certain applications—particularly in flame failure detectors in oil fired furnaces.

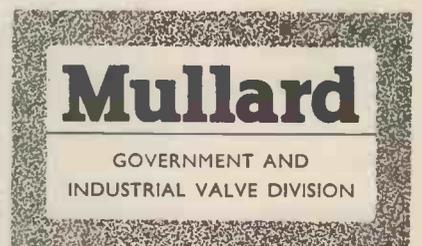
Data sheets giving further information are readily available from the address below.

## ABRIDGED DATA

	ORP 11	ORP 90
Required direction of incident light	End-on	Side-on
Area of photo-element	1.25 sq. cm.	2.9 sq. cm.
Average cell current at 10V d.c., 5 foot candles and lamp colour temperature 2,700°K.	6mA	6mA
Maximum ultimate dark current at 100V d.c.	5 $\mu$ A	< 2.5 $\mu$ A
Maximum cell dissipation at 25°C.	200 mW	600 mW
Spectral response	Same for both cells—see curve.	



Mullard Limited  
Mullard House, Torrington Place, London, W.C.1  
Telephone: Langham 6633



# Semiconductors

## HF/VHF COMMUNICATIONS TRANSISTORS



The Semiconductors range of H.F./V.H.F. transistors allows complete transistorisation of all communications receivers operating up to 200Mc/s, radar and navigational equipment I.F. amplifiers, and low-level video stages. For mobile transmitters, special techniques allow power outputs as high as 100mW to be obtained up to 70Mc/s.

Data sheets and Application notes are available for the whole range together with immediate assistance in your Application problems.

	TYPE	DESCRIPTION	TYPICAL POWER GAINS			
			1Mc/s	5Mc/s	10Mc/s	20Mc/s
			<b>Surface Barrier</b>	SB345	5V 10mA 20mW at 25°C General purpose R.F., I.F., video amplifier or oscillator to 15Mc/s.	32dB
	SB346	R.F. or I.F. amplifier for use up to 25Mc/s.	32dB	29dB	23dB	27dB
	SB087	R.F. or I.F. amplifier to 40Mc/s.	32dB	32dB	26dB	20dB
<b>Micro Alloy</b>	MA393	6V 50mA 30mW at 25°C High-gain high frequency transistor particularly suited to video amplifier applications; gain x bandwidth (Mc/s) typically 100Mc/s.				
<b>Micro Alloy Diffused</b>	2N499	15V 50mA 50mW at 25°C V.H.F. oscillator, min. R.F. power output 25mW at 100Mc/s.				
	2N500	V.H.F. oscillator, min. R.F. power output 20mW at 200Mc/s.				
	2N502	V.H.F. amplifier, min. power gain 8dB at 200Mc/s.				
	2N503	V.H.F. amplifier, min. power gain 11dB at 100Mc/s.				
	2N504	Video Output Amplifier, 30V rating, gain x bandwidth (Mc/s) typically 60Mc/s.				
<b>Silicon Alloy</b>	SA495	25V 50mA 150mW at 25°C., T <sub>j</sub> max. 140°C. Low saturation resistance p-n-p silicon transistor for use as R.F., I.F., video amplifier or oscillator up to 5Mc/s. Alpha cut-off typically 15Mc/s.				

# Semiconductors Limited

CHENEY MANOR  
SWINDON · WILTS  
TELEPHONE: SWINDON 6421/4

## More seals than ever!

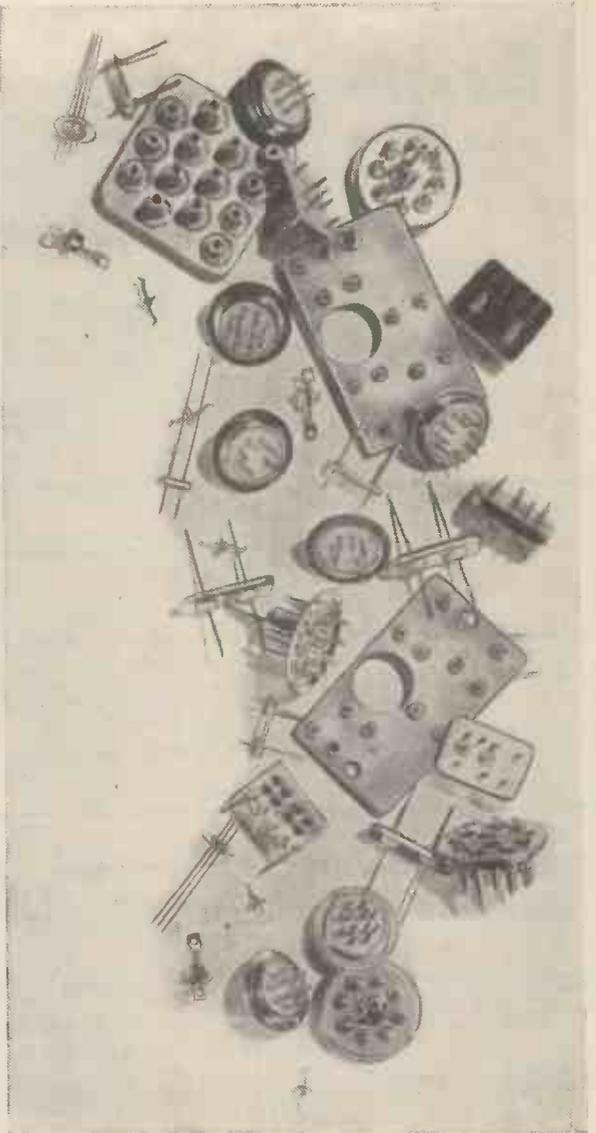
We are continually extending our range of standard metal-to-glass seals as more and more equipment designers realise their advantages. You will find these Ediswan seals in such devices as: indicating instruments, gyros, vibrators, transistors, crystals, relays, transformers and vacuum systems.

Increasing use is being made of them in the nuclear energy and guided weapon fields.

These metal-to-glass seals have excellent electrical and mechanical properties with the added advantage of being available in a wide variety of standard designs which can be supplied promptly and fitted easily—usually by soft soldering.

Our present range of seals embodies the latest techniques and will almost certainly include types suitable for your needs. If your product calls for something out of the ordinary, let us know; we are always ready to develop new seals to meet special requirements where necessary.

Publication R.1843 will give you full information about our standard range; you are welcome to a copy.



**Heard  
about our  
TRANSISTOR  
HEADERS?**

Thanks to recent big advances in our metal-to-glass sealing techniques, increased production capacity and highly developed systems of quality control, we can now supply first quality transistor headers at competitive prices. We are already supplying many well-known transistor manufacturers. If you are interested in cutting your transistor manufacturing costs, ask us to quote for the type of headers you are using and send you samples.

# EDISWAN

**SIEMENS EDISON SWAN LIMITED**  
*An A.E.I. Company.*  
155 Charing Cross Road, London, W.C.2. Tel: GERrard 8660.

CRC 16/8



PRESENTING



HEWLETT-PACKARD

524D

ELECTRONIC

COUNTER

**New 8-decade numerical readout!**

**New  $5/10^8$  per week stability!**

### SPECIFICATIONS

(Basic 424D without plug-ins)

#### Frequency:

Range: 10 cps to 10.1 Mc.  
 Gate Time: 0.001, 0.01, 0.1, 1, 10 secs or manual  
 Accuracy:  $\pm 1$  count  $\pm 0.000005\%$   
 Reads in: KC. Automatic decimal

#### Period:

Range: 0 cps to 10 KC  
 Gate Time: 1 or 10 cycles of unknown  
 Accuracy:  $\pm 0.3\%$  (1 period)  
 $\pm 0.03\%$  (10 period average)  
 Stan. Freq. Counted: 10 cps, 1 KC, 100 KC, or 10 MC, or external  
 Reads in: Secs., msec,  $\mu$ sec

#### General:

Registration: 8 places (99,999,999 max.)  
 Stability:  $5/100,000,000$ . May be standardized with WWV or external 100 KC or 1 MC primary standard.  
 Display Time: Variable 0.1 to 10 secs; or "Hold"  
 Input Voltage: 1 v min, 1.5 v peak. Rise time 0.2 seconds, max.  
 Input Impedance: Approx. 1 megohm; 40  $\mu$ f shunt.

plus all these frequency and time measuring advantages!

Direct, instantaneous, automatic readings

Frequency coverage 10 cps to 220 MC  
 (with plug-in units)

Time interval 1  $\mu$ sec to 100 days

Resolution 0.1  $\mu$ sec.

High sensitivity, high impedance

No calculation or interpolation.

New convenience of uniform 8-decade numerical readout without meters—new 5 parts in  $10^8$  stability simplifying standards and other microwave measurements—this is the capsule story of the new -hp- 524D Electronic Counter.

Electrically similar to the widely used -hp- 524B Counter, the new 524D provides for full frequency measurements from 10 cps to 10 MC and period measurements from 0 cps to 10 MC. Low cost plug-in units extend frequency measuring range to 220 MC, permit period measurements of over 10,000 periods, and increase sensitivity for precise measurement of weak signals. Still another plug-in provides for time measurements from 1  $\mu$ sec to 100 days with 0.1  $\mu$ sec resolution. When used with -hp- 540A Transfer Oscillator, the 524D will measure accurately to 12 KMC. For complete details, write or call your -hp- representative; or write direct.



HEWLETT-PACKARD COMPANY

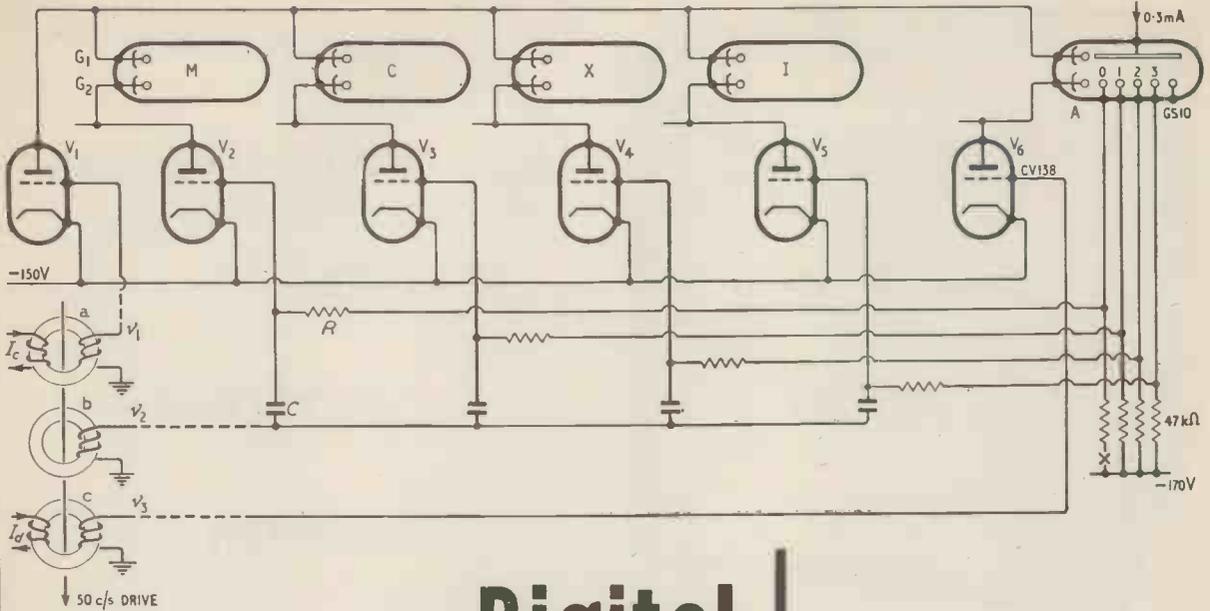
Represented by



LIVINGSTON LABORATORIES LTD.

RETCAR STREET · LONDON · N.19

Telephone: Archway 6251



# Digital Voltmeter

An article in the May issue of *Electronic & Radio Engineer* describes a digital decade voltmeter which, unlike the moving-pointer types, provides a visual display of voltage measurements in decimal form. Besides featuring high operating speed and very high input impedance, the instrument is capable of measuring up to 10 V with an accuracy of  $\pm 0.02\%$ .

*Original articles by leading authorities are a prominent feature of ELECTRONIC & RADIO ENGINEER. Regular readership will keep you in constant touch with progress in the entire field of electronics, radio and television.*

## ARTICLES IN THE JUNE ISSUE INCLUDE

**Square-Wave Generators**  
This article reviews the modern trend in design of generators of square waves and pulses and is illustrated by examples drawn from current commercial practice.

**Transistorized Pulse Amplifier**  
The design of a high-speed transistorized pulse amplifier is described. The circuit employs high-frequency drift transistors of a type specially developed for switching applications.

**ALSO**  
The unique monthly Abstracts and References feature compiled by the Radio Research Organization of the Department of Scientific and Industrial Research.

# ELECTRONIC & RADIO ENGINEER

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Please enter my name as a subscriber to:- ELECTRONIC & RADIO ENGINEER for 12 months commencing with the June issue. I enclose remittance £2.9.0 (U.S.A. and Canada \$7.50)

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SSU-1

**S-88 HI-FI STEREO AMPLIFIER KIT—£25/5/6**

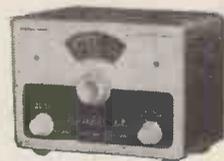
This amplifier gives 16 watts output (8 per channel with 0.1 per cent. distortion at 6 watts per channel). It has ganged controls, STEREO/MONAUROAL gram, radio and tape recorder inputs and push-button selection as well as many other first class features well above its price range. In two-tone grey metal cabinet with a golden surround and fittings. Also ultra-linear push-pull output.



V-7A

**S-33, 6 WATTS STEREO AMPLIFIER KIT—£11/8/-**

Produced for those wanting a versatile high-quality self-contained STEREO/MONAUROAL Amplifier with adequate output for an average or large living room—or with which to convert a favourite (monaural) radiogram into a stereo-radiogram, for the smallest possible outlay, this easy-to-build S-33 is unquestionably the ideal and logical choice. 3 watts per channel; 0.3% distortion at 2.5 w/chnl.; 20 dB N.F.B., inputs for Radio (or Tape) and Gram, Stereo or Monaural; Ganged controls. Sensitivity 100 mV.



VF-1U



USP-1

**UXR-1 TRANSISTOR PORTABLE KIT—£16/18/6**

This model is presented in elegant real hide case with tasteful gold relief. It can be assembled in 4 to 6 hours and you have a set in the top flight of the 25-30 guinea class. It has pre-aligned I.F. transformers, printed circuit and a 7in. high-flux speaker.

**DX-40U "HAM" TRANSMITTER KIT—£29/10/-**

This covers all amateur bands from 80 to 10 metres. Power input 75 watts C.W., 60 watts peak controlled carrier phone. Output 40 watts to aerial. Provision for V.F.O. Filters minimise T.V. interference.



C-3U



S-88

**O-12U 5IN. OSCILLOSCOPE KIT—£34/15/-**

Laboratory quality at utility oscilloscope price and ease of assembly make this kit of outstanding value. Vertical frequency response 3 c/s to 5 Mc.,  $\pm 1.5$  dB.  $-5$  dB., sensitivity 10 mV. per cm. at 1 kc. Horizontal frequency 1 c/s. to over 400 kc. ( $\pm 1$  dB. up to 200 kc.).

The Heath patented sweep circuit functions from 10 c/s. to over 500 kc. in five steps giving five times the usual sweep of other scopes.

In addition it has exceedingly short re-trace and rise times and electronically stabilised power supply. Included is a 48-page Instruction Manual.



D-X 40U

**V-7A VALVE VOLTMETER KIT—£13**

The world's most popular valve voltmeter, with printed circuit and 1 per cent. precision resistors to ensure consistent laboratory performance. It has 7 voltage ranges measuring d.c. volts to 1,500 and a.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance measurements from 0.1 ohm to 1,000 M ohms with internal battery. Input impedance is 11 megohms and dB measurement has a centre-zero scale. Complete with test prods, leads and battery.



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**SSU-1 HI-FI SPEAKER SYSTEM—£10/5/6**

Ducted-port bass reflex cabinet "in the white". Twin speakers. With legs £11.12.6.

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10 c/s to 100 Kc/s., switch selected. Distortion less than 0.1%. 10 V. sine wave output. Measures volts and dB's.

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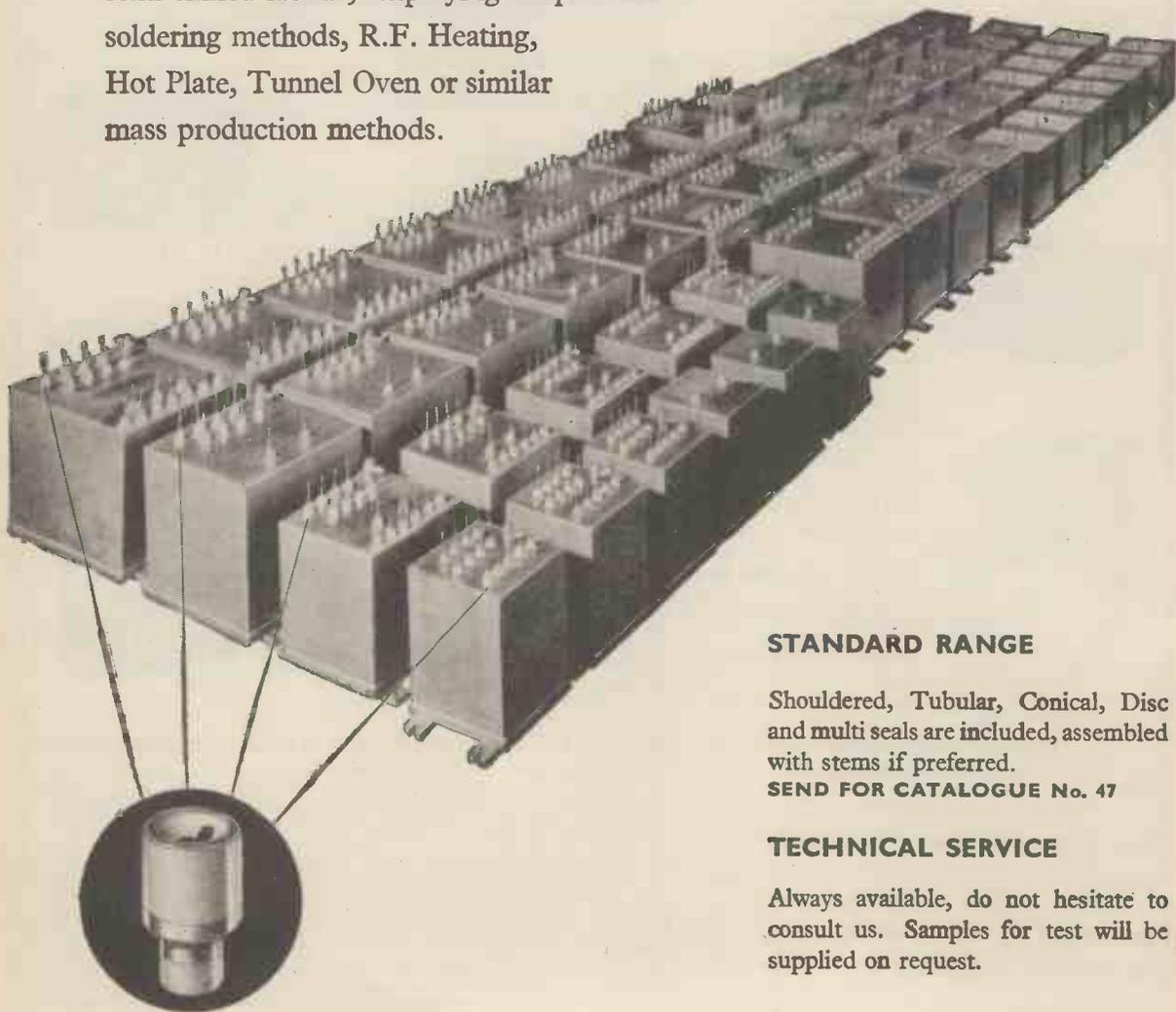
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(Effectively symmetrical in significant parameters)

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## CHOOSING YOUR SOUND

Selecting a loudspeaker by audition is the most difficult problem confronting the purchaser of high quality equipment as it is necessary to differentiate the sound heard into two components—that due to the programme and that due to the speaker. The following procedure, whilst being by no means exhaustive, will help to ensure that the choice is the correct one to give the maximum musical pleasure in the years to come.



### 8 POINTERS FOR YOU TO FOLLOW

Not more than four loudspeakers should be tested at one time in order to avoid confusion and the listener should be symmetrically seated in relation to the loudspeakers.

Ask your dealer to feed a clean programme to one of the loudspeakers with all amplifier controls level. A good local studio VHF transmission is best for this test as very few records can be played on wide range speakers without some degree of filtering.

Adjust the volume level to give the correct perspective for the programme. (i.e., so that the volume is commensurate with the impression of distance in the programme.)

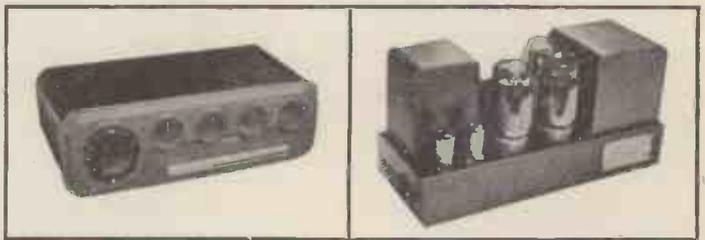
Listen to each loudspeaker in turn. In professional listening tests the greatest care is taken to pre-set the relative power fed to each loudspeaker as it is very important that they all operate at the same apparent loudness. If your dealer is not fitted up with this facility, then he or you will have to adjust the volume by hand—as accurately as possible.

Try to decide which loudspeaker is the most natural. Beware of sensationalism or "gimmick" balances. If the sound is sensational, make sure it is the music that is sensational and not the loudspeaker.

Next take a modern recording or recordings of your choice (as sensational as you like this time). Using the loudspeaker previously selected as the most natural, play the recording and adjust the filters to reproduce the maximum quality inherent in the recording. With these same settings refer back to the other loudspeakers to see that the one selected in the first test remains the best in the second test.

Should there still be doubt, try changing the relative positions of the loudspeakers in the room.

There are of course additional tests which should be made—adequate power output—adequate dispersion, etc. Best of all—but unfortunately seldom possible—is to borrow the speaker of your choice from a friend and try it at home.



The fact that the QUAD electrostatic shows up as first choice under these conditions does not invalidate the test procedure. It may be recommended for loudspeakers of all types, shapes and sizes.

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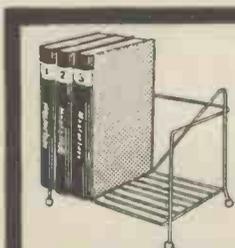




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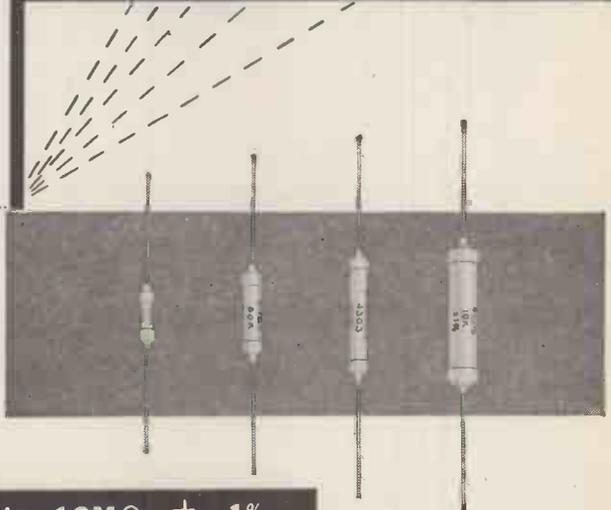
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- 4303

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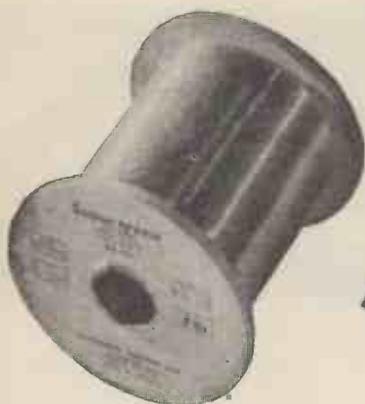
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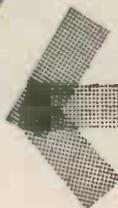
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## joint responsibility . . .

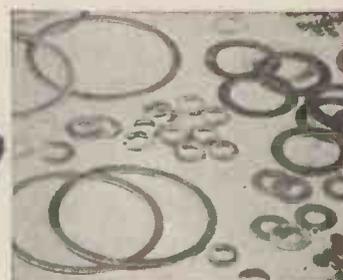
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FINE GAUGE ALUMINIUM and its alloys *can* be satisfactorily joined—in the flux bath. In fact, the flux bath makes possible joints, and therefore components, that cannot be produced by any other method. Consider these points.

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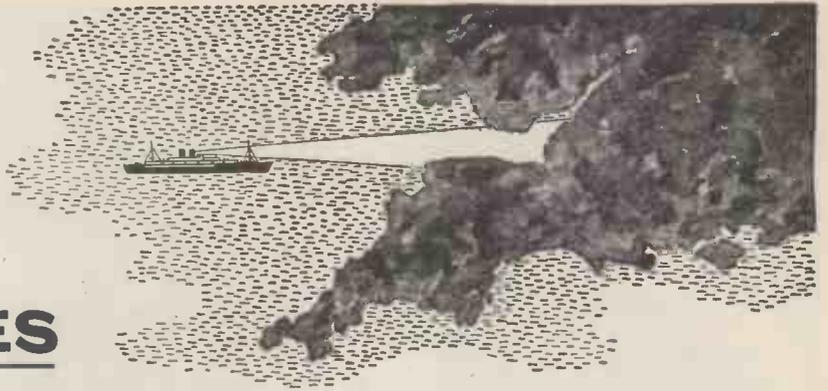
We have this 'know-how.' If you are interested in using it, please consult us. We shall be equally happy either to design for you or co-operate with your own designers.

We are specialists in heat exchange, heat insulation, and all types of brazing and welding

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**THYRATRON 5C22/HT415**

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This valve meets all the requirements of military and commercial specifications with the additional advantage of smaller bulk. Conditioning at 30kV and rigorous testing ensure thoroughly reliable operation right up to the maximum peak anode voltage and current ratings of 25kV, 18A.



**MAGNETRON 2J42**



Full details of this magnetron and others in the EEV range, which is the widest in Europe, will be sent on request. Magnetrons can be supplied packaged or unpackaged with peak output powers from 5kW to 5MW.

**KLYSTRONS**



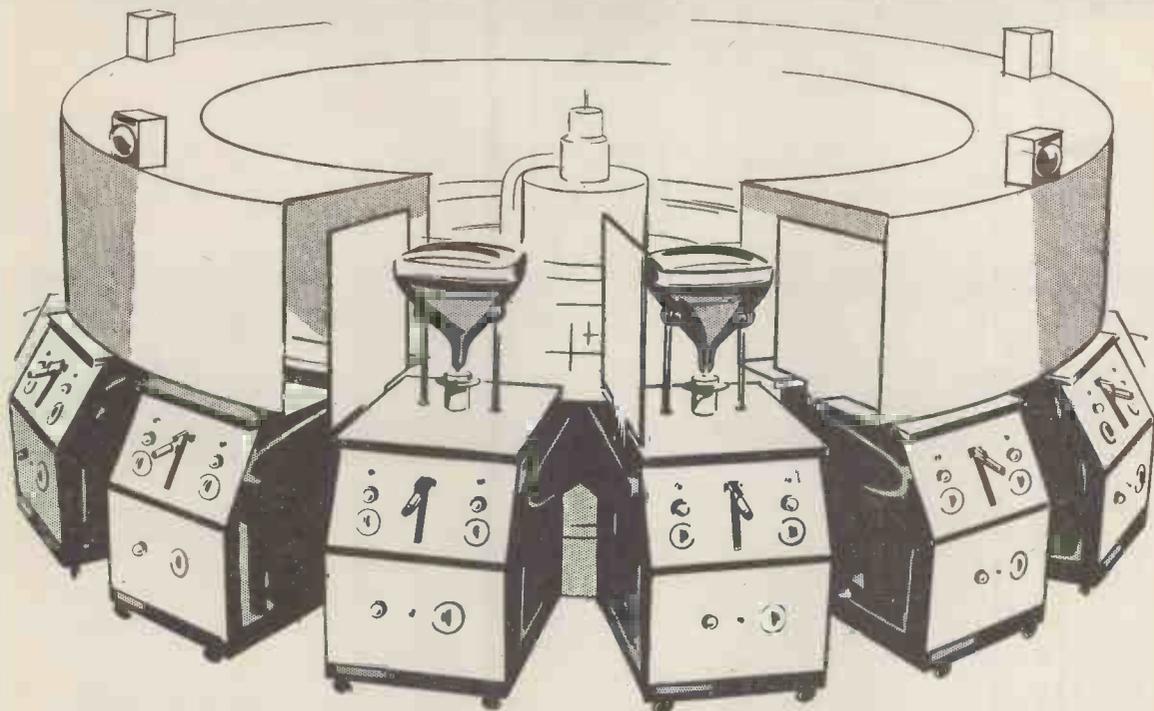
The full range of klystrons produced by EEV contains types which operate into Standard X-Band British Waveguide and others which use Standard Waveguide 16. The frequency coverage can be varied within certain limits to meet the requirements of equipment designers. All valves are supplied with integral resonant cavity.

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# W197 – a unique, vibration and acceleration resistant capacitor

Capacitance μF ± 25%	List Number	Joint Service Cat. No.	Style Part. Size Ref.
<b>200 volts D.C. Working</b>			
0.1 0.25 0.5 1 2	B5000KZ	5910-99-011-9827	CPM4-G
	B5010KZ	5910-99-011-9830	CPM4-H
	B5020KZ	5910-99-011-9833	CPM4-J
	B5030KZ	5910-99-011-9836	CPM4-K
	B5040KZ	5910-99-011-9839	CPM4-N
<b>250 volts D.C. Working</b>			
0.05 0.1 0.25 0.5 1 2	B5050KZ	5910-99-011-9825	CPM4-G
	B5060KZ	5910-99-011-9828	CPM4-H
	B5070KZ	5910-99-011-9831	CPM4-J
	B5080KZ	5910-99-011-9834	CPM4-K
	B5090KZ	5910-99-011-9837	CPM4-L
	B5100KZ	5910-99-011-9840	CPM4-P
<b>400 volts D.C. Working</b>			
0.05 0.1 0.25 0.5 1	B5110KZ	5910-99-011-9826	CPM4-H
	B5120KZ	5910-99-011-9829	CPM4-J
	B5130KZ	5910-99-011-9832	CPM4-K
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- Frequency measurement up to 100 kc/s.
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# Electronics

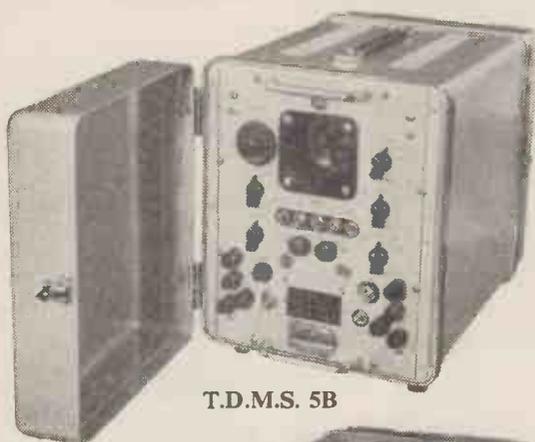
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# Distortion Display

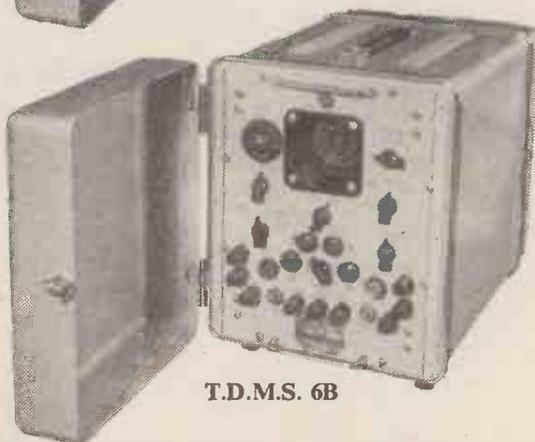
A visual indication of any type of distortion on a radio or line teleprinter circuit is given by A.T.E. Telegraph Distortion Measuring Equipment. The T.D.M.S. 5B, which is basically a test signal generator with variable distortion, also provides a display on a 2½" C.R.T. derived from a circular time base which enables distortion of synchronous signals to be measured to an accuracy of 1%.

The speed of incoming and outgoing signals can also be determined. The T.D.M.S. 6B is fitted with a C.R.T. actuated by a spiral time

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T.D.M.S. 5B



T.D.M.S. 6B

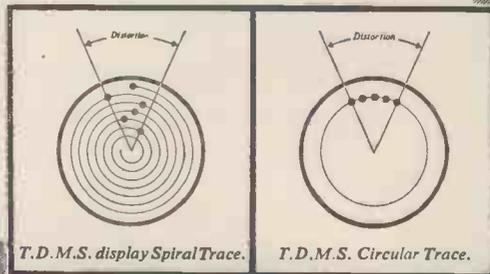
## T.D.M.S. 5B

*Sends an automatic test message, or characters, or reversals at any speed between 40-80, 140-160 bauds with or without distortion. The C.R.T. has a circular time base for distortion measurements on synchronous signals only. Weight 38 lb. 17.1 Kg.*

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*For distortion measurements on working circuits without interrupting service. Each element of a start-stop signal appears separately on a spiral time base display. Speed 40-80, 140-160 bauds. Weight 34 lb. 15.3 Kg.*

You are invited to apply for a descriptive brochure.



T.D.M.S. display Spiral Trace.

T.D.M.S. Circular Trace.



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*Flexible in the E and H planes.*

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*Twistable about the longitudinal axis, as well as being flexible in the E and H planes, and the new*

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*Flexible in E and H planes with a built-in longitudinal 'twist' which relieves strain on end flanges.*

Standard lengths range from 1 1/2" to 36".

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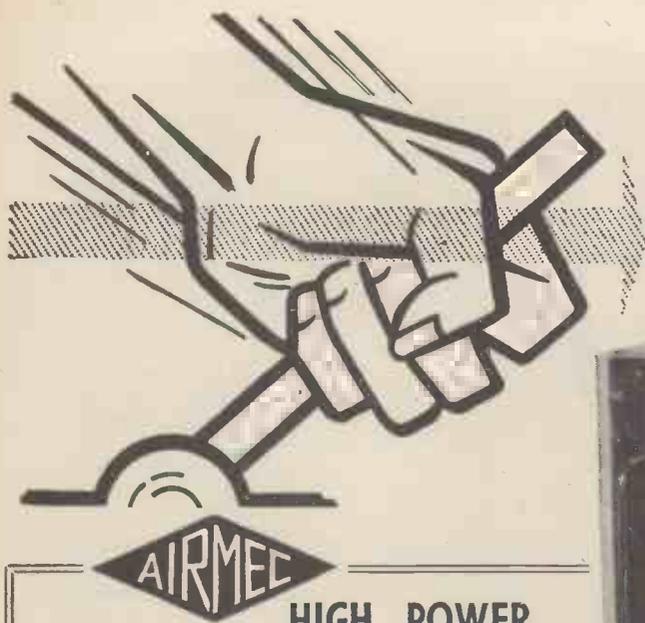
# WAVEFLEX

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## HIGH POWER OSCILLATOR/AMPLIFIER

TYPE 254



The High Power Oscillator/Amplifier is an instrument which combines an L.F. oscillator operating over the frequency range 30 c/s to 30 kc/s with a power amplifier capable of delivering up to 150 watts into a wide range of output impedances. The amplifier output is monitored by means of a built-in Voltmeter and an input socket is provided for use with external signal sources (microphones, pick-ups, signal generators, etc.).

### SPECIFICATION

#### OSCILLATOR

Frequency range: 30 c/s to 30 kc/s in 3 ranges.  
Calibration accuracy:  $\pm 2\%$  on all ranges.

#### AMPLIFIER

Sensitivity: 0.1 volt r.m.s. input for full output.

#### MAXIMUM CONTINUOUS POWER OUTPUT (SINE WAVE):

150 watts from 50 c/s to 5 kc/s.  
100 watts from 30 c/s to 10 kc/s.  
50 watts from 30 c/s to 30 kc/s.

### THERE'S NO END TO ITS APPLICATIONS

*The instrument has a wide variety of uses of which the following are representative:—*

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- ★ Drive for synchronous clocks

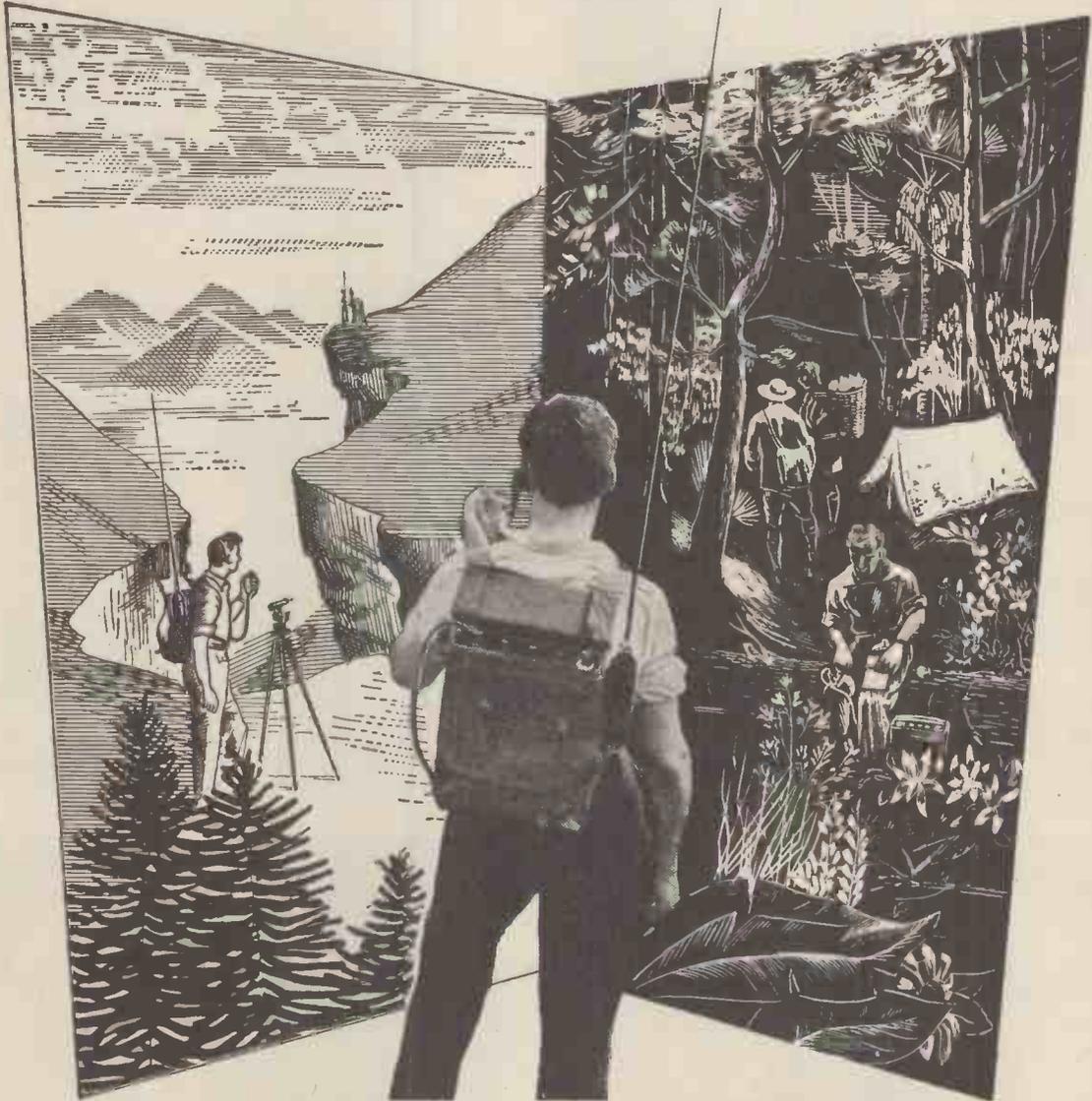
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## HIGH POWER OSCILLATOR/AMPLIFIERS

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## NEW SIX CHANNEL MILITARY VERSION H. F. PACKSET



**SIMPLE TO OPERATE—NO SPECIAL SKILL REQUIRED**

**PACKSET H.F. 156 TECHNICAL SPECIFICATION**

- Channels 1-3: 2.5-4.5 Mc/s.
- Channels 4-6: 4.5-7.5 Mc/s.
- Transmitter: C.W. or R.T.  
Power output 1.5 watts
- Receiver: R.T. 3 $\mu$ V for 12 db signal/noise ratio  
C.W. 20 db signal/noise ratio
- Power Supply: Vibratory. Two 2 volt accumulators.



**BRITISH COMMUNICATIONS CORPORATION LIMITED**

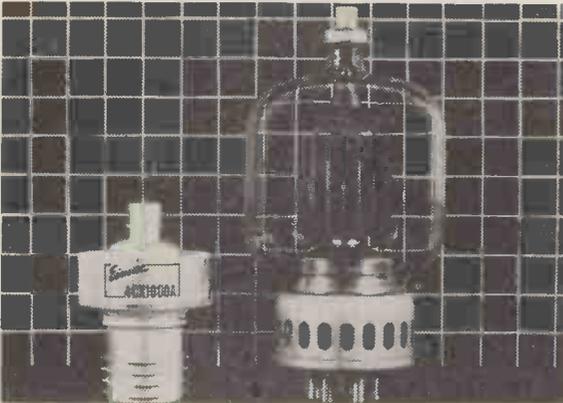
Second Way  
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Exhibition Grounds

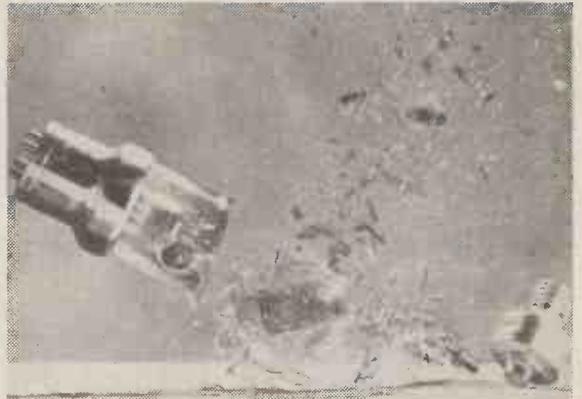
Wembley, England

Cables BeeCeeCee

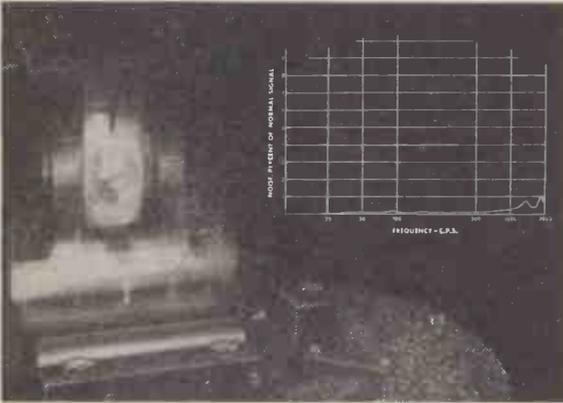
# Only EIMAC gives you ceramic "extras" in more than 40 tube types



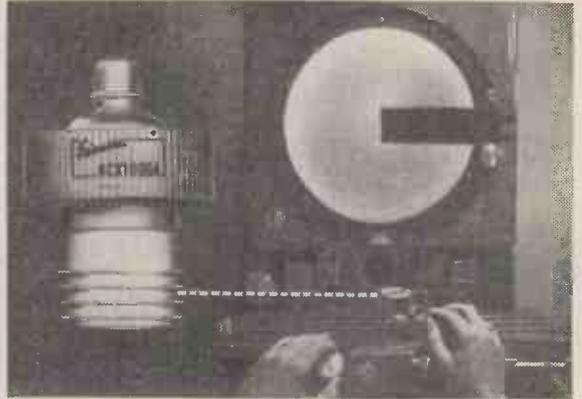
SMALLER SIZE



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LOWER DIELECTRIC LOSS

Write for literature on these incomparable ceramic reflex and amplifier klystrons, negative grid and travelling wave tubes.

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*Eimac First with ceramic tubes that can take it*



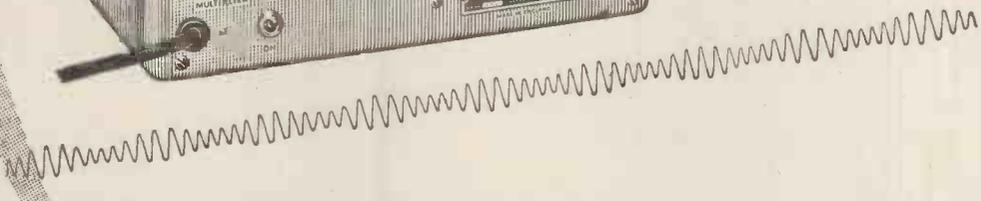
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# Complete Coverage from 7.5 Mc/s to 230 Mc/s

fm



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## MODEL 63 FM/AM SIGNAL GENERATOR

Here, within this one modestly priced instrument, are the essential facilities and the essential accuracy demanded for servicing radio and television receivers on bands I, II and III. But more than that, its excellent specification and wide range make the 63 FM/AM a valuable instrument for the electronic development laboratory.

net price in U.K.

**£85**



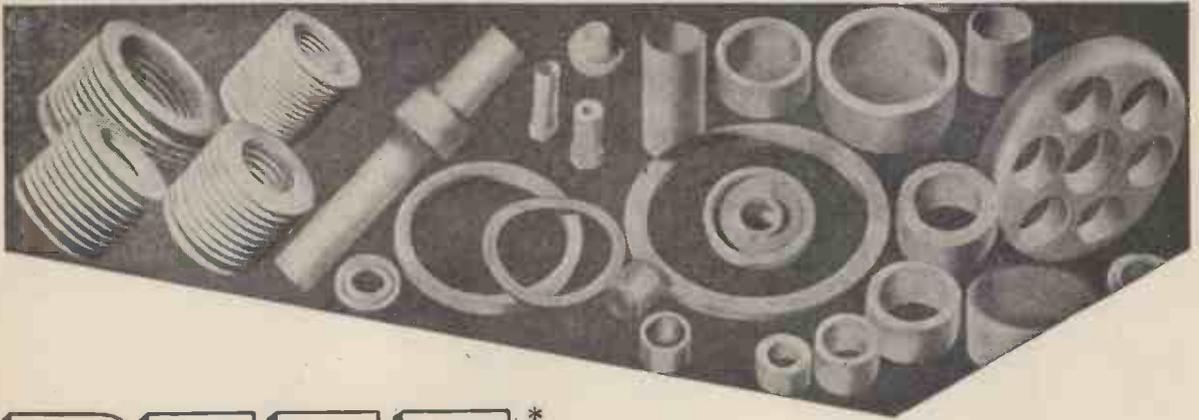
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Full technical details in leaflet W/36, available on request.

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GD23



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We were one of the first companies to process this unique material, and equally we were one of the first companies to develop methods of machining and otherwise fashioning it into a multitude of component forms.

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*Whether you require to buy PTFE in order to transform it into component forms in your own works, or whether you wish to buy small or large numbers of PTFE components, we should welcome your enquiries, and you would find advantage in utilising our accumulated resources of "know how" and experience in handling the material.*

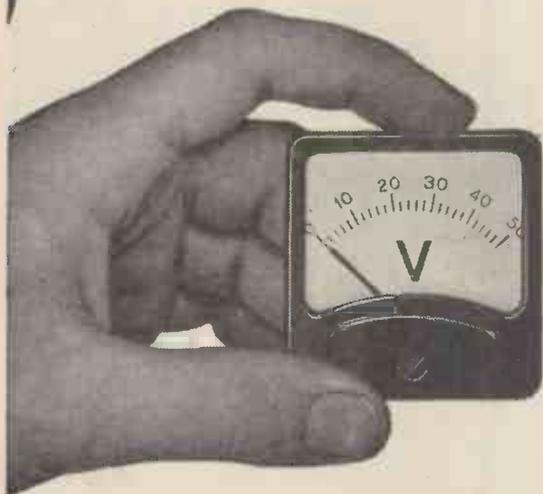
\* PTFE (Polytetrafluoroethylene)—the basic polymer is manufactured in this country by I.C.I. Ltd., under the trade name "FLUON".



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# A COMPREHENSIVE RANGE OF "Miniature" Instruments



Above: 2" square moving coil voltmeter

- ★ DESIGNED TO HARMONISE WITH ALL MODERN ELECTRONIC EQUIPMENT
- ★ FIXINGS CONFORM TO ACCEPTED PRACTICE
- ★ PRICES ARE HIGHLY COMPETITIVE

For utmost reliability all 'ENGLISH ELECTRIC' miniature instruments have been designed with a higher-than-normal torque/weight ratio in combination with lower power consumption. All types have been successfully subjected to the following tests:

RESISTANCE TO IMPACT SHOCK OF 200g in any plane.

VIBRATION FATIGUE TEST—two million cycles at peak resonant frequency.

OSCILLATORY TEST—up to one million operations.

SPECIFICATIONS B.S. 89-1954 and other International Specifications.

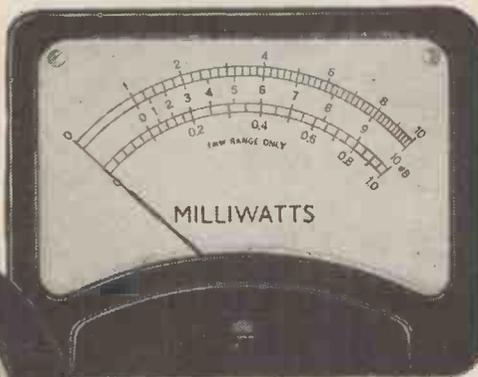
**TYPES**

Moving coil for D.C. applications.  
Rectifier moving coil for A.F. applications.  
Thermo-couple operated moving coil for R.F. applications.

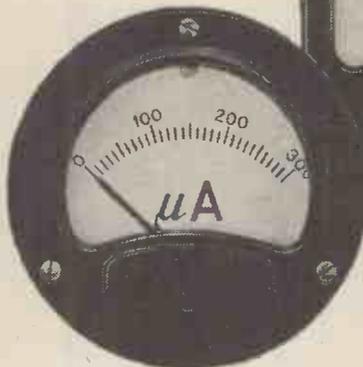
**SIZES**

Square: 2", 2½" and 3½" nominal scale length.  
Round: 2½" and 3½" nominal scale length.  
Rectangular: 5" x 6" or 3" x 4" nominal case size.

Design registrations pending.



Above: 3" x 4" rectangular absorption wattmeter



Left: 2½" round moving coil microammeter

Over 50 standard ranges in any of the seven case types.

Delivery ex stock for standard ranges.

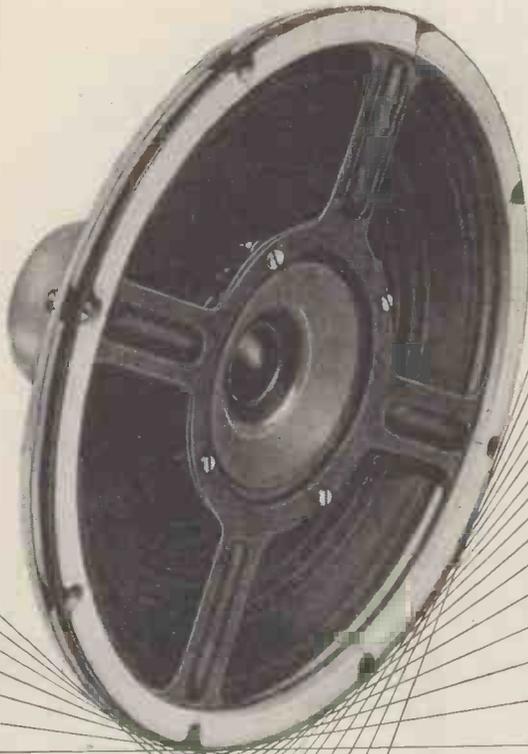
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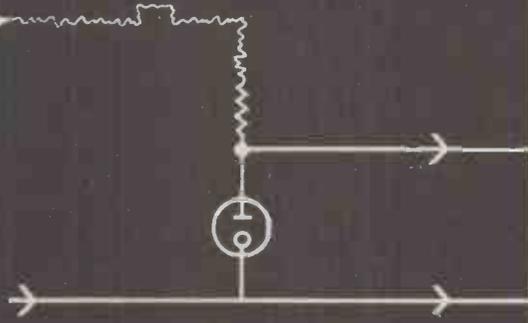
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VALVE	VOLTAGE RANGE	STANDARD VOLTAGE	SIZE
SC1	350-2000V	350, 400, 600, 800, 1000 1200, 1400, 1600, 1800, 2000	B7G
SC2	2000-4500V	2500, 3000, 3500, 4000	B9A
SC4	4500-7000V	5000, 6000, 7000	B9A
SC3	350-400V	350, 400 (Low current)	B9A + Flying leads

*Minimum currents range from 5 $\mu$ A to 50 $\mu$ A,  
maximum currents range from 50 $\mu$ A to 2mA, according to type.*

Please write for further information to—  
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Makers of G.E.C. high grade radio valves and cathode ray tubes  
A subsidiary of The General Electric Co. Ltd.

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## A.M. SIGNAL GENERATOR TF 801 D

The TF 801D is the latest addition to the Marconi family of precision a.m. generators. With a frequency range of 10 to 470 Mc/s, its salient features include superfine tuning with crystal checking, and oscillator l.t. regulation for maximum stability. Spurious f.m. is less than 0.001% of carrier frequency, and its high-quality 50-ohm output has a v.s.w.r. better than 1.2.

Carrier level is continuously variable from 0.1  $\mu$ V to 1 volt and is stabilized by an automatic level control system. Sinewave a.m. up to 90% may be applied both internally and externally; pulse modulation may be applied externally in the p.r.f. range 50 c/s to 50 kc/s.

*Full details will be gladly sent on request—please ask for leaflet G142*



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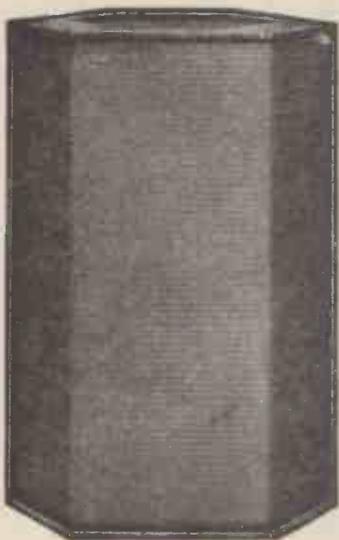
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# ..... and now

## A 4 SPEAKER SYSTEM FROM WHARFEDALE

### THE W4

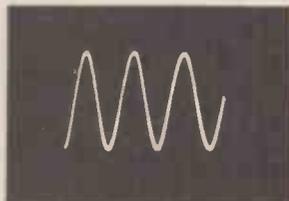


With Independent mid-range and treble controls to facilitate stereo operation with different speakers.

The W4 is a new 4-speaker system designed for stereo use in conjunction with an existing 9 cu. ft. corner 3-speaker system or in pairs where identical speakers are required. It also gives superb results on single channel input.

Although primarily a corner design, it can be used along a wall side if required, since it is completely enclosed at the rear. The design is based on the Wharfedale 12in. linear suspension unit type WLS/12 which gives pure bass down to 30 c/s, as shown by the waveform at 4 watts input.

A half section three way network is fitted crossing over at 400 c/s to a pair of 5in. units in parallel. A Super 3 is used for the extreme treble. The treble units are arranged for omni-directional radiation, giving the effect of a broad sound source in keeping with the large three-speaker corner system. The similarity of treble radiation ensures good balance when the latter is used in the opposite channel on stereo.



Waveform of output at 30 c/s with 4 watts input

Other compact speaker systems are the

**W2**

Cabinet 23½" x 14" x 12"  
Price £29 . 10 . 0 tax free

**W3**

Cabinet 28" x 14" x 12"  
Price £39 . 10 . 0 tax free

*Specification of the W4*

**Size 35in. x 24in. x 12in. Weight 65lb. complete.**

**Impedance 15 ohms.**

**Max. input 15 watts.**

**Price in whitewood £47 - 5 - 0.**

**Veneered and polished £49 - 10 - 0.**

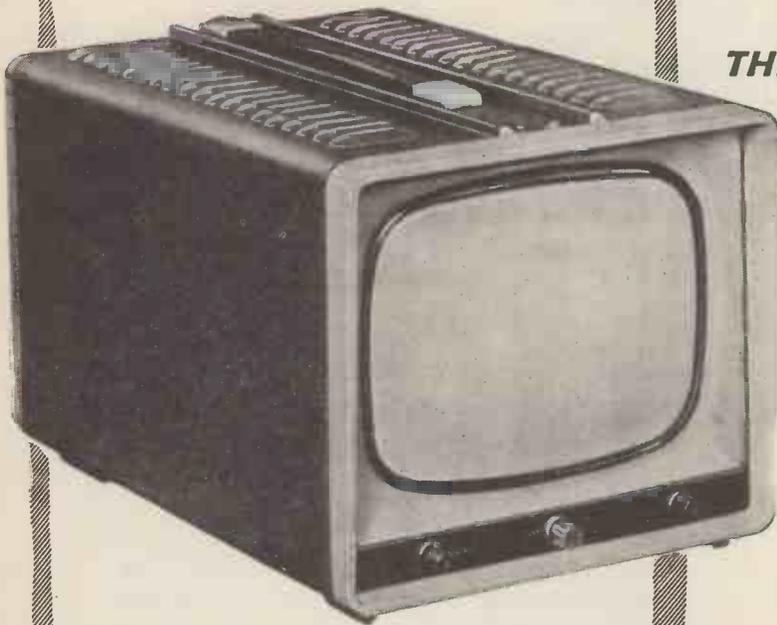
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Tropical model can be supplied at £2/10/- extra.

Descriptive folder on all 3 models available free on request.

Telephone : Idle 1235/6. Telegrams : 'Wharfedel,' Idle, Bradford

**Wharfedale**  
WIRELESS WORKS LTD  
IDLE BRADFORD YORKS



THE NEW



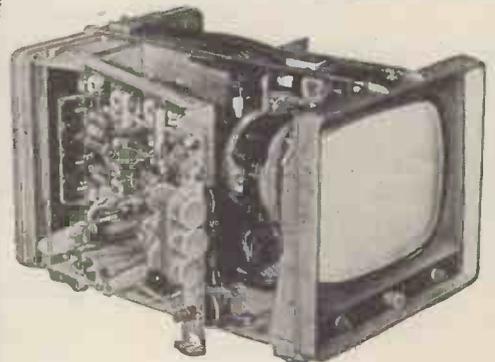
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MONITOR

TYPE 2823

LIGHT  
COMPACT  
RELIABLE

The Pye Picture Monitor Type 2823 has been specially designed for field or studio locations where the use of a precision monitor is not essential. The monitor is light, small and easily carried. It can also be used with a Pye industrial television chain or other closed circuit television systems. Outstanding Features:

- ★ The monitor will operate on either a complete video waveform or by means of separate video and synchronising waveforms.
- ★ Chassis is isolated from the A.C. power supply.
- ★ Available for operation on either 405, 525, or 625-line standards.
- ★ Main controls are mounted at the front of the unit.
- ★ Provided with easily removable side panels and hinged chassis for maintenance.
- ★ Incorporates printed circuits for reliability.
- ★ Small dimensions allow mounting in restricted places. Measures only 9½" x 10" x 16½". (24 x 25 x 42 cm.).
- ★ Features an 8½" (21 cm.) rectangular, aluminised picture tube.
- ★ May be used at microwave link repeater stations for checking the quality of the received picture signal.
- ★ Light weight for easy portability. Weighs only 24 lbs. (11 kg.).
- ★ Remote control of Brightness and Contrast.



For full technical details, please  
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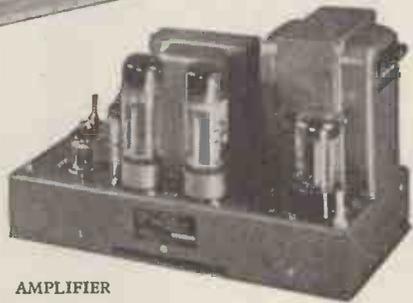
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**LOW PRICE**

# HI-FI

**BTH EXPERIENCE  
BRINGS OUT THE BEST  
IN SOUND REPRODUCTION**

CONTROL PANEL



AMPLIFIER



The most brilliant disc or tape recording is wasted unless it can be brilliantly reproduced. The thousands of Hi-Fi enthusiasts who visited the 1958 Radio Show were most impressed by the results achieved with the new BTH equipment. Designed by Mr. James Moir, M.I.E.E., the control unit and amplifier give entirely new standards of stereophonic or single-channel reproduction. Behind this achievement is 30 years' BTH experience in building the highest quality sound reproduction equipment for cinemas and public buildings. At the Festival of Britain in 1951, it was BTH who first introduced the public to stereophonic sound.

**THESE FEATURES ARE UNIQUE**

Infinitely-variable cut-off constant-slope filter provides the best adjustment for individual records or radio programmes. High sensitivity inputs available for direct connection to tape head or pick-up without the need for additional pre-amplifiers. Separate low sensitivity inputs for disc or tape also provided. Printed circuits ensure reliability and negligible background noise. Output is 20 watts with very low harmonic and intermodulation distortion at full power. Built-in compensation for disc and tape recording characteristics is automatically selected by the input switch. The amplifier covers the entire audio frequency range and has separate bass and treble controls.

*A range of matching loudspeakers is also available.*



SEND FOR DESCRIPTIVE LITERATURE

Control Panel and Amplifier £42 AVAILABLE DIRECT FROM STOCK

**HEAR IT—AND YOU'LL CHOOSE BTH**

**BTH SOUND EQUIPMENT LTD**

CROWN HOUSE, ALDWYCH, W.C.2

Take an outstanding amplifier... double it... and you have

the finest instrument of its kind available today

**Mozart**

**DOUBLE  
10 WATT  
STEREO  
AMPLIFIER**



**MODEL HFS20 (CHASSIS)  
MODEL HFS20M (CASED)**

**TECHNICAL SPECIFICATION PER CHANNEL**

**PRE AMPLIFIER**

Sensitivities P.U. 7 mV. Tape 100 mV. Radio 100 mV. Tape record output 300 mV at above specified input sensitivities.

Hum and Noise P.U. — 55 db. Tape — 60 db. Radio — 60 db.

Frequency Response Tape 20 to 20000 cycles  $\pm$  1½ db. Radio 20 to 20000 cycles  $\pm$  1½ db. P.U. Within 1½ db of published relay curves.

Channel Separation between — 40 db and — 50 db overall.

Controls Volume: Continuously variable; Bass: + 10 db to — 15 db at 50 cycles. Treble: + 10 db to — 15 db at 10000 cycles. Balance: Variation of 6 db per channel. Illuminated Push/Push on/off switch.

Selector Switch 5 Position: Tape. Radio. 78 (all 78 records). L.P.O. (Pre 1955 recordings) L.P.N. (Recordings to R.I.A.A.).

Output 0.2 V into 100K for above stated input sensitivities.

Pick-up matching by "Diplomatic" compensation.

Control panel is identical in size and finish to the Mozart FM Tuner.

**MAIN AMPLIFIER**

Sensitivity 0.2 V.

Output 10 watts per channel.

Distortion 0.3% total harmonic at 9 watts.

L.F. Power Output 8 watts at 40 cps

Loudspeaker Impedance 4, 8, and 15 ohms (with phase reverse switch).

Damping Factor 30.

Hum and Noise — 70 DB with 100K input impedance.

Frequency Response 10-50,000 cycles  $\pm$  2 db.

Negative Feedback 27 db (in 3 loops).

Total Power Consumption 110 vA.

Mains 200 V to 250 V AC 50 cycles. 110 V to 120 V AC 60 c.p.s. (Export model)



**HIGH FIDELITY IS A  
SPECIALIST BUSINESS**

*Meticulous attention is paid to every detail. Exact performance tests are carried out at every stage. Hand-finishing is by experts. The result is a range of instruments which are among the finest available in their power rating.*

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Conforming to Sections B & C  
of Specification EL1930, M.O.S: (Air)

Siemens Ediswan PTFE insulated instrument wire, developed for certain highly specialised services, has a wide potential field of application in modern electronic engineering. The physical and electrical properties of PTFE make it the best material available wherever the emphasis is on performance and complete stability. In brief, PTFE has these advantages:

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- High resistance to corrosives and solvents
- Non-chafing and self-lubricating
- Available in 11 colours
- Non-adhesive

PTFE is extremely difficult to form, but we have considerable pioneering experience in its processing and fabrication. As a result we are able to produce PTFE insulation by extrusion with concentricity guaranteed to close limits. We are anxious to extend the uses of this wire and will gladly supply interested manufacturers with samples for them to test. If we can help you with information on the use of PTFE in any shape or form, please let us know.



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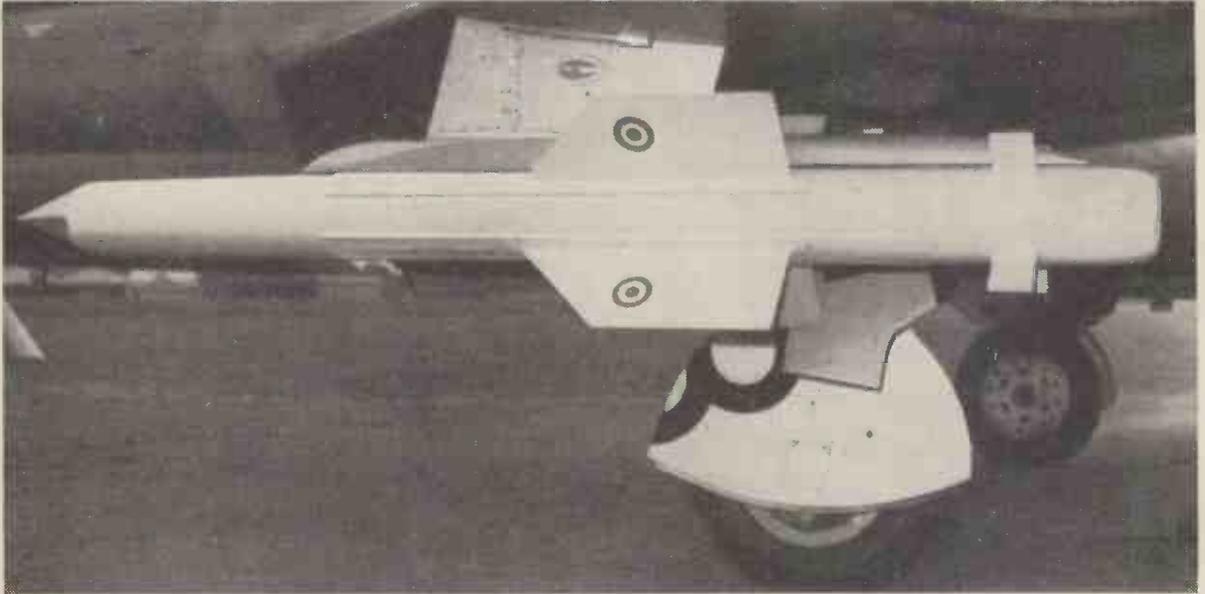
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155 Charing Cross Road, London WC2

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TELCON METALS  
AND THE DE HAVILLAND  
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We are proud to be associated with DE HAVILLAND PROPELLERS LTD., in the manufacture of the FIRESTREAK guided missile. The majority of electronic assemblies used in this missile embrace components which depend on our alloys—MUMETAL, RADIOMETAL and H.C.R.—for their exacting operation.

Other Telcon alloys such as PERMENDUR, RHOMETAL and BERYLLIUM COPPER—Cu.Be.250 (DTD.900) are also widely used by the Aircraft Industry. *We are manufacturers of super pure basic metals and alloys for the instrument, electronic and aircraft industries. Our range includes:*

## SOFT MAGNETIC ALLOYS

<b>Mumetal</b>	High permeability.
<b>Supermumetal</b>	Nickel Iron Alloys for cores and laminations.
<b>Radiometal</b>	
<b>Super Radiometal</b>	
<b>Rhometal</b>	
<b>Supermendur</b>	High permeability. Cobalt-Vanadium.
<b>Permendur</b>	Iron Alloys with high saturation for light-weight generators and vibration test gear.
<b>HCR Alloy</b>	Rectangular hysteresis Loop Nickel-Iron Alloy for magnetic amplifiers and reactors.
<b>H.S. Alloy</b>	High-speed switching alloy for computers and magnetic amplifiers.

## DUCTILE HARD MAGNETIC ALLOY

<b>Vicalloy</b>	Permanent magnet alloy (Cobalt-Iron-Vanadium) of ductile and machinable quality.
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## THERMOSTATIC BIMETALS

Various grades for instrument protection, and compensation-overload protection of motors, synchros and similar electrical devices.

*Most alloys are available as strip, rod, bar or wire, and enquiries are invited for ultra-thin magnetic materials for high frequency applications. A.I.D., A.R.B., and Admiralty approved.*



# TELCON METALS

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD.

Enquiries to: Metals Division, Telcon Works, Manor Royal, Crawley, Sussex. Crawley 1560  
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## Are you using S.S.B.?

Single Sideband HF Communication, with its advantages of increased effective power and reduced bandwidth, used to call for such elaborate installations that its use was confined to the large-scale communication organisations of the world. Intensive development effort has resulted in considerable reductions in the complexity of S.S.B. equipment, so that reliable, simple sets can now be made available for even the smallest communication systems.

With the object of making S.S.B. operation available to the greatest number of users, RACAL have designed a well-balanced range of S.S.B. transmitting and receiving equipment. The demand for the popular TRA.55, shown in full-scale production, has demonstrated clearly the great need for this equipment. The other members of the series have been designed to the same policy of maximum utility and minimum frills.

With this equipment, designed with the requirements of tomorrow in mind, RACAL offers you the solution to your HF communication problems today.

### Brief details of the TRA.55 Radio telephone.

**Frequency Channels:**

Channels 1 & 2—3 to 6 Mc/s.  
Channels 3 & 4—6 to 12 Mc/s.  
(Channel 4 can be supplied as 7.5 to 15 Mc/s).

**Emission:**

Single (lower) sideband suppressed carrier radio telephony.  
Single sideband keyed tone.  
(Carrier re-insertion is available for pilot carrier or D.S.B. working).

**Peak Envelope Power:**

60 watts.

**Input:**

100-125 and 200-250v 40/60 c/s.  
300 watts maximum.

The TRA.55B can also be supplied. This version has switching facilities to provide conventional D.S.B. reception and transmission in addition to S.S.B. working.



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N. ENGLAND AGENT: Farnell Instruments, Ltd., Wetherby Industrial Estate, York Road, Wetherby, Yorks. Tel: Wetherby 2544  
SCOTTISH AGENT: A. R. Bolton & Co., Ltd. 3A St. Vincent Street, Edinburgh. Tel: Edinburgh 32035  
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... a new  
approach  
to better  
listening



#### ESSENTIAL DATA

NOMINAL SIZE	15"
PEAK POWER HANDLING CAPACITY	25 watts
VOICE COIL DIAMETER	3"
TOTAL FLUX	290,000 Maxwells
FREQUENCY RESPONSE	30-15,000 c/s
BASS RESONANCE	35 c/s
IMPEDANCE AT 400 c/s	15 ohms

**CELESTION**

The COLAUDIO provides a new incentive to listening, creates a new realism in reproduced sound, adds a new beauty to music and the finer nuances of speech. Combining a 15 in. direct radiator bass loudspeaker with two direct radiator, pressure-type high frequency reproducers in column form, the COLAUDIO is the culmination of over thirty years research, development and manufacture of loudspeakers for all purposes. Its perfection of tone can be truly appreciated only by an aural test—once heard, you will never be satisfied until you install one in your own reproducing equipment.

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FOR THE FIRST TIME IN BRITAIN

**New POWER WIRE-WOUND RESISTORS!**



HIGH GRADE RESISTORS AT LOW COST

A new Dubilier process makes available to the design engineer a power wire-wound resistor possessing high-grade characteristics which costs no more than an equivalent standard type. The resistance wire is uniformly wound on a silicone-processed fibre-glass core which is then sealed into a ceramic housing. The result is a remarkably stable resistor which is completely insulated except for the connecting wires.

**PERFORMANCE UNDER OPERATING CONDITIONS**

- \* Resistance change less than 5% after 100 hours at 40°C. ambient temperature and 95% relative humidity.
- \* Resistance change less than 2% after three times normal load for 5 seconds.
- \* Resistance change less than 5% after 500 hours at full load in 25°C. ambient temperature.
- \* Resistance change less than 1% and no physical effects due to soldering.

**MAXIMUM TEMPERATURE COEFFICIENT BETWEEN -55 and +275°C.**

TYPE	0.05%/°C.	0.03%/°C.
PW5	0.5Ω to 2.5Ω	2.5Ω to 2.0kΩ
PW7	0.5Ω to 8.0Ω	8.0Ω to 6.5kΩ
PW10	1.0Ω to 10Ω	10Ω to 10kΩ

FIG. 1. DERATING CURVE

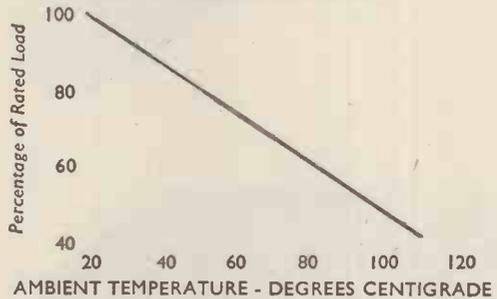
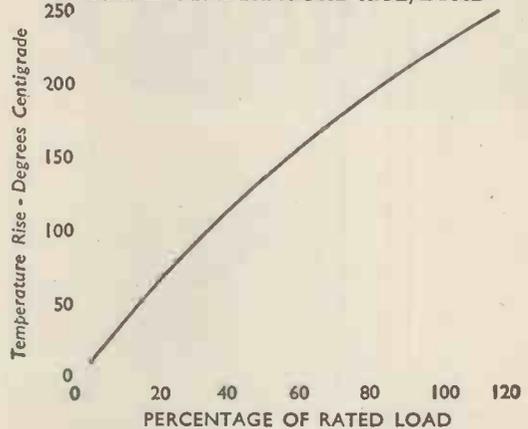


FIG. 2. TEMPERATURE RISE/LOAD



TYPE	PW5	PW7	PW10
Wattage	5.0	7.0	10.0
Min. Value	0.5Ω	0.5Ω	1.0Ω
Max. Value	2.0kΩ	6.5kΩ	10kΩ
Length	7/8"	1 25/64"	1 7/8"

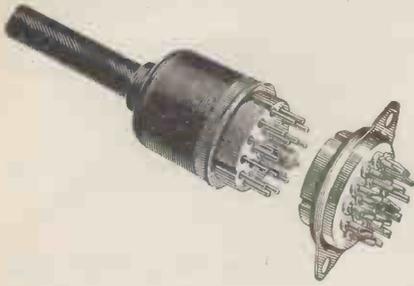
Width and height of all three types are 3/8" and 11/32" respectively.

**DUBILIER**

Catalogue R15A available on request.

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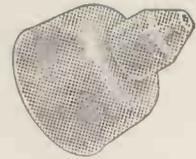
## ELECTRONIC



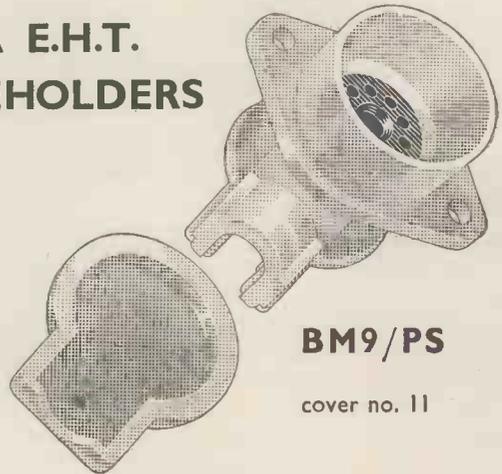
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Polythene Shrouded B9A. Valveholder for Television E.H.T. Rectifiers.

TC2



### B9A E.H.T. VALVEHOLDERS BM9/UV

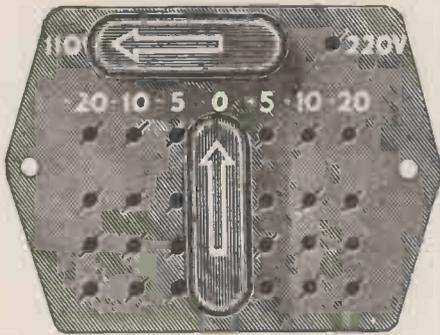


BM9/PS

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Send for full details to:—

The McMurdo Instrument Co. Ltd.,



**14 WAY B279001**  
BLACK P.F. MOULDING

**VOLTAGE  
SELECTORS**



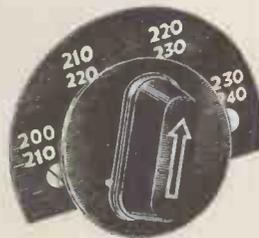
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NYLON LOADED P.F. MOULDING

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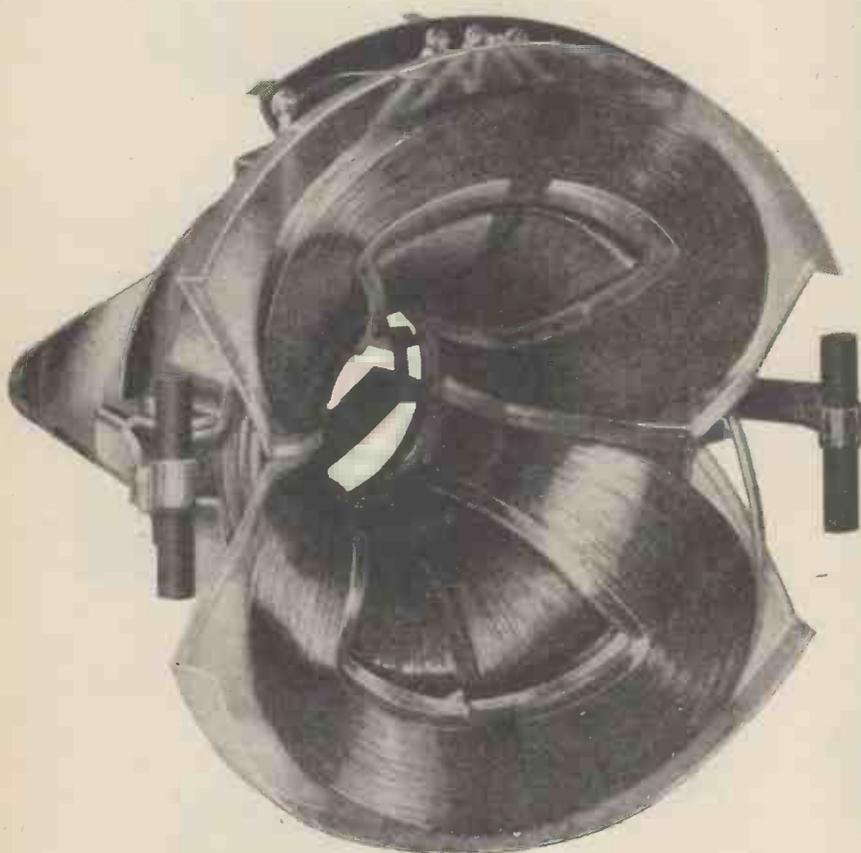


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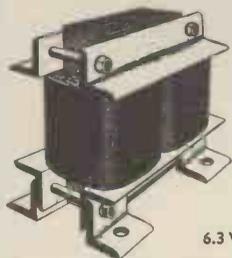


**ELECTRO ACOUSTIC INDUSTRIES LTD.**, Stamford Works, Broad Lane, London, N.15,  
Tel: TOT 0505.

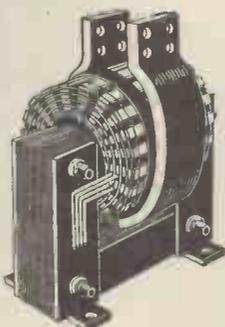
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All for 220/250 V. Input, Other Supply Voltages as required  
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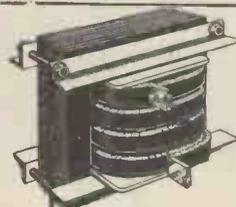
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OUTPUTS:  
12 V. 40 Amps.  
6-12-18-24-30 V. 12 Amps.  
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18 V. 30 Amps.  
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55 V. 12 Amps.  
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6.3 V. 18 Amps. or 12.6 V. 9 Amps.

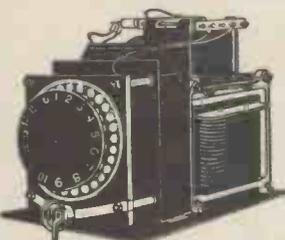


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5 V. 300 Amps. £15 0 0  
6-12 V. 50 Amps. £8 10 0  
12 V. 60 Amps. £10 0 0  
12 V. 100 Amps. £15 10 0  
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Input 230/240 V. Output 50 V. to 250 V. In 16 steps of 12.5 V. at 25 Amps. These are Auto Transformers with Quick Make-and-Break Tapping Switches.

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2 V., 30,000 Amps. £130 0 0  
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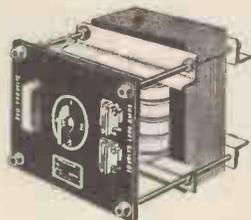
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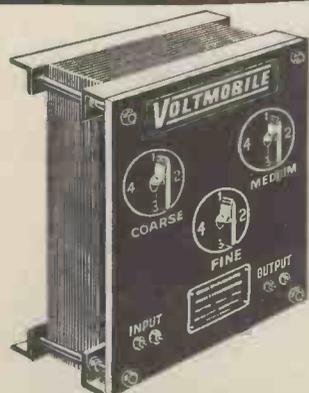
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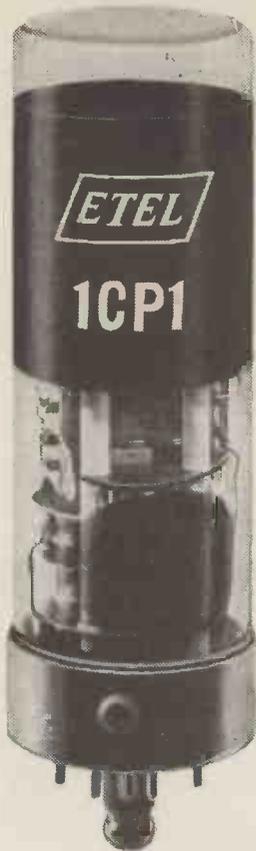
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Actual size

**Abridged data**

- Vh = 6.3V
- Vh-k (pk) = ±250V max.
- Val+a3 = 350V min.
- Sx =  $\frac{95}{Va3}$  mm/V
- Sy =  $\frac{110}{Va3}$  mm/V

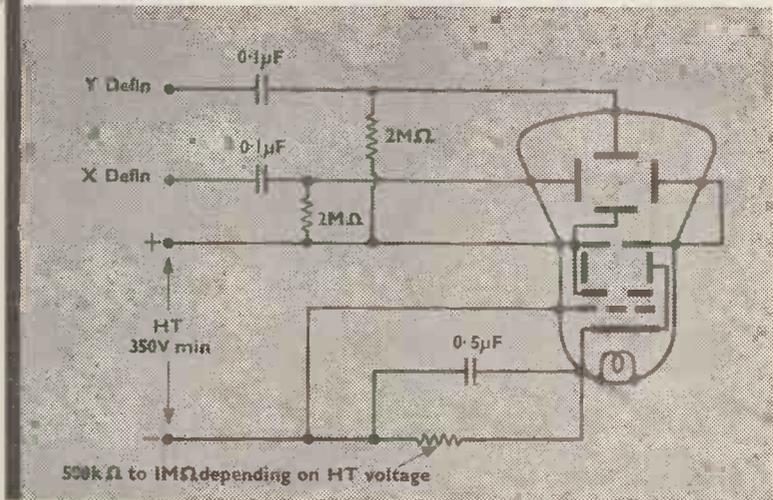
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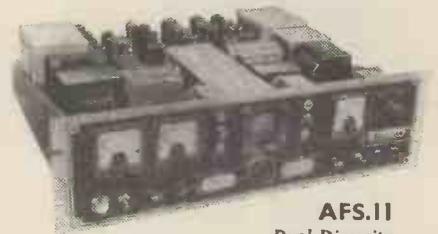
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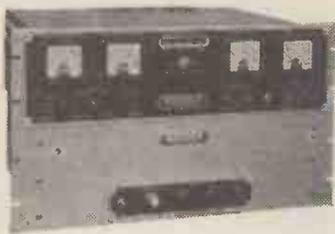


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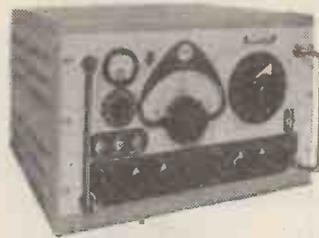


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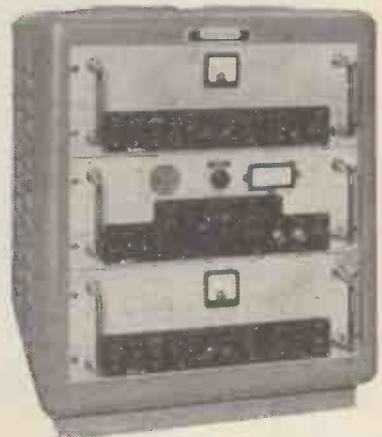
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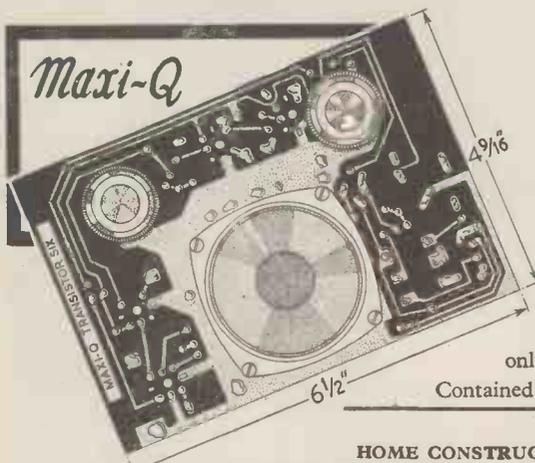
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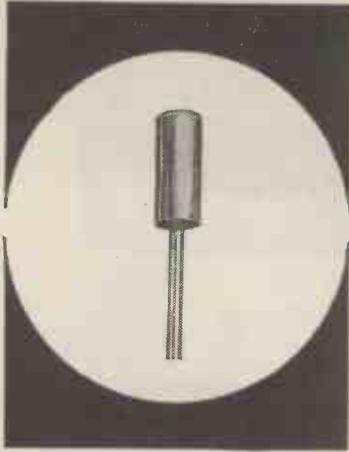
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## ... a higher $\alpha'$ version of the recently announced OC200

The new Mullard silicon alloy transistor OC201 is similar to the recently introduced OC200, but with the average current gain increased from 20 to 30 and the minimum  $f_c$  increased from 0.5 to 2 Mc/s.

Like other transistors in the silicon alloy range now being introduced by Mullard, the OC201 has a low bottoming voltage and all the advantages of the well-known OC71 germanium series. In addition these silicon transistors feature a low collector leakage, reduced noise figure and high permissible operating temperature.

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The OC201 is now being put into large scale production and designers can depend on it to remain available for many years as a standard transistor. Write on your company notepaper to the address below for complete data.

### ABRIDGED DATA

Silicon p-n-p alloy junction transistor OC201

T <sub>junction</sub> ... ..	-55 to +150°C	$\alpha'$ (or $\beta$ ) spread ... ..	20 to 80
V <sub>cb</sub> (pk) max. ... ..	-25 V	V <sub>ce</sub> (I <sub>c</sub> =7mA, I <sub>b</sub> =1mA) ... ..	100 mV
V <sub>cb</sub> max. (av. or d.c.) ... ..	-25 V	Average noise figure ... ..	6 dB
i <sub>c</sub> (pk) max. ... ..	50 mA	$r_{bb}'$ ... ..	125 ohms.
I <sub>c</sub> max. ... ..	50 mA		



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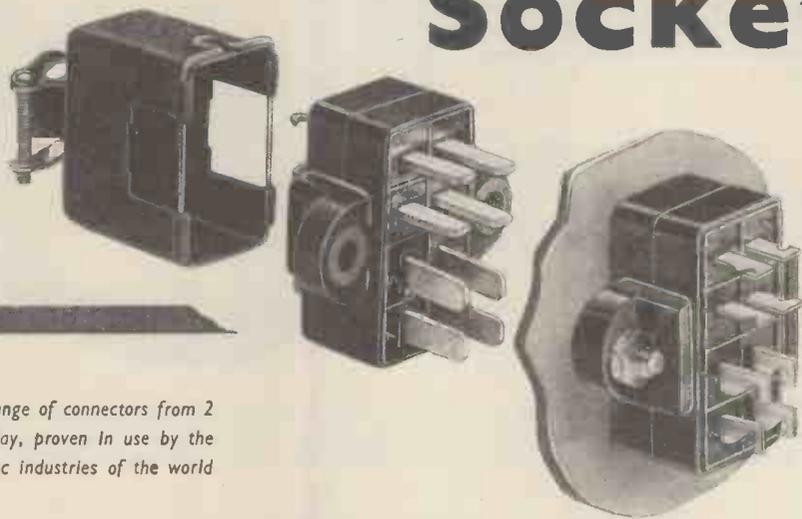
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## Electronic Components

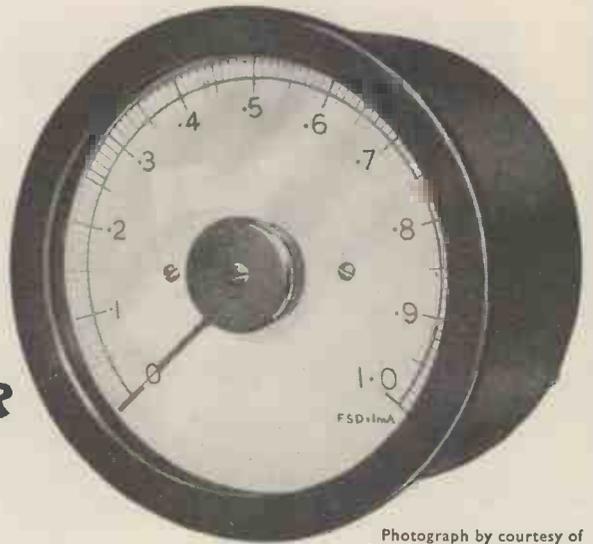
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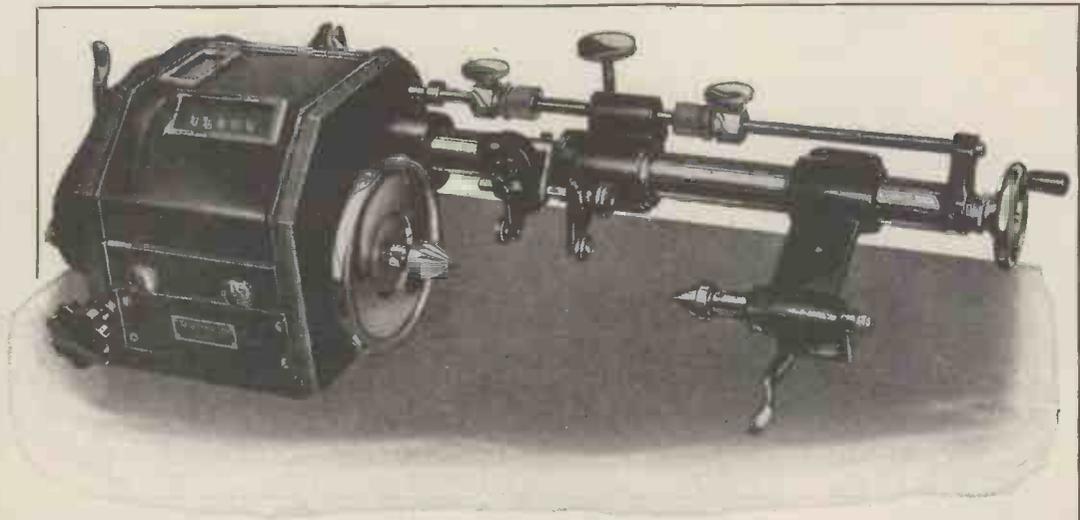


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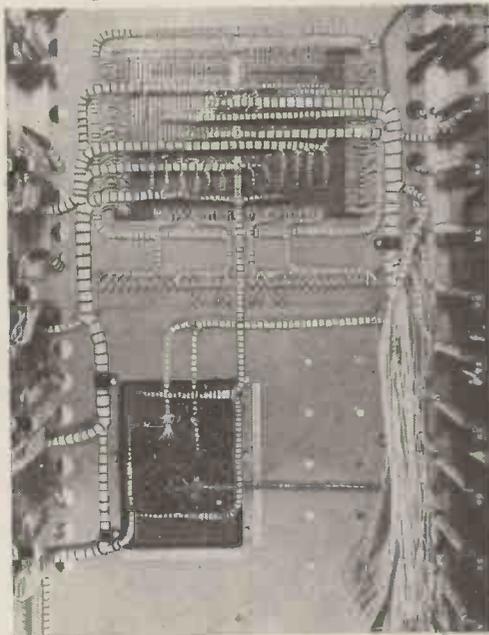
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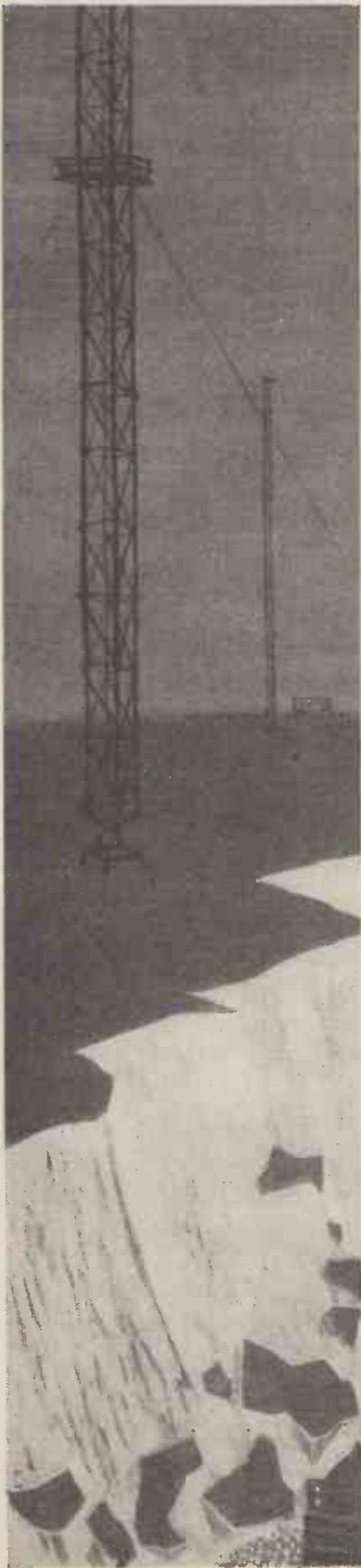
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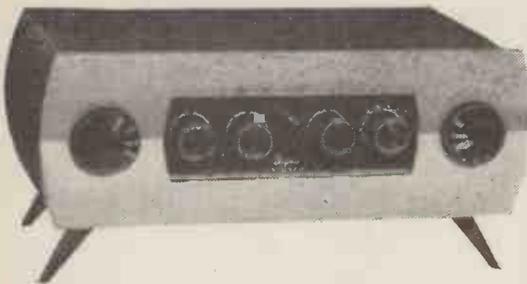
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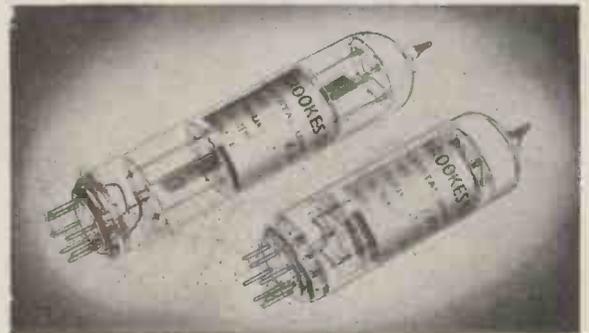
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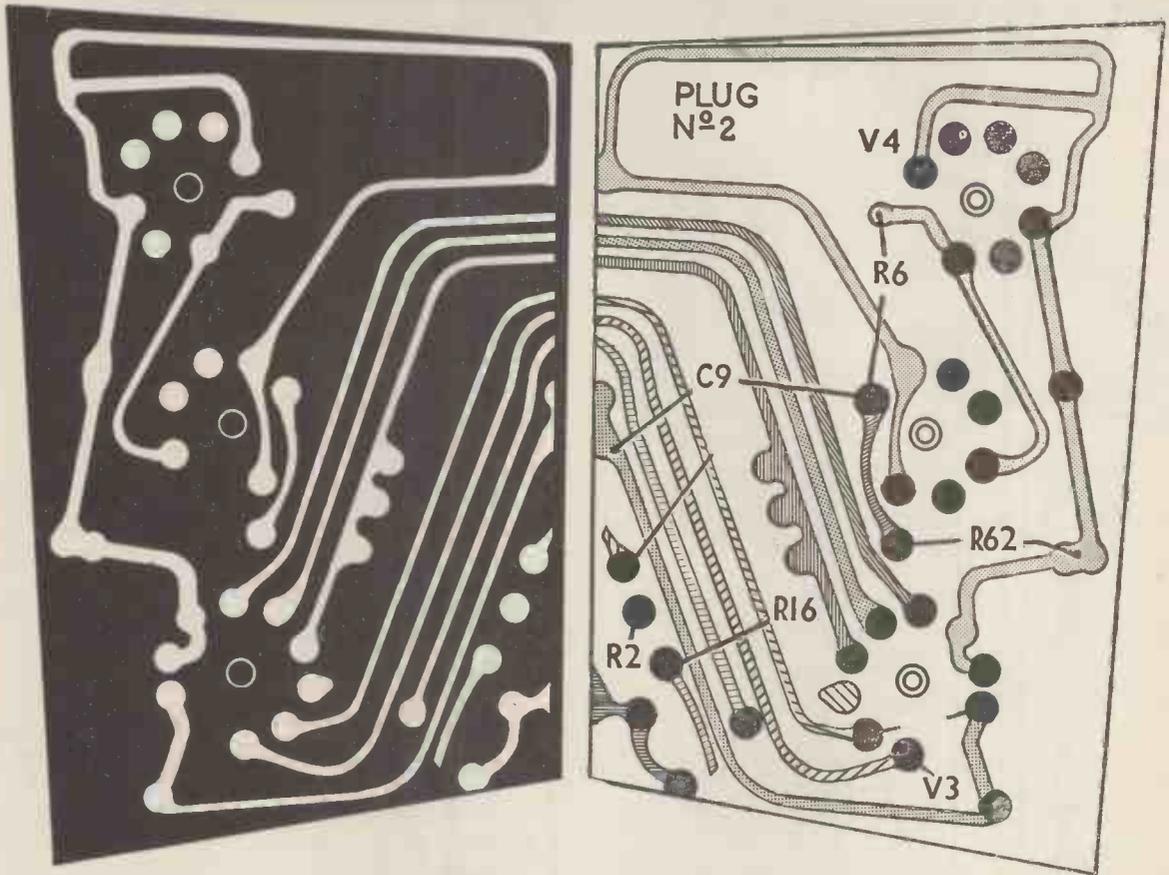
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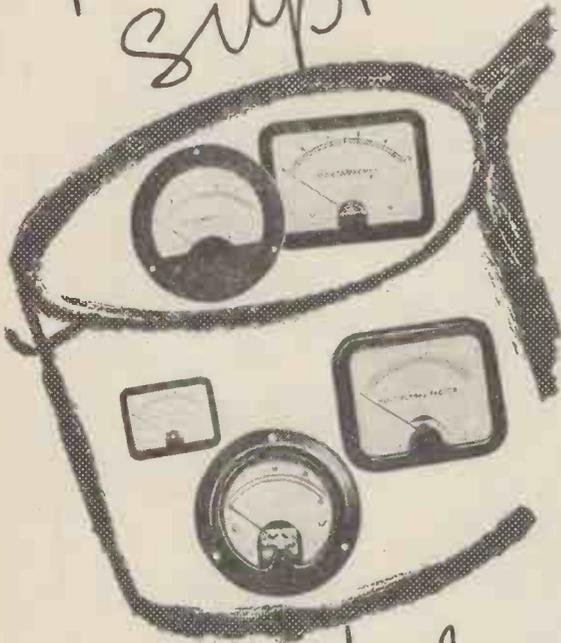
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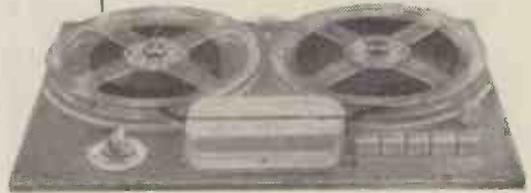
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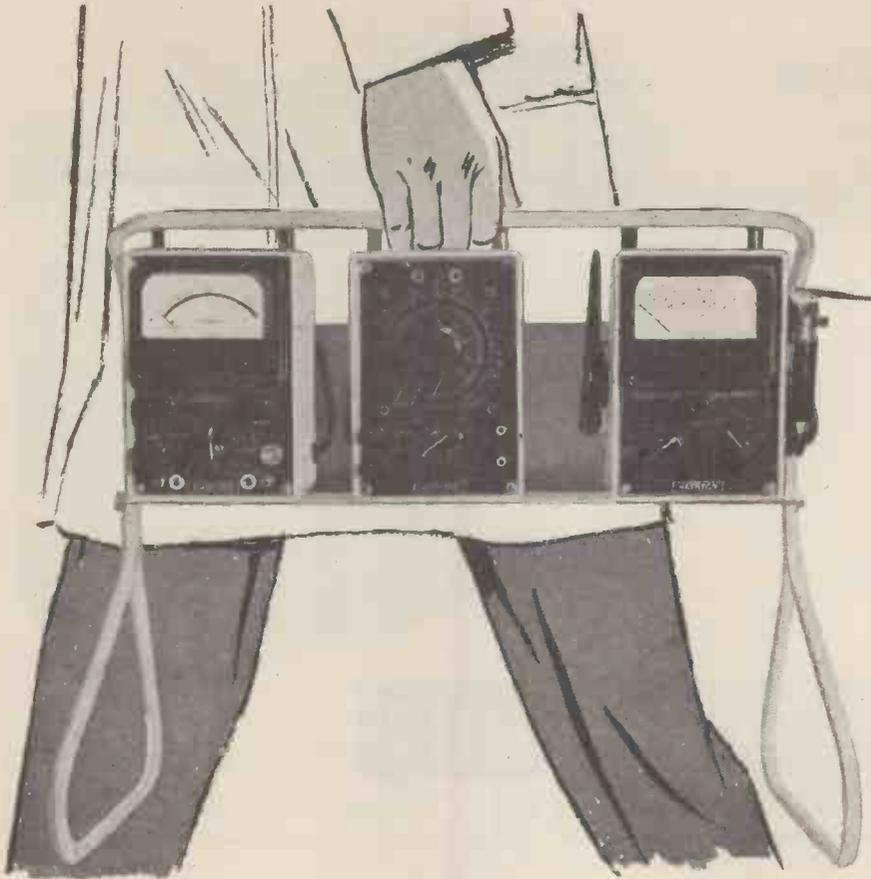


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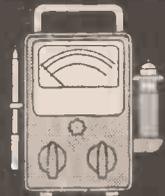
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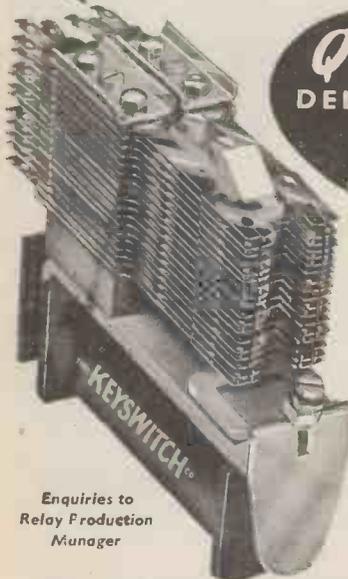
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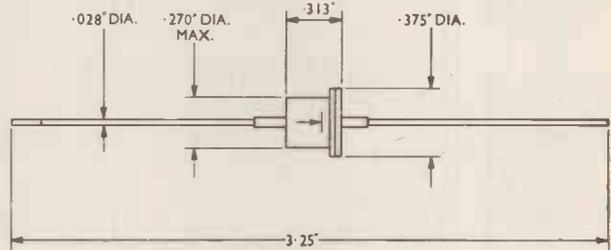
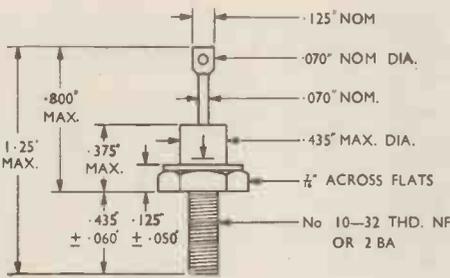
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# SIMET

## Silicon Rectifiers

### "G" Series 1N TYPES



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1N340	100	.2 @ 150°	.1 mA @ 150°	Stud	Mag. Amp.	
1N342	400	.2 @ 150°	.5 mA @ 150°	Stud	Power Supply	
1N440	100	.30 @ 100° .15 @ 125°	.30 μA @ 25°	Wired	Mag. Amp.	
1N441	200		.75 μA @ 25°	Wired	Mag. Amp.	
1N442	300		1.0 μA @ 25°	Wired	Mag. Amp.	
1N443	400		1.5 μA @ 25°	Wired	Mag. Amp.	
1N444	500		1.75 μA @ 25°	Wired	Mag. Amp.	
1N445	600		2.0 μA @ 25°	Wired	Mag. Amp.	
1N530	100		3.0 μA @ 25°	Wired	Power Supply	
1N531	200		7.5 μA @ 25°	Wired	Power Supply	
1N532	300		10 μA @ 25°	Wired	Power Supply	
1N533	400		15 μA @ 25°	Wired	Power Supply	
1N534	500		17.5 μA @ 25°	Wired	Power Supply	
1N535	600		20 μA @ 25°	Wired	Power Supply	
1N550	100		.5 μA @ 25°	Stud	Gen. Purpose	
1N551	200		1.0 μA @ 25°	Stud	Gen. Purpose	
1N552	300		.5 @ 100°	1.5 μA @ 25°	Stud	Gen. Purpose
1N553	400	.4 @ 125°	2.5 μA @ 25°	Stud	Gen. Purpose	
1N554	500	.25 @ 100° .25 @ 100°	3.5 μA @ 25°	Stud	Gen. Purpose	
1N555	600		5.0 μA @ 25°	Stud	Gen. Purpose	
1N560	800		15 μA @ 25°	Wired	Power Supply	
1N561	1000		20 μA @ 25°	Wired	Power Supply	
1N562	800		.4 @ 100°	15 μA @ 25°	Stud	Power Supply
1N563	1000		.4 @ 100°	20 μA @ 25°	Stud	Power Supply
1N1100	100		.25 @ 150°	.2 mA @ 150°	Wired	Gen. Purpose
1N1101	200			.2 mA @ 150°	Wired	Gen. Purpose
1N1102	300			.2 mA @ 150°	Wired	Gen. Purpose
1N1103	400			.2 mA @ 150°	Wired	Gen. Purpose
1N1104	500	.2 mA @ 150°		Wired	Gen. Purpose	
1N1105	600	.2 mA @ 150°		Wired	Gen. Purpose	

\* Maximum reverse currents indicated in milliamperes (mA) are averaged over one full cycle, inductive or resistive load with rectifier operating at rated current. Where maximum reverse currents are expressed in microamperes (μA), these are measured by the direct current volt-ampere method.

For the convenience of engineers accustomed to specifying rectifiers from the "1N" notation, the types listed here are covered by the regular "G" series range now in regular production.

Full details of the "G" series and all other Simet silicon rectifiers are obtainable on request. In addition, we would be pleased to include you on our mailing list to receive information on all new types as they are introduced.

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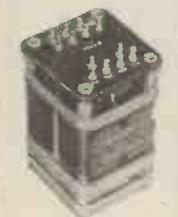
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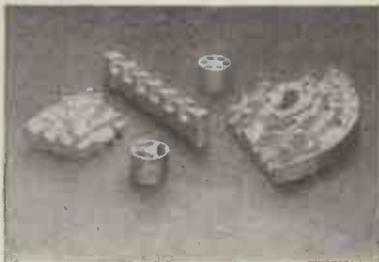
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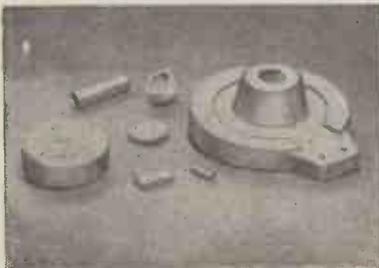


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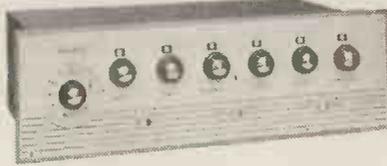
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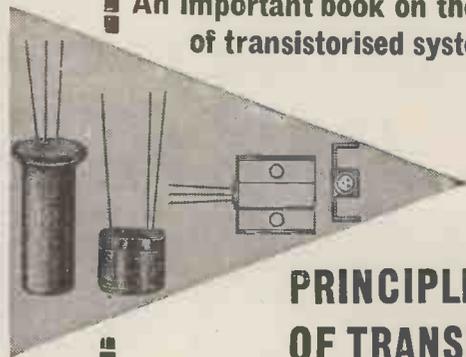
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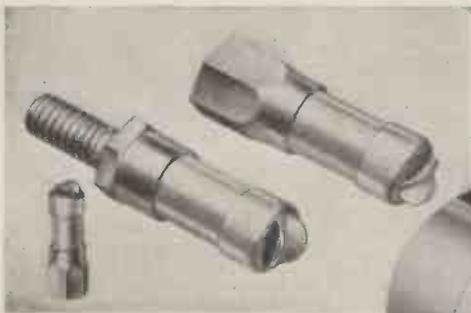
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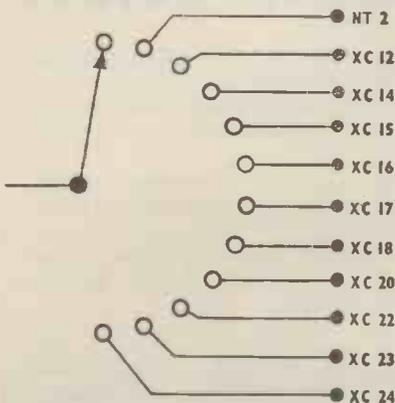
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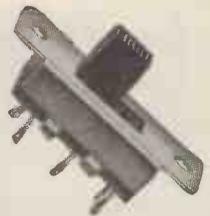
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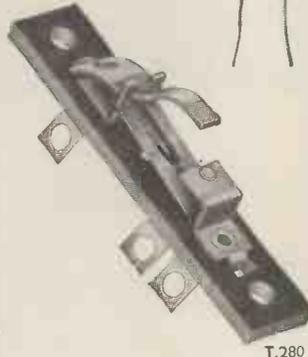
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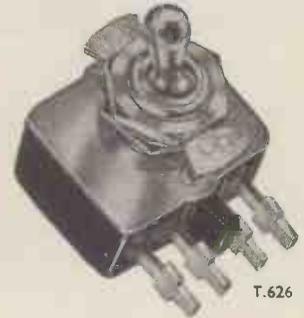
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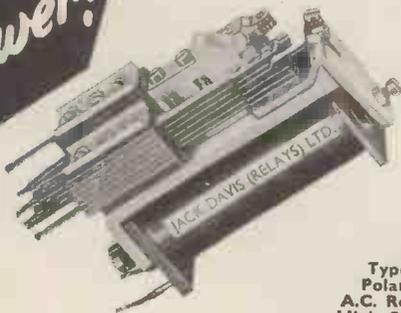
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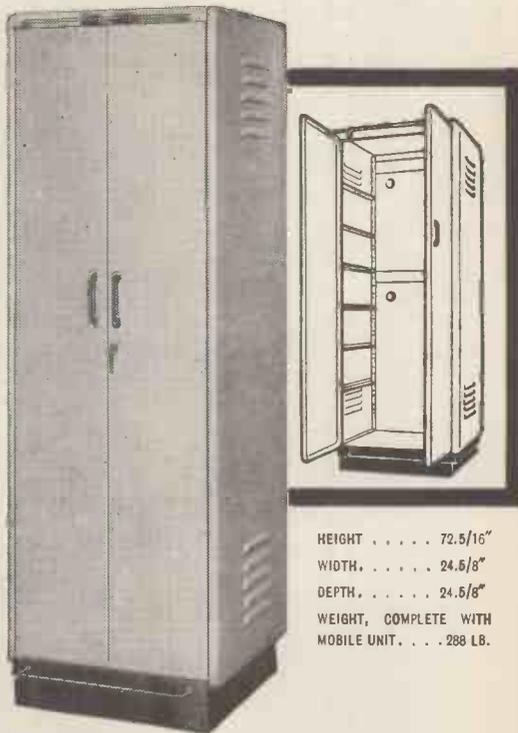
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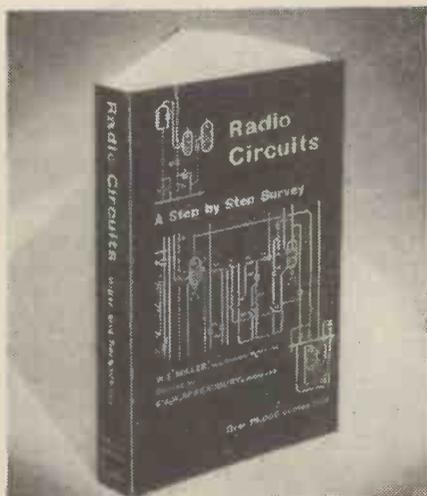


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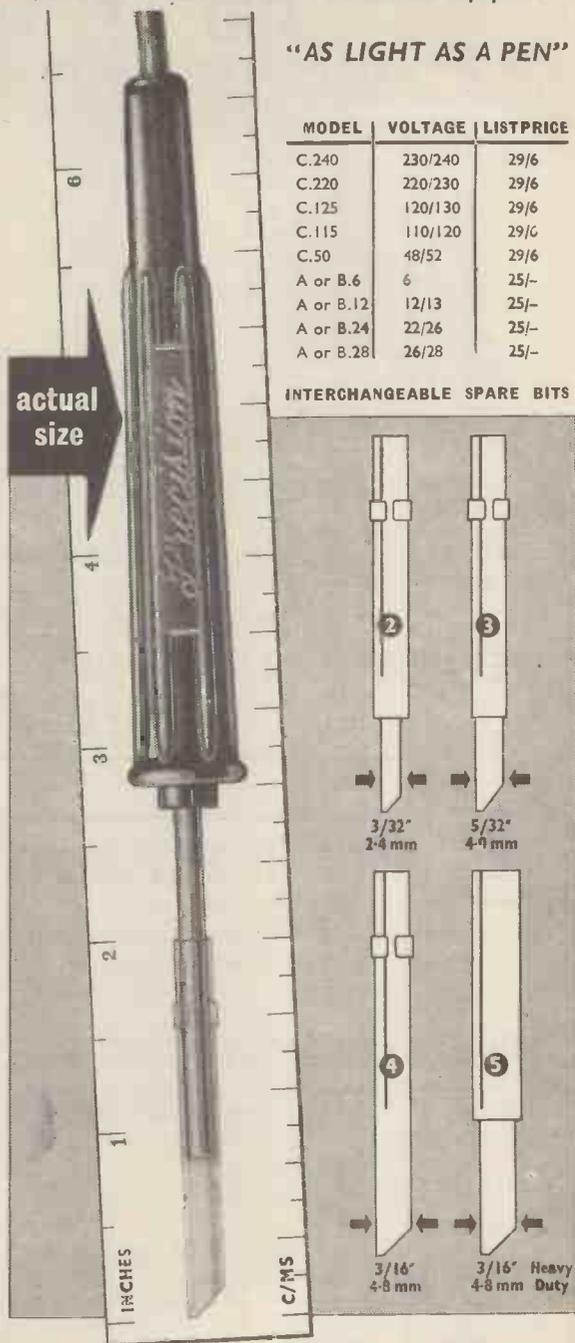
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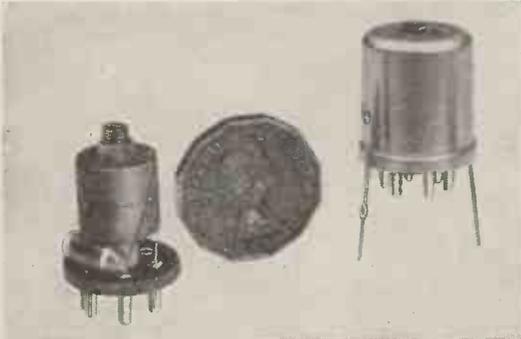
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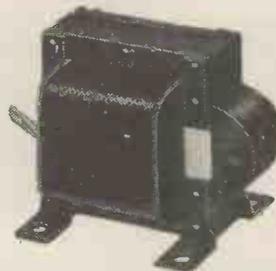
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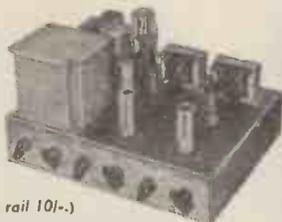
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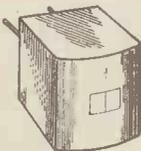
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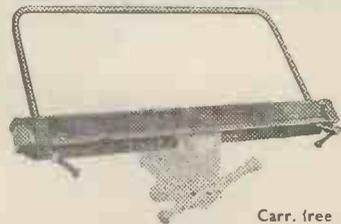
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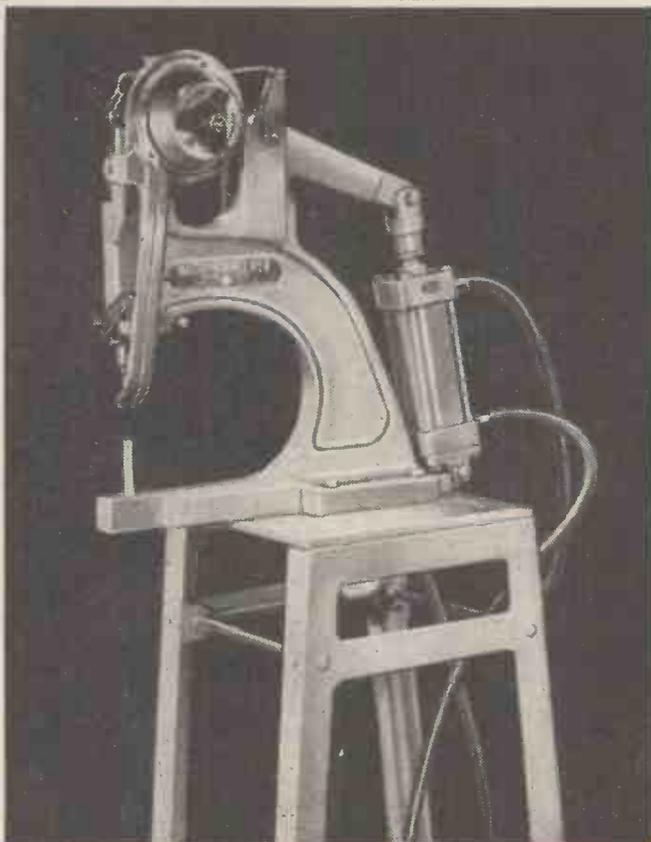
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ELECTRONICS, RADIO, TELEVISION

JUNE 1959

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255	Editorial Comment	
256	Ferroelectrics—1	By J. C. Burfoot
260	Improved Audio Input Circuit	By R. C. Marshall
262	Sporadic 'E' and the F <sub>2</sub> Layer	By T. W. Bennington
264	Simple Oscilloscope Camera	By A. J. Key
266	World of Wireless	
267	Personalities	
269	Pickup Arm Design	By J. Walton
272	Displaying Valve Characteristics	By R. G. Christian
274	Feedback Amplifiers as Filters	By Thomas Roddam
276	Elements of Electronic Circuits—3	By J. M. Peters
279	Magnetic Matrix Stores	By W. A. Cole
283	Letters to the Editor	
285	R.H.F.	By "Cathode Ray"
289	Electronics and the Phonetician	By H. J. F. Crabbe
294	Technical Notebook	
296	Manufacturers' Products	
299	New Marine Radar	
300	News from the Industry	
302	Random Radiations	By "Diallist"
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Transistor

Automatic-keying Circuit

Various modulation arrangements can be used with the 500kc/s marine-distress transmitter (see previous advertisement). For c.w. operation a morse key can be connected in series with the base winding of the modulator transistor, together with an r.f. choke and a bypass capacitor to prevent r.f. voltages floating across the key.

Low-power modulation is used for radio telephony. The modulator transistor is biased into Class C operation, using a parallel CR combination, to a point where the output of the transmitter falls to half its normal value, and an a.f. signal is applied across the bias resistor.

The circuit shown here is for an automatic-keying device which generates the distress signal. A time interval of 0.1 sec was chosen for the duration of a dot and for the interval between successive dots or dashes. The duration of a dash is then 0.3 sec.

Transistors Tr1 and Tr2 form the dot multivibrator and the Tr2, Tr3 combination is the dash multivibrator. As the spacing between dots is the same as the spacing between dashes, no gate is required for mixing and so the output can be taken from the collector of Tr2, the common transistor.

To square-off the waveform of this output an emitter follower Tr4 is added. The output from Tr2 is inverted by Tr13 to the negative-going pulses required for keying the transmitter. A positive line is provided for the combined multivibrator by connecting the three emitters to a suitably decoupled resistor R2. This ensures that the appropriate transistor (Tr1 or Tr3) is definitely cut off by the sequence multivibrator which acts as an on-off switch in the base leads of Tr1 and Tr3.

This multivibrator consists of transistors Tr6 and Tr7, which conduct alternately, switching the supply voltages across the base resistor R7 and R6 respectively. When Tr6 is on, Tr5 is off and the voltage across R9 (approximately  $V_{cc}$ ) appears across R7, the base resistor of Tr1, and three dots are generated. The timing of this sequence is mainly governed by the combination C9R11.

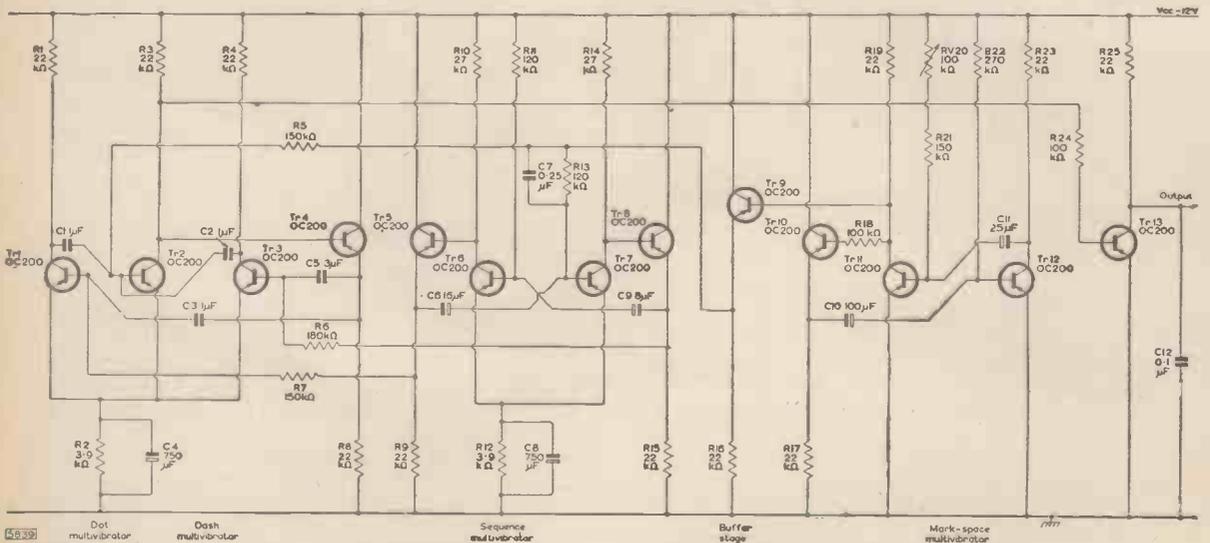
The capacitor C7 reduces the switch-on time of transistor Tr7. If it is omitted, the inhibiting signal from Tr7 does not reach the dash multivibrator soon enough and a spurious

dash precedes the dot-dash sequence. When Tr7 is on, Tr8 is off, the supply voltage appears across R6, and Tr3 generates three dashes. Transistors Tr5 and Tr8 are emitter followers which square-off the collector waveforms from Tr6 and Tr7. The sequence multivibrator is in turn controlled by the mark-space multivibrator by connecting R13, the base-feed resistor to Tr7, across the emitter load of Tr9. The mark-space multivibrator is the only free-running one in the whole circuit. It controls the whole automatic timing circuit. Tr10 is an emitter follower which squares-off the collector waveform of Tr11. A buffer stage, Tr9, is required to reduce interaction between the mark-space multivibrator and the previous stage.

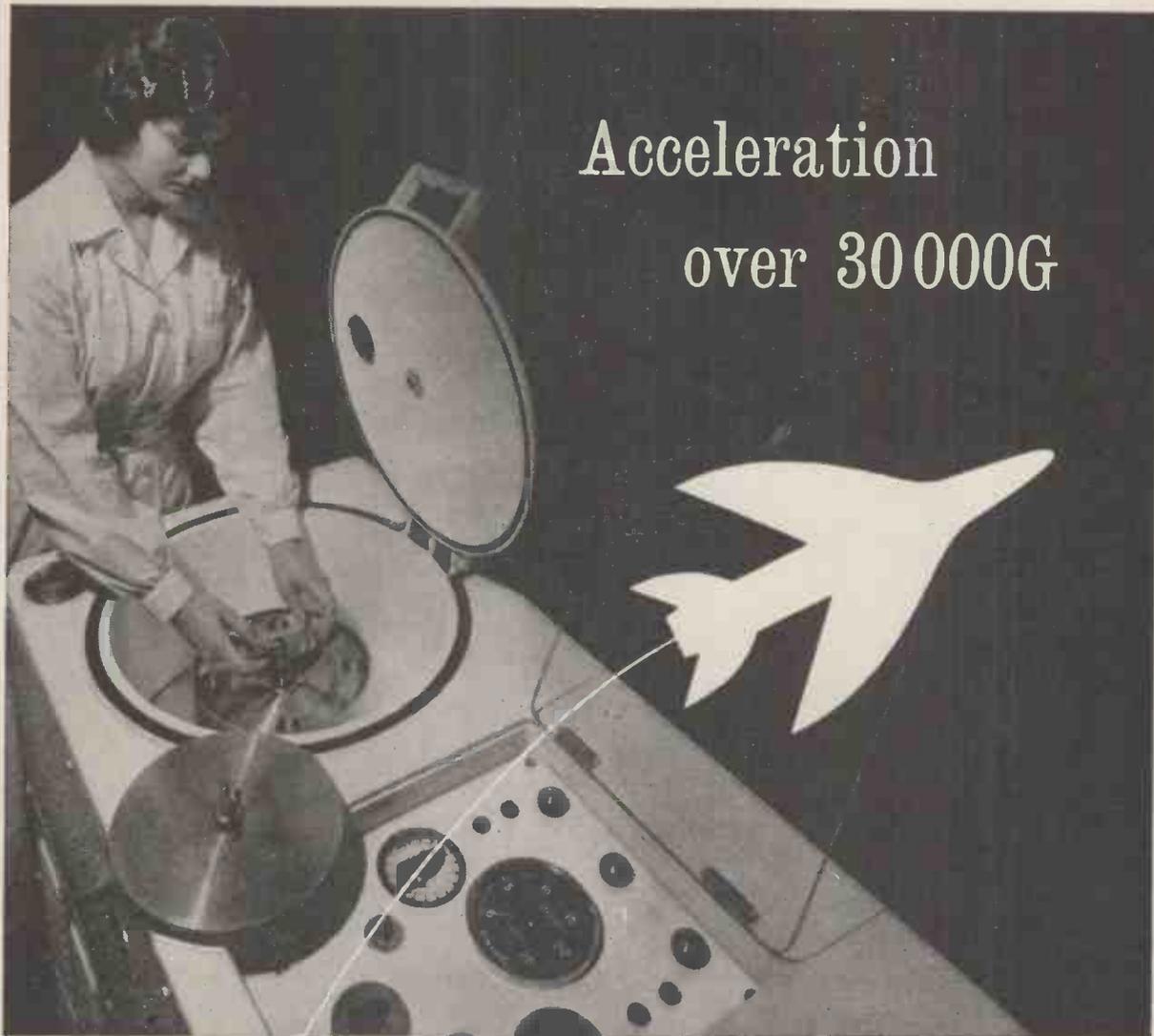
The resistor R18, in the base lead of Tr10, is necessary to prevent pulses, fed back from the sequence and dot-dash multivibrators, triggering the mark-space multivibrator. It also reduces the voltage developed across the emitter resistor, R17, thereby reducing the on-period of Tr11. This time can be easily adjusted because it is the off-period for the complete timing circuit. If R22 is 270kΩ and C10 is 100 μF, the space period between signals is about 15 sec.

Some of the timing components need careful selection; all the resistors for these circuits should be of high stability, and the capacitors should have low leakage currents. These capacitors should preferably be metallised paper types (C1, C2, C3, C5, C7, C12), and tantalum electrolytic for the others. All the transistors operate at less than 500μA per stage; the total current drain from a 12V battery is about 4mA. The circuit operates satisfactorily with supplies down to about 10V, and over a range of temperature from 0 to 60°C. Taking into account the on-off power ratio of the combination of transmitter and keying circuit, a life of 50 hours can be expected from a 4 ampere-hour accumulator.

It cannot be emphasised too strongly that indiscriminate transmission of the international distress signal, whether licensed or not, is very undesirable. However, the principles of the design described can be used for the automatic keying of any morse signal, such as a call sign, by suitable adjustment of the timing components.



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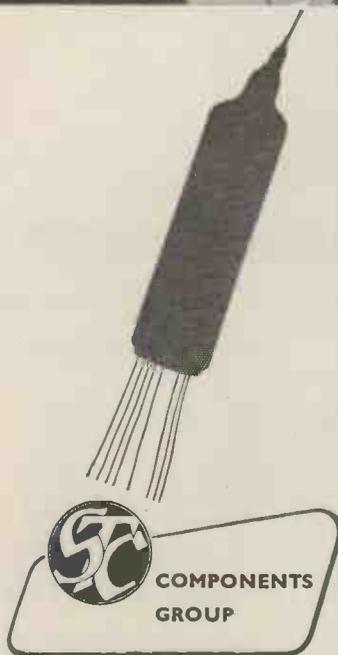
**better make it**

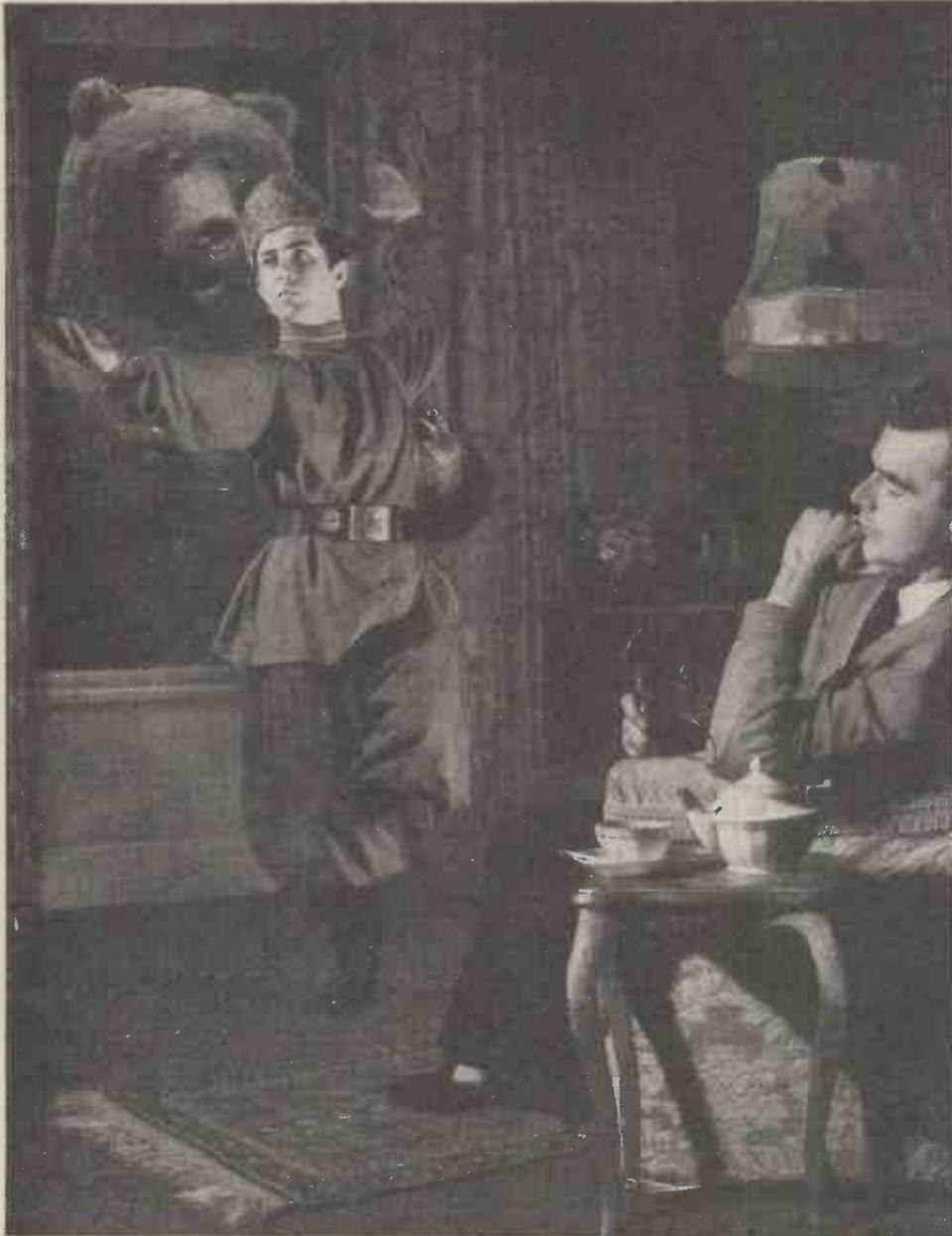


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**"BELLING-LEE" NOTES**

**PARAMETERS OF DESIGN**

**Some problems of sealing**

*No. 6 of a series*

Towards the end of the last article we implied that it was relatively easy to seal a can, but the difficulty arose when you tried to take some leads through it, and keep the container sealed indefinitely. Various synthetic rubbers have been tried with varying degrees of success provided the correct form and the most suitable grade have been chosen for a particular application, e.g. high temperature, oil resistant, etc.

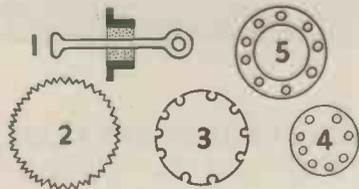
Metallized ceramic has been used for quite a long time, but present designs are not as popular as they used to be and further development work is being carried out.

There are several types of glass to metal seals, some using too costly materials, some suitable only for small metal-glass interface, some too fragile. Glass to metal seals can be divided into two main groups, matched and compression.

A matched seal is where the coefficient of expansion of the glass and metal parts is matched. Such a seal can generally withstand a greater thermal shock i.e. sudden extreme changes of temperature, as when a soldering iron is applied to a centre conductor (1). In a matched seal, the metal parts can be thin, as they are not under tension but it is not so strong mechanically as a compression seal. Those manufactured by us, in general, stand up to the required specifications.

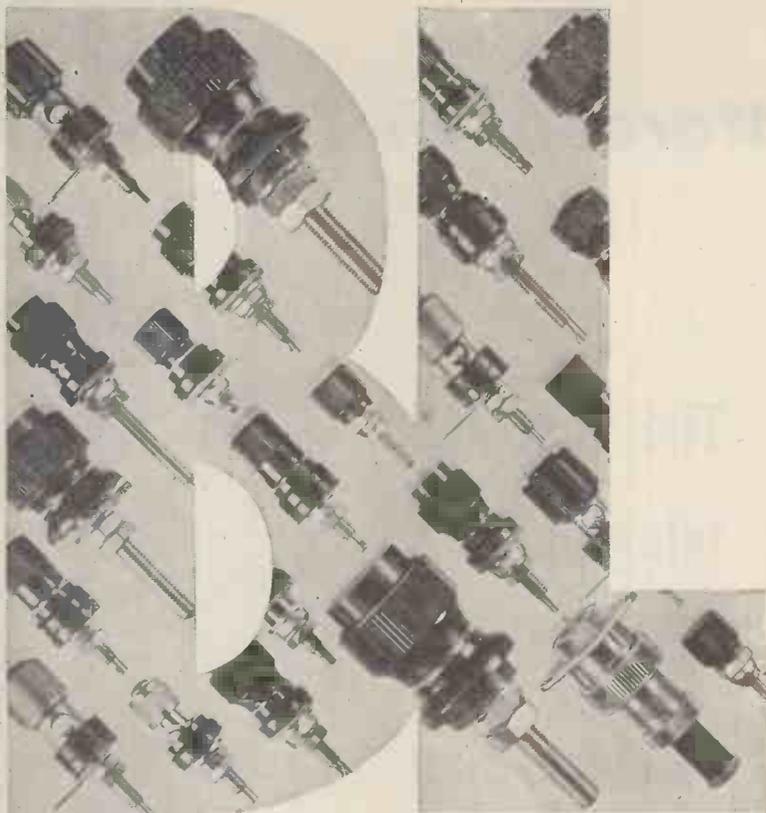
There are two tests (a) temperature cycling from  $-65^{\circ}\text{C}$  to  $+20^{\circ}\text{C}$  then to  $150^{\circ}\text{C}$  and in reverse several times (b) thermal shock, out of freezing water into boiling water and in reverse several times. In some cases the seals must withstand plunging into molten tin for tin-dipping.

There is an interesting mechanical problem in the drawing down of wire or tubing to be used as a conductor through a seal. Such a wire is reduced many times and is scored in the process. Such scores are small grooves (2), and these may be closed in during subsequent reduction stages, forming microscopic pipes or capillary tubes (3 and 4). Thus, an apparently solid wire can, in fact, be porous along its length, and the same problem can occur in the walls of a tube (5). More about this next month.



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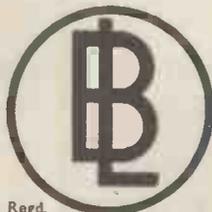


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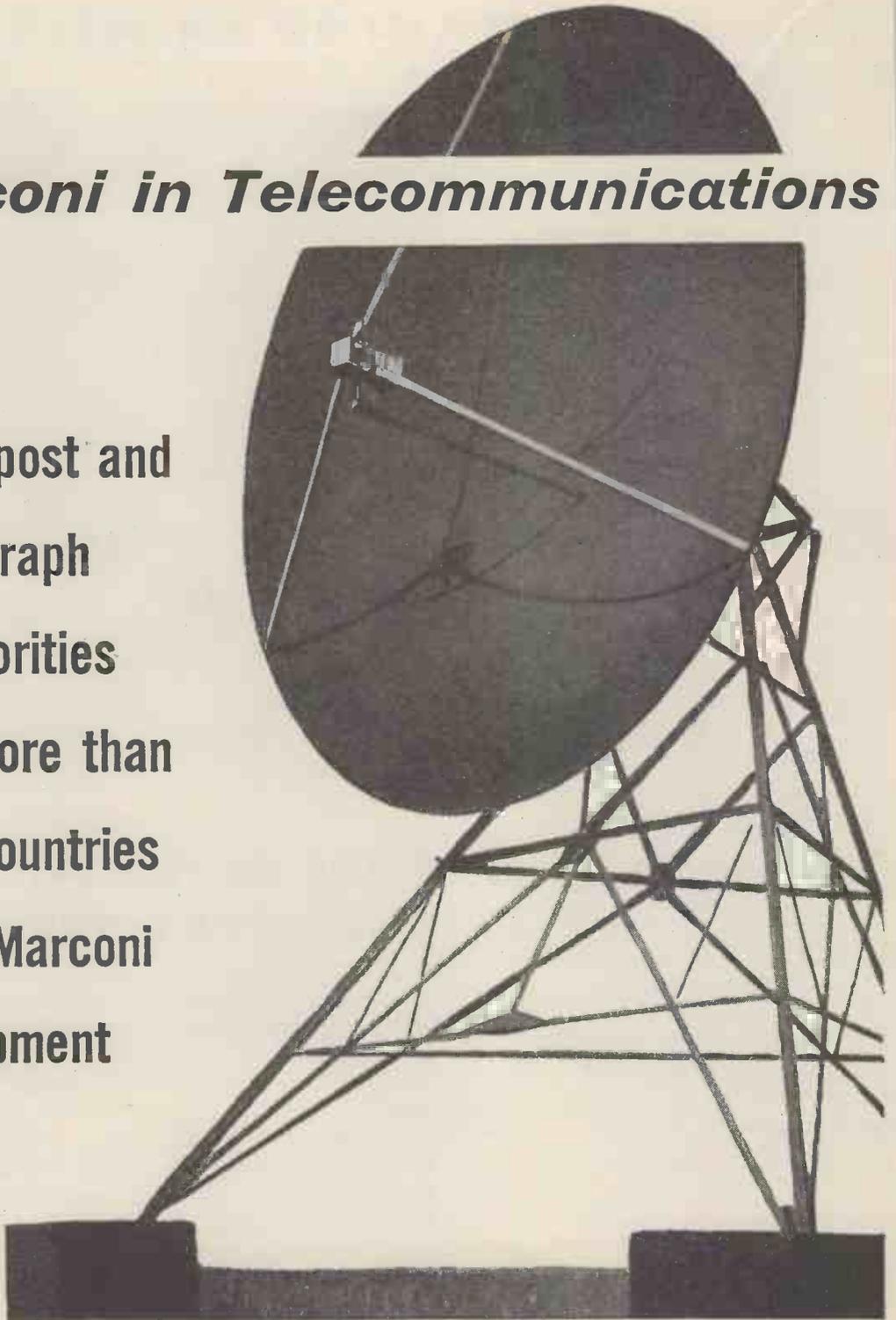
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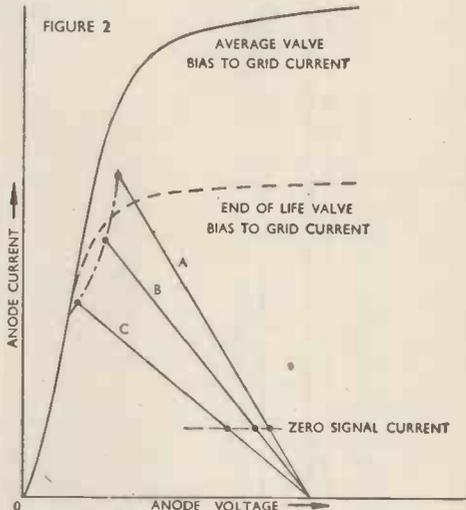
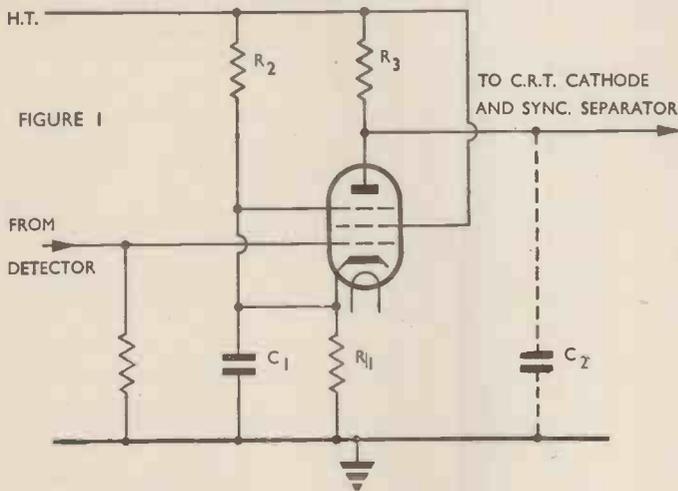
# Aspects of design

# 12 VIDEO AMPLIFIERS

This is the twelfth of a series of special features dealing with advanced problems in television and radio circuit design to be published by Siemens Edison Swan. The Ediswan Mazda Applications Laboratory will be pleased to deal with any questions arising from this or other articles, the thirteenth of which will appear in the July 1959 issue.

Among the factors to be considered in designing a video amplifier for a television receiver are several in which the characteristics of the valves and cathode ray tubes are involved. The requirements and limitations imposed by the normal spread in these characteristics and their change during life are discussed in the following paragraphs in relation to a circuit designed to drive the cathode of the cathode ray tube. A simplified diagram is shown in Figure 1.

If a low resistance,  $A$ , is chosen, the required output may not be obtainable without driving the valve to a high grid current, resulting in clipping by reduction of the effective load of the preceding diode detector. This effect will become more apparent as the available peak current of the valve falls during life. On the other hand, a high anode load resistance,  $C$ , can also result in clipping or inversion of highlights when the voltage is driven below the "knee" of the anode characteristics. The correct choice,  $B$ , is the lowest resistance which will give a peak anode current within the capabilities of the valve throughout its life and allow a margin for spread of knee characteristics and tolerances on both the anode and bias resistances.



### ZERO SIGNAL BIAS CONDITIONS

The cathode bias voltage should be arranged so that, with zero grid signal, the anode current is low. The working point should, however, not be down in the very curved part of the anode current/grid voltage characteristics or compression of the synchronising pulse amplitude will occur and will tend to become more pronounced during the life of the valve. For valve types such as the Ediswan Mazda 6F23, 30F5 and 30FL1, a zero signal anode current of 4-5 mA is generally satisfactory.

Unless some of this bias voltage is derived by means other than cathode current feedback, the gain of the amplifier will be very low. The usual method is to drain current from the H.T. supply through a resistance,  $R_3$ , compromising at about the same value as the cathode current. This retains a cathode resistance,  $R_1$ , large enough to use conveniently for H.F. compensation and does not require an expensive component for  $R_3$ .

### CATHODE RAY TUBE DRIVE

During the life of a cathode ray tube, its emission tends to fall until it is necessary to drive it to near zero voltage between grid and cathode to obtain adequate highlight brightness. At this end-of-life condition, a picture signal of up to 70 volts peak may be required when the spread of raster cut-off voltage is considered. This corresponds to a peak-to-peak video signal, including synchronising pulses, of 100 volts. Thus, to ensure full use of the cathode ray tube, it is desirable that the video amplifier should be capable of delivering this output voltage when required.

### CHOICE OF ANODE LOAD

From the point of view of frequency response a low anode load resistance,  $R_3$ , is desirable, but the choice of values is restricted by the maximum output voltage requirement and the characteristics of the valve, as is shown in Figure 2. Load lines are drawn, each showing a peak swing of 100 volts from the zero signal condition, thus determining a locus of peak anode current against minimum anode voltage.

### H.F. COMPENSATION

The previous paragraphs have considered the design almost entirely at low frequencies. The effective capacity,  $C_2$ , at the anode due to the loading of the cathode ray tube, synchronising pulse separator and other circuits results in a loss of gain at higher frequencies. As long as the time constant  $C_2 R_3$  is not excessive, an adequate bandwidth can be obtained by reducing cathode feedback at higher frequencies. For optimum compensation,  $C_2 R_3$  should be approximately equal to  $C_2 R_1$ , but experimental adjustment on a test picture is the simplest method.

### PRACTICAL DESIGN

From the considerations discussed above it will be obvious that the problem of obtaining sufficient maximum video drive for the cathode ray tube becomes increasingly more difficult as the H.T. supply voltage is reduced. Satisfactory component values for use with valve types 6F23 and 30F5 from an H.T. supply voltage of 190 volts are as follows:—

- $R_1$  270 ohms  $\pm$  5%
- $R_2$  33,000 ohms  $\pm$  10%
- $R_3$  8,200 ohms  $\pm$  10%

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### Tentative Ratings and Characteristics

#### MAXIMUM DESIGN CENTRE RATINGS

Anode Dissipation (watts)	$P_a(\max)$	3*
Screen Dissipation (watts)	$P_{g2}(\max)$	1*
Anode Voltage (volts)	$V_a(\max)$	250
Screen Voltage (volts)	$V_{g2}(\max)$	250
Heater to Cathode Voltage (volts r.m.s.)	$V_{h-k}(\max)$ r.m.s.	200**

\*With a grid to cathode circuit resistance not exceeding 10,000 ohms.

\*\*Measured from cathode to higher potential heater pin.

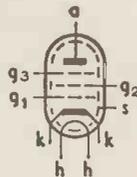
#### INTER-ELECTRODE CAPACITANCES (pF)†

Grid 1 to Earth	$C_{10}$	9.0
Anode to Earth	$C_{0a}$	3.7
Grid 1 to Anode	$C_{g1-a}$	0.007

†Measured in fully shielded jig, without can.

#### MAXIMUM DIMENSIONS (mm)

Overall Length	67.5
Seated Height	60.5
Diameter	22.2



#### TYPICAL OPERATION

Anode Voltage (volts)	$V_a$	170
Screen Voltage (volts)	$V_{g2}$	170
Self Bias Resistance (ohms)	$R_k$	150
Anode Current (mA)	$I_a$	10
Screen Current (mA)	$I_{g2}$	2.6
Mutual Conductance (mA/V)	$g_m$	9.2
Inner Amplification Factor	$\mu_{g1-g2}$	64
Equivalent Grid Noise Resistance (ohms)	$R_{eq}$	670
Input Loss at 38 Mc/s (ohms)	$r_{g1-k}(W)$	8500*
Input Capacity Working (pF)	$C_{in}(W)$	12.1† $\Delta$
Change in Input Capacity produced by biasing valve to cut-off (pF)	$\Delta C_{in}(W)$	2.45 $\Delta$
Figure of Merit (Valve only) (Mc/s)		210†
Effective Figure of Merit (Valve and Circuit) (Mc/s)		130

\*The two cathodes strapped and joined directly to earth.

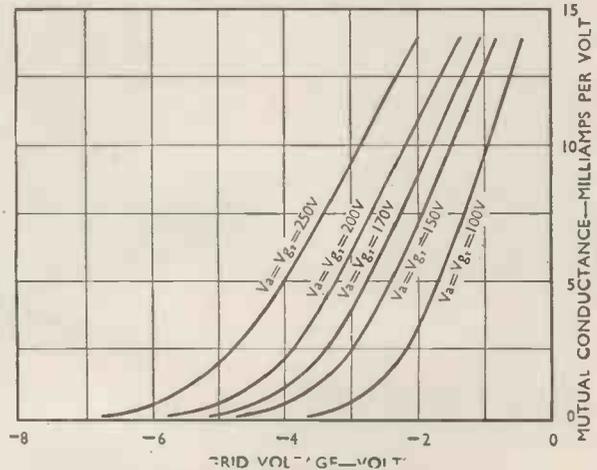
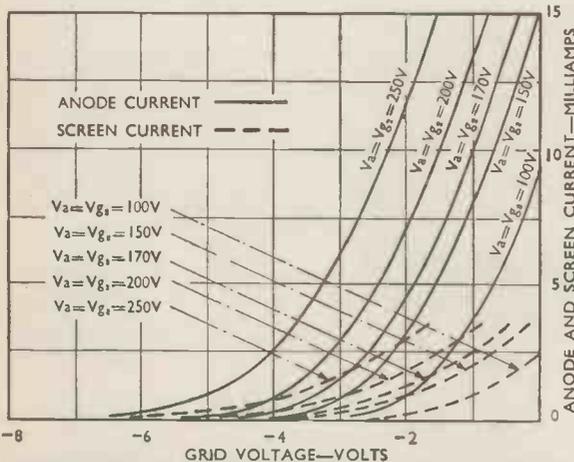
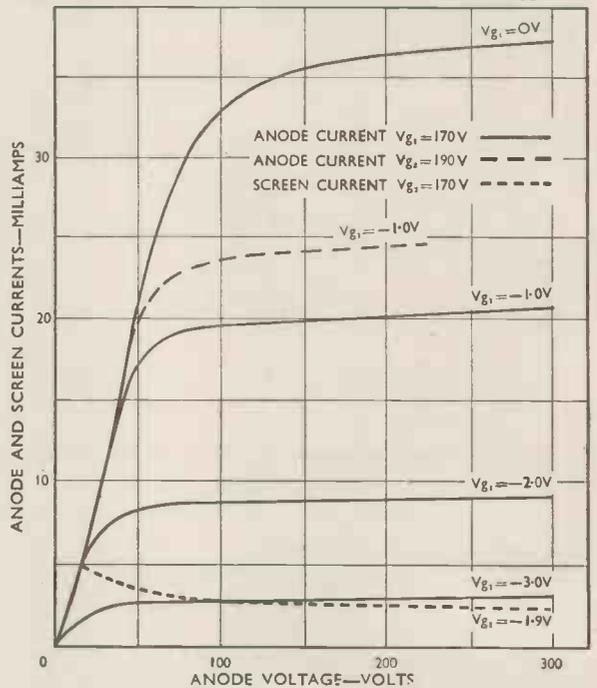
$\Delta$  Measured at 38 Mc/s.

†Inter-electrode capacity with holder capacity balanced out.

‡Given by  $\frac{g_m \times 10^3}{2\pi \sqrt{C_{in} C_{out}}}$  See "Aspects of Design" Article 1 for further details.

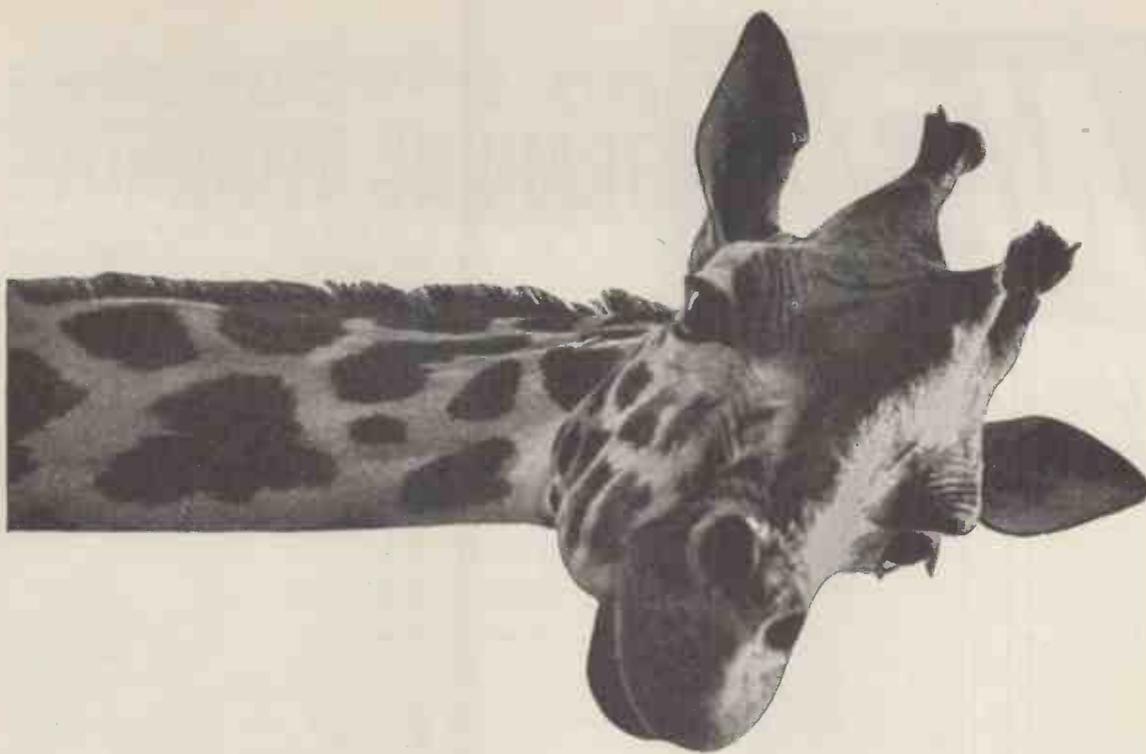


Tentative Characteristic Curves of Ediswan Mazda Valve Type 6F23



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I <sub>c</sub> (pk)(A)	—	I					I		
V <sub>ce</sub> (pk)(V)	15	15	15	30*	30*	30	15	30*	40*
	GET106	GET114	GET113‡	GET103	GET102‡	GET104	GET115	GET116	GET105

‡ New high gain types \* Re/R<sub>b</sub>>0.03 † Can be supplied in matched pairs

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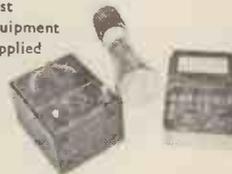
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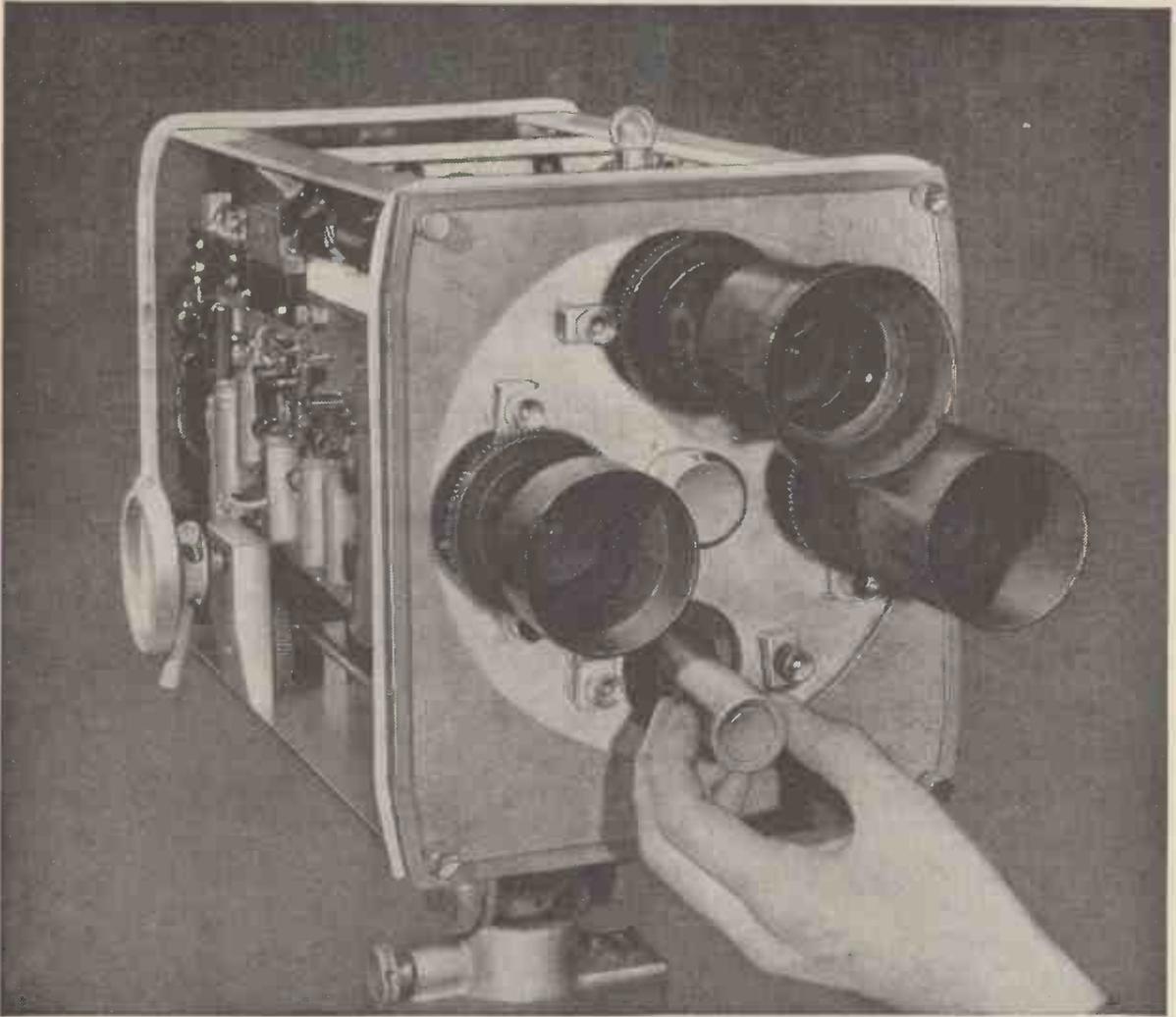
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Camera Type 201 with panels removed illustrating accessibility

# EMI

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Known as the Type 201, the new camera channel utilises printed circuits and plug-in techniques to reduce size and weight to a minimum.

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The Type 201 camera channel has already been ordered by broadcasting organisations in the United Kingdom and overseas.

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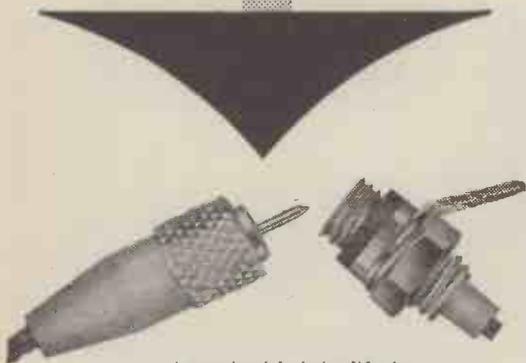
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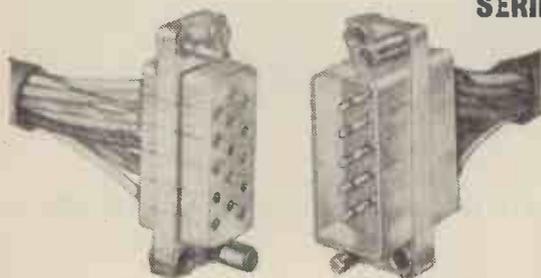
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*For further information, please write for Publication numbers 128 and 114.*

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- It is completely stable with any type of load and may be used to drive motors or other devices to over 120 watts at frequencies from 20,000 down to 30 cps in standard form or other frequencies to order. The distortion is less than 0.2% and the noise level -95 db. A floating series parallel output is provided for 100-120 V. or 200-250 V. and this cool running amplifier occupies 12½ inches of standard rack space by 11 inches deep. Weight 60lb.

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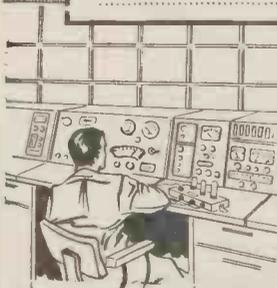
If NO we will send you full particulars of our amplifiers.

If YES we will make sure we have your name on our mailing list for details of our new stereo amplifiers and future products.

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WW/6/59



Leak amplifiers were the first in the world to be marketed with a distortion content as low as 0.1%, a claim received with incredulity in 1945 but which was subsequently confirmed by the National Physical Laboratory and has since become an accepted world-wide standard.

LEAK amplifiers are the choice of professional engineers such as the B.B.C. (over 500 delivered), the South African Broadcasting Corporation (600), ITV and many other Commonwealth and overseas broadcasting and TV systems, who use them for transmitting and/or monitoring (quality checking) the broadcasts to which you listen.

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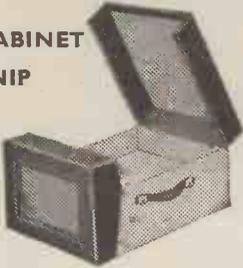
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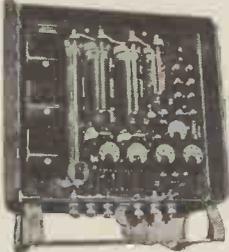
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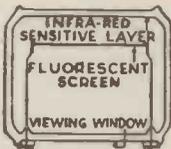
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A pocket size meter but with a big scale and a sensitivity of 20,000 ohms per volt D.C., therefore an ideal unit for television servicing—robustly made and complete with leads and prods—20 ranges as follow:—  
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**TRANSISTOR SET  
As featured on B.B.C. Television**

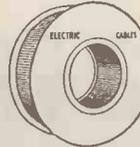
All parts available—total cost, including two transistors, with copy of circuit diagram and instructions. 22/19/6. Postage 2/- extra.

**—THIS MONTH'S SNIP—  
American Receiver C646068**



This is a 12 valve receiver originally designed for military operation on the 60-80 mc. band. One stage of R.F. and three stages of I.F. with additional stages for noise suppression and A.V.C. make this an extremely versatile receiver, also crystal in oscillator provides highest stability. On the front panel are all controls and moving coil input and output meters. Complete with its own power supplies, these, however, are intended to operate on American Voltage 115 v. So with each receiver we supply a step down transformer. A limited quantity only of these offered at the extremely low price of 26/10/- Plus 12/6 carriage and packing. Size approx. 20in. x 9in. x 17in. Note: These sets are unused but have been in store for some years and may therefore require servicing before being put into operation. At the low price charged we cannot test these nor do we give any guarantee. Complete with valves and one crystal. Circuit diagram and technical notes free with equipment or separately price 2/6.

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**W.D. Circuit Details**

Diagrams and other information extracted from official manuals. All 1/6 per copy. 12 for 15/-.

- |                           |                     |
|---------------------------|---------------------|
| A.1134                    | R.109               |
| BC.348                    | HERO Receiver       |
| BC.312                    | R29/ARC5            |
| R.103A                    | E1181A              |
| BC.342                    | RA-1B               |
| RA-1B                     | AR88D               |
| R-208                     | AN/APA-1            |
| R-1156                    | 78                  |
| R-1124A                   | 70                  |
| R-1132A/R-1481            | R.T.19              |
| R-1147                    | CAY-46-AAM-         |
| R-1234A                   | RADAR               |
| R-1082                    | A.S.B.-3            |
| R-1355                    | Indicator 62A       |
| B.C.1206-A/B              | Indicator A.S.B.3   |
| B-45-A (or -B)            | Indicator 62        |
| B-45-A (or -B)            | Indicator 6K,       |
| B-45-M-A (or -B)          | R.F. unit 24        |
| Transmitter T1184         | R.F. unit 25        |
| Fifty-eight walkie talkie | R.F. unit 26        |
| Frequency meter           | R.F. unit 27        |
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|                           | Demobbed valves     |

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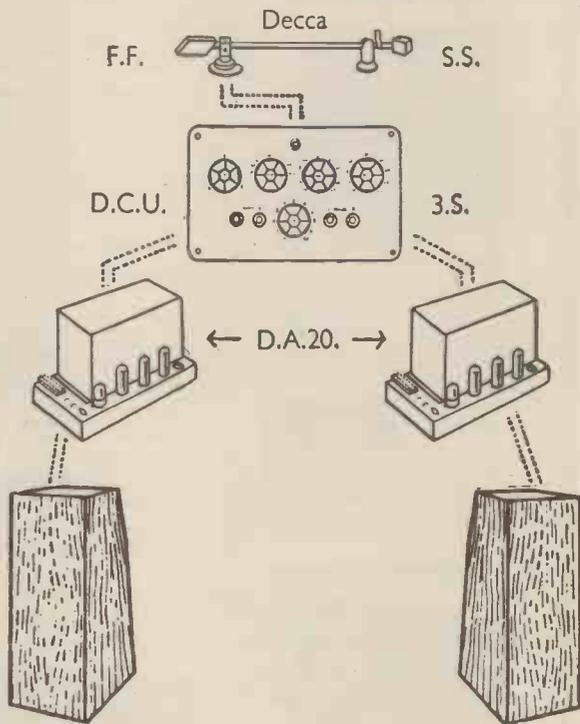
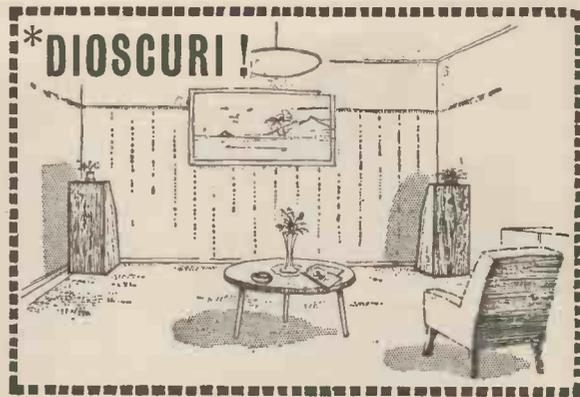
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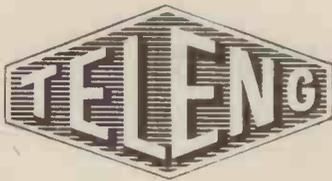
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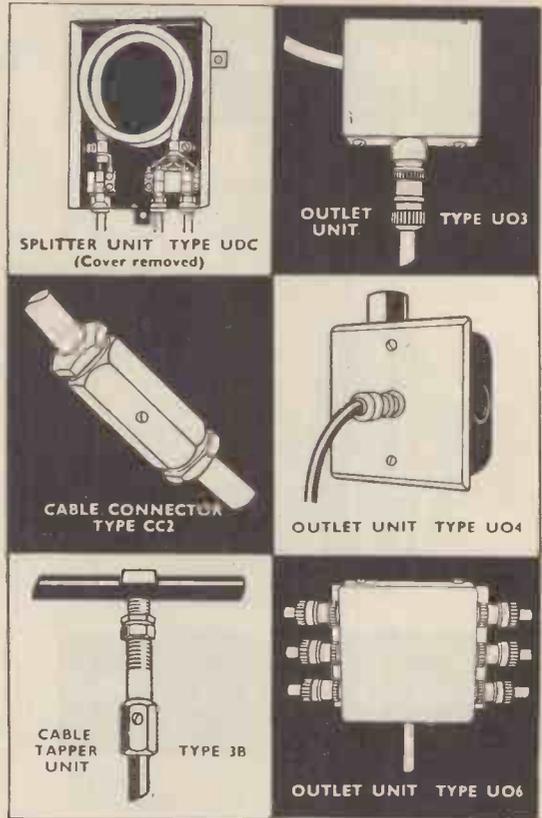
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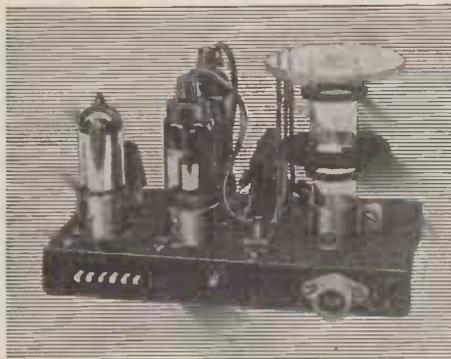
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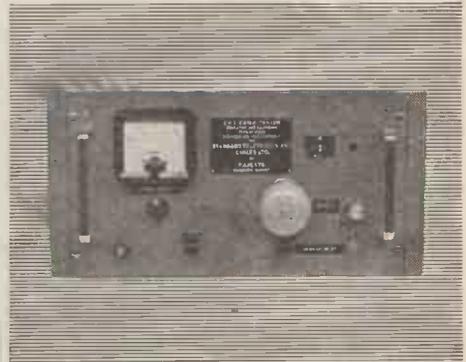
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This E.H.T. Cable Insulation Tester has been designed and made by Tyer & Co. Ltd. for detecting and recording faults in the insulating coverings of cables during manufacture. The system permits a very high speed of operation.

\* *Whichever stage of the struggle you've reached, we can save you time and trouble—maybe money too—write or 'phone without delay.*



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## Axiom 400

A twin-cone Unit of similar design to the Axiom 300, but having an even heavier ring type magnetic assembly producing a total flux of 195,000 Maxwells, with consequently a very high degree of electro-magnetic damping. In addition, the power handling capacity is higher.



Thus, the Axiom 400 will perform all the functions of the Axiom 300 and is additionally capable of High Fidelity reproduction in very large rooms, public buildings, etc.

**SPECIFICATION**  
 Frequency Response: 30-16,000 c.p.s.  
 Fundamental Resonance: 35 c.p.s.  
 Maximum Power Handling Capacity: 20 watts  
 Flux Density: 17,500 gauss  
 Voice Coil Diameter: 1 1/2 ins.  
 Impedance: 15 ohms

## for High Fidelity

## Axiom 300

The most advanced twin-cone High Fidelity loudspeaker yet produced, incorporating new developments which not only reduce distortion to a very low level, but also provide a smoother and more extended response than ever before achieved in this type of Unit.

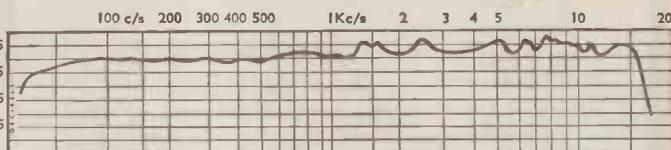
Both diaphragms are carefully terminated to prevent standing waves and spurious resonances and are driven by a long aluminium coil suspended in a total flux of 158,000 Maxwells. A robust cast chassis is employed and the construction is dust-proof.



**SPECIFICATION**

Frequency Response: 30-16,000 c.p.s.  
 Fundamental Resonance: 35 c.p.s.  
 Maximum Power Handling Capacity: 15 watts  
 Flux Density: 14,000 gauss  
 Voice Coil Diameter: 1 1/2 ins.  
 Impedance: 15 ohms

Typical on-axis response curve for Axiom 300



# GOODMANS

GOODMANS INDUSTRIES, LIMITED,  
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Goodmans High Fidelity Loudspeaker Manual, which contains full information on Goodmans High Fidelity products, free on request.

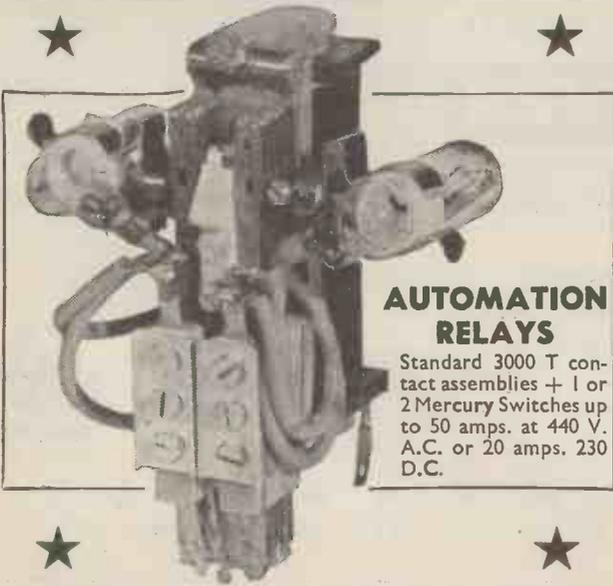
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  - LIQUID CONTROL
- etc., etc.

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variable high power  
**Amplifiers**



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SAVAGE 10KW POWER  
AMPLIFIER**

The **SAVAGE 10KW AMPLIFIER** is designed to meet the high power drive requirements of large vibrators. It has an output of 10 KW (continuous sine wave rating) over the frequency band 40 c/s. to 10 Kc/s. The output has eight secondary sections of  $41\frac{1}{2}$  V. each which may be cross connected to give a range of output voltages from  $41\frac{1}{2}$  V. to 330 V. Accessibility of components and ease of installation are features of this very compact 10 KW amplifier.

**SAVAGE AMPLIFIERS** are suitable for driving 60 cycle American equipment; 400-2500 cycles for aircraft equipment; ultrasonic power supplies for cleaning, drilling, etc.

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you



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EARLS COURT · LONDON

**AUGUST 26 TO SEPTEMBER 5**

# LINEAR

## MODEL L10 HIGH FIDELITY 10 WATT AMPLIFIER WITH SEPARATE PRE-AMPLIFIER

Supplied complete only (i.e. Main Amplifier and Pre-amp.) **15** Retail Price **GNS.**

Size of main amplifier 9in. x 7in. x 5in., Pre-amp. 11in. x 4½in. x 2½in. Front-Plate 12in. x 3½in. Stoved Gold hammered finished chassis. Front Plate Polychromatic Gold. Weight of main amplifier 10lbs. Pre-amp. 3lbs. For 50/60 c.p.s. A.C. mains 200-230-250v. or to order for export.

The Following Outstanding Test Figures include Pre-amplifier.

**Sensitivity (for 10 watts)**

L.P. 25 m.v.  
78 n.p.m. 20 m.v.  
Radio, 35 m.v.  
Microphone, 2.5 m.v.

**Input Impedance**  
All inputs 500k. Plus 10pfd.

**Frequency Response**  
±2 d.b. 30—25,000 c.p.s.

**Power Consumption**  
90 watts.

**Maximum Power Output**  
in excess of 12 watts.

**Negative Feedback**  
Total 32 d.b.



**HARMONIC DISTORTION**  
(Inc. Pre-amplifier)  
0.09% measured at 10 watts.  
**Damping Factor 35**  
**Bass Control**  
+9 d.b. to -9 d.b. at 50 c.p.s.  
**Treble Control**  
+9 d.b. to -9 d.b. at 12,000 c.p.s.  
**Hum Level**  
-70 d.b.  
**Filter**  
-7 d.b. at 9 Kc/s.  
-10 d.b. at 5 Kc/s.

**MULLARD VALVES**  
EF86(1); ECC83(2); EL84(2); EZ81(1).

**OUTPUT MATCHINGS**  
For 3 ohm and 15 ohm L/ Speakers from high grade sectionally wound output transformer.

**RESERVE POWER SUPPLY** (for Radio Tuner) 300v. 30 m.a. smoothed and 6.3v. 1.5a. at 4-pin socket.

### The L45. A compact High Quality 4-5 watt amplifier

Size approx. 7-5½in. high. Sensitivity is 28 millivolts so that the input socket can be used for either microphone or gram. tape, radio tuner, etc. B.V.A. valves used are ECC83, EL84, EZ90. Controls are: Vol. Treble and Bass with mains switch. The Tone controls provide full compensation for long playing records. Output matching for 3 ohm loudspeaker Retail price £5/19/6.

**THE LT45 TAPE DECK AMPLIFIER.** A complete unit (power pack and oscillator incorporated) ready for connection to A.C. mains. 3 ohm loudspeaker and practically any make of deck. Negative feedback equalization adjustment by multi-position switch for 3½, 7½ and 15in. per set. Retail price 12 gns.

**THE LG3 GRAM AMPLIFIER.** Overall size 6½ x 4½ x 2½in. Controls: Vol. and Tone (with mains switch). Output for 2-3 ohm loudspeaker. All above for 200-250 v. 50 c.p.s. A.C. mains. Retail price 55/9.

**L50 50 WATT AMPLIFIER.** Size approx. 13 x 9 x 7in. Sensitivity 25 m.v. Outputs for 3 and 15 ohm speakers. Retail Price 19 gns.

**L10-12 WATT HIGH FIDELITY AMPLIFIER** with separate pre-amplifier. Retail price 15 gns.

**L3/3 STEREOPHONIC AMPLIFIER** Sensitivity 150 m.v. Output 3 watts on each channel. Retail 7 gns.

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**LINEAR PRODUCTS LTD.**

**ELECTRON WORKS, ARMLEY, LEEDS**

Tel.: Leeds 63-0126 (3 lines)

# THE NU-LIFE TELETUBE

## "TWINS" At your service!



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The normal service you have enjoyed for so many years in which we rebuild the electron gun.

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12in. or 14in. from £5 10 0  
15in., 16in. or 17in.  
from ..... £7 0 0  
21in. from ..... £10 10 0

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We supply a virtually new tube, new in every respect other than the bulb which is rescreened in every case and fitted with a new English gun. Aluminised tubes will be re-aluminised.

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(Aluminised £7 10 0)  
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(Aluminised £8 17 6)



Trade discounts allowed.

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**AUDIO OSCILLATOR TYPE AO50**

covering 20 cps to 200 kc/s in four ranges.  
£10 plus 4/6 carr./packing.

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measures 1 milli-volt to 100 volts rms over the range 20-200,000 cps.  
£14 plus 4/6 carr./packing.

**CAPACITY AND RESISTANCE BRIDGE TYPE CR50**

measures 10 pF to 100 mFd and 1 ohm to 10 Megohms plus capacitor leakage test.  
£8/2/6 plus 4/6 carr./packing.

All these instruments are complete with valves and instructions ready for use from 200/250 volt 50 cycle supply.

Full details sent on receipt of stamped addressed envelope.

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**"RECO" MIDDY TRANSISTOR ONE KIT**  
(Med and Long or Med. and Short Waves). Size: 4 1/2 in. x 3 1/2 in. x 1 in. Variable sensitivity control. High gain Vari Q ferrite rod aerial. "Sonotone" dynamic min. earpiece. Months of listening pleasure from pencil battery, 37/6. p.p. 2/-

**"RECO" PUSH-PULL FIVE. M/L WAVES**

Indoors or outdoors this brilliant radio brings Light, Home and Continental stations to your finger tips. 5 transistors including OC45 R.F. stage. Pale blue case with red spk. grille. Complete with 2 1/2 in. M/C speaker (Celestion) £6/7/6, p.p. 2/6. Data 2/6. Size: 6 1/2 in. x 4 1/2 in. x 1 1/2 in.



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(Med. and Long Waves or Med. and Trawler Band). Size: 6 1/2 in. x 4 1/2 in. x 1 1/2 in. Entirely self contained (no external aerial req.). R.F. stage with Mullard OC 45 transistor followed by two high gain transistor stages.

On test tuned in Third, Home, Light, Radio Luxembourg after dark and many others at good listening level. The receiver was tested at approx. 50 miles from nearest transmitter. Complete kit with easy build practical wiring diagrams, "Sonotone" super dynamic min. earphone with insert or bal. arm. reproducer. Pencil battery for months of listening pleasure. 75/-, p.p. 2/6.

**NEW "RECO" SUPER TRANSIGEN FOUR TRANSISTOR KIT**

As above but with 2 1/2 in. Celestion moving coil speaker. A fine portable in pale blue polystyrene case with contrasting red spkr. grille. Complete with pencil batteries, easy build practical wiring diagrams. 99/6, p.p. 2/6.



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Microphone with dual impedance head in presentation case, 8/6 gns.

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2-transistor Portable Radio

- ★ No aerial or earth.
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- ★ May be assembled within an hour.
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Size 4½ x 3 x 1½ in.

Weight less than 4 oz.

We can supply all items including 2 EDISWAN TRANSISTORS, case and personal earphone for ... **72'6**

All parts sold separately.

Post free.

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**CONSTRUCTORS' PARCEL FOR TRANSISTOR POCKET RADIO**



Size 5½ x 3½ x 1½ in.

SPECIAL PRICE

**55/-** P.P. 2/6

Component lists supplied.

- ★ Attractive moulded cabinet (blue, red or cream) with gold, 12/6
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**THE IDEAL BASIS FOR A POCKET TRANSISTOR RADIO**

**"THE MAJOR-3"**

A 3-transistor version of the Major-2 in the same cabinet fitted with volume control. Fantastic output! 90/- Post free.

**THE "TRANSISTOR-8" COMBINED CAR-RADIO/PORTABLE**

**PUSH-PULL SUPERHET**

*Now in its third year!*

- ★ Medium and long wave tuning.
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Complete set of components including cabinet, speaker, etc.

**£11.10.0** P.P. 2/6.

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Car Radio Conversion 8/- AVC 4/3, 325 mW version, £13/10/- P.P. 2/6.



**FULL COMPREHENSIVE INSTRUCTION BOOKLET FREE**

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A permanent power transistor stage for your car etc.

- ★ Works from 12 volt battery supply.
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- ★ 6 EDISWAN TRANSISTORS.
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All components for construction including cabinet, printed circuit, etc., can be supplied for

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**SEND 9d. FOR CIRCUIT, PLANS AND PRICES**

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This set is recommended as an ideal Portable Highly sensitive, selective, containing the latest features giving simplicity in construction with amazing results.

All items supplied special inclusive price of

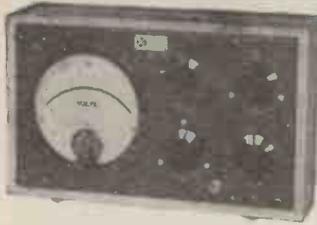
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**ALL COMPONENTS SOLD SEPARATELY. SEND FOR FREE LIST. Instruction Book, 5/6.**

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**1. PIRANI CONTROL UNIT**

- Includes:
- ★ 6in. 1 mA. movement meter with mirrored scale.
- ★ Fully set Wheatstone Bridge.
- ★ Complete in best quality case.
- ★ Built-in galvo-shunt.

ONLY **£5/19/6** P.P. 5/-  
Including Circuit diagram.

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500 volt 50 Meg. BRAND NEW sealed in cartons with leather case and handbook.

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100-volt type used but in new condition. With leather case. **£6** Post free

**1355 RECEIVERS**  
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Complete with the following valves:  
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**RCA 6½-inch P.M. SPEAKER** in Cabinet. With vol. control and 600 ohm Line Trans. **27/6** P.P. 2/6

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Complete with screened case with 6SL7GT; 28D7; relay, leads, jack plugs; handbook, etc. Sealed in carton.

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All complete in new condition less valves. **35/-** P.P. 5/-

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A large range of frequencies in stock from 100 Kc/s. upwards. Fundamentals: 54th and 72nd harmonics, etc. Send for NEW free complete list.



**2. PIRANI DIFFERENTIAL LEAK DETECTOR**

- Includes:
- ★ 2-arm Wheatstone Bridge.
- ★ Masses of high quality switches and controls.
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- ★ Circuit diagram.

ONLY **59/6** P.P. 5/-

**PYE 45 Mc/s STRIP TYPE 3583**

Complete with 12 valves. 10-EF50; EB34; EA50, with modification data.

**39/6** Carriage 5/6

**"372" MINIATURE IF STRIP 9-72 Mc/s**



The ideal F.M. conversion unit as described in "P.V." April/May, 1957. Complete with 6 valves, three EF91's, two EF92's and one

EB91.I.I.F.T's, etc., in absolutely new condition. With circuit and conversion data.

**12/6** (less valves) **37/6** (with valves)  
Postage and Packing 2/6 (either type).  
FM AT ITS CHEAPEST!

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24 v. D.C. to 230 v. A.C. 50 cycles. 100 watts. Brand new and unused.

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Includes: 4—EF50; 2—SP61; EB34; multibank switches; pots; transformer, etc.

ONLY **30/-** P.P. 3/-

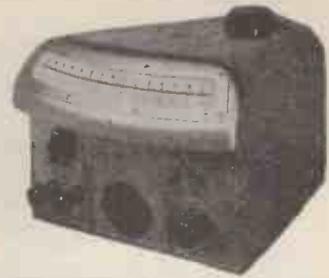
**TRANSISTORS:—**

(Junction Type PNP)

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New data sheet available on all types.

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- Includes:
- ★ Pye Scalamp Galvo type 2000.
- ★ Mains or battery operation.
- ★ Sensitivity (typical) 33.5 mm/μA. 0.670 mm/μV.

ONLY **£12/10/-** P.P. 5/-.

**WAVE-GUIDE WATTMETER**

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**VHF TRANS/RECEIVER Type TR1920,** 100 to 120 Mc/s. IF frequency 9.72 Mc/s; Bandwidth 40 Kc/s, 4 channel crystal controlled VHF airborne trans/rec. Complete with 21 valves, transmitting crystal and 24-v. rotary unit, all contained in metal case. In new condition with full circuit diagram. Circuits sold separately, **£8/19/6** P.P. 1/9 post free. 10/6

**VHF 10-CHANNEL TRANS/REC Type 1986.** Frequency range 124.5/156 Mc/s. IF frequency 9.72 Mc/s; Bandwidth 23 Kc/s.

Sub-units	Type	With	Less	P.P.
TRANSMITTER	81	75/-	25/-	2/6
RECEIVER	114	27/6	7/6	2/6
IF Amplifier	476	37/6	12/6	2/6
24 v. Rotary unit	3	15/-	—	2/6
10-way Control unit	382	6/-	—	9d.

All the above are in absolute new condition. Full circuits available, 1/9 post free.

**CRYSTAL CALIBRATOR For No. 19 Set** 10 Kc/s; 100 Kc/s; 1 Mc/s; spot frequencies; Crystal controlled oscillators; includes 5—12SC7 valves, neon modulator handbook, etc. BRAND NEW **£4/19/6** Post free

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Frequency range 172 to 190 Mc/s. Comprising: VCR139A Cath. ray tubes; 7—EF50; EF55; 4—EA50; 2—EB91; 5U4; VU120 and EC52. 5 standard main input 200-250 volts 50 c/s. Ideal Scope Basis. **£5/10/-** Carriage 5/-

**WALKIE/TALKIE TYPE 38 TRANSMITTER/RECEIVER**

Complete with 5 valves. In new condition. These Sets are sold without Guarantee, but are serviceable. **22/6** P.P. 2/6

H/phone 7/6 pair. Junction Box 2/6. Throat Mike 4/6. Canvas Bag 4/-. Aerial Rod 2/6.

**TRANSMITTER/RECEIVER**

**Army Type 17 Mk. II** Complete with Valves, High Resistance Headphones, Handmike and instruction Book and circuit. Frequency Range 44.0 to 61 Mc/s. Range approximately 3 to 8 miles. Power requirements: Standard 120 v. H.T. and 2 v. L.T.



Ideal for Civil Defence and communications. BRAND NEW **45/-** P.P. 5/-  
44-61 Mc/s. Calibrated Wavemeter. for same, 10/- extra.

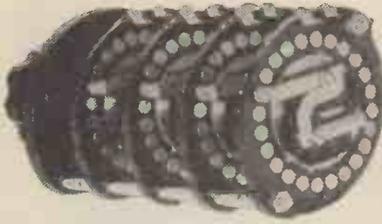
**RADIO AND TV VALVES, ETC.**  
OVER 400 DIFFERENT TYPES IN STOCK: SEND FOR NEW FREE LIST.

**HENRY'S RADIO LTD.**

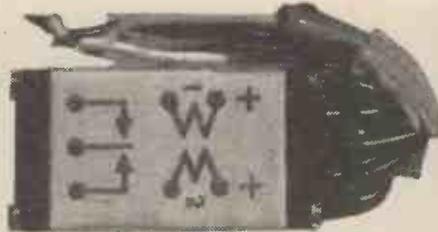
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**5, HARROW ROAD, PADDINGTON, W.2**

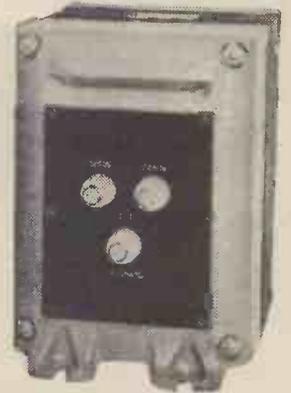
(AT JUNCTION OF EDGWARE ROAD PAD 1008/9 AND HARROW ROAD)



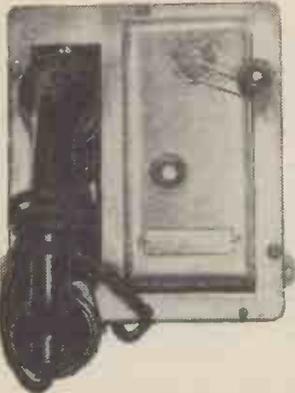
**MUIRHEAD PRECISION**, 4 bank, 1 pole, 24 position Stud Switch. Heavy duty contacts, brand new, original boxes. Price 17/6 each. P. & P. 1/-.



**MINIATURE MOVING COIL DIFFERENTIAL RELAY**. Two coils 350 ohms each. Operating current minimum 140 microamp, nominal 400 microamp, maximum 8 milliamp. One pole two way, or, centre stable. Two way contact current 100 mA at 50 V A.C. or D.C. Size 1 1/2 x 3/4 x 3/8 in. Price: 22/6 each.



**PLATE TRANSFORMER** of very best U.S.A. make, brand new, original manufacturer's cases. Input tapped at 190/210/230/250 V. Output 2250-0-2250, centre tapped 400 mA. Net weight 76lb., size 13in. x 9in. x 6 1/2in. Price £6/10/- each, plus carr. 10/-.



**SOUND POWER TELEPHONE UNIT**. No batteries required. Fitted with neon indicator lamp and high pitched buzzer, operated by built-in generator. Entirely self-contained, ex Admiralty. Rebuilt and guaranteed working. Effective up to half a mile, waterproof.

£3 Unit or £5/17/6 pr. Carr. 7/6. Master Units to take five extensions also available. £4 each.

**SOUND POWER TELEPHONE HAND-SETS**. New, 17/6 each. P. & P. 2/-.

**AERIAL AS ILLUSTRATED**. Ideal for Car. Overall length 33in., khaki, with flexible shaft which enables the aerial to be fixed firmly in any position. Price 8/6, plus P. & P. 1/6.

**NEW WIRE WOUND RHEO-STAT ON CERAMIC**. 58 ohms, 50 watt, complete with instrument knob. Price 8/6. P. & P. 1/6.

**NEW 10 watt DUAL VOLUME CONTROL**. 25 ohms, plus 25 ohms. 7/6 each. P. & P. 1/6.

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**TRIPODS**. Solid wooden legs 38ins. long, metal top and metal toes. As new. Price 10/6 each, plus 3/- carr.

**HIGH SPEED RELAY**. Siemens, two bobbins, 1,000 ohms each. New, 10/6 each. P. & P. 1/-.

**U.S.A. 27-volt 4-pole CHANGE-OVER RELAYS**. Brand new and boxed, 5/6 each. P. & P. 6d.

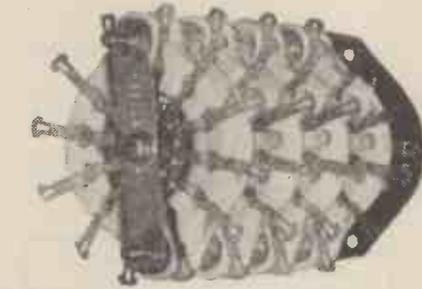
**PACKARD BELL RELAYS**. 12/24 volt, 650 ohms coil, 2 pole changeover, 1.5 amp contacts. Brand new. Price 5/6 each. P. & P. 6d.

**EVERSHED AND VIGNOLES**. Circuit testing Ohms Meter, pattern "S" complete with testing prods. inst. book, etc. Two ranges: 0-3 and 0-30 ohms. Brand new, guaranteed perfect, as illus. Offered at fraction of maker's price. £4/17/6 each. P. & P. 2/6.

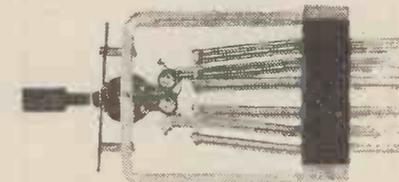
**EVERSHED AND VIGNOLES "Wee Megger"** 500 volt in leather case. Guaranteed perfect. Price £13/15/-. P. & P. 2/6.

**TRIPLE RANGE VOLT-METER**, 0-5 25-250V D.C. M/C 3 1/2in. meter 3in. scale, mounted in bakelite carrying case 7 1/2in. x 4 1/2in. x 3in. complete with handle and test leads. 27/6 each. P. & P. 2/-.

**AUTO TRANSFORMERS**, step up, step down, 110-200-220-240 v. Fully shrouded. New. 300 watt type £2/2/- each. P. & P. 2/6. 500 watt type £3/3/- each. P. & P. 3/9. 1,000 watt type £4/4/- each. P. & P. 6/6. Also 60 watts, 19/6 each. Plus P. & P. 2/-.



**CERAMIC PRECISION SWITCH** 2 pole, 6 way, 4 banks. New in manufacturers' boxes. Price: 10/6 each. P. & P. 1/6.



**MUIRHEAD PRECISION KEY SWITCHES**. Low capacitance, 4 single pole c/o each side. Brand new. Chrome-plated bezel. Price 12/6 each. P. & P. 1/-.



**20 WAY STRIP** containing standard Post Office telephone Jack Sockets, overall size 11 x 3 1/2 x 1/2 in. New. Price 15/- each. P. & P. 1/6.

**METERS BRAND NEW GUARANTEED PERFECT**

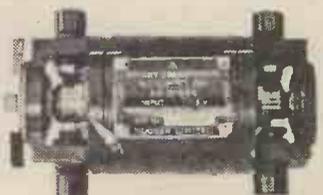
**Charging Types**  
 2 1/2 amp. DC M.I. 2in. fl. rnd. 7/6  
 5 amp. D.C. M.I. 2 1/2in. fl. rnd. 11/6  
 7 1/2in. D.C. M.I. 3 1/2in. proj. rnd. 12/6  
 9 amp. D.C. Hot Wire W.R. 2 1/2in. fl. rnd. 6/6

**Voltmeters**  
 12 v. D.C. M.C. 2 1/2in. proj. rnd. 8/6  
 20 v. D.C. M.C. 2in. fl. sq. 9/6  
 25 Volt D.C. M.C. 2in. fl. rnd. 7/6  
 30 Volt M.I. 3in. proj. rnd. 10/6  
 40 Volt M.C. 2in. fl. sq. 9/6  
 250 Volt A.C. rectified moving coil linear scale 3 1/2in. fl. rnd. 35/-  
 300 Volt A.C. M.I. 2 1/2in. fl. rnd. 22/-  
 400 Volt A.C. M.I. 4 1/2in. fl. rnd. 35/-

**Millammeters**  
 5 mA. M.C. 2in. fl. sq. 12/6  
 30 mA. M.C. 2 1/2in. fl. rnd. 9/6  
 50 mA. M.C. 2in. fl. sq. 8/6  
 200 mA. M.C. 2 1/2in. fl. rnd. 9/6  
 500 mA. M.O. 2 1/2in. fl. rnd. 9/6  
 1 MA. M.C. 2in. sq. fl. 19/6  
 0-1 MA Flush mounting Pullen M.C. Meter 4" x 5", correctly Scaled, Price. 57/6 each

**Thermo-coupled**  
 350 mA. 2in. rnd. plug-in. 3/6  
 500 mA. 2in. rnd. plug-in. 3/6

POSTAGE ON ALL METERS 1/-  
**U.S.A. PRECISION SERIES 834S MULTIRANGE TESTERS** for A.C. and D.C. volts, ohms and milliamps., basic movement 400 microamps., in wooden carrying case, complete with test prods, new batteries, guaranteed perfect. Price £5/19/6. P. & P. 2/6.



**MIDGET ROTARY TRANSFORMERS**. 2 1/2in. dia. x 4 1/2in. Input 11.5 volt Output 310/365 volts at 30 mA. Brand new. 12/6 each. P. & P. 1/6.

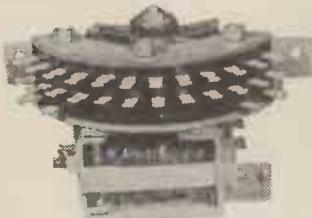
**DYNAMOTOR (Rotary Converter)**. 6 volt in, 250 volt at 100 mA., ex new equipment, 25/- each. P. & P. 3/-.

**MICROPHONES-NEW**. Throat, British, magnetic, 4/6. P. & P. 1/-.  
**HEADPHONES**. 4,000 ohms, imported, new, 15/-

**SERVICE TRADING COMPANY** →



**MINIATURE UNISELECTOR SWITCH**, two banks of ten plus home contacts, one bank continuous of normal. 30 ohms coil for 24 volt operation. Brand new, manufacturers' packing. Price 22/6 each. P. & P. 2/6. Illustrations above and below.



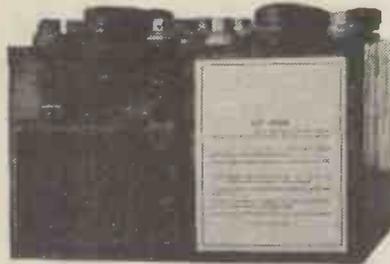
**VARIABLE VOLTAGE TRANSFORMERS**, as illustrated above. Brand new in manufacturers' original cases. Input 230-volt A.C., output variable from 0 to 270 volt at 9 amperes. Price £15 each, plus carr. 12/6.



**NEW GALVANOMETERS**, solid brass, 3in. dial, in polished wooden case. 70 degree scale, 35 mA either side. 100 ohm coil. Price: 12/6 each. P. & P. 1/6.



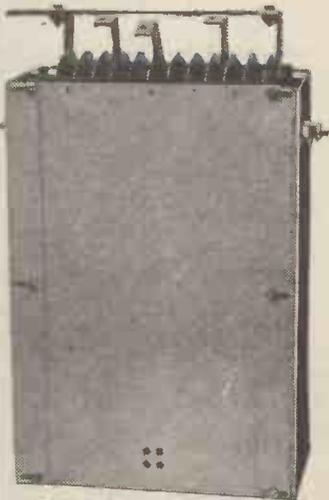
**MINIATURE P.M. MOTOR** 12/24 volt, reversible, 1 1/2 in. dia. New Price 9/6 each. P. & P. 1/-.



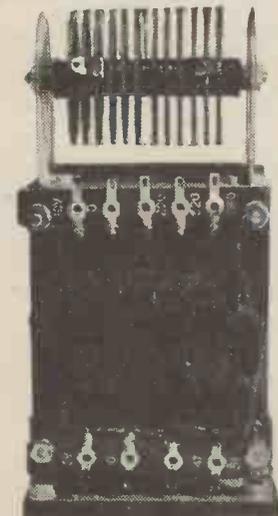
**NEW UNCHARGED UNFILLED 12 VOLT ACCUMULATOR** 9 ampere in unspillable plastic cases. Comprises 6 x 2 volt separate coils connected by terminal strips. 6 x 5 1/2 x 4 1/2 in. over terminals. Price 19/-, plus P. & P. 2/9. Wooden carrying case for same with lid and strap, price 3/6.



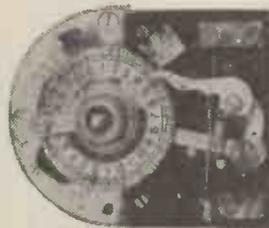
**NEW CAR-PENTER'S TYPE POLARISED RELAYS**. 2 x 9500 turns at 1,685 ohms. Price 22/6 ea. P. & P. 1/-.



**NEW MOVING COIL HEADSETS**, complete with Tannoy carbon hand microphone, with plug suitable for No. 19 sec. Price: 12/6 each plus P. & P. 2/-.



**TWELVE PLATE F.W. BRIDGE CONNECTED RECTIFIER** mounted on 200/250 volt A.C. input transformer. Output 36/40 volt D.C. at 1.2 amps. New, perfect. Price 16/6. P. & P. 3/6.



**VENNER 8-day clockwork Time Switch**. Contacts 1 amp. 230 volt. 24 hour phase, 1/4 hour divisions, allows setting for one make and one break to be made every 24 hours, complete with key. Used but guaranteed perfect. Price 27/6 each. P. & P. 1/6.



**CONSTANT VOLTAGE TRANSFORMER** by Advanced Components Ltd., Type No. MT.140A. Input 190/260 volt 50 cycles. Constant output at 230 volt 150 watt. Unused, guaranteed perfect. Price: £8/5/-, Carr. in England 6/6.



**200/250 v. A.C. MOTORS**. New 1/80 h.p., 2 drives, direct 6000 r.p.m., reduction 300 r.p.m. 22/6 each. P. & P. 2/6.

**BRAND NEW SELENIUM FULL WAVE BRIDGE TYPE RECTIFIERS**. In manufacturers' original packing. D.C. output 36 v. 10 amp., made up of 12 x 110 mm. dial plates. These fitted in cooling funnel (removable), size 1 1/2 in. x 8 in. x 4 1/2 in. Price 45/-, P. & P. 3/3.

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AC/P ..... 2/6	EC54 ..... 3/6	MH4 ..... 4/-	SP13C ..... 4/6	2D4A ..... 4/-	6L6GA ..... 8/6	19E2 ..... 5/-	866A ..... 13/-
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ARP3 ..... 3/-	EF39 ..... 5/6	MS/PENB ..... 6/-	U18 ..... 6/-	4D1 ..... 2/6	6SG7 ..... 7/-	45 ..... 7/-	1625 ..... 6/-
ARP4 ..... 3/3	EF50 ..... 3/-	N34 ..... 8/-	V1906 ..... 4/6	5U4G ..... 7/-	6SH7 ..... 5/-	53A ..... 3/-	1626 ..... 4/6
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DET19 ..... 1/6	KRN3 ..... 15/6	QP25 ..... 5/3	IB24 ..... 11/-	6F12 ..... 7/-	12AH7 ..... 7/-	350B ..... 8/-	
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				6L6 ..... 5/-	12S17 ..... 3/6	717A ..... 8/6	
				6L6G ..... 5/-	12SG7 ..... 6/6	801 ..... 6/-	
				6L6GA ..... 5/-	12SH7 ..... 4/9	803 ..... 22/6	
				6L6GT ..... 5/-		805 ..... 30/-	

All U.K. orders below 10/-, P. & P. 1/-; over 10/-, 1/6; orders over £2 P. & P. free. Overseas postage extra at cost.

### BRAND NEW ORIGINAL SPARE PARTS FOR AR88 RECEIVERS.

Please see advertisement December issue.

Complete set of strong aerial rods (American). Screw-in type MP49, 50, 51, 52, 53, total length 15ft. 10in., top diameter 0.615in., bottom diameter 0.185in., together with matched aerial base. MP37 with ceramic insulator, ideal for car or roof insulation, £2/10/-, post free.

High Resistance Headphones, 4,000 ohms. Brand new, ex W.D., boxed, 10/6 per pair. P. & P. 1/-.

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Complete Installation ILS. Consisting of transmitter, receiver, control unit, aerial, plugs, etc., £22/10/-. Post free.

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Rotary Converter Unit. Input 11.5-12.5 v. D.C. Output 300 v. 200 mA. D.C. 30/-, postage and packing 15/-.

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Projection Lamps, Osram. 250 v. 500 w. meas. of glass bulb dia. 2 1/2 in., length 4 in., 7/6. P. & P. 2/-.

Vacuum Condenser. 32,000 V. 50 pF., 25/-, Post free.

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CARBON INSET MICROPHONE. G.P.O. type 2/6. P. & P. 1/-.

Miniature Lead Acid Accumulator. 2 v. 1.5 amp. hr. at the 10 hour rate. Size 4 in. x 1 1/2 in. x 1 in., price 6/-, P. & P. 2/-.

Thermo-couple Heating Element. .75 amp. in Bakelite housing. Made for aerial current meters DW52 (G.E. made) or other purposes, 10/-, P. & P. 1/-.

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Other styles available. R.C.S.C. type approval applied for.

RCSC Style	CGS Style	Rating in watts		
		Service	Commercial	Range
RWV4-J	VPF4	3	4	5Ω to 8KΩ
RWV4-K	VPF10	4.5	10	5Ω to 68KΩ
RWV4-L	VPF14	6	14	10Ω to 100KΩ

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For Cathode Ray Tubes having Heater/Cathode short-circuit and for C.R. Tubes with falling emission.  
 Type A. Low Leakage windings. Optional Boost 25% and 50%. Tapped mains primaries.  
 2 volt ..... 12/6 each  
 4 volt ..... 12/6 each With Tag.  
 6.3 volt ..... 12/6 each Panel and  
 10.8 volt ..... 12/6 each Solder Tag  
 13.3 volt ..... 12/6 each

**OUR LATEST SUPERIOR PRODUCT. Type A2.**  
 High Quality. Low capacity, 10/15 pf. **16/6** each  
 Optional boost 25%, 50%, 75%.  
 Type B. Mains input. Low Capacity. Multi Output 2, 4, 6.3, 7.3, 10 and 13 volts. Optional boost 25% and 50%. Suitable for all Cathode Ray Tubes. 21/-.

**RESISTORS.** All preferred values. 20% 10 ohms to 10 meg. 1/2 w. 4d.; 1/4 w. 4d.; 1/8 w. 6d.; 1/16 w. 8d.; 2 w. 1/-.  
**HIGH STABILITY.** 1/2 w. 1% 2/-. Preferred values 100Ω to 10 meg. Ditto 5%, 9d. to 5 meg. 10%, 6d. to 10 meg. 5 watt

**WIRE-WOUND RESISTORS** 1/3  
 15 watt 25 ohms 10,000 ohms 1/6  
 15,000 ohms 50,000 ohms 5 w. 1/9; 10 w. 2/3

**WIRE-WOUND POTS, 3 w.** Standard size Pots, 2 1/2 in. Spindle High Grade. All Values 100 ohms to 50 K. 6/6; 100 K, 7/6.  
**W/W EXT. SPEAKER** to 2 Meg., 3/-  
**CONTROL 100. 3/-**

**O/P TRANSFORMERS.** Heavy Duty 50 mA., 4/6. Multi-tap push-pull, 7/6. Miniature 3/4, etc., 4/6. Hydrate Push-pull 10 watts, 15/6. MULLARD "610" 8k or 8k 30/-.  
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**MAINS TRANSFORMERS 200-250 v. A.C.**  
 STANDARD 250-0-250, 80 mA., 6.3 v. 8 d. a. tapped 4 v. 4 a. Rectifier, 6.3 v. 1 a., tapped, 5 v. or 4 v. 2 a. Ditto 350 0 350 ..... 22/6  
 MINIATURE 220 v. 20 mA., 6.3 v. 1 a. .... 10/6  
 MIDGET, 250 v. 45 mA., 6.3 v. 2 a. .... 15/6  
 SMALL, 250 0-250 100 mA., 6.3 v. 3.5 a. .... 18/6  
 STANDARD, 250 0-250, 65 mA., 6.3 v. 3.5 a. .... 17/6  
**HEATER TRANS., 6.3 v. 1 1/2 a. 7/6. 3 amp. .... 10/6**

**ALADDIN FORMERS** and cores, 1/2 in. 8d.; 1/2 in. 10d.  
 0.3 in. FORMERS 5937/8 and Cans TV/2. 1/2 in. sq. x 2 1/2 in. and 1/2 in. sq. x 1 1/2 in. 2/- complete with cores.  
**SLOW MOTION DRIVES.** Epicycloid ratio 6 : 1, 2/3.  
**TYANA.** Midget Soldering Iron. 40 w., 16/9.  
**REMPOLY INSTRUMENT IRON.** 25 w., 17/-.  
**MAINS DROPPERS.** 3 x 1 1/2 in. Three 4 in. Sliders, 3 amp. 750 ohms, 4/3. 2 amp., 1,000 ohms, 4/3.  
**LINE CORD.** 3 amp., 60 ohms, per foot, 2 amp., 100 ohms, per foot, 2 way, 6d. per foot, 3 way, 7d. per foot.

**CRYSTAL MIKE INSERT** by Acos 6/6  
 Precision engineered. Size only 1/4 x 1/2 in. Bargain!  
**AGOS CRYSTAL DISK MIKE,** 33-2, switched, 35/-.

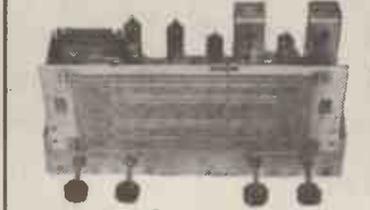
**MIKE TRANSF.** 50:1, 3/9 ea.; 100:1 Potted, 10/6.  
**LOUDSPEAKERS P.M. 3 OHM.** 2 1/2 in. and 5 in., 17/6.  
 6 in. x 4 in. Rola, 18/-. 7 in. x 4 in. Goodman, 21/6.  
 10 in. x 5 in. Rola, 27/6. 10 in. x 10 in. B.A., 30/-.  
 10 in. Rola 18/6.  
**HI FI TWEETERS, 25/-.** 12 in. Plessey, 30/-.  
 12 in. Baker 15 w. 3 ohm and 15 ohm models 105/-.  
 12 in. 15 ohm Plessey 10 w. with Tweeter, 97/6.

**I.F. TRANSFORMERS 7/6 pair**  
 465 kc/s. slug tuning miniature can 2 1/2 x 1 x 1 in. High Q and good bandwidth. By Pye Radio. Data sheet supplied.  
 Wearite M800 I.F. Miniature 465 kc/s. 12/6 pair.  
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**CRYSTAL DIODE G.E.C. 2/-.** GEX34, 4/- 40 Circuits, 3/-.  
**H.E. HEADPHONES,** 4,000 ohms, brand new, 16/6 pair.  
**SWITCH CLEANER** Fluid, squirt sprout, 4/3 tin.  
**TWIN GANG CONDENSERS.** 385 pf. Miniature, 1 1/2 in. x 1 1/2 in. 10/- .0005 Standard with trimmers, 9/-; 15% trimmers, 8/- . Midget, 7/6; Single 50 pF, 2/6; 100 pF, 150 pF, 7/- . Solid Dielectric 100, 300, 500 pF, 5/6.  
**VALVE HOLDERS.** Pa. int. Oct., 4d. EF50, EF50, 6d. B1A, CRT, 1/2. Eng. and Amer. 4, 5, 6, 7 pin, 1/-.  
 MOULDED Mazda and Int. Oct. 6d., 8/6, B8A, B8B, B9A, 9d. 8/6 with can, 1/6; B12A, 1/3. B9A with can, 2/6.  
**CERAMIC, EF50, 8/6, B9A, Oct. 1/-.** 8/6 with can, 1/6.  
**SPEAKER FRET.** Gold Cloth 17 in. x 25 in., 5/-, 25 in. x 35 in., 10/- . Expanded metal, Silver 15 in. x 9 1/2 in., 2/- . Tysan 5 1/2 in. wide, 10/-; 10 in. wide, 5/- . Samples.  
**WAVECHANCE SWITCHES.**  
 2 p. 2-way, 3 p. 2-way, short spindle ..... 2/6  
 5 p. 4-way, 2 p. 2-way, long spindle ..... 6/6  
 2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle ..... 3/6  
 3 p. 4-way, 1 p. 12-way, long spindle ..... 3/6  
 Wave change "WAKITS" 1 w. water, 8/6; 2 w. water, 12/6; 3 w. water, 16/6; 4 w. water, 19/6; 5 w. water, 23/6; 6 w. water, 26/6.  
**TOGGLE SWITCHES.** S.P., 2/-; D.P., 2/6; D.F.T., 4/-.  
**MOSKEY KEYS,** good quality, 2/6.  
**SUB-MINIATURE ELECTROLYTICS** (45 v.), 1, 2, 4, 5, 8, 25, 50 mfd. 3/- each.

**GOLTPOT TRANSISTORS JUNCTION TYPE P.N.P.**  
 AUDIO V.10/15a. for amplif. R.F. V.6/82 for oscillators, detectors and output stages in frequency changers and I.F. to 250 mHz in push-pull amplifiers cut off, 3 Mc/s. pull. average.  
**PRICE 10/-** **PRICE 18/-**  
 Power V16/10P, up to 10W with heat sink 20/-.

### 1959 RADIOGRAM CHASSIS FINEST VALUE



**THREE WAVEBANDS** **FIVE VALVES**  
 S.W. 16 m.-50 m. **LATEST MULLARD**  
 M.W. 200 m.-550 m. ECH 42, EF41, EBC41, EL41, E240  
 12 month Guarantee. A.C. 200/250 v., 4-way switch.  
**Short-Medium-Long Gram.** A.V.C. and Negative Feedback 4.2 watis. Chassis 13 1/2 in. x 5 1/2 in. x 2 1/2 in. Glass Dial 1 1/2 x 5 1/2 in. horizontal or 10 x 4 1/2 in. vertical. 2 Pilot Lamps. Four Knobs. Walnut or Ivory, aligned and calibrated. Chassis isolated from mains.

**BRAND NEW £9.10.0** Carr. 4/6  
**TERMS:** Deposit £5/5 and 5 monthly payments of £1. MATCHED SPEAKERS 8 in., 17/6; 10 in., 25/-; 12 in. 30/-.

**GARRARD 4-SPEED RECORD CHANGERS RC121/D MKII MODELS**  
 Brand new and fully guaranteed 12 months.

**AUDIO PERFECTION**  
 Designed to play 16, 33, 45, 78 r.p.m. Records 7 in., 10 in., 12 in. With plug-in NORMAL HEAD.  
**OUR PRICE £10.15.0** each. Post Free.  
 Optional Plug-in STEREO HEAD £2 extra.

**COLLARO 14' HIGH-FIDELITY AUTOCHANGER**  
 Latest Model  
**4-SPEEDS-10 RECORDS**  
 With Studio "O" pick-up  
**BRAND NEW IN MAKER'S BOXES**  
**OUR PRICE £7.19.6** post free

**B.S.R. MONARCH U8 4-SPEED AUTOMATIC RECORD CHANGERS**  
 Brand new and fully guaranteed 12 months.  
**OUR PRICE £6.19.6** post free  
 STEREO MODEL U8S, £9/19/6. UA12, £11/17/6.

**AUTOCHANGER ACCESSORIES**  
 Suitable player cabinets (uncut boards) ... 49/6  
 Amplifier player cabinets with cut boards 63/-  
 2 valve amplifier and 6 1/2 in. speaker for above 72/6  
 3 valve amplifier and 6 1/2 in. speaker for above 95/-  
 Wired and tested ready for use.

**EXCEPTIONAL OPPORTUNITY**  
**COLLARO 4-speed MODEL 4/564 Single**  
 Player, heavyweight turntable and lightweight Studio O Pick-up with turnover Xtal mounted on baseplate. Autostop fitted. 6gns. Carr. 4/-.  
 Amplifier Player Cabinets, 45/-.

**GARRARD 4-SPEED SINGLE RECORD PLAYER 4SP**  
**£8 AUDIO PERFECTION POST FREE**  
 De luxe Cabinet with amplifier and 6 1/2 in. speaker £6/15/-, or complete kit £14/10/-.

**Teletron Transistor Pocket Radios**  
 Designer's Specified Kits  
**COMPANION PRINTED CIRCUIT 3**  
 Local station receiver kit, 4 1/2 x 3 1/2 in. **£4.19.6**  
 3 Mullard or Goltpot transistors: plans 6d.

**Stratdyne Superhet Six 6 x 4 x 1 1/2 in.**  
 T.C.C. Printed Circuit, internal Ferrite aerial, Rola loudspeaker, push-pull output. All parts, cabinet and 6 Mullard or Goltpot transistors.  
**£11.19.6** Plans, etc., 9d.  
 No surplus reject transistors supplied

**THE HI-GAIN BAND 3 PRE-AMP**  
 Cascade circuit using Valve ECC84. 17db gain. Kit 29/6 less power; or 49/6 with power pack kit. Plans only 6d.  
 Also Band I version same Prices.

**Volume Controls 80 ohm CABLE COAXIAL**  
 Midget size:  
 Long spindle. Guaranteed 1 year. All values 5 K. ohms up to 2 Meg., No switch. D.P. Sw. 3/-  
 4/9  
 Linear or Log Tracks.

**COAXIAL PLUGS 1/-** **DOUBLE SOCKET 1/3**  
**SOCKETS 1/-** **OUTLET BOXES 4/6**  
**BALANCED TWIN FEEDER** per yd. 6d. 80d or 300d.  
**TWIN SCREENED BALANCED FEEDER 1/6** yd., 80 ohm.  
**TRIMMERS, Ceramic,** 80, 50, 70 pl., 90 pl., 150 pl., 1/3. 250 pl., 1/6. 600 pl., 750 pl., 1/9. Phillips, 1/- ea.

**ALUMINIUM CHASSIS.** 18 s.w.g. Plain, undrilled with 4 sides, riveted corners and lattice fixing holes, with 2 1/2 in. sides, 7 x 4 in., 4/8; 9 x 7 in., 5/8; 11 x 7 in., 6/8; 13 x 9 in., 8/6; 14 x 11 in., 10/6; 15 x 14 in., 12/6; and 18 x 16 x 8 in., 16/6.

**BLACK CRACKLE PAINT.** Air drying, 3/- tin.  
**P.V.C. CONN. WIRE,** 8 colours, single or stranded, 2d. yd.  
**NEON MAINS TESTER SCREWDRIVERS, 5/-**  
**CORED SOLDER RADIOGRADE** 3 yds. 9d. 4lb. 2/6.  
**PAXOLIN SHEET,** 8 in. x 10 in., 1/6. ION TRAPS 5/-.

**"GEVART GEVASON"**  
 50% Extra Long Play Plastic Tape, 1,700ft. 7 in. Reel 35/-, 850ft. 5 in. Reel 21/-.  
**SUPERIOR 1,200ft. 7 in. Plastic Tape 21/-**  
 Spare Reels Plastic, all sizes 3/- ea.  
**"INSTANT" Bulk Tape Eraser, 200/250 v. A.C.**  
 For any make and size of tape 27/6

**SENTERCEL RECTIFIERS. E.H.T. TYPE FLY BACK VOLTAGES.** K3/25 2 kv, 5/-; K3/40 3.2 kv, 7/-; K3/45 3.5 kv, 7/6; K3/50 4 kv, 8/-; K3/100 8 kv, 14/6.  
 50 cps. Voltage 50% of above.  
**MAINS TYPE, R.M1, 125 v., 60 mA., 5/-; R.M2, 100 mA., 6/-; R.M3, 120 mA., 8/-; R.M4, 250 v. 275 mA., 18/6.**  
**MINIATURE CONTACT COOLED RECTIFIERS, 250 v. 50 mA., 7/6; 60 mA., 8/6; 85 mA., 9/6; 200 mA., 21/-; 300 mA., 27/6; Full Wave 120 mA., 15/-.**  
**Wearite "T" type, 3/- each. Osamor Midget "O" type adjt. dust core from 3/- each. All ranges.**  
**TELETRON, L. and M. T.B.F. with reaction, 3/6.**  
**FERRITE RODS AERIALS. M.W., 8/9; M. & L., 12/6.**  
**T.F. COILS A/HF 7/- pair. H.F. CHOKES, 2/6.**

**JASON F.M. TUNER COIL SET, 26/-.** H.F. coil, aerial coil, Oscillator coil, two I.F. transformers 10.7 Mc/s. Detector, transformer and heater, choke, Circuit with component book using four 6AM6 2/-. [Complete kit with Jason Calibrated dial and 4 valves. £5/15/-].  
 50 cps. Voltage Switched FM Tuner 6 v. 12 v. £5/19/6.  
 Mullard 3-3 quality Amplifier. Ready built, £7/17/6.  
**CONDENSERS.** New Stock. .001 mfd. 7 kv. T.O. 5/6. Ditto 20 kv., 9/6; 100 pf. 49,500 pf. Micaf. 6d. Tubular 500 v., .001 to .01 mfd., 9d.; .05 1/1/-; .25 1/6; 5 1/9; 1/350 v., .9d.; 0.1 mfd., 2,000 v., 3/6; .001 mfd., 2,000 v., 1/8. CERAMIC CONDS. 500 v., .3 pf. to .01 mfd., 9d. SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-; 600 pf. to 3,000 pf., 1/3.  
**CLOSE TOLERANCE** (±1 pf.) 1.5 pf. to 47 pf., 1/6. DITTO 1% 50 pf. to 815 pf., 1/9; 1,000 pf. to 5,000 pf., 2/-.

**NEW ELECTROLYTICS. FAMOUS MAKES.**  
**TUBULAR CAN TYPES**  

1/350 v.	2/-	64/350 v.	5/6	8/500 v.	3/-
2/450 v.	2/3	100/25 v.	1/-	16/500 v.	4/-
4/450 v.	2/3	250/25 v.	2/-	32/350 v.	4/-
8/450 v.	2/3	500/12 v.	3/-	100/270 v.	5/6
9/500 v.	2/6	8+8/450 v.	4/6	2,500/75 v.	4/-
12/450 v.	3/6	8+8/500 v.	5/6	5,000/60 v.	5/-
16/500 v.	4/-	8+16/450 v.	5/6	8+16/500 v.	7/-
32/450 v.	5/6	8+16/800 v.	5/6	32+32/350 v.	4/6
25/25 v.	1/9	16+16/450 v.	5/6	50+50/350 v.	7/6
50/25 v.	2/-	16+16/500 v.	5/6	64+120/350 v.	11/6
50/-	2/-	32+32/350 v.	4/6	100+200/75 v.	12/6

**FULL WAVE BRIDGE SELENIUM RECTIFIERS, 2, 6 or 12 v. 1 1/2 amp., 8/9; 2 a., 11/3; 4 a., 17/6; 6 a., 22/6.**  
**CHARGER TRANSFORMERS.** Tapped input 200/250 v. for charging at 2, 6 or 12 v. 1 1/2 a., 15/6; 2 a., 17/6; 4 a., 22/6. Charger circuit free. AMPMETERS, 4 a and 5 a., 14/6.

**NEW and boxed VALVES 90-day guarantee**  

1R5	8/6	6L6G	10/6	E8A50	1/6	EZ81	1/6
1R5	8/6	6N7M	7/6	E8BC30	1/6	E1143	1/6
1T4	8/6	6Q7G	10/6	E8B91	6/6	HABCO8	12/6
2X2	2/6	68A7M	10/6	E8C33	8/6	HVBR2A	7/6
384	8/6	68J7M	10/6	E8C41	10/6	MU14	10/6
3Y4	8/6	68N7	8/6	E8F80	10/6	EB	10/6
6X4	8/6	6V6G	7/6	E8CC8A	5/6	PCC8A	12/6
5Y3	8/6	6X4	7/6	E8CF80	11/6	PCF80	11/6
5Z4	10/6	6X5	7/6	E8CF82	11/6	PCF82	11/6
6AM6	8/6	787	10/6	E8C42	10/6	PCL82	11/6
6BE6	7/6	12A8	10/6	E8CL82	12/6	PEN25	6/6
6BE6	10/6	12AT7	10/6	E8F39	7/6	PL2	10/6
6C7G	10/6	12AU7	9/6	E8F41	10/6	PY80	10/6
6D6	7/6	12AX7	9/6	E8F50	5/6	PY81	10/6
6F6G	7/6	12BE6	9/6	E8F50	8/6	PY82	10/6
6HG6T	3/6	12K7	8/6	8svt.		SP81	5/6
6J5M	6/6	12Q7	8/6	E8F80	10/6	UBC41	10/6
6J7	7/6	35T4	9/6	E8F92	5/6	UC242	10/6
6J7G	9/6	35Z4	9/6	E8L2	5/6	UF41	10/6
6K6GT	8/6	40	10/6	EL34	10/6	UL41	10/6
6K7G	5/6	807	6/6	E240	10/6	UY41	10/6
6K8G	8/6	954	1/6	E230	9/6	U22	10/6

# RADIO COMPONENT SPECIALISTS

OUR ONLY ADDRESS  
 337 WHITEHORSE RD.,  
 WEST CROYDON

POSTAL SERVICE 1/- OVER £2 FREE. C.O.D. 1/6 (EXPORT C.W.O. POST EXTRA.) Wed. 1 p.m. Catalogue 1/6. THO. 1665. Buses 133 or 68.

# G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155  
Cables: SMITHEX LESQUARE  
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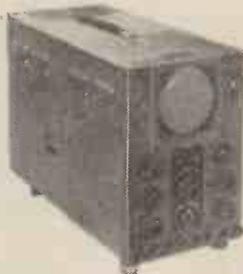
## WESTON MODEL 772 TESTMETER



<b>A.C. VOLTS</b>	<b>D.C. CURRENT</b>	<b>A.C. CURRENT</b>
2.5 v.	100 micro/a.	500 ma.
10 v.	1 ma.	1 amp.
50 v.	10 ma.	5 amp.
250 v.	50 ma.	<b>RESISTANCE</b>
1,000 v.	100 ma.	ANCE
<b>D.C. VOLTS</b>	500 ma.	100 ohms
2.5 v.	<b>OUTPUT METER</b>	1,000 ohms
10 v.		100 k. ohms
50 v.		10 megohm
250 v.		
1,000 v.		

Supplied in perfect working order, complete with rexine carrying case, internal batteries and instructions. £8/19/6 each. P/P 4/-.

## COSSOR DOUBLE BEAM OSCILLOSCOPE TYPE 339



Operation 110/200/250 volts A.C. 120 watts. Time Base 10 positions. 6 cps. to 250,000 cps. Amplifier 10 cps. to 2,000,000 cps. Sensitivity, Y1.Y2.3.1 v. D.C. 1.1 v. rms. X. 2.25 v. D.C. .8 v. rms.

Supplied in good working order complete with handbook and circuit. £27/10/- each. P/P £1.

## AN/ARN-5D GLIDE PATH RECEIVERS

Three-channel U.H.F. receiver operating on 332.6, 333.8 and 335 mc/s by plug-in crystals (not supplied). Contains 11 valves 1 28D7, 2 12SN7, 7 6AJ5, 1 12SR7, relays, etc. Operation from 24/28 volt. D.C. Size 5½ x 6½ x 14in. Supplied brand new and boxed. ONLY 59/6 each. P/P 5/-.



300FT. COPPER AERIAL WIRE. Ex-U.S.A. 3/6 per reel. P/P 1/-.  
LEACH AERIAL CHANGEVER RELAYS. 12 v. D.C. double pole transmitter type. New boxed, 7/6 each. P/P 9d.

MARCONI SIGNAL GENERATORS TF-517. Frequency coverage 10-18 Mc/s. 33-58 Mc/s. and 150-300 Mc/s. Operation 200/250 volt A.C. Supplied in good working order. £12/10/- each. P/P 10/-.

750-WATT AUTO TRANSFORMERS. Ex-Admiralty, fine jobs. Tapped from 110 to 230 volts. Brand new, 69/6 each. P/P 5/-.  
HEAVY DUTY MAINS ISOLATION TRANSFORMERS. 230 volt input. Output 230 volts 5 amps. Housed in ventilated metal case, unused, £5 each. P/P 10/-.

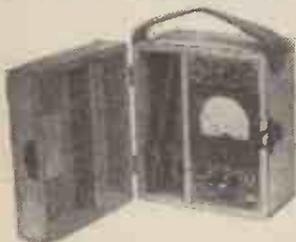
### MUIRHEAD PRECISION STUD SWITCHES



4 banks, 1 pole 24 positions each bank. Self cleaning heavy duty contacts. Brand new, 17/6 each. P/P 1/-, Ditto 2-bank, 10/6.

AMERICAN SUPER LIGHTWEIGHT HEADPHONES. Res. 50 ohms. Fitted with rubber earmoulds, extremely good quality deal if used for long periods. 15/- per pair brand new boxed. P/P 1/3.

## AMERICAN MULTI-RANGE TESTMETERS



1,000 ohms per volt, 400 microamp basic movement	
<b>A.C. VOLTS</b>	<b>D.C. VOLTS</b>
2.5 v.	2.5 v.
10 v.	10 v.
50 v.	50 v.
250 v.	250 v.
1,000 v.	1,000 v.
5,000 v.	5,000 v.
<b>D.C. CURRENT</b>	<b>RESISTANCE</b>
1 ma.	500 ohms
10 ma.	100k. ohms
100 ma.	megohm
1 amp.	<b>DECIBELS</b>
	-10 to +69

ALL BRAND NEW. COMPLETE WITH INTERNAL BATTERY. TEST PRODS AND INSTRUCTIONS. £5/19/6 EACH. P/P 3/-.

## C.R.100 SPARES KITS

Complete set of new valves 2 X66, 2 U50, 2 DH63, 2 KT63, 6 KTW61. Also set of resistors, condensers, pots, toggle switch and output transformer. Supplied new and boxed. 59/6 each. P/P 4/6.

## FERRANTI TESTMETERS TYPE Q

D.C. VOLTS 3 v. 30 v. 150 v. 600 v. 500 ohms per volt on all ranges B.S.S. first-grade accuracy on all self contained ranges. Supplied in perfect working order complete with leads, battery, instructions and rexine covered carrying case. Price 72/6 each. P/P 2/6.



## ROTARY CONVERTERS



12 v. D.C. input. 230 volt A.C. 150 watts 50 cycles output. Housed in wooden case and fitted with voltage control slider resistance, switch, plugs and A.C. mains voltage output check meter. Supplied in perfect condition, individually tested £9/19/6 each. P/P 10/-.

PARMEKO MAINS TRANSFORMERS. Input 230 volts. Output 350/0/350 volts 150 mA. 6.3 v. 4 amp. 5 v. 4 amp. Brand new, 32/6 each. P/P 2/6.

R.1155 "N" TYPE SUPER SLOW MOTION DRIVES. Brand new 12/6 each. P/P 1/-.

## AMERICAN GEARED MOTORS



24 volt D.C. motor fitted with precision gearbox giving twin outputs of 20 and 6 r.p.m. Also operates on 12 volts. ½ in. shafts. Brand new. 19/6 each. P/P 1/6.

POST OFFICE TELEPHONE HANDSETS. Std. type. New, boxed. 12/6. P/P 1/3.

CRYSTAL MICROPHONE INSERTS. Only 4/6 each. P/P 6d.

## ALKALINE NIFE ACCUMULATORS

Banks of 10 cells giving 12 v. 45 A.H. Unused in wooden crates. £5/10/- each. P/P 7/6. Size 26½ x 8½ x 5½ in.

MIDGET NIFE ACCUMULATORS. Single units, 1.2v. for models etc., 2/3 each. P/P 9d.  
12-VOLT MOBILE AMPLIFIERS. Ex-Admiralty. Mic. or gram. inputs. 10 watts output to 3 or 15 ohm speakers. Not new but in good working order, £8/19/6 each. P/P 5/-.

## RCA ET 4336 PLATE TRANSFORMERS.

Special release, brand new in original transit cases. Primary tapped 200/250 v. 50 cycles. Secondary 2,000/0/2,000 v. 400 ma. tapped 1,500/0/1,500 v. Price £12/10/- each. P/P £1.

## VORTEXION PORTABLE AMPLIFIERS

Operation from 200. 250 volts A.C. or 1½ volts D.C. Separate inputs for microphone or gram. Output matched to 7.5, 15, 250 or 500 ohms. incorporates volume control and full switched tone control. Valve line-up: 6Q7, 6J5, 6V6, 6V6, 5Z4. Size 8½ x 6½ x 17½ in., not brand new but supplied in perfect working order, fully tested. £10/10/- each. P/P 6/-.



## FURZEHILL BEAT FREQUENCY AUDIO OSCILLATORS



Frequency range 0 to 10,000 cycles. Output 0.5v. at 10 ohms or 0.5v. at 600 ohms. Separate 50 cycle check Set zero control. 200/250 volt A.C. operation. Supplied in perfect working order, fully tested. £9/19/6 each. P/P 10/-.

**ADMIRALTY POWER UNITS 234A.**



200/250 volt A.C. Input. Output 250 volts 15 mA. and 6.3 volts 6 amps. Fully smoothed double choke and paper condensers, fused and fitted with input and output plugs. Sockets are provided on the front panel for meter check. Housed in grey metal case for standard 19in. rack mounting. Supplied brand new. 59/6 each. P/P 7/6.

**TINSLEY D.C. PHOTOCELL CURRENT AMPLIFIERS**



These special units will give an amplification of 10,000, i.e. 1 microamp input. 10 ma. output. Circuit incorporates a 1 MICROAMP GALVONOMETER, photocell, GT1C thyatron and a vacuum thermal relay. Operation is from 200/250 volts A.C. Housed in metal case size 20 x 15 x 15in. Supplied brand new and crated Price £10/10/- each. Carriage 12/6.

**UNIVERSAL AVOMETERS.** Few available, reconditioned and in perfect condition. MODEL 40, £10/10/- each. MODEL 47A, £10/19/6 each. MODEL 7, £12/19/6 each. P/P 4/-.

**HOOVER MIDGET ROTARY TRANSFORMERS.** 2½ x 4½in. input 12 v. D.C. Output 310 v. 30 ma. Brand new and boxed, 12/6 each. P/P 1/3.  
**6-VOLT VIBRATOR POWER PACKS.** Output 120 v. 30 ma. Fully smoothed, uses standard Mallory 4-pin vibrator. New and boxed, 12/6 each. P/P 2/-.

**100-WATT ROTARY CONVERTORS.** Input 24 v. D.C. Output 230 v. A.C. 50 cycles, 100 watts. Housed in grey metal case with input/output plugs. Supplied brand new 92/6 each. P/P 7/6.

**AMERICAN MOBILE RIG POWER SUPPLIES.** 6v. D.C. Input. Outputs 500v. 200ma., 250v., 70ma. Utilises rotary trans. and vibrator. Fully smoothed. Brand new boxed, £4/10/- each. P/P 10/-.

**HALLICRAFTER S.27 COMMUNICATION RECEIVERS.** F.M. or A.M. coverage 27 to 143 Mc/s on 3 bands. Incorporates S meter, var. sel, B.F.O., etc., output for phone or speaker. Operation 110 or 230 volt A.C. Supplied reconditioned in perfect working order. £32/10/- each. P/P 10/-.

**R.1155 COMMUNICATION RECEIVERS.**

MODELS L & N. Both models incorporating the trowler and top band. Supplied in perfect condition, realigned, fully tested. £12/19/6 each. STANDARD MODEL B. Fitted with improved N type drive, perfect order re-aligned, etc., £7/19/6 each. Carriage 7/6 both types. COMBINED POWER PACK AND OUTPUT STAGE, to suit either models, 85/- extra. Illustrated instruction book with all receivers.

**METER BARGAINS**

50 Microamp. D.C. M/C, flush sq. in.	119/6
50 Microamp D.C. M/C, proj. rd.	49/6
100 Microamp D.C. M/C, flush rd.	42/6
500 Microamp. D.C. M/C, flush rd., 2in.	15/6
500/0/500 Microamp. D.C. M/C, proj. rd.	19/6
1 Milliamper D.C. M/C, flush rd., 2in.	25/-
50 Milliamper D.C. M/C, flush sq. 2in.	7/6
200 Milliamper D/C M/C, flush rd. 2in.	9/6
50 Amp. D.C. M/C, flush rd., 2in.	9/6
15 Volt D.C. M/C, flush rd., 1½in.	10/6
25 Volt D.C. M/C, proj. rd. 2in.	8/6
120 Volt D.C. M/C, flush rd., 3in.	32/6
300 Volt A.C. M/C, flush rd., 2in.	25/-
300 Volt A.C. M/C, rectifier, flush rd. 2in.	25/-
500 Volt A.C. M/C, flush rd., 2in.	25/-

ALL BRAND NEW AND TESTED

**PARMEKOTABLE TOP TRANSFORMERS,** input 230 v. 50 cycles. Output 620/550/375/0/375/550/620 volts 250 mA. Also 2-5 volt 3 amp. windings. Size: 6½ x 6½ x 5½in. Brand new only 45/- each. P/P 5/-.



**FERRANTI POTTED FILAMENT TRANSFORMERS.** Hermetically sealed ceramic terminations. All new and boxed, Type 1: 200/250 v. input. Output 6.3 v. C.T. 5.6 a. tapped 5 v. 6.3 v. C.T. 4.8 a. tapped 5 v. 6.3 v. CT. 1 a., tapped 4 v., 19/6 each. Type 2: Input 200/250 v. Output 6.3 v. CT, 3.3 a., tapped 5 v. 6.3 v. CT, 1 a., tapped 4 v. 6.3 v. CT, 9 a. 6.3 v. CT, 6 a., 15/6 each. P/P 2/-, each type.

**EDDYSTONE MAINS POWER PACKS.** 200/250 volts input. Output 175 volts 60 ma. and 12 volts 2.5 amps. Double choke and condenser smoothed, 5Z4 rectifier. Housed in grey metal case. Supplied new and unused, 32/6 each. P/P 3/6.

**45 AMPERE NIFE ACCUMULATORS.** Single cells 1.2 v., 12/6 each. P/P 2/-.

**POTTED MAINS TRANSFORMERS.** Primary 230 volts Secondary 350/310/0/310/350 volts. 220 ma., 6.3 volts 13 amps., 5 volts 3 amps., 49/6 each. P/P 3/-.

**R.1294 V.H.F. RECEIVERS.** Coverage 500 to 3,000 Mc/s. Perfect condition, with handbook £35 each. P/P 10/-.

**PORTABLE PRECISION VOLTMETERS** BRAND NEW instruments by famous manufacturer. Housed in polished teak case. Moving iron movement reading A.C. or D.C. volts on 2 ranges, 0-160 v. or 0-230 v., Bin. mirror scale. Accuracy within 2%. Supplied at a fraction of original cost, £5/19/6 each. P/P 3/6.

**A.C. MAINS VOLTAGE REGULATOR TRANSFORMERS.** Input 230 v. Output variable from 185 to 250 v. at 24 amps. or 185-250 v. input. 230 v. output £12/10/- each. P/P 10/-.

**BARGAIN GRAM MOTORS.** Garrard centre drive motors complete with turntable, 220/250 v. A.C. Adjustable mechanically from 0-45 r.p.m. Only 22/6 each. P/P 3/-.

**MINE DETECTORS No. 4a**

Complete equipment comprises Search Head, Amplifier Headset, Control Box, Telescopic Rods for Search Head, Search Head Test Unit and Test Depth Measure and Heaversack.

Operation is from a standard 60 v./1.5 v. combined dry battery. The unit will detect ferrous or non-ferrous metals to a depth of 24in. giving maximum signal but can be used at greater depths giving lower output. Ideal for tracing underground pipes or cables and any hidden metallic objects.

Complete equipment supplied brand new in original transit cases complete with circuit and operating instructions.



PRICE  
**99/6** EACH

Carriage 10/6

**GRESHAM POTTED LT. TRANSFORMER.**

Input 230 volts, Output tapped 80 v., 75 v. and 70 v. at 4 amps. Supplied brand new, boxed, 42/6 each. P/P 3/6.

**UNIVERSAL AVOMINOR TESTMETERS**

Small, compact, accurate instrument. Resistance measurements from 0 to 20k. ohms, D.C. volts from 0 to 500 v., A.C. volts from 0 to 500 v., D.C. current from 0 to 500 mA. Supplied in perfect working order, complete with leather case and leads. £5/10/- each. P/P 2/6.



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# LASKY'S RADIO

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STEREO & Hi-Fi  
Demonstration  
Studio**

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*The most comprehensive range of leading makes of Hi-Fi equipment in London's West End. Come and have comparative demonstrations assisted by our specialist staff. If unable to call, write for latest lists.*

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QUAD, ROGERS, LEAK, RCA, JASON, LINEAR, PAMPHONIC, DULCI, W/B, AVANTIC ARMSTRONG, etc.

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COLLARO, GARRARD, LENCO, CONNOISSEUR.

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GRUNDIG, ELIZABETHAN, BRENNELL, TRUVOX, SOUND, VORTEXION, FERROGRAPH, ELON, HARTING, SIMON, REFLECTOGRAPH, STUZZI, TANDBERG, TELEFUNKEN, STELLA, WALTER.

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Wide choice including G-PLAN, NORDYK and CAPRIOL.

**MULLARD 510  
AMPLIFIER KIT**

All specified components and your choice of transformers and chokes by Partridge, Haddon W/B, Ellison or Gilson. COMPLETE KIT and printed circuit as low as **£9.9.0**. Details on request. Printed Circuit separately 22/6. Also available built ready for use. Price according to transformers used.

**3-3 AMPLIFIER**

Built to Mullard's exact specification, with 3 Mullard valves EL84, EP86, EZ81, complete with front panel. Post free. **£8.8.0**

**HIRE PURCHASE**  
available. Call or write stating your requirements.

**ALL MAKES OF RECORDING  
TAPE POST FREE**

Standard, L.P. and Double Play post free. Write for our Special List.

**TAPE BULK RECORDER, 27/6**

20,000 VALVES. Brand new surplus and imported, also full stocks of B.V.A. List post free.

**ALL TYPES OF CHASSIS**  
We hold the largest selection of leading makes including all models ARMSTRONG, EMPRESS, DULCI, etc. A.M. chassis, L.M.S. from 7 Gns. A.M./P.M. chassis from 14 Gns. A.M./P.M. STEREO from 22 Gns.

**MOVING COIL  
P.M. SPEAKERS**

2 1/2in. 17/6. 3in. and 3 1/2in. 19/6  
5in. 14/6. 6 1/2in. 17/6. 8in. 19/6  
10in. 29/6 12in. 29/6  
6 1/2in. with transformer .. 21/-  
7 x 4in. Elliptical ..... 19/6  
10 x 7in. Elliptical ..... 32/6  
8 x 5in. Elliptical ..... 25/-  
10 x 2 1/2in. Rectangular ..... 27/6

**MICROPHONE BARGAINS**

ACOS MIC 89-1. Crystal Stick Microphone for use as a hand, desk stand or floor stand unit for high quality recording, broadcasting and public address work.

LIST  
£5/5/-

LASKY'S  
PRICE

**39/6** Less Stand

With Stand  
49/6.



ACOS type 33/1. Crystal hand or table Microphone. Incorporates specially designed acoustic filter. Flat response 30-7,000 c.p.s. Omni-directional. Attractive dark brown plastic case. LIST 50/- LASKY'S PRICE **29/6**  
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**SNIP! THE LOWEST-PRICED  
RECORDER EVER OFFERED!**



Foreign

Limited number only, brand new in maker's cartons. 2-spd. 3 1/2 and 7 1/2, twin track, 60 min. playing time at 3 1/2; 30 min. at 7 1/2. Inputs for mike and tuner 5in speaker. Smart duotone blue/grey carrying case. Dimensions: 12 1/2 x 8 1/2 x 7 1/2in. Weight approx. 6 1/2 lbs. TODAY'S VALUE £35.

LASKY'S PRICE including 5in. Spool of Tape and empty Spool

**19 Gns.**

Carr. & Ins. 12/6.

Crystal Hand Mike, 19/6 extra.

Special Offer for this Recorder. A 2-station RADIO JACK supplied at 30/- extra.

**TAPE DECK OFFERS**

COLLARO Tape Transcripitor Mk. III, with digital counter. Limited number. LIST £22. LASKY'S PRICE 15 Gns.

COLLARO Mk. IV £17/19/6. Carr. & Ins. 21/-.

TAPE RECORDER AMPLIFIER for use with Collaro Tape Deck. Maker's surplus. Complete, £27/19/6. Post 3/6.

COLLARO 4-spd. Transcription Turntables, 4T200/PX, with Studio trans. p.u. LIST £19/10/- LASKY'S PRICE £16/9/6. Carr. paid.

**SPECIAL OFFER  
RECORDING TAPE**

Famous make, P.V.C. base on latest plastic spools Brand new, perfect, boxed and guaranteed. 1,200ft. (7in.) 21/-, 850ft. (5 1/2in.) 16/6.

**GEVAERT L.P. PLASTIC**

1,760ft. (7in.) 35/-, 850ft. (5in.) 18/6, 210ft. (3in.), 6/6. Post: 1 spool. 1/6. Orders over 60/-, post free.

**SAVE POUNDS ON THIS TRUVOX  
TAPE DECK**

Mark III. New and unused, in maker's cartons. Limited number only, fully guaranteed. 2-spd. 3 1/2 and 7 1/2in., 3 shaded pole B.H.H. motors. Simple drop-in type loading (no threading); takes standard 7in. spools. Twin track, high impedance heads. Push-button controls. Size: 14 1/2 x 12 1/2in.



LISTED AT 23 Gns. LASKY'S PRICE **£14.19.6**

Carr. & Insurance 12/6. Full instruction booklet with circuit diagrams for amplifiers with each Deck.

**ALL "LINEAR"  
AMPLIFIERS  
IN STOCK**

TAPE DECK AMPLIFIER, type LT45, complete, 12 Gns. Post & Pkg. 5/-.

"DIATONIC" 10-14 watt ultra linear Amplifier. 12 Gns. Post & Pkg. 5/-.

"CONCHORD." High fidelity 30-watt Amplifier. 15 Gns. Post & Pkg. 7/6.

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**SPECIAL OFFER  
HIGH FIDELITY TAPE  
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Leading make, new and unused. Upper or lower track RECORD/PLAYBACK, high impedance. Double wound and will reproduce up to 12,000 c.p.s. at 7 1/2 i.p.s. Azimuth adjustments. Output 5 millivolts at 1 Kc. at 7 1/2 i.p.s. ERASH, low impedance. LIST £4 PAIR

LASKY'S PRICE Per pair, **39/6**

Post 1/3. Please specify upper or lower track.

**COMBINED AM/FM TUNER,  
CONTROL UNIT AND  
PRE-AMPLIFIER  
(Self-Powered)**

Mdl. H11 Famous make. Note these star features:

- ★ FM plus Long, Medium and Short
- ★ High Fidelity Pre-Amplifier
- ★ Independent Bass and Treble Control
- ★ Pick-up Matching Device and Switch positions for LP and 78
- ★ Tape Record and Replay facilities.
- ★ For use with any Hi-Fi Amplifier
- ★ Magic Eye Tuning Indicator

For A.C. 200-250 v. 7 B.V.A. glass miniature valves, ECC85, ECH81, EP89, two EP86, EM81, EZ81, and two matched Diodes. Glass dial, 1 1/2in. x 5 1/2in., fine readings and 'LOG' scale. Length 12in., depth 9in. from dial front (10in. including knobs and spindles), height 7in.

LISTED AT £29/3/10.

LASKY'S  
PRICE

**20 GNS.**

Carr. and Ins. 12/6.

Available on H.P. terms.

**7-VALVE AM/FM  
RADIOGRAM CHASSIS**

Famous make, for 200-250 v. A.C. Output 4 watts matched to 3 ohms speaker, 7 valves: ECC85, ECH81, EP89, EABC80, EL84, EZ80, EM81, Magic eye tuning indicator. Covers medium, long and FM bands. Length 12in., height 7 1/2in., front to back 8 1/2in. Limited number only. Brochure on request.

LISTED AT 22 GNS.

**£16.19.6**

LASKY'S PRICE

Carr. and Ins. 12/6.

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**PICK-UP CARTRIDGES  
BELOW HALF PRICE!**

Your choice of ACOS HGP.59, GARRARD GC2, B.S.B. "ful-8" TC8, COLLARO Studio O or T turnover crystal p.u. Cartridges, complete with L.P. and standard styl. ALL LISTED AT £2/11/7. LASKY'S PRICE **18/-**  
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ACOS GP43 t.o. crystal cartridge complete with L.P. and standard styl 15/-.

GARRARD GC64 ceramic cartridge complete with styl 19/6.

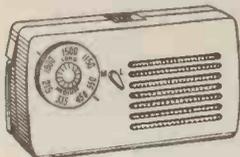
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Lasky's Price 25/-.

GARRARD turnover head shells. MPMI 4/6. MPM2 5/6 each

**STEREO PICK-UP  
CARTRIDGES**

ALL MAKES AND TYPES IN STOCK. WRITE FOR BARGAIN LIST.



**BUILD THIS  
6-TRANSISTOR  
POCKET RADIO  
FOR ONLY £9.19.6**

Plus 3/6 Post.

Printed Circuit construction. FULL medium and long wave superhet using latest components including 6 transistors. 2 1/2 in. moving coil speaker and Ferrite aerial. Cream or coloured plastic case. 5 1/2 x 3 1/2 x 1 1/2 in., weight 12 oz. Full assembly instructions supplied. All components available separately.

Available assembled ready for use, MEDIUM wave only, £9/9/- plus 3/6 post.

**BARGAINS IN 4-SPEED  
MIXER AUTO-CHANGERS**



COLLARO EC.457. Manual and auto control, complete with Studio crystal p.u. and sapphire styli. LIST £13/17/- LASKY'S PRICE **£7.19.6**

Post 3/6.

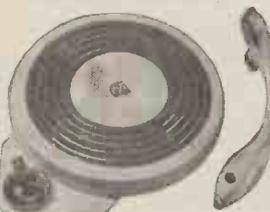
B.S.R. Type UAS, complete with latest B.S.R. "ful-n" pick-up £8/19/6.

Post 5/-.

B.S.R. Latest type UA12, wired for STEREO, complete with stereo cartridge, £8/19/6. Post & Pkg. 5/-.

Garrard Auto Changers, Transcription Motors, Pick-ups, all latest types in stock.

**SINGLE PLAYERS**



COLLARO "Junior" 4-spd. motor and separate pick-up complete with cartridge and styl.

MOTOR only, 55/- post free.

PICK-UP only, 29/6 post free.

SPECIAL OFFER. Motor and P.U. together, 75/- post free.

COLLARO 4/564 single player £8/9/6, post free.

GARRARD 4-spd. £6/19/6 post free.

**CARRYING CASES**

Large range of Cases for single players, auto-changers and tape decks at bargain prices. Call or send for List.

**LASKY'S HIGHLY EFFICIENT  
EASY-TO-BUILD  
SETS : TUNERS : AMPLIFIERS**

Circuit Diagram and Building Instructions, 1/6 each, post free.

**7-TRANSISTOR PORTABLE**, 200 milliwatts p.p. output. Printed Circuit, 6 1/2 in. x 2 1/2 in.

COMPLETE PARCEL

£9.19.6  
Post 3/6

**TRANSISTOR SUPERHET TUNER**, used 3 R.F. transistors, 1 germanium diode, etc. Printed Circuit 3 1/2 in. x 3 1/2 in.

£5.12.6  
Post 3/6

**4-TRANSISTOR AUDIO AMPLIFIER, Mk. II**, 200/250 milliwatts. Output imp. 3 ohms. Size: 5 1/2 in. x 2 in. x 1 1/2 in.

£3.19.6  
Post 3/6

**4-VALVE SUPERHET PORTABLE**. Medium and long wave mains/battery version, 9 gns. Battery version

£7.7.0  
Post 3/6

**MIDGET T.R.F.** for 200-250 v. A.C. mains. Uses two latest double-purpose valves. Plastic case, 8 1/2 x 4 1/2 x 5 in.

£4.19.6  
Post 5/-

**LASKY'S F.M. TUNER**. Printed Circuit version of the G.E.C. 912 "F.M. Plus," using 5 valves

£7.19.6  
Post Free

**PORTABLE GRAM AMPLIFIER**, 2 watts. Uses EL84 output and 6X4 rect. Size 6 1/2 in. x 3 1/2 in. x 5 in. high

49/6  
Post 2/6

ALL JASON KITS IN STOCK. Send for Brochures

**TURRET TUNERS**

Cydon and other well-known makers. New in maker's cartons. List 7 gns. A few examples:—

- P.10L (Series heaters), I.F. 9-14 mc/s., 59/6.
- P.16.H. (Series heaters), I.F. 16-19 mc/s., 99/6.
- E.10.L. (Parallel heaters), I.F. 9-14 mc/s., £5/19/6.

Post 3/6. All other types in stock. List on request.

**UNIVERSAL SOUND  
MIXER**

3 channels for use with all tape recorders and audio amplifiers. Size 4 1/2 x 3 1/2 x 4 1/2 in. 37/6. Post-2/6.

**C.R. TUBE BARGAINS**

ALL NEW, UNUSED AND TAX FREE

16in. METAL CONE, famous make, type T901/A. 6.3 volt .3 amp. heater, ion trap, 12-14 Kv. E.H.T., wide angle, standard 38 mm. neck. Guaranteed. LIST £16.

LASKY'S PRICE **£6.9.6**

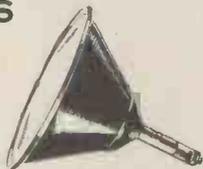
Carr. & Ins. 21/- extra.

Masks, Anti-Corona. Bases and Ion Traps available.

FERRANTI 9in. T9/3, 4 v. heater, triode, octal base, standard deflection. LIST £9/9/-.

LASKY'S PRICE 59/6. Carr. & Insurance 12/6.

FERRANTI 12in. types T12/44 and T12/54, LIST £12. LASKY'S PRICE 99/6. Carr. & Insurance 12/6. Many others. List on request.



**MULTI-TEST METER BARGAINS**

FOR AMATEUR OR SERVICE ENGINEER

FAMOUS MAKE. NEW AND UNUSED.

AN/27. As illustrated. Accurate, highly sensitive 27-RANGE Test Meter. 5,000 ohms per volt A.C. and D.C. In black leatherette-covered wood case, 7 1/2 x 9 1/2 x 3 1/2 in. deep, with carrying handle and ample room for small tools as well as leads.

LIST 15 GNS. LASKY'S PRICE **£11.19.6**  
Post 5/-. Leads 7/6 extra.

AVAILABLE ON EASY TERMS



AN/20. Pocket size Microtester. An accurate 18-RANGE Test Meter for all purposes. 5,000 ohms per volt A.C. and D.C. with accurate linear scales for the lower A.C. ranges. In black leatherette-covered case, 3 1/2 x 3 1/2 x 1 1/2 in. deep.

LIST 9 GNS. LASKY'S PRICE **£5.19.6**  
Post 3/6. Leads 3/9 extra.

**LASKY'S  
RADIO**

**BUILD A  
CAR RADIO**

Do you know that you can build a Car Radio with all these star features?

- ★12 volt operation
- ★New hybrid circuit
- ★Transistor output
- ★New type Brimar valves
- ★No Vibrator, 12 volt H.T. & L.T.
- ★T.C.C. Printed Circuit and Condensers.
- ★Tuned R.F. stage
- ★Medium and long waves
- ★Permeability tuning
- ★Small size. Will fit any car.

CAN BE BUILT FOR  
**£12.19.6**

Send 1/6 for Instruction Booklet giving full details, illustrations, dimensions, circuit diagram and shopping list.

**TRANSISTORS**

AUDIO P.N.P. Junction Types suitable for high gain and low freq. amplifiers, and for output stages up to 250 milliwatts. **7/6** (Double spot—yellow and green.) 3 for 20/-; 6 for 37/6, post free. E.F. P.N.P. Junction Type suitable for medium and low freq. oscillators, freq. changers and I.F. amplifiers **15/-** (1.5 to 8 Mc/s).

(Double spot—yellow and red.) 3 for 40/-; 6 for 75/-.

Special prices for larger quantities.

Transistors. OC44 30/-; OC45 25/-; OC71 15/-; OC72 or OC73 20/-; OC16 60/-.

BRIMAR Transistors. T81 or T82 12/6; T83 15/-; T84 27/6; TP1 or TP2 40/-; TJ1 15/-; TJ2 16/6; TJ3 19/6.

**"GOLDTOP" POWER  
TRANSISTORS**

All types in stock. Example—V15/10P, ideal for output stage of car radio, will give approx. 3 watts operating from 12 v. Each, 15/- post free. Suitable Output Transformer for above, correct ratio, matched to 3 ohms, 9/6. Post 1/-. Driver Transformer, 9/6. Post 1/-.

**MINIATURE INSTRUMENT  
SOLDERING IRONS**

Famous make, £30/250 v., 25 watts with pencil bit and 3-core flex. Warning light in handle. LIST 22/6.

LASKY'S PRICE **16/6**

Post 1/3. Special Offer of 1lb. reels of Erain 8-core "Sarbitt" **SOLDER** List 15/- LASKY'S PRICE 10/- Post 1/8.

CONDENSERS, RESISTANCES. High stability Resistances, Electrolytics. All values and sizes stocked.

SPEAKER COVERINGS. Large stocks of Tygan and "Someweave." Any size piece cut. Samples and prices post free.

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Early Closing  
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LASKY'S (HARROW ROAD) LTD.

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ROAD, W.1.

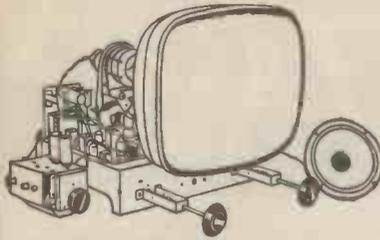
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(Opposite Paddington Hospital)  
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Please address  
Mail Orders to  
Harrow Road.



**17" T.V. CHASSIS, TUBE & SPEAKER 16 GNS.**

17in. Rectangular Tube on modified chassis. Supplied as single channel chassis covering B.B.C. channels 1-5, or, incorporating Turret Tuner, which can be added as an extra, at our special price to chassis purchasers of 50/- giving choice of any 2 channels (B.B.C. and I.T.A.). Extra channels can be supplied at 7/6 each. Chassis size 12 x 14½ x 11in., less valves. Similar chassis are used by well-known companies because of their stability and reliability. With tube and speaker (less valves). 16 guineas. Complete and working with valves and turret tuner. 24 guineas. 12 months' guarantee on the tubes. 3 months' guarantee on the valves and chassis. Ins. carr. (incl. tube) 25/-.

**14in. T.V. CHASSIS TUBE & SPEAKER 11 GNS.**

As above with 14in. Rectangular Tube. 12 months' guarantee on tube, 3 months' guarantee on chassis and valves. Chassis with tube and speaker (less valves). 11 guineas. Complete and working with valves and turret tuner. 19 guineas. Ins. carr. (incl. tube) 25/-.

**A T.V. CHASSIS at Clearance Prices**

The popular 12in. Plessey Chassis 19/6. A bargain for anyone wanting to make up their own T.V. at a very low cost. A chassis in one unit. Less valves and tube. Simply adapted for a 12-channel Turret Tuner and can be modified to take a larger tube. Circuit diagram available at 3/6 or free with order. Carr. and ins. 10/6.

**SOUND/VISION & I.F. STRIP 5/9**  
Salvaged. Complete sound and vision strip. Eight valve holders. Less valves. I.F.s. 16-19.5 Mc/s. Size 8½ x 4½ x 4½in. Drawings free with order. P. & P. 2/6.

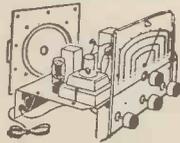
**TIMEBASE 4/9**  
Containing scanning coils, focus unit, line transformer, etc., less valves. Drawings free with order. P. & P. 2/6.

**POWER PACK & AMPLIFIER 9/9**  
Output stage PEN45. O.P. trans. choke. Smoothed H.T. 325 volt at 250 m.a. 4 v. at 5 amp., 6.3 v. at 5 amp., 4 v. at 5 amp., centre tapped. Valve base for rectifier. Octal or 4 pin. Output is taken from standard plugs. Less valves. Ins. carr. 5/6.

**B.S.R. 4-SPEED BATTERY CHANGER. 6 volts or 9 volts. 109/6. P. & P. 4/6.**

**BATTERY AMPLIFIER (valve). 1½ volts L.T. 60 or 90 volts H.T. 39/6. P. & P. 3/6.**

**3-TRANSISTOR AMPLIFIER. 9 volts, 1 control. 79/6. P. & P. 3/6.**



**SUPER CHASSIS 79/6**

Five-valve superhet chassis including 8in. P.M. speaker and valves. Four control knobs (tone, volume, tuning w/change switch). Four w/bands with position for gram. p.u. and extension speaker. A.C. Ins. carr. 5/6.

**T.V. AERIALS 25/6**  
For all I.T.A. channels. Outdoor or loft. Three elements. P. & P. 2/6.

**AERIALS 15/9**  
B.B.C. indoor type. Folded dipole with 12ft. co-ax. cable fitted. Post 1/9.

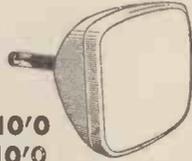
**T.V. AERIALS 7/9**  
For all channels. Complete with co-ax. cable. For use indoors or in the loft. Postage 1/3.

**T.V. MASKS 17in. White 9/9. Grey 10/9. Post 2/-.**  
**12in. Soiled. 1/9. Post 1/6.**

**EXPRESS DESPATCH SERVICE**  
Please phone to confirm tube in stock. Send Telegraph Money Order. Tube despatched Passenger Train same day. This service only available with remittance by a Telegraph Money Order.

**REGETTERED IMPROVED VACUUM T.V. TUBES**

17in. Rect. £7'10'0  
14in. Rect. £5'10'0



Our 12 months' guarantee (6 months' full replacement, 6 months' progressive), illustrates our whole-hearted confidence in the tubes we offer. Remember, they also hold a 10 days' money-back guarantee.

9in., 10in., 14in., 15in. and 16in. Round Tubes.

Our special offer of these sizes £5. 12in. T.V. tubes £6. Three months' guarantee on round tubes. Ins. carr. 15/6.

We now have pleasure in announcing our latest service.

**REBUILT T.V. TUBES**

£8.10.0

12in., 14in., 15in., 16in. and 17in. only. 12 months' full guarantee. Rebuilt to the high standard required to give long picture life, quality and value. Please write for further details and instructions before sending tube and also quote size and type. Carr. and ins. on return of rebuilt tube. 15/6.

**SOLO SOLDERING TOOL 12/6**

110 v., 6 v. or 12 v. (special adaptor for 200/240 v. 10/- extra). Automatic solder feed including a 20ft. reel or Ersin 60/40 solder and spare parts. It is a tool for electronic soldering or car wiring. Revolutionary in design. Instantly ready for use and cannot burn. In light metal case with full instructions for use. Post 2/9.



**HOME RADIO 79/6**

A.C./D.C. Universal mains 5-valve octal

superhet 3 waveband receiver can be adapted to gram. p.u. In attractive wooden cabinet. 9½ x 18½ x 11½in. Ins. carr. 7/6.

**FAMILY RADIO £6/10/0** 5 valve (octal) superhet. A.C. 3 waveband and gram. position. Four controls. Modern attractive cabinet size 15½ x 18 x 10½in. in cream and brown Carr. and ins. 8/6.

**SCANNING COILS 10/6**  
Low impedance. 38 mm. Brand new. P. & P. 1/3.

**GOLVERN PRE-SET POTENTIOMETERS 2/9**  
Brand new. 200 ohms. 10 K. and 20 K. P. & P. 6d.

**FOCUS MAGNET 9/9**  
Brand new. 38 mm. Incorporating picture shift control. P. & P. 1/3.

**R.F. E.H.T. COIL 7/9**  
7-10 KV. R.F. frequency approx. 200 kc/s. Uses 6V6 or P61 as osc. Suitable for ULTRA model V600, W700 and many other sets or replacing E.H.T. mains transformers. Ideal when using larger tube. Size 4½ x 2in. dia. Base 4 x 4½in. Circuit drawing available with order. P. & P. 2/6.

**GANG CONDENSERS 1/9**  
Salvage guaranteed. Standard size two gang. .0003 and .0005. All tested and guaranteed. P. & P. 1/3.

**RECORD PLAYER CABINET 79/6**

R.P.4

Stylish cabinet by famous manufacturer. Cloth covered in contrasting colours (red and grey). Grilled front control panel. Size 15 x 19 x 8½in. deep. Beautifully made—a cabinet you can be really proud of. Takes 4-speed B.S.R. Autochanger. 6½in. round or elliptical speaker. Room for any amplifier of your own choice. Carr. and ins. 4/6.



**B.S.R. MONARCH**

**SPEED AUTOCHANGER**

£6/19/6

Incorporating auto and manual control, complete with turnover crystal p.u. and sapphire stylus.

**COLLARO 4-SPEED AUTOCHANGERS £7/19/6**

U.A.12 Latest B.S.R. MONARCH 4-SPEED MIXER £8/9/6

B.S.R. MONARCH 4-SPEED STEREO AUTOCHANGER £9/19/6

COLLARO CONQUEST STEREO AUTOCHANGER 11 Gns.

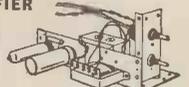
T.U.9 B.S.R. 4-SPEED SINGLE PLAYER £4/9/6

P. & P. on all the above 5/6.

**\* AMPLIFIERS \***

12 months' guarantee

**PORTABLE AMPLIFIER MARK D.1. 59/6.**  
Brand new. Latest design with printed circuit. Dimensions 7 x 2½ x 5in. A.C. only. Mains isolated. 2-3 watts output, incorporating EL84 as high gain output valve. Volume and tone controls. Knobs 2/6 extra. P. & P. 3/6.



**STEREOPHONIC AMPLIFIERS £7/19/6**  
Beautifully made for portable stereophonic record players. Latest design with printed circuit. Dimensions 3 x 5½ x 9½in. A.C. only. Mains isolated. Twin amplifiers each side giving 3-4 watts output. Incorporating ECL82 triode pentode valve. Full tone, volume and balance controls. Complete and ready to fit. Knobs 3/6 per set extra. P.P. and ins. 4/6.

**\* IDEAL FOR STEREOPHONIC SOUND.**

**EXTENSION SPEAKERS 19/9**

Polished oak cabinet of attractive appearance. Fitted with 8in. P.M. speaker, W.B. or Goodmans of the highest quality. Standard matching to any receiver (2-5 ohms). Switch and flex included. Ins. carr. 3/6. 8in. P.M. Speakers 8/9. With O.P. trans. fitted 10/-.  
6½in. P.M. Speakers 12/6.  
4 x 7in. Elliptical Speakers 19/6.  
8 x 5in. Elliptical Speakers 22/-.  
P. & P. 2/9.



**DUKE & CO.**  
(DEPT. C.6)  
621/3, ROMFORD RD., MANOR PK., E.12  
Tel. ILF 6001/3  
**TERMS AVAILABLE**  
Send for FREE Catalogue

# AMPLIFIERS PRE-AMPLIFIERS

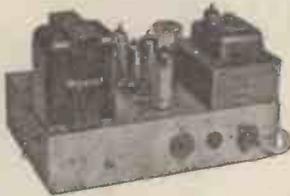
COMPLETE KITS OF PARTS  
FOR THE "HI-FI" ENTHUSIAST

Designed by MULLARD—Presented by US strictly  
to their specification

# MULLARD DESIGNS FOR THE HOME CONSTRUCTOR

MODEL 510/M

THE VERY POPULAR  
MULLARD "5-10"  
MAIN AMPLIFIER



Undoubtedly the most successful amplifier yet designed, and used in conjunction with the new Mullard Pre-Amplifier, an undistorted power output of up to 10 watts is obtained. Thoroughly recommended to the "HI-FI" enthusiast who contemplates a very high quality home installation. In addition the versatility of the equipment makes it quite suitable for use in small halls, etc. We supply complete to MULLARD'S SPECIFICATION with specified valves and components and including the latest PARMEKO Ultra-linear Output transformer and the Parmeko mains transformer which has power available to drive Radio Tuning Unit

Price for COMPLETE KIT OF PARTS ..... **£10.00**  
Alternatively we supply ASSEMBLED and TESTED ..... **£11.10.0**  
(Carriage and Insurance 5/- extra)  
We also offer this "5-10" incorporating the latest PATRIDGE ULTRA-LINEAR OUTPUT TRANSFORMER for £1/6/- extra.

MULLARD'S NEW  
2-STAGE  
PRE-AMPLIFIER  
TONE CONTROL UNIT



A completely new design employing two EF86 valves, and in particular designed to operate with the Mullard range of Power Amplifiers, but also perfectly suitable for other makes.

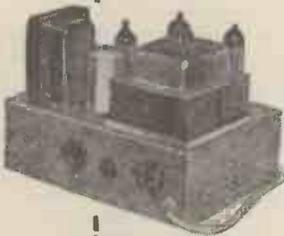
Briefly it incorporates:—

- Equalisation for the latest R.I.A.A. characteristics.
- Input for variable reactance. Magnetic Pick-ups.
- Input for Crystal Pick-ups.
- Input for Tape replay.
- (a) Direct from High Impedance Tape Head.
- (b) From a Tape Amplifier or Pre-amplifier.
- Sensitive Microphone Channel.
- Wide range BASS and TREBLE Controls.
- Attractive Perspex front control panel.

Our Kit is strictly to MULLARD'S SPECIFICATION. **£6.6.0**  
Price, COMPLETE KIT OF PARTS .....  
Alternatively we supply ASSEMBLED AND TESTED ..... **£8.8.0**  
(Carriage and Insurance 5/- extra)

MODEL 3-3/M

THE NEW  
MULLARD "3-3"  
MAIN AMPLIFIER



Based entirely on the present very popular "3-3" model and designed to operate in conjunction with the new 2-stage PRE-AMPLIFIER (shown here) thus providing all the facilities associated with the more expensive "HI-FI" equipment. We recommend it as the IDEAL SMALL HOME INSTALLATION where very high quality is desired at the lower volume level (up to 3 watts). We supply complete to MULLARD'S SPECIFICATION INCLUDING the latest PARMEKO Output Transformer specified Valves and Components. Has Power available to drive a Radio Tuning Unit.

Price for COMPLETE KIT OF PARTS ..... **£7.0.0**  
Alternatively we supply ASSEMBLED and TESTED ..... **£8.0.0**  
(Carriage and Insurance 6/- extra)

Special  
Price  
Reductions  
WE OFFER

Only NEW HIGH GRADE Components and Mullard Valves are supplied with these kits—we DO NOT use "Surplus or Cheap" components

(a) THE COMPLETE KIT OF PARTS to build both the "3-3" MAIN AMPLIFIER and the 2-stage PRE-AMPLIFIER-CONTROL UNIT ..... **£12.10.0**

(b) THE COMPLETE KIT OF PARTS to build both the "5-10" MAIN AMPLIFIER and the 2-STAGE PRE-AMPLIFIER-CONTROL UNIT ..... **£15.15.0**  
\*ALL PRICES QUOTED FOR THE "5-10" ARE SUBJECT TO £1/6/- EXTRA IF THE PATRIDGE TRANS. IS REQUIRED.

Please enclose S.A.E. ILLUSTRATED and DESCRIPTIVE LEAFLETS are required . . . alternatively the COMPLETE ASSEMBLY MANUALS containing component Price Lists and practical Drawings, etc., are available at 1/6 each.

(a) THE "3-3" and the 2-STAGE PRE-AMPLIFIER both ASSEMBLED and TESTED ..... **£15.0.0**

H.P. TERMS: DEP. £3 and 12 monthly payments of £1/2/- or DEP. £5 and 12 monthly payments of 18/4.

(b) THE "5-10" and the 2-STAGE PRE-AMPLIFIER both ASSEMBLED and TESTED ..... **£18.18.0**

H.P. TERMS DEP. £3/16/- and 12 monthly payments of £1/7/8 or DEP. £6/6/- and 12 monthly payments of £1/3/1.

When ordering please include an extra 7/6 to cover the cost of carriage and insurance

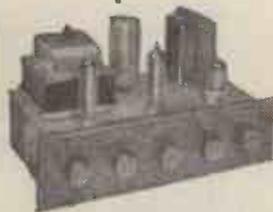
THE NEW  
COMPLETE  
MULLARD "5-10"  
AMPLIFIER



MODEL 510/RC

We offer this popular and very successful design COMPLETE to MULLARD'S SPECIFICATION, but incorporating some improvements in the general layout. HIGH QUALITY REPRODUCTION up to a maximum of 10 watts output. The CONTROL UNIT is separate and completely enclosed; it is normally fitted to the Main Amplifier Chassis as shown in the illustration but, if it is desired to use the unit remote from the Main Chassis, it can be quite easily detached and used up to 2 yards distance. We incorporate SPECIFIED COMPONENTS and NEW MULLARD VALVES. We also give the purchaser the choice of two of the best ULTRA-LINEAR OUTPUT TRANSFORMERS made—first the latest by PARMEKO LTD., and also the latest by PATRIDGE (£1/6/- extra), which is generally recognised as the best U/L Output Transformer made today and ensures maximum undistorted output and the widest frequency range. We also supply the PARMEKO MAINS TRANSFORMER and this has extra power available to supply a Radio Tuning Unit amounting to 250 volts at 35 mA, and a separate heater winding giving 6.3 volts 2½ amp. Price COMPLETE KIT OF PARTS (PARMEKO TRANSFORMER) MODEL 510/RC ..... **£11.10.0**  
(Plus 6/6 Carriage and Insurance).  
Alternatively we supply ASSEMBLED and TESTED (plus 6/6) ..... **£13.10.0**  
H.P. TERMS: Dep. £2/14/- and 12 monthly payments of 19/10.  
Send S.A.E. for ILLUSTRATED LEAFLET or 1/6 for the COMPLETE ASSEMBLY MANUAL.

THE NEW  
COMPLETE  
MULLARD "3-3"  
MODEL 3-3/RC



A VERY HIGH QUALITY 3-WATT AMPLIFIER PROVIDING EXCELLENT REPRODUCTION and HAVING AN ATTRACTIVE ENGRAVED PERSPEX FRONT PANEL. Price for COMPLETE KIT OF PARTS ..... **£7.10.0**  
(plus 6/6 carriage and insurance).  
Alternatively supplied ASSEMBLED and FULLY TESTED ..... **£8.19.6**  
(Plus 6/6 carriage and insurance).  
H.P. Terms deposit £2 and 8 monthly payments of £1.  
Developed from the very popular 3-valve 3-watt Amplifier designed in the Mullard Laboratories. Our kit is complete to the Mullard specification including supply of specified components, valves and PARMEKO OUTPUT TRANSFORMER. We also include switched inputs for 78 and L.P. records plus a Radio position. Extra power to drive a Radio Tuning Unit is also available:—  
THE COMPLETE ASSEMBLY MANUAL AVAILABLE FOR 1/6.

Please enclose S.A.E. with all enquiries

**STERN RADIO LTD.**

109 & 115 FLEET ST., LONDON, E.C.4  
Telephone: FLEET STREET 5812/3/4

**THE BEST VALUE ON THE MARKET**

**Stern's "fidelity" TAPE RECORDER**

**DIRECT—MANUFACTURER to USER**  
**NO "MIDDLEMAN'S" DISCOUNT IS INCLUDED IN OUR PRICES**

**IT INCORPORATES:**

- The latest COLLARO TRANSCRIBOR TAPE DECK.
- The model HF/TR3 "Fidelity" AMPLIFIER. (Described below).
- HIGH QUALITY 7in. x 4in. P.M. Speaker.
- 1,200ft. reel High Quality Emiteape.
- ACOS Crystal Microphone.

**BEFORE CHOOSING YOUR TAPE RECORDER YOU SHOULD HEAR THIS MODEL—TRULY "Hi-Fi" RECORDINGS ARE OBTAINABLE and it is comparable to much higher-priced Recorders. ALTERNATIVELY send S.A.E. for ILLUSTRATED LEAFLET.**

(Plus £1/10/- carriage and insurance of which £1 is refunded on return of packing case.)

**PRICE**  
**£49.10.0**

Terms: Dep. £9/18 and 12 monthly payments of £3/19/7 or Dep. £18/10/- and 12 monthly payments of £3/-/6

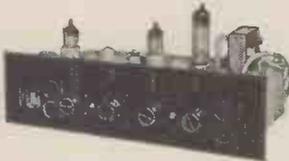


THE LEGS SHOWN IN THE ILLUSTRATION ARE READILY DETACHABLE AND ARE AN OPTIONAL EXTRA AT £1/2/6.

**THE MODEL HF/TR3 TAPE AMPLIFIER**

Incorporating 3-SPEED TREBLE EQUALISATION by means of the latest FERROXCUBE POT CORE INDUCTOR.

PRICE for COMPLETE KIT OF PARTS..... **£12/15/-**  
 FULLY ASSEMBLED AND TESTED..... **£16/10/-**  
 HIRE PURCHASE: Deposit £3/6/6 and 12 months at £1/4/2.



A very high quality amplifier based on the very successful Type "A" design completed in the MULLARD LABORATORIES. ONLY NEW HIGH-GRADE COMPONENTS are incorporated including MULLARD VALVES and a GILSON OUTPUT TRANSFORMER... other features are: Magic Eye Recording Hand Indicator—Effective Tone Control—Monitoring and Extension Speaker Sockets—has own Power Supply and can be used as independent Amplifier for direct reproduction of Gram Records or from Radio Tuner. Overall size 11 x 6 x 6in.—Truvox—Collaro—or Brenell—please specify which. Send S.A.E. for leaflet or 2/6 for Assembly Manual.

**THE NEW MULLARD TYPE "C" TAPE PRE-AMPLIFIER—ERASE UNIT**

INCORPORATING THE NEW FERROXCUBE POT CORE PUSH-PULL OSCILLATOR and 3 SPEED TREBLE EQUALISATION by means of the latest FERROXCUBE POT CORE INDUCTOR.



PRICES... INCLUDING SEPARATE SMALL POWER SUPPLY UNIT COMPLETE KIT **£14.0.0** ASSEMBLED AND TESTED **£17.0.0**

Deposit £3/8/- and 12 months of £1/4/11. Assembled unit only. ALSO AVAILABLE EXCLUDING POWER SUPPLY UNIT FOR **£11.15.0** and **£14.10.0** respectively. (Carr. and Ins. 5/- extra) Send S.A.E. for leaflet or 2/6 for Complete Assembly Manual.

**WHEN ORDERING PLEASE STATE MAKE OF TAPE DECK TO BE USED**

We present this "Hi-Fi" Pre-amplifier strictly to Mullards specification, etc. incorporating ONLY NEW HIGH GRADE COMPONENTS and the SPECIFIED NEW MULLARD VALVES. It comprises a COMPLETELY SELF-CONTAINED UNIT, all components and valves being contained in a well ventilated Box—Chassis neatly finished in Hammered gold with a very attractively engraved PERSPEX FRONT PANEL.



**HOME CONSTRUCTORS**  
**YOU CAN BUILD THIS PORTABLE TAPE RECORDER from £39.15.0**

WE HAVE THE NEW 2-SPEED TWIN TRACK TRUVOX Mk.VI TAPE DECK **£26.5.0**

It incorporates PRECISION REV. COUNTER and PAUSE CONTROL and operates at 3½ or 7½ in/sec.

**WE OFFER THIS SELECTION**

- (a) The COLLARO Mk. IV TAPE DECK with the assembled and tested HF/TR3 Amplifier..... **£34.10.0**  
 H.P. Deposit £6/18/- and 12 months £2/10/8.
- (b) As above but the HF/TR3 supplied as KIT OF PARTS... **£30.15.0**  
 NOTE: Messrs. Collaro when supplying the Mk. IV Deck do not wire up the Deck Switch backs. We will do this for £1 or supply a wiring diagram to the Home constructor.
- (c) The TRUVOX Mk. VI TAPE DECK with the assembled and tested HF/TR3 amplifier..... **£37.0.0**  
 H.P. Deposit £7/8/- and 12 months £2/14/3.
- (d) As above but the HF/TR3 supplied as KIT OF PARTS... **£33.10.0**
- (e) The BRENNELL Mk. V DECK with the assembled and tested HF/TR3 amplifier..... **£45.0.0**  
 H.P. Deposit £9 and 12 months £3/6/-.
- (f) As above but the HF/TR3 supplied as KIT OF PARTS... **£42.0.0**
- (g) THE PORTABLE CASE illustrated here (£5), 1,200ft. EMITAPE (35/-), ACOS CRYSTAL MIKE (35/-), ROLA 10 x 6in. LOUDSPEAKER (30/-) ALL FOR..... **£9.0.0**  
 Carriage and Insurance on each above 10/- extra.

**TO ADD FULL TAPE RECORDING FACILITIES**

To any modern "Hi-Fi" AUDIO AMPLIFIER (such as our Mullard "5-10" and 2 valve Preampifier) ALL YOU WE OFFER

- NEED IS... THE TYPE "C" PREAMPLIFIER and a TAPE DECK... WE OFFER
- (a) The COLLARO Mk. IV TAPE DECK and the MULLARD TYPE "C" PREAMPLIFIER & Power Unit assembled, tested H.P. Deposit £7 and 12 months £2/11/4. **£35.0.0**
- (b) As in (a) above but the Type "C" supplied as COMPLETE KIT OF PARTS..... **£32.0.0**
- (c) The TRUVOX Mk. VI TAPE DECK and the assembled Type "C" Preampifier and Power Unit..... **£37.10.0**  
 H.P. Deposit £7/10/- and 12 months £2/15/-.
- (d) As above but the Type "C" supplied as complete KIT OF PARTS..... **£34.10.0**
- (e) The BRENNELL Mk. V DECK and the assembled Type "C" PREAMPLIFIER and POWER UNIT..... **£46.0.0**  
 H.P. Deposit £9/4/- and 12 months £3/7/6.
- (f) As above but the Type "C" supplied as complete KIT OF PARTS..... **£43.0.0**

(Carriage and Insurance on above quotes 10/- extra.) PLEASE ENCLOSE S.A.E. WITH ALL CORRESPONDENCE.

**STERN RADIO LTD.**  
 109 & 115 FLEET ST., LONDON, E.C.4  
 Telephone: FLEET STREET 5812/3/4

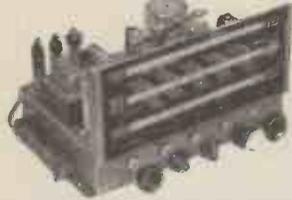
# MODERNISE YOUR OLD RADIOGRAM

It is **CHEAPER** and **BETTER VALUE** TO REPLACE YOUR OLD CHASSIS and **GRAM UNIT**

## !! RADIOGRAM CHASSIS !!

### ARMSTRONG "STEREO TWELVE" £37/16/0

The most complete unit yet produced for Stereo giving 6 watts high fidelity push-pull output on each channel, 12 watts for monaural. Full VHF band, medium and long wavebands. Stereo and monaural inputs for records, tape and radio and a tape output for stereo and monaural tape recording. Comprehensive matching for all types of crystal pick-ups. The perfect basis for a complete monaural reproducing system or for a complete stereophonic system now or later.



### ARMSTRONG "JUBILEE"

An AM/FM chassis with nine valves and two diodes and with push-pull output stage providing 6 watts. Full VHF medium and long wavebands with automatic frequency control on FM and ferrite aerial on AM. Tape record and playback facilities. Can be adapted for stereo at any time by the addition of our compact, easy-to-fit converter amplifier.

### ARMSTRONG "STEREO 44" £28/7/0

Provision is made for Stereo and monaural playback from pick-up or tape. Outputs provided for Stereo or Monaural tape recordings. Alternative inputs enable the use of most crystal pick-ups, together with tape recorders or tape preamplifiers (such as our type "C" unit). 6 watts output. Radio covers med. waveband and the complete VHF/FM transmission 87-108 Mc/s.

### DULCI "H4PP" £27/16/6

An 8 valve AM/FM 4 waveband chassis giving 6 watts ultra linear output. Covers short, long, medium wavebands plus the VHF/FM band and has internal aerial on the medium and long wavebands. Tape outlet incorporated and suitable for 3 to 15 loudspeakers.

### DULCI "H3" £19/17/6

A 6 valve AM/FM chassis giving 4 watts output. Covers medium and long wavebands, on which an internal aerial operates, plus the VHF/FM band. Full AVC on all wavebands and tape outlet incorporated. NEW HIRE PURCHASE TERMS are available on all above. Illustrated leaflets available—send S.A.E.

## AM/FM RADIO TUNING UNITS

### Incorporating own Power Supply Units ARMSTRONG "S.T.3" £27/6/0

A self-powered high fidelity tuner covering full VHF, medium and long wavebands with automatic frequency control on VHF. Excellent in combination with our MULLARD AMPLIFIERS but the cathode follower stage and variable feedback output control enable this tuner to be used with virtually any amplifier available.

### DULCI "H4/T" £23/15/8

A 4 waveband self-powered high fidelity tuner covering the VHF/FM transmissions plus the long, medium and short wavebands. Excellent performance in combination with our MULLARD AMPLIFIERS and also all high quality designs. ILLUSTRATED LEAFLET showing recommended HIGH QUALITY LOUDSPEAKERS is available—send S.A.E.

## STERN'S FOR STEREO

OUR POPULAR MULLARD MAIN AMPLIFIERS ARE RECOMMENDED FOR USE WITH THE DULCI DUAL CHANNEL STEREO PREAMPLIFIERS

### The "STEREO EIGHT" PREAMPLIFIER £23.2.0

(Carr. & Ins. 5/- extra)

### The "STEREO TWO" PREAMPLIFIER £9.9.0

(Carr. & Ins. 5/- Extra)

Both Preamplifiers can be supplied to correctly operate with our very popular MULLARD "3-3" and "6-10" MAIN AMPLIFIERS (described on page 138). For Stereo reproduction TWO Main Amplifiers are necessary but for normal "HI-FI" reproduction the "Stereo Eight" and the "Stereo Two" are perfectly suitable to operate with ONE Main Amplifier and the second Main Amplifier can then be added at any time thus transforming a standard "HI-FI" installation over to the Stereo.

WE OFFER PREAMPLIFIERS and AMPLIFIERS AT SPECIALLY REDUCED PRICES. Send S.A.E. for fully descriptive leaflets.

## STERN'S 12 VOLT CAR RADIO



incorporating . . .

### PRINTED CIRCUIT and POWER TRANSISTOR

A versatile design covering both LONG and MEDIUM WAVEBANDS, incorporating Transistor Output thus having very low battery consumption. Is operated direct off 12 volt car battery.

We offer it on the UNIT ASSEMBLY BASIS . . . consisting of . . . THREE SEPARATE FULLY WIRED, ALIGNED AND TESTED UNITS £15.0.0

Only 12 solder joints are required to finish the complete receiver. ALL FOR send 1/6 for manual containing complete data

### SPECIAL CASH ONLY BARGAIN

A bulk purchase enables us to offer this very useful INTERCOM SET or BABY ALARM For only £5.5.0

Consists of MASTER UNIT (illustrated) and one EXTENSION, providing 2-way TALK-LISTEN facility. Complete in polished wood cases, size of each only 7½ x 4½ x 6in. high.

## !! RECORD PLAYERS !!

The LATEST MODELS are in Stock. Many at REDUCED PRICES!!! Send S.A.E. for ILLUSTRATED LEAFLET

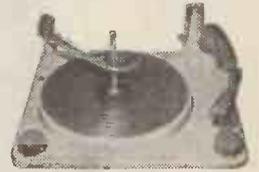
### A FEW CASH BARGAINS

B.S.R. MONARCH UA84-epd. Mixer £6.12.6

Autochanger with Crystal Pick-up. £6.12.6

The COLLARO "CONQUEST" 4-speed auto-changer Studio "O" Pick-up. £7.10.0

The latest COLLARO "CONTINENTAL" 4-speed MIXER Autochanger, Studio "O" Pick-up. £8.10.0



The COLLARO model 4/564 4-speed Single Record Player, Studio Pick-up £6. 6. 0

THE NEW B.S.R. model UA12 is in stock. A4 "SPEED" MIXER AUTOCHANGER £8. 7. 6

UA12 also available incorporating the B.S.R. STEREO Pick-up £10. 10. 0

plays L.P. and 78 records GARRARD RC121/4 4-speed Autochanger fitted with latest Crystal Pick-up £10. 0. 0

B.S.R. Model TU9 4-speed single record player, complete with separate crystal pick-up £4. 4. 0

(This high output pick-up is available separately for £1/12/6.)

Carriage and insurance on each above 5/- extra.

## HIGH FIDELITY UNITS IN STOCK

The latest GARRARD TRANSCRIPTION MOTOR "301" with Stroboscopically marked turntable. £26. 14. 6

The new GARRARD Model 4HP High Quality single Record Player fitted with the latest T.P.A. 12 pick-up arm and G.C.3 Crystal Cartridge £18. 9. 9

GARRARD Model TA/MK II Single Record Player fitted with high output Crystal Pick-up, detachable head. £8. 15. 0

The GARRARD T.P.A. 12 TRANSCRIPTION PICK-UP ARM is available separately or with Crystal or Moving Coil Pick-up Heads.

HIRE PURCHASE TERMS available on all units £8/19/6 and over. Send S.A.E. for Leaflet

## SPECIAL CASH ONLY OFFER !!

This very attractive PORTABLE AMPLIFIER CASE together with a good quality GRAM AMPLIFIER and a matched P.M. SPEAKER. ALL FOR ONLY £8.7.6

(plus 7/6 carr. and ins.). The Amplifier consists of a 2-stage design incorporating the 3 modern 6V4 valves and has separate BASS and TREBLE CONTROLS. The Portable Case will also accommodate almost any make of Autochanger and is attractively finished in Grey colour Rexine—WE ALSO SUPPLY SEPARATELY:

(a) The 2-stage (plus Rectifier) AMPLIFIER £4 2 6

(b) The PORTABLE CARRYING CASE £3 17 6

(c) 6in. P.M. SPEAKER 18 9

(Carriage and insurance 4/- extra)

We also have a smaller PORTABLE CASE ideal for Record Players. PRICE ONLY £3/3/- (plus carriage and ins.).



## !! HOME CONSTRUCTORS !!

A RANGE OF "EASY TO ASSEMBLE" PREFABRICATED CABINETS

Designed by the W.B. "STENTORIAN" (COMPANY for "HI-FI" Loudspeaker systems or to accommodate high-quality equipment. The acoustically designed Bass Reflex Cabinets containing the very successful "Stentorian" Speakers give really first-class reproduction and are well recommended. Models are also available to accommodate high-quality Amplifiers, Preamplifiers, Tuning Units, Record Players, etc. All models are very easily assembled, in fact only a screwdriver is required.

Fully illustrated leaflets are available including complete specifications of the various STENTORIAN LOUDSPEAKERS. Please enclose S.A.E.

### STERN'S MK II "fidelity"

F.M. TUNING UNIT

(Plus 5/- carr. and ins.) £14.5.0

HIRE PURCHASE: Deposit PRICE £2/17/- and 12 months at £10/11. Incorporates the latest MULLARD PERMEABILITY TUNING HEART and the corresponding MULLARD VALVE LINE UP comprising EOC85, 2 type EF85s (or EF93s). EM84 Tuning Indicator, plus 2 type O.A. 79s Germanium Diodes. A really first-class Tuner very attractively presented and comparable to many offered at much higher prices. Power consumption is only 1.5 amps at 6.3 volts and 25 m/a at 250 volts.



## HOME CONSTRUCTORS!

YOU CAN BUILD THIS TUNING UNIT FOR ONLY £10.10.0

(Plus 5/- carr. and ins.) Please send S.A.E. for fully descriptive leaflet, or the Assembly Manual is available for 1/6

The JASON "MERCURY" Switched F.M. TUNER IS IN STOCK

PRICE ASSEMBLED £13.10.0

AND TESTED

CREDIT SALE Deposit £3/7/6 and 9 monthly payments of £1/4/10.

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A COMPLETE KIT OF PARTS FOR ONLY £2.19.6

Will charge 6 or 12 volt batteries at max. 2½ amps. The design incorporates Bellini Resistor and Fuse and we supply complete with Metal Box container. EASY TO FOLLOW ASSEMBLY INSTRUCTIONS ARE INCLUDED.

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# CLYNE RADIO LTD.

THE  
COMPONENT  
SPECIALISTS



*Special Summer Offer!!*

Our super-sensitive "FAMILY FOUR" T.R.F. Receiver for home construction. Covers Long and Medium Wavebands, is housed in very smart plastic table cabinet in Brown or Black. For A.C. Mains 200/250 v. Comprehensive assembly instructions provided, including practical and theoretical diagrams, which are easy to follow and will enable you to complete this receiver which will be the envy of your friends. ALL NECESSARY COMPONENTS ARE BEING OFFERED FOR LIMITED PERIOD ONLY AT THE REMARKABLE PRICE OF ONLY 79/6, plus 2/6 p. & p. Instruction book available separately if you wish to study before purchase at 1/6 post free.



## LEADING THE FIELD— in equipment for

### THE CONSTRUCTOR & HI-FI ENTHUSIAST

SEND STAMP FOR FULL LIST including F.M. Tuners, Receivers, Amplifiers, Stereo Amplifiers, Tape Pre-Amplifiers, Transistor Portables, Crystal Receivers, Battery Charger, Baby Alarm, etc., etc.  
NOTE: ALL components supplied, including valves (even if surplus types) are guaranteed to be BRAND NEW!!!

### THE NEW LOOK RAMBLER ALL DRY BATTERY PORTABLE

This wonderful receiver (the ideal companion for your summer holiday) with the "hall-mark" of quality, is housed in a most attractive cabinet finished in two-tone RED/GREY "Lionide" with chrome fittings. The very neat appearance is set off by the smart cream plastic top panel engraved with the stylized "Clyne" logo. Employing modern miniature valves: 1R5, 1T4, 1S5, 3V4, and a good quality 5in. loudspeaker, this receiver has everything—quality, sensitivity, volume, tone and economy. Uses all-dry batteries AD35 (1/6), B126 (9/-). All necessary components (less batteries) are offered at a special inclusive price of only £7/7/- plus 2/6 p. & p. or Special extra-economy version with latest range of low consumption valves (DK96, DF96, DAF96, DL96), £7/15/6, plus p. & p. Easy-to-follow Instruction Book, containing full description, itemised price list, practical and theoretical diagrams, available separately at 1/6 post free.

RAMBLER MAINS UNIT enabling the above receiver to be run directly off any A.C. mains supply 200/250 v. Fits snugly into the battery compartment (dimensions 7in. x 2½in. x 1½in. overall). All necessary components supplied at ONLY 47/6, plus 1/6 p. & p., or can be supplied assembled and tested at £3/5/-, plus p. & p. (Also suitable for many other portables.)

### THE NEW JASON FM TUNER

The latest addition to the impressive JASON range, and like all JASON equipment, can be depended upon for QUALITY, RELIABILITY and PERFORMANCE.



Incorporates the very latest features in design to ensure simplicity of operation and faultless performance. Housed in smart metal shelf mounting cabinet in pastel green with grey plastic dial. Built-in power supplies enable connection to any amplifier or radio fitted with Pick-up sockets, without complication. Two versions are available, i.e. Standard or Fringe Area. ALL NECESSARY COMPONENTS SUPPLIED AT SPECIAL INCLUSIVE PRICE OF: STANDARD TUNER £8/19/6; FRINGE AREA TUNER £10/19/6, both plus 3/6 p. & p. Comprehensive Assembly Instructions with full description and itemised price list are available separately if required at 2/6 post free.

### AGOS MIC 39-1

Crystal stick microphone. List price 5 gns. Our price 39/6, plus 1/6 p. & p. Stand included.

### THE CLYNE RADIO "DE LUXE" PRINTED CIRCUIT SUPERHET

A new two wave band (L and M) Superhet using the latest miniature valves: ECH81, EF85 and ECL80, plus contact cooled Rectifier, Incorporates Ferrite Rod Aerial and is of unit construction. Exceptional sensitivity and selectivity. Outstanding performance and quality T.C.C. condensers throughout. Easily constructed in one evening. Brown Ivory Bakelite or wooden Walnut finish cabinet. A.C. mains 200/250 v. All necessary components at special inclusive price of £7/19/6 plus 3/6 p. & p. Instruction Book with itemised price list available separately at 1/6 post free. Also available in De Luxe Cabinet (as "Economy Four" at 5/- extra).

### SUPER 5 WAVE BAND CAR RADIO (By Pye of Cambridge.)

This excellent receiver is very easily fitted in any car with 12 v. system. Comprising: power unit, 6½in. speaker on baffle and tuner unit. Valve line-up: 2-EF41, ECH42, EBC41, EL42, EZ41. THREE SHORT WAVE BANDS 5 (16-31 m.), MEDIUM (190-550 m.) and LONG (1,900-2,000 m.), variably tuned. Controls: volume on/off/tone, wave change/tuning. Horizontal dial with chrome surround. BRAND NEW, FULLY G'TEED AND UNREPEATABLE AT £17/19/6 plus 5/- p. & p. Terms available.

### MULLARD 510 HIGH-FIDELITY AMPLIFIER

Printed circuit version with ULTRA LINEAR PUSH-PULL output stage, giving excellent output of 10 watt (max.). Built-in controls. Will suit all types of high impedance input. All required components of best quality to Mullard Spec. are offered at special inclusive price of £9/9/- plus 3/6 p. & p. Instruction Book with full construction details, diagrams, etc., and itemised price list available separately at 3/6 post free.



### MAJOR SEVEN ALL PURPOSE TRANSISTOR PORTABLE

Special de Luxe Cabinet in maroon/grey or black and white polka dot/grey. Supplied complete with 7 specially selected transistors, 7 x 4in. elliptical loudspeaker, slab aerial, and batteries. Push-pull output, Medium and Long Wave coverage. All necessary components and full assembly instructions at SPECIAL INCLUSIVE PRICE of £9/9/- plus 3/6 p. & p. or with MAZDA Transistors (250 mw. output), 15/- extra. Instruction envelope and itemised price list available separately at 1/6 post free.



### NEW LOOK ECONOMY FOUR

Our very popular three valve mains T.R.F. receiver is now available with a new De Luxe cabinet with polished Walnut finish and Cream trimming (as illustrated). Brief Spec.: Valve line-up 6K7, 6J7, 6V6. Ready drilled chassis, good quality 5in. loudspeaker, Special Denco Coils. Covers Medium and Long Wavebands. Overall dimensions: 12in. x 6in. x 5in. high. A.C. 200/250 v. Simple construction with guaranteed results. Easy to follow practical and theoretical diagrams supplied. All necessary components, down to the last nut and bolt, are offered at a SPECIAL INCLUSIVE PRICE OF £5/10/-, plus 2/6 p. & p. Instruction book available separately 1/6, post free. Also available with plastic cabinet in IVORY or BROWN if preferred at ONLY £5/5/-, plus p. & p.



If not stated, please add postage on orders under £1. Cash with order or C.O.D. (charges extra).

## CLYNE RADIO LTD.

Open: Tottenham Court Rd.: 9 a.m. to 6 p.m. Mon. to Fri. Sat 1 p.m. Holloway Road: 9 a.m. to 6 p.m. daily. Thurs. 1 p.m., Sat. 5.30 p.m.

Our advantageous H.P. and Credit Sale terms are available on any single item over £5. Your enquiries invited.

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All post orders and correspondence to 162 HOLLOWAY ROAD, LONDON, N.7.

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- TRANSISTORS !!! —**
- SURPLUS—P.N.P.**  
**RED SPOT** (Audio/Experimental Application) ..... 7/6 ea.  
**WHITE SPOT, R.F.** up to 2.5 Mc/s. .... 12/6 ea.  
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 V10/15A. .... 15/- ea.  
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**AMPLIVOX HEADSET SPECIAL.** (not surplus.) As used in up-to-date ships, aircraft, etc. Excellent quality super lightweight low impedance magnetic headphones complete with button microphone attached and plastic ear moulds. Absolutely brand new. 45/- pair. Plus 1/6 P. & P.  
**12in. BAKERS SELHURST LOUD-SPEAKERS** 15 ohms, 15 watt, 30-14,000 cps. Brand new, £4/10/- plus 3/6.

**LATEST B.S.R. UA12 STEREO** 4-speed autochanger unit complete with FUL-FI stereo cartridge for monoaural or stereo records. Brand new and fully guaranteed. £10/19/6 plus 3/6 P. & P. Terms available

**GARRARD RC.121D MK. II STEREO MONAURAL 4-SPEED AUTO-CHANGER.** Complete with GC8 plug-in crystal head and sapphire styli for monoaural records. Brand new, fully guaranteed. Limited stocks. ONLY £11/0/6, plus 5/- P. & P. NOTE: Garrard L.P. Stereo plug-in head for above available as optional extra for £2/0/1 inc. P.T. Terms available.

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**THE LATEST COLLARO "CONQUEST"**  
 4-speed autochanger  
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 £7/19/6, plus P. & P. 3/6.



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## A QUALITY RECORDER FOR 39 GNS.

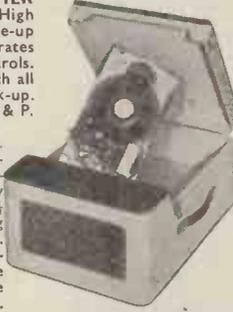
Collaro Mark IV Tape	£25 0
Transcriptor Deck	£14 14
Special amplifier	£1 10
8 x 6in. loudspeaker	£4 10
De Luxe Cabinet with gilt fittings	£2 5
Collaro Mike (or similar)	£1 15
1,200ft. EMI tape	£1 15
<b>TOTAL</b>	<b>£49 14</b>

**OUR SPECIAL INCLUSIVE PRICE ONLY 39 GNS.** if all items purchased together. Terms: £4/19/- dep. and 12 monthly payments of £3/3/- C. & P.

15/- extra. Full assembly instructions provided. Note: We shall be pleased to wire the tape deckswitches at extra charge of £1. Send stamp for further details.

## EXTRA SPECIAL OFFER !!

A small three-valve **PORTABLE RECORD-PLAYER AMPLIFIER** mounted on baffle 12 x 7in. with High Flux 6½in. Loudspeaker, Valve line-up ECC83, EL84 EZ80. Incorporates separate bass and treble controls. Max. output 3 watts. Will match all types of high impedance pick-up. Ready to use, £5/12/6 plus 3/6 P. & P.  
**NEW STYLE CABINET** finished in two-tone Leatherette. Will accommodate above Amplifier and Baffle without modification, also most types of Ancillary Equipment. Overall size 18 x 13½ x 8½in. Fitted with carrying handle, £3/9/6 plus 5/- P. & P.  
**NOTE.** If both items purchased together they will be supplied at a special Inclusive price of £8/7/6 plus 6/6 P. & P.



# CLYNE RADIO LTD.

162 HOLLOWAY ROAD, LONDON, N.7 and 18 TOTTENHAM COURT ROAD, W.1.

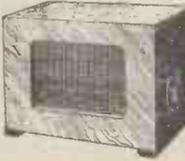


**CABINETS.** We carry large stocks of cabinets to suit all types of equipment at prices ranging from 45/-. This cabinet is an example of the wonderful new "RECORD HOUSING" range and is priced at only £12/19/6, plus 20/- carriage and packing. Suitable for housing all types of turntable, tape deck, amplifier etc. Terms available if required. Send stamp for illustrated leaflets of full range.

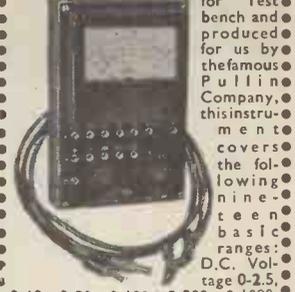
**RADIO JACK.** A recent addition to our comprehensive range of equipment to build yourself. Covers local Medium Wave Stations variably tuned. Compact self-contained unit requiring only connection to aerial (no power supplies required) for first-class reception when used in conjunction with your tape recorder or high gain amplifier. All necessary components available at a special inclusive price of only 19/6 plus 1/6 P. & P.

**VALVES.** We have perhaps the most up-to-date valve stocks in the trade. New imported valve types fully guaranteed and P.T. paid and all the usual surplus types at special prices. We also carry a comprehensive stock of all B.V.A. types at current list prices. Send stamp for list. Note: Certain other American special purpose types can be supplied. Enquiries invited.

**ATTRACTIVE POLISHED WOODEN EXTENSION SPEAKER CABINET** (slight blemishes) fitted with good quality 8in. loudspeaker unit (for example: Goodman, W.B., or similar). Supplied as High Impedance unit with volume control easily converted to standard Low impedance for matching domestic Radio etc. Size approx. 11in. x 14in. x 6½in. These are reclaimed "Rental" units in first class working order and are ONLY 16/6, complete, plus 3/6 P. & P.



## A PRECISION TEST METER (To build yourself)



Designed for Test bench and produced for us by the famous Pullin Company, this instrument covers the following nine basic ranges: D.C. Voltage 0-2.5, 0-10, 0-50, 0-100, 0-500, 0-1000. (All ranges 5000 ohms per volt). A.C. Voltage 0-10, 0-50, 0-100, 0-500, 0-1000. (All ranges 5000 ohms per volt). D.C. Current 0-10 ma., 0-100 ma., 0-250 ma., 0-500 ma., A.C. current, 0-200 microamps. Resistance, 0-200,000 ohms. (Easily extendible to 2 megohms.) Accuracy, 3% of F.S.D. on D.C. ranges. 41% on A.C. ranges; any frequency between 15-20,000 C.P.S. (Sine wave) 5% on resistance range. Positive Range selection by means of plug and socket. This fine instrument is easily constructed, full instructions being given with each assembly. All necessary components available at a **SPECIAL INCLUSIVE PRICE OF £7/5/-** plus 2/6 P. & P. Illustrated leaflet on request.

## PORTABLE GRAM AMPLIFIERS

**RC2A.** Small PRINTED CIRCUIT single-valve high-gain amplifier for the smaller type of portable. Employs latest type ECL82 valve. Full details on request. Price 59/6 plus 2/- P. & P.  
**RC3A.** A superior quality 3-valve amplifier employing E280, EL84 and ECC83. With separate bass and treble controls. Price £3/19/6 plus 2/6 P. & P. O.P. Transformer available at 4/6 extra.

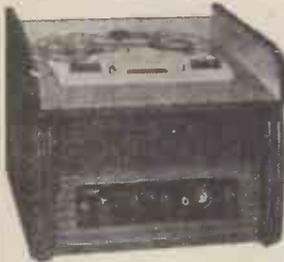
The **BABY CRY ALARM**

This highly efficient unit is simple to assemble, extremely sensitive and may be installed in a matter of minutes. Completely SAFE employing a double wound mains transformer. Attractively finished in Red and Grey (washable) "Lionide" with cream plastic escutcheon. Size only 7½in x 3½in. x 6½in. Supplied in kit form complete with mike at ONLY 72/6 plus 2/6 P. & P. or assembled and tested 89/6 P. & P. 2/6. Suitable mike flex available at 3d. a yard. Instruction book and price list separately 1/- post free. A.C. 200-250 v.

**TRANSFORMER SPECIAL.** Superior quality half shrouded drop thro' Mains Transformer. Input 20/250 v. Output 350-0-350 v. 80 mA. 6.3 v. 3 amps. 5 v. 2 amps. Ex-equipment guaranteed O.K. Only 9/6 plus 1/- P. & P.

### R.S.C. HI-FI TAPE RECORDER

For space conservation the lid is omitted from illustration.



The unit is housed in an attractive walnut veneered cabinet as illustrated. Size approx. 18x17x14 in. high.

INCORPORATING THE LATEST MK. IV COLLARO TAPE TRANSCRIBTOR. THE LINEAR LT45 HIGH QUALITY TAPE AMPLIFIER AND A HIGH FLUX 8 x 5in. LOUD-SPEAKER.

**39½** Carr. 15/- GNS.

A spare tape spool and an 850 ft. reel of first quality L.P. tape is included.

A Collaro Studio Microphone can be supplied with the recorder only at a special price of 37/6.

YOU CAN PAY TWICE THE COST FOR THE SAME QUALITY. Full descriptive leaflet supplied on receipt of S.A.E.

H.P. TERMS. DEPOSIT 3 gns. and 12 monthly payments £3/10/6.

### HI-FI 8 WATT AMPLIFIER

SPECIAL PURCHASE DUE TO CANCELLED EXPORT ORDER **£4-19-6**

For 200-250 v. A.C. mains. Carr. 7/6

A REMARKABLE OPPORTUNITY!

Push-pull output. Latest high efficiency B.V.A. valves. Dual separately controlled inputs for mike and gram. Separate bass and treble controls. High sensitivity. Output for 15 ohm loudspeaker. Guaranteed brand new, tested, and in perfect working order.

#### AUTO-CHANGER COLLARO RG54 3-SPEED MIXER

Fitted Studio pick-up with turnover head. Brand new cartoned, but for 110 v. 50 c.p.s. A.C. mains. So that the unit can be operated from normal 200-250 v. A.C. mains we are supplying free with every changer a suitable auto-transformer with input and output voltage clearly marked. Limited number only. £5/19/6. Carr. 5/6.

### THE SKYFOUR T.R.F. RECEIVER



A design of a 3 valve 200-250 v. A.C. mains. L and M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated or walnut veneered type. It employs valves 6K7, 6F6, 6F9, and is especially

designed for simplicity in wiring. Sensitivity and quality are well up to standard. Point-to-point wiring diagram. Instructions and parts list. 1/9. This receiver can be built for a maximum of £4/10/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

### R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½x4½x2in. approx. Completely replaces batteries supply 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s is available. Suitable for all battery portable receivers requiring 1.4 v. and 90 v. This includes latest low consumption types. Complete kit with diagram 39/9 or ready for use 46/9.

Type BM2. Size 8x5½x2½in. Supplies 120 v., 90 v. and 60 v., 400 mA. and 2 v. 0.4 a. to 1 amp., fully smoothed. THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND K.T. 2 v. ACCUMULATORS when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit with diagrams and instructions. 49/9 or ready for use 59/6.



### SIX TRANSISTOR POCKET RADIO RECEIVER

All parts including cream or coloured plastic case, printed superhet circuit, ferrite aerial. Transistors, 2½in. P.M. speaker. Long and medium wavebands. Size of unit 5½x3¼x1½in. Detailed construction booklet supplied.



**£9-19-6**

Total cost of parts. A working unit can be demonstrated at our County Arcade premises. All items are available separately.

### R.S.C. TRANSFORMERS

FULLY GUARANTEED INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS	
Primaries 200-230-250 v. 50 c/s.	
FULLY SHEATHED UPRIGHT MOUNTING	
250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a.	17/6
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 610 Amplifier	33/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
350-0-350 v. 160 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	33/9
425-0-425 v. 20 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a., c.t. 5 v. 3 a.	49/9
TOP SHEATHED DROP-THROUGH TYPE	
260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	22/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9
ELIMINATOR TRANSFORMERS	
Primaries 200-250 v. 50 c/s.	
120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 60-0-6 v. 250 mA.	9/11
FILAMENT TRANSFORMERS	
Primaries 200-250 v. 50 c/s.	
6.3 v. 1.5 a.	5/9
6.3 v. 2 a.	7/6
0-4-6 v. 2 a.	7/9
12 v. 1 v.	7/9
6.3 v. 3 a.	8/11
6.3 v. 6 a.	17/6
12 v. 3 a. or 24 v.	17/6
1.5 a.	17/6
OUTPUT TRANSFORMERS	
Midget Battery Pentode 661 for 334, etc.	3/6
Small Pentode 5,000Ω to 3Ω	3/9
Standard Pentode 5,000Ω to 5Ω	4/6
Standard Pentode 8,000Ω to 3Ω	4/9
Push-pull 8 watts 6V6 to 5 ohms	8/9
Push-pull 10-12 watts 6V6 to 3Ω or 15Ω	15/9
Push-pull 10-12 watts to match 6V6 to 3-5-8 or 15Ω	16/9
Push-pull EL84 to 3 or 15 ohms	16/9
Push-pull 15-18 watts, sectionally wound 6L6, KT66, etc., or 3 to 15 ohms	12/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9
SMOOTHING CHOKES	
250 mA., 5 H., 100 ohms	11/9
150 mA., 7-10 H., 250 ohms	11/9
100 mA., 10 H., 200 ohms	8/9
80 mA., 10 H., 350 ohms	5/6
60 mA., 10 H., 400 ohms	4/11
1 amp. 0.5 ohm L.T. type	6/6

#### PHILCO F.M. RADIO TUNERS

With self-contained power pack. A 6-valve de luxe unit housed in beautiful walnut veneered cabinet. For 110-200-250 v. A.C. mains. Magic eye tuning indicator **12½** Carr. 5/- (list £21).



#### EXTENSION SPEAKERS

Limited number in hand-some Walnut veneered cabinets. 2-3 ohm speech coils, 6½in. 29/9. 8in. 35/9. 10in. 56/9.

DRY SHAVERS. Brand new in carrying case. Operation from 3 U2 batteries, fitted in case. Just the thing for travel. Only 59/6 (approx. half price).  
RECORDING TAPE. 600ft. reels, 8/9. 1,200ft. reels 14/9.  
ELECTRIC SOLDERING IRONS with neon indicator. Lightweight type for radio work, 19/9.

### LINEAR L3/3 STEREO AMPLIFIER



Sensitivity 150 m.v. for 3 watts output on each channel. Ganged Vol. and Tone Controls. Pre-set balance control. Outputs for two matched 2-3 ohm speakers. (Can be used as

straight 6-watt amplifier). Provides remarkably realistic output when connected to 200-250 v. A.C. mains point. Stereophonic pick-up head and good quality speakers. Instructions and guarantee included. Carr. free. Send S.A.E. for leaflet. **7 gns.**

Or deposit 27/9 and 5 monthly payments of 27/9.

#### COLLARO JUNIOR 4-SPEED RECORD PLAYER

with separate pick-up having dual point sapphire stylus. Brand new, cartoned. For 200-250 v. A.C. mains only. Only £4/10/6. Post 3/6.

### R.S.C. A12 STEREO AMPLIFIER KIT

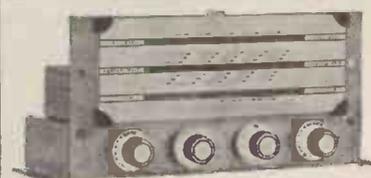
**£3-19-6**

Carr. & packing 7/6.

A complete kit of parts to construct a good quality 3+3 watt (total 6 watt) stereo amplifier providing really life-like reproduction. Suitable for use with all stereo, pick-up heads at present available. Ganged volume and tone controls. Preset balance control. Outputs for matched 2-3 ohm speakers. For 200-250 v. A.C. mains. Astonishing value.

#### W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS

HF1012, 10 watts 15 ohms (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance. £4/10/9. Please state whether 3 ohm or 15 ohm required.



AM/FM RADIOGRAM CHASSIS, HIGH QUALITY. PUSH-PULL. 6-8 WATT OUTPUT. Current manufacture. 12 months guarantee. For 200-250 v. mains. Covers L. and M. wavebands plus F.M. Includes 8 latest type miniature B.V.A. valves. Only 22 gns. plus 7/6 carr. Or deposit £2/12/- and 9 monthly payments of £2/12/-.

COLLARO AC/4/564 4 Speed Single Players £6/9/6. Carr. 4/6.

# R.S.C. A.10 ULTRA LINEAR HIGH FIDELITY 12-14 WATT 30 WATT AMPLIFIER

**HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES.** EP86 EF86, ECC83, 807, GZ34. Tone Control Pre-amp. stages are incorporated. Sensitivity is extremely high. Only 12 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. An extra input with associated vol. control is provided so that two separate inputs such as "mike" and gram, etc., can be simultaneously applied for mixing purposes. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 a. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams.



Only **11 Gns.** Carr. 10/- Cover as illustrated 18/9 extra.  
Or Factory built with 12 months' guarantee £13/19/6. **TERMS ON ASSEMBLED UNITS. DEPOSIT 24/9 and 12 monthly payments of 24/9.**

Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 20 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE TYPES AVAILABLE.** Frequency response  $\pm 3$  D.B. 30-20,000 c/ps. Tone Controls  $\pm 12$  D.B. at 50 c/ps.  $\pm 12$  D.B. to  $-6$  D.B. at 12,000 c/ps., hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12 x 9 in. approx. Power consumption 160 watts. For A.C. mains 200-250-250 v. 50 c/ps. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS or OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc., etc.** We can supply Microphones, Speakers, etc., at keen cash prices or on terms with amplifiers. **EXPORT ENQUIRIES INVITED.**

**LINEAR "DIATONIC" 10 WATT HIGH FIDELITY AMPLIFIER.** A compact attractively finished unit. 112 Gns. Cash. Send S.A.E. for leaflet. H.P. Terms. Dep. 22/3 and twelve monthly payments of 22/3.

**LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER.** Suitable for use with any record playing unit and most microphones. Negative feedback 12 D.B. Bass and Treble controls. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves. Size only 6 x 5 x 5 1/2 in. Chassis fully isolated from mains: Guaranteed 12 months. Only **£5/19/6.** Or Deposit 22/- and 5 monthly payments of 22/- Send S.A.E. for leaflet.

**LG3 MINIATURE 3 WATT GRAM AMPLIFIER**  
For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 6 1/2 x 4 x 2 1/2 in. Fitted vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changing unit. Output for 2-3 ohm speaker. Guaranteed 12 months. Only 55/9.

**R.S.C. A7 3-4 WATT QUALITY AMPLIFIER.** Spec. exactly as A5 below with exception of output wattage. Complete kit of parts, diagrams and instructions £3/15/-, Carr. 3/6.

**R.S.C. A5 4-5 WATT HIGH GAIN AMPLIFIER**  
A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. or 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-250-250 v. 50 c/ps. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/- or assembled ready for use 25/- extra, plus 3/6 carriage. Or Deposit 22/- and five monthly payments of 22/- for assembled unit

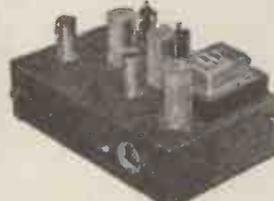
**P.M. SPEAKERS**  
2-3 ohm 2 1/2 in. Rola 17/9. 5 in. Goodmans 17/9. 7 x 4 in. Goodmans Elliptical 19/9. 6 1/2 in. Rola 19/9. 8 in. Rola 19/9. 8 in. Goodmans 21/9. 10 in. R.A. 23/9. 10 x 6 in. Elliptical Goodmans 29/9. 12 in. Plessey 29/11. 12 in. Plessey 3 or 15 ohms, 10 watts, 12,000 lines, 59/6.

**COLLARO 4-SPEED AUTO-CHANGERS.** With studio pick-up with turnover head. **BRAND NEW.** Cartoned latest model. For 200-250 v. A.C. mains. Very limited number. Conquest £7/19/6. Continental 9 gns. Carr. 3/6.  
**ACOS Crystal Microphone Inserts.** Brand new. Only 5/11 ea. Ex. Equip. 4/11 ea. **ACOS HG259 Hi Fi Crystal Cartridges.** (Turnover type with sapphire stylus). Standard replacement for Garrard and B.S.R. Only 19/9.

**PUSH PULL ULTRA LINEAR OUTPUT "BUILT IN" TONE CONTROL/PREAMP STAGES.**



Two input sockets with associated controls allow mixing of "mike" and gram. as in A10. High sensitivity. Includes 5 valves, ECC83, EOC83, EL84, EL84, 5Y3. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. **INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut."** Frequency response  $\pm 3$  D.B. 30-50,000 c/ps. Six negative feedback loops. Hum level 60 D.B. down **ONLY 23 millivolts INPUT** required for **FULL OUTPUT.** Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs. For **STANDARD or LONG PLAYING RECORDS.** For **MUSICAL INSTRUMENTS** such as **STRING BASS, GUITARS, etc.** **OUTPUT SOCKET** with plug provides 300 v. 30 mA. and 6.3 v. 1.5 a. For supply of a **RADIO FEEDER UNIT.** Size approx. 12-9 in. For A.C. mains 200-250 v. 60 c/ps. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. Only **8 Gns.** Carr. 10/- If required louvred metal cover with 2 carrying handles can be supplied for 18/9. **TERMS ON ASSEMBLED UNITS. DEPOSIT 24/9 and 12 monthly payments of 18/9.** Send S.A.E. for illustrated leaflet detailing Ready-to-assemble Cabinets, Speakers, Microphones etc. with cash and credit terms.



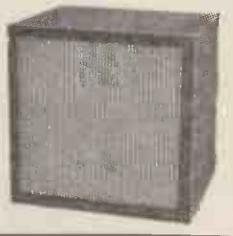
**LINEAR LT/45 HIGH QUALITY TAPE DECK AMPLIFIER**  
**COMPLETE WITH POWER PACK and OSC. STAGE.** Suitable for Collaro, Lane, Truvox, Brenell, etc. State make of Deck when ordering. Chassis size 12-7-3 in. Overall size 12-7-6 1/2 in. For 200-250 v. 50 c/ps. A.C. mains. Output for standard 2-3 ohm speaker. Only 15 millivolts input required for full recording. Only 2 millivolts minimum output required from recording head. Magic Eye recording level indicator. Provision for feeding P.A. amplifier. Negative feedback equalisation. Linear frequency response  $\pm 3$  D.B. 50-11,000 c/ps.

**12** Ready for use GNS. Carr. 7/6. Or Dep. 22/3 and 12 payments 22/3.

Facilities for recordings at 15 in., 7 1/2 in. or 3 1/2 in. per second. Separate gain and output controls. Valves type ECC83 EOC83, EL84, E290, EM34 Output 4 watts. 12 months' guarantee. Leaflet 6d.

**SUPERHET RADIO FEEDER UNIT**  
Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode P/Changer is used. Pentode I.F. and double Diode Second Detector, delayed A.B.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. Sw incorporates Gram. position. Controls are Tuning, W. Ch. and Vol. Output will load most Amplifiers requiring 500 mV. input depending on Ae location. Only 250 v. 15 mA. H.T. and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7 in. high. Send S.A.E. for illustrated leaflet. Total building cost is £4/15/-. Point-to-Point wiring diagrams and instructions 2/6.

**HI-FI TAPE RECORDER KIT**  
Consisting of LT45 amplifier, 29 1/2 GNS. Collaro Tape Transcriber, Mk IV Carr. 15/- Studio Microphone, Reel of best quality tape, 6 1/2 in. Speaker and diagrams

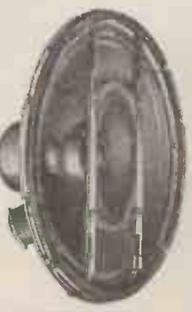


**12in. 10 WATT HIGH QUALITY LOUDSPEAKERS IN POLISHED WALNUT FINISHED CABINET**  
Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only £4/19/6. Carr. 5/-. Terms: Deposit 11/- and 9 monthly payments of 11/-.

**PORTABLE CABINETS.** Inside measurements 17 x 12 1/2 x 8 1/2 in. high. Clearance above baseboard 5 1/2 in. Below 2 1/2 in. Attractive design. Rexine covered. 69/6. Carr. 5/-.

**ACOS HIGH FIDELITY PICK-UPS.** HG259 with HGP 59/52 Cartridge. Turnover sapphire stylus, cream finish. Limited number at approx. half price. Only 35/9.

**SPECIAL OFFER**  
Above cabinet, Starr Auto-changer, LG3 Amplifier, and 6in. x 4in. speaker. Only 11 GNS. Carr. 10/-



**PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS**  
(15 ohms), consisting of a high quality 12in. speaker of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A11 or any similar amplifier. Rating is 10 watts. Gauss 12,000 lines. Price only £5/17/6. Or Deposit 10/9 and 12 monthly payments of 10/6.

**Radio Supply Co. (LEEDS) LTD.**

Personal Shoppers to 5 and 7 County Arcade, Briggate, Leeds, 1.  
Mail Orders to 29-31, Moorfield Road, LEEDS, 12.

Terms: C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on all orders under £2 2/9 extra under £5 unless carriage charge stated. Full Price List 6d. Trade supplied. Open to callers: 9 a.m. to 6 p.m. Wednesday until 1 p.m. S.A.E. please with all enquiries.

# RADIO SUPPLY CO. (LEEDS) LTD.

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Terms C.W.O. or C.O.D. No. C.O.D. under £1. Post, 1/9 under £2, 2/9 under £5 unless quoted. Open 9-6 p.m. Weds until 1 p.m.

CO-AXIAL CABLE, 75 ohms, 1/4 in., 8d. yard. Twin screened feeder 11d. yard.

VOLUME CONTROLS with long spindles, all values, less switch, 2/8; with S.P. switch, 3/9.

EX GOVT. STEP UP/STEP DOWN TRANSFORMERS. Double wound. 10-0-100-200-220-240 v. to 9-0-110-120-130-148 v. or Reverse. 300 watts, 35/8, plus 7/6 carr.

2 v. 16 A.H. EX GOVT. ACCUMULATORS. New, boxed. Only 5/6 each, 3 for 15/-, plus 2/6 carr., 6 for 27/6. Carr. 3/6.

D.C. SUPPLY KITS. Suitable for electric trains. Consists of mains trans. 200-250 v. 50 c.p.s.; 12 v. lamp selenium rect. (F.W. Bridge); 2 fuseholders, 2 fuses, change direction switch, variable speed regulator, partially drilled steel case, and circuit. Very limited number, 29/9.

VIBRATORS. Oak and Wearite, synchronous 7 pin, 2 v. 7/9, 6 v. 8/9.

JUNCTION TRANSISTORS. R.F. type, 16/9. Audio type 7/9.

R3683 UNITS. Comprising chassis and strong cover 16 x 10 x 8 1/2 in. Over 70 resistors (many high stability) and condensers, valve holders, IFTs, co-ax. sockets, controls, fuseholders, tagboards, etc., etc. Exceptional value at only 12/9 carr. paid.

JACK PLUGS. Standard type complete with 4ft. screened lead. 1/11 each. New Jack Sockets to suit (moulded type). 2/9 each.

EX GOVT. MAINS TRANSFORMERS

All 200-250 v. 50 c/s. Input.	
Pr. 0-110-200-230-250 v., 275-0-275 v. 100 mA., 6.3 v. 7 a., 5 v. 3 a.	22/9
250-0-250 v. 150 mA. 5 v. 3 a.	16/9
350-0-350 v. 180 mA. 6.3 v. 5 a., 5 v. 3 a.	27/9
400-0-400 v. 250 mA. 5 v. 2 a., 5 v. 2 a.	18/9
450-0-450 v. 250 mA. 6.3 v. 3 a., 6.3 v. 1 a., 5 v. 6 a.	49/9
12.5 v. 3 a., 5 v. 3 a.	12/9
0-24-26-28 v. 15 amps. A.C. conservative Govt. rating (marked with D.C. rating after rectification) 8/9. Carr. 15/-	
0-10-20-25 v. 24 a. (Govt. rating) 79/6. Carr. 15/-	

**SPECIAL OFFER. Brand New Ex. 24 v. 15 amp. F.W. Bridge Selenium Rectifiers. Only 25/9 ea.**

EX GOVT. SMOOTHING CHOKES

350 mA., 20 H., 150 ohms	19/6
200 mA., 8-5 H., 50 ohms. Parmeko	3/9
150 mA., 10 H., 50 ohms	8/9
120 mA., 12 H., 100 ohms	8/9
100 mA., 10 H., 100 ohms	6/9
100 mA., 5 H., 100 ohms, tropicalised	3/11
80 mA., 20 H., 900 ohms	5/9
60 mA., 5-10 H., 250 ohms	2/11

EX GOVT. CASES. Well ventilated, black crackle finished, undrilled cover. Size 14 x 10 x 8 1/2 in. high. IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE, COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post.

## SELENIUM RECTIFIERS BATTERY CHARGING EQUIPMENT

All for A.C. Mains 200-250 v. 50 c/s. Guaranteed 12 months

L.T. Types

2/6 v. 1/4 a.h.w.	1/9
6/12 v. 1/4 a.h.w.	2/9

F.W. Bridge

6/12 v. 1 a.	3/11
6/12 v. 2 a.	6/11
6/12 v. 3 a.	9/9
6/12 v. 4 a.	12/3
6/12 v. 5 a.	14/6
6/12 v. 6 a.	15/6
6/12 v. 10 a.	25/9
6/12 v. 15 a.	35/9

ASSEMBLED CHARGERS

6 v. 1 a.	19/9
6 v. 2 a.	29/9
6/12 v. 1 a.	27/9
6/12 v. 2 a.	38/9
6/12 v. 4 a.	56/9

Above ready for use with mains and output leads. Cases well ventilated and finished in stoved blue hammer. Carr. & pkg. 3/6.

CHARGER TRANSFORMERS

200-230-250 v. 50 c/s.,	
120 v. 40 mA.	3/9
250 v. 50 mA.	5/9
250 v. 80 mA.	7/9
250 v. 250 mA.	10/9
0-9-15 v. 1 1/2 a.,	11/9;
0-9-15 v. 3 a.,	16/9;
0-9-15 v. 5 a.,	19/9;
0-9-15 v. 6 a.,	23/9.

BATTERY CHARGER KITS

Consisting of Mains Transformer F. W. Bridge. Metal Rectified, well ventilated steel case. Fuses, fuse-holders, grommets, panels and circuit. Carr. 2/6 extra.

6 v. or 12 v. 1 amp.	22/9
As above, with ammeter	32/9
6 v. 2 amps.	25/9
6 v. or 12 v. 2 amps.	31/6
6 v. or 12 v. 2 amps. (inclusive of ammeter)	41/6
6 v. or 12 v. 4 amps.	53/9

BATTERY CHARGER KIT

6/12 v., 6 amp., consisting of F.W. Bridge Rectifier Mains Trans. and ammeter. 49/9. Post 4/6.

ASSEMBLED CHARGER

6 v. or 12 v. 2 amps.	49/9
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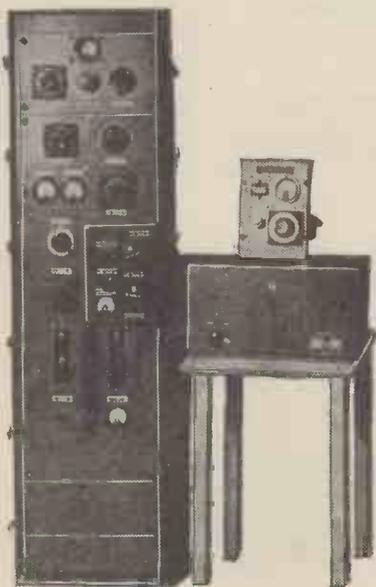
ASSEMBLED 6 v. or 12 v. 4 amps.



Fitted Ammeter and variable charge selector. Also selector plus for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. Carr. 4/6. Or Deposit 14/11 and five monthly payments 14/11.

As above but for 6 amp. charging. 5 GNS. Carr. 5/-. Or Deposit 19/9 and five monthly payments of 19/9.

## FAMOUS RCA TRANSMITTERS TYPES ET 4336, K & L



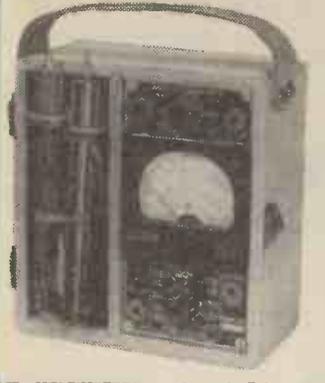
Frequency 2 mc.-20 mc.  
 Power output: 350 w. telegraph.  
 250 w. telephone.  
 Type of modulation—Class B high level.  
 Audio Input impedance 500 ohms.  
 Power supply 190 to 250 v. single phase 50-60 c.  
 Tube complement: Crystal oscillators—807, Master oscillators—807, Intermediate amplifier—807, Power amplifier—813(2), Modulator—805(2), Rectifier—866A(4).  
 Complete with Master Oscillators, crystal multipliers, speech amplifiers, microphones, keys, instruction manual, etc.  
 We guarantee full supply of all replacement parts for a minimum of 5 years after purchase.

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**MARCONI CR100**  
 Completely overhauled In perfect working order. LOOK LIKE NEW. £21.  
 Later model with Noise Limiter, £25.  
 Carr. Eng. and Wales 30/-. Send S.A.E. for full details.  
**SPARES KITS.** 15 valves, o.p.t. conds., pots., res. drive cord. etc. BRAND NEW. 59/6, post 4/6.

**Z MATCH!** Cydon 230 + 250pFd. split stator double spaced transmitting variables. Ceramic insulation. BRAND NEW boxed, 19/6. Post 2/6.  
**WHEATSTONE BRIDGES.** Post Office plug-type 1 to 10,000 ohms. 79/6. Post 3/6.

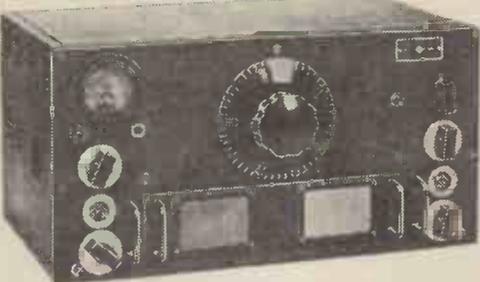
**MORE METER BARGAINS**

RANGE	TYPE	SIZE	PRICE
25 Microamp.	D.C. M/C	2 1/2in.	69/6
25 Microamp.	D.C. M/C	2 1/2in.	59/6
50 Microamp.	D.C. M/C	2 1/2in.	79/6
50 Microamp.	D.C. M/C	2 1/2in.	59/6
100 Microamp.	D.C. M/C	3 1/2in.	62/6
100 Microamp.	D.C. M/C	2 1/2in.	42/6
1 Millamp.	D.C. M/C	3 1/2in.	50/-
1 Millamp.	D.C. M/C	2in.	22/6
200 Millamp.	D.C. M/C	2 1/2in.	10/6
1 Amp. Thermocouple	2 1/2in.	Projecting Circular	6/9
300 Volts	A.C. M/I	6in.	79/6
300 Volts	A.C. M/I	2 1/2in.	25/-
500 Volts	A.C. M/I	2 1/2in.	25/-
40 Amperes	D.C. M/C	2in.	7/6

**METAL RECTIFIERS.** Full wave bridge. BRAND NEW. Salford 1 mA., 8/6, 5 mA., 8/6. 5TC 2 mA., 5/6.

**MINIATURE 373 IF STRIPS.** For FM tuner described in "Practical Wireless." Complete with 3 of EP91, 2 of EP92 and 1 of EB91. A fresh release enables us to offer these once again. BRAND NEW. Complete reprint of conversion instructions and circuit supplied free. 37/6. OR less valves, 12/6. Post, either 2/6.

**HRO SENIOR MODELS**



Complete with ALL NINE general coverage plug-in coils for 50 Kc/s. to 30 Mc/s. Instruction booklet, and circuit, but less external power supply unit. Table models, as new condition, 21 GNS. Rack mounting, 18 GNS. Packing and carriage 22/- extra. Send S.A.E. for further details.

**HRO POWER PACKS.** 115/230 v. A.C. mains input. Tested, and in good condition., 69/6. Post 4/-.

**MONITOR TYPE 61**  
 3 1/2in. C.R. Tube. A.C. mains power pack. Very modern design. Ideal for conversion to oscilloscope, full data supplied. Condition as new, 27/19/6. Carr. 15/-.

**COLLINS TCS TRANSMITTERS**

Cover 1.5-12 Mc/s. (25-200 metres) in 3 bands. Complete with 7 valves: 3 of 12A5 Osc.; 1 6X5 RT; 2 of 12Z5 PA.; 1 6X5 Mod. VFO or crystal control. with 4 crystal positions. C/W or R.T. Meters for plate and aerial current. BRAND NEW internally and unused, but externally store soiled. 27/19/6. Carr. 15/-.

**R.F. UNITS**

RP24. 20-30 Mc/s. 5 switched positions.....	12/6
RP28. 50-65 Mc/s. Super slow-motion drive.....	17/6
RP27. 65-85 Mc/s. Super slow-motion drive.....	22/6

Unboxed, but as new condition. Post 3/6.

**MINIATURE RELAYS**

G.E.C. sealed, wire ends. 670 ohms. 2 H/D makes, M1099.....	15/-
G.E.C. sealed, wire ends. 670 ohms. 4 C/overs, platinum, M1092.....	19/6
G.E.C. sealed, wire ends. 5000 ohms. 2 C/overs, platinum, M1032.....	17/6
S.T.C. size 1 1/2 x 1 in. 250 ohms. 2 C/overs, double contacts.....	7/6
Siemens High Speed 1K + 1K ohms. 1 C/over.....	10/6

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 Shop Hours: 9-6 p.m. (9-1 p.m. Thursday). Open all day Saturday



**MARCONI TF987/1 NOISE GENERATORS.** Range 100 Kc/s. to 200 Mc/s. Determines noise factor of AM and FM receivers. Fully established H.T. supply. A.C. mains operation. Brand new and in original boxes 22/5.

**HICKOCK 1-177 VALVE TESTERS.** Checks dynamic mutual conductance, shorts emission, gas, and noise. For UX4, UX5, UX6, UX7, Octal, Locat B7G, and Acorn types. Portable in wooden carrying case 15 1/2 x 8 x 5 1/2 in. Wt. 1 1/2 lb. BRAND NEW. Complete with instruction book and valve testing charts. For 117 v. A.C. 10 gns. Carr. 7/6. Matching auto. transformer for 230 v. A.C., 12/6.

**FERRANTI TESTMETER TYPE Q.** Volts 0 to 30, 150, 500 A.C./D.C. with additional 0-3 v. D.C. and 0-15 v. A.C. ranges, milliamps 0 to 7.5, 30, 150 and 750 D.C. ohms 0-25 K. Accuracy BSS 1st grade. 500 ohms per volt. With leads, probe battery, and instructions. In velvet lined 4 x 7 x 3 in. case. Brand new condition perfect working order 72/6. Post 2/6.

**INSULATION TESTERS.** "Record" hand generator type. 0-50 Megohms at 500 volts pressure. Complete in leather case 27/19/6. Post 4/-.

**R1155 RECEIVERS.** With latest type super slow motion drive. In good condition and perfect working order, re-aligned and air tested. Model "B" 27/19/6. Model "L" (covers trawler and shipping bands) 12/19/6. Carr. (either) 10/6. Send S.A.E. for details of sets and power units, or 1/3 for illustrated booklet.

**MARCONI LOOP AERIAL** type 696 A small, compact, enclosed loop. On swivel mount with degree scale. BRAND NEW. 69/6. Post 2/6. Ideal for R1155, etc.

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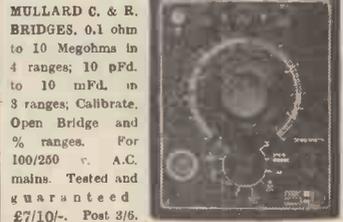
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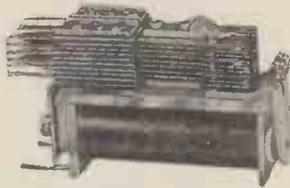
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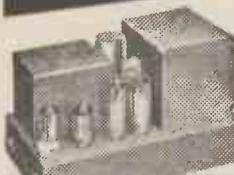


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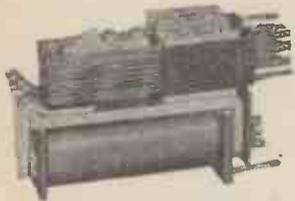
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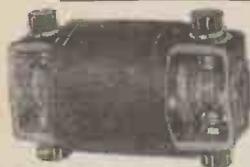
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# STEREO £7.7.0

Independent twin channel amplifier with excess of 3 watts per channel.

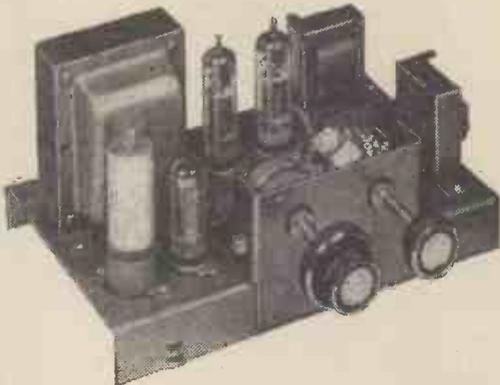
Concentric volume control (optimum balance arranged immediately without additional knobs).

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Stoved grey or blue hammer chassis 9 1/2in. x 5 1/2in. x 6in.

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Many other Bargains; send stamped addressed envelope for lists  
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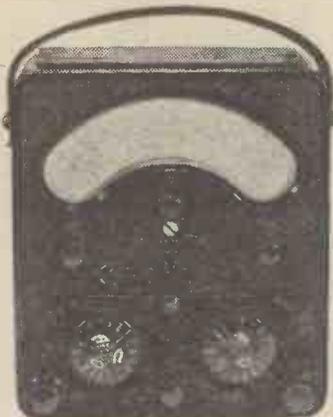
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120 mV.	12 V.	6 mA.	12 mA.
600 mV.	60 V.	12 mA.	60 mA.
1.2 V.	120 V.	60 mA.	120 mA.
6 V.	240 V.	120 mA.	600 mA.
12 V.	480 V.	600 mA.	1.2 A.
60 V.	600 V.	1.2 A.	6 A.
120 V.	1200 V.	6 A.	12 A.
240 V.		12 A.	
480 V.			
600 V.			
1200 V.			

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10,000 Ohms  
100,000 Ohms

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**RCA AR 88 RECEIVERS.** Re-conditioned and in perfect working order. "LF" Model, covers 75-140 kcs. and 1.2-30 mcs., ONLY £50. "D" Model, covers 500 kcs.-31 mcs., ONLY £55 (Carriage etc., 25/-).

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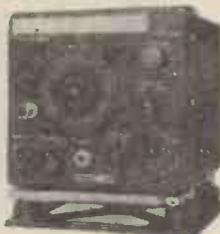
F.S.D.	SIZE AND TYPE	PRICE
25 microamps D.C.	2 1/2 in. Flush circular	69/6
25 microamps D.C.	2 1/2 in. Proj. circular	59/6
50 microamps D.C.	2 1/2 in. Flush circular	59/6
80 microamps D.C.	3 1/2 in. Flush circular	80/-
1 mA. D.C.	2 in. Flush square	25/6
1 mA. D.C.	2 1/2 in. Flush circular	25/-
1 mA. D.C.	3 1/2 in. Flush circular	50/-
150 mA. D.C.	2 in. Flush square	7/6
200 mA. D.C.	2 1/2 in. Flush circular	12/6
20 amps. D.C.	2 in. Proj. circular	7/6
40 amps. D.C.	2 in. Proj. circular	7/6
15-0-15 amps. D.C.	3 1/2 in. Flush square	25/-
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each. 2 mfd., 1.5 kv. wkg., 4/8 each  
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**GRAHAM GEARED MOTORS.** 115 volts A.C. 50 cys., 1/6th H.P., variable speed gearbox 0-166 R.P.M. (as new). £8/10/- each. Transformers to operate this unit 35/- each. Carr. 10/-.

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6F13	9/6	26A6G	8/-	ECC85	9/-	EV61	10/6	PEN48	6/6	UB41	8/6
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Table listing various electronic components and valves. Columns include part numbers (e.g., AC6PEN, E1148, PY83) and their corresponding prices or specifications.

Boost Transformers Mains Input. NR20A 2 volt, MR20B 4 volt, NR20C 6.3 v. all with optional 25% boost, 10/6 each. 5in. P.M. Loudspeaker Units by Goodmans or Plessey 17/6 ea. 3 Core Line Cord, 2 amp. 100 ohms per foot, 3 amp. 60 ohms per foot 1/9 yd. Miniature I.F. Transformers 465 Kc/s 9/- pair. Hanley Solon Instrument Irons 25 watts 220/240 v. 24/- ea. Full Range Warite 'P' Coils 3/- ea. Jackson Bros. Drive for FM/VHF or Shortwave Converters, etc., type SL16 13/6 ea. Acos Microphone, type 39-1 Pencil Stick, listed 105/-, our price 59/6. Coaxial plugs and sockets 7 1/2 each part. High Resistance Headphones type CHR 13/6 pair. Cydon Aerial and Oscillator Coils (all channels, all frequencies), 7/6 pair. Cydon Front Panel & Contact Springs 7/6. BSR Monarch UAB, 4 speed automatic record changer 46/19/6. One Pound Reels Solder, resin cored 7/6 per lb. Line Output Transformer, type LO4 for Pye V4, V7, Invicta 118, 119, 120, PAM 908, 909, etc. 55/2 each. Wafer Switches 3 pole 4 way, 1 pole 12 way, 2 pole 6 way, etc. 3/- ea. Empty Tape Spools, 3in., 3/-, 5in., 3/6, 5 1/2in., 3/9, 7in., 4/3. Westinghouse Metal Rectifiers, 14A86, 14A97, 14A100, all 17/6 each. Books: T.V. Faults by N. Stevens. Guide giving more than 60 faults with test procedure 5/- TCC Visconal, 1 mfd. 7 Kv. 10/- each. Philips Beehive Trimmers 0/30 pf 10d. each. Outlet Boxes for skirting board mounting 3/6 each. Belling Lee 7-pin Flexible Plug Fixed Socket 2/-

B7G B9A Ampenval Valveholders with or without skirt 9d. each. Screening Cans 6d. each. Crocodile Clips 3d. each. Heater Transformers Mains Primary 6.3 v. 1 1/2 amp. 6/9; 6.3 v. 3 amp. 10/-; W.B. HF1012 10in. 10 watts Universal Speech Coil Loudspeaker 99/9. Mains Dropping Resistors 1 amp. 2,000 ohms, 15 amp. 1,500 ohms. 5/3 each. Push-on Knobs, cream, 1 1/2in. dia., brown 1 1/2in. dia. 6d. each. 2 gang 500 pf. Condensers Standard or Midget 7/6 each. Solid Dielectric Tuning

Keys 2/- each. 5 cored cable (1 screened) 1/- yard. 12 volt 4-pin UX Vibrators 2/6 ea. 4 BA x 1in. round head bolts and nuts 4/- gross. Escutcheons for TV 12in. and 17in. 7/6 each. 25 yard coils 23/26 3 core T.R.S. Circular flexible 20/- coil. Condensers wax tubular .02 mfd. 750 v., .01 mfd. 350 v., 1 mfd. 500 v., all 4d. each. Crystal diodes 1/- each. Dial bulbs MBCT 6.5 volts 3 amps. 4d. each. Acos Mic 33-1 Desk or Hand Microphone listed 50/- brand new and boxed 29/6. TRF Coils

phone complete with strap and plug 3/- 100 resistors mixed, 1/2, 1 and 1 watt popular values 100 for 12/6. Copper plated tubular rods 12in. long, designed to plug into one another 4/- doz. Monarch UA12, the de luxe 4-speed automatic record changer. 49/9/- Tyana Soldering Iron, Instrument Model 230/250 v. 40 watts 16/9. Acos Cartridges, Type HGP37/37 and HGP59/59C 18/6 each. Garrard 4-speed Single Player, fitted with the GC2 cartridge 46/19/6. Charger Rectifiers, Bridge type, 12 v. 1 amp. 4/3, 2 amp. 7/-, 3 amp. 10/-, 4 amp. 12/6, 6 amp. 15/9. Charger Transformers, Universal Primary Secondary 2, 6 and 12 v. 2 amp. version 13/-, 4 amp. version 18/6. Reclaimed Richard Allan Relay Baffle, 8in. unit with volume control and output transformer 18/6, post paid. Universal Booster Isolation Transformer, tapped Primary for 2, 6 and 13 v. Secondary with a fixed 25% boost, 13/6 ea. Celestion 8in. x 5in. Elliptical Loudspeaker Hi-flux Model, 25/6. Ex-Government 38 set, complete with headphones, throat microphone, junction box, whip aerial and canvas battery case, 65/-, carriage 7/6. Goodmans 10in. Loudspeaker, 2/3 ohms impedance 25/6. Plessey 10in. x 6in. Loudspeaker Unit 25/6. Line Output Transformer for Pye V14 33/9. Contact Cooled Rectifiers by Westinghouse 14RA 1-2-8-3, 18RA-1-1-16-1, 9/- Osrom Chassis Cutter, type 2, holds 1in. and 1 1/2in., 21/6 ea. Crystal Microphone Insert, 1 1/2in. diameter, 3/9 each.

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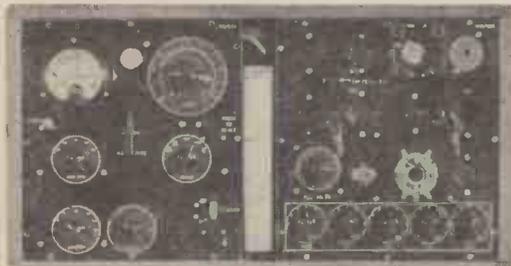
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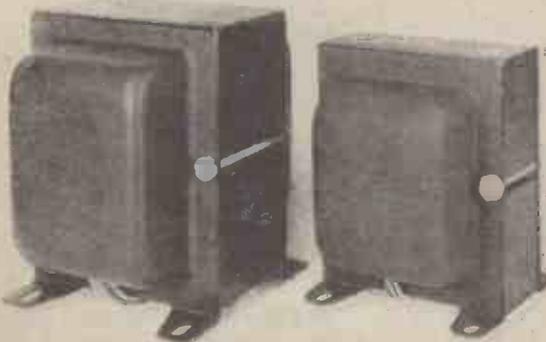
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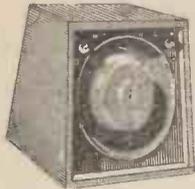
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Heavy duty 20 watts all-metal 15 ohms. Diameter 15in., length 15in., (approx.). Perfect condition. £6/10/- Carr. 10/-.

Ditto, Brand new £8. Carr. 10/-.

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12in. P.M. 15 ohms 15 watts, 30-14,000 c.p.s. Our price £4/10/-.

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Adjustable every 6in. to approx. 9ft. 6in. when fully extended. (Folds up to only 4ft. 6in. for storage). Suitable for outdoor speakers, public address systems, floodlighting, etc., etc.

OUR PRICE **£3.10.0** Carr. 5/-

These stands are ideal for our RE-ENTRANT LOUD HAILER as described on left.



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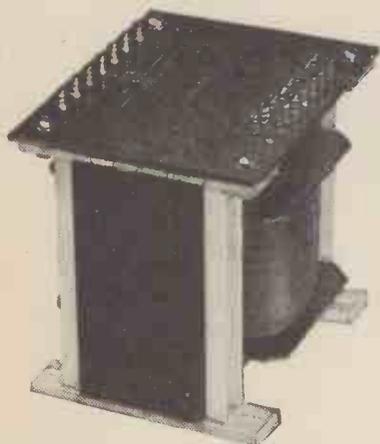
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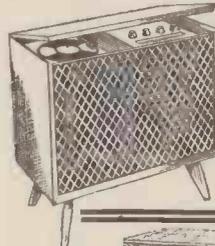
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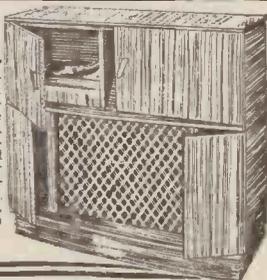
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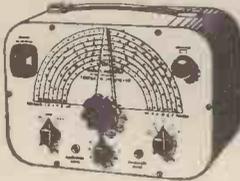


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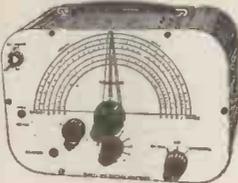


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Size 6 $\frac{1}{2}$ in. long, 5in. high, 2 $\frac{1}{2}$ in. deep. Will suit any type of crystal pick-up. Output approx. 2 watts. Incorporated ECC 83 double triode. Cosor 142BT output pentode and contact-cooled rectifier. Fully isolated mains transformer for 230-250 A.C. mains. Bass, treble and volume controls. **49/6** Plus P. & P. 3/6.

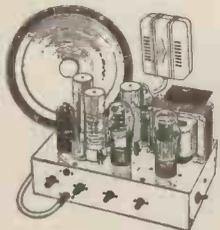
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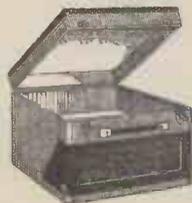
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COMPLETE WITH CRYSTAL MIKE AND 8in. LOUDSPEAKER

A.C. mains 110/250 v. Size 10 $\frac{1}{2}$ in. x 6 $\frac{1}{2}$ in. x 2 $\frac{1}{2}$ in. Incorporating 6 valves, H.F. pen., 2 triodes, 2 output pens., and rectifier. For use with all makes and types of pick-up and mike. Negative feed back. Two inputs, mike and gram., and controls for same. Separate controls for Bass and Treble lift. For use with 8in. or 12in. records, musical instruments such as Guitars, etc.

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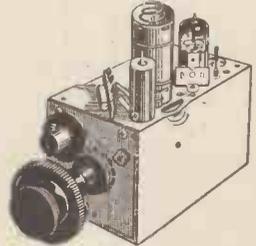


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34 to 38 Mc/s. complete with PCF30 and PCC84. These have been removed from chassis.

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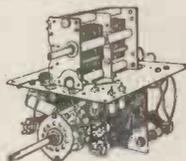
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**BRIDGE CONNECTED HEAVY DUTY FUNNEL COOLED OR 7 1/2 in. SQUARE COOLING FINS.** Both types, same price. 17 v. 20 a. 120/-; 30 a. 172/-; 50 a. 280/-; 33 v. 6 a. 89/-; 10 a. 102/-; 20 a. 202/6; 54 v. 6 a. 124/-; 10 a. 144/-; 72 v. 6 a. 160/-; 10 a. 186/-; 100 v. 6 a. 227/6; 10 a. 270/-; all post 3/-.

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Off Pentonville Road. Between King's Cross and Angel

## SOUTHERN RADIO'S SPECIAL BARGAINS

**TRANSPARENT MAP CASES.** Plastic 14in. x 10 1/2in. Ideal for Maps, Display, etc., 5/6.

**STAR IDENTIFIERS.** Type I A-N Covers both Hemispheres, 5/6.

**CONTACTOR TIME SWITCHES.** 2 impulses per sec. in case, 11/6.

**REMOTE CONTACTOR.** For use with above, 7/6.

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**MORSE PRACTICE SET. TAPPER with BUZZER** on base. Complete with battery, 12/6. BRAND NEW.

**MAGNETS.** Strong Bar type, 2 x 1/2in., 1/6 each. **PACKARD-BELL AMPLIFIERS.** Complete, BRAND NEW, with valves, relay, etc., etc., 17/6 each.

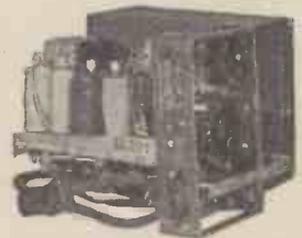
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**TRANSMITTER - RECEIVER**

TYPE 38 MK II

★ WALKIE-TALKIE ★



Complete in Metal Carrying Case. 9in. x 6 1/2in. x 4in. Weight 6lb. Frequency 7.3 to 9 Mc/s. Five valves. £12/6. Post paid.

These TX-Rs are in NEW CONDITION, but owing to demand they are not tested by us and carry no guarantee, but should prove SERVICEABLE.

**ATTACHMENTS** for Type "38" Transmitters. ALL BRAND NEW. Headphones 15/6; Throat Microphones 4/6; Junction Boxes 2/6; Aerials, No. 1 2/6; No. 2 5/-; Webbing 4/-; Haversacks 5/-; Valves—A.R.P.12 4/6; A.T.P.4 3/6; Set of FIVE VALVES 19/- the set. OFFER No. 2:

"38", as above, complete with set of external attachments, 42/6, post paid.

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**RESISTANCES.** 100 assorted useful values. New wire end 12/6. NEW.

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Input speed 500-1,000 r.p.m. maximum power 1½ h.p. Both shafts ½" dia. with Woodruff key.

Tested and fully guaranteed, supplied complete with technical data, instructions, and input and output, speed, power, and torque performance charts for the remarkable price of only **£20 carriage paid.**



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American panel mounting "Radio Altitude" meter with modern (coil round magnet) movement giving beautifully steady deflection to reading on large dial boldly marked 1 to 4 with sub-divisions in tenths. Supplied with suppressed zero which requires 6.5 mA. for full scale deflection (0=1.5 mA.) but pointer is easily re-set to zero by moving conventional hair spring adjuster behind dial, when 5 mA. gives f.s.d. Rear housing incorporates on/off switch (operated by rotating small knob on front face) and 5-pin plug, two pins direct to meter and two to switch. Brand New, boxed, 12/6, post free.

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Well known wobblulator unit. Brand new, 7/6, post free.

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Suitable for monitoring amateur television. Heater 6.3 v. at 0.6 A. Anode 7,000 v. Grid 250 v. Cut-off 25-75 v. Brand new. Boxed, 15/-, post free.



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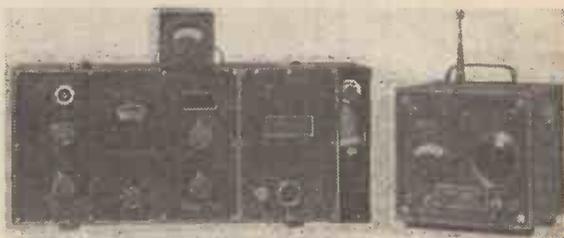
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Circuit embodies U.K.A.E.A. patent. Specially moulded case locates components and standardizes wiring. Printed circuit plates for battery pack supplied. Batteries £2/15/3 extra. Spares, replacements and service permanently available. Supplied complete with fully illustrated assembly instructions and 40-page manual specially written for student, experimenter and radio amateur.

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**BRAND NEW OR £7.0.0** The Whole Kit, plus 7/6 carriage. **HARDLY USED**

Circuit diagram supplied. Specially reproduced comprehensive technical data 15/- extra, by order only.

#### TEST KIT 25.

Set of 3 cm. Waveguides, coupling unit, tubular feeder, adaptor unit and waveguide connectors with 30ft. of USA/British terminated co-axial cable and potted 230-110 volt step-down transformer. Brand new. £7/10/0 carriage paid.

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Beautifully built, compact, modern, dual purpose unit with crystal controlled precision time base giving delayed, gated or continuous circular traces accurate to .02% and a separate linear time base giving delayed, triggered or repetitive sweeps for general purpose work. 10 valves. 115 or 230 volt 50 c/s mains. Comprehensive technical information and circuit diagram with all working voltages supplied. Brand New. £20 carriage paid.

#### G.93 WAVEMETER. 2,300-3,100 Mc/s.

Precision cavity in robust case with HRO type dial. Complete with calibration charts. £2.10.0 Plus 10/- packing and carriage.

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Exceptionally rugged silver plated micrometer tuned precision cavity covering 2,900-3,150 Mc/s. Resonance shown on 100 microamp meter. Brand New. £15 Plus £1 packing and carriage.

#### MARCONI WIDEBAND WAVEMETER TF643B

The "B" is superior to earlier models with valve.

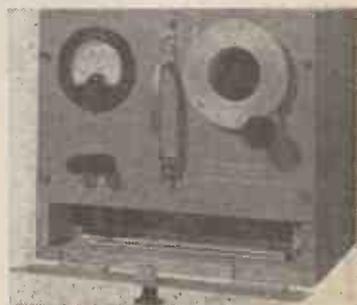
A modern professional plug-in coil absorption wavemeter covering 20 to 300 Mc/s in 4 fully calibrated bands with an accuracy of 1% up to 150 Mc/s and 2% from 150 to 300 Mc/s.

Half-inch thick polished oak cabinet, immensely rigid inductors and ceramic body soldered-brass-plate capacitor. 50 microamp crystal voltmeter, 4" slow motion dial, terminals for phone monitoring.

Snap open compartment houses coils framed calibration charts.

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**MORSE TAPPERS**. Plated Contacts, Adjustable Gaps, Heavy Duty. 3/6. Post 9d.

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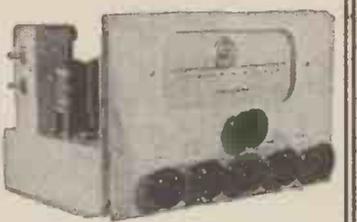
**GUITAR PICK-UPS "THE ELECTRO"** Super Hi-Fi Non-Acoustical Universal Fitting. 3in. x 1 1/2in. x 1/2in. High output complete with Lead and Plug. Full and Easy Instructions, 39/11. Post 1/-.

**ALL ABOVE ARE NEW AND GUARANTEED**

**NEW AND SURPLUS GUARANTEED VALVES— ALL TESTED BEFORE DESPATCH**

1C5GT 12/-	6K7GT 7/-	956 .....	2/11
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Any Parcel Insured against damage in transit for only 6d. extra per order. All uninsured parcels at customer's risk. C.O.D. or C.W.O. only. S.A.E. with all enquiries. Postage and Packing 6d. per valve extra. Over £3 Free. Trade Enquiries Invited.



## Fidelia

The Fidelia range of hand built high fidelity equipment includes Radio Tuners, Radio Tuners incorporating a gramophone pre-amplifier and tone controls, also high quality audio amplifiers both stereophonic and single channel types.

**Fidelia Major AM/FM tuner unit with pre-amp., tone controls etc., R.F. stage on all wavebands, variable selectivity etc.** Price £27/4/-, or with the Major amplifier, £42/14/-.

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**Fidelia Major amplifier, £18.**

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Full details willingly on request. (6d. for postage is appreciated.)

**ELECTRO Acoustics DEVELOPMENTS**

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### TRANSISTOR POCKET RADIO BY WELL-KNOWN MANUFACTURER.

Cream Plastic Case 5 1/2 x 3 1/4 x 1 1/4 in. Weight 12oz. Printed circuit with 6 Transistors and tested components. You will be pleased to own this fine commercial set. **£10/10/-**. P.P. battery 2/3.

### FAMOUS MAKE LIGHTWEIGHT PENCIL BIT SOLDERING IRON, (220/240 v. 25 w. Indicator light in handle (list price 24/6). Price 16/6. P.P.

### 800TER BATTERIES. 6 v. 10 A.H. Hard rubber case. Size 5 x 5 x 1 1/2 in. Weight 3lb. 15/-.

P.P. Also ideal for model use.

### NEW AND BOXED COLLARO CONQUEST 4-SPEED RECORD AUTO CHANGERS. 200/250 v. A.C. £6/19/6. Carriage 5/-.

### OUR FAMOUS TRANSFORMERS. Input 240/250. Output tapped 3 to 30 v. 2 a. or tapped 5, 11, 17 v. 5 a. each. 24/6. P.P. 18 amp 53/6.

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All items new and guaranteed.

### UNISELECTOR SWITCHES. 50P, 3B or 25P, 3 or 6B, 50 v. D.C. 25/-.

### RELAYS. We hold large stocks. Any contact combination and operating coil voltage supplied from 3/-.

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Type W139. A.C. input 200-240 v. D.C. output 36 v. 18 amps. Completely fused, built-in metal cabinet size approx. 26 x 19 x 15in. Brand new. £17/10/- ex warehouse.

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Motor voltage 110 v. 3.25 amps. Submerged fitting. Approx. size 14 x 8 x 7in. 65/-.

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A heavy-duty turbine pump driven directly from a splined socket. 1,000-1,500 g.p.h. 1 1/2in. bore output. Brand new in maker's cartons. 47/6. Carr. 4/-.

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Type W191, 230 v./230 v. C.T. Very conservatively rated at 4.6 kva., Pri. 230 v. Sec. 230 v. Centre tapped 20 amps. Tested to earth 2,000 v. R.M.S. Completely enclosed in metal container. Weight 315lb. Supplied brand new and guaranteed. £17/10/- ex warehouse.

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Pri. 400-440 v. 50 cycles. Sec., 50 v. 6 amp. Completely tropicalised. Size 7 1/2 x 14 x 5in. Weight approx. 60lb., 85/-.

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Input 230 v. Output 0-260 v. 9 amps. Complete with control handle. Supplied in maker's sealed cartons. Limited number only £15. Carr. 10/-.

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Special bargain offer 5/- carton of 2, 4, 6 nuts, bolts and washers. P.P. 1/-.

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11Q 4.5A 12/6. 3Q 10A 12/6. 12Q 15A 10/6. 1Q 12A 8/6. All single tube slider control. 12Q 4A horizontal sweep control 12/6. 26Q 6A double tube slider control 45/-.

125Q 20A double tube slider control 27/6. 0.4Q 25A geared drive 17/6. 79Q 2.9-0.65A double tube geared drive 32/6. 76Q 6-0.5A slider control 22/6. Carr. on all resistors 3/-.

We have one of the largest stocks of sliding resistors in the country. Let us know your requirements.

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No. 1. Pri. 230 v. Sec. 50 v. 50 amps. adjustable by voltage regulator stud switch on primary. Built in steel case with meter reading 0-100 v. Mains switch and O.P. sockets. Will stand 100% overload. Supplied brand new £15. Carr. according to distance.

No. 2. Pri. 230 v. Sec. tapped 4 v., 6 v., 10 v., 200 amps. £8/10/-.

No. 3. Pri. 200-250 v. Sec. 50 v. 30 amps. £6/10/-.

No. 4. Pri. 200-250 v. Sec. tapped 28, 29, 30, 31 volts, 21 amps. £4/10/-.

No. 5. Pri. 150-250 v. Sec. 50 v. 20 amps. £4/10/-.

No. 7. Pri. 200-240 v. Sec. 45 v. 2 amps 25/-.

No. 8. Pri. 200-250 v. Sec. 6.3v. 15 amps. 27/6.

No. 9. Pri. 200-240 v. Sec. 30 v. 1.2 amp. and 6.3 v. C.T. 3 amps. Tropicly rated.

No. 10. Powerstat variac transformers. Input 115 v. Output 0-130 v. 7.5 amps. 85/-.

Latest arrivals. Brand new STC Pri. 200-260 v. Sec. 26-41 volts in 1 volt steps 15 amp, tropically rated and one HT winding tapped 120-136-152-168 volts 700 m/a. £4/5/-.

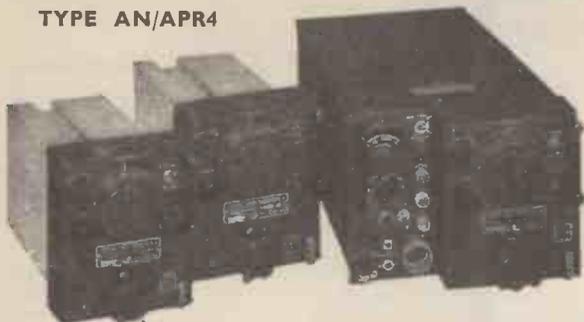
Brand new STC Pri. 115-230 v. Sec. 5 v. 13 amps, tropically rated, insulated for 15 kv. Brand new. 37/6. Carr. 7/6

169-171 EDGWARE ROAD, LONDON, W.2  
TELEPHONE: PAD. 7851 or AMB. 5125

# Receivers—Test Equipment—H.F. V.H.F. Microwave

## RADAR SEARCH RECEIVER

TYPE AN/APR4



This Receiver is designed to determine the presence and measure the frequency of any radar or radio signals within the range of 38 to 2,000 Mc/s. To determine what modulation may be present on these signals giving an identification of relative strength of these signals.

The equipment consists of:—

- 5-stage IF (30 Mc/s Amplifier provision is made to feed the IF amplifier to a panoramic adaptor)
- 1 Detector
- 2 Stage Video Amplifier (100 c/s—1 Mc/s,  $\pm 2.5$  db)
- 1 Beat frequency oscillator

The signal is fed through RF "plug in" heads consisting of types:—

- TN16 38-95 Mc/s 1 RF Triode first detector, 1 Oscillator.
- TN17 74-320 Mc/s Butterfly resonant circuit 1 diode first detector, 1 triode oscillator.
- TN18 300-1,000 Mc/s. Butterfly resonant circuit. 1 Crystal first detector. 1 Triode oscillator.  
The above three units are available now.
- TN19 950-2,000 Mc/s. Tuneable cavity used for first detector and mixer. Butterfly oscillator. 1 Crystal detector. 1 triode oscillator.

Accuracy of frequency calibration 1%.

Power Requirements:—115 V 60-2,600 c/s.

Also available to be used in conjunction with the above receiver AN/APA10 Panoramic Adaptor, and AN/APA23 Injected Frequency Recording Apparatus.

AVAILABLE FOR INSPECTION. Price **£260** complete with TN16, 17, 18.

### OSCILLOSCOPE (U.S.A.) AN/ASM32

Screen size: 2½ in. x 2½ in.

Y Sensitivity: 100 mV/in. r.m.s. amplitude calibrated.

Frequency Response: —2dB, 10 c.p.s. microseconds.

Z markers: 1-10-100-1,000-10,000 microseconds.

Supplied with cathode follower-attenuator-detector test prods in grey metal housing.

Overall size: 9½ in. x 6½ in. x 16½ in.

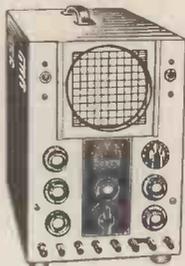
Weight: Approximately 20 lbs.

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Transmitter Type: Master oscillator, power amplifier.  
Type of Signal: Voice.  
Distance Range: 1 mile.  
Type of Modulator: Frequency.  
Number of Valves: Four.  
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Power Supply: Internal dry battery.

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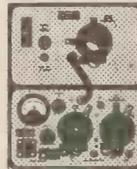
### H.R.O. SENIOR RECEIVERS



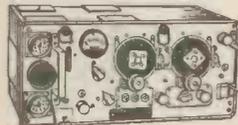
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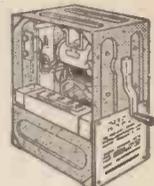
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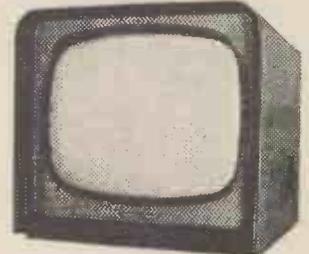
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Readers are warned that Government surplus components and valves which may be offered for sale through our displayed or classified columns carry no manufacturers' guarantee. Many of these items will have been designed for special purposes making them unsuitable for civilian use, or may have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such items purchased.

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**H**RO Rx's, etc., AR88, CR100, BRT400, HG209, S640, etc., in stock.—R. T. & I. Service, Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [0053]

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### NEW GRAMOPHONE AND SOUND EQUIPMENT

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**G**LASGOW.—Recorders bought, sold, exchanged, cameras, etc., exchanged for recorders or vice versa.—Victor Morris, 406, Argyle St., Glasgow, C.2. [0201]

**T**APE recorders: Ferrograph, Vortexion, Brenell, Telefunken, Truvox, Reflectograph, and M.S.S.

**T**APE decks: Wearite, Brenell, Truvox, Bradmatic, Dulc-Harting, Amplifiers and tuners: Leak, Quad, R.C.A. Dynatron, and Dulclet. Microphones: Reslo, Lustraphone, Philips, Acos, Gramplan, etc. All tapes and accessories, Audio service department and recording studio. HIRE purchase facilities available.

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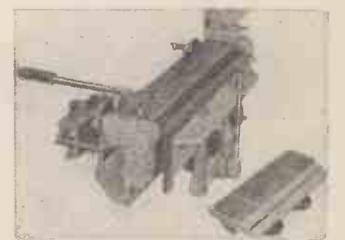
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### GOVERNMENT OF SINGAPORE.

ASSISTANT Controller of Telecommunications, Department of Telecommunications. To manage staff and be responsible for maintenance, installation and operation of tele-communications equipment including multi-channel carrier equipment, teleprinters and V.F. telegraph apparatus, overhead and underground plant, railway signalling equipment, multi-channel V.H.F. radar and microwave equipment and major receiving and transmitting radio stations. CONTRACT appointment for 3 years; salary in the range £1,290-£2,358 according to experience, temporary variable allowance £210-£250 p.a., gratuity payable on satisfactory completion of contract; free passages; quarters, if available, at low rent; generous home leave; candidates, not over 45 years of age, must be Corporate or Graduate members of the Institution of Electrical Engineers, or possess a University Degree or Diploma giving exemption from the Institution's examination and have at least 2 years' practical experience in telecommunications. WRITE Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting BCD 133/25/03(B). [8488]

ASSOCIATED TELEVISION, Ltd., have several vacancies in its development and maintenance department at Wembley. THE work involved is of a particularly interesting character, concerned with the development, design and maintenance of audio and video broadcasting equipment. CANDIDATES must be thoroughly familiar with television broadcasting techniques, and preferably be of H.N.C. or degree status. THESE appointments carry salaries in accordance with the union scale ranging from £840 to £2,260 per annum. A pension scheme is in operation. LETTERS of application should be addressed to Personnel Manager, Associated Television, Ltd., Television House, Kingsway, London, W.C.2, quoting WW/DM. [8525]

"A" licensed radio engineer required; good salary.—Apply Chief Engineer, Morton Engineering Services, Ltd., Croydon Airport, Surrey. [0251]

HILGER & WATTS, Ltd., Scientific Instrument Makers, are extending their Electronics Department and are seeking men experienced in Drawing Electronic Wiring Layouts.

APPLICATIONS are also invited from men or women experienced in electronic wiring who are able to work from circuit diagrams. FIVE day week, generous pension and sick pay schemes.—Apply Personnel Officer, 123, Camberwell Rd., S.E.5. [8527]

TELEVISION bench and field engineers required at all times for vacancies in most parts of the British Isles; permanent positions with highest salaries plus bonus for suitable applicants. 5 1/2 day week.—Box 1757. [0251]

A.B.C. Television require an engineer for their Manchester Studios. Considerable experience camera control operating and maintenance is necessary.—Apply giving details of age and experience to The Technical Supervisor, A.B.C. Television, Ltd., Manchester, 20. [8505]

ASSISTANT engineer required for laboratory developing communications and industrial R.F. heating equipment; age under 30; Graduate or Higher National preferred.—Apply Personnel Assistant, Redifon, Ltd., Gatwick Rd., Crawley Sussex, quoting reference C.Ll. [8484]

SENIOR draughtsmen for electronic and electro-mechanical work to service requirements; permanent positions; ideal working conditions; 5-day-week; all amenities; write or telephone.—Cottage Laboratories, Ltd., Portsmouth Rd., Cobham, Surrey (Cobham 3191). [8499]

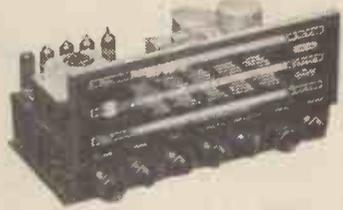
JUNIOR Technician required to assist in prototype construction and development of medical electronic equipment. Apply giving age, experience, and salary required to—Electro-Medical Supplies (Greenham), Ltd., 209b, Great Portland Street, London, W.1. Langham 5433. [8512]

ASSISTANT Technical Writer required for Radio and Television Service Manuals. Experience in preparing copy for printing an advantage. Good starting salary and prospects. 5-day week. Can give welfare and social club amenities.—Apply quoting Ref. No. F 4578, to the Personnel Manager, Ferguson Radio Corporation, Ltd., Gt. Cambridge Road, Enfield. [8513]



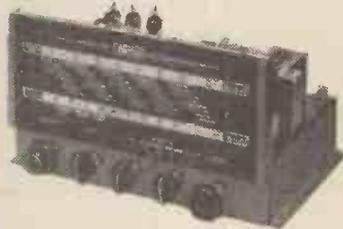
## STEREO - TWELVE CHASSIS

36 GNS



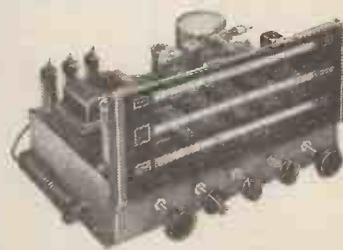
The most complete unit yet produced for stereo giving 6 watts high fidelity push-pull output on each channel, 12 watts total. Full VHF, medium and long wavebands. Stereo and monaural inputs for records, tape and radio and tape outputs for stereo and monaural tape recording. Comprehensive matching for all types of crystal pick-ups. The perfect basis for a complete monaural reproducing system or for a complete stereophonic system now or later.

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A stereo and monaural chassis providing 8 watts output, 4 watts on each channel, and covering the full VHF and medium wavebands. Stereo and monaural inputs for tape playback and all types of crystal pick-ups and tape outputs for stereo and monaural tape recording. Separate wide range bass and treble ganged controls together with dual volume control for ease of balancing. FM and AM tuners and two separate amplifiers on one compact chassis.

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"The performance of the recorder is very good and I recommend it to all those who wish to get 1st class performance at approx. half cost."

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**ENGINEERS** with some five years practical experience of radio frequency design work required for interesting new project in laboratory situated in South West outskirts of London, pension scheme.—Write giving full particulars of experience and salary required to Box 2409. [8453]

**TECHNICIAN** with general experience in electronics, some experience in workshop practice, to maintain electronic and other equipment for medical research; salary between £550 and £760, according to experience and qualifications.—Apply Secretary, Postgraduate Medical School, Ducane Rd., W.12. [8522]

**AUSTRALIA:** Experienced servicemen in field and depot work required by large Television installation and maintenance company. Excellent opportunities. Single men preferred. Advise details of TV service experience. Salary £1,100—£1,200 Australian with adequate advancement possibilities. Apply Box 3312 [8509]

**PHYSICIST** or electronic engineer.—Young graduate required by small Medical Research Establishment for construction and maintenance of electronic devices; salary in scales up to £1,050 or £1,500 p.a. according to qualifications and experience.—Applications to the Records Officer, Anaesthetics Laboratory, Radcliffe Infirmary, Oxford. [8486]

**CLARENDON LABORATORY,** University of Oxford, has vacancies for Senior Technician (maximum £715 p.a.) and a Technician (maximum £590 p.a.) to work on electronics. Appropriate qualifications and experience essential. Excellent conditions, good holidays, generous pension scheme.—Write giving full details of career to the Administrator. [8501]

**PAINTON & Co., Ltd.,** Northampton, electrical component manufacturers, require an electro-mechanical designer to take charge of the design of small components for the electronic industry.—Applicants should state age, qualifications, and outline experience to date, and address to the Personnel Officer, Painton & Co., Ltd., Kingshorpe, Northampton. [8485]

**ACOUSTICS** engineer required by manufacturers of miniature electronic transistorised equipment. Applicants must have B.Sc. or H.N.C. and have three years' experience in this field. Successful applicant will be required to spend some time in the United States after initial period at home factory. Apply, giving qualifications, age and salary required, to Box 3299. [8507]

**RADIO** Technicians required by International Aeradio Ltd. for overseas service. Permanent and pensionable posts. Normally tax-free. Inclusive salary in local currency varying with location, and additional marriage and child differentials. U.K. leave, free air passages and insurance. Kit allowance. Qualified candidates to whom replies will be sent write to Personnel Officer, 40, Park St., W.1. [0262]

**RADIO** technicians of all grades are invited to apply for interesting and varied positions in car radio servicing; a high standard of practical and theoretical knowledge is required; excellent conditions of service, 5-day week, pension scheme; vacancies also occur from time to time with our dealers in all parts of the country.—Write in strict confidence to The Staff Manager, S. Smith & Sons (England), Ltd., Cricklewood Works, London, N.W.2, quoting reference SM/170. [8452]

**HOUSING** and good pay offered to electrical fitter required for the development, installation and maintenance of electrical and electronic devices.

**THIS** interesting post in an expanding department of an old-established paper-making company in Hampshire, is open to candidates under 40 years of age who have experience of fault-finding in electronic circuits.—Box 3424. [8524]

**DRAUGHTSMEN**—E. K. Cole, Ltd., Southend-on-Sea, have vacancies for draughtsmen in their development and engineering drawing office for men with experience in design and production drawing for radio, TV and electronic apparatus, and for draughtsmen with experience of press tool design and tooling for automatic screw machines, for posts in their tool design section.—Write Personnel Manager. [8523]

**SENIOR** technician or technician, with some experience and training in electronics, required in the Pharmacology Department, Royal Free Hospital School of Medicine, Hunter Street, London, W.C.1. Sales: Senior technician £645 x £20(1) x £25(5)—£790. Technician, £535 x £20(1) x £25(4)—£655, plus London Weighing Superannuation benefits. Five weeks' holiday. Apply Secretary with names of two referees. [8510]

**SCIENTIFIC** Glass Blower is required for an interesting and responsible post in the development laboratories of the Ericsson Tube Division. Experience in the hand and machine manipulation of hard and soft glasses and in small glass-to-metal seals would be required. A knowledge of high vacuum technology would also be an advantage. A good starting salary commensurate with experience in these fields is envisaged. The post would be a staff appointment, and the working conditions in modern well-equipped laboratories are excellent.—Write in the first instance giving brief details of previous experience to the Personnel Manager, Ericsson Telephones Ltd., Beeston, Nottingham, quoting reference LK/5. [8504]

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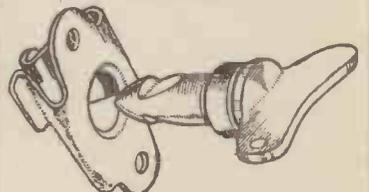
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**SITUATIONS VACANT**  
VACANCY for Demonstrator (Technical) Grade III in R.E.M.E. Training Centre, Arbourfield. Applicants should be in the Trade Group (Radar), with theoretical and practical knowledge of Radar Techniques and current Army Radar equipments, and able to teach the practical maintenance and repair of this equipment up to Sergeant's level. Apply in writing to—Officer Commanding, 5 (Radar) Training Battalion, R.E.M.E., Hazebrook Barracks, Arbourfield, Berks. [8506]

**AN Electronic Engineer**, with experience in the design of pulse circuits, required to investigate the application of the Tube Division's products to specific problems. The technical liaison work involved may entail visits to customers' laboratories. The post is a full staff appointment, carrying an attractive starting salary. Superannuation scheme. Please send details of age, experience, qualifications, quoting reference LK/4 to—The Personnel Manager, Ericsson Telephones, Ltd., Beeston, Nottingham. [8503 h.m.]

**RADIO operators**—Air Ministry have vacancies for temporary radio operators (male); good prospects of permanent, pensionable appointments and promotion; initial appointments in U.K. but subsequent tour of duty in Far East likely; trainees £422/10 to £605; qualified operators £507/10 to £975 (these rates are subject to a small deduction at provincial stations and a small increase in London and overseas); special allowances payable for overseas service.—Apply Air Ministry, C.E.4m., Cornwall House, Stamford St., S.E.1. [0231]

**INDEPENDENT Television News** requires a Cameraman/Technical Assistant to operate electronic camera during transmission time and act as technical assistant outside transmission periods, constructing and maintaining equipment, with minimum of supervision. Sound knowledge of electronic theory with practical experience required. Junior development engineer in radio or electronics would suit. Position temporary for approximately six months, with possibility of permanency.—Apply in writing to the Secretary, I.T.N., Television House, Kingsway W.C.2. [8519]

**A VACANCY** has arisen in the design laboratory for an engineer to assist in the mechanical design of radio and television receivers for home and export; applicants should have a good knowledge of designing receivers for mass-production, and preferably with experience of plastics and moulding techniques; an appointment will be made at a salary commensurate with age, experience and qualifications, details of which should be forwarded in writing in the first instance to the Personnel Manager (R.17) Murphy Radio, Ltd., Welwyn Garden City, Herts. [8470]

**D.S.I.R.** requires assistant experimental officer in instrumentation section at Hydraulics Research Station, Wallingford, Berks, on design and development of electronic and mechanical instruments. Qualifications: G.C.E. "A" level in 2 science or maths. subjects. Over 22 H.N.C. in Electrical or Mechanical Engineering or equivalent generally expected. Applicants should have active interest in electronics and preferably some experience in use of hand tools. Salary range: £382/10 (age 18)—£670 (age 26)—£830 (men). Five-day week. Promotion prospects. Housing facilities for married staff. Forms from M.L.N.S. Technical and Scientific Register (K) 26, King St., London, S.W.1. quoting D 196/9A. Closing date 12 June, 1959. [8526]

**VACANCIES** will shortly arise in the Valve Division of Ericsson Telephones, Ltd., for qualified and experienced physicists or engineers to undertake development and technical control of special valves and other electronic devices. These are senior posts and the successful applicants will report directly to the heads of either the Development or Technical laboratories. A good starting salary and a progressive career can be offered to suitable applicants. The working conditions, in modern well-equipped laboratories, are excellent. The usual amenities (pension scheme, social activities, canteen facilities, etc.) are available. Applications, which will be treated as strictly confidential, giving a brief summary of academic and industrial experience should be addressed to—The Personnel Manager, Ericsson Telephones, Ltd., Beeston, Nottingham, quoting reference LK.1/3. [8502]

**INSPECTOR of Police Grade II**, with telecommunications skill, required by Nyasaland Government; the post is a permanent and pensionable one, subject to a period of probation served on agreement; salary scale £705 rising to £1,200 a year; commencing salary according to experience; outfit allowance £50; uniform allowance £18 a year; free passages; liberal leave on full salary; candidates must be between 20 and 35 years of age, of good physique, not below 5ft 6in in height and have normal vision without glasses; the educational qualification required of candidates is General Certificate of Education Standard at Ordinary level in 5 subjects, which should include English and Mathematics or Science; essential to have wide practical experience in the installation and maintenance of V.H.F. radio equipment with City and Guilds Certificate if possible; candidates without previous police experience will be required to undergo a 13-week period of training in London before proceeding to Nyasaland. Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M1/46661/WF. [8493]

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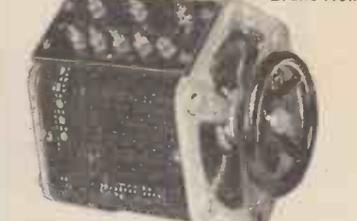


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Specification: A.C. input 100/260 volts 45/65 cycles. D.C. OUTPUT—VARIABLE UP TO 20 AMPS. AND 24 V. or trickle charge 126/350/700 amperes-hours. ESSENTIAL EQUIPMENT FOR ELECTRONIC ENGINEERING CONCERNS, RESEARCH LABORATORIES, SCHOOLS, etc., as HEAVY DUTY L.T. SUPPLY UNITS. Also as BATTERY CHARGERS FOR MULTIPLES OF 6/12/24 V. Batteries. FUSED AND SWITCHED ALL CIRCUITS, OUTPUT METEERED FOR 20 AMPS. Max. In grey metal cabinet 16 x 24 x 3 1/2 in. high. (These units are more than 90% under-rated by manufacturers at 10 amps for TROPICAL USE, but we guarantee them for 20 AMPS IN TEMPERATE CLIMATES.)

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**FERRANTI 71-KVA MOVING COIL AUTOMATIC VOLTAGE REGULATORS.**  
Stabilized output voltage in the range 200-250 v. Plug-board tapings. The selected output voltage is constant within ±1%, at all loads 0 to 30/37 1/2 amps, when the supply voltage is varying over the range +8% to -13%.  
● Frequency compensated 45-55 and 54-66 c/s.  
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● Unused. Complete with spares and instruction book at a fraction of the normal cost.

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RESEARCH engineers.—A. V. Roe & Co.,  
Ltd., Woodford, Cheshire, Systems Re-  
search Group of Weapons Research Division,  
invites applications from junior engineers and  
technicians for laboratory research work on  
electronics instrument design, servo-mechan-  
isms and mechanical engineering; applicants  
should have O.N.C. and be keen to improve  
their qualifications; canteen and social facili-  
ties are provided and there is a group pension  
scheme.—Applications, quoting reference No.  
WRD/RFD/R.79/W, should be addressed to  
Mr. W. Clover, A. V. Roe & Co., Ltd., Wood-  
ford Cheshire. [8487]

MINISTRY of Supply Royal Aircraft Estab-  
lishment, Bedford require experienced  
electrical/electronic Leading Draughtsman for  
instrumentation work in wind tunnels. Candi-  
dates must have served an appropriate appren-  
ticeship and possess the E.N.C. (Elec.) Salary  
£845-£995 p.a. 5-day week of 44 hours (includ-  
ing meal breaks). Paid sick leave. 18 days  
holiday excluding public holidays. Opportunities  
for promotion and to become pensionable.  
House available with reasonable time for  
candidate appointed if married and not resi-  
dent in district.—Applications stating age,  
qual. and exp. to Ministry of Supply,  
Est. 3.R.1, Room 517 Adelphi Strand, London,  
W.C.2, or any Employment Exchange quoting  
Order Number Bedford 291. Closing date 9  
June, 1959. [8511]

ASSISTANTS (scientific).—Pensionable posts  
for men or women at least 17½ and nor-  
mally under 26 on 1/1/59 with appropriate  
educational or technical qualifications (normally  
G.C.E. with passes at C or A level in  
4 distinct subjects including English Language  
and a scientific or mathematical subject, or  
O.N.C., or equivalent qualifications) and at  
least 2 years' experience in either: (i) engineer-  
ing or physical sciences, or (ii) chemistry, bio-  
chemistry or metallurgy, or (iii) biological  
sciences, or (iv) geology, meteorology, or skilled  
work in laboratory crafts such as glass-blow-  
ing. Starting salary (men) from £320 (at 17½)  
to £530 (at 25 or over). Maximum (London)  
£690. Promotion prospects. Five-day week  
generally.—Write Civil Service Commission, 17,  
North Audley St, London, W.1, for application  
form, quoting S.59/59. [8520]

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AMERICAN citizen, 31, desires to work and  
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years' experience in electronics industry in pur-  
chasing, sales, field service, and technical  
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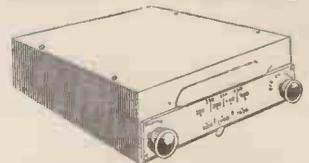
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## INDEX TO ADVERTISERS

	Page		Page		Page
A.A. Tools	168	Ferranti, Ltd.	6, 7	Quartz Crystal Co., Ltd.	94
Acoustical Mfg. Co., Ltd.	30	Frazar & Hansen, Ltd.	116	Racal Engineering Ltd.	57
Adcoia Products, Ltd.	64	Fringevison, Ltd.	90	Radio & Electrical Mart, The	156
Advance Components, Ltd.	54	Gabriel Mfg. Co., Ltd.	41	Radio & T.V. Components (Acton), Ltd.	153
Aircraft Marine Products (Gt. Britain), Ltd.	73	Garrard Eng. & Mfg. Co., Ltd. The	150, 151	radio Clearance, Ltd.	143
Airmec, Ltd.	42	General Electric Co., Ltd.	49, 95, 105, 173	Radio Component Specialists	127
Alpha Radio Supply Co., The	149	Gilfillan, R., & Co., Ltd.	158	Radio Exchange Co., The	121
Anders Electronics, Ltd.	78	Gilson, R. F., Ltd.	160	Radio Experimental Products Co.	172
A.N.T.E.S., Ltd.	91	Glaser, L., & Co.	158	Radio Industry Council	119
Appointments Vacant	162, 163, 164	Goodmans Industries, Ltd.	118	Radio Resistor, Ltd.	21
Arcoelectric Switches, Ltd.	88	Grayshaw Instruments	121	Radio Supply Co. (Leeds), Ltd.	138, 139, 140
Arden Acoustic Laboratories, Ltd.	68	Grey & Marten, Ltd.	88	Radio Traders, Ltd.	142
Armstrong Wireless & Television Co., Ltd.	84, 169	Griffiths Hansen (Recordings), Ltd.	158, 160	Radiospares, Ltd.	84
Army Reserve	161	Hall Electric, Ltd.	31	Radiostructure	82, 106
Aspden, W.	170	Harmsworth, Townley & Co.	63, 158	Rank Cintel, Ltd.	5
Automat	70	Harris Electronics (London), Ltd.	147	Redifon, Ltd.	66, 87
Automatic Telephone & Electric Co., Ltd.	40	Harris, P.	158	Re da Rad Co. Ltd.	159
Avo, Ltd.	1	Hatter & Davis, Ltd.	171	Reliance Manufacturing Co., Ltd.	76
		Henry's (Radio), Ltd.	122, 125	Renfrew Electronics	172
		Hivac, Ltd.	87	Reproducers & Amplifiers, Ltd.	48
		H.P. Radio Services, Ltd.	80	Rola-Celestion, Ltd.	58
		Hunt, A. H. (Capacitors), Ltd.	38	Rollet, H., & Co., Ltd.	170
		Hunton, Ltd.	95		
				Sabrina C.R. Tube Co.	154
Beamish, V. W.	160			Samsons Surplus Stores	156
Belling & Lee, Ltd.	101			Savage Transformers, Ltd.	152
Benson, W. A.	163			Savaze, W. Bryan, Ltd.	119
Berry's Radio	82			Semiconductors, Ltd.	23
Bestfriend Electrical Co., Ltd.	160			Service Trading Co.	124, 125
Birmingham Sound Reproducers, Ltd.	110			Shell Chemical Co., Ltd.	20
Brayford Institute of Technology	165			Siemens Edison-Swan, Ltd.	24, 55, 103, 104
Britain, Chas. (Radio), Ltd.	141			Sifam Electrical Instrument Co., Ltd.	158
British Communications Corporation, Ltd.	43			Simmonds, L. E., Ltd.	74
British Institute of Engineering Technology	160			Simon Sound Service, Ltd.	121
British Insulated Callender's Cables, Ltd.	Cover 11			Skymasts	174
British National Radio School	172			Smith, A. K. & L. G. Ltd.	158
British Physical Laboratories	11			Smith, G. W. (Radio), Ltd.	128, 129
British Thomson-Houston Co., Ltd.	53			Smith, H. L., & Co., Ltd.	173
Brookes Crystals, Ltd.	85			Southampton Technical College	165
Brown, S. G., Ltd.	85			Southern Radio Supply, Ltd.	154
Bulgin, A. F., & Co., Ltd.	Edit. 303			Southern Technical Supplies	152
Bullers, Ltd.	83			Specialist Switches	92
				Spencer-West, Ltd.	160
				Stamford, A. L.	169
				Standard Telephones & Cables, Ltd.	29, 33, 99
				Stearle & Porcelain Products, Ltd.	28
				Stern Radio, Ltd.	135, 134, 135
				Stewart Transformers, Ltd.	74
				Susden, A. R., & Co. (Engineers), Ltd.	70
				Tannoy Products, Ltd.	165
				Taylor Electrical, Ltd.	87
				Technical Trading Co.	148
				Tefusion (Eng.) Ltd.	117
				Telegaph Condenser Co., Ltd.	Cover 111
				Telegaph Construction & Maintenance Co., Ltd.	56
				Telemechanics, Ltd.	114
				Tele-Radio (1943), Ltd.	83
				Teletone Co., The	160
				Tellux, Ltd.	95
				Thompson, A. J.	160
				Tri-Electrical Co., Ltd.	Edit. 301
				T.R.S. Radio	142
				Tyer & Co., Ltd.	117
				Universal Book Co.	165
				Universal Electronics	157
				Nash, C. V.	165
				Nash & Thompson, Ltd.	79
				Newnes, George, Ltd.	32a, 32b
				Northern Radio Services	94
				Nu-life Teletubes	120
				Oddie, Bradbury & Cull, Ltd.	170
				P.A.R., Ltd.	114
				Parker, A. B.	94
				Partridge Transformers, Ltd.	167
				P.C.A. Radio	140
				P.C. Radio	126
				Pearce, T. W.	154
				Pembroke College of Electronics	181
				Pezo Limited	92
				Plessey Co., Ltd.	81, 108, 113, 158
				Portland Electronics	158
				Post Radio Supplies	172
				Proper Bros., Ltd.	155
				Pulleys, Electronics	150
				Pye, Ltd.	52, 54
				Pye Telecommunications, Ltd.	96
				Z. & I. Aero Services, Ltd.	168

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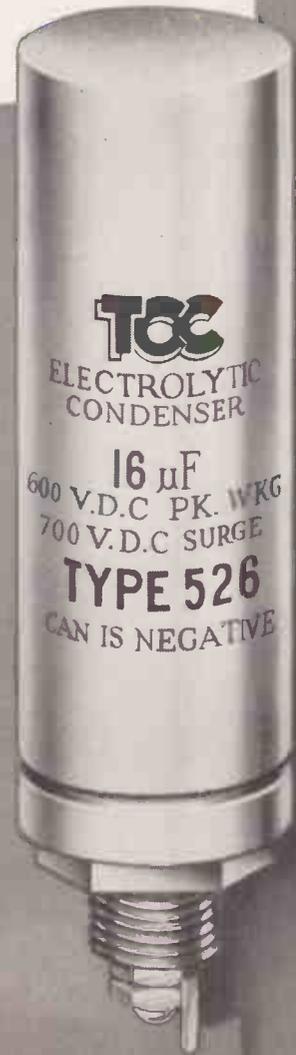
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