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Wireless World

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JUNE 1961

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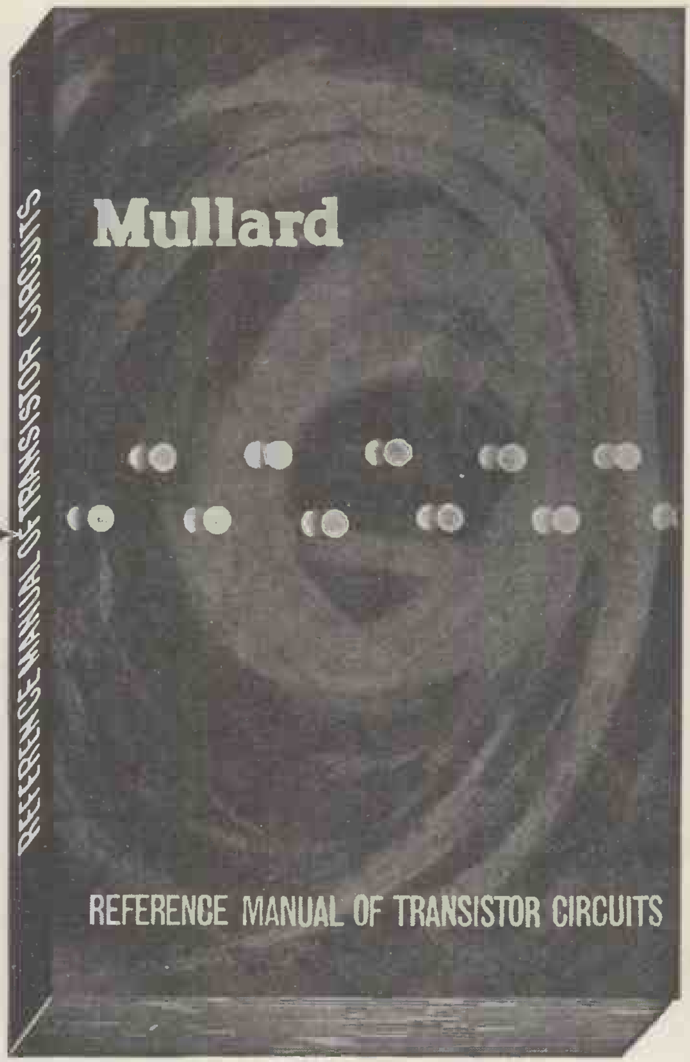

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Wireless World

VOL 67 NO 6 JUNE 1961

Line Standards in 1946

IN recent weeks we have observed the growth of a myth which we feel should be dispersed before it becomes permanently entangled in the present gyratory arguments about television line standards. Its wide acceptance is understandable, for, if it is believed, it removes responsibility for the present line-standards dilemma (real or imagined) from the present generation and attributes it to the folly of our administrators in re-starting television too soon in 1946, and in any case on 405 lines!

What, then, should we have done? Waited for complete international agreement? We should still be waiting now. Tagged along, viewless and clueless, behind the rest of the field until a majority movement became apparent? Sweden began technical experiments with a 625-line system in 1947 and was followed by Italy in 1949, but the first regular 625 television broadcasts (in Federal Germany) did not start until the end of 1950. Prior to that (in July 1950) a meeting of the Television Study Group of the International Radio Consultative Committee (C.C.I.R.) in Geneva, attended by delegates from Belgium, Denmark, Italy, the Netherlands, Sweden, Switzerland, France, the U.S.A. and the U.K., established standards which were recommended for those countries wishing to adopt a 625-line system. These were endorsed together with three other systems on 405, 525 and 819 lines at the VIth Plenary Meeting of the C.C.I.R. in Geneva in the following year, but, and this point was made clear in our issue of August 1952, none of these systems was adopted as an international standard; nor has any been agreed upon to this day.

By the end of 1953 eleven countries in West Europe had either started broadcasting or were sending test transmissions on 625 lines, and Argentina, Turkey and Venezuela had also declared for this system. So we should have been pretty safe in starting a 625-line service in that year or even in 1950 without much risk, but we should have lost four valuable years. Years in which television engineers and technicians, whose skill and knowledge had been extended by radar and communications work during the war would have been disbanded, and years in which this country would have lagged instead of leading in the post-war development of television.

All these factors were seen clearly by the Television Committee appointed in 1943 under the chairmanship of Lord Hankey to prepare plans for the reinstatement and development of the television service after the war. This report emphasizes the need for an international standard, and because no one had yet thought of the magic number 625 the established 525 American standard was considered. They gave two reasons for rejecting it: that the improvement in picture quality over the 405 was not significant, and the differences in mains and field frequency would involve more serious problems than a mere change in the number of lines. Wisely they decided not to defer the reopening of the television service "for the uncertain period required to give an opportunity of incorporating some fundamental improvement in the system" but to restart broadcasting with 405 lines "which had achieved a high degree of reliability and afforded consistently good entertainment value in the home." The inherent limitations of the 405-line system were squarely faced, and intensive research into a radically improved system with a line standard of the order of 1000 and with colour and stereoscopic effects was strongly urged to keep this country in the forefront of the television field. While we are awaiting this or a comparable radical improvement we enjoy what is in practice the world's best television service.

Belated Acknowledgment

WE apologize to our readers for what may have seemed a discourteous delay in thanking them for their congratulations and good wishes on the occasion of our Jubilee. It had been our intention to publish their letters, or at least some extracts from them in our June issue, but as they were still coming in from distant parts we delayed doing so. The file is now so voluminous that there is just not room in the journal to do justice to them all, and selection would, we feel, be invidious.

Our historical survey has evoked much reminiscence among our readers and the word nostalgia has been on everyone's lips (excepting "Free Grid's" who tells us that we have forgotten the original derivation and meaning of the word!). We claim his indulgence for the duration of these celebrations. They have been particularly pleasant for us, and we again thank our many friends for making them so.

Having, so to speak, crossed the line, we can now square away on our course with renewed confidence in the future.

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Television Standards Conversion

REMOVING THE 10C/S FLICKER IN 50C/S-60C/S FIELD CONVERSIONS

CONVERSION of television pictures from one standard to another has been common practice for a number of years, and has made possible the Eurovision link. However, conversion of European standards, which all employ a 50c/s field frequency, to the 525-line 60c/s system in use in North America, and *vice versa*, has set a new problem. In addition to the relatively easily removed moiré pattern, caused by the interaction of closely related line-structures, a new type of picture deformation becomes apparent. The different field frequencies interact one with the other to produce a 10c/s amplitude modulation of the video signal, which appears as a flicker at this frequency, and which renders the converted picture intolerable to the viewer.

Equipment designed to overcome this problem has been developed by the B.B.C. Engineering Division and has already been used to handle recordings, for translation to the American standard, of the Paris Summit Conference and the wedding of H.R.H. Princess Margaret.

The principle of a standards converter is shown in diagrammatic form in Fig. 1. The incoming video signal is amplified and displayed on a high-quality cathode-ray tube which has an afterglow time constant of 7msec. A lens focuses the displayed picture on to the storage mosaic of a camera tube scanned at the rate corresponding to the new standard, the output of which is processed in a sync-pulse insertion and blanking unit. The signal emerging from this unit is the converted signal.

As has been mentioned, when the number of lines per field of the two standards under consideration are closely related the picture on the new standard is subject to moiré interference caused by the fact that the lines of the two systems will be at very slightly different angles to the horizontal. In practice this effect is removed by the addition of "spot wobble" to the displayed incoming picture of such an amplitude as to camouflage the line structure of each field.

The mechanism producing the 10c/s flicker is indicated in Fig. 2. The top curve is a graph of the brightness of a single displayed picture element plotted against time and it is assumed that the signal at this point is peak white. It will be seen that the brightness increases to peak white as the element is scanned, once every 16.6msec, and that it then dies away exponentially. The time constant of this decay is, with the cathode-ray tube used, 7msec. The middle curve is the charge on the C.P.S. Emitron camera tube target, which in this case is being scanned at a 50c/s field frequency. The charge would increase linearly with time if display brightness were constant, but as the brightness of the display tube decays exponentially the charging curve of the target is also exponential.

The target charge increases in this way until the display tube element is rescanned. The camera tube element has not yet been neutralized by its scanning beam and continues to increase for a further 3.4msec, when it is discharged. It now commences to charge again, but at a lower rate, as the display tube element brightness has decayed from its peak level. The action continues in this manner until the fifth camera tube scan, when the two scans are once more coincident. If the peaks of the target charging curve are joined, a sawtooth type of waveform is obtained at a frequency of 10c/s, and this is proportional to the output of the camera tube. The signal is thereby amplitude modulated at 10c/s.

Removal of this flicker is effected by a pulse-sampling, manually adjusted amplitude compensator, followed by an automatic compensator which removes any flicker remaining after the signal has been subjected to the effect of the manually set circuit. The system, which is the subject of British Patent 801140 (T. C. Macnamara and A. M. Spooner), operates in the manner indicated in Fig. 3. The incoming video signal is passed through a low-pass filter which is switch-selected to pass the band of frequencies used by the incoming standard (3Mc/s for 405-line 50c/s standard). The next process is the insertion at the end of each line of the picture of a reference pulse which has a width of about 2% of the line period, and an amplitude of about 85% peak white. The pulse slightly overlaps the right-hand edge of a line of video signal and is apparent as a bright vertical stripe on the picture. The video signal with the reference pulse added is now amplified and displayed on the cathode-ray tube. The conversion process referred to earlier

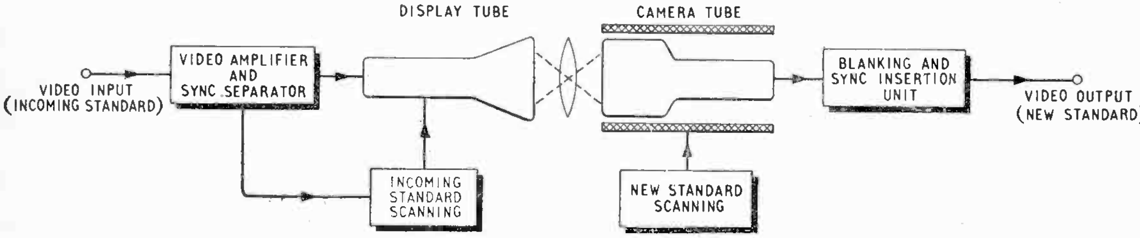

Fig. 1. The basic principle of a standards converter.

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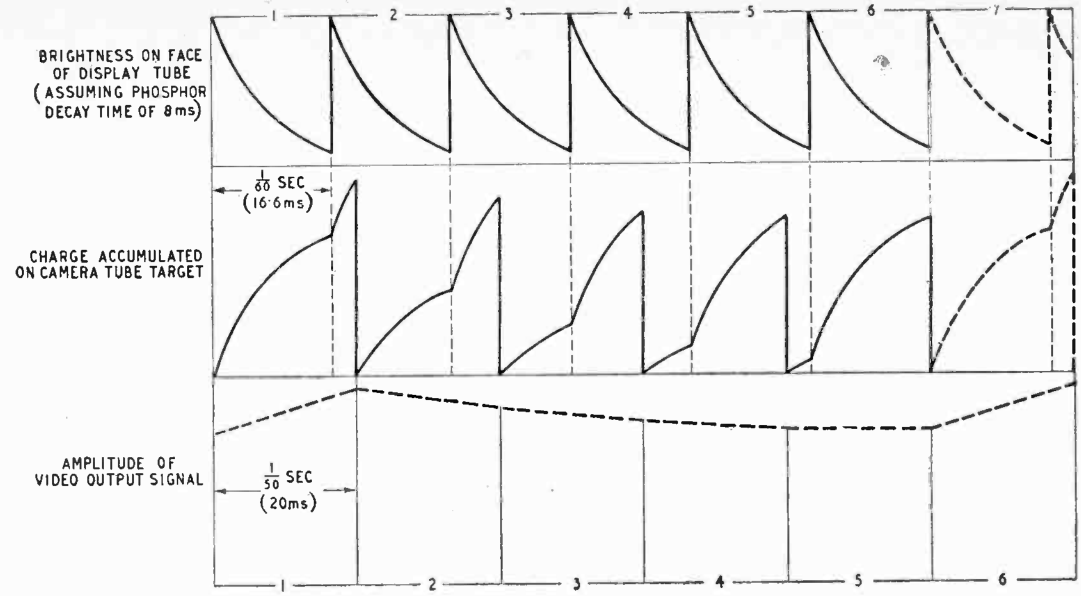
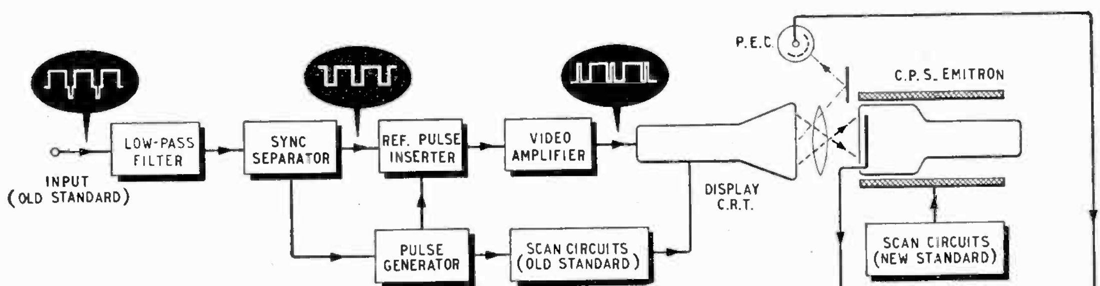
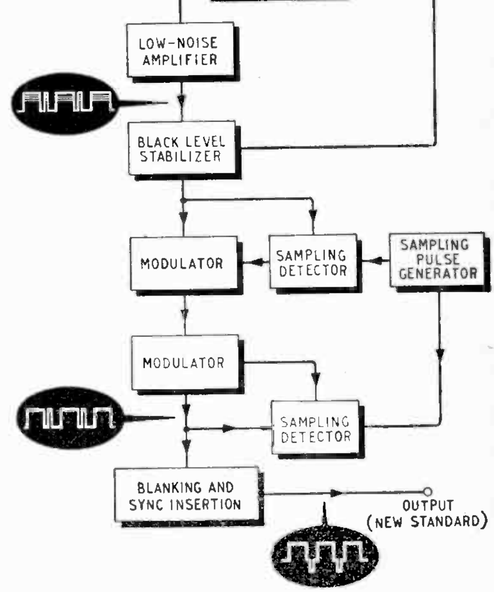


Fig. 2. The mechanism producing the 10c/s amplitude modulation of the video signal, in a conversion from 525 lines 60 fields/sec to 405 lines 50 fields/sec.

Fig. 3. Block diagram of B.B.C. 50c/s-60c/s converter, showing units concerned with 10c/s flicker removal. Waveforms shown are of peak white lines.





takes place and the 10c/s amplitude modulation of the signal is also impressed on the reference pulse.

The voltage developed across the C.P.S. Emitron output resistor consists of the wanted video signal—proportional to the target discharging current—and also, the tube being a photo-electric device, a signal which is proportional to the total light emitted by the display tube. To cancel the effects of this latter unwanted signal, a photo-cell views the display screen through an angled mirror, the output being again proportional to the total light on the screen. The signal is amplified and applied to the black-level stabilizing unit, where it is subtracted from the output of the camera tube. The signal remaining after subtraction is then the video waveform alone.

After amplification and black-level stabilization the composite video signal and reference pulse is fed to the two compensators. A sampling pulse is generated at line frequency to coincide in time with the reference pulse and used to operate a sampling gate. The varying amplitude of the reference pulse is sampled in the gate and a correction signal related to the envelope of the references pulses is derived,

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The B.B.C. standards converter. From left to right: the flicker correction bay, the camera and display control unit with monitor, and the display pedestal including the camera and display tube.

this being used to drive a modulator which is in series with the signal path. The manual gain control adjusts the amplitude of the correction signal until the flicker is at minimum level. After this compensator the signal passes through a similar circuit which functions as an a.g.c. After passing through a modulator the signal feeds the sampling gate, which then applies the derived correction signal to the series modulator. The whole circuit is a feedback loop and is capable of reducing amplitude variations at 10c/s from 30% to less than 1%. The signal, then, first passes through a manually adjusted compensator, which reduces the level of modulation to a value which is within the range of control of the automatic circuit.

On leaving the two compensating circuits the signal is processed in a unit which inserts sync pulses and blanking intervals, and in which the reference pulses are removed. The signal is now converted to the new standard and ready for use.

BOOKS RECEIVED

A Textbook of Electricity, by H. G. Mitchell. A school textbook suitable for use up to advanced level G.C.E., and by University Scholarship candidates. A complete account of electric and magnetic phenomena is given, and the rationalized m.k.s. system of units is used throughout. A short description of technological applications is included, and the final chapters include discussions of atomic and nuclear physics, the quantum theory and a physical picture of wave-mechanics. Some 300 questions, taken from recent examination papers are set. Pp. 598; Illustrated. Methuen & Co., Ltd., 36, Essex Street, London, W.C.2. Price 25s.

V.H.F. Line Techniques, by C. S. Gledhill. Designed for both undergraduate and practising engineer, the book seeks to impress the advantages of the circle-diagram over the more traditional, analytical methods of transmission-line problem solution. Worked examples of typical problems are given, which enable the work to be used as a reference book. Pp. 60; Figs. 51. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 12s 6d.

How To Use Meters, by John F. Rider and Sol D. Prensky. The second edition of a practical handbook on the principles and operation of all types of meters. The basic types of movement are described, and their use as voltage and current meters, with descriptions of more sophisticated instruments such as chopper electrometers and valve-voltmeters. Information is given on measurement of quantities in receivers and transmitters and a chapter is included on more sophisticated electronic measurements. Pp. 210; Figs. 181. John F. Rider Publisher, Inc., 116, West 14th Street, New York 11, N.Y. Price $3.90.

Hi-Fi Amplifier Circuits, by E. Rodenhuis, translated by G. Du Cloux. For all who are interested in the design and construction of high-quality audio amplifiers. A chapter on general design considerations is followed by descriptions of several power amplifiers and pre-amplifiers, including a four-channel mixer. Pp. 105; Figs. 64. Philips' Technical Library. Obtainable from Cleaver Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 15s.

Boolean Algebra and its Applications, by J. E. Whitesitt. Introduction to algebra of logical deductions with particular reference to computer and switching circuit applications. Pp. 182; Figs. 100. Addison-Wesley Publishing Co., Inc., 10-15, Chitty Street, London, W.1. Price 51s.

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TRANSISTOR PARAMETERS

By G. de VISME*, B.Sc.

DEFINITIONS AND INTER-RELATIONSHIPS

ANYONE who has glanced at the manufacturer's figures for transistor characteristics must have been bewildered, as I was, by their profusion. Figures are quoted for some or all of about thirty different quantities, with careful stipulations as to which of the three configurations (grounded base, grounded emitter or grounded collector) these figures relate to.

How easy-going seem those far-off days of thermionic valves, when only three figures appeared, namely g_m, R_a, and μ—and anyone who pursued a course at a Technical College would have learned at a very early stage that μ equals $g_m \times R_a$, so only two parameters were really needed!

It is the purpose of this article to sort out and relate the transistor parameters, beginning with a description of the transistor in terms of its static characteristics, and including one or two digressions which may be of interest.

Transistor Behaviour.—The simple transistor is basically a three-terminal active network. Very briefly its action is as follows: for suitable voltages between the electrodes, the current flowing into the emitter divides between the collector and base, with about 97% of it flowing to the collector and about 3% flowing to the base.

Variations of the voltages produce corresponding variations of these currents, and whilst the overall currents remain roughly in the above proportion, the incremental changes of each current depend on the incremental changes of voltage.

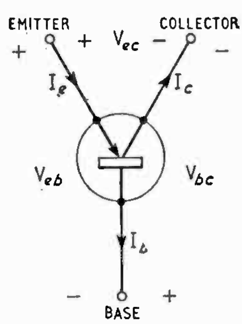

Fig. 1. Three voltage and three current variables for the transistor.

It is true to say, however, that a change of emitter current produces a roughly comparable change of collector current, whilst a change of base current is accompanied by a much larger change in collector current. For this reason, the base current is treated as an independent variable.

We may compare the above behaviour with that of a triode in which the anode current is slightly affected by the anode voltage, but very much more affected by the grid voltage, and so the grid voltage is usually treated as an independent variable.

We have six variables—three voltages and three currents—as shown in Fig. 1. Two suffixes are used for each voltage, their order defining which electrode is positive with respect to the other.

Two fundamental equations hold:—

$$V_{ec} = V_{eb} + V_{bc} \text{ and}$$
$$I_e = I_b + I_c$$

so in fact there are only four variables, which four being entirely a matter of choice.

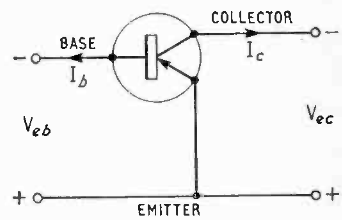

Fig. 2. Grounded-emitter configuration for the transistor.

If, out of these four, any *two* are fixed externally, the transistor fixes the other two. Thus if a certain voltage is applied between emitter and base, and another voltage between base and collector, the emitter-collector voltage is determined by the first equation above, and the three currents I_e, I_b and I_c are determined by the transistor and the second equation.

It is equally true to say, if a given emitter-collector voltage is applied, in order that a given base current shall flow, a unique value of emitter-base voltage will be needed, and so unique values of collector current and emitter current will flow. Once again, therefore, two variables, in this case V_{ec} and I_b, effectively determine the other four.

It is important to realize that, whilst the voltages are in a sense the "prime movers" and *cause* the currents to flow, this does not mean that we cannot regard a current as an independent variable —in fact, as we saw above, the base current is usually so considered.

Static Characteristics of a Transistor.—Since we have four separate variables, two of which are independent and two dependent, the characteristics of a transistor cannot be expressed by means of one set of curves, as can those of a valve. Two sets are needed, each incorporating either one voltage and two currents or two voltages and one current, the two sets together covering two currents and two voltages. Evidently a set incorporating the three voltages or the three currents is useless, as these are related by the fundamental equations anyway.

Which variables to plot against which is once

* Squadron Leader, Royal Air Force Technical College, Henlow.

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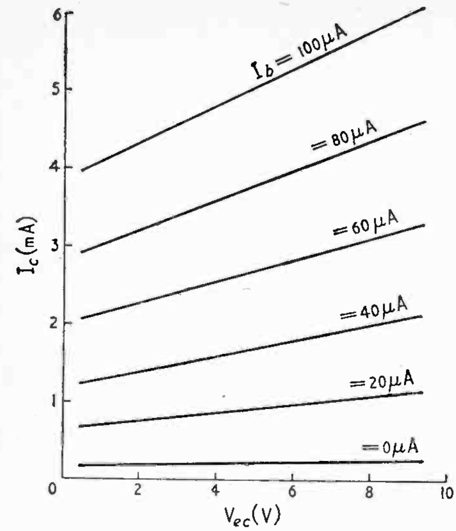

Fig. 3. Typical output curves for a transistor in the grounded-emitter configuration.

again a matter of convenience. The following table gives a few of the possibilities:—

X axis (first independent variable)	V_{ec}	V_{ec}	I_b	I_b	V_{bc}	V_{bc}	...
Parameter (second independent variable)	I_b	I_b	V_{ec}	V_{ec}	I_b	I_b	...
Y axis (dependent variable)	I_c	V_{eb}	I_c	V_{eb}	I_e	V_{eb}	...

There are 108 permissible sets in all. In those given here, I_b has been chosen as an independent variable for the reason given above. A bracketed pair supplies the whole information about the transistor's behaviour and consequently, given one such pair, it is possible to plot from it any of the remaining 106 sets of curves.

It is possible to choose the variables in such a way that both the sets needed may be plotted on one sheet of graph paper, for example:—

X axis	I_c	I_c
Parameter	I_b	I_b
Y axis	V_{ec}	V_{eb}

but although the first of these is a re-arrangement of the "output characteristic" in the grounded-emitter configuration, the second set is of little practical value.

Four sets of curves are usually supplied though only two are necessary. Since the transistor is usually used in the grounded-emitter configuration as in Fig. 2, the four sets are plotted for this configuration. For the reason set out above, I_b is treated as an independent variable in each set. Also, to enable the location of a working point, one of the sets relates the output current (y axis) with the output voltage (x axis). The four sets are called "output", "voltage feedback", "current transfer" and "input" characteristics, and are the first four sets of curves respectively in the above table.

Typical output curves are shown in Fig. 3. They closely resemble those of a pentode valve, except that the parameter I_b takes the place of the corresponding parameter V_g.

By what has been said above, analogous characteristics for either of the other two configurations (grounded base and grounded collector—see Figs. 4a and b) may be derived from these.

Transistor Parameters.—Three quite separate sets of parameters are defined expressing the behaviour of a transistor for small signal amplification. These are: (i) The Hybrid, or "*h*", parameters; (ii) The T-network parameters; and (iii) The Mullard parameters.

Each of these sets is in turn subdivided into three sets—undashed, dashed and double-dashed—respectively expressing the small-signal behaviour of the transistor in the grounded-base, grounded-emitter and grounded-collector configuration.

Three other quantities a, a', and a'' are further defined, rather loosely called "current amplification" (dI_{out}/dI_{in}), for the three configurations.

Hybrid Parameters.—To define the *h*-parameters, the transistor is regarded as an active four-terminal network, the lower pair of terminals being connected together and joined to the "common" electrode, i.e., base, emitter or collector (see Fig. 5). In this diagram I_1 signifies the input current, I_2 the output current, V_1 the input voltage and V_2 the output voltage.

Fixing any two of these quantities automatically

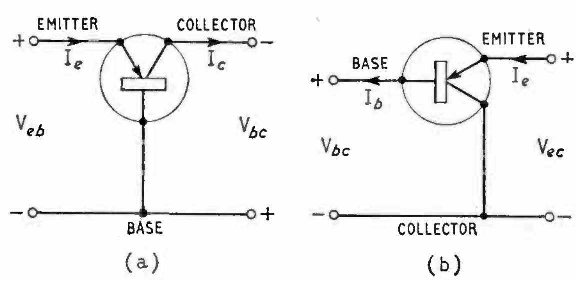

Fig. 4. (a) Grounded-base and (b) grounded-collector configuration for the transistor.

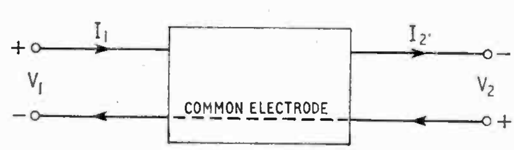

Fig. 5. Four-terminal network treatment of a transistor.

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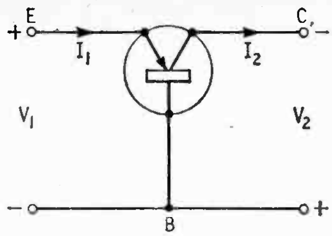

Fig. 6. Four-terminal network treatment of a transistor in the grounded-base configuration.

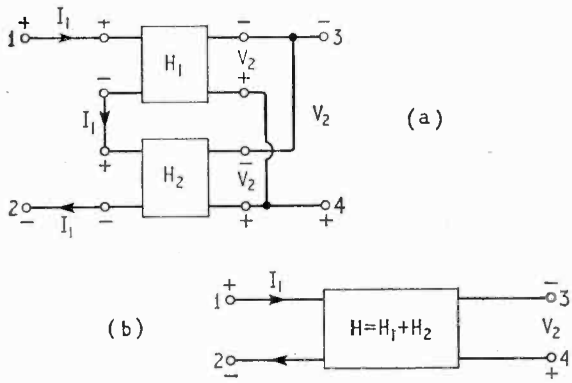

Fig. 7. Two four-terminal networks connected as in (a) can be reduced to a single four-terminal network as in (b) whose hybrid parameters are each the sum of the two corresponding hybrid parameters of the two four-terminal networks of (a).

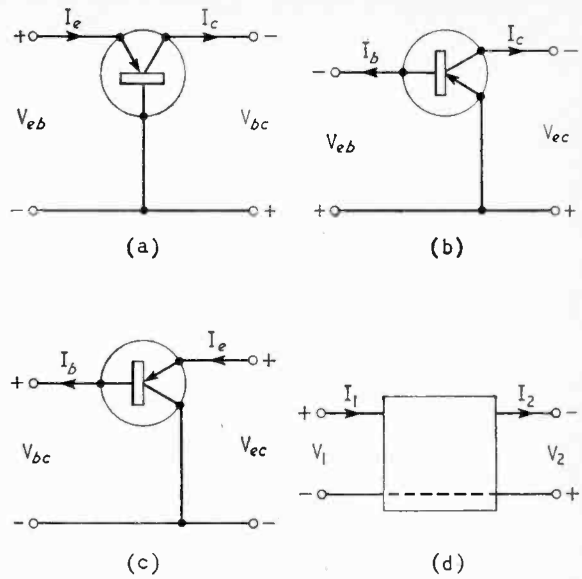

Fig. 8. (a), (b) and (c) Three configurations of a transistor and (d) four-terminal network treatment of a transistor.

fixes the other two, as was explained above. Thus if we take I_1 and V_2 as independent variables, we may express the dependent variables V_1 and I_2 in terms of these as follows:—

$$dV_1 = \left(\frac{\delta V_1}{\delta I_1}\right)_{V_2} dI_1 + \left(\frac{\delta V_1}{\delta V_2}\right)_{I_1} dV_2 \text{ and}$$

$$dI_2 = \left(\frac{\delta I_2}{\delta I_1}\right)_{V_2} dI_1 + \left(\frac{\delta I_2}{\delta V_2}\right)_{I_1} dV_2$$

For small increments, the partial differential coefficients may be considered constant, so the equations may be re-written:—

$$dV_1 = h_{11}dI_1 - h_{12}dV_2 \text{ and}$$
$$dI_2 = - h_{21}dI_1 + h_{22}dV_2$$

where h_{11}, h_{12}, h_{21} and h_{22} are the "hybrid parameters". The name arises from the fact that h_{11} has dimensions of resistance, h_{22} has dimensions of conductance, while h_{12} and h_{21} are pure numbers. The negative signs are conventional.

Actually these symbols represent the parameters for the transistor in the grounded-base configuration (see Fig. 6), and it is easily seen, by considering the action of a transistor, that h_{11} is positive, h_{12} is also positive since $\left(\frac{\delta V_1}{\delta V_2}\right)_{I_1}$ is negative, h_{21} is negative since $\left(\frac{\delta I_2}{\delta I_1}\right)_{V_2}$ is positive, and h_{22} is positive.

Corresponding h-parameters for the grounded-emitter and grounded-collector configurations are defined by exactly the same equations, but the "h"s are dashed and double-dashed respectively, and have correspondingly different values.

An interesting property of hybrid parameters follows from their definition. If two four-terminal networks, having sets of parameters H_1 and H_2, are connected as shown in Fig. 7(a), they can be reduced to a single four-terminal network whose four parameters, forming a set H, are the sum of the corresponding parameters of sets H_1 and H_2, as shown in Fig. 7(b).

Sinusoidal Voltages and Currents.—The equations may be re-written:—

$$V_1 = h_{11}I_1 - h_{12}V_2 \text{ and}$$
$$I_2 = - h_{21}I_1 + h_{22}V_2$$

where V_1, I_1, V_2 and I_2 are complex numbers (" rotating vectors ") representing sinusoids of small amplitude.

For low frequencies, the coefficients h_{11}, etc., are real numbers. For higher frequencies, it is necessary to regard them as complex functions of frequency.

Relation Between h-Parameters for Different Configurations.—Figs. 8(a), (b) and (c) show the transistor connected in its three possible configurations, along with applied voltages and currents, while Fig. 8(d) shows the transistor treated as a four-terminal network with its input and output voltages and currents.

Comparing the diagrams 8(a), (b) and (c) in turn with (d), we have, for the grounded-base configuration:—

$$V_{eb} = V_1,\ I_e = I_1,\ I_c = I_2 \text{ and } V_{bc} = V_2$$

and therefore

$$dV_{eb} = h_{11}dI_e - h_{12}dV_{bc} \text{ and}$$
$$dI_c = -h_{21}dI_e + h_{22}dV_{bc}$$

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For the grounded-emitter configuration we have:—

$V_{eb} = -V_1, I_b = -I_1, I_c = I_2,$ and $V_{ec} = V_2$

and therefore

$-dV_{eb} = -h'_{11}dI_b - h'_{12}dV_{ec}$ and
$dI_c = h'_{21}dI_b + h'_{22}dV_{ec}$

For the grounded-collector configuration we have:—

$V_{bc} = V_1, I_b = -I_1, I_e = -I_2,$ and $V_{ec} = -V_2$

and therefore

$dV_{bc} = -h''_{11}dI_b + h''_{12}dV_{ec}$ and
$-dI_e = h''_{21}dI_b - h''_{22}dV_{ec}$

We also have the two Kirchhoff equations

$V_{ec} = V_{eb} + V_{bc}$ and
$I_e = I_b + I_c$

and we can therefore find all the members of any one set of parameters in terms of those of any other set.

We will derive, as a demonstration, h'_{21} and h'_{22} in terms of h-parameters, merely quoting the remainder.

$$\begin{aligned} dV_{eb} &= h_{11}dI_e - h_{12}dV_{bc} \\ &= h_{11}dI_b + h_{11}dI_c - h_{12}dV_{ec} + h_{12}dV_{eb} \\ &= h_{11}dI_b/(1 - h_{12}) + h_{11}dI_c/(1 - h_{12}) - h_{12}dV_{ec}/(1 - h_{12}) \\ dI_c &= -h_{21}dI_e + h_{22}dV_{bc} \\ &= -h_{21}dI_b - h_{21}dI_c + h_{22}dV_{ec} - h_{22}dV_{eb} \\ &= -h_{21}dI_b/(1 + h_{21}) + h_{22}dV_{ec}/(1 + h_{21}) - h_{22}dV_{eb}/(1 + h_{21}) \end{aligned}$$

Therefore

$$\begin{aligned} dI_c &= -h_{21}dI_b - h_{21}dI_c + h_{22}dV_{ec} - h_{11}h_{22}dI_b/(1 - h_{12}) - h_{11}h_{22}dI_c/(1 - h_{12}) + h_{12}h_{22}dV_{ec}/(1 - h_{12}) \\ &= \left[\frac{-h_{21} - h_{11}h_{22}/(1 - h_{12})}{1 + h_{21} + h_{11}h_{22}/(1 - h_{12})}\right]dI_b + \left[\frac{h_{22} + h_{12}h_{22}/(1 - h_{12})}{1 + h_{21} + h_{11}h_{22}/(1 - h_{12})}\right]dV_{ec} \end{aligned}$$

Comparing this with

$dI_c = h'_{21}dI_b + h'_{22}dV_{ec}$

we see that

$h'_{21} = (h_{12}h_{21} - h_{11}h_{22} - h_{21})/D$ and $h'_{22} = h_{22}/D$
where $D = (1 + h_{21})(1 - h_{12}) + h_{11}h_{22}$

Summarizing the results, we have:—

$h'_{11} = h_{11}/D, h'_{22} = h_{22}/D, h'_{12} = 1 - (1 + h_{21})/D$
and $h'_{21} = (1 - h_{12})/D - 1$
$h''_{11} = h_{11}/D,\ h''_{22} = h_{22}/D,\ h''_{12} = (1 + h_{21})/D$
and $h''_{21} = -(1 - h_{12})/D$

We can write down certain simple relations, for example:—

$h'_{11} = h''_{11},\ h'_{22} = h''_{22},\ h'_{12} + h''_{12} = 1,$
$h'_{21} + h''_{21} = -1$ and $(h'_{11}h'_{22} - h'_{12}h'_{21}) = (h_{11}h_{22} - h_{12}h_{21})(h''_{11}h''_{22} - h''_{21}h''_{12})$

Measurement of h-Parameters.—From the equations

$dV_{eb} = h'_{11}dI_b + h'_{12}dV_{ec}$ and
$dI_c = h'_{21}dI_b + h'_{22}dV_{ec}$

we have

$h'_{11} = \left(\frac{\delta V_{eb}}{\delta I_b}\right)_{V_{ec}}$, which is the slope of the *input* characteristic,

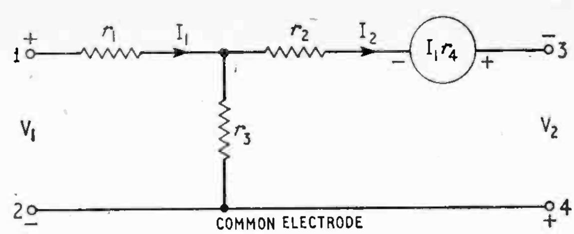

Fig. 9. T-network representation of a transistor.

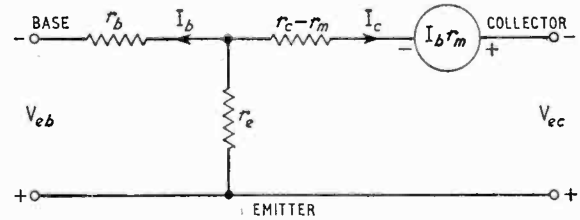

Fig. 10. T-network representation of a transistor in the grounded-emitter configuration.

$h'_{12} = \left(\frac{\delta V_{eb}}{\delta V_{ec}}\right)_{I_b}$, which is the slope of the *voltage feedback* characteristic,

$h'_{21} = \left(\frac{\delta I_c}{\delta I_b}\right)_{V_{ec}}$, which is the slope of the *current transfer* characteristic, and

$h'_{22} = \left(\frac{\delta I_c}{\delta V_{ec}}\right)_{I_b}$, which is the slope of the *output* characteristic.

All of these are in fact positive, as can be seen by considering the transistor action.

We have to calculate the values of the grounded-base and grounded-collector parameters from these slopes, using the relations quoted above.

One very important point must be noted: the relations calculated above hold only for increments about the *same* working point in the three configurations. Thus, if the values of h and h' are quoted for $V_c = -2V$ and $I_c = 1mA$, we must remember that "$V_c = -2V$" in the grounded-base configuration means "$V_{bc} = 2V$", whilst "$V_c = -2V$" in the grounded-emitter configuration means "$V_{ec} = 2V$", so in fact the values of h and h' are quoted for slightly different working points since V_{ec} usually exceeds V_{bc} by about 0.2V.

Hybrid parameters must be regarded as the fundamental parameters describing the behaviour of any four-terminal network (active or passive, linear or non-linear, frequency sensitive or otherwise). They are somewhat too academic, however, for an electronic engineer seeking to analyze transistor circuits.

T-Network Parameters.—When considering the behaviour of a transistor in circuit, it is convenient to represent it as a T-network consisting of three resistances and one active element, as shown in Fig. 9.

The four parameters (clearly four, and only four,

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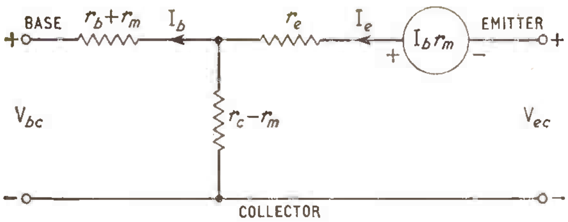


Fig. 11. T-network representation of a transistor in the grounded-collector configuration.

separate constants will be required whatever system of parameters is adopted) in this case are r_1, r_2, r_3 and r_4.

The equations relating V_1 with I_1 and V_2, and I_2 with I_1 and V_2, are respectively:—

$V_1 = (r_1r_2 + r_1r_3 + r_2r_3 - r_3r_4)I_1/(r_2 + r_3) - r_3V_2/(r_2 + r_3)$

$I_2 = (r_3 + r_4)I_1/(r_2 + r_3) + V_2/(r_2 + r_3)$

By comparing these equations with those relating the same quantities in terms of h-parameters, we obtain the following relations between the resistances in this representation and the h-parameters:—

$h_{11} = r_1 + r_3(r_2 - r_4)/(r_2 + r_3)$, $h_{12} = r_3/(r_2 + r_3)$, $h_{21} = -(r_3 + r_4)/(r_2 + r_3)$ and $h_{22} = 1/(r_2 + r_3)$

For the grounded-base configuration, terminal 1 is the emitter and r_1 is called the emitter resistance r_e; terminal 2 is the collector and r_2 is called the collector resistance r_c, and terminals 3 and 4 are the base and r_3 is called the base resistance r_b. Resistance r_4 is usually denoted r_m. So, for this configuration the above relations yield:—

$r_b = r_3 = h_{12}/h_{22}$, $r_c = r_2 = (1 - h_{12})/h_{22}$, $r_e = r_1 = (h_{11}h_{22} - h_{12}h_{21} - h_{12})/h_{22}$, and $r_m = r_4 = -(h_{12} + h_{21})/h_{22}$

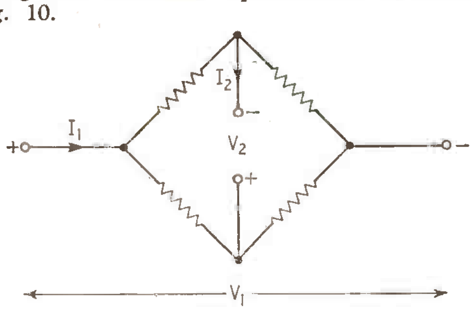
For the grounded-emitter configuration similar equations apply, except that the coefficients of I_1 and V_2 are dashed, yielding therefore:—

$r_1 = (h'_{11}h'_{22} - h'_{12}h'_{21} - h'_{12})/h'_{22}$, ... and $r_4 = -(h'_{12} + h'_{21})/h'_{22}$

Substituting h-parameters for h' ones and using the relations derived for r_b, r_c, r_e and r_m, we obtain:

$r_1 = r_b$, $r_2 = r_c - r_m$, $r_3 = r_e$ and $r_4 = -r_m$

giving the T-network representation as shown in Fig. 10.



Above: Fig. 12. Four passive elements as shown cannot fully represent a transistor.

For the grounded-collector configuration, the coefficients of I_1 and V_2 in the equations are double-dashed, and so

$r_1 = (h''_{11}h''_{22} - h''_{12}h''_{21} - h''_{12})/h''_{22}$, .. and $r_4 = -(h''_{12} + h''_{21})/h''_{22}$

Again, substituting h-parameters for h'' ones and using the relations above for r_b, r_c, r_e and r_m, we get:—

$r_1 = r_b + r_m$, $r_2 = r_e$, $r_3 = r_c - r_m$ and $r_4 = r_m$

so the equivalent T-network becomes as shown in Fig. 11.

One advantage of the T-network representation is immediately apparent—the elements of the equivalent circuits for the grounded-emitter and grounded-collector configurations are extremely simply related to those for the grounded-base configuration.

Other Equivalent Circuits.—The representation above included three passive and one active element. Four separate constants are required; one therefore asks oneself if a representation such as Fig. 12, containing four separate passive elements, will do. If however one forms equations for this network in the form $V_1 = h_{11}I_1 - h_{12}V_2$ and $I_2 = -h_{21}I_1 + h_{22}V_2$, where the h coefficients are functions of the four resistances, one finds that $h_{21} = h_{12}$. This representation therefore only provides us with three separate h-parameters and cannot therefore represent a transistor. We could have predicted this from the theorem of reciprocity, a theorem which applies in the case of passive, but not active, networks.

However, other representations are possible. All that is required of a representation is that we should be able to form two equations of the form shown above in which all four h-parameters are different. One such alternative representation containing two passive and two active elements is shown in Fig. 13. The constants of this circuit can, of course, readily be worked out in terms of h or any other set of parameters. In particular, the factor "b" for the grounded-base configuration is very nearly equal to 1.

"a" and "a dashed".—As was mentioned at the start, a and a' are two additional parameters loosely termed "current gain" in grounded-base and grounded-emitter configurations, respectively.

Current gain under what conditions?

With the *output* short-circuited to a.c., i.e., with $dV_2 = 0$, $a = (dI_c/dI_e)$ in the grounded-base configuration

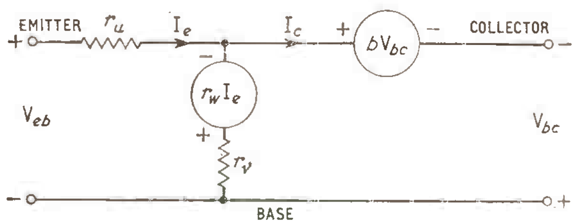
$= -h_{21} = (r_b + r_m)/(r_b + r_c)$

while $a' = (dI_c/dI_b)$ in the grounded-emitter configuration

$= h'_{21} = (r_m - r_e)/(r_e + r_c - r_m)$

and there is no relation whatever between them.

On the other hand, if the *input* is short-circuited



Right: Fig. 13. Possible transistor representation containing two passive and two active elements.

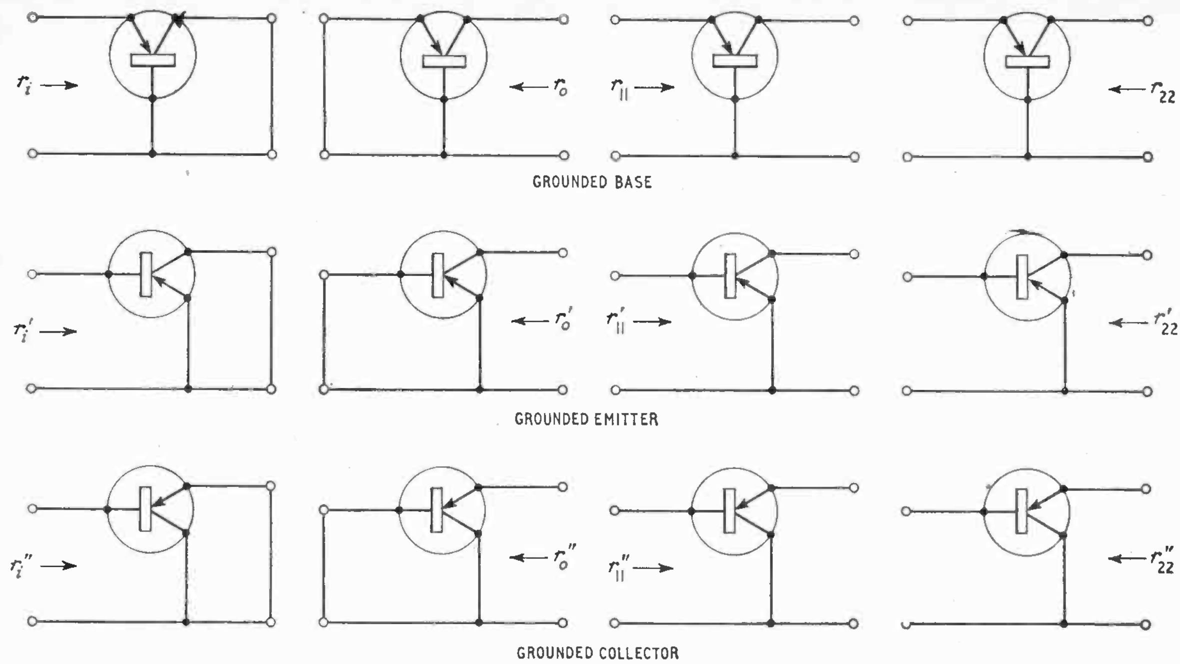


Fig. 14. Definition of the Mullard transistor parameters.

to a.c., i.e., $dV_1 = 0$ and the currents are varied by varying the output voltage, $a = (dI_c/dI_e)$ in the grounded-base configuration

$= (h_{11}h_{22} - h_{12}h_{21})/h_{12} = (r_b + r_e)/r_b$

and $a' = (dI_c/dI_b)$ in the grounded-emitter configuration

$= -(h'_{11}h'_{22} - h'_{12}h'_{21})/h'_{12} = -(r_b + r_e)/r_e$

$= a/(1 - a)$

We note that a in this case is greater than 1, and so a' is negative. This latter case is *not* equivalent to using the transistor the reverse way round.

When treating a transistor as a T-network, we find a quoted as r_m/r_c and a' given as $r_m/(r_c - r_m) = a/(1-a)$. In fact, in order that the current gain may be r_m/r_c in the grounded-base configuration, it is necessary to measure it with a collector load of $r_b(1 - r_c/r_m)$ in circuit (about -17Ω!), whilst to get a current gain of $r_m/(r_c - r_m)$ in the grounded-emitter configuration, you would need a collector load of $(r_c r_e/r_m)$, that is, about 18Ω.

In view of the constants of a normal transistor, this ambiguity is perhaps rather academic. Taking r_b as 700 Ω, r_c as 1 MΩ, r_e as 18 Ω and r_m as 976 kΩ, the short-circuit current gain in the grounded-base configuration $= (r_b + r_m)/(r_b + r_c) = 976.7/1000.7$, whilst the usual expression, r_m/r_c, for current gain in this configuration comes to 0.976.

Likewise, the short-circuit current gain in the grounded emitter configuration $= (r_m - r_e)/(r_e + r_c - r_m) = 975.982/24.018$, whilst the usual expression, $r_m/(r_c - r_m)$, for current gain in this configuration comes to 976/24.

However, it is as well to be on one's guard when discussing current gain.

Mullard Parameters.—Mullard parameters are the input and output resistances of a transistor with output and input respectively open-circuited and short-circuited to a.c.

The symbols for the grounded-base parameters are r_i, r_o, r_{11} and r_{22}. Corresponding dashed and double-dashed symbols are defined for the other two configurations. The parameters are defined in Fig. 14.

Mullard parameters perhaps betray the influence of the electrical engineer, who tends to define the properties of all his machinery in terms of its open and short circuit impedances or their equivalent, but they have the great advantage of being *directly measurable*. A large inductance is used to provide an open circuit to a.c. if a d.c. path is required, and a large condenser is used to provide a short circuit to a.c. where a d.c. open circuit is required.

Mullard parameters, however, suffer from one vital limitation. Unlike the other two sets of parameters, they fail in themselves to give all the properties of the transistor.

The reason is very simple. Consider for example the grounded-base configuration:—

r_i = input resistance with output short-circuit to a.c., i.e. with $dV_2 = 0$,

$= h_{11}$

r_o = output resistance with input short-circuit to a.c., i.e. with $dV_1 = 0$,

$= h_{11}/(h_{11}h_{22} - h_{12}h_{21})$

r_{11} = input resistance with output open-circuit to a.c., i.e. with $dI_2 = 0$,

$= (h_{11}h_{22} - h_{12}h_{21})/h_{22}$ and

r_{22} = output resistance with input open-circuit to a.c., i.e. with $dI_1 = 0$,

$= 1/h_{22}$

It is seen at once that $r_i r_{22} = r_o r_{11}$.

In the same way, similar relations may be obtained for the other two configurations.

Thus, although you can measure *four* constants of the transistor, you only obtain three separate

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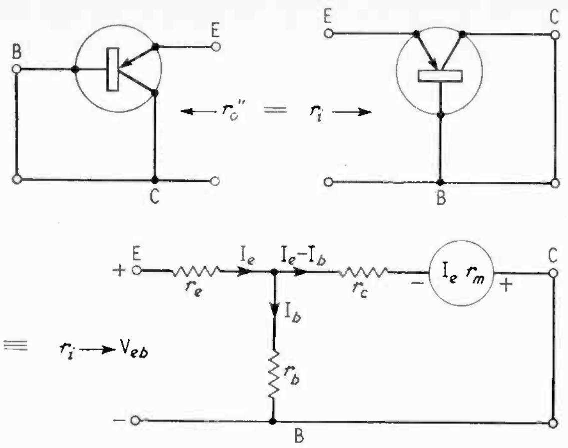


Fig. 15. Equivalent circuits of a transistor using Mullard and T-network parameters.

pieces of information about it; it is therefore necessary to measure one *other* property of the transistor, for instance the short-circuit current gain in the grounded-emitter configuration, h'_{21}.

Be that as it may, Mullard parameters are defined, and can be very easily related to the other sets of parameters. We limit ourselves to a derivation of only one of these relations to show the method:— r''_o in terms of the T-network parameters.

Fig. 15 gives the equivalent circuits, from which we have:—

$$V_{eb} = r_e I_e + r_b I_b = r_e I_e + r_c (I_e - I_b) - r_m I_e$$

Therefore

$$I_b = I_e(r_c - r_m)/(r_b + r_c)$$

Therefore

$$V_{eb} = I_e(r_e + r_b(r_c - r_m)/(r_b + r_c))$$

and so

$$V_{eb}/I_e = r_i = r_o'' = r_e + r_b(r_c - r_m)/(r_b + r_c)$$

We give a table of various parameters in terms of h'_{21} and the Mullard parameters for the grounded-emitter configuration, since the latter are those most easily measured:—

T-network Parameters

$r_b = [(1 + h'_{21})r'_{11} - r'_i]h'_{21}$, $r_c = (1 + h'_{21}) r'_{22}$, $r_e = (r'_i - r'_{11})/h'_{21}$ and $r_m = h'_{21}r'_{22} - (r_i' - r'_{11})/h'_{21}$

Grounded-Base Mullard Parameters

$1/r_i = (1 + h'_{21})/h'_{21}r'_o + (1 + h'_{21})/r'_i - 1/h'_{21}r'_{22}$, $r_o = r'_o$, $r_{11} = r'_{11}$ and $r_{22} = r'_o r'_{11} (1/r_i)$ (q.v.)

Grounded-Collector Mullard Parameters

$r_i'' = r_i$, $r_o'' = r_i$ (q.v.), $r''_{11} = r_{22}$ (q.v.) and $r''_{22} = r'_{22}$

Grounded-Base h-parameters

$h_{11} = r'_i(r'_{22}/r_{22})$ (q.v.), $h_{12} = 1 - (1 + h'_{21}) (r'_{22}/r_{22})$ (q.v.), $h_{21} = -(h'_{21} + (r'_i/r'_o)) (r'_{22}/r_{22})$ (q.v.) and $h_{22} = 1/r_{22}$ (q.v.)

Grounded-Emitter h-parameters

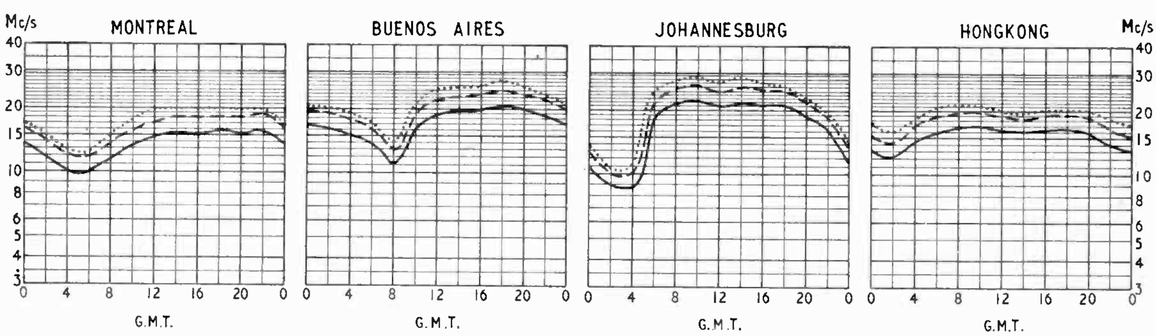
$h'_{11} = r'_i$, $h'_{12} = (r'_i - r'_{11})/h'_{21}r'_{22}$ and $h'_{22} = 1/r'_{22}$

Grounded-Collector h-parameters

$h''_{11} = r'_i$, $h''_{12} = 1 - h'_{12}$ (q.v.), $h''_{21} = -(1 + h'_{21})$ and $h''_{22} = 1/r'_{22}$

Conclusion.—The whole of this article has been written around the transistor and a number of approximations may therefore be made by reason of its nature. The treatment, however, has been quite general and is therefore equally applicable to any quasi-linear active four-terminal network.

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 MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

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WORLD OF WIRELESS

Stereo Broadcasting

ON April 20th the U.S. Federal Communications Commission authorized the introduction of f.m. multiplex stereo broadcasting from June 1st. The technical standards approved are a combination of proposals put forward by the Zenith Radio Corp. and General Electric. Other systems investigated by the American Electronic Industries Association at the request of the F.C.C. included those of Crosby Teletronics Corp., Multiplex Development Corp., Calbest Electronics Co. and also the E.M.I. Percival system (see *W.W.* November, 1958).

The approved system, which is fully compatible with single-channel f.m. broadcasting, is f.m./a.m. with the sub-carrier amplitude modulated.

New F.M. Stations

WORK is well advanced on the first two of the ten additional v.h.f. sound broadcasting stations announced by the B.B.C. in 1959. They both share sites with existing television stations—at Londonderry, Northern Ireland, and Les Platons, Jersey—and their directional aerials will be erected on the stations' television masts.

Both stations are planned to be brought into operation during this summer. The Londonderry station, which will have a mean e.r.p. of 5.6 kW, will radiate on 88.3 Mc/s (Light), 90.5 Mc/s (Third), and 92.7 Mc/s (Home). Les Platons, which will have a mean e.r.p. of 3.1 kW, will transmit on 91.1 Mc/s (Light), 94.45 Mc/s (Third), and 97.1 Mc/s (Home). At Les Platons the programmes will be received by radio from either the North Hessary Tor or Rowridge v.h.f. stations.

Technical Writing Scheme

MODIFICATIONS have been made to the Technical Writing Award Scheme which is now jointly sponsored by the Radio Industry Council, the Electronic Engineering Association and the Electronic Valve and Semi-Conductor Manufacturers' Association. In future the number of annual awards will be increased from six to eight and their value increased from 25 to 30 guineas each. Also some of them will be awarded for purely technical articles in addition to those made for articles of "commercial or interpretative merit."

The judges for 1961 will be H. E. F. Taylor (E.E.A.), who is chairman, B. C. Brookes (University College, London), A. H. Cooper (E.M.I.), F. Jeffery (Murphy), Professor C. W. Oatley (Cambridge University), G. Reeves (A.E.I.), and Dr. R. C. G. Williams (Philips).

Band V Colour

COLOUR transmissions on 625 lines are to be radiated experimentally in Band V by the B.B.C. from the Crystal Palace station. E.M.I. Electronics are carrying out the necessary modifications to the 10-kW transmitter which was used for the 405- and 625-line monochrome test transmissions in Band V during 1957 and 1958. No date has yet been announced for these transmissions nor has it been stated whether the sense of vision modulation will be positive or negative or if a.m. or f.m. will be used for sound. It is understood that an 8 Mc/s bandwidth will be employed.

The P.M.G., in reply to a question in the House on May 10th, reiterated his decision not to accede to the request of the B.B.C. for a limited service of colour television on 405 lines.

U.H.F. Television in Germany

WEST GERMANY'S first regular u.h.f. television service was inaugurated by Hesse Radio, Frankfurt, on May 1st. Other West German broadcasting organizations are planning to start u.h.f. services in June. Hesse Radio is using some of the 30 u.h.f. stations set up by the Government in preparation for the start of the "Adenauer" network, which, it will be remembered, was finally banned by a decision of the Federal Court earlier in the year.

A second programme is being introduced by each of the broadcasting organizations on u.h.f., but it is planned to combine their operations from June 1962 into a network with a proportion of local programmes.

Italy's second TV service is scheduled to come into operation at the beginning of November. It will be operated by the national broadcasting organization—Radiotelevisione Italiana (RAI)—whose present TV network totals nearly 400 stations, the majority of which are low-power relay transmitters. About 20% of last year's income of RAI was from advertising which is carried on by both the sound and television services.

Dual TV Standards.—France, which has used the 819-line standard for its television service since 1950, is introducing the 625-line standard for its second service scheduled to start in June next year in the Paris region. Stations will operate in Band IV (470-582 Mc/s).

Plastics Exhibition.—Over 350 U.K. and overseas manufacturers of plastics materials, finished products and machinery will be exhibiting at the biennial International Plastics Exhibition which opens at Olympia, London, on June 21st for 10 days. A three-day convention (June 26th-28th) is being held in conjunction with the Exhibition and admission to both is by ticket obtainable free from *British Plastics* (Dorset House, Stamford Street, London, S.E.1), which, with the co-operation of the British Plastics Federation, is organizing the show.

Berlin Radio Show.—The German national radio and television show is to be held for the first time for 22 years in Berlin from August 25th to September 3rd. There will be 150 exhibitors in the 13 halls in the exhibition grounds at the Funkturm in West Berlin. The Federal Post Office is issuing a special 20-pfennig stamp to mark the occasion.

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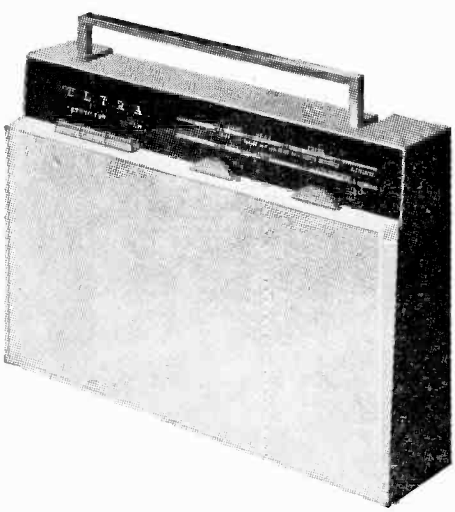
B.R.E.M.A. Council.—The new council of the British Radio Equipment Manufacturers' Association consists of the following firms, whose representatives' names are in parentheses:—A. J. Balcombe (E. K. Balcombe), British Radio Corporation (F. W. Perks), Bush Radio (G. Darnley-Smith), Ferguson Radio Corporation (S. T. Holmes), General Electric Co. (M. M. Macqueen), Kolster-Brandes (E. P. Wethey), Murphy Radio (A. P. Power), Perdio (Viscount Suirdale), Philips Electrical (A. L. Sutherland), Radio and Allied Industries (R. H. Pengelly), Rediffusion Vision Service (M. Exwood), and Ultra Radio and Television (E. E. Rosen). A. L. Sutherland is again chairman of the association.

British Wireless Dinner Club.—At the 38th annual dinner of the Club on April 14th Air Marshal Sir Leslie Dalton-Morris, was elected president in succession to Admiral Sir Alan Scott-Moncrieff. Sir Leslie was Air Officer C.-in-C., Signals Command R.A.F. until his appointment earlier this year to the Maintenance Command. The new vice-president of the Club is Major-General L. de M. Thuillier, who headed the U.K. team which towards the end of last year visited the U.S.A. for discussions on the use of earth satellites for communications systems. The joint honorary secretaries of the Club are Capt. F. J. Wylie, director of the Marine Radio Advisory Service, and L. T. Hinton, of Standard Telephones and Cables.

B.E.A.M.A.—An Industrial Electronic Equipment Section has been formed by the British Electrical and Allied Manufacturers' Association. In addition to the day-to-day work relating to technical matters, standardization, exports, and statistics, the section is intended also to "provide a means of closer discussions with other associations and help towards the wider examination of general policy questions affecting the industrial electronics industry as a whole." W. Gregson, of Ferranti, has been elected chairman, and R. J. F. Howard, of Metal Industries, is vice-chairman. A. Newton has been appointed secretary.

Society of Relay Engineers.—R. I. Kinross, managing director of Rediffusion Research, Ltd., has been re-elected president of the Society of Relay Engineers, and R. P. Gabriel, chief engineer of Rediffusion, Ltd., re-elected vice-president. The secretary of the society is T. H. Hall, Obelisk House, Finedon, Northants.



ELEGANCE.—The Ultra TR70 transistor portable which was selected by the Council of Industrial Design for the Duke of Edinburgh's Award for Elegant Design. It employs seven transistors and two crystal diodes (one of which provides additional a.g.c.) and covers both m.w. and l.w. bands. The dimensions are 12 x $8\frac{1}{4}$ x 3 in.

Television Society Council.—At the annual general meeting of the Television Society on April 27th the following were elected to fill the vacancies on the council:—B. Eastwood (A.E.I.), I. J. P. James (E.M.I.), C. A. Marshall (*British Communications and Electronics*) and Dr. R. D. A. Maurice (B.B.C.). Three new vice-presidents were elected. They are Sir Willis Jackson, Dr. R. L. Smith-Rose and P. H. Spagnoletti.

R.E.C.M.F.—John Clark (Plessey Company) has been elected vice-chairman of the Radio and Electronic Component Manufacturers' Federation, in succession to Dr. G. A. V. Sowter (Telcon Metals) who, as announced last month, is now chairman.

Stockholm R.E.C.M.F. Show.—The date of the fourth British Components Show to be held in Stockholm should be added to the list of exhibitions on page 337. Organized by the Radio and Electronic Component Manufacturers' Federation it will be held from October 9th to 13th.

Milan.—Another addition should be made to the list of exhibitions on page 337. It is the date of the Milan Radio Show which will be held from September 10th to 17th.

Baird Memorial Lecture.—Professor Martin Ryle, Professor of Radio-Astronomy at Cambridge University, is to deliver the second Baird Memorial Lecture at the Royal College of Science and Technology, Glasgow, on June 7th. His lecture is entitled "Exploring the Universe with Radio Waves."

Industrial Electronics.—C. Metcalfe, of E.M.I., who is chairman of the Electronic Forum for Industry, will be one of the speakers at the Industrial Electronics Symposium in Boston on September 20th and 21st.

CLUB NEWS

Barnet.—At the May 30th meeting of the Barnet and District Radio Club V. A. Frisbee (G3KVF) will talk about mobile equipment. On June 27th T. H. A. Withers (G3HGE) will deal with v.h.f. equipment. Meetings are held at 8.0 at the Red Lion Hotel, Barnet.

Bexleyheath.—The North Kent Radio Society will be operating the club transmitter (G3ENT/A) at the Careers Exhibition being held in the Crayford Town Hall in connection with the Commonwealth Technical Training Week (May 29th-June 3rd). It will be using telephony on all bands but mainly on 1.8 and 7 Mc/s.

Birmingham.—"Transistors" is the title of the talk to be given by N. B. Simmonds to the Slade Radio Society on June 16th at 7.45 at Church House, High Street, Erdington.

East London.—Short-wave listeners in the London districts of East Ham, Manor Park, Ilford and Barking are invited to join the East Ham Group of the Radio Society of Great Britain. Details of activities are obtainable from J. Brown (G3DBO), 19, Compton Avenue, London, E.6.

Halifax.—The Halifax and District Amateur Radio Society now meets at the Beehive and Crosskeys Inn at 7.45 on alternate Tuesdays. The June meetings are on the 6th and 20th. The town's second radio club has recently been formed and is known as the Northern Heights Amateur Radio Society. It meets on alternate Wednesdays at 7.45 at the Sportsman Inn, Ogden.

Harlow.—A mobile rally is being organized by the Harlow and District Radio Society for June 11th. It will be held at Magdalen Laver, near Harlow, Essex. There will be two "talk-in" stations—G3ERN on 160 m and G3JMA on 2 m.

Sheffield Amateur Radio Club meets on the 2nd and 4th Wednesday of each month at 7.45 at the Dog and Partridge, Trippett Lane. Details of forthcoming meetings are available from D. R. A. Hill, 16 Tylney Road, Sheffield, 2.

Warminster.—On June 25th the City and County of Bristol Group of the R.S.G.B. is holding a mobile rally at Longleat House, near Warminster, Wiltshire. The control stations will operate on 1.9 Mc/s (G3CHW/A) and 144.15 Mc/s (G3GYQ/A). Particulars from C. N. Chapman (G2HDR), "Yeovil," Stoke Hill, Stoke Bishop, Bristol, 9.

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Personalities

Sir Harold Roxbee Cox, D.Sc., Ph.D., D.I.C., who is 58, has been appointed chairman of the Council for Scientific and Industrial Research for five years from October 1st. He will succeed **Sir Harry Jephcott,** who has been chairman of the Council since its formation in 1956. Sir Harold has been a member of the Council since 1957. He spent over twenty years in the Government service prior to 1954 when he became associated with a number of industrial companies. He is chairman of the National Council for Technological Awards, and vice-chairman of the Governors of the College of Aeronautics.

W. J. Richards, C.B., C.B.E., director of the Royal Radar Establishment, Malvern, since 1953, has been appointed director of the proposed new Staff College for Further Education. He will take up his new appointment in July. The aim of the College, premises for which have yet to be found, is to create a "national centre at which principals and other selected staff from colleges of technology and commerce can exchange ideas and experience with senior staff from industry, local and central government, the universities and overseas and where they can jointly study the aims, ideas and the growth of education in the light of the rapid advances in science and technology." Mr. Richards, who is 57, graduated in engineering with first-class honours from Manchester University. After spending some years in research and development work at the R.A.E., Farnborough, he became deputy director of scientific research at the Ministry of Aircraft Production in 1942. During his tenure of office at R.R.E. he has established the College of Electronics.

W. J. Richards

Dr. R. A. Bones

Roger A. Bones, B.Sc., Ph.D., A.Inst.P., has joined Wayne Kerr Laboratories as head of the company's contracts division. After graduating at London University in 1949 with first-class honours in physics and mathematics, Dr. Bones studied X-ray crystallography at University College, London. After a period with the Foreign Office, where he was concerned with electronics and telecommunications research, he lectured at Hong Kong University for three years, later becoming an industrial adviser to the Federal Ministry of Commerce and Industries in Nigeria. Immediately prior to joining Wayne Kerr, Dr. Bones was with the de Havilland Aircraft Company.

D. J. Cole, B.A., LL.B., son of the founder and present chairman of E. K. Cole, Ltd., has been appointed to the board of directors. He joined the company in 1954.

R. Wrathall, formerly radio and television sales manager of E. K. Cole Ltd., has been appointed director and general manager of Ekco Radio and Television Ltd., which has been formed to control the marketing of all Ekco television and radio receivers, car radio and allied

R. Wrathall

R. A. Drummond

products. **W. M. York** is chairman of the board of directors. Three additional directors have been appointed to the board of the associated company Ferranti Radio & Television Ltd. **R. A. Drummond,** who has been with the Ekco Group for nearly 30 years and has been sales manager of Ferranti Radio and Television Ltd. since its formation four years ago, has become director and general manager. The other new directors are **N. T. Atkinson** and **A. C. Segger,** who have also joined the board of Ekco Radio & Television.

J. W. Soulsby has been re-elected chairman of the Radio Officers' Union for his seventh consecutive term of office. Born in 1900, he joined Marconi's in 1918, and is at present Chief Radio Officer in the British India Steam Navigation Company's *Uganda*. The new vice-chairman of the Union is **J. G. Salveson,** who is a radio officer with British European Airways, which he joined soon after demobilization from the R.A.F. in 1946. He is 41.

K. J. H. Adams, recently appointed production manager of the semiconductor division of Brush Crystal Company, Hythe, Southampton, was formerly senior production engineer at Semiconductors Ltd. After graduating with honours in physics at London University in 1951, he joined Mullard Radio Valve Company as a development engineer working on problems associated with repeater valves. In 1953 he left the company but returned the following year to head the department handling its guided missile valve project. He joined Semiconductors in 1959.

J. W. C. Robinson, M.B.E., managing director of Relay Exchanges Ltd., has been appointed chairman of the company in succession to the late **Sir Walter J. Womersley,** Bart. Mr. Robinson is also joint managing director of Goodmans Industries, which was acquired by Relay Exchanges in 1958.

E. G. Westray has retired after 49 years' service with Ericsson where, since 1946, he has been export sales manager. Mr. Westray, who was for many years in the company's laboratories, was throughout the last war Ericsson's liaison officer to the Ministries.

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F. A. Vick, O.B.E., Ph.D., who was appointed director of the Atomic Energy Research Establishment at Harwell last September, has also been appointed director of the Research Group of the U.K. Atomic Energy Authority. Dr. Vick, who is 49, was Professor of Physics in the University of North Staffordshire from 1950 until 1959 when he joined the A.E.R.E. as deputy director. Prior to that he was for five years on the staff of Manchester University and throughout the war was Assistant Director of Scientific Research in the Ministry of Supply.

Air Commodore John C. Millar, D.S.O., the new commandant of the R.A.F. Central Signals Establishment, was formerly Director of Flight Safety at the Air Ministry. Air Commodore Millar, who is 47 and was educated at Trinity College, Cambridge, was Chief Signals Officer at R.A.F. Bomber Command in 1954.

Colin H. Gardner, manager of the Mullard Films and Lectures Organization for the past eight years, has retired after thirty-two years' service with the company. He will continue to act in an advisory capacity to the organization. He has been succeeded by **P. I. Nicholson,** M.Brit.I.R.E., who joined the company in 1950 and for the past two years has been deputy manager of the Films and Lectures Organization.

Arthur L. Budlong (W1BUD), secretary and general manager of the American Radio Relay League, and editor of *QST*, has retired and is succeeded by **John Huntoon** (W1LVQ). "Bud," as he is affectionately known in amateur circles, is also secretary to the International Amateur Radio Union. He has been on the staff of the A.R.R.L. for 37 years.

Peter Rushen, who writes in this issue on leakage in printed circuits, has been with Bush Radio since 1946, except for a two-year break when he was with English Electric. Whilst at English Electric he worked on the Thunderbird ground-to-air missile. He is at present engaged in the development of export television receivers.

Graham Miller, B.Sc., has been appointed home sales manager of Wayne Kerr Laboratories, which he joined two years ago. He studied electronics at Manchester College of Technology and was a graduate in physics at Swansea University. He subsequently became a circuit design engineer and spent two years as head of the Ferranti Standards Laboratory at Wythenshawe.

G. Miller *H. G. Hinckley*

H. G. Hinckley has been appointed manager of the Machine Tool Control Department of Ferranti, Ltd., Edinburgh, in place of **D. T. N. Williamson,** manager of the department since its inception in 1952. Mr. Hinckley, who is 40, served with T.R.E. and British European Airways before joining Ferranti in 1948. Mr. Williamson, who has joined Molins Machine Co., as director of research and development, will be remembered as the designer of the amplifier bearing his name which he described in *Wireless World* in 1947.

Brian M. Lee, who a few months ago was appointed manager of the Industrial Division of Belling & Lee Ltd., has become a member of the board of executive directors.

News from Industry

British Space Development Company, which, as announced in our March issue, has been formed by a consortium of companies, has appointed Sir Robert Renwick as chairman and the following have been elected to the board: J. R. Brinkley (Pye), Grp. Capt. E. Fennessy (Decca Radar), G. C. I. Gardiner (Hawker Siddeley Aviation), A. A. Rubbra (Rolls-Royce) and Grp. Capt. D. Saward (Rank Organization). The following companies, together with those already mentioned, are founder members: A.E.I., Associated Television, B.I. Callender's Cables and Plessey. A technical committee has been set up "to examine and prepare plans designed to achieve British participation" in the future utilization of "space." The members of the Technical Committee, of which G. K. C. Pardoe is chairman, are: D. E. Burchett (A.E.I.), A. V. Cleaver (Rolls-Royce), J. M. C. Dukes (Plessey), Dr. W. F. Hilton (Hawker Siddeley), W. M. Lloyd (Rank), L. F. Mathews (A.T.V.), Dr. K. Milne (Decca Radar), T. P. Blott (Pye) and G. A. Dodd (B.I.C.C.).

Vactric.—The News of the World Organisation Ltd., has purchased the whole of the issued share capital of Vactric (Control Equipment) Ltd., and Vactric (Precision Tools) Ltd., from the receiver of Vactric Ltd. (in liquidation). New boards will be formed with Sir William Carr as chairman, and the present managing director, T. W. Roberts, continuing in that capacity.

G.E.C.-Sobell-McMichael.—The merger between the General Electric Company and Radio & Allied (Holdings) has now been completed and M. Sobell, chairman of R. & A., and A. Weinstock, the managing director, have joined the board of G.E.C. Lord Coleraine has also joined the board and Sir Toby Low has been elected vice-chairman. The object of the merger is to "strengthen the operations of the two companies in the radio and television field and in domestic appliances." Each company will continue to market its own range of receivers and to this end a new G.E.C. company, G.E.C. (Radio & Television) Ltd., has been formed. The headquarters are at Langley Park, Slough (Tel.: Slough 22201). The service department is at Lena Gardens, London, W.6 (Tel.: Riverside 4671).

Relay Exchanges Ltd. announce a group trading profit for 1960 of £3,949,892 which is almost £600,000 above the 1959 figure. After deducting £2,747,397 for depreciation and further sums for taxation, the net group profit was £1,024,825.

Elliott-Automation.—Preliminary figures for 1960 issued by Elliott-Automation Ltd., show a group profit before taxation of £1,776,510 compared with £1,015,630 the year before. The recently acquired Rheostat Company Group contributed £520,648 towards the 1960 total.

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Ultra have entered into two agreements with companies in the western hemisphere. Ultra Electronics has signed an agreement with Electronics Investment Management Corp., of the U.S.A., for the interchange of information on research, development, marketing and production of electronic equipment. The corporation is associated with a number of companies both in the U.S.A. and outside to which it renders advisory and consulting services. The parent company Ultra Electric (Holdings) has entered into an agreement with Electronics International Capital Ltd., of Bermuda, whereby E.I.C. has purchased 40% of the shares of Ultra Electronics Ltd. for a sum of £800,000. Electronics International Capital Ltd. has, in addition, agreed to make available five-year loan facilities up to a total of £950,000.

B.S.R. announce record production and sales of all their products in 1960 resulting in a group net profit of £860,452 after deducting £666,124 for tax. The net profit was some £73,000 up on 1959. The group recently purchased for cash majority shareholdings in two companies, Tape Heads Ltd. (formerly Bradmatic Productions Ltd.), of Birmingham, and P. A. Marriott & Company Ltd., of Wembley, Middlesex. The managing directors of these two companies—G. Littlewood and P. A. Marriott, respectively—will continue in office.

Southern Areas Electric Corp., of which Ross, Courtney & Co. is a subsidiary, record a profit for 1960 of £47,782 (after taxation) which was £4,000 above the 1959 figure.

Plessey-Mallory.—Under an agreement with P. R. Mallory and Company Inc., the Plessey Company is now manufacturing a range of solid electrolyte tantalum capacitors. Chief features of the new capacitors are stability of capacitance with changes of temperature, and the ability to operate at extremely low temperatures down to −80°C without loss of performance. The range of capacitance values available is 0.33 to 330 microfarad at d.c. working voltages of 35 to 6.

Bach-Simpson Company, instrument manufacturers of London, Ontario, have appointed Aveley Electric Ltd., of South Ockendon, Essex, as their sole U.K. agents.

Marconi's W.T. Company has acquired the Wembley factory of E.M.I. Electronics Ltd. as a staffed and equipped working entity. The factory is approximately 85,000 sq ft and at present employs between 400-500 people.

Cossor Radar & Electronics.—As a result of severe damage by fire to its Servicing Department at West Norwood, Cossor Radar and Electronics have transferred the department to Edinburgh Place, Temple Fields, Harlow, Essex (Tel.: Harlow 25537).

Western Electric Company, manufacturing and supply unit of the Bell Telephone System, of the United States, has charged Transitron Electronic Corp., of Wakefield, Mass., with infringement of five separate Bell System U.S. Patents relating to semiconductor devices such as transistors and silicon diodes.

Aveley.—The recently formed Components Division of Aveley Electric Ltd. is holding an exhibition of its products in the Grill Foyer of the Kensington Palace Hotel, London, W.8, from May 30th to June 2nd.

Perth Radios Manufacturing Ltd., which was formed in 1953 by Mohamed Hussain Ismail, has gone into liquidation. Since 1957 the company has been operating from Marten House, 39-47 East Road, London, N.1. The liquidator is A. J. Cooke, 9 Basinghall Street, London, E.C.2.

CQ Audio, formerly R.G.A. Sound Services, of 111 Cecil Road, Enfield, Middx., have gone into liquidation.

C.R.T. Servicing.—Facilities for the servicing of Ediswan Mazda cathode-ray tubes, formerly available at A.E.I. Radio and Electronic Components Division's service department at Brimsdown, Middx., have been moved to the division's factory at Ducklees Lane, Ponders End, Middx. Bulbs for salvage under A.E.I.'s reclamation scheme should be returned to the same address.

EXPORTS

B.E.A.M.A. will hold a two-day export conference on October 5th and 6th. The opening speaker will be the Rt. Hon. Reginald Maudling, President of the Board of Trade.

Marconi Instruments' mobile demonstration unit is now on a 3,000-mile tour of Germany and Scandinavia. The vehicle houses over 30 electronic measuring instruments.

New Zealand.—Le Quesne Electronics Ltd., of 3, Faraday Street, Napier, New Zealand, wish to represent British radio and electronic equipment and component manufacturers.

Swedish Agents.—Telequipment have appointed their Swedish agents Magnetic AB, Stora Ny Gatan, Stockholm 3.

New Zealand Agents.—Telemechanics Ltd., of Southampton, have appointed Electronic Development and Applications Ltd., P.O. Box 1905, Auckland, C.1, as their agents in New Zealand.

Portuguese Agents.—Telemechanics have appointed Rualdo Lda., Rua S. Jose 15-1, Lisbon 2, Portugal, as their agents.

BRITISH TRADE FAIR MOSCOW

THE radio and electronics industry is well represented among the 600 or more companies participating in the first British Trade Fair to be held in Moscow which opened on May 19th for a fortnight. The following companies and research establishments are among the exhibitors in the fourteen sections, one of which is devoted to electrical equipment (which includes radio and television consumer and capital goods and electronic equipment) and another to scientific instruments.

This fair will be followed in July by a reciprocal Soviet Trade and Industrial Exhibition to be held at Earls Court, London. Both exhibitions are sponsored jointly by the Association of British Chambers of Commerce and the All-Union Chamber of Commerce of the U.S.S.R.

Advance Components
Associated Electrical Industries
Automatic Telephone & Electric Co.
Avo
Blackburn Electronics
Board of Trade
British Ferrograph Recorder Co.
Brush Electrical Engineering Co.
Cambridge Instrument Co.
Casella (Electronics)
Cossor Instruments
Crompton Parkinson
Dawe Instruments
E.M.I. Electronics
Electronic Instruments
Elliott Automation Group
Endecotts (Filters)
English Electric
English Electric Valve Co.
Faraday
Fleming Radio (Developments)
G. B. Kalee
Goodmans Industries
Griffin & George
Kelvin & Hughes
Labgear
Lancashire Dynamo Holdings
Langham Thompson, J.
Marconi Instruments
Marconi International Marine
Marconi's Wireless Telegraph Co.
Mullard Equipment
Napier, D., & Son
Pye
Pye T.V.T.
Pye Telecommunications
Pye, W. G., & Co.
Rank Cintel
Savage, Bryan
Scientific Instrument Manufacturers Assoc.
Solartron Electronic Group
Standard Telephones & Cables
Taylor, Taylor & Hobson
Telequipment
Thermionic Products (Electronics)
Ultra Electronics
Wayne Kerr Laboratories

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Reliable Circuit Designs

REDUCTION OF DEPENDENCE ON VALVE CHARACTERISTICS

By B. PRIESTLEY

THE object of this article is to suggest some general pointers to good design procedures which can be used to produce a required standard of performance in most circuits. Electronic circuit design is not a black art, giving unpredictable results, but a logical science capable of producing reliable and stable performance. By reliability is meant stability in the face of variations both in circuit components, due to tolerances, ageing and temperature, and in external supplies.

The extent to which good design can help reliability does not always seem to be realized. This may be due to many textbooks giving explanations of how a particular circuit works, once constructed, but no explicit design information.

Circuits which depend on ill-defined parameters should be avoided. Thus, for example, one can design a blocking oscillator for a specific pulse width, but with no great accuracy. If an accurate pulse width is required it is preferable to define it with a delay line.

The effects of supply voltage variations and component tolerances are calculable and should be evaluated in all cases where high reliability is required. This, of course, does not reduce the effects of variations, but calls attention to the variation in performance to be expected and may spotlight defects such as working with unequal safety margins for under- and over-voltage, or decide between two apparently equally suitable circuits.

Some components, particularly valves and transistors, have parameters which are subject to wide tolerances, made wider by variations due to age and temperature respectively. While more information on the form of variation to be expected would be welcome, much can be done by the application of negative feed-back and similar techniques to make the operating conditions largely independent of valve and transistor parameters.

In order to illustrate the above points, two similar cathode-coupled monostable multivibrator circuits are discussed in detail. Both are practical circuits but one is much more dependent on valve parameters.

The anode voltage/anode current curves used in the designs have 130% and 50% of nominal anode current curves added at each relevant value of grid potential, Fig. 1. These are dotted and broken lines, respectively, and are intended to take account of initial high emission and deterioration with life.

Consider first in Fig. 2 the reliability of the multivibrator's stable state (V_2 conducting V_1 off). In circuit (1) V_2 anode current is controlled by the flow of grid current through R. Thus, without positive-grid data, accurate design is impossible. However, experience indicates that with R in the region of 1MΩ the grid/cathode potential will be about 0V. Referring to the load line of slope (RL_2 + Rk), the anode current is a nominal 12.8 mA with limits of 14 and 9.5 mA.

Now examine the circuit in Fig. 3. The grid is clamped at −40V, and since Rk is much greater than 1/gm the cathode will "follow" the grid fairly closely; hence the anode current will be about

40 volts ÷ 4700 ohms = 8.5 mA.

Note that this can be calculated with only a very rough idea of the valve characteristics, thus variations in these characteristics are not going to affect the result greatly. More accurate design using the same characteristics gives a nominal 8.85 mA with limits of 8.95 and 8.65 mA. The method of calcu-

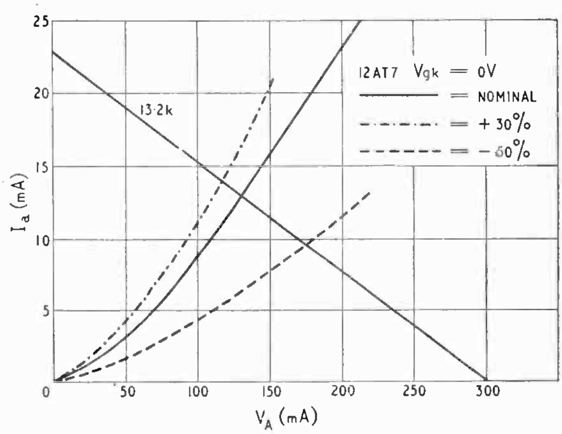

Fig. 1. In the absence of grid-clamping, anode current is seen to vary between 14mA and 9.5mA.

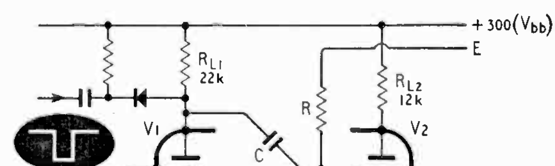

Fig. 2. In this cathode-coupled multivibrator, V2 anode-current is controlled by an unspecified grid-current in R. Accurate design is, therefore, impossible.

lation is given in appendix (1). This considerable improvement illustrates the extent to which tolerances can be designed out by letting the external circuit define the current.

Unfortunately, a price must be paid for this gain. It will be seen that the current in circuit (2) is less but it would appear that by clamping the grid to a higher potential, more current could be passed. However, this is not so. In the low-emission case considered the anode current was 8.6 mA, implying a cathode potential of 8.655 × 4.7 = 40.5V. Thus the grid/cathode potential would be −0.5V, already at the edge of grid current, so that any increase in grid potential would result in grid current, reducing the accuracy with which the cathode " follows " the grid. If more current is required either more h.t. is needed or the user must accept a shorter valve life.

This reduction in performance is the normal consequence of negative feedback, but in most cases is not too high a price to pay for the simplification in design which has been almost reduced to a problem in Ohms Law. It may be objected that another variable — the clamping-potential tolerance — has been introduced, but the effects of this variable are more easily calculated, and its magnitude more easily controlled than valve tolerances.

Stabilization of the clamping potential may seem attractive, but if this is done, then any variations in the h.t. supply are reflected in full at V_2 anode, since this valve passes a constant current. Also considerable dependence of pulse width upon h.t. is introduced by stabilization. Consideration of the expression for pulse width:—

$$\tau \simeq CR \log_e \left(\frac{E + V - Vk_2}{E + Vco - Vk_1}\right) \quad \ldots \quad \ldots \quad (1)$$

shows that if all the terms in the bracket are allowed to vary together there is no change in τ, but obviously this is not so if Vk_1 and Vk_2 are fixed. Thus the best procedure is to derive all potentials from the same h.t. rail which may be stabilized if necessary.

Also in the second circuit the current in the quasi-stable state is fixed at approximately 20V ÷ 4.7kΩ = 4.3 mA in the same way as in the stable state. Consequently, the value of V is given by 10kΩ × 4.3 mA within similar limits. In circuit (2) the magnitude of V has deliberately been kept low so that for a given pulse width the logarithmic term of expression (1) is less than in circuit (1), and C may be increased to compensate giving less dependence on stray capacities. These two points give

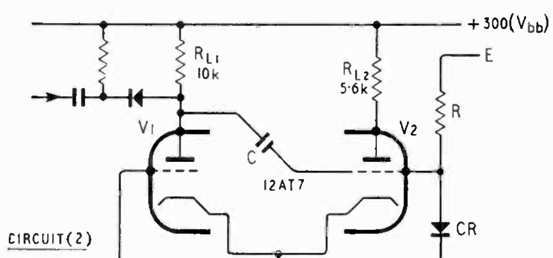

Fig. 3. This is a similar circuit to that in Fig. 2, but in this case, grid-current does not flow, and V2 anode current can be accurately determined.

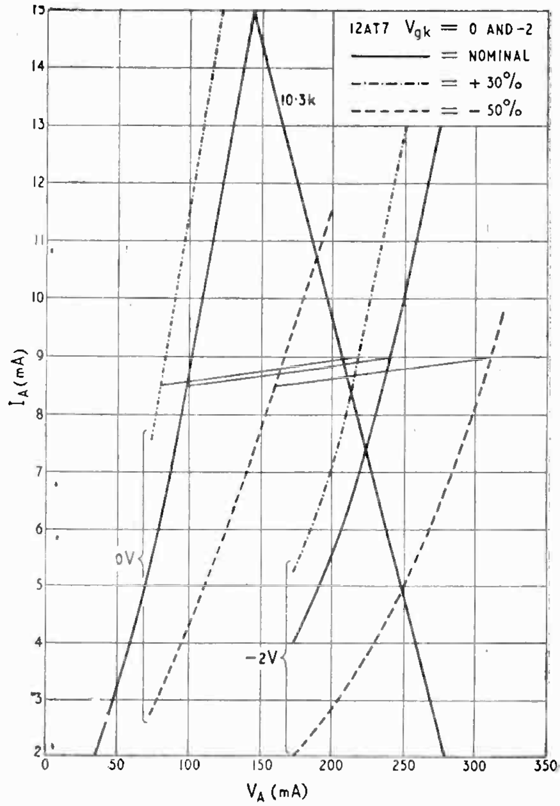

Fig. 4. Negative-feedback and grid-clamping greatly reduce anode current variations. Only a small portion of the curves are shown, in order to show the three " bias lines."

greater control of the pulse width in the second circuit.

It will also be clear that in circuit (1), R must be high to prevent excessive grid dissipation, without being so large as to give trouble due to negative grid current. In circuit (2), however, the limitations are solely the rating of CR1 and the internal impedance of the clamping voltage. Thus in circuit (2) it is possible to vary the pulse width by variation in R, giving a linear relation, but in circuit (1) E must be varied, giving a non-linear relation.

Enough should have been said to demonstrate that these two circuits, though identical in operation, differ considerably in " designability." Circuit (1) will always show wide variation in performance even when close tolerance components are used. Circuit (2), however, will repay the use of such components, as the variations in performance will be corresponding and simply-calculable, In fact it can be designed on paper with a high degree of accuracy. If the effects of all valve, component and voltage tolerances are calculated the procedure, though simple, becomes a little tedious, even when common sense is used to pick the extreme combinations, but this does save having to "frig" a design at the production stage.

APPENDIX I

Calculation of D.C. level in circuit (2)

If Vgk = 0V then Vk = 40V as Vg_2 is clamped at +40. Thus Ia = Vk/Rk = 40/4.7 = 8.5 mA and this point is plotted on the Vgk = 0 curve, in Fig. 4.

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Similarly if Vgk = −2V then Vk=42V and so Ia = 42/4.7 = 8.9 mA and this point is plotted on the −2V curve.

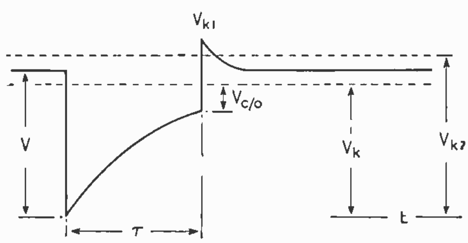
The " bias line " defined by these points cuts the load line at the actual working point. In theory several points are needed to define the bias line as this is not exactly straight, but the error is very small.

By repeating this procedure on the +30% and −50% sets of curves, the consequential variation in D.C. level can be calculated.

APPENDIX II

Calculation of Pulse Width.

Vk_2 — Cathode potential in stable state.
Vk_1 — Cathode potential in quasi-stable state.
V — drop in potential at V_1 anode.
$V_{c/o}$ — cut off bias of V_2
E — aiming potential of V_2 grid.
R′ — $R + [R_{L1} R_{D1} \div (R_{L1} + R_{D1})]$
R_{D1} — D.C. resistance of V_1.
— $\frac{(Vbb - V).Rk}{Vk_1}$



Grid 2 potential rises from (Vk_2—V) toward E with a time constant CR′. Changeover occurs terminating the pulse when the grid rises to $Vk_1 - V_{c/o}$.

i.e. $e_g = E - (E + V - Vk_2)\,e^{-\frac{t}{CR'}}$
at $t = \tau$
$e_g = Vk_1 - V_{c/o}$

$$\therefore \frac{E + V_{c/o} - Vk_1}{E + V - Vk_2} = e^{-\frac{\tau}{CR'}}$$

$$\therefore \log_e \left\{\frac{E + V_{c/o} - Vk_1}{E + V - Vk_2}\right\} = \frac{-\tau}{CR'}$$

$$\therefore \quad \tau = CR' \log_e \left\{\frac{E + V - Vk_2}{E + V_{c/o} - Vk_1}\right\}$$

X-ray Image Amplifier

MUCH effort has been directed, in recent years, towards the improvement in sensitivity of X-ray fluoroscopy equipment. Reduction of the X-ray dose incurred by the patient and greater flexibility of operation have been two of the chief aims. By the introduction of the Marconi Instruments 12-inch Image Amplifier, many former obstacles to the wider adoption of fluoroscopy in diagnosis and treatment have been removed.

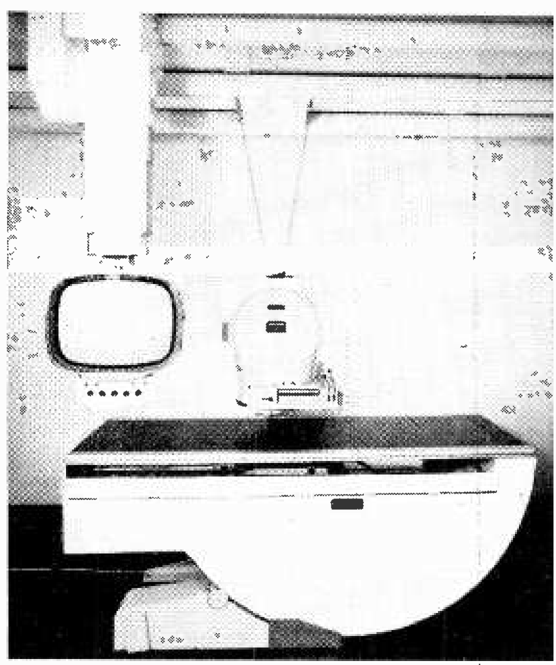
Formerly, the light from the fluorescent screen was viewed at the output of an optical system. The disadvantages were that the image was of very low density and that the radiologist, who must be dark-adapted, was obliged to devote a large proportion of his attention to the purely mechanical business of operating the equipment.

In the Marconi system, amplification of the image produced on the fluorescent screen is accomplished electronically and the image is viewed on a high-definition television-style monitor. The X-ray shadow image is produced on a 12-inch diameter fluorescent screen and focused by a Schmidt optical system on to the photocathode of a specially developed 4½-inch image orthicon camera tube. The output is fed, via a low-noise head amplifier situated near the camera tube, to a high-gain video amplifier of 10Mc/s bandwidth. It is possible to vary the proportion of the image which is focused on to the target of the camera tube, thereby enabling the operator to control the magnification, while giving greater definition, as the number of lines per unit area of the original image is effectively increased.

The picture on the 17-inch monitor tube is of 1024-line, triple-interlace standard with a horizontal resolution of 10Mc/s. Cine-recording is provided for and a system known as target-pulsing is employed. With this in operation, alternate fields are stored on the orthicon target, which results in the scan producing twice the normal signal amplitude at half the frequency. The pull-down time of the cine film is thereby not wasted, and during film exposure the picture is twice the normal brightness, which permits the use of fine-grain, slow-speed film. The full potentialities of 1000-line working are realized, with no trouble from faulty or critical interlace; time-base synchronizing pulses are not mixed with the video signal, as in a television system, but are fed separately.

The video signal polarity may be inverted when copies are required, eliminating the necessity for photographic reversal. It is also possible to reverse the scanning direction, a procedure which is of advantage when the radiologist finds it convenient to reverse the patient on the table.

The most important features of this equipment are the brilliance and convenience of the display, allowing the radiologist to work with no distraction and necessitating no dark-adaptation. The X-ray dose to the patient and, indeed, to the radiologist, is greatly reduced, and several people may view the monitor simultaneously, remotely if necessary.



The 12-in Image Amplifier. The unit containing the optical system and orthicon camera tube is over the centre of the table. The X-ray tube is situated underneath.

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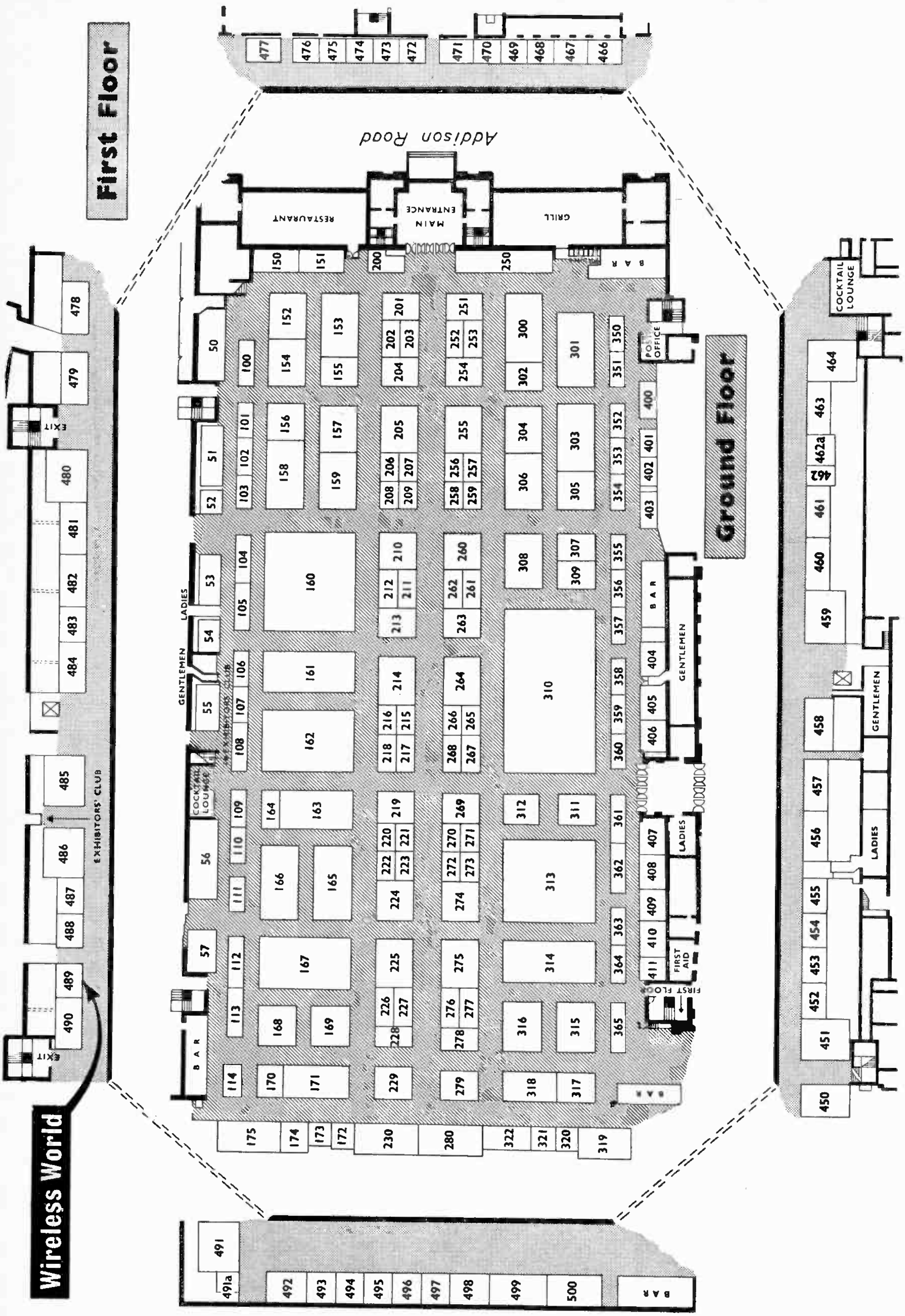
First Floor
Ground Floor
Addison Road
Wireless World
MAIN ENTRANCE
RESTAURANT
GRILL
BAR
POST OFFICE
COCKTAIL LOUNGE
EXHIBITORS' CLUB
GENTLEMEN
LADIES
FIRST AID
FIRST FLOOR
EXIT

RADIO AND ELECTRONIC COMPONENTS SHOW

Olympia, London, 30th May – 2nd June

ON May 30th the Components Show, sponsored by the Radio and Electronic Component Manufacturers' Federation, opens for four days. This show, which for 16 consecutive years was held at Grosvenor House, is for the first time to be in the Grand Hall at Olympia. This change of venue has enabled considerably more space to be devoted to each of the 220 stands and also a much greater freedom of access. With the aid of the following list of exhibitors and the plan opposite it is hoped visitors will readily be able to find individual stands. For the convenience of readers unable to visit Olympia we plan to include a report on the show in our next issue.

The Exhibition will be open daily from 10 to 6. Admission is no longer by invitation card, except for overseas visitors, but will cost 5s.

A.B. Metal Products	210
A.E.I.	162
A.K. Fans	353
Air Control Installations	358
Aircraft-Marine Products	301
Alma Components	478
Amphenol	226
Ancillary Developments	476
Andec	455
Anderton Springs	351
Antiference	354
Ardente Acoustic Labs.	100
Ariel Pressings	404
Arrell Electrical	207
Arrow Electric Switches	500
Arrow	498
Ashburton Resistance	473
Autop Foundry	458
Aveley Electric	360
Avo	225
BICC-Burndy	156
B.I. Callender's Cables	156
Bader Machinery	494
Bakelite	491
Beckman Instruments	471
Belclere	472
Belling & Lee	313
Berec International	401
Beulah Electronics	152
Bird, Sydney S.	109
Birmingham Sound Reproducers	161
Bradley, G. & E.	456
Bray, Geo.	108
Brayhead Electronics	318
Bribond	57
Brimar	274
British Electric Resistance	103
British Physical Labs.	479
Brush	317
Bulgin	315
Burndept	52
C.C.L.	457
Carr Fastener	202
Cathodeon Crystals	362
Chapman Ultrasonics	152
Ciba (A.R.L.)	228
Clarke, H., & Co.	157
Colvern	154
Connollys (Blackley)	171
Continental Connector	402
Cosmocord	213
D.S.I.R.	462
Dagnall & Kendall	102
Darwins	409
Datum Metal Products	450
Dawe Instruments	212
Day, J., & Co.	110
"Diamond H" Switches	254
Direct T/V Replacements	152
Doran Instrument	152
Dubilier	214
Duratube & Wire	252
E.M.I. Sales & Service	105
Egen Electric	265
Ekco Plastics	271
Electrical Remote Control	411
Electro Acoustic Industries	259
Electrolube	474
Electro Methods	223
Electronic Components	488
Electronic Technology	489
Electrothermal Engineering	204
Elliott Brothers	482
Enalon Plastics	406
English Electric	221
English Electric Valve	165
Enthoven, H. J., & Sons	268
Equipment & Services	411
Erg Industrial Corp.	256
Erie Resistor	51
Ever Ready	401
Fane Acoustics	364
Ferranti	300
Fine Wires	270
Floform Parts	251
Formica	316
Fortiphone	352
Fox, P. X.	350
G.E.C.	163
Gardners Radio	475
Garrard Engineering	275
Gayler & Hall	453
General Controls	465
Goldring Manufacturing	208
Goodmans Industries	264
Gramophone Company	105
Greencoat Industries	111
Gresham Transformers	460
Guest, Keen & Nettlefolds	251
Haddon Transformers	276
Hallam, Sleigh & Cheston	224
Harwin Engineers	492
Hassett & Harper	408
Hellermann	269
Henry & Thomas	357
Herbert Publishing Co.	114
Heywood & Co.	107
Hinchley Engineering	164
Hughes International	499
Hunt (Capacitors)	166
I.C.I. Plastics Division	309
Iliffe Electrical Publications	489
Imhof, Alfred	159
Insulating Components & Materials	151
International Rectifier Co.	158
Ionic Plating	251
Irish Cables	229
Jackson Brothers	263
Jobling, James A.	220
K.L.G. Sparking Plugs	458
L.S.B. Components	152
Labgear	362
Langley London	464
Lewis Spring	113
Linton & Hirst	150
Linvar	469
Livingston Laboratories	451
London Electric Wire Co.	262
London Electrical Mfg.	311
Lucas, Joseph	456
Lustraphone	272
M.C.P. Electronics	468
M-O Valve Co.	163
M.S.S. Recording	477
McMurdo Instrument	400
Magnetic Devices	279
Magnetic & Electrical Alloys	306
Mallory Batteries	222
Mansol (Great Britain)	104
Marconi Instruments	314
Marrison & Catherall	466
Measuring Instruments	55
Mec-Test	486
Metway Electrical Industries	470
Microcell Electronics	481
Microvernier	224
Midland Silicones	459
Miniature Electronic Components	486
Ministry of Aviation	461
Minnesota Mining & Mfg.	169
Morganite Resistors	305
Mullard	160
Mullard Equipment	491a
Multicore Solders	308
Multimusic	308
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Mycalex & T.I.M.	253
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Neill, James, & Company	227
Newmarket Transistor	361
Oliver Pell Control	483
Painton & Company	155
Parmeko	168
Permanoid	207
Plannair	53
Plessey	310
Preformations	310
Pressac	410
Printed Circuits	495
Pye Switch Division	362
Redcliffe Industries	483
Rejafix	359
Reliance Cords & Cables	312
Reliance Manufacturing Co.	273
Rendar Instruments	363
Reproducers & Amplifiers	403
Reslosound	152
Richard Allan Radio	112
Rivlin Instruments	407
Rola Celestion	255
Ross, Courtney	493
S.T.C.	167
Salford Electrical Instruments	216
Salter, George	170
Sanders, W. H. (Electronics)	498
Scott, Geo. L.,	50
Semiconductors	310
Service Electric	356
Sheffield Steel Products	483
Simmonds Aerocessories	278
Sims, F. D.	484
Smith & Nephew	355
South London Elec. Equipment	487
Spear Engineering	215
Stability Capacitors	266
Standard Insulator	54
Steatite & Porcelain Products	307
Stevenage Relays	498
Stocko (Metal Works)	101
Stratton	201
Suflex	302
Swift, Levick & Sons	258
Sylvania Thorn Colour TV Labs.	274
Symonds, H. D.	277
Taylor Electrical	211
Technograph	463
Tektronix Inc.,	451
Telcon Metals	306
Telegraph Condenser Co.	205
Telephone Manufacturing	304
Telequipment	497
Texas Instruments	303
Thermionic Products	106
Thermo-Plastics	209
Thorn Electrical Industries	480
Tickopres	454
Transradio	452
Tucker Eyelet Co.	261
Turner, Ernest	110
United Trade Press	467
Vactite Wire	365
Venner Electronics	496
Vidor	52
Wandleside Cable Works	229
Wayne Kerr Laboratories	485
Wego Condenser	203
Welwyn Electrical Labs.	260
Westinghouse	153
Weymouth Radio Mfg.	218
Whiteley Electrical	56
Widney Manufacturing Co.	224
Wingrove & Rogers	217
Wire Products & Machine Design	490
Wireless & Electrical Trader	489
Wireless Telephone Co.	310
Wireless World	489
Woden Transformer	267
Wolsey Electronics	405
Zenith Electric	257

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Elements of Electronic Circuits

26.—Pulse Modulation (1)

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

IN the preceding article (May, 1961) we saw how an open-ended delay line could be used as a pulse-forming network in a simple pulse modulator. Other types of pulse modulator are used, however, and some of the various ways of producing a pulse-modulated signal will be dealt with in this and the next instalments. It is usual to divide pulse modulators into two main categories, grid modulators and anode modulators.

Grid modulation, as the name implies, can only be used when the transmitting valve has a control grid, and consequently its use is restricted to frequencies below about 500 Mc/s. At centimetric wavelengths, where the transmitting valve is usually a magnetron, anode modulation must be used.

Grid Modulation

Fig. 1 illustrates a tuned-anode tuned-grid r.f. oscillator V2 which is prevented from oscillating by the bias caused by a heavy current flowing through its grid resistor R. This grid resistor forms the anode load of a triode pulse amplifier stage which in the absence of an input is conducting heavily. A negative pulse applied to the pulse amplifier grid cuts off the anode current of V1, produces a positive voltage at V1 anode (i.e., V2 grid) and consequently allows V2 to oscillate for the duration of the pulse. Unfortunately the combination of R, the r.f. bypass capacitor C and the inter-electrode anode/grid capacitance of V1 tends to cause a slow rate-of-rise of oscillator grid voltage to zero. This in turn produces a slow build-up of r.f. oscillations and the leading edge of the r.f. pulse is of poor shape. This can be improved by making the value of R small, thus the time constant represented by the total shunt capacitance multiplied by

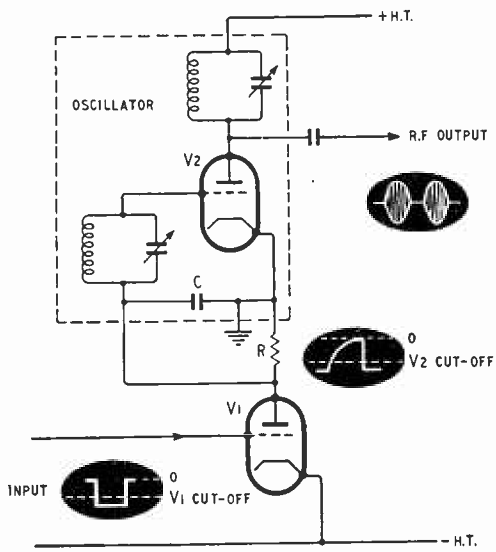

Fig. 1

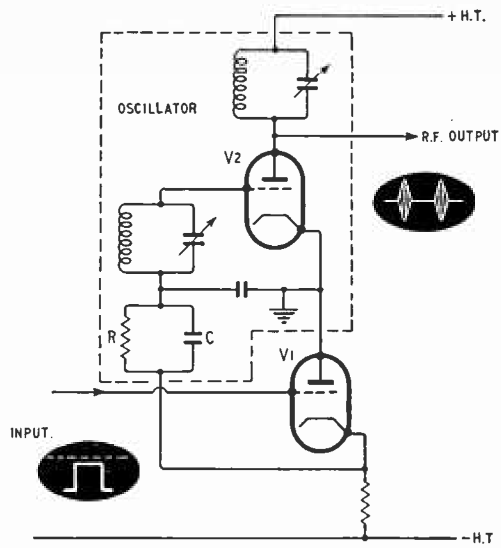

Fig. 2

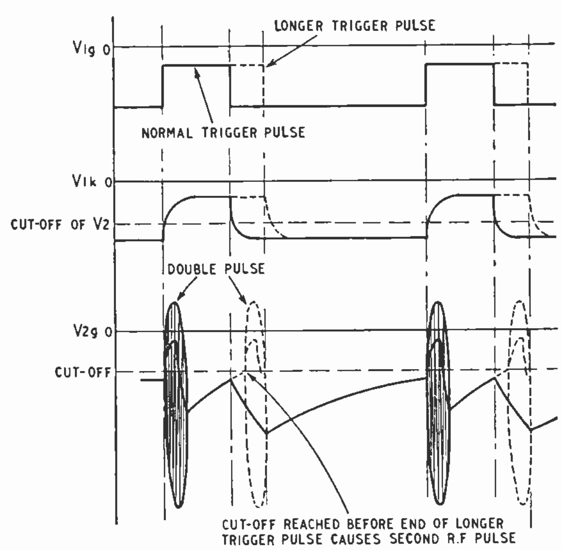

Fig. 3

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R is smaller and the build-up of r.f. oscillations is quicker.

Squegging Oscillator.—Another type of grid modulator is the squegging oscillator which is often triggered by a cathode-follower stage (Fig. 2). First let us consider the action of a squegging oscillator: If the auto-bias CR time constant of the oscillator is too long, a charge is built up on C (by grid current) and the bias voltage becomes greater than the value at which oscillations can be maintained; r.f. oscillations then die away. The charge on C leaks away through R until the bias voltage rises through cut-off when r.f. oscillation recommences. This again causes grid current and an increase in bias so that the cycle repeats. The repetition frequency of these free-running bursts of r.f. oscillation is largely dependent on the time constant CR. If we now trigger the grid circuit of the oscillator, as shown in Fig. 2, the recurrence frequency of the bursts of r.f. oscillation may be locked to the input (from the sub-modulator). The action of the oscillator is initiated by the triggering pulse which is made longer than the required duration of the r.f. pulse. The duration of the r.f. oscillation is thus still dependent on the rate at which C is charged by grid current flow but, due to the trigger circuit, an r.f. pulse cannot be generated unless a trigger pulse is present. If the duration of the trigger pulse is made longer still, or if the rate-of-rise of mean grid potential after the end of the r.f. pulse is such that cut-off is reached before the end of the trigger pulse, then it is possible for a second r.f. pulse to be produced. This results in the production of double pulses or "doublets" (see Fig. 3). So that the valve is ready for operation by the time each trigger pulse is applied, the free-running repetition frequency is chosen to be greater than the p.r.f. of the trigger pulse.

LETTERS TO THE EDITOR

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

Negative Feedback and Non-linearity

ONE must admire the way in which "Cathode Ray" in the April issue handles this very tricky subject, the care and hard work that has obviously gone into the article, and the guarding against snipers at every point, for example "apparent reduction of distortion" in the caption of Fig. 2, and the checking up on what he said in 1946.

Added to all this is his ingenious method of proving that feedback improves the signal-to-distortion ratio, so that it will surely be called mud slinging if I venture to ask if "Cathode Ray" would have trusted this method if he had not checked it experimentally?

I suggest this because hum (or noise) is another important factor in amplifier design, and by substituting "hum" for "distortion" and h for p the method seems to apply practically word for word to hum, in fact even slightly better as in this case the amplifier gain can be assumed constant.

We "prove" that negative feedback increases the signal-to-hum ratio by the feedback factor, but "Cathode Ray" states at the beginning of the article that feedback may or may not increase this ratio, and even may decrease it. The writer believes that it does not change it.

We reluctantly conclude therefore that even this method does not always work, and so, as often happens with the corresponding explanations in text books, we do not know when to be trusting.

Another point arises in Fig. 6(a) where it is assumed that −40, −48 should read −32, −40 respectively.

The maximum negative output possible in Fig. 5 is −24V, which is assumed equal to a fundamental of −32V + 8V second harmonic. This seems fair enough. But it is difficult to understand why it is considered fair to apply an 8V bias here to make these figures −32V and −40V and not to apply any bias in the Fig. 7 case.

Binley, nr. Coventry D. L. CLAY

"CATHODE RAY" in his article on the above topic has raised several interesting points but has, I feel, missed an important one. In discussing the output power available with feedback he has assumed that it is necessary to maintain an input signal centred about the same zero as that without feedback. Since, in theory, the zero value of any signal can be adjusted at will, it would perhaps be better to consider his amplifier curve with feedback when driven from a ± 4 volt swing centred about the 1·5 volt value of V'_f. The fundamental output voltage available is then ± 40 volts and is produced with negligible distortion.

If such an arrangement is permissible, and there seems no practicable objection, then some of the conclusions reached in the article would need reconsidering since under the proposed alternative the output power with feedback is certainly no less than that obtainable without feedback.

I do not agree with conclusion 6: large power-handling capacity in "hi-fi" systems is to enable the occasional peak levels to be handled without distortion.

Finally his remark about feedback that is not precisely negative is open to doubt since the magnitude of AB and not its phase is important in the reduction of non-linear distortion.

Since the harmonic distortion in a feedback amplifier is reduced in value by the factor $|1+AB|$ evaluated at the harmonic frequency in a region or frequency range where a reasonable amount of feedback has been applied and the approximation $|1+AB|=|AB|$ holds, the harmonic distortion will depend on the magnitude of AB and not the phase of AB.

Dartford, Kent J. F. TILLY

The author replies:

I am grateful to Mr. Clay for his appreciative remarks and for pointing out the error in the scale of Fig 6(a). Meanwhile I have observed that the same or another gremlin added noughts to the last two figures in column (2) of the table on the same page.

My statement that negative feedback may either reduce or increase hum was proved both theoretically and experimentally in your issue of May 1946, but as that may be rather far back for even Mr. Clay to recall (though it was reprinted in "Second Thoughts on Radio Theory," Chap. 19) I hope to return to the subject before long, with particular reference to present-day circuit practice.

The question of fairness does not really arise with regard to the 8V "bias." It represents the d.c. component, which is removed before the signal reaches its ultimate destination.

The comparison made in the article, on which the

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conclusions were based, was between Fig. 5 and Fig. 8, the latter representing the same working conditions as the former except for the ten-fold increase of input to make up for the ten-fold reduction of gain due to feedback. It is quite true, as Mr. Tilly points out, that a better result could be obtained—at least on paper—with feedback if the working point were altered. The same means would also achieve a better result without feedback. But it was tacitly assumed that the output stage (which is normally responsible for nearly all the non-linearity) was already being worked at its limit of power dissipation, so that in practice such adjustment would be inadmissible.

It might well be, in any particular practical case, that some slight readjustment of working conditions would be desirable when feedback is adopted, but this does not, I think, substantially affect the main conclusions. The object of my exercise was to bring out what happens when non-linearity at some part of the signal cycle is large—a condition that is inevitable when the input amplitude is excessive.

I am at a loss to understand Mr. Tilly's disagreement with my conclusion 6; his alternative statement is in perfect agreement with it.

There is surely no doubt at all that the phase of the fed-back voltage is important, for it is what decides whether the feedback is negative or positive. In his final paragraph Mr. Tilly commits the logical fallacy of assuming what he is attempting to prove, by putting "magnitude" signs around the feedback impressions he has used.

With regard to the last two words of his penultimate paragraph I would refer Mr. Tilly to the top right-hand corner of p. 173 of the April issue.

"CATHODE RAY"

Further Thoughts on Inductance

THE abstract and intangible quantities involved in the understanding of the behaviour of magnetic circuits seldom fails to present real difficulties to students. It is for this reason that authors must write with great care on such matters.

It is to be regretted that Thomas Roddam writing on Inductance in the April issue has confused

(a) magnetizing and magnetomotive force

(b) flux and flux density

throughout the whole of his article.

His appreciation of engineers being unwilling to "put back the clock" is very sound. One wonders why the older and more cumbersome magnetic expressions were employed in preference to those of the m.k.s. system.

Finally, no useful purpose whatsoever is served by assigning a proper noun to cover the product or quotient of electrical quantities. On the contrary, a very serious barrier to learning is set up, as the identity of the expression is lost.

For example, the pedant gives Roddam about half marks for stating the energy stored in a magnetic circuit as $\frac{1}{2}LI^2$. "Joules" have been overlooked even as the pedagogue may well have overlooked the fact that his pupils are not very happy about this particular unit and its derivation.

Malvern. F. K. WEBB.

AFTER I had tried, in your March issue, to clarify magnetic units and relationships for the beginner, it was a little naughty, was it not, of Thomas Roddam to confuse them again in the April issue by referring to H as magnetomotive force and B as flux? A lot of readers will be sure enough of their ground not to be tripped up by this loose language, but ought we not to remember that there are others who are liable to be so confused by such a contradictory usage right at the start of the article as to fall out at that point and thereby fail to benefit from Mr. Roddam's interesting thoughts on non-linear inductance.

Encouraged by your historical reference, in the same issue, to my efforts to make logic and order prevail in our terminology, I will also lodge a protest against "HENRYS" in the sub-title. I know this is in accordance with B.S.560:1934 (Amendment 1), but (owing to my objections?) it was dropped in B.S.1991:Part I:1954 which has superseded it. Clearly the names of units are common nouns, as indicated by their lower-case initial letters, and therefore the plural of "henry," like other English common nouns ending in -ry, is "henries." Only the Welsh could take any pleasure in "rys."

"CATHODE RAY".

The author replies:

Mr. Webb and Mr. Ray are quite correct in reprimanding me for using loose language. Last July, however, and the reference to rain rather than snow indicates that my holiday was in summer, I had not had an opportunity of reading Mr. Ray's clarification.

Why do I get confused over these magnetic terms and why do I not use m.k.s. units? The answer to the second question is easy: our makers of magnetic materials express all their information in oersteds and lines per square centimetre. The answer to the first question is also, I am afraid, an engineer's answer, too. Most of my transformer designing life was associated with a well-defined set of standard sizes of core with a range of standard air-gaps. I think of maximum flux as so many ampere-turns because once a size is chosen that NI term is the only one which is free. Like Mr. Ray (page 145, March issue) I sweep all the dirt under the carpet but I have chosen a different corner.

I must disagree with Mr. Webb's blanket damnation of proper nouns for products and quotients. Does he really want to use volts per amp for his resistors and kilovolt-amps for his electric fire?

Finally, sir, should I be taken to task? When I was a student I was assured that it was my stupidity which led me into those difficulties. Surely either the students of today or other pedagogues of yesterday are to blame. The manufacturers of magnetic materials could, however, make it easier for us to fall into righteousness.

THOMAS RODDAM.

Graphical Solutions

MAY I suggest that the graphical solution proposed in the Appendix to Foss and Sizmur's article in "Multivibrator Design" (p. 224, April issue) would be made even simpler by the use of linear/log scales?

To provide a graphical solution which really replaces the use of (low-accuracy) tables, $E_1/E_0 = e^{-t/T}$ should be drawn on linear X/logarithmic Y paper, whereby it becomes a straight line, a property which this function shares with all functions of the form a^x. It is then only necessary to know one point on this graph in addition to the point (0 — 1).

As an example a straight line was ruled from (0 — 1) to (4.60 — 0.01) on paper with two log decades along the Y-axis and a linear X-axis scale. The accurate figure for Y at this point, taken from "Tafels van e^x," H. W. Holtappel (Groningen, 1938), is 0.0100518357.

These tables show that the point (4.605 — 0.010) is closer to the correct figure, but the easily memorized co-ordinates (4.60 — 0.01) give ample accuracy for the purpose at hand.

The above assumes that linear-log graph paper is available, but in an emergency the two decades of the vertical scale can be transferred from the upper scale of a slide rule. If an ordinary log table can be assumed to be available, the ordinates can be marked off in proportion to the logarithms of 1, 2, 3, etc., the units being centimetres, inches or multiples thereof.

Finally, when required, it is easy to draw the curved graph on ordinary linear-X/linear-Y paper, taking individual points from the straight line graph first prepared.

Ramstad, Norway. KAYE WEEDON.

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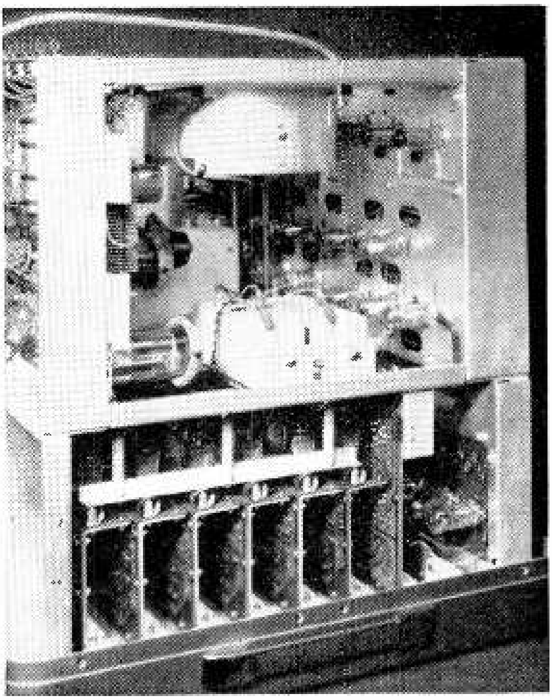

The Marconi Instruments TF1345 10Mc/s Counter, showing the plug-in, printed-circuit decade units.

SOME APPLICATIONS OF COUNTING TECHNIQUES

By P. R. DARRINGTON

DIGITAL MEASUREMENTS

IMPROVEMENTS in the stability of oscillators have brought in their train a demand for more and more accurate methods of frequency measurement. Accuracies of a few parts in a hundred or even a thousand million are becoming commonplace, and the most easily operated instruments for measurements of this order are the digital frequency-meters now being produced in many parts of the world.

Digital measurements of time and the counting of random events have been adopted by the industries concerned with nuclear energy, and many types of input transducer have extended the advantages of digital measurement to the engineering industry in general.

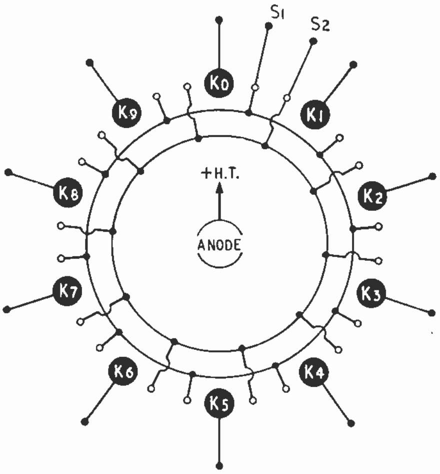

Fig. 1. Dekatron.

The advantages of this type of measurement may be summed up as extremely high accuracy, simplicity and freedom from operator fatigue, the latter being influenced to some extent by the type of read-out presentation adopted.

Counters generally available are divisible broadly into two groups. The lower-speed instruments tend to rely on the counting tubes, as instanced by the Dekatron. This is a gas-filled device consisting of a central anode surrounded by ten cathodes (K0 to K9 in Fig. 1). Between each pair of cathodes are two electrodes known as switching-grids. On first switching on, an ionization path is formed between the positive anode and one of the cathodes which are returned to earth: from this time, the path will be formed to whichever is the most negative electrode in the tube. If a negative-going pulse is applied to all the grids connected to S1, the path will move to the S1 grid nearest the original cathode; it cannot move backwards to S2, as S1 is more negative. A second negative-going pulse, delayed slightly to overlap the first, is now applied to S2. When the S1 pulse ends, S2 is more negative and the path is formed here. At the expiry of this second pulse, the path moves on to K1, as all cathodes are maintained at a more negative d.c. potential than the grids. The two pulses are obtained from a mono-

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stable multivibrator triggered by the input signal, a delay network providing the overlap. Ten pulses at the input to the multivibrator result in the ionized path performing a complete circuit of the tube. A resistor in K0 will develop a voltage when the path is formed between K0 and the anode, which results in division by ten. Reset is effected by the momentary application of a negative voltage to K0. The position of the path is identified by the formation of a glow on the cathode in use, which corresponds to a numbered surround on the instrument front-panel. This type of presentation can be fatiguing to the operator, and the principal disadvantage is that the maximum switching frequency is limited to about 20kc/s. Counting tubes are used widely in comparatively low-speed industrial applications.

A device belonging to the family of counting tubes, but working on a different principle is the beam-switching tube. This is a vacuum tube, the electron stream being directed from a central cathode to one of ten anodes, or "targets," by the combined influence of a magnetic field and the voltage applied to a grid or "spade." The maximum switching speed of later developments of the beam-switching tube is in the region of 10Mc/s, and the tube will drive read-out devices, such as neon tubes and printers directly.

Most of the higher-speed counters—10Mc/s and above—employ as their basic counting element the bi-stable flip-flop or toggle. Circuits using transistors are capable of switching at speeds in excess of 50Mc/s, although in commercial instruments the present-day limit is about 20Mc/s.

Principle of Operation

The basic requirement of an electronic counter, when used other than purely as a batch counter, is that it should have an accurate and stable source of frequency. When built into the instrument, this almost invariably takes the form of a temperature-controlled crystal oscillator, usually working at a frequency of 100kc/s, 1Mc/s or 5Mc/s. The 5Mc/s crystal is being widely adopted because of its low long-term ageing drift. The temperature of the crystal, and sometimes of the complete oscillator is held constant by enclosing it in an oven, controlled by a bimetallic thermostat, or an electronic circuit using a temperature-sensitive element in a bridge circuit. The more sophisticated control circuits are capable of working with differentials of a few millidegrees; divergence from nominal frequency is normally limited to not more than a few parts in 10^7 per week, or even an order better. Oven temperature control employing the latent heat of fusion has also been described.*

The output of the crystal oscillator is used as a reference frequency in the gating and timing cir-

*_Wireless World_, Dec. 1960, p. 613, "Technical Notebook".

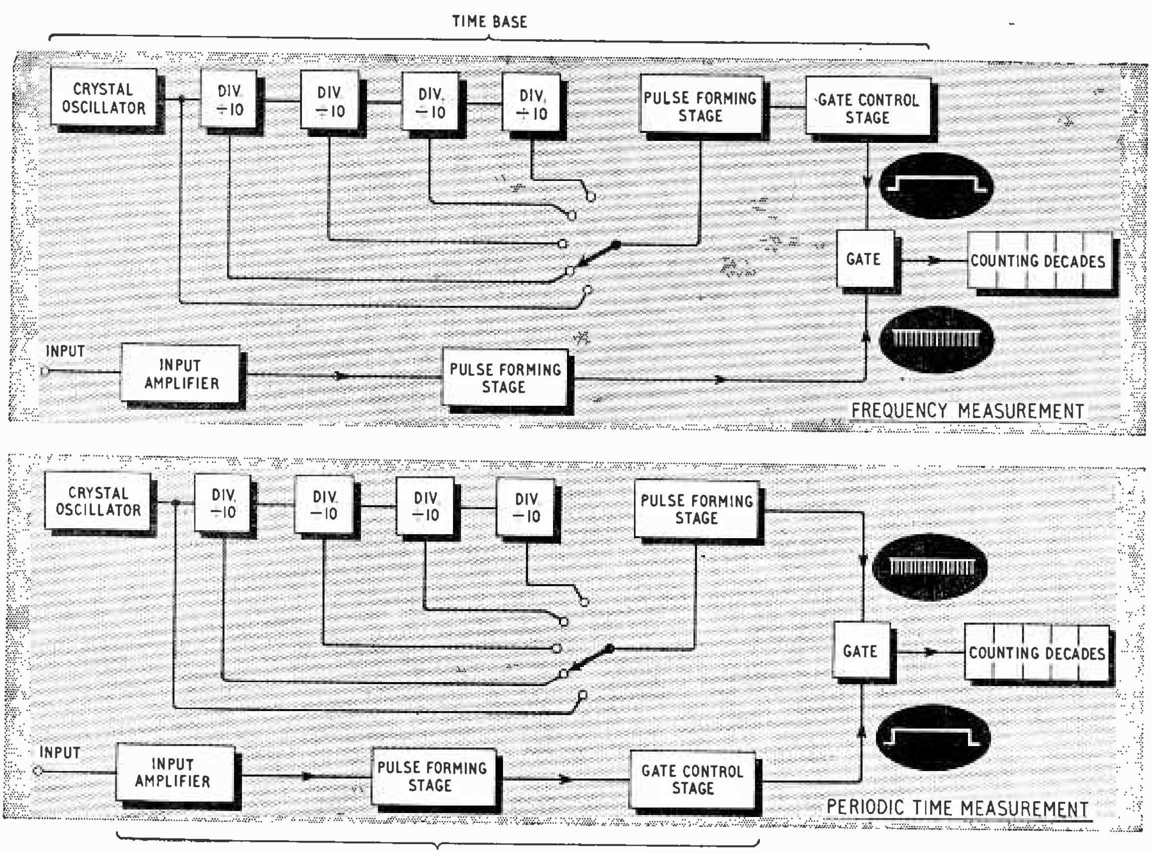

Fig. 2. Circuit configurations for frequency and time measurements.

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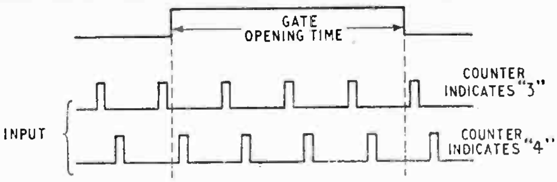

Fig. 3. The ± 1 digit error inherent in the system of gating is due to the lack of phase relationship between the crystal oscillator and the unknown frequency.

cuits of the counter. Two main configurations of the internal circuits are required, providing the two functions of frequency and time measurement. Block diagrams are shown in Fig. 2.

The obvious method of frequency measurement is to allow the input to pass through an electronic gate which is open for one second precisely. The output of the gate is fed to a chain of counting decades of one of the types described earlier; the result showing on the display when the gate closes is the frequency in cycles per second. The accuracy of the result is governed by the stability of the crystal oscillator which indirectly determines the opening time of the gate, and also by an inherent error of ±one digit, caused by the lack of a phase relationship between the frequency being measured and the output of the crystal oscillator (Fig. 3).

At very low frequencies, say 10c/s, the accuracy is determined by the gating error (1c/s) which is, in this case, ±10%. The method of measurement is therefore inverted. In order to obtain a larger number of significant figures on the display, the unknown frequency itself is made to determine the gate opening time, during which a high frequency derived from the crystal oscillator is counted. In this way, the gating error is reduced, the major inaccuracy being due to crystal frequency tolerance, which is controllable. The result displayed is now the time of one cycle of the unknown frequency in units of the standard frequency being counted, and the frequency is obtained by a reference to a set of reciprocal tables.

Measurement of time is made in exactly the same way; the input determines the opening time of the gate, this being defined precisely by the standard frequency derived from the crystal oscillator. In some counters it is possible to vary, by means of a calibrated front-panel control, the standing bias on the trigger circuit which controls the gate opening time. The points on a waveform at which the gate opens and closes are therefore variable. This is a useful facility for the measurement of pulse widths at different amplitudes, the time taken for a slowly-varying voltage to cross predetermined levels, etc.; but it must be borne in mind that the accuracy of measurement has a limit set by the maximum frequency employed as a standard. For instance, if the standard frequency used is 10Mc/s, the accuracy cannot be better than ±0.1μsec. In many counters, automatic positioning of a decimal-point gives the result in kc/s, or, if time is being measured, in the appropriate timing-units.

The measurement of frequencies outside the range of the basic counter is made possible by recourse to heterodyne techniques. The method is to beat the unknown frequency against a multiple of the crystal frequency, selected by a front-panel control, and obtained by harmonic generation or locked-oscillator techniques, the difference frequency being measured on the counter. The presentation is then the selected multiple added to the counter indication. For instance, if the frequency to be measured is 185.734Mc/s, the harmonic selection control is set to 180Mc/s. The difference frequency is fed to the counter and is displayed as 5734kc/s. The problem of which harmonic to select is usually resolved by means of a wavemeter. This method is applicable up to about 200-300Mc/s, above which it is general practice to employ a transfer-oscillator. This consists of an oscillator operating within the range of the counter, with or without heterodyne facilities, harmonics of which beat with the unknown frequency. Provided that the harmonic is known, the result is obtained by measuring the frequency of the transfer-oscillator and multiplying by the harmonic number.

It has been mentioned that the crystal oscillator determines the opening time of the gate. To achieve this, the crystal oscillator output must be divided in frequency to give pulses spaced in time by an amount equal to the gate time required. In practice, several frequencies are produced to give a selection of gate times depending on the frequency being measured and the accuracy required.

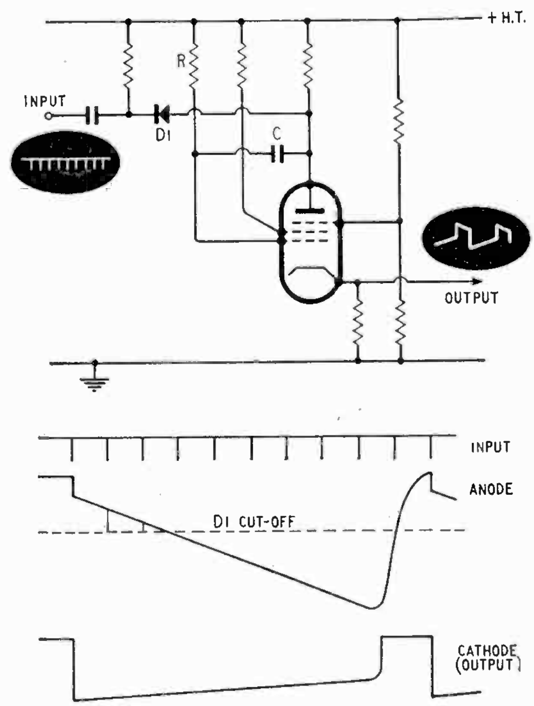

Fig. 4. A typical phantastron divider. The division ratio is set by the value of C and R.

Circuits employed as dividers are well-established, among them being blocking oscillators[1], phantastrons[1], multivibrators[1] and the diode-pump integrator with transistron linearization and flyback[2]. Fig. 4 shows a typical phantastron divider. Characteristics required are stability with temperature and supply voltage changes and ease of setting-up. The divider should not free-run in the absence of input pulses.

All these circuits depend on a time-constant, which, at frequencies below about 10c/s, becomes

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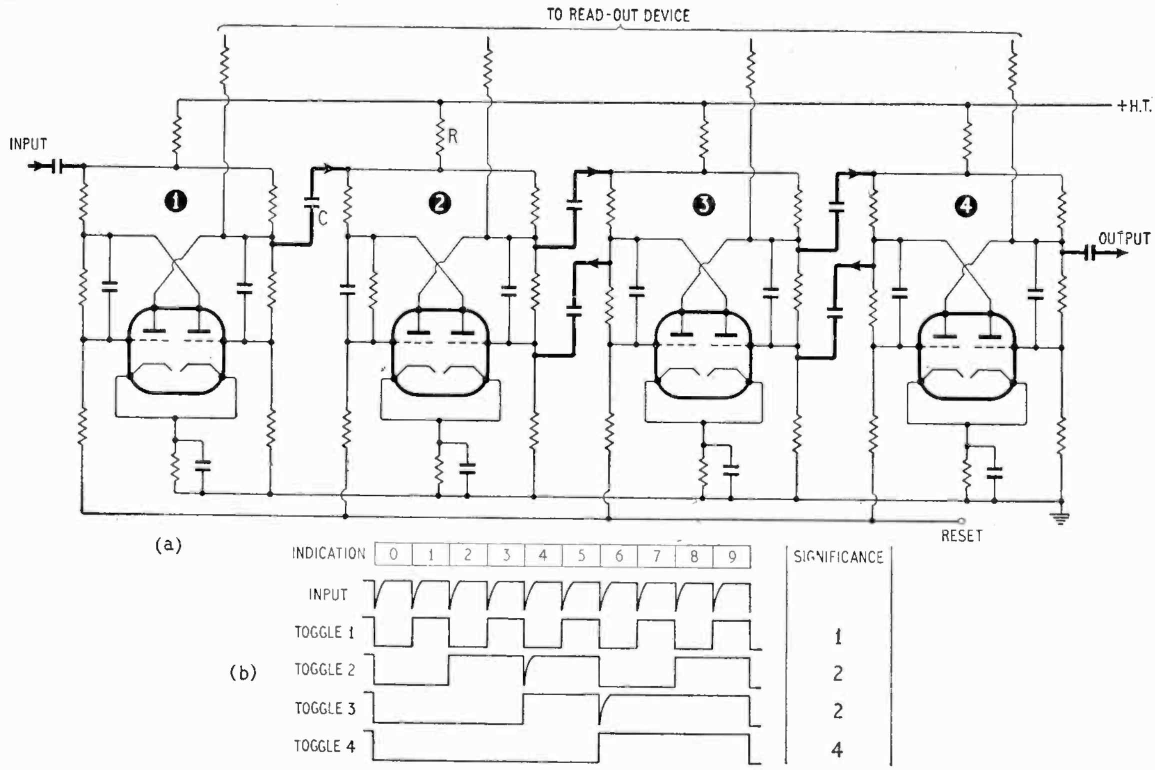

Fig. 5 (a). A counting decade, showing the signal and feedback paths in heavy lines. (b) Waveforms appearing at the anodes of valves whose grids have the reset pulse applied.

unmanageably large, and insulation resistance of circuit components tends to cause trouble. To overcome this, aperiodic circuits, such as toggle decades are used, there being no lower limit to their frequency of operation. Many transistor circuits use decades throughout the dividing chain.

A self-checking facility is incorporated in most counters which tests for correct working of all division, gating and counting circuits. The gating circuitry is set to function as in the case of frequency-measurement, while the output of the crystal oscillator and the stages in the division chain are counted.

The result should be exactly correct, although accumulated phase-shifts in the division chain, and the finite opening and closing times of the gate circuit may result in a ± 1 digit error.

This check does not give an indication of crystal accuracy, as a low crystal frequency gives rise to a longer gate time, and the two effects cancel out.

Decade Operation

Referring to Fig. 5a it is seen that the decade is composed of four bi-stable toggles, the output of each triggering the succeeding stage: the last toggle provides the input to the next decade.

The line marked RESET may be considered, for the moment, as being returned to earth. Assume an initial state where all left-hand valves are conducting.

The grid of a toggle in the conducting condition is returned to a positive voltage with respect to cathode, but is held at very nearly cathode voltage by grid current limiting. When cut off, the grid may be up to 50V negative. Obviously, then, a positive-going pulse applied to a toggle will not affect the conducting valve, and will need to exceed 50V to trigger the stage. On the other hand, a small negative-going pulse will be amplified by the conducting valve, and will "flip" the toggle into the reverse condition. All trigger pulses, therefore, are negative-going.

The first input pulse triggers toggle 1 into the condition where the output anode (left-hand) has performed a positive-going step-function. The step is differentiated by C R, but this has no effect on toggle 2 for the reason explained above.

The second pulse compels toggle 1 to revert to its original state, the negative-going step-function on its anode being differentiated to form a negative-going pulse suitable for triggering toggle 2. Toggle 1 continues in this manner; a negative-going output pulse is delivered for two pulses at the input.

At the onset of the fourth pulse, the output of the second toggle is of the correct polarity to trigger toggle 3, which is duly reversed. However, at the opposite anode of toggle 3, a negative-going step-function is performed which is differentiated by C R and used to re-trigger the second stage. In the absence of feedback this state of affairs would not be achieved until the sixth input pulse. The count has therefore been advanced by two.

Operation proceeds normally until the sixth pulse, when feedback occurs between toggle 4 and toggle 3. The "natural" count of 2^4—sixteen—has been

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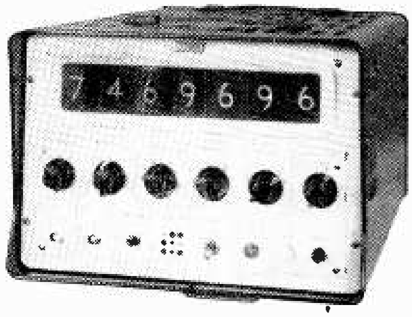

The Racal Type SA505 10Mc/s Digital Frequency Meter. Transistor decades are used in both the counting and dividing chains.

reduced to ten by feedback, and the tenth pulse restores all toggles to the initial condition.

The system of feedback is typical of operation at frequencies up to about 100kc/s. At higher frequencies, although the principle remains, accumulated delay in successive stages of the decade enforces refinements such as gated feedback, whereby the first toggle triggers the fourth directly, via a gate. Heavy clamping of anode and grid excursions is required to reduce recovery times and valve ageing effects.

Reset is effected by applying a large-amplitude positive-going pulse to all the left-hand grids. The source impedance of the circuit producing the pulse is low, to avoid grid impedance unbalance between the toggle halves.

The information stored in the decades is indicated by the condition of each of the toggles when the gate closes, and is readable by several different methods. The most often used are meters, graduated 0-9, vertical decades of neon lamps numbered 0-9, and several kinds of in-line read-out, consisting of a horizontal row of numerals, one per decade.

A meter display is probably the simplest to provide, as it consists of only four resistors and a meter. Each toggle has connected to one of its anodes a resistor, the four resistors being taken to a common output which feeds the meter, as in Fig. 6. The problem is to assign to the four resistors values which will give a current output proportional to the significance of each toggle. In a "decade" without feedback, these four currents would increase in powers of two, i.e., the first toggle would signify 1, the second 2, the third 4 and the last one 8. This is known as pure binary code and is often referred to as 8421 code. However, with the addition of feedback necessary to make the four toggles work as a decade, the significance of each toggle is altered; the decade shown in Fig. 5a produces a 4221 code. If each resistor is given a value calculated to provide the required current, the result will be a ten-step staircase. The system described is used in several commercial counters, but suffers from the disadvantages common to analogue devices presenting digital information. The meter movements are comparatively slow in operation, and in low-speed decades, where anode travel is not clamped, varying valve characteristics necessitate setting-up of limits, by means of variable resistors. Considerable effort is required to make a long series of readings; the result is not immediately apparent.

Read-out employing vertical decades of neon lamps is used widely and is probably the ideal form of display. Each neon lamp is fed via resistors from the anodes of three toggles, the connections being arranged so that one cut off and two conducting valves are connected across the appropriate neon for each indication. This avoids any tendency for more than one neon to fire at any one time. This form of display is instantaneous in operation and has the advantage that it is, in effect, a positional-analogue indicator, in addition to being digital in form. The point is of some importance on many counters, as the display and reset time can be so short as to give a virtually continuous reading. Variations of the input parameter are apparent as a slow rise or fall of the decade indications, and the direction of drift of frequency or time is obvious.

One method of in-line read-out is an extension of the method described above. In front of each neon lamp of the vertical decade is mounted a photo-electric cell. As the neon lights, a voltage is applied to the appropriate electrode of a gas-filled indicator tube. Each electrode consists of a wire formed to represent a numeral 0-9; as the decade neon lights, a glow forms on the indicator tube electrode.

Another common method of obtaining an in-line read-out is to decode the four outputs of a counting decade by means of either semiconductors or relays, Fig. 7. A conducting path is formed from the common input of the decoding matrix to one of ten outputs by the relay-controlling valves or transistors, which are controlled by the four decade outputs. Current is fed via this path to one of a series of ten lamps in a projection display unit.

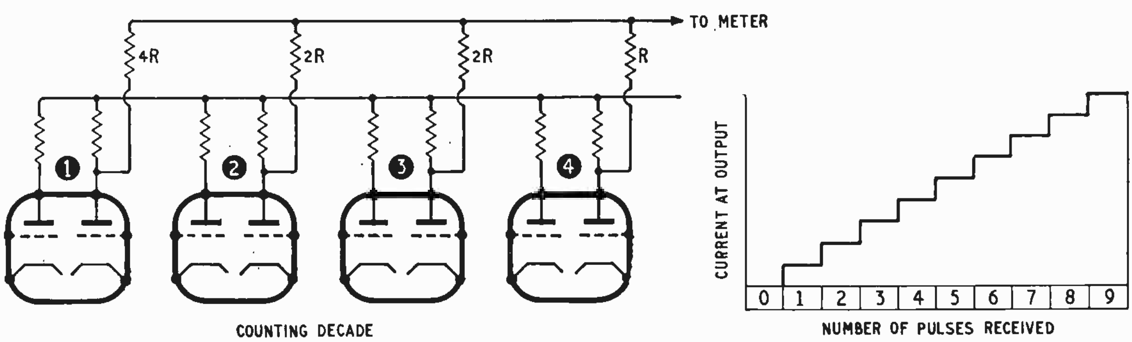

Fig. 6. Circuit giving meter readout. The anode resistors are graded to accommodate the differing "significance" of each toggle.

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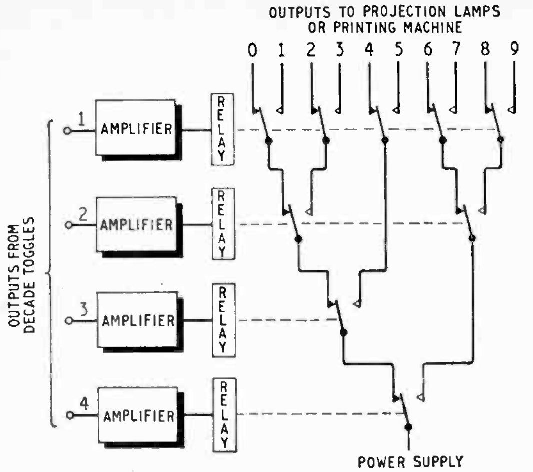


Fig. 7. A relay decoding matrix to convert a 4221 code to a decimal output.

Each lamp has a focusing-lens and a number mask, the number being projected on to a ground-glass screen.

The meter read-out referred to previously is capable of modification to provide an in-line display. The movement carries, in place of the needle, a transparency, consisting of the numerals 0-9 and moving in an optical system. The appropriate numeral is thereby projected on to a screen. The system is especially useful as an indicator for use with transistor decades, where voltages of a magnitude suitable for the operation of neons do not exist.

In-line displays are most useful for a measurement in which the reading is either used once only, or stays sensibly constant during a series of readings. If the input is varying, the display becomes a mere jumble of numbers and cannot be read if the cycling time of the counter is short. The analogue feature of the vertical display is then lost.

Both the vertical display and the in-line read-out may be read from a distance; the vertical display by virtue of the fact that the numbers do not have to be read, as the position gives the result, and the in-line system because the numbers can be made large.

The type of equipment so far described is used, as has been said, for the measurement of frequency and time. An extension of the principle is that of voltage measurement. The direct voltage to be determined must first be converted into either a frequency or a time-delay. A common method is to trigger a time-delay circuit, e.g., a phantastron, by means of the pulse that also opens the gate. As the phantastron anode "runs down," a comparator compares the anode voltage with the amplified input voltage. When the two are in coincidence, a pulse is formed which closes the gate. During the gate opening time, pulses from a crystal oscillator have been counted by a series of counting decades, and the displayed result can be arranged to indicate voltage numerically.

Errors in this method of measurement stem from non-linearity of the time-delay circuit, drift in the direct-coupled input amplifier and possibly frequency error in the circuit providing the standard frequency pulses.

An alternative method is to control, with the amplified input, the frequency of a pulse generator, the output of which is then measured as in the case of a normal frequency measurement. In this case, the inaccuracy is due to a non-linear relationship between voltage and frequency in the pulse generator and drift in the d.c. amplifier.

To obtain a more linear voltage-frequency conversion, especially at the extreme lower end of the range, a common method is to employ a b.f.o. system, in which one oscillator is made voltage-variable. In this way, the transfer characteristic may be made linear down to zero frequency.

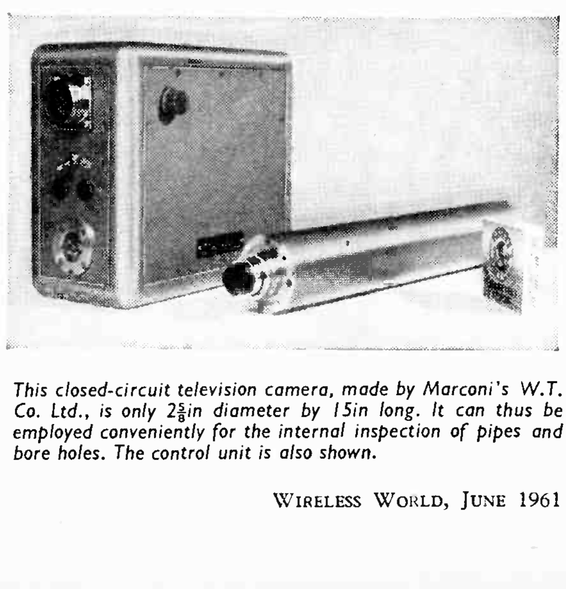
It frequently becomes desirable to preserve the results of a series of measurements in the form of a numerical printed record. To achieve this, some form of decoding is necessary between the binary-form of the decade four-wire outputs and the required decimal presentation. This may be achieved either electrically or electromechanically. The most common method is to employ a relay matrix, shown in Fig. 7, controlled by valves which have on their grids the outputs from each toggle of a decade. The relay contacts are arranged to provide, for each decade indication, a path from the input of the matrix to one of ten outputs, which feed a printing machine.

An analogue output which may be used to drive a pen recorder is easily obtained from a resistive network on the four outputs as in the meter display circuit. If several decades are in use, the analogue outputs from each decade may be combined in a further network to provide, for instance, units, tens and hundreds.

It can be seen that digital techniques afford, in general, a convenient and rapid method of frequency and time measurement with a high potential accuracy. With the advent of v.h.f. transistors and tunnel diodes, it is inevitable that counting-speeds will rise and that the simplicity of operation and compactness of the counter will bring measurement at an accuracy of 1 part in 10^7 down to the level of the production line.

REFERENCES

[1] A. H. Frederick, *et al.* "Waveforms." M.I.T. series, Chap. 16.
[2] P. R. Darrington. "Marconi Instrumentation." Vol. 7, No. 3. Sept., 1959. Page 82.



This closed-circuit television camera, made by Marconi's W.T. Co. Ltd., is only $2\frac{5}{8}$in diameter by 15in long. It can thus be employed conveniently for the internal inspection of pipes and bore holes. The control unit is also shown.

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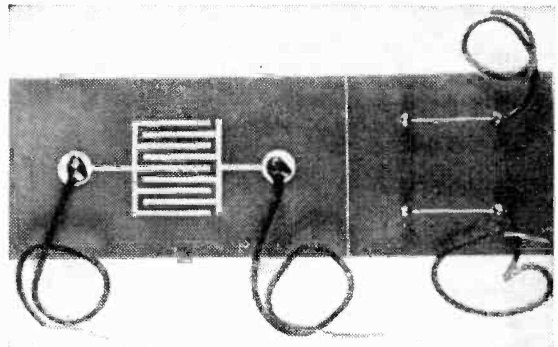
Leakage in Printed Circuits

PROS AND CONS OF WAX COATING AS A CURE

By P. RUSHEN*

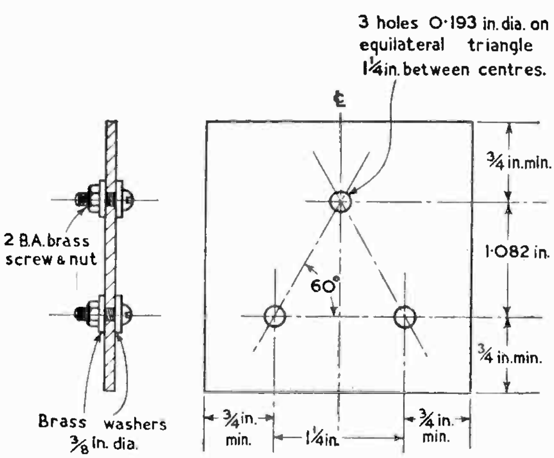


Test piece, showing arrangements used by author for determining surface leakage on material (left) and (right) insulation resistance of "body" of board. In latter case pins are driven through board: consequently surface contact is negligible.

THIS article is based on some original work done on printed wiring and its use in conditions of high humidity and temperature. Cost of materials and ease of production were two of the factors considered throughout, whilst the successful use of printed wiring in exported radio receivers was the main object.

Effects of Leakage

Consider some aspects of a conventional valve circuit using printed wiring—in general, every valve-base tag will be in intimate contact with the base material and in some cases anode and grid tags are adjacent to each other. An a.g.c. line may have as many as four or five contacting points. The h.t. line, the filament supply and, possibly, near-mains voltages all make close contact with the base material at various points on a typical panel.



This drawing, extracted from B.S. 1137:1949,† shows the recommended arrangement of specimen and electrodes for test of insulation resistance. The specimen is immersed in water for 24 hours at 20°C (Type I material) or subjected to relative humidity 75% at 20°C for 48 hours (Type III material) before electrical test is applied.

The effect of any leakage resistance will of course depend on the type of equipment concerned: an unrequired component at a significant point in a radio or television receiver can cause malfunction and, possibly, complete failure. A 100-MΩ leakage resistance from a 6.3-V filament line to the control grid of an amplifier could result in an audio power output of 100mW or more. No less depressing may be the prospect of a similar value of resistance from the h.t. line to an a.g.c. point.

Base Materials

If one were able to consider the use of only the more expensive base materials, the foil-to-foil leakage resistance on the surface would be the main factor. For practical purposes, however, one is obliged to look to the less expensive and more common synthetic-resin-bonded paper (s.r.b.p.) materials and those considered here are in general use and conform to British Standard Specifications 1137 Type 1, 2572 Type P1 and Type P3. When used as a base material for printed wiring, the insulation resistance of these materials becomes as important as the surface leakage resistance.

With these base materials one could therefore anticipate:—

1. Leakage through the base material.
2. Foil-to-foil leakage through any surface material whether intentionally added or otherwise acquired.

Base-material Leakage

Insulation resistance can be related fairly well to the quality of the material and thus, inevitably, to the cost, for which 25% of the total cost of a board, printed, etched, punched and finished appears to be acceptable. Although the quality of the material undoubtedly has some effect on the punching operation, it seems unlikely that the cost of the complete process would be very much affected. For example, an increase in the cost of base material of, say, 20% would probably result in an increase of 5% in the cost of the finished article.

The British Standard Specification for the three materials considered above calls for a 24-hour period of water immersion prior to measurements of insulation resistance. We might be inclined to regard water immersion as rather a hard test and the re-

* Bush Radio Ltd.
† Full title: *Synthetic-resin Bonded-paper Sheets for use at Power Frequencies.* Copies of British Standards may be obtained from British Standards House, 2 Park Street, London, W.1.

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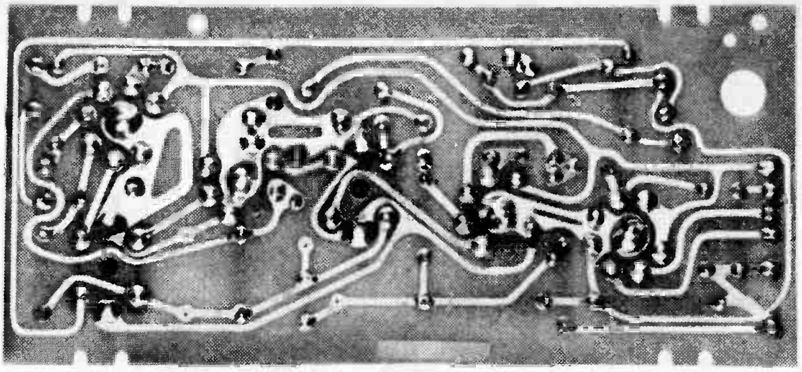
sults as a little unrealistic; but after subjecting samples of each material to exposure at 35°C and 95% relative humidity, leakages far worse than those specified for insulation resistance can be obtained over similar distances in the material. Deterioration in insulation resistance is gradual and continuous with hours of exposure; recovery is also a slow process. The insulation resistance of the base material is mainly dependent on the average conditions of humidity. Tests on the three materials considered led to the conclusion that only the best quality (B.S.S. 1137/1) would be free of serious leakage resistance after only 48 hours of tropical exposure.



Foil side of assembled wax-treated board.

Surface Leakage

Evidence suggests that the surface leakage is not affected seriously by the quality of the base material but is dependent far more on the nature and quality of surface accretions. These may be of any substance which covers the board surface and may include chemicals left by the etching process or subsequently acquired, any fluxes, waxes or preservatives which are added to or allowed to remain on the surface of the board. The volume of surface material will in all cases be small compared to the volume of base material and this gives the surface leakage a rather different character. The insulation resistance of the base material is "solid" and semi-permanent, the surface leakage is variable by comparison. The variability of the surface leakage is usually due to the absorption and evaporation of moisture from the surface material. If the volume of surface material is small, it can be expected to dry out very rapidly with any increase in temperature or any improvement in local conditions of humidity. Power dissipation in the surface material due to leakage current, although very small, assists the evaporation of moisture. In mains-operated or heated equipments, leakage resistance in the surface material may well disappear before its effects become apparent. Unfortunately in practice we cannot separate the two forms of leakage resistance, neither can we, being aware of the effects of time and environment, be very sure of the quality or quantity of the surface material.

Improvement of Existing Materials

We are obliged to consider whether we can improve the conventional materials. The possibility of adding slots in the board was first considered; but this exposes more of the inner material and thus leads to a greater absorption of moisture and worsened leakage.

The most successful results were obtained with a wax treatment of the material. Samples of base materials were immersed in a wax bath at a temperature of 130-150°C for 3 to 5 minutes and a considerable improvement in insulation resistance was obtained. Sample boards, etched and pierced but without components or fixtures, were treated in a similar fashion and the results were equally successful. Even the lowest grade of material gave surprisingly good results when treated and maintained its improved qualities after 200 hours of exposure.

The semi-absorbent nature of the inner material, assisted by some de-lamination which occurs as a result of the punching operation, permits absorption of wax at every hole or edge on the board. The thickness of wax deposited on the board is about .001″. Unfortunately one cannot achieve the same degree of success with wax treatment applied after assembly, because the holes which would provide access to the inner material will be sealed with solder. Some success may be achieved by having open and unoccupied holes or slots at known vulnerable points but an immersion time of at least three minutes may well be impractical with a complete assembly. A "flash" dip of assembled board has very limited value by itself.

Pre-assembly Waxing

The pre-assembly waxing process, though adequately fulfilling requirements for insulation, has a number of disadvantages. Whether these are acceptable will depend on individual considerations of quantity, production facilities and various other factors, not the least important of which will be the standard of quality acceptable for the product. Many manufacturers are using hand soldering processes on printed wiring in quantity production and reduced reject rates and greater reliability are achieved in most cases. The wax treatment of panels to be hand soldered has little effect on the soldering process but the "people who do the work" are sensitive to changes of any sort and some difference will be apparent to them.

The wax treatment may render difficult the utilization of automatic soldering processes. Individual evaluation would probably be necessary for a specific assembly and process.

Although it is normal to complete the board production process with an application of fluxing varnish of some sort, the waxing process makes this impractical and unnecessary. It becomes essential, therefore, that the waxing process immediately

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follows the post-etching cleaning and drying. It replaces the lacquering process both in time taken and sequence of operations.

It is possible that long periods of storage of unassembled boards may make a subsequent soldering operation a little difficult but it is to be emphasized here that the protection afforded by a surface preservative is also somewhat limited. Some unlacquered waxed boards were exposed to extreme conditions of humidity and others left outdoors, in both cases for some days, without any apparent deterioration in solderability.

Mounting of Panels

It is possible that some edges of the board may have excess wax deposits due to the drain-off after removal from the bath. If by misfortune these occur at mounting points, it may be necessary to remove the excess to establish a firm fixing. It is possible of course that arrangements can be made for the board to be drained in such a way that any surplus wax does not build up on the mounting positions.

Conclusion

The pre-assembly waxing should enable use to be made of the lower grades of base material. It may introduce some minor difficulties and inconveniences into a production system but these would appear to be a small price to pay for the degree of success likely to be achieved. The usual care and attention paid to the cleaning and preparation of the surface and the common-sense arranging of foils and holes to isolate vulnerable points in the circuit from high potentials are, of course, still necessary.

TELEVISION AND FILM TECHNIQUES

HIGHLIGHTS AND POINTERS FROM A RECENT CONVENTION

"PENNY plain and tuppence coloured" was definitely the tenor of the convention on television and film techniques held at the Institution of Electrical Engineers on 20th and 21st April, sponsored by the British Kinematograph and Television Societies. Of the eight papers, five were primarily concerned with colour: one other paper contained more than a passing mention, and delegates insisted on raising the subject in the discussion following the two others.

Naturally, great general interest centres on the choice of standards for colour television, and those who favoured an adaptation of the N.T.S.C. system (which, it will be remembered, uses phase and amplitude modulation of a subcarrier to transmit colour information and a.m. of the main carrier for luminance or "brightness") might well have had doubts raised in their minds by the paper and demonstration by Polonsky, Sauvenet and Cassagne. The system was the Henri de France* (or as it is now much less euphoniously known—SECAM) in its latest form. The original system used a.m. of the subcarrier to transmit colour-difference signals, the two signals required being transmitted sequentially on alternate lines of the picture. Changing of the subcarrier modulation to f.m. has resulted, in the main, in a reduction of sensitivity to the effects of noise. Visibility of the f.m. subcarrier has been reduced to the point where, at the moment, it is only 4 to 5dB worse than in the N.T.S.C. system. That the performance of SECAM in the presence of transmission distortions such as phase errors or differential gain effects is vastly superior to N.T.S.C. was demonstrated by the switching-in of such distortions and noise. In the case of a delayed secondary signal (ghost) the amplitude and delay was such that the line synchronizing of one receiver was upset, but no effect on the colour could be seen. It was claimed that the stability of the system was good enough to eliminate the need for either hue or saturation controls; although it was stated by Rodgers (Bush) in discussion that experimental 405-line N.T.S.C. receivers have been made without such extra "colour" controls. A feature of the discussion was the listing, by Maurice (B.B.C.), of points for and against SECAM in comparison with N.T.S.C.: the results were close, being slightly in favour of one system or the other depending on the viewpoint taken for assessment. It is perhaps appropriate at this point to note the gist of Polonsky's reply to another questioner: over the years thousands have worked on N.T.S.C., SECAM has occupied ten or fifteen people only for a shorter time.

Pictures for the demonstrations were generated by a flying spot scanner at the Hirst Research Centre of G.E.C. and transmitted over radio link and cable.

Colour on Record

The recording on magnetic tape of N.T.S.C. signals was the subject dealt with by Roizen (Ampex International) who reviewed the methods employed and described a new technique, which (as he pointed out) like all good solutions to problems, is extremely simple. The major difficulty is that an inaccuracy in phase greater than 5° is unacceptable, and timing has to be held accurate to 0.002μsec. The scheme that was put into operation some time ago is known as "burst lock." On the American standard, about eighteen lines are recorded in one sweep of one recording head: within one line the errors caused by non-uniform head motion could not, due to the inertia of the head system, exceed the permissible limits. Thus by taking the subcarrier reference burst or pulse which occurs during the back porch of each line-sync pulse and "remembering" its phase with a ringing oscillator correct relative information of colour can be achieved for that line. Then this can be translated back to the stable subcarrier reference required for transmission. This must, as is apparent even from the over-simplification above, lead to much "electronic" complication. The new method, though, is very much simpler and was developed from a device called Amtec (AMpex Time Element Compensator). Amtec was designed to remove the "cogging" effect sometimes apparent on recorded vertical edges when a display employing a flywheel line timebase is used. The device uses a lumped-constant delay line whose capacitors are back-biased junction diodes†. Alteration of the bias, and thus the capacitance, provides a continuously variable delay to which the vision signal is subjected. The sync pulses from the tape replay are compared with a source of local, stable sync: when a timing

* *Wireless World*, p. 287, June 1960

† *Wireless World*, p. 361, July 1960.

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error develops, the error voltage is made to change the delay time to compress or stretch out the picture line to its right length, so correcting the "cogging." For colour, the process is carried a step further by comparing, after time correction, the phases of the replayed and local colour burst to develop a "fine" correcting signal.

Another method of registering video signals, in this case by the use of a thermoplastic recording technique‡ was described by Glenn of the General Electric Research Laboratories (U.S.A.). This technique employs a base material of relatively high melting point coated with a thermoplastic film which is softened by r.f. heating. A "picture" is written in the form of surface charges on to the material by an electron beam: the film is then softened and the electrostatic forces caused by the charges form "ripples" which can be fixed by cooling the film below its melting point. Visual reproduction can be achieved with an interference-type optical system giving a picture which can either be displayed on a screen directly or converted to a television signal for transmission. The demonstration used optical projection: a grating is imaged by a lens on to another grating so that the passage of light is blocked. The ripples of the recording diffract the light allowing it to pass through the grating to be focused on the screen.

Colour recordings can be made too: for this the image itself is registered as very fine diffraction gratings. A photograph of a reproduced thermoplastic recording of one of the "standard" test slides was shown.

Colour Techniques

One source of input to a colour television system is likely to be colour film. Grimshaw (British Kodak) read a paper by Veal and Ritchey of Eastman Kodak, in which they described the measures they had found to be advisable in the production of colour films for television. Measurements of the overall transfer characteristic from a flying spot or three-vidicon telecine equipment to a display using the shadow-mask tube were made. One test, for contrast range, was accomplished by taking an "average" scene and punching holes in the transparency. The holes were then covered by known densities to discover, against the background of an average picture, the highlight and "black" shadow levels usable. Other tests discovered the definition realizable, colour rendering and noise level corresponding to grain in the film. Broadly the conclusions drawn were that contrast ratio should not exceed 40:1—corresponding to a key light/general light ratio of about 2:1—and that the sharpness and grain acceptable for the U.S. system could be achieved by 16mm film. Colour rendering capabilities of film and TV are slightly different and, in fact, television covers a greater overall area on the colour triangle.

It appeared from the discussion on this paper that the European television engineer would far rather achieve the down-grading of film's full contrast range by electronic means: then as the system was improved the full potential of the film could be employed. The reduction in contrast range necessary would be achieved by a luminance feedback "compression" system: if this were employed with an improved TV system to "restore" a film specially produced for television, it would have to be a type of positive feedback and thus would be difficult to control.

Davies (Kodak) described a compact new machine for the fast processing of black-and-white film for television: the technique makes use of viscous solutions applied to the film.

Stanley and Treays (B.B.C.) gave a thorough account of the experimental programmes broadcast by the B.B.C. since 1954. The purpose of these tests was to assess the 405-line version of the N.T.S.C. system and also to discover its artistic possibilities. Many of the techniques for studio productions turned out, in fact, to be similar to the techniques for using colour film, although, judging from the account, some of the "subjective" effects of colour (the influence of the appearance of one colour by another) may well prove rather more serious under television conditions. This paper was followed by Stanley and Watson (B.B.C.) reviewing some of the equipment problems and techniques, illustrated by N.T.S.C. colour signals from Lime Grove thrown on a 12×9ft screen by a new Marconi projector.

One objectionable form of distortion is that which results from gain inequalities at different signal levels—in a black-and-white system this distorts the relative contrast between tones but normally is not obvious. The effect on a colour picture of a change of gamma from 0.6 to 0.4 (demonstrated by Stanley and Watson) was to alter a peaches-and-cream complexion to florid, almost fevered appearance! Shading signals, which have to be applied to enable a camera to reproduce an even field of illumination, can result in spurious colours in patches of low luminance. Great care has to be taken here and one solution might be to "common" the red, green and blue signals at low levels. Phase distortion, too, is most important—a shift of 5° in subcarrier phase can produce objectionable colour changes; also the behaviour of a receiver's detector when presented with components in quadrature can, with positive vision modulation, reduce the saturation of colours. However, the fact that it is possible to make a system which produces good results was demonstrated by the switching into the link carrying the demonstration picture of two low-power transmitters and two receivers, all in series. The major effects (and the large picture was being viewed from only thirty feet away) were a slight reduction in saturation and a rise in noise level.

Large-screen Projectors

The slides used in the demonstration were followed by two films which, due to their content, must have placed severe demands on the system and the projector which, incidentally, used three English Electric c.r.t.s with Schmidt optical systems. Beam current was 1mA maximum for each tube (at 50kV e.h.t.) and a screen brightness of about 5 foot lamberts was realized. The definition achieved was a great advance on earlier systems too—the potentialities of the 405-line system were fully realized.

Another large-screen demonstration, again on 405 lines, featured the Eidophor projector. Baumann, of the Instut für Technische Physik der ETH, Switzerland, described how a beam of electrons, modulated by the video signal, builds up a picture upon a rastar scanned out on a uniform oil film on a mirror, so causing the oil film to be distorted, by electrostatic effects, in proportion to the modulation. An interference-type optical system, using a Xenon lamp, projects the picture, although in this case the light is reflected from the mirror through "rippled" film. The oil is chosen to have a charge-decay time similar to one field of the picture, and, as it is damaged by the bombardment of the beam it is constantly changed by rotation of the mirror and an oil-circulation system. A recent improvement is the use of focus-modulation of the electron beam by an electrostatic lens: when black is required, the beam is out of focus and has little effect on the oil. However, for high brightness the beam is focused sharply and so exerts a greater effect on the oil film.

Once again, the resolution made full use of the 405-line system and it must be recorded that, after demonstrations of both the Eidophor and Marconi projectors, questioners asked whether the standard used was 625 lines. Field interlace was excellent in both cases.

Finally, to conclude this short report, may we ask why the cobbler should *always* be the worst shod of men? Lecturers were put at a disadvantage by several failures of slide-projection arrangements (it is greatly to their credit that they were not too put out) and the sound reinforcement system behaved, throughout the two days, in a manner that would have disgraced a village fête, let alone the I.E.E.

‡ *Wireless World*, p. 196, April 1960.

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U.K. TELEVISION LINKS

POST OFFICE DISTRIBUTION NETWORK

By W. L. NEWMAN*

ALTHOUGH the B.B.C. and I.T.A. are individually responsible for providing and operating their television stations, the links between studios and transmitters and between stations in each network are provided by the Post Office which is, of course, also responsible for the links between the B.B.C.'s sound broadcasting stations.

The development of the Post Office television network commenced in 1937, the year after the start of the television service, when a cable of the balanced pair type was laid between various points of interest in London. This ran between Westminster Abbey, Buckingham Palace, Hyde Park, Broadcasting House and the transmitter at Alexandra Palace and was used to televise the Coronation in that year.

The first inter-city television link was provided in 1949 between London and Birmingham. This has now grown to a national network covering the whole of Britain and Northern Ireland, with a connection to Lille in France forming the British Post Office component of the Eurovision chain. It includes 2,500 miles of cable and 2,200 miles of radio circuits used for the distribution of the vision signals. Corresponding networks have been set up for the associated sound and control lines, which are an essential part of the circuits provided for the broadcasting authorities, and these, for the B.B.C. and I.T.A. services combined, account for 10,000 circuit miles. The sound and control circuits are provided over cable links, even when the vision circuits with which they are associated are carried by a radio system.

The main Post Office inter-city circuits are routed between

(Crown copyright reserved)

The radio and cable links in the U.K. television network. Where a station relies on the reception of a nearby transmitter for its programmes (in Post Office parlance, R.R.B.—radio re-broadcast) no link is shown. The links between the terminal points and the transmitters are a combination of radio and cable.

* Post Office, London Telecommunications Region.

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Network Switching Centres (N.S.Cs), of which there are about 12 covering the country. Of these, London, Birmingham, Manchester and Carlisle are the largest. Between the N.S.C.s are provided a number of vision and sound channels in each direction; these can be interconnected to provide tandem connections between selected points. The vision channels must have a 3-Mc/s bandwidth to carry a 405-line signal with minimum distortion and the sound channels 10 kc/s. The inter-city channels are rented by either the B.B.C. or the I.T.A. Radiating from each centre are a number of circuits to and from the local studios and broadcast transmitting stations, each link being rented by the appropriate authority. In addition, the B.B.C. and the programme contractors, who provide the I.T.A. programme material, usually have a Programme Switching Centre (P.S.C.) in the main towns. The function of these centres is broadly similar to that of the N.S.C., but deals with a small group of studio connections, and a circuit to the local broadcast transmitter via the N.S.C.

Circuit Routing

The day to day work performed by the Post Office, in setting up and controlling the circuits, varies according to the authority concerned. The B.B.C. television service is essentially a national one, with only a small number of locally produced and transmitted programme items. Therefore, the circuits rented by the B.B.C. are connected from the N.S.C. through to the Corporation's premises; the B.B.C. then retains control of them, unless a fault develops, until the completion of the day's programme. Any inter-connection of circuits is performed by the B.B.C.'s own engineers, as required.

The I.T.A. service is based on regional units, each region being served by a programme contractor, the I.T.A. being responsible only for renting the inter-city and broadcast transmitter circuits. The individual programme contractors rent from the Post Office the circuits to link their studios and P.S.Cs. The I.T.A. programme in any one region is provided by the local programme contractor who is free to sell or buy programme material from any other contractor in the country. To inter-connect the various regions, the I.T.A.-rented circuits are used, and it is the responsibility of the Post Office to link these circuits as required. This is done on a time basis, so that the appropriate programme material is available at the right time and place.

The Post Office also provides circuits for organizations who perform specialized work for the various companies, one such unit provides a video-tape recording service.

The Post Office may be asked to establish a circuit between a studio and a recording unit so that a particular programme may be recorded for use later or for sending abroad for use by other television services. Other companies provide studio facilities which can be hired for use by advertising agents or for closed-circuit television demonstrations, here again the Post Office provides the links.

Another type of circuit requirement is the provision of channels to viewing rooms. These circuits are provided on normal telephone plant using ordinary subscriber's pairs, outside broadcast amplifiers being used to provide the necessary equalization and gain for a bandwidth of 2.5 Mc/s. These rooms are usually owned or rented by programme contractors whose operational region is not London. They are used to show either broadcast or closed-circuit programmes from their own studios and the Post Office has to provide a circuit from, say, Manchester, to the appropriate viewing room in London.

The main distribution, as explained earlier, is by means of cable and radio system. In general coaxial cables are used for the land line portion of the vision circuits, but there are a few balanced pair cables still in use. The vision signals can readily be carried over coaxial cables at video frequency up to a distance of 15 miles and development work indicates that this will soon be extended.

The main connections between the studios, broadcast transmitter and the programme switching centres in one area radiate from the network switching centre using unbalanced transmission on coaxial cables. The size of the cable may be 0.163in, 0.375in or 0.975in in diameter, depending on the installation, the equalization and gain in the amplifiers being adjusted according to the type used. One of the chief disadvantages of this type of transmission was the induced 50 c/s signal from mains cables, but this difficulty has been overcome by the use of large coaxial chokes at each amplifier point which effectively suppress the longitudinal current in the cable sheath. The signals carried on the coaxial cables are amplified at intervals, usually in telephone exchange buildings, if one is conveniently placed, or in repeater stations erected for this purpose.

For longer distance transmission, because of interference to signals below 10 kc/s on coaxial cables, the vision signals are shifted to a higher frequency band using a vestigal sideband transmission system. By a modulation process the video signal is transformed to another range, the limits of which vary with the system employed. Various line frequency standards are employed, the most common being 0.5-4.0 Mc/s with a 1,056 Mc/s carrier frequency, whilst the first system between London and Birmingham has a 3-7 Mc/s band and a 6.12 Mc/s carrier frequency. At the receiving end of a long-distance system a demodulation process restores the video signal. All main line transmission systems have duplicated equipment to guard against failure.

The radio systems vary because of rapid developments in this field, but the main equipments are built to operate in the 2000 and 4000 Mc/s bands, with an intermediate frequency of 70 Mc/s. These systems are frequency modulated using equipment designed in the Post Office Research Station. The original London-Birmingham radio system which was recently replaced by more modern equipment, used carrier frequencies in the 900 Mc/s band and an intermediate frequency of 34 Mc/s.

In the case of the radio equipment some of the earlier systems have complete standby transmitters and receivers, the later systems, however, usually have a complete reserve available from end to end known as a protection channel. This is a separate link working at a different carrier frequency and can be taken into service, either automatically or by manual operation, in the event of a failure.

The London Television Network Switching Centre is situated in part of the Museum Exchange building and comprises a repeater station where the cable systems terminate, a radio station on the roof,

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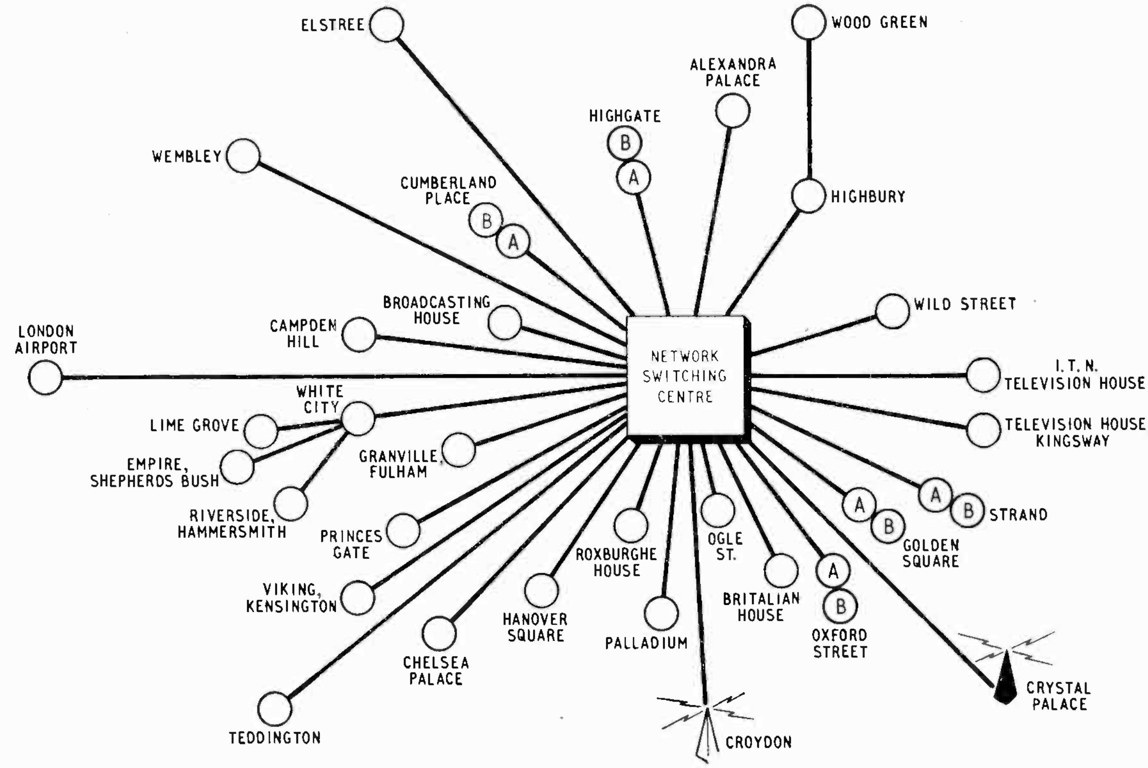

Permanent cable links from the London Network Switching Centre to the television transmitters, studios and centres of entertainment in the London area.

a sound amplifier room, and a control room. The repeater station, besides housing the amplifier and translation equipment, has extensive supervisory apparatus to assist the maintenance engineers in their work. The main cable systems are provided with amplifiers at distances of either three, six or 12 miles, mainly in unattended stations. Any abnormal condition in these stations is signalled over a supervisory circuit to the Centre and remedial action is started. Where there are reserve amplifiers in distant stations they are automatically switched into circuit to cure a fault, or they can be operated remotely from the Centre over other supervisory pairs. Power faults in remote stations are also signalled and standby diesel-powered generators automatically start and supply power if the local mains supply fails. Extensive supervisory equipment is also provided on all the radio systems so that faults can be quickly detected and corrected. On some systems the switching of the protection channel is controlled by detecting the 10.125 kc/s synchronising pulses at both input and output of the system and using these signals to control the switching circuit.

London Focal Point

The Control Room in the London centre is the terminal point of the incoming and outgoing vision links, which now number over 100. In addition there are over 250 sound and 300 control lines. This room is the focal point of the work in the station and the point from which the cable and radio links are operated. Upon the engineers here and their colleagues in other stations, depend the television services for the country. Two test consoles in the room are equipped with the apparatus to carry out the routine testing of the circuits.

The engineers have a group of 15 picture monitors in front of them which allow them to keep a constant watch on the signals passing through the station. In addition they have monitors and c.r.o.s built into the consoles so that detailed examination of a signal can be undertaken. From the video distribution rack behind them, the engineers can instantly connect any circuit to their test equipment.

On a number of vision circuits, remotely operated vision test signal generators are provided, so that a maintenance engineer is not required to visit distant stations for routine work. One such circuit provided with this type of equipment is the circuit from London Airport which is rented by the B.B.C. When this is required for service, at any hour of the day or night, operation of the appropriate switches will connect a waveform generator in Queens Building to the outgoing circuit. On completion of the lining-up procedure, the circuit will be connected direct to the camera by restoration of the switches. Between London Airport and the London N.S.C. there are four intermediate amplifier points, each with reserve equipment. These reserve amplifiers can also be switched into circuit from the control room. Tests are applied to all sound and vision circuits at regular intervals, vision circuits being tested daily.

In a side room off the control area is the Automatic Network Distribution Equipment (A.N.D.E.). This is provided to switch the I.T.A.-rented inter-city links to the various programme contractors who wish to send programmes to, or receive programmes from,

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the I.T.A. network. Incidentally, "networking" has resulted in the growth of switching operations from 136 in May, 1956, to 4,540 in April, 1961. The equipment is divided into sound and vision components and can cater for changes of routing from any of 15 sources to any one or all of 15 destinations, in any order. Three changes of routing can be set up at the beginning of each day and at any time subsequently two changes are always available in advance. The times at which changes can be made can be set to take place at intervals of ten seconds if necessary. The electronic clock mechanism, which is driven from the 50 c/s mains supply, is automatically synchronized by TIM every ten seconds. To ensure complete reliability, two clocks are provided and the indications of these are continuously compared electronically, any deviation being detected and the faulty clock switched out of service until the fault is corrected, during which time manual switching operations are carried out. Instructions for the operation of the equipment are received from the I.T.A. on a daily schedule; this is amended as required during the day. A news item of major importance can mean the complete rearrangement of an evening's switching schedule; fortunately this is a rare occurrence. Switching operations have to be carried out in a period of three seconds and are usually completed ten seconds before a minute and frequently are required to provide networking conditions for the start of a new programme concurrent with the end of the previous item.

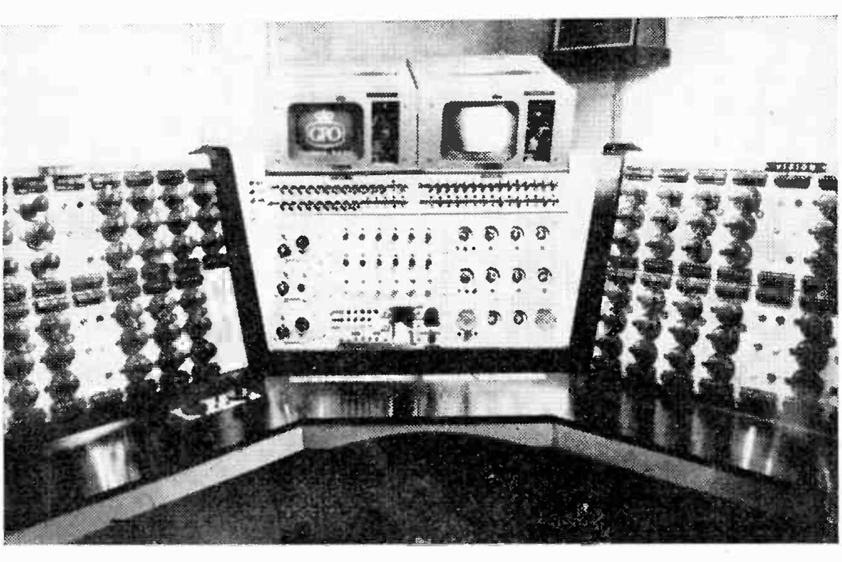
The Automatic Network Distribution Equipment incorporates two vision picture monitors, one of which can be switched by the controlling engineer to any of the signal sources and the other to the destination signals. In addition, a high-quality music amplifier and loudspeaker allows the various sound signals to be monitored. The engineer is able to check both sound and vision before and after a switch operation to ensure that it has been successfully completed.

On coaxial cable systems, to reduce the risk of breakdowns to equipment in remote repeater stations due to mains supply failures, it is only at what are known as power-feeding repeater stations that power is taken from the local supply. These repeaters are usually in towns and from these power is fed at high voltage over the coaxial cable itself to the other repeater stations. At the dependent stations the supply is transformed to a voltage suitable for the local amplifying equipment. At the power-feeding stations, diesel-powered generators are installed and these are automatically switched into service in a period of ten seconds in the event of a mains failure.

Coaxial cables are liable to damage due to road works and by working parties of other public utilities. To give early warning of damage which might interrupt a service, all cables are continually monitored to check their insulation. In addition, on the latest installations, the cables are kept under pressure from a gas reservoir and any damage causes an alarm indication to be given. Also, the escape of the gas limits the amount of damage which can be caused by water, if present. Everything is done to reduce the risk of accidental damage but emergency repair teams are available in all parts of the country to go to the site of any damage. In London the external repair team can keep in touch with the Centre by means of mobile radio equipment in their vans. The fixed station on this system is at Harrow Weald, which is the first intermediate amplifier point on the London-Birmingham radio link system; this is controlled over a land line from the London Network Switching Centre.

Besides the permanent television distribution network, the Post Office also provides a large number of vision and sound circuits on a temporary basis for use from outside broadcast sites. Some of these sites are in regular use and permanent cable facilities are provided, the amplifying equipment being provided only for the duration of the broadcast, however. Other broadcasts need the use of temporary circuits established on ordinary underground telephone wires. Such circuits can be provided using up to three miles of cable, with variable equalization amplifiers at mile intervals. Some O.B.s use a combination of various types of transmision equipment, perhaps starting from a site using a normal telephone pair to the nearest hilltop, where the signal is injected into a portable microwave radio link, which carries the signal to a receiver positioned near a repeater station on a permanent coaxial cable system, where the signal, in turn, is fed into the main distribution network.

In addition to providing vision circuits for the present standards, a number have been installed to carry 625-line signals. Some of these circuits are used for recording purposes, the tapes being intended for use abroad, others are for closed-circuit work.



Combined vision and sound control position at the London Network Switching Centre which is housed in the Museum Telephone Exchange off Tottenham Court Road.

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MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

High-impedance Voltmeter

THE Electrosensor voltmeter developed by the American firm of Halex is, in essence, a highly sensitive, unity gain amplifier. The electrometer-valve input stage is followed by three unity gain cathode-followers, the earth of each forming the screen for the succeeding stage. Each screen is connected to one of three guard rings on the coaxial input socket, and as each has impressed on it a voltage very nearly equal to that at the input, the impedance is very considerably increased. This same technique also serves to decrease the input capacitance, and the overall effect is a very high-impedance, short time-constant input.

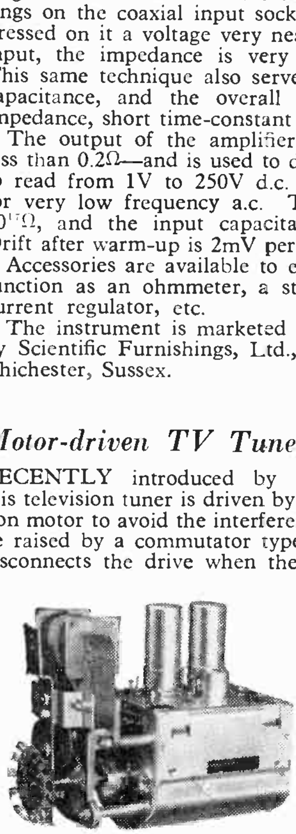
The output of the amplifier is at low-impedance—less than 0.2Ω—and is used to drive a meter, switchable to read from 1V to 250V d.c. full-scale, or 500V p.p. for very low frequency a.c. The input impedance is 10^{17}Ω, and the input capacitance less than 0.01 pf. Drift after warm-up is 2mV per hour.

Accessories are available to enable the instrument to function as an ohmmeter, a static charge indicator, a current regulator, etc.

The instrument is marketed in the United Kingdom by Scientific Furnishings, Ltd., West Hampnett Road, Chichester, Sussex.

Motor-driven TV Tuner

RECENTLY introduced by the Plessey Company, this television tuner is driven by a mains-powered induction motor to avoid the interference problems that would be raised by a commutator type. An automatic clutch disconnects the drive when the motor is switched off, allowing the indexing mechanism in the tuner to exert full control. Remote push buttons or a rotary switch can be used for channel selection and the tuner has the valuable advantage that, as it does not require fine tuning, it can be placed anywhere in the receiver.



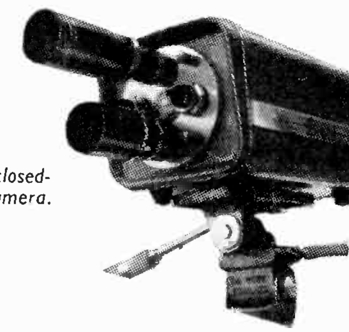
Plessey motor-driven turret tuner.

The tuner uses frame-grid valves and Band II v.h.f., as well as TV, channels can be incorporated. A complete rotation takes only seven seconds.

The Plessey Co., Ltd., Ilford, Essex.

Closed-circuit Television Camera

THE "Nashton" Mark I industrial closed-circuit television camera provides a signal which can be fed directly into a standard 405- or 625-line domestic receiver (preferably without flywheel sync) covering Band I. Costing £275, this camera is only 13½×7¼×7¼in and is completely self-contained. A Vidicon-type tube is used and the standard lens fitted to the four-position turret has an aperture of f/1.9, the 1in focal length giving a horizontal field of view of 28° (at 10ft this corresponds to an area 5ft by 3ft 9in). As is common practice, the time bases used are not locked together—the resulting pictures are thus not interlaced. Resolution is about 300 lines overall.



Nashton Mk I closed-circuit television camera.

Nash and Thompson, Ltd., Hook Rise, Tolworth, Surrey.

Safe Grease Solvent

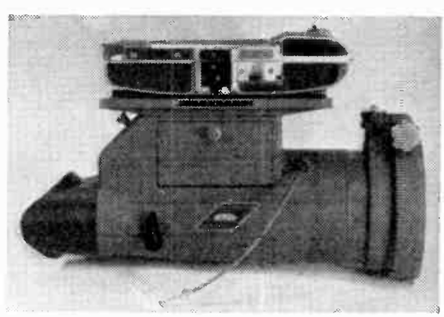
CHLOROTHENE NU, marketed by Penetone-Paripan, is a form of methyl chloroform and has valuable advantages as a solvent for oils, greases and waxes.

The solvent evaporates quickly and is claimed to leave no residue liable to cause tracking. In addition it is far less toxic than the ubiquitous "carbon tet." Comparable maximum allowable atmospheric concentrations are 25 parts in 10^6 for carbon tetrachloride, and 500 parts in 10^6 for methyl chloroform. It is non-inflammable.

Penetone-Paripan, Ltd., Egham, Surrey.

Oscilloscope Cameras

AVELEY Electric are to market two oscilloscope cameras manufactured by Du Mont. The type 299, which accepts 120 roll- or cut-film, is for general recording from a 5in tube, while the type 302 incorporates a Polaroid-Land back, and will deliver a finished print



Du Mont type 302 oscilloscope camera. A pointer shows the position of the sliding back in relation to the lens.

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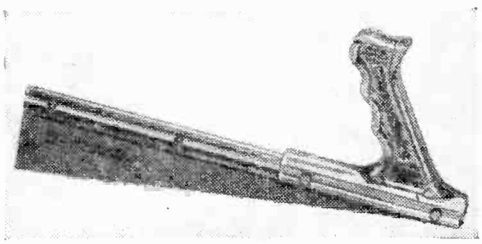
on transparent or opaque film within one minute. Both cameras have a sliding back which facilitates the recording of more than one trace on each frame. Either an f/2.8 three-element Wollensak Du Mont or an f/1.9 six-element lens is available, both of 75mm focal length. Adaptors enable the camera to be used with most 5in oscilloscope tubes. Aveley Electric, Ltd., Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.

Saw for Cutting Sheet Material

THE ordinary hacksaw is inconvenient for the hand cutting of sheet metal or insulating material because the frame gets in the way—this can lead either to the use of blades without a frame or a wood saw, neither of which is the best of tools for the job. Stead's



"Steadfast" sheet saw.

"Steadfast Sheet Saw" employs replaceable 12in-long triangular blades (14 or 24 teeth/in), supported by a "spine"—the edge bearing the teeth is thus presented at the correct angle for cutting without the necessity for the spine to pass through the material being cut. The saw can be used for cutting unlimited length of flat or corrugated sheet as well as being suitable for most of the jobs for which a hacksaw is normally used.

J. Stead and Co., Ltd., Manor Works, Cricket Inn Road, Sheffield, 2.

Pulse Generator

WITH rise- and fall-times of 15 and 20 millimicroseconds respectively, the Wayne-Kerr Short Duration Pulse Generator P131 has many applications in computer development and pulse work generally. The pulse recurrence frequency may be from 50 p.p.s. to 50 k.p.p.s., while the pulse widths available are from 50-1,000 millimicroseconds. The output amplitude is variable in 0·5 dB steps between 0·1V and 10V at an impedance of 75 ohms, while a high level output of up to 40V is available at a source impedance which varies between 50 and 100 ohms. Facilities for pre-pulse, delay and external triggering are provided. Details are obtainable from Wayne-Kerr Laboratories, 44, Coombe Road, New Malden, Surrey.

High-speed Printer

A PRINT-OUT unit capable of operation at a speed of over 10 lines/second has been developed by Solartron. Fourteen columns are printed by continuously-rotating print wheels, which are struck at the required times by hammers. No reset mechanism is employed; as the next available character moves to the correct position on any print wheel, printing begins, no waiting being necessary. The equipment is in two sections—the printing machine proper and the electronic rack in a separate case. Inputs may be either decimal or binary at a voltage of -6V to -12V and the print command signal required is a 6V, 1 msec, negative-going pulse. The equipment is produced by the Solartron Electronic Group, Ltd., Victoria Road, Farnborough, Hants.

Wide Band Oscilloscope

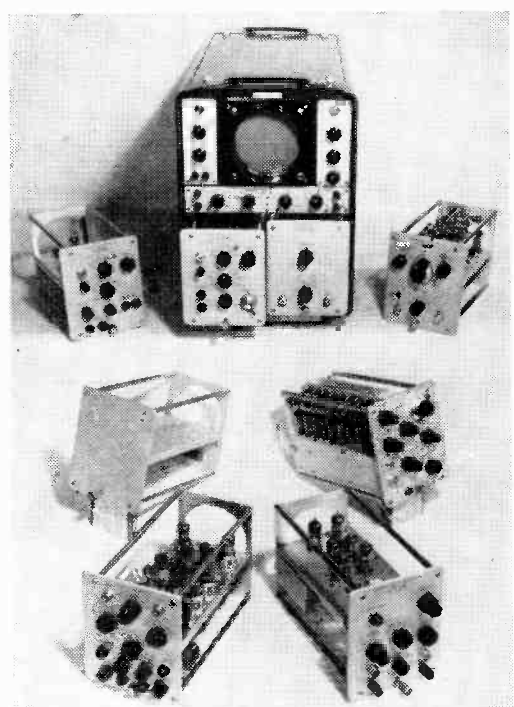
THE Cossor 1076 oscilloscope continues the trend towards a high quality basic instrument with plug-in extension facilities. An extremely wide frequency response (d.c. -60Mc/s at -3dB) is coupled with a sensitivity of 50mV/cm, which it is possible to increase to 5mV/cm while still retaining a bandwidth of d.c. -40Mc/s. Voltage and time are calibrated within $\pm 2\%$ and $\pm 3\%$ respectively, and a useful feature is the provision for Z-modulation at frequencies of 50Mc/s and 500Mc/s.

The 5in-diameter tube is operated at 10kV, the useful area being 6cm $\times$ 10cm. All the usual facilities are provided—illuminated graticule, spot-position indicators, etc., and outputs provided are the amplified Y signal, and the gate and sawtooth waveforms of the timebase. Signal delay, of 150msec, is by a specially developed distributed-constant delay cable.

Extension Y facilities available include a high-gain amplifier, which affords a sensitivity of 1mV/cm from d.c. to 1Mc/s, and which has two input sockets. The inputs may be viewed separately, or combined differentially, in which case the common-mode rejection ratio is of the order of 80dB up to 50kc/s. A dual channel unit is also available which provides for the viewing of two inputs separately, algebraically added, or simultaneously by chopping or beam-switching on alternate sweeps.

A comprehensive range of triggering and delay facilities is provided by three X units. In addition to the normal triggering and windowing modes at a minimum signal level of 2mm deflection, or 0.2V external trigger, two calibrated units provide for sweep delays of from 2μsec/cm to 1sec/cm, with the delaying sweep brightened over the portion to be expanded.

The instrument is manufactured by Cossor Instruments, Ltd., Cossor House, Highbury Grove, London, N.5. The oscilloscope with the wide-band preamplifier and general-purpose trigger unit costs £650.



The Cossor 1076 wide band oscilloscope, with its range of plug-in units, which extend the X and Y performance.

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Transformer-Ratio-Arm Bridges

USE IN THREE-TERMINAL IMPEDANCE MEASUREMENTS

By J. F. GOLDING*

BRIDGES of the transformer-ratio-arm type are not by any means new. Indeed, the system was the subject of a patent by Blumlein as long ago as 1928. The author first encountered a bridge of this type—an armed-forces instrument designed by E.M.I.—during the early years of the war. It was then known as the *in situ* bridge because its three-terminal-measuring facility permitted measurement of a circuit-component's value without disconnecting it.

The transformer-ratio-arm bridge has a number of other important attributes; but, as the three-terminal facility is probably the most impressive, let us consider the derivation of the bridge from this point of view.

Three-Terminal Measurements.—The requirement for three-terminal measurement arises when the impedance to be measured is in parallel with some unwanted impedance. A typical example is the stray shunt capacitance between test leads or terminals that often makes measurement of low capacitance somewhat uncertain. The effect of this unwanted shunt impedance can be eliminated if it can be divided into two elements in series, with their junction connected to a neutral point in the bridge.

The rudiments of this kind of three-terminal measurements can be illustrated by examination of the circuit arrangement shown in Fig. 1. G is a zero-impedance voltage source generating an e.m.f., E, which causes a current I to flow in the unknown impedance, Z_u. This current is monitored by a zero-impedance meter M. Thus the impedance of the unknown is obviously given by E/I.

But the dotted lines show, in parallel with Z_u, the series combination of two unwanted impedances, Z_1 and Z_2. The effect of this shunt impedance is, however, obviated by connecting the junction of Z_1 and Z_2 to the neutral line. Z_1 is then connected directly across the source, and Z_2 is across the current monitor. It is manifest that, since the source has zero impedance, the p.d. across Z_1 must be equal to E; and, as no p.d. can be developed across the zero-impedance meter, there is no current flowing in Z_2. So neither of these unwanted impedances can effect the accuracy of the measurement.

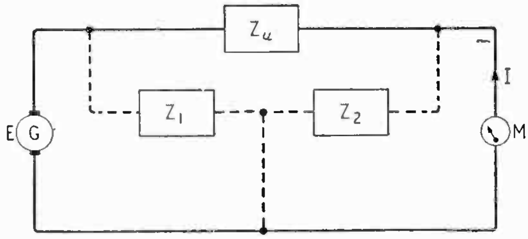

Fig. 1. Basic three-terminal-measurement system.

That this idealized arrangement could not be used in practice is too obvious to justify further comment; but the principle demonstrated can be applied to practical bridge systems.

The arrangement of a conventional impedance bridge with resistive ratio arms is shown in Fig. 2(a). This form is very well known, the conditions for balance being $Z_u/Z_s = R_1/R_2$, where Z_u is the unknown, Z_s is the standard impedance, and R_1 and R_2 are the ratio arms.

Applying Thevenin's theorem, the equivalent circuit shown in Fig. 2(b) can be derived. Here the resistive ratio arms are replaced by two e.m.f. generators producing voltages, E_1 and E_2, equal to those appearing across the respective ratio arms at balance. The equivalent resistance of the ratio arms is represented by R_r between the detector and the junction of the two generators, the value of R_r being that of the two ratio-arm resistors in parallel.

It is conceivable that the values of the ratio-arm resistors could be made so small that R_r became negligible compared with the other impedances in the circuit. The equivalent circuit in Fig. 2(b) could then be redrawn as shown in Fig. 2(c).

In this last diagram the series combination of unwanted stray impedances, Z_1 and Z_2, is also shown in dotted lines, their junction being taken to the point in the circuit where the detector joins the ratio arms; i.e., point C in Figs. 2(a) and 2(b).

Part of the circuit in Fig. 2(c) is drawn in heavy line; and this part is recognizable as being very similar to the circuit in Fig. 1. The essential difference lies in the fact that, in Fig. 2(c), the current in the unknown impedance is not monitored directly; instead it is balanced by the current in the standard impedance Z_s. But the same arguments regarding the cancellation of the unwanted stray impedance apply to both circuits. Although, in practice, the detector in Fig. 2(c) would not have zero impedance, this would not affect the accuracy of three-terminal measurements because no p.d. is developed across the detector when the bridge is balanced, and thus no current flows in Z_2.

However, reduction of the ratio-arm resistance to the point where R_r is negligible is not practical in a conventional bridge; for, to obtain a workable

* Marconi Instruments Ltd., St. Albans.

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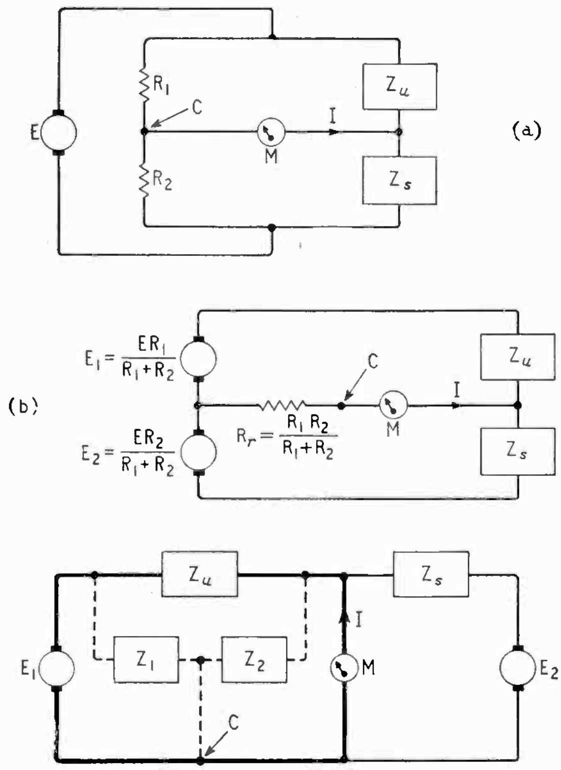

(c)

Fig. 2. (a) Conventional Impedance Bridge. (b) Equivalent circuit of conventional bridge of Fig. 2(a). (c) Equivalent circuit of conventional bridge when R_r of Fig. 2(b) is negligible.

sensitivity with such an arrangement, the current in the ratio arms would have to be very high indeed. And, if R_r has an appreciable value, the stray impedance Z_1 appears across the generator E_1 and R_r in series. The current flowing in the unknown and the detector due to E_1 is then reduced by the loading of Z_1, thus affecting the accuracy of the bridge.

It becomes evident, therefore, that in the practical bridge the impedance of the detector is of secondary importance from the point of view of three-terminal measurements, whereas the impedance of the ratio arms is very important. And the problem resolves into one of producing two voltages, having a constant ratio, from very-low-impedance sources.

This is easily achieved by replacing the resistive ratio arms by a pair of secondary windings of a voltage transformer as shown in Fig. 3. Such a bridge closely approaches the ideal of Fig. 2(c). For, providing the leakage inductance and losses in the voltage transformer are small, the loading of an unwanted impedance, Z_1, across one ratio-arm winding is distributed proportionally between the windings, and the voltage ratio remains constant.

Circuit Arrangements

Tapped Voltage Transformer.—In the basic circuit of Fig. 3, the standard impedance, Z_s, must be varied to achieve balance. Indeed, the impedance

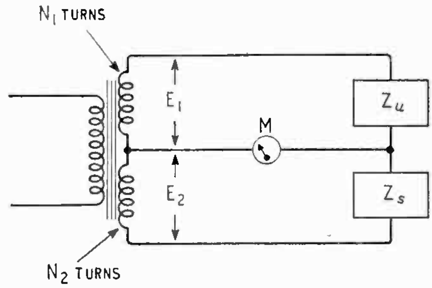

Fig. 3. Basic circuit of transformer-ratio-arm bridge.

range of the bridge is determined by the range over which the standard can be varied.

A variable-impedance standard is costly, complex, and susceptible to errors. Many conventional bridges are therefore built with fixed standards and variable ratio arms; and this system is ideally suited to the transformer-ratio-arm bridge. Fig. 4(a) shows a simple bridge in which a fixed standard is used and the voltage ratio is varied by the use of a tapped winding on the transformer.

The number of turns in the winding feeding the unknown is N_1, and the winding feeding the standard impedance is tapped at N_2 turns, so that the conditions for balance are:—

$$\frac{N_1}{N_2} = \frac{Z_u}{Z_s} \quad \text{or} \quad Z_u = \frac{N_1 Z_s}{N_2} \quad \ldots\ldots\ldots\ldots (1)$$

Thus, the effect of switching the standard impedance through 10 tappings, spaced equally over the winding as shown in Fig. 4(a), is equivalent to changing its value over a range of 10 to 1 in equal steps.

By using a number of standard impedances having decade relationships to each other a multiple-decade bridge can be made. Such an arrangement is shown in Fig. 4(b). This diagram shows three standards Z_{s1}, Z_{s2}, and Z_{s3}, whose values are such that $Z_{s1} = 10Z_{s2} = 100Z_{s3}$. The effective admittances—N_2/N_1Z_s—of these standards can be added together.

To simplify the expression for balance conditions of such a bridge, let the ratio N_1/N_2 for Z_{s1} be written n_1, that for Z_{s2} be n_2 and that for Z_{s3} be n_3. The expression then becomes:

$$\frac{1}{Z_u} = \frac{1}{n_1 Z_{s1}} + \frac{1}{n_2 Z_{s2}} + \frac{1}{n_3 Z_{s3}} \ldots\ldots\ldots\ldots (2)$$

Tapped Current Transformer.—If the bridge is intended to cover a wide range of impedances or if more than three significant figures are required, a practical difficulty arises due to the wide divergence of standard-impedance values. This is overcome by feeding the detector via a current transformer with a tapped primary winding as shown in Fig. 4(c).

Here the unknown is connected at N_3 turns, and the standard is connected to a tap at N_4 turns. The voltage across the secondary winding of the current transformer is proportional to the difference between the flux due to the current in Z_u and that due to the current in Z_s. This can be expressed as:—

$$\frac{N_1 N_3}{Z_u} - \frac{N_2 N_4}{Z_s}$$

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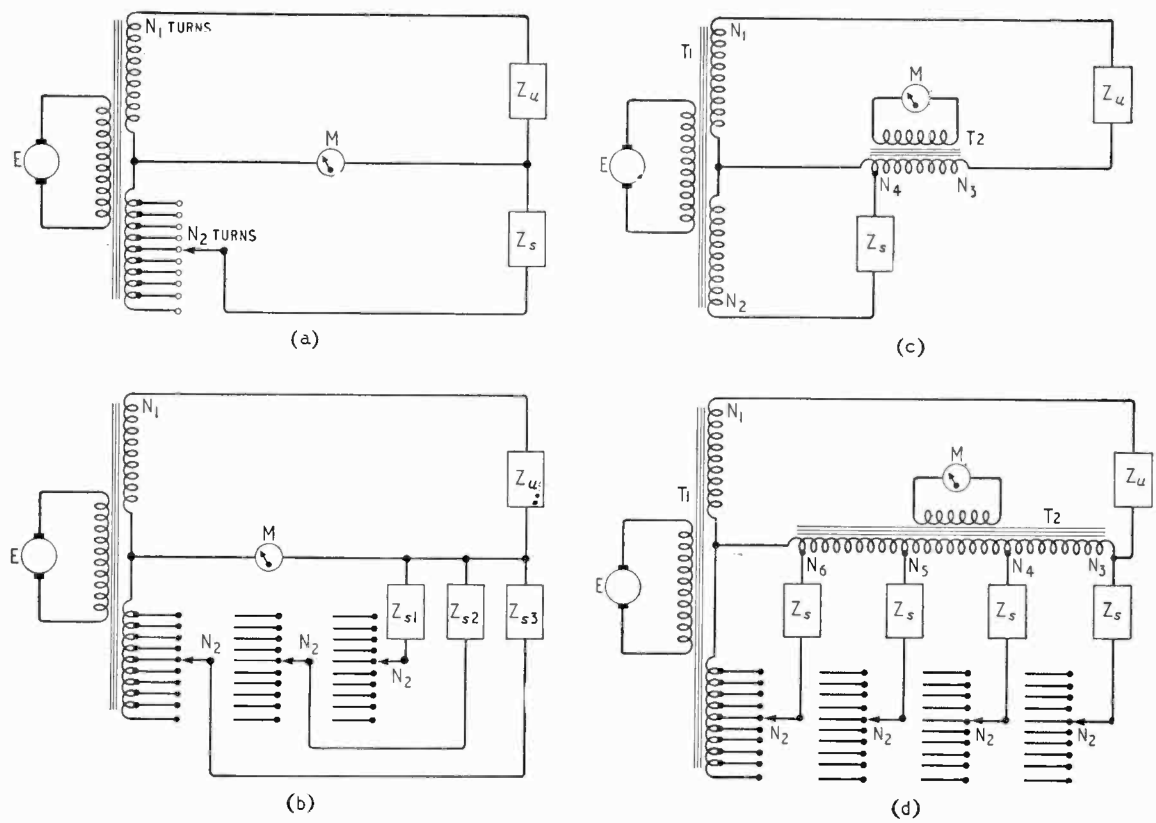


Fig. 4. (a) Use of a tapped-ratio-arm winding instead of a variable standard. (b) Use of three standards to give a three-decade read-out. (c) Use of a tapped current transformer T2 to increase the effective value of the standard Z_s. (d) Application of Fig. 4(c) to give a four-decade read-out.

Equating this to zero, the balance-condition expression becomes:—

$$Z_u = \frac{N_1 Z_s N_3}{N_2 N_4} \quad \ldots\ldots\ldots\ldots \quad (3)$$

Comparing expression (3) with expression (1), it is evident that the effective value of Z_s, has been changed by the ratio N_3/N_4.

It follows, then, that a number of tappings on the current-transformer primary winding can be used in order to provide decade-impedance steps. Fig. 4(d) shows the application of this reasoning. The primary winding of T2 has N_3 turns, and it is tapped at N_4 turns, N_5 turns, and N_6 turns, where $N_4 = N_3/10$, $N_5 = N_3/100$ and $N_6 = N_3/1000$.

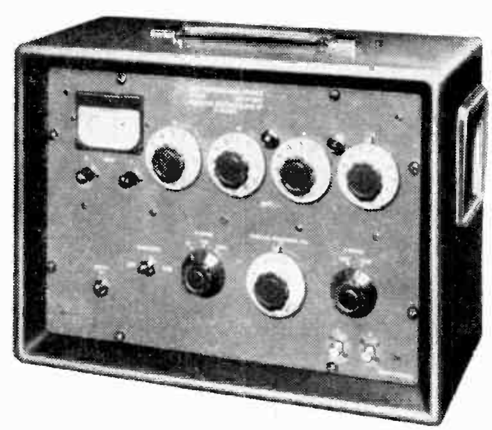
Four standards are used having an equal impedance value, Z_s. But, due to the action of T2, their effective impedances are in decade relation. The balance-condition expression is thus a composite of expressions (2) and (3) as follows:

$$\frac{1}{Z_u} = \frac{1}{n_1 Z_s} + \frac{N_4}{N_3 n_2 Z_s} + \frac{N_5}{N_3 n_3 Z_s} + \frac{N_6}{N_3 n_4 Z_s} \quad \ldots\ldots \quad (4)$$

It has already been stated, however, that the turns at N_3, N_4, N_5 and N_6 are in decade relationship. This being so, the general expression (4) can be simplified to:—

$$\frac{1}{Z_u} = \frac{1}{Z_s}\left(\frac{1}{n_1} + \frac{1}{10n_2} + \frac{1}{100n_3} + \frac{1}{1000n_4}\right) \quad \ldots\ldots \quad (5)$$

Complex Impedances.—Any complex impedance measured at a single frequency can be resolved into an equivalent series or parallel network; and it has already been shown that the transformer-ratio-arm bridge indicates the sum of the effective admittances of its standards. So it is logical to regard the impedance being measured as a reactance in parallel with



The Marconi Low-Capacitance Bridge Type TF 1342 is suitable for the measurement of capacitance down to 0.002 $\mu\mu$F. It is a transformer-ratio-arm bridge of the form shown in Fig. 4(d).

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a resistance. These two parts are then balanced against reactive and resistive standards respectively.

It appears then that the transformer-ratio-arm principle is particularly applicable to multi-decade capacitance bridges. For example, expression (5), rewritten for the measurement of pure capacitance, simplifies to:—

$$C_u = C_s \left(\frac{1}{n_1} + \frac{1}{10n_2} + \frac{1}{100n_3} + \frac{1}{1000n_4} \right)$$

where C_u is the unknown capacitance and C_s is the value of the capacitance standards.

Multi-decade resistance or inductance measurement, however, is not nearly so straightforward. Indeed, where the required accuracy is such that a multi-decade system is necessary, the bridge is usually calibrated in terms of conductance and susceptance rather than resistance and reactance.

Continuously-Variable Controls.—Where a high degree of accuracy is not required, a single continuously-variable balance control is sometimes preferable to a series of decade switches. This applies particularly to resistance and inductance measurement; for a variable control with direct calibration is likely to be more convenient than switched decade controls with reciprocal calibration. A continuously-variable control is also usually desirable to indicate the last significant figure on a bridge with decade controls.

There are two ways of providing continuous variation. The more obvious is by the use of a variable standard; i.e., a variable capacitor or resistor. The other method, which is more convenient when a high effective impedance is required, is shown in Fig. 5.

Here a variable potentiometer is connected across the ratio-arm winding, and the standard impedance is connected to its slider. The action of varying the potentiometer is then exactly analagous to that of switching through a series of tappings on the transformer winding. And, providing the resistance of the potentiometer is small, the behaviour of the ratio arm remains that of a low-impedance e.m.f. generator.

Very high effective impedances can be produced by this second method since the voltage at the slider can be reduced almost to zero. In fact this method gives an effective impedance many times greater than could reasonably be attained with a variable impedance connected to the end of the winding.

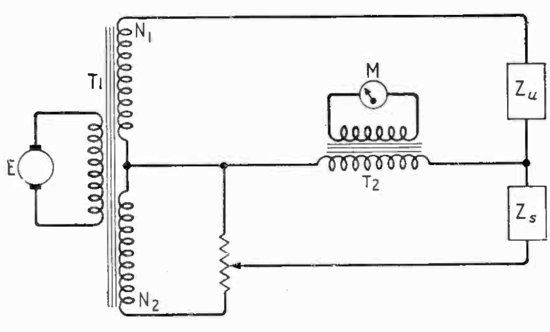

Fig. 5. Continuously-variable standard arm.

Correction of Standard Impedances.—Although high-quality components are naturally used for the standard impedances, some phase-angle errors in the standards are inevitable; a standard capacitor is bound to have some loss, and the standard resistor may possibly have some stray reactance.

Such errors can easily be compensated for by the deliberate introduction of the right amount of loss or stray reactance into the opposite arm of the bridge as shown in Fig. 6(a). In this diagram C_s is the standard having an equivalent shunt loss of R_L. Resistor R_c balances R_L so that the resistive component of Z_u is balanced againts the standard resistance R_s. The value of R_c is obviously given by:—

$$R_c = \frac{N_1 R_L}{N_2}$$

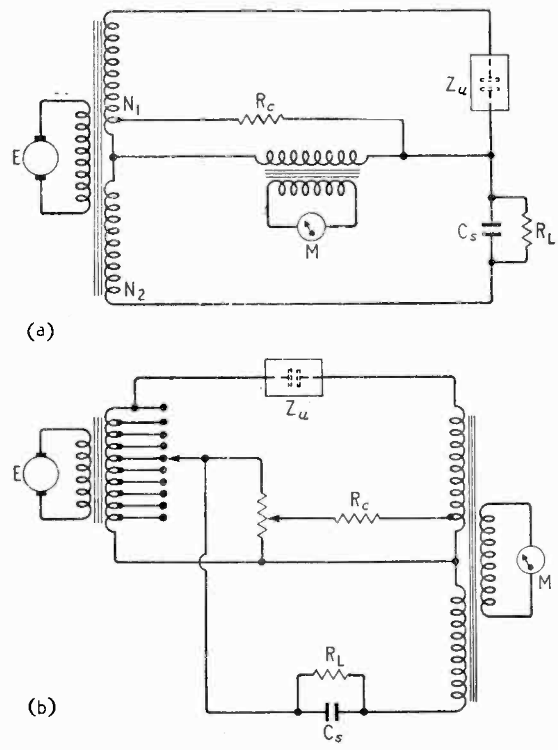

Fig. 6. (a) Use of a compensating resistance R_c to balance the loss, R_L, in the capacitive standard. (b) Reversed arrangement to Fig. 6(a) keeping a constant ratio between R_L and R_c.

But, referring to a practical arrangement of the bridge as shown in Fig. 4, an obvious difficulty becomes evident. For balance is achieved by varying the ratio N_1/N_2 and this implies a different value of R_c for each setting of the balance control.

The difficulty can be overcome by rearranging the bridge as shown in Fig. 6(b). Here the transformers have been interchanged; the ratio arms are in the current transformer and a single voltage-transformer winding feeds both the standard and the unknown impedance. With this arrangement, the ratio N_1/N_2 remains constant for all settings of the balance-control switch; so a

(*Continued on page 333*)

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single value of R_c can be selected to offset the loss in the standard capacitor.

Fig. 6(b) also shows a preset-variable-adjustment arrangement, obviating the need for individual selection of R_c. This uses the principle illustrated in Fig. 5. The potentiometer is adjusted during the initial calibration of the instrument to give correct phase balance using a capacitor with known shunt loss connected to the unknown terminals.

This inverted arrangement also simplifies the design of a multi-decade bridge for measurement of both inductance and capacitance. Capacitive standards are almost invariably used, and, for inductance measurement, they are switched into the same arm of the bridge as the unknown.

Inductance is then indicated in terms of "negative capacitance", which may be converted by the formula:—

$$L_u = \frac{1}{\omega^2 C_i}$$

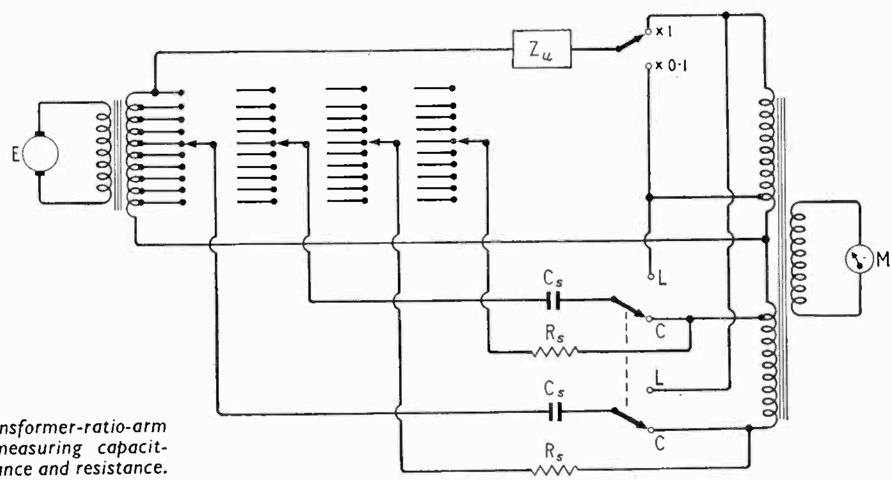

Fig. 7. Transformer-ratio-arm bridge for measuring capacitance, inductance and resistance.

where L_u is the unknown, C_i is the indicated capacitance and ω is 2π times the measurement frequency.

Bridges employing this system usually operate at such a frequency that ω is equal to some convenient power of 10, so that the conversion can easily be made with the aid of a set of reciprocal tables.

An example circuit of a bridge suitable for measuring capacitance, inductance, and resistance is given in Fig. 7. (For simplicity, only two capacitance and two resistance decades are shown.) Such a bridge should be regarded as an admittance bridge and would normally be calibrated in positive and negative capacitance and conductance.

Quantitative Analysis

Three-Terminal Measurements.—The accuracy of three-terminal measurements with low-value shunt impedances is directly related to loss and leakage inductance in the transformers.

For assessment of the errors caused by shunt impedance, consider first the bridge arrangements shown in Fig. 4.

The simplest practical form of the bridge is that of Fig. 4(b). In this arrangement no current transformer is used, so that any shunt impedance (Z_2 in Fig. 2) across the detector cannot produce an error.

Regarding the ratio-arm windings of the transformer as voltage generators, leakage inductance and loss can be regarded as an inductance, L_t, and a resistance, R_t, in series. For simplicity let $R_t + j\omega L_t = Z_t$.

Providing Z_t is small compared with Z_u, the normal condition for balance remains:—

$$Z_u = \frac{E_1 Z_s}{E_2}$$

Any stray impedance, Z_1, across the winding will, however, drop the voltage applied to the unknown to a value given by $E_1 Z_1/(Z_1 + Z_t)$. The conditions for balance are then:—

$$Z_u = \frac{E_1}{E_o} Z_s \frac{Z_1}{Z_1 + Z_t}$$

But $E_1 Z_s/E_2$ is the indicated impedance, and calling this Z_{ind} we have:—

$$Z_u = Z_{ind} \frac{Z_1}{Z_1 + Z_t}$$

$$\text{or, } Z_u = Z_{ind}\left(1 + \frac{Z_t}{Z_1}\right)^{-1}$$

This can be expanded to a binomial series:—

$$Z_u = Z_{ind}\left(1 - \frac{Z_t}{Z_1} + \frac{1}{2!}\cdot\frac{Z_t^2}{Z_1^2} - \frac{1}{3!}\cdot\frac{Z_t^3}{Z_1^3} + \text{etc}\right)$$

Unless the shunt impedance is so small that it reduces the bridge sensitivity, the second order and subsequent terms can be neglected and the expression written:—

$$Z_u = Z_{ind}\left(1 - \frac{Z_t}{Z_1}\right) \qquad (6)$$

The bridge thus reads high by a percentage error equal to $(Z_t/Z_1) \times 100$.

The value of Z_t of course varies with the number of secondary terms, and this is directly related to the impedance range. However, Z_t seldom exceeds 1 part in 10^4 relative to Z_u, the unknown. Accepting this value of Z_t, if Z_1 is as low as a tenth of Z_u the error will be only 0.1%.

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In practice the output impedance of the transformer is usually much lower relative to the unknown so that even lower value shunt impedances can be tolerated.

Where a current transformer is used as shown in Fig. 4(d), the loss and leakage inductance become significant only in relation to those standards which are tapped down the winding. The error due to shunt impedance across the detector is thus more difficult to evaluate.

However, the worst possible condition occurs when the bridge is operating at the extreme high-impedance end of its range so that the standard impedance tapped lowest on the primary of the current transformer is the only one in use. The conditions in the current transformer are then similar to those in the voltage transformer, and the leakage inductance and loss can also be represented as a series impedance Z_i.

The current in the transformer winding is thus lowered by the introduction of shunt impedance Z_2, to a value given by $IZ_2/(Z_i + Z_2)$. Similar reasoning to that used for assessing the error due to Z_t can thus be followed giving:—

$$Z_u = Z_{ind}\left(1 - \frac{Z_i}{Z_2}\right) \quad \ldots\ldots\ldots\ldots \quad (7)$$

Depending on the position of the tap on the primary windings, Z_i may vary from zero to something approaching 1 part in 10^4 relative to Z_u; and the probable error due to shunt impedance across the detector is likely to be very much less than that due to impedance across the voltage transformer.

Measurement Range.—An important attribute of the transformer-ratio-arm arrangement is its facility for very wide ranges of impedance measurement with a single bridge. Range switching is normally accomplished by switching the unknown impedance to an appropriate tapping on the ratio-arm winding, the switch being calibrated as a range multiplier. Such an arrangement is incorporated in the example shown in Fig. 7.

This diagram shows range switching through only one decade; but, assuming that the low-impedance tapping is across 10 turns, the use of three decades is not unreasonable. A 10,000 turn winding would, thus, be required with tappings at 1,000 turns, 100 turns, and 10 turns. Impedance-range multiplication would then be possible from x1 to x1,000.

Such a multiplier arrangement used in a bridge with four decade controls, as shown in Fig. 4(d), would provide an overall ratio of ten million to one between the lowest and highest impedances that can be measured.

Measurement Accuracy.—The accuracy of any bridge is a function of the accuracies of its standard impedances and its ratio arms. Furthermore, in practice, the attainable bridge accuracy can be assessed in terms of the stability of its components; for, by the use of suitable padding, the value of any component can be effectively corrected to any desired accuracy within the limits of its stability.

In conventional—impedance-ratio-arm—bridges stability of the ratio-arm components is an important factor affecting the accuracy of the bridge. Transformer ratio arms, however, are intrinsically completely stable; for the turns ratio cannot possibly vary.

The bridge stability is thus the stability of its standards alone. Also, the use of transformer multiplication at the detector as well as at the voltage source permits selection of standard-impedance values for maximal stability regardless of the range of the bridge.

Transformer-ratio-arm bridges having accuracies of the order of 0.1% are, therefore, simple to construct and are normally modestly priced.

Application Notes

It is evident from the foregoing that the transformer-ratio-arm system exhibits clear advantages for certain applications. A tendency thus arises to suppose that the system is superior to the conventional bridge arrangement for all applications. This, of course, is not so; and the following comparison notes may be helpful in assessing the suitability of a transformer-ratio-arm bridge for any particular purpose.

Capacitance Measurement.—Unlike resistance and inductance, capacitance is a direct measure of admittance rather than of impedance. As the transformer-ratio-arm bridge is basically more suitable for measurement in terms of admittance, it is automatically admirably suited to capacitance measurement.

Furthermore, it follows that with the transformer-ratio-arm system the loss is more conveniently indicated in terms of equivalent shunt resistance. This is fairly realistic as applied to most capacitance measurements. If the loss is small it is unimportant whether it is regarded as shunt or series loss. In capacitors having an abnormally high power factor, the loss is generally due to poor dielectric so that the representation as equivalent shunt resistance is largely the true one.

The transformer-ratio-arm bridge is particularly suitable for measurement of very-low capacitance values. Such measurements with a conventional bridge are susceptible to errors due to the stray capacitance between connecting leads and between bridge terminals. When short rigid connecting leads are used this stray capacitance is sensibly constant, and errors can be largely eliminated by evaluating the strays and correcting accordingly.

There are many applications, however, where short rigid connections cannot be used. Determination of a capacitor's temperature coefficient is a typical example.

With the component under test housed in a temperature-controlled oven comparatively long leads must inevitably be used for connection to the bridge. Such a test is likely to involve a protracted series of measurements; the changes in capacitance may be quite small; and, even though care is taken to prevent physical movement of the leads, the magnitude of possible error due to quite small changes in stray capacitance introduces an element of uncertainty in the final result.

The difficulty can be completely overcome if a transformer-ratio-arm bridge is used. The test leads may then take the form of screened cables with the screens taken to the neutral point of the bridge. The stray shunt capacitance is then divided into two capacitances effectively in series and is

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automatically cancelled by the three-terminal measurement.

Inductance Measurement.—Measurement of inductive reactance by means of a transformer-ratio-arm bridge is normally made by switching the standard capacitors into the "unknown" arm as shown in Fig. 7.

For bridges having accuracies up to about 1%, the continuously-variable arrangement can be used (see Fig. 5) with a direct inductance calibration on the dial. For higher-order accuracies a multi-decade bridge must be used; and the inductance is indicated in terms of "negative capacitance". This is converted to inductance by the formula $L = 1/\omega^2C$.

Apart from the inconvenience of making this conversion, it is immediately evident that the accuracy of the bridge is very dependent upon the frequency of its exciting voltage. The conventional Maxwell bridge, on the other hand, is independent of frequency, and the Hay bridge is largely independent of frequency providing the loss tangent is less than 0.1.

As with capacitance measurement, the loss in an inductance is indicated in terms of effective shunt resistance by the transformer-ratio-arm bridge. Where the loss is small this is unimportant; but inductors frequently have a noticeable loss tangent, especially at low frequencies. At low frequencies the loss in air-cored inductors is principally due to the resistance of the conductors and is therefore effectively series resistance. This must be taken into account when determining the inductance, because, for loss tangents greater than 0.1, the measured inductance with effective shunt loss may be appreciably different from that with effective series loss. This is explained fully in the appendix to this article.

Three-terminal measurement of inductance at low frequencies is useful mainly for measurement of components *in situ*. With low-value inductors the impedance of any shunt strays is unlikely to be low enough to produce any noticeable error, the main source of error being the series inductance of the connecting leads. With high-value inductors the self-capacitance of the inductor itself is usually a more important source of error than stray shunt capacitance between the connecting leads or bridge terminals.

Resistance Measurement.—Being essentially an a.c. measuring device, the transformer-ratio-arm bridge measures both the reactance and the resistance of any impedance. This has no particular advantages or disadvantages; but it will be appreciated that "universal" or "LCR" versions of transformer-ratio-arm bridges are switched for capacitance or inductance measurement, and there is no condition equivalent to the "Wheatstone-bridge" setting of the conventional universal bridge.

Bridges having measuring accuracies better than 0.5% are normally multi-decade bridges (see Fig. 7) and are necessarily calibrated in terms of conductance. Simple resistance measurement is thus less direct than with conventional bridges. Where the measuring accuracy is of the order of 1%, however, a continuously-variable standard can be used having direct calibration.

For measurement of very-high resistance values the transformer-ratio-arm arrangement has the advantage that shunt leakage resistance can often be cancelled by three-terminal measurement.

APPENDIX

Effective Series and Shunt Loss in Reactive Components.—A series impedance combination R_1+jx_1, in one arm of a bridge can be balanced by a shunt impedance combination, $jxR/(R+jx)$, in the opposite arm. Assuming the ratio arms are equal, conditions for balance are:—

$$R_1+jx_1 = jxR/(R+jx)$$

$$\text{so that, } x_1 = \frac{x}{1+x^2/R^2} = \frac{x}{1+\tan^2\delta}$$

$$\text{and, } R_1 = \frac{R}{1+R^2/x^2} = \frac{R}{1+Q^2}$$

If R is large compared with x—i.e., the loss tangent is small:—

$$x_1 = x, \text{ and } R_1 = \frac{1}{\frac{1}{R}+R}$$

which is approximately equal to 1/R.

Thus, when the loss is small, it is relatively unimportant whether the bridge measures in terms of equivalent shunt or series resistance. For loss tangents greater than 0.1 however, the error in measured reactance becomes comparable with the accuracy of the bridge, and a correction should be made if it is possible to determine whether the unknown has series or shunt loss.

The table gives correction factors to be applied when an impedance having series loss is measured with a transformer-ratio-arm bridge—the indicated inductance or capacitance should be multiplied by the correction factor.

Tan δ (x/R)	Correction Factor	
	Inductance	Capacitance
0.01	1.000	1.000
0.02	1.000	1.000
0.04	1.000	1.002
0.06	1.000	1.004
0.08	0.990	1.006
0.10	0.990	1.010
0.15	0.980	1.023
0.20	0.962	1.040
0.25	0.943	1.063
0.30	0.917	1.090
0.33	0.901	1.109
0.35	0.893	1.123
0.40	0.862	1.160
0.45	0.833	1.203
0.50	0.800	1.250
0.60	0.735	1.360
0.70	0.671	1.490
0.80	0.610	1.640
0.90	0.553	1.810
1.00	0.500	2.000

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TECHNICAL NOTEBOOK

Parametric Amplifier using only electrostatic fields to produce focusing and interaction of an electron beam is proposed by B. J. Udelson in a letter in the August 1960 issue of *Proc.I.R.E.* (In previous parametric amplifiers using electron beams, as well as electrostatic fields, magnetic fields have had to be used, either to focus the beam or, as in Adler-type valves using cyclotron resonance, to produce interaction.) In the new proposed valve the electron beam would pass between a linear array of pairs of parallel plates divided into input, pump and output sections and fed alternately from two different direct voltage sources. The voltage differences between adjacent pairs of plates produce forces which both focus the beam and also give rise to transverse oscillations of the electrons (at a frequency determined by the voltages and dimensions of the plates). These transverse oscillations can be made to interact with a signal at the same frequency and pump at twice their frequency by superimposing the signal and pump voltages on to the direct parallel plate voltages. Low-noise fast-wave interaction should be possible in such valves.

Permanent Marking of Teflon-insulated wires is difficult because the insulation is one of the least-easily damaged materials used. However, a process for the production of identifying markings which are as durable as the insulation itself has been developed by the Martin Company of Baltimore, Maryland, U.S.A. Teflon foil, bearing identifying letters or figures of darker colour than the insulation, is placed on the wire which then passes into an infra-red oven. The dark legend heats up rapidly and "sinters" on to the insulation, forming an indelible marking, whilst a fan draws in cool air to prevent the air temperature rising to the point where the whole covering is melted.

Interstellar Communication possibilities using optical masers are discussed by Dr. R. N. Schwartz and Prof. C. H. Townes in an article in the April 15, 1961, issue of *Nature*. Because of the intense beams available from such masers, such communication seems reasonably possible. The best chance of producing a signal distinguishable from the background light of the local star would be to transmit within one of the absorption spectral lines of this star, since the stellar intensity is reduced by a factor of 10 or more in such lines. The authors therefore suggest a search for very narrow emission lines (such as would be produced by optical masers) within the absorption lines of the spectra of neighbouring stars. (Possibilities of using radio waves for interstellar communication were discussed by G. Cocconi and P. Morrison on p. 844 of the Sept. 19, 1959, issue of *Nature* and in this section of our February 1960 issue.)

Computer-Designed Computer has been recently constructed using the Bell Laboratories Automatic Design System (abbreviated to BLADES). In this system the computer is designed as far as possible around a single general-purpose type of logic unit. (Each such unit contains four independent switching circuits which can be interconnected in different ways to produce various types of logic circuit.) The required computer functions are expressed in logical and geometrical terms, which are then used to programme an ordinary general-purpose digital computer. This then specifies the number of general-purpose logic units required for each sub-assembly of the computer being designed, the logic unit pins to be interconnected, the sizes of wire to be used in connecting them, the connecting wire paths to be followed for minimum path length, any special logic units required, and finally a complete parts list. Power wiring is also arranged so that no two successive functions are supplied from the same power line.

Magnetic Tape Tester used by M.S.S. uses a high-quality tape recorder to record signals at 1 and 10kc/s on the tape. These signals are replayed through the same recorder, and the replay output rectified and displayed on a c.r.t. This enables any fluctuations in the tape output to be observed. Both the rise and fall times of the rectified output display are made independently variable to allow different phenomena to be observed under the best conditions. For example, for observing modulation noise (which can be very "peaky") fast rise and slow fall response times are required, whereas just the opposite—slow rise and fast fall response times—are required for observing short dropouts.

New Magnetic Tape introduced by Gevaert—Type F—has been given a rough backing so as to reduce the risk of spillage when using large professional open- and single-sided spools. The roughness is produced in this tape by applying a coating to the normal tape backing, rather than by mechanically roughening the backing itself.

Audio-Frequency "Comb" Filter described by L. H. Bedford in the April 1961 issue of *Electronic Technology* consists simply of a stretched (non-magnetic) conductor, the centre portion of which lies in a transverse magnetic field. At frequencies at which the stretched conductor is *mechanically* resonant, its *electrical* impedance rises. This rise can be made use of, for example by connecting the string in a feedback path, to produce a "comb" filter, i.e. a filter having pass or stop bands spaced at uniform frequency intervals. Quite high Q's can be achieved in this way; for example in the phosphor bronze wire 50c/s fundamental filter for reducing hum described in the article, the fundamental Q was 220. At harmonic resonant frequencies even greater Q's (of the order of 1500) were observed. This last factor usefully counteracts the reduction in the attenuation at *exact* harmonic frequencies which would otherwise be caused by the small (of the order of 0.4%) departures of the *mechanical* harmonic resonant frequencies from a true harmonic series. Resonant attenuations of the order of 20dB were observed.

New Ultrasonic Transducer being developed at the Bell Telephone Laboratories consists simply of a plate of a piezoelectric semi-conductor (such as gallium arsenide) on which a thin metal film is deposited. Since the charge carriers in these two materials have different Fermi quantum energy levels, an electric field is produced across their junction. This field decreases the density of charge carriers around this junction, producing a high-resistivity region which is known as a depletion layer. If a voltage is now applied across the transducer, most of this voltage is dropped across the high resistivity depletion layer, so that this layer behaves as a very thin (10^{-5}—10^{-3}cm thick) piezoelectric crystal. Because of this extreme thinness large piezoelectric stresses are produced, and the efficiency is greatest at very high frequencies. (In the 1 to 10kMc/s range, efficiencies as high as 100 times those of other known ultrasonic transducers should be achievable.) Another advantage of the new

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type of transducer is that, by varying a direct bias voltage across the transducer, the thickness of the depletion layer and thus also the transducer resonant frequency can be varied: this is not possible with normal piezoelectric transducers. Bandwidths of the order of 5% or more, i.e., considerably more than at present obtainable, should also be possible. The main use of the new transducer is expected to be to allow longer delay lines to be produced since the higher efficiency will make up for the greater delay-line losses. The longer delay and greater bandwidth should allow a considerably greater amount of information to be stored in such lines. Work at higher frequencies should also be possible with the iew transducer: although still in the early research stage, operation up to 830 Mc/s has already been achieved.

Character Readers using an area covered by a number of small detectors are not, of course, a new idea. An unusual feature of such a reader developed by the Electrical Engineering Department of the University of Birmingham, however, is that the outputs from the detectors (in this case photo-diodes) instead of being individually processed in logic circuits, are summed in a resistive matrix to give an output level corresponding to the character being read. In this way the interfering effects of noise (character imperfections) can be greatly reduced.

"Potting" of sub-assemblies in polyester or epoxy resins is often carried out to protect the components and wiring from deterioration due to vibration or moisture. Heat is another potential source of danger though, whether applied externally as in the case of an exothermic reaction of the potting resin or internally from electrical dissipation within the components themselves.

Croxton and Garry Ltd., of High Street, Kingston-on-Thames, Surrey, are the sole licensees of a process employing an aluminium wool which, when added to the "mix," increases considerably the heat conductivity of potting resins.

Typically, heat conductivities of the treated resin range from 20 B.Th.U./hr/ft²/ft/°F for added aluminium wool 30% of the weight of the total mix, to 100 B.Th.U./hr/ft²/ft/°F for just over 90%; both results being obtained with a pure resin of conductivity 0.13. These values are far better than those obtained either by the addition of steel wool (90%, conductivity about 15) or aluminium powder (negligible effect until almost 100% concentration).

Naturally, electrical conductivity is also increased by the added metal and an insulating skin may have to be used between the components and aluminium loaded resin.

CONFERENCES AND EXHIBITIONS

Latest information on forthcoming events both in the U.K. and abroad is given below. Further details are obtainable from the addresses in parentheses.

LONDON

June 12-16	**Components and Materials used in Electronic Engineering (Conference)** (I.E.E., Savoy Place, W.C.2.)	Central Hall
June 19-22	**Laboratory Apparatus and Materials** (U.T.P. Exhibitions, 9 Gough Sq., E.C.4.)	Horticultural Hall
June 21-July 1	**International Plastics Exhibition and Convention** (*British Plastics*, Dorset House, Stamford Street, S.E.1.)	Olympia
June 26-28	**European Symposium on Space Technology** (British Interplanetary Society, 12 Bessborough Gardens, S.W.1.)	21 Tothill Street
July 7-29	**Soviet Trade Fair** (Industrial & Trade Fairs, Russell Street, W.C.2.)	Earls Court
Aug. 23-Sept. 2	**National Radio and Television Show** (Radio Industry Exhibitions, 59 Russell Sq., W.C.1.)	Earls Court
Sept. 6-8	**Microwave Measurement Techniques Conference** (I.E.E., Savoy Place, W.C.2.)	Savoy Place
Sept. 13-15	**Symposium on Photomultiplier Tube Applications** (E.M.I. Electronics, Valve Division, Hayes, Middx.)	Manchester Sq., W.1
Oct. 4-12	**Computer Exhibition and Symposium** (E.E.A., 11 Green Street, W.1.)	Olympia
Nov. 8-10	**Non-Destructive Testing in Electrical Engineering (Conference)** (I.E.E., Savoy Place, W.C.2.)	Savoy Place

FARNBOROUGH

Sept. 4-10	**Farnborough Air Show** (S.B.A.C., 29 King Street, London, S.W.1.)

NORWICH

Aug. 30-Sept. 6	**British Association for the Advancement of Science annual meeting** (B.A.A.S., 19 Adam Street, London, W.C.2.)

OXFORD

July 5-9	**Communications and Space Research Convention** (Brit. I.R.E., 9 Bedford Square, London, W.C.1.)
Sept. 2-8	**Engineering Inspection and Non-Destructive Testing** (Institution of Engineering Inspection, 616 Grand Bldgs., Trafalgar Sq., London, W.C.2.)

OVERSEAS

June 12-25	**International Exhibition of Electronics, Nuclear Energy, Radio, Television and Cinematography** (Fairs & Exhibitions, 2 Dunraven St., London, W.1.)	Rome
June 26-July 1	**International Measurement Conference** (Prof. J. F. Coales, The University, Cambridge.)	Budapest
June 28-30	**Joint Automatic Control Conference** (Dr. R. Kramer, M.I.T., Cambridge 39, Mass.)	Boulder
July 9-14	**Bio-Medical Electronics Conference** (Dr. A. Rémond, 131 Boulevard Malesherbes, Paris 17.)	New York
July 16-21	**Medical Electronics Conference** (Dr. A. Nightingale, St. Thomas's Hospital, London, S.E.1.)	New York
Aug. 22-25	**Western Electronics Show and Convention** (Wescon, 1435 LaCienega Blvd., Los Angeles.)	San Francisco
Aug. 25-Sept. 3	**German Radio Exhibition** (Berliner Ausstellungen, Charlottenburg 9, Berlin.)	Berlin
Sept. 1-8	**Firato—International Radio Show** (Firato Secretariat, Emmalaan 20, Amsterdam.)	Amsterdam
Sept. 1-10	**Danish Radio Exhibition**	Copenhagen
Sept. 11-15	**International Cybernetics Congress** (International Association of Cybernetics, 13 Rue Basse-Marcelle, Namur, Belgium.)	Namur
Sept. 11-19	**International Congress of Navigation** (Permanent International Association of Navigation Congresses, 60 rue Juste Lipse, Brussels, Belgium.)	Baltimore
Sept. 14-25	**French Electronics, Radio & Television Show** (F.N.I.E., 23 rue de Lubeck, Paris XVI.)	Paris
Sept. 20-21	**Industrial Electronics Symposium** (I.R.E., 1 E. 79 St., New York, 21.)	Boston
Sept. 25-30	**Irish Television and Radio Show** (Castle Publications Ltd., 38 Merrion Square, Dublin.)	Dublin
Oct. 2-4	**I.R.E. Canadian Convention** (I.R.E. Convention, 1819 Yonge Street, Toronto 7.)	Toronto
Oct. 9-11	**National Electronics Conference** (N.E.C., 228 N. LaSalle St., Chicago.)	Chicago

RANDOM RADIATIONS

By "DIALLIST"

A Remarkable TV Feat

THE B.B.C., having made all arrangements for the May Day television transmissions from Moscow, was in the fortunate position of being able to broadcast Yuri Gagarin's reception in Moscow after his space flight. It was a wonderful achievement as was the May Day transmission. Signals travelled over a rather complicated route: Moscow, Leningrad, Tallinn, Helsinki, Stockholm, Copenhagen, Brussels and so to London. Considering the length of their journey and the many stages of reception and retransmission through which they had to pass, the signals gave remarkably good and steady pictures in this country. Now that a link with Moscow has proved successful the accomplishment of round-the-world television could become a reality while we are waiting to see whether satellite communications are practicable. Relays would cross Siberia to somewhere near the Bering Strait and go thence to Canada and the U.S.A. thus linking the two hemispheres. France has already a tropospheric scatter link with Algeria and in time to come Europe and many parts of Africa should be able to exchange programmes. What a wonderful world it'll become when the saying that one half of it doesn't know how the other half lives ceases to be true.

Inter-school Television

SOMEHOW, I'm personally not at all enthusiastic about the use of TV for teaching purposes. For lectures, yes: classes get a chance of listening to someone eminent in his or her own line which might not otherwise come their way. But there's a world of difference between lecturing and teaching. The former is more or less impersonal: the lecturer tries to put his subject over in a clear and interesting way; but he's little chance of discovering whether or not it's sinking in as it should. Teaching on the other hand is (or should be) a closely personal business. The teacher knows the members of his class and has every opportunity of finding out that what he says is learnt and not just listened to.

'Phone Cable Round the World

ON 8th April *Monarch*, the world's biggest cable-laying ship (owned by Cable & Wireless), sailed from Oban and began to pay out cable for CANTAT, the transatlantic link of what by 1964 will provide the British Commonwealth round-the-world telephone cable system. The other end of this link is Hampden in Newfoundland, 2,100 miles away. As *Monarch* can't carry more than 700 miles of cable she'll twice have to buoy the end and return here for another consignment. From Newfoundland the link is to cross Canada partly by cable and partly by wireless to Vancouver. There it will connect with the cable to be laid to Hawaii, Fiji, New Zealand and Australia. The cable now being laid is of an entirely new type, developed at the G.P.O.'s Dollis Hill research station, and made by Submarine Cable, Ltd. It has a steel core and round this is the first conductor, a copper tube. A layer of polythene insulation and then comes an aluminium tube as the second conductor. Then after further layers of insulation and screening a strong polythene outer casing. With the exception of the sections laid in shallow water the cable is not armoured. It is so much more efficient than earlier cables that repeaters will be 26 miles apart instead of 16. The new cable will provide 60 two-way circuits. An interesting little booklet outlining the "Story of the Submarine Cable" from 1849 to this latest project has been produced by Submarine Cables Ltd. which, as you may know, is owned jointly by A.E.I. and B.I. Callender's Cables.

Electronic Locks

IN the United States (and for all I know in this country, too) work on the production of electronic locks for safes and strong rooms is going ahead. The bolt is thrust home by an electro-magnet or by a motor and with power of that kind doing the job it can be made to engage much more securely than is possible with a key-operated bolt. Outside the door to which it is fitted is a panel carrying ten numbered buttons, which must be pressed in a predetermined order to actuate the lock. Should would-be burglars try to work the lock and get the combination wrong an alarm signal is radia-

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ted. The idea looks pretty good to me and I expect we'll hear much more in days to come of electronic locks.

"*Lifeline*"

THE use of inflatable life rafts by ships of all kinds is rapidly increasing. For use in these Marconi's have marketed a special small lightweight transmitter receiver. "Lifeline," as it's called, weighs less than 20 lbs and measures only 17×7×5 inches. There's a telescopic aerial which is very easily erected. In use, the equipment is strapped to the operator's knee. Only two controls are needed: one selects speech or an automatic alarm signal; the other tunes the transmitter for the best possible performance. The equipment is pretuned to 2,182kc/s, the international distress and calling frequency. Much use is made of transistors to keep down both size and power demands. Power is supplied by a generator worked by a handle and it is stated that little effort is needed to turn this.

Radio Towers

IN a recent number of the *Journal of the Institution of Electrical Engineers*, J. F. Goodger described the television tower at Stuttgart as a smokestack surmounted by a crow's nest. And that's just what it looks like. In this stack are high-speed lifts which carry visitors to restaurants and viewing galleries 500ft above the ground. We're told that in the five years since the tower was built four million people have visited it and have more than repaid the cost of putting it up. This makes one wonder whether there'll be similar happenings in London, where a 500-ft radio link tower is to be built at the Museum telephone exchange, and is due to be completed by the end of 1963. It will replace the existing radio mast with which an effective height of only 180ft is obtained. The tall buildings that have gone up in London during the past few years and the many more that are planned make a much greater effective height necessary. It will be used by the Post Office as a radio link for the telephone and television services. Like the Stuttgart tower, it is to have a public viewing platform—at a height of 463 feet. If a moderate admission fee is charged, it, too, should pay for itself within a few years.

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UNBIASED

By "FREE GRID"

Jiggers and Gee-gees

IN our Jubilee issue the learned contributor of the historical survey drew attention to our ignorance of the origin of the word "jigger," which was used in the early days of wireless to describe the r.f. transformer which linked aerial and closed circuit. I hope to lighten his darkness forthwith, and if I'm wrong I feel sure some of you will put me right.

The word "jigger" had, and still has, certain particularized meanings aboard ship and also ashore but, in general, it means an auxiliary device; it is, in fact, something which carries out a function described by the verbal expression "to jig up," which means to increase or step-up something. Surely this meaning of stepping up or increasing describes precisely the function of the early wireless jigger which did indeed jig up the volts as our contributor indicated (April issue, page 158).

The expression "to jig up" was, and probably still is, in very common use among certain horse dealers, particularly Irish ones, and when we

Common among horse dealers

recall that Marconi's mother was Irish, and he paid many visits to his Irish grandparents in his boyhood, we begin to see daylight.

For the benefit of non-horsey people, I should explain that the term "jigged up" describes the result of dosing a horse to make it prance in a lively manner, reminiscent of an Irish jig, in front of its intending buyer. Such treatment involves the use of ginger and is sometimes referred to as gingering up.

Without doubt, Marconi, in his boyhood visits to his mother's native land, would have become acquainted with the expression "jigging up," as applied to horses, and he would also have recognized in the Irish jig, a dance which, in his native Italy, was called *giga*, pronounced "jeegah."

Ham and Eggs

MY enquiry in the March issue as to the precise meaning and derivation of the "x" in the well-known abbreviation xtal has provoked some interesting replies. Many correspondents seem to think the "x" is the Greek letter "chi" which is used in Xmas. This seems all wrong because there is no "ch" in crystal as there is in Christmas.

At the same time I dropped a brick when I suggested that the "x" in the common abbreviation xmitter came from the Latin "trans." A German correspondent, Paul Hameyer, to whose excellent English I pay tribute, has made it clear to me that it is a natural abbreviation of the Latin word "ex."

He also convinces me that the "x" in xtal was the work of the American Hams who delighted in such abbreviations as rx for receiver to an even greater extent than their British opposite numbers, who might well have been called Eggs, so closely have the amateur transmitters in the two countries always been linked together.

Morphean Music

IT is far too late for me to make any comments on the Audio Festival and Fair, but I feel that I cannot refrain from calling attention to the lack of a very necessary audio service in our good-class hotels such as the one in which the Fair was held.

When in the various bedrooms in which demonstrations were given, I could not help noticing that over each basin a socket for an electric shaver was provided, this being of the very latest type with a built-in isolating transformer. But I looked in vain for a socket into which a pillowphone could be plugged so that a sleepless guest might lull himself into dreamland with morphean music.

All-night music is not available from the B.B.C., but surely in these days of tape recorders it is not too much to expect an hotel to provide an all-night service from recorded tapes. No expensive disc-jockey would be needed as in these days of long-playing multi-track recorders, an automatic all-night service could be provided. By using a three-wire circuit and a simple switch, it would be possible to give the sleepless guest the choice of two programmes; after all, the cost of a couple of tape recorders should be a small matter to an hotel.

Reverting to the electric-shaver socket, there is one curious thing which I observed in this particular hotel which I have also noticed in all others where this facility is provided, and that is that the majority of the guests expected would seem to be monks. The reason is that one bar light is provided, and this is invariably above the mirror where it shines on the top of the head, and could, therefore, only be of real use to a monk desiring to trim his tonsure.

Experience has taught me that a bar light on the top of the mirror is almost useless for shaving, especially under the chin. What I have at home is a bar light on each side of the mirror. Perhaps the various hotel managements would attend to this small point when putting in the wiring for the morphean music service I have suggested. An even better idea to my mind would be that the shaver makers should provide their products with a small floodlight such as is fitted to certain vacuum cleaners. This is, however, really more a matter for our sister journal, *Electrical Review*, than for *Wireless World*.

Photaural Fair

JUST about the time some of you are reading these lines the biennial Photo Fair will be on at Olympia (May 29th to June 3rd). I am not getting any bribe from our sister journal *Amateur Photographer*—not even a free ticket—for this free advertisement. I only mention it because I always think it a pity it does not join forces with the Audio Festival and Fair because both exhibitions are really for more or less the same type of people.

I find that most people like myself, who take a serious interest in hi-fi audio, are also interested in hi-fi fotos, and most, again like myself, have about the same technical knowledge of each art or science.

At the Photo Fair there are a certain number of inexpensive "snapshot" cameras, but on the whole, the show is not intended for the soot and whitewash brigade any more than the Audio Fair is meant to attract those whose taste in music is the jungle jangling of juke boxes.

If these two fairs put their resources together they could afford to rent the main Olympia hall as well as the lesser ones and so be able to erect properly designed demonstration theatres for both the audio and video arts, and for the best of stereo in both the arts.

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INSTRUMENTS OF THE FUTURE NOW by AVO

NEW AVO TRANSISTOR ANALYSER

A portable battery-operated instrument, suitable for testing PNP, NPN and Point Contact transistors, in the grounded emitter configuration. Provision is included for *in situ* measurements. The instrument is supplied complete with comprehensive operating instructions, together with the AVO International Transistor Data Manual which provides test data for approximately 3000 transistors.

Brief Specification:

Range of Collector Voltage:	1.5V to 10.5V (up to 150V using external supplies)
I'co:	First indication 2μA
Base Current:	0-1 mA, 0-40 mA
Collector Current:	0-1A
Beta:	0-25, 0-250 measured at 1 Kc/s
Noise Measurement:	1-20, 21-40 dB

Construction in general conforms with U.K. Inter-Service Spec. K114

NEW AVO VALVE CHARACTERISTIC METER MK. IV

This instrument has been designed to test any standard receiving or transmitting valve having up to a maximum anode dissipation of 25W. Inter-electrode insulation, anode current, mutual conductance and 'gas' current can be measured, and by making a series of tests, complete families of curves may be plotted. Rectifiers and signal diodes are tested under suitable load conditions. A comprehensive data manual is supplied with the instrument, which operates from 100-120 volts and 200-260 volts 50-60 c/s A.C. mains.

Brief Specification:

Range of Anode-Voltage:	12.6–400 volts
Range of Screen Voltage:	12.6–300 volts
Range of Heater Voltage:	0.625–117.5
Heater Current:	3A max.
Anode Current:	100 mA max.
Mutual Conductance:	0.1–60 mA/V max.
Negative Grid Voltage:	0–100V in 9 ranges
'Gas' Current:	2μA first indication

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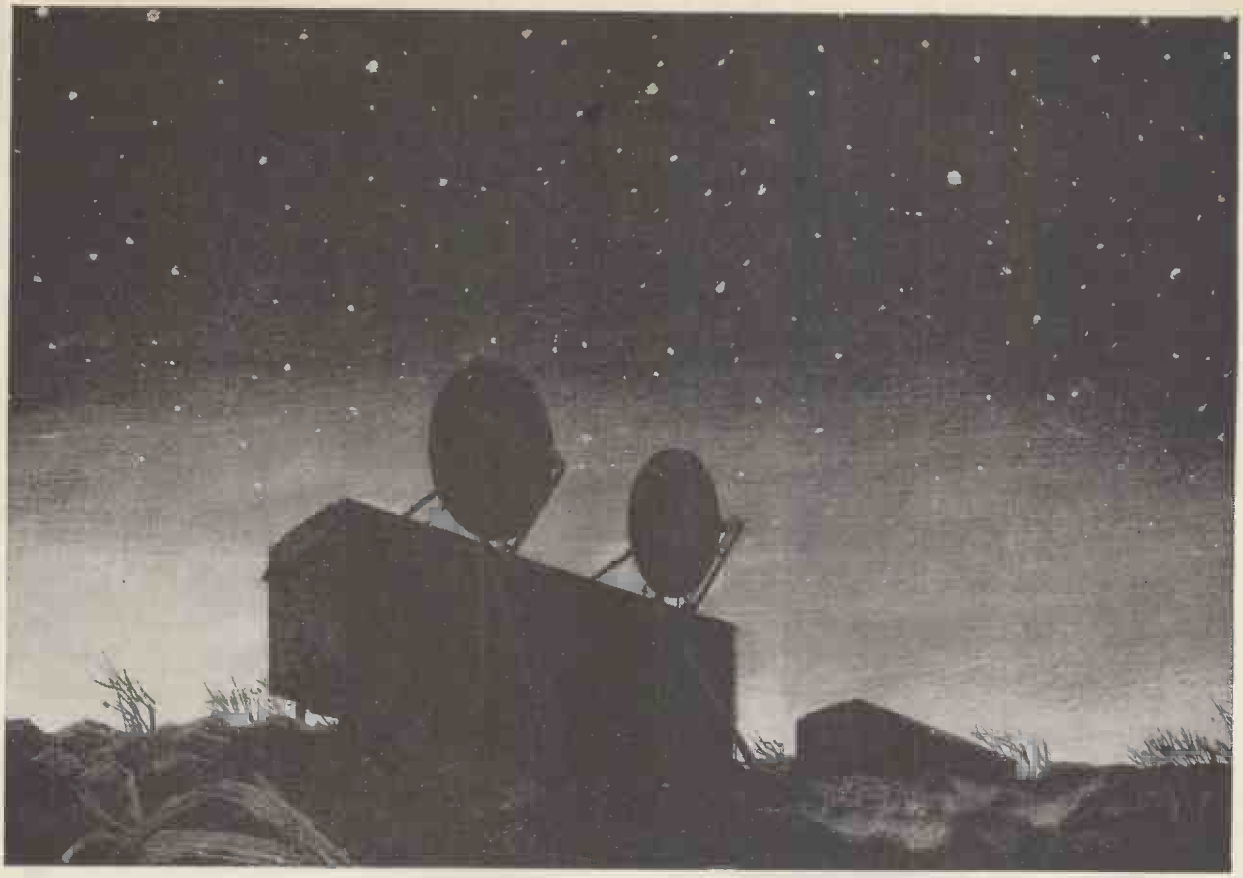

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Transportable MICROSCATTER is a super high frequency radio system for long-range communication. Developed by Canadian Westinghouse, MICROSCATTER beams signals high above the earth sending two-way voice and teletype messages up to 200 miles over land and water . . . *without* costly relay stations.

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Transportable	—60 telephone channels	Tactical and Transportable	—60 voice channels
	—teletype		—teletype
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- Frequency—4400-5000 mc
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- Range—100 to 200 miles

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60-A-745

MODEL 5G-5"

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MODEL 58C-8"x5"

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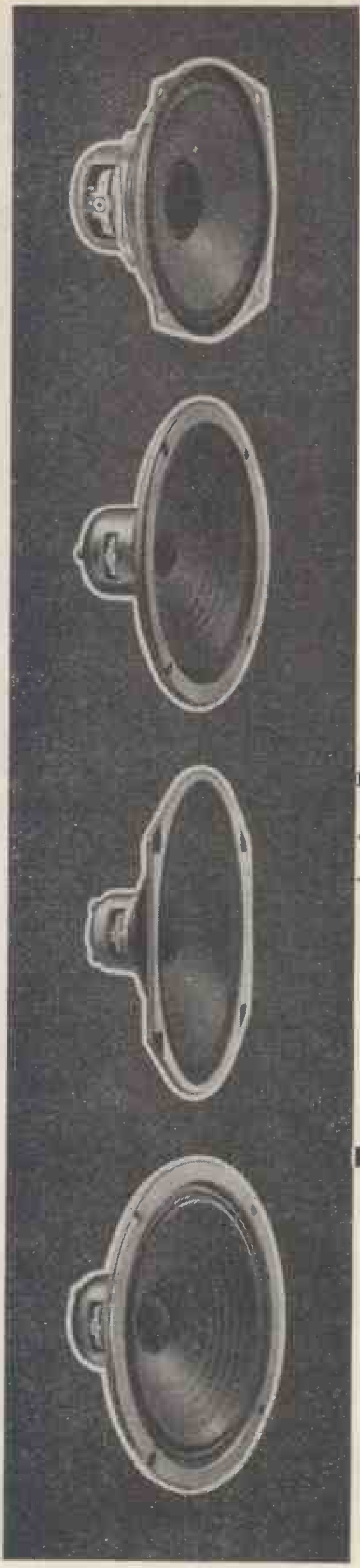

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For the guidance of the trade and public we publish below a list of the most popular ELAC replacement loudspeakers.

We have made this selection from our wide range of speakers as they cover practically all the requirements of the replacement trade.

The new prices are now operative.

POPULAR REPLACEMENT MODELS

Type	Ref	Flux	Retail Price	Purchase Tax
5in.	5G	6500 g	20/6	6/7
6½in.	6G	6500 g	21/6	6/11
7 x 4in.	47G	6500 g	20/6	6/7
7 x 3in.	37G	6500 g	20/6	6/7
8 x 3in.	38G	6500 g	20/6	6/7
8 x 5in.	58C	8500 g	24/6	7/10
8in.	8C	7000 g	25/6	8/2

All loudspeakers have Standard 3 Ohm impedance. Higher impedances can be supplied at an extra cost of 3/- plus 1/- Purchase Tax.

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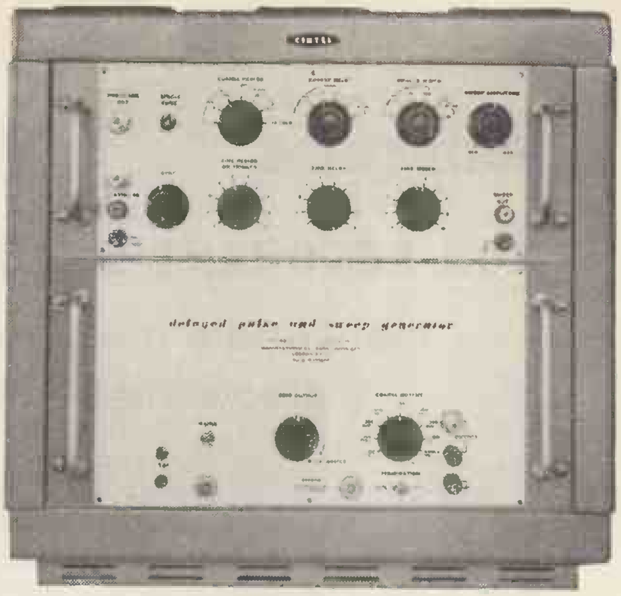
DELAYED PULSE AND SWEEP GENERATOR



A versatile pulse generator designed to meet the need for a comprehensive instrument covering a wide range of pulse work. Four main facilities are provided: a pre-pulse, a main pulse delayed on the pre-pulse, a negative going sawtooth and a fast rising pulse formed from a pure line.

BRIEF SPECIFICATION

Period

Continuously variable from 0·9μsec to 1·05sec i.e. 0·95c/s to 1·1Mc/s. Accuracy ±5%.

Pre-pulse

40mμsec. 8V peak in 75Ω, positive going.

Main pulse

Width: Variable from 0·09μsec to 105msec ±5%.

Amplitude: Control gives 4:1 attenuation of each of four maximum outputs as follows:

5V max in	75Ω	rise time	10mμsec
10V max in	150Ω	rise time	<20mμsec
25V max in	600Ω	rise time	<40mμsec
50V max in	1000Ω	rise time	50mμsec

Polarity: Positive or negative going.

Accuracy: ±2%.

Delay

Conclusion of pre-pulse to advent of main pulse, delay variable from 0·09μsec to 105msec. Accuracy ±5%.

Sweep

D.C. coupled negative going sawtooth same width and delay as main pulse. 15V peak max.

Cable pulse

Obtained from short circuited pure line. One positive and one negative going pulse coincident with main pulse. 25mμsec wide 3V max in 75Ω, rise time <8mμsec.

Sync, trigger or single shot facilities provided. Full data available on request.

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Vibration: 30G at 2,000 c/s.
Optimum operating range: 0-700 c/s.
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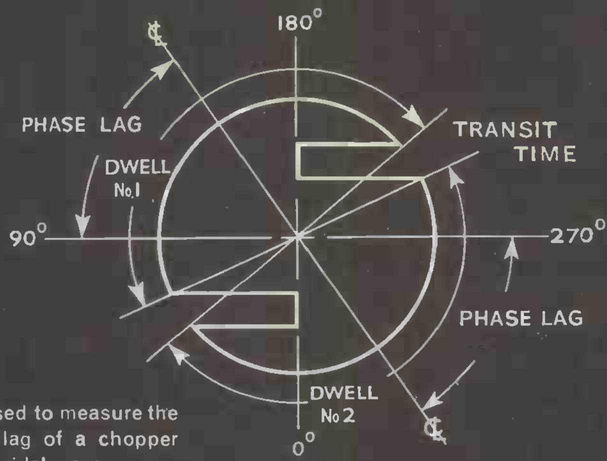
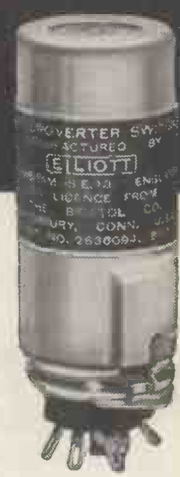


Oscilloscope pattern used to measure the dwell time and phase lag of a chopper being driven by a sinusoidal wave.



95908 general purpose series
Frequency range: 0-2,400 c/s.
Noise: less than 0.5 mV r.m.s.
Coil ranges: 6.3V, 12V and 24V
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Heat distortion temperatures of around 140°C are obtainable after suitable post-curing. *Low exotherm* temperatures.

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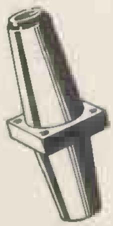

HOT SETTING SYSTEMS

These include solid and liquid resins for use with anhydride and aromatic amine hardeners used in the production of large castings.

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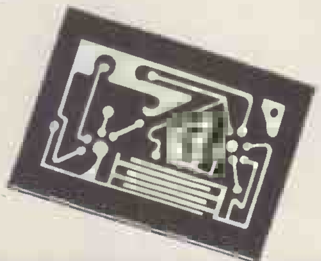

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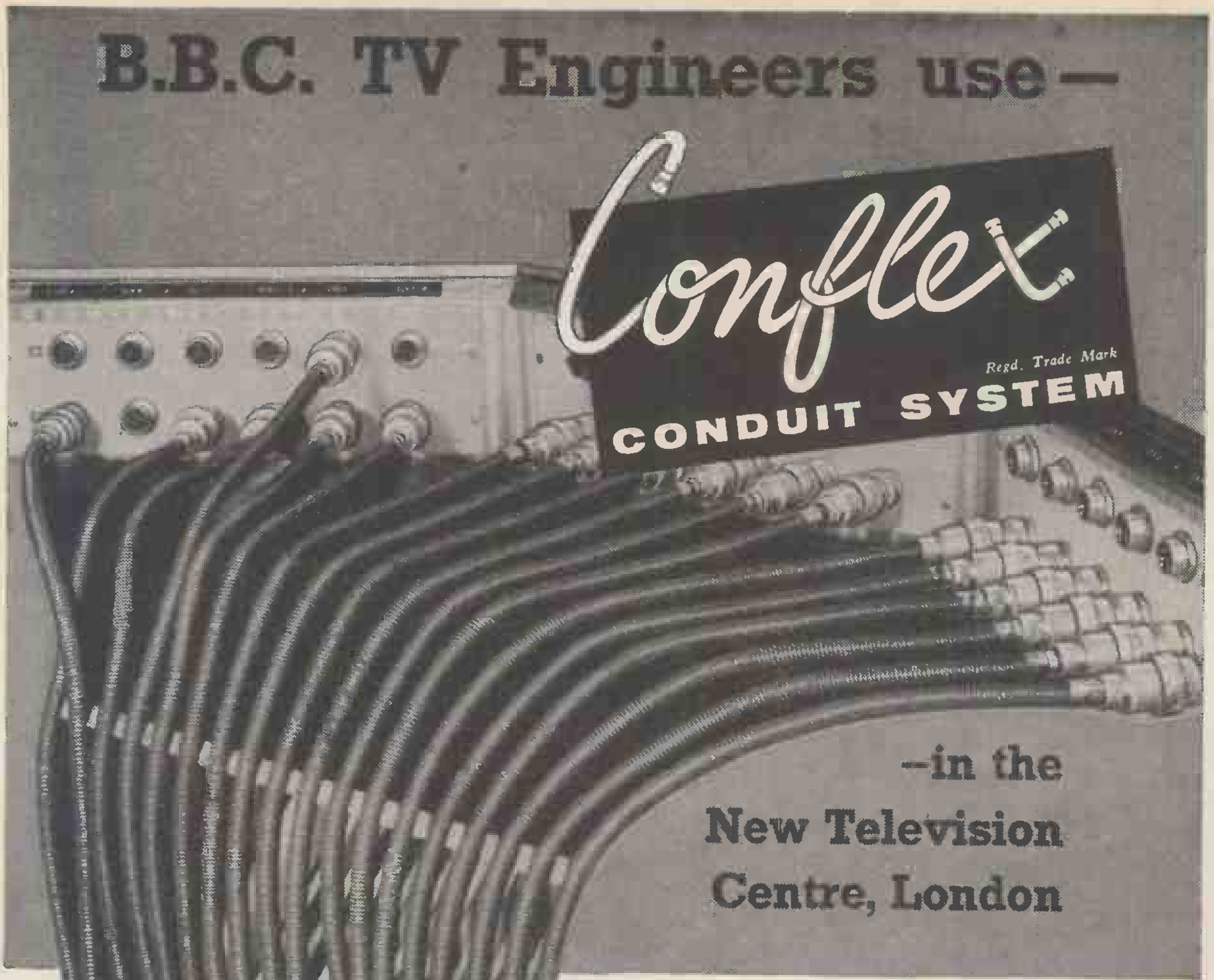

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The use of Conflex conduit system on the Telecine Routing Desk at the B.B.C.'s new Television Centre is a completely new approach to installations of this nature. Many troubles that are normally associated with circuit changing are completely eliminated.

Advantages of this system are many and include:—

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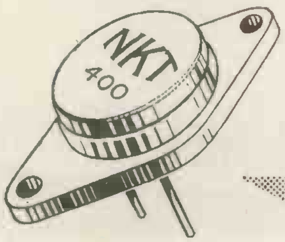
the power transistor of the "60's"



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NKT 400 POWER TRANSISTORS *listed below all have cold weld closure for reliability and Industry standard TO3 outline*

NKT 401 24V High Power D.C. Converter Transistor (6A Voltage Rating 60V, 6A Beta 15-30).

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THE NKT 400 POWER RANGE *includes units with these characteristics:*

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6.0A Voltage Ratings	(Volts)	**60**
Max. Tj Rise above 25°C	(°C)	**60**
Beta 3A/Beta 1A	(%)	**60**
Leakage Current	(μA)	**60**
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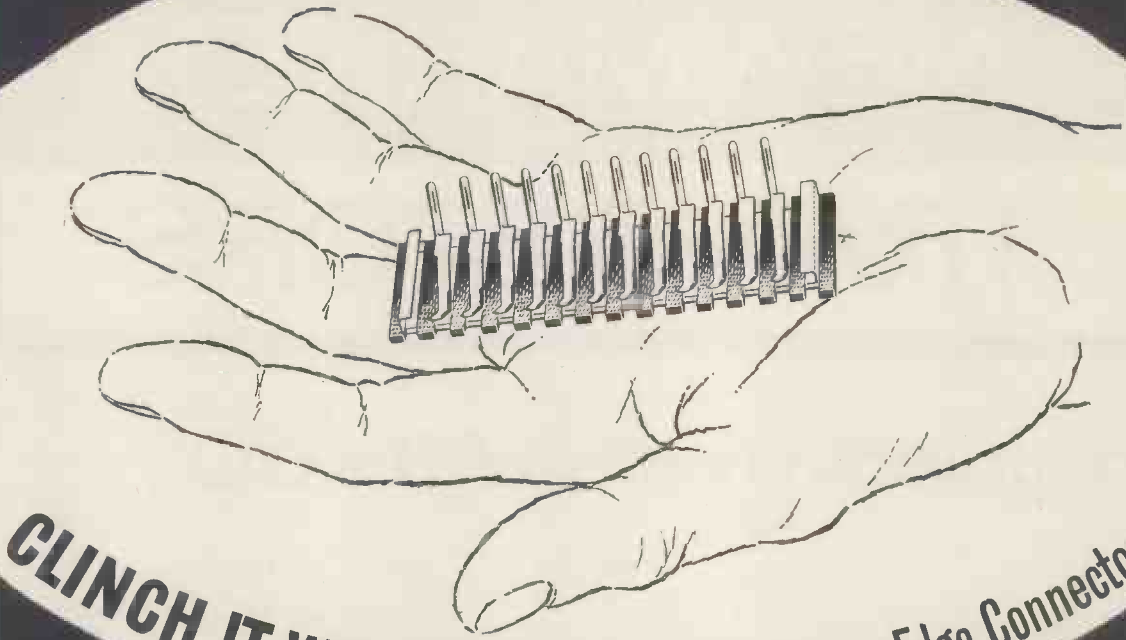


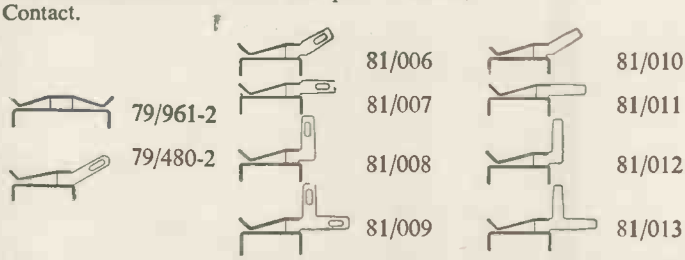
CLINCH IT WITH CINCH Printed Wiring Edge Connectors

FAST, LOW COST ASSEMBLY

SPECIFICATION

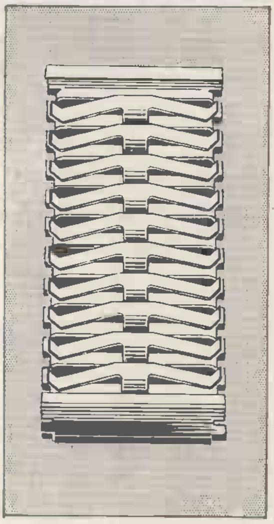
Available in: Any no. of ways up to 40.
Centres: 0.150″ or 0.156″ as specified.
Current rating: 5 Amps per Contact.
Working voltage: 500 V.D.C.
Voltage proof: 2 K.V./D.C.
Contact resistance: < 5 m Ω after 1,000 sizings and exposure to DEF.5000 tropical conditions.
Withdrawal force: 4 to 6.5 ozs. per Contact.

Contacts: Phosphor Bronze, finished Gold plate on Silver, Silver or E.T.
Note: 79/480-2 & 79/961-2 Brass only; finish as above.
Laminate: Best quality Commercial Grade, Grade II; Fibreglass to order. (Fibreglass 0.150″ ctrs. only).
End guides: Hard Brass; finish as above.



Tails accept Amp 98 Taper Tab

Tails accept Amp 78 Taper Tab



Double Edge Connector using 79/961-2 Contacts

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Mk. I **£16.13.6.** Mk. II **£17.18.6**

"COTSWOLD" HI-FI SPEAKER SYSTEM KIT. Acoustically designed enclosure "in the white" 26in. x 23in. x 15½in. housing a 12in. bass speaker with 2in. speech coil, elliptical middle speaker together with pressure unit to cover the full frequency range of 30-20,000 c/s. Complete with speakers, cross-over unit, level control, etc. **£21.19.0**

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AG-9U MA-12

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TAPE DECKS are now available as "packaged deals" with other equipment. *Details on request.*

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AUDIO SINE-SQUARE WAVE GENERATOR. Model AO-1U. Inexpensive generator covering 20 c/s. to 150 kc/s. in four ranges with choice of sine or square waves. Size 9½in. x 6½in. x 5in. **£12.18.6**

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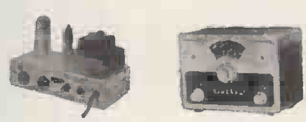
DUAL-WAVE TRANSISTOR RADIO KIT. Model UJR-1. This sensitive headphone set is a fine introduction to electronics for any youngster. **£2.16.6**



MGP-1 VF-1U

4-WAVE TRANSISTORISED PORTABLE KIT. Model RSW-1. 7 Transistors and three diodes. For short snd Medium wave-bands (200-550, 90-200, 18-50, and 11-18 m.). In solid leather case fitted with retractable whip aerial. **£21.18.6**

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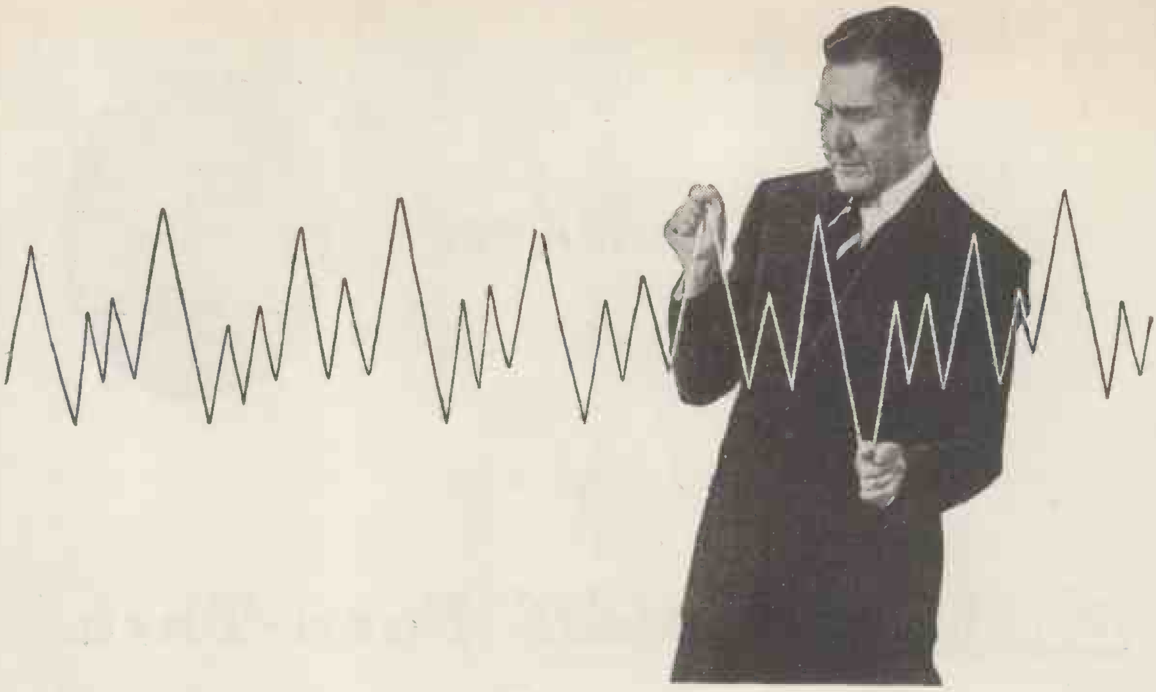

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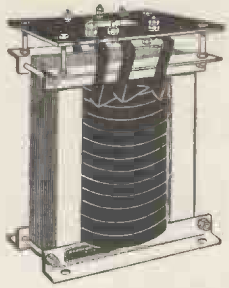

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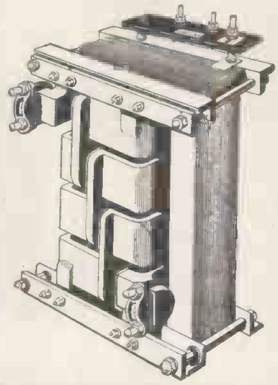

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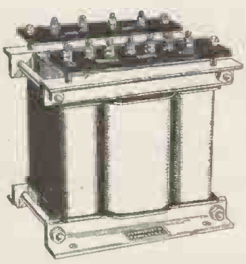

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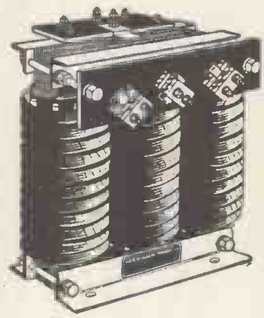

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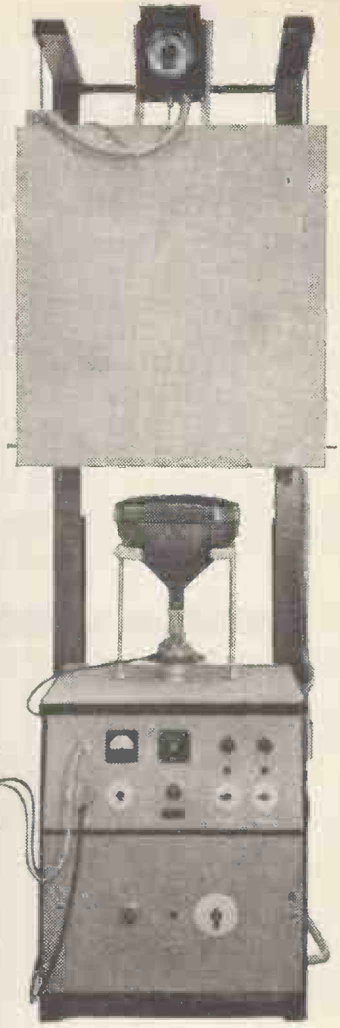

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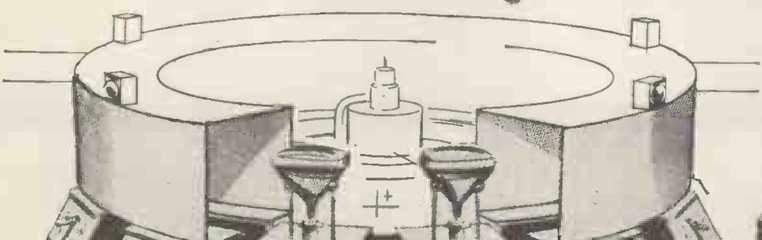

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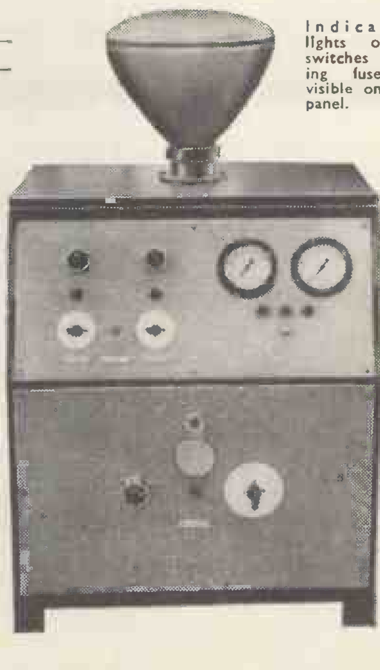

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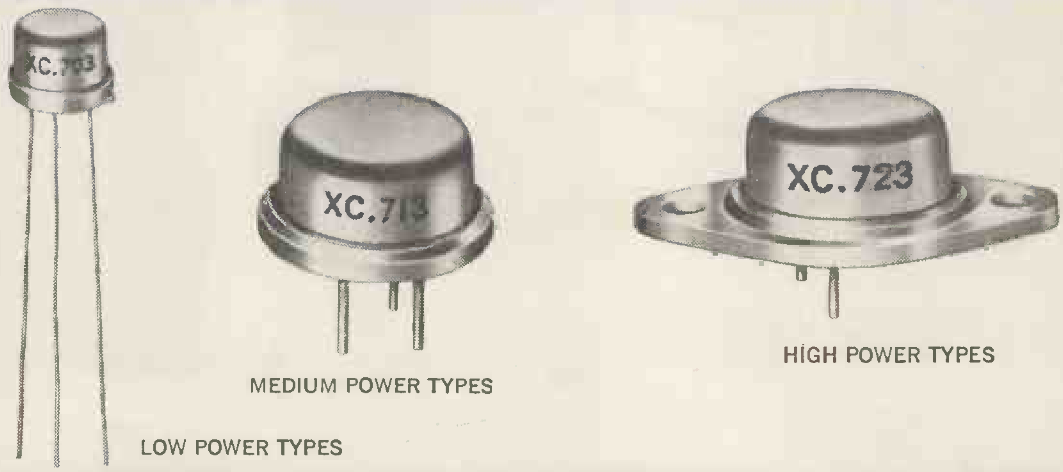

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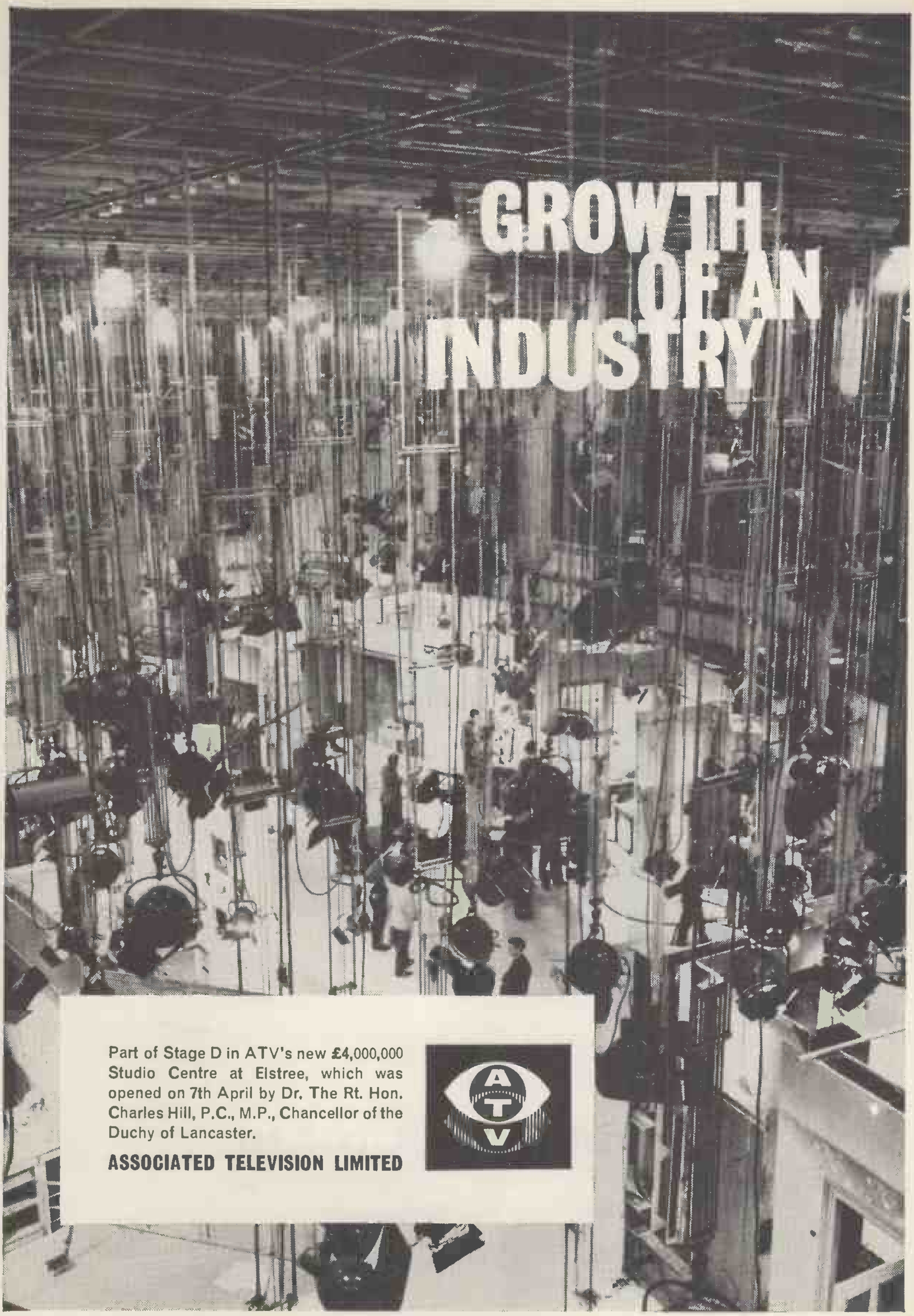
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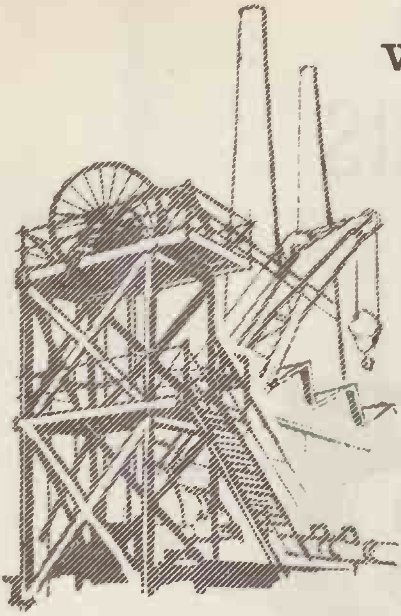

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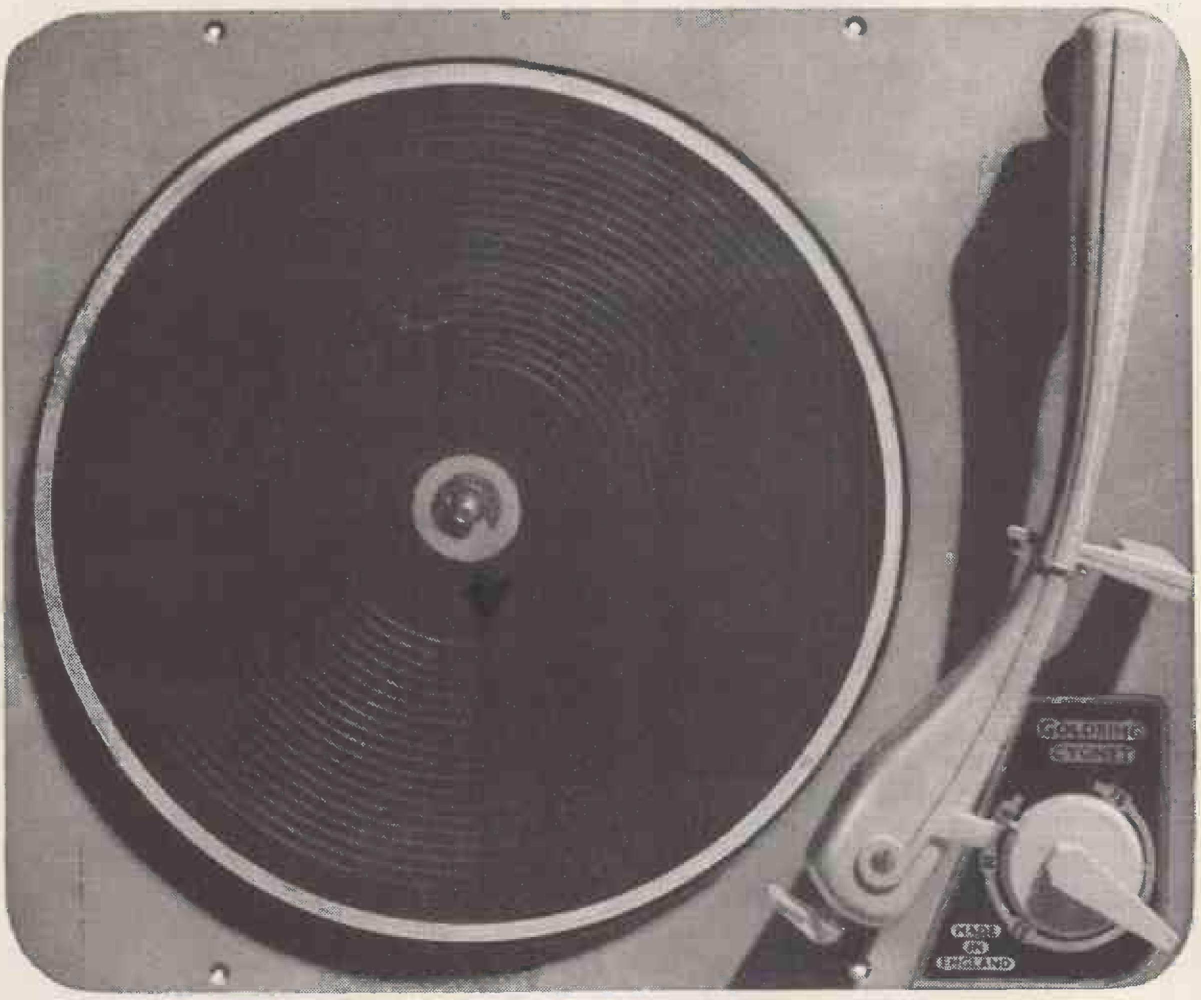

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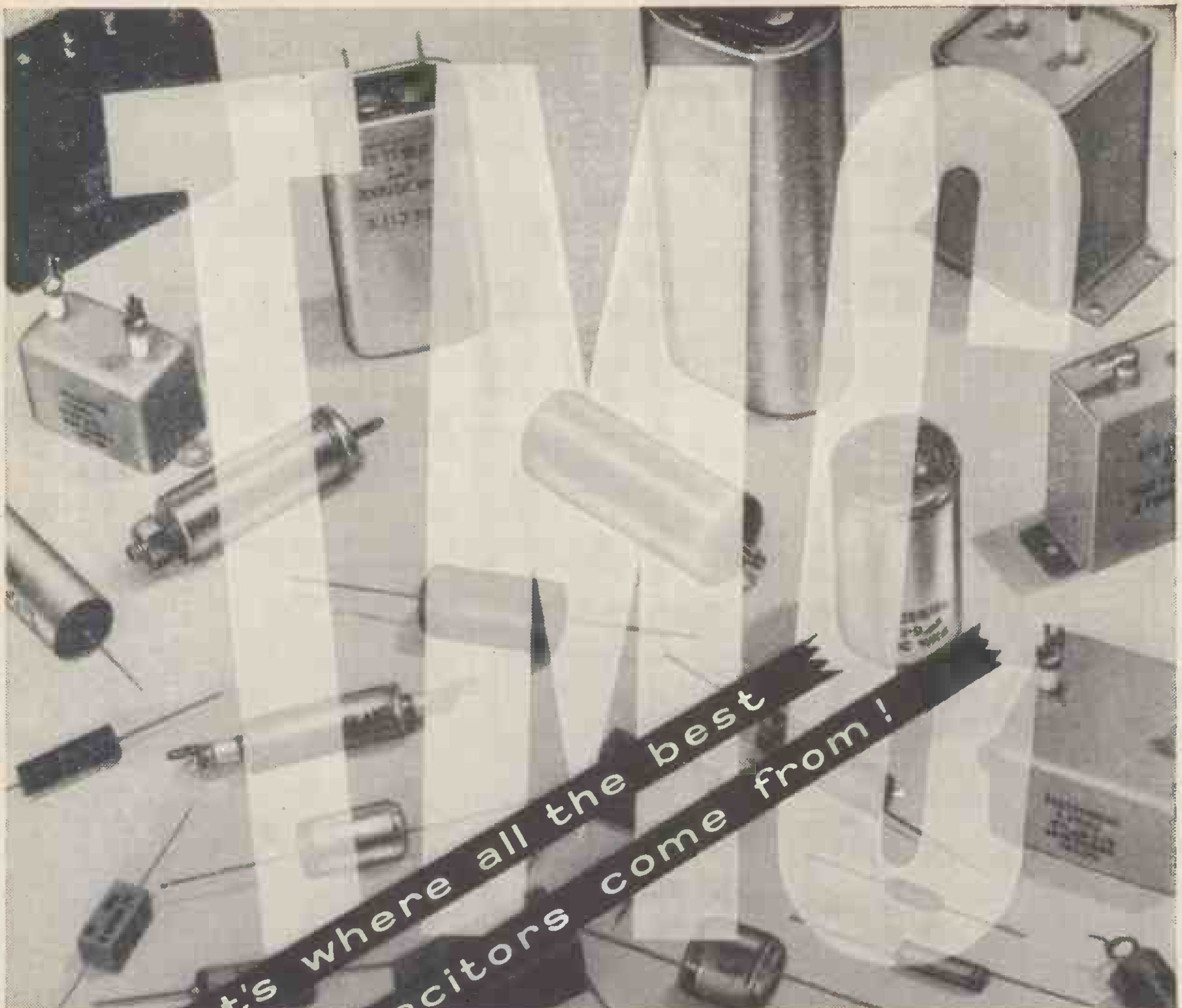

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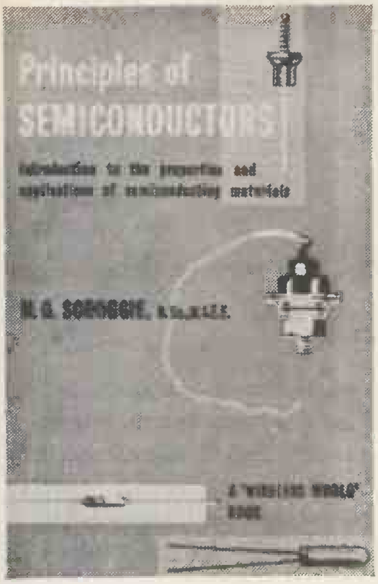

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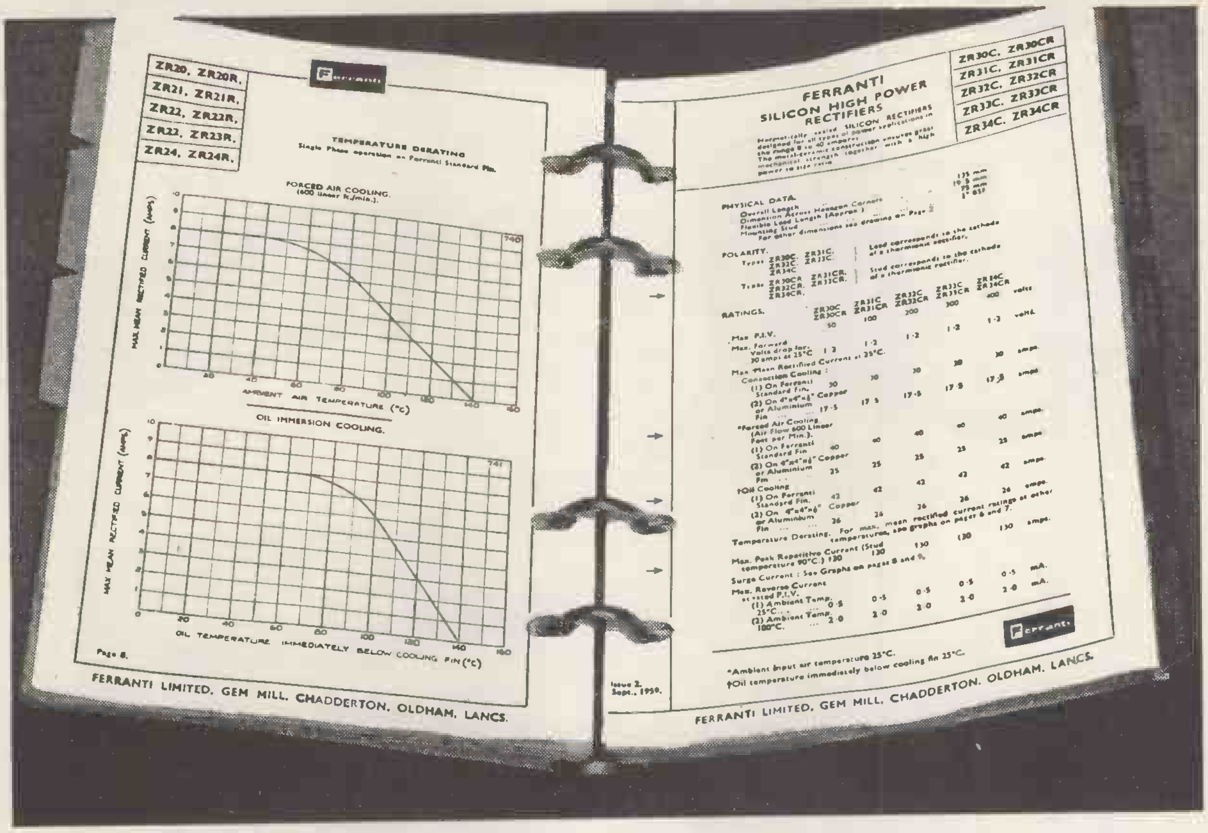

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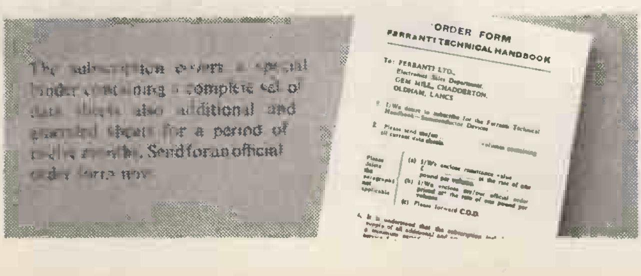

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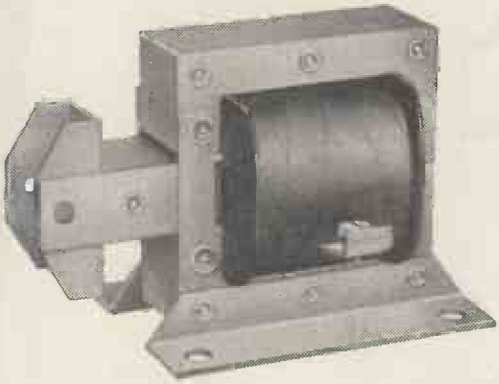

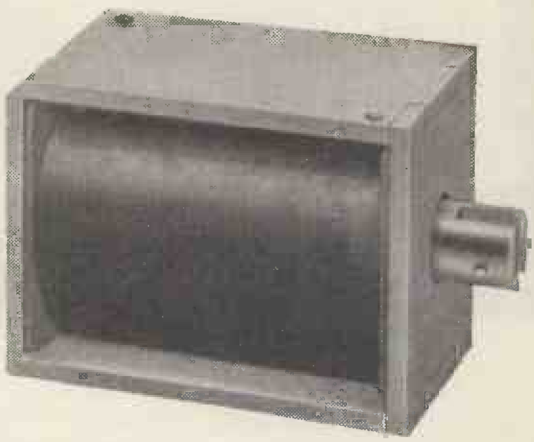

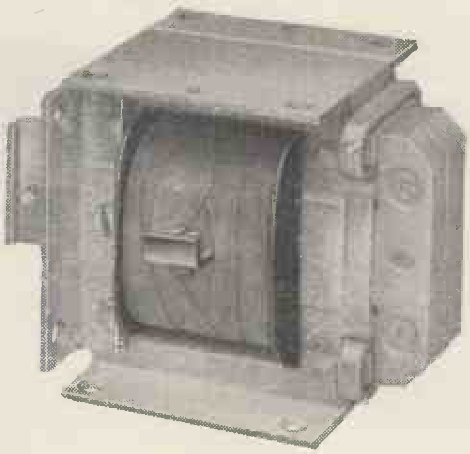

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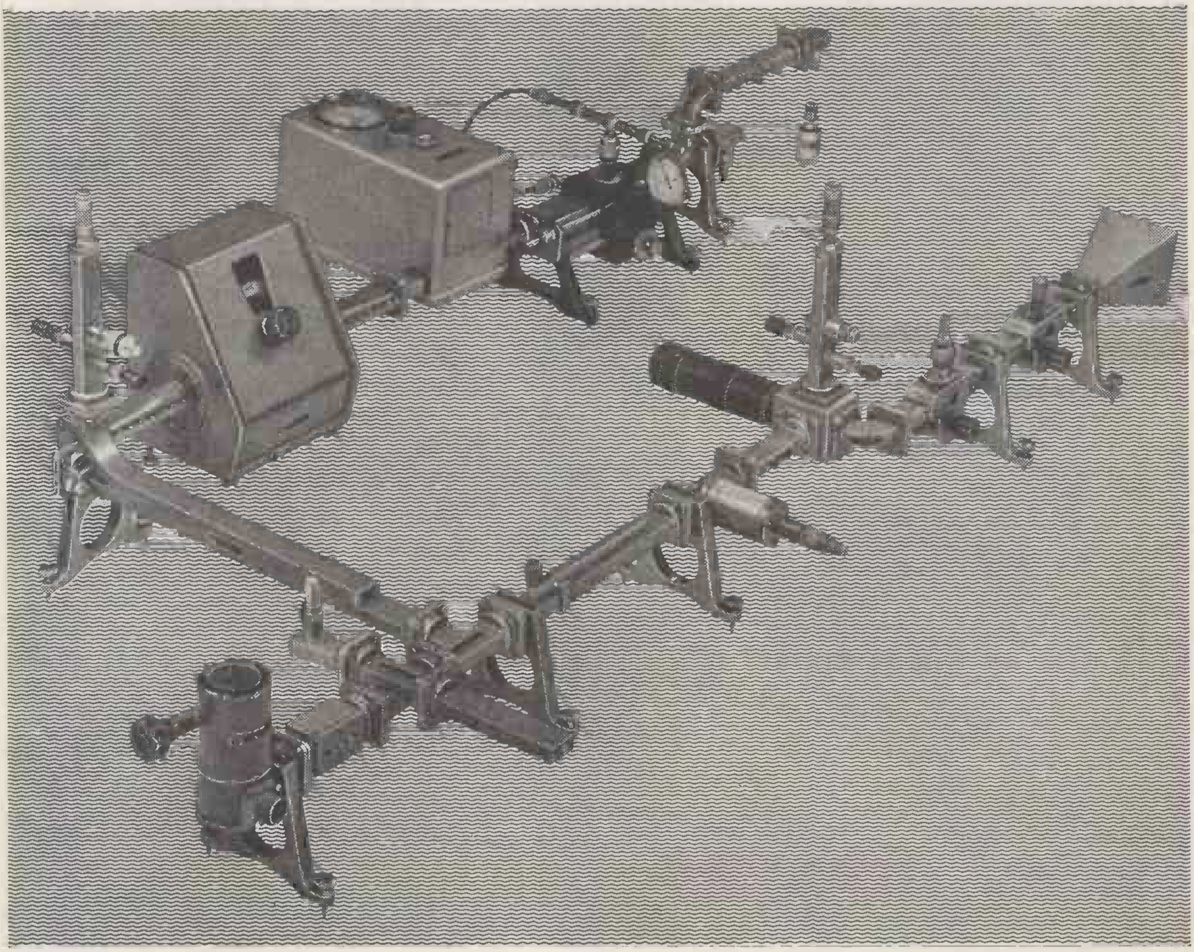

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X TYPE	DESCRIPTION	MAX. VSWR.	
PP 4020 X	Straight Waveguide Section	—	Length 10, 20, and 40 cm
PP 4025 X	E-plane Bend	1.07	Radius of curvature 29 mm
PP 4030 X	H-plane Bend	1.07	Radius of curvature 29 mm
PP 4035 X	Twist	1.10	Length 187 mm
PP 4040 X	Shunt Tee	—	Length 80 mm
PP 4045 X	Series Tee	—	Length 80 mm
PP 4050 X	Hybrid Tee	—	Decoupling >40dB
PP 4070 X	Waveguide/Coaxial Adapter	1.50	50 Ω N-connector
PP 4080 X	Horn	1.25	Directivity: E-plane 20°, H-plane 25°
PP 4090 X	Multi-hole Directional Coupler	1.05	Directivity: >40dB, coupling factor 10dB or 20dB (± 0.2dB)
PP 4095 X	Cross-guide Directional Coupler	—	Directivity: 20dB, coupling factor 26dB (± 0.5dB)
PP 4110 X	Fixed Attenuator	1.10	Attenuation 6, 10 or 20dB (± 0.2dB), max. peak power 1 kW
PP 4130 X	Variable Flap Attenuator	1.15	Max. attenuation >20dB
PP 4150 X	Variable Rotary Attenuator	1.15	Max. mean power 1 W, max. attenuation 50dB, accuracy ± 2 %
PP 4170 X	Low-power Matched Load	1.05	Max. mean power 2 W
PP 4200 X	Klystron Mount	—	When using klystron 2K25 the output power is >20 mW
PP 4220 X	Adjustable X-tal Mount	1.10	Sensitivity: 1 mV D.C. for 0.1 μW, 50 Ω N-connector
PP 4225 X	Broadband X-tal Mount	1.50	Sensitivity: 1 mV D.C. for 10 μW, 50 Ω BNC-connector
PP 4245 X	Tunable Thermistor Mount	1.10	Freq. range 8.2-11 kMc/s, 50 Ω BNC-connector
PP 4260 X	Calibrated Short Circuit	>100	Accuracy of the displacement 0.02 mm
PP 4280 X	Sliding Screw Tuner	from 20 to >1.02	Insertion loss for a VSWR of 20 is >2dB
PP 4290 X	Direct Reading Wavemeter	—	Freq. range 8.5-9.8 kMc/s, absolute accuracy ± 2 Mc/s, loaded Q 10,000
PP 4300 X	Broadband Wavemeter	1.10	Relative accuracy 3.10⁻⁴, loaded Q >3,000
PP 4360 X	Measuring Cavity	—	Freq. range 8.65-8.95 kMc/s, loaded Q >3,000, magnetic field for electron resonance 3,300 gauss
PP 4380 X	Standing Wave Detector	1.05	Accuracy of the probe displacement 0.01 mm, 50 Ω BNC-connector
PP 4385 X	High Precision Standing Wave Detector	—	Measurable VSWR between 1.005-2.000, accuracy probe displacement 2 μ, probe penetration 0-3 mm
PP 4421 X	Ferrite Isolator	1.15	Freq. range 8.5-9.6 kMc/s, forward att. <0.8dB, reverse att. >13dB, max. peak power 50 kW
PP 4422 X	Ferrite Isolator	1.20	Freq. range 8.5-9.6 kMc/s, forward att. <0.5dB, reverse att. >20dB, max. mean power 1 W
PP 4500 X	3 cm Noise Generator	>1.20	Noise factor 18.7dB (K50A), attenuation 0·13dB

***Additional Instruments*: D.C. Microvoltmeter, type GM 6020 - Klystron Supply, type GM 4561 - Bolometer Bridge, type GM 4460**

Q TYPE	DESCRIPTION	MAX. VSWR.	
PP 4020 Q	Straight Waveguide Section	—	Length 5, 10 or 20 cm
PP 4025 Q	E-plane Bend	1.07	Radius of curvature 35 mm
PP 4030 Q	H-plane Bend	1.07	Radius of curvature 37 mm
PP 4035 Q	Twist	1.07	Length 50 mm
PP 4050 Q	Hybrid Tee	—	Decoupling >35dB
PP 4080 Q	Horn	1.15	Directivity: E-plane 15°, H-plane 16°
PP 4130 Q	Variable Flap Attenuator	1.15	Max. attenuation >20dB max. mean power 200 mW
PP 4150 Q	Variable Rotary Attenuator	1.15	Max. attenuation 50dB, accuracy ± 3 %
PP 4170 Q	Low-power Matched Load	1.05	Max. mean power 1 W
PP 4200 Q	Klystron Mount	—	When using klystron 55,335 the output power is 100 mW
PP 4222 Q	Adjustable X-tal Mount	1.25	50 Ω BNC-connector
PP 4260 Q	Calibrated Short Circuit	50	Accuracy of the displacement 0.02 mm
PP 4270 Q	Sliding Screw Tuner	from 10 to 1.03	Insertion loss for a VSWR of 10 is ≯2dB
PP 4300 Q	Broadband Wavemeter	1.20	Relative accuracy 5.10⁻⁴ loaded Q >3000
PP 4382 Q	Standing Wave Detector	1.03	Accuracy of the displacement 0.01 mm max. probe penetration 1 mm, 50 Ω BNC-connector
PP 4420 Q	Ferrite Isolator	1.15	Freq. range 33-36 kMc/s, forward att. <1dB reverse att. 13-26dB, max. mean power 200 mW

***Additional Instruments*: Klystron Supply, type 4485 - D.C. Microvoltmeter, type GM 6020**

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40— 7,000 c/s ± 3dB at 1⅞ ips

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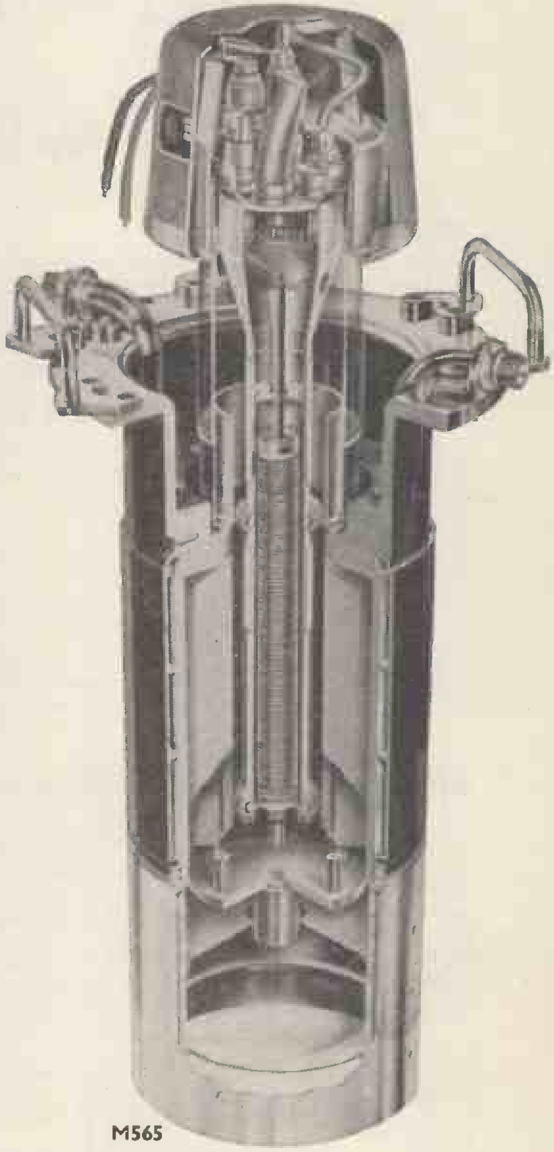
Magnetron	Typical Peak Output Power (kW)	Freq. Band	Magnetron	Typical Peak Output Power (kW)	Freq. Band	Magnetron	Typical Peak Output Power (kW)	Freq. Band
2J30	300	S	CV1498	200	S	CV3982	50	X
2J31	300	S	CV1499	200	S	CV5018	80	X
2J32	300	S	CV1500	200	S	CV5031	50	X
2J33	300	S	CV1747	45	X	CV5235	45	X
2J34	300	S	CV1807	300	S	M501	500	S
2J42	8	X	CV1808	300	S	M501A	500	S
2J55	45	X	CV1809	300	S	M501B	500	S
2J56	45	X	CV1810	300	S	M502A	180	X
4J31	1000	S	CV1897	1000	S	M503A	8	X
4J32	1000	S	CV1898	1000	S	M504	750	X
4J33	1000	S	CV1914	1000	S	M505	45	X
4J34	1000	S	CV1916	1000	S	M506A	50	X
4J35	1000	S	CV2281	8	X	M507	425	S
4J43	900	S	CV2284	225	X	M508	8	X
4J44	900	S	CV2362	1150	S	M509	8	X
4J50A	225	X	CV2363	1150	S	M513A	18	X
4J52A	80	X	CV2364	1150	S	M519	425	S
4J53	1000	S	CV2365	1150	S	M521	45	X
4J78	250	X	CV2366	1150	S	M523	225	X
5586	1000	S	CV2367	1150	S	M525	1150	S
5657	1000	S	CV2368	1150	S	M528	200	S
6027	20	X	CV2373	180	X	M529	225	X
7182	2500	S	CV2376	45	X	M535	7.2	X
CV370	8	X	CV2412	225	X	M537	8	X
CV513	1000	S	CV2424	225	X	M538A	225	X
CV1475	425	S	CV2425	225	X	M539	225	X
CV1476	425	S	CV2426	225	X	M546	225	X
CV1477	425	S	CV2473	225	X	M547	225	X
CV1478	425	S	CV2744	1000	S	M548	50	X
CV1479	500	S	CV2852	45	X	M549	225	X
CV1480	500	S	CV3528	18	X	M554	2600	L
CV1481	500	S	CV3611	1000	S	M558	8	X
CV1482	500	S	CV3659	500	S	M559	20	X
CV1483	425	S	CV3660	500	S	M561	80	S
CV1484	425	S	CV3661	500	S	M565	5000	L
CV1485	425	S	CV3662	500	S	M566	2500	S
CV1486	425	S	CV3676	8	X	M569	2500	S
CV1495	200	S	CV3953	250	X	M570	2500	S
CV1496	200	S	CV3958	1000	S	M573	2500	S
CV1497	200	S	CV3976	8	X	M574	2500	S



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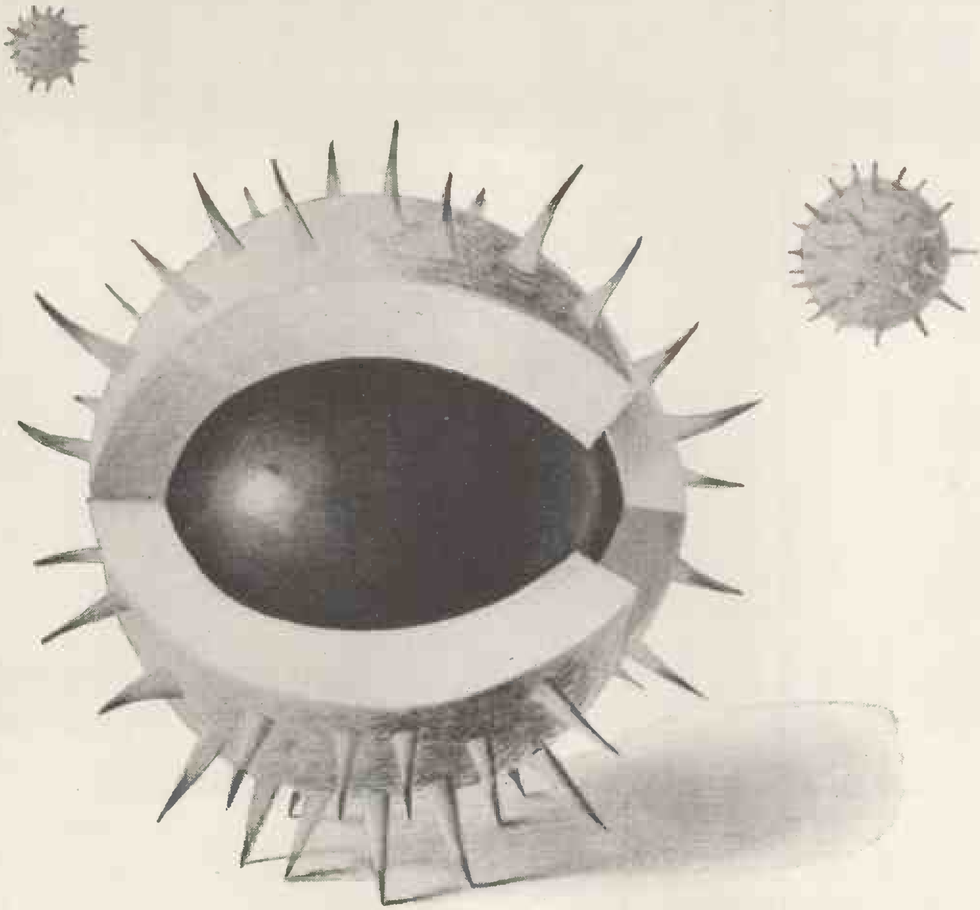

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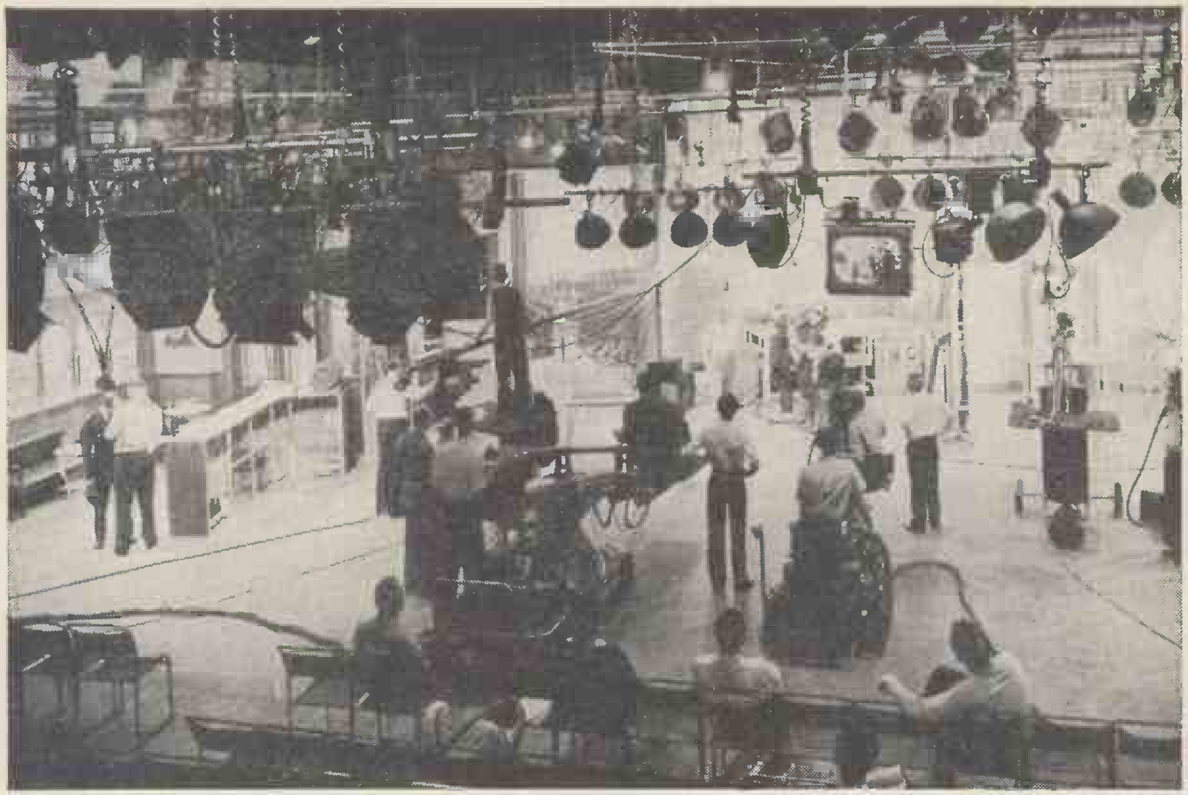

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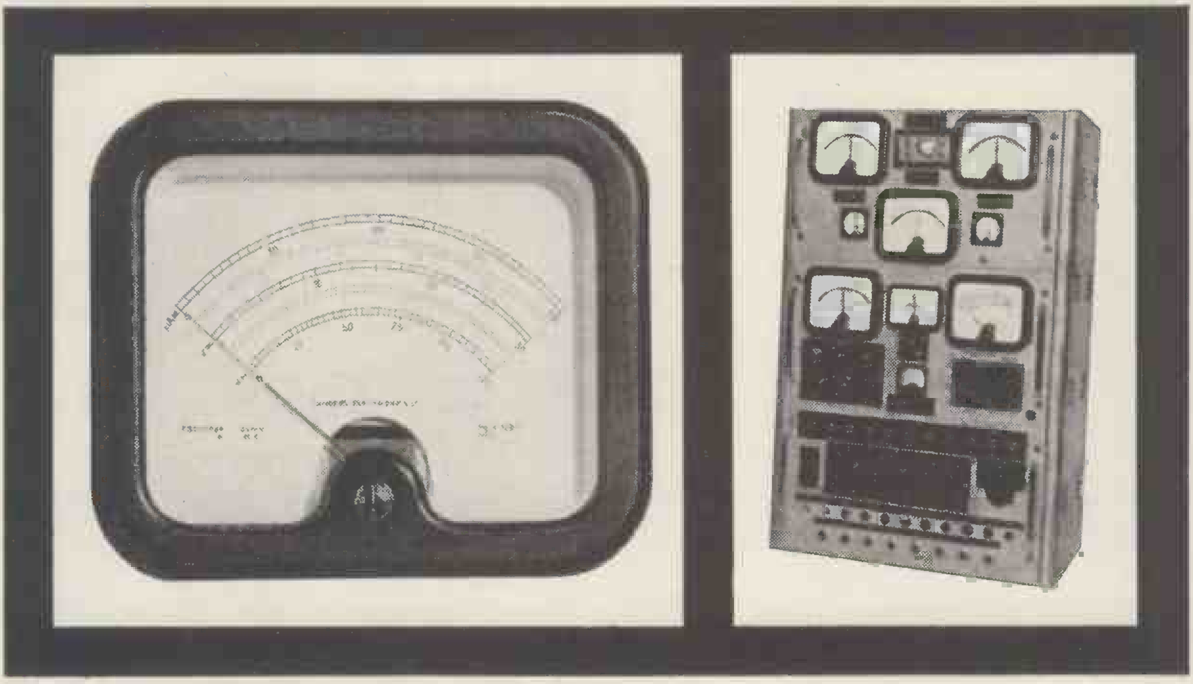

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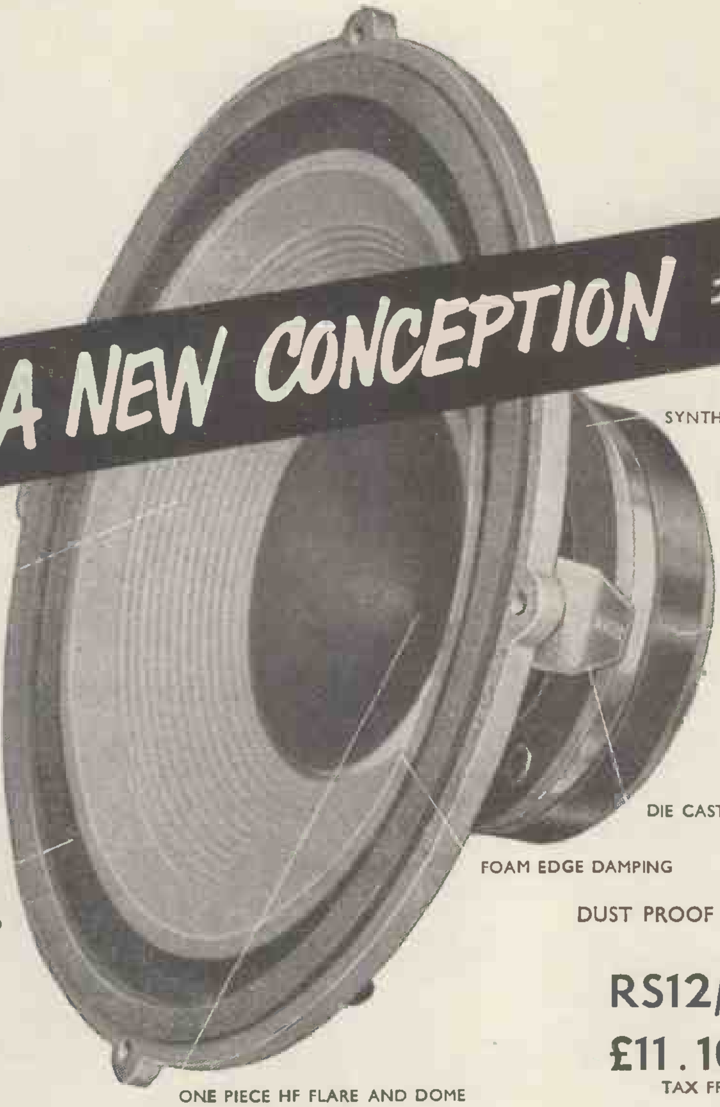

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The moving assembly is supported by a roll surround, formed from resin impregnated cloth permanently moulded under heat and pressure. Together with the high-grade synthetic centring device this roll surround permits very large, cone and coil excursions with minimum distortion.

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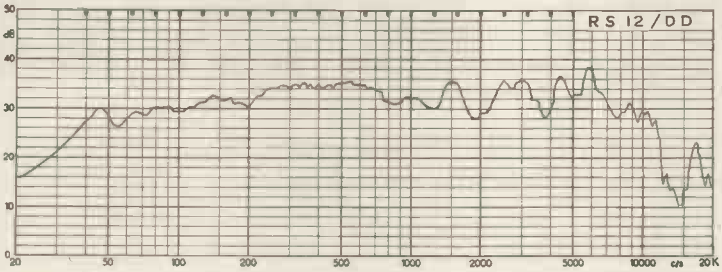
. . wide range Loudspeakers

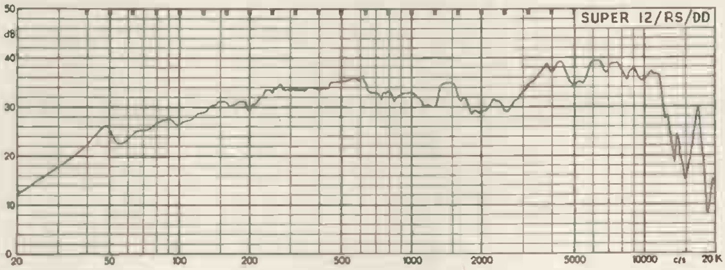
RS12/DD

Specification.

Fundamental Resonance	25-30 c/s
Frequency Range	30 c/s-15 Kc/s
Flux Density	14,000 gauss
Total Flux	156,000 maxwells
1¾in. dia. Centre Pole Aluminium Voice Coil	
Impedance	12-15 ohms only
Max. Input	15 watts r.m.s. 30 watts peak



Axial frequency response curves taken indoors with units mounted in recommended 2 cu. ft. enclosure.



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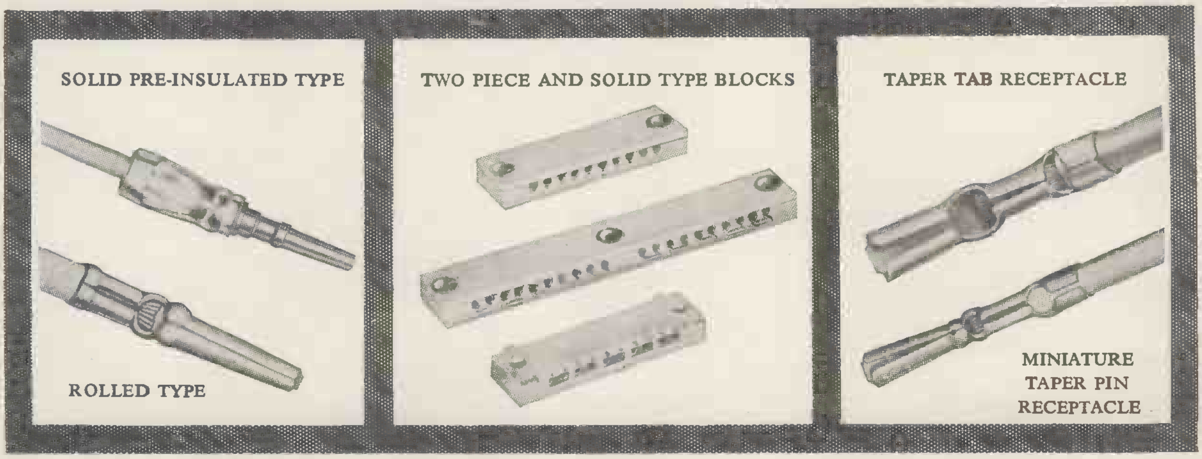

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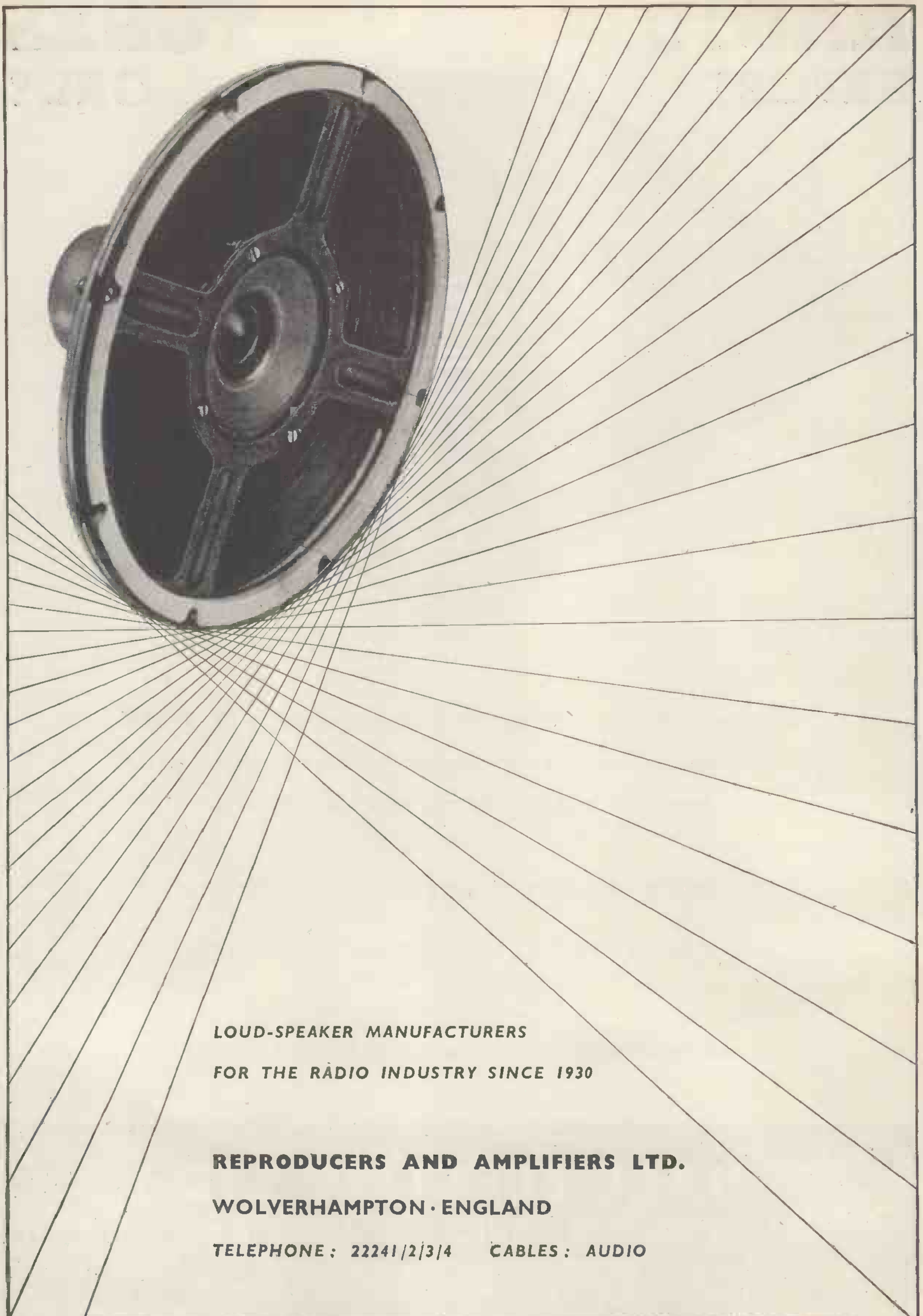
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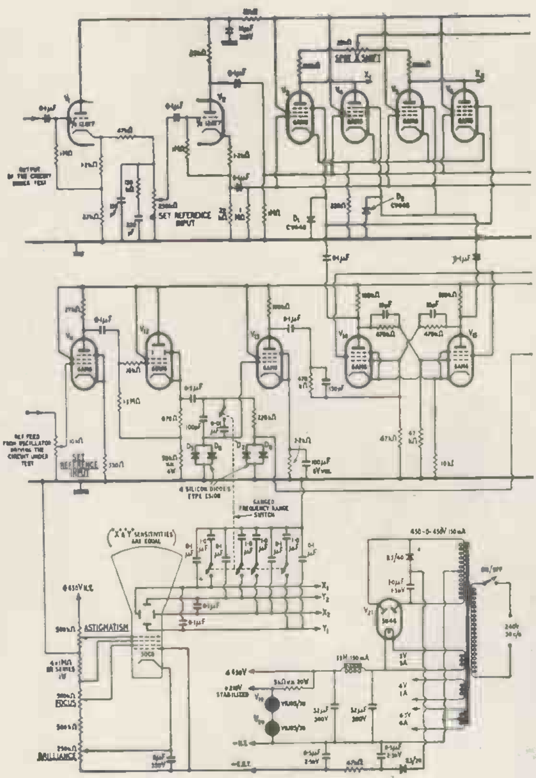

This article in the current May issue of ELECTRONIC TECHNOLOGY describes in detail an instrument which enables the shape of the Nyquist diagram of a circuit to be determined quickly and relatively easily. The frequency range covered by the instrument is from 20 c/s to 5 kc/s, with up to 20 kc/s being obtainable if suitable magnitude corrections are applied. A complete circuit diagram with component values is given along with performance details.

ARTICLES IN THE JUNE ISSUE INCLUDE:

PHOTOELECTRIC CELLS AND PHOTOMULTIPLIERS
In this article, a discussion of the properties and applications of photoelectric cells and multiplier tubes is presented. The treatment is limited to photoemissive devices in which electrons produced by the action of light are emitted from the sensitive surface into a vacuum, or near vacuum, to be collected by a positive electrode. Some aspects of human vision, units used in photometry, elementary physics of quantum theory, and of the photoelectric process are included to remind the reader of the fundamentals which are involved.

PRINTED-CIRCUIT PLATING
The noble metal plating of printed circuits is discussed in this article. Details are given of the various metals used and their properties are considered. Tables are included which indicate recommended plating thicknesses for most modern materials along with illustrations and details of plating techniques.

Electronic technology

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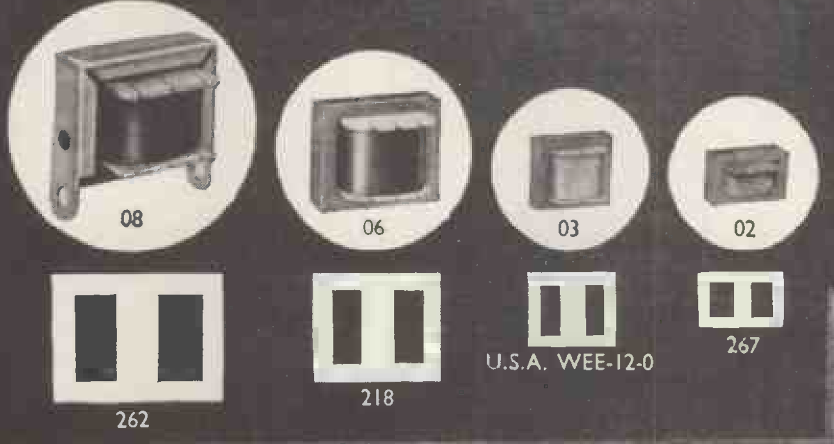

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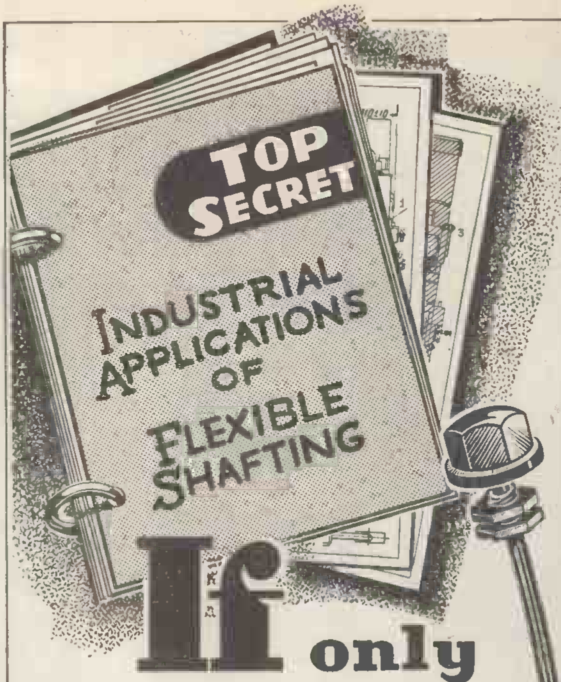

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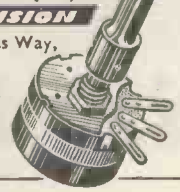

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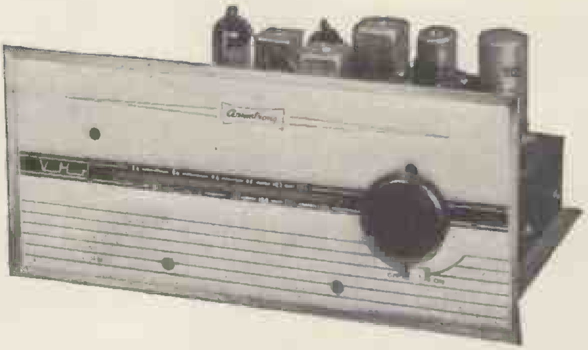

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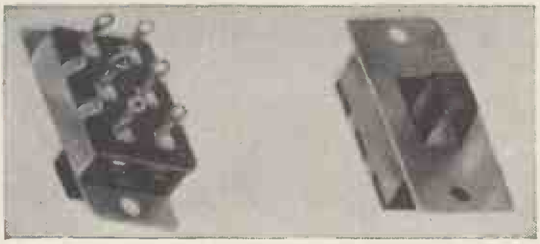

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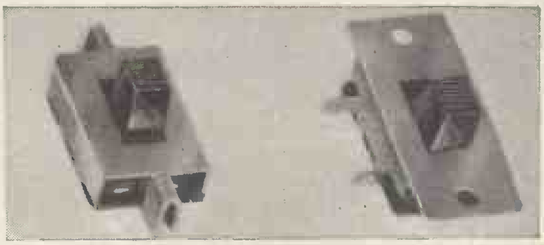

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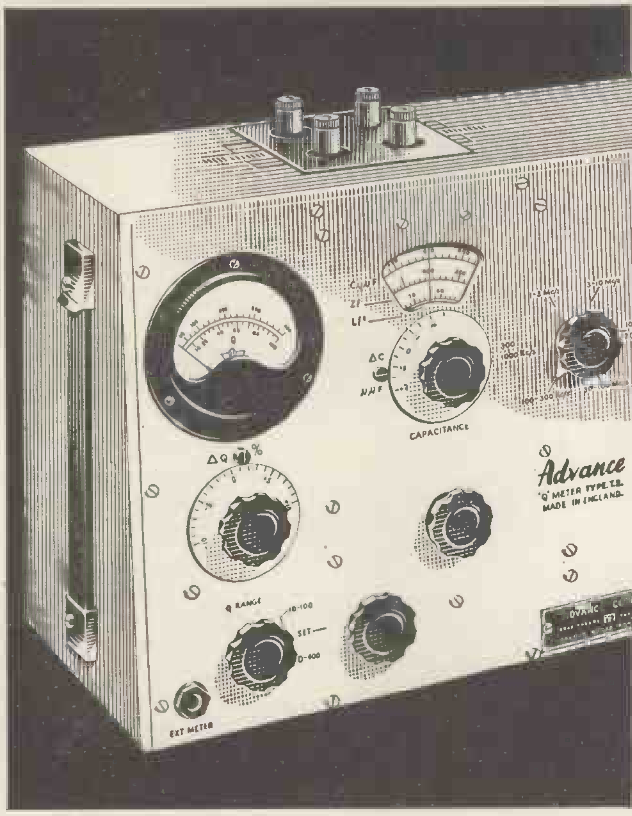

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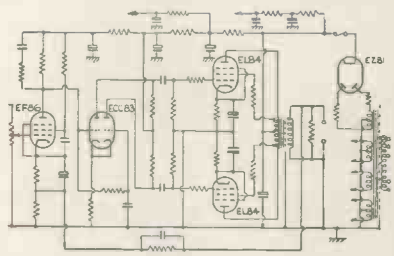

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*This is one of twenty-two Audio Transformers in the Solent and Miniford series described in Gardners new leaflet "S/M" especially prepared for retailers and private users, which includes over a hundred standard Mains Transformers and Chokes. We shall be pleased to post you a copy upon request.

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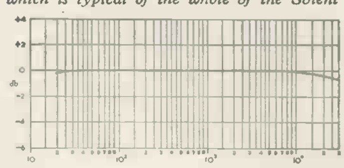

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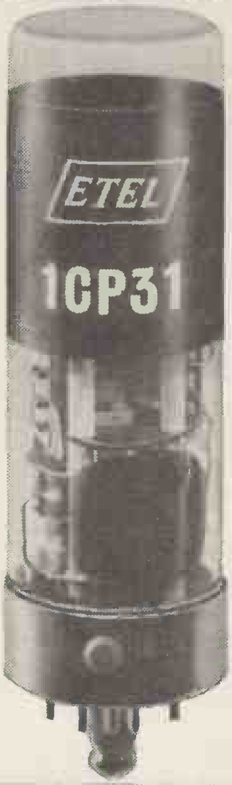

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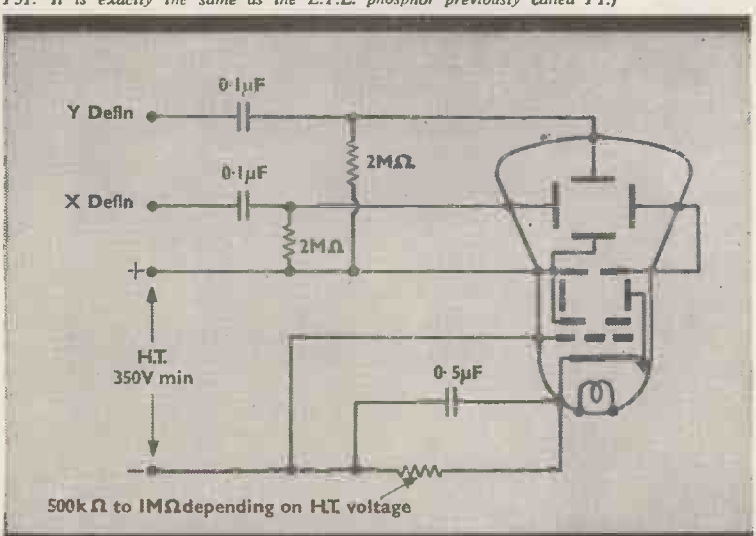

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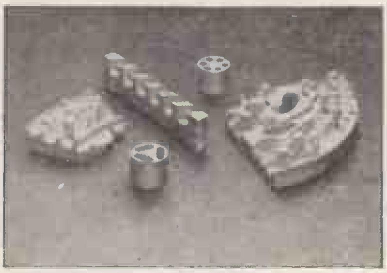


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Name ....

Firm ....

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"SIMPLEX" SOUND HEADS

STANDARD ½ TRACK MONAURAL

R/P
Gap .0002
.55 Inductance at 1 Kc.
7.5 MV. Output at 1 Kc.
Fully Modulated Tape.

ERASE
Dual gap.
20/25 v. at 55 Kc.
Inductance .8 Mh at 60 Kc.
—70 db. at 1 Kc. with 1 VA.

TYPE 'B' ½ TRACK ERASE HEAD

Specially designed for battery operated equipment and incorporating a secondary winding giving 90 V. output to provide A.C. Bias, for our standard ½-track R/P Head at the same time will provide a supply for neon tuning indicator. Used in conjunction with oscillator coil will provide A.C. erasure from a D.C. source, consumption being .2 VA at 50 Kc. untuned .15 VA tuned.

STANDARD ¼ TRACK FOUR TRACK

Stereo or Monaural operation.

R/P
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.55 Inductance at 1 Kc.
3 MV Output at 1 Kc.
0 to + 6 db at 10 Kc.
Fully modulated Tape.

ERASE
Single Gap.
Impedance 300 ohms at 50 Kc.
— 70 db with .6/1.0 VA.

Full specification, technical data and samples to the trade on request.

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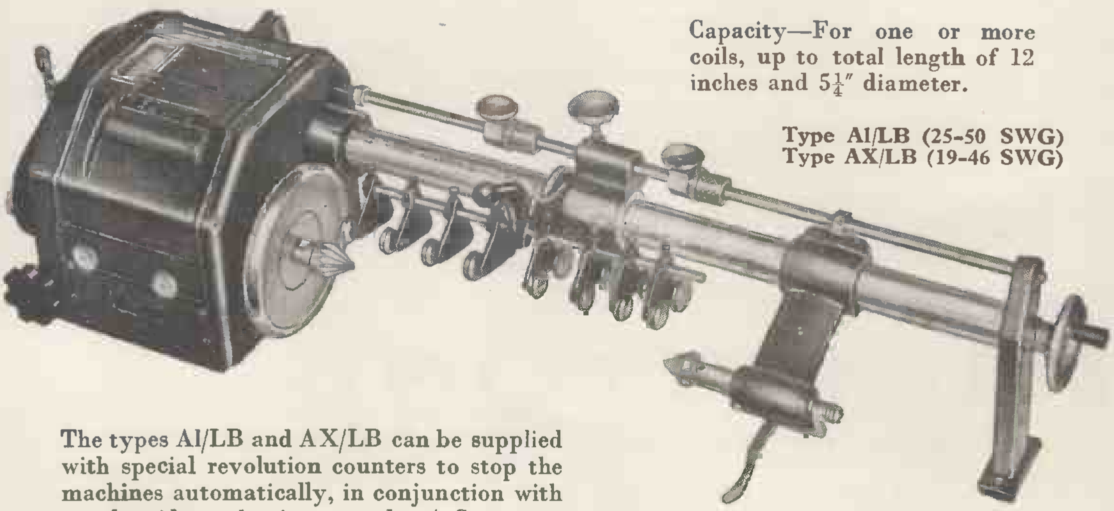

Capacity—For one or more coils, up to total length of 12 inches and 5¼″ diameter.

Type Al/LB (25-50 SWG)
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The types Al/LB and AX/LB can be supplied with special revolution counters to stop the machines automatically, in conjunction with a solenoid mechanism on the A.C. motor, when the required number of turns have been wound.

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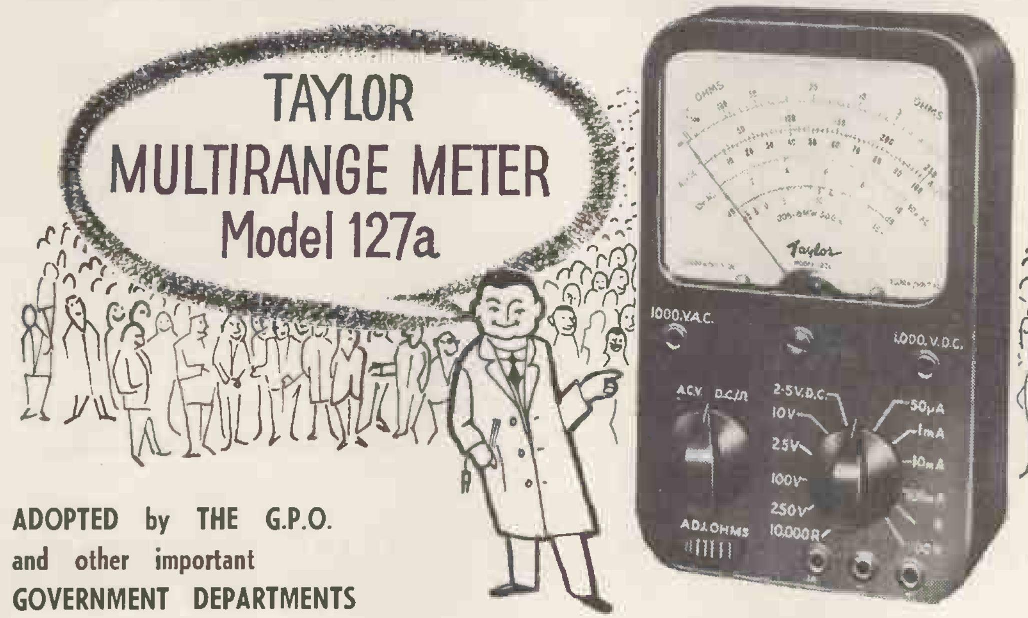
THOUSANDS OF SERVICE ENGINEERS INSIST ON IT!



ADOPTED by THE G.P.O. and other important GOVERNMENT DEPARTMENTS

Pocket size—20,000 o.p.v.!

OUTSTANDING FEATURES:

- ★ Sensitivity: 20,000 o.p.v. D.C. 1,000 o.p.v. A.C.
- ★ Very robust—shock proof moulding
- ★ Portability
- ★ 26 Ranges
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- ★ Volts D.C.: 0-3, 2-5, 10, 25, 100, 250, 1,000 V. (25 kV by probe).
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- ★ 3 Resistance Ranges from 0-20 Megohms (self-contained)
- ★ 40µA meter: 3¼in. arc.
- ★ Accuracy: D.C. 3% A.C. 4%.
- ★ Dimensions: 5¾ x 3¾ x 1¾in.
- ★ Weight: 14 oz.

RETAIL PRICE:

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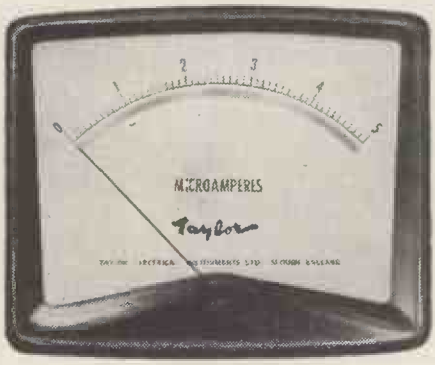
or 9 monthly instalments of £1.4.4 each

Complete with instruction manual and interchangeable test prods and clips. High Quality leather case, if required, £2. 5. 0

H.V. Probe for 25 kV......... £5. 5. 0



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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 4⅝in x 2¾in Front Plate 12in x 3¼in Stoved Gold hammered finished chassis Front Plate Polychromatic Gold. Weight of main amplifier 10lb Pre-amp. 3lb. For 50/60 c.p.s. A.C. mains 200-230-250 v. or to order for export.

The Following Outstanding Test Figures include Pre-amplifier.

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L.P. 25 m.v.
78 r.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.

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—70 d.b.

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—7 d.b. at 9 Kc/s.
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For 3 ohm and 15 ohm L/Speakers from high grade sectionally wound output transformer.

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P.S. Our prices are very competitive too!

CARBON	WATTS	OHMIC RANGE	TOLERANCES ±
1. Solid	1/10—1/2, 1 and 2	10—10M	5% 10% 20%
2. Cracked	1/30—1	1Ω—10M	5% and 10%
5. V. High Resistance	1/4—3	50M—10^{13}	5%—25%
6. * High Stability	1/10—2	1—50M	0·5% 1% 2% 5%
7. High Stability encapsulated in Epoxy Resin	1/4, 1/2, 1	10Ω—4·7M	1% 2% 5%
4. Metal Oxide Precision	1/4—2	100—4·2M	1% 2% 5%
WIREWOUND			
8. Vitreous	1—500	1—150K	1% 2% 5%
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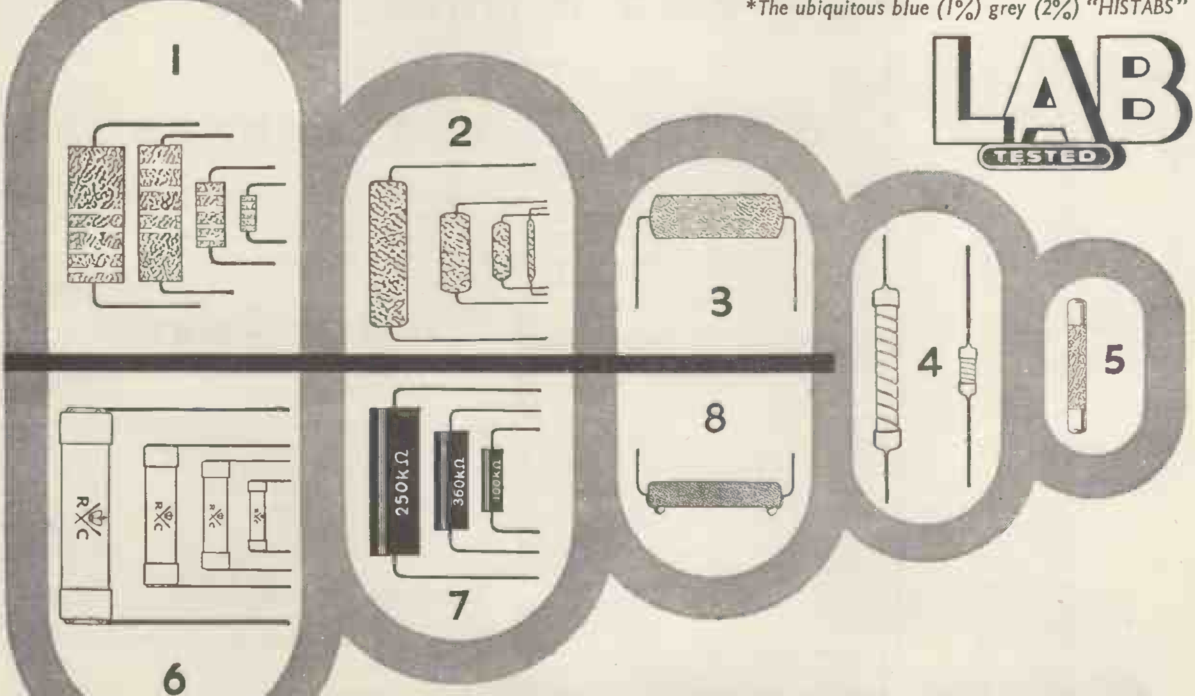

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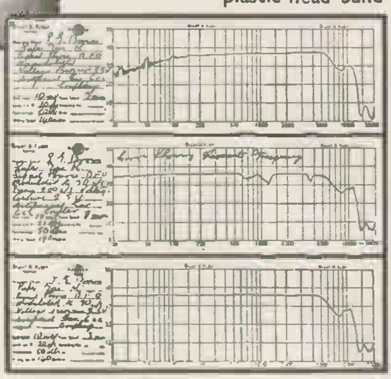

Spans 9 Octaves

These Frequency Response curves were produced under the following conditions:

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Component trends

in the sixties...

Plessey on stand 310 RECMF exhibition

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Loudspeaker Division · Components Group

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Plessey *Overseas Sales Organisation*
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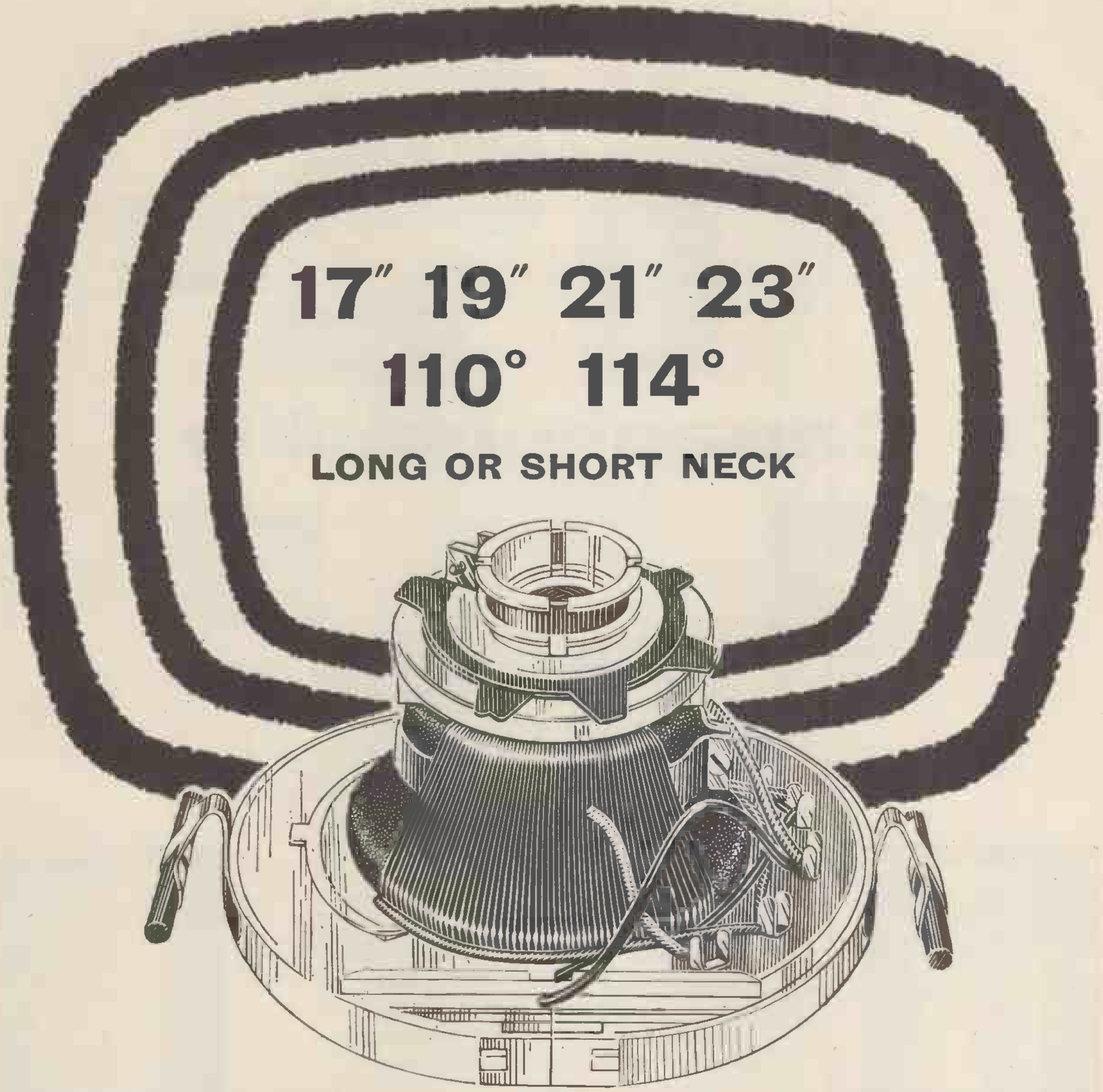
PL6b

COMPONENT TRENDS IN THE SIXTIES—*STAND 310*



A Plessey SCAN COIL FOR EVERY TUBE

The new Plessey scan coil, designed for operation with the full range of 110° and 114° tubes, incorporates several novel features which improve performance and versatility.

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- Three methods of picture correction available.

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THE PLESSEY COMPANY LIMITED

TVIR

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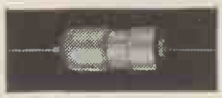
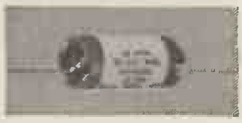
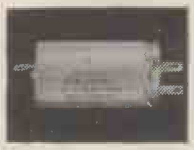
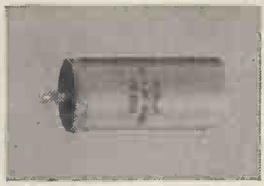


Capacitorability




In the design and production of thoroughly reliable electrolytic capacitors, Plessey have for years held a commanding lead. To every new demand made by rapid developments in radio, television and electronic equipment Plessey can respond by bringing to bear unrivalled experience, tremendous resources and highly skilled staff. Such is the care taken to obtain impeccable standards of quality and performance, that virtually clinical conditions of manufacture are maintained in the superbly equipped laboratories and workshops. These same exacting standards are imposed throughout the comprehensive range of capacitors produced by Plessey.

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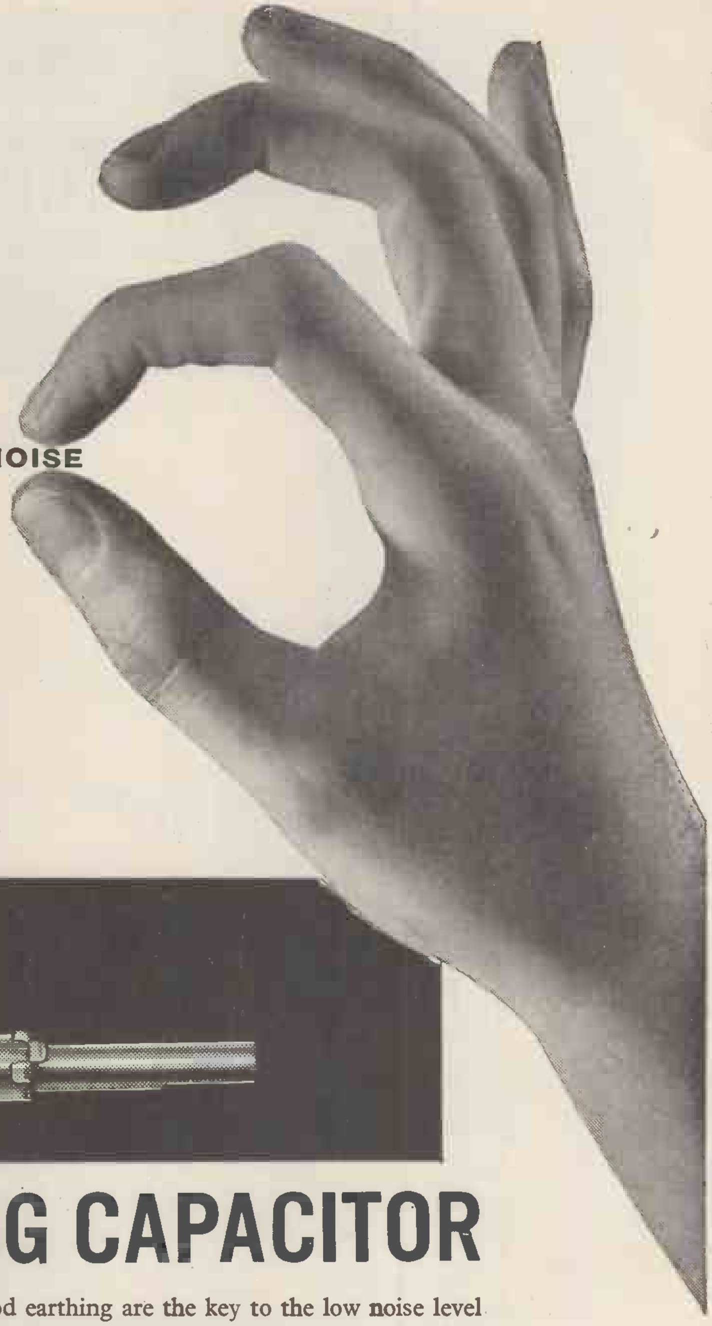
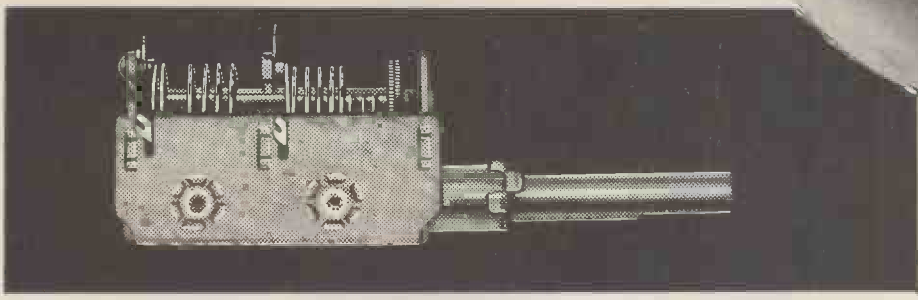
COMPONENT TRENDS IN THE SIXTIES—*STAND 310*



LOW NOISE

FM TUNING with the



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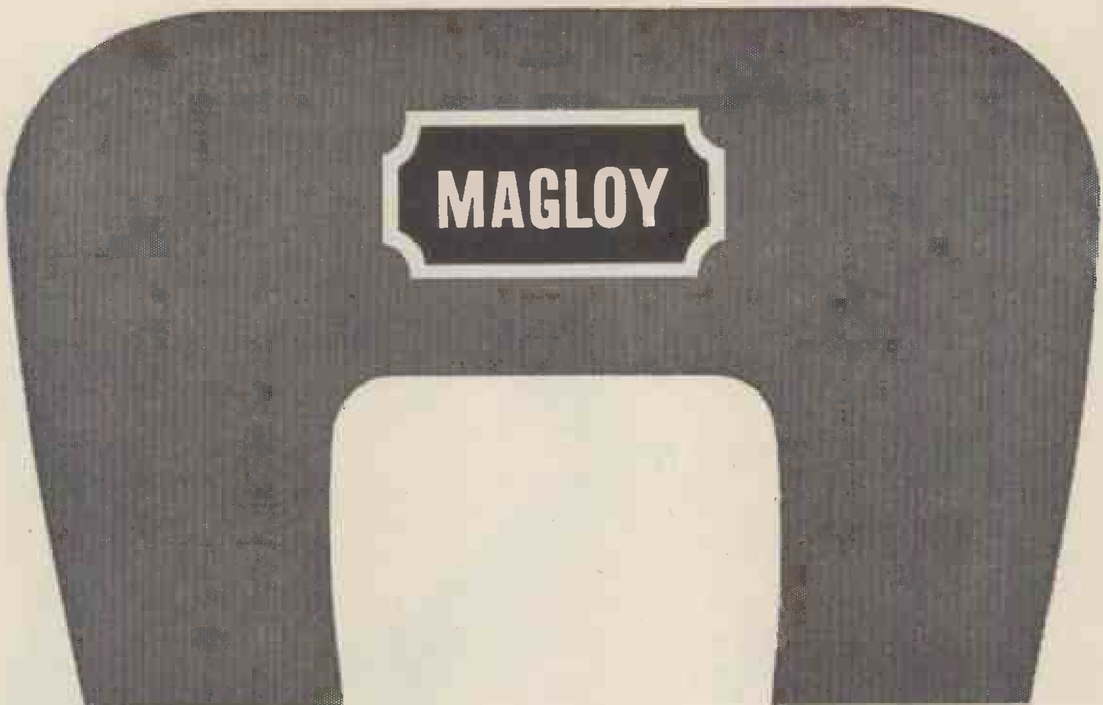
Further information will gladly be supplied to designers and engineers—please ask for publication No. 6-346.

Components Group, Havant Components Division

THE PLESSEY COMPANY LIMITED

HC7b

COMPONENT TRENDS IN THE SIXTIES—*STAND 310*



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MAGLOY CAST PERMANENT MAGNETS

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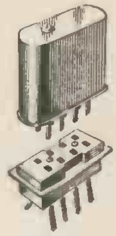
COMPONENT TRENDS IN THE SIXTIES—*STAND 310*

Plessey relays

SUB-MINIATURE TYPE CE



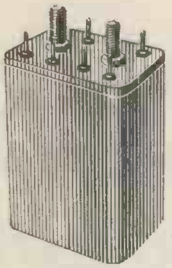
Occupies less than ¼ square inch of chassis area.

Two changeover contacts rated 0.25A at 28 V d.c.

Insulation proof against 500 V a.c., r.m.s. between coil and contact stack.

—55°C to +100°C operational temperature range.

MINIATURE TYPE CA



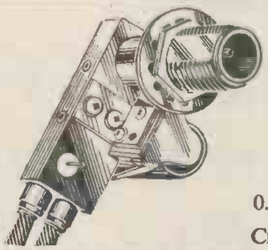
Fully Type Approved to RCS 165 and 166.

Light and medium duty types have two changeover contacts.

Heavy duty types single make or break.

Available sealed, or unsealed with dustcover.

PANEL SEAL COAXIAL TYPE CX



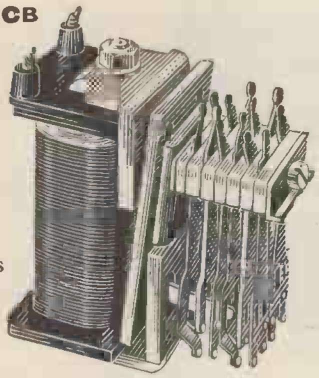
Meets Spec. DEF 5000 for materials and finish.

Single pole changeover, rated at 30 W RF in 50 ohms.

0.05 dB max. loss up to 400 Mc/s.

Crosstalk better than 40 dB down.

MINIATURE TYPE CB



Based on Type CA with heavier magnetic circuit.

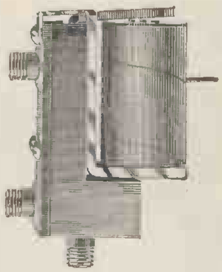
All versions fully Type Approved.

Available with up to twelve springs.

Twinned platinum contacts on light duty versions.

Available sealed, or unsealed with dustcover.

MINIATURE COAXIAL TYPE CY



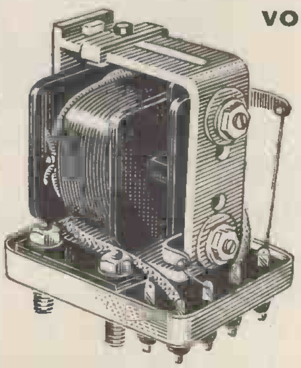
Single pole changeover, rated at 1 W RF in 50 ohms.

0.05 dB max. loss up to approx. 100 Mc/s.

—55°C to +100°C operational temperature range.

Better than 100 megohms insulation resistance at 250 V d.c.

VOLTAGE REGULATING TYPE XC 269



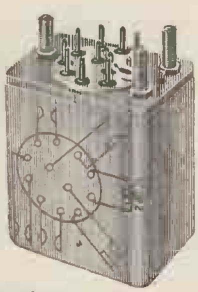
Fully Approved to S.R.D.E. Spec. 166/1.

Temperature compensated in range —40°C to +85°C.

Available for 6, 12 or 24 V operation.

Typical changeover voltage differential 1 V in 24 V.

MINIATURE TYPE CC



Meets RCS 165 and MIL-R-5757 specifications.

Based on Type CA magnetic circuit, providing up to four light or medium-duty contact sets.

Available sealed, or unsealed with dustcover.

Printed circuit versions available.

Contact loadings up to 10 A d.c., non-inductive, can be arranged for Types CA, CB, and CC.

meet the latest electronic requirements

THE PLESSEY COMPANY LIMITED
(Relays and Control Systems Unit)

RCS1a

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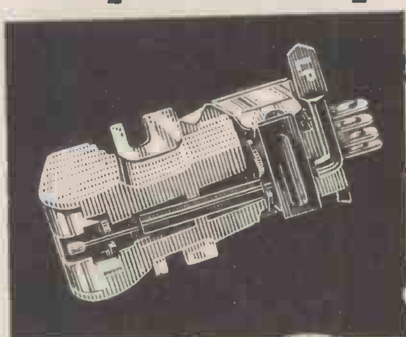
HIGHEST FIDELITY in stereo or mono with the Sonotone 8T pickup



unaffected by humidity and temperature

With its crisp clean reproduction in both stereophonic and monaural equipment, the Sonotone type 8T ceramic cartridge has become established among critical listeners. Fully compatible for stereo, LP and 78 r.p.m. records, the TCL type 8T has frequency response within ± 1.5 dB over 40-12,000 c/s and a sensitivity of 200 mV at 1 kc/s. The styli are micro-finished for minimum record wear and the stylus unit is easily replaceable.

Manufacturers and design engineers are invited to write for full details.

2T MONAURAL CARTRIDGE

A well established unit, fully compatible for LP and 78 r.p.m. records.

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TCL 12

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STABLE
ROBUST

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At your disposal, and backed by 20 years' experience of thermistor manufacture, is a wide range of types suitable for temperature measurement, control and compensation.

Consult leaflet MK/140 which contains summary information on all types in the standard range, or contact the Transistor Division for guidance on your particular problem and for details of non-standard types.

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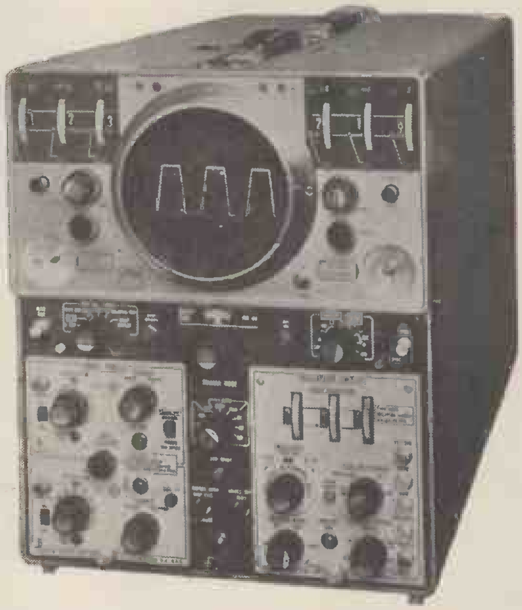

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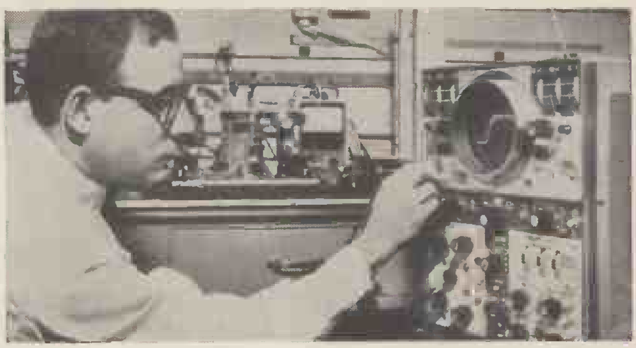

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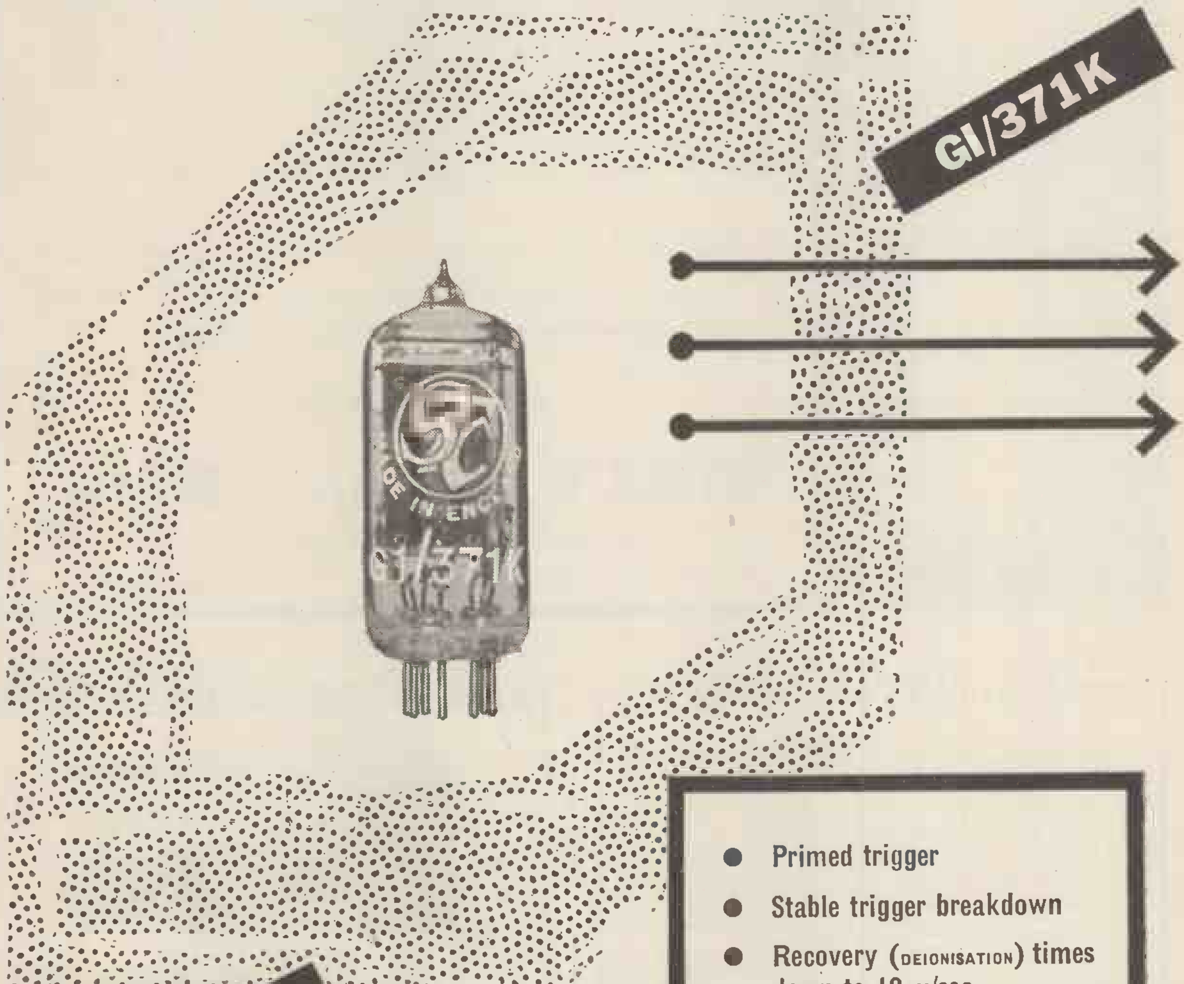

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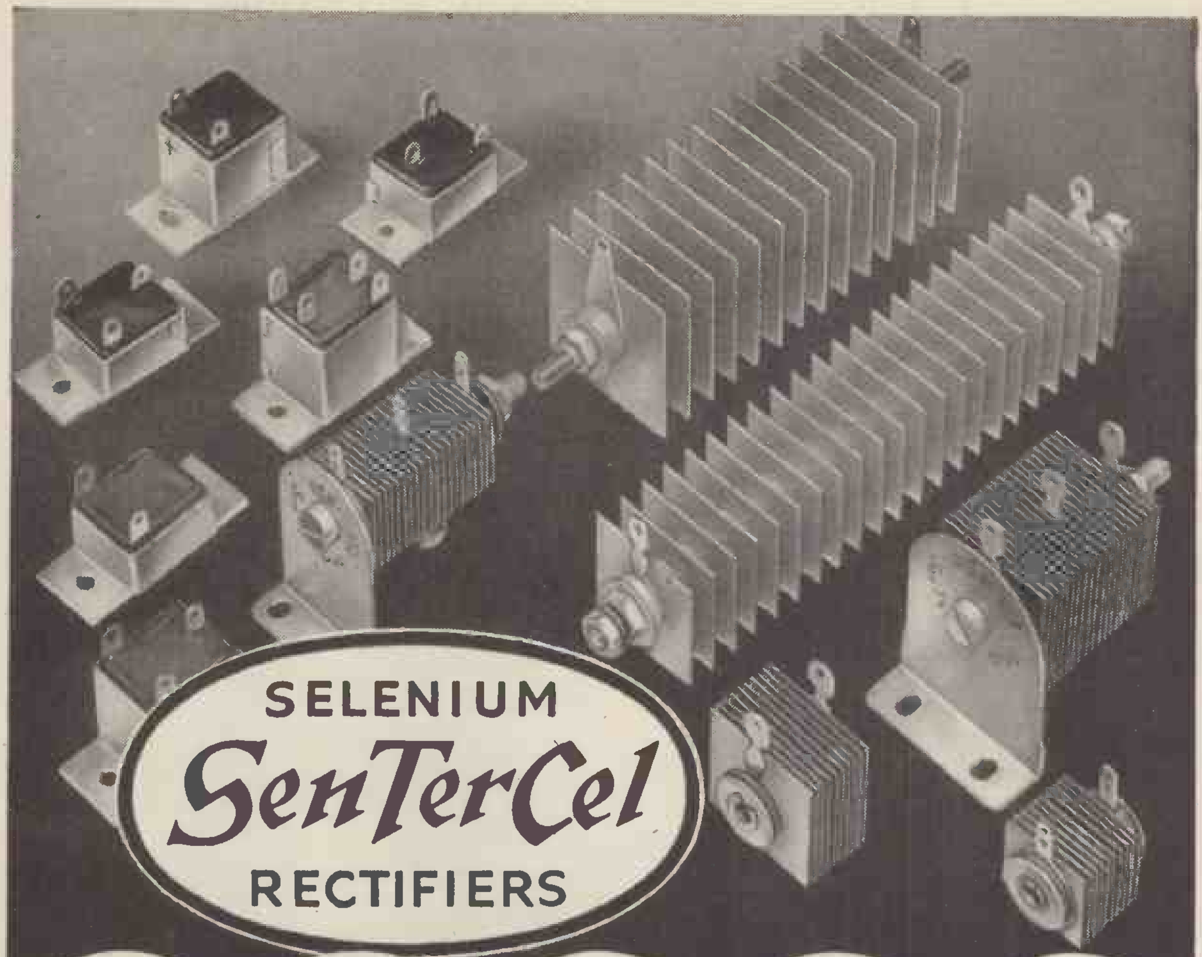

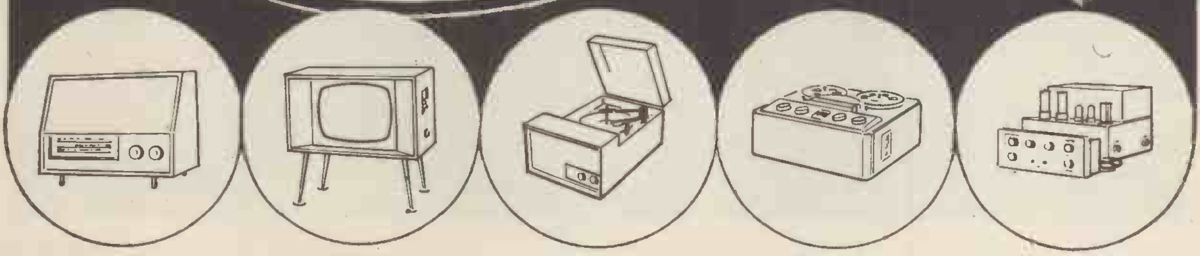

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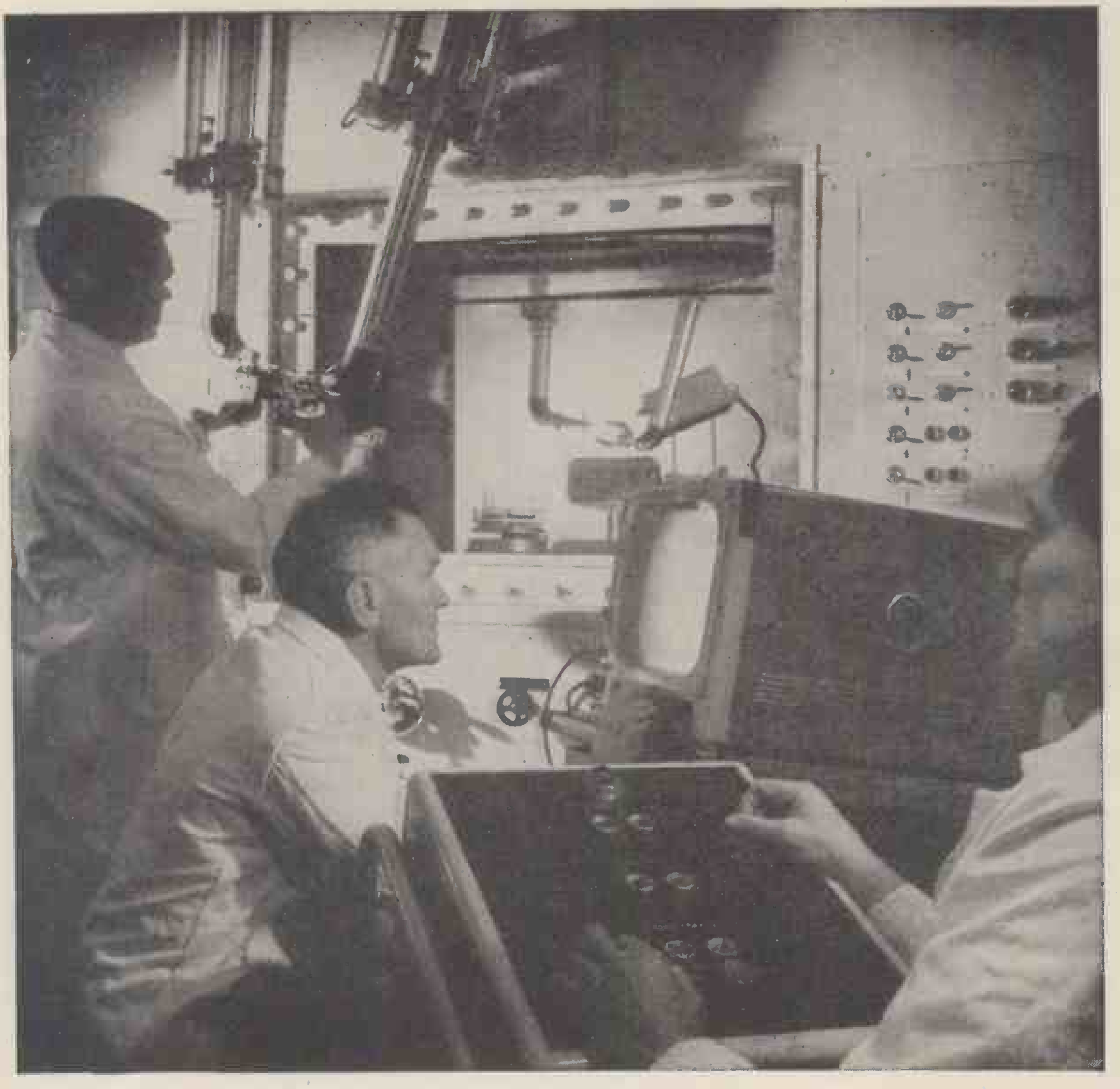

Pye at Dounreay

The Pye Instrument Group has supplied all the equipment to the U.K. Atomic Energy Authority for the irradiated fuel element laboratory at Dounreay. In addition to supplying equipment, Pye Ltd. acted as consultants and designers on all matters in that laboratory relating to instrumentation and remote handling. The illustration above shows manipulators working in conjunction with a television camera to handle and measure a sample from the fast reactor.

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"BELLING-LEE" NOTES

No. 29 of a Series

Some mechanical aspects of design: Part 2.

Last month we mentioned that in a multi-pole connector positional tolerances of the poles might result in excessive mating forces and wear. This is particularly true of connectors which have rigidly mounted pins and sockets, and in better class components it is usual to find that they are allowed a certain amount of individual float so that they can take up correct relative alignment. This principle of positional adjustment is used in "Belling-Lee" unitors, and even though the mouldings on which the contacts are mounted are made with extremely high precision, the plug pins are floating and capable of a controlled amount of lateral movement and variation in angle of approach. Notice that we say "controlled", because excessive float could be more harmful than a slight amount of mis-alignment, and might result in fracture in the event of jamming.

So far we have been talking about conventional plugs and sockets. Now let us look at the new "CAMLECON" and "COLLECON" connectors. These employ an entirely new principle of design whereby the contact pressure is stepped up *after mating has been effected.* Solid round pins are used with slotted sockets, and initially contact is made in the conventional way but with relatively light pressures. However, the pins have a gradual taper near the root, producing a slight waist, and after they are fully engaged in their sockets, a compressive force is applied to the mouth of these causing closure and an enormous increase in pressure on the pins, which is proportional to the amount of closure. Provided this exceeds the minimum necessary to take care of normal tolerances the mouth of the socket does not have to be closed completely to achieve the desired effect, for a small amount of closing force produces a surprisingly large increase in contact pressure. In fact, complete closure is to be avoided since this would impose a limitation, whereas partial closure means that the closing force is in balance with the resultant thrust due to the resilience of the socket material.

With contact pressures so high, variations in resistance due to shock and vibration are virtually eliminated, and it will be obvious that, while the closing force is maintained, it is impossible for the pins to be disengaged from their sockets, which grip them round the waist.

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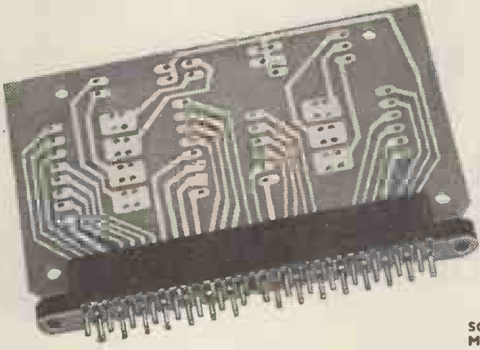

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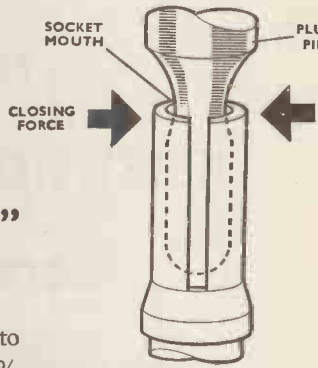

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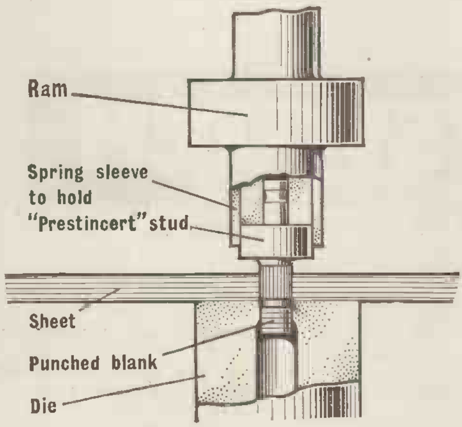

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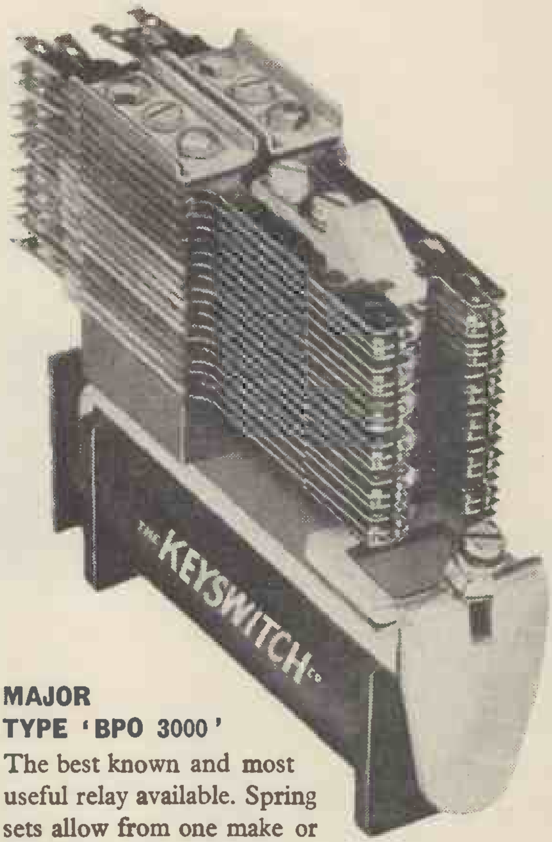

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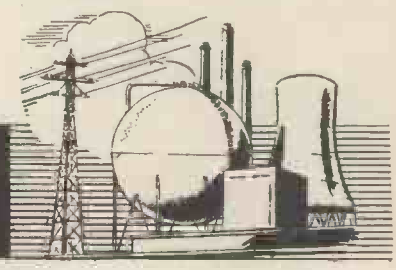

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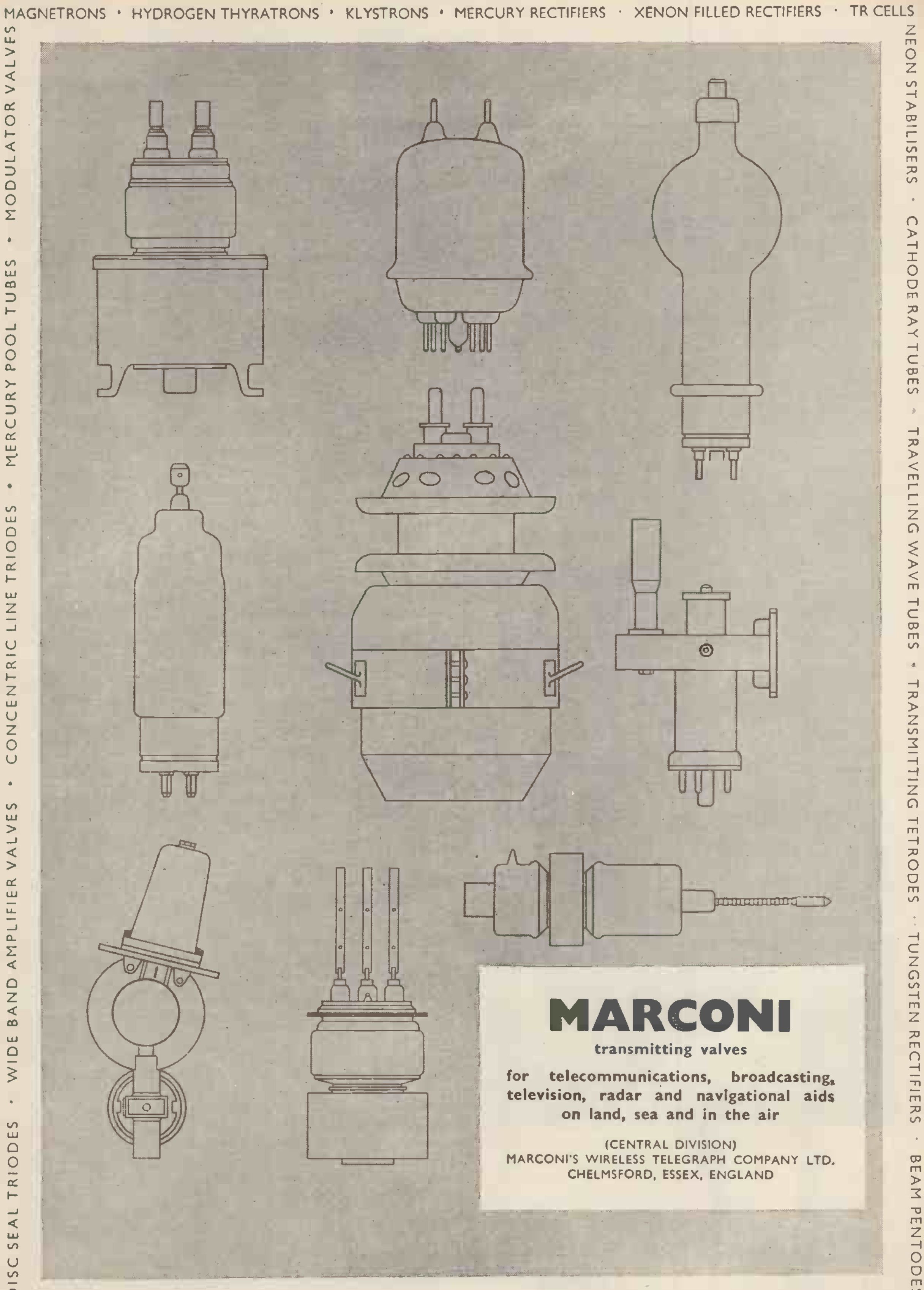
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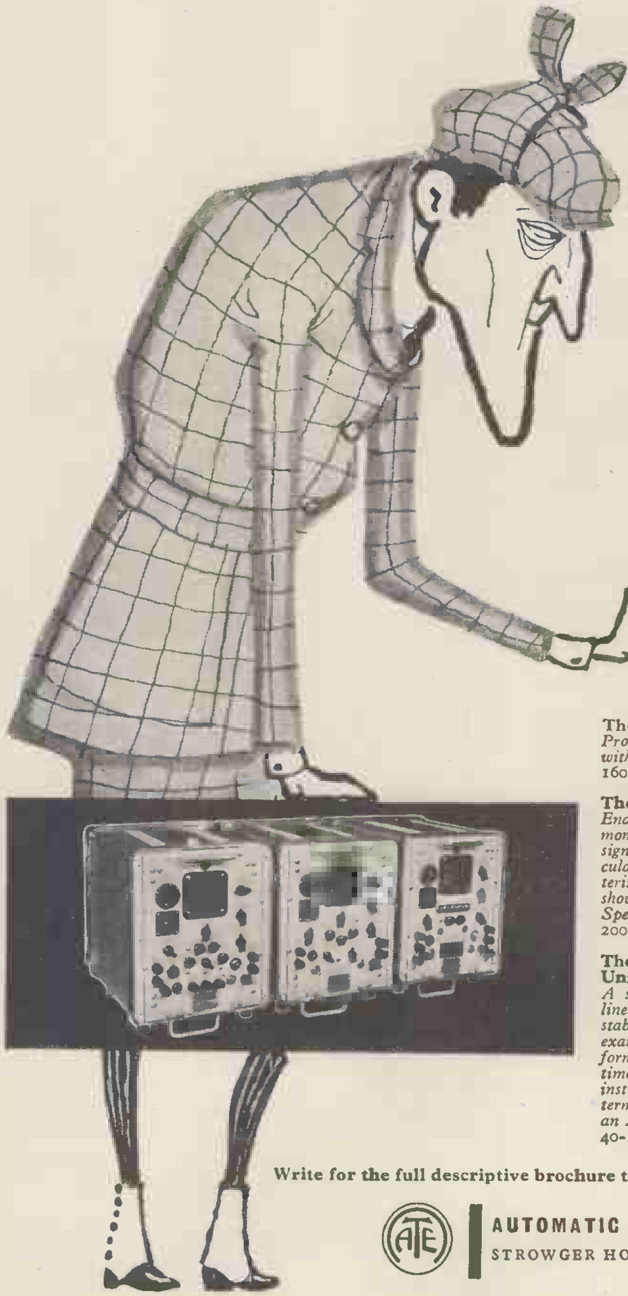


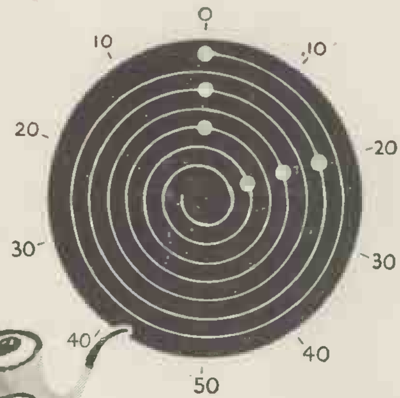
1 BIAS DISTORTION

The uniform lengthening or shortening of the mark or space elements, one at the expense of the other. The total time interval for one mark and one space remains the same. If the mark element is lengthened, then the space element will be shortened by the amount the mark is lengthened.

By examining a suspected transmission using the spiral time-base of a TDMS 6B, distortion becomes immediately apparent from the displacement from the vertical of the 'bright ups' representing the characteristic instants of modulation.

In the example shown, at 50 bauds, the space to mark transitions are all occurring 20% late, this means that the MARK element is being shortened by 4 mS consequently the SPACE element is being lengthened by 4 mS — note that the total allocated for one Mark and one Space (40 mS) remains the same.

Bias distortion may be due to a badly adjusted relay, mistuning of a radio receiver or even to a badly adjusted transmitter.



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Two cheery boys from
Cocklehampton

Dear Cheery Boys,

It isn't the ten and six that breaks us. It's the thought behind it. I suggest you try setting fire to your photographs next time - then we can get on with the job of telling people about our gold-bonded diodes, high frequency transistors and all the other semiconductors we are supplying to manufacturers at a rate of 250 thousand a week. Couldn't you go away ... or something?

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Aspects of design 35

OPERATING CONDITIONS OF FIELD SCANNING OUTPUT STAGES* (PART I)

This is No. 35 in the series of articles dealing with advanced problems in circuit design published by The Ediswan Mazda Applications Laboratory. No. 36 will appear next month. We shall be pleased to answer queries arising from this or other articles. Reprints of the first twenty-four articles, in booklet form, are available on request.

**In accordance with BS204 : 1960 the internationally used term "field" replaces the previously used term "frame."*

VOLTAGE MEASUREMENTS

When designing output stages for field scanning in television receivers it is necessary to ensure that the working conditions are such as to provide reliable operation and good valve life. This means that the stage must be capable of providing sufficient power to scan the full height of the tube face in spite of production variations in components and normal variations in supply voltage. In addition, normal production variations in valve characteristics must be taken into account and a safety factor allowed to accommodate sufficient deterioration of characteristics in use to ensure that early replacement is not necessary.

The purpose of the present article is to outline methods of making the necessary voltage measurements to determine the operating conditions of the stage. Current measurements will be the subject of "Aspects of Design No. 36."

MINIMUM ANODE VOLTAGE

For any field output valve in the Ediswan Mazda range examples are given of available maximum anode current for certain values of minimum anode voltage at the end of the scanning stroke. These figures represent the worst valve likely to pass the factory test, as well as a further deterioration to represent a useful length of life.

It was pointed out in "Aspects of Design No. 3" that the design of the output stage must be carried out in such a way that the anode voltage at the end of the scanning stroke does not swing below this stated minimum even under the most adverse conditions. Accordingly the measurement of operating conditions should be carried out using the highest value of deflector coil resistance likely to be encountered allowing for normal production variations, with this value further increased to correspond to the highest operating temperature.

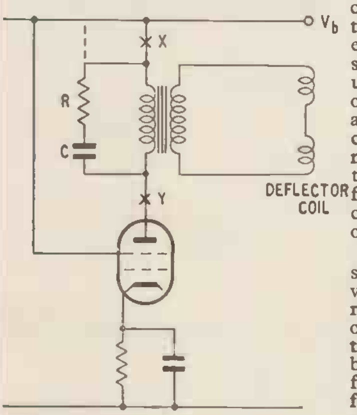

FIG.1

The HT line voltage should be the lowest value obtained over the range of mains taps on the receiver (with taps correctly adjusted), but this value should be further reduced to allow for variations in supply voltage.

Fig. 1 shows the circuit of a typical field output stage and Fig. 2 shows a typical anode voltage waveform. The presence of the high peak voltage during flyback makes accurate measurement of minimum anode voltage difficult. The flyback peak is usually of the order of 1,000 volts. It has been found convenient to carry out minimum anode voltage measurement by means of the circuit shown in Fig. 3. Point P is connected to the anode of the output valve, Q is connected to an oscilloscope of at least 1 megohm input impedance and point S is connected to a d.c. supply of at least 100 volts. With the potentiometer slider at the low potential end, the diode is non-conducting. The output valve anode waveform is displayed on the oscilloscope which may be of the a.c. coupled type but should have a good response down to at least 50 c.p.s. Resistor R must be chosen so that, in conjunction with the input impedance of the oscilloscope there is negligible attenuation of the waveform. For this purpose R should have a value of about 2% of the input impedance of the oscilloscope.

If the potentiometer slider is moved towards a more positive voltage there comes a time when this voltage equals the minimum anode voltage of the valve. The diode then begins to conduct and clipping of the negative extremity of the waveform is seen on the oscilloscope.

When clipping just commences the minimum anode voltage can be read on the voltmeter V. The resistor R is included to increase the impedance of the source from which the voltage waveform is supplied to the clipping diode, thus making the onset of clipping by the diode more noticeable.

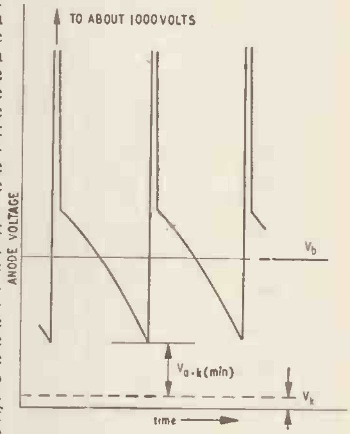

FIG.2

Some care must be exercised in the choice of a suitable diode for this application. During the flyback interval, voltage peaks of the order of one thousand volts appear on the output valve anode. The diode must therefore be capable of withstanding peak inverse voltages of this magnitude. In addition the diode must have low impedance in the forward direction for effective clipping. The heater supply may be provided by an isolated winding with insulation suitable for about 2,000 volts operation, in which case heater and cathode may be connected together. The alternative solution which is probably simpler, is to use a diode having a high heater-cathode voltage rating so that a heater supply at low potential can be used. These conditions are satisfied by the Ediswan Mazda U193 which has adequate heater-cathode insulation for this application. The use of silicon junction rectifiers in this application has been examined but their high capacity entails the use of a low value for the series resistor R, and this makes detection of clipping less sensitive.

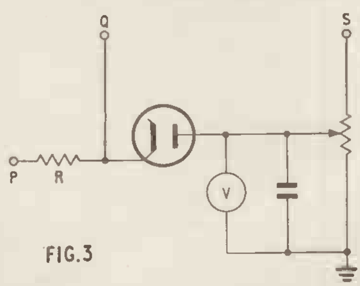

FIG.3

It should be emphasised that the figure to be determined in examining the operation of the stage is the minimum anode-to-cathode voltage of the valve. Therefore, if this circuit is used to measure minimum anode voltage with respect to chassis, the end-of-scan cathode voltage must be subtracted from the result.

PEAK ANODE VOLTAGE

It is also necessary to ensure that the Maximum Peak Positive Anode Voltage rating of the valve is not being exceeded. The Peak Positive Anode Voltage can best be measured by using a capacity compensated potentiometer together with a measuring oscilloscope. The potentiometer must be accurately calibrated after compensation, with the oscilloscope connected during calibration and compensation.

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Technical Service Department
155 Charing Cross Road, London, W.C.2
Tel: GERrard 9797 Grams: Sieswan Westcent: London

NEW HIGH POWER TRIODE BEAM TETRODE

EDISWAN MAZDA 30PL14

The 30PL14 Triode Beam Tetrode is intended principally for use in frame deflection circuits of television receivers using 110° and 114° cathode ray tubes. The tetrode section has been designed to operate with a low ratio of screen to anode current whilst the available peak anode current and anode dissipation are higher than in the 30PL13. The higher available peak anode current will, in many cases, permit economies in output transformer design. The triode section is a general purpose triode with identical characteristics to the 6/30L2, and that of the 30PL13, for use as a deflection drive voltage oscillator, frame sync. pulse separator, etc.

Heater Current (amps)	I_h	0.3
Heater Voltage (volts)	V_h	16

TENTATIVE RATINGS AND DATA

Maximum Design Centre Ratings

		Triode	Tetrode
Anode Dissipation (watts)	$p_{a(max)}$	1	8
Screen Dissipation (watts)	$p_{g2(max)}$	—	2
Peak Anode Voltage (Pulse positive) (kV)		—	2*
Peak Anode Voltage (Pulse negative) (kV)		—	0.5*
Anode Voltage (volts)	$V_{a(max)}$	250	250
Screen Voltage (volts)	$V_{g2(max)}$	—	250
Heater to Cathode Voltage (volts rms)	$V_{h-k(max)}$ rms	150†	150†
Mean Cathode Current (mA)	$I_{k(max)}$	—	75
Resistance Grid 1 to Cathode			
Self Bias (MΩ)		—	2
Fixed Bias (MΩ)		—	1

*Maximum pulse duration 5% of one cycle with a maximum of 1 msec.

†Measured with respect to the higher potential heater pin.

TRIODE CHARACTERISTICS

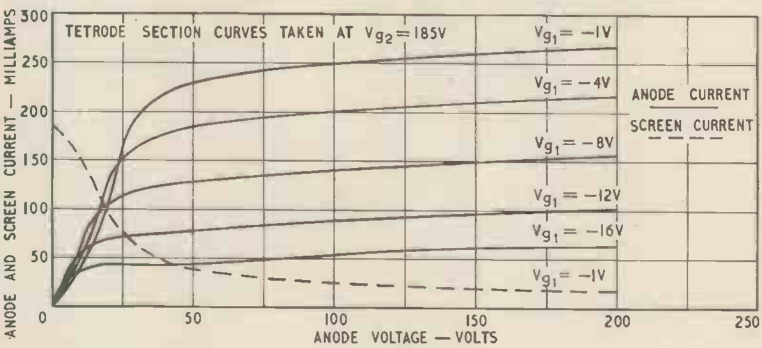
Anode Voltage (volts)	V_a	200
Anode Current (mA)	I_a	10
Grid Voltage (volts)	V_{g1}	−7.7
Mutual Conductance (mA/V)	g_m	3.4
Amplification Factor	μ	18

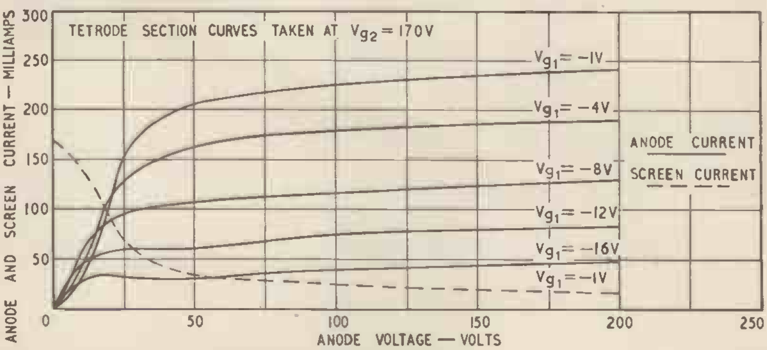
TETRODE OPERATION IN FRAME TIME BASE

Allowance must be made in circuit design, not only for component variation, but for valve spread and deterioration during life. Values of total tetrode peak anode current, for an average valve when new and at the assumed end of life point for any valve, are as follows:—

	V_a (V)	V_{g2} (V)	V_{g1} (V)	I_a (mA)
Average New Valve	55	170	−1	210
Assumed End of Life Condition	50	170	−1	135
Average New Valve	55	185	−1	235
Assumed End of Life Condition	50	185	−1	151

Tentative Characteristic Curves of Ediswan Mazda Valve Type 30PL14

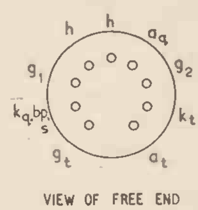


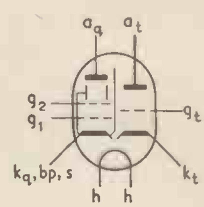


Mounting Position: Unrestricted

Base: B9A (Noval)

Connections





Maximum Dimensions (mm)

Overall Length	78.5
Seated Height	71.5
Diameter	22.2

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HIGH POWER OSCILLATOR/AMPLIFIER TYPE 254

VERSATILITY **Is the instrument capable, as it stands, of performing a wide variety of duties?**

The Airmec Oscillator/Amplifier Type 254 consists of a 150-watt amplifier, which may be driven from an internal oscillator operating over the range 30 c/s to 30 kc/s, or from an external source. It is fully equipped with metering and protective circuits, and may be applied as a power source for "odd-frequency" equipment, vibrators, and small servo-motors, for double-voltage, double-frequency testing of transformers, and for use as a high power audio amplifier.

LOAD IMPEDANCE **Can a variety of loads be matched efficiently?**

Reasonably good matching is essential to reduce distortion and to enable full power output to be obtained. The output transformer of the Airmec Oscillator/Amplifier Type 254 has a number of secondary windings, which may be switched into series/parallel combination to match loads between 16.7 and 4,270 ohms.

POWER OUTPUT **Is the available power output sufficient?**

An amplifier may be designed to provide almost any degree of power, but only at great expense and by using special techniques. The Airmec Oscillator/Amplifier Type 254 provides a useful output with conventional circuitry, the maximum continuous sine-wave output being 150 watts from 50 c/s to 5 kc/s, which is maintained at 100 watts at 30 c/s and 10 kc/s and is still 50 watts at 30 kc/s.

HUM AND NOISE **Is the level of spurious signals acceptable?**

Excessive hum and noise can be a severe disadvantage in any application involving ancillary equipment or comparative measurements. The total hum and noise produced by the Airmec Oscillator/Amplifier Type 254 does not exceed 40 mV at any output impedance.

PRICE AND DELIVERY **Are both the price and delivery reasonable?**

The price of the Airmec Oscillator/Amplifier Type 254 is only £200 and delivery is immediate.

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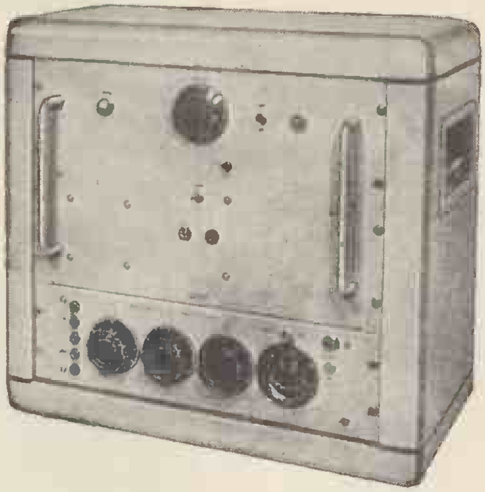
120/200 WATT AMPLIFIER



Will deliver 120 watts continuous signal and over 200 watts peak Audio. 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 12¼ inches of standard rack space by 11 inches deep. Weight 60lb.

30/50 WATT AMPLIFIER

Gives 30 watts continuous signal and 50 watts peak Audio. With voice coil feedback distortion is under 0.1% and when arranged for tertiary feedback and 100 volt line it is under 0.15%. The hum and noise is better than —85 dB referred to 30 watt.

It is available in our standard steel case with Baxendale tone controls and up to 4 mixed inputs, which may be balanced line 30 ohm microphones or equalised P.U.s to choice.

ELECTRONIC MIXER/AMPLIFIER

This high fidelity 10/15 watt Ultra Linear Amplifier has a built-in mixer and Baxendale tone controls. The standard model has 4 inputs, two for balanced 30 ohm microphones, one for pick-up C.C.I.R. compensated and one for tape or radio input. Alternative or additional inputs are available to special order. A feed direct out from the mixer is standard and output impedances of 4-8-16 ohms or 100 volt line are to choice. All inputs and outputs are at the rear and it has been designed for cool continuous operation either on 19 x 7in. rack panel form or in standard ventilated steel case.

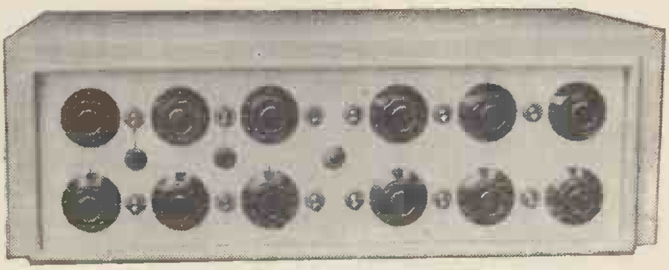
Size 18 x 7½ x 9½in. deep.

Price of standard model **£49.**

12-WAY ELECTRONIC MIXER

The 12-way electronic mixer has facilities for mixing 12 balanced line microphones. Each of the 12 lines has its own potted mumetal shielded microphone transformer and input valve, each control is hermetically sealed. Muting switches are normally fitted on each channel and the unit is fed from its own mumetal shielded mains transformer and metal rectifier.

Also 3-way mixers and Peak Programme Meters. 4-way mixers and 2 x 5-way stereo mixers with outputs for echo chambers, etc. Details on request.



Full details and prices of the above on request

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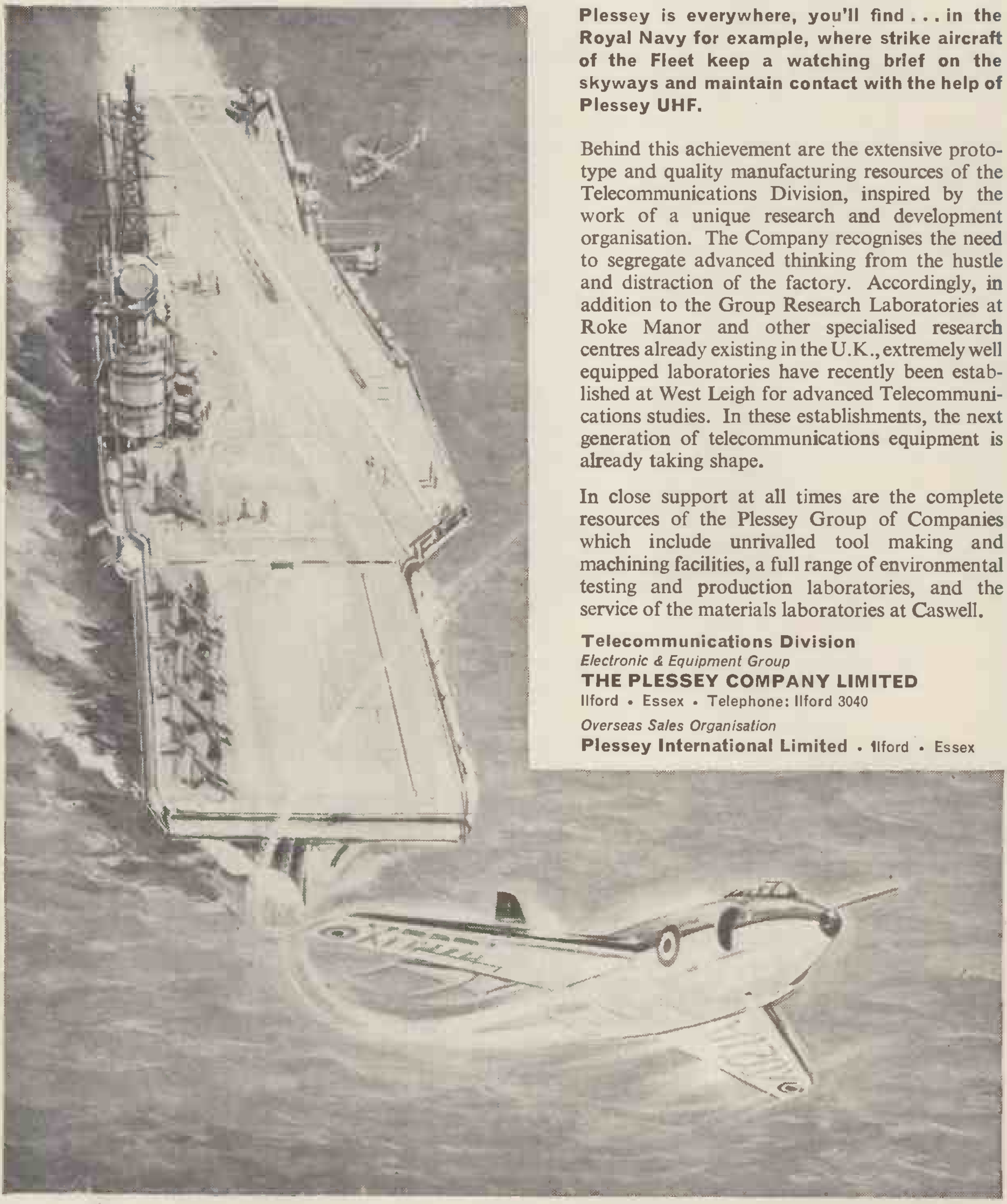

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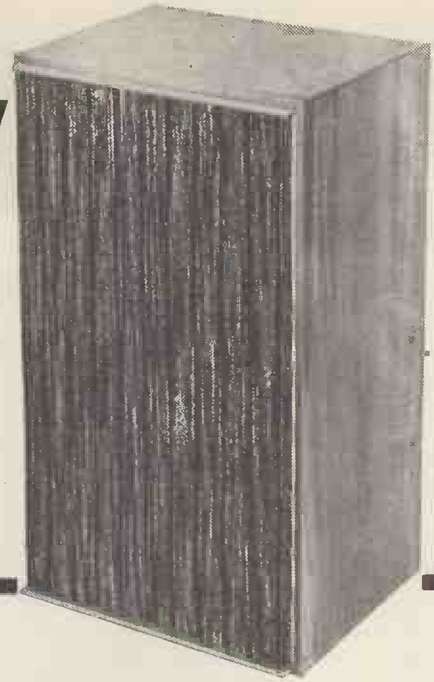

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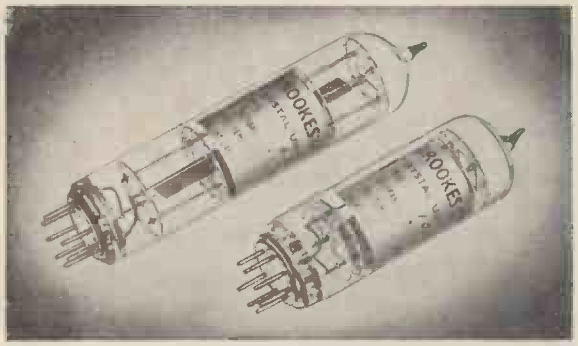

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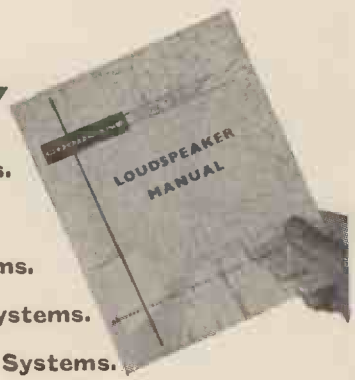

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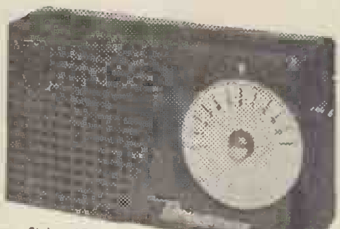
Over 1,000 letters received.

Pocket 5 Q.P.P.

This pocket receiver is just right for taking on holiday. It has a remarkable performance comparable in fact with portables being sold at £10 and over. It uses a three inch moving coil speaker to give high quality tone and the output is circuit push-pull. It completely tunes over the medium and long wavebands. The price is £4/15/- complete, postage and insurance 2/6 extra.

All circuits are reflex type and have been carefully tested and none need aerial or earth, also all are contained in proper radio cases (not adapted sandwich boxes) and use proper tuning condensers and scales.



POCKET 4 (3 Transistors, 1 Diode).
This set gives good performance in all areas and has real entertainment value, and can be heard all over the room in reasonably quiet conditions. It has an internal aerial and works completely from this. Basically it covers Medium Waves, but Long and Medium Waves are available as an optional extra. Also, details are given of additional stages than can be added to bring the volume up to car radio level. Price for all parts and case (size 5½in. × 3in. × 2in.) as illustrated but less motifs is £2/2/-, plus 2/6 postage and insurance. Batteries are 10d. extra.

POCKET 3 (2 Transistors, 1 Diode)
This is the Pocket 4 less the audio stage. In Eastbourne, recognized as a poor reception area, the Home Service comes in at a comfortable level, and the Light Programme comes in well with the Long Wave addition. Some Continental stations are also receivable. The Pocket 3 is essentially a "close to the ear" receiver, and although it is fitted with a miniature loud-speaker the volume is not enough to be heard more than a yard or so away from the loudspeaker except in areas of high signal strength. A point worth noting however, is that a conversion is available which enables the Pocket 3 to be made into a Pocket 4 with very little re-building. Price for all parts and case as illustrated, but less handle and motif is 32/6, plus 2/6 postage and insurance.

POCKET 5 (4 Transistors, 1 Diode and DLR 5 Speaker)
This is the Pocket 4 with the necessary additional parts to add on an audio stage to bring up the volume two or three times, also components are supplied for tone correction, and feed back, features which all go to improve quality of output. Constructors are recommended to build the Pocket 4 first, get this operating properly then add the additional Pocket 5 stage. The price of the additional stage is 12/6 making a total cost of £2/15/6, plus 2/6 postage and insurance. Long and Medium Wave parts for any of the above 6/6 extra. Batteries 10d. extra.

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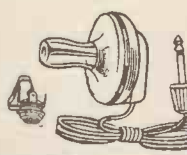

For Transistor Circuits or Deaf Aid. Very light weight and easy to wear, cord almost invisible, good quality production of music and voice, complete with miniature plug and socket, ready to use. Crystal and Magnetic, 9/-. Post and Insurance 1/-. Min. plug and socket as fitted to above, 3/6.

Solderless Transistor 3

Any boy from eight years onwards will easily make this pocket size transistor set. No soldering is involved and in fact the set can be made up virtually without tools. It is nevertheless a workmanlike job which, when completed, will receive Luxemburg and local stations entirely without aerial or earth. Uses two transistors and diode in reflex circuit. Other features include optional medium and long waves and loud speaker.

The parcel contains everything necessary to complete as follows:—
Packet of Solderless terminals.
Packet of Condensers.
Packet of Resistors.
Packet of Transistors.
Connecting wire.
Proper plastic transistor set case with printed scale and tuner.
Hearing aid type headphone.
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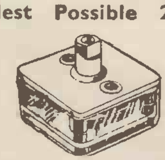

With built-in trimmers, polystyrene cased, size only 1×1×7/16in., price 17/6. Smallest IF and oscillator to match, 21/-. P.P. input and P.P. output transformers, 12/6. Circuit diagram free with any of above.

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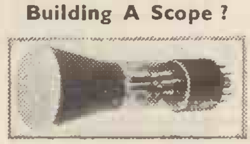

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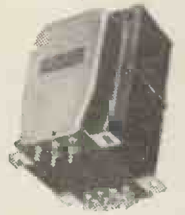

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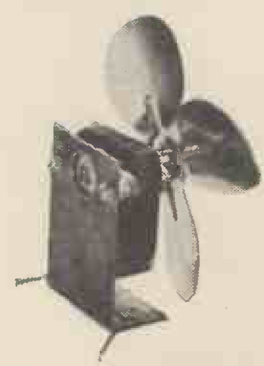

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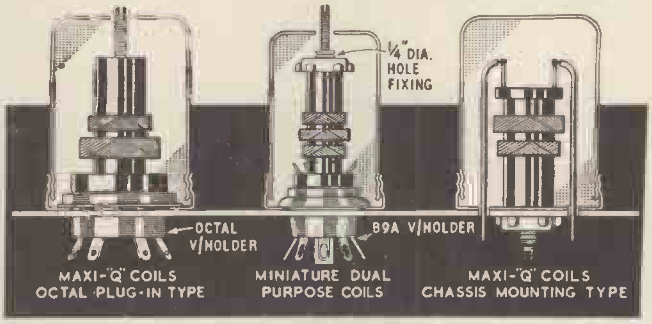

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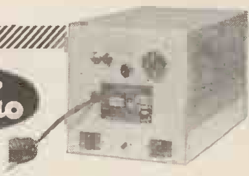

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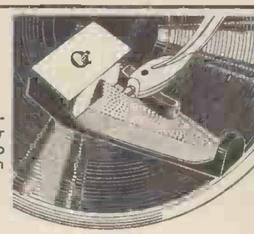

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70	11.45	16.75		
240	20.00	33.45		

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LOW PRICES TO VOLUME BUYERS!

*Derate 20% for battery or capacitive load or D.C.

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WITH BUILT IN RF SURGE AND SERIES BALANCING PROTECTION

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TOP HATS

General Purpose Special 2 for $1 — 400 PIV at 300 MA 20 for $7

Factory Tested — *Guaranteed!*

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rms/piv 210/300 43c	rms/piv 280/400 55c	rms/piv 350/500 70c	rms/piv 420/600 $1.00
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2BP 75Ua ¾×⅝in. c40 @, 11 for $4.
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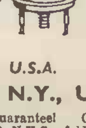

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2N293 NPN 45c, 12 for $5, 100 for $37.
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Pulse Amplifier or High Current Switch Veb. Vce. Veb Approx. 40V.
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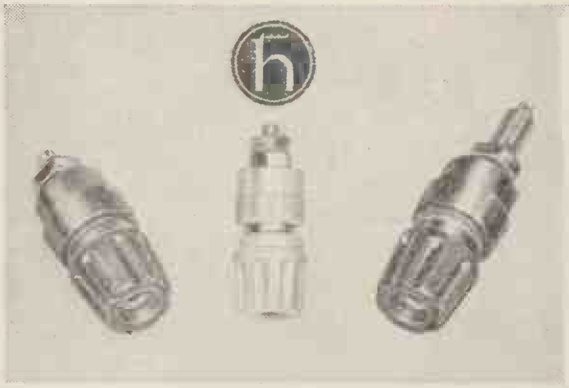

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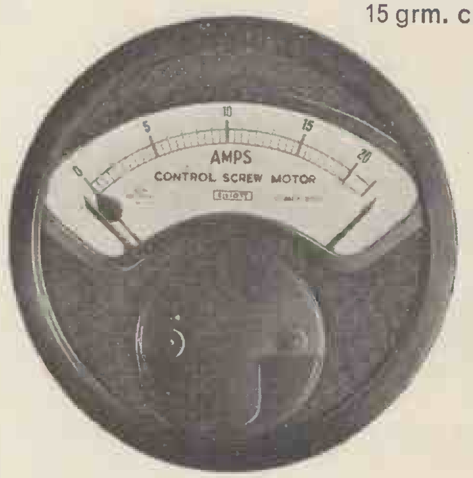

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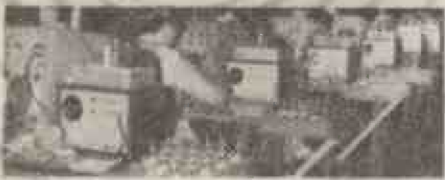

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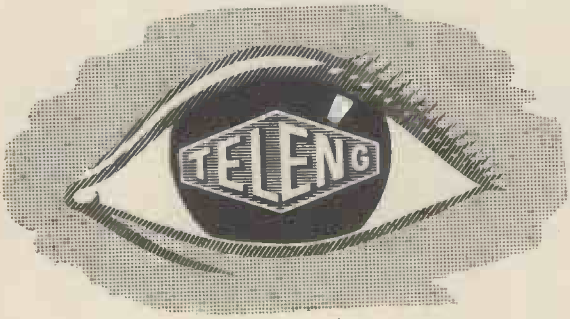

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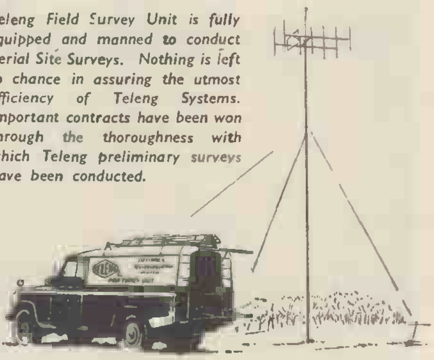

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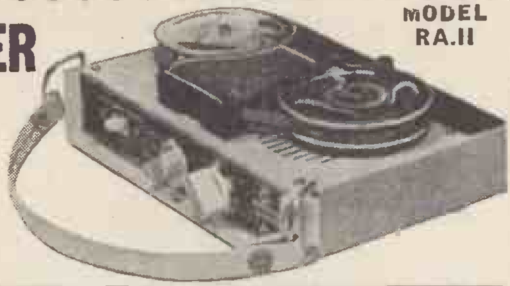
TRANSISTOR TAPE RECORDER

MODEL RA.II



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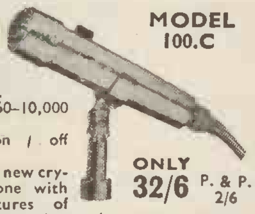
THREE WAY SLIM CRYSTAL MICROPHONE

MODEL 100.C



★ May be hand held, stand mounted or suspended by Lavalier Cord.
★ Response 60–10,000 Cps.
★ Built-in on / off switch.

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ONLY **32/6** P. & P. 2/6

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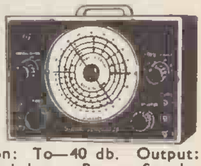

Freq. Range: 150 kc/s–150 Mc/s on fundamentals (6 bands), 150 Mc/s–300 Mc/s on harmonics. Calibration accuracy within ±1 per cent. Modulation Internal and external. Attenuation: To—40 db. Output: Facilities for high and low. Power Supply: Internal 230 v. A.C. Size: 7 x 10 x 5in. Complete with test leads and instruction manual. **ONLY £14/19/6.** Carr. 5/6. Fully guaranteed.

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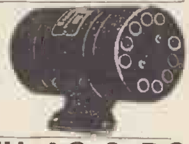

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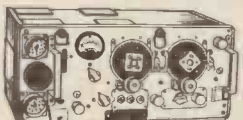

Incorporates TX/RX covering 2–8 Mc/s. (37.5 – 150 metres), and intercom. amplifier. Complete with 15 valves, 500 micro-amp. check and tuning meter, circuits and instruction book.
ONLY 65/-. Carr. 10/-.

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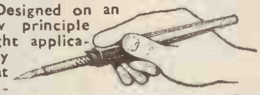

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Can be assembled in ½ hour.

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MULTI-METERS

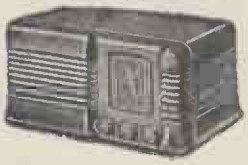
CABY A10 Basic meter, sensitivity 155 micro-amps. A.C. and D.C. ranges. £4/17/6.
CABY B20. Sensitivity up to 10,000 ohms per volt A.C. and D.C. **£6/10/-**
EAGLE. A.C. and D.C. 10,000 ohms per volt. **£5/19/6.**

ACOS HI-FI CRYSTAL 'MIKES'

Mic 40 Hand or Desk type **27/9** (Listed 45/-)
39-1 Stick type **39/6** (Listed 5 Gns.)
Limited number.

VALVES! Full range at really competitive prices.

THE SKY FOUR 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, SP61, 6F6 and is specially 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 £4/19/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

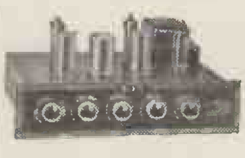
Type BM1. An all-dry battery eliminator. Size 5½ x 4½ x 2in. approx. Completely replaces batteries supply 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s is available. Suitable for all battery portable receivers requiring 1.4 v. and 90 v. This includes latest low consumption types. Complete kit with diagram 39/9 or ready for use 46/9.
Type BM2. Size 8 x 5½ x 2½in. Supplies 120 v. 90 v. and 60 v., 40 mA and 2 v. 0.4 a. to 1 amp., fully smoothed, THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.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.

POWER PACK KITS. Only 19/11. Fully smoothed H.T. output of 250 v. 60 mA and L.T. supply of 6.3 v. 1.5 amp. Consisting of Double Wound Mains Transformer 230/250 v. 50 c.p.s. A.C. primary. Selenium Rectifier. Smoothing Choke, Double Electrolytic Condenser, Aluminium Chassis and Circuit.

R.S.C. A12 STEREO AMPLIFIER KIT — 4 GNS. Carr. 5/6

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.

R.S.C. STEREO/TEN HIGH QUALITY AMPLIFIER KIT



Valves EZ81, ECC83, ECC83, EL84, EL84. Separate bass and treble controls giving "cut" and "boost." Sensitivity 50 mV. 5 watts high quality output on each channel. Can be used as straight 10 watt amplifier. Controls: Stereo/Monaural switch, ganged volume, ganged treble, ganged bass, and balance. Outputs for 3 ohm speakers. Point-to-point wiring diagrams and instructions. Illustration full wiring details and priced parts list, 1/9. **8 GNS.** Carr. 7/9.

POCKET PORTABLE TRANSISTOR

RADIO DESIGN. Employing 2 Brimar R.F. Transistors 1 output Transistor, and crystal diode, Ferrite Rod Aerial, Miniature Speaker unit. Handsome Plastic Case. Constructional Envelope 1/6. Total building cost 49/9.

PRACTICAL WIRELESS SUPER SIX POCKET PORTABLE

6 Transistor Superhet Radio. Full constructional details etc., 1/6. All required parts including attractive plastic case and dial, printed circuit and first grade transistors. Only **£8/19/6**

EXTENSION SPEAKERS. Handsome walnut veneered cabinets. All standard 2-3 ohms. 6½in. 29/9; 8in. 35/9.

SELENIUM RECTIFIERS

L.T. Types		H.T. Types H.W.	
2/6 v. ½ a.H.W.	1/9	120 v. 40 mA	3/9
6/12 v. 1 a.H.W.	2/9	250 v. 50 mA	3/11
Following F.W. (Bridge)		250 v. 60 mA	4/11
6/12 v. 1 a.	3/11	250 v. 80 mA	6/11
6/12 v. 2 a.	6/11	250 v. 250 mA	12/9
6/12 v. 3 a.	9/9	Contact Cooled	
6/12 v. 4 a.	12/3	250 v. 80 mA	6/11
6/12 v. 5 a.	14/6	250 v. 50 mA F.W. (Bridge)	8/11
6/12 v. 6 a.	15/6	250 v. 75 mA F.W. (Bridge)	10/11
6/12 v. 10 a.	25/9		
6/12 v. 15 a.	35/9		

RECORDING HEADS. Baird Record Playback and Erase (housed in one container), 9/6 pair.

VARLEY 2 v. 14 A.H. **ACCUMULATORS.** New ex Govt. 5 x 3 x 1½in. 5/9 each, 3 for 15/-.

JASON F.M. TUNER. Type FMT1. All parts including Dial, Punched Chassis and Valves. Power supply required 180 v. 25 mA and 6.3 v. 1.5 a. **£6/19/6**

EX GOVT. SMOOTHING CHOKES

60 mA 10 h. 400 ohms	3/11
80 mA 20 h. 900 ohms	5/11
100 mA 5 h. 100 ohms	3/11
100 mA 10 h. 100 ohms	6/9
150 mA 10 h. 100 ohms	10/11
120 mA 12 h 100 ohms	9/9
200 mA 5-10 h 100 ohms	11/9
250 mA 5 h. 50 ohms	10/9

Battery Chargers and Kits for 200-230-250 v. 50 c/s. A/C. Mains

HEAVY DUTY KIT

6/12 v. variable charge rate up to 6 amps. Consisting of Mains Trans., F.W. (Bridge) Selenium Rectifier, 0-7 amp. meter. Variable Charge Selector. Fuses, fuse-holders, panels, plugs and circuit. Only 59/6. Post 4/6.

CHARGER TRANSFORMERS

200–230–250 v. 50 c/s.	
0–9–15 v. 1½ a.	12/9
0–9–15 v. 2½ a.	15/9
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 Rectifier, well ventilated steel case. Fuses, fuse-holders, grommets, panels and circuit. Carr. 2/9 extra.

6 v. or 12 v. 1 amp.	24/9
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)	42/9
6/12 v. 4 amps.	49/9
6 v. or 12 v. 4 amps., with variable charge rate selector and ammeter	59/9

ASSEMBLED CHARGER

6 v. or 12 v. 2 amps. Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads. Double Fused. Only **49/9** Carr. 3/9.

ASSEMBLED 6 v. or 12 v. 4 amps.

Fitted Ammeter and variable charge selector. Also selector plug 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. **69/9** Carr. 5/-. Or Deposit **13/3** and 5 monthly payments of **13/3.**
As above, but for 6 amp. charging 4 GNS. Carr. 5/-. Or Deposit 16/- and 5 monthly payments of 16/-.

MICRO-AMMETERS

0-50 micro-amp. Diameter 2¾in. approx. Scaled 0-100. Flush mounting, 29/6.

EX GOVT. MAINS TRANSFORMERS

Primary 0-110-200-230-250 v. 275-0-275 v. 100 mA, 6.3 v. 7 a. 5 v. 3 a.	22/9
Input 200-250 v. 50 c.p.s. 250 v. 60 mA 6.3 v. 2 a.	10/11
Primary 200-250 v. Sec. 12 v. 20 a.	49/9
Primary 230 v. 400-0-400 v. 200 mA	29/9
Primary 200-240 v. Sec. 3.500 v. 5 mA 2 v. 2 a.	39/9
50 watts, 0-110/120-230/250 v.	8/11

D.C. SUPPLY KITS. Suitable for electric trains. Consist of mains trans. 200-250 v. 50 c.p.s. 12 v. 1 amp. selenium rect. (F.W. Bridge); 2 fuseholders, 2 fuses, change direction switch, variable speed regulator, partially drilled steel case and circuit. Very limited number, 33/9.

HEAVY DUTY EX GOVT. SELENIUM RECTIFIERS

With large square aluminium cooling fins. 12 v. 15 amp. F.W. (Bridge). Limited number. 19/6.

EX GOVT. CASES

Well ventilated, black crackle finished, undrilled cover Size 14 x 10 x 8½in. high. IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE. COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post.

RELAYS. Carpenter Type Polarised, 2 x 9,500 turns at 1,685 ohms, 13/9. Miniature type G.E.C. 670 M1092 sealed wire ends 4 c/overs platinum, 12/9.

R.S.C. A10 ULTRA LINEAR 30 WATT AMPLIFIER

HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. EF86, EF86, ECC38, 807, 807, GZ34. Tone Control Pre Amp. stages are incorporated. Sensitivity is extremely high. Only 12 millivolt 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 Carr. 10/-. **11 gns.** Or Factory built using latest EL34 output valves and with 12 months' guarantee. 14 GNS. TERMS ON ASSEMBLED UNITS. DEPOSIT 33/3 and 9 monthly payments of 33/3.

Protective Cover 19/9. 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 UNITS AVAILABLE. Frequency response ± 3 D.B. 30-20,000 c/s. Tone Controls ± 12 D.B. at 50 c/cs. ± 12 D.B. to − 6 D.B. at 12,000 c/cs. hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-250 v. 50 c/s. 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.

FULL RANGE OF LINEAR HIGH FIDELITY AMPLIFIERS ALWAYS IN STOCK.

GL3A MINIATURE 3 WATT GRAM AMPLIFIERS

For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 11½ × 2½ × 2½in. Fitted Vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changer unit. Output for 2-3 ohm speaker. Guaranteed 12 months. Only 59/6.

R.S.C. AS 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 makes. 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. of 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 v. 50 c/s. 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 ohms 2¾in. Perdio 21/9. 5in. Goodmans 17/9. 7 × 4in. R.A. Elliptical 19/9. 6½in. Rola 19/9. 8in. Rola 19/9. 8in. Goodmans 25/9. 8 × 6in. Elac. with high flux magnet 25/9. 10in. R.A. 28/9. 10 × 6in. Ellipical Goodmans 29/9. 12in. R.A. 29/11. 12in. R.A. 3 or 15 ohms, 10 watts, 12,000 lines, 59/6.

TWEETERS, 4in. Plessy, 3 ohms 18/9. R.A. 15 ohms 25/9.

R.S.C. TRANSFORMERS Fully Guaranteed. Interleaved & impregnated.

MAINS TRANSFORMERS. Primaries 200-250-250 v. 50 c/s.

FULLY SHROUDED. UPRIGHT MOUNTING.

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a. 2½-3-3in.	17/11
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	27/11
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	27/11
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	27/11
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/11
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t. 5 v. 3 a.	49/9
450-0-450 v. 250 mA., 6.3 v. 5 a., 5 v. 3 a.	59/9

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	17/9
250-0-250 v. 100 mA., 6.3 v. 3.5 a.	19/9
250-0-250 v. 100 mA., 6.3 v. 2 a., 6.3 v. 1 a.	21/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/11
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	26/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	26/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a. suitable for Mullard 510 Amplifier	29/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9
425-0-425 v. 200 mA., 6.3 v. 4 a., 5 v. 3 a.	47/9

FILAMENT TRANSFORMERS

6.3 v. 1.5 a.	5/9	12 v. 1 a.	7/9
6.3 v. 2 a.	7/6	6.3 v. 3 a.	8/11
0.4-6.3 v. 2 a.	7/9	6.3 v. 6 a.	17/9
		12 v. 3 a. or 24 v. 1.5 a.	17/9

AUTO (Step Up/Step Down) TRANSFORMERS

50-80 watts 110-120 v./230-250 v.	11/9
150 watts 110-120 v./200-250 v.	27/9

OUTPUT TRANSFORMERS

Midget Battery Pentode 66 : 1 for 3S4, etc.	3/9
Small Pentode 5,000Ω to 3Ω	4/6
Standard Pentode 5,000Ω to 3Ω	5/9
Standard Pentode 8,000Ω to 3Ω	5/9
Multi Ratio, Single or P/P 3 or 15Ω	6/9
Push-pull 8 watts EL84s to 3 ohms	8/9
Push-pull 8 watts EL84s to 15 ohms	8/9
Push-pull 10-12 watts 6V6 to 3Ω or 15Ω	16/9
Push-pull 10-12 watts to match 6V6 to 3.5-8 or 15Ω	17/9
Push-pull EL84 to 3 or 15 ohms 10-12 watts	17/9
Push-pull Ultra Linear for Mullard 510	27/9
Push pull 15-18 watts, sectionally wound, 6L6, KT66, etc., for 3 or 15 ohms	23/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT66, etc., or 4 or 15Ω fully shrouded	47/9

MICROPHONE TRANSFORMERS

120 : 1 High quality, clamped	6/9
120 : 1 High quality Mu metal screened	8/9

SMOOTHING CHOKES

250 mA., 5 H., 100Ω	11/9	80 mA. 10 H., 350Ω	5/6
150 mA. 7-10 H., 250Ω	11/9	60 mA., 10 H., 400Ω	4/11
100 mA., 10 H., 200Ω	8/9	1 amp. 0.5Ω L.T. type	6/6

PARMEKO MAINS TRANSFORMERS. Fully shrouded.

500-0-500 v. 120 mA., 6.3 v. 4 a., 5 v. 3 a. 31/9

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 × 5 × 5½in. high. 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.

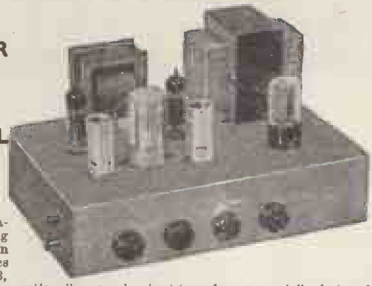
ACOS HGP 59 Hi-Fi Crystal Cartridges. (Turnover type with sapphire stylus.) Standard replacement for Garrard and Collaro. Only 19/9. B.S.R. Ful-Fi 19/9. Garrard GC2, 19/9. Acos Stereo/monaural 49/9.

LINEAR PRE-AMP/TREMOLO UNIT

Suitable for use with any Guitar Amplifier. Controls Volume, Frequency, Amplitude and switches. Valves: EF86 and EF80. Inputs for Guitar Pick-up or Mike, and Radio or Gram. Power required only 250/300 v. 20 mA. 6.3 v. 1 a. **5 GNS.**

HIGH FIDELITY 12-14 WATT AMPLIFIER TYPE A11

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES



Two input sockets with associated controls allow mixing of "mike" and gram. as in A.10 High sensitivity. Includes 5 valves: ECC83, ECC83, 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 ± 3 D.B. 30-30,000 c/cs. 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 × 7in. For A.C. mains 200-250 v. 60 c/cs. 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. (Or factory built 51/- extra.) 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 24/10 and 9 monthly payments of 24/10. Send S.A.E. for illustrated leaflet detailing ready-to-assemble Cabinets. Speakers, Microphones, etc. with cash and credit terms.

R.S.C. PORTABLE GUITAR AMPLIFIERS

JUNIOR 5 WATT. High Quality Output. Separate Bass and Treble "cut" and "boost" controls. Sensitivity 15 mv. High Flux 8in. l/speaker. Input sockets for Radio/Tape or Gram Pick-up and Mike /Instrument Pick-up. Handsome strongly made cabinet (size approx. 14 × 14 × 7in.). Finished in attractive and durable polychrome and fitted carrying handle. **£8.19.6** Carr. 7/6. Or Deposit £1 and nine monthly payments £1.

Send S.A.E. for leaflet.

SENIOR 10 WATTS. High-Fidelity Push-Pull output. Separate Bass and Treble "cut" and "boost" controls. Twin separately controlled high gain inputs so that two instruments such as Guitar and String Bass can be used at the same time. Two Loudspeakers are incorporated in 12in. P.M. for Bass notes and 1 7 × 4in. elliptical for Treble. Cabinet is well made and finished as for Junior model. Size approx. 18 × 18 × 8in. 15 Gns. Plus 10/- carr. H.P. TERMS DEPOSIT 34/9 and 9 monthly payments 34/9. Both models for 200-250 v. A.C. mains.

COLLARO CONQUEST 4-SPEED AUTO-CHANGERS. With studio pick-up with turnover head. Latest model for 200-250 v. A.C. mains, £6/19/6. Carr. 4/6.

B.S.R. MONARCH AUTO-CHANGERS. Type UA8. 4 speed T/O Pick-up with sapphire stylus £6/19/6. Carr. 4/6.

Any of the above supplied with T/O stereo/monaural head for £1 extra.

COLLARO JUNIOR. 4-speed Single Players with Hi-Fi T/O crystal pick-up head, £3/19/6.

LOUDSPEAKER 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/-.

12in. 20 WATT 15,000 line l/speakers 15 ohms in Cabinet finished as above. Size 18 × 18 × 8in. £7/19/6 or Deposit 17/9 and 9 monthly payments of 17/9.

LINEAR TAPE PRE-AMPLIFIER Type LP/1. Switched negative feedback equalisation. Positions for Record 1⅞in.. 3¾in.. 7½in. and Playback. EM84. Recording level indicator. Designed primarily as the link between Collaro Tape Transcriptor and high fidelity amplifier but suitable almost any Tape Deck. **9 GNS.** Send S.A.E. for leaflet.

R.S.C. STANDARD BASS REFLEX CABINET for 12in Loudspeakers, Acoustically lined and ported. Size 20in. × 14in. × 13in. Beautiful walnut veneer finish. Especially recommended for use with Speaker below £5/19/6. Set of four legs can be supplied for 29/6 per set.

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 £5/19/6. Or Deposit 13/9 and 9 monthly payments of 13/9.

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

BC. 221 HETERODYNE FREQUENCY METERS

125 kc/s to 20Mc/s
As new condition. Supplied complete with valves, crystal and calibration charts.
Only **£16** each
P/P 7/6.
Also available less calibration charts only £9/10/- each.

7·5 K.V.A. AUTO TRANSFORMERS. 115/230 volts. Brand new boxed, ex-U.S.A. £15 each. Carriage 10/-.

MARCONI TF-885 VIDIO OSCILLATORS
2 Ranges 0-30 kc/s, 30 kc/s-5 Mc/s., reconditioned to makers' specification. £125.

MARCONI TF-866A Q METER
Reconditioned to makers' specification. £75.

15 PIN AMPHENAL CHASSIS UNITERS
3/6 pair. P.P. 6d.

FIELD TELEPHONES TYPE L.
Generator bell ringing, 2 line connection. Supplied fully tested complete with batteries, 59/6 each. P/P 3/6.

1,000 WATT MAINS ISOLATION TRANSFORMERS
230 volt primary, 230 volt secondary. Ex-Admiralty heavy duty type. New, boxed, £5 each. Carriage 10/-.

24 AMP VARIAC TRANSFORMERS
Primary 230 volts. Secondary adjustable from 185 to 250 volts at 24 amps. Can also be used in reverse. £12/10/- each. Carriage 10/-.

1 MEGOHM 1% WIREWOUND RESISTORS
10/- doz. P/P 1/-.

PHOTO VOLTAGE AMPLIFIERS
These special units contain a 1 microamp Tinsley mirror galvanometer, twin selenium photo cell. 12 v. lamp, lamp housing and focusing unit. Brand new boxed, £9/19/6 each. Carriage 7/6.

MUIRHEAD CELL TESTERS
Housed in teak case containing a 6in. scale 3 amp D.C. meter and large variable rheostat for controlling current. Brand new, 32/6 each. P/P 3/6.

SOUND POWERED TELEPHONE HANDSETS
Make simple intercom system. No batteries required. Just connect with twin flex. Brand new 15/- per handset. P/P 1/6.

FIELD TELEPHONES TYPE F.

Ideal for all intercom. systems, house, office, building sites, etc. Generator bell ringing, 2 line connection. Supplied complete with batteries and wooden carrying case, fully tested, £4/19/6 pair. P/P 5/-.

R.C.A. AR88D RECEIVERS

This world famous 14 valve receiver offered reconditioned, perfect working order and in superlative condition throughout. Frequency coverage on 6 bands 500 kc/s to 32 mc/s. Circuit incorporates variable selectivity with crystal filter, tone control, aerial trimmer, b.f.o., a.v.c., R.F. and A.F. gain controls, mechanical bandspread, etc. Output is for phones or speaker. Operation 115 or 230 volts A.C. £35 each. Carriage 30/-.

BRAND NEW MEDRESCO HEARING AIDS
Supplied complete with earpiece, leads, battery pouch. Brand new boxed, only 32/6 each. P/P 1/-. Batteries 5/- extra.

COLLARO STUDIO TAPE TRANSCRIPTORS

Latest 1961 model. 3 speeds, 1⅞, 3¾ and 7½in./sec. Fitted with 3 separate motors, digital counter, press button switching, provision for fitting extra stereo head. Fitted with new Bradmatic heads. Supplied brand new with instructions, complete with spare 7in. spool. £12 each. P/P 3/6.

AVO SIGNAL GENERATORS
Frequency coverage 95 kc/s to 40 mc/s. Ideal for all general radio work Variable attenuator, 400 cycle int. mod. or provision for ext. mod. Supplied fully tested and checked £7/19/6 each. P/P 3/6. Operation is from 2 v. and 60 v. batteries, but original Avo mains units can be supplied at 19/6 extra.

MINE DETECTOR NO. 4A

Will detect ferrous and non-ferrous metals. Complete and as new in transit cases. Supplied fully tested with instructions. 39/6 each. Carriage 10/-. Batteries 8/- extra.

MARCONI TF-373 UNIVERSAL IMPEDANCE BRIDGES.
Reconditioned to maker's specification. 0-100 H., 0-100 mfd., 0-1 megohm, 0-100 Q. each on 5 ranges at 1,000 c/s. £35 each.

VALVE VOLTMETERS No. 2
Laboratory instruments. Five ranges A.C. and D.C. 1.5 v., 5 v. 15 v., 50 v. and 150 v. Operation 200/250 volts A.C. Supplied as new, fully tested and complete with internally mounted H.F. probe. £17/10/- each. Carriage 10/-.

R1155 RECEIVERS MODEL L/N

This model incorporates the 100-200 metre top band. Full coverage on 5 bands is 200 kc/s to 18 mc/s. Supplied fully tested and in perfect condition £12/19/6 each. Carriage 7/6. A combined 200/250 volt A.C. power unit and audio output stage to match 3 ohms supplied extra at 85/-.

AMERICAN ARB RECEIVERS
Frequency coverage on 4 bands 195 kc/s to 9.05 mc/s. Precision vernier drive. Valve line-up: 12SA7, 4-12SF7, 12A6 and 991. Operation 24 volts D.C. Supplied fully tested and checked, £6/19/6 each. Carriage 7/6.

MULTI-RANGE TESTMETERS MODEL U1
1,000 ohms per volt A.C./D.C. Ranges: Volts A.C. 10, 50, 250, 500, 1,000 v. Volts D.C. 10, 50, 250, 500, 1,000 v. Current D.C. 1 mA. 100mA. 500mA. Resistance, 2,000 ohms, 200,000 ohms. Supplied brand new and guaranteed complete with instructions and leads 59/6 each. P/P 2/6.

SPARES KITS FOR CR.100 RECEIVERS.
Contains 15 valves. 2-DH63, 2-KT63, 2-X66, 2-U50, 7-KTW61. Condenser and resistor packs, pots, toggle switch, output transformer, etc. All brand new, 59/6 each. P/P 3/6.

NATIONAL H.R.O. RECEIVERS

Senior model, table mounting. Supplied with complete set of 9 coils covering 50 kc/s to 30 mc/s. Circuit incorporates a meter, variable selectivity, crystal filter, 2 R.F. and 2 I.F. stages, B.F.O. A.V.C., R.F. and A.F. gain controls, etc. Output is for phone or speaker. Power requirements 250 v. 80 mA. and 6.3 v. 3 amps. Supplied fully tested and aligned and in superb condition throughout. Price 21 gns. Carriage 10/-. Power units are available 59/6 extra.

AR88D SPARES
Complete wavechange switch assembly with screens. New boxed, 17/6 ea. P/P 2/6. 1st I.F. transformers. New, boxed, 3/6 each. P/P 9d.

PAINTON MINIATURE JONES PLUGS AND SOCKETS.
All new and unused.

2 pin	2/6 pr.	12 pin	5/6 pr.
4 pin	3/6 pr.	18 pin	7/6 pr.
6 pin	4/- pr.	24 pin	8/6 pr.
8 pin	4/6 pr.	33 pin	10/6 pr.

PARMEKO TABLE TOP TRANSFORMERS
Input 230 volts 50 cycles. Output 620/550/375/0/375/550/620 volts 250 mA. 5 volt 3 amp., 5 volt 3 amp. Size 6¾ x 6¼ x 5½in. Brand new boxed. 45/- each. Carriage 3/6.

ROTARY CONVERTORS
24 volt D.C. Input. Output 230 volts 50 cycles 100 watts, 72/6 each. Carriage 5/-.

R.C.A. PLATE TRANSFORMERS
Primary 200/250 volt 50 cycles. Secondary 2,000/1,500/1,500/2,000 volts 500 mA. Supplied brand new boxed, £6/10/- each. Carriage 10/-.

POST OFFICE 8 BANK UNISELECTORS
Std. type, 25 position. Ex-brand new equipment, 62/6 each. P/P 2/-.

AN/APR4 SEARCH RECEIVERS
Covers 38 to 1,000 mc/s with 3 plug in R.F. units. TN16 38-95 mc/s. TN 17 74-320 mc/s. TN18 300-1,000 mc/s. Operation 115 v. 50-2,600 cps. Reconditioned to maker's spec. Superb order throughout, £75 each.

SANGAMO WESTON STANDARD VOLTMETERS
Range 0-30 volts D.C. 1,000 ohms per volt. Correct to B.S. 89 pr. limits. 6in. mirror scale, £25 each.

SUB-STANDARD I.F. ALIGNMENT OSCILLATORS. 3 ranges covering 445 to 485 kc/s. Crystal controlled and fitted with precision variable attenuator. Operation 200/250 volts A.C. Brand new, £15 each. Carriage 10/-.

PLESSEY 24-VOLT D.C. PUMPS

Self lubricating, capacity 60 g.p.h. at 30 lb./sq. in. Will operate O.K. on 12 v. ¼ BSP inlet/outlet union. Only 15/6 each. P/P 2/6.

HOURS OF BUSINESS: 9 a.m.-6 p.m. Thursday 1 p.m. Open all day Saturday. Please print name and address clearly.

VALVES

ALL NEW AND GUARANTEED

AZ31 ..	9/6	EF42 ..	10/6	R3	8/6	5V4	9/6	6U4	10/-
AZ41 ..	7/6	EF50 ..	3/6	R10 ..	5/6	5Y3	7/6	6V6G ..	6/-
CL33 ..	9/6	EF55 ..	7/6	R12	9/-	5Z4	7/6	6V6GT	6/6
D77	6/-	EF80 ..	7/-	S130	4/6	6A7	9/-	6X4	5/6
DAF91	6/-	EF85 ..	8/-	U25	11/6	6A8	9/-	6X5	6/-
DAF96	8/6	EF86 ..	11/6	U26	10/6	6AC7 ..	6/-	7B7	8/-
DF91 ..	6/-	EF89 ..	7/6	U50	7/6	6AG5 ..	3/6	7C5	8/-
DF96 ..	8/6	EF91 ..	5/-	U52	10/6	6AK5 ..	5/-	7C6	8/-
DH77 ..	6/-	EF92 ..	5/6	UABC80	8/6	6AL5 ..	6/-	7S7	9/-
DK91 ..	7/-	EK32 ..	6/6	UAF42	9/-	6AM5 ..	5/6	7Y4	7/6
DK32 ..	10/6	EL32 ..	5/6	UBC41..	8/-	6AM6 ..	5/-	8D3	5/-
DK92 ..	9/-	EL33 ..	10/6	UBF80	8/6	6AQ5 ..	7/6	12A6	5/-
DK96 ..	8/6	EL41 ..	9/-	UBF89	8/6	6AT6 ..	6/-	12AH8..	10/-
DL92 ..	5/6	EL42 ..	10/6	UCH42	9/-	6AU6 ..	7/-	12AT6 ..	7/-
DL93 ..	4/6	EL84 ..	7/6	UCH81	8/-	6B7	5/6	12AT7 ..	7/6
DL94 ..	7/6	EL91 ..	5/6	UCL83	12/6	6B8	4/-	12AU7..	7/6
DL96 ..	8/6	EM34 ..	8/6	UF41 ..	8/6	6BA6 ..	7/-	12AX7..	7/6
EA50 ..	1/6	EM80 ..	7/6	UF89 ..	8/6	6BE6 ..	6/-	12BA6	7/6
EABC80	8/-	EM81 ..	8/-	UL41 ..	8/6	6BJ6 ..	7/-	12BE6	7/6
EAF42..	9/-	EM84 ..	10/-	UL84 ..	7/9	6BR7 ..	11/6	12K8 ..	12/6
EB91 ..	6/-	EY51 ..	9/-	UY41 ..	6/6	6BW6 ..	9/-	12J7....	9/6
EBC33..	6/6	EY86 ..	8/6	VR105/30	6/-	6BW7 ..	7/6	12K7 ..	9/6
EBC41..	7/9	EZ40 ..	7/-	VR150/30	6/-	6CH6 ..	10/6	12Q7 ..	9/6
EBF80..	9/-	EZ41 ..	7/-	VR91 ..	3/6	6C4	4/6	12SA7 ..	8/6
EBF89..	9/-	EZ80 ..	6/3	VS70 ..	4/6	6C5	5/-	12SH7 ..	5/-
ECC40	15/-	EZ81 ..	6/6	VS110 ..	4/6	6C6	7/6	12SK7 ..	5/6
ECC81	7/6	GZ32 ..	10/6	VU111 ..	1/9	6D2	6/-	12SQ7 ..	8/-
ECC82	7/6	KT33C..	6/6	Z77 ..	5/-	6D6	7/6	19AQ5	9/6
ECC83	7/6	MU14 ..	8/6	1A7	10/6	6F6	6/-	25L6 ..	9/-
ECC84	9/-	NSP1 ..	5/6	1C5	10/-	6J5	4/6	25Z4 ..	8/6
ECC85	8/6	PCC84	8/6	1H5	9/6	6J6	3/6	25Z5 ..	8/-
ECF80..	9/6	PCF80	9/6	1L4	4/6	6J7	5/6	25Z6 ..	9/-
ECF82..	10/-	PCF82	10/-	1N5	9/6	6J7M ..	6/6	35L6 ..	9/6
ECH35	8/6	PCL82	10/-	1R5	7/-	6K7	3/6	35Z4 ..	9/-
ECH42	9/6	PCL83	12/6	1S5	6/-	6K8	6/6	35Z5 ..	9/-
ECH81	7/6	PL36 ..	12/6	1T4	6/-	6L6	7/6	35W4 ..	6/-
ECL80..	9/-	PL81 ..	11/-	2D21	6/-	6Q7	6/6	42	8/6
ECL82..	10/-	PL82 ..	7/9	3A4	4/6	6SA7 ..	6/-	50C5 ..	8/6
ECL83..	12/6	PL83 ..	8/6	3A5	9/-	6SH7 ..	6/-	50L6 ..	8/-
EF36 ..	4/6	PY32 ..	11/-	3Q4	6/6	6SJ7 ..	6/-	75	10/-
EF37A..	8/6	PY80 ..	7/-	3Q5	9/-	6SK7 ..	6/-	80	7/6
EF39 ..	5/6	PY81 ..	7/6	3S4	5/6	6SL7 ..	6/-	85A2 ..	10/6
EF40 ..	15/-	PY82 ..	7/-	3V4	7/6	6SN7 ..	4/6	807	6/-
EF41 ..	8/6	PY83 ..	8/6	5U4	7/6	6SQ7 ..	6/6		

Please add postage.

SIEMENS 1700 + 1700 OHM HIGH SPEED RELAYS H.96e. Sealed type. S/pole c/over contacts. Brand new, 15/6 each. P/P 9d.

FILMS AND EQUIPMENT COAXIAL PLUGS AND SOCKETS 2/6 pr.

MINIATURE PYE COAXIAL PLUGS AND SOCKETS 2/6 pr.

HI-FI RECORDING TAPES

AMERICAN C.B.S. First grade quality. Extended audio range. Brand new guaranteed, completely splice free.

5in.	std. play	600ft.	aetate	13/–
5in.	long play.........	900ft.	P.V.C.	16/6
5in.	double play ...	1,200ft.	Mylar	32/–
5¾in.	long play.........	1,200ft.	acetate	19/6
5¾in.	double play ...	1,800ft.	Mylar	37/–
7in.	std. play	1,200ft.	P.V.C	21/–
7in.	long play.........	1,800ft.	acetate	28/6
7in.	double play ...	2,400ft.	Mylar	47/–

Brand new guaranteed HI-FI tapes in plain boxes

3in. std. play 175ft.	4/3	5in. long play 900ft.	16/–
3in. long play 225ft.	4/9	5¾in. long play 1,200ft.......	18/6
5in. std. play 600ft.	12/–	7in. std. play 1,200ft.	19/–

7in. long play 1,800ft.......27/–

BRAND NEW Boxed 100 MICROAMP METERS.

Standard 2½in. flush round, panel mounting. Scale calibrated 0–100 microamps. 42/6 each. P/P. 1/3.

BRAND NEW METER BARGAINS

20 microamp ...	D.C....	M/coil ...	flush round...	2½in. ...	69/6
25 microamp ...	D.C....	M/coil ...	proj. round...	2½in. ...	59/6
50 microamp ...	D.C....	M/coil ...	proj. round...	2½in. ...	49/6
100 microamp ..	D.C....	M/coil ...	flush round...	3½in. ...	62/6
1 milliamp	D.C....	M/coil ...	flush round...	2½in. ...	25/–
1 milliamp	D.C....	M/coil ...	flush square	4in. ...	69/6
5/0/5 milliamp ...	D.C....	M/coil ...	flush square	2in. ...	12/6
30/0/30 milliamp	D.C....	M/coil ...	flush round...	2½in. ...	9/6
4 amp	R.F. ...	Termo...	flush square	2in. ...	7/6
7.5 amp	D C....	M/iron...	proj. round...	3½in. ...	10/6
100 amps	D.C....	M/coil ...	proj. round...	6in. ...	65/–
25 volts............	D.C....	M/coil ...	proj. round...	2in. ...	8/6
120 volts	D.C....	M/coil ...	flush round...	3½in. ...	32/6
300 volts	A.C....	M/coil ...	flush round...	2½in. ...	25/–
500 volts	A.C....	M/iron...	flush round...	2½in. ...	25/–
1500 volts	Electrostatic		proj. round...	2½in. ...	25/–

Please add postage.

L.T. TRANSFORMERS

Suitable for charging or models. All primaries tapped 200/250 volts.

3.5, 9 or 17 v. 1 amp	9/9
3.5, 9 or 17 v. 2 amp	14/3
3.5, 9 or 17 v. 4 amp	16/6
9 or 17 v. 6 amp	26/-
3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24 or 30 volts 2 amps	18/6
3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24 or 30 volts 4 amps	30/–

Please add postage.

SELENIUM L.T. METAL RECTIFIERS

Full wave bridge connected, all new and guaranteed.

12/18 v. 1 amp.	4/3	24/36 v. 1 amp	9/6
12/18 v. 2½ amp	6/9	24/36 v. 2 amp	13/6
12/18 v. 4 amp	9/9	24/36 v. 6 amp	22/6
12/18 v. 5 amp	12/6	24/36 v. 10 amp	45/–
12/18 v. 6 amp	13/6	24/36 v. 15 amp	47/6
12/18 v. 10 amp	22/6	36/48 v. 6 amp	32/6
Please add postage.		48/60 v. 10 amp	82/6

COLLINS TCS RECEIVERS

Frequency coverage on 3 bands 1.5 to 12 mc/s. Valve line-up 12SA7, 12SQ7, 2-12A6, 3-12SK7. Power requirements: 12 v. L.T. and 225 v. H.T. Externally store soiled but internally good condition. £5/10/- each. Carriage 10/–.

SPEAKER BARGAINS

All new and guaranteed.

2½in. 3 ohm Elac	17/6
2½in. 15 ohm Purdio	17/6
3in. 3 ohm R.A.	17/6
4½in. 3 ohm Plessey	15/6
5in. 3 ohm Goodmans	15/6
6½in. 3 ohm Elac	17/6
8in. 3 ohm R.A.	19/6
10in. 3 ohm Elac	27/6
12in. 3 ohm Plessey	29/6
12in. 15 ohm Plessey	42/6
7 x 4in. 3 ohm Plessey	15/6
8 x 2¾in. 3 ohm Goodmans	17/6
8 x 6in. 3 ohm Rola	17/6
10 x 2¾in. 3 ohm R.A.	17/6
10 x 6in. 3 ohm Plessey	27/6
13 x 8in. 3 ohm E.M.I.	47/6

Please add postage.

PARMEKO TRANSFORMERS

Primary 115/230 volts. Secondary 350/0/350 volts 150 ma. 6.3 volts 4 amps, 5 volts 3 amp. Brand new, 32/6 each. P/P 2/–.

POTTED TRANSFORMERS

Primary 230 volts. Secondary 350/310/0/310/350 volts 220 ma. Total of 6.3 volt 13 amps, 5 volts 3 amps. 49/6 each. P/P 2/6.

RECORD CHANGERS

B.S.R. UA8 Mono 4 speed	£6 12 6
B.S.R. UA8 Stereo 4 speed	£6 12 6
B.S.R. UA12 Stereo 4 speed	£7 10 0
B.S.R. UA14 Mono 4 speed	£7 19 6
Collaro Studio Mono 4 speed	£6 19 6
Collaro Junior 4-speed single players with pickup	£3 15 0

All new and guaranteed. Post extra.

MINIATURE TRANSISTOR TRANSFORMERS

Size 13/16 x 15/16 x 1 1/16in. Push-pull driver 4.5:1 and push-pull output 20:1 (3 ohm). Supplied brand new boxed with data. 9/6 the pair. P/P 6d.

SPARE PLASTIC SPOOLS. 3in. 1/6, 5in. 2/-, 5¾in. 2/3, 7in. 2/6.

PLASTIC SPOOL CONTAINERS. 5in. 1/6, 5¾in. 2/-, 7in. 2/3, Scotch metal 10½in. spools 5/-.

Please add postage.

MINIATURE PERSONAL EARPIECES

Available high (crystal) or low (magnetic) impedance. Complete with lead and plug and panel jack. Brand new only 7/6 each. P/P 6d.

R.C.A. LOUDSPEAKERS

High quality 8in. 3 ohm speaker housed in black crackle case to match AR88 or H.R.O. receivers. Brand new boxed, 45/- each. P/P 3/6.

PORTABLE PRECISION VOLTMETERS

Brand new moving iron instruments by famous manufacturer. Housed in polished teak case. 8in. mirror scale. 2 ranges, A.C. or D.C. 0 to 160 v. and 0 to 320 v. Accuracy within 2%, £5/19/6 ea. P/P 3/6.

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

Each Model incorporates the highly successful HT/TR3 Amplifier (described below), thus ensuring truly "Hi-Fi" record and playback facilities.

All prices quoted provide for the COMPLETE RECORDER including CRYSTAL MICROPHONE and 1,200ft. Spool of Tape.

There are no "better value for money" Tape Recorders on the market— if you can't call and hear them send S.A.E. for fully descriptive leaflets.

Stern's "fidelity" TAPE RECORDERS

BEFORE YOU BUY—YOU SHOULD HEAR THESE RECORDERS—THEY ARE COMPARABLE TO THE MUCH HIGHER PRICED MODELS

MODEL CR3/S. Incorporates the Collaro "STUDIO" TWIN TRACK 3-speed Deck operating at 1⅞", 3¾" and 7½" speeds. **£39.10.0**
H.P. Terms: Deposit £7/18/- and 12 months of £2/17/11.

MODEL TR3/Mk. VI. Incorporates the New TRUVOX Mk. VI TWIN TRACK 2-speed Tape Deck operating at 3¾" and 7½" speeds **£49.10.0**
H.P. Terms: Deposit £9/18/- and 12 months of £3/12/7.

TAPE AMPLIFIERS and PREAMPLIFIERS presented from MULLARD DESIGNS

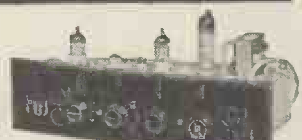
MULLARD TYPE "C" TAPE-PREAMPLIFIER ERASE UNIT

The "Hi-Fi" link to add full tape recording facilities to High Fidelity home installations. Incorporates FERROXCUBE POT CORE PUSH-PULL OSCILLATOR and 3-speed treble equalisation by FERROXCUBE POT CORE INDUCTOR. FOR WEARITE—COLLARO—TRUVOX or BRENELL TAPE DECKS. (STATE which when ordering.) Includes separate Power Supply Unit.

KIT OF PARTS .... **£14.0.0** or ASSEMBLED **£17.0.0**
H.P. £3/8/- Deposit and 12 months at £1/4/11.
(Excluding Power Unit £11/15/- and £14/10/- respectively.)

MODEL HF/TR3 Mk. II TAPE AMPLIFIER

(Mullard Type "A" design)



A very high quality Amplifier incorporating 3-speed treble equalisation, by the latest FERROXCUBE POT CORE INDUCTOR. FOR COLLARO-TRUVOX-BRENELL or WEARITE Tape Decks (STATE which when ordering), has GILSON Output Transformer. Includes separate Power Supply Unit.

KIT OF PARTS .... **£13.13.0** or ASSEMBLED .. **£17.0.0**
H.P. £3/8/- Deposit and 12 months at £1/4/11.

FOR THE HOME CONSTRUCTOR SPECIAL "COMBINED ORDER" PRICES

(a) The COLLARO "STUDIO" TAPE DECK and our Mullard Type "C" PRE-AMPLIFIER and Power Unit assembled and tested **£29.10.0**
H.P. Terms: Deposit £5/18/- and 12 months at £2/3/3.

(b) As above but Type "C" PRE-AMPLIFIER supplied as complete Kit of Parts **£26.10.0**

(c) The TRUVOX Mk. VI TAPE DECK and the assembled Type "C" PRE-AMPLIFIER and Power Unit **£40.0.0**
H.P. Deposit £8 and 12 months £2/18/8.

(d) As above but the Type "C" supplied as complete Kit of Parts **£36.10.0**

(e) The BRENELL Mk. V Deck and the asssmbled Type "C" PRE-AMPLIFIER and Power Unit **£46.0.0**
H.P. Deposit £9/4/- and 12 months at £3/7/6.

(f) As above, but the Type "C" supplied as complete Kit of Parts **£43.0.0**

(g) The WEARITE 4A DECK with Type "C" assembled and tested **£56.0.0**
H.P. Deposit £11/4/- and 12 monthly £4/2/1.

(Carriage and Insurance on above quotes 10/- extra.)

EACH OF ABOVE CAN BE SUPPLIED IN PORTABLE CASE FOR £5/10/- extra. THUS FORMING A COMPLETE PORTABLE PRE-AMPLIFIER. SEND FOR DETAILS.

(a) COMPLETE KIT to build the HF/TR3 Amplifier, together with the COLLARO "STUDIO" DECK **£26.0.0**

(b) As above, but HF/TR3 ASSEMBLED and TESTED H.P. Terms: Deposit £5/18/-, 12 months of £2/3/3 ...... **£29.10.0**

(c) COMPLETE KIT to build the HF/TR3 together with the NEW TRUVOX Mk. VI TAPE DECK **£36.10.0**

(d) As above but HF/TR3 ASSEMBLED and TESTED H.P. Terms: Deposit £8, 12 months of £2/18/8. **£40.0.0**

(e) COMPLETE KIT to build the HF/TR3 AMPLIFIER with the BRENELL Mk. V TAPE DECK **£42.0.0**

(f) As above but HF/TR3 ASSEMBLED and TESTED H.P. Terms: Deposit £9/2/-, 12 months of £3/6/9. **£45.10.0**

(g) THE ASSEMBLED and TESTED HF/TR3 AMPLIFIER with the WEARITE MODEL 4A DECK, Incorporates Wearite Head Lift Transformer, etc. **£55.0.0**
H.P. Terms: Deposit £11, 12 months of £4/0/8.

(Carriage and insurance on each above is 10/- extra.)

Attractive PORTABLE CASE is available to accommodate the TRUVOX or COLLARO TAPE DECKS and we offer it together with ROLA/CELESTION 10 x 6in. LOUDSPEAKER—ACOS CRYSTAL MICROPHONE —and 1,200ft. SPOOL TAPE—ALL FOR......................... **£9.0.0**
(Carriage and Insurance 5/- extra.)

SPECIAL OFFER OF TAPE

P.V.C. base on latest type plastic Spools. New, Boxed and Guaranteed.

225ft. on 3in. Spool	5/9
900ft. on 5in. Spool	18/6
1,200ft. on 5¾in. Spool ...	21/-
1,200ft. on 7in. Spool	21/-
1,800ft. on 7in. Spool	32/6

TAPE ACCESSORY KITS

(a) E.M.I., includes 3 reels Leader Tape, Splicer, Jointing Tape and Stop Foil **37/6**

(b) SCOTCH BOY, includes 3 reels Leader Tape, Splicer, and Jointing Tape **29/6**

A LARGE PURCHASE OF BRAND NEW and FULLY GUARANTEED TRUVOX and GARRARD TAPE EQUIPMENT ENABLES THESE OUTSTANDING PRICE REDUCTIONS

THE "MODEL HF/G2R" PORTABLE TAPE RECORDER (Original Price £33.0.0)

FOR ONLY **22 GNS.** H.P. Dep. £4/14/-, 12 months £1/13/9. (Carriage and Ins. 10/- extra.)

INCORPORATES THE LATEST GARRARD "MAGAZINE" TAPE DECK and MATCHING AMPLIFIER. Based on the successful MULLARD TYPE "A" DESIGN and specifically developed to operate the GARRARD DECK. PRICE INCLUDES THE GARRARD TAPE MAGAZINE and 4in. SPOOL OF DOUBLE PLAY TAPE. A Twin Track Recorder operating at 3¾in./sec. providing up to 1 hour 10 mins. playing time. The outstanding features being excellent performance and simplicity of operation. Incorporates EXT. SPEAKER SOCKET, also operates as independent amplifier for direct reproduction from P.U., mike or Radio tuner. Weighs only 22lb.

WE ALSO OFFER DECK and AMPLIFIER CONNECTED, TESTED, FOR IMMEDIATE OPERATION, 19 gns. H.P. Dep. £4 and 12 months £1/9/4. Carriage and Ins. 10/- ex. INCLUDES SPEAKER, tape Magazine and 4in. Spool of Double Play Tape. Comprises a complete tape recorder chassis ready for easy fitting into cabinet.

THE "MODEL TK/Mk. IV" PORTABLE TAPE RECORDER (Original Price £49/10/-)

FOR ONLY **£36.10.0** PRICE INCLUDES A 7in. SPOOL OF EMI TAPE.
H.P. Dep. £7/6/- and 12 months £2/13/6.
(Carriage and Insurance 10/- extra).

INCORPORATES THE TRUVOX Mk. IV TAPE DECK, ROLA/CELESTION 9 x 5in. LOUDSPEAKER and the Truvox Type "K" AMPLIFIER specifically developed by Truvox Ltd. to correctly operate their Mk. IV Tape Deck. This combination affords first-class tape recording facilities.

A Twin Track Two Speed model operating at 3¾ and 7½in./sec. Incorporates SAFETY BUTTON (prevents accidental erasure). Ext. Speaker. TONE and VOLUME CONTROLS. Also operates as independent AMPLIFIER for direct reproduction from P.U., mike or Radio tuner.

WE ALSO OFFER THE DECK and AMPLIFIER AS FOLLOWS: Mk. IV TAPE DECK, £16/10/-. H.P. Deposit £3/6/-. 12 months £1/4/3. TYPE "K" AMPLIFIER, £15. H.P. Deposit £3. 12 months £1/2/9. COMBINED ORDER FOR BOTH DECK AND AMPLIFIER, £30. H.P. Deposit £6. 12 months £2/4/-.

STERN RADIO LTD. DEPT. W. 109 FLEET ST., LONDON, E.C.4
Telephone: FLEET STREET 5812/3/4

FULLY DESCRIPTIVE LEAFLETS ON ALL OF ABOVE ARE AVAILABLE—BUT PLEASE ENCLOSE S.A.E.

STERN'S MULLARD DESIGNS

COMPLETE KIT OF PARTS

Designed by MULLARD—presented by STERNS strictly to specification

MULLARD "5-10" MAIN AMPLIFIER

For use with the MULLARD 2-stage pre-amplifier with which an undistorted power output of up to 10 watts is obtained. We supply SPECIFIED COMPONENTS AND NEW MULLARD VALVES including PARMEKO MAINS TRANSFORMER and choice of the latest Ultra-linear PARMEKO or the PARTRIDGE Output Transformer.
Price: COMPLETE KIT (Parmeko O/put Trans.) **£10.0.0**
Alternatively we supply ASSEMBLED AND TESTED...... **£11.10.0**
ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra

MULLARD'S 2-VALVE PRE-AMPLIFIER TONE CONTROL UNIT

Employing two EF86 valves and designed to operate with the Mullard MAIN AMPLIFIER but also perfectly suitable for other makes.
Supplied strictly to MULLARD SPECIFICATION and incorporating:
- Equalisation for the latest R.I.A.A. characteristics.
- Input for Crystal Pick-ups and variable reluctance magnetic types.
- Input (a) Direct from High Imp. Tape Head. (b) From a Tape Amplifier or Pre-Amplifier.
- Sensitive Microphone Channel. ● Wide range BASS and TREBLE Controls.

Price: COMPLETE KIT OF PARTS **£6.6.0** ASSEMBLED AND TESTED **£8.0.0**

COMPLETE MULLARD 5-10 AMPLIFIER

The popular and very successful complete "5-10" incorporating Control Unit providing up to 10 watts high quality reproduction.
Specified components and new MULLARD VALVES are supplied including PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE ULTRA Linear Output Transformers.
Price: COMPLETE KIT. Parmeko Transformer......... **£11.10.0**
Alternatively we supply ASSEMBLED AND TESTED. **£13.10.0**
Hire Purchase (Assembled Amp. only). Deposit £2/14/-, 12 months at 19/10.
ABOVE incorporating PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra

COMPLETE MULLARD 3-3

A VERY HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-VALVE 3-WATT AMPLIFIER DESIGNED IN THE MULLARD LABORATORIES.

Price for COMPLETE KIT OF PARTS **£7.10.0**
(Plus 6/6 carriage and insurance).
Alternatively supplied ASSEMBLED AND FULLY TESTED (Plus 6/6 carriage and insurance).... **£8.19.6**

H.P. TERMS: Deposit £2 and 8 monthly payments of £1.
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.

COMPLETE STEREO AMPLIFIER

Meets the many requests for a low priced but good quality Stereophonic Amplifier. Output power is 4 watts. Inputs for Crystal Pick-ups and Radio Tuner.
KIT OF PARTS.......... **£8.10.0** or ASSEMBLED........ **£10.10.0**

Mk. II "Fidelity" FM TUNING UNIT

An attractively presented Unit incorporating MULLARD PERMEABILITY TUNING HEART and corresponding Mullard valve line-up. Very suitable to operate with our Mullard Amplifiers.
FOR THE CONSTRUCTOR.... **£10.0.0** or ASSEMBLED.... **£14.15.0**

SPECIAL CASH ONLY OFFER ! !

The 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 BVA 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) 6½in. P.M. SPEAKER........ 18 9
(Carriage and Insurance 4/- extra).

"Hi-Fi" LOUDSPEAKERS

WE HAVE IN STOCK A COMPLETE RANGE BY GOODMANS—WHARFEDALE—W.B.
ILLUSTRATED AND PRICED LEAFLETS ON REQUEST.

THE "ADD-A-DECK"

INCORPORATING GARRARD "MAGAZINE" TAPE DECK and the MATCHED MODEL HF/G2P PREAMPLIFIER. Supplied on ONE CHASSIS (as illustrated). READY FOR USE.
PRICE: Including GARRARD MAGAZINE and a 4in. SPOOL DOUBLE PLAY TAPE (Carr. & Ins. 10/- extra). **18 gns.**
H.P. Deposit £3/16/- and 12 months of £1/7/8.
Provides complete tape recording facilities and designed to operate through the pick-up sockets of the standard type of RADIO RECEIVER, or an AMPLIFIER, from which really first class reproduction is obtained. It consists of a Twin Track Deck connected to the Pre-amplifier and operates at 3¾in./sec. speed, providing up to 1 hour 10 mins. playing time. Only needs connecting to the mains supply and pick-up sockets. Very simple to operate and easily installed in a cabinet, only four fixing screws being required.

H.P. TERMS ARE AVAILABLE ON ALL EQUIPMENT OVER £9. FULLY DESCRIPTIVE LEAFLETS ARE AVAILABLE FOR ALL EQUIPMENT, BUT PLEASE SEND S.A.E

PRICE REDUCTIONS

(a) The COMPLETE KIT OF PARTS to build both the "5-10" Main Amplifier and the 2-Stage Pre-Amplifier Control Unit............ **£15.15.0**

(b) The "5-10" and the 2-Stage Pre-Amplifier both Assembled and Tested................ **£18.18.0**
H.P. TERMS: Deposit £3/16/- and 12 months of £1/7/8

(c) The COMPLETE KIT OF PARTS to build the Dual Channel "3-3" Amplifier and the Dual Channel Pre-Amplifier Control Unit...... **£21.10.0**

(d) The Dual Channel "3-3" Amplifier and the Dual Channel Pre-Amplifier Control Unit both Assembled and Tested **£25.0.0**
H.P. TERMS: Deposit £5 and 12 months of £1/16/8.

(e) The COMPLETE KIT OF PARTS to build one "5-10" Main Amplifier (Parmeko Transformer) and the Dual Channel Pre-Amplifier Control Unit **£21.10.0**

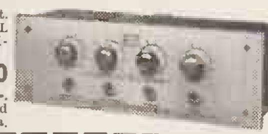
(f) One "5-10" Amplifier (Parmeko Transformer) and the Dual Channel Pre-Ampifier both Assembled and Tested................ **£25.0.0**
H.P. TERMS: Deposit £5 and 12 months of £1/16/8.

(g) COMPLETE KIT OF PARTS to build Two "5-10" Main Amplifiers (incorporating Parmeko Output Transformers) and the Dual Channel Pre-Amplifier Control Unit **£31.0.0**

(h) Two "5-10" Amplifiers (Parmeko Output Transformers) and the Dual Channel Pre-Amplifier Control Unit both Assembled and Tested **£36.0.0**
H.P. TERMS: Deposit £7/4/- and 12 months of £2/12/-.
Carriage and insurance 7/6 extra.

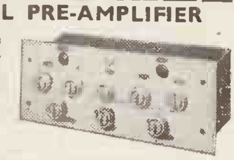
Prices quoted are subject to £1/6/- extra for Partridge Trans'

MULLARD FOUR CHANNEL MIXING UNIT



Self powered with Cathode follower output. Incorporates Two inputs for CRYSTAL MICROPHONES, one for CRYSTAL PICK-UPS and a Fourth for Radio or Tape.
KIT OF PARTS **£8.8.0** ASSEMBLED AND TESTED **£10.0.0**
Terms: Deposit £2 and 12 months at 15/-.
Model I.L. one microphone input matched for moving coil or ribbon mike £1/17/- extra.

STEREO DUAL CHANNEL PRE-AMPLIFIER



This model incorporates two 2-valve Pre-Amplifiers (described above) combined into a Single Unit enabling it to be used for both STEREOPHONIC and MONAURAL operation. It is designed primarily to operate with our range of MULLARD MAIN AMPLIFIERS but will also operate equally well with any make of Amplifiers requiring an input of 250 m/v.

Price: COMPLETE KIT OF PARTS **£12.10.0** Alternatively ASSEMBLED and TESTED **£15.0.0**
H.P. Terms on assembled unit: £3 Deposit and 12 months of £1/2/-.

STEREO "3-3" MAIN AMPLIFIER

Comprises two MULLARD 3-3 Main Amplifiers on one chassis. Operates with above MULLARD STEREO PRE-AMPLIFIER. Output power 6 watts. Inputs for Crystal Pick-up and Radio Tuner
KIT OF PARTS.............. **£10.0.0** or ASSEMBLED...... **£11.15.0**

! ! RECORD PLAYERS ! !

Many at REDUCED PRICES ! ! !
Send S.A.E. for ILLUSTRATED LEAFLET

THE EMI 4-speed single record player with separate crystal pick-up........ **4 gns.**
B.S.R. MONARCH UA8 4-spd. Mixer Autochanger with Crystal Pick-up **£6.19.6**
THE NEW COLLARO "C60" 4-speed autochanger unit with Studio "O" pick-up **£7.19.6**
The NEW COLLARO Model RP594, 4-speed Single Record Player, Studio Cartridge **£9.18.9**
THE E.M.I. 4-speed Single Record Player, incorporating a high output crystal pick-up **£6. 9.6**
B.S.R. MODELS UA12 and UA14. Each a 4-speed Mixer Autochanger with Crystal Pick-up **£7.19.6**
Both available incorporating the B.S.R. STEREO Pick-up, plays L.P. and 78 records **£10.10.0**
GARRARD RC209 4-speed Autochanger fitted with latest Crystal Pick-up **£8.19.6**
The latest GARRARD TRANSCRIPTION MOTOR "301".......... **£22.7.3**

The new GARRARD Model 4HF High Quality Single Record Player fitted with the latest T.P.A. 12 Pick-up arm and G.C.S. Crystal Cartridge **£18.7.6**
GARRARD Model TA/Mk. II Single Record Player fitted with high output Crystal Pick-up, detachable head........................ **£8.10.0**
HIRE PURCHASE TERMS available on all units £8/19/6 and over
Carriage and insurance on each above 5/- extra.

! ! 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, Pre-amplifier, 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 RADIO LTD. DEPT. W. 109 FLEET ST., LONDON, E.C.4
Telephone: FLEET STREET 5812/3/4

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and MAIL ORDER SERVICE

52 Tottenham Court Road, London, W.1 • *Open 9-6, including Sats., Thurs. 9-1* • **LANgham 0141**

SMALL HIGH-SPEED MOTORS

Robust, high-quality, fan-cooled motor built to aircraft standards by English Electric. Continuously rated for 11,000 r.p.m. from 115 volt 3 phase 400 cycle supply. Only 4½ x 2 inches dia. with ⅜in. dia. fibre gear pinned to 3/16in. dia. shaft which protrudes ½in. from end face. Substantial terminal block.

Brand New Post paid. **30/-** each.

ANTENNA BEAM ROTATING MOTOR

Powerful British series-wound split field 24-volt motor with a 600-1 epicyclic reduction gear turning a ¾in. long, ½in. diameter splined drive at 12-15 r.p.m. Removal of the easily detachable (24 volt) magnetic brake housed in a separate rear casing permits operation from either A.C. or D.C. at any voltage between 6 and 30 with corresponding variable speed. Limit switches operate after approximately 3 turns in either direction, but these can be shorted out for continuous running. Designed for external use, easily waterproofed. Consumption 4-6 amps. **55/-** plus 7/6 carriage.

ANTENNA INDICATOR
Remote indication to within 1° on precision instrument type flush fitting black crackle indicator with 3in. dial calibrated in 2° steps plus the four cardinals. Simple D.C. wiring (6-30 volt) from specially wound potentiometer in sealed die-cast housing with ¼in. drilled spindle transmits accurate signal of horizontal or vertical bearing.
Brand New Post Free, **35/-**

POST FREE SNIPS

Double pole knife changeover switch on porcelain base, 2 for	5/-
Pyrex Aerial Insulators. Four 3in. OR one 8in.	7/6
U.S.A./British co-ax. adaptors. Four for	5/-
Neons. Ten 115 volt for 12/6; Six 80 volt for	7/6
G.P.O. electro-mechanical counters. 0-9999	7/6
Bulgin Type M microswitches, new	4 for 11/6

Metal Rectifiers:
Selenium 6-12 v. 1½A., 6/6; 2½A., 9/6; 4A., 16/6; Charge-Transformer, Pri: 200/250 v., sec. 3½ v. 9 v. 17 v. at 4 Amps. 22/- post paid.

CATHODE RAY TUBE

VCR139. (Cossor 23D Equiv.), 2½in. dia. Tube. New in original cartons. **17'6** Post Paid.

TELEVISION OSCILLOSCOPE

Release of a small quantity of the latest version of the well known APN-4 Indicator Unit from the American Loran Airborne radio navigation system. This provides a golden opportunity to make a serious television servicing and development tool as described in the *Wireless World*.

This is a nice looking piece of equipment with a really businesslike inside. Steel, double-deck chassis with fully screened 5CP1 tube in the centre, all high-grade capacitors and resistors, separate tag boards and layout diagrams for individual sections, etc. Modern circuit technique centred around one type of valve (14 of 6SN7 double-triodes and 8 of 6H6, plus three 6SL7 and one 6SJ7), and RCA. 100 kc/s Crystal.

Brand New, with W.W. Circuit for conversion **£6.10.0.**

Master and Remote CONTACTORS

THE MASTER CONTACTOR is a robust high-quality spring driven clock with a Services quality balanced escapement driving a low friction pair of contacts that "make" every half-second. The enclosed mechanism is optionally maintained at a constant temperature by a thermostat and small heating element of 12 to 24 volts is applied to external leads provided. These, together with the contact leads, are brought out through torroidal filter units incorporated in the metal base of the unit—the whole of which is fitted in a practically sound-proof, temperature and vibration eliminating sorbo-rubber-lined wooden box, approx. 6 inches cube. Winding key and stop/start knob accessible on removing snap-on lid.

THE REMOTE CONTACTOR is a solenoid operated ratchet mechanism turning a pointer at one rev. per minute over a two inch dial with adjustable zero and ¼ divisions. The solenoid was designed to be energised by 24 volt pulses at half seconds via the master contactor and the ratchet wheel is secured to a fibre cam that opens a pair of contacts for ¾ of each rev. and lets them close for the remaining quarter. On/off switch on 4in. dia. faceplate.

In first class condition, guaranteed fully serviceable Post paid. **35/-** a pair.

SUPPRESSOR SNIP

Neat, black, die-cast, four partition box, 3½ x 4 x 1½in., with central screwed outlets. Two empty sections and two containing cascaded RF filters each comprising two 0.01 μF non-inductive 350 v. condensers and associated pi-wound coils clamped in die-cast cores mounted on easily removable ebonite blocks.

TYPE P.2 BRAND NEW **3/6** each. Post paid.

TIP: Buy two, fit four filters into one box, steamroller that mains borne interference and have a useful spare box for building a screened pre-amp or oscillator unit into, all for **7/-**. POST PAID

400 CYCLE CHOPPER

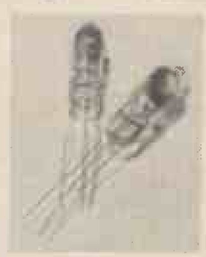
Latest version of U.S.A. Servomechanisms 400 c/s chopper. High quality 6 v. vibrator oscillating between twin contacts for chopping external circuit. Hermetically sealed in octal based can.

Brand New **£2** *post paid*

Receiver Type 1143A

Suitable for conversion to 2 metre FM or Wrotham Transmissions. Valves: 4xEF50, 1xEL32 2xEF39, 1xEBC33, 1xEA50. Complete with circuit diagram, **£1.5.0** Plus 5/- packing and carriage.

Cold Cathode Trigger Tubes



A sub-miniature cold cathode valve developed by Ericsson primarily for computer work, these GTR.120W tubes have great possibilities in a number of experimental electronic automatic control circuits. They have an Anode-Cathode running voltage of 95 to 140 at 4.5 mA, and at 290 anode volts require a trigger current of only 250 microamps to cause the anode to take over the discharge. Typical ionization time =90 micro-seconds. They will withstand up to 310 v. with zero trigger voltage without self-igniting.

Supplied complete with full performance data in original packs of 100 at the Special Price of **£5** *per 100 post paid.*

MEGISTORS, 125, 1,000 or 10,000 MEGohms

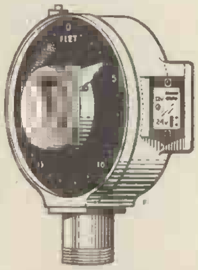
Glass encapsulated 10% tolerance high value resistors for minute grid current applications. Ideal for extending the range of sensitive meters or using in probes to provide a really high impedance input for VTVM's or 'Scopes.
One of each value plus any chosen two, **5 for 10'-** post paid.

25 c/s Tuning Fork Drive AMPLIFIER

Modern, light-alloy cased, Drive Unit, Type 114, containing a robust 8½ inch induction sustained 25 cycles per second tuning fork with attendant induction pick-ups and wave form amplifier comprising 2×DF50, CV1092 diode and 6L6 output. 5U4G rectifier and VS110 stabiliser in power supply derived from high-cycle transformer easily replaced with standard 250 v. mains type providing centre tapped H.T., 5 v. for rectifier and two 6.3 v. filament windings for valves (6L6 is heated from separate winding to EF50's and diode). High grade components throughout. Tuning fork assembly 3-point flexibly mounted, quickly removable, energised by 6.3 v. A.C. *Overall size 8½ × 7½ × 10½in.*

New, only **£3.3.0** *Carriage paid.*

CENTRE SCALE COUNTERS



Ex-RAF camera film footage indicators. Consists of really compact lever solenoid which actuates a pawl on a ratchet wheel to move a pointer progressively round a circular dial. Works on either 12 or 24 volts d.c. and records 125 counts per revolution. Can be used for mechanical counting display, etc., or the lever solenoid could readily be adapted for use in modelling. Housed in diecast case with centre toggle switch, and reset button. Stick-on dial graduated 0-125 supplied. Size 3⅞ × 1½inches.

10/6 post paid.

THERMOSTAT BARGAIN

American Satchwell industrial quality type ST thermostat in neat strong plastic case size 1×1⅞×2⅛in. deep. Heavy duty contacts rated at 15 amp. on 200/250 volt A.C. (3¾ kilowatts) adjustable by pointer in a recess at rear to break over a range of temperature around 70°F. Recessed screw terminals at rear. Flush metal plate at (temperature sensitive) front, with two mounting lugs protruding ⅛in. either side. Attractive red case.

Brand new **8/6** post paid.

Brand New, Individually Tested, Fully Guaranteed

LOW-VOLTAGE HALOGEN-QUENCHED, GEIGER-MUELLER TUBES 25/- post free

Working voltage 400-450. Highly sensitive. Effective length 11.8 cm. Background count 90/minute. Response 30,000 counts/minute. 80-volt plateau. Standard British 4-pin base, stainless iron electrode. Ideal for basic experimentation and instructional demonstration. Circuits of simple all transistor and conventional valve counter circuits supplied on request with each tube.

INVERTORS

28 Volt DC to 115v 1 phase AC

Self-contained motor generator unit with complementary carbon pile voltage regulator, contactor and associated rectifier in separate compartment on same base. Continuously rated for 25/28 volts D.C. input with 360 VA output at 115 volts single phase A.C. at 1,600 cycles with a power factor of 1.0. Fan cooled with end plate for blast or internal cooling as required. Type 200. Ref. 5UB/5083.

In first class condition. **£4.10.0** carriage 7/6.

28 volt DC to 115v 3 phase 400 c/s AC. Type 102A

Output 625VA. Brand new. **£10** carriage 10/-.

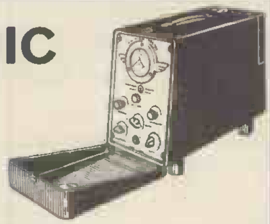
200/220 Volt DC to 200/250v 1 phase 50 c/s AC

Output 260 watts. New, in soundproof cabinet. carriage paid. **£9.10.0**

24 volt DC to 26v 1 phase 400 c/s AC

Output 6 VA. Size 2¼in. dia. × 4in. long on 1½in. high pedestal base. Instrument quality. As new **£1.10.0** carriage paid.

ELECTRONIC IGNITION ANALYSER



A versatile, portable instrument, specially designed for use by the Services in the critical examination of aircraft engine ignition systems during preventive maintenance routines.

It displays the entire performance of the ignition system on a cathode ray screen while the engine is running—simultaneously showing each plug's firing for side-by-side comparison together with any associated contact-breaker bounce, etc. Reveals excessive carbon formation, faulty condenser, leaking cables, wide gap, narrow gap, for either plug or contact-breaker points, worn cams, etc., and contains a 10-step loading switch which absorbs energy from the ignition system and thus accentuates the test to show up deterioration in such items as coil primary or secondary winding, condenser, cables, etc., which will soon cause misfiring and eventual breakdown unless serviced or replaced.

Simply and quickly connected by crocodile clip leads to coil terminals and one "triggering" plug, the power supply can be switched from the front panel to suit either 250 volt A.C. mains, 6, 12 or 24 volt battery, and can thus be used inside the car during road service if desired. In attractive, front and rear opening, black case, 9½ × 13¾ × 17¾in. deep, weight only 33½ lb. Supplied complete with circuit, instructions, and good and faulty trace drawings. Guaranteed fully serviceable.

£15 plus 10/- carriage.

1½ SECS. TIME DELAY SWITCH BRAND NEW

Beautiful little, fast running, precision, ball bearing, double armature motor (1¼in. dia.) driving two spring returned cams through a precision ball bearing gearbox and magnetic solenoid clutch. The 1¼in. diameter steel cams have roller and tooth form followers on twin rocking arms that each operate switches with substantial changeover contacts and sprung microswitch action. A large-contact miniature relay is mounted under the rocker bridge. High quality modern unit made by Teddington Controls (TYPE FHM/A) controlling over-run of camera guns. Designed for 24 v. D.C., but motor runs energetically at 6 v. when detached from gearbox. Totally sealed in robust die cast box 4½ × 3 × 3½in. with rubber cable seal protruding from flush mounted terminal plate. Time delay 1½ seconds. AM Ref. 5C/4435.

35/- post paid.

PRESSURE SENSING INDUCTANCE

Highly sensitive device consisting of a ferrite encapsulated 160 kc/s coil with a movable ferrite core attached to the free end of a single-disc aneroid capsule so that it transmits a change in frequency equivalent to the change in atmosphere pressure with increasing altitude. Coil Q, 43. Capacitance 870 pf. Housed in a ⅞in. square aluminium can on a lightweight 2¼in. diameter plug-in unit.

New **25/-** post paid.

GROUND STATION TRANSMITTER

Type 75C, comprising RF Unit, RF Driver, RF Power Amplifier, Modulator, Modulator Power Unit, and Control Unit, all in 6 foot high 19 inch enclosed rack with full length rear access doors. This was the RAF ground station for operational communication with aircraft in the 100-150 Mc/s range and it is suggested that substitution of a suitable VFO for the existing RF Unit would provide the basis for an exceptional rig. Warehouse inspection invited.

Complete **£35** carriage £4.

TRANSMITTER/RECEIVER APN-1

A complete 14-valve radar set covering 420-460 Mc/s Ideal for conversion to radio control of models or 70 cm. work.

TRANSMITTER COMPRISES:
a push-pull feed-back oscillator tuneable either side of 445 Mc/s., frequency modulated at 100 c/s by a particularly robust moving coil transducer. Two 955 high frequency acorn valves.

RECEIVER is tuneable to transmitter frequency. Two 9004 acorn valves.

AUDIO AMPLIFIER
Self-contained RC coupled 12SH7, 12SH7 and 12SJ7. Amplifies the received signal which is passed to detector circuit giving a D.C. voltage proportional to the difference between the transmitted and received (reflected) signal to operate internal relays which pass appropriate correction signals to autopilot and supply external indicator (5 mA meter).

MAIN CHASSIS
The main chassis carries the 3 sub-units and has a further three 12SH7 one 12SJ7, two 12H6 and one VR150 regulator.

BRAND NEW, a very useful buy indeed at only **£2** plus 7/6 carriage. less Dynamotor.

PROOPS BROTHERS LTD., 52 Tottenham Court Road, London, W.1.

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PROOPS *MECHANICAL OFFERS*

TACHOMETER CALIBRATOR

MARK II

R.P.M. tester with direct and reduced ratio driving shafts and three ranges of speed indication by dual sensitivity galvanometer in Maxwell Bridge circuit. Heavy duty, 24 volt, 6in. dia., $\frac{3}{16}$ h.p. motor with coarse and fine speed control into 1 : 1 and 1 : 4 output drives giving 0 to 1,250 and 0 to 5,000 r.p.m. for testing direct and gearbox type tachometer generators. Interlocked forward and reverse switching. Ten-position speed selector for balancing bridge over each of three ranges 600 to 5,000, 1,200 to 10,000 and 2,400 to 20,000 r.p.m. Final balancing done at increased sensitivity by push button control. Quick mounting provision for two indicators and generators with two sets of quick fitting interconnecting leads, spare flexible drives, spare brushes, bulbs, etc., in rear compartment. Smart grey enamel bench unit with sloping panel, overall size 19in. high × 15in. deep × 16in. wide, plus 11in. extension platform for generators.

Fully serviceable, carriage paid, **£20**

SOLENOID OPERATED VALVES

Self-contained, precision engineered solenoid operated valves for use in gas or fluid flow control circuits. Completely sealed in cylindrical housing size $1\frac{1}{2} \times 3\frac{1}{2}$ inches. Fitted with standard BSP connections. For 12 or 24 volts D.C. operation. Brand new.

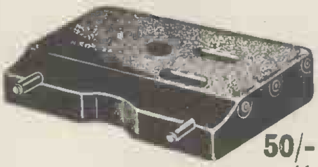
post paid. **10/6**

HIGH-SPEED BEARING GREASE

Large tubes of high temperature, high-speed bearing grease by a famous manufacturer for use in aircraft landing wheel bearings, etc. Suitable for car wheel bearings, high-speed races, etc.

3 tubes for **5/-** post paid.

PORTABLE STORAGE TANKS

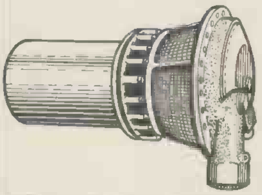


Brand new, high-duty, flexible, aircraft fuel tanks. Made of extremely tough, specially proofed, plastic material impervious to oil, kerosene, water, etc. Capacity approximately 40 galls.—can be folded into convenient carrying size when empty. Size: 34in. × 28in. × 7in. tapering to $4\frac{1}{2}$in.

50/- post paid.

Supplied fitted with submerged pump (described below), £5 post paid.

SUBMERGED PUMP



Precision made, diecast-framed, centrifugal vane type pump. Intended for flange mounting through wall of tank—will pump fuel at 10 lb/sq. in. at rate of 400 galls. per hour. Operated from self-contained, sealed motor rated 24 volts D.C. at 12.5 amp. Overall length 12 inches; flange diameter 8 inches. **In excellent used condition and fully guaranteed** **50/-** post paid.

Oil Pressure Gauge and Transmitter

Ex-R.A.F. remote reading electrical oil pressure gauge. Transmitter is readily fitted to engine pressure connection. Circular scale, 2-inch gauge, graduated 0-120 lb/sq in.

25/- post paid.

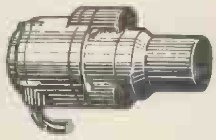
LOW-PRESSURE WARNING SWITCH

Decreasing pressure on diaphragm closes switch contacts when pressure falls to a predetermined value—to operate warning lights, alarm bells, or to automatically shut-off defective engine. Contact adjuster permits any setting between approximately 1 and 15 lb/sq. in. Excellent protection device for marine or generating engine. **10/-** post paid.

ELECTRIC ACTUATORS

Special offer of aircraft quality, precisioned engineered rotary actuators by leading British manufacturers. In new or first class used condition. For 24 volt operation.

Range:

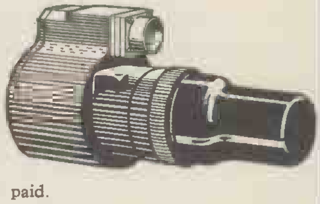


TYPE 1

Current 0.5 amps. Ram travel 90°. Maximum load 4.5 lb/ft. Reduction gear ratio 4450 to 1. Length overall $4\frac{1}{2}$ inches. Weight 2 lb.

50/- post paid.

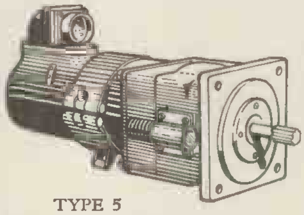
TYPE 2



Split field, series wound, reversible motor fitted with electro-magnetic brake. Max. load 50/60 lb/ft. Output 0.02 h.p. at 13,000 r.p.m. Reduction gear ratio 2857 to 1. Length 7 inches. Weight $2\frac{1}{2}$ lb. Fitted with adjustable limit switches **75/-** post paid.

TYPE 3

Similar in appearance to above. Designed for operation of 3-position type valves in which actuator gives wide variety of angular settings determined by position of limit switches. Max. load 50 lb/ft. Output 0.017 h.p. at 17,000 r.p.m. Full range travel—140° in 2 seconds. Weight 3.25 lb. 75/- post paid.

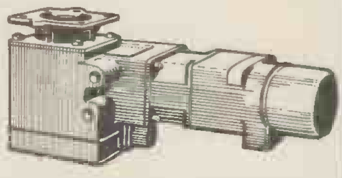


TYPE 4

Maximum load 35 lb/ft. at 52 r.p.m. Clutch setting 37 lb/ft. Reversible, split field motor. Reduction gear ratio 275 to 1. Length $8\frac{3}{4}$ inches. Width $4\frac{3}{4}$ inches. Weight 5 lb.

75/- post paid.

TYPE 5



Two-pole, split series wound motor. Fitted with double-plate friction clutch. Speed of motor 11,000 r.p.m. —reduced through epicyclic and worm gears to 60° rotation of right-angled drive shaft in 3 seconds. Consumption 3 amps.

75/- post paid.

"KIGASS" PRIMING PUMPS

Very powerful hand-operated priming pumps constructed of nickel plated brass and fitted with inlet and outlet non-return valves—standard BSP connections. *Ideal for priming engines, hydraulic systems, large pumps, etc.* Length: $10\frac{1}{4}$ inches. Barrel diameter: $1\frac{1}{4}$ inches. **15/-** post paid.

Similar, smaller type, with plain brass finish. Size: 8 × $\frac{3}{4}$in. dia. **10/-** post paid.

HYMATIC COMPRESSORS

High-quality, with machined cooling fins and detachable head. Compresses up to 450 lb/sq. in. and delivers at up to 60 cu. in. per minute. Basis for home compressor/paint spraying outfits. *Complete with extended splined driving shaft.*

30/- post paid.

TOUGH RUBBER HOSE

Brand new, corrugated rubber hose with cord reinforced carcase and fabric covered exterior moulded to rubber to provide tough yet flexible tubing. Internal diamater $\frac{3}{4}$in. inches. In 3 foot lengths. 2 for **7/6** post paid.

PROOPS BROTHERS LTD., 52 Tottenham Court Road, London, W.1
Head Office and mail order enquiries, Dept. M. LANgham 0141
Shop hours 9 a.m. to 6 p.m. Thurs. 9 a.m. to 1 p.m. OPEN ALL DAY SATURDAY

RCA AR88D RECEIVERS

One of the most renowned American Communications Receivers ever manufactured. Widely used by all the Armed Services to maintain World-wide Communications and Monitoring Posts under all conditions. Employs 14 valves, and has 6 switched overlapping wave bands for complete coverage. Refinements include Mechanical Band Spread with Logging Scale, Automatic or Manual Volume Control. Automatic or Manual Noise Limiter, BFO with pitch control, RF and AF Gain Controls. Variable HF Tone Control, Variable Selectivity with Crystal Filter, Aerial Trimmer, Choice of Headphones or Speaker. Has internal mains power pack for nominal 115-230 volts A.C. In Black Crackled Case size 19½in. W. x 11in. H.x 19½in. D. Thoroughly reconditioned, immaculate in appearance, and in perfect working order. Covers 500 kc/s-32 Mc/s, price **£45** (add carriage 30/- and 50/- deposit on returnable transit case). S.A.E. brings illustrated descriptive leaflet.

TRAWLER BAND R 1155s

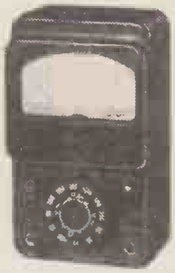
The latest version of this famous Communications Receiver to be released by the Air Ministry. Covers 5 wave ranges 18.5-7.5 Mc/s., 7.5-3.0 Mc/s., 3.0-1.5 Mc/s., 1.5 Mc/s., 600 kc/s., 500-200 kc/s. As used by Coastal Command, Air-sea Rescue Launches, etc. All sets thoroughly tested and in perfect working order before despatch, and on demonstration to callers. Have had slight use, but are in excellent condition. ONLY £12/19/6.

A.C. MAINS POWER PACK OUTPUT STAGE in black metal case to match receiver, enabling it to be operated immediately, by just plugging in, without any modification. Fitted with 8in. P.M. speaker £6/10/-. DEDUCT 10/- IF PURCHASING RECEIVER AND POWER PACK TOGETHER.

Send S.A.E. for illustrated leaflet, or 1/3 for 14-page booklet which gives technical information, circuits, etc., and is supplied free with each receiver. Add carriage 10/6 for Receiver, 5/- for Power Unit.

UNIVERSAL VOLT—OHM—MILLIAMMETER

Reads A.C. and D.C. Volts up to 1,000 in 5 ranges at 1,000 o.p.v., D.C. Current (3 ranges) to 500 mA. Resistance readings to 200 Kohms in 2 ranges. Basic movement 300μA sensitivity. Easily read open scale. Dimensions 5¼in. x 3⅝in. x 2¼in. Beautifully made, and fully guaranteed. Complete with leads, prods and internal battery. ONLY **59/6**



H.R.O. SENIOR COMMUNICATIONS RECEIVERS. Complete with all 9 coils, giving coverage of 50 kc/s—30 Mc/s. Checked and in perfect working order. Rack mounting type 18 gns., Standard Table Model 21 gns. (Carr., etc. 22/- either type.)

HRO MAINS POWER UNITS. A.C. Input 115/230 volts, Output D.C. (fully smoothed) 230 volts 75 mA., and 6.3 volts 3.5 amps. Complete in black crackled case ONLY 59/6.

BC 342 RECEIVERS. A few only of these famous American sets covering 1.15-18.0 Mc/s., in six bands. Internal 115 v. A.C. Mains pack. A super receiver in first-class condition and perfect working order. ONLY £25 (carriage 15/-).

12-WAY SCREENED CABLE. In 10ft. lengths, fitted with plugs, originally made for No. 19 Wireless Set. UNUSED. ONLY 15/- per lead.

UNISELECTOR. 25 way 8 bank 15 ohm coil for 24 volt operation, unused ex-brand new equipment, only 62/6.

SPRAGUE CONDENSERS. Metal cased wire ends. New, .01 mfd. 1,000 v. and .1 mfd., 500 v. 7/6 per dozen. Special quotes for quantities.

HETERODYNE FREQUENCY METERS TYPE LM14

Frequency range 125-20,000 kc/s. in 2 bands. This is the United States Navy Model of the well-known BC.221 Frequency Meter, but has many additional features which increase its usefulness. Voltage stabilisation circuits and Crystal control ensure extreme accuracy and in addition it is fitted with an Internal Modulation switch to allow use as a Signal Generator. Size only 8½in. x 8in. x 8½in. Full information on request.

BC 221 FREQUENCY METERS

Similar specification to LM 14 Frequency Meter below, but does not have internal modulation or voltage stabilising circuits. Complete with original calibration book, crystal, valves, and instruction book. Used, but in very good condition. ONLY £16. Illustrated descriptive leaflet available on request.

20,000 OHMS PER VOLT TESTMETER

Just purchased from the Air Ministry, these magnificent American PRECISION Testmeters provide 31 ranges for reading Voltage Current and Resistance, 6 Decibel ranges, 7 Output ranges, and facilities for testing Electrolytic and Paper Condensers. Single switch control, meter size 4½in. x 4½in. with Red and Black scales, mounted on Black and Silver Panel size 8½in. x 7in., which is fitted into sturdy wood carrying case with removable hinged lid and compartment for leads, etc., the overall size being 10in. x 9in. x 6in. Has 7 D.C. Voltage ranges up to 6,000 volts at 20,000 ohms per volt, 7 similar ranges at 1,000 ohms per volt, 7 similar A.C. ranges at 1,000 ohms per volt, 7 D.C. Current ranges from nought microamps to 12 Amps., 3 Resistance ranges up to 60 Megohms, 6 Decibel ranges from −12 to +70 DB, 7 Output ranges up to 6,000 volts. Supplied with test leads, internal batteries, and operating instructions. Case finished medium Oak, and fitted with leather handle. In excellent condition, thoroughly checked before despatch. 40 only available—first come first served.

ONLY **£9/19/6** (post etc. 5/6).

Further details on receipt of S.A.E.

DOUBLE BEAM OSCILLOSCOPE TUBES

Type CV 1596 equivalent to Cossor 09D as used in oscilloscopes by Cossor (339 series). Hartley and Erskine (13 series). Listed at £12/10/-. Our price £2/19/6 (carriage 5/6). Brand new in makers' crates.

METERS

F.S.D.	SIZE AND TYPE			PRICE
25 microamps	D.C.	2½in. Proj.	circular	59/6
50 microamps	D.C.	2½in. Flush	circular	59/6
50 microamps	D.C.	3½in. Flush	circular	80/-
100 microamps	D.C.	2½in. Flush	circular	39/6
1 milliamp	D.C.	2½in. Flush	circular	30/-
1 milliamp	D.C.	3½in. Flush	circular	50/-
200 milliamp	D.C.	2½in. Flush	circular	12/6
20 amps	D.C.	2in. Proj.	circular	7/6
40 amps	D.C.	2in. Proj.	circular	7/6
5 amps	D.C.	2in. Flush	square	12/6
300 volts	A.C.	2½in. Flush	circular	25/-
500 volts	A.C.	2½in. Flush	circular	25/-

HIGH FREQUENCY A.C. VOLTMETER

A First Grade Moving Iron Instrument with 6in. Mirror Scale, reading up to 150 volts A.C. at 400 and 1,200-2,400 cycles. In substantial Oak case with removable lid, overall size 8½in. x 8½in. x 5½in. Recently made for the Air Ministry by Everett Edgcumbe, and in perfect order. Brand New & Unused. ONLY £7/10/-. Can also be supplied for 50 cycles use, either 0-150 or 0-300 volts.

AMPLIFIER N24. As previously advertised. 4 valves, rack mounting, with internal A.C. mains pack for nominal 110/230 volts. Output to 600 ohms. line, provision for 600 ohms. or High Impedance input. A first class job, NEW IN MAKERS' PACKING. ONLY 89/6 (carr. 10/6).

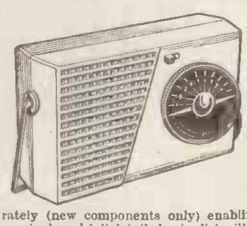
INTERCOM. TELEPHONE SET. Two pairs of Brand New Headphones connected to Breast Microphones, with leads, etc., in fitted carrying cases. Supplied with 4½ volt battery, 10 yards twin flex, and full instructions for connecting to make super intercom. ONLY 27/6. (Post 3/6). Extra flex 3d. per yard.

10,000 OHMS PER VOLT TESTMETER. This latest Caby model is a handy pocket sized tester 5¾ x 3¾ x 2¼in. Reads low D.C. voltages at 10,000 ohms per volt, up to 10,000 v. A.C. and D.C. at 4,000 o.p.v. Resistance to 20 megs. D.C. current to 250 milliamps and also Decibels. Complete with Test Leads, Batteries and Instruction Book. ONLY £6/10/-.

12 VOLTS AMERICAN DYNAMOTOR. Delivers 220 volts at 100 mills. Size 5½ x 3¼in. diameter. Ideal for running Radio and Electric Shaver etc., from car battery. ONLY 32/6.

MARCONI SIGNAL GENERATOR TF 144G/7. Coverage 85 kc/s.-2.5 Mc/s. and 8 Mc/s.-70 Mc/s. Complete, and in AS NEW CONDITION. ONLY £95.

"P.W." 6 TRANSISTOR PERSONAL RECEIVER



Designed by the technical staff of *Practical Wireless*, easy to build, using printed circuit, and 1st Grade Matched Transistors and Diode. Full Medium and Long Wave coverage to internal speaker. All parts sold separately (new components only) enabling you to buy as required, and full detailed price list will be sent on request. Constructional details 1/6. TOTAL COST INCLUDING BATTERY AND CABINET. £8/19/6.

Cash with order please, and print name and address clearly

PLEASE ADD POSTAGE OR CARRIAGE COSTS ON *ALL* ITEMS

HARRIS ELECTRONICS (LONDON) LTD.

Radio Corner, 138 Gray's Inn Road, London, W.C.1. Phone: TERMINUS 7937

Open until 1 p.m. Saturdays. We are 2 mins. from High Holborn (Chancery Lane Station) and 5 mins. by bus from King's Cross.

LASKY'S RADIO

SAVE POUNDS! ORDER BY POST IF YOU CANNOT CALL

'SUPER 60' 6-TRANSISTOR S/HET TABLE RADIO

Printed circuit construction, all components of highest quality. Uses 6 Mullard matched transistors, 1 diode, 2 OC81 valves in push-pull, giving 1 watt undistorted output. I.F. 470 Kc/s. Medium and long wavebands. Ferrite rod internal aerial, high flux 7 × 4in. Loudspeaker. Cabinet with first quality walnut veneer finish and gold embellishments. Size: 18 × 8½ × 5in. deep.

CAN BE BUILT COMPLETE FOR £9 . 15 . 0 P. & P. 4/6

Circuit diagram and full data supplied. Every component available separately.

LASKY'S FOR MINIATURE POCKET TRANSISTOR RADIOS!

Add to the pleasure of Summer outings, holidays, camping, etc. Wide choice of well-known makes at keenest prices. Call and select or order by post. A few examples.

FIDELITY 6	9½ Gns.
LEECO 6	9½ Gns.
PROGRESS 6	9½ Gns.
SHIRA 6	10½ Gns.
PERDIO 6	11½ Gns.
CROWN 6	£11.19.6.
EMERSON 6	14 Gns.
DANSETTE 6	15 Gns.
PHILIPS 7	15 Gns.
BRAUN 7	15½Gns.

Regd. postage and insurance 5/-.

4-SPD AUTO-CHANGERS

New and Unused in Makers' Cartons.

B.S.R. type UA8	£6 19 6
B.S.R. UA8, stereo	£7 19 6
B.S.R. UA12, stereo	£7 19 6
B.S.R. Type UA14	£7 19 6
COLLARO Studio C60 wired for stereo, with monaural p.u.	£7 19 6

Post on all above 5/-.

GARRARD

Model 120	£8 8 0
Model 121	£9 9 0
Model 209	£9 19 6
Mdl. 210, Stereo	£11 0 0
Mdl. 210 with monaural and stereo heads	£12 10 0
RC.88	£12 19 6
RC.88 STEREO	£13 10 0
RC.98	£14 19 6

SINGLE PLAYERS

Auto start and stop. Complete with pick-up and crystal cartridge.

GARRARD 4SP	£6 19 6
GARRARD TA Mk. II, wired for STEREO, plug-in head	£8 9 0
E.M.I. 4-spd., wired for STEREO and fitted mono cartridge	£5 19 6
As above, STEREO	£6 19 6

Post on all above 5/-.

COLLARO JUNIOR 4-speed motor and separate pick-up 75/-
B.S.R. TU9, non-auto Turntable and separate pick-up 79/6
Post free.

PICK-UP CARTRIDGES

ACOS HGP. 59 or HGP.37 turn over crystal cartridge with L.P. and standard styli. List 39/7. **Lasky's Price 18/-** post free.

ACOS 73-1A STEREO. List 52/6. **Lasky's Price 29/6** post free.

MICROPHONE BARGAINS

ACOS CRYSTAL STICK MIKE Type M.C.39/1, complete with cable. List £5/5/-. 39/6 Post free

Crystal Hand or Table Mike. 15/- Post free.

MINIATURE moving coil dynamic microphone, incorporating switch and pocket clip. As used for the "Fi-Cord" 35/- Post 1/6.

HIGH FIDELITY TAPE RECORDER HEADS

Leading make, new and unused. Upper or lower track. RECORD/PLAYBACK, high impedance. Double wound and will reproduce up to 12,000 c.p.c. at 7½ i.p.s. Azimuth adjustments. Output 5 millivolts at 1 Kc. at 7½ i.p.s. ERASE, low impedance. LIST £4 PAIR.

LASKY'S PRICE, per pair Post free. **29/6**

Please specify upper or lower track.

SPECIAL OFFER. Set of 4 Heads (upper & lower) **49/6**

TAPE RECORDER BARGAINS

ELIZABETHAN "BANDBOX" for A.C. mains 200/250 v., fitted fully self-contained Amplifier and 7 × 4in. Speaker. Clock type face indicator, monitoring and l.s. sockets. 2-speed, 3¾ and 1⅞ i.p.s., fast forward and fast rewind. Record level indicator. Facilities for recording from two inputs. Push-button controls. Plays one hour on one reel of tape. Case, 10½ × 9 × 6in., with detachable hinged lid. LIST 29 Gns.

LASKY'S PRICE, with high quality crystal Mike and one reel of Tape, **£15.19.6** Carr. & Ins. 15/-.

ANOTHER RECORDER BARGAIN! Well-known make using Collaro Studio 3-speed deck, 1⅞, 3¾, 7½ i.p.s. Twin track with pause control, rev. counter, latest type electronic recording indicator. Superimposing switch, volume and tone controls, 7 × 4 Speaker. Takes 7in. spools. 4 watts output. Contemporary design carrying Case, 9½ × 16 × 16in. COMPLETE with Mike, Tape and Spool, Carr. & Ins. 25/-. **29 GNS.**

"SHERWIN SIX" TRANSISTOR POCKET SUPERHET

The very latest printed circuit, using six matched top grade S.T.C. transistors and germanium diode. Push-pull output feeding 3in. P.M. speaker. Full medium and long waves. Internal ferrite aerial and provision for car aerial. Housed in attractive leatherette-covered case, size 6¼ x 4¼ x 1⅜in. Full point-to-point instructions supplied.

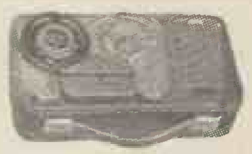
CAN BE BUILT FOR £8/19/6

All components available separately. Circuit diagram and instructions, 2/6 (refunded if you order).

PLASTIC TAPE SPOOLS

3in.	5in.	5¾in.	7in.	8¼in.
1/9	2/6	2/6	2/6	5/6

Post extra.



The "CLARION" TRANSISTOR BATTERY TAPE RECORDER

Capstan drive, push-button controls. Constant speed 3¾ i.p.s., uses 3in. spools. High impact plastic case with transparent upper. Size: 9½ × 5 × 3¾in. List 25 Gns. **Lasky's Price,** with Mike and Tape Carr. 7/6. **18 GNS.**

TRANSISTOR RECORD PLAYER

CAN BE BUILT FOR **£9.19.6**

6 volt operation. For all L.P. and standard records. Complete parcel comprises:—

AMPLIFIER. 300 milliwatts output, using two OC71 and two OC72 transistors. Fully assembled. 79/6. Knobs 3/6 extra.
LOUDSPEAKER. 30 ohms, 7×4in. elliptical Speaker matched to amplifier. 25/-.
3-SPEED TURNTABLE with rubber mat and speed adjustment, complete with t.o. crystal cartridge and two sapphire styli. 79/6
CARRYING CASE as illustrated, handsome two-tone finish, size 17in. deep, 14in. wide, 5⅜in. high. 49/6.

Batteries extra. All items and components available separately.

The LATEST COLLARO STUDIO TAPE TRANSCRIPTOR. 3 motors, 3 speed 1⅞, 3¾, 7½ i.p.s., takes 7in. spools. Push-button controls. Digital counter. **Lasky's Price** complete with Spool, **£10/19/6** Carr. & Ins. 12/6.

TAPE PRE-AMPLIFIER. For use with any Tape Deck including Collaro, Motek, etc. Full recording facilities for 1⅞, 3¾ and 7½ i.p.s., multi-position switch gives automatic equalisation by negative feed-back to each speed. 4 valves including magic eye level indicator. Overall dim.: 12 × 4 × 5in. Front panel: 12½ × 3¼in. Attractive gold hammered finish. **LASKY'S PRICE .... 9 GNS.** Post 3/6.

COLLARO TAPE TRANSCRIPTOR Mk. IV, fitted digital counter. List £25. **Lasky's Price £16/19/6.** Carr. & Ins. 12/6. Tape extra.

MOTEK K10 3-speed Deck. **Lasky's Price £9/19/6.** Carr. & Ins. 7/6.

RECORDING TAPE

Famous make. P.V.C. base on latest type plastic spools. Brand new, perfect, boxed, guaranteed.

1,200ft. on 7in. spool	20/-
1,800ft. on 7in. spool	32/6
1,200ft. on 5¾in. spool	21/-
850ft. on 5¾in. spool	16/6
600ft. on 5in. spool	12/6
225ft. on 3in. spool	6/6

Stereo Amplifier Kit

Twin 4 watt (or 8 watt monaural), employing two ECL82 and EZ80 rect. valves, double-wound mains transformer, etc. Separate panel with bass, treble and volume controls. Indicator lamp, push button on/off switch, elegant gold/cream knobs. Kit comprises two Amplifier Units and one Power Unit, all 5in. × 2in. in size. Fully assembled ready to be wired together. Kit is priced without Loudspeaker so that you can choose the type and size you prefer.

LASKY'S PRICE

Kit complete with new Mullard valves, full data, circuit diagram, assembly instructions and suggested layout. **56/-** Post 5/-.

SPECIAL OFFER OF SPEAKERS WITH THIS KIT

Two 5in. 20/-. Two 6×4in., 25/-. Suitable cabinets callers only.

RADIO · TELEVISION · HI-FI · ELECTRONICS · RECORDERS

LASKY'S RADIO

TRANSISTORS

P.N.P. Junction types.

AUDIO, suitable for high gain and low freq. amplifiers, and for output stages up to 250 milliwatts. Double spot—yellow and green 5/-

R.F. suitable for medium and low freq. oscillators, freq. changers and I.F. amplifiers (1.5 to 8 Mc/s.). Double spot—yellow and red ... 7/6

Type TS1. Suitable for all audio applications 3/6
Post 6d. One dozen 35/- post free. Special prices for larger quantities.

OC44	OC45	OC70	OC71
12/6	10/-	8/6	8/6
OC73	OC76	OC81	OC16
8/6	8/6	8/6	54/-

OC78 8/6 (Matched Pair, 17/-)

EDISWAN MAZDA TRANSISTORS. The very latest types:
XB/102 7/6; XB/103 7/6; XC/101 10/6; XA/101 12/6; XA/102 12/6.

SPECIAL OFFER. Set of 7 Ediswan Transistors: XA/101, XA/102, 2 XB/102, XB/103, 2 matched XC/101. Price 79/6.

CRYSTAL DIODES. General Purpose GEX00, each 1/-. Per doz. 9/-.
All other types in stock.

"GOLTOP" 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/-.

SPECIAL OFFER
WHARFEDALE SUPER 12. FS/AL

Brand new in maker's cartons. 15 ohms, 17,000 lines, 15 to 30 peak watts. List £17/10/-.

Lasky's Price £12.19.6

Carr. 7/6

LASKY'S MIDGET T.R.F.

CAN BE BUILT FOR ONLY 99/6

Post & Pkg. 5/-

For A.C. mains 200/250 v. Medium and long wave. Uses 2 latest double-purpose valves EBF89 and ECL80, contact cooled rectifier. 5in. P.M. Speaker. Handsome plastic cabinet in cream, pastel green, pink, blue. Overall size: 8½in. wide, 4½in. deep, 5in. high.
FULL DATA, circuit diagram, etc., 1/6. (Free with parcel).
All components available separately.

CAR RADIO COIL PACK

(Superhet, I.F. 465 Kc/s)

As used in Lasky's Car Radio (see on right). A permeability tuned Coil Pack covering medium and long wavebands, with tuned R.F. stage. Size 7½ × 5 × 1½in.

LASKY'S PRICE with circuit diagram and full data, 49/6. Post 2/6.

SEND FOR LASKY'S
COMPONENTS CATALOGUE

OVER 100 PAGES
SIZE 8½in. × 5½in.
COPIOUSLY ILLUSTRATED

Price 2/- Post 6d.

Our latest 12-page "BARGAIN BULLETIN" free with each copy.

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COLLARO	JASON	STELLA
CONNOISSEUR	KORTING	STUZZI
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100 large pages, 11½ × 8¾in., copiously illustrated. A COMPARATOR-CATALOGUE to enable you to choose from all the latest equipment.
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PRINTED CIRCUIT VERSION OF G.E.C. 912 "F.M. PLUS" TUNER FOR HOME CONSTRUCTION

CAN BE BUILT FOR (including valves) **7 GNS.**
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for Pocket Transistor Radios

Complete with transparent ear-insert, 3ft. cord, sub-miniature jack and socket. Fully guaranteed.
Mdl. C.R.5. Crystal Earpiece, high imp. **9/-**
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As used in the smallest Japanese pocket transistor radios. Coils, Loudspeakers, I.F. transformers, Ganged Condensers, etc., now available from stock at lowest prices. Also in stock, all T.S.L. transistorised Miniature Units.

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3½in.	4in.	5in.	6½in.	8in.	10in.
17/6	19/6	10/6	16/-	16/6	25/-

12in. 27/6. **ELLIPTICAL:—**

7×4	9×6	10×2½	10×6	10×7
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Post extra.

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Large selection, many by famous makers such as Cyldon, Brayhead, Plessey, Cossor, etc., all I.F.s. New and unused. Let us quote you for the model required. Examples: 33-38 mc/s., 29/6, 6-9 mc/s., 59/6. 9-14 mc/s., 59/6, 14-25 mc/s., 59/6.

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Seconds but in perfect working order and guaranteed 79/6
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Complete with test leads.
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Brand new fully guaranteed

Sensitivity: 1,000 ohms per volt-A.C. and D.C. **Ranges:** (A.C. and D.C.) 0-10-50-250-500-1,000 v. D.C. current 0-100-500 m/a. 0-1 m/a. (used at 0-10 v. range). **Resistance:** 1-2,000 ohms (centre 24 ohms). 100-200,000 ohms (centre 2.4 k.). **Size:** 5in. × 3in. × 2½in.

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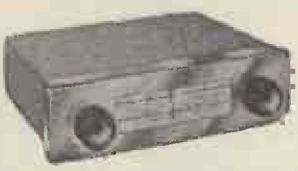
CONDENSERS, RESISTANCES. High stability Resistances, Electrolytics. All values and sizes stocked.

IMPORTANT PRICE REDUCTION

Made possible by the big demand for this very successful model.



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CAN NOW BE BUILT ABSOLUTELY COMPLETE FOR £9.19.6

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- ★ Small size. Will fit any car.
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- ★ New Type Brimar valves.
- ★ No vibrator 12 volt H.T. & L.T.
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Situated 25 yards only from Camberwell Green

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We regret that owing to City roadwidening scheme our branch at Cheapside is now closed for building reconstruction.

"PAGEBOY" 2-TRANSISTOR POCKET PORTABLE

Completely portable—NO EXTERNAL AERIAL OR EARTH REQUIRED. This is an amazing little receiver with built-in aerial and small enough to be held in the palm of the hand. Medium wave reception at wonderful volume. No fiddley tuning!—condenser tuned! Supplied with drilled chassis and colour coded components. Easily assembled with the aid of the easy-to-follow assembly instructions provided.

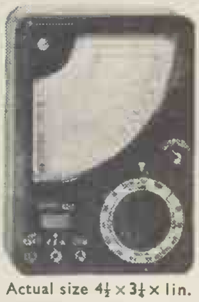
(45)

Total cost of all necessary components, including transistors, wiring wire and even solder **ONLY 32/6** plus 1/6 P. & P. Battery 3/- extra. Ardente type deaf-aid earpiece complete with cord and plugs extra at 12/6. Parts price list and Easy Lay-out Plans 2/- post free. Callers welcome to hear this set demonstrated at any of our branches. Our reputation is your guarantee.

OUTSTANDING METER IMPORT!

20,000 OHMS PER VOLT!!

MODEL 200H. Volt-ohm-Milliammeter



Actual size $4\frac{1}{2} \times 3\frac{1}{4} \times 1$in.

RANGES:
A.C. VOLTAGE: 10, 50, 100, 500, and 1,000 volts (10,000 ohms per volt).
D.C. VOLTAGE: 5-25, 50, 250, 500, and 2.5k. (20,000 ohms per volt).
D.C. CURRENT: 0-50 micro-amps., 0-2.5 m/a., 0-250 m/a.
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CAPACITANCE: 10 pf. to .001 mfd., .001 mfd. to .1 mfd.
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A fully guaranteed pocket size meter, knife edge pointer, top quality, supplied complete with test prods and full operating instructions at **£6.19.6** ONLY. Plus 2/6 P. & P.

Optional extra, attractive carrying case 13/6 only. (Bona-fide trade enquiries invited.) Leaflet available.

THE "CITIZEN"

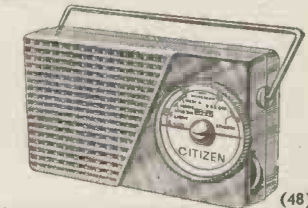
Introducing our new Super-Sensitive 5-Stage (4 transistor plus diode) pocket transistor receiver—for full Medium Wave reception—with the following outstanding features:

- ★ Completely self-contained—No external aerial or earth required.
- ★ Genuine $2\frac{1}{2}$in. High Flux P.M. Speaker.
- ★ Push-Pull output—250 milliwatts.
- ★ Genuine Ediswan transistors.
- ★ Socket provided for personal listening.
- ★ Socket provided for connection to Car Aerial.
- ★ Volume Control with on/off switch—Condenser tuning.
- ★ Easy assembly on colour coded pretagged circuit board.
- ★ Attractive Red polystyrene cabinet measures $5\frac{1}{4} \times 3 \times 1\frac{1}{2}$in., chrome handle, attractive dial.

Suitable crystal deaf-aid type miniature ear-piece fitted with miniature jack plug at ONLY 7/6 extra, if required.

All parts available separately—itemised list and full assembly instructions sent for 1/6 post free.

Hear this amazing little receiver at any of our branches



(48)

All required components including full instructions, solder, etc. and battery at special inclusive price of **ONLY 95/-** Plus 2/6 p. & p.

Yes NINETY FIVE SHILLINGS ONLY! Nothing more to spend.

THE "WAVEMASTER" 7-TRANSISTOR LUXURY PORTABLE

400 MILLIWATTS OUTPUT

To build yourself, Medium and Long waves—Push-Pull Superhet A.V.C. Perfect Car Radio reception. Size 10in. x $6\frac{3}{4}$in. x $4\frac{1}{2}$in. at base tapering to 4in. at top.

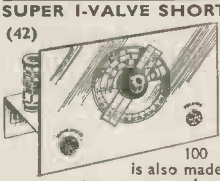
Very attractive two-tone grey Vynide covered cabinet with black and gold printed escutcheon plate, cream and gold knobs, handle and cabinet fittings. ★ Weight—complete with long-life $7\frac{1}{2}$ volt battery—$4\frac{1}{2}$lb. ★ Mazda high-grade transistors throughout. ★ High-Flux 7in. x 4in. Elliptical Speaker. ★ Slow motion tuning. ★ Co-axial socket at rear for direct connection to Car Radio Aerial. ★ Improved reception by use of seven-section plated telescopic aerial disappearing into Cabinet when closed, 34in. above Cabinet when fully extended.

(43)

Construction simplified by Bakelite chassis board with the following components already mounted: I.F. Transformers (3). Oscillator Coil, Trimmer, Bank, Output Transformer, Interstage Transformer, Aerial Brackets and Earth Bar. SPECIAL INCLUSIVE PRICE for all required components, full assembly instructions—nothing more to buy—is £10/19/6 plus 3/6 P. & P. Alignment service available. Full assembly instructions and individually priced parts list, all of which are available separately, 2/6, post free.

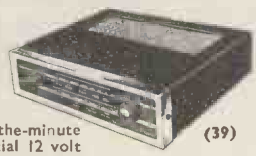
SUPER 1-VALVE SHORT-WAVE RADIO

(42)



World-wide coverage at most reasonable cost. Covers 40–100 metres with the coil supplied. Can be extended to cover 10–100 metres. Provision is also made for the addition of two extra valve stages. Employs the famous Acorn-type 954 valve. All necessary components can be supplied complete with full assembly instructions at **ONLY 35/-** plus 2/- p. & p. Send 2/- for point-to-point wiring diagram and price list.

PRINTED CIRCUIT CAR RADIO



(39)

(for Home Construction). We are proud to be able to offer this New type Car Radio employing up-to-the-minute circuitry, special 12 volt valves and transistorised output stage. The highest degree of sensitivity is assured by the incorporation of Permeability Tuning and a tuned R.F. Stage. Covers Medium and Long Wavebands. NO VIBRATOR PACK IS REQUIRED. This is a really compact receiver that will fit any car. Comprehensive assembly instructions are provided with all necessary components, including valves and transistor at a Special New Low Inclusive Price of Only £11/19/6 plus 3/6 p. & p. Instruction booklet with itemised price list, full description dimensions, etc. available separately at 3/6 post free.

"PRACTICAL WIRELESS" POCKET SUPERHET (46)

All required Components for the complete Osmor version as described in November issue of "Practical Wireless," now available at NEW LOW special inclusive price of £8/19/6 complete, including Printed Circuit and Osmor booklet. Overall size $5\frac{1}{4}$in. x 3in. x $1\frac{3}{4}$in., 6 transistors, $2\frac{1}{2}$ P.M. Speaker. Appearance as "Citizen". All items available separately, send stamp for list.

THE R.C. 3/4 WATT AMPLIFIER

(14)

Compare the advantages. Treble bass AND middle controls. For crystal or magnetic pick-up. A.C. Mains 200/250 v. Valve line-up: 6V6GT, 6SG7 metal, 6X5GT. Negative feed-back. Built on stove enamelled steel chassis, measuring only 8in. x 4in. x $1\frac{3}{4}$in. Four engraved cream knobs are included in the price of the complete kit with all necessary practical and theoretical diagrams at £4/5/- only, plus 2/6 p. & p. or Instruction Book fully illustrated for 1/- post free. This amplifier can be supplied assembled, tested and ready for use at £5/5/-, plus p. & p.

● *JUST ARRIVED! NEW!*

CRYSTAL MICROPHONE. Sensitive Miniature Lapel-type. Complete with clip and screened lead. Brand new, 17/6, plus 6d. P. & P.

SMALL SOLDERING IRON. Complete with vinyl carrying case, mains lead and 2 pin plug, A.C. 220/240 v. Handle unscrews and becomes protective cover for the bit. Only 18/9, plus 1/- P. & P. Spares available. Bit 1/3, Element 4/6.

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HI-FI SHOWROOM
AT TOTTENHAM COURT ROAD FOR DEMONSTRATIONS OF THE LATEST
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BY ALL LEADING MANUFACTURERS

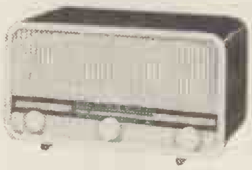
We stock equipment of Quality by all leading makers: i.e., Leak, Quad, Armstrong, Dulci, Ferrograph, Reflectograph, Vortexion, Tannoy, Linear, Wharfedale, Grundig, Goodmans, W.B., Rogers, Garrard, Lenco, B.T.H., Pamphonic, Simon, Brenell, Collaro, Telefunken, Fi-Cord, etc., etc. A full range of high quality cabinets to suit all purposes is on show, i.e., "RECORD HOUSING," "W.B." "A.D.," etc. Enquire about our interesting part-exchange scheme for personal callers. H.P. Available.

PLASTIC TAPE SPOOLS. Best quality. 3in. **1/6**, 5in. **2/-**, 5¾in. **2/3**, 7in. **2/6**. **PLASTIC SPOOL CONTAINERS** for spool sizes 5in. **1/6**, 5¾in. **2/-**, 7in. **2/3**. Any single item plus 6d. P. & P. Orders over £1, post free.

LANGUAGE COURSES ON TAPE!
Complete Elementary Course in French, Italian, German or Spanish. Phrase book supplied. 5in. long play tape, 55 minutes at 3¾ i.p.s. Price ONLY 29/6 per course, Post Free!

NEW! "POPULAR FOUR"

IMPROVED APPEARANCE AND PERFORMANCE!



A new three valve plus miniature contact-cooled rectifier, mains T.R.F. Receiver is now available. New De Luxe Cabinet, polished walnut finish, cream trim, attractive horizontal dial (as illustrated). Quality 5in. P.M. speaker. Specially wound high gain super-sensitive Denco coils. Medium and Long Wavebands. Excellent Continental reception! Overall dimensions: 12in. x 6in. x 5in. 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 £5/5/0**, plus 3/6 p. & p. Instruction book available separately 1/6, post free. ALL PARTS AVAILABLE SEPARATELY. **(47)**

RECORD PLAYERS
Full range at usual competitive prices. Interesting H.P. facilities
E.M.I. MODEL 985 4-SPEED SINGLE RECORD UNIT. Very latest type. Heavy 8¾in. dia. turntable, low flutter performance. 200/250 v. with tap at 80 v. for operating amplifier valve filament if required. Complete with matching pick-up with mount and rest. Brand new and fully guaranteed. **ONLY 89/6**, plus 3/6 P. & P. Pick-up available separately, complete with mount and rest **25/-**, plus 1/6 P. & P.

JUST ARRIVED! 4-SPEED BATTERY OPERATED VERSION OF ABOVE.
6 volt operation complete with pick-up **£5/9/6**, plus P. & P. 3/6.

TRANSISTOR AMPLIFIER now available for use with the above battery player. Compact size, 500 milliwatts output, printed circuit construction, tone and volume controls. Supplied complete with 8in. x 2in. 20 ohms matching quality speaker. Price only 89/6 plus 2/6 P. & P.

LATEST GARRARD MODEL 210. Four-speed manual or automatic. 10in. and 12in. records of same speed can be mixed in any order, wired for stereo, attractive white colour scheme. Price 10½ gns., plus 3/6 P. & P.

LATEST COLLARO 4 SPEED AUTOCHANGER MODEL C60
Complete at **£7.18.6**, plus 3/6 P. & P.

LATEST B.S.R. UA14. 4-speed. Attractive appearance. Wired for stereo. Fully guaranteed. **£7/19/6**, Plus 3/6 P. & P.

B.S.R. UA14. Stereo/Monaural. Fully guaranteed. **£8/19/6**, plus 3/6 P. & P.

B.S.R. UA8. Brand new and guaranteed. Few only. Monaural, **£6/19/6**. Stereo/Monaural, **£7/19/6**. Both plus 3/6 P. & P.

FRUSTRATED EXPORT. Not repeatable! L., M. and S.W. SUPERHET RECEIVER. Manufactured by McCarthy for export. At present for operation on 6 volts, but conversion details supplied free.

Valve line-up: 6K8G, 6K7G, 6Q7C, 6F6G, 6X5G and 6 volt 4-pin non-synchronous vibrator. 8in. P.M. Speaker, 4 watts output, P.U. socket Ext. L.S. socket, etc. Tone control. Fitted in polished wood cabinet, size 21¾in. x 10½in. x 10¼in. These cabinets are slightly soiled owing to storage, but each is guaranteed unused, in serviceable condition, tested prior to despatch. Price **£5/19/6** only plus P. & P. 7/6, plus 27/6 for A.C. Mains Conversion Components if required. **OUTSTANDING BUY!**

TRANSISTOR SIGNAL INJECTION PROBE!
Quickly checks Radio, T/V Sound and all forms of Audio Circuits. Functions as a wide-band modulated Signal Generator emitting a signal rich in A.F., I.F., and R.F. Components. Range 2 kc/s to 25 mc/s. Takes the trouble out of trouble-shooting. Actual size 6½in. long x ½in. diameter. Slips into pocket. Attractive finish, complete with full instructions and long-life Mercury battery. British made. **99/6** only, plus 1/- P. & P. Illustrated leaflet available.

12in. BAKERS SELHURST LOUDSPEAKER. 15 ohms, 15 watt 30-14,000 cps. Brand new, **£4/10/-**. P. & P. 3/6.

SUPER MAGNETIC RECORDING TAPE SPECIAL!!!
Famous American Ferrodynamics **"BRAND FIVE"**

An enthusiast's "must." Brand new (NOT SUB-STANDARD) High grade Acetate Base. 5in. 600ft. **16/-**, 5in. 900ft. **18/6**, 5¾in. 1,200ft. **23/6** 7in. 1,200ft. **25/-**, 7in. 1,800ft. **35/-**. Extra quality Mylar Dupont. 3in. 300ft. **13/-**. 5in. 1,200ft. **37/6**. 7in. 1,800ft. **44/-**. 7in. 2,400ft. **60/-**. Each on plastic spool. All Post free. *Trade enquiries invited.*

RADIO JACK (25)
Covers local medium wave stations variably tuned. Compact self contained unit requiring only connection to aerial (no power supplies reqd.) for 1st class reception when used in conjunction with your tape recorder or high gain amplifier. All necessary parts available at a special inclusive price of only **19/6**. p. & p. 1/6.

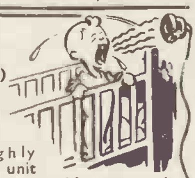
THE P.W. "ROADFARER"

As described in current "Practical Wireless"

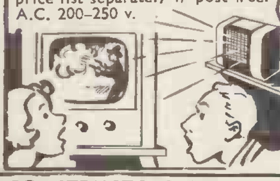
Now available the "OSMOR" version at special inclusive price of **£16.19.6**
Plus 2/6 p. & p.

A completely self-contained transistor portable with many novel features. For battery or mains operation, Medium, Long and V.H.F. bands. Full details and individually priced parts list on request.

The CRY BABY ALARM (19)



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 3¾in. x 6¾in. 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.



★ **TAPE RECORDER CONSTRUCTORS** ★

TELEPHONE PICK-UP COIL. Designed to feed into the microphone input of either a tape recorder or any high gain amplifier. Easily attached to telephone by rubber suction attachment. The coil is electrostatically shielded to minimise hum pick-up. When positioned on telephone this model is more than adequate for a fully modulated tape recording. Brand new complete with 5ft. shielded cable. ONLY **14/-**. P. & P. 1/6.

COLLARO TAPE PRE-AMPLIFIER AND BIAS OSCILLATOR. Complete with power pack for use with Collaro Mk. IV deck. 4 valve plus EM81 magic eye. 110-240 v. A.C. Input sensitivity: microphone socket 5 m/v., auxiliary socket 500 m/v. Speed equalisation switch gives compensation at all 3 speeds. Full wiring instructions included. List price £21. Limited quantity only at **£15/19/6**. P. & P. 5/-.

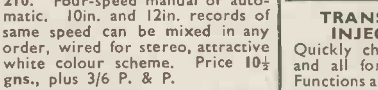
LATEST COLLARO STUDIO TAPE TRANSCRIPTOR. Latest type incorporating Record, Interlock, Lever. Button. 3 motors, 3 speeds, 1⅞, 3¾, 7½ i.p.s., takes 7in. spools. Push-button controls, **£12/19/6** plus 5/- P. & P. Usual H.P. facilities.

LATEST B.S.R. "MONARDECK." Single speed Tape Deck. Takes 5¾in. spools—3¾ i.p.s. At only **£8/5/-** plus **5/-** P. & P.

TAPE RECORDER AMPLIFIER. Suitable for use with either of the above Tape Decks, and most other types. For A.C. mains, 4 watts output. 40–12,000 CPS at 7½ i.p.s. ± 3 db. Facilities for superimpose. Valves: 6BW6, ECL82, 12AX7, EM84, and contact cooled metal rectifier. Radiogram input, microphone input, monitor facilities (can be used as straight through amplifier), volume control and separate treble and bass controls. Chassis measurement 11½ x 3 x 4⅞in. Supplied complete with attractive grey/blue escutcheon plate finished in black and gold. Circuit diagram and connecting instructions included. Price **£11/5/-** only, plus 3/6 P. & P. If purchased with either of the above decks, both items post free!

ATTRACTIVE TWO-TONE PORTABLE CARRYING CASE. Suitable for above amplifier and Collaro, Studio deck. Limited quantity only at **79/6** plus 3/6 P. & P.

MIC 45-1. Acos latest flat pistol-grip crystal microphone. Attractive black and gold finish. OUR PRICE **29/6** plus 1/- P. & P. **ACOS MIC 39-1.** Crystal stick microphone. List price 5 gns. Our price **39/6** plus 1/6 P. & P. **MIC 40.** General-purpose crystal microphone with desk stand. Our price **25/-** only plus 1/6 P. & P. **M.C. 24.** Imported, crystal, attractive streamlined polished metal case, incorporates muting switch. List price 64/-. OUR PRICE **42/-** only. 1/- P. & P.



SUB-MINIATURE TWO-WAY JACK PLUGS & SOCKETS
3/6 per pair.
P. & P. 6d.

SUB-MINIATURE SLIDER SWITCH
Two-pole two-way ONLY **2/6** EACH. P. & P. 6d.
★ Wholesale and manufacturer quantity enquiries invited on both of the above new items. ★

CLYNE RADIO LTD.

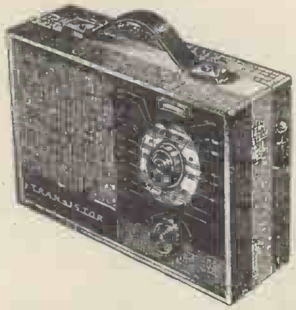
THE COMPONENT SPECIALISTS

18 Tottenham Court Road, London, W.1.
162 Holloway Road, London, N.7.
9 Camberwell Church St., S.E.5.

● CONTESSA ●

6-TRANSISTOR MEDIUM AND LONG WAVE SUPERHET
TERRIFIC SENSITIVITY
UNBEATABLE IN PERFORMANCE AND APPEARANCE

COMBINED PORTABLE AND CAR RADIO



SPECIFICATION
- 425mW Push-Pull Output
- 6 "Top-Grade" Ediswan Transistors
- New Type Printed Circuit with all Components marked
- Full Medium and Long Wave Tuning
- High "Q" Internal Ferrite Aerial
- Car Radio Adaptation and AVC
- Slow Motion Fingertip Tuning with Station Names
- "Hi-Fi" Quality Speaker
- Attractive Rexine Covered Cabinet

TOTAL COST OF ALL PARTS **£11.10.0** P.P. 3/6
● NO EXTRAS TO BUY ●

Call for demonstration. No technical knowledge necessary. All parts sold separately. Only the best in components used throughout. New descriptive Leaflet and Prices on request.

★ 'PW' ROADFARER ★

(as described in April edition of *Practical Wireless*)

A.M. and F.M. 7-transistor mains/battery portable in attractive moulded case. Slow motion tuning; telescopic aerial; 7 x 4in. speaker; Ferrite aerial, etc.

- Full tuning medium wave and F.M. VHF for clear reception of all programmes anywhere in the country.
- 500 mW push-pull output with Mains or Battery supply built in.

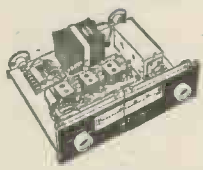
All Parts as Specified **£16.19.6** P.P. 3/-. All components sold separately. List on request.

- PRINTED CIRCUIT—SEVEN TRANSISTORS.
- **FULLY ILLUSTRATED BUILDING INSTRUCTIONS.**

TRANSISTOR FM TUNER

Fully tunable with A.F.C., A.G.C. Incorporating 5 Transistors and Printed Circuit Pre-assembled units.
- 85 to 108 Mc/s.
- Slow motion tuning illuminated dial.
- Hammer finished case.

Output may be fed to valve or transistor equipment. Performance better than many valve types.



All Parts **18 gns.** P.P. 3/-

Fully Illustrated Book 3/6

MULLARD and EDISWAN

Matched Sets of Transistors

- **6 Mullard Transistors and Diode**
  1—OC44, 2—OC45, 1—OC71, 2—OC72 and 1—OA81. ONLY **50/-** PER SET
  or with 2—OA81, **52/6.**
- **6 Ediswan Transistors and two Diodes**
  1—XA102, 2—XA101, 1—XB103, 2—XC101 and 2—Diodes. ONLY **57/6** PER SET
- **6 Mullard Transistors and Diode—1 watt output**
  1—OC44, 2—OC45, 1—OC81D, 2—OC81 and 1—OA81. ONLY **62/6** PER SET
  or with 2—OA81, **65/-.**
- **4 Mullard Transistors for 1 watt amplifier**
  1—OC71, 1—OC81D, 2—OC81 with Cooling Clips. ONLY **49/6** PER SET

TRANSFORMERS
P.Pull, 1 watt 3 ohm. **25/-** pair.

★ RANGER-3 ★

Size 4¾ x 3 x 1½in.

NO EXTERNAL AERIAL OR EARTH
3-TRANSISTOR and 2 DIODES

PERSONAL POCKET RADIO with 5 stages giving clear reception on medium wave, amature top band and shipping. Only first grade components used throughout. As described in March R.C.

ALL COMPONENTS **79/6** P.P 1/6
NO EXTRAS TO BUY
Everything Supplied.

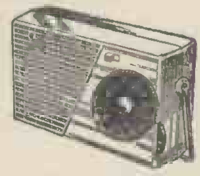
- Easy to follow instructions with pictorial layout.
- Reception of Radio Luxembourg guaranteed (most areas).

Free Instructions and Price List on request. Easy to build.

● **AFTER SALES SERVICE. GUARANTEED SUCCESS** ●

★ 'PW' 6-TRANSISTOR ★

MEDIUM AND LONG WAVE POCKET SUPERHET
(as described November *P.W.*)



- A sensitive superhet with 150mW push-pull output on 2½in. speaker. Uses 6 first-grade Mullard transistors and printed circuit. Moulded cabinet. Red, Blue or Cream.
- All parts sold separately. Send for list. Illustrated Building Plans 1/6 plus post.

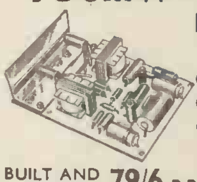
Size 5¼ x 3 x 1¾in.

ALL PARTS REQUIRED **£8.19.6**

★ NO EXTRAS TO BUY—EVERYTHING SUPPLIED ★

750mW 4-TRANSISTOR PUSH-PULL AMPLIFIER

(over 1 watt peak output)



- Uses OC71/OC81D, 2—OC81.
- ±3 dB 70 c/s to 12 kc/s.
- Overall size 3 x 2¾ x ¾in.
- Built on printed circuit.

BUILT AND TESTED **79/6** p.p. 1/6 OR COMPLETE KIT **69/6** p.p. 1/6.

Ideal for Record Player, Intercomm. Baby Alarm, for Tuners, etc.

● 3 ohm output, fully guaranteed, 9 volt operated ● Descriptive leaflet with uses FREE on request.

6-TRANSISTOR RADIO

Fidelity "CORONET"

6-TRANSISTOR MEDIUM AND LONG WAVE POCKET RADIO

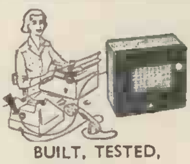
- Size 2¾ x 4¾ x 1¼in.
- Quality Push-Pull Speaker Output.
- Guaranteed for 12 months.
- Phone and Tape Socket.

ALL BRITISH DESIGN AND CONSTRUCTION

9½ gns Reg. Post 2/6. (INCL. BATTERY)

ALL TRANSISTOR ● TIME SAVER ●

OFFICE OR HOME TELEPHONE PICK-UP AMPLIFIER



BUILT, TESTED, READY TO USE
£5.10.0 P.P. 2/6

★ No more "Holding Up" wasting time waiting for your call to come through. When it does the amplifier can be switched off if required. **No** connections, just Sellotape the pick-up coil to back of phone as above.

● **5-inch speaker; 3 months' battery life. Now with 400mW output**

OC16	20 watts	25/-	OC44	15/-	XB103	10/-
OC28	30 watts	30/-	OC45	12/6	XC101	12/6
OC29	30 watts	35/-	OC71	10/-	XA104	12/6
V15/10P	10 watts	15/-	OC72	12/6	XA103	10/-
OC35	30 watts	30/-	OC169	18/-	XC131	34/-
Matched OC35's		60/-	OC170	25/-	OC171	50/-
V30/15IP	2 watts	30/-	XA102	15/-	OCP71	50/-
XC141	2 watts	25/-	XA101	12/6	XC121	12/6
V15/20IP	2 watts	19/6	OC76	15/-	OC75	15/-

MANY OTHER TYPES IN STOCK

WE STOCK THE LARGEST RANGE OF TRANSISTORS IN THE COUNTRY

ALL TRANSISTOR UNITS

SAVE POUNDS ★ TO BUILD YOURSELF ★ DETAILS ON REQUEST

- 4-transistor, OC169/OC71/OC72/V15/20IP, 27 Mc/s, model control relay-less receiver. Very sensitive, small size and weight. 300 mA current rise. Output to servo or actuator. 4 to 5 volt operated. All parts. **85/-.** P.P. 1/6.
- MINI-4, medium and long 6-stage pocket superhet. 4 Mullard transistors. All parts **£6/19/6.** Details on request.
- Super-3 Three-Transistor and Diode Earphone Radio. All components. No extras to buy. **37/6.** P. & P. 1/6.
- 3-transistor hearing aid transformer coupled. Size 3 x 2 x ¾in. High gain. Includes min. mic. and earphone. Volume control. All parts. **79/6.** P. & P. 1/6.
- 7-transistor medium, long and short wave superhet. Pre-built units. Full plans and details. **2/6** plus post.
- Light operated switch. 2-transistor plus selenium cell with relay. Ideal for car parking lights, headlamp dimmer, burglar alarms, etc. All parts. **29/6.** P. & P. 1/-.

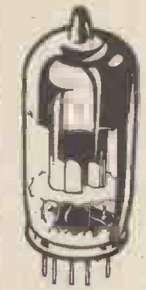
PRACTICAL TRANSISTOR CIRCUITS

Contains easy-to-follow plans of 40 all-transistor units, including light-operated switches, amplifiers, transmitters, receivers, test oscillators, signal tracers, hearing aids, radio control, etc. All parts available separately. POST FREE **3/6**

HENRY'S RADIO LTD.

DEPT. A6, 5 HARROW ROAD, PADDINGTON, LONDON, W.2.
Opposite Edgware Road Tube Station. *PADdington* 1008/9. OPEN MONDAY to SAT. 9-6. THURS. 1 o'clock.

LET US HAVE YOUR ENQUIRIES FOR COMPONENTS, MINIATURE AND STANDARD, VALVES, TUBES, CRYSTALS, SPEAKERS, ETC., ETC.



VALVES & TUBES

TRANSMITTING RADIO AND TV VALVES, TUBES AND INDUSTRIAL TYPES.
NEW **FREE** LIST ON REQUEST.

Bulk order enquiries invited for all types.

931A (27M1)
(CV 2696)
PHOTO MULTIPLIER

Brand new, original cartons.
60/- P.P. 1/-. Base 2/-.
Also: Special purpose 931A-CV337 **80/-** each Base 2/-.

QUARTZ CRYSTALS

FOR TRANSMITTING, RADIO CONTROL, OSCILLATORS, ETC.
FROM **5/-** EACH
Free List on Request
ALL TYPES FOR ALL PURPOSES

Bulk order enquiries invited

CRYSTAL MICROPHONES

ACOS 39-1. Stick Microphone with screened cable and stand (list 5 gns.), 39/6, P.P. 1/6.
ACOS 40 Desk Microphone with screened cable and built-in stand (list 50/-) 19/6 P.P. 1/6.
ACOS 45 Hand Microphone with screened lead, very sensitive, 29/6, P.P. 1/6.
MC 43 Stick Microphone with muting switch and screened cable 42/6. P.P. 1/6.

★ Brand New—Fully Guaranteed ★

9.72 Mc/s IF STRIP

★ 2-EF92 Valves
★ 3-EF91 Valves
★ 1-EB91 Valve

32/6 P.P. 1/6.

BRAND NEW WITH DIAGRAM. IDEAL FOR F.M.

Type 38, Transmitter Receiver

Complete with 5 valves. In new condition. These sets are sold without guarantee, but are serviceable.
7 to 9 Mc/s **22/6** P.P. 2/6.
Headphones 6/- pair. Junction Box 2/6. Throat Mike 4/6. Aerial Rod 2/6.

BARGAIN BUY
2 METRE TX/RX

EX 1520, 1985, 1986, 1987, 2-METRE MULTI-CHANNEL AIRBORNE EQUIPMENT
★ TRANSMITTER (LESS VALVES) **5/-** P. P. 2/6
★ RECEIVER (LESS VALVES) **5/-** P. P. 2/6
★ MODULATOR WITH 5 VALVES **20/-** P. P. 2/6
★ 9.72 MC/S I.F. STRIP DOUBLE TUNED WITH 6 VALVES **25/-** P. P. 2/6.
FULL CIRCUIT DIAGRAMS 1/9 POST FREE.

RF E.H.T. POWER UNIT TYPE 846

Output 1 kV D.C. from 250 v. A.C. and 12 v. D.C. supplies. Uses 6C4 and EY51 with 6J6 Independent multi-vibrator. Size 5½ x 5½ x 4½in. 25/-. Carriage Free.

★ BC221 FREQUENCY METER ★

125 Kc/s to 20 Mc/s. Three valve crystal control oscillator. Used in new condition.
£16 CARRIAGE PAID
Complete with calibration charts and handbook.
★ Battery operated ★

MARCONI 19 SET CRYSTAL CALIBRATOR

10 kc/s. 100 kc/s, 1 Mc/s. 6-valve and neon modulator **79/6** P.P. 2/6. With Handbook (New Condition)

← ADDRESS **HENRY'S RADIO LTD.**
★ ACKNOWLEDGED *THE* SPECIALISTS ★
★ TRANSISTORS ★ QUARTZ CRYSTALS ★ VALVES & TUBES
★ MINIATURE & STANDARD COMPONENTS

WE SEND THE BEST OF BRITAIN'S HI-FI EVERYWHERE

NOW AT LARGER PREMISES

INCLUDING NEW EQUIPMENT AVAILABLE FROM 1961 AUDIO FESTIVAL

PLEASE NOTE—Prices quoted subject to alteration in accordance to those advertised by manufacturers at time of receipt of order.

★ **RECORDERS**

Vortexion W.V.A.	£93 13 0	$268
Vortexion W.V.B.	£110 3 0	$315
Brenell Mk. V	64 gns.	$192
Brenell 3 Star Stereo	89 gns.	$267
Clarion Transistor	25 gns.	$75
Cossor 1601 4 Tr.	37 gns.	$111
Cossor 1602 4 Tr. 3 spd.	59 gns.	$127
Simon Minstrelle	39 gns.	$117
Ferrograph 4AN	81 gns.	$243
Ferrograph 4AH	86 gns.	$258
Ferrograph 808 Stereo	105 gns.	$315
Grundig TK55 Stereo	92 gns.	$276
Grundig TK20 with Mic.	42 gns.	$126
Grundig TK24	55 gns.	$165
Grundig TK30	65 gns.	$195
Philips 4 Track EL 3542	59 gns.	$117
Philips 4 Track Stereo EL 3536	92 gns.	$276
Philips 4 Track	34 gns.	$102
Reflectograph "A" ½ Tr.	105 gns.	$315
Reflectograph "B" 4 Tr.	115 gns.	$345
Stuzzi Magnette	59 gns.	$177
Stuzzi Tri-corder	63 gns.	$189

★ **DECKS**

Wearite 4A mono	£36 10 0	$105
Wearite 4B	£41 10 0	$119
Brenell Mk. V	28 gns.	$84
Brenell Stereo Deck	£33 16 0	$101

Brenell Pre-Amp. and Amp.	£24 0 0	$69

Microphones by Lustraphone, Reslo, Acos, Simon, etc.
● **TAPES BY ALL LEADING MAKERS**

★ **SPEAKER SYSTEMS**

Quad Electrostatic	£52 0 0	$149
Wharfedale SFB/3	£39 10 0	$113
Wharfedale Coaxial 12	£25 0 0	$72
Wharfedale Golden 10	£8 14 11	$20
Tannoy 12in. Monitor	£30 15 0	
Tannoy 15in. Monitor	£37 10 0	
WB. 1016	£7 12 3	$16
Goodmans AL.120	£29 10 0	$84
Goodmans AL.100	£23 10 0	$67
Goodmans Triaxiom	£25 0 0	$72
Goodmans 300	£11 5 9	$32
Goodmans 400	£16 1 0	$41
Kelly Ribbon Mk. II	£10 10 0	$30

★ **MOTORS AND PICK-UPS**

Decca Stereo P.U. complete	£21 0 0	$45
Lenco GL60 Trans. Unit	£27 12 6	$60
Lenco GL58/R, Stereo P.U.	£24 5 7	$53
Garrard 301	£22 7 3	$49
Garrard 4HF/Stereo P.U.	£19 4 8	$45
Connoisseur Motor Type "B"	£27 16 1	$59
Connoisseur, 2 sp. Motor	£16 13 1	$36
Goldring 700	£9 14 9	$21

★ **AMPLIFIERS & TUNERS**

Quad 22-Control Unit	£25 0 0	$73
Quad II Amplifier	£22 10 0	$65
Leak Stereo 20 Amp.	£30 9 0	$87
Leak Point One Pre-Amp.	£21 0 0	$60
Rogers Junior Stereo	£28 10 0	$82
Rogers Master Stereo Unit	£35 0 0	$100
Quad FM Tuner	£28 17 6	$60
Chapman AM/FM	£29 8 0	$60

Enquiries for all items by firms mentioned in this advertisement invited.

BINSON "ECHOREC" UNITS
BINSON STANDARD ECHOREC pre-amplifier unit enables echoes to be imposed on signals between microphone (or other source) and amplifier or recorder. 3 channels available, and timing of echoes is controllable. Details on request. 140 gns. $420
Binson "Baby Echorec," similar to above, but for single-channel working. 100 gns. $300
PROFESSIONAL AND TRADE DISCOUNTS.

● **FULL OFFICIAL RATES OF EXCHANGE FOR PAYMENT IN ANY CURRENCY.**
● **MANY ITEMS FOR 110 VOLTS A.C.**
● **TRANSISTOR RADIOS.**
● **ACCESSORIES.**
● **LARGE AND UP-TO-DATE STOCKS.**
● **PROMPT REPLIES TO ENQUIRIES.**
Carriage charged at cost.

MODERN ELECTRICS (RETAIL) LTD.
120 SHAFTESBURY AVENUE LONDON W.1
(3 mins. from Piccadilly Circus and opposite Columbia Cinema)
Tel: TEM 7587 & COV 1703 Cables: MODCHAREX, LONDON

PREMIER RADIO

23 Tottenham Court Rd., London. W.1. Tel: MUSeum 3451/2

AND AT 309 EDGWARE ROAD, W.1. TELEPHONE PADDINGTON 6963

4-SPEED PORTABLE SINGLE RECORD PLAYER

MAY BE BUILT FOR ONLY **9 GNS.** Plus 6/6 P. & P.

Consisting of:

The new EMI 985 4-speed single Player £4 9 6

2 valve Printed Circuit Gram. Amplifier £2 15 0

8in. × 2½in. Elliptical Speaker £1 1 0

Portable Case—finished rexine covered red and white polka dot £1 1 0

All items available separately if required.

The SUPER 60

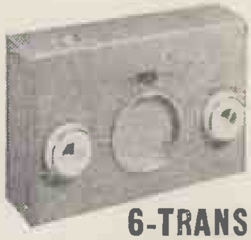
6-Transistor Battery Receiver

MAY BE BUILT FOR **£9.15.0** Plus 4/6 P. & P.

Ever-Ready PP10 Battery Extra 11/-.

★ STAR FEATURES—
★ Six 1st grade Mullard Transistors and one Diode.
★ Internal Ferrite Rod Aerial.
★ 7in. × 4in. Elliptical Speaker.
★ Printed Circuit.
★ 500 mW Push-pull Output.
★ Full medium and long waveband coverage.
★ Calibrated Direct Drive Dial Drive Assembly.
★ Full point-to-point instructions supplied.
★ Dimensions 18in. × 7¾in. × 5½in.

The Receiver is housed in an attractive contemporary mahogany finished cabinet trimmed with gilt, supported by gilt stands.
The Receiver will operate for months on one 9-volt long-life battery.
Instruction Book separately at 2/6 p.p.



6-TRANSISTOR POCKET SUPERHET

MAY BE BUILT FOR **£8.19.6** Plus 2/6 P. & P.

PP3 Battery extra at 2/6.

This Receiver uses the most up-to-date printed circuit method and construction is simplicity itself with the aid of the point-to-point instructions supplied, using 6 Transistors and one Diode and internal Ferrite Rod Aerial, with provision for Car Radio Aerial. Full medium and long waveband coverage and when constructed the Receiver is housed in an attractive leatherette Case size 6¾in. × 4½in. × 1¾in.

THE Petite PORTABLE

MAY BE BUILT FOR **£7** P. & P. 3/-.

Batteries extra.
H.T. 10/- (Type B126) or equivalent).
L.T. 1/6 (Type AD) 35 or equivalent.

- High Q frame aerials.
- High sensitivity on both wavebands.
- Medium and long wave superhet circuit.
- Instruction book 1/6.
- Size only 8 × 8 × 4½in.
- Weight including batteries 5½lb.
- 4 valves of the economy type.

WHY NOT CONVERT YOUR BATTERY PORTABLE TO MAINS OPERATION WITH THE COSSOR MU2 BATTERY ELIMINATOR

This Eliminator is completely assembled and supplied with 4ft. of Mains Lead and Torpedo-type of On/Off Switch. It is housed in 2 Metal Containers approximately the same size as the AD35 and B126 Batteries, and suitable for Receivers using DK96 range valves for use on 200-250 v. A.C. mains. Size: L.T. unit 3in. × 2¼in. × 1⅛in., H.T. Unit 4in. × 2⅜in. × 2in. Original Price 3 Gns. OUR PRICE for a limited period only **39/6** plus 2/- P. & P.

AMERICAN C.B.S. RECORDING TAPE

Brand new, fully guaranteed and with Leader Tape:—

600ft. on 5in. Spool	16/6
1,200ft. on 5¾in. Spool	25/-
1,800ft. on 5¾in. Spool D.P.	42/6
1,200ft. on 7in. Spool	25/-
1,800ft. on 7in. Spool L.P.	32/3

Plus 1/- per Spool P. & P.

THE NEW MODEL EP—10K POCKET MULTI-METER

10,000 O.P.V. ON A.C. & D.C.

Out-performs instruments many times its size and price.

PRICE **£5.19.6** plus 2/6 P. & P.

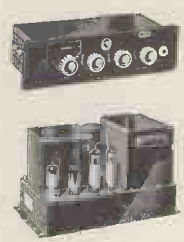
FULL SCALE RANGES

DC Volts: 0-6; 0-30; 0-120; 0-600; 0-1200.
AC Volts: 0-6; 0-30; 0-120; 0-600; 0-1200.
DC Current: 0-120μA; 0-12M; 0-300M.
Resistance: 0-20K; 0-3 meg.
Decibels: −20 to +63 in five scales.
Capacity: 50μF to .01μF and .001μF to .15μF.
Output Ranges: 0-6; 0-30; 0-120; 0-600; 0-1200.

Unbelievable bargain. Revolutionary new Multi Tester incorporating extra large 3½in. Meter Face, unique slide range selector switch which can be appreciated by the novice and engineer alike and can be carried conveniently in the pocket, also featuring an unusually sensitive 10K ohm per volt AC/DC Meter, 1% precision resistance, and largest Meter ever placed on an instrument of this size. Complete with Test Leads and Battery, size 4¾ × 3¼ × 1in.

PORTABLE SOLDERING IRON

Model No. SP-1 30 watt Portable Hand Soldering Iron, the latest—smallest—coolest 30-watt iron available especially suited for precision wiring. Highly stable, long life and safety is assured. Features a removable handle that may be used to cover the top and barrel to permit the Iron to be carried safely, even whilst hot.
Supplied complete with Vinyl Bag, Lead and Plug only **18/9** plus 1/3 P. & P.



THE VERDIK QUALITY TEN AMPLIFIER & PRE-AMPLIFIER

A truly High Fidelity Ultra-linear Amplifier with a push-pull output of 10 watts and incorporating negative feed-back. Provision for Tuner, also bass and treble control and 5-position selector switch for Microphone, Radio Tape and L.P. and Standard Recordings. Finished in an attractive grey/green stove enamel.

FOR A LIMITED PERIOD ONLY **£14/19/6**
Original cost 23 gns. P. & P. 7/6.

TRANSISTORISED BATTERY AMPLIFIER

This exceptionally reliable 4-transistor printed circuit Amplifier is designed with full use of package components. It is complete with volume and tone control and will mount into almost any type of Cabinet, operating on a 9-volt Battery and giving an output of 1 watt. Specifications: sensitivity 120 millivolts 3dB for 50 milliwatts output, sufficient for lowest sensitivity Crystal Pickup frequency response 50 cycles to 10 Kcs., input impedance 330 K. ohms minimum, negative feedback 6dB average. Loudspeaker impedance required 20 ohms, size 6⅛ × 3 × 1½.

PRICE **89/6** incl. 8" × 2½" 20 ohms speaker plus 2/6 P. & P.

introducing

The NEW EMI 985

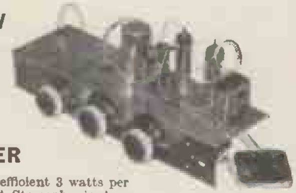
4-SPEED TURNTABLE UNIT COMPLETE WITH PICKUP

PRICE **89/6** Plus 3/6 P. & P.

An extremely reliable and inexpensive Unit suitable for Record Players, and Radiograms, a heavy 8⅝in. dia. Metal Turntable with low flutter performance, 5-position Switch. 4 speeds and off, ivory finish with red T/T mat.

9 volt Battery-operated version available, identical to the above unit in appearance, £5/9/6, plus 3/6 P. & P.

THE NEW LOW PRICED STEREOPHONIC AMPLIFIER



An extremely efficient 3 watts per channel output Stereophonic Amplifier, ideally suitable for the construction of a Portable Stereo, Record Player. Specifications: 3 watts per channel output, valve line-up 2 X ECL82 and one ECC83, Metal Rectifier, ganged controls, tone on/off, balance and volume, suitable for Speakers of 3 ohms impedance and supplied complete with attractive cream with gold centre knobs and gilt control escutcheon, speaker leads fitted with non-reversible sockets, suitable for use on 200/250 v. A.C. mains. Size 12½ × 3¾ × 4⅛in. PRICE **£5/19/6** plus 4/- P. & P.

CRYSTAL CALIBRATOR No. 10
A crystal controlled heterodyne wavemeter covering 500 Kc/s. to 10 Mc/s. (Harmonics up to 30 Mc/s.). Requires 300 V. 15 mA. and 12 V. 0.3 a. D.C., but can be easily modified for 120 V. and 1.4 V. working. Size 7 x 7½ x 4in. Good condition, complete with valves, crystal, instruction manual and circuit. ONLY 59/6. Post 3/6. This item available complete as above. **BRAND NEW** and with spare set of valves. £4/10/-. Post 3/6.

CANADIAN CRYSTAL CALIBRATOR. Uses double crystal and multivibrator circuit to give "pips" at 1 Mc/s., 100 Kc/s. and 10 Kc/s. Incorporates Modulator. With book. 79/6, post 2/6.

TRANSMITTER TYPE 36. A complete 50 watt TX for phone or CW. Covers 10-40 Mc/s. (10-15-20m.). Crystal or stabilised VFO. Push-pull 807's plate and screen modulate parallel 807's. Tested and ready to plug into AC mains. Complete with 16 valves, handset, operating instructions and circuit. Wooden cabinets may be somewhat damaged. £15. Carr. England and Wales £2.

MOVING COIL PHONES. Finest quality Canadian with chamois ear-muffs and leather-covered headband. With lead and jack plug. Noise excluding and supremely comfortable. 19/6. Post 1/6.
MATCHING TRANSFORMER (for Hi impedance) i.e. for HRO, CR100, etc., with standard jack plug. 4/6.

SELENIUM BRIDGE RECTIFIERS. Funnel cooled. A.C. Input 45 v. RMS. D.C., output 30 v. 10 amps. BRAND NEW. Boxed. 45/-, post 3/6.

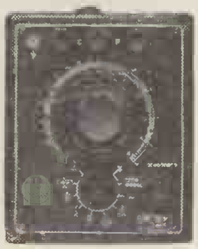
"C" CORE TRANSFORMERS. Pri. 230 v. 50 c.p.s. 510-0-510 at 275 mA. 375-0-375 at 83 mA. 6.3 v. at 9 A. 6.3 v. at 2A. (twice), 6.3 v. at 1A. (twice), 6.3 v. at 1.5A. 6.3 v. at 0.5A., 5 v. at 3A. 6¾ x 6 x 7½in. high. Weight 25 lb. Removed from equipment but in perfect condition. 32/6. Carr. 5/6.

ADMIRALTY HT TRANSFORMERS Pri. 230 v. 50 c/s. Secs. 620-550-375-0, 375-550-620 v. (620 and 550 v. 200 m/amps. 375 v. 250 m/amps.), plus two 5 v. 3 amp. rectifier windings. Total rating 278 VA. Upright mtg. Wt. 25lb. Made 1953. **BRAND NEW.** Original boxes, 45/-. Carr. 5/-.

CO-AXIAL RELAYS. Simultaneously switch two separate inputs to alternative outputs. 24 volt D.C. coils (can be hand operated). Size (approx.) 5 x 3 x 3in., 8/6. Post 1/6.

PRECISION RESISTORS. One Megohm 1% 1 watt wire wound, ex-U.S.A. BRAND NEW. 10/6 per dozen.

MULLARD C. & R. BRIDGES. 0.1 ohm to 10 Megohms in 4 ranges; 10 pFd. to 10 mFd. in 3 ranges; Calibrate, Open Bridge, and % ranges. For 100/250 v. A.C. mains. Tested and guaranteed. £6/15/-. Post 3/6.



AR-88D RECEIVERS

One of the finest communications receivers ever made. Those we offer are in superlative condition, thoroughly checked and tested as regards calibration, alignment and sensitivity.
Personal shoppers can see for themselves that we have the finest receivers on the market. Those unable to choose their receiver personally can rely on our integrity to send them a first class set for ONLY £35.

RCA AR-88 SPEAKERS

A high quality 3 ohm unit fitted into heavy gauge black crackled steel cabinet, size 10½ x 11½ x 6in. Fitted with rubber feet and 6ft. lead. Ideal for extension speaker. CR 100, etc. In original cartons. BRAND NEW, 45/-. Post 3/6.

MARCONI CR100

Still one of the finest surplus communication receivers. Ready for immediate use on A.C. mains. Of new appearance, completely overhauled and in perfect working order. Later model with noise Limiter, £25. Carr. England and Wales 30/-. Send S.A.E. for full details.

RECEIVERS R-1155B

A first-class 10-valve Communications receiver, covering 75 Kc/s. to 18 Mc/s. (16.2–4,000 m.) in 5 bands. The large scale and superior dual ratio slow-motion drive make tuning easy and the R.F. stage and 2 I.F. stages ensure world-wide reception. All the receivers we sell have been thoroughly overhauled, completely realigned and are in first-class working order. ONLY £9/19/6.

A.C. MAINS POWER PACK OUTPUT STAGE. In handsome black crackled steel cabinet to match the R-1155. Fitted with RCA 8in. speaker. Just PLUG IN and switch on! Only the finest quality components are used and we guarantee OUR power packs for 6 months. ONLY £6/10/-. Deduct 10/- when purchasing receiver and power unit together. Send S.A.E. for further details or 1/3 for 10-page illustrated booklet giving technical data and circuits etc. (Free with each receiver.) Add 10/6 carriage for receiver, 5/- for power unit.

MARCONI VALVE VOLTMETERS

Ranges: 0 to 1.5, 5, 15, 50, and 150 volts. Fitted with probe unit for RF measurements.
A.C. mains operation. In good condition and working order. A laboratory instrument for ONLY £8/19/6. Carr. 7/6.

SIGNAL GENERATOR I-196A

An American instrument with a continuous frequency range of 100 to 156 Mc/s. which was used for the alignment of the SCR-522, etc. There is provision for crystal control. A fixed I.F. generator at 12 Mc/s. is incorporated which requires a 6 Mc/s. crystal. (Crystals are not included.) Operation is from internal A.C. mains power unit (115 v.) or batteries. Contained in handsome wooden transit case 25 x 19 x 10in. 69/6. Carr. 10/6.

T.C.C. VISCONOL CONDENSERS. 8 mfd. 800 v. D.C. wkg. at 71 deg. C. CP152V. Size 3 x 1¾ x 5in. high. **BRAND NEW.** Boxed 8/6 each, post paid.
4 mfd. 600 v. wkg. CP 130T, 4/6 each, post paid.

MINIATURE RELAYS (ALL BRAND NEW and BOXED)

G.E.C., sealed, wire ends, 670 2M2B H/D M1095	8/6
G.E.C., sealed, wire ends, 670 Ω, 2 H/D makes. M1099...	15/-
G.E.C., sealed, wire ends, 5,000 Ω 2 c/o., plat., M1052	17/6
Siemens High Speed 1K + 1K Ω, 1 c/over	10/6

GIANT COMPONENT PARCEL

Contains 100 ½ and 1 watt resistors, 50 Hi Stab resistors, wire wound resistors, carbon and W/W pots. 100 capacitors (mica, paper, Sprague, bias, variable, etc.), valveholders, tag strips, metal rectifiers, sleeving, etc. All components are unused. GUARANTEED VALUE, 25/- plus 2/6 post.

STOP PRESS
Now available re-conditioned **AVOMETERS Model 7** and **Model 8.** Details on request.

CHARLES BRITAIN (Radio) LTD.

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Near Leicester Sq. Station. (Opposite Thorn House)
Shop Hours: 9-6 p.m. (9-1 p.m. Thursdays). Open all day Saturday

SANGAMO-WESTON VOLTMETERS
S61. Dual range 0-5 and 0-100 v. D.C. FSD 1 m/A. 3in. scale. Recent manufacture. Ideal for schools. Complete in super quality canvas carrying case, with test prods and leads. **BRAND NEW.** Boxed 27/6. Post 2/6.

BC221 **FREQUENCY METER 125 kc/s. to 20 mc/s.**
This crystal controlled heterodyne frequency meter is too well known to need further description. Those we offer are complete with correct individual calibration book and are carefully tested and guaranteed. Condition is very good. **£16/-/-**

INFRA-RED MONOCULAR. See in the dark. Sealed unit with focusing eyepiece and incorporating Caesium cell and push-button operated Zamboni pile. Brand New in superb hide binocular type carrying case. Sold for experiment and not guaranteed working. 10/-. Post 3/6.

AIRCRAFT CINE CAMERA G45. Takes 25ft. of 16 mm. film. 16 frames per sec. Complete with 24 v. motor and lens. 29/6. Post 3/6.

GAUSS METERS

American type TS-15/AP. Made by Marion Electric for M.I.T. Radiation Lab. AS NEW. £7/10/-.

MARCONI IMPEDANCE BRIDGE. Type TF373. Measures, L, C & R at 1,000 Cycles. Accuracy 1%. 0-100H; 0-100uF; 0-1M Ω each in 5 ranges. Power Factor and "Q." Guaranteed, £35.

PHILIPS RADIATION MONITOR. Type 1092C. A portable self-contained instrument for measuring radio-activity, uses the Mullard MX-115 Geiger counter tube, and is scaled 0-10 milli-Rontgens per hour. Supplied complete with carrying haversack. BRAND NEW. £17/10/-. Carr. 5/-. *Other types of radiation monitoring equipment in stock.*

MARCONI TF987/1 NOISE GENERATORS. Range 100 Kc/s. to 200 Mc/s. Determines noise factor of AM and FM receivers. Fully stabilised H.T. supply A.C. mains operation. Brand new and in original boxes. £15. Carr. 7/6.

D.C./A.C. CONVERTERS. Input 12 v. D.C. Output 230 v. 50 c/s. A.C. at 135 watts. Fitted with 0-300 v. A.C. 2½in. meter and slider resistor for voltage adjustment. In stout wooden carrying case with lid. Perfect working order. £9/19/6. Carr. 10/6.
24 v. Input 230 v. A.C. 50 c/s. 100 watts output. In grey metal case. BRAND NEW. 92/6. Carr. 7/6.

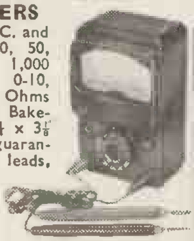
SANGAMO WESTON ANALYSER E772. A useful multi-range meter. Thoroughly overhauled and in perfect working order. For full details see previous adverts. £7/10/-. Carr. 4/6.

MICROAMMETERS

R.C.A. 0-500 microamps. 2½in. circular flush panel mounting. Dials are engraved 0-15, 0-600 volts. As used in the American version of the No. 19 set BRAND NEW. Boxed. 15/-.
American 0-100 microamps. 2½in. square flush panel mounting. BRAND NEW. Boxed. 42/6.

MULTIMETERS

1,000 Ω/Volt A.C. and D.C. volts 0-10, 50, 250, 500 and 1,000 D.C. current 0-10, 0-100 mA. Ohms 0-2,000, 0-200K. Bakelite case size 5¼ x 3⅜ x 2¼in. Fully guaranteed with test leads, prods and internal battery, 59/6



Electronics (FLEET ST.) Ltd

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152/3 FLEET ST., LONDON, E.C.4.
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Business hours: Weekdays 9-6. Saturdays 9-1

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AMPLIFIERS, STEREO AND MONAURAL, BY:
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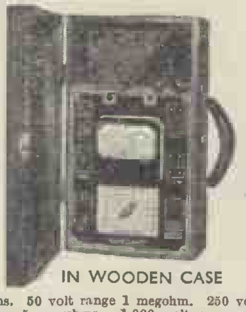
ANOTHER FAMOUS MANUFACTURERS' BARGAIN

COSSOR 4 VALVE S/HET PORTABLE

Long and Medium wave bands, 5in. speaker, built-in frame aerial using Ever Ready B126 90VHT and AD35 1½ VLT batteries. Attractive 2-tone finish, dimensions 9 x 8¼ x 4¼in. Original price 15 gns. **OUR PRICE £8/19/6.** P. & Pkg. 3/-. batts. 10/- extra. Suitable mains unit to fit in place of batteries. Original Price 63/- OUR PRICE 45/-. P. & Pkg. 2/-.

A GIFT FOR THE SERVICE MAN

The Weston Model 772 Type 6 super sensitive analyser. This precision designed multi range test instrument has a large visible finely divided scale giving some of the range shown. Range: D.C. volts 20.000 ohms per volt or 1,000 per volt. 2.5 volt range 50,000 ohms. 10 volt range 200,000



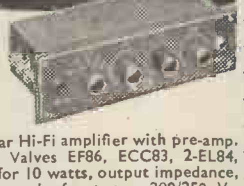
IN WOODEN CASE

ohms. 50 volt range 1 megohm. 250 volt range 5 megohms. 1,000 volt range 20 megohms. Ohms: 0-3,000 ohms, 0-30,000 ohms. 0-3 meg. 0-30 meg. D.C. milliamps: 10, 50, 250 IM/A or 50 microamps. A.C. volts: 1,000 ohms per volt. ONLY £12/10/- plus post and pkg. 7/6.

THE NEW JASON RANGE FOR CONSTRUCTORS

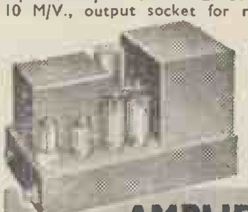
JTV2 Tuner completely assembled ready for use, £25/7/-.
FMT2. In kit form with free standing case with power pack. Including valves, £8/19/6.
FMT3. Variable tuner 88-108 mc/s. Variable AFC control dual limiters, approx. 80 mile range, including valves, £10/19/6.
JTV2 Tuner self powered switched tuner for FM and TV sound. Both BBC and ITA as required, including valves £13/19/6.
MERCURY II switched FM/TV sound tuner in kit form for building into cabinet, including valves, £10/10/-. Power pack kit, £2/14/9.
2/6 post and pkg. on all the above. S.A.E. for details.
Stockists of all other Jason Kits

The VERDIK QUALITY TEN



THE POPULAR "VERDIK QUALITY TEN"

10 watt push-pull ultra linear Hi-Fi amplifier with pre-amp. control unit. **Amplifier** Valves EF86, ECC83, 2-EL84, EZ81. Sensitivity 40 M/V for 10 watts, output impedance, 4, 8 and 16 ohms, spare supply for tuner, 200/250 V., A.C. **Pre-Amp.** valve EF86. **INPUTS Radio** 100M/V., tape 100 M/V. **GRAM** LP 50 M/V, 78 60 M/V. **MIC** 10 M/V., output socket for recording direct to tape recorder. **Treble** between −10DB and +12 DB at 10 KC/S. **BASS** between −10DB and +12 DB at 20 C/S. Finished in grey, green, stone enamel, control panel in gold lettering, fully guaranteed. Original price 20 gns.



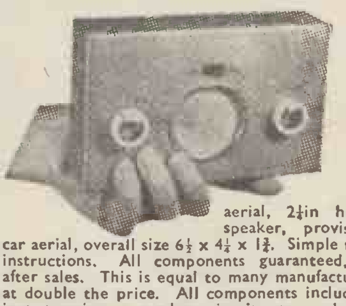
AMPLIFIER AND PRE-AMPLIFIER

OUR PRICE £14/19/6 P. & P. 7/6.

SPECIAL OFFER!

THE "FLEET SIX" TRANSISTOR

The "Fleet 6," a wow of a transistor set that really gets the stations. New design 6 transistor superhet pocket receiver, using 6 guaranteed first grade transistors plus sensitive diode, push pull output, medium and long wave bands, new type printed circuit, high Q internal ferrite rod aerial, 2¼in high flux speaker, provision for car aerial, overall size 6½ x 4¼ x 1¾. Simple to follow instructions. All components guaranteed, service after sales. This is equal to many manufactured sets at double the price. All components including cabinet, transistors, speaker, circuit, etc., only **£8/19/6,** complete. Post and pkg. 3/6. PP4 Battery 2/- extra. Due to overwhelming demand from last month's advert., we have been able to reduce this receiver from £9/19/6. All components sold separately. Send S.A.E. for details. Circuit and Instructions 2/6 post free.



HI-FIDELITY TAPE HEADS

Made by famous manufacturer. Brand new. Upper or lower track, record/play-back, high impedance giving up to 12,000 c.p.s. at 7½ I.P.S. Output 5 m/volts at 1 KC. at 7½ I.P.S. Erase heads low impedance.
Only **29/6** per pair. Post 1/-. State upper or lower track.

The FLEET 6 PORTABLE TRANSISTOR RECEIVER

Using 6 guaranteed first-grade transistors, sensitive diode, p/pull output, medium and long wave bands, printed circuit, high Q ferrite rod aerial, 6 x 4 high flux speaker. Provision for car aerial. Attractive 2-tone cabinet, overall size 9½ x 7 x 3ins. Easy to follow

instructions, all components including cabinet, transistors, speaker circuit, etc., **£9/19/6,** complete, P. & Pk. 3/6. Battery extra. All components guaranteed and sold separately. Send S.A.E. for details. Circuit and instructions 2/6 post free.

BUY NOW!

Definitely the last of the remaining stocks of the

AVANTIC BEAM-ECHO HI-FI EQUIPMENT

SP21 STEREO PRE-AMP CONTROL UNIT

A twin channel pre-amp. control unit, has 6 inputs for each channel. **INPUT SENSITIVITY** for 250 M/V or 1.5 V output **TUNER** 100 and 250 M V. **Tape** 100 M/V flats 250 M/V. **PICK-UP** 5 and 50 M/V. Frequency response: 40 c/s. to 15 Kc/s. **TAPE OUTPUT** 50 M/V., continuously variable bass and treble controls, loudness control and stereo balance control. Power required 6.3 V. at 1.3 amp. A.C. 350 v. at 5 M/A· D.C. Will match any hi-fi amplifier. Manufacturer's price £28/10/- **OUR PRICE** now **£16/19/6.** Carr. and packing 10/-.

AVANTIC PL6-21

High quality monaural power amplifier and pre-amp. compactly housed and suitable for shelf mounting or cabinet. Two EL84, three EF86, one ECC83, one EZ81. 10 watts peak; speaker impedance, 4, 8 or 16 ohms. Sensitivity: 4 M/V. on pick-up, 3 M/V, on tape. 100 M/V. on tuner, intermod. distortion 1% at 10 W. equivalent. Sinewave output. Maker's price £28/10/-. **OUR PRICE** 19 gns. Post and Packing 10/-.

AVANTIC SPA11 Stereo Amplifier

A twin channel amplifier and pre-amp., push-pull output. 10 W. peak each channel, rumble filter speaker, impedance 4, 8 and 16 ohms. Tape output: 100 M/V. Continuously variable treble and bass, stereo balance control. Input sensitivity: for 7W, 100 M/V radio; 100 M/V tape; 650 M/V pickup. Manufacturer's price 28 gns. **OUR PRICE 19** gns. Post and packing 10/-.
STEP 11 Stereo pick up pre-amp. unit, 84/-. P. & P. 2/6.
STEP 21 type pre-amp. unit, also 84/-. P. & P. 2/6.

C.R.T. BOOSTER TRANSFORMERS

TYPE A. OPTIONAL 25% and 50% BOOST. 2 V. OR 4 V. OR 6.3 V. OR 10.8 V. OR 13.3 V. MAINS INPUT. 12/6

TYPE A2. HIGH QUALITY, LOW CAPACITY, 10/15 pF. OPTIONAL BOOST 25%, 50%, 75%. MAINS INPUT. 16/6

TYPE B. MAINS INPUT. MULTI OUTPUT 2, 4, 6.3, 7.3, 10 and 13 VOLTS. BOOST 25% AND 50%. LOW CAPACITY. 21/- Full instructions supplied.

RESISTORS. All preferred values. 20% 10 ohms to 10 meg., ¼ w., 4d.; ½ w., 4d.; 1 w. 6d.; 1½ w., 8d.; 2 w. 1/-. **HIGH STABILITY.** ½ w., 1% 2/-. Preferred values 10 ohms to 10 meg. Ditto 5% 9d., 100 Ω to 5 meg.

WIRE-WOUND RESISTORS 25 ohms—10,000 ohms.

5 watt	3/-
10 watt	1/6
15 watt	2/-

12,500 ohms.—50,000 ohms. 10 w. 3/-

WIRE-WOUND POTS. 3 w. Pre-set Min. T.V. type Knurled Slotted knob. All values 10 ohms to 25 K. 3/- ea.; 30 K., 50 K., 4/-. Ditto ½ w. Carbon Track, 30 K. to 2 Meg. 3/-.

WIRE-WOUND POTS. 4 w. Standard size Pots. long Spindle High Grade. All values 50 ohms to 50 K. 6/6; 100 K., 7/6. **W/W EXT. SPEAKER CONTROL** 10Ω, 3/-.

O/P TRANSFORMERS. Heavy duty 50 mA. 4/6. Multi-ratio push-pull 7/6. Miniature 3V4, etc. 4/6. Hygrade Push-Pull 10 watts 15/6. Push-pull 20 w. 6 k. C.T. 30/-.
L.F. CHOKES. 15/10H 60/65 mA. 5/-. 10H 85 mA. 10/6. 10H 120 mA., 12/6. 10H 150 mA., 14/-.

MAINS TRANSFORMERS 200/250 v. A.C.

STANDARD 250-0-250, 80 mA., 6.3 v. 3.5 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, 220 v. 45 mA., 6.3 v. 2 a. 15/6
SMALL, 200-0-200 50 mA., 6.3 v. 2 a. 17/6
STANDARD, 250-0-250, 65 mA., 6.3 v. 3.5 a. 17/6
HEATER TRANS., 6.3 v. 1½ a., 7/6; 3 amps. 10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 A. 22/6
AUTO. TRANS. 150 w., 0, 10, 120, 200, 230, 250 v. 22/6

ALADDIN FORMERS and cores, ¼in. 8d.; ⅜in. 10d.
0.3in. **FORMERS** 5937 or 8 and Cans TV1 or TV2. 2⅛in. sq. × 2¼in. or ⅝in. sq. × 1¼in., 2/- with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6 : 1, 2/3.
POCKET SIZE SOLDERING IRON 25 w. 220-240 V. Bargain 16/9.
SOLON. Midget Soldering Iron, 220/40 v. 25 w., 24/-.
MAINS DROPPERS. 3 × 1¼in. Adj. Sliders .3 amp. 1,000 ohms 4/3. .2 amps. 4/3. .1 amp. 2,000 ohms 5/-.
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 ⅞ × ⅞ × 3/16in.
ACOS CRYSTAL MIKE 40 X .... Bargain 25/-

MIKE TRANSF. 50 : 1, 3/9 ea., 100 : 1 Potted 10/6.
LOUDSPEAKERS PM. 3 OHM. 5in. Rola, 17/6. 8in. × 5in. Goodmans 21/-. 7in. × 4in. Plessey 18/6. 10in. × 6in. Rola 27/6. 8in. Plessey 19/6. 6½in. Rola 18/6. 8in. Rola 21/-. 10in. R.A. 30/-.
HI-FI TWEETERS. 4in. 25/-. 12in. Plessey, 30/-.
12in. Baker 15 wt. Stalwart, 3 or 15 ohm., 90/-.
12in. Baker ditto., foam suspension 15 ohm, £6.
12in. Baker Ultra Twelve £17/10, 20 c.p.s. to 25 k.c.s.

I.F. TRANSFORMERS 7/6 pair

465 kc/s, slug tuning miniature can 1¾ × ¾ × ¾in. High Q and good bandwidth. By Pye Radio. Data sheet supplied.
Weymouth I.F. Standard size 465 kc/s., 10/6 pair.

CRYSTAL DIODE G.E.C., 2/-. GEX34, 4/-. 40 Circuits 3/-.
H.R. HEADPHONES. 4,000 ohms, brand new, 15/- pair.
SWITCH CLEANER. Fluid, squirt spout, 4/3 tin.
TWIN GANG CONDENSERS. 365 pf. Miniature, 1⅞in. × 1½in. × 1⅞in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers 8/-. Midget 7/6; Single 50 pf. 2/6; 100 pf., 150 pf., 5/6. Solid dielectric 100, 300, 500 pf., 3/6.
VALVE HOLDERS. Pax. int. Oct. 4d. EF50, EA50, 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, 7 pin 1/-.
MOULDED Mazda or Int. Oct., 6d. B7G, B8A, B8G, B9A, 9d. B7G with can, 1/6; B12A, 1/3; B9A with can 1/9.
CERAMIC, EF50, B7G, B9A, Oct. 1/-. B7G, B9A cans. 1/-.

TELEVISION REPLACEMENT

Line Output Transformers
from 45/- each, NEW stock
and other timebase components
Most makes available. S.A.E. with all enquiries

WAVECHANGE SWITCHES
2 p. 2-way, or 3 p. 2-way; short spindle 2/6
5 p. 4-way, 2 wafer, or 3 p. 11-w. 3 wafer, long spindle 6/6
2 p. 6-way, or 4 p. 2-way, or 4 p. 3-way, long spindle 3/6
3 p. 4-way or 1 p. 12-way, long spindle 3/6
Wave change "MAKITS" 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer, 16/-; 4 wafer, 19/6; 5 wafer 23/-; 6 wafer 26/6.
TOGGLE SWITCHES. S.P., 2/-; D.P., 3/6; D.P.D.T., 4/-.
MORSE KEYS, good quality, with morse code 2/6.
FULL WAVE BRIDGE SELENIUM RECTIFIERS. 2, 6 or 12 v. 1½ 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., 1½ a., 15/6; 2 a., 17/6; 4 a., 22/6 Charger circuit free. **AMMETERS,** 4 a., and 5 a., 13/6.

THE HI-GAIN BAND 3 PRE-AMP

Cascode circuit using Valve ECC84. 17db gain. Kit 29/6 less power; or 49/6 with power pack. Plans only 6d.
Also Band I version same prices.
(PCC84 Valve if preferred)

"REGENT" 4 VALVE

"96" RANGE VALVES

KIT PRICE £6. 6. 6. Carr. 4/-

PRINTED CIRCUIT BATTERY PORTABLE KIT

Medium and long wave. Powerful 7 x 4in. high Flux Speaker. T.C.C. Printed Circuit and condensers. Components of finest quality clearly identified with assembly instructions. Osmore Ferrite Aerial Coils. Rexine covered attache case cabinet. Size 12in. x 8in. x 4in. Batteries used B126 (L5512) and AD35 (L5040), 10/- extra. Instructions 9d. (free with kit). Mains Unit ready made for above, 39/6. Sold separately.

MONARCH RECORD PLAYER

SAVE POUNDS

BUILD IT YOURSELF using 4-SPEED BSR MONARCH AUTOCHANGER U.A.8.
READY BUILT 3W. AMPLIFIER, HANDSOME PORTABLE CASE. HIGH FLUX 6in. LOUDSPEAKER.
FULL INSTRUCTIONS SUPPLIED.

Total Price Carr. and ins. 5/-. **£12 . 10 . 0**

RECORD PLAYER BARGAINS

4 Speed Autochangers, BSR, U.A.8.	£6 15 0
Collaro Autochanger	£7 19 6
Garrard RC121 Mk. IID	£8 15 0
Garrard 209 or 210	£10 10 0
4 speed Single Players:	
EMI Stereo or Monaural	£6 19 6
Garrard TA Mk. II	£8 8 0
Garrard 4 HF Transcription...	£17 19 6

Garrard Stereo Heads £2 extra.

AUTOCHANGER ACCESSORIES
Suitable player cabinets (uncut boards) 49/6
Amplifier player cabinets with cut boards 63/-
2-valve amplifier and 6½in. speaker for above.. 79/6
Ready mounted on baffle 12in. × 7in., 3in. deep.

NEW MULLARD TRANSISTORS
Audio OC71 10/-; OC72 12/6. RF OC44 15/6; OC45 12/6.
Sub Miniature Electrolytics. 15 volt. 1, 2, 4, 5, 8, 25, 50, 100 mfd. 3/- each.
Weyrad Printed Circuit Components in Stock. 7 × 4in. Speaker 35 Ω 25/-.

CYLDON TURRET TELETUNER

I.F. 33/38 megs., complete with valves 30C1 and 30L15 Frame Grid (LT 16v. .3a.). With coils for channels 1 to 13. Includes F.M. Brand new, price 45/-, operating data and circuit supplied. Ideal for "P.T." Olympic.

VOLUME CONTROLS

Midget size:
Long spindle. Guaranteed 1 year. All values.
5 K. ohms up to 2 Meg. No switch 3/-. D.P. Sw. 4/6
Linear or Log Tracks.

80 ohm Cable Coaxial

Semi air spaced, ¼in. dia. Ideal Band III Losses cut 50% 6d. yd.
FRINGE QUALITY AIRSPACED .... 1/- yd.

COAXIAL PLUGS .. 1/- LEAD SOCKETS .. 2/-
PANEL SOCKETS .. 1/- OUTLET BOXES .. 4/6
BALANCED TWIN FEEDER per yd. 6d., 80 Ω or 300 Ω.
TWIN SCREENED BALANCED FEEDER 1/6 yd., 80 ohms.

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled, with 4 sides, riveted corners and lattice fixing holes with 2½in. sides 7 × 4in. 4/6; 9 × 7in. 5/9; 11 × 7in. 6/9; 13 × 9in. 8/6; 14 × 11in. 10/6; 15 × 14in. 12/6 and 18 × 16 × 3in., 16/6. Panels 12 × 8in., 3/-.

BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, coloured, single or stranded 2d. yd.
NEON MAINS TESTER SCREWDRIVERS, 5/-.
CORED SOLDER RADIOGRADE, 4d. yd., ½lb. 5/-.
PAXOLIN 1/16in. × 8in. × 10in., 1/6. **ION TRAPS** 5/-.

AMERICAN MAGNETIC RECORDING TAPE FERRODYNAMICS "BRAND FIVE"

5in. 600 feet	16/-	MYLAR DUPONT	
5in. 900 feet	18/6	Super High Fidelity	
5¾in. 1,200 feet	23/6	Double Play	
7in. 1,200 feet	25/-	5in. 1,200 feet	37/6
7in. 1,800 feet	35/-	7in. 2,400 feet	60/-

Illustrated leaflet S.A.E.
Spare Reels, 3inch 1/6; 4in., 5in., 5¾in., 2/-; 7in., 2/6.
"Instant" Bulk Tape Eraser and Head Defluxer, 200/250 v. A.C., 27/6. Leaflet S.A.E.

RECTIFIERS, RM1, 5/-; RM2, 6/-; RM3, 8/-; RM4, 16/-; RM5, 20/-; FC31, 27/6; 14A86, 17/6; 14A100, 21/-.
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 75 mA., 12/6. 120 mA., 15/-.
COILS. Wearite "P" type 3/- each. Osmor Midget "Q" type adj. dust core from 4/- each. All ranges.
TELETRON. L. and M. T.R.F. with reaction, 3/6.
FERRITE ROD AERIALS. M.W., 8/9; M. & L. 12/6.
T.R.F. COILS. A/HF, 7/- pair. **H.F. CHOKES,** 2/6

JASON F.M. TUNER COIL SET, 29/-. H.F. coil aerial coil. Oscillator coil two I.F. transformers. 10.7 Mc/s. Detector transformer and heater chokes. Circuit and component book, using four 6AM6 2/6. Complete kit FMT1 with Jason Calibrated dial and 4 valves, £6/5/-, or with New Jason Cabinet FMT2, £2 extra.

CONDENSERS. New Stock. .001 Mfd. 7kV. T.C.C., 5/6; 20 kV., 9/6. .1 mfd. 7 kV. 9/6. 100 pf. to 500 pf. Micas, 6d. Tubular 500 v. 0.001 to 0.05 mfd., 9d.; 0.1, 1/-; 0.25, 1/6; 0.5 1/9; 0.1/350 v., 9d.; 0.1/1,000 v., 1/9; 0.1 mfd., 2,000 v., 3/6; 0.001 mfd., 2,000 v., 1/9; 500 pf., 20 kV., 9/6.
CERAMIC CONDS. 500 v. 0.3 pf. to 0.01 mfd., 9d.
SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-; 600 pf. to 3,000 pf., 1/3.
CLOSE TOLERANCE (1±pf.) 2 pf. to 47 pf., 1/6. DITTO 1% 50 pf. to 815 pf., 1/9; 1,000 pf. to 2,000 pf., 2/-.
TRIMMERS. Ceramic 30, 50, 70 pf., 9d.; 100 pf., 150 pf., 1/3. 250 pf., 1/6. 600 pf., 750 pf., 1/9. Phillips, 1/- ea.

NEW ELECTROLYTICS. FAMOUS MAKES

TUBULAR		TUBULAR		CAN TYPES	
1/350 v. ..	2/-	50/350 v. ..	5/6	16/450 v.	5/-
2/350 v. ..	2/3	100/25 v. ..	2/-	32/350 v.	4/-
4/450 v. ..	2/3	250/25 v. ..	2/6	100/270 v. ..	5/6
8/450 v. ..	2/3	500/12 v. ..	3/-	5,000/6 v. ..	5/-
8/500 v. ..	2/9	8+8/450 v.	3/6	8+16/450 v. ..	5/-
16/450 v. ..	3/-	8+16/450 v.	3/9	32+32/350 v.	5/-
16/500 v. ..	4/-	8+16/500 v.	5/6	32+32/450 v.	6/-
32/450 v. ..	3/9	16+16/450 v.	4/3	50+50/350 v.	7/-
25/25 v. ..	1/9	16+16/500 v.	6/-	64+120/350v.	11/6
50/50 v. ..	2/-	32+32/350 v.	4/6	100+200/275v.	12/6

SUB-MINIATURE ELECTROLYTICS (15 v.)
1, 2, 4, 5, 8, 25; 50 mfd., 100 mfd., 3/- each.
SPEAKER FRET. Gold Cloth 17in. × 25in., 5/-; 25in. × 35in., 10/-. Tygan 54in. wide, 10/- ft., 27in. wide 5/- ft. Brown, Green or Red. Samples S.A.E.

NEW and boxed VALVES 90 day guarantee

1R5 ..	7/6	6L6G	10/6	EA50 ..	1/6	EY51 ..	9/6
1S5 ..	7/6	6N7M	6/6	EABC80	8/6	EY86 ..	10/-
1T4 ..	6/-	6Q7G	7/6	EB91 ..	6/-	HABC80	12/6
2X2 ..	3/6	6SA7M	6/-	EBC33 ..	8/6	HVR2A	6/6
3S4 ..	7/6	6SJ7M	6/6	EBC41 ..	8/6	MU14 ..	9/-
3V4 ..	7/6	6SN7	6/6	EBF80	10/-	P61 ..	3/6
5U4 ..	7/6	6V6G	6/6	ECC84 ..	9/6	PCC84 ..	9/6
5Y3 ..	7/6	6X4	7/6	ECF80 ..	9/6	PCF80 ..	9/6
5Z4 ..	9/6	6X5	6/6	ECH42	10/6	PCL82 ..	11/6
6AM6	5/-	12A6	7/6	ECL80	10/6	PEN25	6/6
6BE6	7/6	12AT7	8/-	ECL82	10/6	PL82 ..	10/6
6BH6	9/6	12AU7	8/-	EF39 ..	5/6	PY80 ..	7/6
6BW6	9/6	12AX7	8/-	EF41 ..	9/6	PY81 ..	9/6
6D6 ..	6/-	12BA6	8/6	EF50 ..	5/6	PY82 ..	7/6
6FG6	7/6	12BE6	8/6	EF80 ..	8/-	SP61 ..	3/6
6H6GT	3/6	12K7	6/6	EF86 ..	14/6	UBC41 ..	9/6
6J5 ..	5/6	12Q7 ..	6/6	EF92 ..	5/6	UCH42	9/6
6J6 ..	5/6	35L6	9/6	EL32 ..	5/-	UF41 ..	9/6
6J7G ..	6/6	35Z4	7/6	EL41 ..	9/6	UL41 ..	9/6
6K6GT	6/6	80 ..	9/6	EL84 ..	8/6	UY41 ..	8/-
6K7G	5/-	807 ..	5/3	EZ40 ..	7/6	U22 ..	8/-
6K8G	7/6	954 ..	1/6	EZ80 ..	7/6	U52 ..	7/6

RADIO COMPONENT SPECIALISTS

48-HOUR MAIL ORDER
337 WHITEHORSE RD.
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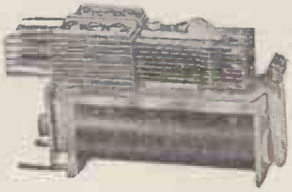
POSTAL SERVICE 1/-, OVER £2 FREE. C.O.D. 1/6. (EXPORT C.W.O. POST EXTRA.) Wed. 1 p.m. THO 1665 Buses 133 or 68

Wilkinsons EST. 1921



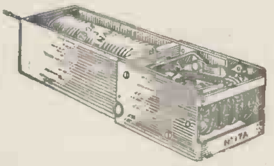
RELAYS P.O. TYPE 3000

Built to your own specification
Keen Prices
Quick Delivery
Contacts up to 8-Changeover

MINIATURE RELAYS:

Siemens High Speed Sealed			S.T.C. and G.E.C. Sealed			
2.2Ω+2.2Ω	H96A	15/6	700Ω	2 C.O.	4184GD	19/6
500Ω+500Ω	H96D	22/6	2500Ω	1 make	HD 4186EE	22/6
1700Ω+1700Ω	H96E	25/-	180Ω	2 m 2 b	M1087	19/6
Siemens High Speed Open			670Ω	4 C.O.	M1092	21/6
100Ω+100Ω	H85N	15/-	2500Ω	1 C.O.	M1022	22/6
1000Ω+1000Ω	H95A	17/6	5000Ω	2 C.O.	M1052	25/-

Comprehensive range available from stock.



MAGNETIC COUNTERS

Counting to 9999.
2-6 v. D.C., **15/-** each, post **1/6.**
75-230 v. D.C., **15/-** each, post **1/6**
HIGH SPEED TYPE No. 100c., **35/-**, post **1/6.**

ROTARY CONVERTERS. Input 12 v. D.C. Output 230 v. A.C. 50 cy. 135 watts. The ideal job for T.V. and tape recorders where A.C. mains are not available, **£8/10/-**, cge. 10/-. Also available with 24 v. D.C. input at same price.

ROTARY CONVERTER. Input 24 v. D.C. Output 220 v. A.C. 250 watts. Pedestal type with D.P. Ironclad switch. **BRAND NEW, £17/10/-**, carr. 15/-.

BATTERIES. Portable Lead Acid type, 6 volts 125 ampere hours. In metal case 16in. × 8in. × 11in. (Two will make an ideal power supply for our 12 volt Rotary Converters). Uncharged **£6/10/-** each, carriage 15/-. 24 volts 85 amperes. **£14** each, carriage **15/-**.

NIFE BATTERIES. Nickel Cadmium. 6 volts 75 amps. Crated and connected. Brand new **£7/10/-**, cge. 15/-. Special inter-crate connector supplied free with two batteries.

WESTALITE BATTERY CHARGERS. Made by Westinghouse (type BC14-6/40). Input 200/250 v. A.C., will charge 6 volt or 12 volt batteries at 0/40 amps. Coarse control switch with eight positions and fine control switch with four positions including "off." Built-in 0/50 meter. Fused A.C. and D.C., grey enamel finish, dimensions 24in. × 14in. × 13in. **£45** each.

TELEPHONE SET TYPE "A." Ringing and speaking both ways on a four-core cable. Carries the voice loudly and clearly over any distance. Two handsets are supplied as illustrated and the set is complete with Pushes, Buzzers, Battery, Plugs and Sockets. Suitable 4-core PVC cable **10d.** per yard. Price **75/-** set, post 3/6.

TELEPHONE SET TYPE "K." The most compact telephone set available as the 4½in. flat battery and buzzer is built-in to the hand instrument. Ringing and speaking both ways on twin wire, instrument is complete with 5ft. flex. Easily hangs on the wall. Set of two instruments, **£5/10/-**, post 3/6. Two coil flex **3d.** yard

FANS INDUSTRIAL TYPE 230/240 volt A.C. Capacitor Motor, 16in. blades, adjustable louvres, filter. Ideal for paint shop. Brand new, **£20**, cge. **25/-**.

AIR BLOWER powered by a 230 v. A.C. motor, 15in. fan. Volume of free air at max. r.p.m. is 1,250 cu. ft. per min. At maximum efficiency 900 cu. ft. per min. Brand new **£25**, carriage **30/-**.

AUTO CABLE waterproof. Single. 14/36. **20/-** per 100 yds., post 1/6.

PUMP Electrically Driven by a 24 v. D.C. motor. Works efficiently on 12 v. Totally enclosed, self lubricating driven through 4 to 1 reduction gearbox delivering 60 g.p.h./30lb./sq. in. Inlet and outlet unions ¼ BSP **37/6**, post **2/6**.

CERAMIC WAFER SWITCHES. Full list available.

1 Bank 1 pole 3-way ...	**4/6** each	2 Bank 2 pole 4-way ...	**10/6** each
1 Bank 1 pole 5-way ...	**5/6** each	3 Bank 1 pole 11-way ...	**18/-** each
1 Bank 2 pole 2-way ...	**5/6** each	3 Bank 6 pole 2-way	**7/6** each
2 Bank 1 pole 11-way ...	**12/6** each	3 Bank 4 pole 3-way ...	**7/6** each
2 Bank 1 pole 12-way ...	**7/6** each	4 Bank 2 pole 4-way ...	**18/6** each

Others including Paxolin types: 1 Bank 3/6, 2 Bank 5/-, 3 Bank 6/6, post 1/-.

HEADPHONES. High resistance 4000Ω with cords **17/6**, post **1/6.**

SELENIUM METAL RECTIFIERS

Charging Rectifiers. Full Wave Bridge.		12 Volts 6 Amps	**22/6** each
12 Volts 1 Amp. ...	**8/6** each	24 Volts 1 Amp	**13/-** each
12 Volts 2 Amps ...	**13/6** each	24 Volts 2 Amps	**24/-** each
12 Volts 3 Amps ...	**16/6** each	24 Volts 3 Amps	**28/-** each
12 Volts 4 Amps ...	**20/-** each	24 Volts 4 Amps	**36/-** each

MAINS TRANSFORMERS to suit above rectifiers.

12 Volts 1 Amp ...	**12/6** each	12 Volts 4 Amps CT107	**29/6** each
12 Volts 2 Amps ...	**24/-** each CT109	12 Volts 4 Amps	**25/-** each
12 Volts 2 Amps ...	**20/-** each	24 Volts 6 Amps	**50/-** each

¼ H.P. CAPACITOR MOTORS

230/240 volts, 50 cycles, 1420 r.p.m. ½in. shaft on Standard foot mounting or with ⅝in. shaft, resilient mounting. Either type, **£5/10/-**, carriage 10/-.

VACUUM PUMP AND COMPRESSOR. Edwards type IV, ½in. shaft, complete with flywheel, couplings, oil filter and union, **£6/10/-**, post 3/6.

METERS GUARANTEED

F.S.D.	Size	Type	Price
100 Microamp	3½in.	MC/FR	80/-
50 Microamp	2½in.	MC/FR	70/-
250 Microamp	2½in.	MC/PR	40/-
500 Microamp	2½in.	MC/FR	37/6
1 Milliamp	2½in.	MC/FR	35/-
2 Milliamp	2½in.	MC/FR	25/-
30 Milliamp	2½in.	MC/FR	25/-
100 Milliamp	2½in.	MC/FR	25/-
200 Milliamp	2½in.	MC/FR	25/-
1 Ampere	2½in.	MC/FR	35/-
3 Ampere	2½in.	MC/FR	35/-
5 Ampere	2½in.	MC/FR	35/-
10 Ampere	2½in.	MC/FR	35/-
20 Volts	2½in.	MC/FR	35/-
30 Volts	2½in.	MC/FR	35/-
40 Volts	2½in.	MC/FR	35/-
500 Microamp	2in.	MC/FR	25/-
1 Milliamp	2in.	MC/FR	27/6
5 Milliamp	2in.	MC/FR	27/6
10 Milliamp	2in.	MC/FR	27/6
20 Volts	2in.	MC/FR	27/6
30 Volts	2in.	MC/FR	27/6
40 Volts	2in.	MC/FR	27/6
15 Amps	2in.	MC/FR	15/-
3 Amps	2in.	MC/FS	27/6
5 Amps	2in.	MC/FS	27/6
30-0-30 Amps	2in.	MC/FR	17/6
50-0-50 Amps.	2in.	MC/FS	17/6
500 Milliamps A.C.	3½in.	MI/FR	40/-
25 Amps. D.C.	2½in.	MI/FR	7/6
50 Amps A.C.	4in.	MI/F or PR	65/-
300 Volts A.C.	2½in.	MI/FR	25/-

Postage on meters 1/6

New Taylor pocket-size Multimeter Model 127A, 20,000 ohms per volt, 20 megohms, 20 ranges, A.C. & D.C. **£10.** Post 2/6.

Complete list of meters available.

FREQUENCY METERS. 45–55 cycles per second, 230 volts, 6in. dia. Flush Round. Brand new in maker's box. **£10/10/-**, post **3/6.**

METER RECTIFIERS 1 M.A., 5 M.A., F.W. bridge, **8/6**, post 6d.

AMMETER. 0–3 amp. D.C., by Turner, MC/FR, 6in. **90/-**, post 2/6.

MICROAMMETER. 250 F.S.D. 3½in. F.R. Sangamo Mod. S37. Scaled for valve voltmeter. Circuit available free, **55/-**, post 1/6.

UNI-PIVOT GALVANOMETER, by Cambridge Instruments, 50–0–50 microamps, dia. 4in. Knife pointer, mirror scale. Complete with leather carrying case. Ideal for laboratory use, **£10**, carriage 3/-.

PORTABLE VOLTMETER. 0–160 volts A.C./D.C., accuracy within 2%, 8in. mirror scale, knife pointer, in polished case. A precision moving iron instrument at a very low price, **£4/19/6**, post **3/6**.

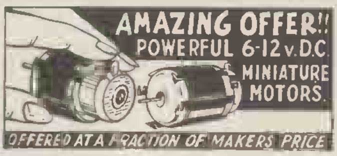
PORTABLE AMMETER. 0–3 amp. A.C./D.C. 3in. scale in case with handle, **35/-**, post **2/6**.

AVO TEST BRIDGES. 220/240 volt A.C. Measure capacities from 5 pf. to 50 mfd. and resistances from 5 ohms to 50 megohms. Valve voltmeter range 0.1 to 15 volts and condensers leakage test, **£9/19/6**, post 3/-.

RACKS—POST OFFICE STANDARD. 6ft. high with U-channel sides drilled for 19in. panels, heavy angle base.

SLYDLOK FUSES. 15 amp. with rewirable cartridge fuse. Latest type G15 M.M. Complete with studs, nuts and washers, **3/6** each, post 6d. Also available 100 amp., type M.M. G 99, **14/6**, post **1/-**.

RESISTORS EX STOCK, IN QUANTITY WIRE WOUND, HIGH STABILITY CARBON ETC., BEST MAKES AT LOWEST PRICES.



MINIATURE PRECISION MOTOR, 12 v. D.C. Size 1⅜ × 1¼in. diam. Latest development. Extremely powerful with low consumption. Weighs as little as two ounces and totally enclosed in polythene protective case. Three-position switch: forward, reverse and stop. 7,000 r.p.m., self lubricating and long life sintered bronze bearing, **15/6**, post 9d. Ask for free length of polythene flexible drive.

ATTENTION ALL MANUFACTURERS. ONE-HOLE FIXING SWITCHES. Single-pole change-over 3 amp., 250 volts A.C. **1/6** each, **12/-** doz., **£37/10/-** per 1,000. Ask for quotation for 5,000 or upwards. 100,000 available from stock now!

SOLENOIDS suitable for remote control, mechanical indicators, etc. 12 v. D.C., 400 mA., 30Ω, 3½in. arm, ½in. movement, **5/-** each, post **1/6**.

TERMINAL BLOCKS. 2-way **4/-** doz., or box of 50 for **15/-**, 3-way **6/-** doz., 50 for **22/6**, post **1/6**.

HEAVY DUTY SWITCHES suitable for switchboards. Carries over 100 amps. Consists of 2 S.P.C.O. coupled, **50/-** pr., post 3/-, or separately at **25/-**, post 3/-.

SATCHWELL THERMOSTATS adjustable between 70°-190° Fahrenheit. 0-440 v. A.C., 20 amps., 11in. stem. Fitted cover. **25/-**, post **2/6**.

ROOM THERMOSTAT. Adjustable between 45 and 75 deg. Fahr., 250 v. 10 amp. A.C. Ideal for greenhouses, etc., **35/-**, post **2/-**.

CATHODE-RAY TUBES. VCR 139A, 2½in. diam., **30/-**; 2AP1, 2in. diam., **25/-**. 5BP1, 5in. diam., **55/-**, all post **3/-**.

MORSE KEYS. Totally enclosed in Bakelite case with easy access for all adjustments. Shrouded terminals. Overall size 5in. × 1½in. × 2in. with mounting holes, **10/6.** Post 1/-.

REMOTE CONTROL SWITCH. Double-Pole Changeover contacts, in tubular hand operated bakelite case, 4in. × 1in. **5/-** each. Post 1/-.

L. WILKINSON (CROYDON) LTD.
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Phone: CRO 0839 Grams: WILCO CROYDON

Bulk Buying means DELIVERY EX-STOCK LOWEST PRICES

HEAVY DUTY 20 AMP. L.T. SUPPLY UNIT

by S.T.C.

Normal cost over £100

Essential equipment for Electronic Engineering, research laboratories, schools. Ideal for battery charging, etc.

Guaranteed for 20 amps.

Output: D.C. Variable up to **20 amps. and 24 v.** or trickle charge 125/350/700 ampere hours.
Input: A.C. 100/260 v. 45/65 cycles.

Size: 16 x 24 x 32in. high.

In attractive Grey Cabinet.

£22 - 10 - 0

ex Warehouse

(Circuit diagrams and instructions loaned for 10/- deposit)

VARIABLE TRANSFORMERS

Brand New

Output: (1.3kVA.) Completely Variable 0 to 260 volts 5 amps.
Input: 230 volts, 50/60 ~

A SHROUDED FULLY VARIABLE TRANSFORMER FOR BENCH OR PANEL MOUNTING.

Size: approx. 6in. cube.
Weight: approx. 13lb.

PRICE: RIDICULOUS ONLY

5 amps **£9 - 0 - 0**

10 amps **£18 - 5 - 0**

20 amps **£32-10-0**

Quantities up to 100 delivered by return of post.

Supplied New and Boxed.

LATEST miniature WALKIE TALKIE

"88" sets just released by Ministry of Supply. Produced to exacting specifications by leading manufacturers E. K. Cole & Co., this Transmitter/Receiver weighs only 5½lb. (approx.) and measures 3½in. x 5½in. x 9½in. It is a 4 frequency channel set, **crystal controlled**, 38-40/40-42 Mc/s., and operates from a Standard Dry Battery—HT/LT. 94/1. 3 v. (i.e. Ruben Mallory Type 1). 14 of the current series of B7G valves are employed: 1-3A4, 6-1L4, 4-1T4, 1-1S5, 2-1A3. Each set is in first-class condition.

SUPPLIED COMPLETE WITH CRYSTALS
Accessories can be supplied to order at extra cost.

Only **£10** Each.

Special quotations for quantities up to 3,000 sets. **"22" SETS** ALSO—300 available only. New condition **£10** each.

AERIAL MASTS

IMPROVED TYPE 50 Mk.II
36ft. HIGH

Kits comprise—six 2¼in. dia. Tubular Steel Sections of 6ft. length, top-section and base Pickets. Guys and Fittings. **YOU** can purchase this normally expensive MAST for a fraction of its cost. Please add £1 for (returnable) wooden carrying case. The MAST is particularly suitable to take aerials for Tx., Rx., F.M. and TV (especially COMMERCIAL) and has many other uses. Extra 6ft. sections can be supplied at 17/6 per section.

£8.10.0 only Carr. 15/6.

U.S.A. Type 45ft. TELECOM. AERIAL MAST. (7 sections, 6ft. 8in. x 2¼in., guys etc.). This entirely complete set in carrying case 12½ Gns. Carr. 17/6. Or 2 sets for **£25.** Carr. extra. *British Manufacture only.*

ARMY TYPE 32FT. MASTS similar to above but 10 1in. screw-sections, suitable for permanent lightweight installation. Kit in, canvas bag. £5/15/-. Carr. 7/6.

World Famous TELEPHONES "F" TYPE

In Attractive Case

£7-10-0 per pair carr. 9/-

The best portable telephone ever made. Original cost £40! Range up to 5 miles. Ideal for FACTORIES BUILDING SITES, FARMS, OFFICES. 2 perfect case sets with batteries, 100ft. cable, etc.

D3 STRANDED TELEPHONE CABLE. New Mile Drum 85/-. Carr. 17/6.

Limited Quantity

36ft. TELESCOPE MASTS

Finest quality brass. Non-rusting. Base diameter 2¼in. Complete with hand-winding winch for easy, rapid extension; and cable-wire bracing stays. One of the best masts ever produced. Winds down to 9ft.

£35 each Carr. £1/10

A COMPLETE EX-GOVT.

PUBLIC ADDRESS SYSTEM

FOR OFFICES, FACTORIES, WHAREHOUSES & CARS

15 GNS

Manufactured by TRUVOX, etc. Complete with Amplifier, four Loudspeakers, Microphone, Leads, etc. 6 or 12 v. D.C. (Car Battery ideal)

Irongate (M.O.) COMPANY

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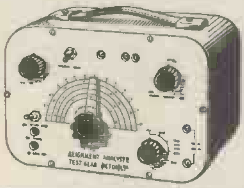
OSCILLOSCOPE

FOR D.C. & A.C. APPLICATIONS

Engineered to precision standards, this high-grade instrument is made available at the lowest possible price, incorporating the essential features usually associated with luxury instruments. This "SCOPE" will appeal particularly to Service Engineers and Amateurs. A high gain, extremely stable differential Y-Amplifier (30 mV/C.M.). Provides ample sensitivity with A.C. or D.C. inputs. Especially suitable for measurement of transistor operating conditions where maintenance of D.C. levels is of paramount importance. Push-Pull X amplifier; Flyback suppression; Internal Time base Scan Waveform available for external use; pulse/output available for checking T.V. Line O/P Transformers, etc.; Provision for external X 1/P and CRT. Brightness Modulation. A.C. mains 200/250 v. £15/15/- plus P. & P. 7/6 or 30/- deposit, plus P. & P. 7/6 and 12 monthly payments of 26/6.

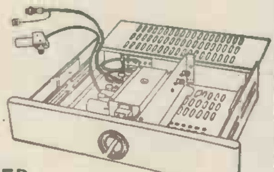
FULL 12 MONTHS' GUARANTEE INCLUDING VALVES AND TUBE

ALIGNMENT ANALYSER TYPE MC12



A.C. MAINS 200/250 volts. Provides:—"WOBBULATOR" (SWEPT FREQUENCY) OPERATION, for FM/TV alignment linear frequency sweep up to 12 Mc/s. From 400 Kc/s—80 Mc/s. CAPACITANCE MEASUREMENT. Two ranges provided 0-60 pf. and 0-120 pf. SPECIAL FACILITY enables true resonant frequency of any tuned circuit I.F. transformer, etc. to be rapidly determined. Cash price £6/19/6 and 5/- P. & P. H.P. terms 25/- deposit and 5/- P. & P. and 6 monthly payments of 21/6.

CHANNEL TUNER



Will tune to all Band I and Band III stations. BRAND NEW by famous manufacturer. Complete with P.C.C. 84 and P.C.F. 80 valves (in series) I.F. 16-19 or 33-38. Also can be modified as an aerial converter (instructions supplied).

Complete with knobs.

32/6 Plus 3/6 P. & P.

HEATER TRANSFORMER

To suit the above, 200-250 v. 6/- plus 1/6 P. & P.

B.S.R. MONARCH UA8 with FUL-FI HEAD

4-speed plays 10 records 12in., 10in. or 7in. at 16, 33, 45 or 78 r.p.m. Intermixes 7in., 10in. and 12in. records of the same speed. Has manual play position; colour brown. Dimensions: 12¼in. × 10¾in. Space required above baseboard 4¾in., below baseboard 2½in. Fitted with Full-Fi turnover crystal head. £6/19/6. Plus 5/- P. & P.

STEREO HEAD £7/19/6 Plus 5/- P. & P.

LINE E.H.T. TRANSFORMER

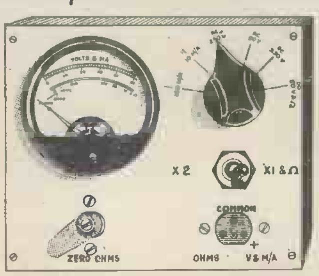
With built-in line and width control. 14 KV Scan Coil, 90in. deflection, on ferrite yokes. Frame O.P. transformer 500 pf. 18 KV. smoothing condenser. Can be used for 14in., 17in. or 21in. tubes.

Complete with circuit diagram **29/6** Plus 4/- P. & P.

As Above, but for 625 lines **£2.10** Plus 4/- P. & P.

FOCUS MAGNET suitable for the above (state tube), 10/-. 2/6 P. & P.

A.C./D.C. POCKET MULTI-METER KIT

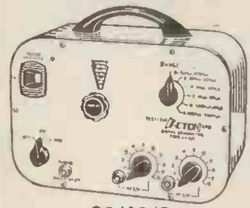


2in. moving coil meter, scale calibrated in A.C./D.C. volts, ohms and milliamps. Voltage range A.C./D.C. 0-50, 0-100, 0-250, 0-500. Milliamps 0-10, 0-100. Ohms range 0-10,000. Front panel, range switch, wirewound pot (for ohms zero setting), toggle switch, resistor and rectifier. 19/6. P. & P. 1/6. Wiring diagram 1/-, FREE with kit.

BATTERY RECORD PLAYER AND AMPLIFIER

Incorporating 45 r.p.m. "Starr" motor, "Acos" crystal pick-up, 3 transistor push-pull amplifier complete with transistors. Ouput 500 milliwatts, 49/6 plus 3/6 P. & P.

SIGNAL GENERATOR

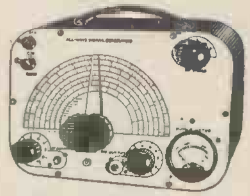


£6/19/6

Covering 100 Kc/s.-100 Mc/s. on fundamentals and 100 Mc/s. to 200 Mc/s. on harmonics. Metal case 10in. × 6½in. × 5¼in., grey hammer finish. Incorporating three miniature valves and Metal Rectifier. A.C. Mains 200/250 v. Internal Modulation of 400 c.p.s. to a depth of 30%. Modulated or unmodulated R.F., output continuously variable 100 millivolts C.W. and mod. switch, variable A.F. output. Incorporating magic-eye as output indicator. Accuracy plus or minus 2%.

Or 25/- deposit and 6 monthly payments of 21/6. Post & Packing 5/- extra.

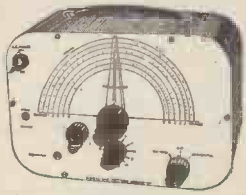
SIGNAL GENERATOR



Coverage 120 Kc/s.-230 Kc/s., 300 Kc/s.-900 Kc/s., 900 Kc/s.-2.75 Mc/s., 2.75 Mc/s.-8.5 Mc/s., 8 Mc/s.-28 Mc/s., 16 Mc/s.-56 Mc/s., 24 Mc/s., 84 Mc/s. Metal case 10in. × 6½in. × 4¼in. Size of scale 6½in. × 3½in. 2 valves and rectifier. A.C. mains 230-250 v. Internal modulation of 400 c.p.s. to a depth of 30 per cent. modulated or unmodulated R.F., Output continuously variable. 100 millivolts C.W. and mod. switch variable A.F. output and moving coil output meter. Grey hammer finish case and white panel. Accuracy plus or minus 2%. **£4/19/6**

Or 25/- deposit and 4 monthly payments 21/6. P. & P. 5/- extra.

SIGNAL & PATTERN GENERATOR



£6/19/6 P. & P. 5/-.

Or 25/- deposit. P. & P. 5/- and 6 monthly payments of 21/6.

Coverage 7/6 Mc/s.-210 Mc/s., in five bands, all on fundamentals slow motion tuning audio output. 8 vertical and horizontal bars, logging scale. In grey hammer finished case with carrying handle. Accuracy ±1% A.C. mains 200-250 v.

MAINS TRANSFORMER

All with tapped primaries 200-250 volts

0-160, 180, 200 v., 60 ma., 6.3 v. 2 amps., 10/6, 350-0-350, 70 ma., 6.3 v. 1 amp., 6.3 v. 2 amp., 10/6, 250-0-250, 70 ma., 6.3 v., 2 amp., 10/6. Postage and packing on the above 3/-.

3-TRANSISTOR POCKET RADIO

INCORPORATING MINIATURE SPEAKER

Plus GERMANIUM DIODE and PRINTED CIRCUIT

Size 3¼ x 4 x ⅞in.

Incorporating Ferrite Rod Aerial. Two Surface Barrier Transistors and one Audio. Tunable over medium and long waves.

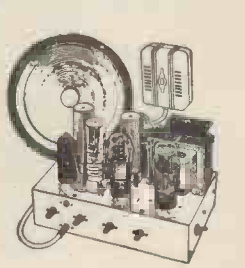
To build yourself **39/6** Plus 1/6 P. & P.

ALL PARTS SOLD SEPARATELY

Circuit diagram 1/6, free with kit.

All transistors guaranteed 100%

5-VALVE AMPLIFIER IDEAL FOR SMALL HALLS



High power—high quality. 200/250 A.C. 2 inputs, mike and gram, bass and treble lifts. For use with Standard/L.P. Records. Two would be suitable for stereophonic. Ideal P.A. system, £3/19/6. P. & P. 1/6. CRYSTAL MIKE to suit, 15/-. P. & P. 1/6. 8" PM SPEAKER to suit, 12/6. P. & P. 6/6.

PORTABLE AMPLIFIER

On printed circuit for A.C. Mains 200/250 v. Size 4in. x 3in. with tone and volume control. Valves: ECL82 and EZ80, 39/6. P. & P. 2/6.

RADIO AND T.V. COMPONENTS (ACTON) LTD.

23A, ACTON HIGH STREET, LONDON, W.3.

GOODS NOT DESPATCHED OUTSIDE U.K. ALL ENQUIRIES S.A.E. TERMS OF BUSINESS C.W.O.

RE-ENTRANT LOUD HAILERS (Ex-Govt.) Heavy duty 20 watts all-metal. 15 ohms. Diameter 15in., length 15in. (approx.), good cond. £6/10/- Carr. 10/-

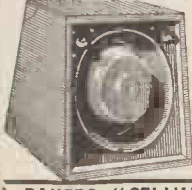
Ditto. Brand new, £8. Carr. 10/-.

HEAVY DUTY ALL STEEL TRIPOD STANDS (as illus., Sept. issue). 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, flood-lighting, etc. OUR PRICE £3/10/-. Carr. 5/-. (Ideal stand for the above loud hailer.)

50-WATT EX-GOVT. AMPLIFIER. Type III with 4-KT66/s in paralleled push-pull. Standard 200–250 v. A.C. input. Output imped. 600 ohms line. High imp. gram. and mike input. Bass boost control fitted. Quality amplifier housed in strong metal case, ready for use. Terrific performance, £25. Carr. £1.

12 VOLT D.C. AMPLIFIER (Parmeko). As new, 15 watt output with 2-EL35's in push-pull. Mike and gram. inputs, tapped output transformer, £9/19/6. Carr. 10/6.

(Suitable hand microphone for above 30/- extra.)



TRUVOX/TANNOY LOUD-HAILERS

With 180 ohm line transformer and condenser. Impedance 7½ ohms, handling capacity 8 watts. Complete in slope-front wooden case. Brand new 27/6. Carr. 4/6.

BAKERS "SELHURST" SPEAKERS ALL BRAND NEW.

SPECIAL NEW ARRIVAL! "15in. VISCOUNT AUDITORIUM." 15 ohms at 400 c.p.s., 35 watts. Flux density 18,000. OUR PRICE £15.

"12in. P.M." 15 ohms, 15 watts, 30–14,000 c.p.s. OUR PRICE £4/10/-.

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"SUPER HI-FI 25." 12in., 15 ohms, 25 watts. 25–20,000 c.p.s. Flux density 17,600. OUR PRICE £9/9/-.

Full descriptive specification available. S.A.E.

EXPONENTIAL HORNS by famous manufacturer of P.A. systems, **15 watt**, 25in long, 20in. square flare, 15 ohms speech coil (Tannoy) Good condition, £7/10/-. Carr 10/-.

NEW P.M. HEAVY DUTY SPEAKERS

Complete with O.P. trans., in all steel blue-grey double grilled cabinet. 6in. 30/-. 8in. 32/6. Carr. 3/6 ea.

ROTARY CONVERTER. 24 v. D.C. input. 230 v. A.C. output at 250 watts. Complete with starting switch. New and unused. £15. Carr. 7/6.

ROTARY CONVERTER. 24 v. D.C. to 230 v. A.C. 50 cycles, 150 watts. Brand new and unused. £8/10/-. Carr. 7/6. Ditto, 100 watts £6/9/6. Carr. 7/6.

ROTARY CONVERTER. Ex-Govt. 12 v. D.C. input, 230 v. A.C. output 50 cycles at 135 watts. Complete in carrying case with lid. Voltage control sliding resistance, mains switch and 0–300 v. A.C. flush meter. In good condition. £10. Carr. 10/-.

Motor only, without case, etc. Brand new and unused. £8/10/-. Carr. 5/-.

Send S.A.E. for comprehensive list of P.A. equipment for outdoor and indoor use.

R.C.A. AR88-D RECEIVER

Mint condition. Freq. coverage 540 Kc/s., 32 Mc/s. £50. Carr. 20/-. Also I.F.'s available. Freq. coverage 75–550 Kc/s., 1.5–30 Mc/s. £45. Carr. 20/-.

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ADJOINING LEICESTER SQ. TUBE STATION—Open 9-6 Weekdays. 9-1 Sat.

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RCA PLATE TRANSFORMERS. 190 to 250 v. primary. 50-60 cycles. Secondary 1,500–0–1,500 or 2,000–0–2,000 at 500 milliamps. Brand new and boxed. £6/10/-. Carr. extra.

L.T. TRANSFORMERS for Battery Chargers, etc. All Pri. 200/250 v. Tapped 50 cycles. Type 048B. Sec. 24, 30, 36 v. 6 amps. 4 x 4 x 4in. £2/9/6. Type 066A. Sec. 18, 24, 30, 36 v. 8 amps. 4 x 4 x 5in. £3/19/6. Type 053A. Sec. 12, 24, 30 v. 10 amps. 4 x 5 x 5in., £4/4/-. Carr. 3/6 each.

AUTO TRANSFORMERS. 0–110, 205, 225, 245 v. Fully shrouded. Terminal block connectors.

Type 063A. 500 w., 4 x 5 x 5in., £3/7/6. Carr. 3/6.
Type 064A. 750 w. 4 x 6 x 5in., £3/17/6. Carr. 3/6
Type 065A. 1,000 w. 4 x 7 x 5in. £4/17/6. Carr. 5/-

20 kV/A AUTO TRANSFORMER. 230/115 v. 50–60 cycles, by Jefferies Transformer Co., U.S.A. Perfect condition. £20. Carr. 20/-.

E.H.T. TRANSFORMER. 8,000–0–8,000 at 400 mA. Primary 230 v. 50 cycles. Oil filled. New and in original crates. £25. Carr. 10/-.

G.P.O. RACKS
19in. Heavy duty all steel
Standard drilling
5ft. 6in. angle uprights.
£3/10/-. Carr. 15/-.
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CONDENSER, oil filled. 240 mfd. 230 v. A.C. or 600 v. D.C. Made in U.S.A. Size 21in. x 5¾in. x 9in. Brand new in original cases, £7/10/-. Carr. 5/-

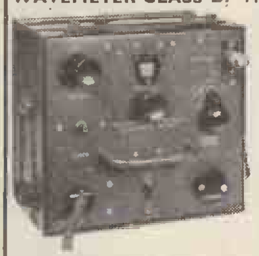
QUALITY TEST EQUIPMENT

METER BARGAIN! POCKET MULTI-METER MODEL U.1

Sensitivity 300μA. 1,000 o.p.v. in 5 ranges. Size 5¼in. x 3⅛in. x 2¼in. Complete with test prods and ready for use. **ONLY 59/6.** P. & P. 2/-

UNREPEATABLE OFFER OF THE POPULAR

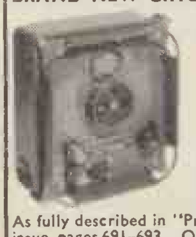
TAYLOR VALVE TESTER Model 45A. Input 200–250 v. A.C. Will test English and American valves with filaments from 1.4 v. to 117 v. Perfect condition. Complete with full instruction manual. £10. Carr. 5/-.



WAVEMETER CLASS D. Freq. band 1,900 Kc/s. to 8,000 Kc/s. (158–37.5 metres) in two ranges. 1,900 Kc/s.–4,000 Kcs. also 4,000 Kc/s. 8,000 Kc/s. Supply 6 v. D.C. input. Complete with twin crystal, spare vibrator, head phones, original instruction manual and transit case. As new, £5/5/-.

BRIDGE MEGGERS. Evershed and Vignoles Series 2 in perfect condition. 250 v. £22. Carr. paid. Leather case available at 20/- extra.

MARCONI SIGNAL GENERATOR TYPE TF517-F/1. Covering 10–18 Mc/s., 33–58 Mc/s., 150–300 Mc/s. In very good condition. Complete with full technical data and instructions. Unrepeatable at only £12/10/-. Carr. 20/-.

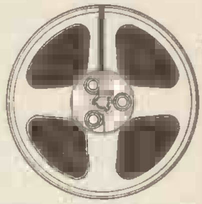


BRAND NEW CRYSTAL CALIBRATOR No. 10. (Battery powered 1.4 v. valves.) Complete with full working instructions, circuit diagram, carrying haversack, connecting lead and spare valves. Frequency range: 1.5 to 10 Mc/s. (nominal) but can actually be used up to 30 Mc/s. Weight 5lb. Size 7 x 7½ x 4in. As fully described in "Practical Wireless," Dec. issue, pages 691–693. ONLY £4/17/6. P. & P. 2/6

MULLARD BRIDGE. Type GM. 4140/1. Mains operated from 100–250 v. A.C. Will test resistances from 0.1 ohm to 10 megohms and condensers from 10pf to 10mfd. Good condition and complete with instruction booklet. £6/19/6. P. & P. 2/6.

JUST ARRIVED!
SUPER QUALITY AMERICAN TAPES "C.B.S," "Triton" etc.

600ft. 5in. 12/6
1,200ft. 5¾in. 19/6
1,200ft. 7in. 19/-
1,800ft. 7in. 29/-
2,400ft. 7in. 48/-



Many other types available including "Scotch," "EMI," etc. Send s.a.e. for our huge money saving literature on Tapes and Accessories.

A.C.-D.C. RECTIFIER POWER SUPPLY UNITS 110/230 v. A.C. 50 cycles input. 100/110 v. D.C. output, max. 2½ amp. Brand new and unused. £4/10/-. Carr. 7/6.

230 v. A.C. 50 cycles input, 200/220 v. D.C. output at 3/4 amps. approx. Good condition. £10. Carr. 10/-.

200/250 v. pri. 110 v. sec. at 4 amps. max. Brand new and unused. £8/10/-. Carr. 10/-.

Type 67. 200/230 v. A.C. 50 cycles input. 240–0–240 v. D.C. output at 1½ amps. (Valve rectification.) Fitted with switch fuses, regulator and overload controls. Brand new in maker's original crates. £10. Carr. 10/-.

MINIATURE LEAD ACID ACCUMULATORS

2 v. 1.5 A.H. Size 4 x 1½ x 1in. Wt. approx. ¾lb., 6/6. 12 v. 0.75 A.H. Size 4 x 3 x 1½in. Wt. approx. 2lb. 22/6.

NEW AND UNUSED ACCUMULATORS

12 v. 75 A.H. £4/10/-. Carr. 8/6.
12 v. 25 A.H. 45/-. Carr. 7/6.
2 v. 100 A.H. (ex-Govt.) with carrying handle. Size 6¼ x 6¼ x 3¼in., 15/- each. Carr. 3/6.
2 v. 16 A.H., 7½ x 4 x 2in., 5/- each. P. & P. 2/-. 6 for 24/-. P. & P. 10/-.
6 v. 75 A.H. Ideal for starting or storage. 59/6. Carr. 7/6.
6 v. 20 A.H. comprising three 2 v. celluloid-cased cells in wooden case. Overall size 5 x 5 x 7½in. 17/6. P. & P. 3/6.

HELLERMAN TOOL KIT. Type T.K.3. Contains sleeve expanding tool, wire stripper, 250 sleeves of assorted sizes. A must for every workshop, etc. 32/6. P. & P. 1/-.

10-LINE TELEPHONE SWITCH-BOARDS. For the complete control of 10 extensions (Tele. "F," etc.). Complete with jacks, leads and operator's hand set. Good condition. £9/19/6. Carr. 10/6.

TELEPHONE SETS (TELE "F") Housed in Bakelite cases, complete with built-in ringing generators and batteries. Ideal between two or more positions up to practically any distance. Tested before despatched. ONLY 70/-. P. & P. 3/6. 2 sent for £6/10/-. Carr. paid

TELEPHONE CABLE. Twin one-mile drums (Don 8), £5. Carr. 20/-. Single one-mile drums (Don 3), 50/-. Carr. 7/6.

CRYSTAL MICROPHONE MODEL BM3

Three way mike for hand, desk or floor stand use. Response 100–8,000 c/s. Sensitivity –62db. Length 7in. Head dia. 1¼in. Supplied with neck band and screened lead. Terrific performance—outstanding value at **ONLY** £2/5/-. (Desk Stand as illus. 12/6 extra).

TELESCOPIC FLOOR STAND. HEAVY 9in. dome chromium base, chromium stand with screw top. Extends to approx. 6ft. Suitable for above mike, etc., £2/10/-. Carr. 5/-.

MOVING COIL MICROPHONE. Complete with 12ft. screened lead £2/10/-.

BUILD THIS HIGH GRADE SIX TRANSISTOR RADIO!!

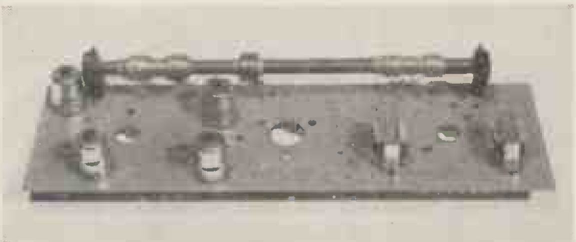
USING OUR MATCHED COMPONENTS

- ★ PRINTED CIRCUIT, READY DRILLED
- ★ MW/LW FERRITE AERIAL
- ★ OSC/I.F. TRANSFORMERS
- ★ DRIVER & OUTPUT TRANSFORMERS

— 500 mW OUTPUT ! —

BASIC COMPONENTS & PRINTED CIRCUIT, AS SHOWN BELOW 55/- Post 2/-.

WITH FULL PARTS LIST OF COMPLETE RECEIVER AND DETAILED ASSEMBLY INSTRUCTIONS.



ALL COMPONENTS MAY BE BOUGHT SEPARATELY.
SEE PRICE LIST OPPOSITE →

TRANSISTOR COMPONENTS

LIST		
35	Oscillator Transformer. MW/LW $\frac{9}{16}$in. dia.	5/9
36	1st/2nd I.F. Transformer (pair) $\frac{9}{16}$in. dia.	11/6
37	3rd I.F. Transformer. $\frac{9}{16}$in. dia.	5/9
38	Driver Transformer (C.T. Sec.) $\frac{3}{4} \times \frac{5}{8}$in.	7/-
39	Driver Transformer (Split Sec.). $\frac{3}{4} \times \frac{5}{8}$in.	7/-
40	Output Transformer 500 mW/3 ohm. $\frac{3}{4} \times \frac{5}{8}$in.	6/9
41	Output Transformer 150mW/3 ohm. $\frac{3}{4} \times \frac{5}{8}$in.	6/9
42	Output Transformer Class A 50mW/3 ohm. $\frac{3}{4} \times \frac{5}{8}$in.	6/9
30	Ferrite Aerial MW/LW. $7 \times \frac{1}{4}$in.	9/3
31	Ferrite Aerial MW/LW. $4\frac{1}{4} \times \frac{1}{4}$in.	8/-
45	Printed Circuit, Drilled. $8 \times 2\frac{1}{2}$in.	9/-
43	Audio Oscillator Transformer, 1,000 C/S. $\frac{3}{4} \times \frac{5}{8}$in.	7/-
29	R.F. Choke, Screened. 250μH. $\frac{9}{16}$in. dia.	4/6

½in. Square Transistor Transformers

20	Oscillator Transformer. MW/LW	Set of 4	22/-
21	I.F. Transformer. (2 required)		
22	I.F. Transformer.		

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TRADE ENQUIRIES WELCOMED

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FINE WIRE WINDINGS

MINIATURE TRANSFORMERS, PICK-UP, CLOCK AND INSTRUMENT COILS, ETC.
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Audiomaster Monaural control unit and power amplifier, control unit suitable for all types of 33 and 78 recordings. 8 mV sensitivity for pick-ups. Provision for direct connection of tape headsequalised to C.C.I.R. 1.8 mV sensitivity. Power amplifier with a nominal output of 25 watts. 50 watts peak and a distortion value of 0.05% at 20 watts. As reviewed in August 1958 "Hi-Fi News." Amplifier and control unit complete listed at £59 10s. 0d. now offered at £29 10s. 0d. (chassis mounting) (carriage 8s. 6d.). ***Call and hear this Phenomenal Amplifier.

Audiomaster Stereo Tape Amplifier

This special version is intended for use with the Harting deck using Telefunken heads. The amplifier contains two record channels which are easy to monitor by means of an exclusive feature, a 1in. Cathode Ray Tube. Play-back can be effected through a suitable pre-amplifier capable of accepting the signal direct from the tape head.

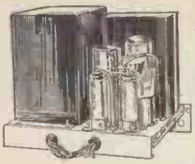
Original price £33 15s. now offered at £19 10s. (plus 3s. 6d. carr.)

FULL DESCRIPTIVE LEAFLETS AND TEST REPORTS AVAILABLE ON REQUEST

TRADE AND EXPORT INQUIRIES INVITED

400 EDGWARE ROAD · PADDINGTON, W.2

PADDINGTON 5521



MAINS POWER SUPPLY UNITS. Potted and sealed transformer and choke by famous maker. Mounted on metal chassis 6½ x 7½in., complete with 5Z4 rectifier valve and full smoothing. Input tapped 220-230-240 volts.
Output: 300 V. D.C. at 100 mA.
6.3 V. A.C. at 4.5 amp.
6.3 V. A.C. at 2 amp.
Rectifier supply 5 V. A.C. at 3 amp. Very conservatively rated. Price 47/6 plus P. & P. 8/-.

BRAND NEW VARIABLE VOLTAGE TRANSFORMER. For 230 volt A.C. input, in cases with meter, fuse and indicator light. Output constantly variable from 0—230 volt A.C. Type 15. 15 amp. Price £22/10/-. Carr. 15/-.

S.T.C. RECTIFIER. 36 plates by 120 mm. Bridge connected. Maximum A.C. input 60 volt. D.C. output 15 amp. New, perfect. Price 60/-. P. & P. 3/6.

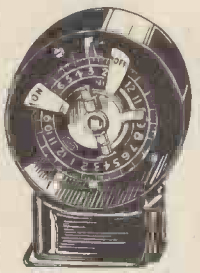
S.T.C. BRIDGE RECTIFIER. New, perfect. 8 plates each 115 mm.. Maximum A.C. input 36 v. D.C. output 5 ampere, 24 volt. Price 20/-. P. & P. 2/-.

NEW WIRE WOUND RHEOSTAT ON CERAMIC. 58 ohm. 50 watt, complete with instrument knob. Price 8/6. P. & P. 1/6.
W. W. RHEOSTAT. New. 3.5K or 5K 25 watts. Price 7/6. P. & P. 1/6.

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.

HEAVY DUTY L.T. TRANSFORMER. Very conservatively rated for continuous duty. New. In manufacturer's cases. Input 110-260 volt multi-tapped. 50 cycles, single phase. Output 28-29-30-31 volts at 21 ampere. Price £6/15/-, carriage 10/-.

ROTARY SWITCH REGULATOR. 25 ohms, very conservatively rated at 4 amp., will handle 8 amp. Overall size 7 x 8 x 6in. Price 15/-. P. & P. 2/6.



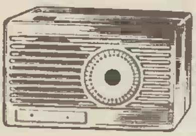
8-day clockwork TIME SWITCH
Contacts 2½ amp., 230 volt, 24 hour phase, ¼ hour divisions, allow setting for one make and one break to be made every 24 hours, complete with key. Used but guaranteed perfect. Price 27/6 each. P. & P. 2/-.

EX P.O. MAGNETIC COUNTER. 3 ohm, type for 6 V. D.C. operation. 4 figures to 9,999. Price 8/6. P. & P. 1/3.

TANNOY P.A. LOUDSPEAKER. For outdoor use, metal exponential horn with 20in. square flare. Overall length 30in. Speech coil 15 ohms. Guaranteed in working order and good condition. Price £7/10/- Carriage 10/-.

20-WAY STRIP. Containing standard Post Office telephone Jack Sockets, overall size 11 x 3¼ x ⅞in. New. Price 15/- each. P. & P. 1/6.

10-WAY STRIP standard Post Office telephone Jack Sockets, spacing allowing Igranic Jack Plugs. New. Price 10/-. P. & P. 1/6.



MOULDED CABINET suitable for Transistor Set. Dual colour red/black. Size 5½in. x 3½in. x 1¾in. Gold metal dial. Price 7/6. P. & P. 1/6.

SPECIAL OFFER. TRANSISTORS EX BRAND NEW EQUIPMENT. 2 off XC.101A Push-Pull pair, Output 400 MW. (=OC72) and 1 off X.B103 Driver (=OC71). Set of 3 15/6, postage paid.

SUPERIOR BRAND NEW RELAY. 7,000 ohms coil. Will pull in at 750 microamps, and out at 450 microamps. Change-over, platinum contacts. Vacuum sealed, will therefore not be affected by oil, moisture or water and never needs adjusting. Weight 2½ oz. Price 18/6. 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 1¼ x ⅝ x ¾in. Price 22/6 each.

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SIEMENS H.S. RELAY. Very latest type, sealed. H96E. 1,700 ohms plus 1,700 ohms, single C/O. contacts. Brand new with fixing clip. In maker's cartons. Price 16/6 each, plus 1/-. P. & P.

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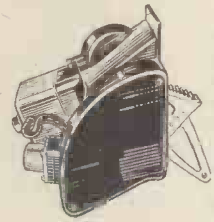
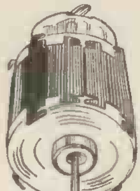
CARPENTER'S TYPE POLARISED RELAYS. 2 x 9,500 turns at 1,685 ohms. Price 22/6 each. P. & P. 1/-.

HIGH SPEED RELAY. Siemens Two bobbins 1,000 ohms each. New, 10/6 each. P. & P. 1/-.

FRACTIONAL H.P. MOTOR MADE BY FRACMO. For 230/250 volt A.C. Delivers ⅛th of a H.P. at 5,000 R.P.M. Complete with wire leads and 1in. x ¼in. spindle. Unused. Price 39/6 each. P. & P. 3/-.



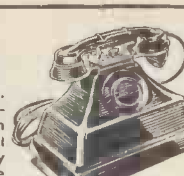
SPECIAL REVERSING 24-VOLT D.C. MOTOR 2 AMPERE. Quadrant moves 90 degrees with limit switches. Ideal for opening doors etc. Price 22/6. P. & P. 2/-.



NEW IMPORTED EXTREMELY EFFICIENT MOTOR with tremendous power weight ratio. For 12 volt D.C. but very efficient on 6 volt. Three position switch. Weight 2.1 oz., size 1⅝in. x 1¼in. dia Speed 7,000 r.p.m. Self lubricating 15/-, plus 1/-. P. & P.

CONSTANT SPEED, PRECISION MADE, BATTERY DRIVEN D.C. GOVERNED MOTOR (Elliott Bros.). Commutator/brush incorporating loading ballast resistor 2,470 r.p.m. ± 2% at 12 volt. Loss on 8.5 volt only 4%. Size 1$\frac{1}{32}$in. dia. x 2$\frac{3}{32}$ in. long. Spindle .77in. long x .15575in. dia. Weight 4 oz. New. Price 25/-. plus 1/-. P. & P. Ideal for portable tape recorders.

DESK TELEPHONE HANDSETS



Used but perfect. Complete with two-way calling system (buzzer), internal battery. All ready for simple two-wire connection. Price £3/2/6 each or £6 the pair. P. & P. 3/6 each handset.

DESK TELEPHONE SETS, similar to G.P.O. extension telephones. Each complete with automatic dial, internal bell and long connection core and junction box. Used but in perfect working order. Price £2/17/6 each. P. & P. 3/6.

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7½ amp. D.C. M.I. 3½in. proj. rnd.	12/6
9 amp. D.C. Hot Wire W.R. 2½in. fl. rnd.	6/6
15 amp. D.C. M.C. 2in. rnd.	10/6
100 amp. A.C. M.I. 4½in. fl rnd.	32/6
Voltmeters	
20 v. D.C. M.C. 2in. fl. sq.	10/6
30 v. M.I. 3in. proj. rnd.	10/6
300 v. A.C. M.I. 2½in. fl. rnd.	22/-
400 v. A.C. M.I. 4½in. rnd.	35/-
90-180 v. A.C. M.I. 4½in. fl iron	25/-
Milliammeters	
1 mA. M.C. 2½in. fl. rnd.	25/-
200 mA. M.C. 2½in. fl. rnd.	12/6
500 mA. M.C. 2½in. fl. rnd.	12/6
Microamp	
50 microamp., scaled 0-100, M-C. 2½in. fl. rnd.	42/6
500 microamp., M.C. 2½in. rnd. F.L. scaled 15/600 volt. NEW	16/6

Postage on all meters 1/- each.

Miniature latest type moving coil 0-5 milliamp meter, 1½in diameter, flush fitting, complete with fixing clip. Price 17/6. P. & P. 1/-.

MINIATURE LATEST TYPE MOVING COIL MICROAMP METER, F.S.D. 300 microamp. flush mounting, square rim 1¾in. x 1¾in. round dial 1¼in. Ideal as field strength meter or output level recorder or tuning meter. Price 26/-. P. & P. 1/-.

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PANEL MOUNTING TOGGLE SWITCH D.P.D.G.T. CENTRE OFF. 250 volt 3 amp. Price 5/6 each.

MINIATURE UNISELECTOR SWITCH. Two banks of ten plus home contacts one bank continuous of normal. 30 ohm coil for 24 volt operation. Brand new, manufacturer's packing. Price 22/6 each. P. & P. 2/6.

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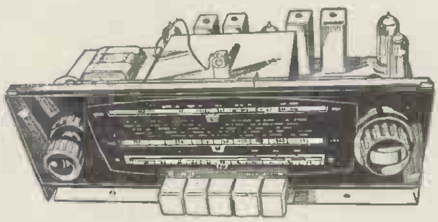
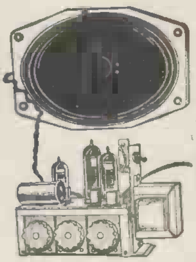
BRAND NEW AM/FM (V.H.F.) CHASSIS AT £14 (Carr. paid)



Tapped input 200-225 v. and 226-250 v. A.C. ONLY.
Chassis size 15 × 6½ × 5¼in. high. New manufacture. Dial 14½ × 4in. in gold and black.
Pick-up Extension speaker, Ae., E., and Dipole sockets. Five "piano" push buttons -OFF, L.W., M.W., F.M. and Gram. Aligned and tested.
With all valves and O.P. Transformer, Tone-control fitted.
Covers 1,000-1,900 M., 200-500 M.; 88-99 Mc/s.
Valves EZ80 rect., ECH81, EF89, EABC80, EL84, ECC85. Speaker and Cabinet to fit chassis, 47/6 (post 3/6).
10 × 6in. ELLIPTICAL SPEAKER, 20/- to purchasers of this chassis.
TERMS:— Chassis £5/10/- down and 6 monthly payments of 30/-, or with Cabinet and Speaker £5/17/- down and 7 monthly payments of 32/-.

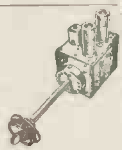


3-VALVE AMPLIFIER (INCL. RECT.)

Capable of giving 4 watts. Mains and output transformer. Valves ECC83, EL84, EZ80, 3 Controls, volume, bass and treble. On/Off switch. Fully guaranteed. Chassis size 6½ × 3 × 2½in.; with 7 × 4in. elliptical speaker of 6½in. round (Goodmans); state which.
ONLY 67/- (3/- P. & P.).

13-CHANNEL TUNER

I.F. 16-19 Mc/s. requires valves PCF80 and PCC84. Removed from chassis but in working order.
7/6 (2/6 P. & P.) Knobs 2/6 extra.



50 SILVERED MICA AND CERAMIC CONDENSERS, 10/-. 50 RESISTORS, 5/-.
144 yds. Imm. P.V.C. flexible sleeving 10/- post paid.

NEW WAXED TUBULARS, 350 v. or above, 3 of each. .001, .002, .005, .01, .02, .05, .1mF, .25, .5mF, Total 21 for 4/6 (post 9d.). Not more than 3 of one type.

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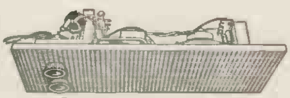

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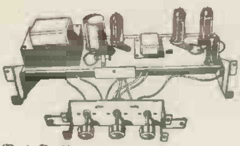
3/- P. & P.



Brand new 200-240 A.C. mains. Bass, treble and vol. controls flying panel. With valves EZ80, ECC83 and 2-EL84 giving full 8 w. Chassis 12 × 3½ × 3½in. With o.p. trans. for 2-3 ohm speaker.
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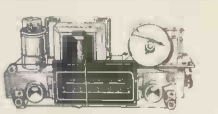

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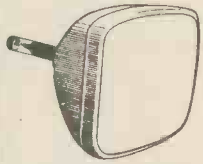

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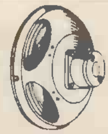

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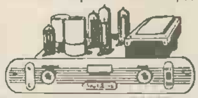

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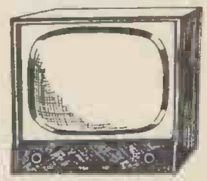

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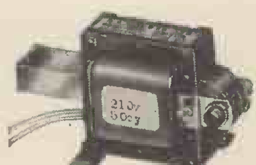

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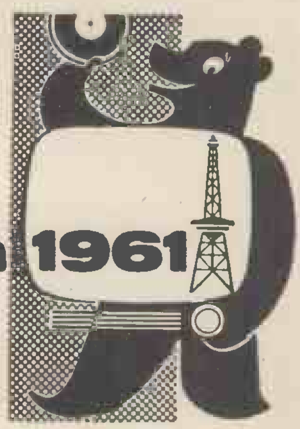

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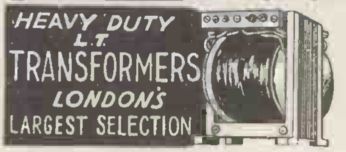

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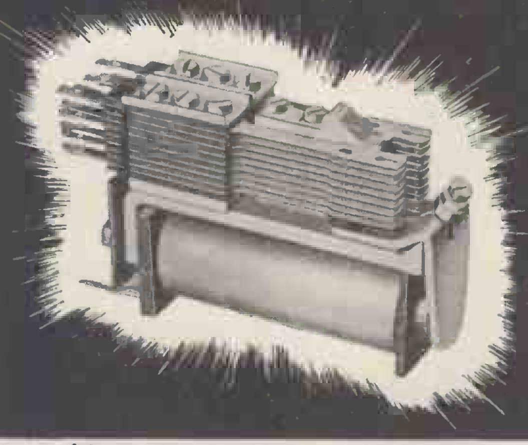

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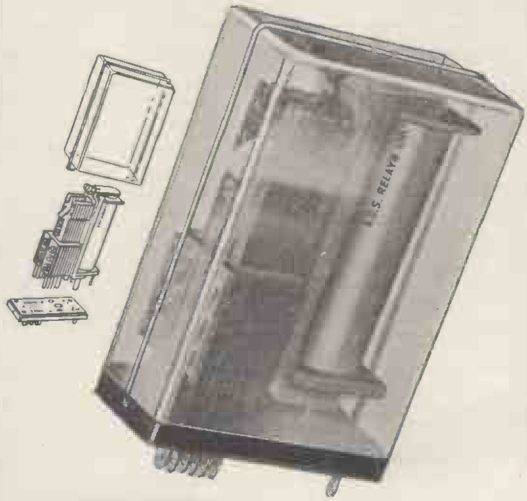

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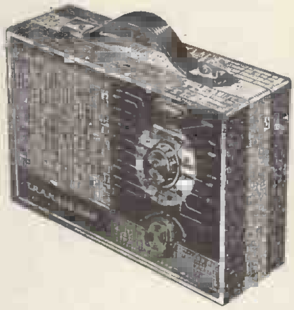

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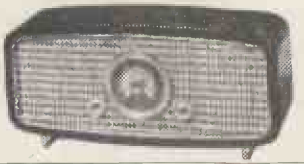

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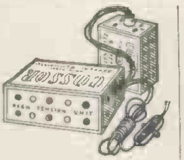

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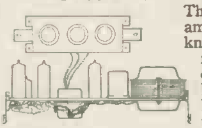

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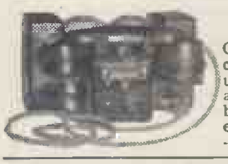

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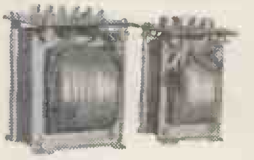

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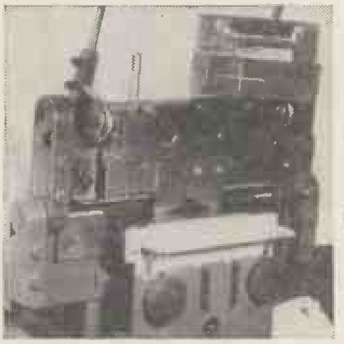

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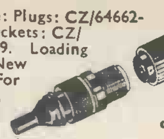

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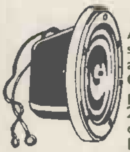

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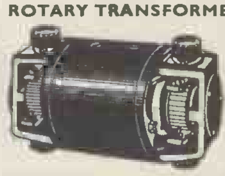

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or

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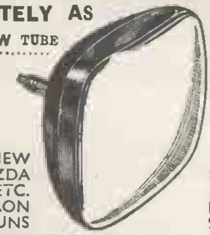

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COSSOR DOUBLE BEAM TYPE 1035. Free-running, triggered or single stroke Time Base. Time scale directly calibrated from 15 µsec full scale to 150 millisec. Full scale in 9 ranges. Three-stage "Y" Amplifier directly calibrated from 50mV to 50V with frequency response from 60kc/s at highest amplification to 7.0mc/s at the lowest for 15% down; at 50% down the response is 250kc/s and 10 mc/s respectively. Single stage "Y2" Amplifier directly calibrated from 5 to 500V in six ranges with bandwidth of 20c/s to 100kc/s. 100-130V and 200-255V A.C. operation. Fully overhauled and guaranteed .. £100 0 0

AIRMEC TYPE 723, SINGLE BEAM. Free-running, triggered or single stroke time base. Sweep range from 1µsec to 500 millisec. Two-stage "Y" Amplifier provides sensitivity from 200mV/cm (D.C. to 5 mc/s) to 30mV/cm (30c/s to 30kc/s). Single stage Auxiliary Amplifier provides sensitivity of 650mV/cm from 30c/s to 2mc/s. EHT Voltage is adjustable and can be selected by control knob at 1, 2, or 4kV. Automatic brilliance control. 100-130 and 200-250V A.C. Mains operation. Fully overhauled and guaranteed £60 0 0

E.M.I. TYPE 3794TA. Trolley mounted oscilloscope with power supply unit separate from the display unit. 4in. screen Cathode Ray Tube. Provision for mixing two separate inputs and displaying their difference on the C.R.T. "Y" Amplifier gives sensitivity from 2 to 120mV/cm in eight ranges; frequency response from D.C. to 1 mc/s within .1db and up to 5mc/s to 2.5 down. "Y" shift meter for voltage measurements from 0 to 500V in 6 ranges. Time base from 1.5µsec to 50 millisec full sweep in ten ranges. "X" amplifier gives sensitivity up to 50cm for max. horizontal deflection. Directly calibrated time scale from .1µsec to 50millisec. Illuminated gratucule. 190-250V A.C. Mains operation. Fully overhauled and guaranteed £130 0 0

Also COSSOR model 339, DUMONT model 241 and others

MARCONI TYPE TF-886A CIRCUIT MAGNIFICATION METER. Frequency Range 15 to 170 mc/s. in four ranges ±2%. Magnification Range 60 to 1,200 in three ranges. Tuning Capacitor 12 to 85µµF with Vernier Tuning Dial. Fully overhauled and guaranteed £130 0 0

MARCONI TYPE TME-18 FIELD STRENGTH METERS

Transportable test set for measuring field strength of signals in the range of 150kc/s to 25mc/s. The instrument consists of sensitive superheterodyne receiver providing I.F. bandwidths of 120 and 600c/s, interchangeable aerial systems to cover complete range, and substitution oscillator. Output of the instrument can be read on a meter, recorded or displayed on an oscilloscope screen. Field strength measurements range from 1µV/metre to 5V/metre with an accuracy of 10%. All readings are in db with reference to 1µV/metre and no calibration curves are required. 6V accumulator operation. Fully overhauled and guaranteed £220 0 0

H.T. FLASH-OVER TESTERS

Test voltage continuously variable from 0 to 5 kV. A.C. or D.C. Power supplies 230 V. A.C. Complete with probes.

PRICE, fully overhauled and guaranteed.. £28 0 0

Packing and carriage £1/10/-.

H.T. LEAKAGE INDICATORS

A.M. Ref. No. 5G/2124

Portable Hand Operated H.T. Tester for testing leakage of Aircraft Ignition Leads. Meter calibrated directly in megohms. Completely rebuilt and fully guaranteed. Complete with two H.T. leads fitted with crocodile clips. PRICE £21 0 0

Packing and carriage 15/-.

BONDING TESTERS

Portable instrument for measuring resistance of bonding under conditions of high current. Scale calibrated from 0 to .10Ω, first division being at .002Ω. Complete with pair of special test leads of heavy cross-section, fitted with special test prods £8 15 0

NIFE cell for use with the above........ £3 10 0

POWER UNIT DRAWERS

RECEIVER POWER UNIT DRAWER. Input 115/230 V. A.C. Output 6.3V. at 6A. A.C. and 250V. H.T. at 200mA. Fully smoothed and fused. Dimensions 6¾in. high × 13½in. wide and 17¾in. deep. Weight 32lb......... £3
P.P. 15/-.

TRANSMITTER POWER UNIT DRAWER. Input 115/230V. A.C. Output: 6.3V. A.C. at 10A.; 24V. D.C. at 60mA. highly smoothed to peak ripple of .1%; 24V. D.C. at 240 mA. for control circuits, etc.; Fixed Bias −8V.; adjustable bias from 0 to −30V.; 300V. H.T. at 135 mA., peak ripple 1%; 300V. H.T. at 215 mA., peak ripple 5%. Dimensions 8¾in. high × 13½in. wide × 19¾in. deep. Weight 60 lb.................... £6
P.P. 25/-.

Both power units are fitted with cooling blowers and will slide into a 12½in. wide rack.

PORTABLE METERS

Moving Iron A.C./D.C. meters, 0-160V. First grade accuracy. 8in. mirror scale. Wooden case with hinged lid Unused, in perfect order and guaranteed. Small quantity available only at a reduced price of £3 0 0

MARCONI VALVE VOLTMETERS No. 2 (TF-428)

Measuring range 1.5V to 150V FSD in five switched ranges. First graduation at .10V. Accuracy ±2% FSD. Resonant frequency approx. 400mc/s. Fully overhauled and guaranteed, complete with Diode Probe £17 10 0

HIRE PURCHASE TERMS

AVAILABLE FOR THE FOLLOWING COMMUNICATIONS RECEIVERS.

MARCONI CR-100, 60kc/s to 30mc/s in good working order. Cash price £25 0 0
Ditto fully overhauled to the manufacturer's specification and guaranteed for 12 months £45 0 0
RCA AR-88D. 540kc/s to 32mc/s, in good working order. Cash Price £35 0 0
Ditto fully overhauled to manufacturer's specification, with replated chassis and rewired where necessary, guaranteed for 12 months £85 0 0
RCA AR-88LF, 73-550kc/s and 1.48—30.5mc/s, in good working order £33 0 0
MARCONI CR-150. 2-60mc/s. Dual Superhet. "S" Meter. Complete with external power pack for mains operation, fully overhauled and guaranteed for 12 months £75 0 0

Please write for details of H.P. Terms.

SPECIAL RECEIVERS

R-1359; frequency range 130-520mc/s in two bands. Tuned coaxial line input circuit, crystal mixer, CV-52 local oscillator, four IF stages at 13.5mc/s and bandwidth of 3.5mc/s and 420kc/s, detector, Video Amplifier and Cathode Follower Stage, Beat Frequency Oscillator. Video or Audio output. Sensitivity approx. 10µV for 6dB S/N ratio. External mains power supply unit. Fully overhauled and guaranteed, complete with power supply unit for 230V mains operation £95 0 0

R-1294; frequency range 500 to 3000mc/s. Tuned coaxial line input circuit, crystal mixer, CV-52 local oscillator. Four IF stages at 13.5mc/s and bandwidth of 3.5mc/s. Detector and two LF stages. Separate power supply unit is required. Fully overhauled and guaranteed, without power supply unit £85 0 0
External power supply unit can be supplied at extra charge

HALLICRAFTER S-27C; AM/FM reception in the range of 130 to 210mc/s in one band. 117V A.C. operation. Fully overhauled and guaranteed £90 0 0

NEW T.C.C. AND DUBILIER BLOCK CAPACITORS

1µF at 1250/800V. Type B257	8/-
1µF at 2000/1700V TCC Visconol	9/-
1µF at 5000/3300 Dubilier	17/6
1µF at 7500/5000V Dubilier	22/-
2µF at 800/550V Dubilier	3/6
2µF at 800/550V TCC Visconol	3/6
2µF at 2500/2000 Dubilier	15/-
4µF at 200/100V Dubilier	5/6
4µF at 660V TCC Visconol	5/6
8µF at 200/100V Dubilier	6/-
8µF at 200/100V TCC Visconol	6/-
8µF at 1250/850V Dubilier	10/-
8µF at 1500/1000V Dubilier	12/6

Packing and carriage 1/6 per capacitor.

When double voltage rating are quoted, the higher voltage refers to working temperature of 71° C and the lower one to 100° C.

AUDIO FREQUENCY METERS

TYPE CT-49 PORTABLE ABSORPTION FREQUENCY METERS. Frequency range 450 c/s to 22 kc/s in four directly calibrated bands. Instruments essentially consist of L-C Resonant circuit tuned by variable capacitors, a detector and valve voltmeter circuit. Power required dry batteries 1.5v. and 22v. PRICE, fully overhauled and guaranteed £22 0 0
HEWLETT PACKARD TYPE 500A ELECTRONIC FREQUENCY METER. Frequency range 0-50,000 c/s. in ten Bands. Sensitivity 0.2vrms; provision for photocell input. 115v. mains operation.
PRICE, fully overhauled and guaranteed £50 0 0

HETERODYNE WAVEMETERS

TS-173 Heterodyne Crystal Controlled Frequency Meters, range 90 to 450 Mc/s. Individual Calibration Books with numerous crystal check points. Accuracy .005% nominal and .01% interpolation. Power required: dry batteries 6V and 135V. PRICE, fully overhauled and guaranteed £120 0 0
TS-323 Heterodyne Crystal Controlled Frequency Meters. Range 30-480 Mc/s. Otherwise as above but provided with internal modulation. Fully overhauled and guaranteed £155 0 0
TS-174 Heterodyne Crystal Controlled Frequency Meters, range 20-200 Mc/s. otherwise as above. PRICE, fully overhauled and guaranteed £140 0 0
TS-175 Heterodyne Crystal Controlled Frequency Meters. range 80 to 1,000 Mc/s., otherwise as above. PRICE, fully overhauled and guaranteed........ £150 0 0

AUDIO OSCILLATORS

FURZEHILL No. 1 BEAT FREQUENCY OSCILLATOR. 0-10,000c/s; output 2 watts into 10 and 600Ω. Mains operation. Fully overhauled and guaranteed £22 10 0
B.S.R. LO-50 BEAT FREQUENCY OSCILLATOR. 0-16,000c/s. Two dial differential tuning. Output .5 watts into 600Ω. Mains operation. Fully overhauled and guaranteed £30 0 0
MARCONI TF-195L BEAT FREQUENCY OSCILLATOR. 0-40,000c/s. Output 2 watts into 600 and 2,500Ω. Mains operation. Fully overhauled and guaranteed £65 0 0
GENERAL RADIO TYPE 700A WIDE RANGE BEAT FREQUENCY OSCILLATOR. 50c/s to 5mc/s in two ranges. Incremental frequency control. Output 150mW into 600Ω. 230V mains operation. Fully overhauled and guaranteed £70 0 0
DAWE INSTRUMENT TYPE 400C WIDE RANGE RESISTANCE TUNED OSCILLATOR. Frequency range .1 (one tenths) c/s to 1000c/s in two ranges. Output 100mW into 10,000Ω balanced. 1in. Cathode Ray Tube for monitoring and frequency measurements. 230V mains operation. Fully overhauled and guaranteed £70 0 0

CT-91 40kV INSULATION TESTER

Output adjustable from 1 to 40kV in two ranges. Current at which the relay will trip is adjustable from 1 to 250µA, 100-150V and 200-250V A.C. mains operation. Fully overhauled and guaranteed £95 0 0

SIGNAL GENERATORS

MARCONI "STANDARD" TF-144G, 85kc/s to 25mc/s output 1µV to 1V £85 0 0
MARCONI TF-390G, 16-150mc/s., output .1µV to 100 mV. £35 0 0
MARCONI TF-517F, 18-58mc/s and 150-300 mc/s., output 200mV max £35 0 0
TYPE 101, 400 to 650mc/s, output 30mV max £55 0 0
GENERAL RADIO TYPE 804, 7.5 to 330mc/s, outpnt 1µV to 20mV £65 0 0
MEASUREMENTS CORPORATION TYPE 84. 300-1000mc/s direct calibration, output .1µV to 100mV, CW. Sinewave or squarewave. Internal sinewave model at 400, 1000 and 2500 c/s. Internal pulse modulation at 60 to 100,000 c/s with variable width and phasing £220 0 0
HEWLETT PACKARD LAE-2, 520-1300mc/s CW or pulsed. Output 1µV to 100mV. Pulse modulation at 60 to 2500c/s with variable width and phasing £135 0 0
BC-1277 10-cm range, 2700-3400mc/s. Comparative measurements of CW and peak-power £85 0 0
TS-14, 10-cm. range, 3200-3370mc/s. Pulsed output with variable width and phasing. Power measurements of 20-200mW. £50 0 0
TS-45, 3-cm. range, 8700-9525mc/s. Power measurements range 0 to 5 Watts. Calibrated frequency meter. Power output 10mW. £45 0 0
TS-35, 3-cm. range. 8700-9500mc/s. Peak output 1mW. Power measurements range 1mW to 2W £75 0 0
TS-13, 3-cm. range, 1305-9445mc/s. Pulsed output with fully adjustable width and phasing £80 0 0

All Prices are Ex Our Warehouse. Packing and Delivery Charged at Cost.

MAINS TRANSFORMERS

Parmeko EHT Filament Transformers.
Input 100/125V. and 200/250V.; output 6.3V. at .3A and 4V. at 1.1A., Test Volts 1200; 4V at .5A, Test Volts 4250; 4V. at 2A. and 4V. at .5A. Test Volts 2500 27/6 P.P. 3/6.

Power Transformer. Input 220V.; output 310-0-310V. at 120mA. and 5V. at 3A. 25/- p.p. 2/-.

Power Transformer. Input 100 to 250 V.; output 275-0-275V. at 80mA., 6.3V. at .6A. and 6.3V. at 2.5A. 17/6 p.p. 2/6

Gardner or Parmeko Power Transformers.
Input 200-250V.; output 350-0-350V. at 70mA.; 6.3V. at 1A.; 6.3V. CT at 3A. and 6.3V. at 3A. 25/-, p.p. 2/6.

Gardner Power Transformers.
Input 200-250V.; 450-0-450V. at 250mA. DC; 6.3V. at 3.5A.; 6.3V. at 8A.; 6.3V. at 10A.; 5.0V. at 6A. The last three outputs have test voltage of 4000V. to earth, 80/-, p.p. 10/-.

Gresham Power Transformers
Input 110/200/230V.; output 6.3V. at 1A.; 6.3V. at 2.5A.; 480V. at 100mA. DC; 6.3V, at 2A.; 5V. at 3A. 30/-, pp. 4/6

MINIATURE AND MIDGET RELAYS.

STKX-20 (Allied Control), 2C.O. contacts at 2 Amps., 300Ω Coil, Operating current 35 mA., release 20 mA. 5/;
55251 (RBM), 1M contact at 1 Amp., 270Ω Coil, Operating current 35 mA., release 10 mA. 3/6
55252 (RBM), 3M contacts at 1 Amp., 270Ω Coil, Operating current 45mA., release 25 mA. 5/-
55836 (RBM), 1 CO contact at 2 Amps., 300Ω Coil, Operating current 40 mA., release 20 mA. 3/6
S.T.C. Relays, secondhand, in good condition and guaranteed; Overall dimensions 1¼in. × 1¼in. × ⅝in.
1M contact at 5 Amps., 250Ω Coil. Operating current 40 mA., release 15 mA. 6/6
2 C.O. bifurcated contacts at 500 mA., 700Ω Coil, operating current 16 mA., release 5 mA. 7/-

HIGH SPEED RELAYS

SIGMA TYPE 4C1 OR ALLIED TYPE G.
1B 1 Amp. contact, 5,000Ω coil. Current 4 mA. ± .5 mA. Will operate with change of current of .2 mA. Secondhand 5/6
STEVENS ARNOLD TYPE 358 MILLISECOND.
Sealed, Octal Base, 24 V. 1,400Ω Coil, 1 C.O. contact 17/-
SIEMENS TYPE HIGH SPEED SEALED RELAYS.
1 C.O. 500 mA. contact. Twin Coil 2×145Ω. Operating current 15 mA. with coils in series and 30 mA. with coils in parallel. Secondhand 5/-

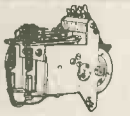
P.O. RELAYS—SECONDHAND, GUARANTEED.
Type 600, 600Ω Coil, 2 CO contact 6/6
Type 3000. 500Ω Coil, 2 CO contacts 7/6

TYPE 3 POWER UNITS

Mains operated rack mounted fully smoothed rectifier power unit providing adjustable H.T. voltage from 180 to 270 V. at 100 mA. and 6.3 V. A.C. at 4 amps. H.T. voltmeter and milliammeter are provided on the front panel.
PRICE, fully guaranteed £3 10 0
Packing and carriage 15 0

WESTINGHOUSE SELENIUM RECTIFIER POWER UNITS

Input 115/230 V., fully smoothed and fused. Output adjustable from 80 to 140V. D.C. by means of fine and coarse tap switches in the secondary winding. Maximum current 400 mA. continuous. Dimensions: 17¼in. × 10½in. deep × 3½in. high .... p.p. 7/6 40/-



RATCHET MOTORS 12v.

1 Amp. (Impulse Motors) 5.75 ohms .... 3/6 each
Packing and postage 1/6

STILL AVAILABLE—LIMITED QUANTITY ONLY

RECEIVER CHASSIS BC-624 (from SCR-522 Transmitter-Receivers). 4 Crystal channels in the range 100-156 mc/s Valves: RF stage 9003, Mixer (9003) three IS Stages (12SG7), Detector/AVC/Audio (12C8), Second Audio (12J5GT), Oscillator 9002, Harmonic Generator (9002), Harmonic Amplifier (9003). High and Low Impedance Output. PRICE, complete with valves, with Squelch Relay removed, with circuit diagram.
Now available without valves only at 7/6. P.P. 3/6.
For valves see below.
We regret we have no more transmitter chassis in stock.

REVERSIBLE 12V D.C. MINIATURE MOTORS IDEAL FOR MODELS AND MINIATURIZED CONTROL CIRCUITS.

Delivers approx. 5 Watts power at 7,000 r.p.m. Dimensions 1⅝in. long × 1⅛in. dia. Shaft extension .077in. dia. × .4in. long. Centre-off reversing switch integral with the motor. Self-lubricated sintered bronze bearings. Brand new .... 15/6 post free.

SUB-CHASSIS FROM TR-1985 AIRCRAFT CRYSTAL CONTROLLED 10-CHANNEL TRANSMITTER-RECEIVER

Transmitter Chassis Type 81.
Frequency range 100-125 mc/s. Consists of 4.86 mc/s. crystal oscillator (CV-136) coupled to Balanced Modulator (two CV-138) to which a signal at half the final receiver frequency is applied. After mixing the resulting frequency is doubled at CV136, A.F. modulated at QV04-7 and finally amplifier at TT-15, PRICE, complete, but less valves .... 3/6, p.p. 2/9
Modulator Chassis. Consists of microphone amplifier CV131. Telephone Amplifier CV-136, and push-pull audio amplifier—two CV-133. Less valves 5/-, p.p. 2/-.
Receiver Chassis type 114.
Frequency range 100-125 mc/s. Consists of crystal oscillator tuned to the third harmonic, CV-136, trebler, CV-136 and doubler CV-138, tuned RF stage CV-138 and Mixer CV-138. Less valves .... 5/-, p.p. 2/6
I.F. Amplifier Chassis. Three stage IF Amplifier—two CV-131 and one CV-138. Detector and AVC Diode CV-140, Squelch valve CV-138 and AVC Amplifier CV-138. Intermediate frequency 9.72 mc/s. Band width 90 kc/s. Less valves .... 5/-, p.p. 3/6
For valves see list below:
All complete with circuit diagrams.

also available
DYNAMOTOR UNITS from the above sets. Input 24/28V. DC Output 250V. HT fully smoothed, at up to 200 mA. and Grid Bias supplies of—50V. At one end of rotary transformer the channel change drive mechanism is mounted. PRICE .... 17/6, p.p. 5/-

METERS

50μA DC MC 2½in. Rd. Proj. Mtd. 45/-
200μA DC MC Rd. Fl. Mtd., 2in. 32/6
200μA DC MC 2½in. Sq. or Round Fl. Mtd. 35/-
1mA FSD Marion Electric Signal Strength Meter, 2in. Rd. Panel Mtd., M.O., calibrated from 0 to 20 S units and from 0 to 20 dB above 20 S units, translucent illuminated scale 45/-
1 mA FSD DC MC 2in. Rd. Panel Mtd., Black scale, calibrated 0-3V/0-30mA. 30/-
1-0-1 mA DC MC 2½in. Rd. Fl. Mtd., Sealed, calibrated 0-100/200/400 Volts/mA. 22/6
50-0-50 mA DC MC 2½in. Rd. Fl. Mtd., SIFAM.. 22/6
2A DC MC 2½in. Rd. Fl. Mtd. 25/-
5A DC MC 2½in. Rd. Fl. Mtd. 25/-
150V AC MI 2½in. Rd. Fl. Mtd. 20/-

TESTED and GUARANTEED VALVES

Type	Price	Type	Price	Type	Price
OA2 ..	6/-	4D32	100/-	6SL7GT	6/6
OA3 ..	10/-	5B/502A	80/-	6SN7GT	4/-
OB2 ..	6/-	5C22	120/-	6SQ7	6/-
OB3 ..	8/-	5R4GY	9/-	6SS7 ..	3/-
OC3 ..	5/6	5T4 ..	9/-	6V6G	5/-
OD3 ..	5/6	5U4G	5/-	6V6M	9/-
OZ4 ..	5/6	5V4G	10/-	6X4 ..	5/-
1A3 ..	3/-	5Y3GT	6/-	6X5GT	5/-
1AH4 ..	5/-	5Z3 ..	7/-	6Y6G	6/-
1B24	30/-	5Z4M	9/-	6Z4 ..	6/-
1B32 ..	5/-	6A6 ..	5/-	7C7 ..	5/-
1B35A	20/-	6A7 ..	9/-	7E5 ..	5/-
1B40	10/-	6AC7	3/-	7F7 ..	5/6
1B41	50/-	6AG5	3/6	7Z4 ..	4/-
1B44	40/-	6AG7	7/6	12A6 ..	3/-
1B63A	70/-	6AK5	5/-	12AH7GT	5/-
1E7G	5/-	6AK6	7/-		
1G6GT/G	7/-	6AL5	4/-	12AT7	6/-
1L4 ..	3/6	6AM5	4/6	12AU7	6/-
1LA6 ..	6/-	6AM6	4/-	12AX7	7/-
1LD5	6/-	6AN5	15/-	12C8 ..	3/-
1LN5	5/-	6AS7G	20/-	12H6 ..	2/-
1Q22	100/-	6AT6	5/-	12J5GT	3/6
1R4 ..	6/-	6B4G	10/-	12K8	8/-
1R5 ..	6/-	6B8 ..	6/-	12SA7	7/-
1S4 ..	6/-	6BA6	6/-	12SG7	3/-
1S5 ..	6/-	6BE6	6/-	12SH7	3/-
1T4 ..	4/-	6C4 ..	2/6	12SK7	5/-
1T5GT	6/-	6C5G	5/-	12Y4 ..	2/6
1U5 ..	6/-	6C6 ..	4/-	13D1 ..	5/-
1V	4/-	6C8G	7/-	25L6GT/G	
2A3 ..	5/-	6CH6	6/-		8/-
2C26A	5/-	6E5 ..	7/-	26A6 ..	20/-
2C34 ..	4/-	6F6 ..	5/-	28D7	7/-
2C39A	90/-	6F7 ..	6/-	32	6/-
2C42	25/-	6F8G	6/6	35T ..	17/6
2C43	42/6	6F33	7/-	39/44	3/-
2C51	15/-	6G6G	2/6	53A ..	3/-
2C52	12/-	6H6 ..	1/6	75	5/6
2D21 ..	6/-	6J5 ..	4/6	76	5/-
2X2 ..	4/-	6J5G	4/-	83	10/-
3A4 ..	5/-	6J6 ..	3/6	83V ..	9/-
3A5 ..	5/-	6K7 ..	4/-	85A1 ..	9/-
3B24 ..	5/-	6K8 ..	9/-	100TH	60/-
3B26	20/-	6L5G	6/-	559 ..	3/-
3B29	30/-	6L6GA	7/6	703A	30/-
3C45	30/-	6L6M	9/-	705A	15/-
3CX100A5		6L7 ..	5/-	717A ..	4/-
	200/-	6N7 ..	6/-	807 ..	6/6
3D6 ..	4/-	6R7 ..	6/-	813 ..	60/-
3Q4 ..	7/-	6SA7GT	7/-	815 ..	40/-
3V4 ..	6/6	6SH7	4/-	829 ..	25/-
4B28	15/-	6SK7	5/6	845 ..	25/-
4B31	120/-	6SK7GT	5/-	866A	10/-

CATHODE RAY TUBES

Type	dia.	Vh	Va_1	Va_2	−Vg	Screen	Focus	Defl.	Price
3JP1	3	6.3	690	2000	90	green	ES	ES	40/-
5CP1	5	6.3	575	2000	60	green	ES	ES	30/-
5FP7	5	6.3	250	7000	45	green/yell.	ES	EM	10/-
5SP7*	5	6.3	430	1500	45	green/yell.	ES	ES	140/-
7BP7	7	6.3	250	7000	45	green/yell.	ES	EM	40/-
CV956**	11½	4.0	1700	1200	50	green/white	ES	ES	15/-
DG7-5	2¾	6.3	—	800	—	green	ES	ES	55/-

*Twin gun tube.
**Complete with mu-metal screen.
STEEL SCREENS FOR 3in. TUBES, 5/-, p.p. 9d.
ALSO AVAILABLE: 3DP1, 3JP1, 3EG1, 5AP1, 5JP1. 12SP7, MX2, O9D, O9J.

KLYSTRONS

Type	CV No.	Vh	V.Res.	−V. Refl.	IamA	Input W	Output mW	Frequency Mc/s.	Base	Price
—	CV35	4.0	1,250	275	8.0	10	100	3,033 mean	I.O.	£5
—	CV36	4.0	1,500	230	—	10	150	2,760-2,924	—	£6
—	CV67	4.0	1,200	0	—	10	100	3,226-3,370	—	£5
KRN2A	CV129	4.0	1,600	420	—	10	75	9,375 mean	I.O.	£4
KRN3	CV217	4.0	1,350	255	7.4	10	15	9,738 mean	I.O.	£3
	CV228	6.3	220	—	500	—	450	4,615 mean	B7G	£9
KRN6/3	CV238	4.0	250	138	—	8	100	3,030 mean	I.O.	£5
726A	CV676	6.3	330	400	—	—	100	3,290 mean	—	£4
707B	CV1768	6.3	300	300	—	—	140	3,315-3,680	I.O.	£3
723A/B	CV1795	6.3	330	400	—	—	20	8,702-9,548	I.O.	£2/10
417A	CV2642	6.3	1,000	200	40.0	50	50	2,650-3,300	I.O.	£2
2K25	CV2792	6.3	300	400	—	—	32	8,500-9,660	I.O.	£4
2K33	—	6.3	1,800	150	—	—	40	2,200-25,000	—	£45
6BN6	—	6.3	—	—	—	—	50	580-3,800	—	£10

ALSO AVAILABLE 2K28, 2K22.

MAGNETRONS

Type	Vh	IhA	Vapk	Iapk	Field Gauss	Frequency mc/s.	Output	Price
2J27	6.3	—	22,000	30.0	2400	2,965-2,992	240kWpk	£2/10
714A/Y	6.3	1.5	22,000	22.0	2250	3,300 mean	—	£5
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VALVE cartons by return at keen prices; send 1/- for all samples and list.—J. & A., Boxmakers, 75a, Godwin St., Bradford, 1. [0172

RECLAIMED valves, all tested and perfect, modern and obsolete, huge stocks, all one price, 5/-, plus 6d postage each; delivery by return; also surplus new valves, guaranteed; s.a.e. for list.—Lewis, 46, Woodford Ave., Ilford, Essex. [9463

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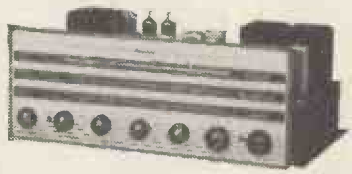

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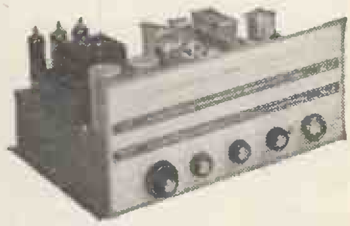

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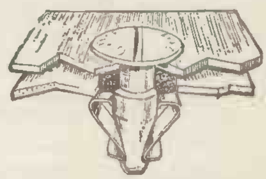

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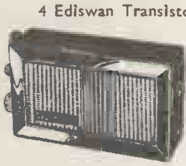

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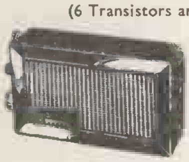

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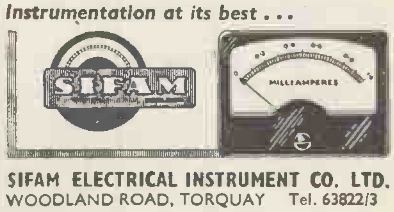

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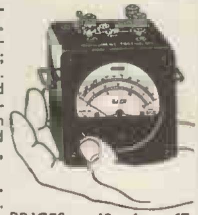

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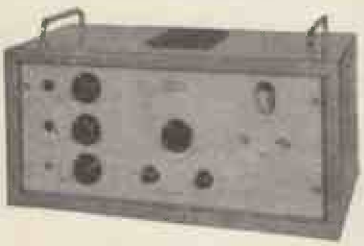

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Please write in block letters with ball pen or pencil.

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TS117GP	S Band Frequency Meter	325.00
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TS270	Echo Box	175.00
TS270A	Echo Box	175.00
TS270B	Echo Box	225.00
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TS419	L Band Signal Generator	895.00
TS488A	Echo Box X Band—New	495.00
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UPM 30, 33 Radar Test Sets.. Prices on Request.
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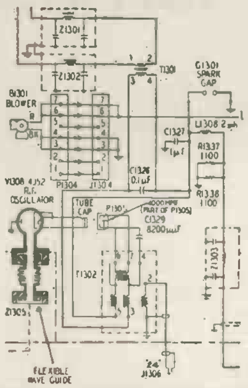
APT2	75.00		
APT5	180.00	APS31 PARTS	

COMPLETE RADAR RECEIVER TRANSMITTER

MAGNETRON TRANSMITTER



APS23 RADAR

Consisting of:

Microwave Plumbing 35 TUBES, including 4J52 Magnetron 2 Klystrons also 3 Silicon crystals, 2 Germanium diodes 7 Relays and countless other parts.

Motor with blower, various transformers, 60 megacycles IF Strip, 10 MC bandwidth etc.

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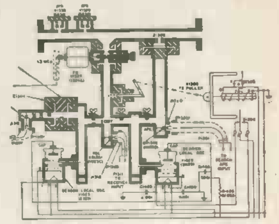

(Government cost for tubes alone over 500 dollars.) Your price with all tubes as above **$195.00**

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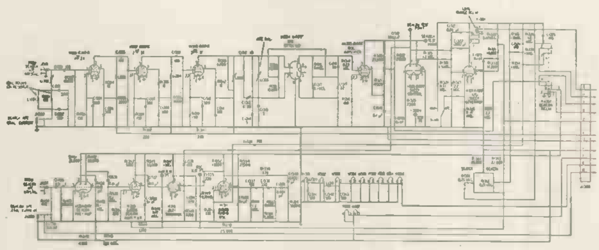
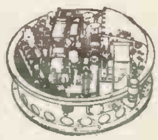
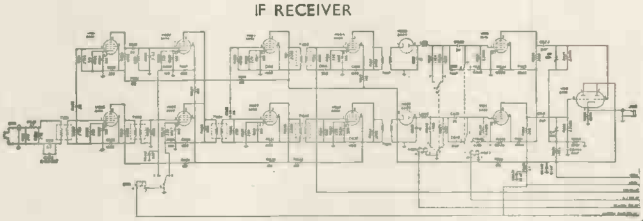




OPEN and CLOSED VIEWS of APS-23 and circuit diagrams illustrated

IF RECEIVER



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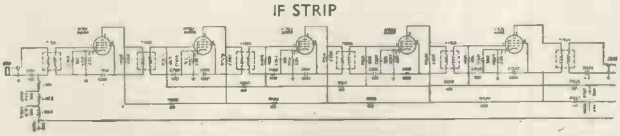

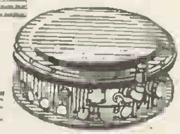

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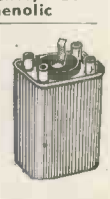

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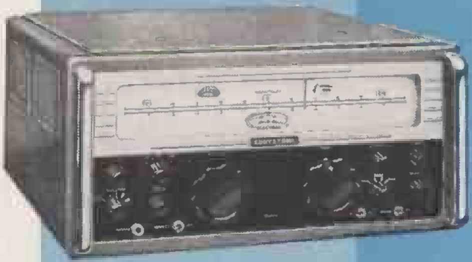

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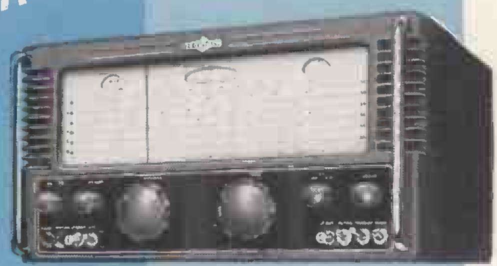

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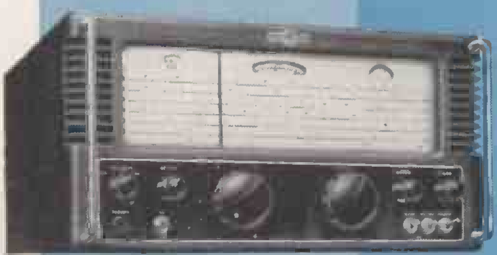

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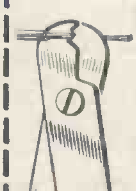

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