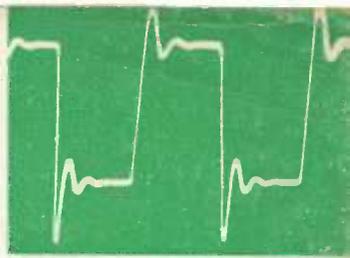


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I. DESIGN REQUIREMENTS

Wireless World



**ELECTRONICS
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MARCH 1963 Price Two Shillings and Sixpence





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ELECTRONICS, RADIO, TELEVISION

MARCH 1963

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- 105 Editorial Comment
- 106 Transistor Bias Networks *By T. Ormond*
- 109 Direct-coupled Pulse Circuits *By R. Thompson*
- 111 Books Received
- 112 Paris Components Show
- 114 Citizens' Radio in U.S.A. *By R. L. Conhaim*
- 115 H. F. Predictions—March
- 116 World of Wireless
- 118 Personalities
- 120 News from Industry
- 121 *Wireless World* Oscilloscope—1
- 128 Aerospace Telemetry
- 129 Physical Society Exhibition 1963
- 134 Letters to the Editor
- 137 Oscillators: a Monastic Approach—3 *By T. Roddam*
- 142 Manufacturers' Products
- 145 Nonconductor Valves *By "Cathode Ray"*
- 148 Transistor Amplifier Output Stages—3 *By O. Greiter*
- 152 Unbiased *By "Free Grid"*
- 154 March Meetings

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CONTROLLED WARM-UP TIMES

FOR TELEVISION SERIES HEATER CHAINS

All Mullard valves designed for operation in television series heater chains now possess equalised heating characteristics. These characteristics obviate damage to the valve heaters during the warm-up period and eliminate the need for a thermistor.

The voltage developed across one heater of a series heater chain depends almost directly on the resistance of that heater. The resistance of the heaters depends on their temperature, and is greater when the valves are hot than when they are cold. When a receiver is switched on, if one valve warms up more rapidly than the rest, the effect on the current will not be appreciable, but the increase in the voltage developed across the heater of that valve can exceed the amount (50% above the nominal heater voltage) which can be tolerated during the warm-up period. This can shorten the life of the valve considerably, and to prevent it, heater chains have normally been designed to incorporate a thermistor.

The resistance of a thermistor is high when it is cold, but falls as heat is generated in it by the heater current. The thermistor thus reduces the rate of increase of the heater current, and prevents unequal rises in the temperature of the heaters from producing an excessive voltage across any heater.

The rate at which the temperature of a valve heater rises depends very much on the mounting of the heater in the valve. Any point of contact between the insulated heater and the surrounding cathode sets up a small drainage of heat away from the heater and thus retards the rate at

which the temperature rises. Since the space inside the cathode is small, it is difficult to ensure consistent positioning of the heater within the cathode, so that the number and extent of these contacts, and therefore the rate at which the heater temperature rises, can vary considerably from one valve to another. Now, however, Mullard have developed accurate and carefully controlled methods of manufacture which produce equalised rates of temperature rise in all their television valves. Extensive tests with a large number of valves in typical heater chains have shown that these equalised heating properties ensure that, without added protection, the voltage developed across any heater will not exceed the permitted 50% above nominal during the warm-up period. Use of Mullard television valves thus enables heater chains to be designed without a thermistor, and this, in addition to the obvious economy, leads to shorter warm-up times and a faster appearance of the picture on the screen.

WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

MULLARD MINIATURE ELECTROLYTICS

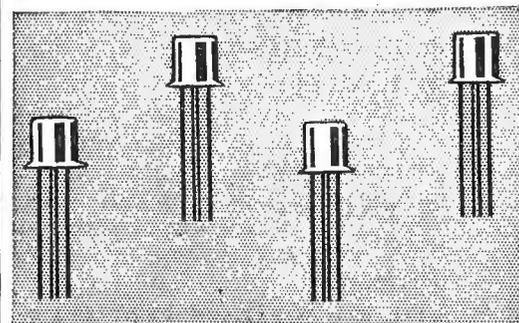
8 Values in the New Can Size 2½

Mullard miniature electrolytic capacitors of the C426 series are a proven success in modern transistor radio receivers, and the group of capacitors recently added to the series offers even better coverage of the already wide range of sizes and values available. The capacitance and working voltage values of electrolytic capacitors are linked closely with the size of the component. The original

Mullard C426 series consisted of five can sizes, each of which offered eight combinations of capacitance and working voltage. A new can size—can size "2½"—has now been added to the series, so that a further eight combinations of capacitance and voltage are now available. As the designation implies, can size 2½ lies between can sizes 2 and 3. It has the same length of 10.7 mm., as can size 2

NEW MINIATURE TRANSISTORS FOR POCKET PORTABLES

A new Mullard range of miniature transistors has recently been introduced for pocket-size portable radios. These very small transistors—the AF124, AF125, AF126 and AF127—have been evolved as a continuation of the Mullard contribution to miniaturisation which began with the well-known OC44 and OC45 alloy-junction transistors.



Early transistor sets were restricted to the long and medium wavebands but short-wave and v.h.f. operation became feasible with the improved frequency performance of transistors manufactured by the alloy-diffusion technique. The first of these r.f. transistors to be introduced by Mullard were the OC170 and OC171, but these were superseded by the now-established AF114, AF115, AF116, and AF117—a series that was soon accepted as fulfilling the h.f. requirements of all forms of portable receiver.

The new series is a miniature counterpart of the AF114 series: the electrical properties are identical, but the transistors are only a quarter of the size. All the many advantages of the alloy-diffusion technique are retained, but considerable economy of space is afforded. These benefits are reflected in the smaller size and improved performance of the latest pocket portables.

compared with the 18.7 mm. of size 3. Its diameter of 6.3 mm. compares with the 5.0 mm. of size 2 and the 6.8 mm. of size 3. As with the other sizes in the C426 range, the eight working voltages follow the logarithmic series: 64, 40, 25, 16, 10, 6.4, 4.0 and 2.5V, and the corresponding values of capacitance are 3.2, 6.4, 12.5, 20, 32, 40, 50 and 64μF. The tolerance on these values is -10% and +50%. The electrical properties of the new capacitors are identical with those of the original capacitors, and in common with the whole range, the capacitors in can size 2½ offer a long and trouble-free service life.

MVE/CA103I

Making and Doing

THIS journal is a meeting place for all interests in the world of radio and electronics. We cover a wide field not only of subject matter but of motives for interest in these subjects. A recent survey showed that 60% of our readers were gainfully employed in the electronics industry, while the remaining 40% were following their natural interest solely as a hobby. There is no hard line of demarcation between these categories and many of our readers have specialist interests in one branch of the subject as professionals and in others as amateurs. No reader is ever likely to be satisfied with the proportion of each issue devoted to his subject(s), but if we cannot supply the quantity we can at least attend to the quality. We are helped in this by pressure on space, which forces us to be selective. At the same time we try to preserve a proper balance between conflicting demands and to adjust our contents to changing needs.

We are grateful to those readers who from time to time write with criticisms and suggestions, and it is clear from their letters that more constructional articles would be welcome—not, as in the early days of broadcasting, as a means of building a receiver cheaper than a proprietary make (those days are long past) but for the satisfaction of proving theory by experiment and for the sense of achievement which comes from building a piece of hardware with one's own hands. Complaints that we have neglected the home constructor and become a "high-brow" journal are often made. True, we have followed the growing complexity of our subject, but a check on the contents of last year's volume shows that there was at least one constructional article in 11 of the 12 issues.

Many of our constructional articles have come from outside contributors whose background is known to us and whose competence is not in doubt. Some (e.g., Williamson) have achieved world-wide fame, but it is with the more plentiful supply of good sound wine, rather than the occasional vintage (which will, in any case, take its own time to appear) that we are primarily concerned.

To provide more of the "right-stuff" we must help ourselves, and to this end we have recently overhauled our own laboratory facilities and brought them up to date with a background of

modern professional measuring equipment. We intend to supplement these with a range of sound, but less expensive, measuring instruments which we shall design and make ourselves with the kind of tools which the average enthusiast can afford and knows how to use.

This work will be undertaken as much for our own satisfaction as for our readers' and we look forward to working together on the many interesting projects which we shall think up between us.

In deference to the often expressed wish of a majority of readers interested in construction we shall start with test instruments. The equipment which we are developing will not compete either in cost with the cheapest commercial instruments or in performance with professional laboratory standards, but our designs will be adequate for most needs and will aim to bridge the gap and combine some of the advantages of both these extremes. Their greatest value will be in the satisfaction they give in the building and the confidence with which they will be handled when finished. Any faults which may develop at some future date will be much easier to trace and rectify in an instrument one has built oneself.

We are starting with a comparatively ambitious oscilloscope, because we think this is not only fundamental as a measuring instrument, but is most rewarding in the variety of observations which can be made with it. Other equipment—some simpler, some more complex—will follow, and as far as possible transistors will be used. It is also planned to build to a standard modular form, so that eventually the units can be used separately or rack-mounted to form a comprehensive test console.

In embarking on this new series of *Wireless World* Test Instruments we are not breaking with any of the principles which have guided us in the past. On the contrary, we are making a slight shift of emphasis to restore the balance of the whole so that we can continue to serve all who have an interest in radio and electronics at any level. We think that the young man who has built his own instruments as an amateur will have better judgement as a professional when it comes to selecting the right kind of equipment for advanced research and development.

Transistor Bias Networks

SIMPLE DESIGN PROCEDURE

By T. ORMOND*

THIS paper is written for the technician or hobbyist in an attempt to fill the void of transistor bias network design. The theory of bias networks can be found in numerous textbooks and has been the subject of many magazine articles. A most serious drawback to the existing literature (as far as the technician or hobbyist is concerned) is that the articles are usually oversimplified with poorly-explained assumptions, while the textbook material is too involved in mathematics and theoretical derivations to be of practical value to the hobbyist or technician.

Because of the wide variety of transistor circuitry, it will be necessary to restrict our discussion somewhat. We will discuss the biasing of a Class A amplifier. Because of its popularity and wide-spread usage, we will use the common-emitter connection in our design example.

Two of the most important criteria for a well-designed bias network are the resultant stability factor and the degree to which the amplifier can be made insensitive to transistor replacement. (The stability factor is a measure of an amplifier's ability to maintain a given set of bias conditions over a range of operating temperatures.) The transistor is a temperature sensitive device, particularly with respect to the collector cut-off current I_{c0} (I_{cbo}) and the input voltage V_{be} . The collector cut-off current will approximately double for every 10°C rise.

In the common-emitter connection, Fig. 1, the collector current is given by the equation:

$$I_c = \beta I_b + S I_{c0} \quad (1)$$

where β is the common-emitter current gain and S is the stability factor (for good stability, S should be low—the ideal being $S = 1$). If the stability factor is high and any great degree of temperature variation is experienced, the change in I_c could be large enough to cause the circuit to become inoperative. There is nothing we can do about the leakage current of any given transistor, this current being inherent in the device, but we can make the stability factor such that the circuit can withstand the expected temperature variation. The amplifier shown in Fig. 1 offers a good degree of stability with minimum sacrifice in other circuit parameters. For this circuit and most circuits, the stability factor is:

$$S = \frac{\beta + 1}{1 + \frac{\beta R_e}{R_b + R_e}} \quad (2)$$

where $R_b = R_1 R_2 / R_1 + R_2$. Examining equation (2), we can see that poor stability results when R_e approaches zero (S approaches $\beta + 1$) and ideal stability results when R_b approaches zero (S approaches 1). We will later show that this ideal stability is unrealisable in the circuit of Fig. 1. The degree of stability designed for will depend

upon the application, but a useful "rule of thumb" for highly stabilised circuits is:

$$S \leq 5 \quad (3)$$

Circuits which possess good temperature stability are usually also insensitive to transistor replacement problems. This is especially true of the circuit of Fig. 1. Obtaining the base bias voltage by means of a resistive divider essentially makes the circuit independent of transistor parameters. For the circuit of Fig. 1, the base bias voltage V_b is given by:

$$V_b = \frac{V_{cc} R_x}{R_1 + R_x} \quad (4)$$

$$\text{where } R_x = \frac{R_2 (\beta + 1) R_e}{R_2 + (\beta + 1) R_e}$$

As shown in equation (2), good temperature stability requires that the ratio R_b/R_e be small. Thus, in most cases, βR_e will be many times larger than R_2 and R_x nearly equals R_2 . Equation (4) then becomes

$$V_b \approx \frac{V_{cc} R_2}{R_1 + R_2} \quad (5)$$

Equation (5) gives V_b in terms completely independent of the transistor. We can also assume that V_b equals V_e (V_b will be greater than V_e by the magnitude of the voltage drop across the forward biased base-emitter diode, a matter of tenths of a volt). Since the value of V_e is independent of the transistor, I_e will also be independent ($I_e = V_e/R_e$), greatly reducing any change in I_c due to transistor replacement. Assumptions usually make the actual case worse than the ideal, so our operating point will not remain as stable as the foregoing discussion would indicate. However, operating-point shifts due to transistor replacement will be greatly alleviated in a circuit of the type shown in Fig. 1. The problems concerned with stability can be

reduced by a wise choice of the quiescent (d.c.) operating point, a choice which we will now discuss.

Fig. 2 shows the common-emitter output characteristics of an n-p-n transistor. It is a plot of collector to emitter voltage (V_{ce}) versus collector current (I_c) for various values of base current (I_b). Values of V_{ce} and I_c should be chosen so that the operating point Q is in the linear range of the characteristic

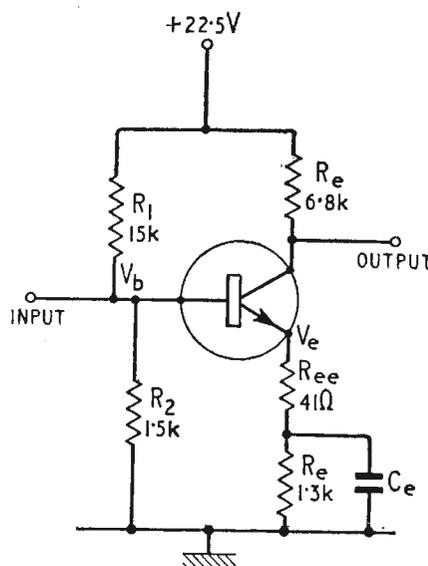


Fig. 1. Stabilisation by potential divider and emitter resistor.

*Sylvania Semiconductor Division, Woburn/Mass. U.S.A.

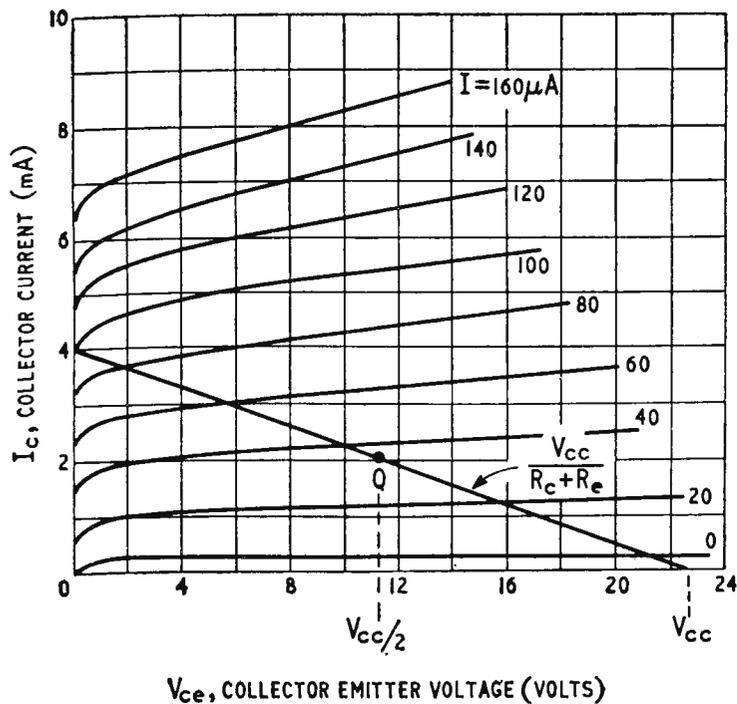


Fig. 2. Output characteristic of common-emitter n-p-n transistor.

curves (the point Q shown on the figure has no meaning other than to demonstrate operating point placement). It can be shown, by means which need not be discussed here, that the optimum condition for temperature stability is when $V_{ce} = V_{cc}/2$. In some instances, such as in direct-coupled stages, it is not always possible to meet this criterion, but the relationship $V_{ce} = V_{cc}/2$ should be met as nearly as possible (standard resistance values may make an exact match impossible). Establishing the operating point is now reduced to determining the value of I_c . There are several factors to be considered in selecting a value for I_c ; stage gain and collector dissipation to mention two. The amplifier gain will depend on I_c , since β is to some extent a function of collector current. Entertainment type transistors are normally used in low-voltage circuits, so appreciable β 's will be found at low collector currents (1-3mA range). A value of I_c must be chosen to give good β but care must be used to insure that it places the operating point in the linear region of the characteristic curves. The supply voltage must also be considered. Its value will probably be dictated by existing circuitry to which we are adding a stage, or by available standard batteries. Meeting the criterion of $V_{ce} = V_{cc}/2$ will allow only $V_{cc}/2$ to be dropped across R_c and R_e . Thus, choosing a high value of I_c to obtain a good β could make R_c so small as to adversely affect stage gain. It naturally follows that the higher the available supply voltage (short of the value that would make V_{ce} greater than the breakdown voltage of the transistor), the greater the latitude in the choice of collector current. The collector power dissipation must also be considered when choosing I_c . The dissipation limit of some transistors may be as low as 25 mW. If we have a V_{cc} such that $V_{ce} = 10$ V, then the maximum collector current, from the equation

$$P_c = V_{ce} I_c \quad (6)$$

would be 2.5 mA. It is evident that the choice of I_c is governed by many factors. In the design procedure outlined in this paper, I_c is determined from values of R_c and R_e which have been calculated from gain and stability considerations. Although this may seem

to be a haphazard way of choosing I_c , the design procedure will show that this is not the case.

Before proceeding with a design example, we must consider a factor which complicates our stability considerations; namely, the input circuit loss factor. Fig. 3 shows the equivalent a.c. input circuit of our amplifier of Fig. 1. r_i , the a.c. input resistance of the transistor, is given by the equation:

$$r_i = r_b + (\beta + 1) R_e \approx (\beta + 1) R_e \quad (7)$$

where R_e is equal to $r_e + R_{ee}$. R_{ee} is equal to any external resistance which is not a.c. by-passed and r_e is the internal emitter resistance, approximately:

$$r_e = \frac{26}{I_e \text{ (mA)}} \Omega \quad (8)$$

We are interested in getting maximum signal power transfer from the source (i.e., a signal generator or the output of a previous stage). In other words, we want $v_2 i_b$ to approach $v_g i_g$ as nearly as possible. The best condition we can obtain is when $r_i = R_g$ in which case $v_2 i_b$ will equal $v_g i_g / 2$ (this represents a 3 dB power loss). This could most easily be accomplished by making $r_i = R_g$ and then making R_b large enough ($R_b > 10 r_i$) so that it will have negligible effect on r_i . This arrangement would pose serious stability problems, however, as well as curtailing the gain possibilities of the amplifier. We have previously noted that for good stability, the ratio R_b/R_e should be small. Now although it is true that r_i is an a.c. resistance, and as such will not necessarily include the full value of R_e , making r_i equal to R_g could make R_b very large when R_g is large (since R_g could be the output resistance of a previous stage, it could vary from the low value of a common-collector to the moderately high value of a common-emitter stage). To get good stability with a large value of R_b , we must make R_e large which in itself is no problem (since in the majority of cases it will be a.c. by-passed). The problem arises when we consider stage gain, which is approximately:

$$A_v = \frac{R_c}{R_e} \quad (9)$$

where R_e is as defined in equation (7). If we desire a high gain from our stage, the ratio R_c/R_e must be large (40 dB would make the ratio equal to 100). Since it is desirable to make V_{ce} equal to $1/2 V_{cc}$, we are faced with the problem of dropping $1/2 V_{cc}$ across the resistances R_c and R_e , both of which will be large (R_c from gain and R_e from stability considerations). This would lead to a low value of I_c which is a condition we do not want. It is evident, therefore, that unless we require a low gain or the source resistance is low, we must accept some loss in our input circuit. The question is, how much loss? Table I shows the degree of loss experienced for various mismatch conditions. Since we cannot avoid a 3 dB loss, we will not consider this loss in

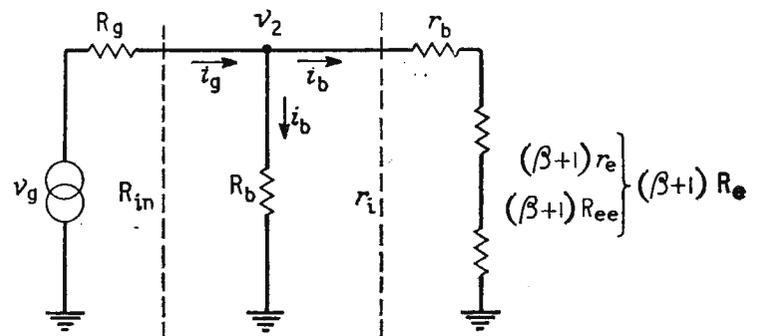


Fig. 3. Equivalent circuit of Fig. 1 amplifier.

our calculations. What we must decide is how much loss, over and above the unavoidable 3 dB, we shall accept in our input circuit. From Table I, we see that if R_{in} equals $R_g/7$, we will have a 6 dB loss in our input circuit (excluding the unavoidable 3 dB). This ratio will allow us to obtain good gain and stability factors without much trouble and it does not represent too severe an input circuit loss. We will, therefore, design around this input condition and define a further loss factor involving R_b and r_i :

$$K = \frac{R_b}{R_b + r_i} \dots \dots \dots (10)$$

Since the lower the ratio R_b/R_e the better, we will assign a design value to K of 0.5; in other words, we will make R_b equal to r_i . Therefore:

$$R_b = r_i = 2R_g/7 \dots \dots \dots (11)$$

will be our starting relationship. The foregoing discussion has been based on the value of β being low which will not always be the case. Any reader in a position to obtain transistors with known high β values will not be faced with the problems just discussed. The following design procedure is based on the premise that β information is not available. A low value of β is assumed which represents a "worst case" condition, a condition which insures that *at least* the objectives designed for will be obtained. If it is felt that input matching is of prime importance, then a multi-stage amplifier can be designed. A paper design will quickly confirm if a single stage will suffice for matched input or whether the ratio R_g/R_{in} can be made more stringent (less than 7/1), reducing input losses. The following example shows the simplicity of the calculations.

We will start with the following information: we require an amplifier with 40 dB of voltage gain, the source resistance is 5 k Ω , and we have a 22.5 volt battery for our power source. We will also take as our "worst case" conditions, a value of $\beta = 20$ and design for $S = 2$ ($\beta = 20$ is not unrealistically low for entertainment-type transistors). We wish to use a single stage without necessarily matching the input. From equation (11), we have:

$$R_b = r_i = \frac{2R_g}{7} = \frac{10K}{7} = 1430 \Omega \dots (12)$$

We can now rewrite equation (2), solving for R_e

$$R_e = \frac{R_b(\beta + 1 - S)}{(S-1)(\beta + 1)} = \frac{1430(19)}{21} = 1300 \Omega (13)$$

With 40 dB of gain required, equation (9) gives

$$R_c = 100 R_e \dots \dots \dots (14)$$

TABLE I

$\frac{R_g}{r_i}$ or $\frac{r_i}{R_g}$	Power Loss (dB)	Power Loss From Optimum (dB)
1	3.0	0
2	4.8	1.8
3	6.0	3.0
4	7.0	4.0
5	7.8	4.8
6	8.5	5.5
7	9.0	6.0
8	9.6	6.6
9	10.0	7.0

TABLE II

β	S	A_v (dB)	I_c (mA)	V_{ce} (volts)	P_c (mW)	Input Losses (dB)	V_b (volts)
25	1.86	40.3	1.46	10.7	15.9	8.8-5.8	1.97
50	1.96	40.4	1.48	10.5	15.6	7.9-4.9	2.0
100	1.98	40.5	1.50	10.4	15.6	7.4-4.4	2.02

From equation (7)

$$R_e = \frac{r_i}{\beta + 1} = \frac{1430}{21} = 68 \Omega \dots \dots (15)$$

Thus, from equation (14)

$$R_c = 100 R_e = 6.8 \text{ k}\Omega \dots \dots (16)$$

We can now calculate I_c

$$I_c = \frac{V_{cc}/2}{R_c + R_e} = \frac{11.25}{8.1} = 1.4 \text{ mA} \dots (17)$$

As seen from the typical characteristics of Fig. 2, an I_c of 1.4 mA places our operating point advantageously and also keeps collector dissipation low ($P_c \approx 16$ mW). The only calculations remaining are those of the resistances R_{ee} , R_1 , and R_2 . From (8),

$$r_e = \frac{26}{1.4} = 19 \Omega \dots \dots (18)$$

$$\text{Since } R_e = r_e + R_{ee} = 68 \Omega \dots \dots (19)$$

$$R_{ee} = 68 - 19 = 47 \Omega \dots \dots (20)$$

Rather than bother to calculate how to divide the value of R_e from equation (13) to give R_{ee} , we will simply add the 47 Ω in series with our calculated value of $R_e = 1.3$ k Ω (this procedure will have negligible effect on our emitter calculations). We can write the following equations for the bias network

$$\frac{R_1 R_2}{R_1 + R_2} = R_b = 1.43 \text{ k}\Omega \dots \dots (21)$$

$$\frac{R_2}{R_1 + R_2} = \frac{V_b}{V_{cc}} = \frac{V_e}{V_{cc}} = \frac{I_c R_e}{V_{cc}} = \frac{1.82}{22.5} \dots (22)$$

Equations (21) and (22) are solved to yield $R_1 = 17.7$ k Ω and $R_2 = 1.56$ k Ω . Fig. 1 shows that we have made R_1 and R_2 equal to the next smallest standard resistance values (a rather obvious choice for R_2). By making R_1 smaller, we take into account that $V_b > V_e$ and not equal to it as we have previously assumed. The completed amplifier is shown in Fig. 1, with standard resistance values for all components. Since C_e will be determined by factors not covered in this paper (desired frequency response), its value has not been calculated.

Using the principles set forth for good bias network design, we have completed the design for a common-emitter amplifier. Since several assumptions were made during the design, bench testing may indicate minor changes for improving operation. By designing around "worst case" conditions for β and S , it is felt that design objectives will be met under a wide variety of conditions. Table II shows measured circuit parameters using transistors with β 's of 25, 50 and 100. It is evident that our desire to make amplifier performance insensitive to transistor replacement has been fulfilled. By following the steps for bias network design outlined in this article, any reader should be able to design a transistor amplifier for his specific needs.

DIRECT-COUPLED PULSE CIRCUITS

GRAPHICAL DESIGN METHOD

By R. THOMPSON,* Grad. I.E.E., Grad. Brit. I.R.E.

IN many pulse circuits it is required to switch a transistor into either its fully conducting or its nonconducting state via a resistive coupling chain. A good example is the bi-stable circuit of the type shown in Fig. 1. The values of R_1 and R_2 must be chosen so that the transistors receive either sufficient base current or sufficient reverse base voltage to maintain the required states under all tolerance conditions. Satisfactory values for the resistors may be found by straightforward calculation, but this involves either surprisingly cumbersome simultaneous equations or tedious repetitive approximations. This is particularly true where the effects of several tolerances are required to be known. A graphical approach to this problem is attractive because the interaction of circuit conditions may be seen at a glance. In effect the construction replaces a series of equations with a series of lines whose implications are more readily appreciated and can be easily altered. The construction described here is extremely simple and consists entirely of straight lines.

The basic construction is shown in Fig. 2; the axes of voltage and resistance allow the circuit currents to be represented by the slope of lines drawn in the construction. Suitable manipulation of these lines will allow the required information to be obtained. For simplicity it is assumed that the bottoming voltage of VT1 and the forward base-emitter voltage of VT2 are both zero. It is required that when VT1 is nonconducting VT2 takes a base current of at least I_b and when VT1 is bottomed VT2 must be cut off by at least V_{BE} volts. The leakage current of VT2 is I_{co} .

Construction Procedure (refer to Fig. 2)

- (1) Mark off the vertical axis in volts and the horizontal axis in ohms.
- (2) On the vertical axis mark in the three supply levels V_1 , V_2 and 0. On the horizontal axis mark in R_L .
- (3) Choose a value of R_1 (see later) and mark in the point $(R_L + R_1)$.

Fig. 1. Basic bi-stable switch.

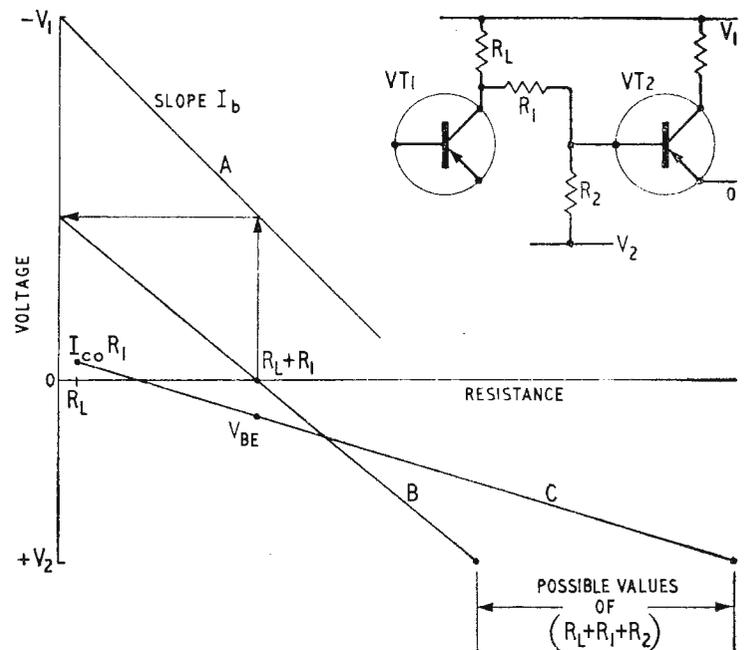
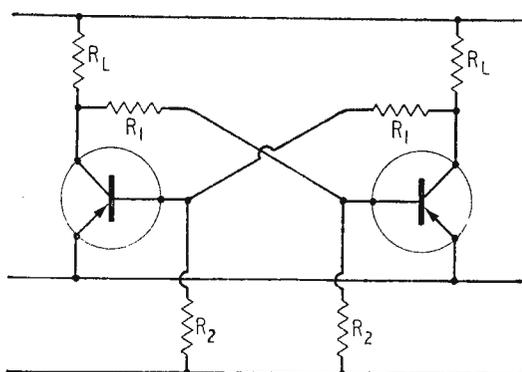


Fig. 2. Construction for R_L , R_1 and R_2 .

- (4) From point $(0, V_1)$ draw a line with slope equal to I_b (line A).
- (5) Construct back from point $(R_L + R_1, 0)$ to line A and hence draw in line B through $(R_L + R_1, 0)$. This construction subtracts I_b from the current flowing in R_1 . The slope of the resulting line is the current through R_2 and therefore its intersection with the V_2 level will give the value of $(R_L + R_1 + R_2)$. The value of R_2 given by line B is the minimum which will result in sufficient base current in VT2.
- (6) Mark in $(R_L, 0)$. Add on a further voltage $I_{co} \times R_1$, to allow for the leakage current that flows when VT2 is cut off, giving point $(R_L, I_{co} R_1)$. Mark in point $(R_L + R_1, V_{BE})$. Draw in line C. Intersection of C with V_2 level gives the maximum value of R_2 which will result in sufficient cut-off bias.

The choice of R_1 (stage (3)) is not as arbitrary as it may at first seem because the range of values which will give a satisfactory solution is limited. While an equation defining this range is cumbersome, and even approximation results in

$$0 = R_1^2 I_b (V_2 - V_{BE}) + R_1 [V_2 V_{BE} + (I_b R_E - V_1) (V_2 - V_{BE})] + R_L V_2 V_{BE}$$

two rough limits may be used. The value chosen must not be greater than $(V_1/I_b - R_1)$ if sufficient base current is to follow (in fact it must always be less than this to obtain a satisfactory cut-off condition). The minimum value of R_1 is restricted by the loading it imposes on VT1 collector. Even if these guides are ignored and an unsatisfactory value of R_1 chosen the

*The Plessey Company (U.K.) Ltd.

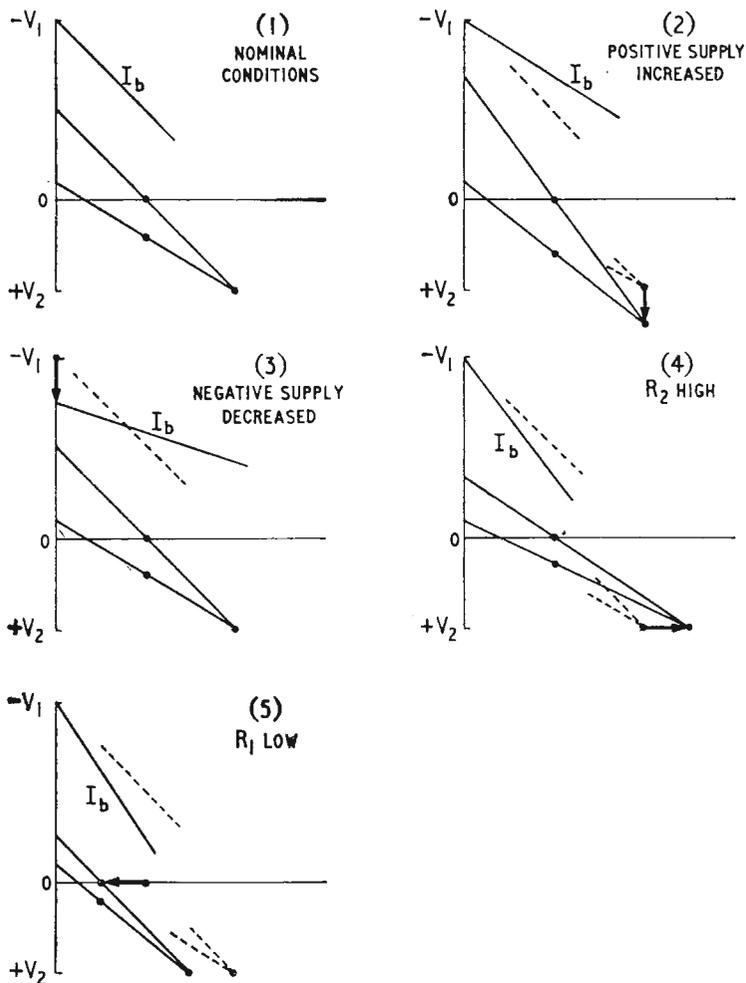


Fig. 3. Modifications to basic construction to take account of variations in supply and resistance values.

simple construction allows alteration in a matter of seconds.

The basic construction described is readily extended to give more precise results and include other design restrictions. The saturation voltage of VT1 (or collector clamping voltage if a non-saturating circuit is used) may be included in stage (6) by using point (R_L, V_{sat}) instead of $(R_L, 0)$. The forward base emitter voltage of VT2, V_{BE} , required for a current of I_b can be included at stage (5) by replacing the point $(R_L + R_1, 0)$ with $(R_L + R_1, V_{BE})$. Because of the danger of voltage breakdown, or in the case of a bi-stable circuit a limit on triggering sensitivity, some maximum reverse emitter base voltage, V_R , may be specified and this could restrict the value of R_2 . The worst condition for reverse base voltage occurs with zero I_{co} ; a line drawn from $(R_L, 0)$ (or (R_L, V_{sat})) through $(R_L + R_1, V_R)$ to intersect the V_2 level will show the minimum safe value of R_2 .

Once a construction has been made it is very easy to alter conditions either to optimise the design for a particular requirement or to investigate the effect of tolerances. The main points of reference will be marked in already and hence only a few movements of a straight edge are required. Fig. 3 illustrates a simple construction and the manner in which it can be modified to show the effects of supply and component tolerances. The tolerance variations used are exaggerated to make their effects readily apparent. It can be seen that the information required can be obtained in a few seconds. If the only information required is the values of R_1 and R_2 for satisfactory operation under "worst case" conditions then a simple construction using appropriate tolerance values will be sufficient.

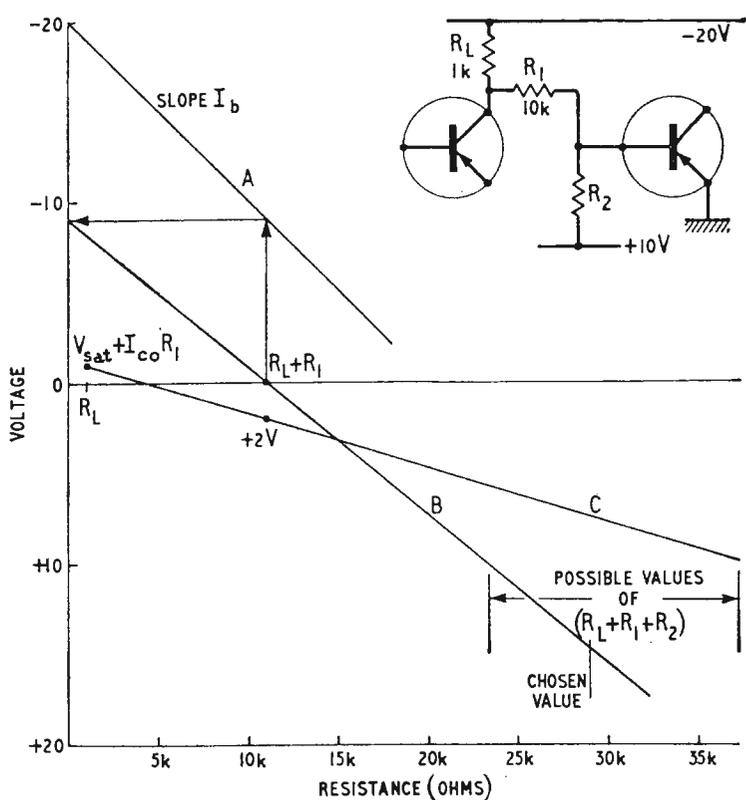


Fig. 4. Practical example of design method.

In a bi-stable circuit the approximate condition for sufficient loop gain is $R_1 < \beta R_L$. Provided the transistors are designed to saturate, this condition is satisfied since R_1 must be less than V_1/I_b or $V_1/(V_1/R_L\beta)$, i.e. less than $R_L\beta$, assuming $R_L \ll R_1$.

Practical Example.—As an example of this constructional design method consider the following problem. Required, a bi-stable circuit to operate with the following conditions.

- $V_1 = -20V, V_2 = +10V, R_L = 1k\Omega.$
- $V_{sat} = -0.5V, I_{co\ max} = 50\ \mu A, V_{BE} = +2V,$
- $I_b = 1mA.$

Transistors to saturate in the ON condition.

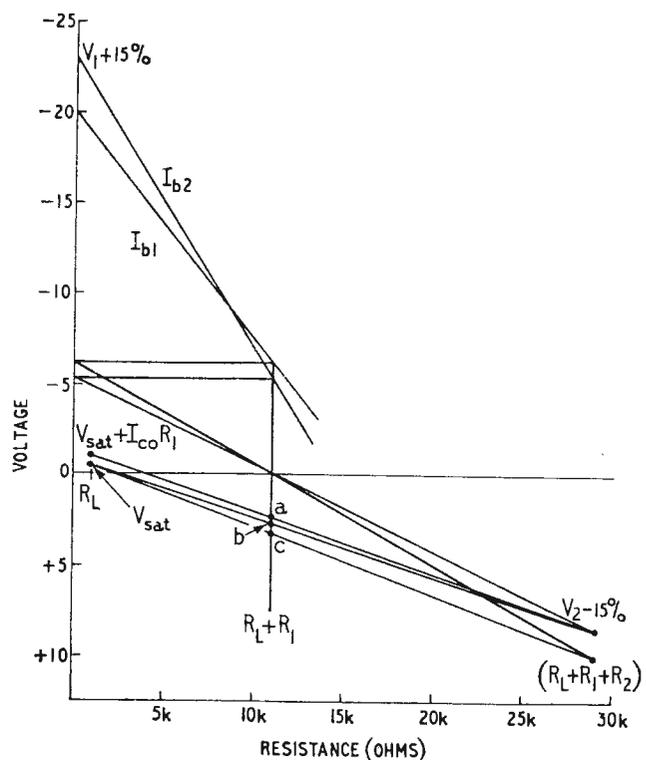


Fig. 5. Extension of Fig. 4 to obtain information on effect of tolerances.

Choose values for R_1 and R_2 , then find the following information:—

Under nominal conditions what is the maximum reverse base voltage? What voltage may V_2 increase to before insufficient base current is obtained? What is the effect of changes of +15% in V_1 and -15% in V_2 on reverse base voltage and base current? What is the minimum reverse base voltage under these conditions?

Fig. 4 shows the construction. A suitable value for R_1 is $10k\Omega$ and this puts R_2 between $12.3k\Omega$ and $26.5k\Omega$. The value chosen was $18k\Omega$ as this is a preferred value and puts $R_1 + R_2 + R_L$ near the centre of the permitted range of values. The maximum value of V_2 which can be tolerated with these resistances may be found by extending line B (which is

concerned with I_b) to intersect with $(R_L + R_1 + R_2)$. The limiting value of V_2 is given by this intersection and is +14.7V in this case.

For the sake of clarity the construction to obtain the other information required is shown in Fig. 5. Under "nominal" conditions the maximum reverse base voltage is given by point C on the line joining (R_L, V_{sat}) and $(R_L + R_1 + R_2, V_2)$, in this case 3.25 volts. With variations in supplies this reverse voltage alters to 2.7 volts, point "b." The minimum experienced occurs when I_{co} is maximum and is given by point "a," 2.4 volts. The base current which flows with nominal supply voltage is given by constructing back from $(R_L + R_1 + R_2, V_2)$ through $(R_L + R_1, 0)$ to give I_{b1} , 1.25 mA. Similarly with varied supply voltages the base current is given by the slope of I_{b2} as 1.62 mA.

BOOKS RECEIVED

Radio-Electronic Transmission Fundamentals, by B. Whitfield Griffith, Jr. A course of study, at an intermediate level, of the elements of radio frequency engineering at high powers. The book is primarily intended for those interested in r.f. transmission. Broadly divided into two aspects, the subjects covered include network theory and transmission lines, with aerials and transmitters in the second part. Higher mathematics are not used, the mathematics that are needed being introduced when necessary. Pp. 612. McGraw-Hill Publishing Co. Ltd., McGraw-Hill House, 95 Farringdon Street, London, E.C.4. Price 60s.

Aviation Electronics Handbook, by Keith W. Bose. This is a practical book, for the owner-pilot or service technician, on the operation and maintenance of a variety of airborne electronic equipment. Communications, navigation and instrument landing systems are described and a chapter covers air radar applications. American regulations for the establishment of servicing facilities are set out, and the final chapter gives guidance on the practical aspect of installation. Pp. 224. Howard W. Sams & Co. Inc., Indianapolis 6, Indiana, U.S.A. Price \$4.95.

Photoelectric Control, by Harvey Pollack. Written at technician level, the book first deals with the design, construction and operation of photocells, and then goes on to describe the use of these devices in conjunction with electromechanical relays. A section then follows on measurement and indication by photo-electronics. The semiconductor photocell and photo-transistors are discussed, and the final chapter describes some industrial applications of photo-electric control. Pp. 136. John F. Rider, Publisher, Inc., 116, West 14th Street, New York 11, N.Y. Price \$3.50.

High Fidelity Home Music Systems (second revised edition), by William R. Wellman. This book was written with the layman music lover in mind. Most aspects of sound reproduction are dealt with. Information is provided for the home constructor and for those contemplating purchase of a complete system. Pp. 241. D. Van Nostrand Co. Ltd., 358 Kensington High Street, London, W.14. Price 51s.

Newnes Radio Engineers Pocket Book. Thirteenth edition, revised by A. T. Collins, contains wire gauges, design data and useful formulae. Pp. 180. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Price 10s 6d.

Electronisch Jaarboekje 1963. Pocket diary (in Dutch) with 150 pages of technical information with rapid-access coloured identification of sections giving general formulae, basic circuits, aerial design, valve and data and general information. De Muiderkring N.V. Bussum, Netherlands. Price Fl. 2.95; plastic cover Fl. 0.50 extra.

Loudspeakers, Theory, Performance, Testing and Design by N. W. McLachlan, D.Sc. (Eng.). This classic work, published originally in 1934 by Oxford Univ. Press is now available in an unabridged paperback version issued by Dover Publications, Inc., 180 Varick Street, New York 14. Pp 399. Price \$2.25, or from Constable and Co. Ltd., 10 Orange Street, London, W.C.2., price 18s.

Thermoelectricity, by D. K. C. MacDonald. Unified treatment of the physical basis of various thermoelectric effects (principally in metals, but with some reference to semiconductors) in terms of modern solid-state theory. Pp. 133 including a three-page bibliography. John Wiley & Sons Ltd., Gordon House, Greencoat Place, London, S.W.1. Price 49s.

Trägerfrequenz-Nachrichtenübertragungen über Hochspannungsleitungen, by H.-K. Podszcek. Third revised edition of this textbook of carrier-frequency communications over high-voltage power supply lines. Pp. 191. Springer-Verlag, (1) Berlin-Wilmersdorf, Heidelberger Platz 3, Germany. Price DM36.

B.B.C. Engineering Division Monographs

No. 42 *Apparatus for Television and Sound Relay Stations*, by P. A. Peachey, M.I.E.E., R. Tooms, D.I.C., A.C.G.I., B.Sc. (Eng.), A.M.I.E.E. and D. L. Stuart, Grad. I.E.E. describes translators, receivers and drive equipment used in later stages of the expansion of television and sound coverage.

No. 43 *Propagational Factors in Short-wave Broadcasting*, by L. J. Prechner, B.Sc., deals with problems of choice of frequencies for the B.B.C. external services and compares typical reception results with theoretical predictions.

No. 44 *A Band V signal-frequency Unit and a Correlation Detector for a VHF/UHF Field-strength Recording Receiver*, by G. J. Phillips, M.A., Ph.D., B.Sc., A.M.I.E.E., P. T. W. Vance, M.Sc. and R. V. Harvey, B.Sc., A.M.I.E.E., describes additional equipment for use with the field-strength recording equipment covered by Monograph No. 6.

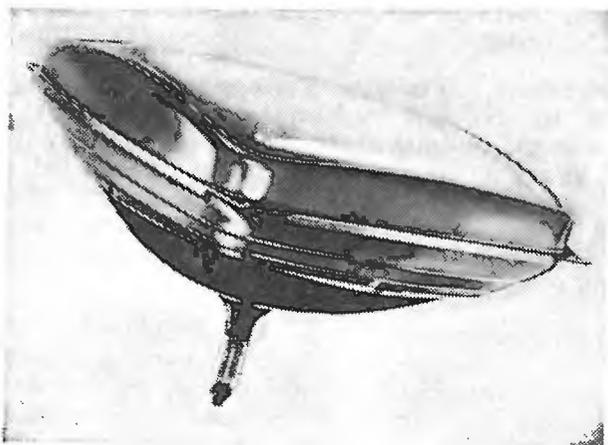
All the above published by B.B.C. Publications, 35 Marylebone High Street, London, W.1. Price 5s each.

Paris Components Show, 1963

FLOOR SPACE DOUBLED TO ACCOMMODATE INCREASED INTERNATIONAL SUPPORT

IN the advance publicity for this exhibition the French use the expression *une grande confrontation*, and this year the literal shade of meaning which suggests in English something of a "facer" was even more apparent. A new hall had been added, nearly doubling the floor area, and the number of stands had risen to 765, a 27% increase on last year. Of these, 342 were from countries other than France (e.g., Germany, 108; U.S.A., 91; U.K., 55; Italy, 22; Switzerland, 20). To visit every stand it was necessary to walk at least $2\frac{3}{4}$ miles, and if one could have attended from 9.30 a.m. to 7 p.m. on each of the five days of the exhibition it would be possible to devote an average time of $3\frac{3}{4}$ minutes per stand—that is if one did not stop for meals!

First impressions were quantitative—of the large



Telefunken A59-12W "anti-implosion" Television tube.

numbers of firms making similar products and of the strongly competitive character of the European component industry, not only in the fields of fundamental materials and components like resistors and capacitors, but also in sub-assemblies such as tuner units and switches. Developments like integrated semiconductor circuits, which were comparatively new last year, were to be found on the stands of most of the large manufacturers in this field.

A new development in television tubes is the introduction of "anti-implosion" types which were shown by three firms ("La Radiotechnique," Sovirel and Telefunken). In principle the stresses in the tube skirt, due to the air pressure on the curved face of the tube, are balanced by compressive forces applied either by a steel band or, as in the case of the Sovirel "Solidex" and the Telefunken A59-12W tubes, by two pressed steel shells clamped together. A softer bonding material between the band (or shells) and the glass distributes the stress evenly, and may be extended, as in the case of the La Radiotechnique "Auto-Protecteur" tube, over the rear cone as an added precaution. Films in slow motion were shown of a comparison between the deliberate destruction, by a striker pin, of tubes of the

old and new types, of the damage caused to the set by the former and the localized cracking, without general collapse, of the new design. Not only are the weight and cost of plate glass or plastic fronts eliminated, but it is claimed that much lighter cabinet construction can be used with safety.

Miniature (8-inch) television tubes with 90° deflection were on show by several manufacturers in anticipation, no doubt, of further numbers of small transistor portable television sets.

Double-beam tubes for oscilloscopes were much in evidence and a very low pattern distortion (1%) is claimed for the Type 1000H, 10-cm tube, shown by the M-O Valve Company, enabling the traces to be superimposed if required for accurate comparison. In the Type E 10-10GH 10-cm tube by "La Radiotechnique" an aluminized screen is used, enabling the advantage of increased brilliance to be retained for an e.h.t. of only 3 kV. The vertical sensitivity is 8V/cm. An interesting special oscilloscope tube (D7-16GJ) was announced by Telefunken. It is designed for use with transistor circuits and its heater is rated at only 80mA (6.3V); the anode potential is 800V. The overall length of the tube is only 154mm (6 inches) and the screen diameter 76.2mm (3 inches). Sensitivity is 22V/cm.

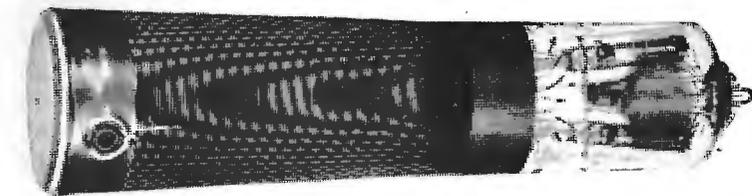
A reversible decade counter tube (ECT100) developed by Elesta S.A., Bad Ragaz, Switzerland, operates with inputs as low as 50V and is used with a transistor switching circuit which applies the pulses with alternating polarity to odd and even numbered cathodes, with which are associated staggered intermediate guide electrodes. Counting speeds up to 100 kc/s are claimed.

Among test and measuring instruments the v.h.f. and u.h.f. wobblers of Ribet-Desjardins were noted. Type 411A covers 0 to 320 Mc/s in three ranges with modulation depths of 7 Mc/s or 25 Mc/s, and Type 412A, in preparation, will extend the frequency from 350 to 950 Mc/s. Principal crystal-controlled frequency markers in the 411A are at 10 Mc/s intervals with smaller 1-Mc/s subdivisions, and the 412A will give additional fixed markers at 29.5 or 39.5 Mc/s. The new Hewlett-Packard 175A oscilloscope uses a c.r.t. with a parallax-free graticule (6cm×10cm) on the inside of the non-glare optically-flat faceplate. Also shown by Hewlett-Packard was the Type 5243L eight-digit electronic counter with a time stability of 3 parts in 10^9 and a basic frequency range of 0-20 Mc/s. A plug-in frequency converter extends the range to 512 Mc/s.

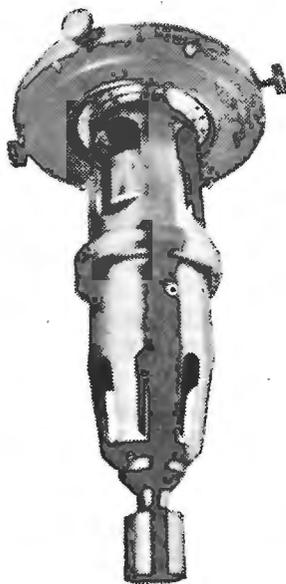
For production line testing of diodes and transistors *in situ* in printed circuit boards the "Diotester," produced by Société d'Études, Recherches et Constructions Électroniques, Montrouge, Seine, is self-contained. Spring-loaded contact points, spaced to fit JEDEC (T0-5) bases, apply a small potential to the appropriate connections and indicate by a press button and lamp the cut-off and saturation conditions of transistors (n-p-n or p-n-p) and the conductivity of diodes. The instrument weighs 300gm (10oz) including a rechargeable

accumulator. Working on a similar principle the tester shown by American Electronic Laboratories uses a separate three-contact probe in conjunction with a rather more sophisticated test instrument, operating from the mains, and automatically running through a series of tests, including gain, with lamp indications of "go" and "no go."

It is appropriate that in France, the birthplace of Peltier, more than usual interest is being revived in that branch of thermoelectricity which deals with the cooling of metallic or semiconductor junctions by the passage of an electric current. Whatever may be the future of these devices in the domestic field, there can be no doubt of their present usefulness in the laboratory. In the Type 18/9 "Frigatron" unit made by Compagnie Industrielle des Ceramiques Electroniques (a subsidiary of C.S.F.) the junction is tellurium-bismuth and the unit forms part of a stable zero (Centigrade) temperature reference for the cold junction of thermocouples. "Le Zerofix," as it is called, maintains a water/ice equilibrium in a sealed vessel which can contain up to 6 junctions. The great advantage of the Peltier refrigerator is that the energy transfer is continuously variable, and L'Omnium de Techniques Avancées (an associate of Soc. Alsacienne d'Électronique et de Mécaniques Appliquées) have developed a thermoelectric module Type P8 which has been applied to the cooling of photomultipliers used in scintillation counters. Going from cold to hot, we find the same group (S.A.E.M.A.) showing equipment for producing high-power (3kW-50kW) electron beams for cutting, melting and vaporizing "difficult" materials in a vacuum.

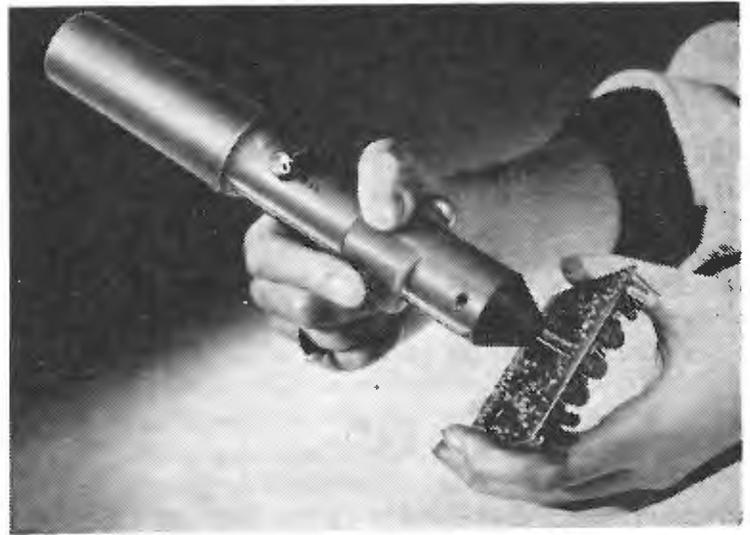
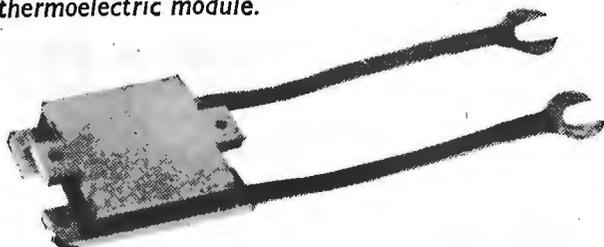


Above: Double-beam oscilloscope tube, Type E10-10GH ("La Radio-technique").



Right: 3kW electron "cannon" for narrow-beam bombardment of materials (S.A.E.M.A.).

Below: "Otechna" Type 8 thermoelectric module.



Diode and transistor Tester (S.E.R.C.E.L.)

In an annexe to the main part of the exhibition, under the title "L'Électronique Quantique," several firms were showing neon-helium gas lasers in operation. This was in support of a conference on lasers and masers held during the same week in Paris. Most of the equipment made use of metre-length tubes, but Philips demonstrated stable laser action at a wavelength of 1.5μ in a tube only 12cm in length, and with a d.c. discharge. A heavy cylindrical quartz block is bored with a hole 3mm diameter and dielectric infra-red reflecting end blocks are held on the optically flat and parallel ends of the tube by the vacuum. Tuning is by an external heating coil. After passage through polarizing elements the beam was detected in a photo-cathode and displayed by a closed-circuit television monitor to show the possible modes of operation.

Among audio exhibits a new electrostatic microphone, Type C 60, by A.K.G. was noted. It weighs only 60gm ($2\frac{1}{8}$ oz) and can be supplied with a cardioid or an omnidirectional capsule (frequency responses 30-18,000 and 30-30,000c/s respectively). The built-in pre-amplifier gives an output into 600 ohms of $1.3\text{mV}/\mu\text{bar}$. Power supply is from mains or a rechargeable battery unit, the latter giving 14 hours continuous service.

An ingenious magnetic tape mechanism known as the "Tape-Top 305," shown by General Television, 17, Avenue de Paris, Vincennes (Seine), is designed to fit on a gramophone turntable (78 r.p.m.) and gives in the standard form, 4 hours playing time on two tracks of a 2,200ft continuous loop $\frac{1}{4}$ in tape. The tape is stored on a shallow conical plastic base 12in diameter and 2in deep, fitted with a dust cover, and the tape feed mechanism and record/replay head are mounted at the centre, and can be adjusted vertically to select the appropriate track. With a special head up to six tracks can be recorded, and played back separately or simultaneously. Using thin (25μ) recording tape a maximum playing time of 24 hours is possible, using the six tracks. The weight of the unit is only 3lb.

The growth of the *Salon International des Composants Électronique* since it changed six years ago from a national to an international exhibition has been phenomenal. It has now reached a critical state of development when a decision must be made, either to limit its size, or to extend the period of opening. This year the material present was sufficient to overwhelm the most hardened "exhibition addict."

Citizens' Radio in U.S.A.

DOES BRITAIN REALLY WANT SUCH A SERVICE ?

By R. L. CONHAIM*

HERE has been a lively discussion in the pages of *Wireless World* on the pros and cons of a Citizens' Radio Service for Great Britain. Experience in the United States, Canada and some of the Central American countries has been cited as the basis for some of these arguments. But, no one could possibly know what the services in these countries are like, without having experienced them. The experiences gained within the United States should be valuable to both those proposing and opposing such a service for Great Britain, for there are now more than 350,000 Citizens' Radio† licensees within the U.S.A., most of them utilizing the Class D or 27-Mc/s band. The actual frequency range is 26.96-27.23 and 27.255 Mc/s with a maximum "plate power" of 5 watts.

Case History

A little background may be of value. Prior to 1958, there existed in the U.S. a Citizens' Radio Service, divided into several classes. Voice communication, however, was limited to the 465-Mc/s band, and there were very few users, due to the propagation characteristics of this band. The other classes were for radiotelegraphy, and for the radio control of models and other radio-controlled devices, where more than 100 milliwatts of power was required. The Class A service, that around 465 Mc/s, attracted little attention. The few transceivers produced for this service were limited in range to about a mile, except over particularly good terrain.

Then in 1958, the Federal Communications Commission opened the relatively unused 11-metre amateur band (around 27 Mc/s) for Citizens' Radio voice communication. The results, at first, were not startling. There was no great rush to apply for licences. Potential manufacturers of equipment adopted a wait-and-see attitude. Then, about the middle of 1958, an article on how to build a Class D (27 Mc/s) Citizens' Radio transceiver was published in a radio journal. The article stirred an immense amount of interest, especially among those frustrated amateurs who knew a little about radio but never had enough ambition to learn the code and the necessary technical information to secure an amateur transmitting licence. Parts stockists were besieged by enthusiasts eager to build this transceiver, which comprised a simple transmitter and a super-regenerative receiver.

That's when the fun began. Bear in mind that most of the original Class D licensees were essen-

tially hobbyists. They used the new band for hobby purposes, and fostered the same kind of use by newcomers to the band. The F.C.C. regulations, which had been written in the usual official language, were completely misinterpreted, often wilfully, and Class D became another amateur band, but without the benefit of amateur licensing. One of the rules stated that the band was for short-distance communications for the business or personal business of the licensee. "Short distance" was interpreted by these early users as anything less than 3,000 miles! and during exceptional propagation conditions DXing was the rule rather than the exception. "Personal business" was interpreted as almost anything. Some owners considered hobby use as personal business. One licensee, to whom the author talked, said the regulations set up the band for business or "pleasure," and, after all, he was only using the band for his personal pleasure!

The F.C.C., with only a few monitoring stations, and limited personnel, realized they had a bear by the tail. There was little they could do about it. New licences were accompanied by instruction sheets, detailing somewhat more specifically the "do's" and "don'ts," and defined more specifically some of the regulations.

The requirement that only holders of professional licences (first- or second-class commercial radio-telephone) should undertake transmitter adjustments was ignored almost completely. Users adjusted transmitters at will, ignored the 5-watt input limitation and "souped up" even commercial transceivers to radiate much higher power than authorized. Any evening you wanted to monitor the band with a frequency meter, you would find that at least half the stations were off frequency. The tolerance of 0.005% was met by few users. The demand for crystals to operate on the 22 channels (now 23) became so great that some crystal manufacturers weren't always too careful about what they supplied.

The band was now becoming really wild. During the daytime hours, it was relatively quiet, except for business use, but at night the screeching, howling heterodynes made the 80-metre amateur band sound like a school room at midnight. Long-winded discussions tied up channels and prevented legitimate users from gaining any benefits from the service. Incidentally the minimum age for a Citizens' Radio licence is 18.

In early 1961 the author visited an F.C.C. secondary monitoring station and it was obvious there were so many violators, and so few monitoring people, that only a small percentage of the errant users ever received citations for their wrong-doings. Reports of television interference increased rapidly, from neighbours of Citizens' Band operators.

* Dayton, Ohio, U.S.A.

† Defined in the F.C.C. regulations as "a radio communication service of fixed, land, and mobile stations intended for personal or business radio communication, radio signalling, control of objects or devices by means of radio and other purposes not specifically prohibited in this part."

The licensing activity, in the meantime, had picked up so enormously, that the "W" numbers which had sufficed for years were exhausted. In 1960 "A" numbers, then "B" numbers were used. In 1961 "Q" numbers were used, then "QA" numbers. And in 1962 a three-letter system was inaugurated.

Equipment manufacturers were now in high gear. You could have your choice of kits or built-up transceivers for prices ranging from \$40.00 to about \$200.00, or roughly £13 to £70. The accessory manufacturers were reaping great profits as well. All manner of special antennas appeared, both for mobile and fixed base stations. Field strength meters, power output meters, standing wave bridges, crystal activity testers, wavemeters, frequency meters, dummy loads and a hundred other items appeared on the market and were gobbled up by ardent C.B. fans.

At this point the F.C.C. realized it would have to modify and clarify its regulations governing the Citizens' Radio Service. Conversations were limited to 5 minutes, kit manufacturers were required to seal the frequency-determining circuits of transmitters, DXing was strictly forbidden. But the users outnumbered the regulators by such tremendous margins that the new regulations had little, if any, effect.

The Present Position

Now the F.C.C. is proposing new regulations, spelling out in detail, what they expect of the band, what a user can do and cannot do. The language is more clear, more specific. Licence applications are receiving closer scrutiny, to be sure the applicant has a legitimate reason for his licence. New requirements cut the conversation limit to three minutes, followed by a five-minute silent period. More stringent rules are being applied to set manufacturers, especially the kit manufacturers. Only

five of the 23 channels are proposed for interstation use. The remaining channels are set aside for communications between stations of the same licensee, or for emergency and Civil Defence communications. All of the proposed new regulations will help to get a measure of order out of the chaos which now exists. But the final answer must of necessity come from self-regulation.

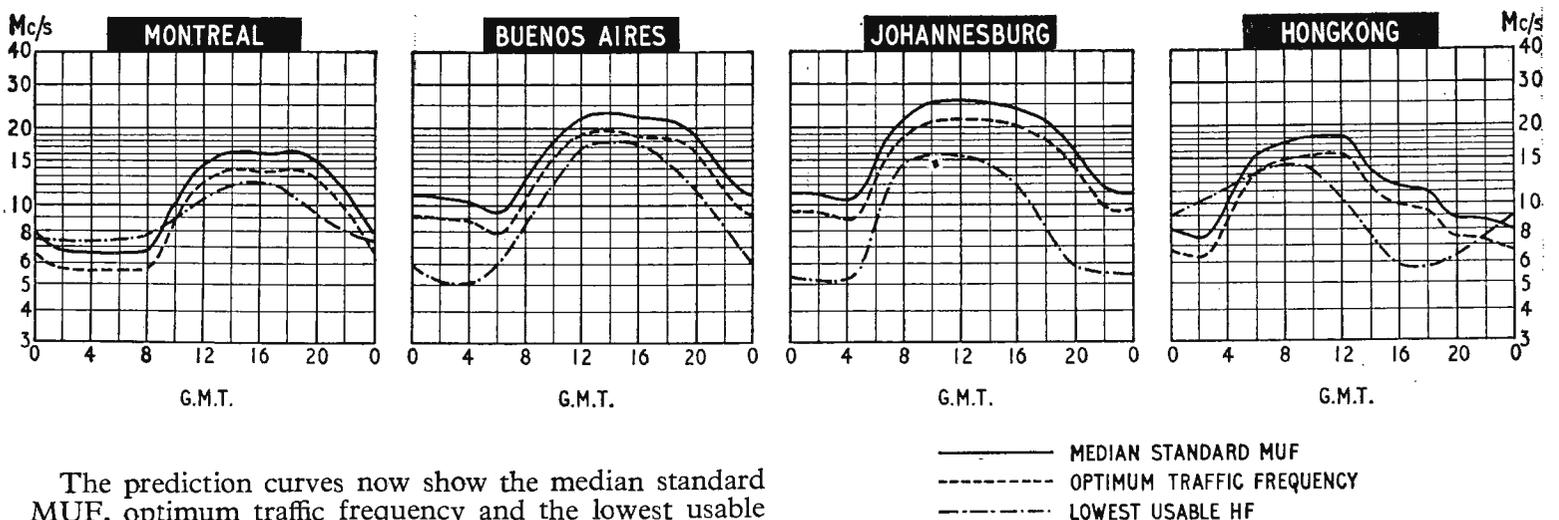
The idea of self-regulation is difficult. Users cannot, for example, report conversations to the F.C.C., for the Communications Act of 1934, under which the F.C.C. operates, forbids the revealing of message content to anyone except the person for whom the message was intended. The formation of Citizens' Band Clubs and associations has become wide-spread. Many of these are making honest attempts to clean up the band, while others are out to promote the idea of making C.B. a hobby.‡

That brings us back to the question, "Does Great Britain Want a Citizens' Radio Service?" Apparently many British citizens do. The idea is basically sound—if it gets off on the right foot. But a Citizens' Radio Service should be set up only to provide a basic communications need. Benefiting from the mistakes made in the U.S., all hobby activities of any kind should be specifically forbidden. There should be tighter controls than we in the U.S.A. have over the manufacturers of equipment. Probably specific frequency assignments for specific purposes would prevent much of the "hamming" with which we have had to contend.

By all means, if you want a Citizens' Radio Service, set one up. But avoid our mistakes. And make your restrictions tight enough that they can be reasonably enforced. Go into it slowly and carefully, and come up with a service that really gives the average citizen a communications medium that will serve him and his fellows well.

‡ A new communication jargon has emerged; "10-4" means message received and "10-7", signing off.—Ed.

H.F. PREDICTIONS—MARCH



The prediction curves now show the median standard MUF, optimum traffic frequency and the lowest usable high frequency (LUF) for reception in this country. Unlike the MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, local noise level and the type of modulation: it should generally be regarded with more diffidence than the MUF. The LUF curves shown are those drawn by Cable and Wireless,

Ltd., for commercial telegraphy and they serve to give some idea of the period of the day for which communication can be expected. The LUF curve for Montreal takes account of auroral absorption.

WORLD OF WIRELESS

U.H.F. Television Tests

THE second stage of the B.B.C.'s field trials of 625-line u.h.f. television began on February 1st when simultaneous transmissions on two channels (34 and 44*) were started from Crystal Palace, London. Transmissions, employing an e.r.p. of 160 kW with horizontal polarization, are radiated from 10 a.m. to 5 p.m. and from 8 p.m. to 9.30 p.m. daily from Monday to Friday. They include test patterns, slides and films in monochrome and in colour, including a colour film between 12.50 and 1.15. During February the N.T.S.C. system has been used for the colour transmissions and in March trials will be conducted with Secam.

Tests will continue until towards the end of the year, after which preparations will be made for the start of the B.B.C.'s second television service scheduled for next April. Incidentally, we understand there is no foundation for the recent rumour that the two channels now being used experimentally will continue to be used for London when the new service starts.

*Channel 34, vision 575.25 Mc/s, sound 581.25 Mc/s. Channel 44, vision 655.25 Mc/s, sound 661.25 Mc/s.

Balance of Trade

IMPORT-EXPORT figures for 1962 culled from the Board of Trade accounts reveal that while there was a 10% increase in the value of exports of radio and electronic equipment, imports increased by over 17%. The year's exports totalled nearly £76M compared with £69M the previous year and imports were £31.6M as against £27M in 1961. Incidentally the value of receiver imports last year exceeded exports by nearly £1M.

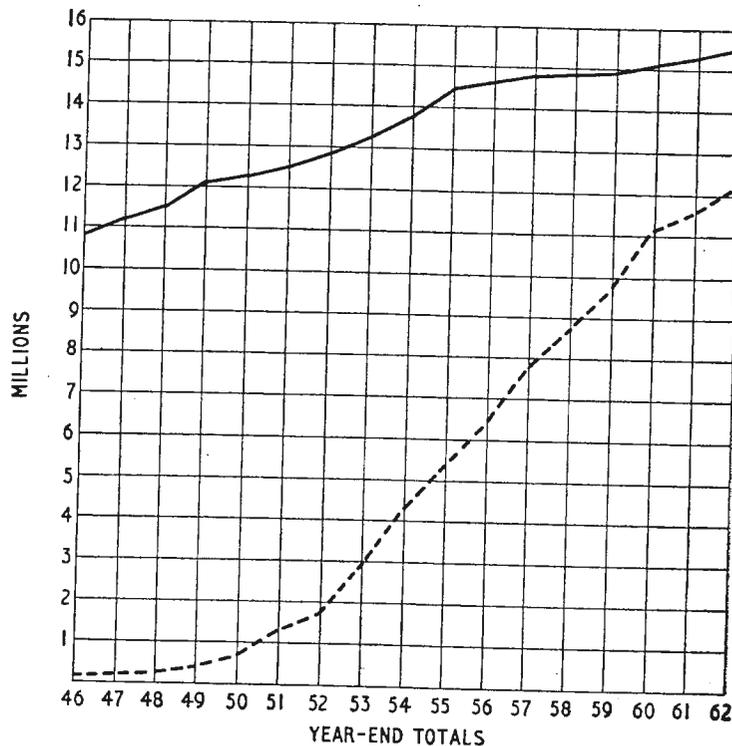
The main increases in imports were in transmitting equipment and navigational aids £8.6M compared with £6.7M, domestic and car receivers £2.3M (£1.4M), instruments £4M (£3M), valves and c.r. tubes £4.8M (£4.4M) and transistors £1.6M (£1.2M).

From the table below can be seen the variations in the value of U.K. exports for the past two years.

	1961	1962
Transmitting equipment and Nav aids ...	21.42	23.50
Valves and c.r. tubes	9.94	11.68
Components	14.84	14.14
Instruments and test gear	11.79	14.22
P.A. gear, loudspeakers and mikes	1.17	1.27
Domestic sound receivers and radiograms	2.23	1.38
Domestic television receivers	1.55	3.47
"Other radio and television apparatus"	2.78	3.71
Electro-medical apparatus	0.45	0.43
Electronic control equipment	2.50	2.28
	£68.67M	£76.08M

Standard Frequency Transmissions

SINCE 1945 the 200-kc/s carrier frequency of the B.B.C.'s light programme transmitter at Droitwich has been stabilized and is now maintained to within 5 parts in 1kM. The diurnal rate of frequency change is not greater than +1 part in 10kM and the resultant error is now being corrected each month. The new carrier frequency generators at Droitwich employ Essen type quartz rings operating at a nominal frequency of 100-kc/s. These quartz rings were provided by the Post Office and operate in equipment supplied by Airmec.



Broadcast Receiving Licences.—The increase in television licences over the past 17 years is shown by the broken curve. The December increase of 6,684 brought the number to 12,230,987. The overall total of sound and television licences is shown by the full curve; the December total being 15,580,400, including 526,549 for radio sets fitted in cars.

P.A. Show

THE annual exhibition of public address equipment organized by the Association of Public Address Engineers will be held at the King's Head Hotel, Harrow, Middlesex, on March 6th and 7th. Demonstrations of stereo recordings are being staged by several companies and the B.B.C. Admission to the show, open from 10.0 a.m. to 6.0 p.m. each day, is by invitation ticket obtainable from the A.P.A.E., 394 Northolt Road, South Harrow, Middlesex, or by business card. This year's exhibitors include:—

Ampex	Pamphonic Reproducers
Audix	Philips Electrical
B.B.C.	Politechna (London)
C.T.H. Electronics	Pye Telecommunications
E.M.I. Electronics	Reosound Engineering
Film Industries	Resosound
Goodmans	Shure Electronics
Grampian Reproducers	Sound Coverage
Lockwood & Company	Standard Telephones & Cables
Lustraphone	Vortexion
Magneta	Westrex Company
Mullard	Williams Cine and P.A. Services
	Warren, Haydon

Stereophonic Transmissions.—In addition to the series of stereo transmissions on Sundays, Wednesdays and Saturdays from the Wrotham station announced in our last issue, the B.B.C. has now introduced weekly tone test transmissions. These will be radiated at midday on Wednesdays from 12.0 to 12.30. A schedule of the tone transmissions is given in Information Sheet 1602, obtainable from the Engineering Information Department, B.B.C., Broadcasting House, London, W.1.

Paris Radio Show.—The dates have now been announced by the Fédération Nationale des Industries Electroniques for the International Radio and Television Exhibition to be held in Paris in September. They are 5th to 15th.

Apprentice Prize Winners.—D. Brooker, a Marconi craft apprentice, won the premier award—the Silvanus P. Thompson prize—in the Physical Society's Apprentices Competition, and also the first prize in the senior grade of scientific instruments and components for his sun shutter and filter drive mechanism for use in closed-circuit television. The other four Marconi entrants also received awards. They are craft apprentices V. L. Cathcart, for his spot wave selector for a communication transmitter; T. H. Lodge, flywheel synchronizing panel for a broadcast television recorder; P. J. Howe, a joystick control assembly for use with radar display consoles; and C. L. Chadwick, inner chassis assembly for a marine radio receiver. A trainee at the Company's Basildon Works, M. A. W. Golding, gained an award for his entry of a printed circuit board assembly for a television test pattern generator.

T.E.M.A. Awards.—The annual awards in the competition for the best final-year apprentice of the member firms of the Telecommunication Engineering & Manufacturing Association were made by the chairman, W. G. Patterson, of A.E.I., at the Association's annual dinner on February 12th. The recipients, who each received £25, were P. H. Morecombe, B.A. (G.E.C.), graduate-in-training; D. G. Hornby, Dip.Tech. (A.T.E.) and M. A. Woods (A.E.I.), who tied for the student apprentice award; and T. R. J. Hill (A.T.E.), technician apprentice.

R.S.G.B. Contests.—The first of this year's contests organized by the Radio Society of Great Britain will be held this month. On March 2nd and 3rd there will be the 144 Mc/s Open and Listeners' V.H.F. Contests, and on the 16th-17th the first 1.8 Mc/s contest. The full list includes a number of qualifying events leading up to the National D/F Final on September 15th. The National Field Day will be on June 8th-9th and the V.H.F. Field Day on September 7th-8th.

After five days of test transmissions for the trade, the Independent Television Authority commenced programme transmissions from its **Moel-y-Parc station** (Channel 11, vertically polarized) located on the borders of Flintshire and Denbighshire, North Wales.

The **Soviet Union economic target** for 1962 was exceeded and according to preliminary estimates industrial output was 9½% higher than the previous year. There was little increase in the production of radio sets and radiograms (4.3M), but production of television sets (2.2M) showed an 11% increase over last year's figure.

G6SL, the call sign of the amateur station operated at the Eddystone Works, Birmingham, has recently been used illicitly. This has been confirmed by the receipt of a number of QSL cards.

New laboratories for Racal Electronics were opened at Bracknell, Berks., by Mr. Julian Amery, Minister of Aviation, on February 12th. The new research and development laboratories, occupying approximately 24,000 sq ft, bring Racal's total floor area to 150,000 sq ft. Since the company moved to Bracknell in 1954 its staff has increased tenfold and is now approximately 1,000.

"**Assembling Radio Valves**" is the title of a new film in the B.B.C. Schools TV series "Going to Work." It deals with a teenage girl who chooses to work in electronics and light electrical engineering. The programme is to be transmitted on March 4th and 5th and viewers will see her going through the normal selection procedure, receiving instruction in a training school and finally making valves for use in industrial electronic equipment. The film was shot at Mullard's factory at Mitcham.

A combined symposium and exhibition on **environmental testing** is to be held on 27th-30th March, at the Imperial College of Science and Technology, South Kensington, London, S.W.7. The symposium will include the presentation of twenty-three papers, many of which will be of direct interest to those concerned with reliability. Full details can be obtained from the secretary of the Society of Environmental Engineers, 167 Victoria Street, London, S.W.1.

Anglo-American consortium of companies has been appointed by the South Arabian Federal Government to organize and operate a radio and television broadcasting system. The companies concerned are Thomson Television International (U.K.), National Broadcasting Company (U.S.A.) and Television International Enterprises (U.K.). A radio service is already in operation and it is hoped to have a 625-line television service operating by the end of the year.

Trader Year Book.—First published in 1925, the "Wireless and Electrical Trader Year Book" is an indispensable reference book to the radio and domestic electrical industries. The 1963 edition, which costs 21s and comprises 444 pages, includes all the sections which have proved so useful in the past, such as the buyers' guide; condensed specifications of current sound and television receivers, radiograms and tape recorders; valve, c.r.t. and transistor connections; receiver i.f.s and a directory of manufacturers.

R.F.C.W.O.O.C.A. Dinner.—The Royal Flying Corps Wireless Operators Old Comrades' Association is to hold its annual dinner in London on March 30th. Details are obtainable from E. J. F. C. Hogg, 57, Hendham Road, London, S.W.17. (Tel.: BALham 6963.)

Professional Engineers.—The inaugural meeting of the South-East Essex Society of Professional Engineers will be held at the Queens Hotel, Westcliff-on-Sea, at 8.0 on March 1st. Particulars are obtainable from E. W. Marsden, 21 Somerset Avenue, Westcliff-on-Sea, Essex.

Semiconductor Applications.—A two-day course on recent advances on semiconductor applications is being held at the Slough College, William Street, Slough, Bucks., on March 27th and 28th. The fee is 2 gn.

The latest **Dip. Tech. awards** bring up the total to over 1,800 since the introduction of the scheme in 1958 by the National Council for Technological Awards. There are now 7,292 students on courses.

CLUB NEWS

Birmingham.—The Slade Radio Society has arranged a Mullard film meeting in the Great Hall of the Birmingham and Midland Institute, Paradise Street, Birmingham, at 7.45 on March 8th. On the 22nd J. E. Smith (G3JZF) will give the fifth of his series of lectures on radio fundamentals at The Church House, High Street, Erdington.

Derby.—"Car Radio; Interference Problems" is the title of the lecture to be given by R. Barrell (G3FOP) to members of the Derby and District Amateur Radio Society on March 13th. Meetings are held at 7.30 at 119 Green Lane.

Edinburgh.—At the March 14th meeting of the Lothians Radio Society M. Russell will give a talk entitled "History of Automobile Communications." On the 28th J. Hughes (GM3LCP) and T. Spiers (GM3OWI) will discuss electronics. The club meets at 7.30 at the Y.M.C.A., South St. Andrew Street.

Prestatyn.—J. T. Lawrence (GW3JGA/T), chairman of the Flintshire Radio Society, will talk about fault finding at 8.30 at the club meeting on March 25th. Monthly meetings are held at the Railway Hotel.

Spenn Valley.—The subject of the talk by J. Belcher, of the G.P.O., to members of the Spenn Valley Amateur Radio Society on March 7th is direction finding. The club meets fortnightly at 7.15 at the Grammar School, Heckmondwike.

Personalities

E. V. D. Glazier, Ph.D., B.Sc., M.I.E.E., has been appointed by the Ministry of Aviation to a new post at the Royal Radar Establishment, Malvern, in which he will be responsible for the "co-ordination of military and civil systems work in the fields of airborne and ground radar, guided weapons and space research." Dr. Glazier, who is 50, has been director of scientific research (electronics and guided weapons) in the Ministry since 1957. He received his early training in electrical and mechanical engineering in industry and joined the Post Office in 1933. In 1942 he was transferred to the Signals Research and Development Establishment and in 1950 was put in charge of the Research Division at Christchurch.

G. E. Bacon, Ph.D., M.A., B.Sc., at present deputy chief scientific officer at the Atomic Energy Research Establishment, Harwell, has been appointed to a chair of physics at the University of Sheffield which he will occupy from next October. He will also assume the headship of the Department of Physics under a new scheme whereby each of the two professors will fill the post for three years. Dr. Bacon graduated at Emmanuel College, Cambridge, and in 1939 joined the Air Ministry. He eventually took charge of a group concerned with ground radar research and development at T.R.E. (now R.R.E.) at Malvern.

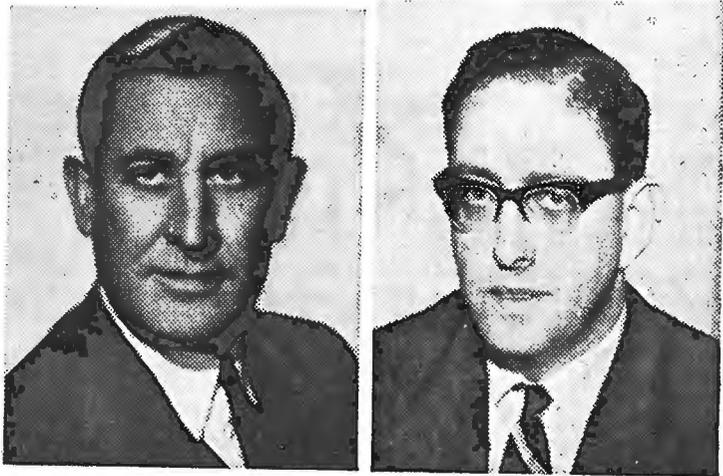
G. C. Gaut, M.A., B.Sc., has been appointed to the board of the Plessey Company, parent of the Plessey group of companies. He joined the Company after graduating at University College, Oxford, in 1934 and was appointed an executive director in 1951. He set up the Company's first laboratory at Ilford for research and development on technical processes for the manufacture of electronic components in 1937. This laboratory was moved to Caswell, Towcester, in 1940 and is now engaged in solid state research. In 1961 Mr. Gaut was appointed to the board of Semiconductors Ltd., a Plessey subsidiary.

Kenneth W. Brittan, Ph.D., B.Sc., D.Sc., who is 31, has been appointed chief engineer of W. G. Pye & Company, scientific instrument manufacturers of Cambridge. Dr. Brittan graduated at Nottingham University with honours in physics in 1952 and continued his studies at the Postgraduate Technical School of Optics in the Royal College of Science, London, where he obtained his doctorate.

D. G. Smee, M.B.E., Assoc.I.E.E., who joined Marconi's W/T Company in 1933 and has been manager of the Broadcasting Division since 1956, has been appointed assistant general manager of the Company. During the war he was first with the Royal Signals and then R.E.M.E., rising to the rank of major. The new manager of the Broadcasting Division is **T. Mayer**, who joined the Company in 1948 and has been sales manager of the division for the past five years. His successor is **F. J. Sidebotham**.

S. Hill, M.Eng., the new chairman of the Acoustics Standards Committee of the British Standards Institution, is also chairman of the B.S.I. committee on electro-acoustic transducers and is a member of the committee on acoustical terms and definitions. He was recently appointed chairman of the Acoustics Standards Committee of the International Organization for Standardization (I.S.O.). Mr. Hill is a senior engineer with Standard Telephones & Cables which he joined in 1919.

N. H. Searby, C.B.E., Ph.D., B.Sc. (Hons.), M.I.E.E., manager of Ferranti's Guided Weapons Department since 1951, has been appointed to the board. Dr. Searby, who is 52, graduated at Birmingham University where he also obtained his Ph.D. He joined Ferranti's as a radio engineer on leaving the University in 1932 and became chief radio engineer in 1941.



Dr. N. H. Searby

P. R. Max

Peter R. Max, B.Sc., A.M.I.E.E., has become chief engineer of the radar division of Cossor Electronics Ltd. and will control all development and systems engineering. He was previously manager of air traffic control and data handling in Marconi's Radar Division.

Dr. Carlo L. Calosi has been appointed to the board of Cossor Electronics Ltd., a subsidiary of Raytheon, U.S.A., of which he is a vice-president in charge of European operations. Dr. Calosi was at one time Professor of Electrical Engineering at the University of Genoa and later head of communications research with Ericssons. He went to the U.S.A. as head of Raytheon's research division at the end of the war. The appointment of **Leonard H. Weall** to the board of Cossor Electronics is also announced. He joined the Cossor group last year after spending several years with G. & E. Bradley Ltd., where he was works manager, having previously been with the Plessey Company.

Bernard Marsden, A.M.I.E.E., M.Brit.I.R.E., has been appointed deputy technical controller in the Engineering Department of Associated Television Ltd. and **Len Mathews**, M.Brit.I.R.E., to the newly-created post of head of special projects (technical). **T. C. Macnamara**, A.M.I.E.E., is ATV's technical controller. Mr. Marsden joined ATV in 1955 as senior engineer (installation and planning). He was promoted assistant controller of studios in 1958. Mr. Mathews also joined ATV in 1955 as senior engineer (communications) and has been assistant controller (communications and outside broadcasts) since 1958. He was previously in the B.B.C. Engineering Department.

F. W. Alexander, Ph.D., B.Sc., A.M.I.E.E., has been appointed superintendent engineer, sound broadcasting (equipment), in the B.B.C. Dr. Alexander joined the B.B.C.'s Engineering Research Department in 1933 from the research section of the Department of Physics of the University of St. Andrews. For the past few years he has been assistant superintendent engineer, sound broadcasting (studios).

Dr. T. E. Allibone, C.B.E., F.R.S., director of the Associated Electrical Industries Research Laboratory, Aldermaston, Berkshire, and director for research and education, A.E.I. (Woolwich) Ltd., has been appointed by the Royal Society to be Rutherford Memorial Lecturer in India and Pakistan, during a period to be arranged in the winter of 1963-64.

G. G. Parfitt, Ph.D., A.R.C.S., D.I.C., recently left the Department of Physics at the Imperial College of Science and Technology, London, and has gone to the University of Ibadan, Nigeria, as senior lecturer in physics. Dr. Parfitt, who has been at the College for about 15 years, spent a year at Göttingen University with Professor E. Meyer under an exchange arrangement. He has been concerned with acoustics research at the College including damping in polymers and noise problems. For the past four years he has been honorary secretary of the Acoustics Group of the Inst. P. and Phys. Soc.

A. H. Appleyard, A.M.I.E.E., A.M.Brit.I.R.E., has joined Avo Ltd. as senior electronics engineer and will deal with the design and development of electronic instruments. The company also announce the appointment of **G. Doye** as senior nucleonic engineer. He was previously with E.M.I. Electronics and on the laboratory staff of University College, London.

Dr. Ernst Weber has been elected as the first president of the Institute of Electrical & Electronic Engineers, formed by the merging of the A.I.E.E. and the I.R.E. Dr. Weber, who is president of the Polytechnic Institute of Brooklyn, was president of I.R.E. in 1959.

Norman Caws (G3BVG), is the new president of the Radio Society of Great Britain, of which he has been honorary treasurer since 1958. Mr. Caws is especially interested in v.h.f. and u.h.f. operation and has been closely associated with the London u.h.f. group since its formation in 1952. His brother **Raymond** (G3BRL) is chairman of the Radar & Electronics Association.

D. J. Collins, B.Sc.(Eng.), A.M.I.E.E., has been appointed divisional engineer responsible for research and development in the recently formed Data Recording Division of Consolidated Electrodynamics Corporation (U.K.) Ltd., of Woking, Surrey, a subsidiary of the Californian corporation of the same name. Mr. Collins, who is 35, was with E.M.I. for five years on missile work and since then with Solartron for ten years.

John Bunton, M.A., M.I.E.E., A.Inst.P., who joined Mullard in 1948 as scientific adviser to the board, has been appointed secretary of Mullard Ltd. Mr. Bunton was educated at Chesterfield School and Cambridge University where he graduated in natural sciences.

Arthur S. R. Toby, for the past 18 years engineer-in-charge of the North American office of the B.B.C., has joined Kramer Magnetics Ltd. of Port Credit, Ontario, Canada, as manager of the magnetic tape division.

OUR AUTHORS

Thomas Ormond, author of the article on transistor bias networks in this issue, joined Sylvania in 1960 as an applications engineer in the Semiconductor Division and recently transferred to the Company's Electronic Systems Division. He is a graduate of Northeastern University, Boston, Mass.

R. Thompson, Grad.I.E.E., Grad.Brit.I.R.E., contributor of "Direct-coupled pulse circuits," studied for his I.E.E. graduateship at the North Gloucestershire Technical College and the Birmingham College of Advanced Technology. He has been in the telecommunications division of the Plessey Co. at West Leigh, Hants., since 1960 where he has been concerned mainly with S.C.R. and transistor high-power inverters. Before joining Plessey Mr. Thompson was with Dowty Nucleonics.

OBITUARY

Lord Hankey, F.R.S., who died on January 25th at the age of 85, was chairman from 1941-1952 of the Technical Personnel Committee of the Ministry of Labour and National Service which was given the task of organizing the scientific manpower of the country. In 1943 he was appointed chairman of the Government Television Committee set up "to prepare plans for the reinstatement and development of the television service after the war." It was on the Hankey committee's recommendation that the 405-line service was re-established rather than defer the restarting "for the uncertain period required to give an opportunity of incorporating some fundamental improvement in the system."

Sir Isaac Shoenberg, M.I.E.E., leader of the team of engineers and physicists at E.M.I. which was responsible for the development of the 405-line television system, died on January 25th at the age of 82. Born in Pinsk, Russia, he was chief engineer of the Russian Wireless Telegraph and Telephone Company, Leningrad, from 1905 until he came to this country in 1914 as a consulting engineer to the Marconi Company of which he later became joint general manager. Sir Isaac, who was knighted last year "for services in the development of television and sound broadcasting", joined the Columbia Graphophone Company as general manager in 1928 and, when it merged with the Gramophone Company in 1931 to form E.M.I. he became director of research. In 1954 he received the Faraday Medal of the I.E.E. "for . . . the outstanding contributions which he has made to the development of high-definition television in this country".

J. H. Dellinger, Ph.D., Sc.D., of "Dellinger Effect" fame, died on December 28th aged 76. He was chief of the Central Radio Propagation Laboratory of the U.S. National Bureau of Standards on his retirement in 1948 after over 40 years' service with the Bureau. He graduated at the George Washington University and obtained the Ph.D. degree from Princeton University in 1913. In 1932 his Alma Mater honoured him with the Sc.D. degree. Dr. Dellinger was an international figure in the world of wireless, especially in the field of propagation, and he had represented the U.S.A. at numerous conferences. He was the first chairman of the C.C.I.R. study group VI concerned with propagation, a position he held for many years.

Laurence B. Turner, M.A., Sc.D., M.I.E.E., a fellow of King's College, Cambridge, who died on January 28th aged 76, was at the Army Signals Experimental Station during the first world war and at the Admiralty Signals Establishment throughout the 1939-45 war. In the intervening years he was director of studies in engineering at King's College, Cambridge, and was closely associated with W. H. Eccles in the development of the Commonwealth chain of long-wave communication stations. After the second world war Dr. Turner returned to Cambridge for research work and in 1948 was appointed a University Reader.

Stephen Oswald Pearson, B.Sc., D.F.H., M.I.E.E., who will be remembered by many of our older readers as a frequent contributor to *Wireless World* in pre-war days, died on January 18th aged 67. Born in South Africa, he was educated at Faraday House Engineering College, London, where, after training with Metropolitan-Vickers, he stayed throughout his academic career. He became senior lecturer, head of electrical engineering section and superintendent of the electrical laboratories at the College.

C. H. Lamborn Edwards, A.M.I.E.E., the well-known operator of amateur station G8TL of Theydon Bois, Essex, died suddenly on January 31st at the age of 61. He had been a member of the council of the Radio Society of Great Britain for nearly 20 years and was chairman of the "mobile" committee of the committee of the Radio Amateur Emergency Network.

News from Industry

Masteradio trade name is being revived by G.E.C. and will be used for a range of television and sound radio receivers, radiograms and tape recorders. Masteradio Ltd. was acquired in 1960 by Radio & Allied Industries (Sobell and McMichael) which is now part of the G.E.C. organization.

Peto Scott television receivers are to be marketed by Stella Radio & Television Co. The servicing of Peto Scott sets will continue to be carried out by Amalgamated Electric Services Ltd., of Croydon.

Muirhead.—A record trading profit of £752,253 for the year ended last September, which was 73% more than the previous year, is recorded by Muirhead & Co. The net profit, after taxation (£389,812) and "retentions for subsidiaries," was £259,791.

AEI Automation Ltd. has been formed by Associated Electrical Industries Ltd. to concentrate the development and supply of industrial automation systems in a single company. A.E.I. has acquired Davy-Ashmore's interest in Steelworks Automation Ltd., hitherto a jointly owned company, which will now be amalgamated with AEI Automation. Headquarters are at Booths Hall, Knutsford, Cheshire.

Universal Capacitor Co. Ltd., of Swindon, has been acquired by the London Electrical Manufacturing Co. All enquiries should in future be sent to Bridges Place, Parsons Green Lane, London, S.W.6.

Derritron.—The names of five subsidiaries in the group have been changed to incorporate the word Derritron. New names, with the old name in brackets, are Derritron Research and Development Ltd. (Beme Research and Development), Derritron Ultrasonics Ltd. (Chapman Ultrasonics), Derritron Instruments Ltd. (Doran Instrument Company), Derritron Electronic Vibrators Ltd. (Electronic Vibrators), Derritron Transformers Ltd. (L.S.B. Components).

Television and sound distribution in the new Hilton Hotel, London, has been installed by **British Relay Wireless Limited**. The relay system, which serves every guest room, has provision for six sound channels and six vision channels. There is also a public address system and to facilitate the transmission of outside broadcasts from the hotel a microwave link to the Post Office Television Centre is installed on the roof.

Decca Radar announce their 13,000th marine radar order—for a new tanker of 68,000-tons d.w. for the Tidemar Corporation of U.S.A. In 1962 they achieved a record number of 1,355 radar sales of which over 80% were exported.

A **three language** sound reproduction system used in conjunction with one film projector was devised by Williams' Cine & P.A. Services, of London, S.E.23, for an international audience at Dusseldorf. Three synchronized sound tracks, in English, French and German, were fed into a Multitone induction transmitting system so that members of the audience equipped with small switchable receivers could hear the commentary of their choice.

Anglo-French Link.—A reciprocal marketing agreement has been concluded between G. & E. Bradley Ltd., of London, and Société Ribet-Desjardins, of Montrouge (Seine). Ribet-Desjardins are leading French manufacturers of precision electronic measuring equipment, and their range of products is now available in the U.K. through G. & E. Bradley.

Perdio, who have specialized in the manufacture of transistor portables, have acquired Electric Audio Reproducers, manufacturers of radiograms, record reproducers and tape recorders.

Raytheon.—Walmore Electronics Ltd. have been appointed by the Raytheon-Elsi organization as sole U.K. distributors of valves, microwave tubes, microwave components, semi-conductors and allied devices made by Raytheon in the U.S.A. and its subsidiaries, Machlett and Trans Sil Corp. The products of Raytheon-Elsi in Europe are also included.

Vinylaz.—Baulma & Co. Ltd., of 16 Berkeley Street, London, W.1, have been appointed by Société Belge de l'Azote et des Produits Chimiques du Marly, of Liège, Belgium, exclusive distributors for their range of Vinylaz unplasticized p.v.c. film and foil in the British Isles. Among its applications is the manufacture of sound recording tape.

Aero Electronics Ltd. are appointed the sole United Kingdom agents and distributors for Owen Laboratories, Inc. of Pasadena, Cal., manufacturers of semi-conductor test sets.

Solid tantalum capacitors of J and N polar and non-polar types are now being manufactured by the Kemet Division of Union Carbide Ltd. at their Aycliffe, Co. Durham, works. All capacitors are being made to the U.S. military specification number MIL-C-26655A.

OVERSEAS TRADE

Tactical control radar system for Australia's first surface-to-air guided missile unit, equipped with the Bristol/Ferranti Bloodhound, has been supplied by Decca. The complete system is built into a series of air transportable cabins.

Travelling-wave tubes for use on the 3,300-mile Montreal-Vancouver microwave communications link of the Canadian Pacific and Canadian National Railways have been ordered from Mullards. The t.w.ts., valued at \$0.5M, will be used in R.C.A. Victor equipment.

O.B. vehicles for the television service of Radiodiffusion Television Belge are being supplied by Marconi's through their Belgian agents Société Anonyme Internationale de Télégraphie sans Fil. There will be four production vehicles containing the control equipment and monitors, and four technical vehicles each with a 4½in camera and associated equipment. Both 625 and 819 line standards are employed.

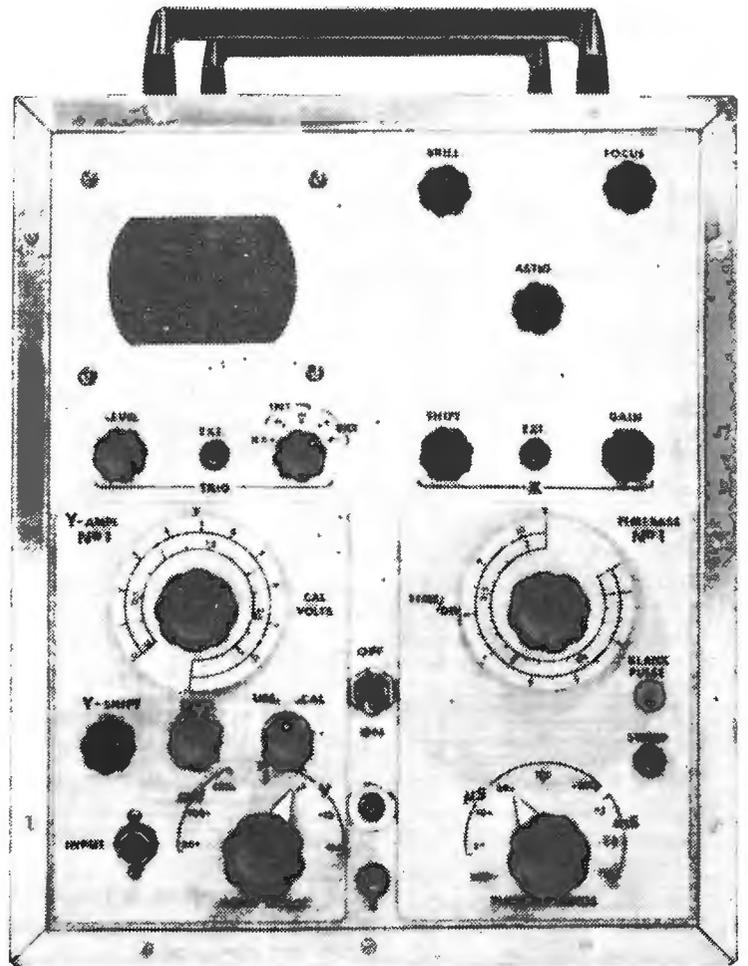
Storm warning radar, supplied by Cossor Electronics and mounted 2,000ft above sea level on Saddle Mountain in North Queensland, is being used by the Australian Bureau of Meteorology. The equipment is radio controlled from Cairns Airport seven miles away and the radar information is transmitted to the airport by a microwave link.

Colour television projection equipment to the value of £6,000 is being supplied by Rank Cintel for the University Medical College, Tokyo.

Television studio equipment, comprising cameras, sound and vision mixers, pulse generators and teleciné units, has been supplied for the Brazzaville station by Pye T.V.T. Ltd. in conjunction with Société Française des Techniques Pye.

With this issue, *Wireless World* embarks on a new series of articles on the construction and use of electronic equipment. The intention is to describe, in the first few articles, a group of measuring instruments (signal generators, voltmeters, oscillators, etc.) so that the reader will be well supplied with test gear before starting work on other projects to be described that may appeal to him.

Throughout the series we will have in mind the fact that the average home constructor does not have extensive workshop facilities, and will design for construction by simple hand tools only. Cost will be kept down to the lowest possible figure, while retaining high performance, using standard commercial components.



Wireless World

OSCILLOSCOPE

THE oscilloscope has long passed the stage at which it was used to display only the shape of voltage and current waveforms, and even the least sophisticated instruments now make some effort to provide voltage and time measurement. Any instrument designed for the home constructor must therefore afford these facilities, and possess as good a general performance as cost will allow. The resulting equipment, for the newcomer to the art, can be a somewhat daunting array of knobs, dials and excrescences, and it is felt that a short discussion of fundamentals will be useful. Techniques in general will be described, with particular reference to those used in our design. Next month's article will be devoted to constructional details of the oscilloscope.

Principles

The essentials of an oscilloscope can be reduced to three functions, shown in Fig. 1. The y amplifier is required to deflect the cathode-ray tube (c.r.t.) trace in the vertical direction, and is so called because the display corresponds to an ordinary x/y graph, and the y axis is usually the vertical one. The time-base or sweep generator deflects the trace in the x ,

horizontal or time direction, and any amplifiers concerned with it are called x amplifiers. The third essential is the c.r.t. itself. This is a smaller, somewhat modified version of the one in the "telly," and although the spot traces out only one line instead of 405 or more, the programmes are frequently much more entertaining. As the spot progresses across the tube from left to right under the influence of the timebase generator, it is subject to a voltage from the y amplifier which moves it up and down, so that the display, Fig. 2, is a voltage/time graph. The average instrument is far from being as simple as this, but these three are basic, and the rest are refinements.

Vertical Amplifiers

Having stripped our oscilloscope down to its bare bones, we can now begin to put the flesh back again, and, as the first part the signal encounters is the y amplifier, this is where we can start. The simple function of amplifying the y signal enough to operate the c.r.t. is attended with so many snares and delusions for the unwary, that the performance of this part of the circuit is usually the limiting factor in the design. Many different forms of ampli-

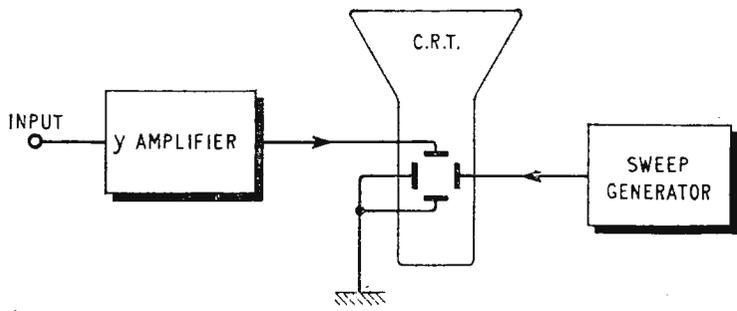


Fig. 1. Basic functions of general purpose oscilloscope.

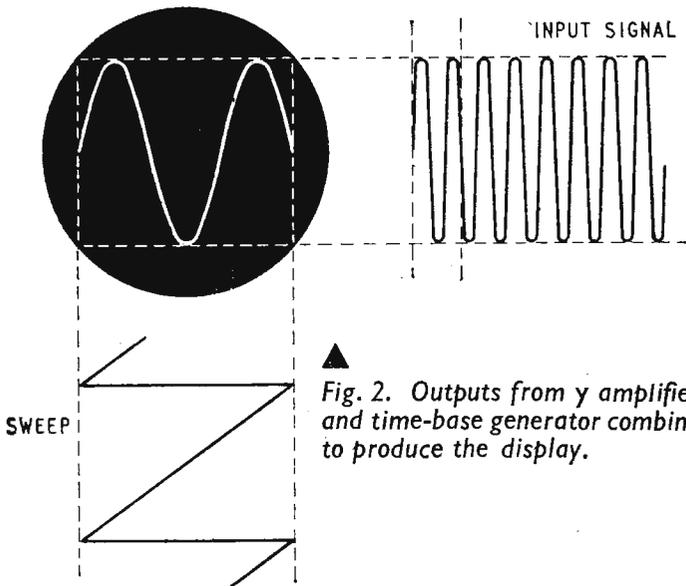


Fig. 2. Outputs from y amplifier and time-base generator combine to produce the display.

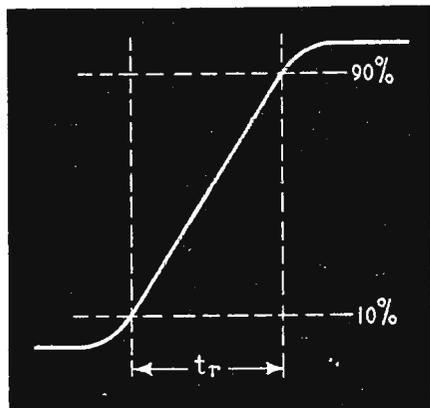


Fig. 5. Method of specifying rise-time.

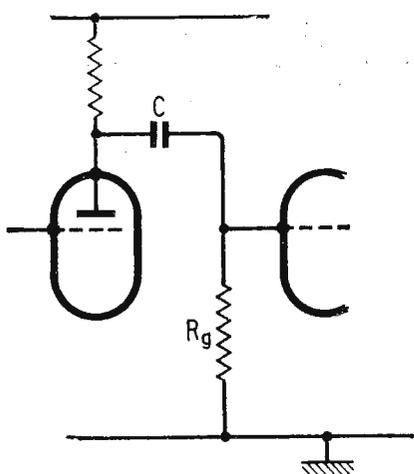


Fig. 8. A.-c. coupling.

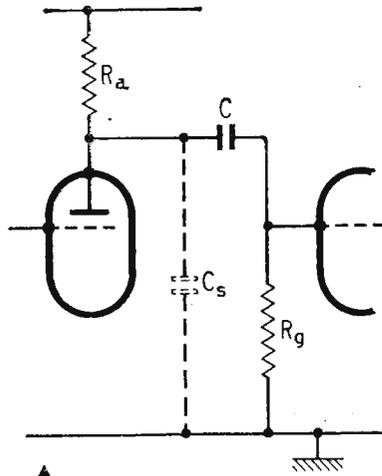


Fig. 3. Stray capacitance is disposed in parallel with the load resistors, assuming the impedance of the power supply is negligible.

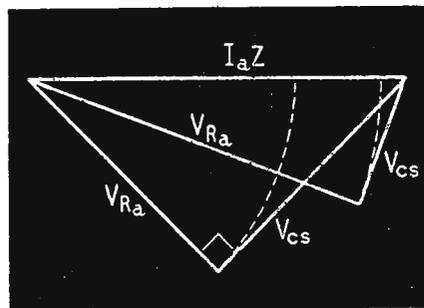
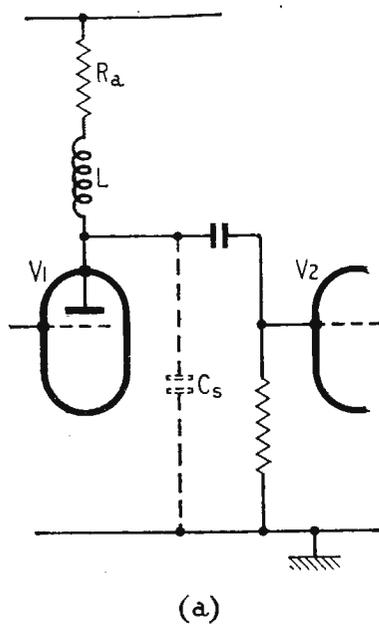
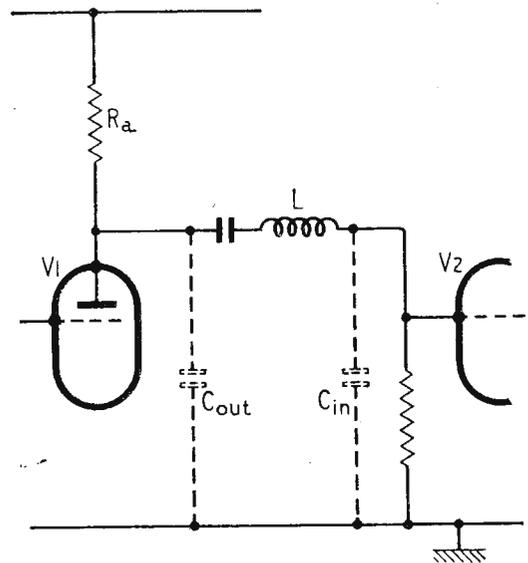


Fig. 4. At l.f., anode signal voltage is effectively developed across R_a alone and is $I_a Z$. At h.f., C_s becomes comparable with R_a .



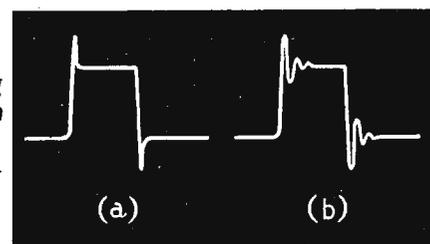
(a)



(b)

Fig. 6. Shunt (a) and series (b) h.f. compensation.

Fig. 7. Effect of carrying high-frequency compensation too far.



(a)

(b)

fier exist, and it is partly for this reason that both y amplifier and timebase generator have, in the *Wireless World* design in common with many others, been made replaceable, plug-in units. The two functions can therefore be suited to a particular purpose and made as simple or as elaborate as required, and a whole series of units will be described from time to time.

A fairly common order of sensitivity is 50mV/cm. This means that 50mV applied to the input will be sufficient to deflect the spot one centimetre. C.r.t.'s need between 10 and 50V for this deflection, so that the amplifier gain required is between 200 and 1,000. This may not seem an outstanding amount of amplification, until it is realized that it must be the same at all frequencies from a few cycles per second to upwards of 10 Mc/s. A response extending to zero frequency is also found very useful at times. Amplifiers exist which will handle frequencies up to 2,000 Mc/s, but these do not bear much relation to the kind we shall be concerned with, and they use entirely different techniques. The ordinary RC-coupled voltage amplifier works fairly happily up to about 50 Mc/s, with a bit of trickery, but above this frequency, different methods are employed which use more valves, are difficult and expensive, and will be left severely alone.

H.f. Compensation: The biggest single headache in high-frequency amplifier design is capacitance, both intended and accidental. It curtails both ends of the frequency-response characteristic and is to be avoided as much as possible. In Fig. 3, C_s represents the total stray capacitance from the anode of one stage of the amplifier to earth. This total takes in the internal capacitance of the valve, the capacitance of the valveholder, the strays of the wiring, and the input capacitance of the next valve or load, and probably amounts to between 15pF and 25pF. The gain from the stage is $g_m Z$, where Z is the impedance of the R_a and C_s combination, and at low frequencies this is simply $g_m R_a$. As the signal frequency increases, the reactance of C_s , which is $1/2\pi f C_s$, begins to become comparable with the resistance R_a , and as C_s is effectively in parallel with R_a , $g_m Z$ decreases. At the point where $1/2\pi f C_s = R_a$, the gain is only 70% of that at low frequencies, as is shown by Fig. 4. This point is the one most often quoted as defining the bandwidth of the amplifier, and as a decrease in gain of 30% is also approximately -3dB, it is known as the 3dB point. With an R_a of 10k Ω and stray capacitance of 20pF, the gain of a valve with $g_m = 5$ will decrease from 50 at low frequencies to 35 at 800 kc/s.

It may not be entirely clear why so much importance is placed on the reproduction of high frequencies, and a digression is therefore needed. Any waveform can be made up by a combination of many frequencies and amplitudes of harmonically related sine waves, and the faster a voltage changes from one value to another, the higher the component frequencies. Frequency response and the time taken for a voltage to change are roughly related by the expression $ft_r = 0.4$, where f is the -3dB point in Mc/s and t_r is the "rise-time" in μ sec of the waveform shown in Fig. 5. The time is measured between 10% and 90% of the total voltage change. For instance, for a rise-time of 0.1 μ sec—not a particularly fast step—the amplifier bandwidth needed is $0.4/0.1 = 4$ Mc/s. In

the present U.K. television transmissions, the video channel contains frequencies up to 3 Mc/s while the 625-line transmissions will have a component of 6 Mc/s. To examine waveforms containing a 6 Mc/s component, the oscilloscope must have a much wider bandwidth, and 10 Mc/s is a reasonable compromise between precision and cost.

To return to our amplifier, there are several methods of postponing the effect of stray capacitance, two being indicated in Fig. 6. The operation of both depends on the use of inductance to compensate for the stray C and the circuits shown in Figs. 6(a) and 6(b) are known as shunt and series compensators respectively. In Fig. 6(a), the reactance of $L—2\pi f L—$ is made to balance that of C_s , and as X_{C_s} falls, X_L rises and tends to keep $g_m Z$ constant. This process can only be effective over a limited range of frequencies, and if L is made too large, L and C_s , which form a parallel-tuned circuit, turn the circuit into a tuned amplifier and the result is a peak in the frequency response curve. If the signal has fast step, the display will take the form of Fig. 7, where the rise is continued into an overshoot, and if the effect is very bad, a train of damped oscillations—a ring—will follow each rise or fall. The circuit shown in Fig. 6(b) uses L to separate the components of C_s , which are the output capacitance of V1 and the input capacitance of V2. The same remarks apply as to Fig. 6(a), but the improvement in frequency response is better. Both these circuits will be discussed more precisely and in more detail when the practical amplifiers are described. For audio and most broadcast radio work, a simple RC-coupled amplifier is sufficient.

L.f. Compensation: At the low-frequency end of the characteristic we are once more in trouble with capacitance, but this time the problem is to get enough. The coupling capacitor C_c in Fig. 8, forms a potential divider with R_g as the bottom arm, and at the frequency where the reactance of $C_c—1/2\pi f C_c—$ is equal to R_g , we are once again 30% down or -3dB. Taking the average value of grid resistor as 470k Ω , a 0.1 μ F capacitor will give this amount of reactance at 3.4c/s. From the point of view of waveforms, a square wave passing through an RC-coupled amplifier takes the form of Fig. 9 and looks more or less weary, depending on the product CR_g . The sag from A to B is roughly calculated from the expression t/CR_g where t is the time from A to B, or half a cycle. For the components assumed, a 50c/s square wave would sag by 20%, and each successive stage makes matters worse. Clearly, some form of compensation is needed, one method being shown in Fig. 10. At high frequencies, R_1 is effectively short-circuited to the signal by C_1 but at low frequencies the anode load becomes R_2 in series with C_1 and R_1 in parallel, and the gain remains constant to a much lower frequency. For best results, $C_1 R_1 = C_2 R_2$. Several other circuits are used, and will be discussed in the appropriate article.

A response extending to zero frequency or, as the specification writers have it, d.c., is useful in several respects, and the difficulty of obtaining a stable amplifier is often worth while. The chief trouble is the tendency of directly-coupled amplifiers to change their characteristics slowly with variations in temperature, h.t. and l.t. voltages. Many are the circuit configurations that have been employed to reduce this trouble, but modern amplifiers follow a fairly

standard pattern. Z.f. amplifiers are mainly used for pulse and waveform techniques, where it is required to know the d.c. level of an a.c. signal. Perhaps this is better described by a diagram, and Fig. 11 is the relevant one. The circuit is a familiar one, the Miller transitron, the electrode voltages being shown at (a) and (b). With a directly-coupled amplifier, the waveforms are displayed in the correct position in relation to h.t. and earth, while in the a.c.-coupled position, they are symmetrically disposed about the zero line. That this can be very convenient is clear, and most modern laboratory instruments possess z.f. amplifiers.

Measurement: As has already been mentioned, the engineer needs information not only on the shape of a signal, but also on the amplitude and time. Three methods of voltage measurement are in common use, all having their pro's and con's and all used in precision equipment. The first type of calibration used is still a perfectly good system and is used in the No. 1 amplifier in the "W.W." instrument. It consists of a known voltage, usually a sine or square wave, applied to the input of the amplifier. The voltage is adjusted by a calibrated control until it occupies the same amount of the c.r.t. screen as the signal, and the voltage read off the scale. A second method relies to a greater extent on the gain stability of the amplifier in that, at each setting of the input attenuator, the sensitivity is set at a given number of divisions on the screen graticule. Any adjustment of the gain control invalidates the measurement, but it is always possible to obtain a conveniently-sized display if the attenuator steps are correctly chosen. The third method is only possible with directly-coupled differential amplifiers. A direct voltage equal to the signal amplitude is applied to the second grid of a long-tailed pair amplifier, the deflection reduced to zero and the amount of direct voltage needed to do this read from the scale of a calibrated potentiometer.

The No. 1 amplifier to be described is essentially a low-frequency design, suitable for audio and radio work, and consists of an a.c.-coupled pentode stage followed by a long-tailed pair phase-splitter to feed the c.r.t. deflection plates. Calibration is of the type shown in Fig. 12(a). It was not felt that in this first unit, any purpose would be served by using direct-coupling with its inevitable extra cost, and signal-injection calibration is rather cheaper to provide than the alternatives, with the advantage that calibration holds with adjustment of the gain control.

So much for the y deflection system. More detailed descriptions will follow when the designs themselves are presented. We must now concern ourselves with the x, or horizontal spot-deflection units, and will start with the time-base generator.

Sweep Generator

Timebase, or sweep-producing circuits are probably responsible for more reputations, of both kinds, than any other single branch of electronics, with the possible exception of sine-wave oscillators. This is all the more strange because every last one of them depends on the same effect—the slow charge or discharge of a capacitor through a resistor, and a rapid recovery. As can be seen from Fig. 2, the voltage waveform required to give the constant-speed scan of the spot across the c.r.t. screen and a rapid "flyback" turns out to be a triangular shape,

or sawtooth. Circuits for producing this shape of wave are many, varying from the simple, highly-curved, free-running devices to the high-precision, triggered generators used in laboratory instruments. The basic principle of them all is shown in Fig. 13, and the No. 1 unit for our oscilloscope uses a modified version. Capacitor C charges up exponentially through R, and when the voltage across it reaches the point at which the discharger, D, comes into operation, the capacitor discharges through it rapidly, the resistance of the discharge circuit being much smaller than R. The sawtooth wave is produced across the capacitor C and the frequency can be varied by adjustment of C or R. Refinements of this circuit are mainly concerned with improvements to the discharger and with attempts to make the voltage rise during the charge period more nearly linear. D can take many forms, the simplest being a gas tube, which approximates to a diode filled with an inert gas such as neon; a voltage across the electrodes ionizes the gas and provides a low-resistance path. The point at which the gas ionizes is 20 to 30 volts higher than the voltage at which the tube extinguished, and the sawtooth is of this amplitude. It is usually required that a pulse is obtained from the sweep generator during the flyback period which can be used to suppress the c.r.t. spot at this time and avoid the confusion of two traces going in opposite directions. A circuit which provides this is shown in Fig. 14. The discharge circuit is formed by two triodes connected in the Schmitt trigger configuration, which, as far as the charging circuit CR is concerned, is the same as a gas tube. During the flyback however, pulses are produced at the two anodes which can be applied to the cathode or grid of the c.r.t. to suppress the spot. This is the form of timebase we shall use in the first unit and it will be described in greater detail in a future article.

Linearity: Perhaps a short discussion of some of the principles of linearization would not be out of place, as we shall make use of some of them at a later stage. The basic fact to get clear is that to obtain a perfectly linear change of voltage across a capacitor, the current flowing into it must be constant. No means have yet been found of conforming to this ideal completely, but some methods produce a sweep which does not measurably depart from linearity. The type of generator described so far relies on a high-value resistor to approximate to a constant-current source, and unless only a small part of the charging curve is used, the curvature is intolerable. A better (and more expensive) method is to make use of the fact that, above about 50V, a pentode presents a very high a.c. impedance, which is seen from a glance at the $I_a - V_a$ curves; a large change of V_a makes almost no difference to the anode current. If, therefore, a pentode is used as a charging resistor, the rise in voltage is almost linear.

Miller Transitron: The most common principle used in modern timebase generators is the use of a feedback amplifier to linearize the voltage sweep. Fig. 15 shows the general arrangement. As the voltage across the capacitor increases, the voltage across R falls, and this fall is amplified. The output voltage of the amplifier increases and is fed in series with the CR circuit to keep the charging current constant. A practical circuit is shown in Fig. 11 and is known as the Miller transitron, the circuit

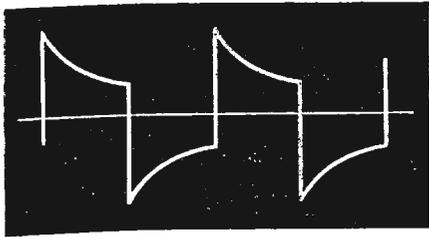
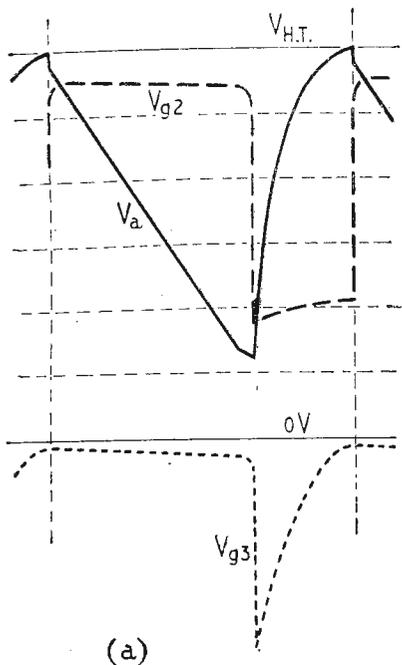


Fig. 9. An attenuated l.f. response distorts a square wave in this manner.



(a)

Fig. 11. A direct-coupled amplifier produces a display as in (a), while a.c. coupling (b) gives no information on level.

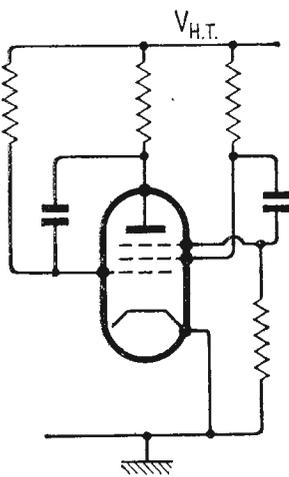
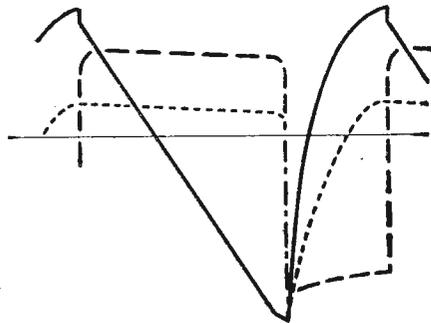
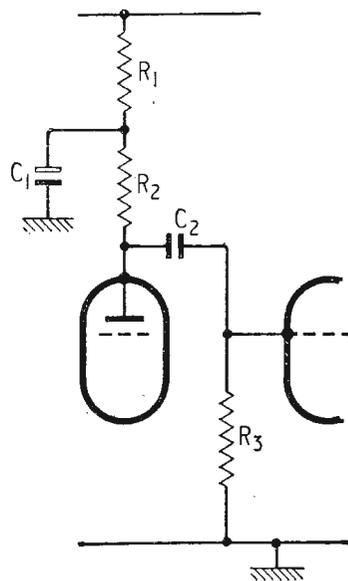
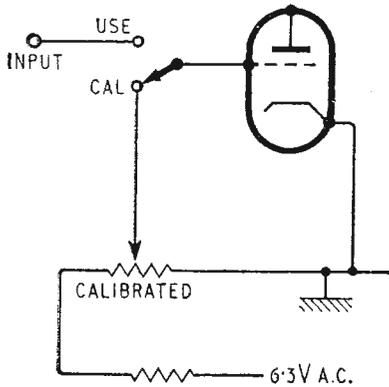


Fig. 10. L.f. compensation components, C_1 and R_1 .

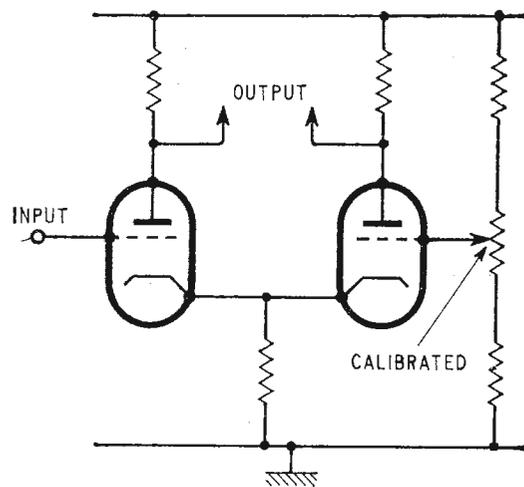


(b)

Fig. 12. The two calibration systems we shall use.



(a)



(b)

Fig. 13. Basic sawtooth or triangular-wave generator.

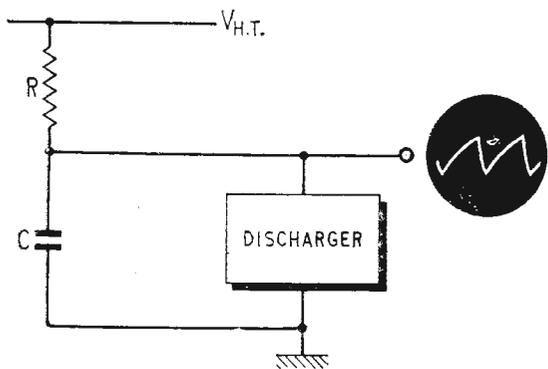
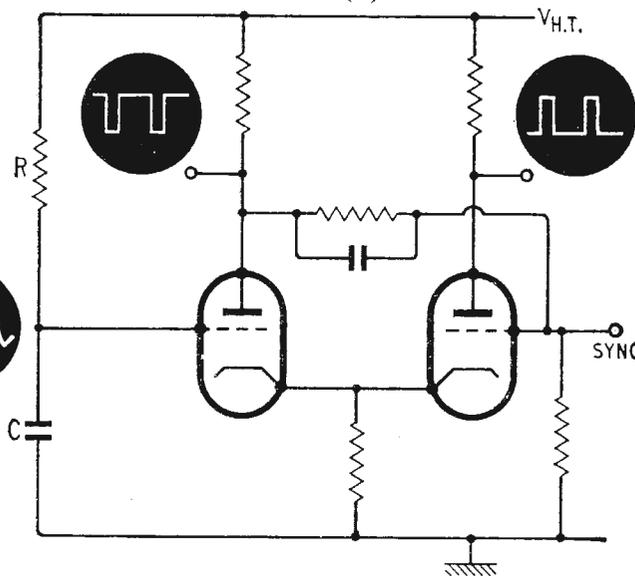


Fig. 14. Schmitt trigger sweep generator giving pulse outputs for fly-back blanking.



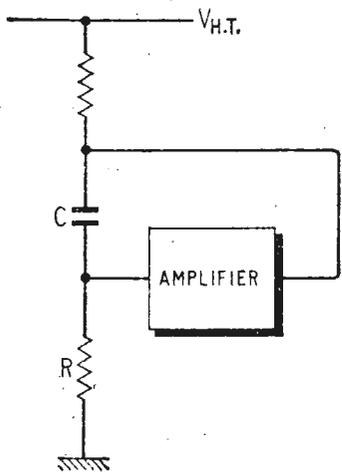


Fig. 15. Principle of feedback - amplifier linearization.

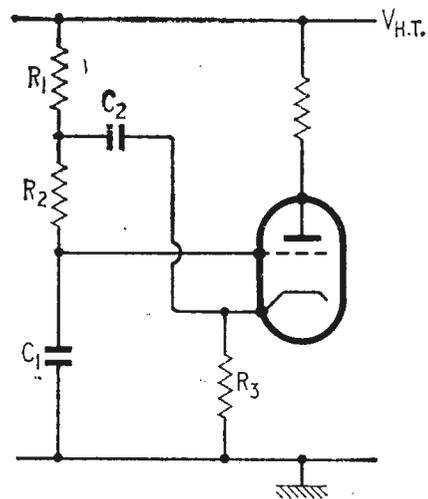


Fig. 16. Bootstrap linearizer.

Fig. 17. In cases (a) and (c) the sweep is not synchronized, while (b) and (d) give a single, synchronized picture. In triggered condition, (c) and (d), sweep is always synchronized if trigger pulse is obtained from y amplifier.

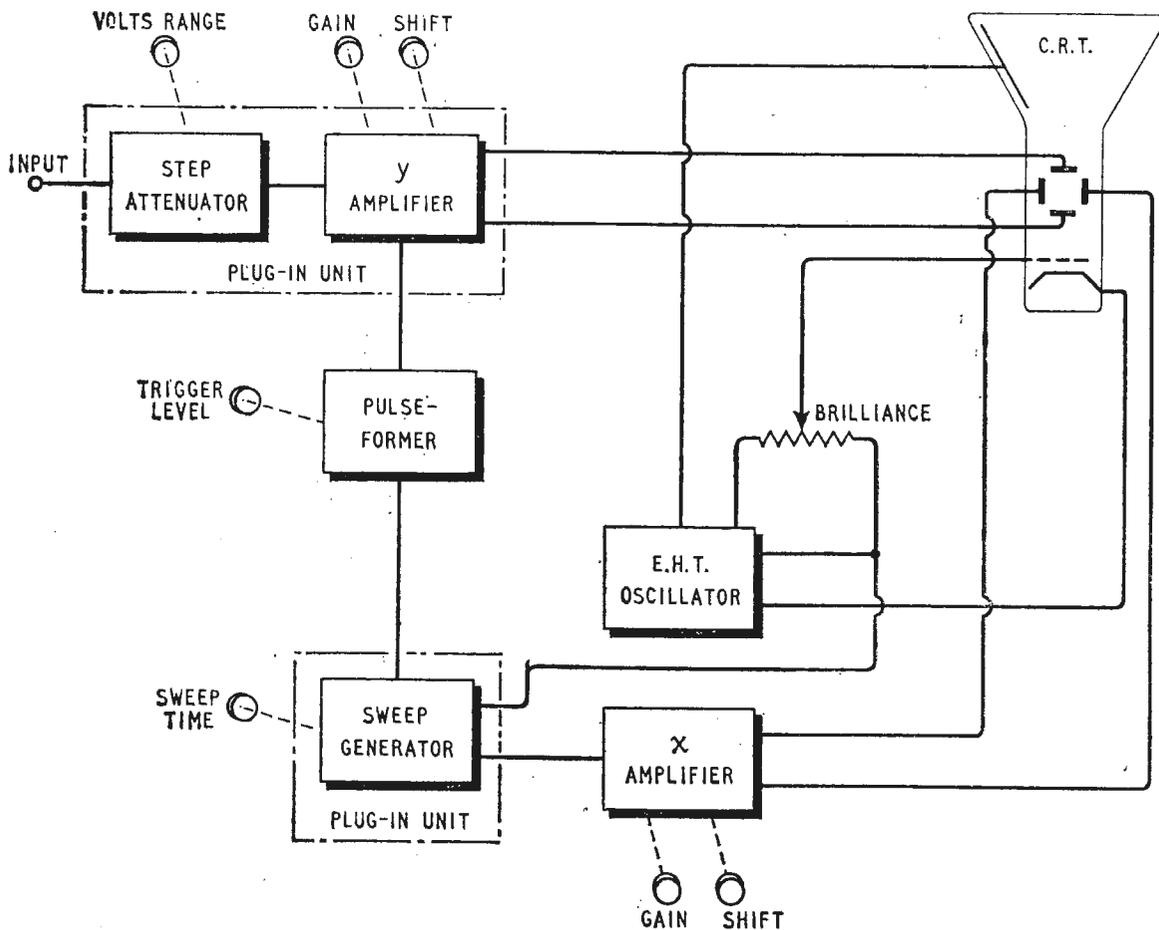
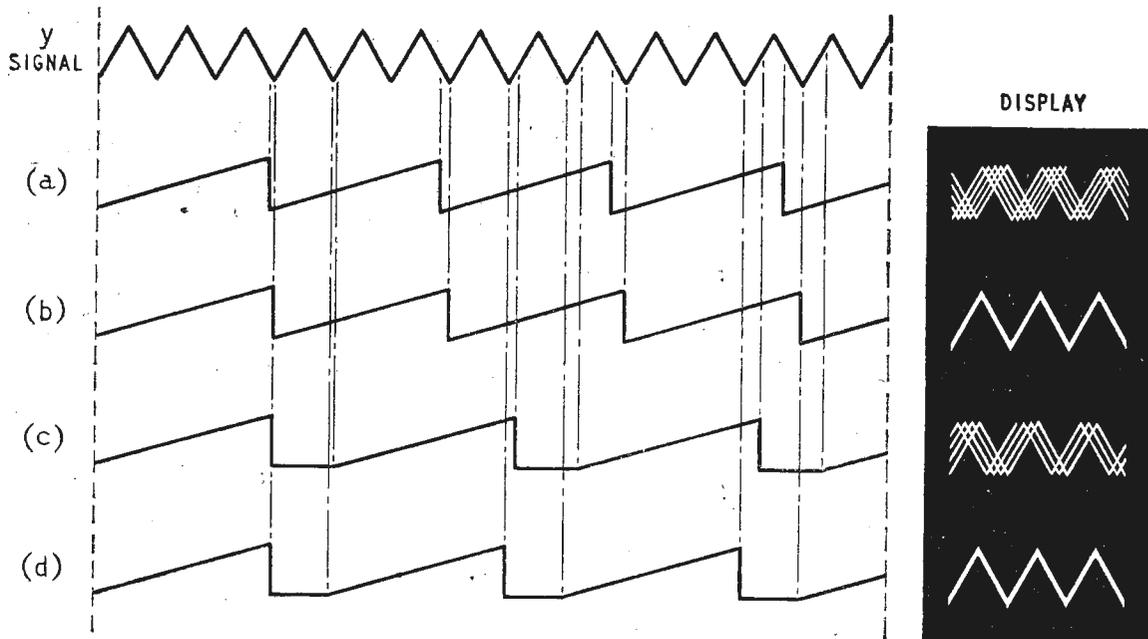


Fig. 18. Block diagram of complete oscilloscope, showing main controls. Main power supply is not included.

also performing the function of a discharger. C and R in Fig. 14 correspond to C and R in Fig. 11. If the gain of the amplifier is high, it can be assumed that the grid voltage remains almost constant for a large charge in anode voltage, and if the grid voltage stays put, so must the current in R. The capacitor discharges through R with, therefore, constant current and, as we have seen, this gives a linear change. The linear fall in anode voltage continues until the voltage is so low that the screen becomes a serious competitor and begins to take more than its normal share of cathode current. The screen voltage falls, and the change is fed to the suppressor grid via $C_2 R_2$, a differentiating circuit. The suppressor being driven negative, anode current is decreased, more cathode current goes to the screen, the fall in screen voltage is passed to the suppressor . . . and so on. The action is a rapid switching sequence and the result is a complete absence of anode current, heavy screen current and a suppressor voltage which is returning to its "cut on" value in a time governed by the product $C_2 R_2$. The anode voltage returns to V_{ht} in a time $C_1 R_1$ and the whole thing starts again. We therefore have a linear, repetitive sweep, the frequency of which is governed by the value of C_1 , R_1 and the voltage to which R_1 is returned.

Bootstrap: A similar principle is employed in the "bootstrap" circuit shown in Fig. 16. This is also a feedback amplifier and, in fact, is almost identical, basically, to the Miller circuit. In this case, the capacitor C_1 changes towards V_{ht} through R_2 and the signal across C_1 is applied to the cathode follower. The output across R_3 is fed to the "top" of R_2 , so that the "aiming" voltage of C_1 increases as the charge increases, tending to keep the current constant, and "pulling itself up by its own bootstraps." The circuit needs a separate discharger.

Refinements and combinations of these two circuits are responsible for the vast majority of oscilloscope timebases, variations being occasioned by the need for synchronizing and triggering by the y signal and external sources, and the difficulties of high-speed operation.

Synchronizing: The time the spot takes to complete one sweep across the c.r.t. must be variable to avoid a confusing jumble of traces. Fig. 17 shows what is meant by this. At (a) the time base does not take an integral number of cycles of the y signal to get across the screen, and therefore does not start at the same point on the y signal at each sweep. At (b) this does happen, and the timebase is said to be synchronized. This state of affairs can also be brought about by keeping the sweep speed constant and varying its repetition rate, as in (c) and (d). This method is used for triggered timebases (i.e., types that require a pulse to produce each sweep) and has the advantage that as the speed is constant, calibration is made much simpler. We will be using a timebase of this type in one of our later units. Sync and trigger pulses in our instrument, are obtained from the y signal by means of a Schmitt pulse forming stage. Either internal or external signals, positive—or negative—going, can be used, with a variable level control to adjust the point on the y waveform at which the sweep starts.

Time Measurement: As in voltage calibration, several equally good methods of time determination are in common use, and we will use at least two of them in our timebases. Possibly the most accurate

way of calibrating the timebase is to impress upon it a series of time markers, either as vertical deflections from the y amplifier or as bright or dark spots by means of intensity-modulating the c.r.t. itself. This method never seems to catch on to any marked extent, although the Cossor 1076 60Mc/s oscilloscope uses it successfully. The modulating signal is often obtained by exciting a high-Q tuned circuit, or even a crystal, by means of a pulse or step from the sweep generator, and applying the train of oscillations to the grid of the c.r.t. A continuous-wave oscillator cannot be used, because the modulating signal must be phase-related to the sweep so that the spots come in the same place every time. Other methods depend on the linearity and constancy of amplitude of the sweep voltage and/or the x amplifier. For instance, the Marconi TF1330 series which uses the type of sweep in Fig. 17(c) and (d) the sweep amplitude is inherently constant, as is the sweep time for a given range, so that, assuming linearity of sweep, the relationship between sweep voltage and time is constant. The calibration can then take the form of a calibrated shift control at the input to the x amplifier, with the advantage that calibration holds for any gain adjustment of the amplifier, and even if it is not linear. A third method of measurement is to calibrate the sweep time control in time per division of the c.r.t. graticule. This is more inconvenient than the others in that it can involve a certain amount of mental arithmetic, but it is simple to provide, and was considered suitable for our first unit.

Power Supplies

The stability and measurement accuracy of an instrument is dependent to a large extent on the constancy of its power supplies, and in the "W.W." oscilloscope, both positive and negative supplies are stabilized. The extra high tension (e.h.t.) supplies for the c.r.t. are derived from an oscillator. This has the twin advantages that the ripple frequency is much higher, and therefore easier to smooth, and that the output impedance is very high, which means that if one touches the output rail accidentally, no damage to either life or limb is caused. With "Battersea power station on the other end" in a mains-derived supply, one cannot be quite so light-hearted about three or four thousand volts. The blanking pulse is applied to the c.r.t. grid via a "floating" winding on the e.h.t. transformer, so avoiding the necessity for a blocking capacitor, with its inevitable differentiation.

Cathode-Ray Tube

The tube we have used is the Mullard DN7-78 3-in flat faced instrument tube which has a post-deflection acceleration ring operated at 3kV. The negative e.h.t. required is of the order of 750V. Deflection sensitivity in the y direction is 9 volts per centimetre at 750V cathode voltage, which makes amplifier design relatively simple.

Applications

Having built the oscilloscope, the uses to which it can be put may not appear entirely obvious, and a further article on this subject is necessary. This will appear after the constructional details have been given, and will describe the operation of the instrument in the testing of audio and radio equipment, and television receivers.

"AEROSPACE" TELEMETRY—a short review

IT is generally accepted that the task facing the designer of "aerospace" telemetry is much more formidable than that encountered with other comparable communication systems. Not only has he to endeavour to produce an utterly reliable system meeting definite standards of accuracy but also this has to be achieved within severe design "constraints," particularly the environmental and other limitations imposed by the rocket or satellite concerned. In relation to these conditions there are three major areas in which improvements in system performance can be sought. The first two of these divisions are associated with the space vehicle itself, and are the bandwidth (fixed basically by the "amount" of measurement intelligence required to be transmitted), and the effective radiated power from the vehicle. The third division embraces the ground receiving installation in terms of its efficiency compounded from the "goodness" of the aerial as a collector of radio energy, and the overall noise figure of the receiving system, usually expressed as an equivalent noise temperature.

With the intensive research and development programmes being undertaken in this field at the present time, demands tend to grow at an ever-increasing rate for more telemetry data channels, each with a wider frequency response. To meet this demand means that the signal bandwidth becomes greater, i.e., that the signal/noise ratio of the whole telemetry link is degraded because of the proportional increase in noise with bandwidth. Clearly, if accepted, this change in the fundamental system parameters must be offset by an improvement in signal/noise ratio obtained elsewhere. It will be realized that little can be done with regard to effective radiated power—the power supplied to the transmitter is strictly limited by the permissible weight and the volume available for its source, while vehicle aerial systems cannot be given high efficiency as radiators (e.g., they must be made isotropic rather than directional and must be kept physically small).

In these circumstances it becomes necessary to concentrate largely on the ground receiving equipment. Improvement in signal input to the receiver can be achieved by increasing the "aperture" of the aerial and with it directivity and hence its gain. A price must be paid for this increased gain in that relatively complex aerial "steering" equipment must be provided to follow the moving transmitter. The other major factor, noise, can be reduced by introducing new techniques such as parametric amplification in the first stage of the receiver, but again complication, and consequently expense, is entailed.

At a recent I.E.E. conference on Satellite Communication it became evident that the trends outlined above were being followed closely both in the satellite telemetry systems themselves and in the corresponding "service" communication links. As an outstanding example of this common ground, it was clear that these communication links had been designed on the basis of the maximum return being obtainable from the ground receiving equipment. Thus at the British station at Goonhilly Downs, Cornwall, and at the U.S. station at Andover, Maine, extremely large aerials with precision steering systems have been installed, together with special low-noise amplifiers in the first stages of the

receivers. The two reflector apertures are 5,700 sq ft and 3,600 sq ft for Goonhilly and Andover respectively, but it appears that the lower aerial gain implied for the latter is counterbalanced by a rather better overall receiving system noise performance.

At this point it should be noted that the operating frequency, 4,170 Mc/s, for the communication link is more than an order up on the 136 Mc/s allocated for the telemetry senders used in the Telstar and Relay satellites. However, it can be taken for radio telemetry as a whole that a move to much higher frequencies must be regarded as inevitable. A number of factors contribute to this result, of which one is the availability of frequencies as determined by international agreement, another is the tendency already mentioned, for signal bandwidths to increase and thus to necessitate a corresponding increase in carrier frequency. Consequently it is a reasonable assumption that the techniques developed for the higher frequencies will find application in the telemetry field in the not too distant future.

In this connection the following points should be made with regard to the difference between the rocket and the satellite applications. This difference is probably greatest for the paths followed by the two types of vehicle and consequently for the tracking methods which can be adopted in each case. Thus the orbit of the satellite is completely predictable for each "pass"; whereas, although a rocket is fired on a planned trajectory, it cannot be expected to follow an exact velocity programme because of variations in motor specific impulse, etc., between individual missiles. It is therefore common practice for satellite tracking to be carried out under the control of a digitally coded tape which has been prepared from predicted orbital data. Such data is made available on a world-wide basis for Telstar by the Goddard Space Flight Center, Greenbelt, Maryland. Provision is usually made for auto-following in the satellite case, but even if it is used the "putting-on" problem is rendered extremely small by prediction. On the other hand, it will be realized that the acquisition of a missile is much more difficult, and it may be that two aerial systems will have to be used at the higher frequencies—a "coarse" one for short range working, and a narrow beam "fine" one to take over in the auto-follow mode for the longer ranges. Furthermore, it may well be that the complexity of the liquid-helium-cooled travelling-wave maser amplifiers in particular, employed at both Goonhilly and Andover, will rule them out for use at "up-range" receiving stations for rockets. This may also be the case at base stations purely for economic reasons.

Finally it is of interest to note that pulse code modulation is used in both the Telstar and Relay telemetry systems. There is a difference between them, however, with regard to the two-stage modulation method which is almost invariably adopted for such systems. Thus for Telstar the modulation sequence is f.m.-p.c.m., while for Relay it is p.c.m.-p.m.

A further point of interest is that the frequency modulation in the Telstar scheme takes place as an a.c. frequency change of 3 kc/s; and that this increment produces the alternation between the equivalents of "0" and "1" or "off" and "on" in the modulated, and hence coded, waveform.

R. E. Y.

PHYSICAL SOCIETY EXHIBITION 1963

Heralded by cold winds and frozen roads, the 1963 Institute of Physics and Physical Society Exhibition opened in the Horticultural Halls, Westminster. Restrictions on the number of exhibits per stand and the provision of wider passage ways eased to a certain extent movement in the halls. Afternoon visitors, however, were still too numerous for comfort and ease of inspection of the exhibits.

Prominent among the exhibits were test and measuring instruments, medical developments, industrial control and components. Worthy of especial mention were the entries in the Craftsmanship competition in scientific instruments and apparatus. The items on show in the vestibule of the New Hall more than justified their prominent position.

TEST AND MEASUREMENT

A tracer for valve and transistor characteristics with several interesting features has been developed for the use of staff and students in the electronic laboratories of the Royal Military College of Science. The equipment enables the display of a single characteristic curve or a family of four such curves. Using the conventional form of display these can be calibrated enabling quantitative information to be obtained. In the case of valves, r_a and g_m and in the case of transistors, slope resistance and " β " are easily derived. Up to seven transistors may be attached to the tracer and the display switched from one to the other enabling rapid comparison of characteristics. The voltage and current markers are calibrated by comparison with a "set-in" d.c. supply which is measured on a meter. Tetrode and pentode valves can have suitable potentials applied to their second and third grids, the potential being measured on the same meter. Two cathode ray tubes, one for direct viewing and the other for photographic purposes, are present on the equipment. By making several exposures on the same plate curves of one valve under various conditions or different valves or transistors may be superimposed on the same photograph. The mains supply at 50c/s operates a squarer stage followed by two binary stages providing eight time intervals in one period of 80 milliseconds or a p.r.f.

of $12\frac{1}{2}$ c/s. Four of these intervals are used to display the characteristic curves and the other four the axes and markers. The squarer and binary stages are also used to initiate the negative step generator which supplies negative known amplitude steps to the valve or transistor base. All the "X" information is applied to a combining circuit, the "Y" information is applied to another combining circuit. The output of these circuits is applied to the display amplifiers which have push-pull outputs for the deflecting plates and provide expansion and shift of the display without disturbing the calibration. Each circuit function is mounted on a separate panel. The supplies are taken to each unit by means of a flexible lead and 6-pole plug, the signals by single coloured leads and single-pole plugs. This arrangement enables signal paths to be easily traced, functioning of the units checked and modifications to be carried out.

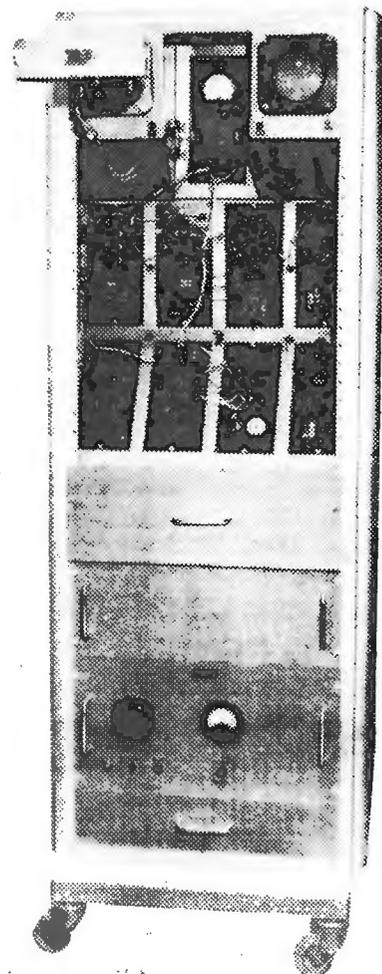
The dearth of pulse generators at the 1962 exhibition was more than made up for by the introduction of three new ones at this year's show.

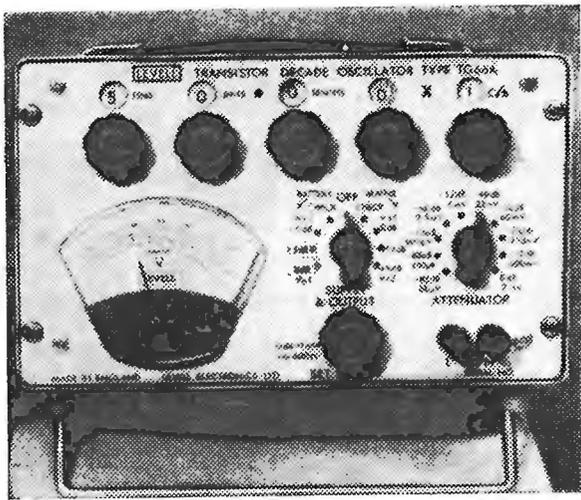
An extremely flexible and fully transistorized pulse generator was shown on the Venner Electronics Ltd. stand. Normal controls associated with pulse generators such as frequency, pulse width, delay of pre-pulse, etc., are supplemented by controls for carrying the rise and fall

Royal Military College of Science valve and transistor characteristic tracer.

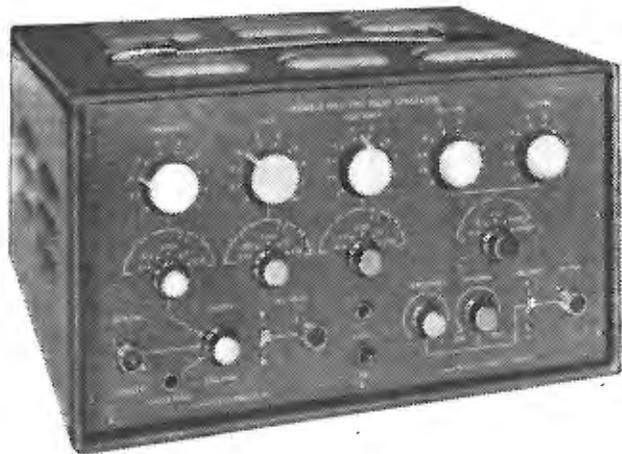
times of the leading and trailing edges. Amplitude controls, d.c. level control and polarity reverse switches are included. The maximum pulse amplitude is ten volts and the output impedance is approximately 50 ohms.

Versatility still being the keyword the pulse generator Type PG 53 introduced by Nagard makes use of plug-in units. Basically the generator consists of power supplies and four units. Of these, one is the trigger source unit; the other three are delayed pulse generators. The trigger source unit initiates pulses produced by the delayed pulse generators. This unit may also be used as a square-wave generator. It can be triggered externally by any type of signal and polarity from 0 to 25 Mc/s (20 mV r.m.s. sine-wave, 10mV P-P pulse), the triggering level being adjustable. Internally, triggering is controlled by a rate generator or clock in three modes; normal mode—100 ms to 100 ns continuously variable and calibrated; synchronized mode—synchronizes without adjustment to sine-wave input of less than 2V from 5c/s to 50 Mc/s; gated mode—positive 2V pulses causes clock to run for period of pulse. A square-wave output is available at the clock frequency (10c/s-10Mc/s) continuously variable and calibrated,

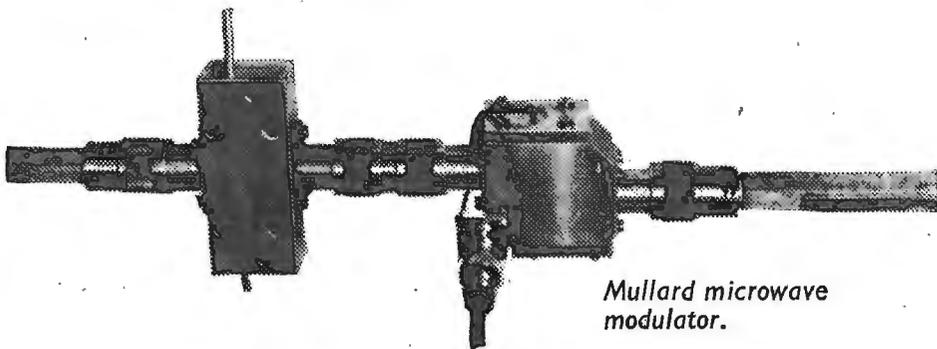




Levell Electronics oscillator Type TG66 A.



Venner variable rise-time pulse generator.



Mullard microwave modulator.

80 μ V to 2V amplitude. The rise time is approximately 3 ns. A wide variety of high-speed complex waveforms are possible by modulation of the square-wave output using the delayed pulse generators singly or in combination. A pre-pulse output is available having adjustable polarity and a pulse width of 20 ns. The delayed pulse generators all have controllable delay from this pre-pulse using the main output as a trigger pulse. All three d.p.g. units are triggered by the trigger source unit and have calibrated delays and main pulse widths. The three outputs may be used separately or mixed without loss of calibration accuracy.

A pulse produced by discharging a cable delay line with a mercury relay mounted coaxially for matching into 75 ohms is used as the basis of the E.M.I. pulse generator Type 2. This generator produces pulses of various widths with rise times of less than 0.5ns. The pulse amplitude is continuously variable from 0 to 150V positive or negative. Three internal cables are provided giving pulse widths of 4,50 and 100ns. An external cable may be used to produce pulses of any required width. The relay gives a p.r.f. in excess of 300 p.p.s. It can produce a single pulse or a continuous train.

A wide-band RC oscillator using ten basic components, of which the only two capacitors are those required for frequency determination, was shown by the Admiralty Surface

Weapons Establishment. This oscillator is a directly-coupled current-fed Wien bridge type. Equal resistances and reactances are chosen in the frequency-sensitive bridge arms; a current gain of 3 is thus required to maintain oscillation. This gain is determined by the ratio of two resistors; one, a thermistor, is used to give amplitude stabilization despite possible minor changes in the gain requirement over the working frequency. Switching capacitors giving steps of 10:1 control frequencies. Fine frequency control is achieved by switching resistors in discrete steps but this system can be replaced by a continuously-variable 2-gang control of high linearity. The oscillator has a frequency rate of 16c/s to 4 Mc/s.

Another transistor oscillator, the Levell Type TG 66A, covering a frequency range from 0.2c/s to 1.22 Mc/s was introduced at the exhibition. Frequency selection is made by four in-line additive decade controls and a five-position multiplier switch. The last control is continuously variable so that any frequency may be selected with a discrimination better than $\pm 0.05\%$ above 10c/s and better than $\pm 0.005c/s$ below 10c/s. Frequency stability in terms of ambient temperature change is better than $\pm 0.03\%$ per $^{\circ}$ C. An unusual feature is that the current-fed dual of the usual Wien is not preferred. The high impedance necessary is obtained from a super-alpha pair.

A d.c. Wheatstone bridge incorporating a number of new features designed for measurement of two-terminal resistors ranging from 0.1 ohm to 100 megohms was exhibited by the Cambridge Instrument Co. Ltd. The accuracy of adjustment of this instrument is to within $\pm 0.005\%$. The bridge fitted with ratio arms consisting of two sets of four coils giving values of 10, 100, 1,000 and 10,000ohms each provides seven bridge ratios from $\times 0.001$ to $\times 1,000$. The two sets of coils are controlled by separate switches and are so arranged that when the instrument is used as an equal-ratio bridge the ratio coils can be interchanged and intercompared. When used as an unequal-ratio bridge any of the coils can be used to establish the ratio. A guard circuit provides a means of eliminating errors due to leakage when using higher resistance ratios. In order to determine whether or not leakage errors are present this circuit can be switched out at will. In addition to conventional battery reversing and battery series resistance controls the bridge is fitted with a means of balancing out lead resistance. This is done by three cascaded adjustable resistors of relatively low accuracy of adjustment which are connected in series with the measuring arm decades. It effectively subtracts the lead resistance from the main measurement enabling the true value of the resistor under test to be read directly.

Low switch resistance, small contact resistance variation and negligible maintenance were emphasized in the W. G. Pye Five Dial Wheatstone Bridge. This bridge was built around their Type 6001 low resistance precision instrument switches. These switches are characterized by contact resistance variation of less than $\pm 20\mu\Omega$. The five-dial standard gives resistance in decades of 1,000, 100, 10, 1 and 0.1; the ratio

arms consist of 1,000, 100, 10 and 1Ω resistors. Operating keys are provided for battery and initial and final galvanometer sensitivity.

The switch demonstrated with the bridge on show was developed for multiway switching applications. Basically a hundred-way switch; fewer ways can be provided on request.

The X-band solid state source demonstrated by Microwave Associates Ltd., employed silicon varactor diodes. A v.h.f. oscillator, crystal controlled, followed by a transistor power amplifier and varactor multiplier stages may be adjusted to give an output at any desired microwave frequency. A stability of 1 part in 10^7 may be attained. The fixed frequency unit as shown gave an output of 10mW at 8.2 Gc/s . A d.c. power supply of 12V at 200mA was required. The overall size of the unit, less power supply, was $6\text{in} \times 4\frac{1}{2}\text{in} \times 4\text{in}$.

A microwave modulator designed to operate within the frequency range 2.5 Gc/s - 7.5 Gc/s without tuning shown by the Mullard Research Laboratories can be applied to low-level microwave power control.

The modulator employs a pair of variable resistance diodes and a 3dB directional coupler. The incident power from the driver stage is transmitted through the coupler only when a pair of similar terminating diodes are biased to either high or low resistance condition. If the diodes are biased so that their resistance equals the output impedance of the coupler the incident power is absorbed in the load formed by the diodes. The device is thus matched to the source and load in all operating conditions. The diodes used in the modulator are junction diodes made up from a sandwich of p-type, intrinsic and n-type semiconductor material.

ceeds the input limits. A moving-coil meter on each channel indicates presence of carrier during record or playback. The reproduced signals emerge at the output socket at unity gain with respect to the recorded signals. Phase distortion is held to less than $\pm 2^\circ$.

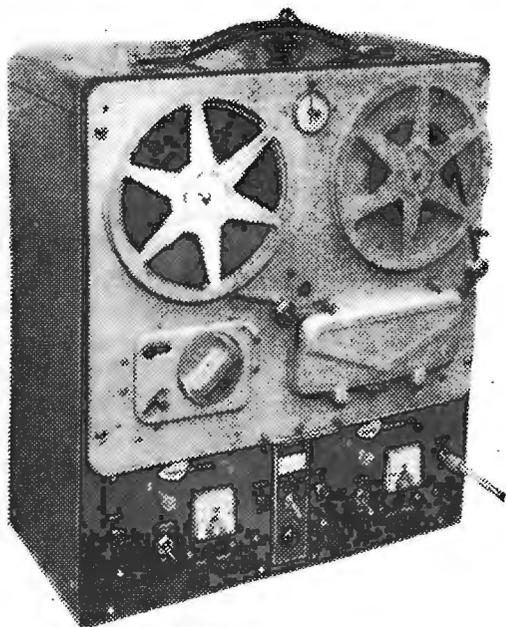
The sensitivity of a transformer ratio arm bridge to small changes of resistance is well known. This used in conjunction with an a.f. oscillator, amplifier and a phase-sensitive detector enables an extremely sensitive control system to be developed. Hatfield Instruments controller Type LE460 is based on this combination. Sensitive elements of either sign placed in one or both arms enable a differential to be determined to a sensitivity of 0.02% when referred to a bridge arm resistance of 250 ohms . When this instrument is used as a temperature controller it is fitted with a standard adjustable arm on one side of the bridge. Terminals for connection to the external sensing element form the other arm. Sensing elements suitable for this arrangement are platinum wire resistances or thermistor devices depending on whether positive or negative signs are required. When the bridge is unbalanced by a change of resistance in the control element a signal is fed to the input of the amplifier and then to the phase detector. When the bridge is unbalanced in one direction the output from the detector is zero and increases proportionately to the unbalance in the other direction. It is possible to select on which side of balance the control signal is obtained thereby enabling proportional control uses.

Temperature control by thermocouple is by far the more common

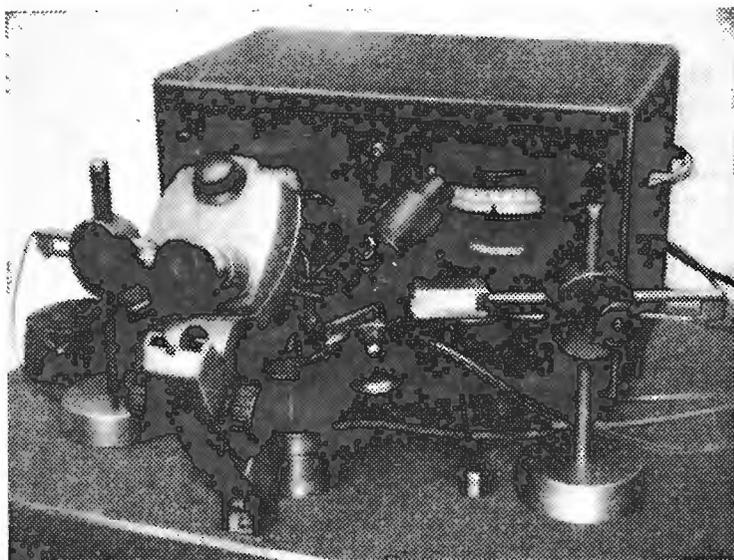
INDUSTRIAL ELECTRONICS

Many methods are available for the recording of electrical outputs from transducers used in industrial monitoring and control. The main requirement is that the information may be conveniently stored for subsequent investigation and analysis. At one time the paper strip with pen tracings reigned supreme. The introduction of magnetic tape shows an improvement over paper charts in that the recorded information can be fed back directly into simulators, analogue computers, etc. When more than one signal is recorded simultaneously, the correct synchronization one to another can be

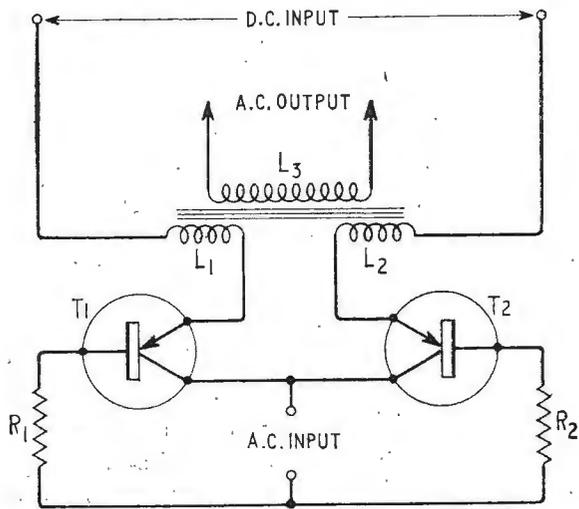
maintained during reproduction. This facility allows a time scale to be introduced to a recording. The Fenlow 2-channel tape recorder Type S.T.R. provides in the same unit, facilities for recording and reproducing on two channels signals between -1 and $+1$ volt from 0 to 100c/s . The recorder uses $\frac{1}{4}$ inch magnetic tape and an uninterrupted running time of 45 minutes on standard reels is possible. Use of oversize reels increases the time to 1 hour. Silicon transistors are used throughout. On each channel an overload signal flashes repetitively whenever the applied signal ex-



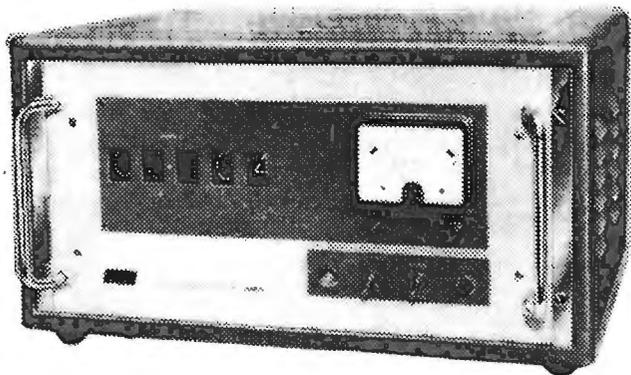
Fenlow 2-channel tape recorder.



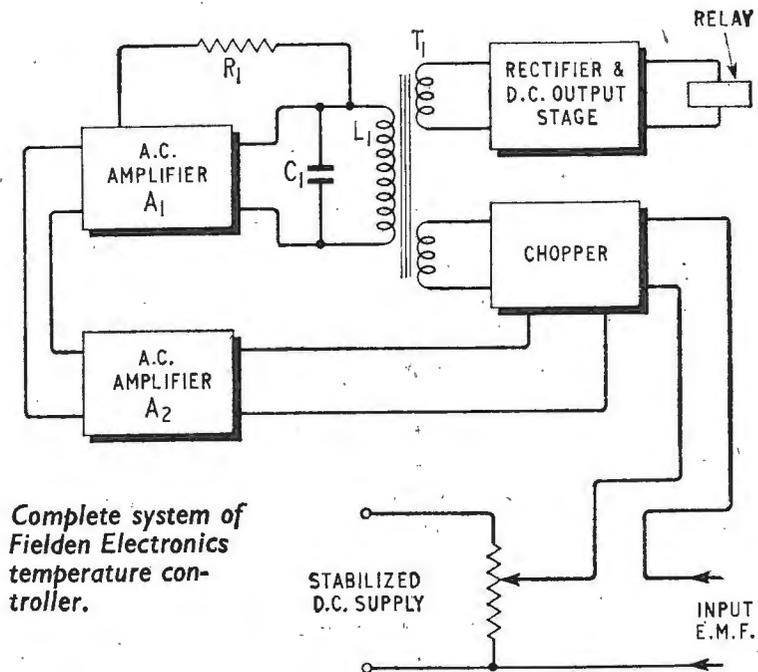
G. V. Planer thermo-compression bonder.



Chopper circuit of Fielden Electronics temperature controller.



Racal reversible decade counter.



Complete system of Fielden Electronics temperature controller.

practice. In the Fielden Electronics transistorized thermocouple temperature controller a d.c. amplifier is used to compare the e.m.f. from any thermocouple with the voltage at the movable contact of a slide-wire. A current of up to 40mA at 12V d.c. is switched when the thermocouple e.m.f. exceeds the voltage at the movable contact. This contact is directly coupled to a pointer on a scale calibrated in temperature. The current can be used to energize a relay or to perform any other function required.

The compensated chopper circuit is shown in the first of the accompanying diagrams. T1 and T2 are two transistors of matched characteristics. L₁ and L₂ are two matched inductances forming the primary windings of a transformer, the secondary of which is L₃. The transistors are driven in phase by an a.c. limited in amplitude by resistors R₁ and R₂; thus they are switched on and off simultaneously. When in the conducting state pulses of d.c. flow through the circuit giving an a.c. output at L₃. Unwanted alternating e.m.f. from the a.c. drive appearing across the transistors are equal and opposite. In practice the a.c. drive is derived from a separate transformer winding allowing the input terminals of the chopper to be d.c. isolated from associated equipment. The second diagram shows a

complete arrangement of the equipment. L₁ and C₁ form a resonant circuit tuned to 1,500c/s. The amplifier A₁, with positive feedback via R₁, is arranged to maintain the circuit at oscillation at about half maximum amplitude. T₁ has two output windings, one driving the chopper, the other providing a voltage which is rectified and used to switch the output current. The a.c. output from the chopper is amplified by A₂ prior to being applied to the input of A₁. The signal at this point adds to or subtracts from the existing positive feedback obtained through R₁, thus controlling the amplitude of oscillation. This arrangement allows the amplitude to rise from zero to maximum for a few microvolts change of input. A trigger circuit eliminates as far as possible relay "chatter."

An equipment developed for the production of thermo-compression bonds, particularly suited for bonding leads to thin film electrical circuit elements and semiconductor materials was exhibited by G. V. Planer Ltd. The workpiece is mounted on a thermostatically controlled base plate suitable for temperatures up to 600°C. An inert gas can be plied on this plate which can also be moved in the horizontal plane. A temperature-controlled (up to 600°C) stainless steel bonding head with variable load is used to effect the junction. The head can be

moved in both horizontal and vertical planes. A wire feed appliance in conjunction with a micro-manipulator is used for the advancement and positioning of the wire or metal strip to be bonded. Designed to accept standard spools and wires between 0.005in and 0.01in diameter the wire feed mechanism has provision for advance and reverse wire feed directions. A wire cutter is mounted at the nozzle of the wire feed channel. A binocular "zoom" microscope with continuously variable magnification and adjustable illumination is incorporated.

The measurement of an a.c. voltage in the presence of other voltages of higher potentials and differing frequencies has always presented a problem when ease of measurement and portability of test equipment were the main considerations. The Avo Frequency Selective Signal Voltmeter was designed with these considerations in mind. The instrument demonstrated at the exhibition was developed for the measurement of voltages used in railway track signalling systems. Three parallel-T-derived networks form the filtering circuits. In this case one of the networks rejects 50c/s interference of up to 100V r.m.s. The others reject interference at 100 and 150 c/s. All three networks allow free passage to low level signals of the order of IV r.m.s. at frequencies of 75 and 83.3c/s. The filters are tuned for a high degree of rejection at the unwanted frequencies and each is associated with a transistor amplifier, the three amplifiers being in cascade. In each amplifier the filter forms part of the forward signal path and negative feedback serves to sharpen the response of the filter in the neighbourhood of the rejection frequency. This

enables the very high slope of the insertion loss characteristic, necessitated by the close proximity of the interfering and signal frequencies to be attained.

Three voltage ranges (3, 15 and 30V) are provided for the measurement of the signals at 75 and 83.3c/s. In addition, a normal 150V, 50c/s range and two d.c. ranges (3 and 15V) are provided. The d.c. ranges are arranged to enable d.c. measurements to be made in the presence of up to 100V, 50c/s interference. A standardizing oscillator is incorporated to enable the sensitivity to be corrected for changes of gain.

A reversible decade counter completely transistorized and developed for work in machine tool control, etc., was shown by Racal Instruments Ltd. The instrument has an in-line digital display which is connected to the counting circuits via a transistor decoding and drive matrix. The counter comprises a number of cascaded reversible decade scaling units capable of operating at a maximum frequency of 100kc/s. High-speed input amplifiers and shaping circuits together with direction discrimination logic circuitry enables detection of the direction of travel of the measuring heads. The instrument can accept several forms of input signal, the most common input being two or more sine waves at 90° phase difference. The relative lead or lag of those signals indicates direction of movement. Where angular position is required to be displayed by the read-out it can be indicated in degrees, minutes and seconds directly.

A technique having wide applications in the design of computer power supplies and three-phase d.c./a.c. inverters was demonstrated by Transatron Electronics. The exhibit consisted of an anode commutated silicon-controlled rectifier (SCR) ring counter sequentially triggered by pulses generated from an SCR pulse generator. Selection of commutating capacitors determines the cisoidal waveform across any diametrically opposite terminal of the ring. The larger the number of stages, the better the sine wave shape. With N stages, N/2 phases of supplies may be generated each differing in phase by 360/N/2 with balanced loads the phase shift between stages is accurately defined by this relationship. If switching is symmetrical, harmonic distortion is mainly contributed by the switching frequency which is N times the output frequency.

MISCELLANEOUS

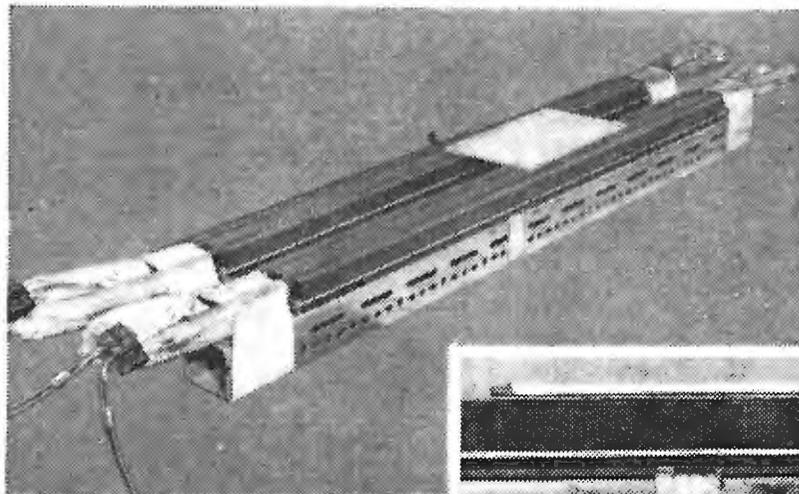
Levitation is fast losing its whimsical character, and industry may well benefit from the process in the foreseeable future. Previous demonstrations have required some means of stabilizing and balancing the supporting field, but the N.R.D.C. demonstration by D. H. Cashmore and E. R. Laithwaite is considerably simplified. The device takes the form of several hundred E-type transformer laminations arranged in two rows, thus providing four slots. Copper bars are placed in the slots and alternating current passed through in such a way that flux from each slot opposes that from adjacent ones. If a conducting plate is placed over the assembly, eddy currents are induced in it, and a repulsive force set up. The flux from the inner slots supports the plate while the outer field stabilizes it in a central position. The space between the two sets of laminations can be occupied by a linear motor, the result being a completely frictionless system. A problem to be solved is the fact that eddy currents heat up the plate, increase its resistance and decrease the currents.

Cathode-ray tubes with several new features were seen at the exhibition. A camera tube by 20th Century Electronics is intended for ultrasonic applications in medicine and industry, where X-ray techniques cannot be used. In operation, the tube is something like a vidicon, the charge pattern being set up on the inside of the transducer. The pattern is scanned by a low-velocity electron

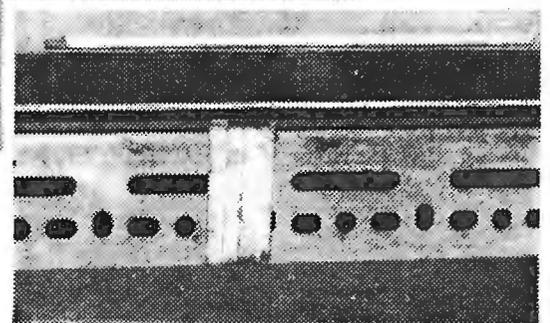
beam and the signal picked off capacitively from the outside surface of the transducer. Cathode-potential stabilization is obtained by ionization set up by the electron beam between the decelerator screen and the transducer. The operating frequency of the transducer is 4Mc/s.

High-sensitivity magnetic deflection is provided in a new E.M.I. tube. The coils, instead of being mounted externally on a deflection yoke, are fitted in place of the normal electrostatic plates. The coils are formed by a printing process, and, being nearer to each other than is normal, produce a greater degree of sensitivity—of the order of 100° per ampère of deflecting current. The signal required is current rather than voltage, and transistors would appear to be the ideal amplifiers for this application. The inductance of the coils is 8μH. It appears possible, by the provision of a centre-tap, to use the coils as an electrostatic deflection system, simultaneously, although cross-talk then becomes a problem.

At low light levels, the performance of the normal image orthicon is degraded by leakage between elements of the target, and at a brightness of 2 foot lamberts with an aperture of f.16, the screen is capable of resolving only 200 lines. In a new English Electric tube, the inter-element leakage has been considerably reduced, and the resolution is 350 lines. The process has also reduced the after-image effect at normal light levels.



N.R.D.C. levitator.



LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

"New Phase-splitter"

IN his letter in the January issue Mr. Baxandall takes me to task over my criticism in an article in the Sept. 1962 issue of the concertina phase-splitter.

Now although I realize that the ideal state is for amplifiers to be driven within their ratings, I feel that it is unrealistic to ignore the possible effects of overload. Indeed the testing specifications laid down by several associations of amplifier manufacturers and other important bodies includes the testing under overload conditions. Most amplifiers are liable to be overloaded and it is very distressing if an amplifier indulges in a fit of hysterics for several seconds after an overload.

The greatly dissimilar, but coupled, output impedances of the concertina phase-splitter can help to cause this defect and the application of overall negative feedback can easily make matters much worse. This is perhaps best seen by considering the conditions that apply in both balanced and unbalanced drive impedances.

The block diagram of a balanced system is shown in Fig. 1 along with the waveforms associated with a suddenly applied sine-wave overload. The effect of the overload is to cause the output valve grids to back-bias due to the flow of grid current. The bias will, however, be equal for both valves as the system is balanced. The valves may easily bias back to class B operation if not beyond, but when the overload ceases they will rapidly return to their correct working point. As the system is balanced there will be no effective d.c. component in the output transformer windings.

If the concertina phase-splitter is now considered, we find that things are no longer the same. This is shown in Fig. 2. The output from the cathode side is at much lower impedance than that from the anode side. Hence for a given overload the output valve driven from the cathode side will tend to take a much larger grid current than the one driven from the anode side. The grid circuit driven from the cathode will, therefore, self-bias much further towards cut-off than the other one.

In addition, the limiting imposed by the output valve grid current on the cathode output valve of the phase

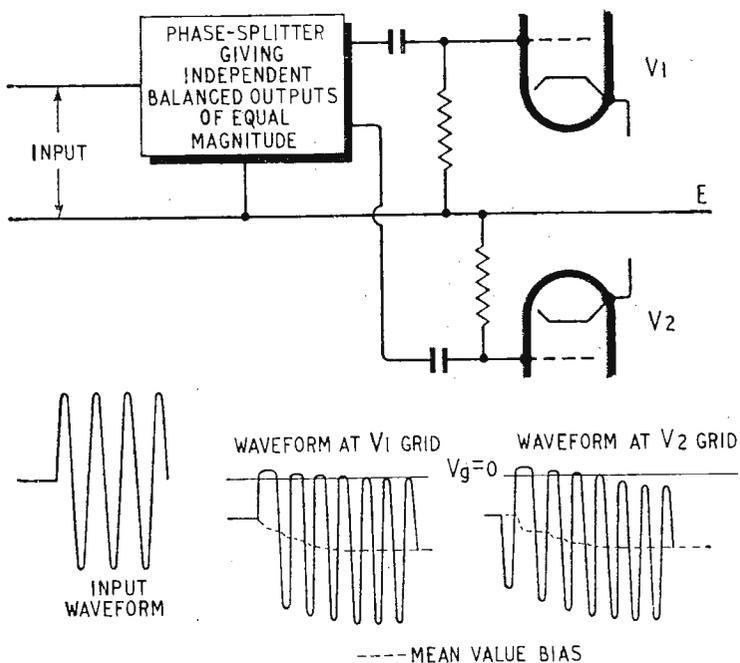


Fig. 1

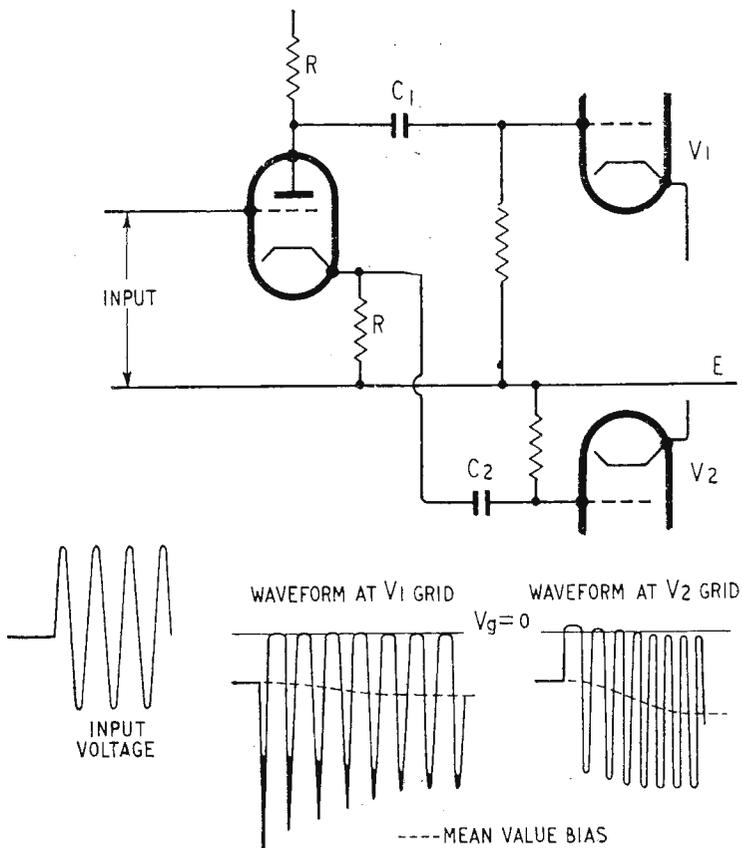


Fig. 2

inverter produces large negative-going spikes on the anode output voltage. It is now seen that there is a large difference between the standing currents in the two output valves. This difference can easily saturate the output transformer and thus severely reduce the output.

If overall negative feedback is present on the amplifier, this reduced output will cause the drive to the output valves to be greatly increased and thus make matters still worse. This defect in performance is not just surmise and has been observed in practice. One could presumably fit limiters to the amplifier input but I personally feel that a safe self-limiting circuit is preferable.

Apart from the question of overload, the concertina phase-splitter gives a gain of about twenty times less than the long-tailed pair. With large amounts of feedback this loss of gain can easily cause the required input voltage to become excessive.

On the question of stability there is no doubt that the concertina phase-splitter is far better than the conventional type of long-tailed pair. It would be interesting to try a normal long-tailed-pair phase inverter in Mr. Baxandall's amplifier using an identical feedback-loop gain. I have a suspicion that it would make the stability far worse even if oscillation did not ensue.

Regarding the subjective assessment of amplifiers: I feel that the only way of doing this is by means of A/B checks with impeccable signals and the best loudspeakers obtainable. The room used for the tests must be absolutely quiet and plenty of time taken over the tests. The last thing necessary—and the most important—is a keen ear. Under these conditions it is surprising what differences can be detected, even today, between amplifiers.

In conclusion I would like to say that I do not profess to have produced the last word in phase inverters. It is

felt, however, that the circuit described possesses to a large degree all the requirements of a phase inverter, without becoming too complex and uneconomic.

ARTHUR R. BAILEY.

“Pulse Modulated AF Amplifiers”

IN view of the article under the above title in the February issue on an audio power amplifier using power switching (a mode of operation which P. J. Baxandall suggests should be called “class D”), readers may be interested in a circuit which I have developed using this same principle. The output power obtainable is greater than 1W and I have used it to drive a 15Ω speaker from a normal crystal gramophone pickup. Only five small transistors are used and they remain substantially cold in operation whilst the “quiet” power consumption is in the region of 15mA from the 10V battery. The level of distortion is low as direct overall feedback from the output to the input is an essential feature of the circuit. A typical assembly with normal components occupies 12 cu in and weighs 4oz, excluding, of course, the battery and loudspeaker.

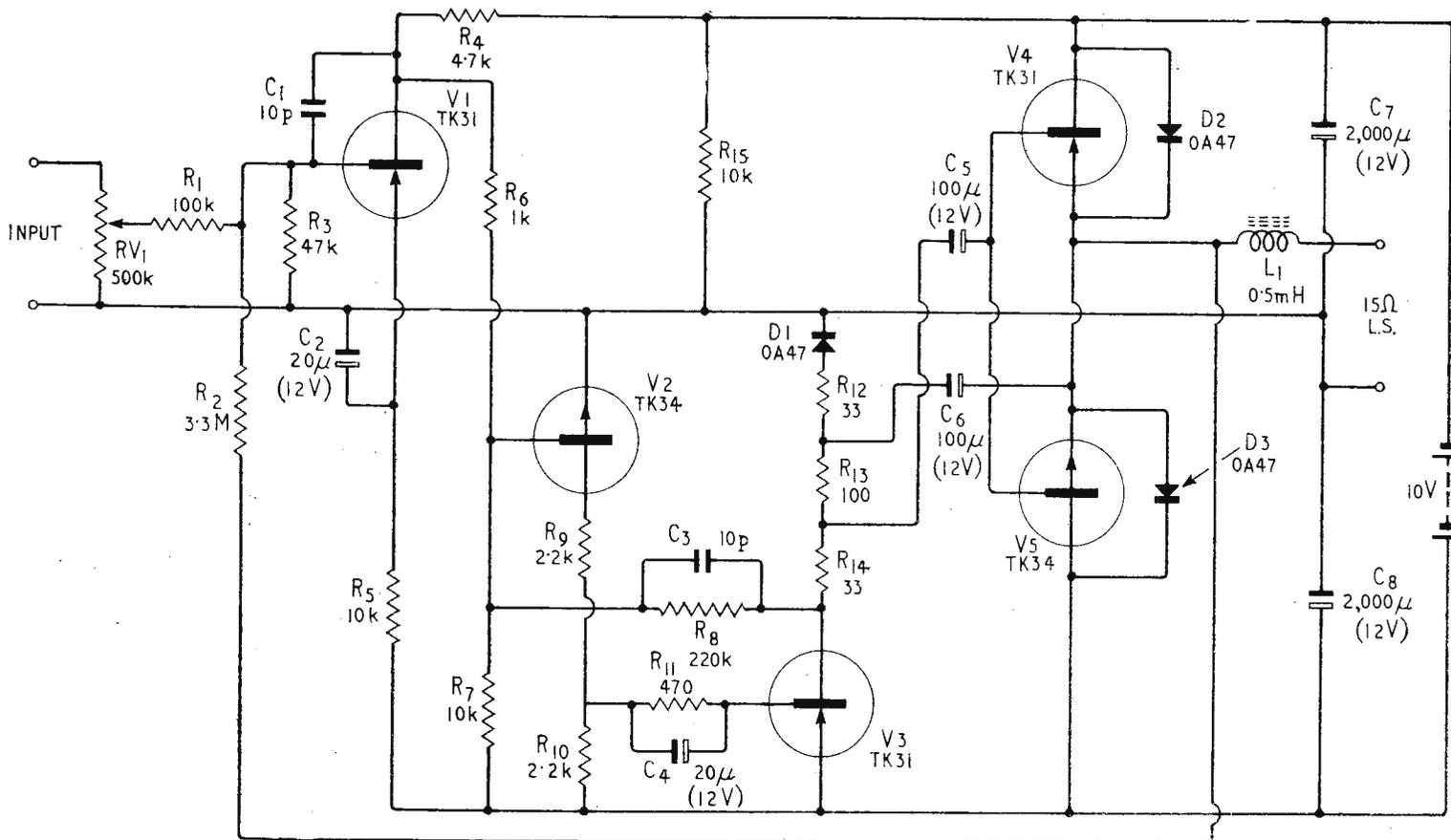
The circuit is shown in the diagram and the operation is most easily explained by working backwards from the output terminals. First the inductance L_1 is added in series with the speaker to give a total series time-constant with the speech coil of about 50μs. This serves as a filter to confine the high frequencies generated by the fast switching of the power stage as far as possible, to prevent radiation, and also to reduce the loading on the fast edges due to the capacitance of a long loudspeaker cable. At the same time the efficiency is improved as less switching frequency power is dissipated in the speech coil and, last but not least, a high-frequency “roll-off” is obtained to match the pre-emphasis normally used in disc recording. The value of L_1 may typically be 0.5mH and it can be wound on a ferrite core. Care must be taken that there is sufficient air-gap to prevent saturation at currents approaching 0.5A and, of course, the d.c. resistance must be small compared with the 15Ω of the speech coil.

The transistors V4 and V5, which should be similar but need not be accurately matched, form a p-n-p/n-p-n pair of which one is cut-off and the other driven into saturation alternately at a frequency of about 50kc/s.

The diodes D2 and D3 are necessary to prevent difficulty when their respective transistors are required to carry large reverse currents during the peaks of loud low notes, since the reverse current-gains, even of alloy transistors, are normally insufficient to ensure saturation under such conditions. Note that not only the emitters but also the bases of these transistors are directly cross-connected, and thus the danger of their both conducting together is eliminated. The collectors of these power transistors are connected to the negative and positive poles of the battery respectively, but notice that the battery is not centre-tapped. The return current from the speech-coil is taken to the centre point of a pair of large capacitors connected in series across the battery, and this same centre rail is used at several other points in the circuit. These two capacitors are by far the bulk-iest components in the whole amplifier.

The drive to the bases of the power stage is taken from V3 through the capacitor C_5 . The load resistor R_{13} in the collector of V3 is taken to a floating-power-rail voltage generated across C_6 by the diode D1 in a bootstrap type of circuit. This enables V4 to be driven hard into saturation when V3 is cut-off whilst at the same time allowing V5 to be driven equally hard when V3 is itself saturated. The drive to the base of V3 comes through a straightforward coupling network from the collector of the n-p-n transistor V2 and the base of V2 is driven partly from the collector of V1, and partly by positive feedback through R_8 and C_3 from the collector of V3. This positive feedback makes these stages act as a toggle and snap sharply from the off state to the saturated state at a particular value of the voltage at the collector of V1 and to snap back at a slightly different value of this voltage.

The transistor V1 now functions as a Miller integrator with the capacitor C_1 . The current at its input is the linear sum of a term from R_1 due to the input signal and a negative feedback term through R_2 from the output of the power stage, whilst it is the output voltage of this integrator which trips the toggle circuit of V2 and V3 and so switches the power stage V4-V5. This in turn reverses the current through R_2 and sets the integrator running back towards the other tripping voltage so that the circuit oscillates continuously. Notice that the capacitor C_1 controls the frequency of operation and its value should be adjusted as necessary to obtain running at about 50kc/s. Too low a frequency may generate



distortion from cross-modulation whilst too high a frequency makes the power stage unnecessarily inefficient.

In the absence of any signal current from R_1 , the voltages across C_7 and C_8 adjust themselves in a few tenths of a second so that the mark/space ratio is very close to 50/50. R_1 may need to be varied slightly if the ratio is not sufficiently exact. Any input signal, however, upsets this balance and, moreover, does so in such a manner that the net current into the integrator remains close to zero whilst the mark/space ratio changes appropriately. Hence the mean voltage applied across L_1 and the speech coil of the loudspeaker changes in exact proportion and there is a powerful overall negative feedback effect fixing the voltage gain from the slider of RV_1 at a factor R_2/R_1 , that is 33:1 with the component values given. The current gain, however, is in the region of 200,000:1 and these values are adequate for ordinary use with a crystal pickup.

The resistor R_{15} in the circuit is included solely to ensure that the oscillation starts correctly when first switched on. Without it the voltage across C_8 might collapse, due to leakage through R_8 , and the transistors V2, V3, V4 and V5 would all remain turned off. Even with R_{15} included the circuit may occasionally switch-on to a state where V3 conducts a small steady current, but the application of a moderate input signal initiates correct operation and once started this will continue until the power is switched off.

The circuit diagram shows S.T.C. transistor type numbers, but other makers are now offering fast high-gain germanium alloy devices of both p-n-p and n-p-n polarities which can almost certainly be used without any need for changes in the component values shown. If a diffused transistor is used for V1 then C_1 will almost certainly need to be increased, whilst a fast silicon device at V3 would allow the components R_{11} and C_4 to be shorted out altogether.

The circuit as shown here is sensitive to ripple on the power supply and hence battery operation is recommended. It is expected, however, that further development will allow this difficulty to be overcome. Again the author has a version of the circuit in which the two power transistors V4 and V5 are of the same polarity, being driven from the collector and emitter of V3 respectively, but although this circuit has, in fact, worked over many months there are severe transients during switching-on which considerably exceed the ratings of the transistors and the circuit is not, therefore, suitable for publication in its present form. In any case satisfactory n-p-n germination devices are now readily available so that there is little need for such a version of the circuit.

These last remarks may, perhaps, encourage readers to experiment with circuits of this type for themselves and the writer is quite sure that much progress remains to be made before any circuit will emerge that could be called conventional.

Cheadle.

K. C. JOHNSON.

The Wireless World Quality Amplifier

I WONDER how many *Wireless World* Quality Amplifiers are still in service? Shortly after the publication in December 1943 of the "Wartime modifications to a well-known design," when 6V6's with feedback were suggested as substitutes for the hard-to-get PX4's, a friend and I co-operated in building one each. Mine was put into daily domestic use for radio and gram in 1946, and continues to this day. The tiny thing in the cot when the "W.W. Quality" started its career is, at the moment I write, feeding delightful Paraguayan folk-music from a tape recorder through it (the amplifier), in the manner of many of her fellow-teenagers. Faults in that time? One 6J5G, substituting for an L63, which was second-hand when it went into service, has failed, and last year the smoothing electrolytics went open-circuit.

I believe that it was in January 1946, in an article on the "genus W.W. Quality" generally, that *Wireless World* wrote modestly of the virtues of a good design which does not run its components to their limits. Well, my 16-odd years of service demonstrates this. The things that come before the power amplifier, and those that follow it in the reproducing chain, have been changed with changing years.

But what comes out the loudspeaker, owing much to a design you prepared in the 'thirties, is still what Ralph West calls "a nice noise." Overall feedback? Ultra-linearity? High efficiency? One day, perhaps, when I have a disruptive fault on my present power amplifier, I'll make this change from Quality to High Fidelity!

St. Albans.

L. F. KEEL.

Transistor R-C Oscillators and Selective Amplifiers

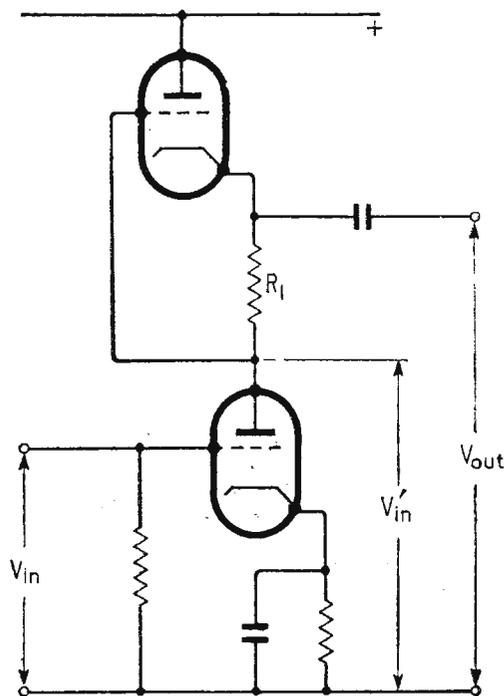
THE article by F. Butler in your December 1962 issue presents a very comprehensive and lucid survey of the subject. However, when discussing the techniques for stabilizing the output level of R-C oscillators, the use of thermistors is criticized on the grounds that excessive power must be dissipated in the thermistor if the effect of varying ambient temperature is to be swamped. Your readers may be interested to hear of the STC type R thermistor produced specifically for low-level work in transistor circuits. No more than 3mW is required to raise the bead temperature to 150°C. This should be adequate to swamp the effect of room temperature variations!

Footscray, Kent.

S. C. RYDER-SMITH,
Transistor Applications Dept.,
Standard Telephones and Cables Ltd.

"Analysis of the Bootstrap Follower"

IN deriving my expression for the gain of a bootstrap follower I made the simplifying assumption that the direct contribution of the input current to the output current is negligible. This is true of the vast majority of practical circuits, in which grid resistances of about



a megohm are employed. However, the rigorous formula given in Mr. Butler's article (January, p. 22) should be used in the case of circuits like the one shown here, and where the grid-cathode resistor of the follower valve (R_1) has a much lower value than usual. (The relevant gain here is V_{out}/V'_{in} .)

Croydon.

G. W. SHORT.

OSCILLATORS: a Monistic Approach

3.—NON-LINEARITY, HARMONICS AND STABILITY

By THOMAS RODDAM

IN two previous articles we have surveyed the two broad classes which we can distinguish in the field of oscillator design. We have seen that some circuits may fall nicely into place in one or other class and that nicely is, for once, correctly used in this context. We have also seen how we are left with a few circuits which fit into this kind of scheme only with difficulty. This is a normal problem in classification and cataloguing. Throughout the discussion it has been assumed that the active system was operating in a linear region.

It is part of the dogma of oscillator theory that the highest stability of frequency necessitates freedom from distortion. This rule is attributed to Groszkowski (*Proc. I.R.E.*, Vol. 21, p. 958 (1933)) although I doubt whether anyone nowadays takes the trouble to verify this. The logic of this rule is rather simple. If there is some non-linearity we shall get components of, say, $2f$ and $3f$ produced at the non-linearity. These will be transmitted through the four-terminal network of a feedback oscillator with some arbitrary phases to appear again at the input. When the non-linearity is reached a component of frequency f will be produced by intermodulation and this component will not have the zero or 180° phase shift assumed in setting up the oscillator equation. Since this is an impossible situation the frequency must shift to bring the total fundamental into the $n\pi$ state.

Dogma is not necessarily completely false: its great danger comes when one believes that it is completely true. We can design our active network for good linearity, we can design our feedback networks so that they reject the harmonic frequencies. This last operation is less simple than it sounds, however. Reactive filters do not absorb the signals they reject; they simply refuse to accept them. In a simple feedback oscillator, therefore, the feedback network will push the harmonics back into the valve anode, or whatever device electrode we may be taking at the output. High harmonic attenuation may not help us at all.

Quite a different approach is possible and it is this approach which I intend to consider in connection with negative resistance oscillators operating at large amplitudes. Our quarrel is not with the harmonics as such, but with the presence of harmonics which are sensitive to the operating conditions. We can arrange to operate under low-distortion conditions and keep the harmonics so small that it does not matter if they vary, but the price we must pay is the price of efficiency. We must operate at a relatively low level. The alternative approach is to fix the amplitudes and phase of the harmonics rigidly so that they do not vary.

There are a good many applications for this principle although I have rarely seen it used. Some long time ago I used it myself in a multi-frequency sig-

nalling system which illustrates its application fairly clearly. A very cheap oscillator with a very variable supply voltage can be switched to any one of a dozen or so frequencies. Filters are to be used to identify the frequency, which is the information to be transmitted. The second, and I think, though memory may be at fault, the third harmonic of the lowest frequency could fall into the pass-band of higher frequency filters if otherwise tolerable performance was accepted. The incoming tone was therefore amplified and limited, to deal broadly with the wide variations of signal level, and was then taken into a very well defined squaring circuit to provide a square wave of fixed amplitude. Although there has been an increase in the harmonic content there is a well-defined margin between fundamental and harmonic which is more than adequate for the reliable control of a trigger circuit.

The same basic idea is used by the best clock-makers. I do not know whether anyone has ever made what we might describe as a class A clock:

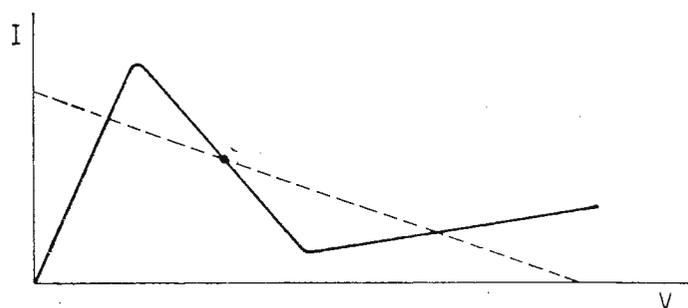


Fig. 1. Short-circuit stable negative resistance characteristic.

at least I do not know if anyone has made a low-frequency one. This change of mind is because I started to think of a design and found myself thinking first of a tuning fork drive system and then of a crystal oscillator using a four-electrode quartz crystal. In both these systems we have a mechanical tank circuit with a driving loop which can be linear. The best pendulum clocks use a pulse to maintain the oscillations in the tank circuit, and a pulse is even richer in harmonics than a square wave.

We know that circuits of the general inverter type produce quite square waves and we may begin by setting this concept down and then not taking too much notice of it. We shall see why we do this in a moment. We can use quite a lot of the concepts introduced in "Transistor Inverters: a Single View" (*W.W.*, Jan. and Feb. 1962), but we will find that we need to make some important circuit changes.

The basic concept may be considered in conjunction with Fig. 1. This is the now familiar N-shaped negative resistance characteristic which we know is short-circuit stable. A load line is sketched in, to

give the three points of intersection, and again we know that the centre point is unstable and the two outer intersections are stable. In a small-amplitude system the point C will be the point at which the circuit is centred but in a large amplitude system the point C is inaccessible. We know the sort of waveform we can expect, for we have seen a modified version of it in our studies of inverters. In an inverter we have parasitic terms which produce an anti-resonant circuit of relatively high characteristic frequency. Here the waveform will be something like that shown in Fig. 2.

In this distorted sine wave we have a section AB in which the anti-resonant circuit is being driven by the negative resistance, followed by the section BC which corresponds to the free swing of the circuit after the active device has been cut off. This is the spike region in ordinary square-wave operation. During CD the negative resistance is driving again until at D the trajectory runs into the diode

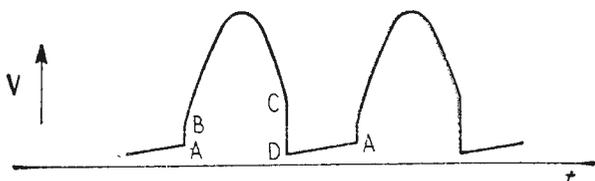


Fig. 2. Large-amplitude waveform in a negative resistance oscillator with an anti-resonant control circuit.

line and the tuned circuit is damped down hard along the region DA.

An oscillator of this type will obviously not be particularly stable, because we have in the region DA a relaxation oscillator mode which is notoriously poor in frequency stability owing to its dependence on the characteristics of the active device. Even in the region BC the active device is having some effect, for it provides some extra damping on the circuit and this damping, if the system is a transistor oscillator, will be temperature dependent.

The fact that the BC section of the waveform is fairly right is the clue to our next step. We must make the end sections of the device characteristic correspond to infinite impedance. In drawing Fig. 3 I have run slightly ahead of myself, but you can see here a short negative resistance region terminated by two regions in which the shape of the device characteristic is infinite. I do not think there is any difficulty in seeing that the waveform produced by this sort of negative resistance characteristic and an anti-resonant circuit will be of the form shown in Fig. 4. We can describe this as two half sine waves joined by short switching sections.

During most of the time the tank circuit is a completely free circuit and so the duration of the swing is fixed only by the anti-resonant frequency. The active device can only influence the duration of the switching interval. We have two available methods, in theory, for reducing the length of time the system spends in the driven mode and on close examination we find that one of them is meaningless. We might try to increase the tuned circuit swing or the size of the voltage step, without changing the actual shape of the negative resistance. What we must do, in fact, is make the negative resistance as small as possible and the tuned circuit parallel resistance as large as possible. The height of the voltage step is

then settled for us, because we shall have some limits on the size of the oscillations.

A circuit operating on this principle was described, although not exactly in this way, by Tillman (*Wireless Engineer*, Dec. 1947). The kind of circuit which we can use is simply our old friend which Terman calls a feedback oscillator. I have drawn it as a two-stage triode amplifier with biased diodes for limiting. If we say that the amplifier gain is 200, quite an arbitrary figure, the negative resistance will be $-R/200$ so long as the diodes are not conducting. When the diodes conduct the gain of the amplifier is pretty well zero and the amplifier input resistance is R .

A typical audio-frequency tuned circuit would be 100mH with a Q of 100 at 1600c/s, giving a parallel resistance of 100,000 ohms. If we degrade the Q by 10% we have a feedback resistance of 1 megaton ohm and a negative resistance of -5000 ohms. I do not claim that this is the correct design, but it gives us some numbers to look at. When we start to examine the circuits more closely we find, at least I do, that the easiest way of treating it is by the feedback method. The swing at the first grid will be one-eleventh of one swing at the second anode, if we assume that at the second anode we are measuring the fundamental. Let us assume that we can allow 1/10 volt swing at the grid, giving us 20 volts at the second anode if we just consider the gain, but only 1.1 volts swing if we consider the feedback ratio. From this we see that the circuit is under drive only for the central 1 volt of a 20-volt swing. For the rest of the time it is swinging free.

Although we could have arrived at this result by working out the negative resistance characteristics we should have needed to examine the way in which the limiting conditions arise. The diode clipper circuit is used in this explanation because this keeps the various functions separate. The second valve may well be used as a limiter rather than as a linear amplifier, but the practical designer must then examine the effect of grid current on the symmetry of the limiting. If the bias point can

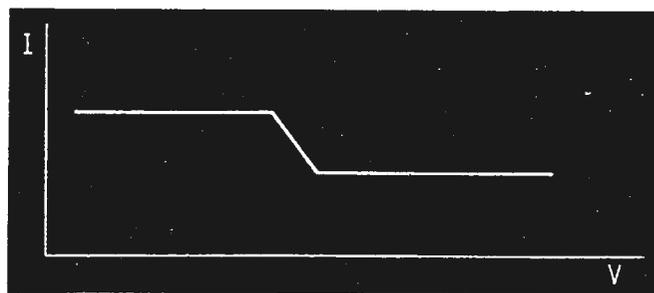


Fig. 3. Negative resistance between infinite-impedance end sections of the characteristic.

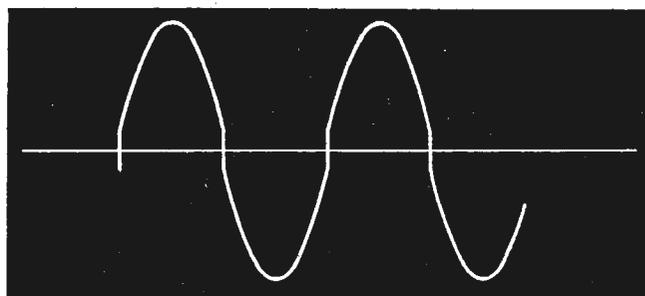
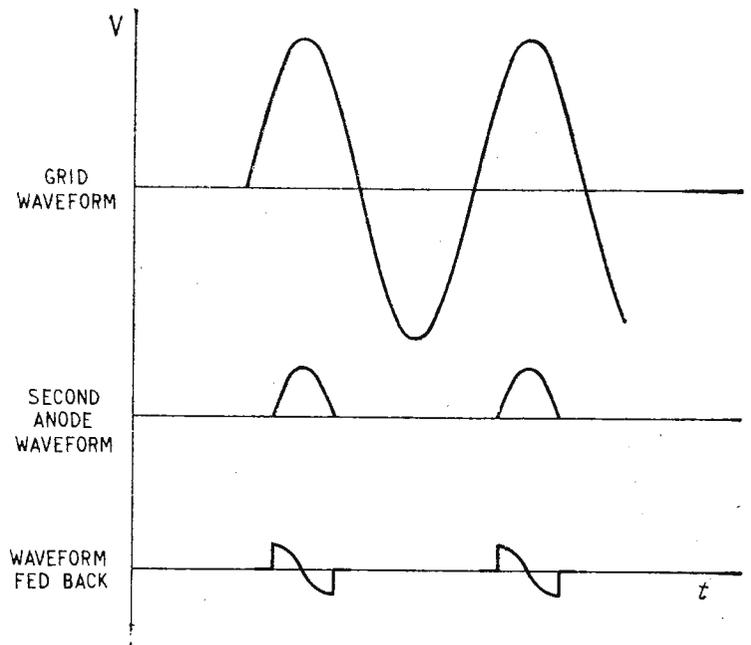
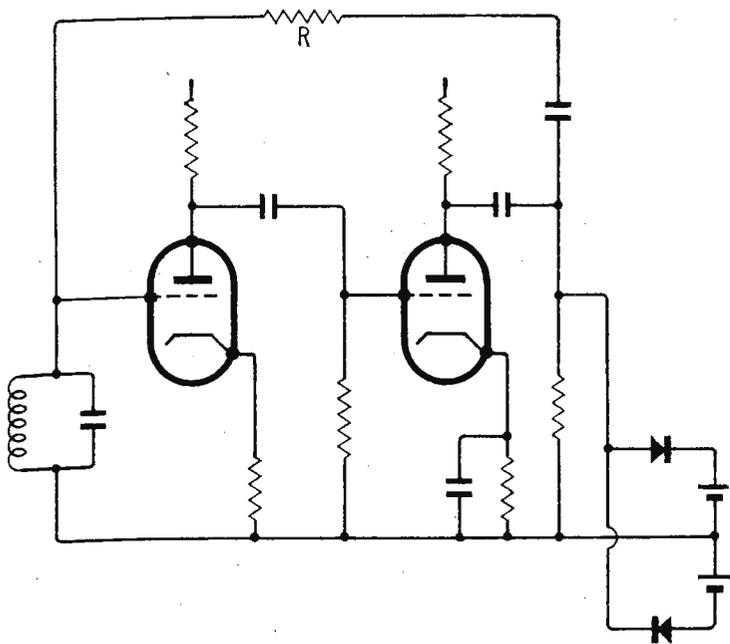


Fig. 4. Waveform associated with the characteristic of Fig. 3.



Left: Fig. 5. Two stage feedback oscillator with gain limited by biased diodes. Right: Fig. 6. Waveforms in class-C operation.

float with signal amplitude the energy pulse as the circuit passes through the negative resistance region will be de-phased and frequency stability will be lost. As shown in the figure there is no provision for loading the circuit, but a sinusoidal signal is available at the first anode and an appropriate square wave at the second anode. Since this oscillator is capable of giving high stability we may expect to use a buffer amplifier to the output.

This technique opens up a whole new range of sinusoidal oscillator techniques and also throws some new light on transistor inverter circuits. The characteristic in Fig. 1 is the characteristic seen at the collector: looking in at the base we do not see the collector diode line, because it is buffered off by the feedback resistance. In its place we see the higher resistance of the base diode line with the feedback effect from the emitter. By using compounded transistors we might get fair frequency stability in an inverter-oscillator of this kind. The negative resistance approach shows us, however, that what we need is a high gain in the amplifier circuit, for with a fixed value of feedback resistance R , the higher the gain the smaller the value of negative resistance and the shorter the duration of the perturbing drive.

There is room here for a good deal of general study, probably enough to rate a Ph.D. at a Yellowbrick University (I understand that yellow bricks are cheaper than red). We can introduce into our amplifier negative feedback to make the gain more stable, and/or positive feedback to increase the gain. The swings-and-roundabouts effect will be in operation, of course, but will not necessarily be in balance. It is a very attractive problem for anyone who wants to spread himself, because to add to the general complexity we have the desirability of putting in negative feedback to the cathode of the first valve to increase the input impedance. I have shown in Fig. 5 an undecoupled cathode resistor, but according to the rules of the game we should like to bring the feedback from the amplified input. This is a real tempter until you notice that it is not going to do any good. Since the output circuit is controlled by the limiter the gain is zero and this feedback will

only affect the input impedance during the switching interval. As you see, there is quite a lot to be learned about this kind of circuit without doing any mathematics at all. Remember, too, that it is not the specific circuit in Fig. 5 that we are talking about, it is the class of circuits of which Fig. 5 is typical.

We can get an insight into the workings of the class-C oscillators by this same method. We have seen that in a typical situation the resistance R is many times the effective resistance of the tank circuit. Let us replace the resistor by a capacitor, which we might expect to have the same sort of impedance. This will enable us to think of the capacitor as providing the familiar differentiation operation. Basically the class-C oscillator is limited on one side only. Practically we must get some peak limiting by the grid current which tops up the bias; but let us overlook this. The waveform after limiting will have the form shown in Fig. 6 (b) and the waveform fed back will begin by looking like Fig. 6 (c), though in fact the tuned circuit will change this. Now in this approach we get the "tap at the end of the swing" effect which we know from pendulum analysis is bad.

If we use the negative resistance approach we simply draw Fig. 7 in which the tip of the wave, when the amplifier is working, is a piece of a sine wave of higher frequency owing to the negative capacitance term we have slapped across the tuned

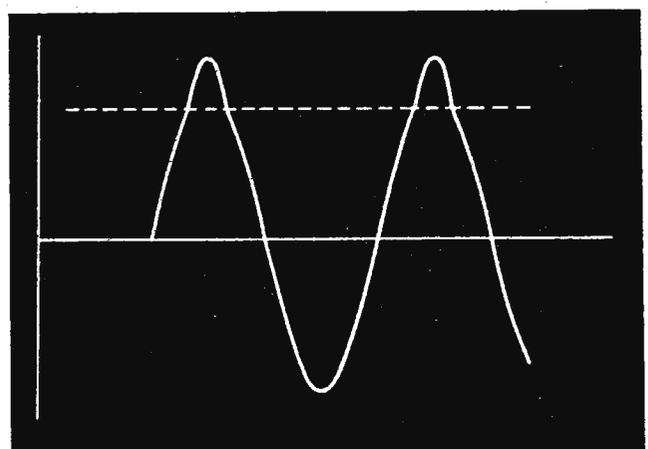


Fig. 7. Feedback at the "top end of the swing".

circuit. We get at once a direct insight into the reason why tip drive is bad, for we can see that we come slowly into this region of changed frequency and small changes of amplitude will make a good deal of difference to the triggering phase. Crossing back to the classic feedback form we are not surprised. The network is listed in "Reference Data for Radio Engineers" (I.T. & T., 4th Edition, 1956) as a 3-element shunt Type II and the image attenuation, shown in Fig 8, rises only slowly with frequency in the upper stop band. This circuit lets the harmonics get back round the loop rather early.

This philosophy points the way towards the design of an oscillator which might have some advantages. We know that we must give our pendulum a tap as it swings through the central position but we need not tap it every time. We can follow our limiter by a divider chain and drive our feedback impulse from this, giving a tap only, say, every 16 cycles, and leaving the tank circuit to oscillate freely in between. From the negative resistance viewpoint we get a gain through the chain only when all dividers are making a transition and then we get the gain of all stages in tandem. To my mind this reveals at once that we shall not have an optimum design: we shall have too many stages, none of them designed to give a good gain-bandwidth product. It will be far better to concentrate in getting a very short and correctly placed switchover every cycle.

I am tempted to say that this class of switching oscillator in the form which uses an open-circuit stable negative resistance and a series resonant circuit is of no interest whatever. Obviously there is some theoretical interest, but it is much more difficult to make an amplifier with an input resistance which is low enough not to degrade the Q of a series circuit, than one with a high input resistance which will not damp an anti-resonant circuit. The problem is made more difficult by the lack of a d.c. path through the circuit. Probably the most likely form of tuned circuit for this purpose will be a crystal, particularly a partially plated crystal with its very high inductance. I shall leave this as an example for the student.

The switching type of negative resistance oscillator, as we have already seen, encourages us to think about the switching type of four-terminal feedback oscillator. We started off with the idea that by fixing the harmonic content we should get the same sort of stability whether we fixed it at small value or a large one, provided we "fixed it good." Let us consider a system like the one shown in Fig. 9 (a). The half-section of band-pass filter feeds a fairly good sine wave into the amplifier and this drives the limiter to generate a well-squared output. In its basic form we may say that the amplifier is fed with a perfect sine wave of constant amplitude and must be designed for zero phase shift and no distortion, at least no distortion which can affect the crossing

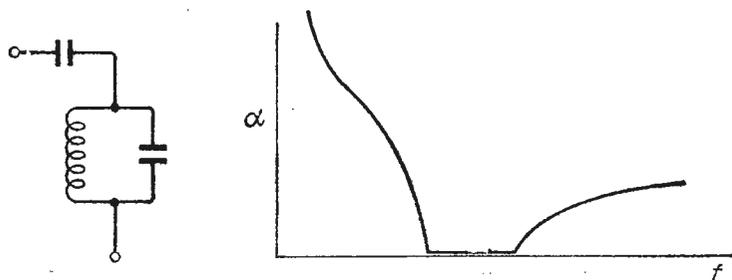
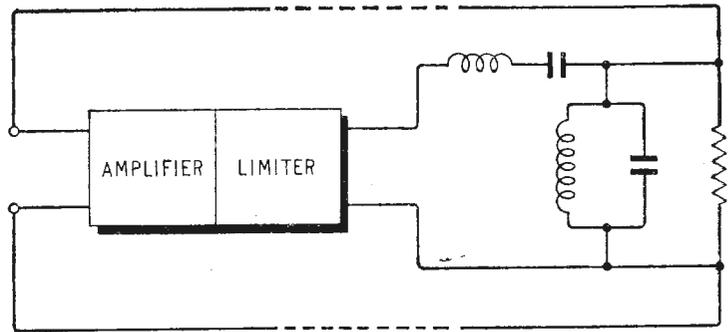
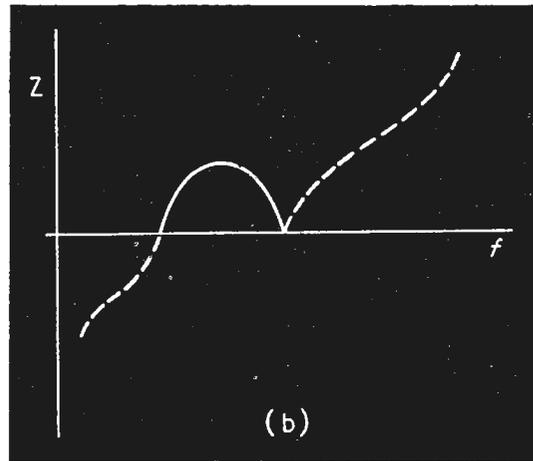


Fig. 8. Attenuation characteristic of 3-element shunt network.



(a)



(b)

Fig. 9. (a) Amplifier-limiter-filter type of oscillator, and (b) image impedance presented to the limiter.

points. The limiter should be symmetrical in action and should have a very short input base.

In this particular technique of amplifier-limiter-network we are faced by a problem in defining what we mean by a limiter. The circuit is loaded not by a resistance but by the input impedance of the network and this will not, in general, be independent of frequency. We therefore have a choice between limiting the output voltage and limiting the output current, between designing the limiter as a low impedance source and designing it as a high impedance source. If we design for a square voltage wave we must accept the fact that the current will be sinusoidal and *vice versa*. We must also choose a network which will accept our choice or will define it.

At this point I reach again for "Radio Engineers' Handbook." The image impedance presented to the limiter in the circuit of Fig. 9 (a) is shown in Fig. 9 (b) and it will be seen that it is high and reactive, for all input harmonics. Consequently although we can hold up a square voltage across the input terminal we shall not pass harmonic current. If we were to use the network the other way round with an amplifier taking a current input we should find that we could get a square-wave current drive and we should have a sinusoidal voltage.

We have a large range of filter networks at our disposal, especially if we allow ourselves to use lattice networks, zig-zag filters and impedance transformations. We can find a very large variety of amplifier and limiter combinations. One such circuit is shown in Fig. 10. You may recognize this as a rearrangement of the basic voltage switching oscillator described by P. J. Baxandall ("Transistor Sine Wave LC Oscillators" *Proc I.E.E.*, Paper No. 2978E, May 1959, Vol. 106B, Supp. 16, p. 748). The amplifier is the well known single-ended push-pull

stage which is operated as a class-B system driven hard to bottoming. It will be noticed that the filter circuit is the constant-k half-section which is shown in Fig. 9.

The logical dual of this is the circuit shown in Fig. 11, but if the supply is taken from a low-impedance source the fixed harmonic voltage will cause a very large current to flow in the high reactive admittance presented by the network. The circuit can, however, be fed from a very high impedance supply, a constant current system. If you can refer to Baxandall's paper (*loc. cit.*) you will find a circuit generally similar to this using an inductor to provide the constant current effect over a cycle of the oscillators. Baxandall uses only a first-order filter, the anti-resonant circuit, in his current switching oscillator, but for the student it is convenient to preserve the network order in changing from one circuit to the other. In the circuit of Fig. 10 the shunt inductance of the anti-resonant circuit must appear in any event, for it is, as you will realize, the same physical component as the input transformer of the amplifier.

The extensions of this principle with the wide variety of available amplifiers and limiters are again a matter of patience. The oscillators based on the system of Fig. 9 have the great disadvantage that the load and the frequency-determining circuit are intimately associated but there seems to be no formal difficulty in arranging for the load to be fed through one network while another network acts as frequency determining element.

The title of these articles may merit a note of explanation. William James divided temperaments into tough and tender minded. The hard-headed pessimistic tough minds are pluralistic and regard a whole field simply as the collection of its parts. The sensitive, optimistic tender minds are monistic and regard the essential unity of the field as dominating the parts. This division cuts very deeply; either you are a logical positivist or you are an existentialist; either you are objective or you are subjective. The reader's temperament will decide whether he sees a neat classification of oscillators, whether he feels that the classification "oscillators" is enough, and each should then be treated on its own merit, or whether he agrees with me in feeling that the classification is too rigid for the subject and that although quite a lot of the thinking can be

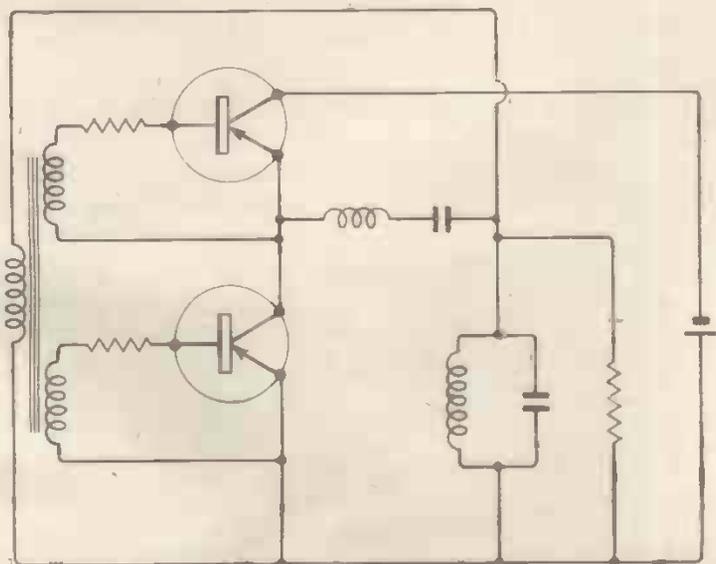


Fig. 10. Voltage-switching oscillator.

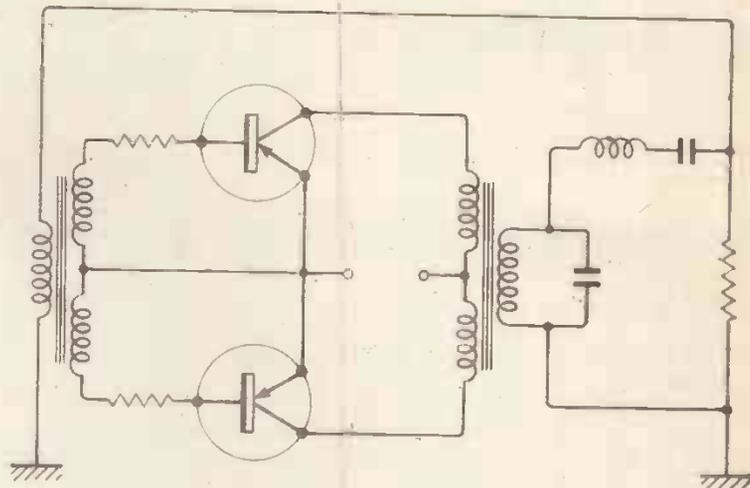


Fig. 11. Current dual of the circuit of Fig. 10.

carried out on the type as a whole, the final examination of a circuit in detail may turn out to be easier if it is regarded as belonging to a different class.

This splitting into two temperaments raises some most interesting problems for the writer. If he takes up one attitude completely, presumably the one to which he is inclined, half his readers are totally out of sympathy. If he takes a balanced view he will probably lean over backwards to be fair. Should he be a whole-hearted holist and lump his oscillators in with feedback amplifiers? Should an atomist list every known and knowable circuit? I think we need to be, in our theory, holists, because there is no way of avoiding the atomist nature of hardware. When you construct an oscillator it is a circuit, a fixed thing, and "th' atomies of which we grow . . . no change can invade." (John Dunne.) Only by adopting a broader outlook before you start to be tough minded with the soldering-iron can you be sure that you have chosen the right atomie to build.

Commercial Literature

Siemens & Halske Test Gear.—A series of leaflets describing a range of test gear manufactured by Siemens & Halske in Germany and marketed in the U.K. by R. H. Cole (Overseas) Ltd., 26-32 Caxton Street, London, S.W.1, includes information of a noise intermodulation measuring setup, a complex-ratio tracing receiver, a level tracer, and a carrier-frequency measuring setup.

"Pulse Equipment Bulletin"—a six-page illustrated brochure describing pulse, sweep, and time delay generators, pulse amplifiers, and variable delay lines—is available on request to General Radio Company, West Concord, Massachusetts, U.S.A.

The Emitape Book, a 30-page loose-leaf brochure describes the making of E.M.I. magnetic recording tape, gives specifications of each of the grades, and lists a range of accessories. Details of Emitape for video recording are also given. E.M.I. Tape Ltd., Blyth Road, Hayes, Middx.

Pye scientific instruments catalogue "P" describes new developments of interest to research laboratories, educational institutions and industrial organizations engaged in production testing and process control. Copies can be obtained from W. G. Pye & Co. Ltd., York Street, Cambridge.

Lustraphone's latest literature includes illustrated leaflets describing a ransistorized p.m. radio microphone system, a miniature ribbon-velocity microphone and a transistorized electronic stethoscope. Lustraphone Ltd., St. George's Works, Regent's Park Road, London, N.W.1.

Prezoelectric and other properties of Rochelle acoustic elements are enumerated in a booklet available from Brush Crystal Co. Ltd., Hythe, Southampton, Hants.

MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Power Amplifier 10-500Mc/s

DESIGNED to operate from any conventional signal generator, the Model 230A amplifier announced by the Boonton Radio division of Hewlett-Packard Company has a frequency range of 10-500Mc/s and provides an output of up to 15 volts across a 50-ohm load. Its input impedance is 50 ohms and 10 volts output is provided into 50 ohms from r.f. inputs ranging from 0.316 volts at 10Mc/s to 0.630 volts at 500Mc/s.

The amplifier is especially suitable for high-power requirements such as wattmeter calibration, attenuation measurements, etc. Priced at £476, the instrument can be obtained in the U.K. from Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.

For further information circle 301 on Service Card.

Universal Bridge

A TRANSISTOR universal bridge type TF2700 with a basic measurement accuracy of $\pm 1\%$ has been introduced by Marconi Instruments. Completely portable (total weight 8½lb) and powered by an internal 9V battery, the bridge is very versatile. The measurement ranges are inductance 0.2 μ H to 110H in 8 decade

ranges, capacitance 0.5pF to 1100 μ F in 8 ranges and resistance 10m Ω to 11M Ω in 8 ranges.

The manufacturers of this instrument are Marconi Instruments Ltd., St. Albans, Herts.

For further information circle 302 on Service Card.

Vacuum Variable Capacitors

ENGLISH Electric Valve Co. Ltd., of Chelmsford, have increased their range of vacuum variable capacitors. The new range, all rated at 40 amperes r.f. can be supplied with capacitance values from 5 to 750pF. With a working voltage of up to 20kV (peak) the components are self-healing in cases of accidental voltage overload. Other advantages include an extremely low power factor (less than 0.0001) and a self inductance of 10⁻⁹ to 10⁻⁸ H (150-600 Mc/s).

For further information circle 303 on Service Card.

Television Analyst

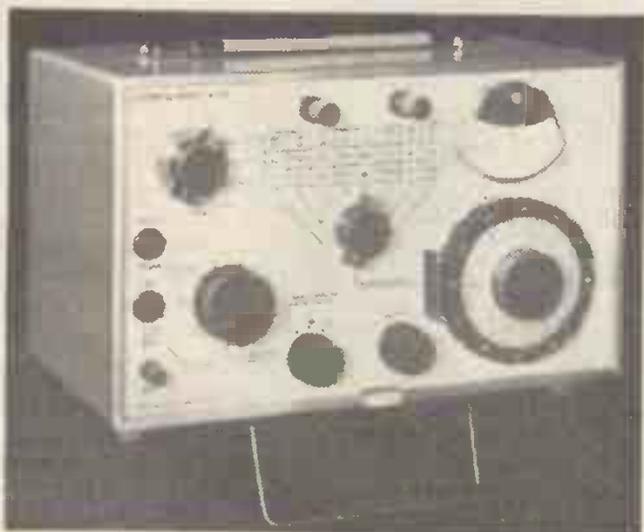
A COMPREHENSIVE television receiver test instrument produced by the B. & K. Manufacturing Company (a division of the Dynascan Corporation of U.S.A.), the



Boonton Radio Type 230A r.f. power amplifier.



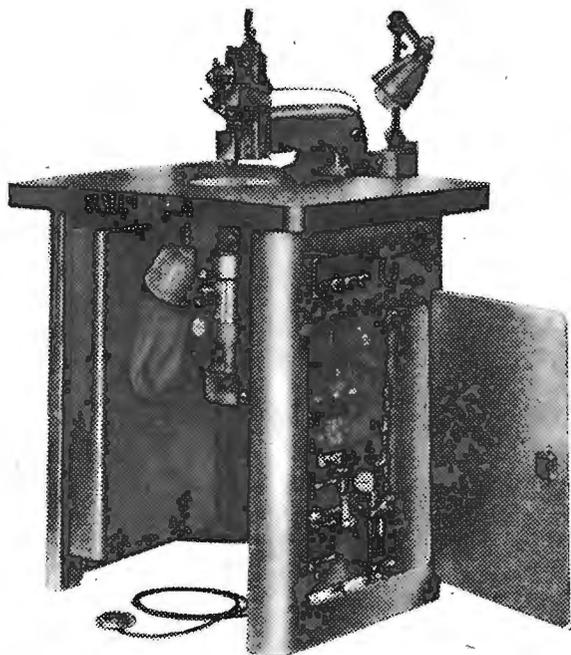
English Electric vacuum variable capacitors.



Marconi Instruments universal bridge, Type TF2700.



Model 1076 television analyst.



Saunders Dumatic drilling machine.

television analyst (Model 1076) provides r.f., i.f., vertical and horizontal sweep drive and sync pulse outputs. It enables the engineer to investigate receiver faults by using signal injection and substitution methods.

Versions are available for various standards. A test pattern output is produced by a flying-spot scanner and a high level signal is available for direct modulation of the c.r.t. Patterns for colour checks are also generated. The U.K. agents are Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.

For further information circle 304 on Service Card.

Drilling Printed Circuit Boards

A SPECIAL machine for drilling circuit boards, either individually or in stacks, is known as the Saunders Dumatic. A template is placed over the work and hole positions are located from above by a pneumatically operated stylus. Pressure is increased when the foot-operated drill rises from below the table and this ensures a burr-free hole when the drill is set to penetrate only half the thickness of the top board, which may be used again as a backing. Swarf is vacuum extracted.

The provisional price is £583 15s and the makers are N. Saunders Metal Products Ltd., 127, Munster Road, London, S.W.6.

For further information circle 305 on Service Card.

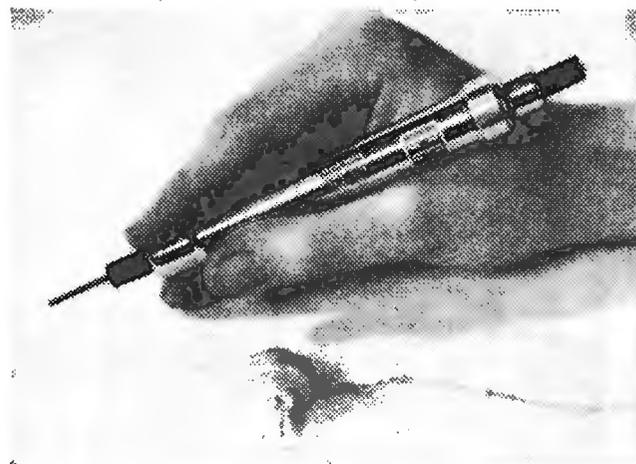
Pocket Signal Tracer

WITH a gain rated at 60dB the "670" pocket test instrument has interchangeable a.f. and r.f. plug-in probes and may be used for tracing signals, hum, noise, etc., in circuits. It is marketed by Controlled Electronics, 62, High Street, Croydon, Surrey, and costs £6 19s 6d including a magnetic earpiece.

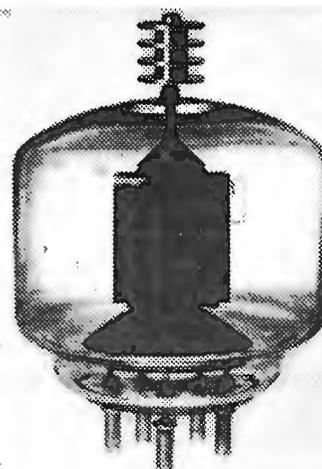
For further information circle 306 on Service Card.

Transmitting Triodes

EITEL-McCULLOUGH have introduced a range of triodes with characteristics suitable for linear amplifier s.s.b. applications. They have been designed to give optimum performance with zero grid bias—so no grid power supply is needed. They give power gains of over 20 and produce intermodulation products less than 35dB below the peak envelope output power. Three glass and three ceramic envelope types are available with ratings varying from 400W to 3kW for the glass types and 1kW to 20kW for the ceramic. These valves



C.E. "670" pocket signal tracer.



Eitel-McCullough zero bias transmitting triode.

are available in this country from Walmore Electronics Ltd., of 11-15 Betterton Street, Drury Lane, London, W.C.2.

For further information circle 307 on Service Card.

Solid State Relays

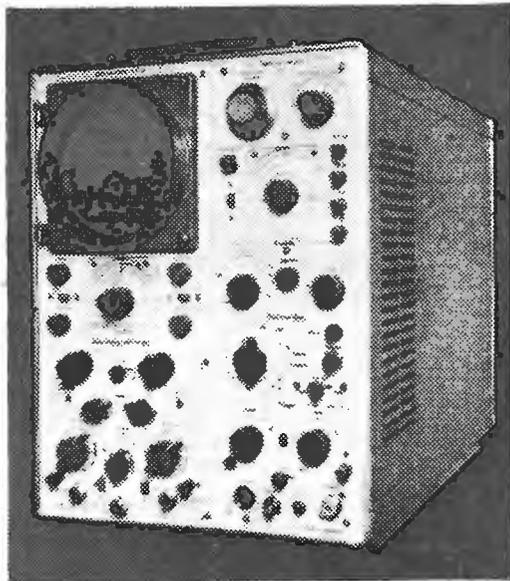
FOR applications where high switching speeds and reliability are essential, M.L. Aviation have introduced a series of solid-state relays. In these units the driving circuit is through a transformer which operates transistor switches. A transistorized oscillator is incorporated in the driving circuit to ensure complete isolation between switch and switching circuit. The relays are fully encapsulated and provided with standard plug-in bases or flying leads as required.

"Contact" rating is given as 1 to 70V d.c. with a maximum current of 1A. The drive current is 600 μ A at 6V d.c. and a standing supply of 12, 24 or 48V d.c. is also necessary. The operating time is quoted as 1 millisecond. The relays are manufactured by M.L. Aviation Co. Ltd., White Waltham Aerodrome, Maidenhead, Berks.

For further information circle 308 on Service Card.

Measuring Oscilloscope

A NEW measuring oscilloscope type TF2200 is announced by Marconi Instruments Ltd. Either a.c.- or d.c.-coupled by switch control the instrument has a 12nsec rise time for less than 1% overshoot at 50mV/cm sensitivity and a bandwidth of 35Mc/s where overshoot may be tolerated, as in sine wave examination. With a maximum writing speed of 10nsec/cm sweep delays from less than 1 μ sec to 5 seconds are



Marconi Instruments oscilloscope, Type TF 2200.

available for detailed waveform examination or line strobe. Triggering controls are simplified.

An interesting feature is the provision of two measuring systems for voltage and time measurement, a calibrated graticule or a calibrated shift potentiometer system. A 5cm display is presented on a tube face of 5in diameter and a post deflection potential of 10kV is used.

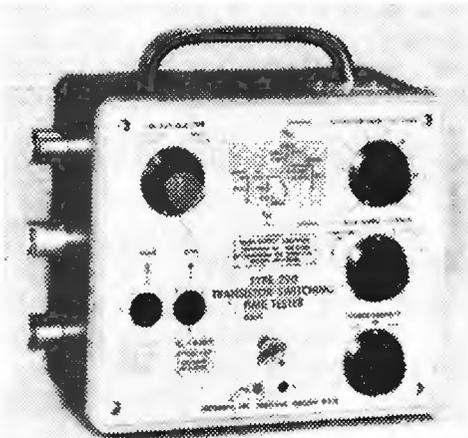
Three plug-in pre-amplifiers, single trace, dual trace and differential (for TV) adapt the y input circuit to cover most requirements. All controls are on the front panel and apart from changing pre-amplifiers and probes all modes of operation may be selected by switching without the use of external links. The manufacturers are Marconi Instruments Ltd., Hatfield Road, St. Albans, Herts.

For further information circle 309 on Service Card.

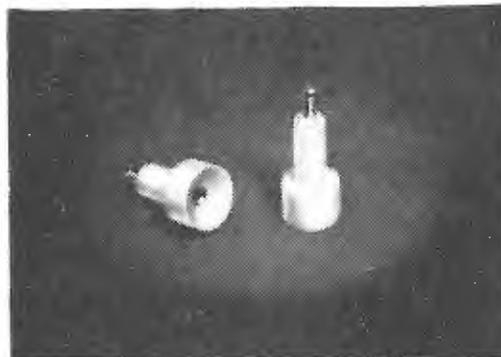
Transistor Switching Time Tester

USERS of Tektronix sampling oscilloscopes now have available as an accessory the Type 290 Transistor Switching Time Tester. Combined with a fast-rise pulse generator and a sampling oscilloscope, this system provides a transistor testing system with an overall transient response of less than 1 nanosecond. The system tests fast transistors on a short duty-cycle basis for delay time, rise time, storage time and fall time with variable collector voltage and base drive conditions.

The transistor rather than the circuit is tested as far as possible by dispensing with speed-up capacitors or



Tektronix Type 290 Transistor Switching Time Tester.



Sealectro SKT-0930 test jack.



Miniature (2-in dia) blower, A. K. Fans Ltd.

catching diodes. The common-emitter base-driven circuit of the instrument introduces into the base of the test transistor a non-overshooting step of current equal to 1mA per volt of input pulse.

Transistor input and output are presented in correct time relationship either simultaneously for dual-trace systems or at the turn of a switch for single-trace systems. The input monitor and output is at a 50-ohm impedance level allowing remote location of tester and sampling system.

The Tektronix agents in the U.K. are Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.

For further information circle 310 on Service Card.

Test Jack

THE SKT-0930 test jack is designed to facilitate insertion of test probes in difficult chassis locations and consists of a gold-on-silver-plated beryllium copper socket with a flared Teflon insulator, which is press-fitted into the chassis. The shank is 0.200in diameter and the socket is designed to take an 0.093in dia., 0.5in long probe.

Complete details are available from Sealectro Corporation, Hershams Estate, Walton-on-Thames, Surrey.

For further information circle 311 on Service Card.

Miniature Blower

A 400-c/s axial flow blower with a 2in diameter moulded impeller an overall length of only 1½in and a weight of 5ozs has been developed by A.K. Fans. Fan performance is 28.5cu ft/min under full flow conditions with a nominal running speed of 11,500 r.p.m. and 12watts input.

This model is claimed to have a life between overhauls of not less than 3,000 hours' continuous operation within the ambient temperature range -65°C to +85°C. The stator windings are fully encapsulated. The fans are made by A.K. Fans Ltd., 20 Upper Park Road, London, N.W.3.

For further information circle 312 on Service Card.

Nonconductor Valves

POSSIBILITIES IN THE CONTROL OF CURRENTS THROUGH INSULATORS

By "CATHODE RAY"

REMEMBERING that nonconductors or insulators are, by definition, materials through which currents do not flow, you may be wondering what sense to make of the above headings. If so, it will help if memory also recalls that the most complete insulator is a vacuum and yet vacuum valves have made a great deal of sense for nearly everyone for quite a long time.

But, you may say, that's different. Electrons can be shot through a vacuum because there is nothing there to stop them. Insulators, if they are worthy of the name, ought to be able to stop electrons going

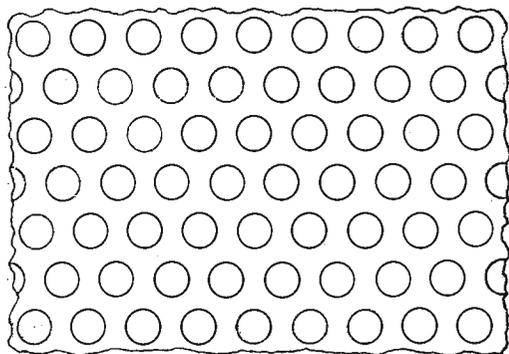


Fig. 1. Elementary diagram of a small piece of perfectly insulating crystal; the circles represent atoms fixed in perfectly regular formation, and with none of their electrons available for conduction. Since each atom is complete it is electrically neutral; its equal positive and negative charges cancel out.

through them. After all, if a valve springs a leak and lets the air in, even that seems to be enough to stop it working. And where are the electrons to come from, anyway? Semiconductors have them—or alternatively holes—distributed throughout the material, ready for use. Nonconductors have none; or, at most, too few to form an appreciable current with any reasonable voltage.

Although there is some truth in these objections, they are not the whole truth. So let us clarify our ideas about electric currents. We started doing this last month, when we saw that there are three kinds of current: displacement, convection and conduction. But we spent most of the time on displacement current—the thing that goes on between the plates of a capacitor and often isn't reckoned as current at all. This month we are concerned with the other two.

The current through a valve or cathode ray tube is an example of the convection kind: a movement of charges introduced from elsewhere, not normally parts of the path itself like the electrons in a conductor. Conduction currents are the "ordinary" sort found in Chapter One of any elementary book on electricity. They are the most complicated and

difficult to understand—a fact about which a discreet silence is maintained in the said elementary book, which works on the principle that education is a process of diminishing deception.

Fortunately we don't have to go fully into the complications to get a rough idea of how to make currents flow freely through insulators. So we shall draw an elementary-book diagram of an enormously enlarged piece of insulator—Fig. 1. Here the circles represent complete atoms, each consisting of a positive nucleus with an electrically equal but negative cloud of electrons around it. As a whole, therefore, it is neutral. The atoms are fixed in position by forces which are prominent among the difficulties referred to above, but the fact that they are fixed means that the insulator is a solid. And they are arrayed in regular formation, which means that it is a crystal. (Another of the things too difficult to explain briefly is that the nature of electrons permits them to flow freely through a perfect crystalline structure provided their "wavelength" is simply related to the regular inter-atom spacing.)

We continue to follow the elementary book in supposing that all the electrons are bound to their respective atoms, whereas in good conductors such as metals at least one electron per atom is free to roam around, as in Fig. 2. And it does, even when no e.m.f. is applied. But such roamings are random, so on the whole cancel out.

When an e.m.f. is applied, the electrons are attracted towards the positive end, and their movement in that direction constitutes an electric conduction current (in the opposite direction, according to convention). But there are the same number of them as before in any part of the metal, which is therefore just as uncharged when current is flowing through it as when there is none. As one can readily

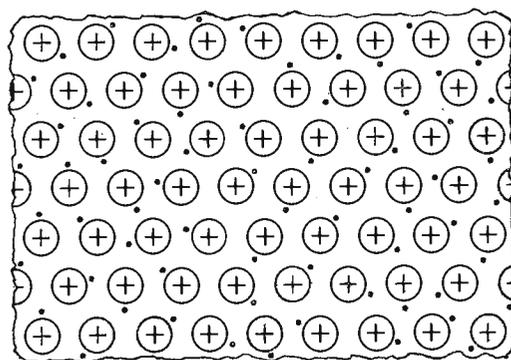


Fig. 2. Here by contrast is a metal, in which each of the atoms has an electron free to take part in a flow of current. Each electron being a negative charge, the fixed parts of the atoms carry an equal positive charge. The material as a whole is neutral.

imagine, the progress of the electrons is considerably impeded by the stationary atoms, like the balls on a pin table. They are interrupted and have to begin again from a standing start so often that instead of accelerating uniformly all the way their average speed is practically constant. This average speed—and therefore the strength of current—is proportional to the e.m.f., as stated in Ohm's law. The obstructiveness of the atoms is usually known as resistance.

In a vacuum, on the other hand, there is no charge at all—or anything else—so when electrons are pushed in and made to flow through it, as in Fig. 3, they charge it negatively. And because charges repel others of the same sign, this space charge (as it is called) discourages those coming on behind from the cathode and restricts the flow. If it were not for the space charge, the current would be limited only by the number of electrons emitted, for (as we saw last month) no e.m.f. is needed to keep a current flowing through empty space. Valve currents are therefore described as "space-charge-limited."

Once the electrons get free from the space-charge huddle around the cathode, they move with constant acceleration to the anode under the influence of the positive voltage there. The ultimate speed they

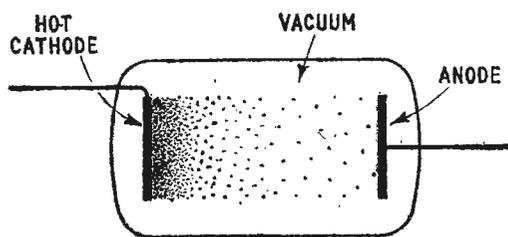


Fig. 3. A vacuum diode, which contrasts with both insulator and metal in having (as nearly as possible) no atoms in the path of the current, so the electrons charge it negatively.

reach is proportional to the square root of that voltage; actually, $594\sqrt{V}$ km/sec, so even with a moderate V it is considerable. For example, with the very usual h.t. of 250 volts it is 9,400km (or 5,830 miles) per second. This contrasts with one tenth of an inch per second through copper even when the current is very strong.

It is possible—as has been confirmed by experiment—to combine features of both types of conduction by introducing the necessary electrons into an insulator. As these are additional to those already present there, they charge it negatively, as in a vacuum valve (Fig 4). But because the conduction is in a solid crystal, it has something in common with transistor operation.

The obvious question is how to introduce the electrons. Presumably not by clamping a red-hot cathode against the insulator. That might indeed cause current to flow—by ruining the material as an insulator. If, on the other hand, electrons can come out of cold metal, why don't they? It would be most awkward if they did, for all insulators would then conduct.

This is where we have to go into the matter a little farther, to understand why cathode heating is necessary and why electrons don't usually flow from metal into insulators.

So long as an electron is moving around inside the

solid of which it is a part, it is within a virtually uncharged space, as we have seen. But the moment it strays outside it finds itself as a negative charge close to the rest of the solid, which is now an equal positive charge. Their mutual attraction prevents the electron escaping unless its take-off speed is sufficient to carry it clear. This is the same sort of problem as sending a vehicle into space from the earth; the rocket has to give it at least a certain minimum velocity to ensure its departure.

The electron's minimum departure speed is expressed as the voltage needed to give it that speed from a standing start in clear space. The amount of energy it has to possess at the surface to escape is therefore reckoned in electron-volts (eV), and it is called the work function (ϕ). It varies from about 1 to 7 according to the kind of surface.

Now heat is nothing more nor less than the mechanical energy of the particles of which things are made. Heating a solid makes the loose electrons circulate faster. When their individual energies exceed ϕ electron-volts and they are favourably placed for a take-off, they can escape. To use the familiar technical term, they are emitted. Surfaces such as barium oxide, having a ϕ not much more than 1eV, emit at a dull red heat; those such as bare tungsten (4.5eV) need white heat. Hence the preference for oxide-coated cathodes.

One way of looking at ϕ is as a measure of the attraction between an electron and the solid from which it has been removed. So if two solids having the same kind of surface—and therefore the same ϕ —are brought into contact, electrons can pass equally easily in either direction from one to the other; the attractions of the two cancel out. On the other hand, if surfaces with different ϕ s touch, the one with the greater ϕ tends to collect rather more electrons than the other. This charges it negative, which makes it repel any further electrons. A balance is reached when the potential on that side due to the acquired charge exactly counteracts the difference in ϕ . This difference is called the contact potential, and between different metals is of the order of $\frac{1}{4}V$. If you are planning to get a supply of electricity for nothing by joining up lots of these contacts in series, you have to remember that the e.m.f. provided by the contact between metal A and metal B will be cancelled out by the next contact, which must be B to A.

What happens when a metal is brought into contact with an insulator? Insulators have a property called electron affinity, which corresponds to work function in metals, and is usually greater, so that the

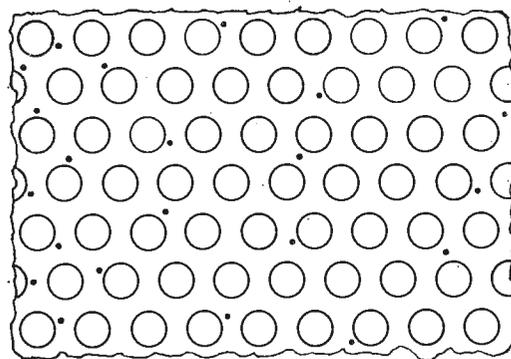


Fig. 4. With the same symbols as in Figs. 1 and 2, a current through an insulating crystal would be represented like this. The atoms being neutral, the current electrons form a space charge.

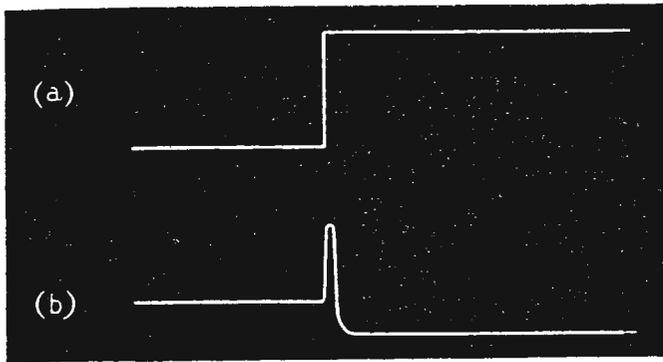


Fig. 5. (a) Potential step between metal and insulator, which prevents electrons flowing freely into the insulator. (b) If the surface of the insulator in contact with the metal has a thin layer of n-type material, the step is reduced to a very thin ridge which is "transparent" to electrons.

insulator becomes negative and repels further electrons from the metal. But it has been found possible to devise contacts that prevent the formation of this potential step or barrier, by diffusing donor impurity—that is to say, one releasing electrons—on the surface of the crystal to a depth of a few millionths of an inch. This cannot eliminate a potential barrier altogether, but instead of a step as in Fig. 5(a) it is a ridge (b) so thin—a small fraction of one millionth of an inch—that electrons can pass through it quite freely by the tunnel effect I described in the August 1960 issue. Such a contact is the equivalent of the hot cathode in a valve, and the crystal takes the place of the vacuum. If a contact at the other side of the crystal is made positive, a space-charge-limited current flows through.

It still isn't quite so simple, because no crystal is perfect, and imperfections act as traps for electrons, delaying them for periods that may extend to days. Every atom is a possible location for such a trap, so even if only one in a thousand is not in perfect crystalline formation the number of traps is enormous. Relatively trap-free crystals have been produced by careful growing and by the process known as compensation—cancelling the effect of residual impurity by adding an impurity of the opposite kind.

These problems have been solved experimentally sufficiently to demonstrate that insulator valves are possible.

But why should anyone want to make them possible? From what I have said they might seem to combine the disadvantages of vacuum and semiconductor valves. The space charge is a nuisance in a vacuum valve, necessitating a high anode voltage to overcome it. And the atoms are a nuisance in solids, obstructing the current flow.

But this would be the wrong way to look at the idea. On the whole, the best features of each are combined. There is the cold cathode, small size and power consumption, almost unlimited life and unbreakableness of the transistor. But unlike the transistor it is not upset by temperature rise. And, as is well known in connection with valves, the space charge reduces noise. Transistors are comparatively noisy devices. High anode voltages are not needed in an insulator valve, because the distance from the cathode can be made very much less than in a vacuum valve. The same feature reduces the transit time between the electrodes, which limits the frequency at which vacuum valves can amplify.

Transistors, in spite of their microscopic inter-

electrode distances, are still more limited, and it is interesting to consider why.

A little while back I contrasted the unimaginably supersonic speeds of the electrons in a vacuum valve with their less than snail pace in the copper wires leading to it, and you may have been left with the impression that this was due to their path through the wire being cluttered with atoms in contrast to the clarity of the vacuum. If so, I must correct it. One could get a given flow of water—say a gallon per second—either by a narrow jet forced out at great speed by high pressure, or by a wide river flowing almost imperceptibly across the plain. Similarly with an electric current. Through the vacuum there are a few electrons flashing by at high speed; in the wires the same current is made up of enormous numbers of them drifting very slowly. Even in a transistor, though free electrons are far sparser than in a metal, they are much more plentiful than in a space-charge-limited device.

Another reason for slow transit in a transistor is that nearly all the collector voltage appears across the base/collector junction, which is a reverse-connected rectifier and therefore presents a very high impedance compared with the main body of base and collector materials. There is, therefore, hardly any electric field across the base region to urge on the electrons or holes received from the emitter. They just diffuse slowly across, like a drop of ink in a glass of water, so no wonder the response to high-frequency signals applied to the base is sluggish. In an insulator valve, however, an appreciable field can be established to expedite the passage of the emitted electrons through the crystal lattice. Moreover, the fewer the active charges, the smaller the input capacitance, and that too helps at v.h.f.

Some basic research has been going on at Birmingham University, an account of which has recently been published by Dr. G. T. Wright (*Journ. I.E.E.*, Oct. 1962) but so far, it seems, the electronic industry has been too busy with semiconductor devices to embark on the considerable development work needed to make insulator valves a commercial success. But it looks as if they offer sufficient attractions to justify the effort. However, don't write to ask me where you can buy some!

INFORMATION SERVICE FOR PROFESSIONAL READERS

The reply-paid forms introduced recently to replace the postcards hitherto included have proved to be very helpful to professional readers, judging by the number of forms returned to us. This improved *Wireless World* service is therefore being continued.

The forms are on the last two pages of the issue, inside the back cover, and are designed so that information about advertised products can be readily obtained merely by ringing the appropriate advertisement page numbers. Space is also provided for requesting more particulars about products mentioned editorially.

By the use of these forms professional readers can obtain the additional information they require quickly and easily.

TRANSISTOR AMPLIFIER OUTPUT STAGES

3.—COMMON-EMITTER WORKING CONDITIONS

By O. GREITER

THE two preceding articles have been concerned mainly with the problem of stage structure and have indicated the paramount position of the common-emitter mode of operation. It is therefore essential to ensure that the design principles of this type of stage are clearly understood. A power stage transistor can be regarded as operating under fairly large signal conditions. These are conditions in which the signal is too large for the characteristic to be approximated by its tangent at the working point but in which operation is not extended to reach both the severely non-linear regions although, as in Class B, one of the non-linear regions may be an important fraction of the working range. The object is, in fact, to provide sufficient overall linearity

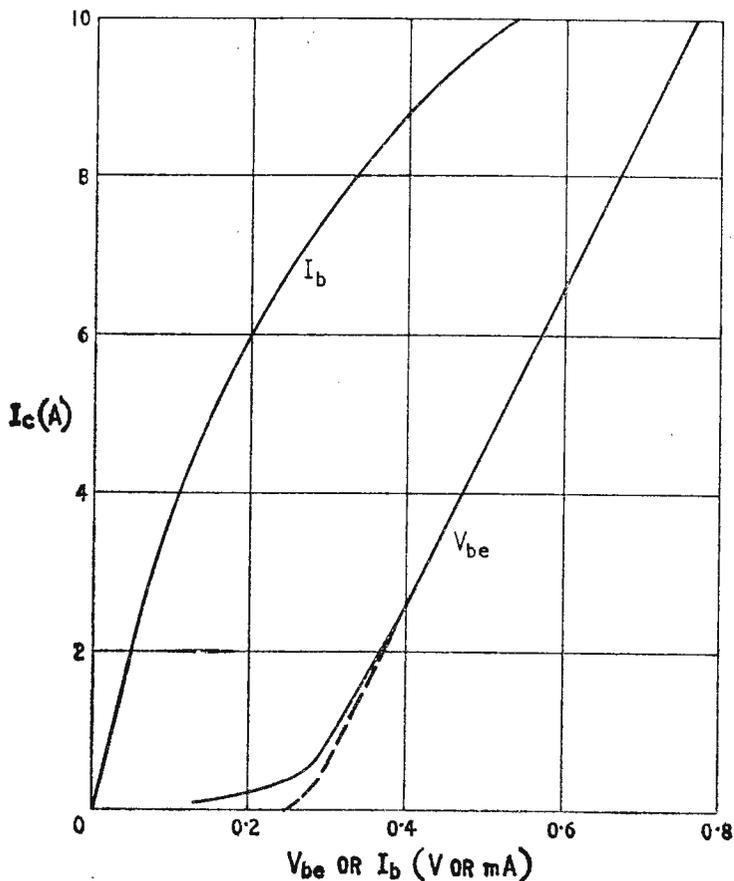


Fig. 10. Typical output transistor characteristics.

for negative feedback to be satisfactory as a distortion-controlling mechanism.

Much of the literature on transistor circuit design is devoted to the problems of common-emitter stages. The first and, in the strictest sense of the word, the most vital is the matter of bias and the stabilization of the operating conditions. In power stages this is a particularly awkward problem since in the analysis of the thermal stability it is inevitable that the heat should be high and that the stabilization should be low. The methods used for stabilizing low-level class A stages are frequently unsuitable for high-level class B stages since they offer a choice between the waste of a substantial part of the power

output and the use of ridiculous values of capacitance.

The biasing of class B stages introduces even more problems, for a new condition is imposed on the bias circuit. Incorrect biasing can lead to crossover distortion and also, in practice, although this is not discussed in the texts, to instability. The instability will only occur when the bias results in extra high gain near the origin due to excessive overlap of the characteristics, and when the amplifier is not designed with adequate stability. Crossover distortion is well-known, but in power transistor stages it is, apparently, not uncommon for crossover distortion to be observed when the amplifier is first switched on and the transistors are cold. This condition is met particularly in car radio circuits when, as is so often the case, the car is kept throughout the winter night under a lamp-post. Since the driver should be driving rather than listening and since few cars have space and few owners the inclination to fit good loudspeaker systems, this particular problem is not of great importance. By the time the driver is warm enough to care the crossover distortion will have vanished. This rather frivolous attitude cannot be applied to serious high-quality equipment and since it is unthinkable that the user should be expected to allow his amplifier to warm up, the designer will need to test with great care to establish that this effect does not occur. It is easily overlooked, since under laboratory conditions some time may elapse after switching on before any measurements are made.

A study of the textbooks reveals some conflict of opinion about the appropriate drive arrangements for common-emitter stages operating at what we are calling fairly high level. We shall consider this from the point of view of distortion generally. It must be stated at once that any conclusions which are reached will be a compromise solution and will, moreover, be a compromise based on inadequate information. Published transistor characteristics seem to fall into two classes. In one class we are given excellent graphs covering an inadequate amount of data, while in the other class we have a large number of graphs so small that even the linear behaviour is difficult to follow. Both sets of information are based on average performance, measured and averaged by engineers like the reader. The curves are drawn, no doubt using some sort of curve-drawing aid, and are redrawn in a drawing office. They do not necessarily cover the whole working range. From these we are attempting to determine the departures from linearity of a real amplifier. It is probably not unfair to accept that the kind of shape, concave up or down, is correct. It would be imprudent to measure the sag and to assign much meaning to it.

The two curves in Fig. 10 indicate the sort of characteristic which is quoted by one manufacturer, brought together so that the features are clearly visible. Particularly distinct is the extremely linear transconductance and on the basis of this we can

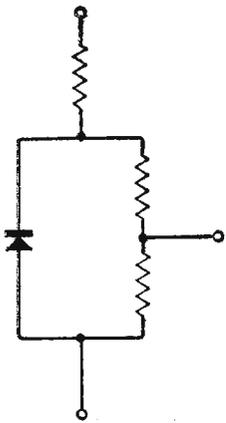


Fig. 11. Bias circuit for low-level stage.

decide without hesitation that this transistor should be operated from a low-impedance source. The shape of the current transfer characteristic makes it abundantly clear that if we allow the input to be a current-controlled signal we shall get a very rounded input-output relationship. The knee of the transconductance graph, however, is surprisingly sharp. If we are to believe the linear portion we must equally believe the knee and when we attempt to fit the two halves of a class B pair together we get a construct shown as a dotted line which indicates a good deal of crossover distortion and a very high sensitivity to the exact bias conditions.

Let us look further at the situation. To obtain a current in the collector of 10 amps we shall need a bias of 0.27 volts plus a signal of 0.5 volts, and the base current will be just over 0.5 amps. The effective input impedance is thus just about 1 ohm. A low-impedance supply feeding a not particularly linear input resistance with an average value at high levels of 1 ohm must have a generator impedance of, say, 0.1 ohm or less. In an analysis of this kind it is sufficient to work in orders of magnitude so that we can watch the broad picture. This sort of source impedance is by no means easy to obtain in a circuit providing a.c. coupling (circuits using d.c. coupling will be treated as compound systems) and when the bias path is added it seems improbable that a solution should be found.

As soon as the bias path is mentioned it directs our attention to the fact that we are calling for a bias of 0.27 volts. If we were considering a low-level stage we might derive this bias from a circuit of the type shown in Fig. 11. The rectifier can be regarded as providing any or all of several functions. To begin with it provides a moderately well stabilized voltage which does not vary too much with changes in the main supply voltage. It has a much lower source impedance than we should obtain for the same current consumption in a purely resistive voltage divider. Some measure of temperature compensa-

tion can be provided against changes in transistor parameters. The value of V_{be} in a typical power transistor has a temperature coefficient of between -2 and -2.5 mV/deg C. The correct bias for a class B stage is therefore likely to vary over quite a wide range, wider than at first one would think. Newly switched on in an unheated room the junction temperature might be 10°C , while after running at full load for some time in a warm room 60°C would be a very conservative figure. This gives a change of value for V_{be} of at least 0.1 volt. The reader can easily plot for himself the combined characteristic in the crossover region of Fig. 10 when the bias is this much in error.

Since the diode can be kept at heat sink temperature it can be assumed that it will vary in voltage in accordance with the average conditions of transistor operation. There is an averaging effect due to the thermal capacitance of the heat sink and a temperature-dividing effect due to the thermal resistance between the transistor junction and the diode junction. More important at this stage is the fact that a diode operating in its low-impedance region will not provide a bias of the required value and the diode voltage must be divided down in the way shown in Fig. 11. The diode temperature coefficient expressed in mV/deg C is naturally divided down in the same ratio and the approximate compensation is lost.

No account has yet been taken of the effect of temperature on I'_{co} . The simple concept of a firmly earthed emitter with a partially compensated bias supply is seen to be very dangerous, for it involves the use of resistance in the base circuit. The expressions for determining stability are well known and need not be reproduced here. It is important to note that the minimum stability signal may not coincide with the maximum dissipation signal. This result is derived by Lin (*I.R.E. Transactions on Circuit Theory*, Sept. 1957) but although he shows how for one amplitude of square wave the stability is rather lower than it is for the maximum-dissipation square wave it is not easy to produce a convincing example using an arbitrarily chosen power transistor. In any event square-wave operation will normally be only a test condition and the tester should be prepared for thermal runaway.

Let us leave this matter unresolved at this stage

and let us consider the characteristics of another transistor, shown as Figs. 12 and 13. The notable feature here is the relatively good linearity of the current transfer characteristic in Fig. 13 and the smooth but continued curvature of the input characteristic in Fig. 12. Indeed a test shows that a parabola with its vertex at (200mV, 0mA) can be found to fit this curve to well within normal transistor limits. Here again, therefore, it is perfectly possible to use a low-impedance drive source and we can assume that the current gain is constant enough and

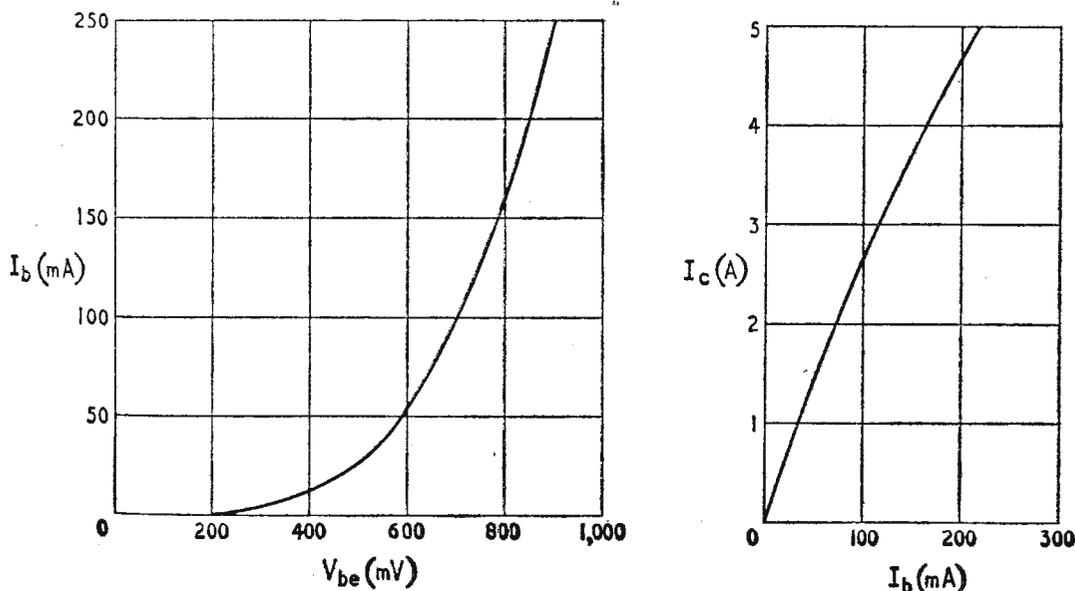


Fig. 12 (left) and Fig. 13 (right). Typical output transistor characteristics.

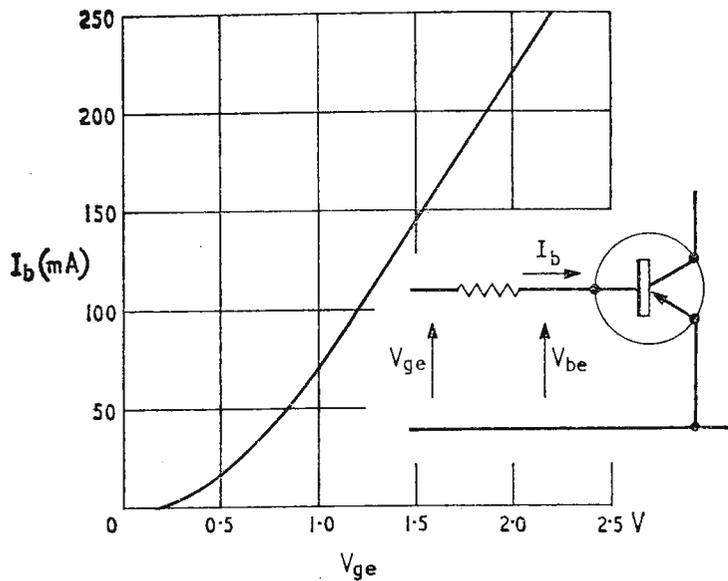


Fig. 14. Effect of a 5-ohm source in straightening the input characteristic.

simply match the two input parabolas one against the other. If we do this on the basis of preserving the match up to a collector current of 5 amps, for which we need a base current of rather over 200mA we find that the bias voltage should be somewhere between 550 and 600mV. The quiescent collector current will then be about 1 amp.

The following reasoning will be found in some of the literature. We wish to straighten out the characteristic of the base-emitter diode and we can do this by **swamping** it with a high resistance. Then we shall need to consider only the current transfer characteristic of Fig. 13. Let us therefore say that a common-emitter stage must be driven by a high-impedance source and all will be well. As an exercise the effect of a 5-ohm source is plotted in Fig. 14. The linearization of the signal voltage (now V_{ge})—base current characteristic is very noticeable and although the plot is on a rather small scale it would seem that the bias should now produce a base current of about 15mA, giving a collector current of perhaps 400mA, instead of the base current of 40mA giving over 1 amp.

There is something unsatisfactory about a situation in which the style of a circuit design depends so completely on the shape, in detail, of particular device characteristics. Even if the shapes were covered by some sort of specification, which they are not, we should hardly be able to enforce a claim for specific performance. In addition, as we shall see later, there are other aspects to be taken into account.

In order to compare our procedure with these two conflicting types of transistor we must bring them to the same terms and we can commence by plotting Fig. 15, the I_c-V_{be} characteristic of our second transistor. Not surprisingly, since the current gain is fairly constant, this has very much the same shape as Fig. 12 but it is undoubtedly very different from the long linear graph of Fig. 10. The obvious step which we can take is to linearize this graph. This can be done quite easily by introducing a resistance and if we assume that the emitter current is the same as the collector current this resistance becomes simply an undecoupled resistance in the emitter lead. A rather rough estimate of the value which will give a result comparable with Fig. 14 is that it must develop about 1 volt across it at a current of 4 amps. The resistance will then be about 0.25 ohms.

A plot of the result is shown in Fig. 16 and it will be seen that it differs very little from the shape shown in Fig. 14 but now, however, there is no residual distortion or intermodulation to be produced by the curvature of the current transfer characteristic. A typical load for the transistor we are considering will be about 5 ohms and so the price of this $\frac{1}{4}$ ohm in the emitter lead will be small and may, indeed, reveal that we can get more power output by working to a higher current because of the effect of the local negative feedback.

Not only does this reveal an arrangement suitable for a low-impedance drive, but it indicates an arrangement in which the term low-impedance has a different meaning. The same base current must be flowing as before, but now a base current of 200mA needs an input voltage change of about 2 volts, so that the definition of low-impedance introduces the qualification "with respect to 10 ohms." This is a much less exacting requirement than before.

The great advantage which has been gained is the advantage of flexibility. The base can be biased directly from the voltage set by the diode so that we have full compensation for the temperature coefficient of the junction voltage. By choosing a suitable value of emitter resistance we can then set the quiescent current where we will. Automatically we have improved thermal stability of the system, for near the origin we have $\alpha \approx 32$, making $\alpha R_e = 8$ and if we take the base feed resistance as 2.75 ohms we get a factor of stability $1/1+8/4 = 1/3$. This is obviously very much better than the value of near unity we obtain if the emitter is connected directly to earth. We can go further and attempt to balance out the effects of the changes in I'_{c_0} with temperature and there is a certain amount of published material on this question. There is also some evidence of unpublished ingenuity. Short periods of high dissipation will heat the junction well above the mounting plate temperature and any averaged compensation will not come into action. One compensating technique is to use an emitter resistor made of wire with a positive temperature coefficient. If this is a lamp filament or a live wire suspended so that it has a fairly small time constant the compensation will track, rather roughly, the junction temperature. Such a filament may also act as a fuse.

It will be clear that the emitter resistance which is

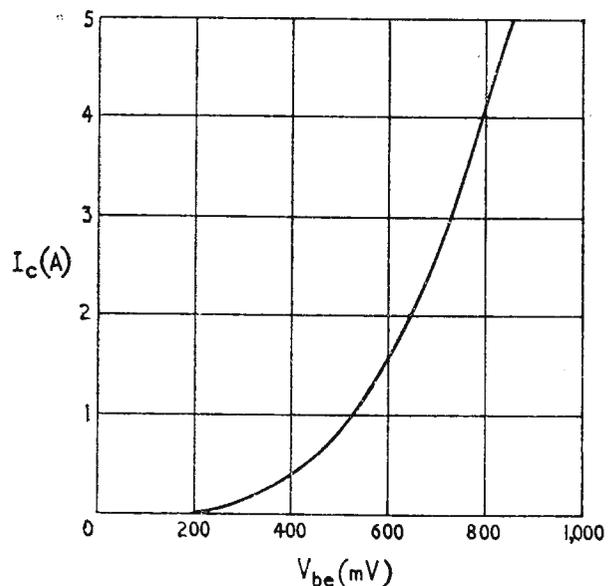


Fig. 15. I_c/V_{be} characteristic of another type of transistor requiring linearization.

introduced for purely practical reasons, among which we must also include the way in which the matching of a pair of transistors will be improved, will also free the circuit from the restraints on generator impedance which might otherwise be imposed. A high generator impedance will certainly linearize the base-emitter diode but will leave unaffected the curvature of the current transfer coefficient. On the other hand, the emitter resistance, while assisting in the overall linearity, will not be able to affect the fact that the current transfer characteristic is curved, and if a really high impedance base drive is used the feedback voltage will be powerless to affect the situation.

The approach here is rather different from that of Tharma in *Mullard Technical Communications* (Vol. 3, No. 24 May 1957, p. 106 and Vol. 3, No. 29, March 1958). In the first of these references the positive temperature coefficient of the emitter resistance is used to compensate for changes of V_{be} and he shows that if the temperature coefficient of V_{be} is 2.5mV/deg C (it is negative in sign) a positive temperature coefficient of 0.004/deg C will compensate the circuit when the drop across the emitter resistance is 0.63 volts. In an example he shows a drop of 0.85 volts giving compensation for I_{co} as well. The base voltage is held constant. No account is taken of the improved linearity. In the second paper he discusses the combinations of shared or common-bias chains and shared or common-emitter resistances but excludes the form which is of interest when a diode is used for bias stabilization, the shared bias chain with separate emitter resistors.

The use of separate emitter resistors is inevitable in the circuits which make use of transistors in series, as in the output transformerless (OTL) circuits. The merits of the common-emitter resistor as an aid to stability in the traditional push-pull circuit are probably overruled by the flexibility introduced when the resistors are separate. Once the use of temperature-dependent elements is allowed the subject becomes one of very great complexity, for the problem becomes one of balancing distortion, efficiency and power output against maximum operating temperature and heat sink size. Engineers who were taught at school that you cannot equate apples and pears find this type of balance sheet particularly difficult.

We have managed to produce a decision to make use of a low driver impedance on the grounds of circuit convenience, the introduction of an emitter resistance to simplify the biasing and to enable us to bias to a low quiescent current being the dominant factors. A quick check, which is not reproduced as a figure shows that the knee which appears in Fig. 10 is rounded to a more satisfactory shape by the use of this technique although in fact this knee is itself suspect. There is another factor which must also be taken into consideration.

The classical theory of transistor frequency response is usually summarized into the following form. The current gain in the common-base mode, α , has a frequency variation which can be described approximately by the expression $\alpha = \alpha_0 / (1 + jf/f_\alpha)$ where α_0 is the low-frequency limit of the current gain and f_α is the characteristic frequency at which the response has fallen by 3dB. This is an approximation to the theoretically sound expression

$$\alpha = \frac{\alpha_0}{\cosh \frac{\pi}{2} \left(j \frac{f}{f_\alpha} \right)}$$

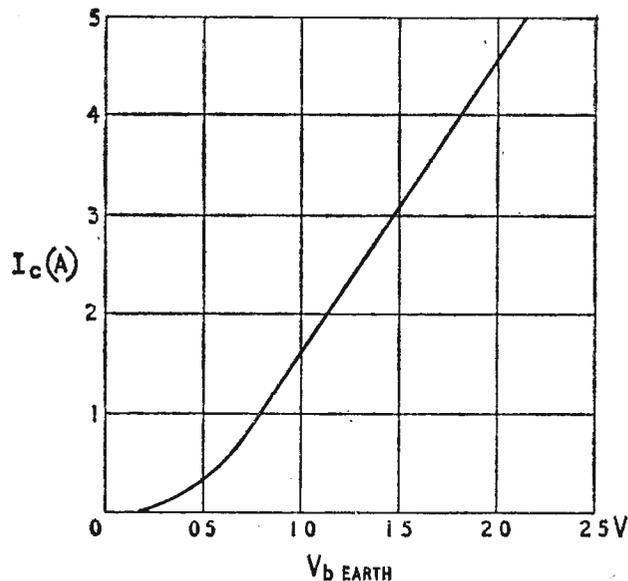


Fig. 16. Transistor of Fig. 15 with added 0.25Ω in the emitter lead.

and it is sometimes important to remember this since the exact expression does not have a limiting phase shift of 90° but at the 20dB down frequency has a phase shift of close to 180° . The significance of this phase shift in the design of feedback amplifiers need not be stressed.

When the common-emitter configuration is considered it is usual to write $\alpha' = \alpha / (1 - \alpha)$ and to derive from this an expression similar to the one above except that in place of f_α we have $f_{\alpha'}$ and

$$f_{\alpha'} = (1 - \alpha_0) f_\alpha$$

The frequency $f_{\alpha'}$ is often very low, for if $\alpha_0 = 0.98$ and $f_\alpha = 250$ kc/s we have $f_{\alpha'} = 5$ kc/s. In the derivation of this result it has been assumed that the common-emitter transistor is current-controlled but already it has been shown that this is not the condition which will be adopted. An expression which is given for a transistor operated with a resistance R_e in the emitter lead and a total of R_b in the base lead is

$$f_{\alpha'_1} = \left[(1 - \alpha) + \frac{R_e}{R_b + R_e} \right] f_\alpha$$

This can be rearranged into the form

$$\begin{aligned} f_{\alpha'_1} &= (1 - \alpha) \left[1 + \frac{1}{(1 - \alpha) + \frac{R_b(1 - \alpha)}{R_e}} \right] f_\alpha \\ &= \left[1 + \frac{1}{(1 - \alpha) + \frac{R_b(1 - \alpha)}{R_e}} \right] f_{\alpha'} \end{aligned}$$

The conditions discussed earlier will be such that is a good deal larger than $(1 - \alpha)$ and a good deal smaller than unity. Two approximations are therefore

$$f_{\alpha'_1} \approx \left[1 + \frac{R_e}{R_b(1 - \alpha)} \right] f_{\alpha'} \approx \frac{R_e}{R_b(1 - \alpha)} f_{\alpha'}$$

From this it is possible to draw the conclusion that with a low-impedance drive circuit we are not limited by the common-emitter cut-off frequency. This conclusion merits a much closer examination, which must be postponed until next month.



By "FREE GRID"

Is Hi-Fi Ni-Fi?

HI-FI is a relative term and merely indicates that the amplifier or what-have-you, to which it is applied, gives a greater degree of fidelity to the original input than do ordinary run-of-the-mill instruments.

The ultimate aim, of course, is to build an amplifier to which the simple term "fi" can be applied. It will obviously never be possible to go beyond that, and so clearly such a term as "super-fi" which I saw recently is absurd. It could only mean that the instrument to which it was applied, went beyond "fi" inasmuch as it added something of its own to the original sound which it was designed to reproduce. If it did that, then it wouldn't be entitled to the honourable title of "fi."

Things are exactly the same if we use the word "reproduction" instead of "fi." Obviously the perfect amplifier and loudspeaker system would be capable of reproduction, and nothing more. Any euphemistic qualifying adjectives would, therefore, mean that the equipment fell short of the goal of reproduction. The term "good reproduction" is permissible in a loose sort of way to indicate that it approaches nearer to the aim of reproduction, than is normally heard.

Now I may be asked what all these obvious statements of mine are in aid of? The answer is that I want to know how near to "fi" is the quality of reproduction which to-day is called "hi-fi"; in other words, is to-day's "high-fi" "nigh-fi"; and if so how "ni" is it to "fi"? Year by year we get closer to "fi"; indeed day by day we get closer to it by infinitesimally small degrees, and I suppose that those skilled in juggling with the calculus are really the only people who could sort it all out.

Personally, I don't think we shall ever reach the goal of "fi," but as the years go on we shall get even closer to it, and the closer we get, the more infinitesimal will be each move nearer to the target. The thing which set me thinking about all this was an article by E. R. Whittaker in our sister journal, *Wireless and Electrical Trader*, some months ago. I don't suppose many of you see this journal as it is intended only for those who—sordid fellows—seek to make a profit out of us by making and selling wireless sets and accessories.

Mr. Whittaker tells us that the "hi-fi" of 10 years ago was by present-day standards, only medium

"fi," we have thus moved considerably nearer to the goal of "fi" in the past decade, and it cannot be doubted, I think, that in 10 years' time our present "hi-fi" standards will sound relatively poor. But I still wonder how "ni" to "fi" is our present "hi-fi"? Can any one of you tell me, or is my question as unanswerable as asking what is beauty?

TV Aerial Design

I WONDER if any of you, especially those who live in "fringe" or "extra-fringe" areas, noticed—or seemed to notice—a loss of television signal strength during one of the Arctic spells we recently experienced. If so you may have been tempted by your womenfolk into wrong thinking.

The guiding or misguiding rule of every woman in technical matters seems to be "*post hoc, ergo propter hoc.*" Working on this theory Mrs. "Free Grid" misled even me into thinking that because a drop in signal strength occurred when the TV aerial was encrusted with a thick coating of ice, therefore, this was obviously the cause of the trouble.

However, calm reasoning made me realize that she was all wrong. The only cause of signal-strength loss would be a direct electrical leakage between the aerial elements and the earthed support, but ice is an insulator like distilled water, and not a conductor because all the various impurities associated with the water from which it is formed, especially in urban areas, get thrown out when it freezes.

Dismissing this idea of a direct leakage path, I then recalled that the dielectric constant of ice is on the high side. Thus, I reasoned, the ice around the aerial elements could act as a series of paralleled shunting capacitances to the earthed support. The fact that the major drop in signal strength was in the I.T.A. transmission with its higher i.f. seemed at first to support this idea, until I recalled that most TV aerials are rather "broad-band" and will stand quite a bit of mistuning.

The real nigger-in-the-woodpile was, I found eventually, the new I.T.A. aerial at Croydon which had also a new radiation pattern.

Despite all this, however, I do think TV aerial manufacturers should seriously turn their attention to the production of electrically-heated antennae in readiness for the winter of 1964/5 when the 625-line u.h.f. system will be in full swing, and we shall all be using horizontal

aerials. Obviously if these become heavily coated with ice their rods may tend to droop with the weight, more especially some of the very complicated combined-band ones, supported at only one end.

But apart from any question of snow and ice, I would point out that it will be necessary to provide electrical heating for these Band IV aerials at all seasons of the year, because horizontal rods will form natural perching places for various types of bird including the ubiquitous pigeon which is of no mean weight and bulk and so would tend to have quite a considerable distorting effect on the aerial.

Also, of course, the self-capacitance of several well-fed pigeons might just possibly have an adverse effect despite its broad tuning. It is, however, a matter for the slide-rule addicts to work out. Perhaps they will send me a few figures in support or ridicule of my idea.

At any rate it is clear, I hope, that it would be desirable to keep large birds off our Band IV aerials, and hot rods seem to be the answer. The rods need not be so hot as to invite the attention of the R.S.P.C.A.

Of course it might well be that aerial designers already have the matter in hand, and have devised a far better preventive than I have suggested.

Pioneer Propagation Problems

NOWADAYS continuous radio communication over vast distances throughout the 24 hours of the day is so commonplace that we pay no more heed to it than we do to the constant broadcasting service given by the B.B.C. It is just taken for granted. Things were far different before the first world war, however, as I was recently reminded when re-reading the *Wireless World* Golden Jubilee number of April 1961.

In that issue the author of the history of wireless, writing under the title of "Since the Wireless World Began" stated (p. 161) "a few of the early point-to-point stations, working at distances well beyond daylight range, provided a rather erratic service by taking advantage of night-time propagation conditions."

At the time I first read this, I made a resolve to find out just how many of these direct high-power services were in operation. As far as I can ascertain, there were only two. There was in the first place, the

San Francisco-Honolulu service run by the Federal Co., using the Poulson arc system. As far as I can find out, this service never did succeed in establishing communication in the period when there was daylight over the whole path, but relied solely on night-time propagation.

There was also the link between Port Stanley, in the Falkland Isles, and Montevideo, the Uruguayan capital, the distance being well over one thousand nautical miles. Quite frankly I cannot find evidence of any other long-distance service.

It would almost seem as though the Kaiser did the promoters of the various proposed long-distance services, including our own Imperial Wireless chain, a good turn by saving them the embarrassment (financial as well as emotional) of being unable to fulfil their contracts. The Kaiser's war and its aftermath gave time for the development of beamed short waves which have completely taken the place of the old long waves* of the pre-1914 efforts at continuous and reliable long-distance communication.

* The building of v.l.f. stations at Solway and in the U.S.A. is evidence that the lower end of the radio spectrum has not been completely superseded.—ED.

Etymological Enquiry

I HAVE always been interested to find out when the word "radio" was first used as a synonym for what we in this part of the world call "wireless," and have ventilated my views on the matter previously in these columns.

My only excuse for returning to the subject is that I have had a letter about it from a correspondent. He draws my attention to some remarks by Süsskind in the October 1962 issue of *Proc. I.R.E.* Süsskind states that in 1897 Branly described his coherer as a radio-conductor. Süsskind italicizes the term but my correspondent suggests that Branly, being a Frenchman, would surely have called it a radio-conducteur.

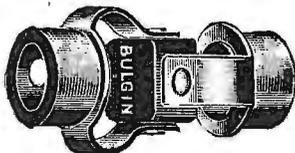
However, my own opinion is that Branly might have used the termination "or" because he thought it had an international flavour. He certainly had a useful precedent a century earlier when, in the interests of international homophony, the French adopted the word kilometre instead of the more correct chilio-metre.

I wonder if any of you can throw any more light on the matter of Branly's term, or name any earlier instances of the use of the word radio as a synonym for wireless.

The orthodox view is that "radio" was coined by the Germans as an acceptable word for use in the first international radio convention drawn up in Berlin in 1903. The word had already been used in a non-wireless sense, in X-ray work and other fields.



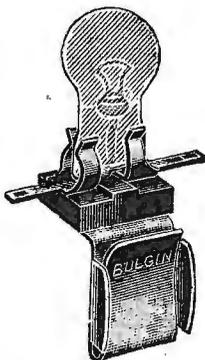
BRAND NEW COMPONENTS



List Nos.: E.H.18, 19, 20.

E.H.18, 19, 20.

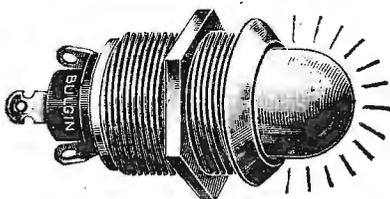
A set of three flexible shaft couplers to fit shafts of $\frac{1}{8}$ in., $\frac{3}{16}$ in. and $\frac{1}{4}$ in. diameter respectively. They will transmit up to 25 in. lbs. torque in up to 10° axial deviation and are therefore suited to many varied applications.



List No. L.C.15.

L.C.15.

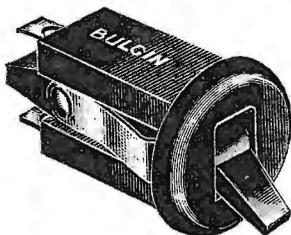
We are the first manufacturers in the United Kingdom to develop a lampholder to accept the new "Capless-lamps"; having "open" construction and high insulation its performance, even under adverse climatic conditions, is exceptionally good. There are various fixing brackets or clips available and the range is still being increased. Write now for fuller details and drawings.



List Nos. D.862-3.

D.862-3.

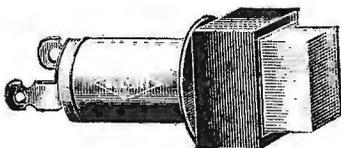
The Signal Lamp illustrated left incorporates a new design of lamp-holder which has very high insulation properties. It can work at a higher voltage than most signal lamps of comparable size and can also be used under adverse, high humidity conditions.



List No. S.805.

S.805.

This completely new toggle switch has been designed to meet heavy duty requirements of up to 10 amps, 250 volts (50c/s A.C. only). The body, operating dolly and front bezel are all moulded, thus giving high insulation and safety even under adverse conditions. Fixing is by push-in, spring grip fit, to a rectangular hole.



List No. M.P.20.

M.P.20.

A new push-button, for 28 Volt, 3 Amps maximum working, which has an extremely modern and clean front-of-panel appearance. The operating button and bezel are square and are moulded in contrasting colours of red and black respectively. Switching is normally "OFF", press for "ON".

FURTHER DETAILS & DRAWINGS AVAILABLE ON REQUEST

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MARCH MEETINGS

Tickets are required for some meetings; readers are advised, therefore, to communicate with the secretary of the society concerned.

LONDON

4th. I.E.E.—Discussion on “The evaluation of technologies for fabricating h.f. transistors” at 5.30 at Savoy Place, W.C.2.

6th. British Interplanetary Society.—One-day symposium on “Ground support equipment” at 4 Hamilton Place, W.1.

6th. Brit.I.R.E.—“Travelling-wave crystal amplifiers” by C. S. Brown at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

7th. Television Society.—“Colour television in medicine” by Prof. R. Warwick at 7.0 at 164 Shaftesbury Avenue, W.C.2.

11th. I.E.E.—“Microwave theory or microwave green fingers?” by L. Lewin at 5.30 at Savoy Place, W.C.2.

13th. I.E.E.—“Pulse techniques in line communications” by R. O. Carter at 5.30 at Savoy Place, W.C.2.

13th. Brit.I.R.E.—“Industrial leadership” by Prof. A. Rodger at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

14th. Radar & Electronics Assoc.—“The rôle of the computer in radar systems” by D. Hunter at 7.0 at the R.S.A., John Adam Street, W.C.2.

15th. Institute of Navigation.—“The application of inertia navigation systems to air transport” contributions from several authors at 2.30 at 10 Upper Belgrave Street, S.W.1.

18th. I.E.E.—Discussion on “Merits of using the metric system” at 6.0 at Savoy Place, W.C.2.

19th. I.E.E. and R.Ae.S.—Discussion on “Semiconductors and their application to airborne equipment” at 6.0 at Savoy Place, W.C.2.

20th. Brit.I.R.E.—Symposium on “Multi-aperture ferrite devices” at 6.0 at London School of Hygiene, Keppel Street, W.C.1.

25th-27th. I.E.E.—Convention on h.f. communication at Savoy Place, W.C.2.

27th. Brit.I.R.E. and I.E.E.—Discussion on “Instrumentation for applied psychology” at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

ARBORFIELD

14th. I.E.E.—“The general problems of f.m. multi-channel communications” by R. G. Medhurst at 5.0 at the Garrison Hall, Arborfield Camp.

BASINGSTOKE

1st. Brit.I.R.E.—“Self-adaptive control systems” by K. R. McLachlan at 7.30 at the Technical College.

BEDFORD

18th. I.E.E.—“Solid circuits” by J. Walker at 7.0 at the Bridge Hotel.

BIRMINGHAM

4th. I.E.E.—“What is a magnetic field?” by J. J. Matthews at 6.30 at the James Watt Memorial Institute.

25th. I.E.E.—“Some aspects of radio propagation research” by Dr. K. G. Budden at 6.0 at the James Watt Memorial Institute.

28th. I.E.E. & Brit.I.R.E.—Symposium on “Automatic control” at 10.15 at the Electrical Eng'g Dept., the University.

BRISTOL

12th. Television Society.—“U.H.F.” by H. W. N. Long at 7.30 at Royal Hotel, College Green.

27th. Brit.I.R.E. & British Computer Society.—“Hybrid computers” at 7.0 at the University Engineering Lecture Rooms, Queens Building, University Walk.

CAMBRIDGE

20th. I.E.E.—“Electronics in neurophysiology” by P. E. K. Donaldson and Dr. J. G. Robson at 8.0 at the Dept. of Physiology, Downing Street.

CARDIFF

6th. Brit.I.R.E.—“Masers and lasers” by Dr. R. C. Smith at 6.30 at the Welsh College of Advanced Technology.

27th. Society of Instrument Technology.—“Electronic weighing” by L. F. Cohen at 6.45 at the Welsh College of Advanced Technology.

COVENTRY

25th. Brit.I.R.E.—“Satellite communications” by R. W. White at 7.15 at the Herbert Theatre.

CRAWLEY

27th. I.E.E.—“Some aspects of the use of computers in process-control applications” by J. F. Roth at 6.30 at the Institute of Further Education.

EDINBURGH

12th. I.E.E.—“Some aspects of the use of computers in process-control applications” by J. F. Roth at 7.0 at the Carlton Hotel, North Bridge.

13th. Brit.I.R.E.—“Communication satellites” by L. F. Mathews at 7.0 at the Department of Natural Philosophy, The University, Drummond Street.

19th. I.E.E.—“The Fylingdales ballistic missile early warning station” by F. Harrison at 7.0 at the Carlton Hotel.

28th. I.E.E.—Faraday lecture on “Electronics—the key to air safety” by Dr. E. Eastwood at 7.0 at the Usher Hall.

EVESHAM

1st. Brit.I.R.E.—“Electrical synthesis of music” by A. Douglas at 7.0 at the B.B.C. Club, High Street.

11th. I.E.E.—“Transistor video amplifiers for colour television” by F. G. Parker at 7.30 at the B.B.C. Club.

FARNBOROUGH

19th. I.E.E.—“The principles and operation of large radio-telescopes” by Dr. A. Hewish at 6.15 at the Technical College.

26th. I.E.E.—“Communication tests using the Telstar satellite” by Capt. C. F. Booth at 6.30 at the Technical College.

GLASGOW

11th. I.E.E.—“Some aspects of the use of computers in process-control applications” by J. F. Roth at 6.0 at

the Royal College of Science and Technology.

14th. Brit.I.R.E.—“Communication satellites” by L. F. Mathews at 7.0 at 39 Elmbank Crescent.

IPSWICH

4th. I.E.E.—“The automatic control of machines for assembling mechanical components” by A. V. Hemingway at 6.30 at the Electric House.

LEICESTER

19th. Television Society.—“GRACE” by C. G. Lloyd and J. G. Allen at 7.30 at the New Vaughan College, St. Nicholas Street.

LIVERPOOL

4th. I.E.E.—“Optical masers” by I. L. Davies at 6.30 at the Royal Institution.

MALVERN

28th. Brit.I.R.E.—“Techniques for precise frequency measurement in the microwave region” by K. G. Hope at 7.0 at the Winter Gardens.

MANCHESTER

7th. Brit.I.R.E. and I.E.E.—“Satellite communications” by W. J. Bray at 7.0 at the Reynolds Hall, Manchester College of Science and Technology.

13th. I.E.E.—“The Atlas computer” by Dr. D. B. G. Edwards at 6.15 at the Electrical Eng'g Dept., the University.

19th. I.E.E.—“Some aspects of the use of computers in process-control applications” by J. F. Roth at 6.15 at the Engineers' Club.

NEWCASTLE-ON-TYNE

4th. I.E.E.—“The impact of the epitaxial technique on semiconductor devices” by Dr. J. T. Kendall at 6.30 at Rutherford College of Technology, Ellison Place.

13th. Brit.I.R.E.—“Manufacture and test procedure of reliable resistors” by B. H. Nichols at 6.30 at Nevillie Hall, Westgate Road.

18th. I.E.E.—“The principles and operation of large radio-telescopes” by Dr. A. Hewish at 6.30 at Rutherford College of Technology, Ellison Place.

25th. I.E.E.—Faraday Lecture on “Electronics—the key to air safety” by Dr. E. Eastwood at 7.15 at City Hall.

PORTSMOUTH

20th. I.E.E.—“Delta—modulation” by R. T. A. Standford and A. Poulett at 6.30 at the College of Technology.

RUGBY

13th. I.E.E.—“Superconductivity” by Prof. W. F. Vinen at 6.30 at the College of Engineering Technology.

SOUTHAMPTON

12th. I.E.E.—“Pulse transformers” by Dr. R. C. V. Macario at 6.30 at the University.

26th. Brit.I.R.E.—“The analogue computer as a tool in engineering research and design” by A. J. Collins at 7.0 at the Lanchester Building, the University.

WOLVERHAMPTON

6th. Brit.I.R.E.—“Lasers and their practical applications” by K. D. Harris at 7.15 at the College of Technology.



Mk 4 MULTIMINOR

The Mk. 4 MULTIMINOR is an entirely new version of this famous Avo instrument and supersedes all previous models. It is styled on modern lines, with new high standards of accuracy, improved internal assemblies, and incorporating panclimatic properties.

The instrument is supplied in an attractive black carrying case, which also houses a pair of leads with interchangeable prods and clips, and an instruction booklet. It is packed in an attractive display carton. Robust real leather cases are available, if required, in two sizes, one to take the instrument with leads, clips and prods, and the other to house these and also a high voltage multiplier and a d.c. shunt.



D.C. CURRENT: 100 μ A f.s.d. — 1A f.s.d. in 5 ranges
A.C. VOLTAGE: 10V f.s.d. — 1,000V f.s.d. in 5 ranges
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RESISTANCE: 0—2M Ω in 2 ranges using 1.5V cell
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Modern styling in light grey with legible black engraving.

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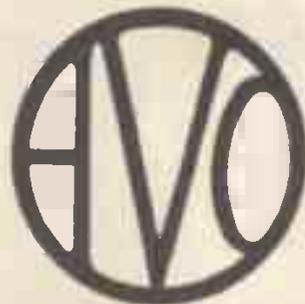
Re-styled scale plate for easy, rapid reading. Two basic scales each 2.5in. in length.

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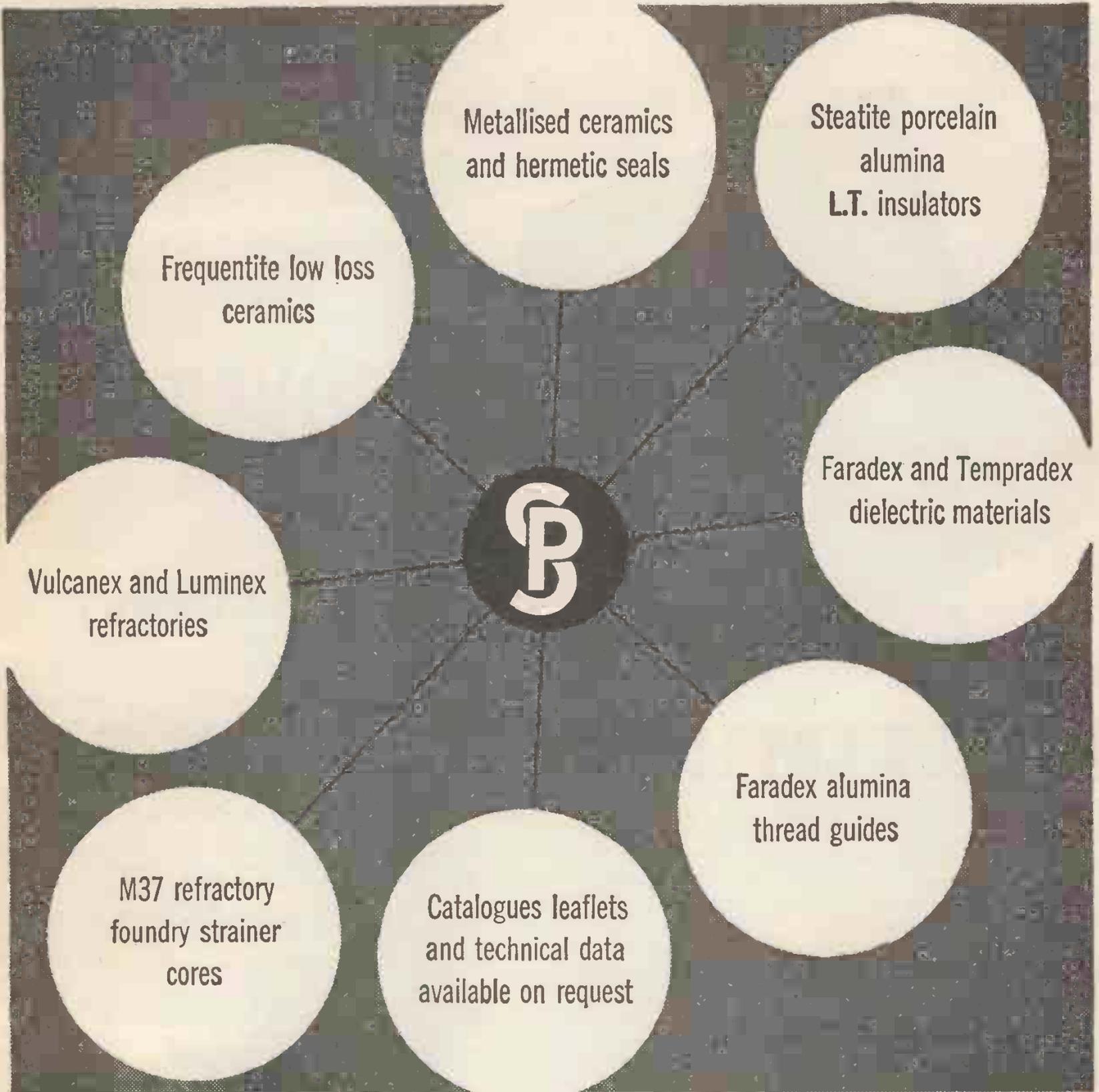
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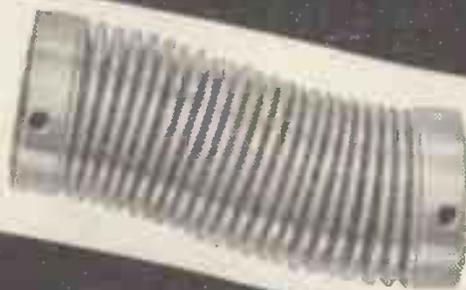
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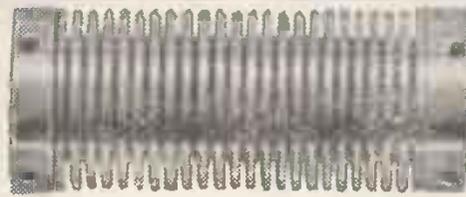
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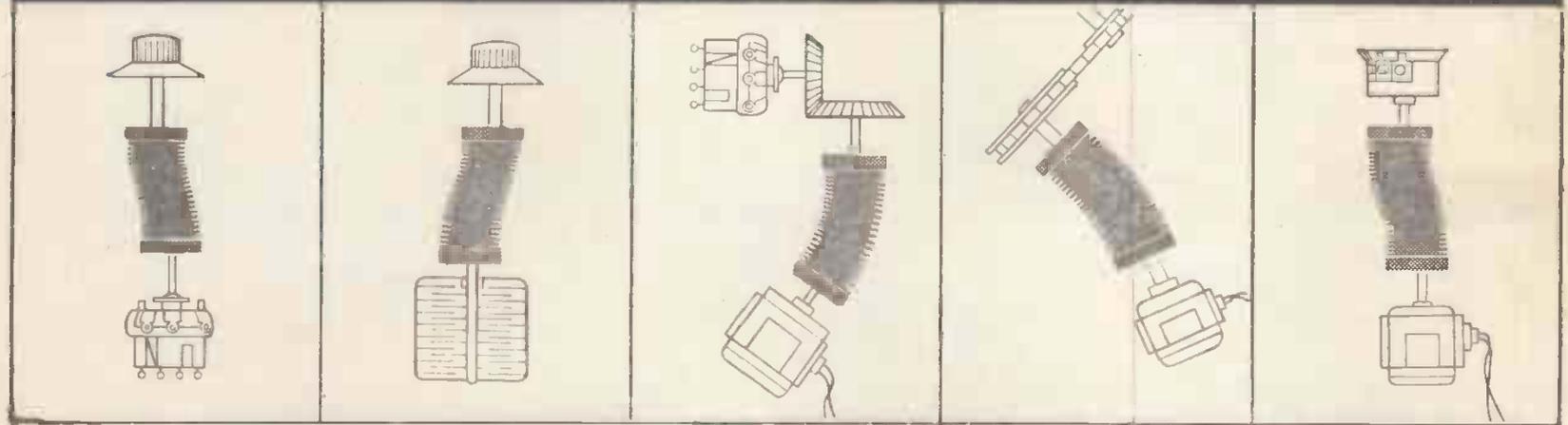
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7000 Mc/s PORTABLE OUTSIDE BROADCAST LINK FOR TELEVISION

NOW AVAILABLE EX-STOCK

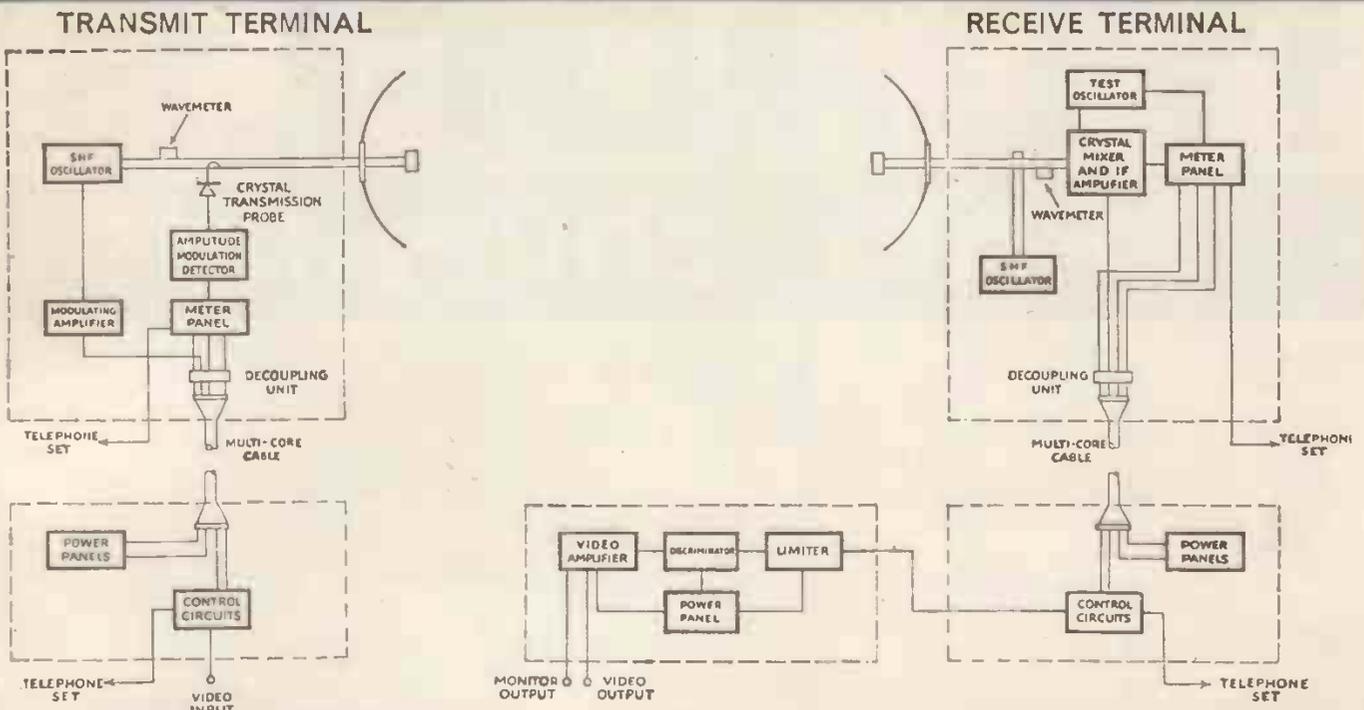
This equipment comprises a number of easily portable units forming independent frequency-modulated transmit and receive terminals operating in the frequency range 6850 Mc/s to 7300 Mc/s.

The design is based on considerable experience gained since 1948 with STC portable television links supplied to the British Broadcasting Corporation, and administrations in various parts of the world.

- Suitable for 405, 525, or 625 line, monochrome or colour, television picture transmission.
- C.C.I.R. approved i.f. of 70 Mc/s.
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- Has built-in lining-up equipment.
- Range 30 to 40 miles. Extended by connecting a limited number of links in tandem.



Receive terminal disassembled into its component parts for transport.



Block schematic of transmit and receive terminals.



used by the BBC

STC engineers can advise on all problems concerning radio links for both television and telephone transmission.

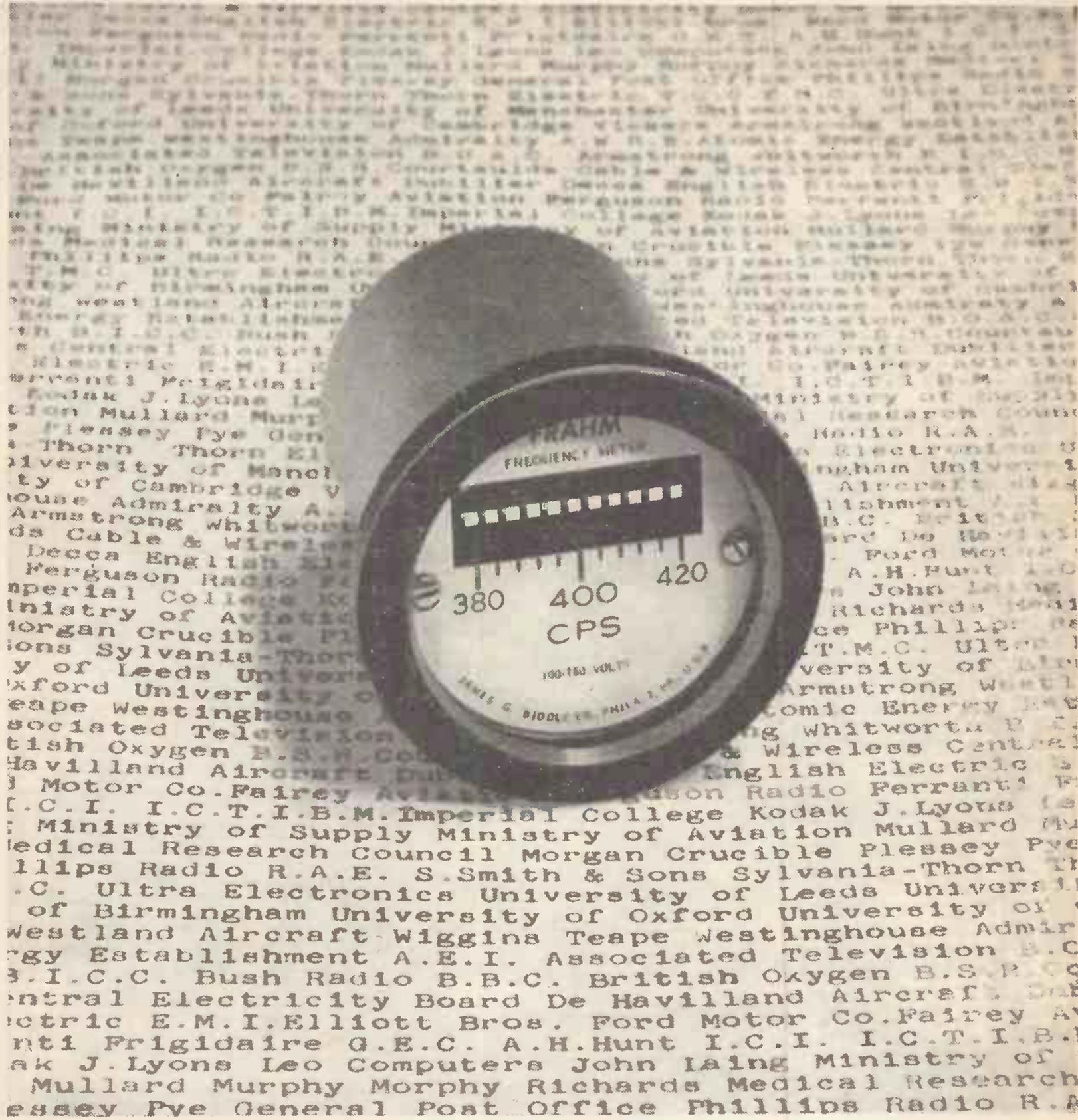
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RCA HIGH FREQUENCY COMMUNICATION TRANSMITTER ET 4331



Frequency Range: 3,000-20,000 K/c.

Power Output: 1 KW Telephone, 1.4 KW Telegraph.

Supply Requirements: 220 v. single phase 50/60C.

Crystal Selector switch for six crystal frequencies.

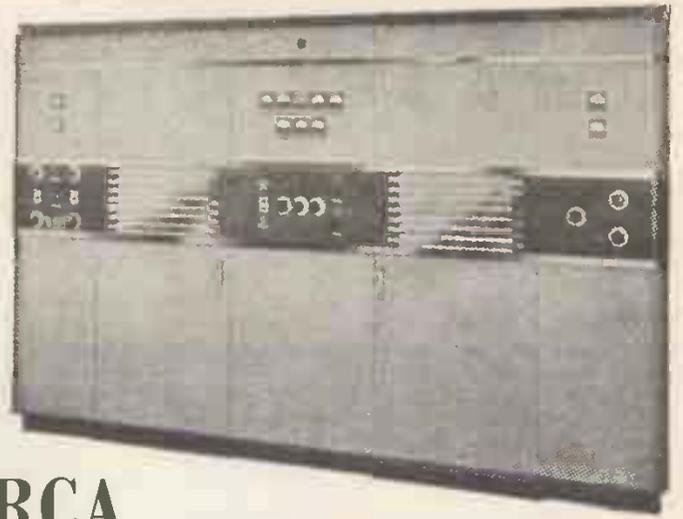
The transmitter is capable of high speed keying.

Tube Complement: Crystal Oscillator (802), Interm. P.A. (803), Power Ampl. (2-833A), 1st Audio Ampl. (53), 2nd Audio Ampl. (4-2A3), Modulator (2-833A), Rectifier (4-872A).

All transmitter stages including modulator and power supply unit are housed in one cabinet as per photo.

Dimensions: Height 84½ in. Width 36½ in. Depth 27¼ in. Weight 1,900 lb. (nett).

We have a full range of spares for this equipment.



RCA 15 KW TELEGRAPH TRANSMITTER Type ET-4750-X

Frequency Range—2 to 22 megacycles.

Keying Speed—up to 250 words per minute.

Power Supply Requirements—230 v. 3-phase 50/60 cycles.

	Length	Height	Depth
Enclosure	11ft. 0in.	7ft. 6in.	4ft. 1in.
Rectifier Unit	4ft. 2in.	5ft. 3in.	3ft. 2in.
Plate Transformer	2ft. 6½in.	3ft. 6½in.	1ft. 9½in.

	Weight (Nett)
Enclosure (including control, R.F. and Output panels)	3,000lb.
Rectifier Unit	1,675lb.
Plate Transformer 7,000 volts	1,250lb.

Tube Complement: Oscillator—807 (1), Doubler(1st) Amplifier—807 (1), Intermediate Power (2nd) Amplifier—813 (4), Power (3rd) Amplifier—889-R (2), Plate Rectifier—872A (6), Auxiliary Rectifier—872A (3), Bias Rectifier—872A (2), Keyer—807 (2).

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5 KW COMMUNICATIONS TRANSMITTER

AVT 22C

Voice, tone Telegraph or CW.

2.5 mc/s. to 19 mc/s.

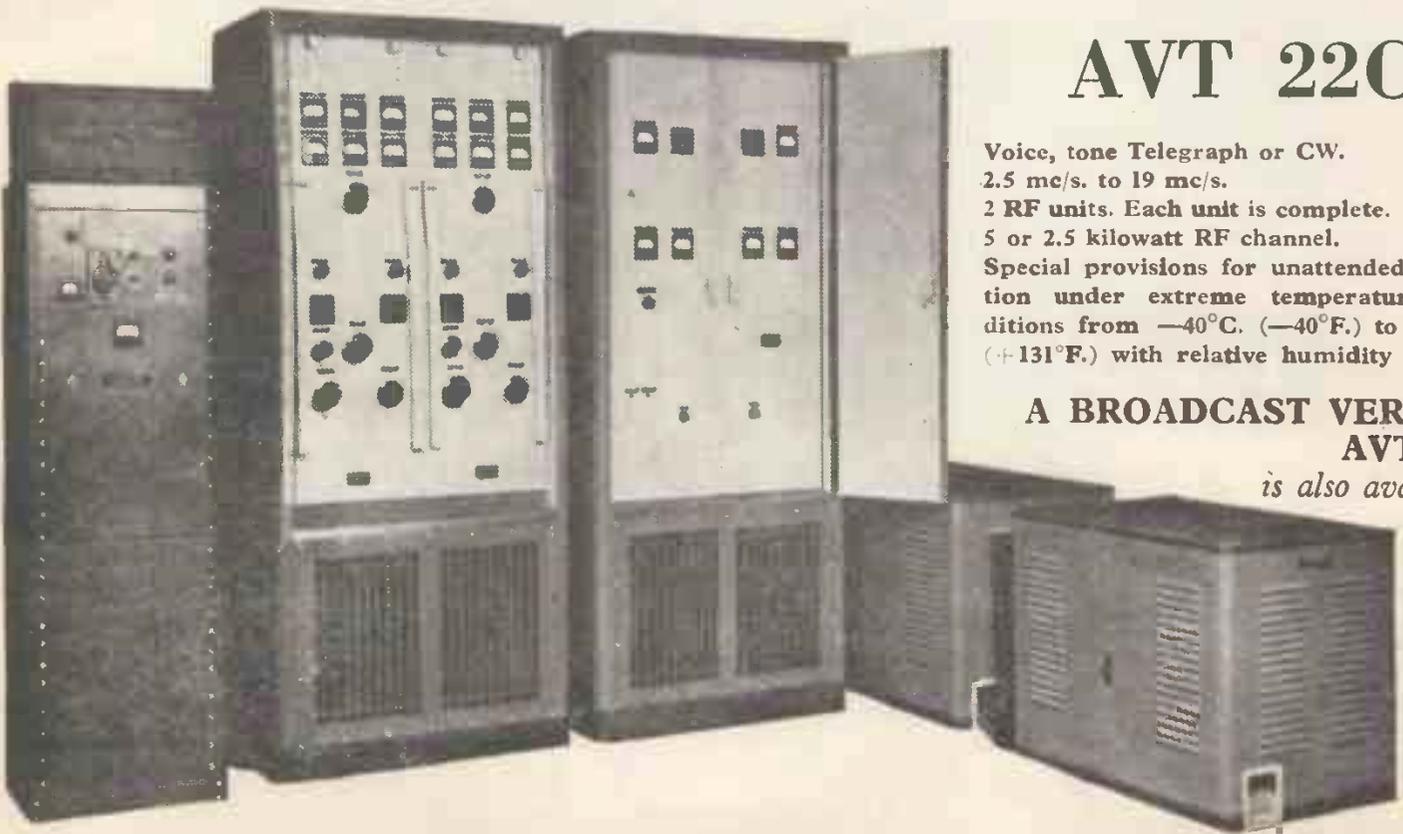
2 RF units. Each unit is complete.

5 or 2.5 kilowatt RF channel.

Special provisions for unattended operation under extreme temperature conditions from -40°C . (-40°F .) to $+55^{\circ}\text{C}$. ($+131^{\circ}\text{F}$.) with relative humidity of 95%.

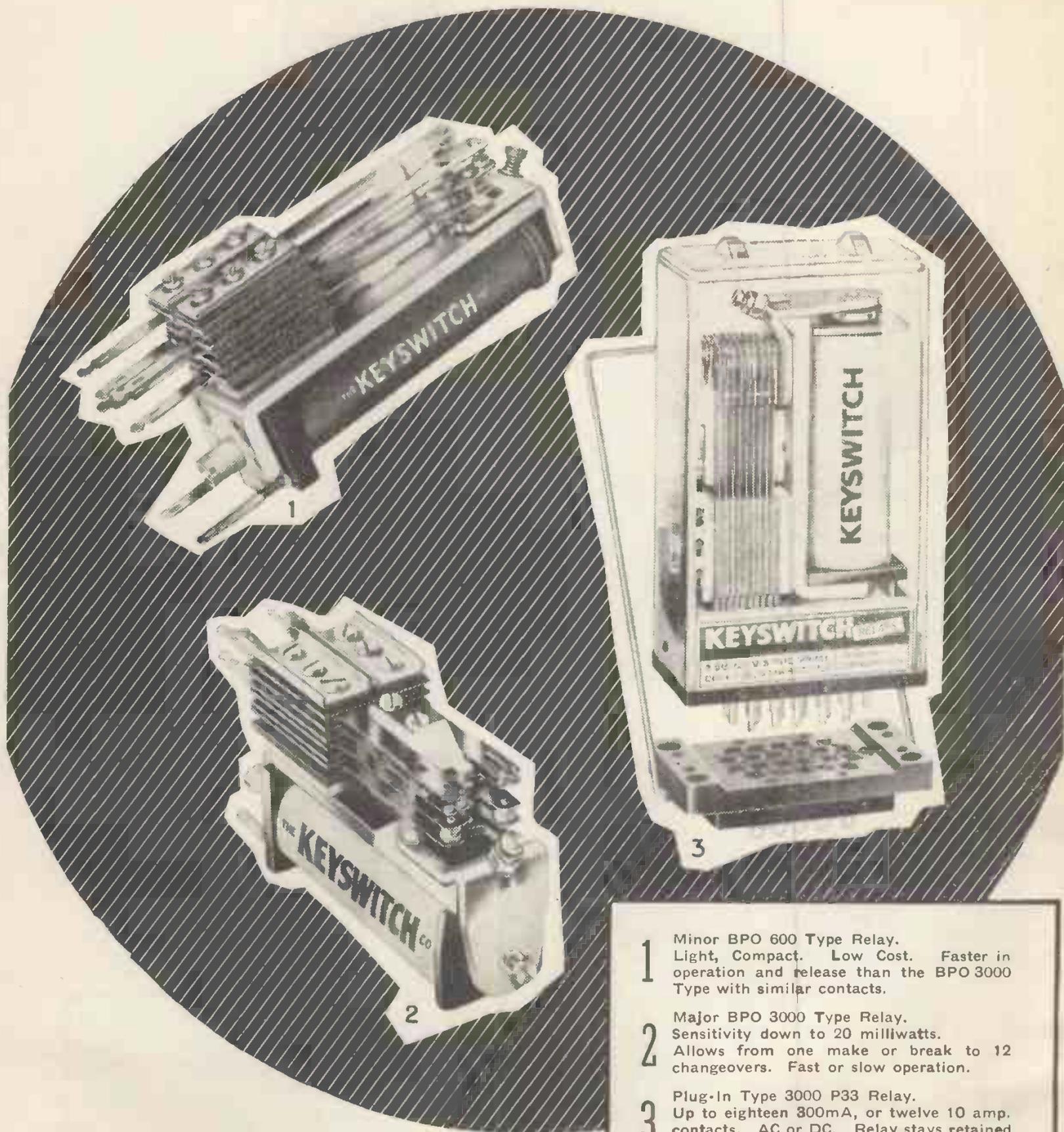
**A BROADCAST VERSION
AVT 22D**

is also available.



Three V.I.R.'s (very important relays)

Guaranteed always at hand for Immediate Delivery these three basic units form part of the KEYSWITCH Standard Range manufactured to Ministry and Post Office standards.



1 Minor BPO 600 Type Relay.
Light, Compact. Low Cost. Faster in operation and release than the BPO 3000 Type with similar contacts.

2 Major BPO 3000 Type Relay.
Sensitivity down to 20 milliwatts. Allows from one make or break to 12 changeovers. Fast or slow operation.

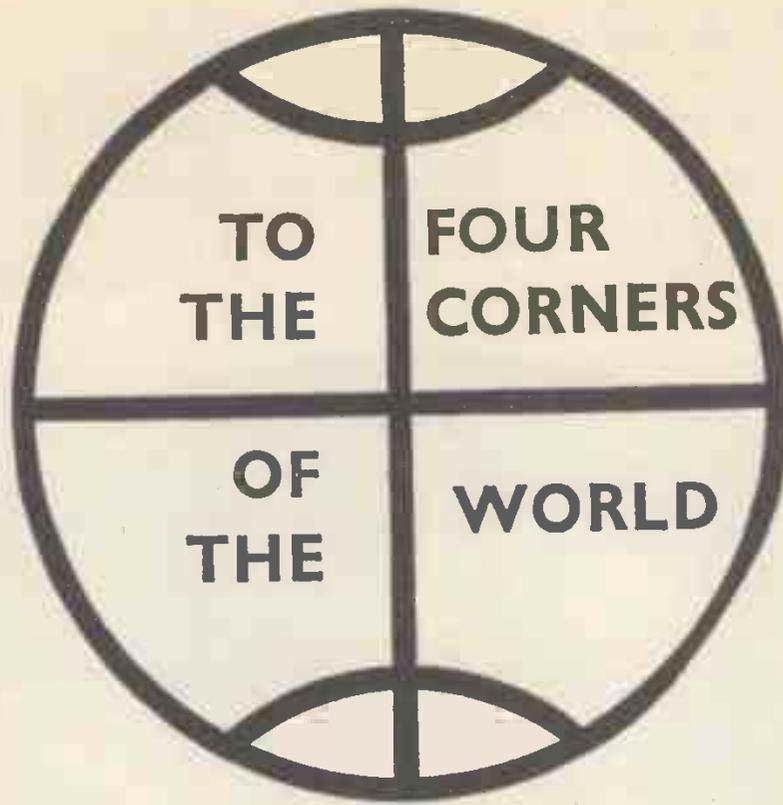
3 Plug-In Type 3000 P33 Relay.
Up to eighteen 300mA, or twelve 10 amp. contacts, AC or DC. Relay stays retained positively in any position.

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RELAYS

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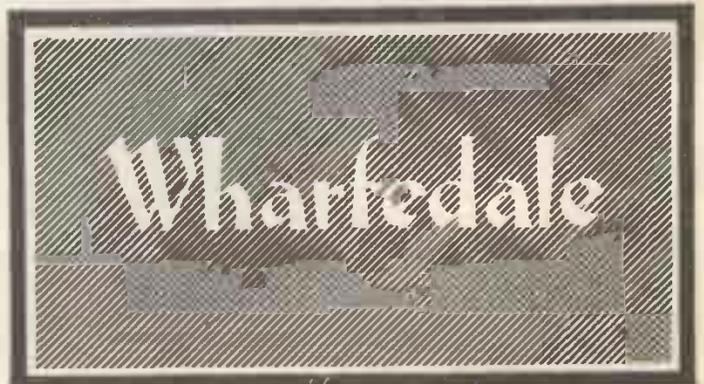
Each week sees new consignments of Wharfedale Loudspeakers set off on lengthy journeys. Some go to Australasia, others to the Americas and Japan also takes its share as do most European Countries. In fact, wherever people wish to listen to music or speech, reproduced as near to "live" as possible, you will find Wharfedale Loudspeakers—undoubtedly among the best in the world.

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So easy to build



so easy to use

**6 W STEREO AMPLIFIER KIT
Model S-33**



A versatile high-quality self-contained STEREO/MONAUROAL Amplifier with adequate output for a living room. Can be used to convert a favourite (monaural) radiogram into a stereo-radiogram. 3 watts per channel; 0.3% distortion at 2.5 w/chnl.; 20 dB N.F.B., inputs for Radio (or Tape) and Gram., Stereo or Monaural; Ganged controls. Sensitivity 200 mV.

£13.7.6

**6 W HI-FI STEREO AMPLIFIER
KIT Model S-33H**

An inexpensive stereo-mono amplifier with the high sensitivity necessary for lightweight miniature ceramic pick-ups (e.g., Decca Deram). De luxe version of the S-33 with attractive two-tone grey perspex panel.

£15.17.6

**5 W HI-FI MONO AMPLIFIER
KIT Model MA-5**



A low-priced general purpose Hi-Fidelity amplifier based on the popular S-33 and intended for those who do not require a stereophonic system. Separate bass and treble controls, Gram and Radio inputs. Suitable for most crystal pick-ups. A printed circuit simplifies construction.

£10.19.6

**HI-FI SINGLE CHANNEL
AMPLIFIER KIT Model MA-12**



A compact high fidelity power amplifier (including auxiliary power supply). 12 watts output. Wide frequency range and low distortion. A variable sensitivity control is fitted enabling it to be used with an existing amplifier in a stereophonic system. Other applications include sound reinforcing systems, transmitter modulators, for use with tape recorders, also as a general purpose laboratory amplifier.

£11.9.6

**STEREO-HEAD BOOSTER KIT
Model USP-1**



Hi-Fi Stereo Pre-amplifier for low-output Hi-Fi P.U.s. Input 2 mV. to 20 mV. Output adjustable from 20 mV. to 2 V. 40-20,000 c/s. Also suitable as low-noise R.C.-coupled amplifier.

£7.7.6

**STEREO CONTROL UNIT KIT
Model USC-1**



Incorporates all worthwhile features for high fidelity stereo and mono. Push-button selection, accurately matched ganged controls to ± 1 dB. Negative feedback rumble and variable low-pass filters. Printed circuit boards. Accepts inputs from most tape-heads and any stereo or mono pick-up.

£19.10.0

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

'MALVERN'

**HI-FI EQUIPMENT
CABINET KIT**



AN ATTRACTIVE CABINET in modern style designed to house all your Hi-Fi equipment (including tape deck and full-sized transcription record player). The cabinet parts are veneered

and pre-drilled, with edging in Panoplex plastic strip for ease of finishing. Complete with everything you need for assembly, including screws, hinges and even a pad saw! Left "in the white" for finishing to choice.

£18.1.0

Size 39½ x 32 x 21½ in.

**TAPE AMPLIFIER KITS
Models TA-IM and TA-IS**



This Combined Tape-Record Replay Amplifier is available in both monophonic and stereophonic models. Model TA-IM can be modified to the stereo version with modification kit TA-IC.

TA-IM £19-2-6 TA-IS £24-10-0
TA-IC £6-15-0

All models available

ASSEMBLED and TESTED

Prices on request

**TELEPHONE AMPLIFIER KIT
Model TTA-1**



For Home, Office or Shop

Don't be tied to your telephone. By placing handset on Amplifier cradle you can talk or listen with both hands free. All transistor circuit, inductive pick-up coil, built-in speaker and volume control. 9V battery operated. Ivory toned cabinet. Size 6 x 5½ x 9¼ in. deep.

£7.9.6

'GLOUCESTER'

HI-FI CABINET KIT



Will accommodate Tape Deck and/or Record Player, F.M. Tuner and Stereo Amplifier. For those with limited floor space speaker systems can be housed at each end. For this purpose a loudspeaker kit comprising two 4in. plus 8in. speaker systems, balance unit, speaker grille cutting template, pad saw and mounting details are also available. Neutral hardwoods have been carefully selected so that the finished product can be stained and polished to individual choice. There is storage space for records, etc., also for power amplifiers. Dimensions: length 46½ in., height 30 in., depth 21 in.

Mk. I for Tape Deck or Record Player... £17 3 6
Mk. II for both T/D and R/P..... £18 10 0

Deferred Terms available on all orders above £10.

**"CHEPSTOW"
EQUIPMENT CABINET KIT**



Specially designed for those whose floor space is at a premium. Will house Record Player, FM Tuner, Stereo Amplifier and additional power amplifiers where needed. An upper deck is available for the self-powered stereo amplifiers to ensure maximum heat dissipation. Veneered and left in white for finishing to personal taste. Overall dimensions are 35 x 18 x 33 in. high.

£11.12.6

**HI-FI STEREO AMPLIFIER KIT
Model S-99**



Gives 18 w. output (9 per channel with 0.2 per cent. distortion at 9 w. per channel). It has ganged controls. STEREO/MONAUROAL gram., radio and tape recorder inputs and push-button selection as well as many other first-class features well above its price range. In grey metal cabinet with a golden surfound and perspex panel. Also ultra-linear push-pull output. Printed circuit construction.

£27.19.6

**HI-FI SPEAKER SYSTEM KIT
Model SSU-1**



Ducted-port bass reflex cabinet, "in the white." Frequency response is 40-16,000 c/s. Power rating 25 watts. Matched speaker units 8in. high flux (12,000 lines) with hyperbolic cone and 4in. wide angle dispersion type for higher frequencies. With legs £11/12/-.

£10.17.6

**"COTSWOLD" SPEAKER
SYSTEM KIT**



This acoustically designed enclosure measures 26 x 23 x 15½ in., and houses a special 12in. bass speaker with 2in. speech coil, elliptical middle speaker together with a pressure unit to cover the full frequency range of 30-20,000 c/s. Its polar distribution makes it ideal for really Hi-Fi Stereo. Delivered complete, with speakers, cross-over unit, level control, Tygan grille cloth, etc. Left "in the white" for finish to personal taste, all parts are pre-cut and drilled for ease of assembly.

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Model XI-IU (Master) **£4.7.6**

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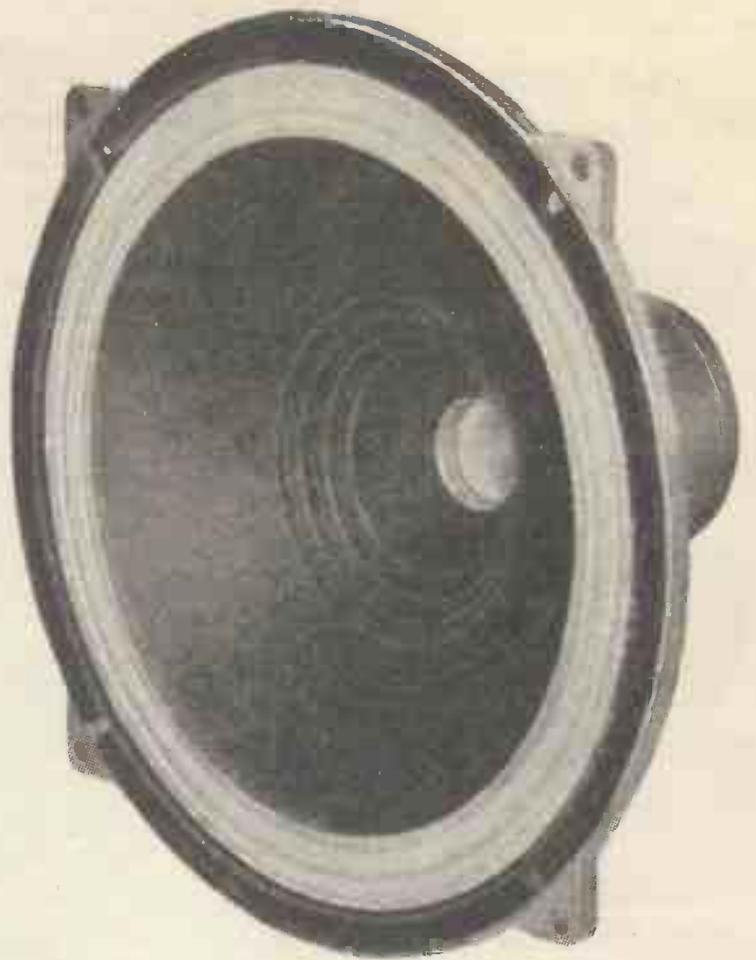
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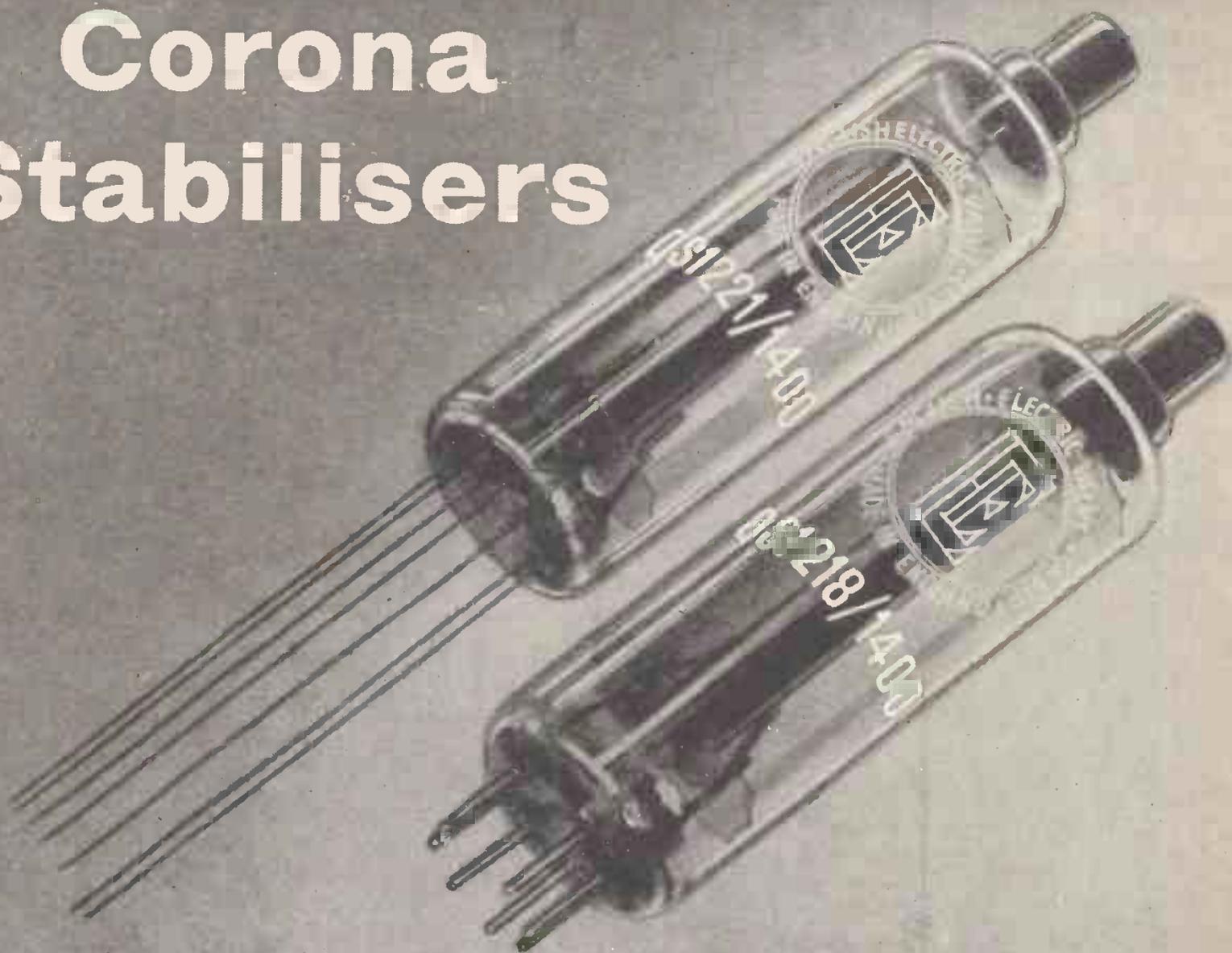
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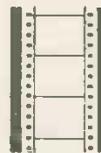
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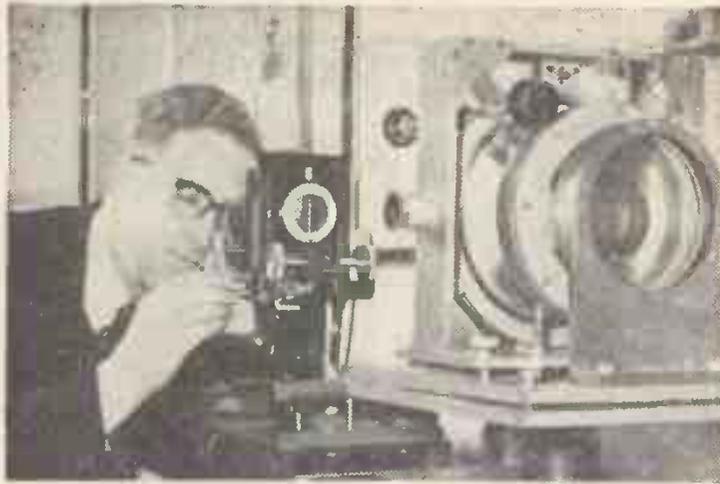
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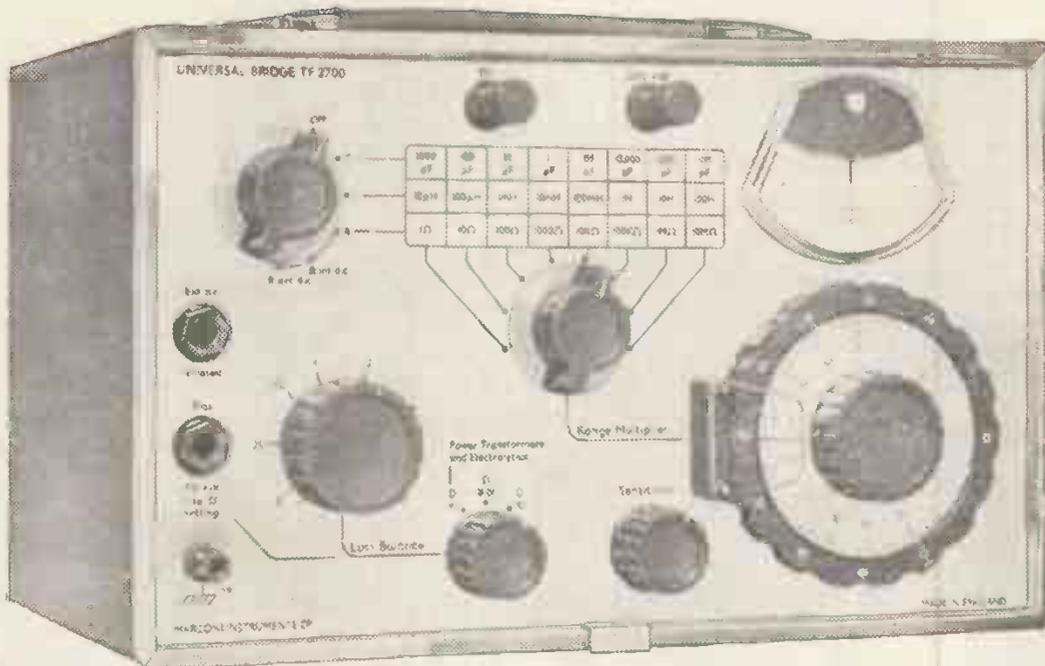
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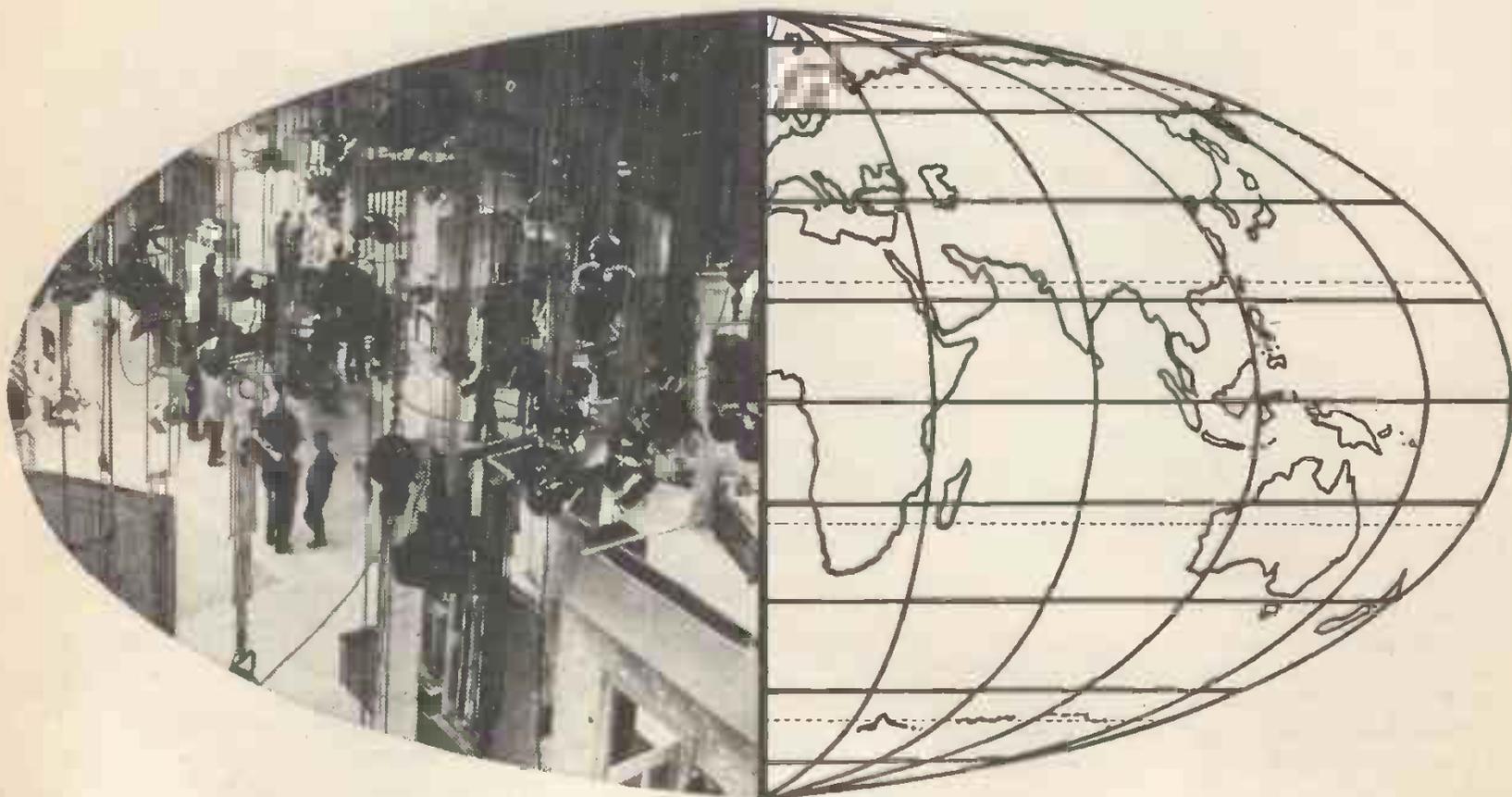
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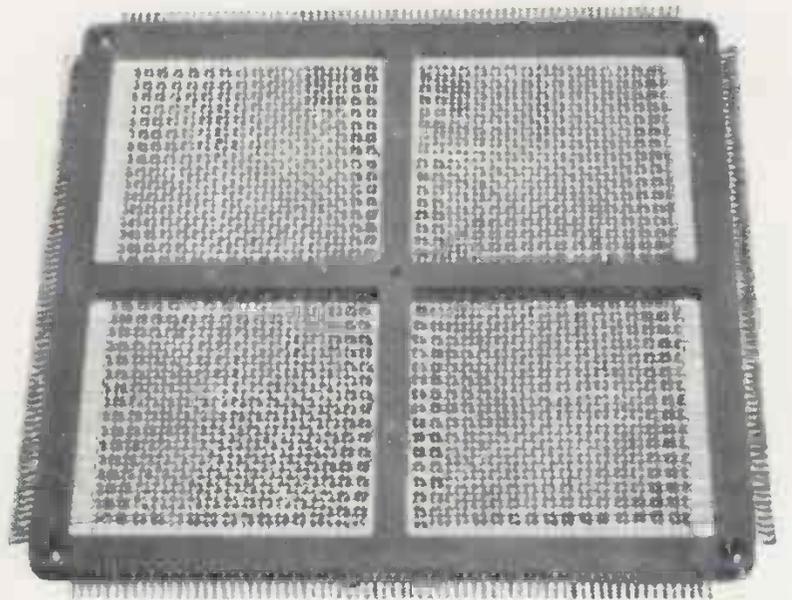
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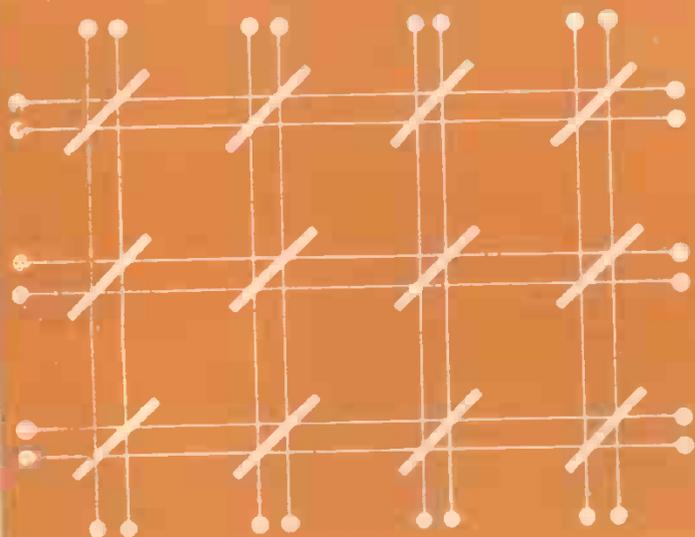
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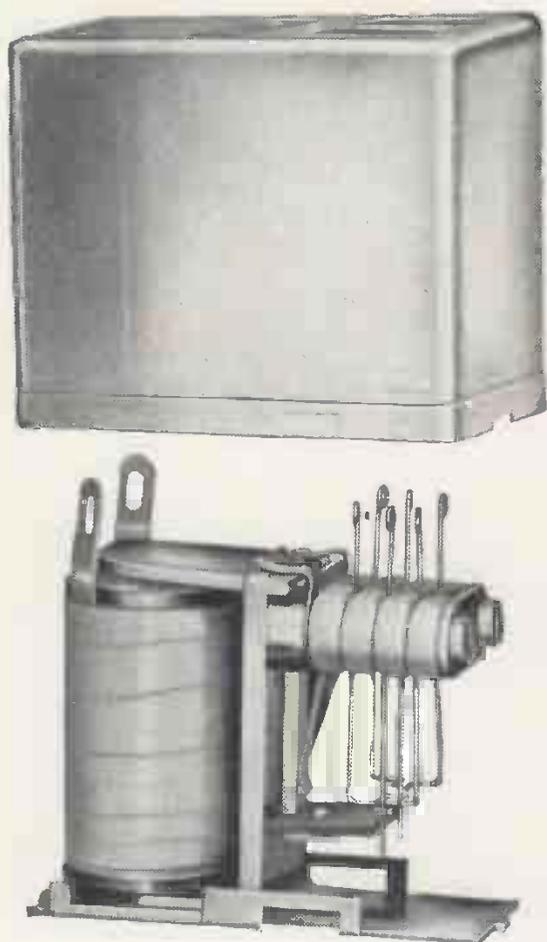
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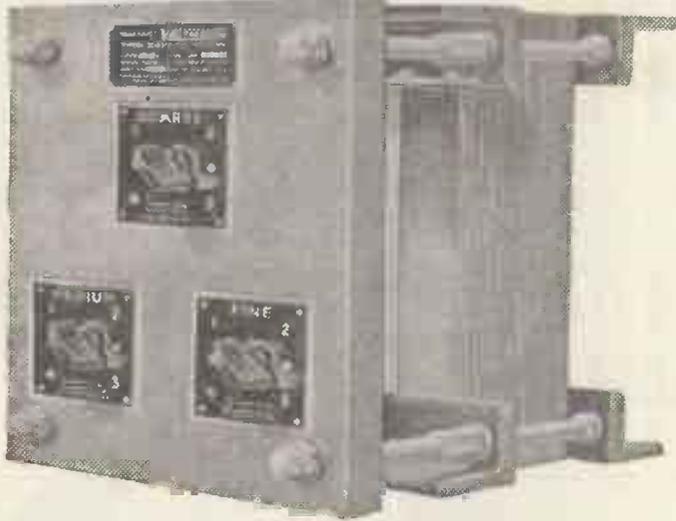
Fast-switching relay for V.H.F.

The new Plessey miniature Type 'CH' low capacitance relay has been developed to meet the increasing demand for high frequency switching. It has low loss insulation and can be used for r.f. switching at frequencies up to 100Mc/s. Contact life at a load of up to 5mA at 200V is better than 10^8 operations, and the operate time is 6 milliseconds. The two-pole changeover silver-palladium wire contacts are self-cleaning and the frame-contact capacitance is less than 1 pF up to 100Mc/s. For full details on the Plessey range of miniature relays, write to:

Plessey

THE PLESSEY COMPANY (UK) LIMITED Components Group
Industrial Relays Division : Abbey Works, Titchfield, Fareham, Hants, Titchfield 3031
Overseas Sales Organisation : Plessey International Limited, Ilford, Essex.
Telephone: Ilford 3040

VOLTMOBILE VOLTAGE SELECTOR AUTO-TRANSFORMERS



Output from 1.6% to 100% of supply volts in 64 steps. ON LOAD SWITCHING. VOLTMOBILES can be connected directly to the load or used with a Transformer or Rectifier Set. 1 PHASE and 3 PHASE models with outputs of 20A, 30A, 60A, 100A, 150A, 200A. 25% OVER VOLTS AVAILABLE AS EXTRA.



AMPMOBILE TRANSFORMERS

Typical Secondaries

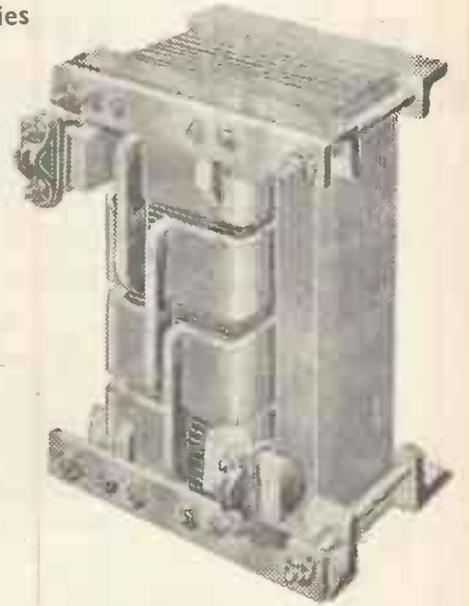
2 V	200 A	12 V	60 A
4 V	100 A	12 V	100 A
5 V	80 A	18 V	30 A
5 V	150 A	24 V	30 A
5 V	300 A	30 V	5 A
6 V	60 A	30 V	25 A
6 V	100 A	30 V	40 A
6-12 V	50 A	40 V	25 A
8 V	125 A	50 V	60 A
10 V	150 A	55 V	20 A
10 V	200 A	60 V	40 A
10-20-30 V	100 A	110 V	10 A
12 V	25 A	160 V	300 A

110 V centre-tapped at currents from 5 A to 1000 A

S-MOBILE HEAVY CURRENT TRANSFORMERS

Typical Secondaries

2 V	2,000 A
3 V	4,000 A
4 V	6,000 A
5 V	500 A
5 V	7,000 A
6 V	300 A
8 V	3,000 A
10 V	300 A
10 V	500 A
10 V	700 A
10 V	1,000 A
20 V	3,000 A
20 V	4,000 A
27 V	8,000 A
50 V	600 A
100 V	700 A
110 V	800 A



These and other transformers can be supplied for 1 phase and 3 phase and for use with rectifiers.

TRANSMOBILE

SATURABLE REACTORS from 1 kVA to 300 kVA. Available for all standard supplies. Standard D.C. control: 12, 24, 36, 110 and 240 V, or as specified.



D-CMOBILE RECTIFIER SETS

TYPICAL OUTPUTS Full load DC Volts and Amperes.

6 V	15 A	36 V	10 A
6 V	50 A	36 V	20 A
6 V	100 A	36 V	40 A
12 V	10 A	36 V	60 A
12 V	20 A	70 V	100 A
12 V	30 A	110 V	5 A
12 V	60 A	110 V	10 A
12 V	105 A	110 V	15 A
12 V	210 A	110 V	20 A
12 V	1,000 A	110 V	25 A
12 V	2,100 A	110 V	600 A
24 V	750 A	220 V	100 A
24 V	12 A	250 V	6 A
24 V	20 A	250 V	10 A
24 V	30 A	250 V	15 A
24 V	60 A	250 V	20 A
24 V	105 A	250 V	200 A
24 V	200 A	250 V	300 A

For 1 phase or 3 phase input



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Transformers and Chokes	64-Step Switched Auto-Transformers	Rectifier Sets	Arc Welding Sets and Spot Welders	Saturable Reactors	Moving Coil Controllers	Infinitely Variable Voltage Regulators	Heavy Current Transformers

SPECIFIC ENQUIRIES are invited for Transformers and Rectifiers. We specialize in HEAVY CURRENT EQUIPMENT.

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TRANSISTOR A.C. VOLTMETER TYPE TM2B

**MEASURES FROM 50 μ V TO 500V ON
12 RANGES, AND CAN BE USED AS AN
AMPLIFIER**

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SPECIFICATION

VOLTMETER RANGES

1.5mV, 5mV, 15mV . . . 500V f.s.d.

ACCURACY

$\pm 2\%$ of reading $\pm 1\%$ of f.s.d. at 1kc/s.

dB RANGES

-80dB to +56dB relative to 1mW into 600 Ω .

FREQUENCY RESPONSE

± 3 dB from 6c/s to 250kc/s.
 ± 0.7 dB from 10c/s to 100kc/s.
 ± 0.2 dB from 20c/s to 50kc/s.
 ± 0.1 dB from 30c/s to 30kc/s.

INPUT IMPEDANCE

1.8M Ω and 20pF on 1.5V to 500V.
>0.8M Ω and <60pF on 5mV to 500mV.
>0.5M Ω and <65pF on 1.5mV.

INPUT NOISE LEVEL

<15 μ V for zero source resistance.
<30 μ V for 100k Ω source resistance.

AMPLIFIER RANGES

10dB steps up to 60dB with frequency response and input impedance as above; 80dB gain from 10c/s to 30kc/s with input impedance >50k Ω .
Output 1.5V into 10k Ω .

MICROVOLT INDICATOR RANGE

<150 μ V f.s.d. <10 μ V readable from 30c/s to 30kc/s.

MAXIMUM INPUT VOLTAGES

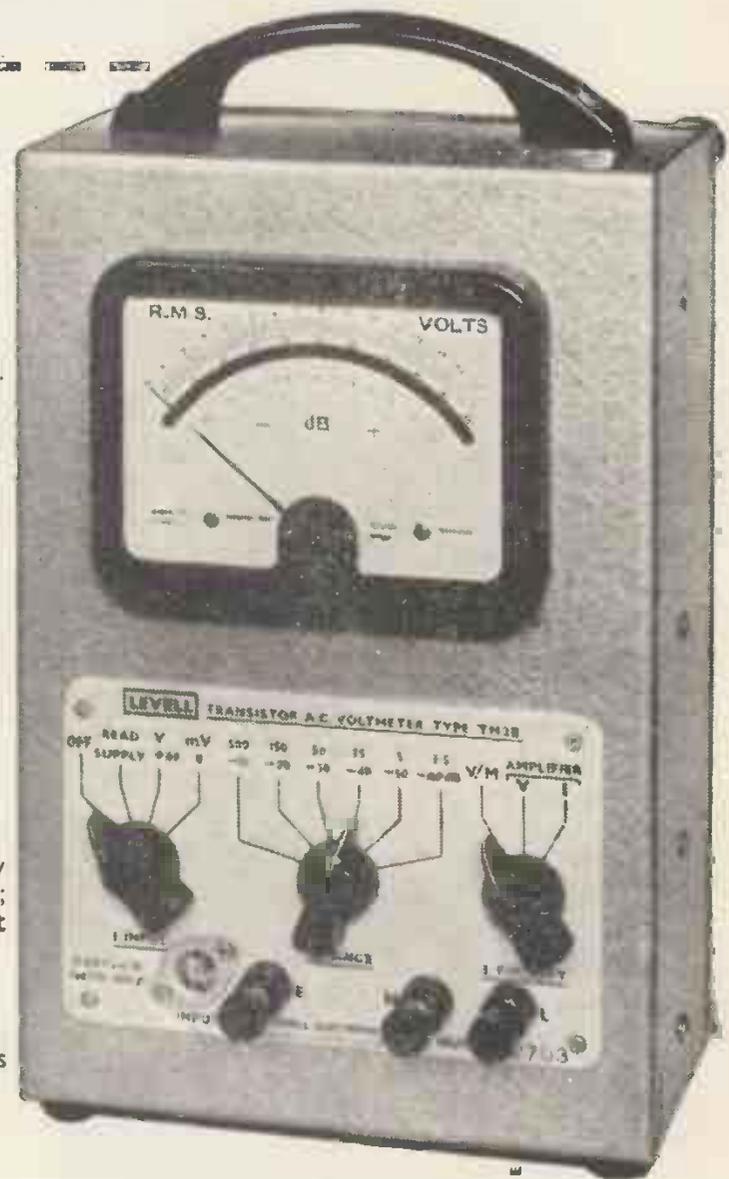
75V A.C. and 350V D.C. on "mV".
750V A.C. peak plus D.C. on "V".

SUPPLY

Self-contained PP9 batteries; typical life 1000 hours.

SIZE & WEIGHT

10" high x 6" wide x 4" deep; 6 pounds.



PRICE
£38

with batteries and
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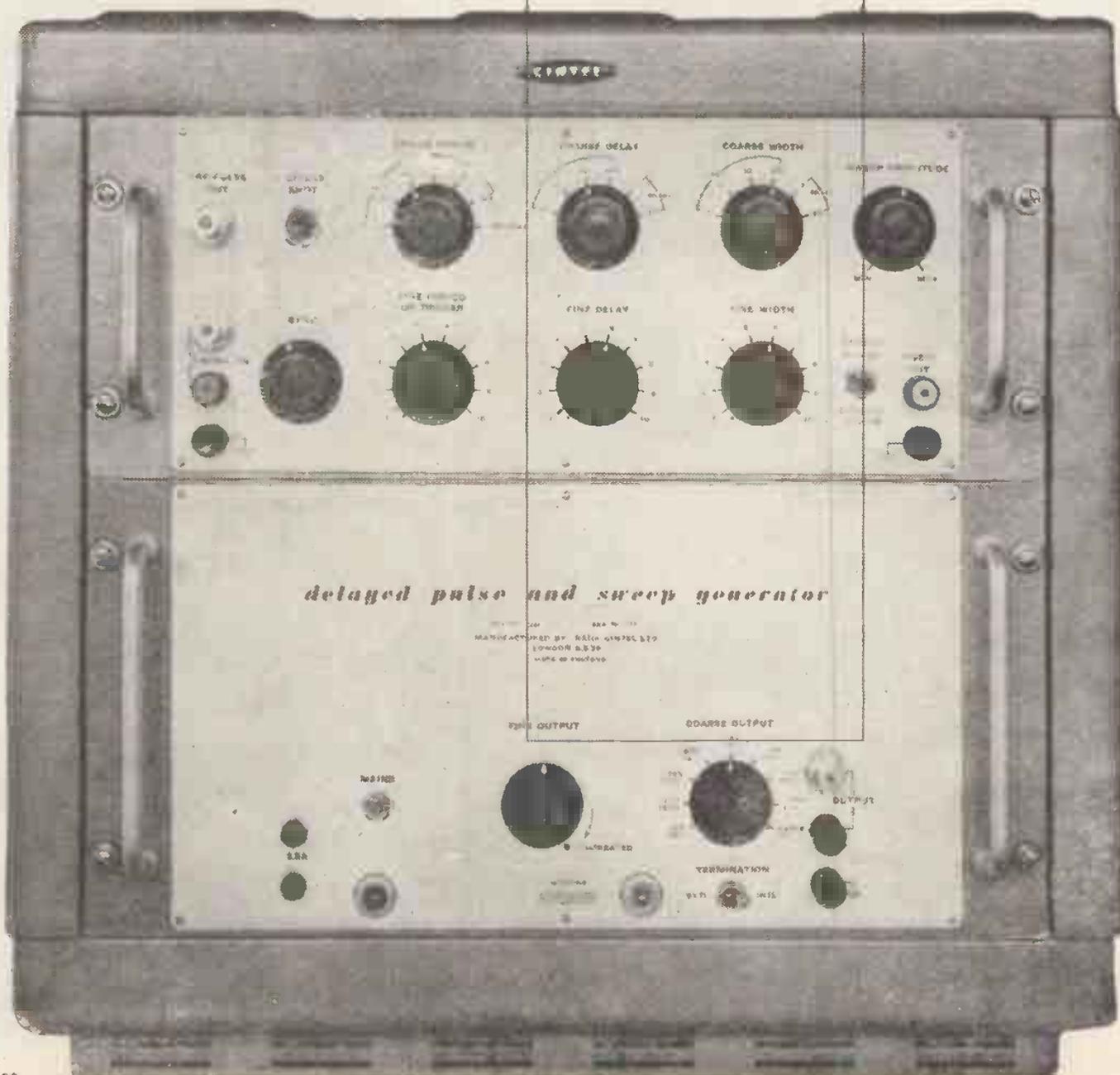
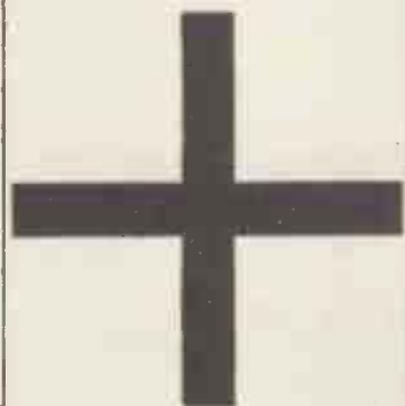
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Rise Time less than 10nanosec
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 True positive or negative pulse output
 Sweep output gives jitter free oscillograms

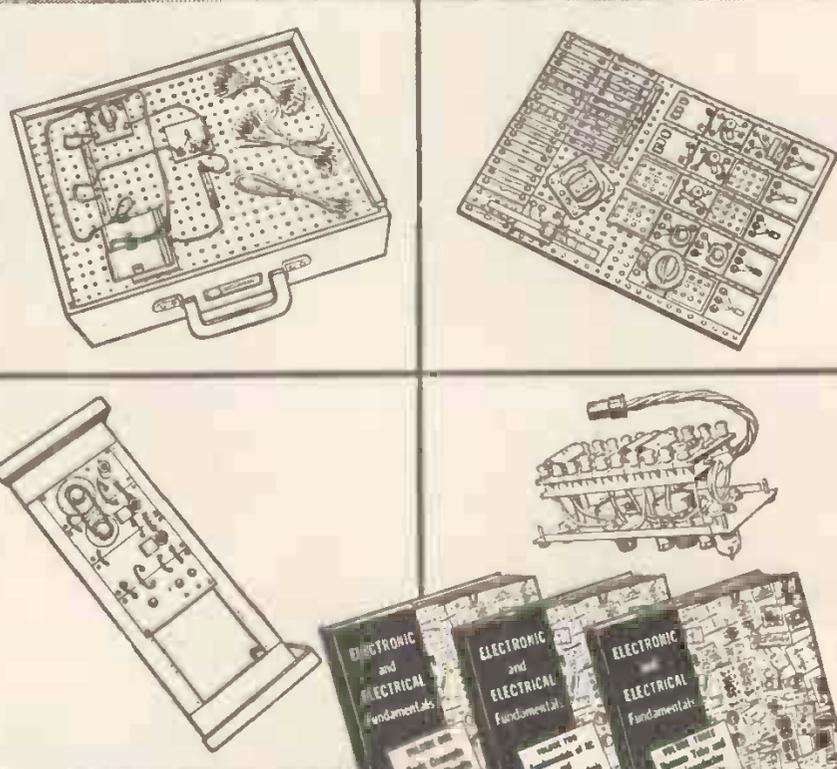
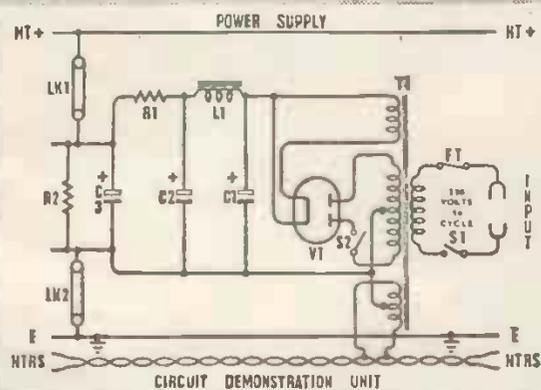
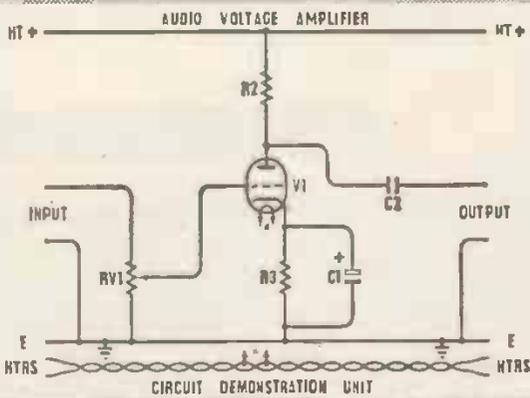
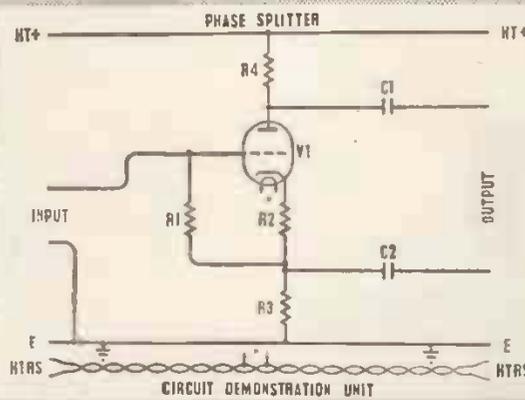
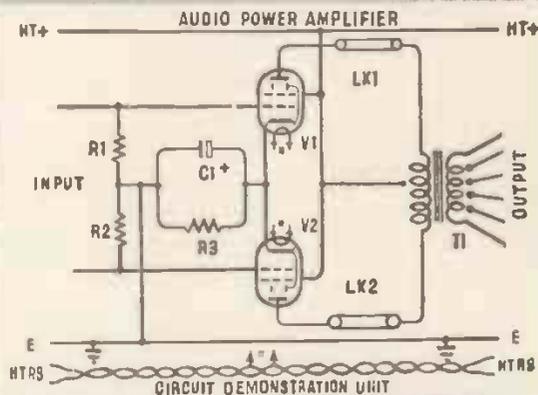
pulse width and delay 0.09 μ sec to 105msec

period 0.9 μ sec to 1.05sec

output max. 5V in 75 Ω , max. 50V in 1k Ω

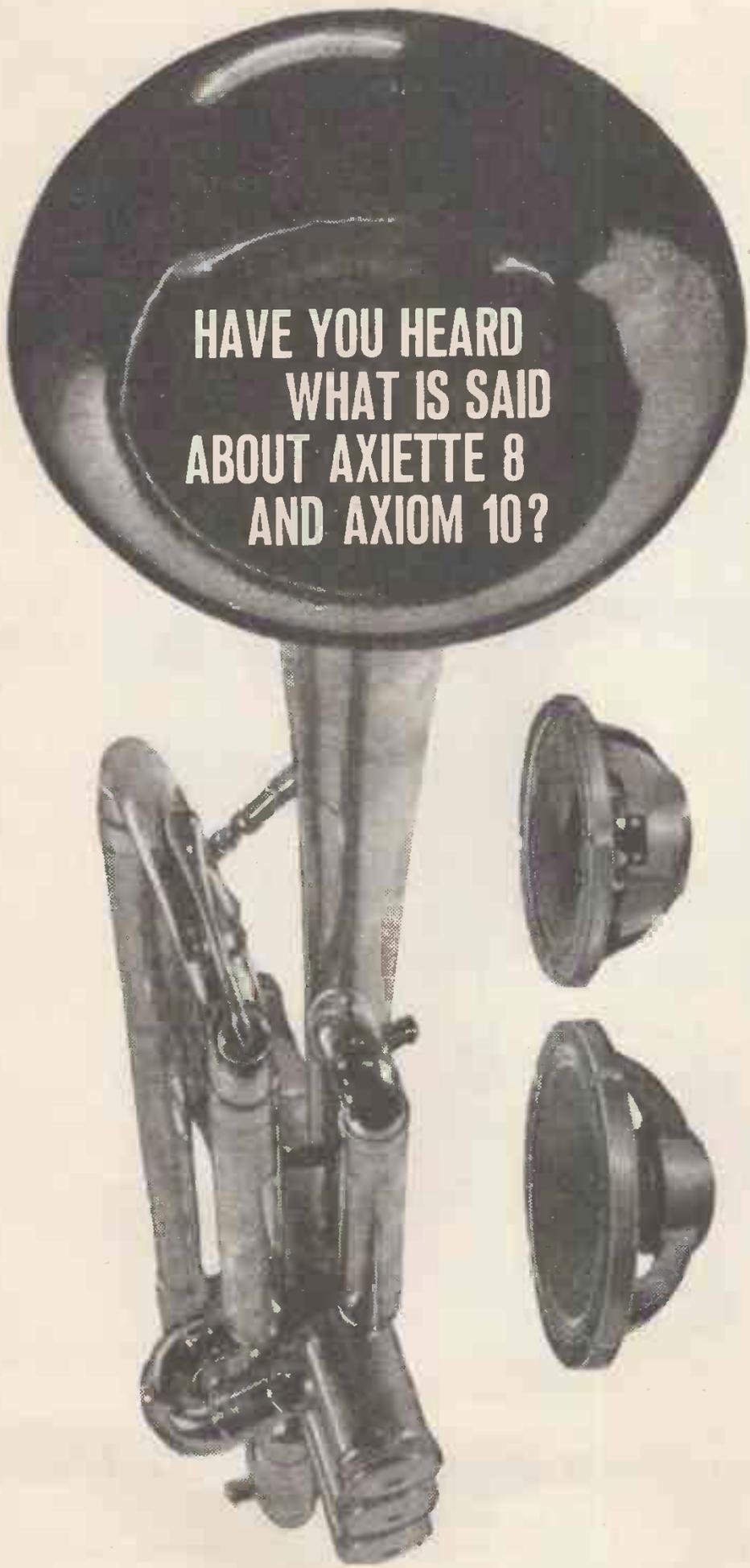


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PHILCO ELECTRONIC TRAINING EQUIPMENT



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ABOUT AXIETTE 8
AND AXIOM 10?**

Brighton College of Technology, Richmond Terrace, Brighton.

I have recently purchased an Axiette 8 speaker for experimental purposes, and we have carried out a series of tests on it in our anechoic chamber. I feel I should like to tell you how excellently it compares with all the other speakers I have used for test purposes. The response is well maintained up to 20 Kc/s, in fact it can be used as an excellent sound source for diffraction experiments. Also the curves we have obtained agree closely with the curves you publish for this unit, which is more than can be said for the majority of electroacoustic transducers offered for sale.

At the price, I consider that this speaker offers a really remarkable performance, and one which could scarcely be improved upon at the present time for the reproduction of speech and music at moderate power levels.

A. SHILTON, MSc. Senior Lecturer in Acoustics.

TYSONS—Sound Engineers, 41 Russell Street, Leamington Spa, Warwickshire.

We have just demonstrated the AXIOM 10 at the Regent Hotel, Leamington Spa (for three days) with outstanding success. The excellent frequency response and the very conveniently sized enclosure commend it to a large section of the quality-conscious public who are pleasantly surprised to see how well the AXIOM 10 satisfies the critical ear without dominating valuable living-space.

We find the AXIOM 10 is a top-seller and we find it necessary to keep a formidable stock of them to satisfy our customers.

Congratulations on another excellent AXIOM loudspeaker, both with regard to quality and size.

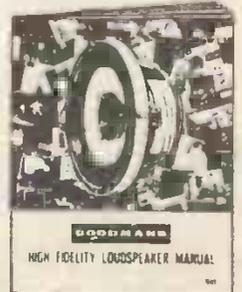
W. M. TYSON

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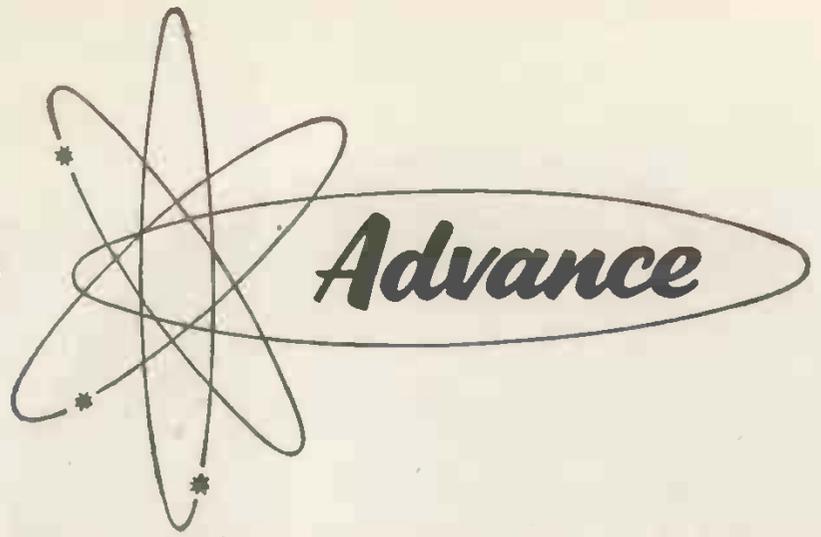
GOODMANS

GOODMANS INDUSTRIES LIMITED, Axiom Works, Wembley, Middlesex.

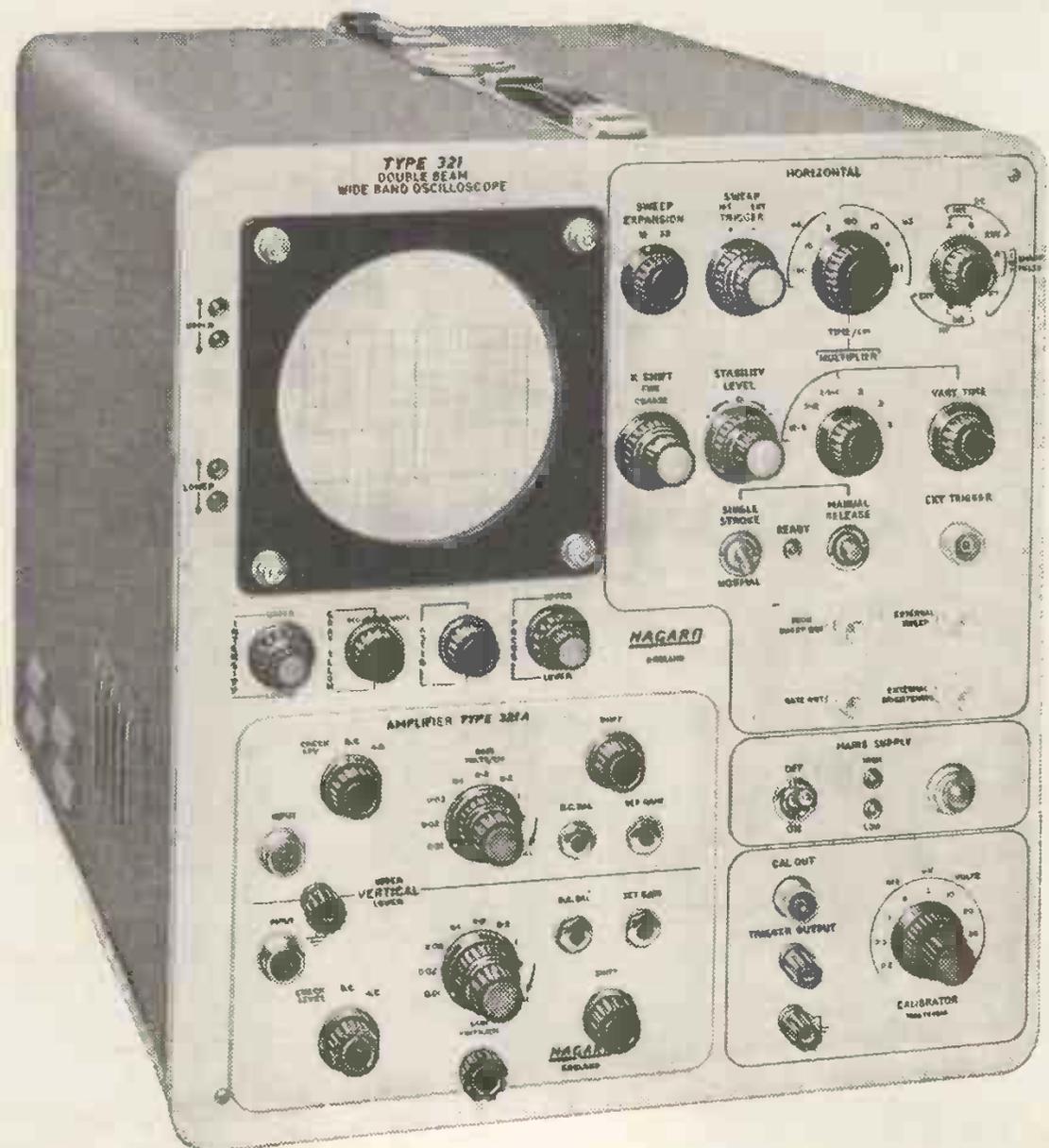
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SWITCH TO



Nagard Oscilloscopes



OS321 DOUBLE-BEAM OSCILLOSCOPE WITH INTERCHANGEABLE PRE-AMPLIFIERS

Sweep Rate 20ns/cm to 1.2s/cm.

Sweep Expansion x5 on both channels.

Trigger Internal 2 mm. or external down to 100mVp.p.

Single Delay on both channels 170ns.

C.R.T. 5-inch flat-faced double-gun with minimum 2cm overlap and adequate intensity for single-stroke recording at fastest time base speeds.

Accuracy Time and voltage direct from graticule $\pm 3\%$.

Built-in Amplitude Calibrator.

PRICE NETT IN U.K. £550.

PI321A 2-Channel Pre-Amplifier Sensitivity 10mV/cm to 12.5V/cm; Bandwidth D.C. to 20Mc/s; Rise time 18ns; Input impedance constant at $1M\Omega$ shunted by 35pF.

PRICE NETT IN U.K. £95.

PI321D 2-Channel Pre-Amplifier Sensitivity 1mV/cm to 125V/cm; Bandwidth D.C. to 5Mc/s; Rise time 70ns; Input impedance constant at $1M\Omega$ shunted by 35pF (each side). Balanced inputs with in-phase rejection ratio better than 500:1 at 5Mc/s for 5Vp.p. input and maximum sensitivity.

PRICE NETT IN U.K. £95.

Nagard Oscilloscopes cover varied requirements for wide bandwidth and high sensitivity by using integral switched pre-amplifiers or interchangeable plug-in pre-amplifier units. Three models are available, the OS301 being a high-speed, wide-band, single-beam Oscilloscope, while the OS311 and OS321 utilise double-gun cathode ray tubes and interchangeable pre-amplifiers. We suggest you write or telephone for complete specifications. Technical representatives are always available to arrange demonstrations and to discuss your particular requirements on request.

OS301 HIGH-SPEED WIDE-BAND SINGLE-BEAM OSCILLOSCOPE

Sweep Rate 0.1 μ s/cm to 1.2s/cm.

Sweep Expansion x10 giving maximum sweep rate of 10ns/cm.

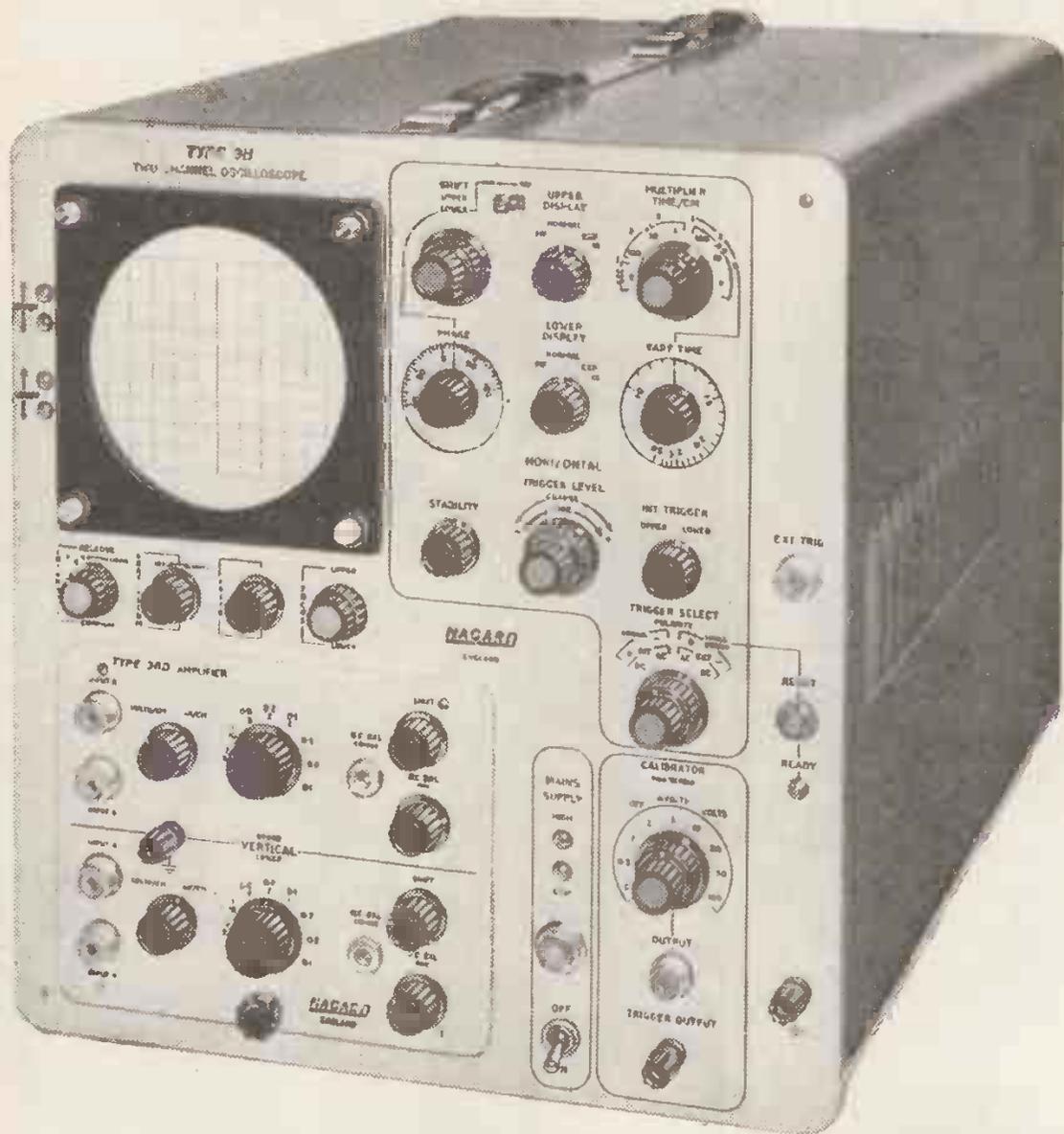
Trigger Internal 2mm. or external down to 0.1Vp.p.

C.R.T. 5-inch flat-faced.

Integral Pre-Amplifier Switched in Sensitivity 10mV/cm; Bandwidth 2.5c/s to 20Mc/s; Rise time 18ns.

Integral Pre-Amplifier Switched out Sensitivity 100mV/cm to 20V/cm; Bandwidth D.C. to 40Mc/s; Rise time 9ns; Signal delay 180ns.

PRICE NETT IN U.K. £550.



OS311 DOUBLE-BEAM OSCILLOSCOPE WITH INTERCHANGEABLE PRE-AMPLIFIERS

Sweep Rate 1 μ s/cm to 15s/cm.

Sweep Expansion x5 on either or both channels.

Phase Measurement $\pm 180^\circ$ by calibrated horizontal shift.

Lissajous Displays by switching lower vertical channel to give horizontal deflection on upper channel.

Trigger Internal 2mm. or external down to 50mVp.p.

C.R.T. 5-inch flat-faced double-gun with full screen display overlap.

Accuracy Time and voltage direct from graticule $\pm 3\%$.

Built-in Amplitude Calibrator. PRICE NETT IN U.K. £415.

PI311D 2-Channel Pre-Amplifier Sensitivity 100 μ V/cm; Bandwidth D.C. to 150Kc/s; Rise time 2.3 μ s; Input impedance 10M Ω shunted by 35pF (each side).

Balanced inputs with in-phase rejection ratio better than 1000:1 for 1Vp.p. input and maximum sensitivity. PRICE NETT IN U.K. £75.

PI311V 2-Channel Pre-Amplifier As for PI311D but with switched H.F. and L.F. attenuation. PRICE NETT IN U.K. £120.

PI311E 2-Channel Pre-Amplifier Sensitivity 1mV/cm; Bandwidth D.C. to 1Mc/s; Rise time 0.35 μ s; Input impedance 1M Ω shunted by 25pF. Balanced inputs with in-phase rejection ratio better than 1000:1 for 1Vp.p. input and maximum sensitivity. PRICE NETT IN U.K. £95.

PI311Q 4-Channel Pre-Amplifier As for PI311E but beam switching provides FOUR channels. PRICE NETT IN U.K. £140.

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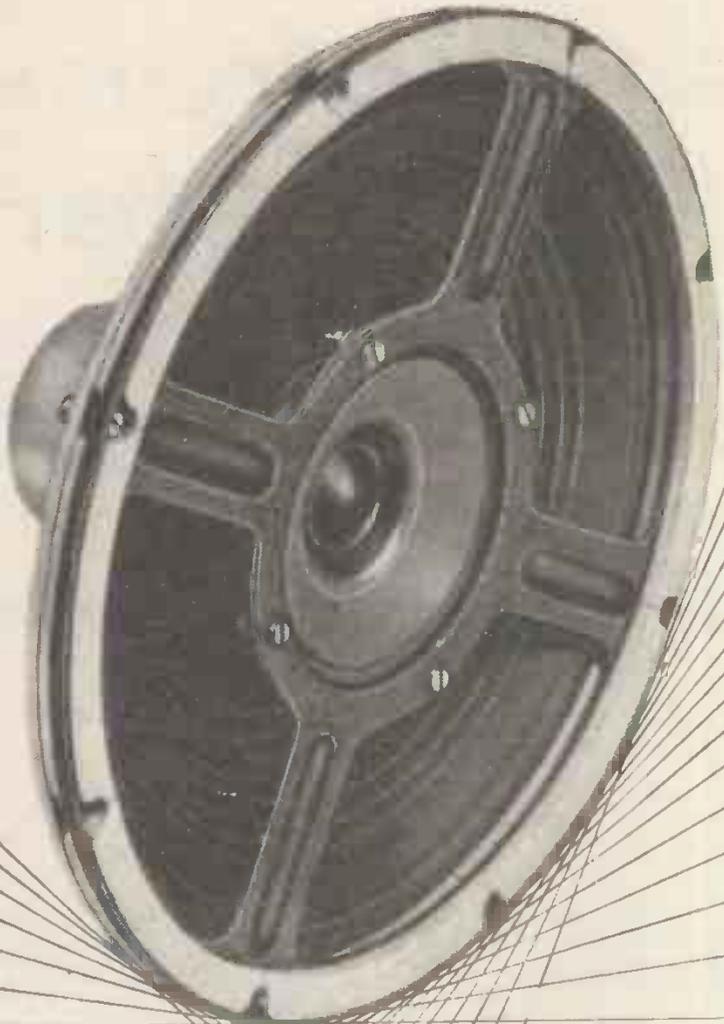
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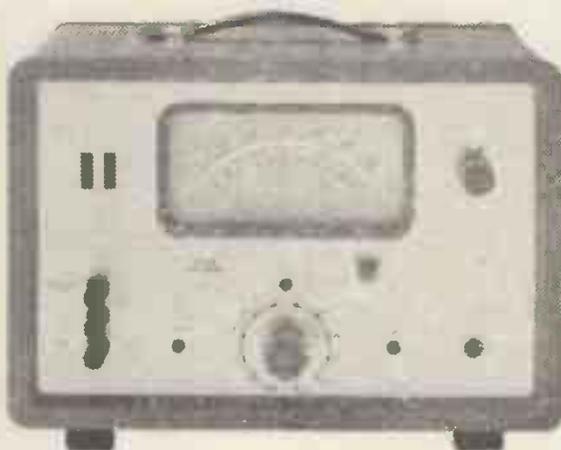
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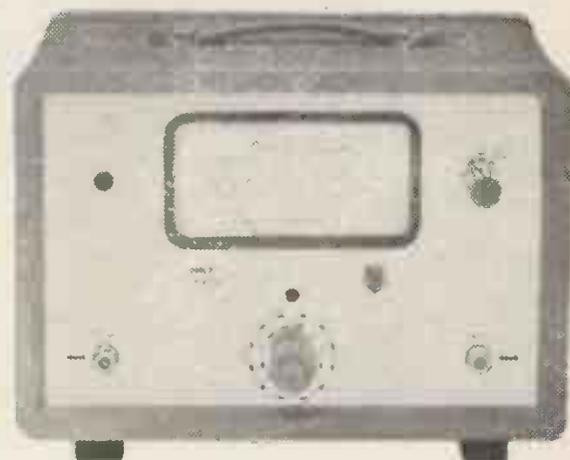
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**D.C.
GM 6020**
Range (fsd) 100 μ V - 1000 V
Input impedance
Input I 1 M Ω
Input II 100 M Ω
Accuracy 3%
Predeflection < 5 μ V
Automatic polarity indication
DC current measurements
(10 μ A - 10 μ A); with UHF probe
for AC measurements up to 800 Mc/s,
as an indicator up to 4000 Mc/s.



**L.F. 2 c/s - 1 Mc/s
GM 6012**
Range (fsd) 1 mV - 300 V
-80 dB to +52 dB
Input impedance
(1 mV - 3 V) 4 M Ω // 20 pF
(10V - 300V) 10 M Ω // 10 pF
Accuracy
(5 c/s - 100 kc/s) 2.5%
(2 c/s - 1 Mc/s) 5 %
Calibration voltage 30 mV and 10 V
Amplifier output 50 x

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GM 6001

DC Range (fsd) 300 mV - 1000 V
with EHT probe up to 30 kV
Input impedance 10Ω - $100\text{M}\Omega$
Accuracy 2.5%

AC 20 c/s - 1000 Mc/s
Range (fsd) 1 V - 300 V
Input capacitance 3.5 pF
Accuracy 3%

Resistances
Range 1Ω - $1000\text{M}\Omega$ (centre scale values 10Ω - $100\text{M}\Omega$)

Special features
Floating input. Centre scale facility.
Calibration voltage incorporated.
Special heater stabilisation.



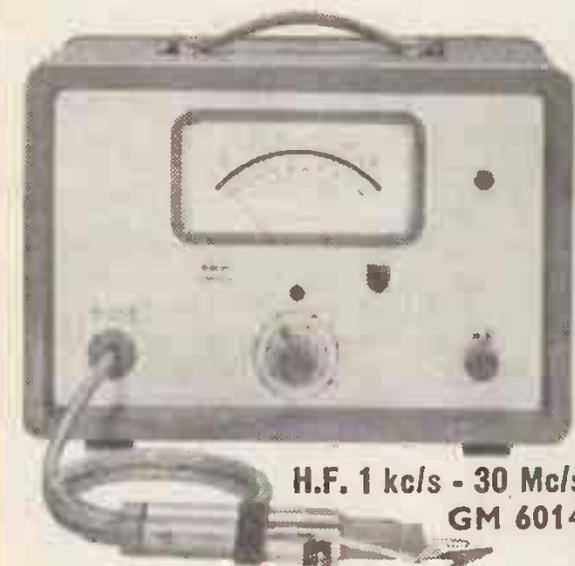
GM 6000

DC Range (fsd) 1 V - 1000 V
Input impedance $10\text{M}\Omega$
(with probe GM 6070: $1000\text{M}\Omega$)
Accuracy $\pm 3\%$ of full scale

AC (20 c/s - 100 Mc/s)
Range (fsd) 1 V - 300 V
Input impedance at 1 Mc/s
 $1.2\text{M}\Omega // 8\text{pF}$
Accuracy $\pm 3\%$ of full scale

Resistances
Range 10Ω - $5\text{M}\Omega$
Floating input.
Calibration possibility incorporated.

**UNIVERSAL
VOLT-
OHM-METERS**



H.F. 1 kc/s - 30 Mc/s
GM 6014

Range (fsd) 1 mV - 300 V
-80 dB to +32 dB

Input impedance
without attenuator
 $1\text{M}\Omega$ - $50\text{k}\Omega // 7\text{pF}$
with attenuator
 $50\text{M}\Omega$ - $2\text{M}\Omega // 2\text{pF}$
Accuracy 3%

Calibration voltages 30 mV and 3 V

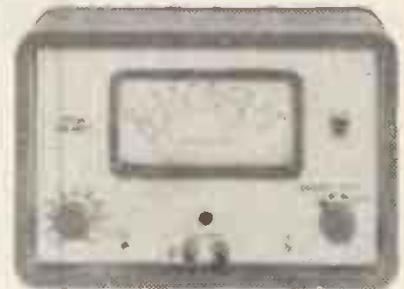


U.H.F. 0.1 Mc/s - 800 Mc/s
GM 6025

Range (fsd) 10 mV - 10 V
-60 dB to +22 dB

Input impedance at 200 Mc/s
 $35\text{k}\Omega // 1\text{pF}$
Accuracy 5%

Calibration voltages for each range
Probe-diode quickly exchangeable
T-piece for measurements on 50Ω -coaxial lines available



Simple L.F. millivoltmeter
GM 6023

Frequency range 10 c/s - 1 Mc/s
Measuring range 10 mV (fsd) - 300 V
-60 dB to +52 dB

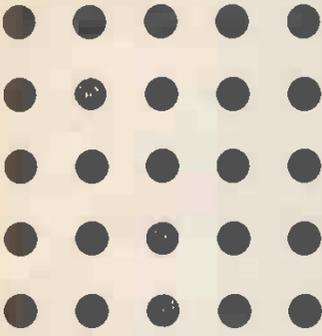
Overall accuracy 5% (from 20 c/s - 200 kc/s); 8% (from 10 c/s - 20 c/s and 200 kc/s - 1 Mc/s)

Input impedance $1.5\text{M}\Omega // 25\text{pF}$
(10 mV - 1 V); $1.5\text{M}\Omega // 15\text{pF}$
(3 V - 300 V)

Pre-deflection $< 300\mu\text{V}$
Calibration voltage incorporated

instruments: quality tools for industry and research





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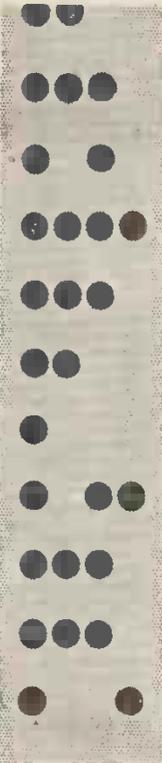
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C.R.E.I. (LONDON)

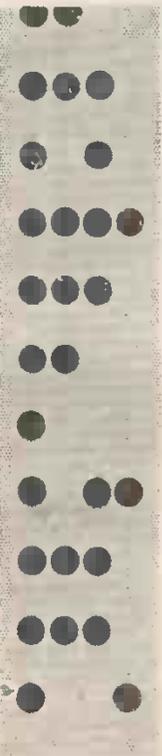
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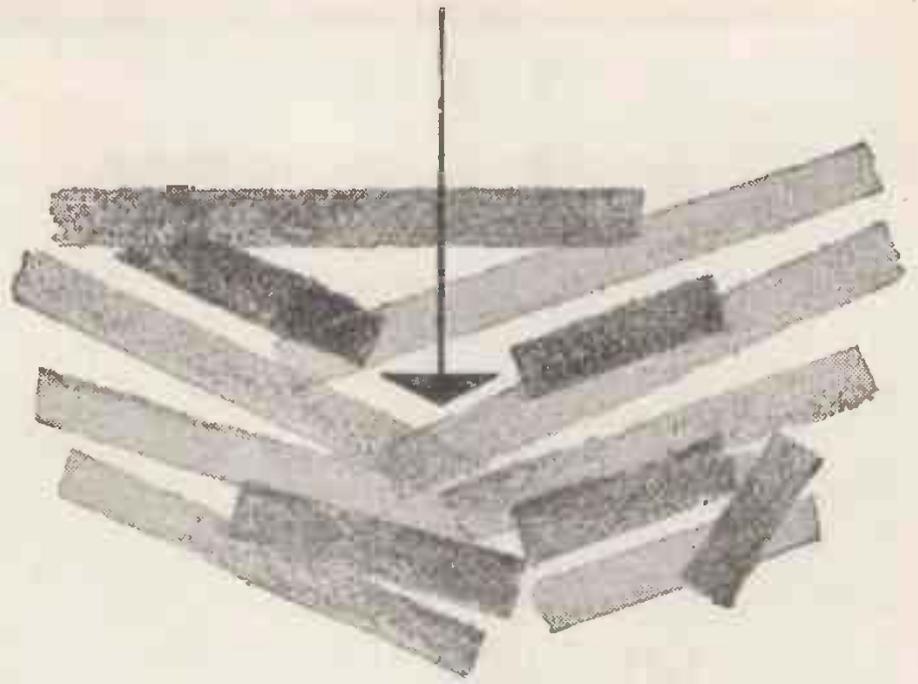
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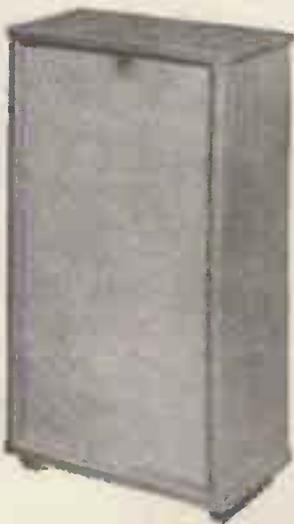
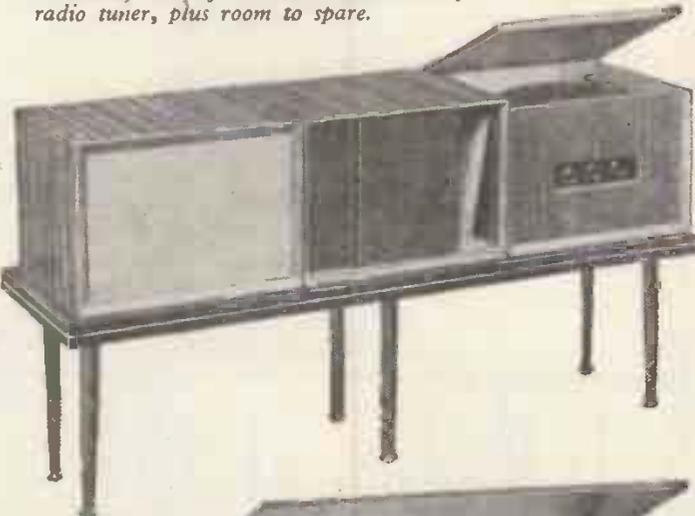
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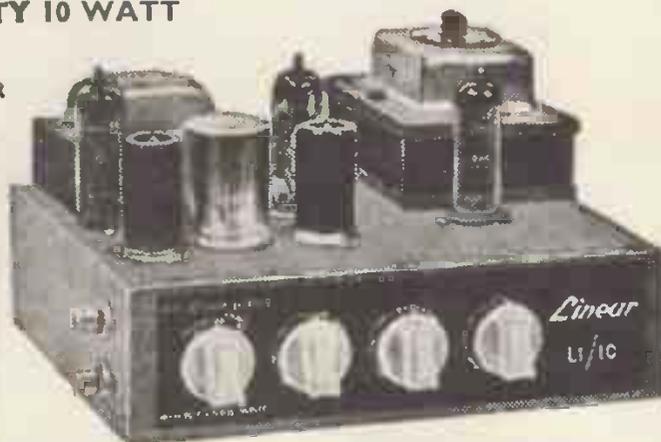
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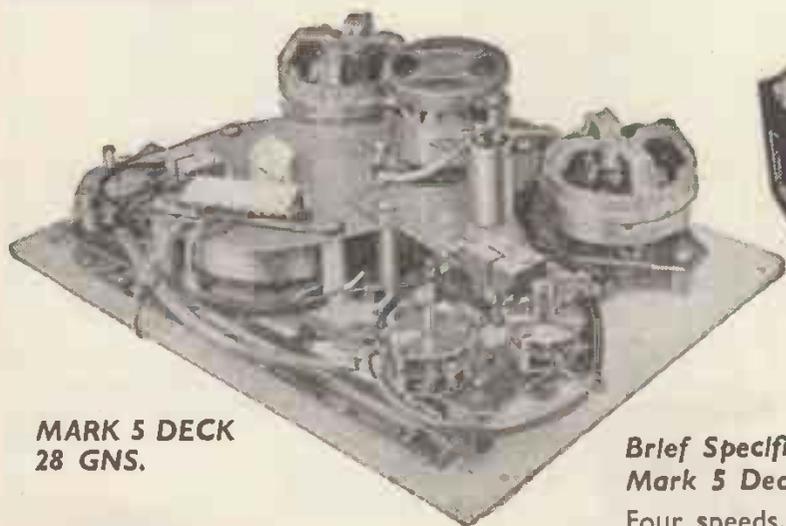
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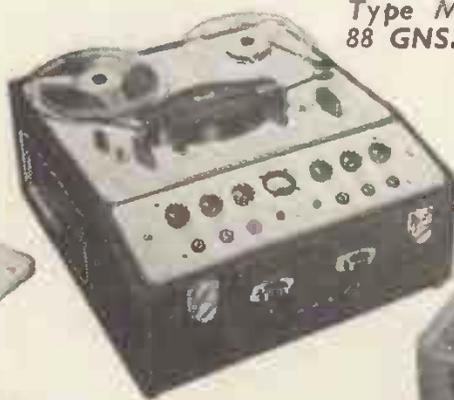
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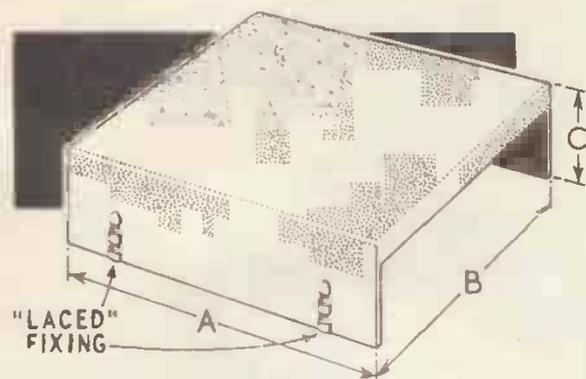
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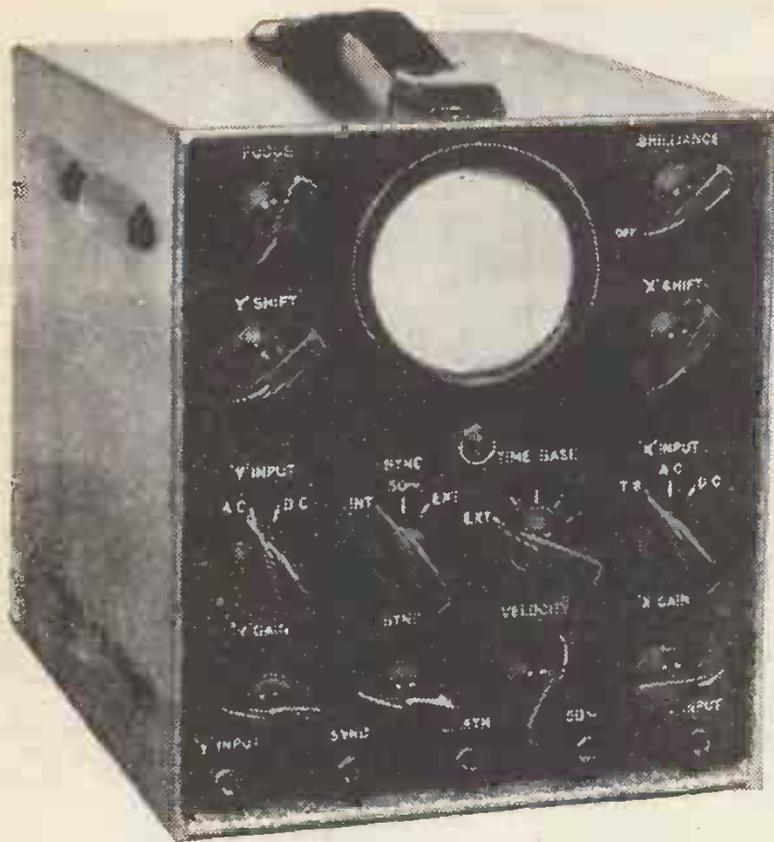
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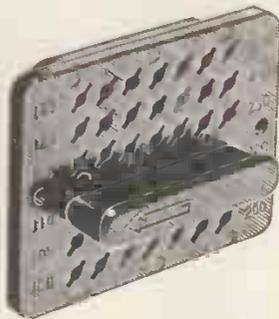
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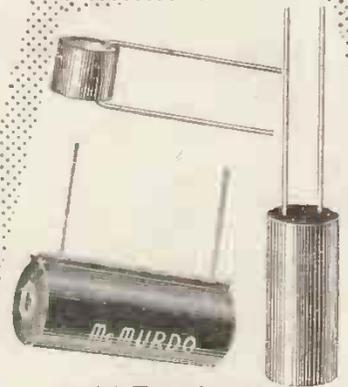
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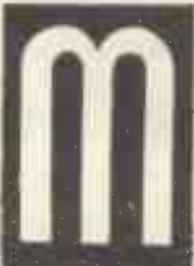
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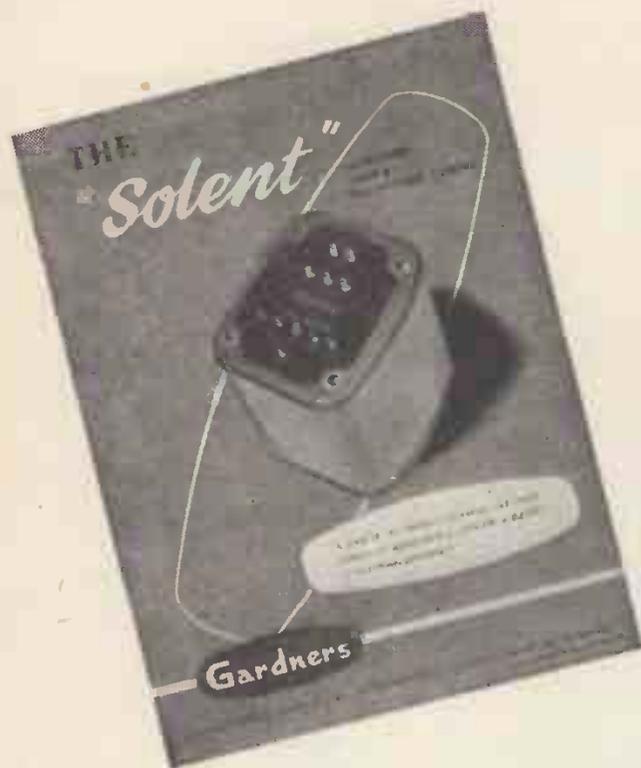


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Fluttermeter
Type 1740

Brief Technical Data

Operating carrier frequency 3,000 c.p.s. $\pm 5\%$
 Minimum Input Signal 50mV R.M.S.
 Input Impedance 1 Megohm.
 Input amplifier bandwidth -3db at 2,500 and 3,500 c.p.s.
 Effective limiter range ± 10 dB.
 Meter scaling—"Peak wow" 0 to $\pm 1\%$ (centre zero).
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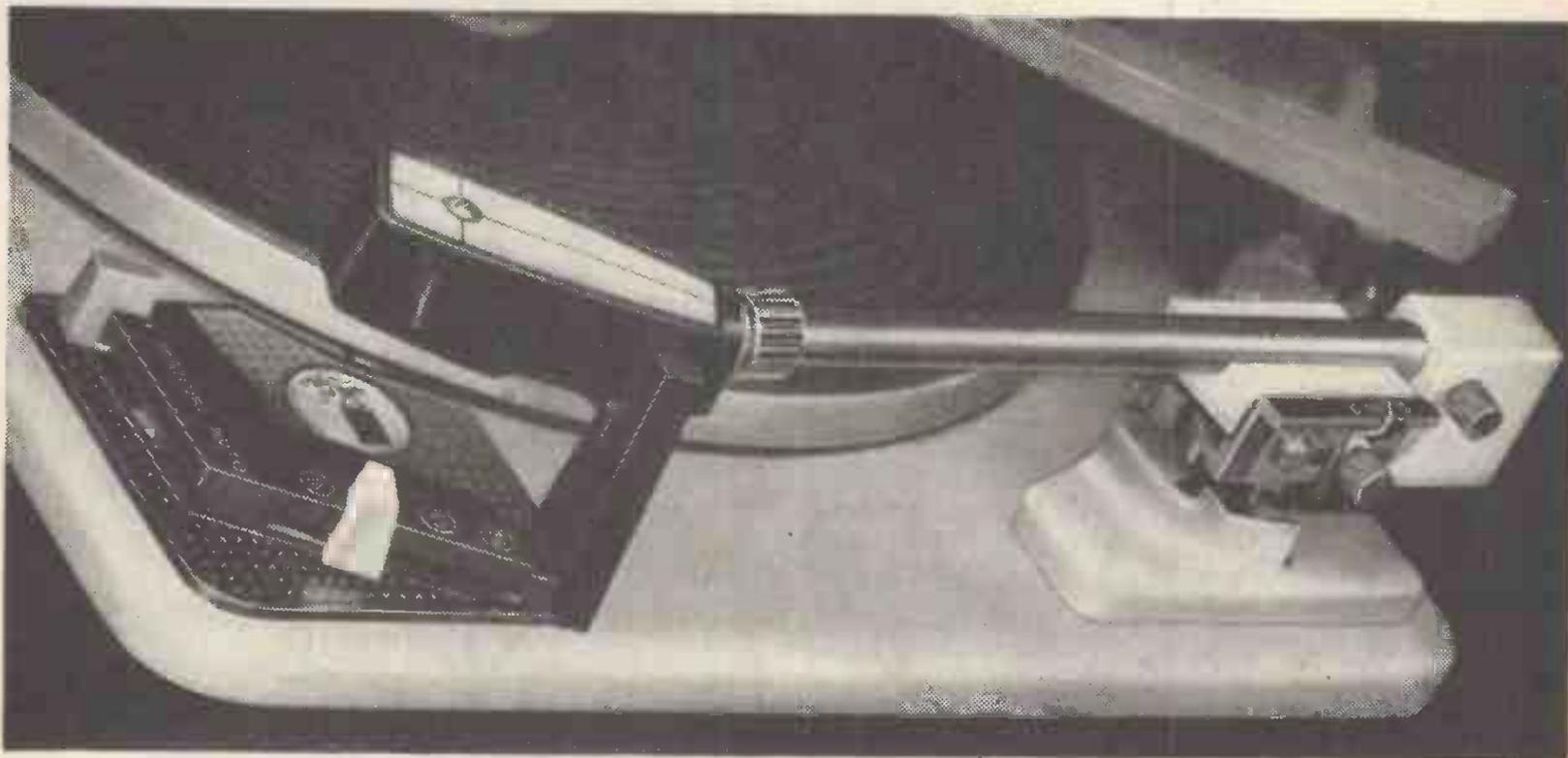
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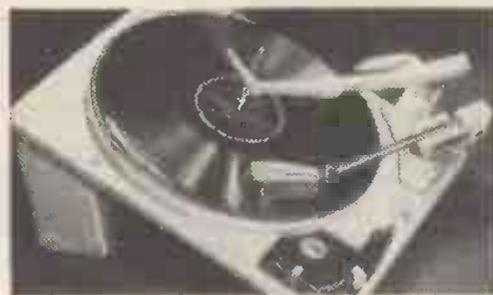
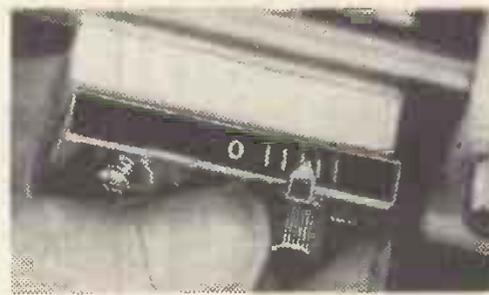
MODEL AT6 AUTOMATIC RECORD PLAYER

Here, with its brilliant pickup arm, you see a striking example of Garrard design and engineering. Up to now, this type of arm was considered as a separate component—an added luxury. An aluminium tubular pickup arm dynamically balanced and counter-weighted—it is a professional arm in every respect—is provided as a standard fitting with the AT6, assuring perfect installation. This is just one of the precision features that enable the AT6 to provide the quality performance required of a Garrard unit built for knowledgeable, critical listeners. All the skill, the experience and the established facilities which Garrard have put behind the development of the highly successful Type "A" have also gone into the new AT6 unit.



The arm is balanced and tracking force adjusted in two easy steps. First . . . it is set on zero tracking pressure, by moving the counter-weight until the arm is level, in perfect equal balance.

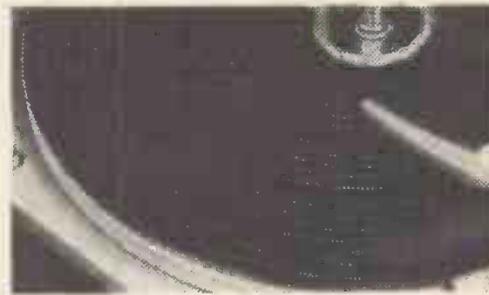
Now . . . you fix the tracking force desired on the built-in stylus pressure gauge conveniently mounted in upright position at the side of the arm.



The AT6 will now track each side of the stereo grooves accurately at the lowest pressure specified, even for cartridges labelled "professional," and if the unit is intentionally tilted.



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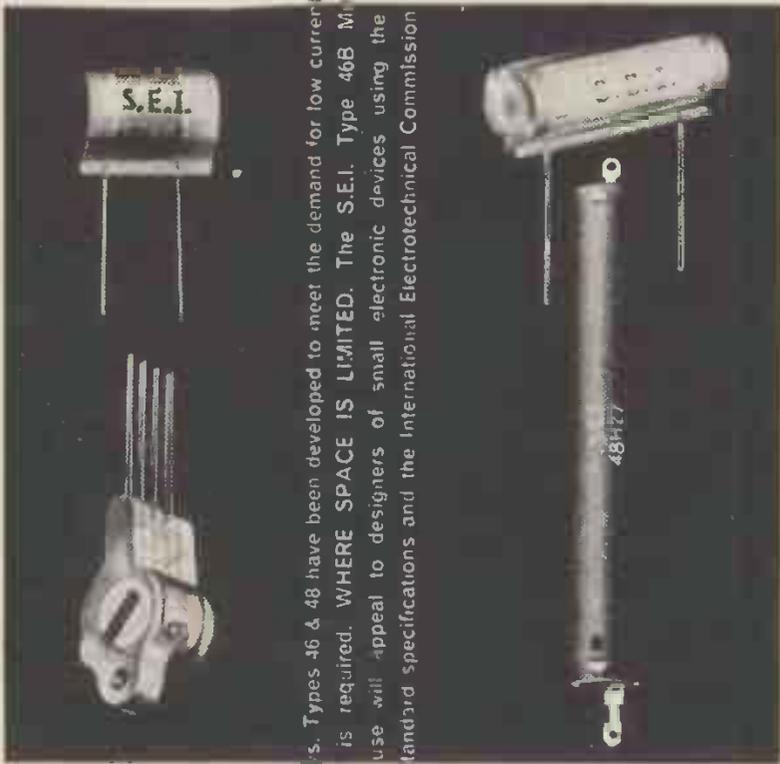
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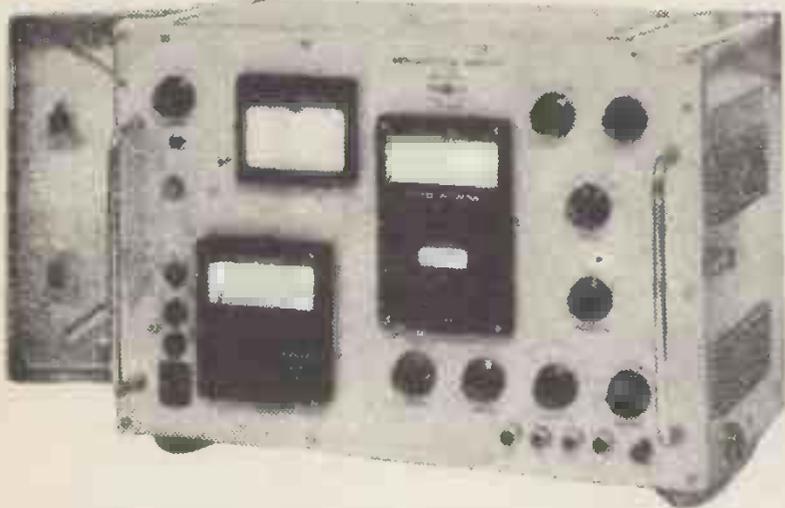
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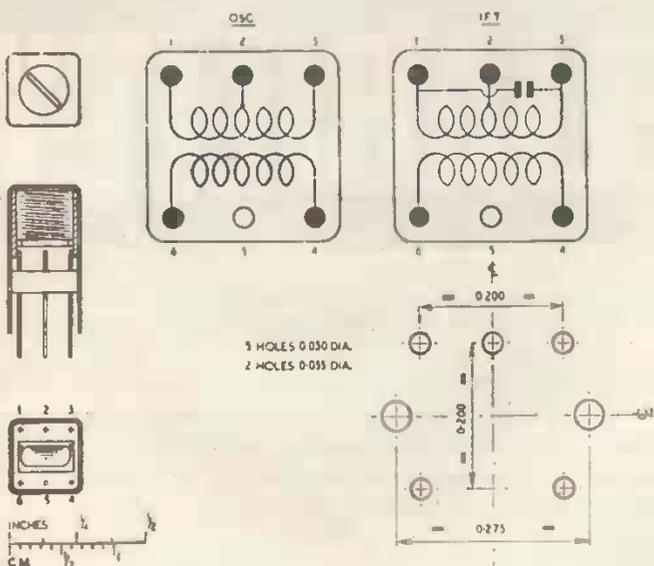
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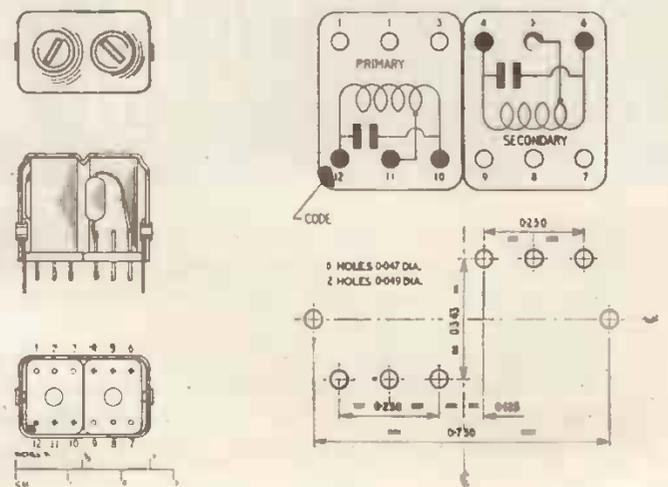
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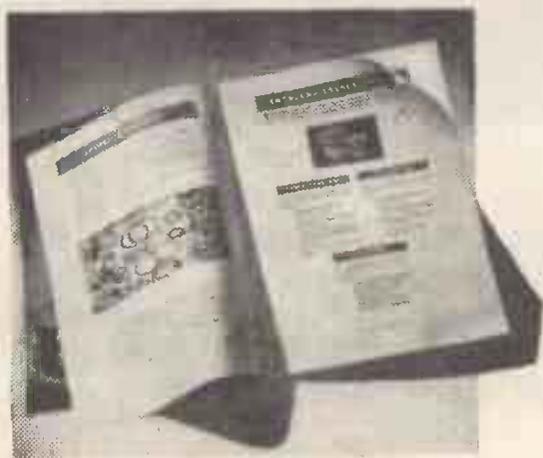
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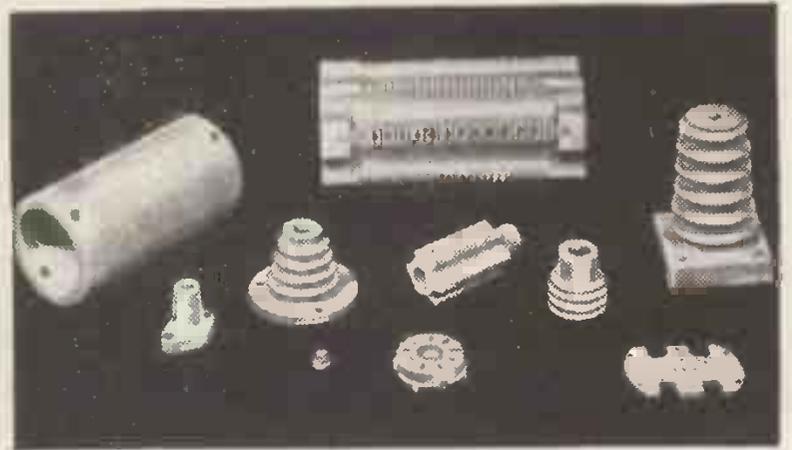
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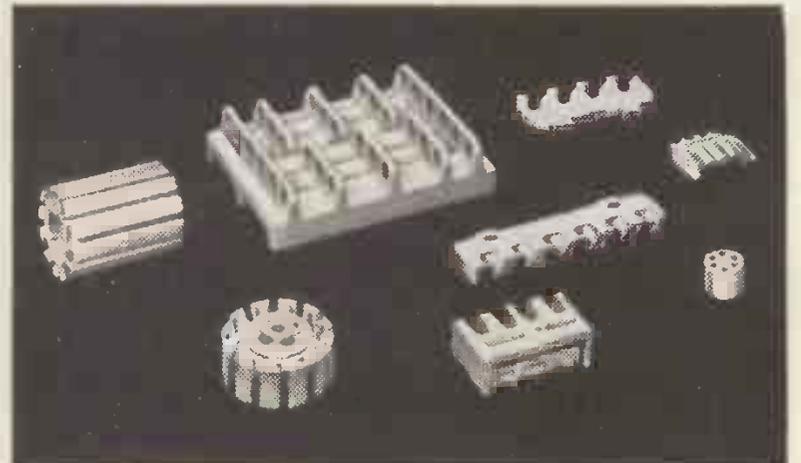
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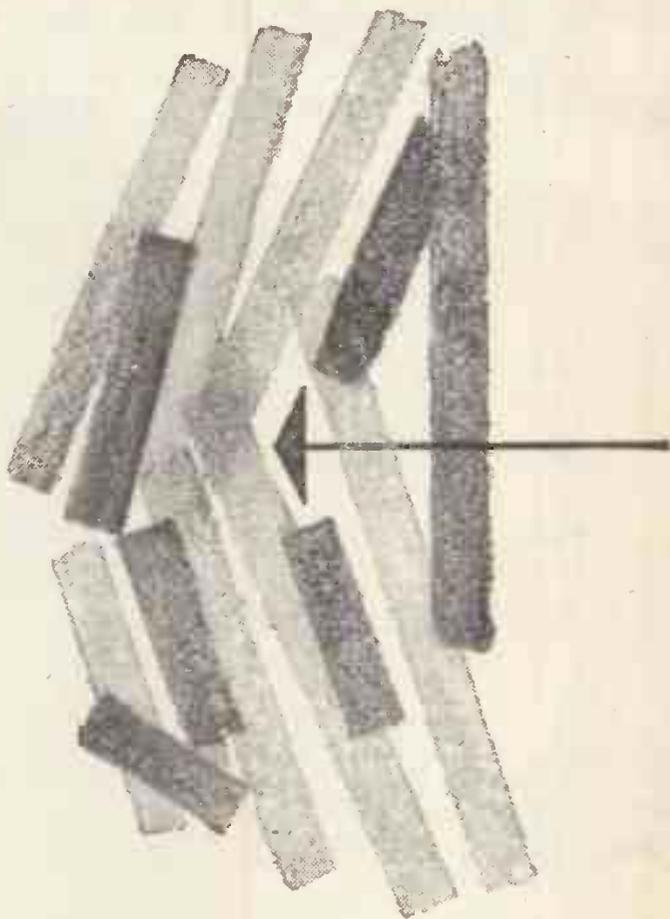
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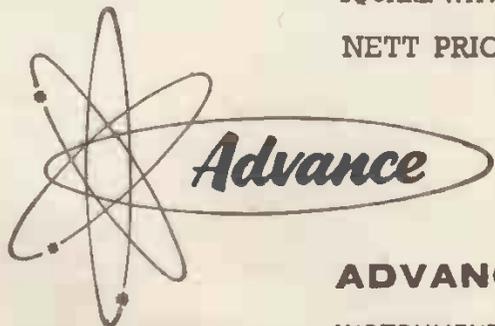
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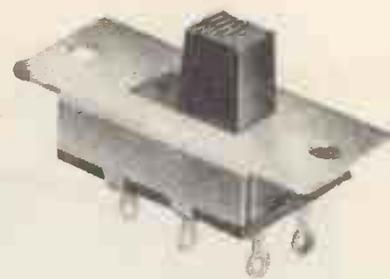
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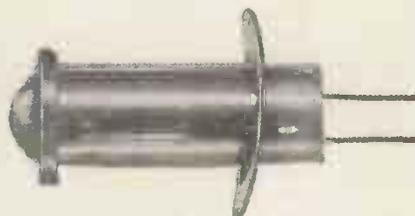
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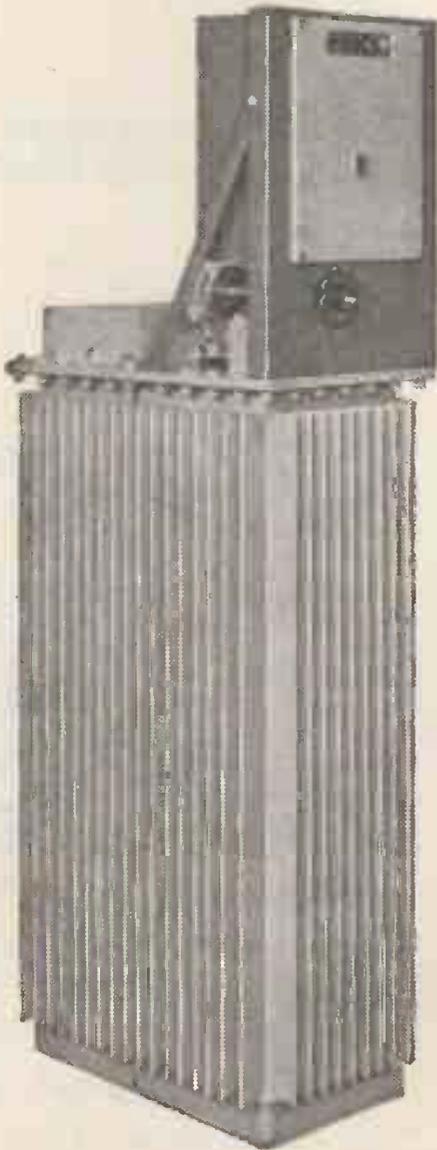
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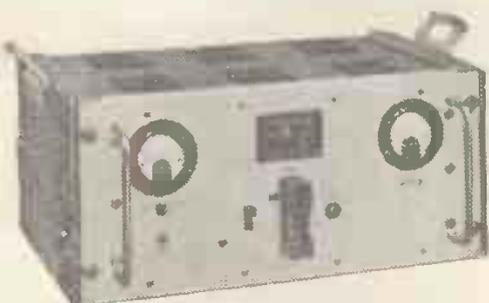
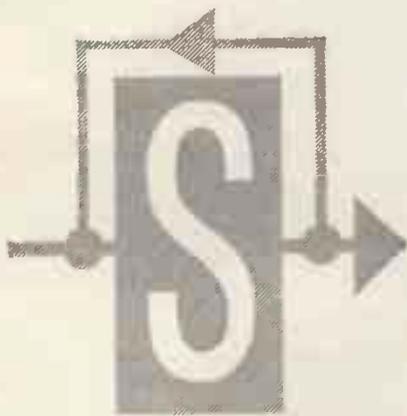
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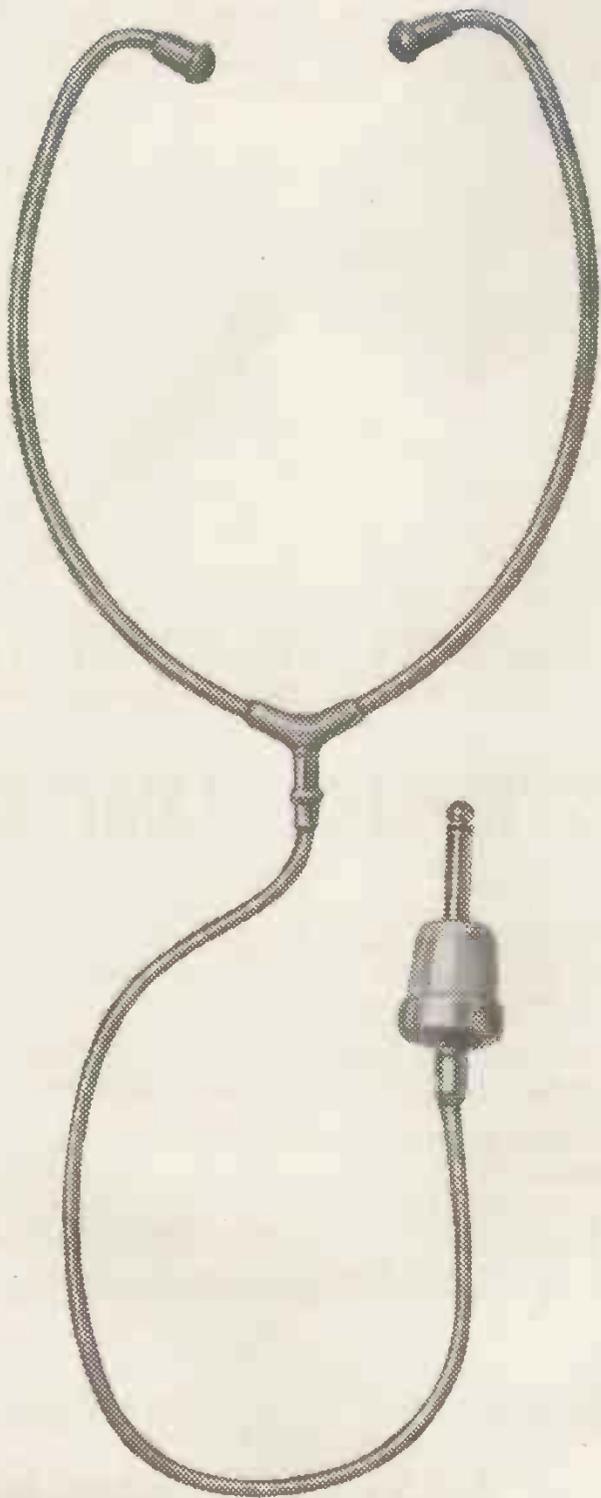


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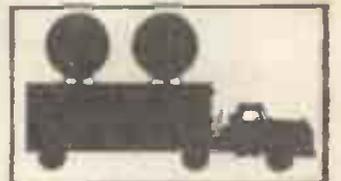
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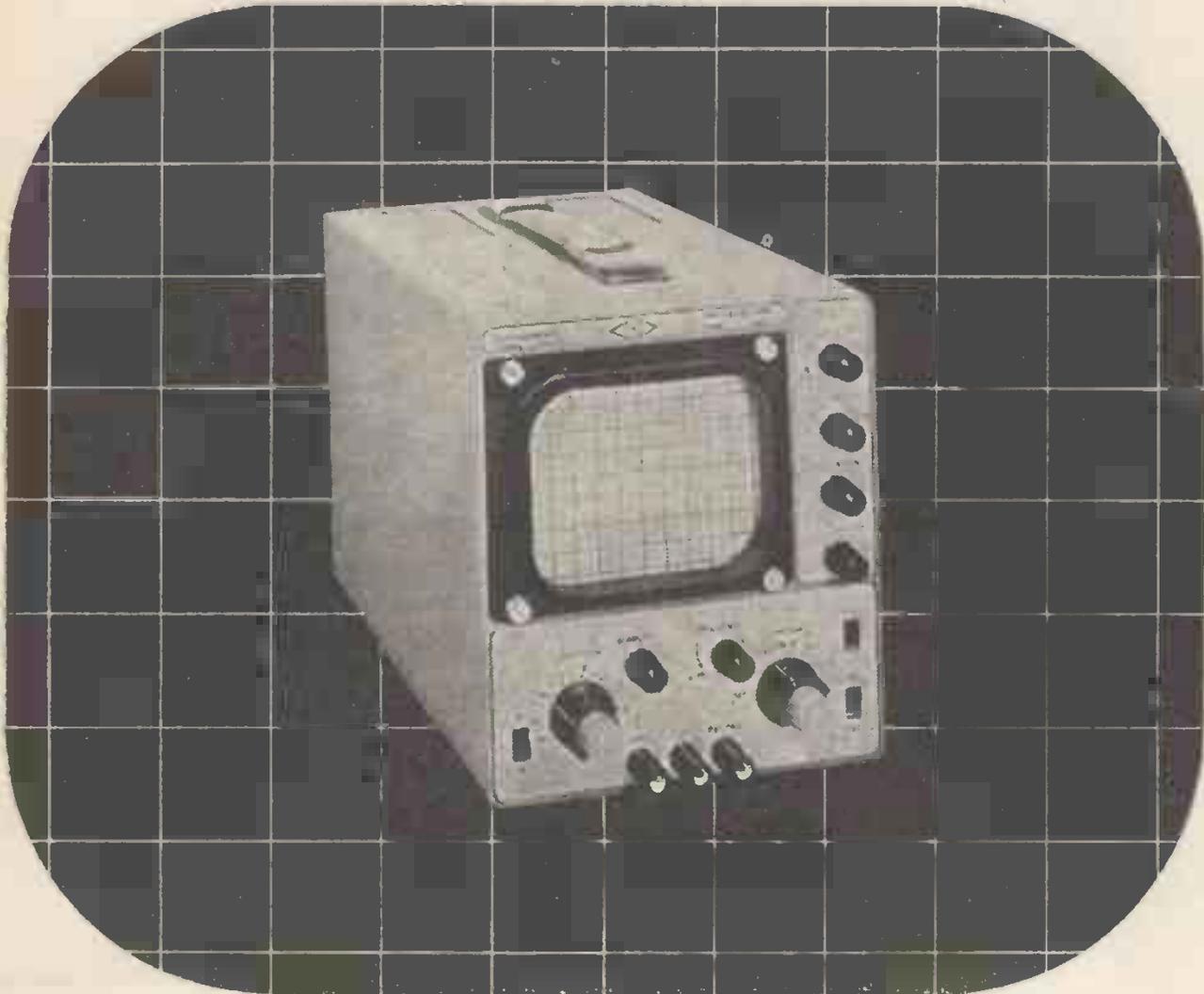
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ELECTRONICS, RADIO, TELEVISION

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- 105 Editorial Comment
- 106 Transistor Bias Networks *By T. Ormond*
- 109 Direct-coupled Pulse Circuits *By R. Thompson*
- 111 Books Received
- 112 Paris Components Show
- 114 Citizens' Radio in U.S.A. *By R. L. Conhaim*
- 115 H. F. Predictions—March
- 116 World of Wireless
- 118 Personalities
- 120 News from Industry
- 121 *Wireless World* Oscilloscope—1
- 128 Aerospace Telemetry
- 129 Physical Society Exhibition 1963
- 134 Letters to the Editor
- 137 Oscillators: a Monastic Approach—3 *By T. Roddam*
- 142 Manufacturers' Products
- 145 Nonconductor Valves *By "Cathode Ray"*
- 148 Transistor Amplifier Output Stages—3 *By O. Greiter*
- 152 Unbiased *By "Free Grid"*
- 154 March Meetings

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CONTROLLED WARM-UP TIMES

FOR TELEVISION SERIES HEATER CHAINS

All Mullard valves designed for operation in television series heater chains now possess equalised heating characteristics. These characteristics obviate damage to the valve heaters during the warm-up period and eliminate the need for a thermistor.

The voltage developed across one heater of a series heater chain depends almost directly on the resistance of that heater. The resistance of the heaters depends on their temperature, and is greater when the valves are hot than when they are cold. When a receiver is switched on, if one valve warms up more rapidly than the rest, the effect on the current will not be appreciable, but the increase in the voltage developed across the heater of that valve can exceed the amount (50% above the nominal heater voltage) which can be tolerated during the warm-up period. This can shorten the life of the valve considerably, and to prevent it, heater chains have normally been designed to incorporate a thermistor.

The resistance of a thermistor is high when it is cold, but falls as heat is generated in it by the heater current. The thermistor thus reduces the rate of increase of the heater current, and prevents unequal rises in the temperature of the heaters from producing an excessive voltage across any heater.

The rate at which the temperature of a valve heater rises depends very much on the mounting of the heater in the valve. Any point of contact between the insulated heater and the surrounding cathode sets up a small drainage of heat away from the heater and thus retards the rate at

which the temperature rises. Since the space inside the cathode is small, it is difficult to ensure consistent positioning of the heater within the cathode, so that the number and extent of these contacts, and therefore the rate at which the heater temperature rises, can vary considerably from one valve to another. Now, however, Mullard have developed accurate and carefully controlled methods of manufacture which produce equalised rates of temperature rise in all their television valves. Extensive tests with a large number of valves in typical heater chains have shown that these equalised heating properties ensure that, without added protection, the voltage developed across any heater will not exceed the permitted 50% above nominal during the warm-up period. Use of Mullard television valves thus enables heater chains to be designed without a thermistor, and this, in addition to the obvious economy, leads to shorter warm-up times and a faster appearance of the picture on the screen.

WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

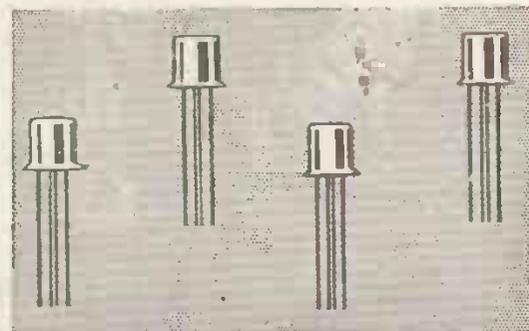
MULLARD MINIATURE ELECTROLYTICS 8 Values in the New Can Size 2½

Mullard miniature electrolytic capacitors of the C426 series are a proven success in modern transistor radio receivers, and the group of capacitors recently added to the series offers even better coverage of the already wide range of sizes and values available. The capacitance and working voltage values of electrolytic capacitors are linked closely with the size of the component. The original

Mullard C426 series consisted of five can sizes, each of which offered eight combinations of capacitance and working voltage. A new can size—can size "2½"—has now been added to the series, so that a further eight combinations of capacitance and voltage are now available. As the designation implies, can size 2½ lies between can sizes 2 and 3. It has the same length of 10.7 mm., as can size 2

NEW MINIATURE TRANSISTORS FOR POCKET PORTABLES

A new Mullard range of miniature transistors has recently been introduced for pocket-size portable radios. These very small transistors—the AF124, AF125, AF126 and AF127—have been evolved as a continuation of the Mullard contribution to miniaturisation which began with the well-known OC44 and OC45 alloy-junction transistors.



Early transistor sets were restricted to the long and medium wavebands but short-wave and v.h.f. operation became feasible with the improved frequency performance of transistors manufactured by the alloy-diffusion technique. The first of these r.f. transistors to be introduced by Mullard were the OC170 and OC171, but these were superseded by the now-established AF114, AF115, AF116, and AF117—a series that was soon accepted as fulfilling the h.f. requirements of all forms of portable receiver.

The new series is a miniature counterpart of the AF114 series: the electrical properties are identical, but the transistors are only a quarter of the size. All the many advantages of the alloy-diffusion technique are retained, but considerable economy of space is afforded. These benefits are reflected in the smaller size and improved performance of the latest pocket portables.

compared with the 18.7 mm. of size 3. Its diameter of 6.3 mm. compares with the 5.0 mm. of size 2 and the 6.8 mm. of size 3. As with the other sizes in the C426 range, the eight working voltages follow the logarithmic series: 64, 40, 25, 16, 10, 6.4, 4.0 and 2.5V, and the corresponding values of capacitance are 3.2, 6.4, 12.5, 20, 32, 40, 50 and 64µF. The tolerance on these values is -10% and +50%. The electrical properties of the new capacitors are identical with those of the original capacitors, and in common with the whole range, the capacitors in can size 2½ offer a long and trouble-free service life.

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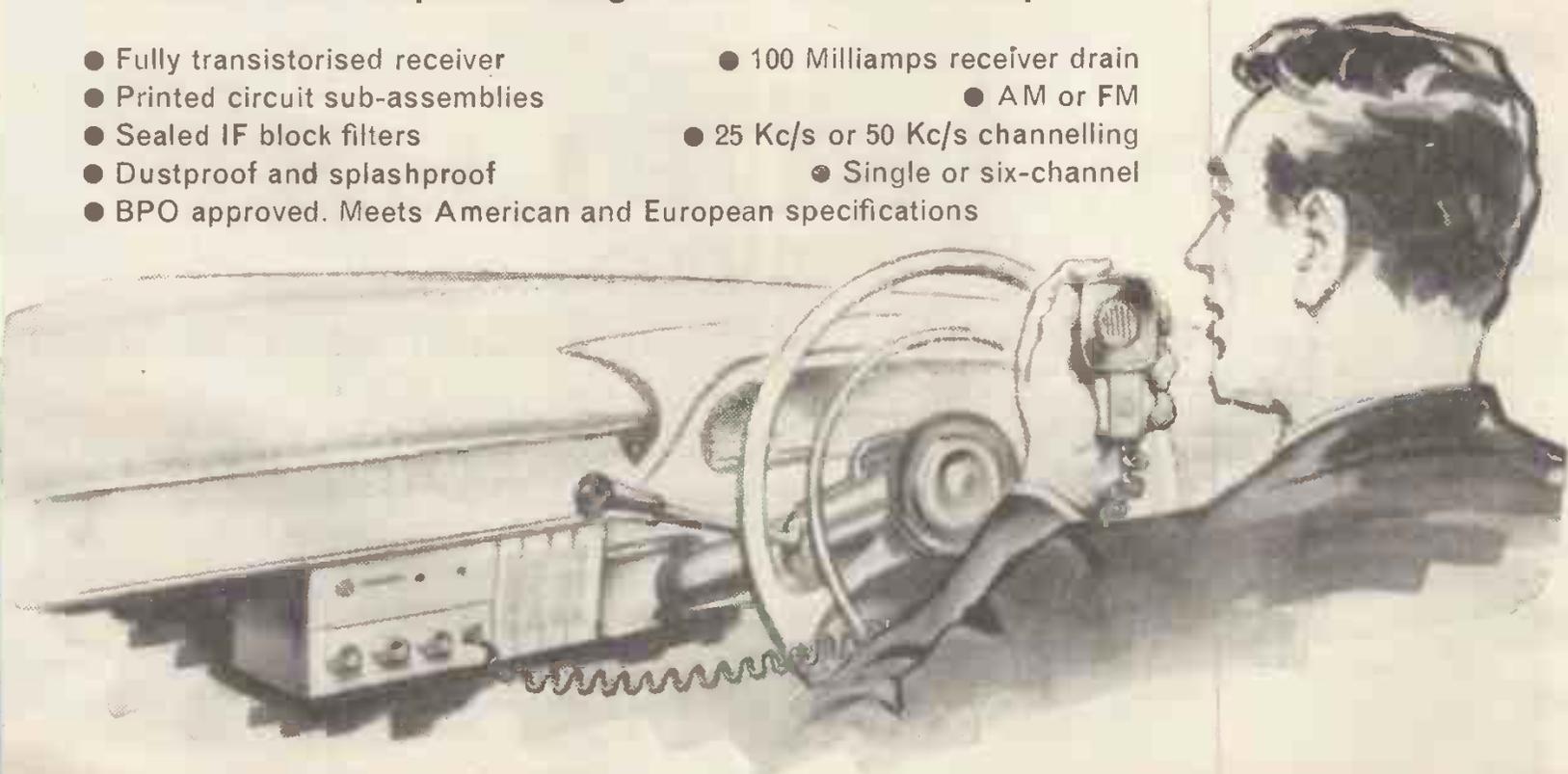
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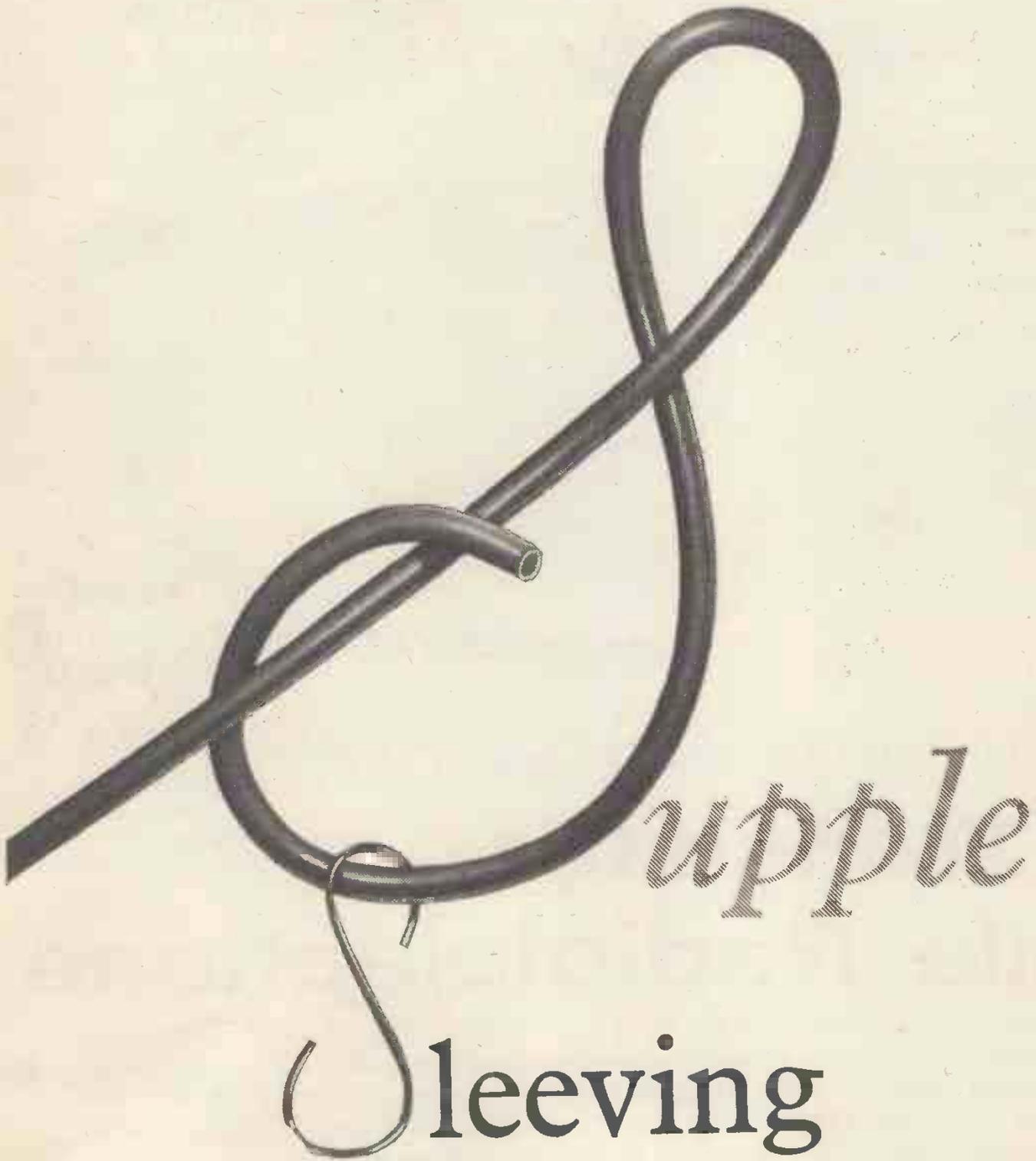
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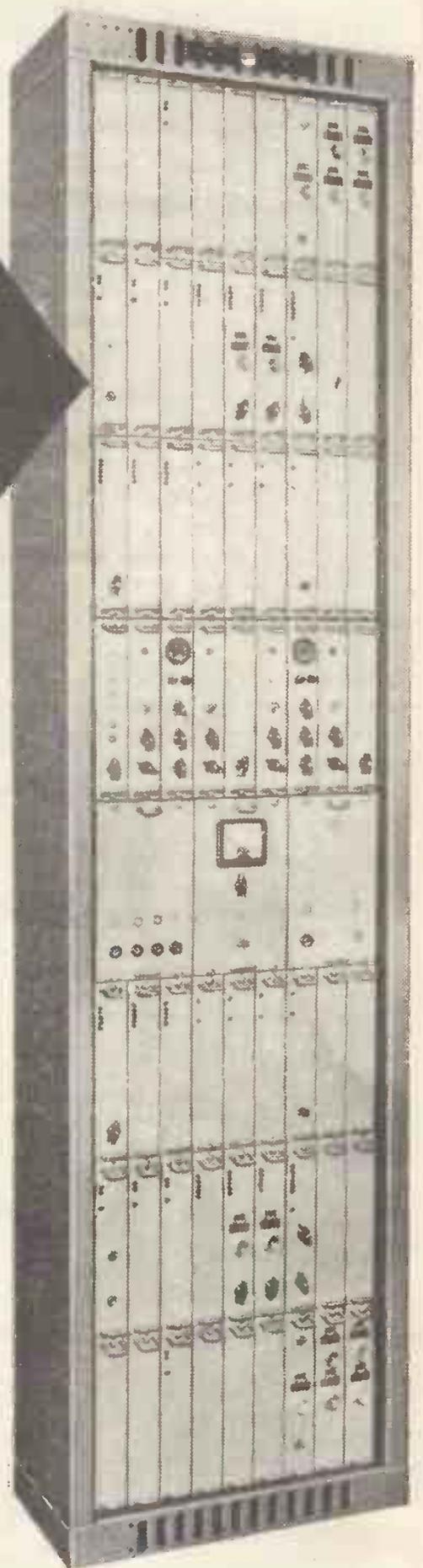


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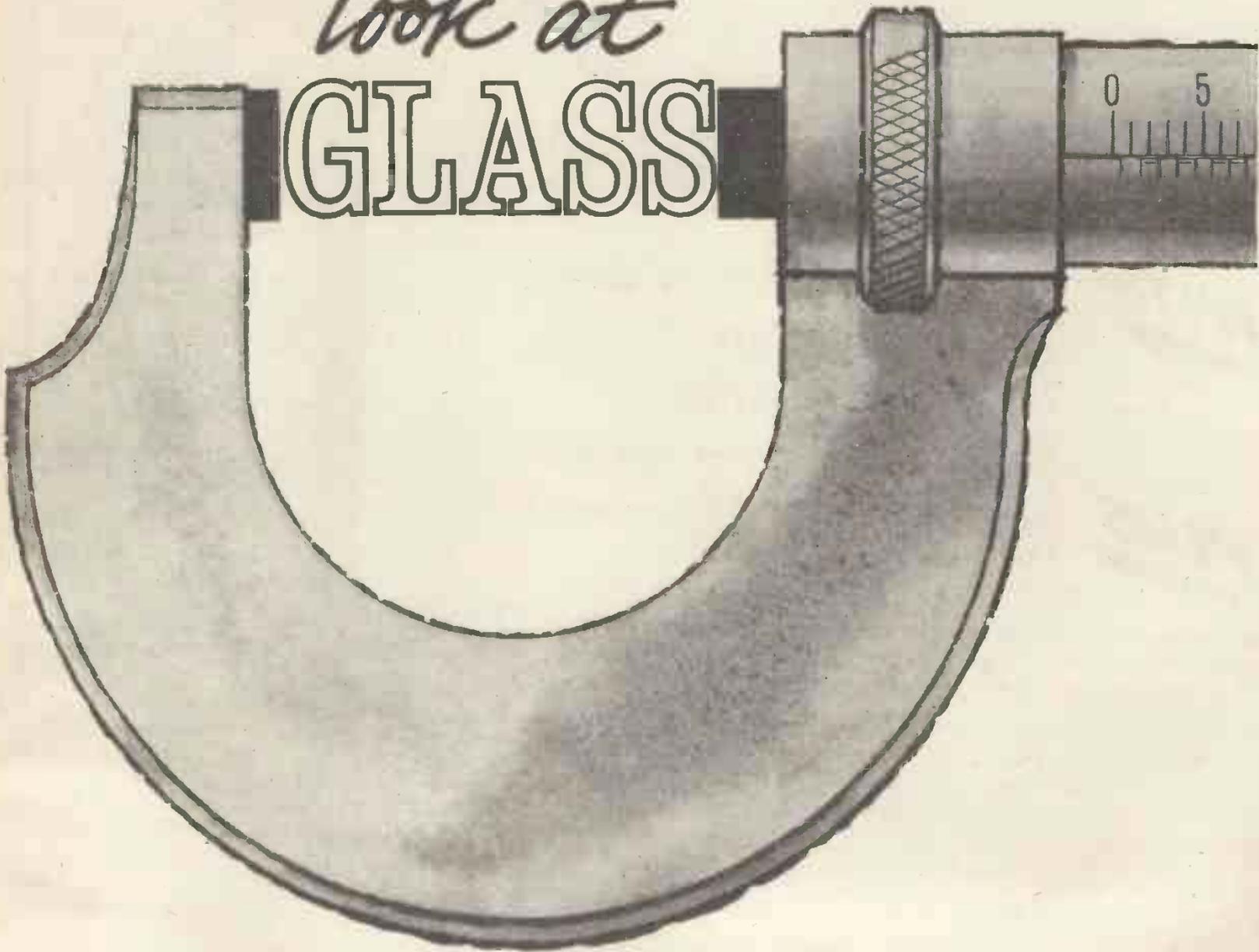
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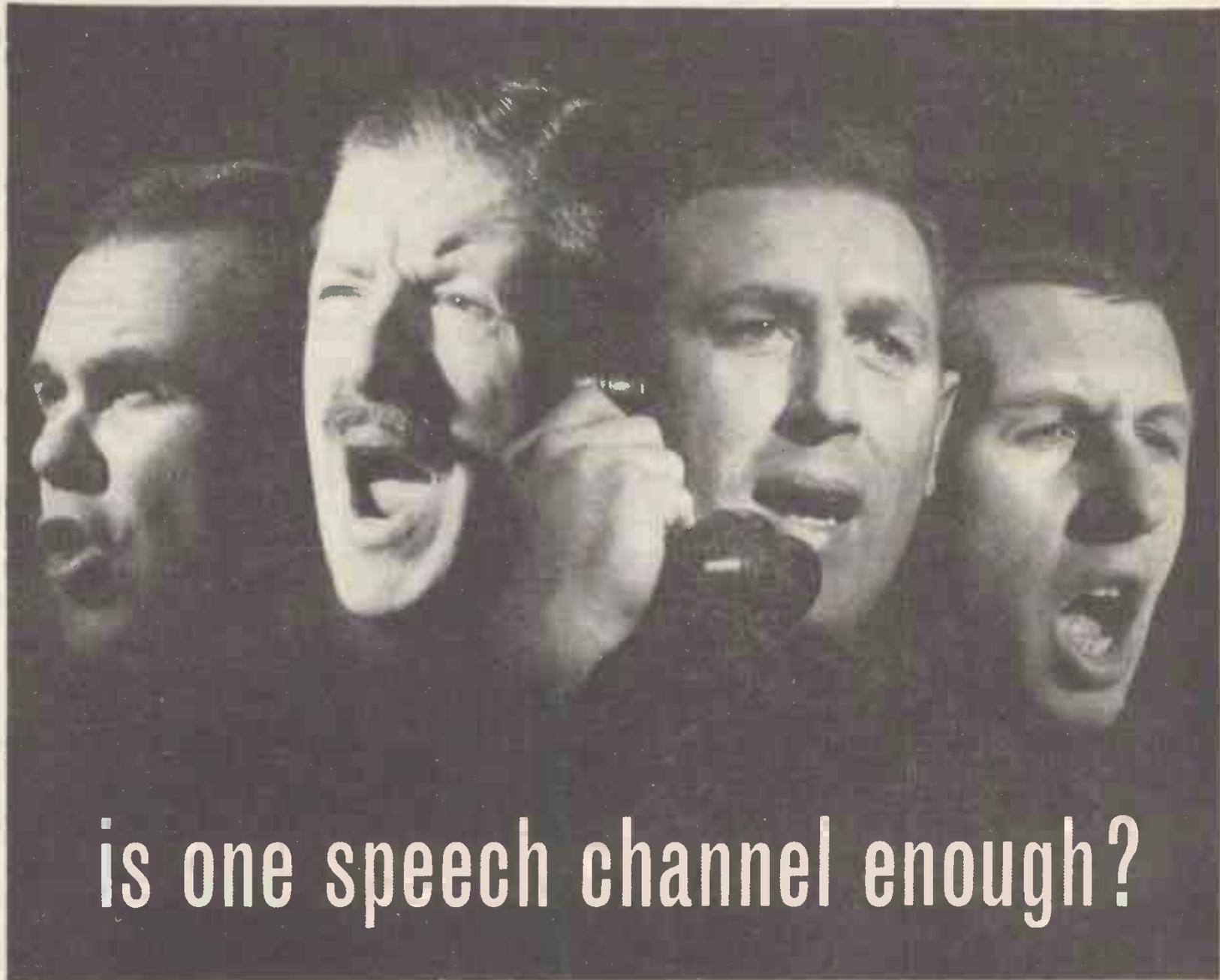
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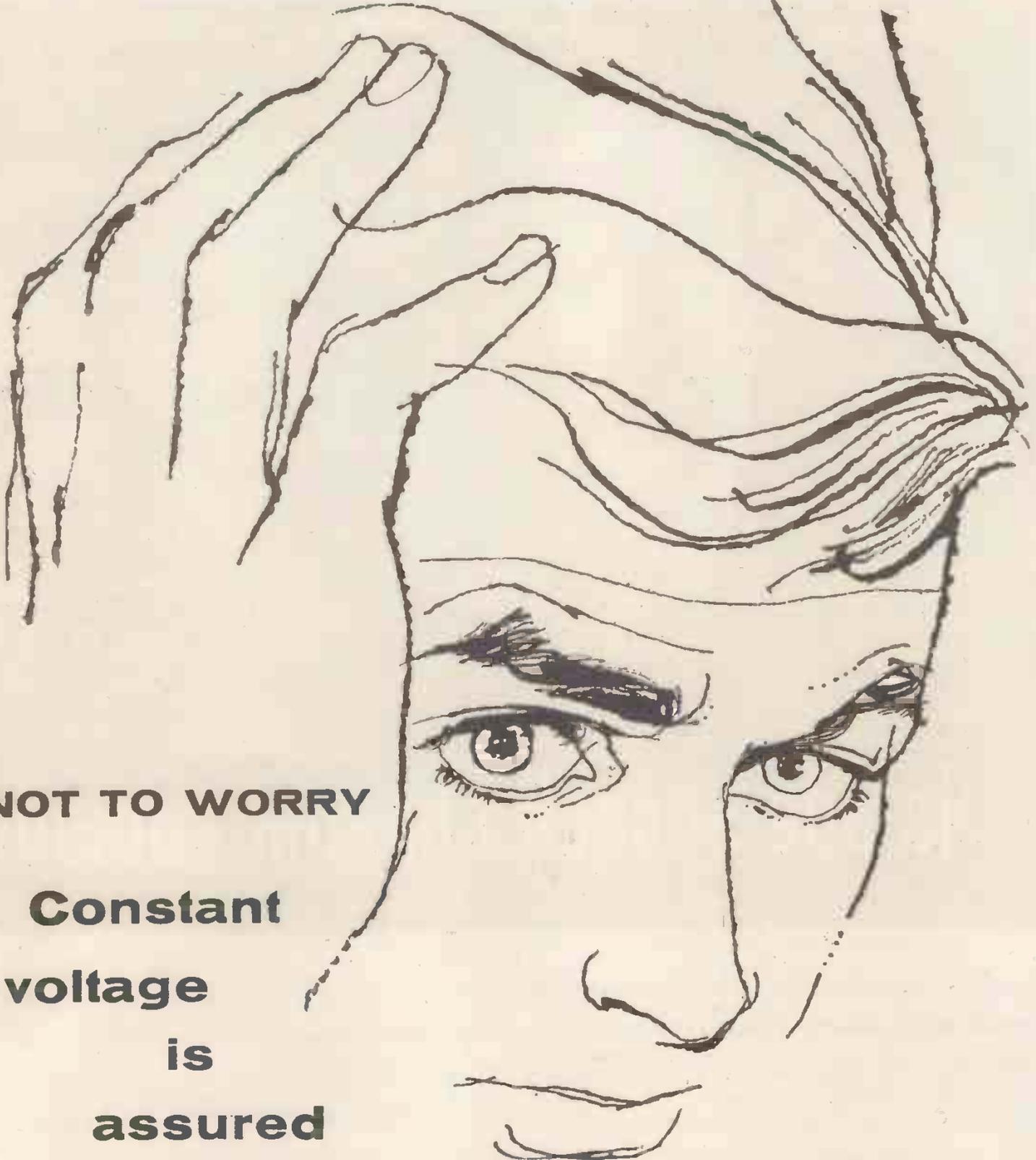
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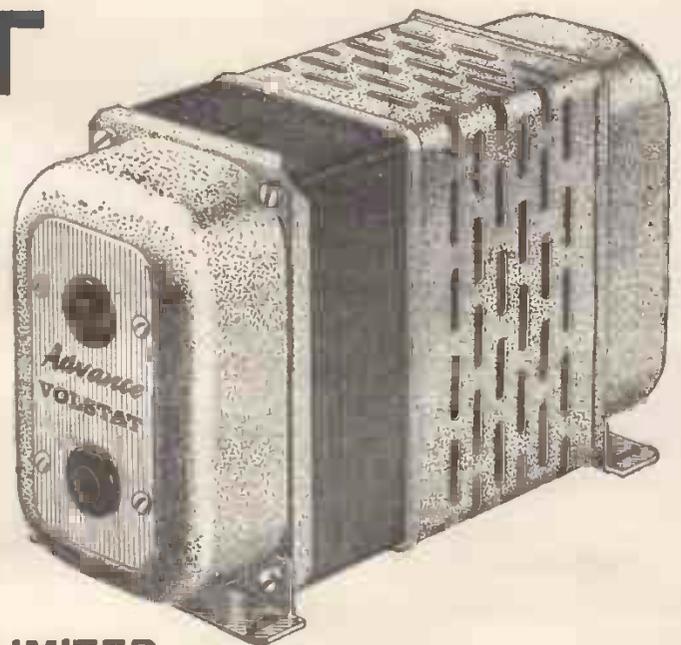


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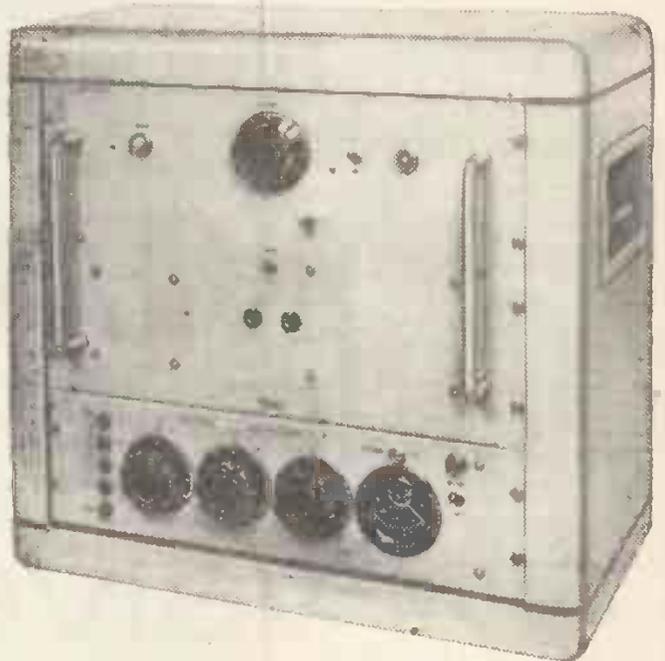
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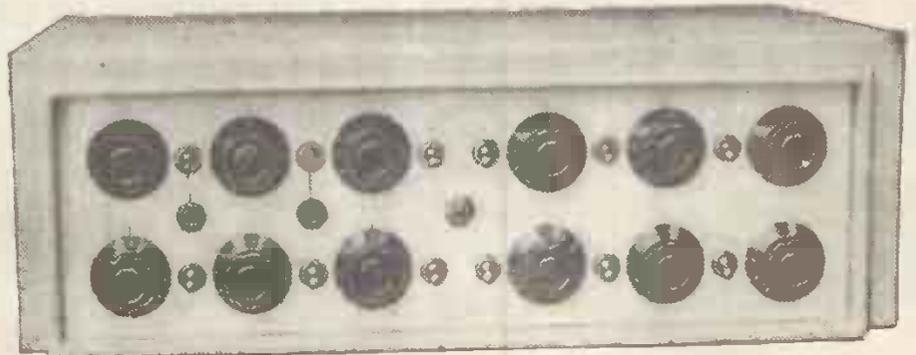
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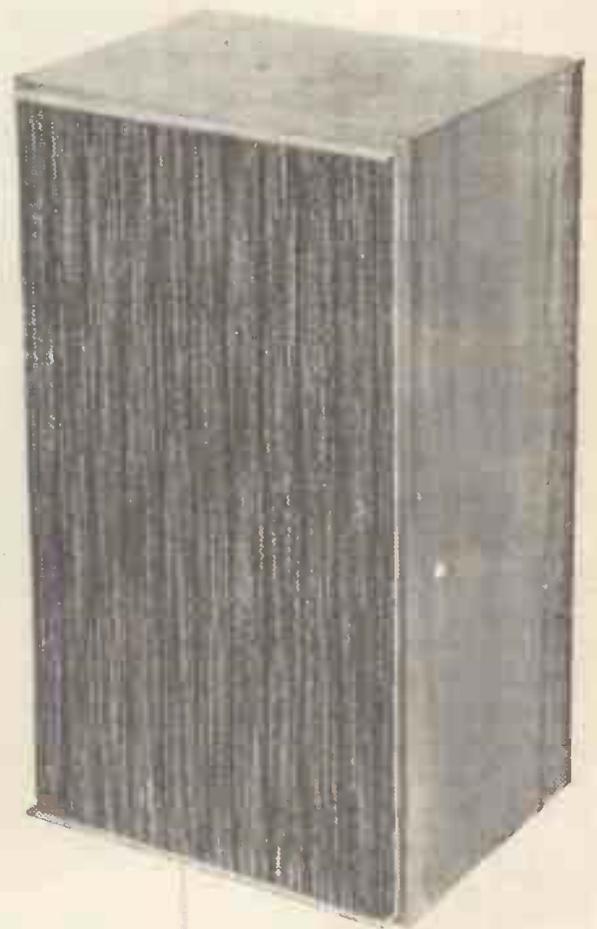
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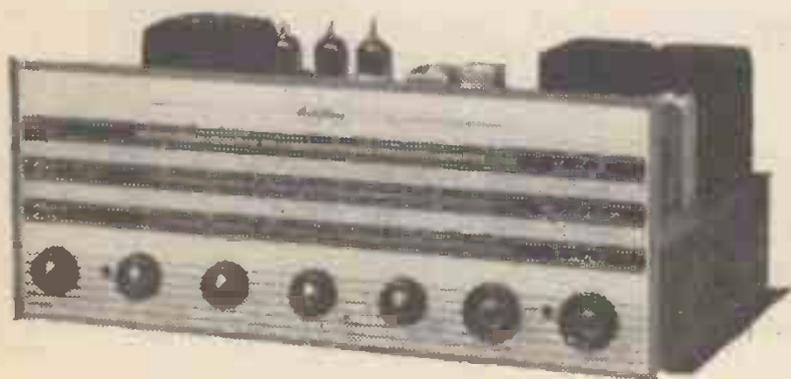
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Junior version of Stereo 12; 5 watts per channel, 10 watts total; VHF and medium bands; Inputs for tape, pick-ups and future stereo radio.

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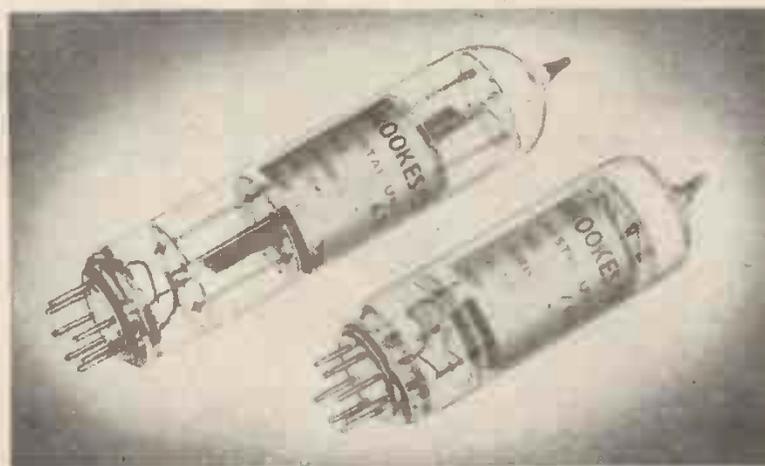
An AM/FM mono chassis of 5 watts output covering VHF and medium bands. An inexpensive version of the Jubilee Mk. 2.

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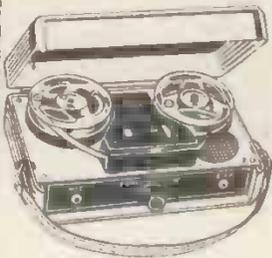
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Tape Recorders



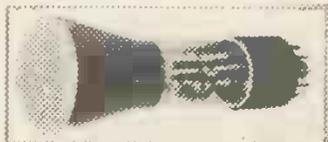
One of the easiest ways to learn anything, is to "tape" it and then keep playing it back. Try this new learning technique — you will be amazed. The industrious Japanese have really gone to town.

on tape recorders this year, and many bargains are on offer. It is the writer's opinion that there is bound to be a big demand for them so there is a good reason why you should buy your tape recorder immediately. **KIT OF PARTS** £4/19/6 or ready assembled £4/19/6 plus 5/- carriage and insurance.

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Waterproof heater wire. 16 yd. length. 70 watts. Self regulating temperature control, 10/-, post free.

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3in. oscilloscope tube. American made type No. 3FP7. base 6.3 v., 6 amp. heater electrostatic deflection, brand new and guaranteed. with circuit diagram of scope, 15/- each plus 2/6 post and insurance.

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(Or repairable fuse)

You will have experienced the annoyance of having to repair a fuse especially in the middle of an experiment or repair job. Save yourself this bother by installing a simple circuit breaker. All you have to do then (if you touch the wrong wires together) is to reset (push in) the circuit breaker. Offered with instructions at 15/- each. (Will save its cost in time and temper in no time.)

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This is a small thermostat which cuts on and off at around freezing point. Has many uses, one of which could be an ice warning device to be fitted under your motor car. Price 7/6. Post 1/-.

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Adjustable over a fairly wide range of temperatures but set for 70°F. suitable for wall mounting to control room heaters. Exceptional bargain at 9/6, plus 1/- post and ins. Crackle finished and calibrated case, suitable for mounting this (only minor adjustment), 5/- extra.

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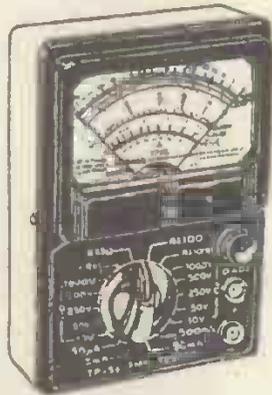
SIMMERSTAT HEATER REGULATOR

Suitable to control elements, heaters, soldering irons, and boiling rings up to 2,500 watts. Complete adjustable, normal price 56/- each, special snip price 12/6, plus 1/6 postage and insurance.

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MODEL TPS5. (Illns. on left). 20,000 ohms per volt. D.C. volts, 5 ranges up to 1,000. A.C. volts, 5 ranges up to 1,000, resistance, 2 ranges up to 10 meg., capacity, 2 ranges up to .1 decibels — 20 to 26. One switch control, really beautifully made precision instrument, size only 3 1/2 x 5 1/2 x 1 1/2 in., price only £5/19/6. Post free.

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In the "de-luxe" cabinet as illustrated it costs £10/19/6 to build—but what a set!

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Specification: Dimensions: 6 1/2 x 2 1/2 x 1 1/2 in., weight: 14 oz.; recording time: 12 mins.; rewinding time: 4 mins.; recording system: D.C. Bias; erasing system: Magnetic erasing, wow and flutter: within 2% and frequency response: 500-1,200 c/s (within -6dB).

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Make up one of these latest



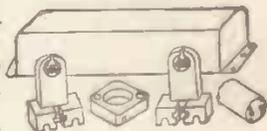
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Power Output: 10W, 20W, 50W, or
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Input for Specification Output: 250 mV

Total Harmonic Distortion: 0.1% at full output

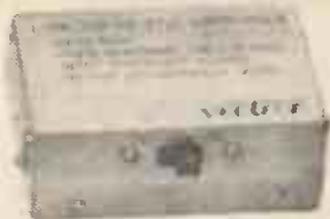
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Signal/Noise-Ratio: Better than 80 dB

Damping Factor: More than 50

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Size: 11 x 4 x 7 $\frac{1}{2}$ inches



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Input Impedance: More than 30 K ohms

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Noise level is better than -60 dB at

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Supply: A long service battery is supplied
with a life of 350 hours

Size: 3 $\frac{1}{2}$ x 1 $\frac{1}{2}$ x 2 $\frac{1}{2}$ inches



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Output Signal: 15 mV

Output Impedance: Less than 100 ohms

Frequency Response: 250 c/s-3,500 c/s

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Supply: A long service battery is supplied with a
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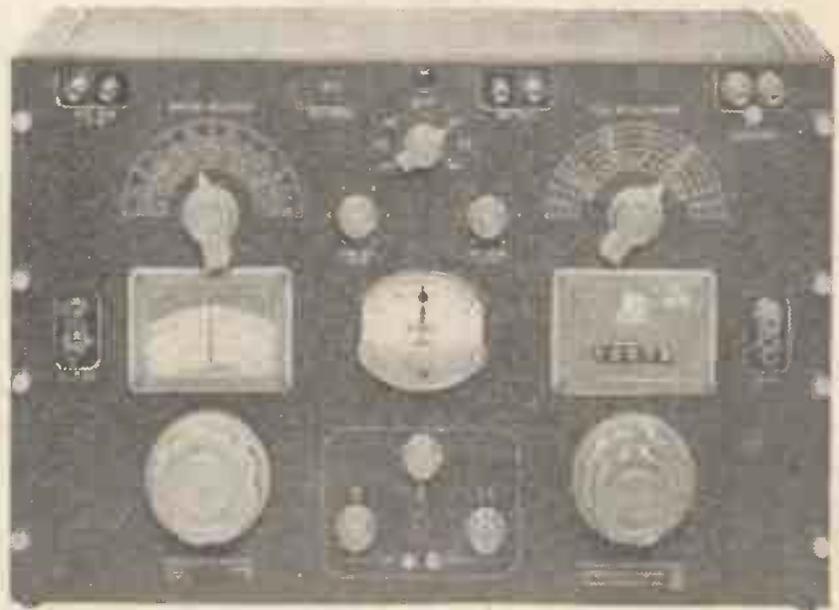
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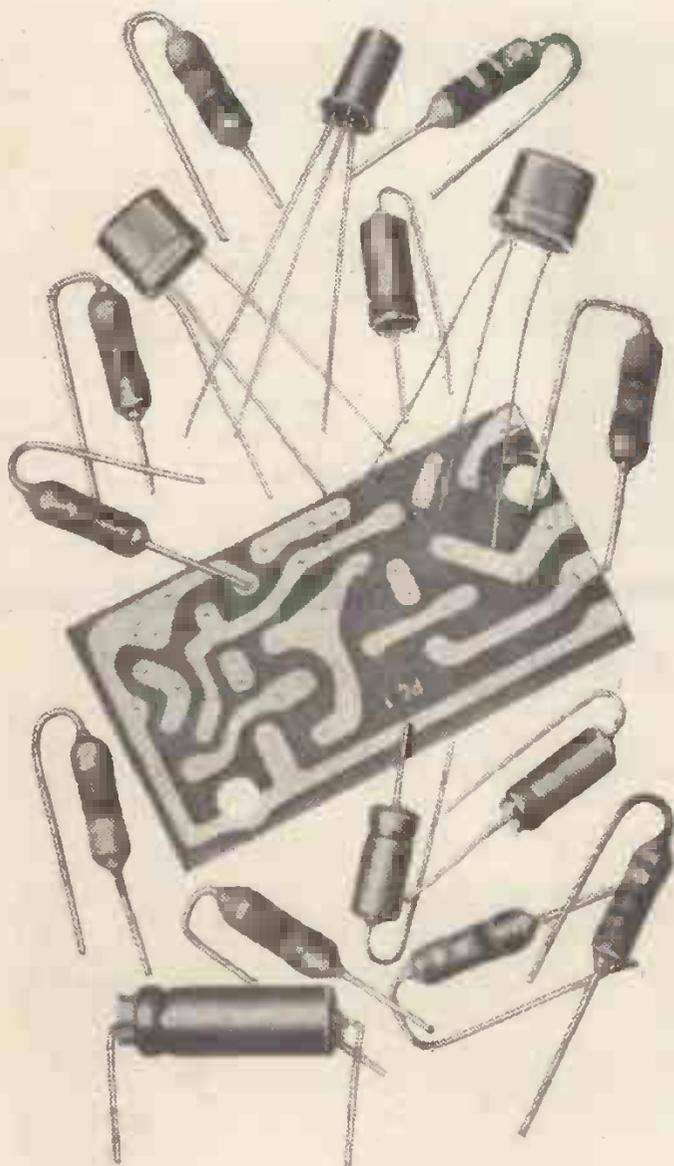
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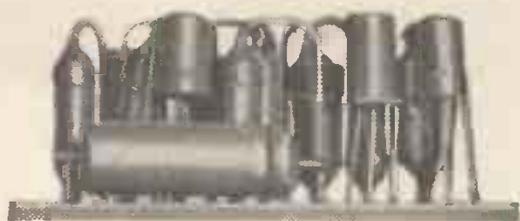
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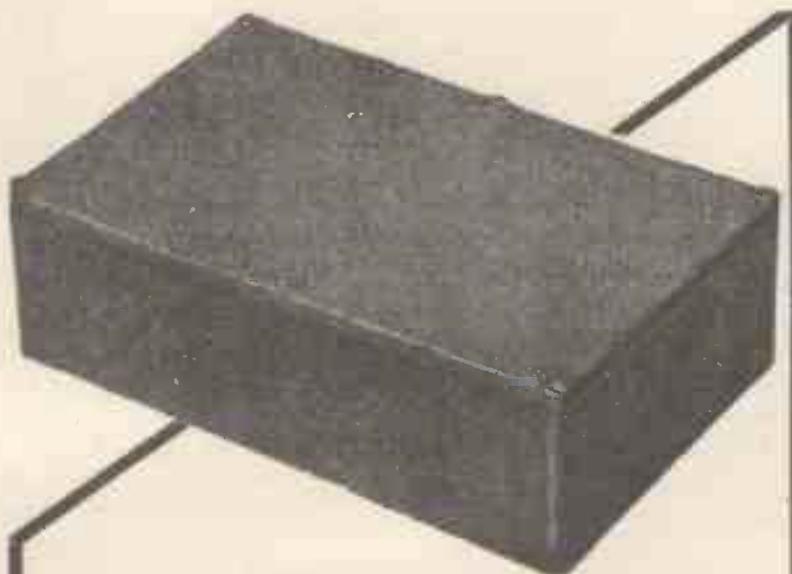
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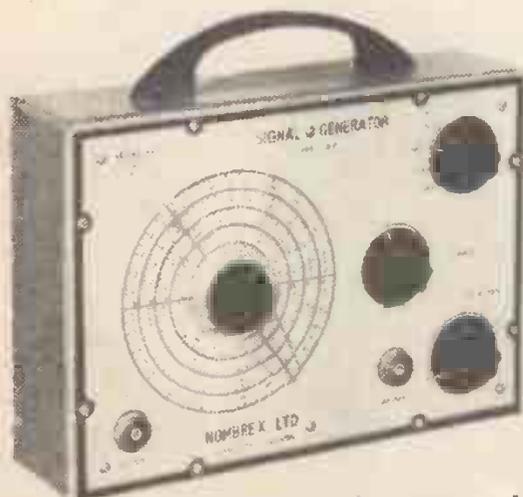
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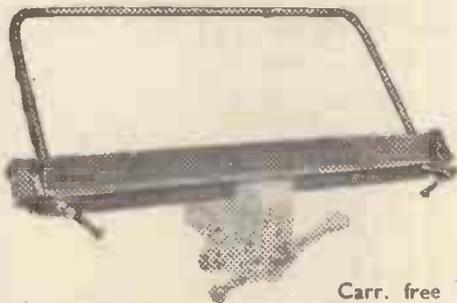
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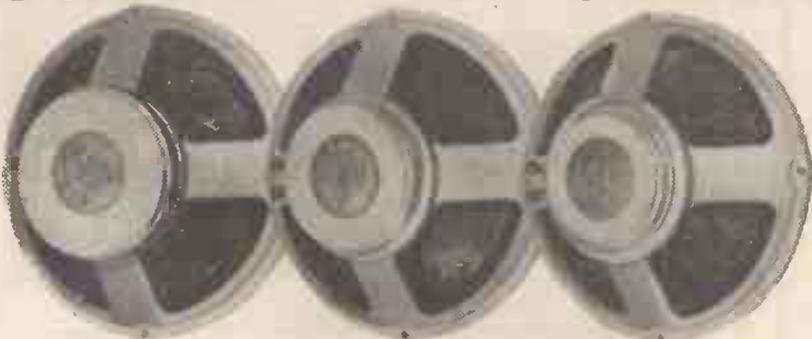
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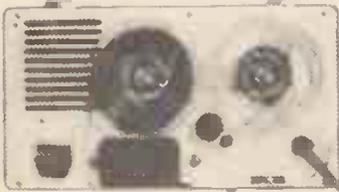


Illustration shows top of deck.

19 Gns.

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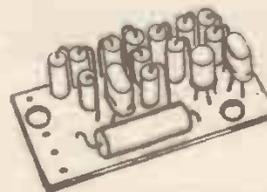
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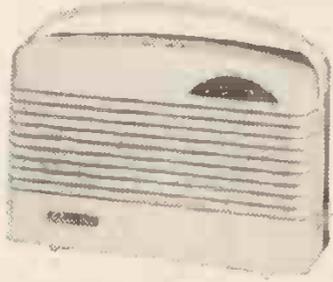
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The finest receiver at present available for home construction

Fully tunable long and medium wavebands. Uses 7 Mullard Transistors: OC44, 2OC45's, OC71, OC81D and 2OC81's, plus Crystal Diode OA70.

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- ★ A 6-transistor plus 2-diode superhet receiver using the latest circuitry.
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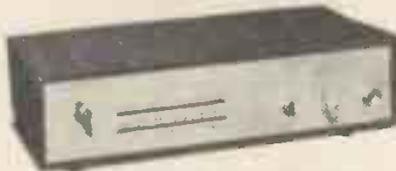


LASKY'S PRICE

£15.19.6

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LASKY'S PRICE £16.19.6

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- L50 50-watt 22 Gns.
- L5/5 Amplifier and Pre-amp. 12 Gns.
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High impedance Record/ Lasky's
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 Upper or lower track. Post free
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- GARRARD 4HF, stereo or mono, with plug-in head £16 19 6
 - GARRARD 301 £20 12 0
 - GARRARD 301 (Strobe) £22 0 0
 - GARRARD A with GC8 £19 14 0
 - GARRARD A with GSC10 £20 10 0
 - PHILIPS AG/1016 £12 12 0
- Carr. and Ins. 5/-.
 Also Lenco, Connoisseur, etc.

DISTLER MINIATURE MOTORS

6 volt battery operated. 7/11
 P. & P. 2/6.

20,000 VALVES IN STOCK AT NEW LOW PRICES

Brand new surplus and imported, also full stocks of B.V.A. valves. List post free.

SUB-MIN COMPONENTS

As used in the smallest Japanese pocket transistor radios. Coils, loudspeakers, I.F. transformers. Ganged Condensers, etc., in stock at lowest prices. Also all T.S.L. transistorised Miniature Units.

TRANSISTORS

All Brand New and Guaranteed

- GET.S1 2/6; GET.S5 2/6; GET.S6 2/6;
- GET.873A 3/6; GET.874P 3/6; OC44 7/6;
- OC45 6/6; OC70 6/6; OC71 6/6; OC72 8/-;
- OC73 16/-; OC75 8/-; OC76 8/-; OC81D 6/6;
- OC28 19/6; OC81 (matched) 8/6 pair 13/-.

SPECIAL PRICES FOR QUANTITIES.

STAAR KINDER RECORD PLAYER

45 r.p.m., 6 v. Battery operated. Complete with pick-up fitted crystal cartridge. Size only 7 1/2 x 6in. Fitted auto. stop and start. New and perfect. LASKY'S PRICE 49/6. P. & P. 2/6.

2 speed model for 33 1/2 and 45 r.p.m. 79/6. P. & P. 2/6.

ONE WATT FULLY TRANSISTORISED AMPLIFIER

Can be used with Staar Kinder to make a fully portable record player. Incorporates two GET114 and two power transistors, in push-pull output. Fully built. Complete with tone and volume controls, on printed circuit. Size 2 1/2 x 2 1/2 x 1 1/2in. Uses 9 v. PP11 or similar battery. Complete with 3in. P.M. speaker. LASKY'S PRICE 49/6. P. 2/-.



CELLULOSE WADDING

For lining the interior of loudspeaker enclosures. Width 36in.: Any length cut to nearest 6in. LASKY'S PRICE 2/11 per sq. yard and pro-rata. P. & P. extra.

HEADPHONES

High impedance. 14/6 per pair. A.K.G. Model K.50 Stereo headphones, superb quality moving coil headphones. Low impedance 27/10/- per pair including ear pads.

TESLA SONET DUOTAPE RECORDER

Continental manufactured. 2 speed Tape Recorder with 1 1/2 and 3 1/2 i.p.s. Twin Track Recording to International standards. Takes 5 1/2in. spools. Fast forward and fast re-wind.

- ★ Record level indicator.
- ★ Inputs for Microphone, Radio and Pick-up.
- ★ For use on 110 and 200/250 volts, 50 c.p.s. mains
- ★ Digital position indicator. ★ In attractive wood case with metal top cover. Fitted with storage compartments and carrying handle. Size 13in. x 10in. x 7in.
- ★ High quality record-replay amplifier with internal loudspeaker provides immediate high quality reproduction.
- ★ Socket for internal speaker.
- ★ Tone control.
- ★ Supplied with reel of tape, empty spool, microphone and a selection of inter-connecting leads etc., with canvas waterproof cover. Brand new and unused.

LASKY'S PRICE 24 Gns. Carr. and Ins. 10/6.

SEE OVERLEAF FOR MORE NEWS FROM LASKY'S RADIO

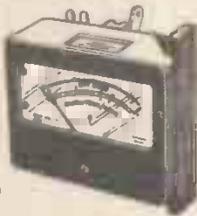
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HIGHLY SENSITIVE METER

High-grade, 2½in. rectangular scale, 0-50 micro-amp. meter by Sangamo Weston which provides an excellent basis for a really sensitive multi-meter, valve voltmeter, etc. At present calibrated in Rontgens/Hour, but complete scale can be simply removed, pasted over and re-calibrated. An extra feature is a spring-loaded scale change slide which can be moved to any of four positions in conjunction with a range change switch, if required. Unused in original package and fully guaranteed.



25/-

Post free

GREER MICRO-MANOMETER A novel and highly sensitive, de-focusing, photo-electric pressure transducer having an output large enough to operate a pen recorder. Supplied as a basic laboratory nucleus which is suitable for a variety of applications and consisting of transducer, rigid precision cast chassis and mirror system. Photo transistors, minor components and a 6 v. supply only are required to provide a manometer for operating a meter or pen recorder, the maximum output being about 3.5 v. (2.5 mA) for a pressure of 30 cm. H₂O. Drift is approx. 1 to 2 mV. per two hours so that pressure of 1 mm. of water may readily be measured using an amplifier or micro-ammeter. Frequency response is 3 dB down at 400 c/s. Full technical information, calibrating instructions and suggested circuitry supplied. Complete and calibrated instruments can be supplied. Prices on request.

£9. 10s.

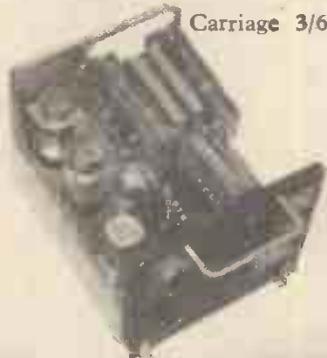
ANTENNA BEAM ROTATING MOTOR 55/- Carr. 7/6

Magnificent series wound, split field motor which is ideal for beam rotation, winch operation, etc. Extremely robust unit incorporates a 600 to 1 epicyclic gearbox (output speed 12/15 r.p.m.) and a magnetic brake to prevent overrun, together with limit switches which allow rotation of approximately 3 turns in either direction. Originally designed for use on 24 volt D.C. to actuate cowl gills on aircraft, but limit switches can be disconnected to provide continuous running in either direction and removal of magnetic brake enables unit to be operated on any voltage between 6 and 30 volts A.C. or D.C. Size overall: 12 x 3½in. diam. with ½in. diam. splined driving shaft x ½in. long. Current consumption: 4 to 6 amps. at 24 volts D.C. Unused in original cartons.



25c/s TUNING FORK DRIVE AMPLIFIER 60/- Carriage 3/6

Modern, light-alloy cased, drive unit Type 114 containing a robust 8½in. induction sustained, 25 c/s. tuning fork with attendant induction pick-ups and waveform amplifier comprising 2 x DF50, CV1092 diode, and 6L6 output. Power is derived from a high cycle transformer (easily replaced by a mains type) together with a 5U4G rectifier and VS11Q stabiliser. High grade components throughout. Easily removed, flexibly mounted tuning fork assembly can be separately energized from 6.3 volts A.C. only. Case size overall 8½ x 7½ x 10½in.



EXCLUSIVE OFFER—MICRO-MINIATURE TRANSISTOR AMPLIFIERS

Completely encapsulated, top quality, ultra-modern equipment originally designed for famous Hearing Aids. Type 2: 3 transistors, rectangular pattern, size ½in. x ½in. x ½in. thick. Gain 40dB, frequency response substantially flat over 500—3,000 c/s. Ideal for probe units, signal tracers, electronic stethoscopes, etc. Operates from miniature Mallory Cell, size only ½in. diam., ½in. thick. Complete with wiring instructions. 35/- Post free

4-TRANSISTOR AMPLIFIER 45/- Post and Packing 1/6

Specifically designed for general use in Portable Gramophones, Radios, Intercoms, Tape Recorders, etc. Latest circuit design with transformer coupled transistors in Class B operation. Two separate inputs and 3 ohms output to match standard loudspeakers. Built on printed circuit board and measures only 4½in. x 1½in. x 5in. high. 200 mW. high quality output, completely wired and tested with flying leads, battery, snap-on clip, circuit and instructions. Uses transistor radio 9 volt battery.



VACUUM SEALED ARMATURE RELAYS

Size 1½ x 1½ x 1½in. high excluding contacts and mounting studs and in unused, perfectly sealed condition. All with 1,000 ohm energising coils except where otherwise stated.



Type 1790 (10F/18937), 1 single pole changeover and one 2 pole changeover.

Type 1791 (10F/18938), 3 separate pairs of contacts (made when coil is energised).

Type 1792 (10F/18939), 3 separate single pole changeover switches (1400 coil).

Type 1793 (10F/18940), 1 single pole changeover switch. 8/6 Post and Packing 1/6.

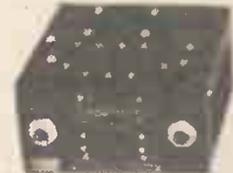
TYPE 102A INVERTOR

Input: 28 volts D.C. Output: 115 volts. 400 c/s, 3-phase A.C. at 625 VA. In excellent unused condition. Size: 11in. x 5½in.



TYPE 34 REGULATOR (5UC/5820)

Self-contained voltage and frequency control unit for use with Type 102A Invertor. Both units complete £15 Carriage 10/-.



SMITH'S HYSTERESIS MOTOR 30/- Post and packing 2/-



Input 115 volts, 3 phase, 400 c/s. Output torque 25 gm. cm. at 12,000 r.p.m. Size (excl. contacts and spindle) 2½in. long x 1½in. dia. Driving spindle 0.165in. dia. x ½in. long. Unused in original packing.

PHOTO MULTIPLIER 30/- P. & P. 1/6

Type 27M1 by Ediswan and directly equivalent to RCA Type 831A. Specially produced with flying leads and without valve base, but absolutely unused in original packing.

COLD CATHODE TRIGGER TUBES

Sub-miniature cold cathode valve developed by Ericsson primarily for computer work. 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 microseconds. Will withstand up to 310 volts with zero trigger voltage without self-igniting. Complete with full performance data in original packs of 100 at the special price of £5.0.0

Minimum quantity supplied: 6 for 10/-, post paid. Post paid

ETCH YOUR OWN PRINTED CIRCUIT KITS 21/- post free

Each contains over 60 sq. in. of laminated board and sufficient chemicals to make dozens of printed circuits, plus comprehensive instruction book giving advice and examples on translating theoretical circuits into layouts ready for etching. High quality materials—completely safe to handle—carefully prepared to ensure fine definition and uniform results without laboratory control.

GEIGER COUNTER TUBES

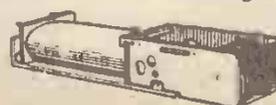
Brand new, individually tested, fully guaranteed, low voltage Halogen-quenched Geiger Mueller tubes specially manufactured by 20th Century Electronics Ltd. Highly sensitive and similar to tubes fitted in high-grade instruments. Used in demonstration counters on B.B.C and I.T.V. television programmes. IDEALLY SUITED FOR HOME-BUILT GEIGER COUNTERS, BASIC EXPERIMENTATION, INSTRUCTION, and for serious work also. Circuits of simple all-transistor and conventional valve counters supplied on request to purchasers. 25/- Post & Packing 2/-.

COPPER LAMINATE BOARD

Excellent quality single sided Copper Laminate on 1/16in. thick backing board. Sizes 6in. x 3in.—3 panels for 6/- Post free. 10in. x 8in.—7/- each. Post free.

ELECTRO/MECHANICAL COUNTERS 10/- Post and Packing 1/6

Ultra modern, miniature style, precision made units reading 0.9999. Fitted with 300 ohm coil. Size overall only: 3½in. long x ½in. square. In excellent guaranteed condition.



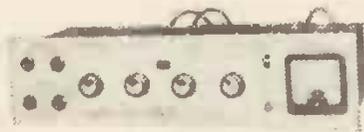
Stern's

SPECIALISTS IN SOUND EQUIPMENT FOR OVER 25 YEARS

STEREO TAPE PRE-AMPLIFIER

Model STP-1. For use with current TRUVOX, BRENELL or COLLARO "STUDIO" 1/2 and 1/4 track Stereo Decks. Incorporates Ferroxcube Oscillator, 4-speed Equalisation Signal Level Meter and separate Gain Controls. Includes separate Power Unit.

KIT OF PARTS **£22.0.0** ASSEMBLED AND TESTED **£28.0.0**



MULLARD'S TYPE "C" TAPE PRE-AMPLIFIER

Suitable for most 1/4-track Mono Tape Decks. Incorporates Ferroxcube Push Pull Oscillator and 3-speed Treble Inductor. Includes separate Power Unit.



Kit of parts..... **£14.0.0**
Assembled **£19.10.0**

MULLARD'S TAPE AMPLIFIER (Model HF/TR3)

Based on Mullard's Type "A" design and suitable for most 1/4 track Mono Tape Decks. Incorporates Ferroxcube 3-speed Treble Inductor and Gilson Output Transformer. Includes separate Power Unit.



Kit of parts **£13.13.0** Assembled **£19.10.0**

STERN'S "ADD-A-DECK"

A self contained Unit consisting of Garrard Deck and matched Pre-Amplifier on one chassis. Provides full tape recording facilities and replays through Pick-up Sockets of standard Radio receiver or Amplifier.

PRICE Includes Spool of Tape **£18.18.0**



TAPE DECKS and COMPLETE RECORDERS

By Collaro, Brenell, Truvox, Wearite, Grundig, Ferrograph, Philips and others Descriptive leaflets readily available.

THE "TUDOR" AM/FM TUNING UNIT

A SELF-POWERED HIGH FIDELITY TUNER OF OUTSTANDING DESIGN. PROVIDES FULL COVERAGE of the VHF/FM TRANSMISSIONS and also the LONG and MEDIUM WAVEBANDS.

PRICE ONLY **£19.19.0**

Operates perfectly with the STERN-MULLARD AMPLIFIERS and contains matching FRONT PANEL in Black/Gold or White/Black. Also operates equally well with any Amplifier requiring input of 100 to 350 mV/Volts.

Mk. II "Fidelity" FM TUNING UNIT

KIT OF PARTS **£10.10.0**

An attractively presented Unit incorporating MULLARD PERMEABILITY TUNING HEART and corresponding Mullard valve line-up. Very suitable to operate with our Mullard Amplifiers.

ASSEMBLED AND TESTED **£14.5.0**

ARMSTRONG RADIOGRAM CHASSIS

FULL RANGE IN STOCK, ALL PROVIDES AM and FM RECEPTION.

Model STEREO 12 Mk. 2 **£40.5.0**
10 watts (illustrated)



The most complete chassis ever produced, combines AM and FM Tuners, a Stereo Control Unit and two High Fidelity Amplifiers in one compact unit, provide a total of 16 watts for both mono and stereo. Other features include: inputs for tape recording, play back, pick-ups and stereo radio (should this come about); separate wide range bass and treble controls and balance control.

Model STEREO 85 **£29.18.0** Model AF 208 **£21.4.0**
5 Watts 5 Watts

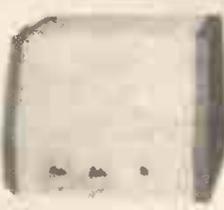
Model JUBILEE Mk 2 **£28. 5.0** Model TVB VHF TUNER **£20.8.0**
8 Watts A self-powered tuner of outstanding design

STERN'S INTER-COMM. or BABY ALARM

Employing the new MULLARD ECL86 valve to provide two (or three) way conversation up to extreme distances. Operates from A.C. mains 200 to 250 volts.

PRICES—MASTER UNIT and ONE EXTENSION. KIT OF PARTS **£6.17.6** ASSEMBLED and TESTED **£8.0.0**

Consists of a MASTER UNIT, size only 8 1/2 in. x 5 in. x 8 in. and ONE EXTENSION (a second extension may be added at any time).



!! COMBINED PRICE OFFERS !!

Includes small charge for special testing and PRECISE MATCHING of the ASSEMBLED PRE-AMPLIFIER (or Amplifier) to TAPE DECK.

STP-1 (Kit) and "STUDIO" Deck	£39	0	0
STP-1 (Assembled) "STUDIO" Deck	£46	0	0
STP-1 (Kit) and Brenell Deck	£66	0	0
STP-1 (Assembled) Brenell Deck	£75	0	0
STP-1 (Kit) and Truvox Deck	£51	0	0
STP-1 (Assembled) Truvox Deck	£59	0	0
TYPE "C" (Kit) and "STUDIO" Deck	£26	10	0
TYPE "C" (Kit) and BRENELL Deck	£43	0	0
TYPE "C" (Assembled) and WEARITE Deck	£70	0	0
HF/TR3 (Kit) and "STUDIO" Deck	£28	0	0
HF/TR3 (Kit) and BRENELL Deck	£42	0	0
HF/TR3 (Assembled) and WEARITE Deck	£70	0	0
Assembled	£33	0	0
Assembled	£50	0	0
(Includes Head Lift Transf.)			
Assembled	£33	0	0
Assembled	£50	0	0
(Includes Head Lift Transf.)			

To build a complete TAPE RECORDER . . . We offer HF/TR3 AMPLIFIER . . . STUDIO DECK . . . PORTABLE CASE . . . ROLA 10 x 6 SPEAKER . . . MICROPHONE and 1200ft. TAPE . . . ALL FOR **£35.0.0**

ALTERNATIVELY WE OFFER . . . THE COMPLETELY ASSEMBLED and GUARANTEED PORTABLE RECORDER MODEL CR3/5 . . . FOR **£43**

Stereo Amplifiers

MULLARD'S "10+10" STEREO AMPLIFIER

A HIGH FIDELITY DESIGN PROVIDING UP TO 10 WATTS (per channel). SUPERB REPRODUCTION FREQUENCY RESPONSE FLAT TO WITHIN 3db from 3 c/s to 80 Kc/s at 50 mW.



TOTAL HARMONIC DISTORTION AT 10 WATTS. 0.1%.

PRICE: (a) ASSEMBLED AMP-LIFIER (as illustrated) **£24.0.0** (b) A complete KIT of PARTS for **£20.0.0**

Built to the highest technical standards and presented strictly to MULLARD'S Specification. Two specially designed GILSON OUTPUT TRANSFORMERS with 20% taps are used.

We can also supply the assembled MAIN AMPLIFIER only for operation with our DUAL CHANNEL PRE-AMPLIFIER; this provides for a more versatile installation and is essential if a low output Magnetic Pick-up is to be used. When ordering specify loudspeaker impedance.

(a) THE ASSEMBLED MAIN AMPLIFIER and ASSEMBLED DUAL CHANNEL PRE-AMP **£34.0.0**

(b) KIT OF PARTS for both Units. **£27.0.0**

THE "TWIN THREE" STEREO AMPLIFIER ASSEMBLED AND TESTED for **£9.0.0**

(Carr. & Ins. 7/8 extra).



Based on a recent design by MULLARD LTD. is ideally suited for use in PORTABLE RECORD PLAYERS for which purpose we offer a specially designed Case:

It incorporates MULLARD ECL86 Valves, separate BASS and TREBLE CONTROLS and produces up to 3 watts per channel. Frequency response is 40 c/s to 30 Kc/s, size 11 1/2 in. x 3 in. x 5 in.

To construct a STEREO PORTABLE RECORD PLAYER we offer:— Assembled AMPLIFIER with two ROLA 8 in. x 5 in. LOUDSPEAKERS and PORTABLE CASE for **£16/10/0** (Carr. & Ins. 7/8 extra).

MULLARD DUAL CHANNEL PRE-AMPLIFIER

A four Valve design for both STEREOPHONIC and MONOPHONIC operation. Operate equally well with any make of Amplifier requiring input of up to 250 mV.

KIT OF PARTS **£12.10.0**

ASSEMBLED and TESTED **£15.0.0**



The "TUDOR" STEREO AMP-LIFIER PRICE ONLY **£18.18.0**

A self contained Amplifier designed to provide high quality stereophonic and monophonic reproduction. Each channel provides a rated output of 6 watts and for monophonic operation approx. 12 watts is produced. Separate BASS and TREBLE CONTROLS

TERMS are available on Equipment over..... **£10/0/0**

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Stern's

MULLARD DESIGNS

Designed by MULLARD—presented by STERNS strictly to specification.

COMPLETE KITS OF PARTS

MULLARD 3-VALVE PRE-AMPLIFIER TONE CONTROL UNIT

Designed mainly for the STERN/MULLARD range of monophonic Power Amplifiers, but also suitable for any Amplifier requiring an input signal up to 250 mV. Five inputs, including one equalised for replay direct from high impedance tape head, and one for low output magnetic pick up. Output for tape record. Separate Bass and Treble controls. High Pass Filter 20 to 160 c/s. Low pass Filter 5 to 9 Kc/s. Power requirements 250 v. at 6 mA., 6.3 v. at 0.8 amps. Totally enclosed case silver hammered. Size 11½ x 4½ x 4in. Front panel. Polished perspex in choice Black or white.



KIT OF PARTS **£10.10.0**

ASSEMBLED & TESTED **£13.13.0**

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.

- ★ Equalisation for the latest R.I.A.A. characteristic
- ★ Input for Crystal Pick-ups and variable reluctance magnetic types.
- ★ Input (a) Direct from High Imp. Tape Head.
- ★ Input (b) From a Tape Amplifier or Pre-Amplifier.
- ★ Sensitive Microphone Channel. Wide range BASS and TREBLE Controls.



KIT OF PARTS **£6.6.0**

ASSEMBLED AND TESTED **£9.10.0**

COMBINED PRICE REDUCTIONS

(a) The KIT OF PARTS to build both the "5-10" Main Amplifier and the 2-Valve Pre-Amplifier...

£15.15.0

(a) The "5-10" and the 2-Valve Pre-amplifier both Assembled and Tested

£21.10.0

(b) KIT OF PARTS to build the "5-10" Main Amplifier and 3-Valve Pre-Amplifier

£19.10.0

(b) The "5-10" and the 3-Valve Pre-Amplifier both Assembled and Tested...

£25.10.0

With PARTRIDGE OUTPUT TRANSFORMER **£1/6/-** extra.

MULLARD "5-10" MAIN AMPLIFIER

For use with MULLARD 2-stage pre-amplifier with which an undistorted power output of up to 10 watts is obtained. SPECIFIED COMPONENTS AND MULLARD VALVES including PARMEKO MAINS TRANSFORMER and choice of PARMEKO or PARTRIDGE Output Transformer.

£10.0.0

COMPLETE KIT (Parmeko Output trans) **£13.10.0**

ASSEMBLED AND TESTED ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER **£1/6/-** extra.

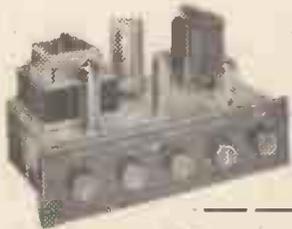


THE MULLARD 33/RC

A HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-WATT MULLARD "3-3" DESIGN.

KIT OF PARTS **£8.8.0** ASSEMBLED AND TESTED **£11.10.0**

Complete to the MULLARD specification including PARMEKO OUTPUT TRANSFORMER. Switched inputs for 78 and L.P. records plus a Radio position. Power to drive a Radio Tuner is also available.



THE MONO-GRAM

A small Amplifier of genuine high quality performance. Incorporates new MULLARD ECL86 Valve separate BASS and TREBLE controls and produces up to 3 watts undistorted output.

KIT OF PARTS **£4.10.0**

ASSEMBLED AND TESTED **£6.10.0**



Perfectly suited for Portable Installations for which purpose we offer... PORTABLE CASE **£3/10/-**, the AMPLIFIER (KIT) and 8 x 5in. SPEAKER (**£1**). All for **£9**. Alternatively with ASSEMBLED AMPLIFIER **£10**.

The case quoted above will accommodate some 4 speed Single Record Units. A larger model for autochanger is available for extra **10/-**. With this Equipment a COMPLETE PORTABLE RECORD PLAYER CAN be built for **£14**.



MULLARD FOUR CHANNEL MIXING UNIT

Self powered 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 **£11.10.0**

Alternative Model I/L provides for one input matched for moving coil or ribbon mike **£1/17/-** extra.



THE MULLARD 510/RC AMPLIFIER

The popular complete "5-10" incorporating Control Unit providing up to 10 watts high quality reproduction. Specified components and new MULLARD VALVES. Includes PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE Output Transformers.

Price: COMPLETE KIT **£12.0.0**

ASSEMBLED AND TESTED **£16.0.0**

With PARTRIDGE OUTPUT TRANSFORMER **£1/6/-** extra.



WE STOCK THE COMPLETE RANGE OF HIGH FIDELITY LOUDSPEAKERS BY GOODMAN'S, WHARFEDALE AND W.B. STENTORIAN

A few recommended examples:

8 INCH TYPES	12 INCH TYPES
GOODMANS "AXIETTE" £5 5 0	GOODMANS "AXIOM 201" £9 15 0
W.B. HF.816 £5 19 6	15 watts
WHARFEDALE "SUPER 8/RS/DD" £6 14 0	GOODMANS "AXIOM 301" £14 0 0
10 INCH TYPES	20 watts
GOODMANS "AXIOM 10" £5 16 8	W.B. Model HF1214 15 watts £10 5 6
W.B. Model HPI016 £7 0 0	WHARFEDALE "W12/RS" £10 10 0
WHARFEDALE "GOLDEN 10/RS/DD" £7 17 0	WHARFEDALE "Super 12/RS/DD" £17 10 0

ARE YOU PLANNING TO INSTALL HI-FI?

AND UNCERTAIN OF THE TYPE OF EQUIPMENT TO USE—OUR WIDELY EXPERIENCED TECHNICAL STAFF WILL WITH PLEASURE PUT FORWARD RECOMMENDATIONS—STATE TYPE OF INSTALLATION CONTEMPLATED AND APPROX. PRICE LEVEL.

CREDIT SALE TERMS are available on all Equipment over **£10**.

FULLY DESCRIPTIVE LEAFLETS are readily available—please enclose S.A.E.

LEAK and QUAD AMPLIFIERS

LEAK. "TL12 PLUS" POWER AMPLIFIER with the "POINT ONE PLUS" PRE-AMPLIFIER... 14 watts rated output	£31.10.0
LEAK. "TL25 PLUS" with the "POINT ONE PLUS" PRE-AMPLIFIER... 28 watts rated output	£37.16.0
LEAK. "STEREO 20" POWER AMPLIFIER with the "VARISLOPE STEREO" PRE-AMPLIFIER... 22 watts (11 watts per channel)	£55. 9.0
QUAD II. POWER AMPLIFIER with QUAD II CONTROL UNIT 15 watts output	£42. 0.0

RECORD PLAYERS

THE COLLARO "JUNIOR" 4-speed single player with separate crystal pick-up	£3.10.0
GARRARD Model SRP10 Single Record Player fitted with high output crystal pick-up	£5.0.0
THE NEW GARRARD "AUTOSLIM" 4-speed Autochanger with crystal pick-up	£7.10.0
GARRARD "AUTOSLIM DE LUXE" 4-speed Autochanger, incorporates transcription Pick-up Arm	£11.8.0
THE COLLARO "O60" 4-speed autochanger unit with Studio "O" pick-up	£6.19.6
B.S.R. Model UA14, a 4-speed Mixer Autochanger with crystal pick-up	£6.10.0
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	£16.17.6
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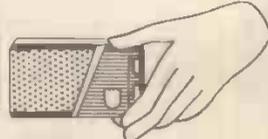
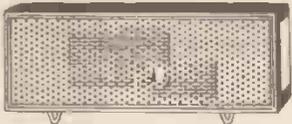
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The "LITTLE" SET with "BIG" PERFORMANCE



ORIGINAL PRICE IS **£26.5.0**

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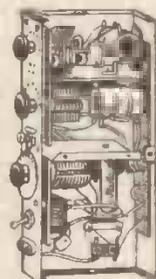
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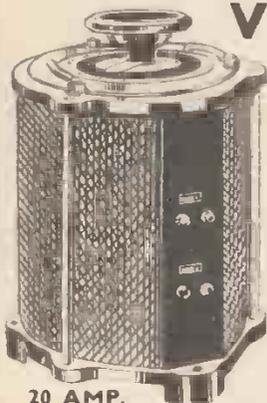
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20 AMP.



2.5 AMP.

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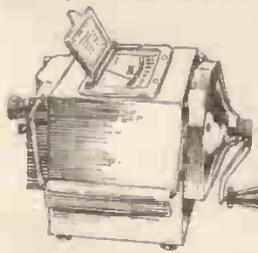
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7 Ampere A.C./D.C.

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Input 230 v. A.C. Output continuously VARIABLE from 0 to 260 volts A.C. OR 0 to 230 volts D.C. at 7 amps. Robustly constructed in metal case, complete with safety fuse, neon indicator and voltmeter. Size 17in. x 12in. x 7in. Weight 36lb. Price £34/10/-, carriage 20/-.



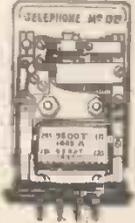
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1,750 ohms 100 watt. Wound on Ceramic former. In metal case with lin. x 1/2 in. spindle. New in maker's packing. 32/6. P. & P. 3/-.

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1 1/2 in. diameter, flush mounting, single hole fixing. Scaled 0-1 MA. Supplied with Resistor for use as 1 MA if required. This miniature instrument is fully tropicalised, and made to the highest Ministry standard.



29/6, plus 1/- P. & P.

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Very latest High Speed type ex P.O., guaranteed perfect, type No. 100B, coil 2,300 ohms, for 48 volt D.C. operation (will work on 36 volt), overall size 4 x 1 x 1 in. Also available, type 101A which can be used as an interesting accessory with our Strobe unit. Either type price 15/-. P. & P. 1/6. New Miniature Type 3 1/2 long x 1/2 square. 300 ohm coil 12 volt D.C. operation. Skeleton type (less outer cover), 10/- plus 1/6 P. & P.



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Type B16G 80 r.p.m. .26lb inch £1/19/6. P. & P. 2/-.

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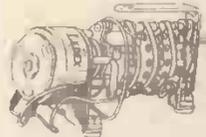
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24 volt D.C. operation. 2 Bank II position plus Homing Contact. A Miniature and compact form of uniselector. Ex-brand new equipment, 32/6. P. & P. 2/-.



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E25C5	25	50	70	5
E37.5C5	37.5	75	105	5
E50C5	50	100	140	5
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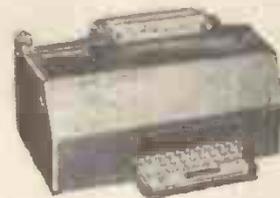
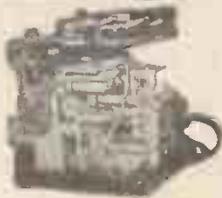
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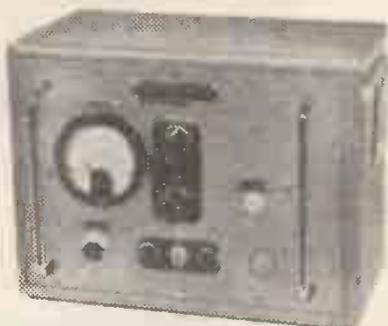


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SILICON RECTIFIER. 800 P.I.V. The Modern Marvel. 1/2in. x 1/2in. Can be used to replace T.V. rectifiers up to 500 mA. (40Ω ballast resistor). 7/6.

SANGAMO WESTON VOLTMETERS S61. Dual range 0-5 and 0-100 v. D.C. FSD 1 mA. 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.



ABSORPTION WAVEMETERS MARCONI TF-634B. Covers from 20 to 300 Mc/s in four plug-in coil ranges. Complete with individual calibration charts. Accuracy 1%. Indication is on a 50 mA 2 1/2in. panel meter. Self contained 1 1/2 v. battery. In original transit cases. Condition as new. £5/19/6. Carr. 7/6.

STANDARD SIGNAL GENERATORS MARCONI TF-144G. This covers from 85 Kc/s to 25 Mc/s with calibrated output from 1μV to 1 volt. It operates from A.C. mains 200 to 250 volts 50 cps. Stray radiation is virtually zero and monitor meter for "Set Carrier" and "Set Mod" is a 3 1/2in. panel meter. Supplied complete with mains lead and correct dummy aerial lead. **IN EXCELLENT CONDITION AND TESTED £25.** Carr. 30/-

L, C & R BRIDGES AVO. Capacity 5 pfd. to 50 mfd. Resistance 5 ohms to 50 Megohms. Inductance can be measured against external standard. Balance is indicated on a meter which can be used as a valve voltmeter from 0.1 to 15 v. Leakage test and Power Factor scale. A.C. mains operation. Tested and guaranteed and in superlative condition. £9/10/-, plus 5/- P. & P.

MINIATURE RELAYS (ALL BRAND NEW and BOXED)
G.E.C., sealed, wire ends, 670Ω, 2 H/D makes, M1099 10/6
G.E.C., sealed wire ends, 5,000Ω 2 c/o, plat., M1052 12/6

UNISELECTORS
25 position, 8 bank double wipers, 50 volt operation. Ex-equipment and tested. 45/-. Post 2/6.

LOUD-HAILER EQUIPMENT
IDEAL FOR CROWD CONTROL, FACTORIES, FETES, ETC. CONSISTS OF 4 SPEAKER UNITS AND CONTROL UNIT. COMPLETE WITH MICROPHONE, HEADPHONE AND SPARE. OPERATES FROM 12 VOLTS (D.C. OR 6 VOLTS A.C. WITH SLIGHTLY REDUCED OUTPUT) CONSUMING ONLY 3 AMPS. OUTPUT POWER 8 WATTS. ALL TESTED WORKING, BUT SLIGHTLY SOILED. A GENUINE BARGAIN. £4/18/8, CARRIAGE 25/6.

RECEIVER R 206 MK. 2
A super communication receiver with ALL the right features. 550 Kc/s to 30 Mc/s in 6 ranges. Turret tuning, osc. vernier control super slow motion tuning. Fantastic sensitivity. Complete with power supply and speaker and in good condition £16, plus carriage £2.

SEARCH RECEIVER
Type AN/APR4. Covers 38 to 1000 Mc/s. with 3 Plug-in R.F. Heads. TN 16 (38-95 Mc/s.), TN 17 (74-320 Mc/s.) and TN 18 (300-1000 Mc/s.). Self-contained power supply for 115 v. 50-2,600 c.p.s. Thoroughly reconditioned as new. In 100 per cent. mechanical and operational order. £100.

R 1475 RECEIVERS
Also known as receiver Type 88 these exceedingly versatile ex R.A.F. 11 valve receivers cover 2-20 Mc/s in four bands. Many unusual features such as 600 Kc/s. Xtal reference oscillator, Xtal controlled BFO, voltage stabiliser and variable selectivity are incorporated. The dial is exceptionally large and readable and sensitivity is of the order of 1 microvolt. In very good condition, complete with power unit (A.C. and 12 v.) and working order. £15. Carr. 10/-.

PCR COMMUNICATION RECEIVERS
Made by Philips these compact 6-valve receivers incorporate an RF, two IF and a full size output stage for loud-speaker use. There is a phone jack for moving coil phones. All sets are in PERFECT WORKING ORDER and give very fine results on short waves.
TYPE PCR has a self-contained speaker and covers 850 to 2,000, 200 to 550, and 16 to 50 metres. **AS NEW CONDITION** £6 19 6
TYPE PCR2 requires external speaker and covers 850 to 2,000, 200 to 550, and 13 to 50 metres. **USED (GOOD CONDITION)** £5 19 6
TYPE PCR3. Requires external speaker. Has medium and two short wave bands. Covers 200 to 550 metres, 2.5 and 7 Mc/s (120 to 43 Metres) and 7 to 23 Mc/s (43 to 13 Metres). **USED (GOOD CONDITION)** £8 8 0
CARRIAGE (any type) 10/6.

POWER SUPPLIES. The above receivers require 250 volts HT and 12 volts LT. We will supply any of the above receivers fitted with a **BRAND NEW INTERNAL POWER SUPPLY** for £2 extra. Fully guaranteed ready for use on A.C. mains.

CHARLES BRITAIN (Radio) LTD.
11 UPPER SAINT MARTIN'S LANE
LONDON, W.C.2 TEMple Bar 0545

Near Leicester Sq. Station. (Opposite Thorn House)
Shop hours: 9-6 p.m. (9-1 p.m.) Thursdays. Open all day Saturday



AVO MODEL 7 £11-0-0
AVO MODEL D £8-19-6

With Leather Case £1 extra.
All meters are in perfect working order and first-class condition. Complete with batteries, leads and instructions. Please add 5/- for registered post and packing.

MILLIAMMETERS
Panel meter 0-1 milliamp. Flush mounting circular. Barrel diameter 2 1/2in., outside diameter 3 1/2in. Dials are scaled 0-100. Resistance is 75 ohms. Fe & NFe. BRAND NEW. 25/-. P. & P. 1/-.
Meter Rectifiers (S.E.I.). 1 mA. 8/6.

GAUSS METERS
American type T5-15/AP. Made by Marion Electric for M.I.T. Radiation Lab. AS NEW. £7/10/-.

AR-88 SPARES
Escutcheons (Windows), 10/6.
Knobs. Medium size. Set of 8, 15/-.

Mains Transformer, 29/6. P. & P. 4/-.
Block Condenser (3 x 4 mfd.). 15/-.
P. & P. 2/6.

CONSTANT VOLTAGE TRANSFORMERS. Input 190 to 260 volts. 50 c.p.s. Output 115 volts at kVA. A pair of these will give a constant output of 230 volts at 4 kVA. Price £15 each, plus £1 carriage. Two for £30, carriage paid.

"C" CORE TRANSFORMERS
Pri. 230 v. 50 c.p.s. 510-0-510 at 275 mA. 375-0-375 at 83 mA. 6.3 at 9A. 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. 6 1/2 x 6 x 7 1/2in. high. Weight 25lb. Removed from equipment but in perfect condition. 32/6. Carr. 10/-.

HEAVY DUTY BLOWERS
For 200-250 v. A.C./D.C. mains, 300 watts. With 1 1/2 inch diam. twin "V" shape outlets. 2 lengths of hose. 4 spare filters and brushes. Suitable for industrial use, forges, etc. Brand new, £4/19/6. Carr. 10/6.

FERRANTI VOLTMETERS N5.
0-300 volts, 25-100 c/s. Moving iron, 6in. scale. Fl. mtg. Hermetically sealed, grade IN. Made 1955. BRAND NEW. Boxed. 79/6. Post 4/-.



INDUSTRIAL METER. Iron clad. 0 to 300 v. A.C. 50 cycle. Moving Iron. 6in. scale. Fl. mtg. BRAND NEW. 59/6. P. 4/-.

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ARMSTRONG AF208 AM/FM
RADIOGRAM CHASSIS



★ Full VHF Band (87-108 Mc/s.) and Medium Band, 187-570M ★ 7 Valves ★ 5 Watts Output ★ 15dB Negative Feedback ★ For 3, 7½ and 15 ohm speakers. Send S.A.E. for leaflet.

Price **£21.40** Carr. Free

Armstrong Stereo 12 Mk. 2 Chassis £40/5/-
 Two separate push-pull channels each 8 watts output giving 16 watts total, full coverage of VHF, medium and long wave-bands. Stereo and mono inputs for tape record, tape playback, radio and any type of pick-up.

Armstrong Stereo 55 Chassis £29/18/-
 10 watts output is available from two separate channels, each 5 watts. Full coverage of the VHF and medium bands.

C.R.T. BOOSTER TRANSFORMERS

For Cathode Ray Tubes having heater Cathode short circuit and for C.R. Tubes with falling emission, full instructions. Mains input, 10/6 ea.

TYPE A. LOW LEAKAGE WINDINGS, OPTIONAL 25% and 50% BOOST ON SECONDARY; 2 V. OR 4 V. OR 6.3 V. OR 10.3 V. OR 13.3 V. (State tube voltage required.)

BARGAIN SALE PRICES

New boxed VALVES 90-day guarantee

0Z4	5/-	6K7G	5/-	EABC80	8/-	PCL82	10/-
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1T4	3/-	8N7M	6/-	EBC81	8/-	PL83	8/-
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6BA6	7/-	12KB	14/-	EZ40	7/-	UBF80	9/-
6BE6	5/-	12Q7	5/-	EZ80	7/-	UCH81	9/-
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6C4	5/-	35L6	9/-	HABC80	10/-	UCL83	12/-
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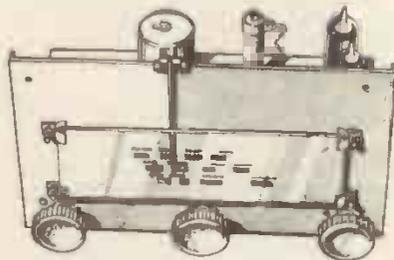
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TUBULAR	TUBULAR	CAN TYPES
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2/350v.	2/3	100/25v. 2/8
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8/450v.	2/3	500/12v. 3/-
16/450v.	3/-	1000/12v. 3/-
32/450v.	3/9	8 + 8/450v. 3/6
25/25v.	1/9	8 + 16/450v. 3/9
50/25v.	2/-	16 + 16/450v. 1/3
50/50v.	2/-	32 + 32/350v. 4/6
		16/450v. 5/-
		32/350v. 4/-
		47/350v. 6/6
		100/270v. 5/6
		5,000/8v. 5/-
		32 + 34/450v. 6/-
		32 + 32 + 32/350v. 7/-
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ADAstra 2-STAGE HI-FI AMPLIFIER
 READY BUILT, WIRED & TESTED
 A.C. only, 200-250 V. Valves ECL86 and EZ80. 3 watt quality output. Mullard tone circuits bass boost, treble and volume controls. Separate engraved front-panel with de luxe finish. Heavy duty output transformer 3 ohm. Quality mains transformer. Stove enamelled chassis size 6in. x 5in. x 3in. Bargain Price £4/19/6. Circuit supplied.

MORSE KEY with code—2/6; BUZZER—4/-.
 VALVEHOLDERS. Pax. int., oct., 4d. EA50, 6d. B12A. CRT, 1/3. Eng. and Amer. 4, 5, 6, and 7 pin 1/-.
 MOULDED int. Oct. or Mazda Oct., 6d.; B7G, B8A, B8G, B9A 9d. B7G with can. 1/6. B9A with can. 1/9. Ceramic. EF50 B7G, B9A, Int. Oct., 1/-; B7G, B9A cans, 1/- each.

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COMPLETE RADIO
CHASSIS £4.19.6 post 5/-



4 Mullard valves, 5in. speaker. Superhet Circuit, BRAND NEW. Size 9 x 6 x 5 1/2 in. high. Tested by us ready for use. 200/250 v. A.C./D.C. mains, as illustrated with illuminated dial. Fully tunable over medium and long wave. 12 months guarantee. Only £4/19/6 post 5/-.

MAINS TRANSFORMERS
200/250 AC Post 2/- each

STANDARD 250-0-250, 80 mA., 6.3 v., 2.5 a., tapped 4 v. 4 a., Rectifier 6.3 v. 1 a. tapped 5 v. or 4 v. 2 a. 22/8
 Ditto 350-0-350 28/8
 MINIATURE, 200 v. 20 mA., 6.3 v. 1 a. 10/6
 MIDGET, 220 v. 45 mA., 6.3 v. 2 a. 15/6
 SMALL, 220-0-220 v. 50 mA., 6.3 v. 2 a. 17/8
 STANDARD, 250-0-250 65 mA., 6.3 v. 3.5 a. 17/6
 HEATER TRANS., 6.3 v. 1 1/4 a. 7/8
 Ditto tapped sec. 1.4 v., 2, 3, 4, 6, 6.3 v. 1 1/4 amp. 8/8
 HEATER TRANS. 6.3 v. 4 a. 10/8
 GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 22/8
 AUTO TRANS. 150 w., 0, 115 v. 200, 230, 250 v. 22/8
 AUTO. TRANS. 500 w., 0, 115, 200, 230, 250 v. 82/8

PARMEKO MAINS TRANSFORMER. Made for special contract, the ratings can safely be doubled. Guaranteed 2 years. Primary 0-110-210-230-250 v. H.T. 300-0-300 v. 50 mA. L.T. 6.3 v. 1.8a. Weight 6lb. Price 17/6, post 2/8.
 MAINS POWER PACK. Size 3 1/2 x 4 1/2 x 4 in. with mains transformer, metal rectifier and condensers provides smoothed H.T. 220 v. 45 mA. D.C. L.T. 6.3 v. 2 a. Centre tapped A.C. Ready built on strong metal chassis. Brand new. Bargain 29/6. Post 2/8.
 MULLARD "510" MAINS TRANS. TO SPEC. 30/-

O.P. TRANSFORMERS. Heavy duty 50 mA., 4/6. Miniature 3V4, etc., 5/9. Small, pentode, 4/6. Multi-ratio, 7/6. Multi-ratio heavy duty push-pull 10 w., 15/6. Goodmans heavy duty 10/20 w. 6K push-pull, 30/-.
 Estone ultra-linear OT/ML 10 w., Spec. for "510" 45/-.
 INTERVALLE TRANSFORMERS. 3:1 4:1 5:1 9/-.
 L.F. CHOKES 15/10 H., 60/85 mA., 5/-; 10 H. 85 mA., 10/6; 10 H. 120 mA., 12/6; 10 H. 150 mA., 14/-.
 FULL WAVE BRIDGE CHARGER RECTIFIERS. 2, 6 or 12 v. 1 1/2 a., 8/9; 2 a., 11/3; 4 a., 17/6.
 Free charger circuit.
 CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v. 1 1/2 a., 15/6; 2 a., 17/6; 4 a., 22/6. Ammeter 0 to 5 a., 9/6.
 4 AMP. CAR BATTERY CHARGER with Ameter, Leads, Fuse, Case, etc., for 6 v. or 12 v., 69/6.

BOOKS (List S.A.E.)

"W.W." Radio Valve Data 6/-
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 COPPER ENAMEL WIRE 1lb. 16 to 22 s.w.g., 2/9, 24 to 30 s.w.g., 3/6, 32 to 40 s.w.g., 4/6.

CRYSTAL MIKE INSERTS. High Output..... 6/6
 Miniature size. 1 x 1 1/4 x 1 1/4 in. or dia. x 1 in.
 ACOS MIC. 60, insert 1 1/4 in. dia. x 1 in. 8/6
 ACOS STICK MIKE 39-1 35/-
 T.S.L. DE LUXE STICK MIKE 25/-

! TAX — CUT — PRICES !
BAKERS Quality Loudspeakers

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12in. Baker 15 w. Stalwart, 3 or 15 ohms 90/-
 12in. Stereo, foam suspension, 15 ohms £6/17/6
 12in. Standard 20 w. 40-14,500 c.p.s. £8.
 12in. Bass 25w. 20-18,000 c.p.s. £12/12/-
 12in. Ultra Twelve, 20 c.p.s. to 25 k/cs. £17/10/-
 15in. Baker Bass Auditorium, 35 w. MK. II. £18
 Details and Enclosure Plans S.A.E.

LOUDSPEAKERS. P.M. 3 OHM. FAMOUS MAKES. 2 1/2 in., 3 in., 4 in., 5 in., 7 in. x 4 in., 15/6 each; 4 in. Hi-Fi Tweeter, 25/-; 8 in. Plessey, 17/6; 6 in. Goodmans, 16/6; 10 in. E.A., 30/-; 12 in. Plessey, 30/-; 10 in. x 6 in. E.M.I. 22/6. E.M.I. 13 in. x 8 in., 35/-; Stentorian HF1012 10 in., 82/6; HF1016, £8/10/-; 12 in. R.A. 15Ω 35/-.
 CRYSTAL DIODES. G.E.C., 2/-; GEX34, 4/-; OAS1, 3/-.
 Crystal Coils HAX, 3/-; HAXL, 3/6; DRR2, 4/-; DRX1, 2/6.
 CRYSTAL SET BOOKLET 1/-.
 CRYSTAL SET KIT, 12/6.
 HEADPHONES, 4,000 ohms, 15/- pair. HEADPHONES, moving coil 100 ohms 10/- pair.
 SWITCH Cleaner fluid, squirt spout, 4/6 tin.
 TWIN GANG CONDENSERS "0-0." Transistor 208 pF and 176 pF, with trimmers and screen, 10/6 each; 365 pF, miniature, 1 1/2 in. x 1 1/2 in. x 1 1/2 in., 10/-; 500 pF standard with trimmers, 9/-; midget, 7/6; midget with trimmers, 9/-; 500 pF slow motion drive, standard or midget, 9/-.
 Small 3 gang, 500 pF, 17/6. Single "O" 365 pF, 7/6.
 SHORT WAVE. Single 10pF, 25pF, 50pF, 75pF, 100pF, 180pF, 5/6 each. 365pF, 7/6.
 TUNING AND REACTION CONDENSERS. 100 pF, 300 pF, 500pF, 3/6 each, solid dielectric.
 CONDENSERS. J.001 mid. 7kV. T.C.C., 5/6; ditto 20 kV., 9/6; 0.1 mid. 7 kV., 9/6; 100 pF to 500 pF Micas, 6d.; Tubular 500 v. 0.001 to 0.05, 9d.; 0.1, 1/-; 0.25 1/6; 0.1/350 v., 9d.; 0.5/500 v., 1/9; 0.01/2,000 v., 1/9; 0.1/2,000 v., 3/6.
 CERAMIC CONDENSERS. 500 v. 0.3 pF to 0.01 mid., 9d. 0.1/30 v., 1/3. High voltage pulse ceramics, 100 pF., etc., 2/6.
 SILVER MICA. 10% 5 to 500 pF., 9d.; 600 to 3,000 pF., 1/-; close tolerance (plus or minus 1 pF), 2.2 to 47 pF., 1/-; ditto 1% 50 to 815 pF., 1/-; 1,000 to 5,000 pF., 1/9.

465 Kc/s. SIGNAL GENERATOR.
 Price 15/- Uses B.F.O. Unit ZA 30038 ready made with valve 1S5. POCKET SIZE 2 1/2 in. x 4 1/2 in. x 1 in. Only one resistor to change! Full instructions supplied. Battery 8/6 extra. 69 v. + 1 1/2 v. Details S.A.E.

WAVECHANGE SWITCHES
 2 p. 2-way, or 2-p. 8-way, long spindle 3/6
 2 p. 4-way or 1 p. 12-way, long spindle 3/6
 4 p. 2-way or 4 p. 3 way, long spindle 3/6
 8 p. 4-way 2 water, long spindle 6/6
 Wavechange "MAKITS" Wafers available: 1 p. 12-way 2 p. 6-way, 3 p. 4-way, 4 p. 3-way, 6 p. 2-way.
 1 water, 8/6; 2 water, 12/6; 3 water, 16/- Additional wafers up to 12, 3/6 each extra.
 TOGGLE SWITCHES. s.p., 2/-; d.p., 3/6; d.p.d.t., 4/-.
 Rotary Toggles, s.p., 3/6; d.p., 4/6.
 JACKS. English open-circuit 2/6, closed-circuit 4/6.
 Grundig-type 3-pin, 1/3; Grundig Lead Type, 3/6.
 JACK-PLUGS, 3/-, Screened 4/-, Grundig 3-pin, 3/6.
 BULGIN NON-REVERSIBLE PLUGS AND SOCKETS
 P74 2-pin 4/3; P73 3-pin 4/6; P194 6-pin 5/6;
 Mains selector Panel with plug, 1/-.

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 choke. Circuit and component book using four 6AM6, 2/6.

COMPLETE Jason FMT1 KIT.
 Jason chassis with calibrated dial, all components and 4 valves. £6/5/-.
 Ready Built FMT1 Power Pack 29/6 extra.
MODEL FMT2 KIT
 with New Jason Cabinet, all components Power Pack and 5 valves £10. Or less Power Pack £8/5/0.

48-HOUR RETURN OF POST MAIL ORDER SERVICE

RADIO COMPONENT

Our written guarantee with every purchase. Buses 133 or 68 pass door. S.R. Stn. Selhurst.

! TAX - CUT - PRICES !

Volume Controls

Long spindles. Midget 5K ohms to 2 Meg. L/S 3/-. D.F. 4/6. Stereo L/S 10/6, D.F. 14/6. Linear or Log. Tracks.

80 ohm Cable Coax

Semi-air spaced 1/2in. Stranded core, 6d. yd. 40 yds. 17/6; 60 yds. 25/-. Fringe Quality, Air Spaced Losses Cut 50%. 1/- yd.

CAR AERIAL PLUGS 1/6. Ditto sockets 1/3. TRIPLEXERS, Bands I, II, III. 12/6. COAXIAL PLUGS 1/-. PANEL SOCKETS 1/-. LEAD SOCKET 2/-. COAX. OUTLET BOXES 4/-. BALANCED TWIN FEEDER 6d. yd., 80 or 300 ohms. TWIN SCREENED FEEDER 1/6 yd., 80 ohms. EXTENSION SPKR. CONTROL. 10 ohm 3/-. 25 ohm 6/6. TELESCOPIC CHROME AERIALS. 13in. extending to 43in., 8/6 each. Coax. Adaptor 1/6. RESISTORS. Preferred values. 10 ohms to 10 meg. 1/2 w., 4d.; 1 w., 4d.; 1 w. 6d.; 1 1/2 w., 8d.; 2 w., 1/-. HIGH STABILITY. 1/2 w. 1% 2/-. Preferred values, 10 ohms to 10 meg. Ditto 5%, 10 ohms to 22 meg., 9d. 5 watt } WIRE-WOUND RESISTORS 1/3 10 watt } 10 ohms-10,000 ohms 1/6 15 watt } 2/-. 12.5K to 47K 10 w. 3/-

I.F. TRANSFORMERS 7/6 pair 465 kc/s. Slug Tuning Miniature Can. 2in. x 1/2in. x 1/2in. High Q and good band width. Data sheet supplied.

WIRE-WOUND Pots. 3 WATT. Pre-set Min. TV Type. All values 10 ohms to 25K, 3/- ea.; 30K, 50K, 4/- Carbon 30K to 2 meg., 3/-. WIRE-SOUND 4-WATT STANDARD SIZE POTS. LONG SPINDLE. VALUES 50 OHMS to 50K. 6/6; 100K, 7/6.

TRIMMERS. Compression ceramic 30, 50, 70 pF, 9d.; 100 pF, 150 pF, 1/3; 250 pF, 1/6; 600 pF, 750 pF, 1/9. Philips 0 to 10 pF., 3 to 30 pF. 1/- each.

1963 RADIOGRAM CHASSIS



Three Wavebands S.W. 16 m.-50 m. M.W. 200 m.-500 m. L.W. 800 m.-2,000 m. Five Valves Latest Mullard ECH81, EF89, EBC81, EL84, EZ80

12-month guarantee. A.C. 200-250 v. 4-way switch. Short-Medium-Long-Gram. A.V.C. and Negative Feedback. 5 watts. Chassis 13 1/2in. x 5 1/2in. x 2 1/2in. Glass dial size 10in. x 4 1/2in., horizontal or vertical. Two Pilot Lamps. Four Knobs, Walnut or Ivory. Aligned and calibrated. Chassis isolated from mains.

BRAND NEW £8.19.6 Carr. 4/6.

Matched Speakers 8in. 17/6; 10in. 25/-; 12in. 30/-.

BLACK CRACKLE PAINT. Air drying, 3/- tin. RADIO SCREWDRIVER, 5in., 6d. NEON MAINS TESTER SCREWDRIVER 5/-. SOLDER RADIOGRADE 4d. yd., 1lb. 5/-.

HIGH GAIN TV PRE-AMPLIFIERS BAND I B.B.C. Tunable channels 1 to 5. Gain 18 dB. ECC84 valve. Kit price 29/6 or 49/6 with power pack. Details 6d. (PCC84 valves if preferred).

BAND III I.T.A. - same prices. Tunable channels 8 to 13. Gain 17 dB. Set of coils and circuit only, 9/6. Band I or III.

PAXOLIN PANELS. 1/2in. x 10in. x 8in., 2/-. RECTIFIERS. RM1 5/-; RM2 6/-; RM3 8/-; RM4 10/-; RM5 10/-; 14A100 10/-; 14A118 10/-. MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 mA., 7/6; 250 v. 60 mA., 8/6; 250 v. 85 mA., 9/6; 200 mA. 21/-; 300 mA. 27/6; Full Wave Bridge 250 v. 75 mA. 10/-; 120 mA. 15/-. Silicon 250 v. 450 mA. 10/-. SELENIUM RECT. Popular type. 300 v. 85 mA., 5/-. COILS. Wearite "P" type, 3/- each. OSMOR MIDGET "Q" type, adj. dust core, from 4/- each. TELETRON D.W.R. L. and Med. T.R.F. with reaction, 4/-; Medium only DR. 3/6. FERRITE ROD AERIALS, M.W. 8/9; M. and L. 12/6. FERRITE ROD AERIALS. L. and M. for transistor circuits. 10/- each. FERRITE RODS 8in. x 1/2in. 3/-. 6in. x 1/2in. 3/-.

QMAX CHASSIS CUTTER

The cutter consists of four parts: a die, a punch, an Allen screw and key.

Table with 4 columns: Die size, Punch size, Allen screw size, Key size. Values range from 1/4in. to 1 1/2in.

EXPERTS ANSWER ENQUIRIES

! TAX - CUT - PRICES !

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled, 4 sides, rivetted corners, lattice fixing holes, 2 1/2in. sides, 7in. x 4in., 4/6; 9in. x 7in., 5/9; 11in. x 7in., 6/9; 13in. x 9in., 8/6; 14in. x 11in., 10/6; 15in. x 14in., 12/6. ALUMINIUM PANELS. 18 s.w.g. 12in. x 12in., 4/6. 14in. x 9in. 4/-; 12in. x 8in. 3/-; 10in. x 7in. 2/3; 8in. x 6in. 2/-.

H.F. CHOKES 2/6. Osmor QC1 6/9. T.R.F. COILS A/H.F. 7/- pair; HAX 3/-; HAXL 3/6; DR2 4/-; DRX1 2/6. ALADDIN FORMERS and cores. 1/2in. 9d., 1in. 10d. 0.3in. FORMERS 5937 or 8 and cans TV1 or 2, 1in. sq. x 2 1/2in. or 1in. sq. x 1 1/2in., 2/- with cores. SLOW MOTION DRIVES. Epicyclic ratio 6-1. 2/3. SOLON IRON, 25 w. 200 v. or 230 v., 24/-; 65 w. 29/-. A.N.T.E.X. PRECISION sub-miniature iron, 200 or 240 v. 29/6. Stands for above irons 12/6 extra. Spares in stock for above irons.

EAGLE 4 TRANSISTOR PUSH-PULL AUDIO AMPLIFIER

Size 3 x 1 1/2 x 3/8in. A ready built miniature push-pull amplifier with input and output transformers, 4 transistors. Ideal for use with record players, intercoms, or "BABY ALARM" Complete with full instruction and circuit.

PRICE 52/6 9 v. Batt. 2/3. 2 1/2in. SPEAKER 15/- Xtal Mike insert, 6/6

MAINS DROPPERS. Midget. With adj. sliders. 0.3A. 1,000 ohms, 5/- 0.15A. 1,500 ohms, 5/- 0.2A. 1,200 ohms, 5/- 0.1A. 2,000 ohms, 5/-

TELEVISION REPLACEMENTS

Line Output Transformers from 45/- each. NEW stock. and other timebase components. Most makes available. S.A.E. with all enquiries.

MIKE TRANSFORMER 50 : 1, 3/9. P.V.C. CONN. WIRE, single or stranded, 2d. yd. TWIN P.V.C. FLEX, 2 amp., 4d. yd. SLEEPING, 1 or 2 mm., 2d.; 4 mm., 3d.; 6 mm., 5d. yd. ENAMELLED WIRE 1lb. 16 to 22 s.w.g. 2/9. 24 to 30 s.w.g. 3/6. 32 to 40 s.w.g. 4/6. T.C. WIRE. 1lb. 16, 18, 20, 22 s.w.g., 3/-.

FERRODYNAMICS AMERICAN "BRAND FIVE" PLASTIC RECORDING TAPE

Table with columns: Play type, Reel size, Length, Price per reel, Spare Plastic Reels price.

7in. Metal Reels 3/- each. "Instant" Bulk Tape Eraser and Head Defluxer, 200/250 v. A.C. 27/6. Leaflet S.A.E.

ARDENTE TRANSISTOR TRANSFORMERS. D3035, 7.3 CT : 1 Push Pull to 3 ohms for OC72... 9/6 D3034, 1.75 : 1 C.T. Push Pull Driver for OC72... 9/6 D3058, 11.5 : 1 Output to 3 ohms for OC72, etc... 9/6 D167, 18.2 : 1 Output to 3 ohms for OC72, etc... 12/- D239, 4.5 : 1 Driver, 1/2in. x 1/2in. x 1/2in... 10/- D240, 8.5 : 1 Driver, 1/2in. x 1/2in. x 1/2in... 10/- ARDENTE TRANSISTOR VOLUME CONTROLS. 5K or 1 meg. with switch, din. 9in., 5/3. VC1780, 5K with switch, dia. 7in., 10/6. DEAF AID EARPIECE Xtal or magnetic, 7/6. SUB-MIN JACK and PLUG, 3/6 pair.

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Gold Cloth, 17in. x 25in., 5/-; 25in. x 35in., 10/- TYGAN Various colours, 52in. wide, from 10/- ft. 26in. wide from 5/- ft. Samples S.A.E. Expanded Metal, Gold, 12in. x 12in., 6/-.

BARGAIN SINGLE PLAYER KIT

£7.19.6 post 5/- WITH 2-STAGE 2-VALVE 3-WATT AMPLIFIER. HIGH-FLUX 5in. SPEAKER. HANDSOME PORTABLE CASE 13in. x 10 1/2in. x 7 1/2in. COLLARO JUNIOR 4-SPEED MOTOR. 16, 33, 45, 78 R.P.M. CRYSTAL PICK-UP FOR L.P./STD. RECORDS, 7in., 10in., 12in.

B.B.C. 2 TRANSISTOR

M.W. and L.W. Radio. Kit 22/6; Earpiece 7/6; Battery 2/3. Circuit and Details 6d.

! TAX - CUT - PRICES !

MONARCH RECORD PLAYER



BUILD IT YOURSELF using 4-SPEED BSR MONARCH AUTOCHANGER READY BUILT 3W AMPLIFIER, HANDSOME PORTABLE CASE. HIGH FLUX LOUSPEAKER. FULL INSTRUCTIONS

Total Price £11.10.0 Carr. and ins. 5/-.

GARRARD DE LUXE AUTO-PLAYER KIT

£11.19.6 Carr. and ins. 5/- details S.A.E.

GARRARD AUTOCHANGER (plug-in xtal head). Ready-built 2-valve amplifier, Loudspeaker and contemporary styled Portable Player Case. All items guaranteed to fit together perfectly, can be assembled in thirty minutes, full instructions supplied.

RECORD PLAYER BARGAINS

Complete with LP/STD Xtal Heads. 4-SPEED AUTOCHANGERS: INSURED POST 3/6 each BSR U.A.14... £6/15/- BSR U.A.12 Stereo/Monaural... £7/10/- Garrard Autoslim Changer... £6/17/6 Collaro S600 Mk. III with Stereo/Mono Cartridge, diamond stereo Stylus and Record Dust Cleaning attachment... £7/17/6 4-SPEED SINGLE PLAYERS: E.M.I. with separate pick-up, complete... £3/7/6 EMI with auto. stop on baseplate... £5/15/- Philips Transcription AG1016 Stereo/Mono... £12/5/- Garrard SRP10, £5/10/-; Model 4HF... £18/10/- Replacement Sapphire Stylus, from 6/3. Replacement Crystal Cartridge with 2 Stylus from 15/-.

RECORD PLAYER CABINETS, 70/-

Two-tone handsome rexine covered, size 18 x 14 x 8. all accessories, baffle, fret and mounting board 14in. x 13in. Space for amplifier, speaker and all modern Auto-changers or single players etc. Mounting board will be cut, free of charge for any modern record player.

RECORD PLAYER AMPLIFIER 95/-

2-valve 3w, A.C. amplifier and 6in. speaker all ready mounted on baffle, 12in. x 7in., 3in. deep. Wired and tested ready for use with above cabinet.

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First-class components to make a 6-transistor 2-wave-band superhet chassis. Ideal for portable or table radio. All parts including BVA transistors, ferrite aerial, printed circuit, 8in. x 2 1/2in., but EXCLUDING speaker and cabinet, 35 ohm output. Simple instructions 1/6 (free with kit). Speakers, 35 ohm, 7 x 4in., 21/- 5in., 17/6; 3 1/2in., 15/6. £4.5.0

NEW MULLARD TRANSISTORS

OC71 6/-; OC81D 7/6; OC44 8/9; OC171 10/6; OC72 7/6; OC81 7/6; OC45 8/6; AF117 9/6. Sub-miniature Electrolytics (15 v.) 1 mfd. 2 mfd., 4 mfd., 5 mfd., 8 mfd., 16 mfd., 25 mfd., 30 mfd., 50 mfd., 100 mfd., 2/6. Diodes OA81, 3/-; GEX34, 4/-.

WEYRAD

COILS AND TRANSFORMERS FOR A 2-WAVE TRANSISTOR SUPERHET WITH PRINTED CIRCUIT AND FERRITE ROD AERIAL.

Long and Medium Wave Aerial-BA2W with CAR AERIAL COLL. On 6in. rod, 1/8in. diameter, 208pF. tuning... 12/6 Oscillator Coil, P50/1A0, 178pF tuning... 5/4 1st and 2nd I.F. Transformers-P50/2CC, 470 Kc/s. 1/2in. diameter by 1/2in. high, ea. 5/7 3rd I.F. P50/3CC, diode detector... 6/- Driver Transformer-LFDT4... 9/6 Printed Circuit-PCAL. Size 2 1/2in. x 8 1/2in. Ready drilled and printed... 9/6 Jackson "00" gang 208 + 178 pF. with trimmers... 10/6 24 Fixed Resistors... 10/6 16 Fixed Condensers... 21/- Volume Control 5K D.P. 4/6 35 ohm Speakers, 5in. 15/6. 5in. 17/6. 7 x 4in. Wavechange Switch... 3/6 Set of 6 Mullard Transistors and diode... 42/6 Constructor's Notebook with full details... 2/- 3 ohm Output Modification parts... 12/6

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NEW LOW PRICE MADE POSSIBLE THROUGH FURTHER BULK PURCHASES

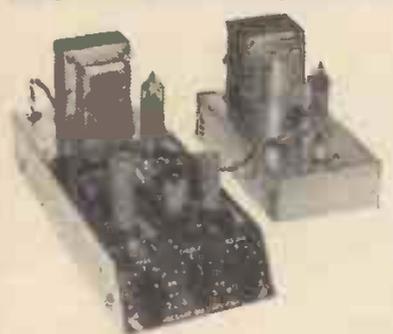


Our 6-transistor pocket size superhet for Medium and Long Waves. All required components. Nothing more to buy.

NOW ONLY **99/6** Plus 2/6 P. & P.

★ Completely self contained. No external aerial or earth required. ★ Full medium wave coverage, plus switched Light programme on Long Waves. ★ Push-pull output—250 milliwatts. ★ Matched set of latest Mullard transistors. ★ Genuine 2½ in. P.M. Speaker. ★ New High-Q coils. ★ Ferrite rod aerial with high selectivity. ★ Size 5½ x 3½ x 1½ in. Two-tone cabinet. ★ Precision etched printed circuit with component references clearly marked. Alignment service available. All parts available separately. Full assembly instructions and individually priced parts list 2/- post free.

MULLARD 510 HIGH-FIDELITY AMPLIFIER



Our printed circuit version of this excellent amplifier, with ULTRA-LINEAR PUSH-PULL output stage, giving an exceptionally high quality output of 10 watts (max.). Built-in Controls are provided for independent bass and treble Tone correction to suit all types of signal input. Will match all crystal or high impedance magnetic pick-up heads, F.M., A.M. or A.M./F.M. tuners or tape recorder output. All required components of best quality to Mullard spec. are offered at a special inclusive **£8.19.6** plus 4/- price of ONLY **£8.19.6** plus 4/- P. & P. Instruction book, containing full constructional details, theoretical practical wiring

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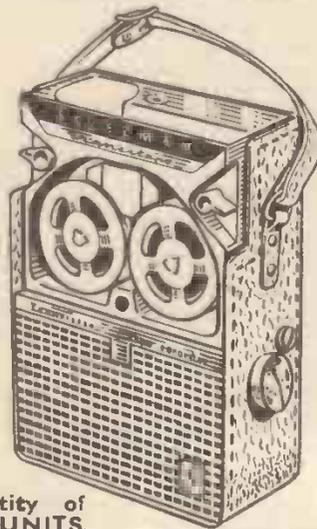
THE OUTSTANDING TAPE RECORDER BUY! THE STEELMAN TRANSITAPE

Fully portable, all transistor 2-speed Tape Recorder. Carry it like a Camera and capture the sound of any event when it happens, where it happens. Big set fidelity. For business or pleasure.

★ Fully transistorized. 7 Transistors—2 diodes. ★ 2 standard speeds, 3½ for music, 1½ for voice. ★ Over 1 hour on a single reel of tape. ★ Recording level indicator. ★ Precision made. Jewelled and Oilite bearings require no lubrication. ★ Illuminated overload and battery life indicators ensure uniform quality performance. ★ Heavy duty 4in. speaker ★ sensitive crystal microphone. ★ Compact size 6½ x 9½ x 2½ in. ★ Wt. under 6½ lbs. less batteries. ★ Many other refinements.

Supplied complete with free set of Mallory Mercury Long Life Batteries complete with tape and microphone in solid leather case with shoulder strap. Illustrated instruction manual. In original manufacturers sealed cartons. Fully guaranteed. Original list price less batteries, 85 guineas. Our price including batteries,

24 GNS. ONLY Plus 7/6 p.k., carr. and ins. Limited supply. Buy now!! H.P. available.



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List Price 9 gns. OUR PRICE 5 gns. Enquiries also invited for other accessories.

The "HIGHWAYMAN"

OUR QUALITY CAR RADIO TO BUILD YOURSELF AT AN ECONOMICAL PRICE

Look at these features:

- ★ Attractive styling. ★ Push-pull output.
- ★ Three latest Mullard transistors plus valve types EBF63 and ECH83.
- ★ No Buzz, high output and sensitivity.
- ★ Printed circuit (newest type).
- ★ 7 x 4in. high flux p.m. speaker and baffle.
- ★ Medium and Long Waves.
- ★ Push button for fingertip control.
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All parts available separately but if purchased at one time, the whole will be supplied at a special inclusive price of **ONLY £10.19.6** Plus 4/- P. & P. Individually priced parts list and comprehensive instruction booklet 2/6 post free. (Deducted from cost if complete parcel purchased later.)

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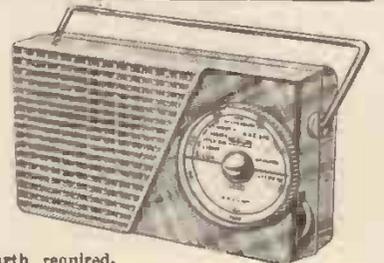
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Our 3 transistor plus 2 diode pocket receiver with full Medium and Long Wave coverage.

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- ★ No external aerial and earth required.
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Combines quality with simplicity of construction (only specially selected top-grade components are used). The refinements provided, and the performance achieved are equal to many commercial

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- ★ Magic-eye tuning indicator. ★ Two I.F. Stages and Discriminator.
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Special inclusive price for all components, full assembly instructions, circuit diagram, etc. **£6.12.6**

Plus 5/- P. & P. Full assembly instructions, etc., available separately if required at 1/6 Post Free.

● **TAPE RECORDER CONSTRUCTORS** ●
LATEST COLLARO STUDIO TAPE TRANSCRIPTOR. Latest type incorporating Record, Interlock, Lever, Button, 3 motors, 3 speeds. 1½, 3½, 7½ i.p.s. takes 7in. spools. Push-button controls. **NEW LOW PRICE OF £10/10/- ONLY!** plus 7/6 P. & P. Usual H.P. Facilities.

NEW! TAPE RECORDER AMPLIFIER TYPE 8311-V. Sub-assembled — anyone can build! Printed Circuit, all components mounted and dip soldered. Already tested. Each lead cut to length. All that is required to complete with tape recorder is for a few components to be mounted in the cabinet and the free ends of the leads soldered to terminals which are clearly marked, everything supplied, all you need is solder iron, pliers and screwdriver. Valve line-up: EF86, ECC83, 2 x EL84, EZ81 and EM34 magic eye. Monitoring facilities, output socket for feeding to high quality amplifier, can be used as "straight" amplifier for record reproduction. **EQUALISING ON TWO SPEEDS. OUTSTANDING VALUE AT £11/11/-** plus 2/6 P. & P. including all necessary instructions.

ATTRACTIVE TWO-TONE PORTABLE CARRYING CASE. Suitable for above amplifier and Collaro Studio deck. Fitted with 9in. x 5in. High Flux P.M. speaker for high quality reproduction. Inclusive price £5/5/- plus 5/- P. & P. Full list of competitively priced mics, and stands, on request. The above 3 items purchased at one time, **SUPPLIED CARR. PAID.**



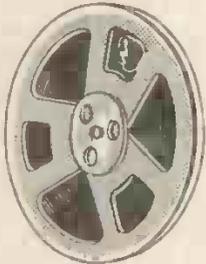
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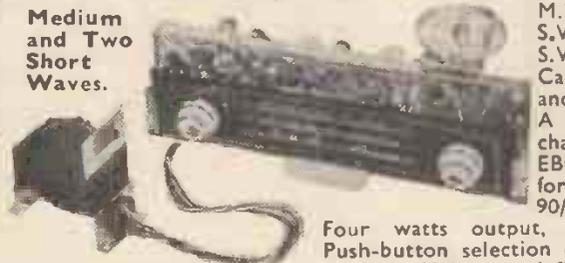
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BRAND NEW—NOT SUB-STANDARD.
 High grade acetate base. Attractively boxed, fitted leaders, fully guaranteed.
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Medium and Two Short Waves.
 M.W. 200-550 metres. S.W.1. 13-30 metres. S.W.2. 31-90 metres. Calibrated also in kc/s. and mc/s.
 A five-valve superhet chassis—EHC81, EF89, EBC81, EL84 and EZ80 for A.C. Mains. 90/110/200/230/250 v.
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 Quantity strictly limited **AT BARGAIN PRICE OF £12.12.0** (P.T. Paid.) Carriage and packing in U.K. only 7/6. H.P. available.

ANOTHER Unrepeatable CHASSIS BARGAIN



A six-valve waveband AM/FM Superhet Radio-gram chassis for 200/240 A.C. mains. Brand new, manufacturer's surplus. Covering:—
 1,200-2,000 metres L.W.
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 Internal Ferrite rod aerial for long and medium wave. Permeability tuner unit on VHF. Piano keyboard style push buttons for waveband and gram selection. Other controls: Volume-Tone on/off Tuning. Valves: ECC85, EHC81, EF89, EABC80, EL84, EZ80. Audio output: 4 watts. Chassis: 15½in. x 7in. x 7½in. high. Dial aperture: 13½in. x 4in. Attractive dial printed in gold on dark brown background. An ideal chassis, especially recommended for use with any of the latest autochanger units. Wonderful tone and dynamic range. Come and hear it at any of our branches. **PRICE COMPLETE £15/15/-** tax paid, plus 7/6 P. & P. H.P. available.

VISIT OUR FULLY EQUIPPED HI-FI SHOWROOM AT TOTTENHAM COURT ROAD FOR DEMONSTRATIONS OF THE LATEST HI-FIDELITY EQUIPMENT BY ALL LEADING MANUFACTURERS, i.e., Leak, Quad, Armstrong, Dulci, Ferrograph, Reflectograph, Tandberg, Vortexion, Tannoy, Linear, Wharfedale, Grundig, Goodmans, W.B., Rogers, Garrard, Lenco, B.T.H., Pamphonic, Simon, Brenell, Collaro, Telefunken, Fi-Cord, Butoba, etc., etc. A full range of high quality cabinets to suit all purposes is on show. Enquire about our interesting part-exchange scheme for personal callers. H.P. available.
 ★ **HI-FI DEMONSTRATION ROOM NOW OPEN AT MANCHESTER** ★

SEND STAMP FOR COPY OF OUR INTERESTING LITTLE BOOKLET

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and Suggestion List of Budget Hi-Fi Systems

THREE NEW BATTERY CHARGER KITS



All complete with ammeter! For 6 and 12 v. operation. Louvred metal case, fuses, metal rectifier, transformer, absolutely complete including heavy duty crocodile clips. Full instructions provided. 1½ amp. 35/-; 2½ amp. 42/6; 4 amp. 50/- each, plus 2/6 P. & P. Also available 2 amp. charger kit complete, no ammeter, fully shrouded mains transformer, full instructions 30/- plus 2/6 P. & P.

HI-FI ENTHUSIASTS LAST FEW ONLY

GRUNDIG TM 20, special version of TK 20 complete with pre-amplifier for recording and playback. Ready to connect. **BRAND NEW.** Full guarantee. Supplied complete with GCM3 microphone (listed 6 gns.) at special price of 29 gns. only, plus 15/- pkg. and carr.

HEADPHONES. Brand new Japanese High Resistance 'phones. 2,000 ohms, 12/6 per pair. 4,000 ohms 14/6 per pair. Both plus 1/6 P. & P.

E.M.I. FULL FREQUENCY SPEAKER. Size 13½in. x 8in. A further small quantity available. 3 ohm speech coil. 39/6 **ONLY**, plus 2/- P. & P.



Actual size 4½ x 3½ x 1½in.

NEW IMPORT!! Large quantity shipments enable us to offer the keenest meter value yet!
20,000 OHMS PER VOLT !!

MODEL 200H. Volt-ohm-Milliammeter. **RANGES:**
 A.C. VOLTAGE: 10, 50, 100, 500 and 1,000 volts (10,000 ohms per volt).
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 D.C. CURRENT: 0-50 micro-amps., 0-2.5 m/a., 0-250 m/a.
 RESISTANCE: 0-6k, 0-6 meg. (300 ohm and 30k. at centre scale).
 CAPACITANCE: 10 pf. to .001 mfd., .001 mfd. to .1 mfd.
 DECIBELS: -20 to +22 db.
 A fully guaranteed pocket size meter, knife edge pointer, top quality, supplied complete with test prods and full **£5.5.0** **ONLY.** operating instructions at Post free.

ALSO AVAILABLE: Model TE10. Identical in appearance and size with rotary type switch but 10,000 ohms per volt. Ranges: D.C. voltages: 0-6-30-120-600-1,200 volts (10,000 ohms per volt). A.C. Voltages: 0-6-30-120-600-1,200 volts (10,000 ohms per volt). D.C. current: 0-120 microamp., 0-3-300 mA. Resistance: 0-30K, 0-3 Meg. (150 ohms and 15K at centre scale). Capacitance: 50pF to 0.01 mfd., 0.001 mfd. to 0.15 mfd. Decibels: -20 to +63 db in 5 ranges. **PRICE 89/6** Post free. Optional extra, attractive carrying case suitable for either meter 13/6 only. Leaflet available. Bona-fide trade enquiries invited.

MODEL TK20A
 Size 3½ x 2½ x 1½in. Meter size 2½ x 1½in. Sensitivity 1,000 o.p.v. on both A.C. and D.C.! A.C. and D.C. volts 0/15, 0/150, 0/1,000 volts. D.C. current 0/150 mA. Resistance 0/100K. Complete with test prods, battery and full instructions.

OUTSTANDING VALUE AT 42/- Plus 1/6 P. & P.

MODEL 500
30,000 OHMS PER VOLT
MULTI METER!
 9 ranges D.C. voltage to 1 kV. 7 ranges A.C. voltage to 1 kV. 5 ranges D.C. current to 12 amp. 3 ranges resistance to 60 meg. Incorporates internal buzzer for audible warning of direct shorts and blocking condensers for A.F. output. Capacity -20 +56. Measurements 3½ x 6½ x 2½in. Outstanding value at **£8/19/6.** H.P. available. Just arrived! **SOLID LEATHER CARRYING CASE** for Model 500. Price 30/- only.



CLYNE RADIO LTD. THE COMPONENT SPECIALISTS

13 Tottenham Court Road, London, W.1.
 162 Holloway Road, London, N.7.
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ALSO SEE OPPOSITE PAGE

R.S.C.

Post Orders to R.S.C. (M/C) Ltd., 5, County Arcade, Leeds 1. Trade Supplied. Personal shoppers to any of Branches below.

R.S.C.

Post Terms. C.W.O. or C.O.D. No C.O.D. under £1. Postage 2/9 extra on orders under £2. 4/6 extra under £5 unless carr. stated.

R.S.C.

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56 Morley Street
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Only 3 pairs of soldered joints plus mains.



Or available with Audiotrine Equipment Cabinet as shown at foot of opp. page and larger speaker for 8½ gns. extra. Cash or Terms.

AUDIOTRON HI-FI TAPE RECORDER KIT
Build a high quality recorder in the £70 class for only

25 1/2 GNS. Carr. 17/6. Can be assembled in 1 hour OR DEPOSIT £2.13.9 and 12 monthly payments of 44/- Cash price if settled in 3 months.

INCORPORATING THE LATEST COLLARO STUDIO TAPE TRANSCRIPTION THE AUDIOTRON HIGH QUALITY TAPE AMPLIFIER. A HIGH FLUX 7x4in. LOUDSPEAKER. Reel of Best Quality TAPE, Spare Tape Spools, a Portable Cabinet, size approx. 14½ x 15 x 8½in., finished in durable and attractive duo tone Poliorome and connection diagram for wiring amplifier to transcripator. FEATURES INCLUDE:

- ★ 3 SPEEDS ★ FREQUENCY RESPONSE 50-11,000 c.p.s. ★ SWITCHED NEGATIVE FEEDBACK EQUALIZING FOR EACH SPEED ★ OUTPUT 4 WATTS ★ MAGIC EYE RECORDING LEVEL INDICATOR ★ 3 MOTORS. Fast rewind ★ TAPE MEASURING AND CALIBRATING DEVICE ★ TAKES FULL 7in. DIAMETER REELS OF TAPE ★ NEGLIGIBLE HUM ★ ENTIRELY EFFECTIVE AUTOMATIC ERASURE. Send S.A.E. for leaflet.

HI-FI 10 WATT AMPLIFIERS

BRAND NEW CARTONED MANUFACTURERS' DISCONTINUED £7.19.6 MODEL. A REMARKABLE OPPORTUNITY. Carr. 4/6. Push-pull output. Latest high efficiency Mullard valves. Dual separately controlled inputs for mike and gram. Separate bass and treble controls. High sensitivity. Output for 3 ohm or 15 ohm loudspeaker. Guaranteed, tested and in perfect working order. For 200-250 A.C. mains.

SUPERHET RADIO FEEDER UNIT

Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F. and double Diode Second Detector delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. Sw. incorporates Gram. position. Controls are Tuning, W. Ch. and Vol. Output will load most Amplifiers requiring 500 mV. input depending on Ae. location. Only 250 v. 15 mA. H.T. and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost of £4/15/-. Point-to-point wiring diagrams and instructions 2/6.

CRYSTAL MICROPHONES

Hand type 14/9. Hand or Desk R.T.C. 19/9. Acos Mic 45 29/9. Mic 39 Stick 39/9. BM3 Stick with table stand 59/9.

LINEAR TAPE PRE-AMPLIFIER Type LP/1. Switched negative feedback equalisation. Positions for Record 1½in., 3½in., 7½in. and Playback. EM84. Recording Level Indicator. Designed primarily as the link between Collaro Tape Transcripator and high fidelity amplifier but suitable almost any Tape Deck. 9 GNS. Send S.A.E. for leaflet.

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 ohms speaker. Three miniature Mullard valves. Size only 6x5x5½in. 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.

EXTENSION SPEAKERS, in handsome, walnut veneered cabinets. All standard 2-3 ohms, 6½in. 29/9. 6in. 35/9.

CABY MULTIMETERS. M1. Sensitivity 2,000 ohms per volt. A.C. and D.C. 54/- A10. Basic meter, sensitivity 155 microamp. A.C. and D.C. ranges. £4/17/6. B.20. Sensitivity up to 10,000 ohms per volt A.C. and D.C. £6/10/-. Send S.A.E. for leaflet.

STOCKISTS OF ARMSTRONG CHASSIS, GOODMAN'S, AND W.B. SPEAKERS. CASH OR H.P.

THE SKYFOUR T.R.F. RECEIVER

A design of a 3-valve 200-250 v. A.C. mains L. and M. wave T.R.F. receiver with selenium rectifier. It employs valves 6K7, 6P61, 6V6 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 veneered walnut cabinet.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5½ x 4½ x 2½in. 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.

LEICESTER

New Branch opening early March. See above

SENSATIONAL STEREO OFFER

Complete kit of parts including twin 6½in. P.M. speakers, to construct a 3+3 watt good quality stereo amplifier providing realist reproduction. Suitable all stereo pick-up heads. Ganged vol. and tone controls. Pre-set balance. For 200-250 v. A.C. mains only. Fully isolated chassis. 4 GNS. Carr. 4/6 Or including Stereo Head 19/9 extra.

R.S.C. STEREO/TEN HIGH QUALITY AMPLIFIER KIT



Valves EZ81, ECC 83, 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. 8 GNS. Carr. 7/9. Assembled and tested 59/6 extra.

ACOS GP67-2G HI-FI Crystal Cartridges with sapphire stylus. Standard replacement for Garrard, B.S.R. and Collaro. Only 19/9. Acos Stereo/Monaural 49/9. Ronette Stereo/Monaural 59/6. BSR Full-Fi Stereo/Mono 39/6.

R.S.C. 3 WATT GRAM AMPLIFIER KIT

All parts to construct a very compact, highly sensitive amplifier suitable for any type of single or autochange player. Size 12 x 2½ x 2½in. Chassis is isolated. Mains transformer for 200-250 v. A.C. mains. Output for 2-3 ohm speaker. Volume and tone control with-mains switch. ONLY 39/9

HEAVY DUTY SELENIUM RECTIFIERS
SPECIAL PURCHASE OF LARGE QUANTITY OF

Brand New 24 v. 20 amp (Bridge) F.W. 59/9 ea.

SELENIUM RECTIFIERS

L.T. Types	H.T. Types H.W.
2/8 v. 1 a. H.W. 1/9	120 v. 40 mA. 3/9
6/12 v. 1 a. H.W. 2/6	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. 11/9
6/12 v. 3 a. 9/9	Contact Cooled
6/12 v. 4 a. 12/3	250 v. 60 mA. H.W. 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
5/12 v. 10 a. 25/9	
6/12 v. 15 a. 35/9	

TRANSISTOR SALE

Mullard OC71 3/9. OC45 4/11. OC44 4/11. OC72 4/9. OC81 4/11. OC171 8/9. Ediswan XA101 XB102, XA112, XB113, XB104, XC101A 3/9 ea. Postage 6d. for up to 3 Transistors.

JASON F.M. TUNER

Type FMT1. All parts including Dial, Escutcheon, Punched Chassis & Valves. Power supply required 180 v. 25 mA. and 6.3 v. 1.5 a. £6/19/6 Type FMT2 8 Gns.

CHARGER KIT 14A

At 12 v. or 24 v. 7 amp. Consisting of Mains Trans. 200-250 v. F.W. Set, Rect., Ammeter, Fuses, Variable Resistor and Circuit, 6 GNS. Carr. 15/-.

EX GOVT. SELENIUM RECTIFIERS 19/9
12 v. 15 amp. F.W. (Bridge). Only

EX GOVT. SMOOTHING CHOKES

60 mA. 10 h. 400 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.

ACCUMULATORS 2 v. 16 A.H. New ex Govt. 8 x 4 x 2½in. 6/9 each. 3 for 15/-.

R.S.C. Battery Chargers & Kits for 200-230-250 v. 50 c/s. A.C. Mains Guaranteed 12 mths.

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 59/9. Post 4/6.

CHARGER TRANSFORMERS

200-230-250 v. 50 c/s.	
0-9-15 v. 1½ a. 11/9	
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	
0-9-15 v. 8 a. 28/9	

BATTERY CHARGER KITS

Consisting of Mains Transformer, F.W. Bridge, Metal Rectifier, well ventilated steel case. Fuses, fuse-holders, grommets, panels, battery clips and circuit. Carr. 2/9 extra.
6 v. or 12 v. 1 amp. 22/9
As above with ammeter... 28/9
6 v. 2 amps. 19/9
6 v. or 12 v. 2 amps. 25/9
6 v. or 12 v. 2 amps. (inclusive of ammeter) 35/9
6 v. or 12 v. 4 amps., with variable charge rate selector and ammeter 52/9

CHARGER AMMETERS

0-1.5 a., 0-3 a., 0-7 a. 8/9

ASSEMBLED CHARGERS

6-12v. 1a. less meter 27/9
6-12 v. 2 amp. 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. 49/9 Carr. 3/9.
6-12 v. 3 amp. with variable charge rate selector and ammeter. 59/9.

ASSEMBLED 12 v. 10 AMP. with variable charge rate adjustment, ammeter and strong louvred stove enamelled case. Ready for use. Carr. 10/- Or in Kit Form 5 GNS.

ASSEMBLED 6 v. or 12 v. 4/5 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. 3/- 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/-.

VALVES: Full range at really competitive prices.

D.C. SUPPLY KITS. Suitable for electric trains. Consists of mains trans. 200-250 v. 50 c.p.s. 12 v. 1 amp. selenium rect. (F.W. Bridge); 2 fuse-holders, 2 fuses, change direction switch, variable speed regulator, partially drilled steel case and circuit. Very limited number, 29/11.

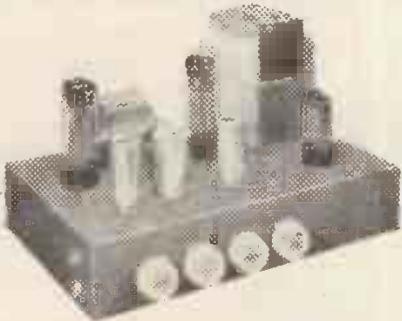
R.S.C. POWER PACKS, 200-250 v. A.C. Completely enclosed in louvred enamelled case, 8 x 5½ x 2½in. Output fully smoothed 250 v. 60 mA. and 6.3 v. 2 a. 39/9.

R.S.C. BABY ALARM or INTERCOMM. UNIT KIT

For 200-250 v. A.C. mains. Includes all parts, diagrams and instructions. High sensitivity. Completely safe. Controllable at either end. Housed in two cabinets of pleasing design £3/19/6. Carr. 5/- Or assembled & tested £5/15/-.

R.S.C. A10 30 WATT AMPLIFIER

**HIGH FIDELITY
ULTRA LINEAR
PUSH-PULL
OUTPUT**



SIX VALVES. EF86, EF86, ECC83, 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 diagram.

ONLY 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/s. ± 12 d.b. to -6 D.B. at 12,000 c/s., hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12x9x9in. approx. Power consumption 150 watts. For A.C. mains 200-250 v. 50 c/s. Output for 3 and 15 ohms 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.

LOUDSPEAKERS. 2 1/2 in. to 15 in., at keen prices. 12 in. 6-8 watt 3 ohm 29/11. 12 in. 10 watt 12,000 lines 3 ohm or 15 ohms 59/9. TWEETERS. 4 in. Plessey 3 ohms 18/9. R.A. 15 ohms 25/9. W.B. 15 ohms 31/9. Fane 15 ohms, Pressure type, £3/15/-.

GL3A MINIATURE 3 WATT GRAM AMPLIFIERS

For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 11 1/2 x 2 1/2 x 2 1/2 in. 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 59/9.

R.S.C. A5 4-5 WATT HIGH GAIN AMPLIFIER

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high fidelity pick-up heads in addition to all other types of pick-ups and practically all 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 ohms 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.



GARRARD AUTO-SLIM 4-SPEED AUTO-CHANGERS. With GC8 turnover Head. For 200-250 v. A.C. mains. £7/19/6. Carr. 4/6.

B.S.R. MONARCH AUTO-CHANGERS. Type UA14 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.

R.S.C. TRANSFORMERS Fully Guaranteed, Interleaved & Impregnated.

MAINS TRANSFORMERS. Primaries 200-230-250 v. 50 c/s. FULLY SHROUDED. UPRIGHT MOUNTING.

250-0-250 v. 60 mA., 6.3 v. 2 a., 0-5-6.3 v. 2 a. 2 1/2 x 3 1/2 in.	17/11
250-0-250 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a.	27/11
300-0-300 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a.	27/11
300-0-300 v. 130 mA., 6.3 v. 4 a. c.t., 6.3 v. 1 a. For Mullard 510 Amplifier	33/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a.	27/11
350-0-350 v. 150 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a.	33/11
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 5 v. 3 a.	55/-
425-0-425 v. 200 mA., 6.3 v. 4 a., 6.3 v. 4 a., 5 v. 3 a.	59/9
450-0-450 v. 250 mA., 6.3 v. 5 a., 5 v. 3 a.	69/9

TOP SHROUDED DROP-THROUGH TYPE

250-0-250 v. 70 mA., 6.3 v. 2 a., 0-5-6.3 v. 2 a.	17/9
250-0-250 v. 100 mA., 6.3 v. 3 a., 6.3 v. 1 a.	19/9
250-0-250 v. 100 mA., 6.3 v. 2 a., 5 v. 2 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., 0-5-6.3 v. 3 a.	26/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 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., 0-5-6.3 v. 3 a.	25/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a.	29/9
425-0-425 v. 200 mA., 6.3 v. 4 a., 5 v. 3 a.	55/9

MIDGET CLAMPED TYPE. Primaries 200-250 v.

250-0-250 v. 60 mA., 6.3 v. 2 a., 2 1/2 x 2 1/2 x 2 1/2 in.	12/9
250 v. 60 mA., 6.3 v. 2 a., Size 2 1/2 x 2 1/2 x 2 1/2 in.	11/9

FILAMENT TRANSFORMERS 12 v. 1 a.

6.3 v. 1.5 a.	5/9	6.3 v. 3 a.	8/11
6.3 v. 2 a.	7/6	6.3 v. 6 a.	17/9
0.4-6.3 v. 2 a.	7/9	12v. 3 a. or 24v. 1.5 a.	17/9

AUTO (Step Up/Step Down) TRANSFORMERS

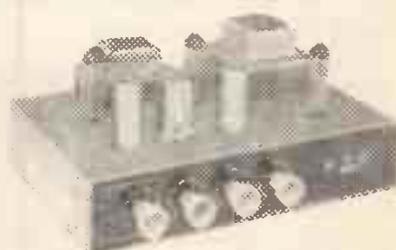
50-80 watts 110-120 v./230-250 v.	13/9
150 watts 110-120 v./200-250 v.	27/9
250 watts 110-120 v./200-250 v.	39/9

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS. HF1012, 10 watts rating. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance, £4/7/6. Please state whether 3 ohm or 15 ohm required.

BASS REFLEX CABINET. Designed for above speaker. Acoustically lined and ported. Polished walnut veneer finish. Size 18x12x10in. Strongly made. Handsome appearance. Ensure superb reproduction for only £3/19/6.

A11 12-14 WATT AMPLIFIER

**HIGH FIDELITY
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, EZ81. 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/s. 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 x 9 x 7 in. For A.C. mains 200-250 v. 50 c/s. Output for 3 and 15 ohms speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. (Or factory built 51/6 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 24/9 and 9 monthly payments of 24/9. Send S.A.E. for illustrated leaflet detailing ready-to-assemble Cabinets, Speakers, Microphones, etc., with cash and credit terms.

AUDIOTRINE HIGH FIDELITY REPRODUCERS

THE DUO/10. Consisting of a 12in. 12,000 line Speaker with heavy four layer voice coil, the Audiotrine cross-over unit, and a 4in. Diameter Tweeter Unit incorporated in the extremely attractive Audiotrine Senior Corner Console Cabinet as described below. Matching impedance 15 ohms. Power handling 10 watts nominal, 14 watts peak. Frequency range 40-18,000 c.p.s. ONLY 12 gns. Or Deposit 27/9 and nine monthly payments 27/9. THE DUO/20. Incorporating a 12in. High Flux 20 watt Speaker with 2in. Diameter Speech Coil. (Total Flux 160,000 lines), the Audiotrine cross-over unit, and a highly sensitive Tweeter unit, in the Audiotrine Senior Corner Console Cabinet. Matching impedance 15 ohms. Peak Power Output 25 watts. Frequency range 30-18,000 c.p.s. ONLY 14 gns. Or Deposit 33/3 and nine monthly payments 33/9.

R.S.C. JUNIOR HI-FI REPRODUCER. The very latest Goodmans Axiote 8 High Fidelity loudspeaker (retailing at £5/17/7) fitted in a specially designed Bass Reflex cabinet size 12in. x 18in. x 10in. Acoustically lined and ported and finished in polished walnut veneer. Matching impedance 15 ohms. Frequency range 40-15,000 c.p.s. Power handling 6 watts nominal. Ideal for Stereo. Limited number at ONLY £8/19/6. Carr. 4/6.

LOUDSPEAKERS IN CABINETS.

12in. 10 WATT. Walnut Veneered. Cabinet size 15 x 15 x 8in. approx. High quality 12in. 10 watt 12,000 line Speaker. 3 ohms or 15 ohms. £4/19/6. Carr. 5/-. Or Deposit 11/3 and nine monthly payments 11/3. 12in. 20 WATT. High Quality. 15,000 line l/speakers 15 ohms in Cabinet finished as above. Size 18 x 15 x 8in. £7/19/6. Carr. 7/9. Or Deposit 17/9 and 9 monthly payments of 17/9. 15in. 50 WATT. 14,000 line speaker with 3in. diameter speech coil, 15 ohms Impedance, in Substantial Two-tone Rexine and Vynair covered cabinet of pleasing appearance. Acoustically lined. IDEAL FOR BASS GUITAR. Size 30 x 24 x 16ins. approx. ONLY 29 Gns. Or Deposit £3/15/- and twelve monthly payments 50/-.



LARGE REXINE COVERED CABINETS

Extremely attractive Two Tone Grey Rexine and Vynair. Substantial construction. Fitted castors. To house single 15 in. or 18 in. speakers or two 12 in. speakers. Size 30 x 24 x 16 in. 11 Gns. or Deposit 25/9 and nine monthly payments 25/9. Size 30 x 30 x 14 ins. Acoustically lined 13 Gns. or Deposit 30/4 and nine monthly payments 30/4.

Standard Pentode 7,000 Ω to 30 Ω	5/9
Multi Ratio Single or P/P 3 to 15 Ω	6/9
Push pull 8 watts EL84s to 30 Ω	8/9
Push pull 8 watts EL84s to 15 Ω	8/9
Push pull 10-12 watts 6V6 to 30 Ω or 15 Ω	16/9
Push pull 10-12 watts to match 6V6 to 3-5-8 or 15 Ω	17/9
Push pull EL84 to 3 or 15 Ω 10-12 watts	17/9
Push pull Ultra Linear for Mullard 510, etc.	29/9
Push pull 15-18 watts, sectionally wound 6L6, KT66, etc., for 3 or 15 Ω	23/9
Push pull 20 watt high-quality sectionally wound, EL34, 6L6, KT66, etc. to 3 or 15 Ω 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., 100 Ω	11/9	80 mA., 10 H., 350 Ω	5/6
150 mA., 7-10 H., 250 Ω	11/9	60 mA., 10 H., 400 Ω	4/11
100 mA., 10 H., 200 Ω	8/9	1 amp. 0.5 Ω L.T. type	6/6

AUDIOTRINE EQUIPMENT CABINET

Elegant contemporary design. Robust, beautiful polished walnut finish. Size 36 x 15 x 17 ins. Removable Baseboard. Depth below lid 5 1/2 in. Complete with brass ferruled legs.



12 1/2 Gns. Carr. 10/-

Or Deposit 28/9 and 9 monthly payments 28/9.

B.S.R. MONARDEOK TAPE DECKS

Speed 3 1/2 in. per sec. As fitted to most leading make Tape Recorders. Brand New £6/19/6. Carr. 5/-. Suitable Portable Cabinets to take Deck and Tape Amplifier, 39/9.

R.S.C. STANDARD BASS REFLEX CABINET. For 12in.

Loudspeakers, acoustically lined and ported. Size 20in. x 14in. x 13in. Beautiful walnut veneer finish. Especially recommended for use with Speaker system below, £5/19/6. Set of four legs can be supplied with brass ferrules for 19/6 per set.

AUDIOTRINE CORNER CONSOLE CABINETS. Strongly made.

Beautiful polished walnut veneered finish. Pleasing design.

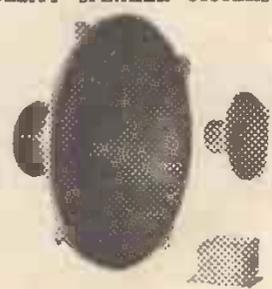
JUNIOR MODEL. To take up to 8in. speaker. Size approx. 20 x 11 x 8in. Only 49/9.

STANDARD MODEL. To take up to 10in. speaker. Size 27 x 18 x 12in. £4/11/9.

SENIOR MODEL. To take up to 12in. speaker and with Tweeter cut-out. Size approx. 30 x 20 x 15in. Recommended for use with speaker system below. 7 gns.

AUDIOTRINE HIGH FIDELITY SPEAKER SYSTEMS

Designed to provide a smooth frequency response from 40-20,000 c.p.s. consisting of 12in. 12,000 line 15 ohm speaker. Crossover Unit and Tweeter. Highly recommended for use with any High Fidelity Amplifier. 10 Watt Unit, £4/19/6 or Deposit 11/3 and nine monthly payments of 11/3. 15 Watt Unit £7/19/6 or Deposit 17/3 and nine monthly payments of 17/3.



INTRODUCING THE R.S.C. BASS-MAJOR 30-WATT GUITAR AMPLIFIER

A MULTI-PURPOSE HIGH FIDELITY, HIGH OUTPUT UNIT FOR VOCAL AND INSTRUMENTALIST GROUPS

- ★ Incorporating two 12in. heavy duty 25-watt high flux (17,000 lines) loudspeakers with 2in. diameter pole pieces (total flux 220,000 lines). Designed for efficiently handling more than full output of amplifier at frequencies down to 25 c.p.s.
- ★ One speaker has an aluminium speech coil and dual cone to extend frequency range up to 17,000 c.p.s.
- ★ Heavily made cabinet of convenient size 24 x 21 x 14in. has an exceptionally attractive covering in two contrasting tones of Vynair.
- ★ For 200-250 v. 50 c.p.s. A.C. mains operation. Send S.A.E. for leaflet.



EMINENTLY SUITABLE FOR BASS GUITAR AND ALL OTHER MUSICAL INSTRUMENTS.

- ★ Four jack socket inputs and two independent vol. controls for simultaneous connection of up to four instrument pick-ups or microphones.
- ★ Separate bass and treble controls providing more than adequate "Boost" or "Cut."
- ★ Level frequency response throughout the audible range.

39½ Gns. Or DEPOSIT £4/3/- and Carr. 17/6 £3/9/11.
Superior to units at twice the cost.

R.S.C. JUNIOR GUITAR AMPLIFIER.
5-watt high quality output. Separate bass and treble "cut" and "boost" controls. Sensitivity 15 m.v. Two high impedance inputs. 10in. loudspeaker. Handsome strongly made cabinet (size 14 x 14 x 7in. approx.) finished in attractive and durable polychrome. 200-250 A.C. mains operation. Send S.A.E. for leaflet.

£8/19/6 Carr. 7/6
Or DEPOSIT £1 and nine monthly payments of £1.

LINEAR TREMOLO/PREAMP. UNIT.
Designed for introducing the Tremolo effect to any amplifier fitted with a reserve power supply point for smoothed H.T. and 6.3 v. A.C. This applies to practically all amplifiers of our manufacture and to those of several other manufacturers. The unit plugs into power supply point and any input socket of amplifier. Controls are Speed (frequency of interruptions), Depth (for heavy or light effect), Volume, and Switch. Three sockets are for 2 inputs and Foot Switch. Only **4 Gns.**

FOR BASS GUITAR SPEAKERS IN CABINET See Page 105

R.S.C. SENIOR 10-WATT GUITAR AMPLIFIER.

High-fidelity push-pull output. Separate bass and treble "cut" and "boost" controls. Twin separately controlled inputs so that two instruments or "mike" and pick-up can be used at the same time. Two loudspeakers are incorporated, a 12in. high flux 14-watt bass unit, and a 8 x 4in. elliptical for treble. Cabinet is well made and finished as Junior Model. Size approx. 18 x 18 x 8in. Only **15 gns.** Carr. Or DEPOSIT 34/9 and 9 monthly payments 34/9. Send S.A.E. for leaflet.



LEICESTER

New Branch opens early March. See below

R.S.C. SUPER HI-FI 15-WATT.

An exceptionally efficient high fidelity Guitar Amplifier incorporating a heavy duty 12in. 20-watt speaker with excellent frequency response. Individual bass and treble controls give ample "boost" and "cut." Two high impedance Jack Socket inputs are separately controlled. If required one or two additional inputs can be provided at a cost of 7/6 per extra socket. Cabinet is of substantial construction and attractively finished in two contrasting tones of polychrome. Size approx. 20 x 18 x 10in. Operation from 200-250 v. 50 c.p.s. A.C. mains. PLEASE DO NOT COMPARE THIS UNIT WITH OTHERS OF SIMILAR RATING UNTIL YOU HAVE HEARD THE DIFFERENCE.

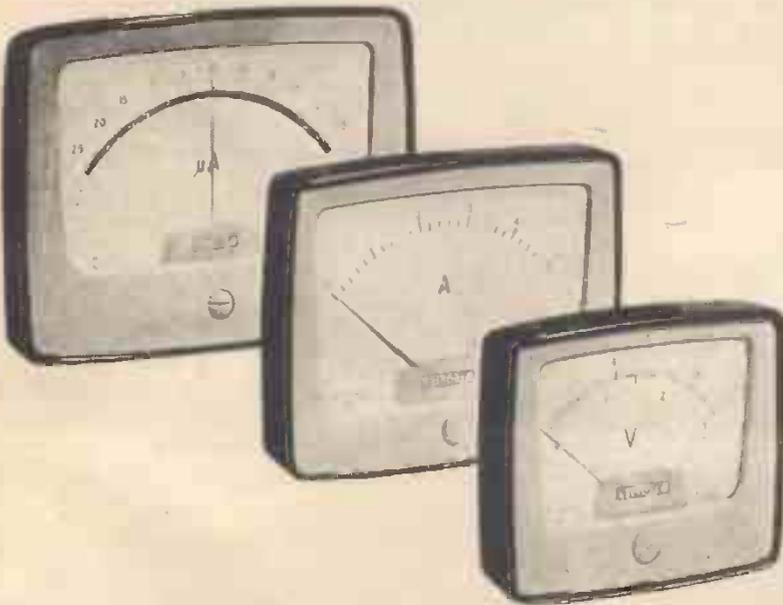
Or DEPOSIT 51/6 and nine monthly payments of 51/6. Send S.A.E. for leaflet. **22 Gns.** Carr. 12/6

R.S.C.	(Manchester) Ltd.	MAIL ORDERS to 5 County Arcade, Leeds 1.				Terms: C.W.O. or C.O.D. No C.O.D. under £1 Trade Supplied. S.A.E. with all enquiries please		
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32, High Street Leicester	6 Gt. Western Arcade, Birmingham	13 Exchange St., Castle Market Bldgs., Sheffield	51 Savile St., Hull	73 Dale St., Liverpool, 2	56 Morley St. (above Alhambra Theatre), Bradford	8-10 Brown St. (Market St.), Manchester, 2	5-7 County (Mecca) Arcade, Briggate, Leeds	
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The BEST is now even BETTER!

A BRILLIANT CONCEPTION OF THE FINEST 2-BAND 6-TRANSISTOR RADIO AVAILABLE

★ Ultra-modern styling with a magnificent twin-tone cabinet fitted with fully expanded metal front and a slide-rule type waveband dial. GREATER OUTPUT using the latest high-efficiency Mullard Transistors and Diodes, incorporating an improved design, featuring different circuit constants.

MORE punch—MORE gain—MORE stations—SUPERB appearance—the NEW "Contessa" scores again!!

SEE it—HEAR it—you will BUY it!

- Waveband coverage of 530 kc/s to 1,620 kc/s and 160 kc/s to 270 kc/s.
- Assured reception of at least a dozen stations in daylight!
- Large clearly-calibrated station-named dial.
- Internal high-gain Ferrite aerial
- 5:1 ratio slow motion tuning.
- Fitted with the latest 12,000-line high-flux loudspeaker.
- Power of 600 milliwatts from the single-ended push-pull final stage.
- Specially designed aerial matching coil for use in a CAR.
- Only first-grade Mullard fully-guaranteed matched transistors and diodes are used.
- Tape recorder socket provided.

- Double tuned IF transformers for maximum gain and knife-edged selectivity.
- Fully drilled printed circuit panel marked with component numbers.
- The two-tone case outer measurements are 10½ x 7½ x 3½ in. and weighs approx. 4 lb. when assembled.
- Battery lasts 4 months with normal usage.
- Books supplied with detailed assembly instructions, diagrams and circuitry.
- Anyone can build this set—everything supplied, just a soldering iron required.
- Cabinets available in two-tone beige and two-tone blue.
- Adjustable carrying handle.



Inclusive price for all associated components, cabinet and battery, complete in every detail. Or our BUY AS YOU BUILD SCHEME any parts sold separately. Send for comprehensive descriptive Manual and Parts List, 2/10 post free.

NOW £9:19:6
plus 3/6 P. Pkg.



YOU CAN HOLD EUROPE IN THE PALM OF YOUR HAND WITH—The "CAPRI"!

A miniature pocket transistor Radio that REALLY works, retaining the most attractive features of the famous "Contessa." Six first-grade Mullard transistors plus diode are employed in a highly sensitive superhet MW and pre-set LW circuit embodying the most modern design practices. A special 2¼ in. high gauss loudspeaker provides surprising volume and a personal earpiece socket is also available. An attractive two-tone plastic case is supplied in two colours—ivory/red or ivory/blue, the full constructional details being furnished with each set of parts. The total measurements of the Capri are 4½ x 2¾ x 1½ in.

SEE AND HEAR A WORKING MODEL TODAY

Inclusive price for all associated components, case and constructional data, complete in every detail, or our BUY AS YOU BUILD Scheme. ANY PARTS SOLD SEPARATELY. (9 volt battery 2/6 extra).

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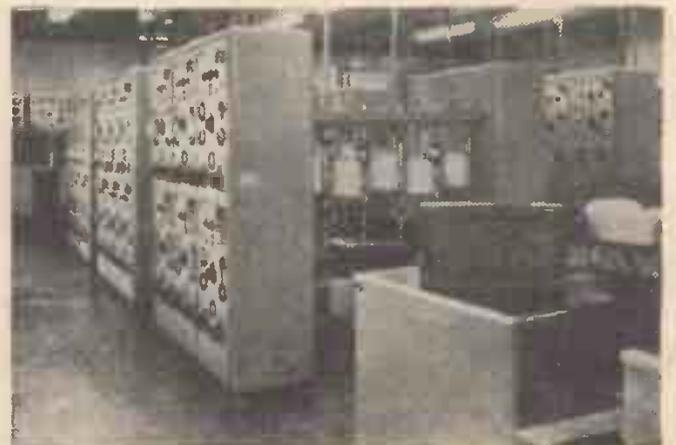
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COLLARO STUDIO TAPE RECORDER KIT

SPECIAL BARGAIN OFFER. Comp. Kit only £25 Carr. 12/6.



Famous mfrs. surplus offer—Listed 42 gns. A quality Tape Recorder Kit based on Mullard's famous design—EF86, ECC83, EL84, EM81 and Rectifier Specially designed Kit for Collaro latest Studio Deck, Freq. response $\pm 3\text{dB}$, 60 c/s. —10 Kc/s. Amp. and Power Pack already wired, inter. unit wiring only required. Cabinet size: 18" x 16½" x 6" finished in contemp. 2 tone blue Rexine with gilt speaker Escutcheon. Magic Eye indicator. Circuit and Tech. H/Book, supplied free with kit. Send 3d. stamp now for full details of to-day's outstanding Tape Recorder Bargain.

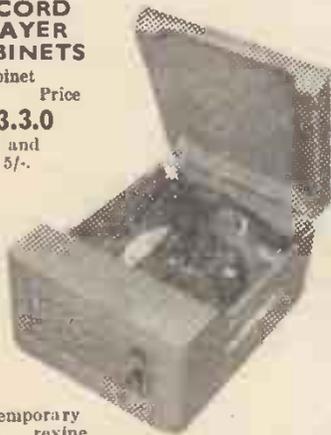
CABINET £3/15/- P. & P. 6/6.
AMPLIFIER KIT £8/19/6. P. & P. 5/-
SPEAKER 7 x 4 16/6. P. & P. 2/-
If above items are purchased together **£12.19.6** P.&P. 10/-

RECORD PLAYER BARGAINS Latest 4-speed models

NEW RELEASE by E.M.I.—4-speed Single Player Unit fitted with latest stereo and monaural Xtal cartridge and dual sapphire styl. Auto stop and start. A fidelity unit and bargain buy at only £6/19/6, carr. and ins. 4/6.
SINGLE PLAYERS: B.S.R. Latest model TU12 70/-; COLLARO JUNIOR studio P.U., 75/- EMI Junior "985" 79/6.
AUTOCHANGERS: Latest Model GARRARD "Auto-slim" £7/10/0. B.S.R. (U-A14). Latest model, £6/19/6. COLLARO "C60" Latest Model, £7/7/0. Carr. & Ins. 5/-

RECORD PLAYER CABINETS

Cabinet Price
£3.3.0
Carr. and Ins. 5/-



Contemporary style rexine covered cabinet in 2-tone wine and cream. Size 18½ x 13½ x 8½ in. ht. fitted with all accessories including baffle board and anodised metal fret. Space available for all modern amplifiers and autochangers etc. Uncut record player mounted board 14 x 13 in. supplied.

2-VALVE 2-WATT AMPLIFIER

Twin stage ECL82 with vol. and neg. feedback Tone control. AC 200/250 v. with knobs, etc., ready wired to fit above cabinet, complete with 6in. Quality Speaker and O/P Trans., £3/19/6. Carr. 2/6. Complete Record Player Kit as illustrated, nc. BSR UA 14 Unit, New reduced price: £12/10/0. Carr. 7/6.

TRANSISTOR BARGAINS!
Brand New—BVA 1st Grade.

OC44	8/6	873	9/-	
OC45	8/-	GET114	6/6	
OC81	7/6	OC72	7/6	
2/OC81	15/6	OC70	5/6	
XA102	10/-	OC71	6/-	
XA101	9/6	OC78	7/6	
XB103	7/6	GEX13	2/9	
XC101	3/6	GEX34	2/9	
BB305	9/6	OA70	2/9	
874	9/6	OA81	2/9	
SPECIAL OFFER	2/OC44	21/6	2/OC81	19/6

BARGAINS GARRARD PLAYER UNITS

SINGLE PLAYERS: Carr. 4/6.
Model 48P £6/17/6.
Model TA Mk. 2 £6/19/6.
Model 4HF £17/19/6. Carr. 7/6.
Model 301 transcription unit £21/19/6. Carr. 7/6.
AUTOCHANGERS:
Latest 4-speed Model 209 with GC8 head, 8½ gns. Carr. 5/- Model A Lab. Series Transcription Unit, new release. £18/19/6. Carr. & Ins. 7/6. Comprehensive range in stock.

TRANSISTOR COMPONENTS

Midget I.F.'s—465 Kc/s ½ in. diam. 5/6
Osc. Coil M. & L.W. 5/9
Midget Driver Trans. 3.5 : 1 6/9
Midget Output Trans. Push-Pull—3 ohms 6/9
Elect. Condensers—Midget Type 1 mfd.-50 mfd. ea. 1/9, 100 mfd. 2/-, 12V.
Condensers 150 v. working: .01 mfd., .02 mfd., .03 mfd., .04 mfd. 9d.; .05 mfd., .1 mfd., 1/-, .25 mfd. 1/3; .5 mfd. 1/6, etc.
Midget Tuning Condensers. J.B. "OO" 208 pf. and 176 pf. 8/6, ditto with trimmers 9/6. JB 220pf. and 105pf. conc. slow motion 10/6. 365 pf. single 7/6. Sub. Min. ½ in. Dilemin 100pf., 300pf. 500 pf. 7/- each.
FERRITE AERIALS. M. & L.W., car aerial coil 9/3.
Midget Vol. Control with edge control knob, 5 K/ohms, with switch 4/9. Ditto less switch 3/9, Speakers: P.M.: 2in. Plessey 75 ohms 15/6. 2½ in. Continental 8 ohms. 13/6. 7 x 4in. Plessey 35 ohms. 23/6.
Ear Plug Phones—Min. Continental type 3ft. lead, jack plug and socket. High Imp. 8/- Low Imp. 7/6.

MULLARD "3-3" HI-FI AMPLIFIER. 3 VALVES 3 WATT



3 ohm and 15 ohm Output. A really first-class Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line up: EF86, EL84, EZ81. Extra HT and LT available for Tuner Unit addition. This is the ideal companion Amplifier for FM tuner units.

TECHNICAL SPECIFICATION—Freq. Response: +1db. 40 c/s-25 Kc/s. Tone controls: Max. Treble Cut 12 db. at 10 Kc/s. Max. Bass Boost 14 db. at 80 c/s. Sensitivity: 100 Mv for 3w. output. Output Power (at 400 c/s): 3 w. at 1% total harmonic distortion. Hum and Noise Level: At least 70 db. below 3 w.

COMPLETE KIT (incl. valves, all components wiring diagram and special quality sectional Output Trans.) ONLY £8/19/6. Carr. 4/6. Complete wired and tested, 8 gns. Wired power O/P socket and additional smoothing or Tuner Unit, 10/6 extra.

Bronze Escutcheon Panel, Printed Vol. Treble, Bass, On-Off, supplied with each Kit.

Recommended Speakers—WB. HF 1012 £5. Goodmans AXIOM 10 £5/15/-, 8" AXIETTE £8/10/0, or AXIOM £8/10/0.

SPECIAL BARGAIN OFFER!

A self-contained Portable Unit incorporating latest BSR 4-speed Auto Changer Record Player and famous High Fidelity "Full-Fi" Xtal Pick Up with Turn-over Cartridge. Fitted with LP and 78 Sapphire Styl. Internal 2-valve Amplifier of Modern design with variable Tone and Volume Controls. This, together with a quality P.M. Speaker ensures a high standard of reproduction. The whole is housed in a robust wooden cabinet attractively styled in two-tone contemporary leathercloth with contrasting polka dot relief. Kit consists of 3 sub-assemblies already wired. Grub screw connections between units only necessary—absolutely no soldering. **ORIGINALLY BUILT TO BE SOLD AT 17 GNS. Recommended Buy!**



STANDARD MODEL £12/10
Carr. & Ins. 7/6.
Autochanger Unit BSR Model UA20. Amplifier Valves UCL82, UY85 and 7 x 4in. Elliptical Speaker. Cabinet size 17 x 14½ x 8½ in.

SPEAKERS P.M. 3 ohms. 2½ in. EMI 17/6. 3in. Goodmans 18/6. 5in. Rola 17/6. 6in. Elac 18/6. 7in. x 4in. Goodmans, 18/6. 8in. Rola 20/-. 10in. Elac 25/- 10in. x 6in. Goodmans 25/- 2½ in. E.M.I. Tweeter. 29/6.

ENAMELLED COPPER WIRE—1lb. reels. 14g-20g, 2/6; 22g-28g, 3/-; 30g-40g, 3/9. Other gauges quoted for.

VALVE HOLDERS—Int. Oct. 6d. Nylon or Ceramic. B7G, B9A unskirted, 9d. B7G, B9A skirted, 1/- each; B7G with Can 1/6; B9A with Can, 1/9 etc.

KNOBS—Modern Continental types: Brown or Ivory with Gold Ring, 1in. dia., 9d. each; 1½ in., 1/- each; Brown or Ivory with Gold Centre 1in. dia., 10d. each; 1½ in., 1/3 each. LARGE SELECTION AVAILABLE.

CO-AX 80 ohm CABLE

High grade low loss Cellular Air Spaced Polythene—½ in. diam. Stranded Cond. Now only 6d. a yard.

BARGAIN PRICES—SPECIAL LENGTHS
20 yds. 9/-; P. & P. 1/6. Coax. Plugs 1/- 40 yds. 17/6. P. & P. 2/- Sockets 1/- 60 yds. 25/- P. & P. 3/- Couplers 1/3.

VOLUME CONTROLS—5K—2 Meg. ohms, 3in. SPINDLES. MORGANITE MIDGET TYPE. 1½ in. diam. Guar. 1 year. LOG. or LIN., ratios less Sw., 3/- D.P. Sw. 4/6. Twin Stereo less Sw., 6/6. D.P. Sw., 8/-.

CONDENSERS—Silver Mica. All values. 2 pf. to 1,000 pf., 6d. each. Dltto, ceramics 9d. Tub. 450 v. T.G.C., etc., .001 mfd. .01 and .1/350 v. 9d. .02-1/500 v., 1/- 25 Hunts 1/6. 5 T.C.C. 1/9 etc., etc.

CLOSE TOL. S/MICAS. 10% 5 pf.-500 pf., 8d. 600-5,000 pf., 1/- 1% 2 pf.-100 pf., 9d. 100 pf.-500 pf., 11d. 575 pf.-5,000 pf. 1/6.

RESISTORS—FULL RANGE 10 ohms—10 megohms 20% \pm & w., 3d., 1 w., 5d. (Midget type modern ratings), 1 w. 6d. 2 w. 9d. HI-STAB. 10% \pm w. 5d. \pm w. 7d. 5% \pm w. 9d. 1% \pm w. 1/6 etc.

W/W RESISTORS. 25 ohms to 10 K 5 w., 1/3. 10 w. 1/8. 15 w., 2/-

PRE-SET T/V POTS. W/W 25 ohms-50 K., 3/- 50 K.-2 Meg. (Carbon), 3/-.

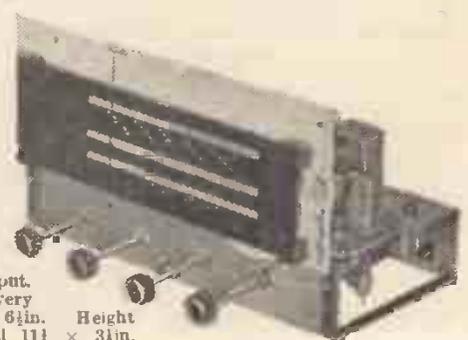
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8/450 v. 1/350 v. 2/3	50+50/350 v. 6/6
16 16/450 v. 5/6	80+250/275 v. 12/6
32 32/450 v. 6/6	100+200/275v. 12/6
Transistor Midget types—all values 1 mfd to 50 mfd. 1/9 ea., 100 mfd. 2/- 12 v.	

7 VALVE AM/FM RADIOGRAM CHASSIS

Valve line-up ECC85, ECH81, EF89, EABC80, EL84, EM81, EZ80.

Three Waveband and Switched Gram positions. Med. 200-550 m. Long 1,000-2,000 m. VHF/FM 88-95 Mc/s. Philips Continental Tuning Insert with permeability tuning on FM and combined AM/FM IF transformers. 460 Kc/s. and 10.7 Mc/s. Dust core tuning all coils. Latest circuitry including AVC and Neg. Feedback. Three watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½ x 6½ in. Height 7½ in. Edge illuminated glass dial 11½ x 3½ in. Vertical pointer Horizontal station names. Gold on brown background. A.C. 200/250 v. operation. Magic-eye tuning.



Aligned and tested ready for use. **£13.10.0** Carr. & Ins. 7/6.

Complete with 4 Knobs—walnut or ivory to choice. Indoor FM aerial 3/6 extra. 3 ohm P.M. Speaker only required. Recommended Quality Speakers 10in. H/DUTY PLESSEY 30/-. 8in. H/DUTY ROLA 25/- 13½ in. x 8 EMI Fidelity 35/- P. & P. 2/6.

Terms: C.W.O. or C.O.D., post and packing up to ½ lb. 7d.; 1 lb. 1/1, 3 lb. 1/6; 5 lb. 2/-; 10 lb. 2/9.



RADIO COMPONENT SPECIALISTS Established 1946

70 BRIGSTOCK RD., THORNTON HEATH, SURREY
Tel: THO 2188. Hours: 9 a.m.—6 p.m. 1 p.m. Wednesday.

REDA OFFERS "EAGLE PRODUCTS" AT THE NEW REDUCED PRICES

ALL DIRECTIONAL STUDIO CRYSTAL MICROPHONE MODEL MC-70



A professional microphone with 360 deg. pickup, using a new variable "D" shock mounted crystal cartridge for added power and sensitivity. Smooth response (50-12,000 cps) and natural reproduction. Size 7in. high x 3in. wide. Complete with shielded cable. Lavalier cord and 3/8in. stand holder:

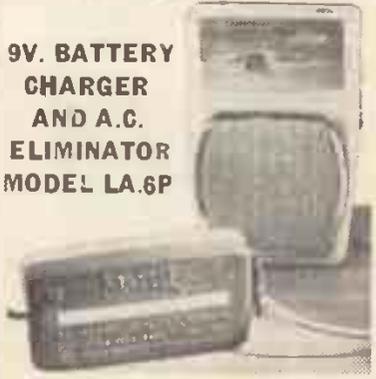
NOW ONLY **59'6**

Save those batteries by running your transistor set direct from A.C. mains. Reactivate all your old 9 v. batteries. A "must" for every transistor set owner!

Unit contains neon indicator and standard battery connections with nearly 2 yards of mains lead and plug. Also snap cord for connection to set.

NOW ONLY **24'6**

9V. BATTERY CHARGER AND A.C. ELIMINATOR MODEL LA.6P



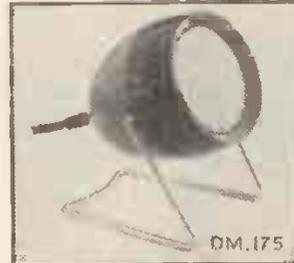
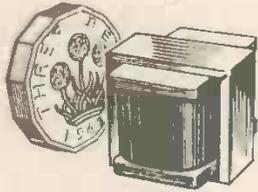
SUB-MINIATURE TRANSFORMERS

Outstanding value in transistor transformers consisting of one Driver Transformer, and one Output Transformer. Ideal pair for miniature transistor portables, etc.

Driver Model LT44: Primary: 20k. Secondary: 1k. Centre Tapped. Ratio: 5 : 1.

Output Model LT700: Primary: 1.2K. Centre Tapped. Output: 3.2 ohms. Ratio: 20 : 1.

NOW ONLY **8' - PER PAIR**



DYNAMIC MICROPHONE MODEL DM-175

Beautifully designed and attractively finished. Lightweight, complete with stand. Output imp. 1K, ohm freq. response: 150-9,000 c.p.s.

± 3db. Sensitivity: -73db. Ideal for almost all applications.

NOW ONLY **39'6**

LAPEL MICROPHONE BM.36R

Precision engineered Magnetic Microphone—for lapel or hand use. Only 1 1/2 in. dia. Exceptionally sensitive. Chrome-plated case. Sft. shielded cable. Only 12/6.

R.101 TUNING AND BATTERY INDICATOR

This ultra-miniature tuning and battery indicator is easily mounted into portable radios or tape-recorders for indicating tuning centre and residual capacity of batteries. Galvanometer movement assures complete accuracy. Insulation resistance between case and terminals: 20 Megohms/500V. Sensitivity: 400 µA. Solder terminals are provided at rear. Plastic case cover. Complete with example circuit for use. Size: 3/4 in. x 1/2 in. dial. Price 24/6.

STYLUS MICROSCOPE MODEL SC. 8

Specially and most carefully designed to solve all stylus problems with a magnification lens of x 230. the scope is battery operated, the needle is placed on the inspection plate, the tip is then magnified, and projected on the screen at any desired angle by use of back and forth, up and down controls. Complete with on/off switch, bulb and instruction book, fully guaranteed—S.A.E. for leaflet. **84'6**

SPECIAL OFFERS!

NOW ONLY **£4.19.6** P. & P. 4/-

OUR TRANSISTOR TAPE RECORDER IN ECONOMICAL SEMI-ASSEMBLED KIT FORM

COMPLETE—NO EXTRAS TO BUY!

Consists of three transistor amplifier, record, play, volume control, miniature speaker, forward-stop-rewind-switch, reel of tape and spare reel, motor, attractive coloured case. Mic. and earphone sockets, pick-up coil, mike earphone and carrying handle supplied. Standard battery operated. Simple to put together in less than one hour. Brand new and guaranteed.



SIGNAL INJECTION PROBE MODEL ITI-1

Injects a signal into the circuit at any given point. Produces a signal rich in harmonics from a built-in miniature transistor oscillator. Push button operation, and neon battery strength indicator. Ideal for making rapid checks on radios, amplifiers, T.V., Tuners, etc. A must for the amateur, hobbyist and service man. PRICE 42/6. Complete with batteries.

TRANSISTOR MEGAPHONE MODEL ER.304



The smallest ever! Incorporates printed circuit amplifier with current limiting device to give effective battery life. Range up to 1,000 feet. Size 10 3/8 x 6in. dia.

12 Gns. Complete with batteries and shoulder strap. S.A.E. for illustrated leaflet.

"ZEPHYR" 6 TRANSISTOR POCKET RADIOS

NOW ONLY **£4.19.6**

Complete with battery, earphone and leather case.

INTEGRATED STEREO AMPLIFIER, Model S.A.300

Engineered for the professional... designed for the home. A completely new dual 15 watt stereo amplifier for professional quality reproduction, remarkable versatility and new distinctive styling—worthy of a place in the finest stereo Hi-Fi system, a full range of front panel controls and switches permit adjusting volume, balance and tonal characteristics through every delicate shading of the entire audio range. Supplied complete with installation and operation manual £32/10/- S.A.E. for further details.



3-WAY SLIM CRYSTAL MICROPHONE MODEL 100C



May be hand-held, stand mounted (either floor stand or desk stand) or suspended by lavalier cord. Response 60-10,000 c.p.s. Built-in on/off switch, output level—52db, Omni-directional head. Clips on or off standard stand adaptor permitting tilting for multi-angle use. Satin chrome finish.

ONLY **48' -**

Supplied complete with Desk stand, 7ft. of shielded cable, lavalier cord.

10,000 O.P.V. MULTI-TESTER in semi-assembled kit form. Ranges: D.C. voltage: 0-6-30-120-600-1,200v. (10,000 o.p.v.)

69'6



A.C. voltage: 0-6-30-120-600-1,200 v. (10,000 o.p.v.).
D.C. current: 0-120µA, 0-12-300 mA.
Resistance: 0-20K, 0-2 Meg. (150 ohm, 15K at centre scale).
Decibels: -20 to ±63db (600 ohms 1 mV. odbm = 0.775 v.).
Accuracy: D.C. voltage and current ±2% f.s. A.C. voltage ±4% f.s. Resistance ±3% of total scale length.
Size 4 1/2 in. x 3 1/2 in. x 1 1/2 in. Complete with test leads, battery and instructions.
Few only available, rush your order now whilst stocks last.

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Guaranteed perfect working order. Supplied complete with leads, batteries and instructions.
 Model "D" 34 range ... £8 19 6
 Model "7" 50 range ... £11 0 0
 Registered Post 5/- extra.

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0-500 microamps. 2½ in. Circular flush panel mounting. Dials are engraved 0-15, 0-600 volts. Brand new, boxed, 15/- P.P. 1/3.

7.5 K.V.A. AUTO TRANSFORMERS

0-115-230 volts. Brand new, boxed, £15. Carr. 10/-.

230/250 VOLT A.C. MOTORS

4½ x 3 in. dia., 90 watts, 5,000 r.p.m. ½ in. spindle, 22/6. P.P. 1/6.

1 K.V.A. ISOLATION TRANSFORMERS

230 v. Pri.; 230 v. Sec. Boxed, £5 ea. Carr. 10/-.

VARIAC TRANSFORMERS

24 amp., 230 volt primary, 185 to 250 volt output, £12/10/-. Carr. 10/-.

TELEPHONES TYPE "L"

Generator Bell Ringing, 2 line connection. With batteries, fully tested, 69/6 per pair. Carr. 5/-.

HELIPOTS

Available in 10kΩ, 50kΩ, or 10k+2kΩ. New, bored, 22/6 each. P.P. 1/3.

3000 WATT AUTO TRANSFORMERS

0-115-230 volts, step-up or step-down. Brand new, boxed ex-U.S.A., £7/10/- each. Carr. 10/-.

PANEL METERS

100μA	2½ in. F.M.	D.C.	42/6
100μA	3½ in. F.M.	D.C.	62/6
1 mA	2½ in. F.M.	D.C.	25/-
30/0/30 mA	2½ in. F.M.	D.C.	9/6
350 mA	2½ in. F.M.	D.C.	10/6
300 v.	2½ in. Proj.	A.C.	19/6
300 v.	2½ in. F.M.	A.C.	25/-
500 v.	2½ in. F.M.	A.C.	25/-
120 v.	3½ in. F.M.	D.C.	32/6
1500 v.	2½ in. Electrostatic		25/-

FIELD TELEPHONES TYPE "F"

Suitable for many applications. Generator bell ringing, 2 line connection. With batteries and wooden carrying case, fully tested, £4/19/6 per pair. Carr. 5/-.

8 RANGE SUB STANDARD D.C. AMMETERS

Ranges 1.5A, 3A, 7.5A, 15A, 30A, 60A, 150A, 300A and 450 amp. Housed in wooden carrying case, 8 in. mirror scale. Supplied brand new complete with all shunts and leather carrying case price £15 and 10/- carriage.

R.107 COMMUNICATIONS RECEIVERS

This receiver covers 1.2 to 17.5 Mc/s continuously on 3 Bands. Completely self contained with built-in speaker and power unit for mains or 12 volt battery. Offered Brand New. Boxed, fully checked, £12/10/-. Carr. 30/-.

PCR.2 RECEIVERS

850-2,000 metres. 190-550 metres 6-22 Mc/s output for phones or 3Ω speaker. As new, £5/19/6. Carr. 7/6.
 PCR3 as PCR2 but covers 190/550 metres, 2-7 Mc/s, 7-22 Mc/s, including top band. As new, £8/8/-. Carr. 7/6.
 All above models can be supplied with internal power unit to operate on 200/250v. A.C. at 39/6 extra or alternatively plug-in external power units are 35/-.



NATIONAL H.R.O. RECEIVERS

BRAND NEW! Senior model, table mounting. Complete with a full set of 9 coils covering 50 kc/s to 30 Mc/s. Supplied complete in original transit cases, £25. Carr. 20/-. Power units to operate direct from 200/250 volt A.C., 59/6 extra.



PRECISION COMBINATION VOLT/METER/AMMETER FOR A.C. AND D.C.

Two separate instruments housed in polished wood case, 6 in. scales with knife-edge pointers. Ranges:—
 Volts A.C. and D.C., 160-300-600 v.
 Amps. A.C. and D.C., 25-50-150-200 A.
 Supplied complete with all current shunts, leads and leather carrying case. Manufactured by Elliott Bros. Supplied brand new, £9/19/6. Carr. 7/6.



MINE DETECTOR No. 4A

Will detect all types of metal. Fully portable. Complete equipment supplied tested with instructions, 39/6. Carr. 10/6. Battery 8/6 extra.

COLLARO STUDIO TAPE TRANSCRIPTOR

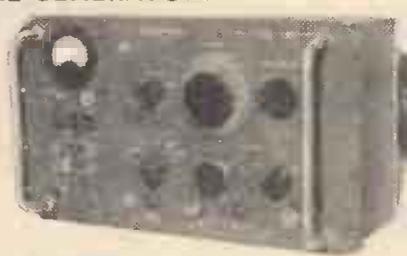
Brand new 1962 model, 3 speeds, 3 motors, digital counter, etc. With latest bradmatic heads and interlock button. Supplied with spare spool, instructions, fixings, 10 gns. each. Carr. paid.

FABULOUS TAPE OFFER

Famous American Brand Tapes. Brand new, fully guaranteed. 5in.—600ft., 10/6; 5in.—900ft., 13/6; 5in.—1,200ft., 17/-; 7in.—1,200ft., 13/6; 7in.—1,800ft., 18/6; 7in.—2,400ft., 30/-; P.P. extra. S.A.E. for full Tape List.

CT.53 SIGNAL GENERATORS

Precision instruments covering 8.9 to 15.5 Mc/s and 20 to 300 Mc/s on 6 bands. Variable attenuator from 1 microvolt to 100 millivolts. Operation 110/200/250 volts A.C. Supplied in perfect working order. Complete with calibration charts. 19 gns. each. Carr. 10/6.



PRECISION A.C. AND D.C. VOLTMETERS

Two ranges, 160 and 320 volts, 8 in. mirror scale with knife-edge pointer. Housed in polished wooden case. Ideal for schools, labs., etc. Supplied brand new, £5/19/6 each. P.P. 3/6.

NATIONAL H.R.O. 5T RECEIVERS

Later model using metallised octal valves. Complete with a full set of 9 coils covering 50 kc/s to 30 Mc/s. Brand new, only £30. Carr. £1.

DELCO 24 VOLT D.C. MOTORS

Shunt wound, 5,400 r.p.m. Torque 4 in. oz. Double spindle. Smooth running, extremely powerful. Also runs on 12 volt. Brand new, 10/6 each. P.P. 2/-.

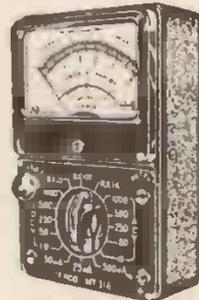
MINIATURE MODEL ACCUMULATORS

Lead acid. Brand new, unused. 2 v. 1.5 A.H. Size 4 x 1½ x 1 in., ½ lb., 5/6 each. P.P. 1/3. 12 v. 0.75 A.H. Size 4 x 3 x 1½ in., 2 lb., 15/6 each. P.P. 1/6.

Hours of Business: 3 LISLE STREET, 9 a.m.—6 p.m. Half Day Saturday
 34 LISLE STREET, 9 a.m.—6 p.m. Half Day Thursday

JEMCO 4,000 OHM/VOLT TESTMETER

1% Precision Resistors throughout. Single control system for all ranges. Highly accurate. Sensitivity 4,000 Ω/volt A.C. and D.C.



Ranges:
 D.C. volts: 0-10-50-250-500-1,000 v.
 A.C. volts: 0-10-50-250-500-1,000 v.
 D.C. current: 0-250 vA
 0-25-500 mA
 Resistance: 0-30kΩ
 0-300kΩ
 0-3MΩ

Decibels: -20 to +36dB (2 ranges).
 Meter sensitivity: 100 microamp.
 59/6. P.P. 2/6.

JEMCO 20,000 OHM/VOLT TESTMETER

As above but with increased sensitivity and extended resistance range (0-5MΩ), 97/6. P.P. 2/6. Either type brand new. Guaranteed, with leads, prods, batteries, instructions.

L.T. METAL RECTIFIERS

All full wave, bridge connected. Brand new, guaranteed.
 12/18v. 1.5A. 3/9 24/36v. 4A. 22/6
 12/18v. 2.5A. 6/3 24/36v. 15A. 45/-
 12/18v. 4A. 8/6 36/48v. 2A. 19/6
 12/18v. 6A. 12/3 36/48v. 4A. 29/6
 12/18v. 10A. 22/6 36/48v. 6A. 32/6
 12/18v. 15A. 37/6 48/60v. 2A. 21/-
 24/36v. 1A. 7/3 48/60v. 10A. 82/6
 Please add postage.

L.T. TRANSFORMERS

All primaries tapped 200/250 volts. 1 Battery Charging. 3.5, 9 or 17 v. 1 amp, 9/9. Ditto, 2 amp, 14/3. Ditto, 4 amp, 16/6. 9 or 17 v. 6 amp, 26/-.
 2 Model Type. 3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24 or 30 v. 2 amp, 18/6. Ditto, 4 amp, 27/6. Ditto, 5 amp, 37/6. Add postage.

AUTO TRANSFORMERS

Step-up, step-down, tapped 0-115-200-230-250 volts. 15 w., 9/-; 60 w., 12/6; 150 w., 18/6; 200 w., 27/6; 300 w., 42/6; 500 w., 67/6; 1,000 w., 99/6; 1,500 w., £6/19/6. P.P. extra.

R.C.A. PLATE TRANSFORMERS

Pri. 200/250 v. sec., 2,000-0-2,000 v. 500 mA. tapped 1,500 v., new, boxed, £6/10/-. Carriage 15/-.

DUMONT K1051PI DOUBLE BEAM C.R.T.

Twin Gun, Brand new, boxed, 59/6. P.P. 3/6.

1.2 Ohm 12 Amp. RHEOSTAT

Geared slider type, new, boxed, 15/6 each. P.O. 3/6.

MARCONI TF 885 VIDEO OSCILLATORS

Frequency coverage 25 c/s to 5 Mc/s. Supplied as new. Price £90 each.

CADMIUM SULPHIDE PHOTOCELLS

Very sensitive, full data supplied, 12/6 each. P.P. 6d.

MINIATURE PANEL METERS

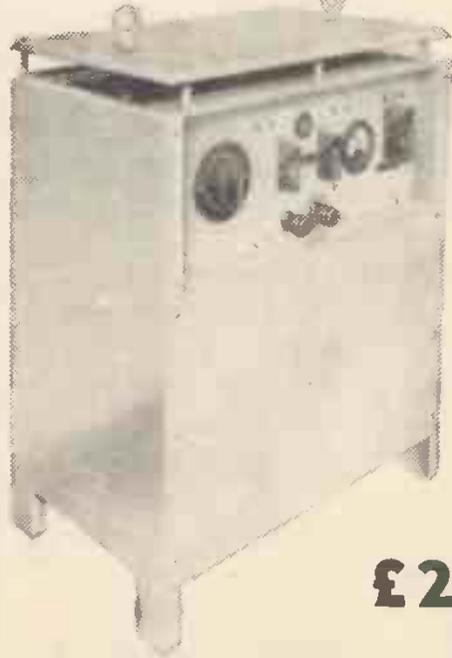
For 1½ in. dia. panel hole.
 0-50μA ... 39/6 0-300 v. D.C. 27/6
 0-500μA ... 32/6 "S" meter 35/-
 0-1 mA ... 27/6 "VU" meter 42/6
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Normal cost over £100

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.

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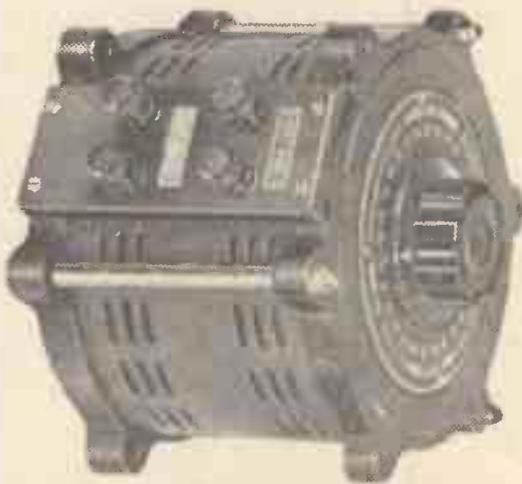
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VARIABLE TRANSFORMERS

QUANTITIES UP TO 100 DELIVERED BY RETURN. NEW AND BOXED.

Brand New



SOLE AGENT

Output: (1.3 kVA). 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.

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10 amps.

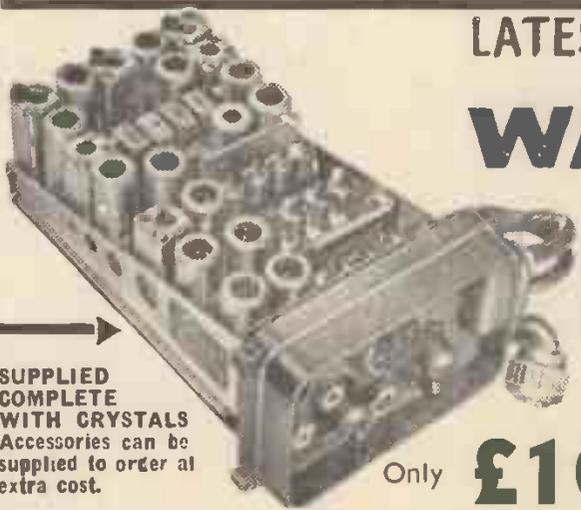
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20 amps.

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WALKIE TALKIE



SUPPLIED COMPLETE WITH CRYSTALS. Accessories can be supplied to order at extra cost.

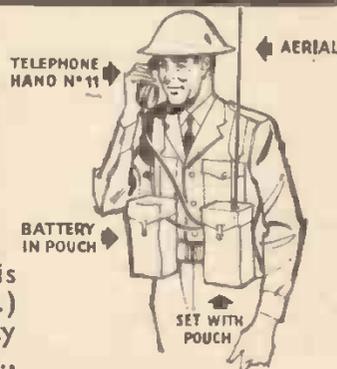
Only **£10** Each

"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. 90 v./1.3 v. (i.e. Ever Ready/Berec B1538). 14 of the current series of B7G valves are employed: 1-3A4, 6-IL4, 4-IT4, 1-IS5, 2-1A3.

Each set is in first-class condition.

Special quotations for quantities up to 3,000 sets.



AERIAL MASTS

IMPROVED TYPE 50 Mk. II 36ft. HIGH

Kits comprise—six 2½in. 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 overseas. Extra 6ft. sections can be supplied at 17/6 per section.

only **£9.10.0** Carr. 15/6.

U.S.A. Type 45ft. TELECOM. AERIAL MAST

(7 sections, 6ft. 8in. x 2½in., guys, etc.) This entirely complete set in carrying case, 12½ Gns. Carr. 17/6. Wood packing case (refund on return) add 20/- extra. Or 2 sets for £25. Carr. extra. British manufacture only.

SAVE £100

A COMPLETE Ex Govt. PUBLIC ADDRESS SYSTEM For Office, Factories, Sports Grounds & Cars

15 GNS By Truvox carr. 30/- Amplifier, Mike, 4 Loudspeakers, etc. (Operate from 6/12 v. Car Battery).

LOUD HAILERS

COMPLETE with POWER MICROPHONE. For calling personnel in stores, warehouses, factories, etc, similar to Police type, ex-H.M. Forces. Simply connect to 6/12 volt car battery and use. Amazingly powerful. Why pay £2 a day hire charge for amplifiers? Buy this complete unit. Sent by return. Carriage Free.

ONLY **£7.10.0**

Additional extension Speaker £3.

REVOLUTIONARY 80-WAY MINIATURE PLUG and SOCKET



Manufacturers: G.E.C. LIMITED STOCKS— **£5 PER PAIR**

- (a) Precision-made silver plated connectors.
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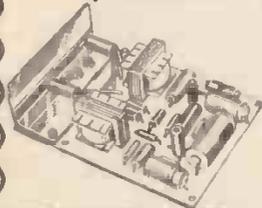
NEW FROM STOCK 8-BANK-25 WAY UNISELECTORS

Full wipe, non bridge. 24 volt op. Due to circuit modification removed from Electronic Units. Unused and undamaged. **£5 EACH**

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★ FULL DETAILS OF ALL ITEMS STOCKED IN OUR ILLUSTRATED CATALOGUE 1/-.

1/2 WATT 4 TRANSISTOR AMPLIFIER



● 1 watt peak output.
±3db 70 c/s. to 12 kc/s.
Output to 3 ohm speaker.
9 volt operated.
Full details on request.

Built and Tested 59/6 OR Kit of Parts 52/6
P.P. 1/6 P.P. 1/6

OC81D and 2-OC81 Transistors. Ideal for intercomm. Record Player, Tuner Amplifier or any application requiring a quality and reliable amplifier.

- 4 Transistor printed circuit 250mW amplifier. 3 x 1 1/2 x 7/8 in. 9 volt 52/6.
- 3-Transistor. 125 mW. 9 volt. 1.9 x 1 x 1 in. 45/-.

BATTERY ELIMINATORS AND CHARGERS

1. For PP3 or equivalent 9 volt Pocket Radio Battery, 18/6. P.P. 1/-.
2. For PP4, PP7, PP9, PP10, 9 volt Portable Radio Batteries up to 300 mA. 45/- P.P. 2/-.
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4. Rechargeable PP3 battery. Runs as long as 100 batteries. Complete with charger unit, 25/- P.P. 1/-.

METERS. P.P. 1/6 any type.

0/500µA. 2 1/2 in. MC. FR. D.C.	20/-
1 mA. 2 in. MC. Square	27/6
1 mA. 2 1/2 in. MC. FR. D.C.	30/-
50µA. 2 in. MC. Square	35/-
2 1/2-0-2 1/2 mA. 2 1/2 in. MC. FR.	12/6
0/40/120 2 in. MC. Square	10/-

DEKATRON ERICSSON GS12C (CV-1740) Bi-directional 12-way Selector Tube. 25/- BRAND NEW

PHOTO MULTIPLIER 931A (CV2696). Brand new, 60/- each. Base 2/- Special purpose version 931A-CV337, 80/- each. Base 2/-.

MINIATURE LEDEX SWITCHES—BRAND NEW

24 volt D.C. rotating switches, fitted actuator at each end of bank of contacts. Uses standard switch wafers.

- 5 Bank 45/-.
- 8 Bank 50/-.

NEW PURCHASE REDUCES TOTAL COST

"CONTESSA" III

● **COMBINED PORTABLE AND CAR RADIO** ●
AMAZING SENSITIVITY AND SELECTIVITY ON MEDIUM AND LONG WAVEBANDS

● The easiest Superhet Radio to build on the market. Features clearly marked printed circuit and packaged components with full illustrated building instructions. Full tuning of medium and long wave bands with unbeatable sensitivity and selectivity. Excellent tone and volume with over 600MW push-pull output.

● Clearly marked horizontal station dial with slow motion tuning. Two colour Blue or Beige cabinets with Gold handles, grilles and fittings. Size 10 1/2 x 7 1/2 x 3 1/2 in. include car aerial socket, recording sockets.

● 6-Mullard Transistors and 2-Diodes.

Guaranteed the Best Obtainable.

● Attractive Appearance—Reliable Design—Quality Performance ●

FULL DETAILS WITH PARTS LIST AND PRICES FREE ON REQUEST.

★ TOTAL COST OF ALL PARTS **£9.19.6** P.P. 3/6. ★
All parts sold separately and fully guaranteed.



"CAPRI" POCKET-SIX 6-TRANSISTOR MEDIUM AND LONG WAVE POCKET SUPERHET RADIO

● SIZE 4 1/2 in. x 2 1/2 in. x 1 1/2 in. REALLY POCKET SIZE ●

The most compact 6-transistor and diode radio with speaker available to the home constructor. Features the latest in miniature components and circuitry. Supplied with Mullard transistors and two-tone moulded cabinets in red/white or blue/white with gold fittings. All components are supplied in packets and clearly identified. A printed circuit is used with fully illustrated building instructions. Push-pull output coupled with a sensitive and selective circuit make the "CAPRI" hard to beat. Fitted Earphone/Record socket.

● FULL AFTER-SALES SERVICE AND GUARANTEE

● ALL PARTS SOLD SEPARATELY—DETAILED LEAFLET ON REQUEST.

TOTAL COST **£5.19.6** P.P. 2/-.



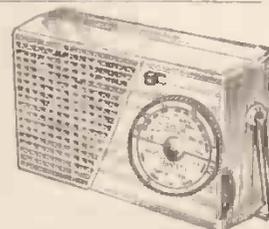
"MINIRANGER"

3-Transistor Plus 2-Diodes. Smallest radio to build yourself. Printed circuit full tuning. ONLY 3 x 2 x 3/4 in. Over 20 stations

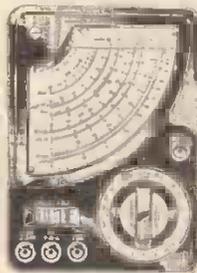
TOTAL COST **59/6** P.P. 1/6

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Size 5 1/4 x 3 x 1 1/2 in. 5-Transistor, plus Diode MW/LW to build. P.P. 2/- **99/6**



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5 GNS.

20,000 ohms per Volt Model ITI-2

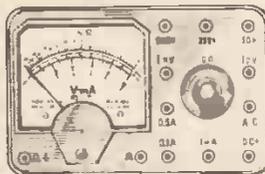
6 Ranges D.C. voltage to 2 1/2 kV.
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Capacity and dB ranges.
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£8.19.6



49/6

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0/10/50/250/500/1,000 volts A.C./D.C. 0/1/100/500 mA. D.C. Resistance 0/100k ohm.

Ideal pocket sized multi-tester for all radio and domestic work.
Size 3 1/2 x 2 3/8 x 1 1/2 in. with battery, leads and instructions.

All Meters Fully Guaranteed for 6 months. Full Service Facilities.



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5 Ranges D.C. volts to 1 kV.
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5 Ranges A.C. volts to 1 kV.
4 Ranges resistance to 10 Megohms.
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TP55, 20,000 ohms/volt. Complete 5 1/2 x 3 1/2 x 1 1/2 in.



75/-

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0/10/50/250/500/1,000 volts D.C.
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0/500µA/10/250mA., D.C.
Resistance 0/10K/100K/1 Meg.
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5 HARROW ROAD, EDGWARE ROAD, PADDINGTON, LONDON, W.2.

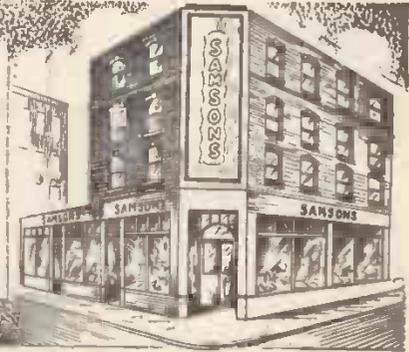
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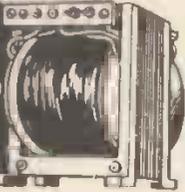


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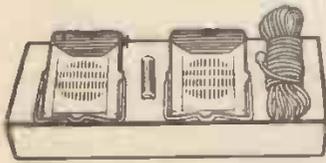
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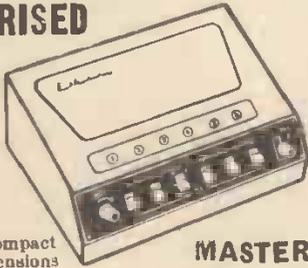
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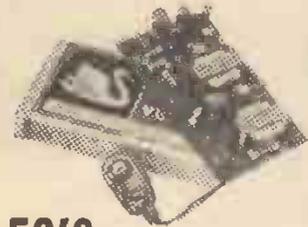
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52/6
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8 ohm speaker to suit above, 2 1/2 in. flux density 7,800 gauss, power 200 mW **16/6**
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Printed circuit board and set of 27 capacitors ranging from 50+50µF at 350 V. to 47 pF.

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- Hand Held
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A complete Probe Type Transistor Oscillator with Indicator Lamp, batteries and instructions. **IDEAL FOR FAULT TRACING ON TRANSISTOR SETS.**

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8in. **DOUBLE CONE HI-FI SPEAKER** (Big 8in. Model 8A7)

Frequency response 50-16,000 c/s. Lowest resonance 60 c/s. Sensitivity 98 db. Impedance 16 ohms. Total Flux 53,000 maxwells. Voice coil dia. 1in.

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Designed on an entirely new principle for lightweight applications. Highly stable heat characteristics ensure long life. Removable handle permits iron to be carried safely even white hot. Supplied complete with Vinyl bag, lead and plug.

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Spares available. Element 4/6. P. & P. 6d.

Miniature Clear Plastic Panel Meters FOR YOUR HOME-BUILT TEST EQUIPMENT

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 All models Individually Boxed and Fully Guaranteed.

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5 GNS.



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D.M.11 MICROPHONE with Base A flexible, newly designed dynamic microphone integrated with matching desk stand. Professional quality. Ideal for tape recording, public address, broadcasting and communications. Ruggedly constructed, removable base for desk or hand use. 360° swivel ball joint allows tilting in any direction. 9in. high. Body dia. 2in. tapering to 1 1/2 in. Base 5in. dia. Magnificently finished in mist blue with chrome trimming. Complete with shielded cable stand. Fully guaranteed.

The famous WELLER SOLDERING GUN

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72/- P. & P. 3/-

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Enables telephone conversations to be amplified or recorded. Complete with 5ft. shielded cable. P. & P. 9d.

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Tests T.V. Windings for shorting turns by unique pulse method. This compact instrument can save you pounds. It detects a single shorting turn in a line output transformer, deflector coil or other Windings. The pulses provided by the instrument detect intermittent faults. In position one, the continuity of the Windings is checked; in position two, high-impedance coils and in position three, low-impedance coils. Once you have used the Skantest you will regard it as a "must" in T.V. Servicing.

EXCLUSIVE MAILPLAN OFFER

99/6

P. & P. 2/9.



The D900 TRANSISTOR TESTER/ POWER SUPPLY

Checks Alpha gain. (Current gain A.C.) with transistor in place. Checks Beta gain. (Current gain under-D.C. conditions). Measures leakage currents between Collector/Base and Collector/Emitter, at any voltage between zero and 25 V. Specially designed for all receivers using PNP Transistors.

NOW you can carry out easy, fast testing of transistors and miniature transistor receivers without removing transistors from circuit. Self-contained signal tracing oscillator, self-contained variable power supply.

Labour-saving, Speedy, Simple, ONLY £10

Size 5 1/2 in. by 3 in. by 2 1/2 in.

Ask for full technical specification.

High Resistance Standard Type TWIN HEADPHONES

2,000 ohm Model 8F20. **13/6** P. & P. 1/-
 Complete with headband.



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48 pages of valves and accessories. Send 1/- in stamps for your copy. Trade catalogue also available for which please attach your business letter heading.

RECTIFIERS suitable for Battery Chargers 12 volt output, 2 amp. 7/-; 4 amp 12/6 and 6 amp. 15/6.

POTENTIOMETERS: A range of Ardenite miniature potentiometers is available. In the circular type adjustment of the control is made by rotating the peripheral ring.

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TYPE VC.1545, with switch, diameter 0.900in., width with pins 0.490in., available in the following values:— 5 Kohm semi-log, 20 Kohm semi-log, 1 Megohm semi-log, 5/3.

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6in. x 4in. x 2½in.	4/6 each
8in. x 6in. x 2½in.	6/3 each
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14in. x 3in. x 2½in.	6/- each
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all are four-sided—ideal for radio receivers—amplifiers—power packs, etc.

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For use with our chassis, as front panels base plates, etc. Available in the following sizes:—

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8in. Bronze/RS
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14,500 gauss. Fitted roll surround and double diaphragm. Resonance 50/55 c/s. Impedance 10/15 ohms. Total £6 15 0

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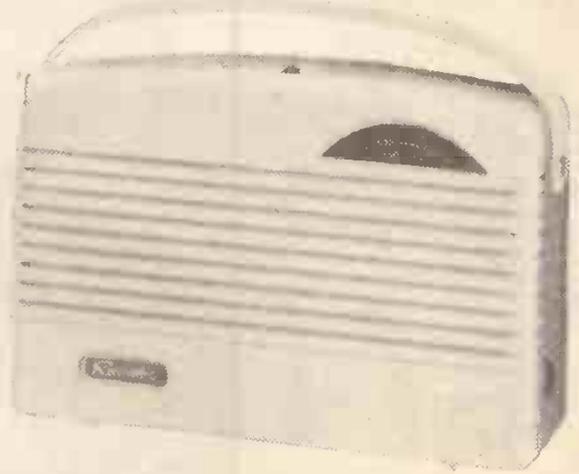
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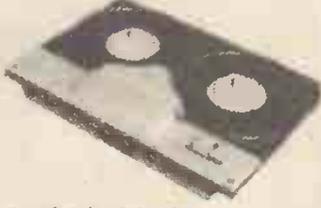
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Made by well-known manufacturer. 5 valves, record level indicator, inputs for mic. and gram. Volume and tone controls. In sub-assemblies. Self-powered. **WIRECOMP'S PRICE** **£8.19.6** P. & P. 5/-

Carrying case to suit above amplifier and Studio deck, **£3/15/-**. P. & P. 7/6 extra. 7x4in. Speaker, 16/6. P. & P. 1/6 extra. **IF PURCHASED TOGETHER WE OFFER THE AMPLIFIER, CASE AND SPEAKER AT THE SPECIAL PRICE OF £12/19/6.** P. & P. 7/6 extra.

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High fidelity, recording tapes.	
5in. Standard play, 600ft.	12/-
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Double Play Tape.	
5in., 1,200ft.	32/6
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7in., 2,400ft.	45/-
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LOOK AT OUR NEW PRICES!

THE 'SPRITE'



A six transistor superhet Miniature Pocket Radio of Commercial Quality. Fully tunable over Long and Medium wavebands. Uses printed circuit and High sensitivity internal ferrite rod aerial. I.F. frequency 470 Kc/s. Transistors: 3-Philco 2067s, 2-Mullard OC81M, OC81DM and OA90 diode. 3 inch speaker. Works on single PP3 battery. Supplied with the complete RF and IF stages, Driver and Output stages, ready built and mounted on the printed circuit; for final assembly you have only to fit the wave-change switch, tuning condenser and drive, volume control, earphone socket and aerial rod. In very attractive plastic case, size 4 x 2½ x 1½in. **COMPLETE AS ABOVE** **79/6** All parts sold separately.

Real Cali Leather Case, wrist strap and Personal Earphone with case and battery 12/6 extra. P. & P. 3/6 extra. (Data and instructions 2/6, free if all parts bought).

THE COROVER '6'

This superhet receiver uses the very latest circuitry, 6 transistors and two diodes and is fully tunable over both medium and long wavebands. First stage uses three Mullard AF.117 alloy diffused transistors with OA.79 and OA.91 diodes, output—OC.81D and two OC.81's in push-pull. I.F. frequency 470 Kc/s. Large internal ferrite rod aerial gives excellent reception over all ranges. 3 inch high flux speaker has a maximum output of 330 mW. Operates on four 1.5 v. pen torch batteries. All components are mounted on a single printed circuit board. Attractive plastic case with carrying handle—fitted sockets for personal earpiece, tape recorder and car aerial. Size 6½ x 4 x 1½in. **MAY BE BUILT FOR** **£5.7.6** All Parts sold separately.

P. & P. 4/- extra. (Data and instructions 2/6, free if all parts bought)

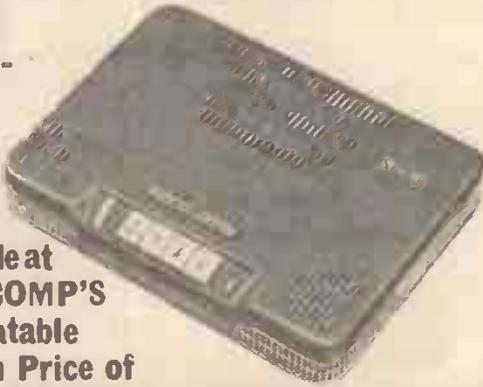


TYPE 82 TELEFUNKEN STEREO

HI - FI AMPLIFIERS

NOW

available at **WIRECOMP'S** unrepeatable Bargain Price of **ONLY £5.19.6** P. & P. 7/6 extra.



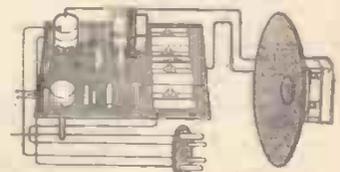
The perfect Stereo amplifier designed to unequalled specifications. Power output 5 watts (2½ watts per channel). Frequency response 50 c/s to 40 Kc/s, 2 dB. 45 c/s. to 30 Kc/s. ½ dB. Suitable for all normal inputs from tape recorders, pickups, microphones and radio. Power requirements 110, 125, 150, 220, 240 volts A.C. Piano key selecting. Preset tone control. Size 12 x 9 x 2in. Finished in grey/green hammered enamel.

TRANSISTOR AMPLIFIER

COMPLETE WITH 3in. MOVING COIL SPEAKER

49/6

P. & P. 2/-



1 watt fully transistorised Amplifier. Incorporates 2 power Transistors and 3 G.E.T. 114 Transistors in push/pull—complete with separate tone and volume controls on 2½ x 4½in. printed circuit board Operates from Ever Ready P.P. 11 Battery. Suitable for use with the Starr Kinder Players. See below.

THE STAAR "KINDER"

45 R.P.M.



9 v. Battery Operated Single Player Complete with P.U.

The ideal deck for your transistorized portable Record Player, complete with Cartridge and Stylus. Size 7½ x 6in., depth below motor 2½in. Attractive two-tone grey finish. Ideally suited for use with the above Transistor Amplifier.

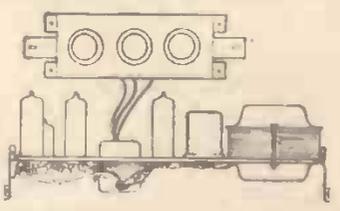
£2.9.6 P. & P. 2/6.

Two speed Model 33 & 45 r.p.m. 79/6.

8 WATT AMPLIFIER

£5.5.0

Made by well-known manufacturer. Spec. 2-EL84, 1-EZ80 and 1-ECC85 Push-pull output. Separate Bass and Treble controls on panel with extended lead.



P. & P. 3/6.

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KAPURA Mdl. UI Multi-Meter

Offered for **39/6** P. & P. 2/6



A must for the home constructor. Sensitivity: 1,000 ohms per volt. A.C. and D.C. Ranges (A.C./D.C.): 0-10-50-250-500-1,000 v. D.C. current 0-100-500 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 5 x 3 x 2½in. Complete with test leads.

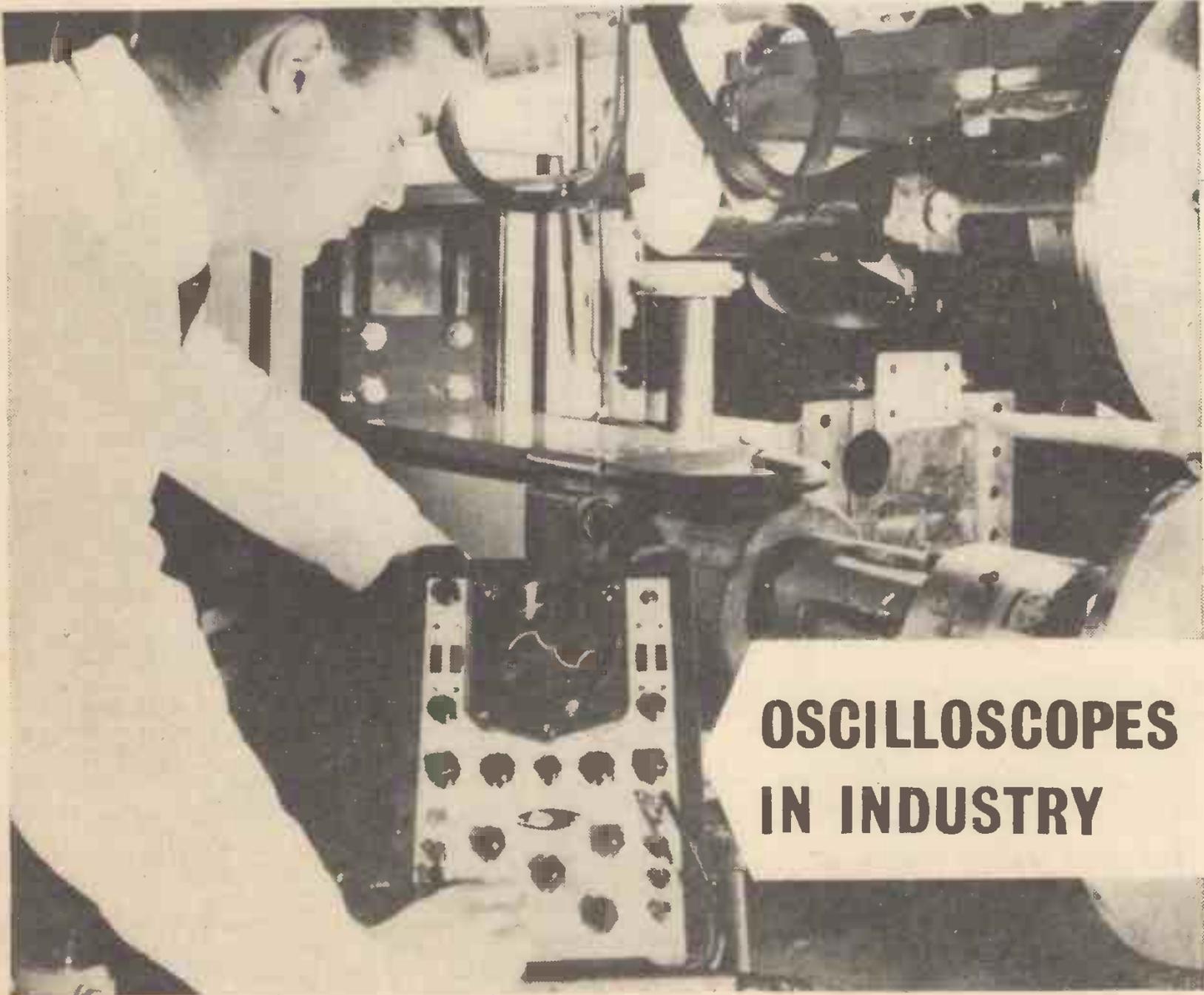
ELECTRIC MOTORS

Brand new tape recorder motors. Single phase, fully shrouded. 200-250 v. A.C. ½ x ½in. spindle with detachable pulley, fitted switch. Suitable for tape decks, record players and many other uses. P. & P. 3/6. **14/11**

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The application of cathode-ray oscilloscopes in measuring effects of shock and vibration, as well as the more conventional stress, torque, pressure, displacement and acceleration, is described in February **INDUSTRIAL ELECTRONICS**, now on sale—one of many articles showing how electronics can cut costs and increase productivity in all kinds of industrial processes. **INDUSTRIAL ELECTRONICS** is vital to all who must use electronics to meet ever-increasing competition. Other articles in the current issue are summarised below; March issue will include *Tunnel Diode Computer Stores*.

ALSO IN FEBRUARY ISSUE:

- **DYNAMIC BALANCING**
Accurate balancing of rotating parts is essential to prevent vibration; this article describes apparatus which determines magnitude and position of the balancing weights.
- **THE POLYVAC PROCESS**
Equipment for spectrochemical analysis, comprising spectrometer, electronic measuring apparatus and computer, which presents its output as a typed record.
- **GOONHILLY AERIAL CONTROL SYSTEM**
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FIRST EVER! 100,000 O.P.V. MULTI-TESTER

MODEL 370-N

£14.14.0

Incorporates 0.5 μ A. basic meter, scale size 4 2/3 in. Ranges D.C. volts, 8 ranges 100 mV. to 5 kv. D.C. amps., 7 ranges, 10 μ A. to 10 A. A.C. volts, 8 ranges 2.5 v. to 1 kv. Ohms 5 ranges 0-50 megohms and 5 ranges 40 ohms to 400 K ohms. Overall size 7 1/2 x 5 2/3 in. Complete with instruction manual.



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1,000 o.p.v. **MODEL TK.50.** Ranges D.C. mA. 1,250 mA D.C. and A.C. Volts 10-250-500-1,000 v. Ohms 0-10 K ohms, 0-100 K ohms. Special prices 59/6. Few only. All above are complete and ready to use with batteries, test leads and instructions.

AVO MODEL 7. This well-known test instrument supplying 50 ranges of current, voltage and resistance tests. Complete with leads and batteries. Ready for use. Perfect order. **ONLY £11.**

AVO WIDE RANGE SIGNAL GENERATOR. Covering 50 kc/s. to 80 Mc/s. in 6 turret-operated ranges. Perfect condition in original transit case with accessories. Standard A.C. mains operation, **£15.**



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Evershed & Vignoles Series 2, 500v. Accurate working order, perfect condition, fully tested. Complete with leather case, **£40.**

EVERSHED & VIGNOLES MEGGER CIRCUIT TESTER (low reading ohm meter). 2 ranges 0-3, 0-30 ohm. Complete with leather case and test leads. As 'new'. **£6/6/-.** Ditto, 0-500, 100-5,000 ohms, **£5,19/6.**



EVERSHED & VIGNOLES. Wee Megger 500 v. Brand new with leather carrying case. 16 Gns. Ditto, 250 v. **£12 10/-**

SPARE LEATHER CASES for Wee Meggers, 15/- each.

ALL TEST EQUIPMENT SUPPLIED CARRIAGE PAID

TRANSFORMERS 'POWERSTAT' VARIABLE TRANSFORMERS MADE IN U.S.A.



Input 230 volts. 50/60 cycles. Output 0-260 volts at 9 amps. Fully shrouded. For bench or panel mounting. A robust job of outstanding quality and performance. Brand new and guaranteed.

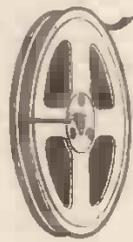
£15 CARR. 7/6.

MAINS ISOLATING TRANSFORMER (Gresham) Pri. 230/250 v. Secs. 240-0-250 v. 1.5 amps., also 5 v. 12.5 amps. Potted. Size 7 in. x 7 1/2 in. x 10 1/2 in. Weight 50 lb. Ideal for obtaining TWO ISOLATED 240 v. lines at 360 watts each. Perfect condition. Removed from new equipment, **£5. Carr. 5/-.**

AUTO TRANSFORMERS. Step up, step down. 110,115, 220/230 v. Full shrouded, terminal block connectors. 150 w. 32, 6, 300 w. 37/6, 500 w. 67/6, 750 w. 77/6, 1,000 w. 97/6, 1,750 w. 175/- Carriage 4/- on each type.

RCA PLATE TRANSFORMERS 100 to 250 v. primary 50-60 cycles. Secondary 1,500-0-1,500 v. or 2,000-0-2,000 v. at 500 milliamperes. Brand new and boxed **£8 10/-.** Carriage extra.

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5in.	Std.	600ft.	8/6
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5in.	L.P.	900ft.	12/6
5 1/2 in.	L.P.	1,200ft.	15/-
7in.	L.P.	1,800ft.	22/6
4in.	D.P.	1,200ft.	12/6
5in.	D.P.	1,200ft.	21/-
5 1/2 in.	D.P.	1,800ft.	28/6
7in.	D.P.	2,400ft.	30/-

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5in.	Std.	600ft. (CIP-6)	13/-
5 1/2 in.	Std.	900ft. (CIP-9)	16/-
7in.	Std.	1,200ft. (CIP-12)	21/-
5in.	L.P.	900ft. (LP-9)	16/-
5 1/2 in.	L.P.	1,200ft. (LP-12)	19/6
7in.	L.P.	1,800ft. (LP-18)	28/6
5in.	D.P.	1,200ft. (CMXP-12)	32/-
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SPARE SPOOLS. 4in., 5in., 5 1/2 in., 2/- each.			
7in. 2/6; 8 1/2 in. 5/-.			

"GEE'S" ACCESSORY KIT
1 "BIB" Splicer, 1 Splicing Tape, 3 Leader Tapes (3 colours), 10 Retaining Clips. Packed in plastic container. **PRICE 32/6.** While stocks last.

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"Lafayette" high quality. 7in. L.P., 1,800ft., 20/-; 7in. Std., 1,200ft. 2 for 30/- post paid.

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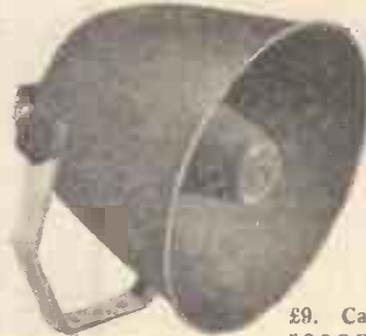
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AR. 88 Original 8in. P.M. SPEAKERS. Black crackle metal cases. Brand new in original cartons. Few only. **£3/10/-.** Carr. 3/6.

12 VOLT D.C. AMPLIFIER (Ardente). 15 watt push-pull output Mike and gram. inputs, tapped output transformer. Brand new, maker's cartons, **£12/10/-.** Carr. 10/6. (Original hand microphone for above 30/-.)

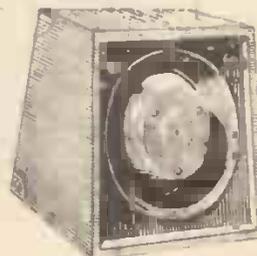
BEAM PROJECTION EXPONENTIAL HORN. 19in. long, 12in. square flare. Complete with mounting bracket, ideal for mobile use. Brand new, **£8/10/-.** Carr. 7/6.

HEAVY DUTY PRESSURE UNIT. Special quality. 15 ohm, 20 watts P.M. 1 1/2 in. Screw top, 79/6. Carr. 4/-.

6 inch P.M. HEAVY DUTY SPEAKERS. Complete with line trans., in all steel blue-grey double gridded cabinet, 30/- P. & P. 3/-.



TRUVOX / TANNOY LOUD HAILERS. With 180 ohm line transformer and condenser impedance 7 1/2 ohms, handling capacity 8 watts. Complete in slope-front wooden case, 27/6. Carr. 5/-.



CRYSTAL MICROPHONE MODEL BM.3
Three-way mike for hand, desk or floor stand use. Response 100-8,000 c/s. Sensitivity -62 dB. Length 7in. Head dia. 1 1/2 in. Supplied with neck band, lead and standard jack plug. Terrific performance. Outstanding value at **ONLY 39/6.** P. & P. 2/-. Table stand 12/6 extra.

SUPER QUALITY HI-FI DYNAMIC (M/C) MICROPHONE Model MD. 180 with built-in transformer, 50 K impedance. Suitable for hand or stand use. Complete with screened lead. Outstanding Value **£4,15/-.** Post free.

MICROPHONE FLOOR STAND (Telescopic). HEAVY 9in. dome, chromium base, chromium stand with screw top. Extends to approx. 6ft. Suitable for above mikes, etc., **55/-.** Carr. 5/-.

TELEFUNKEN HI-FI STEREO AMPLIFIER LATEST MODEL 882 with balance control **FEW ONLY LEFT!!**



£7.7.0 Carr. 6/-

110/250 v. A.C. 5 watt undistorted output (10 watts nominal) size 12 9 2in., wt. 9 lb. Complete with spec. and instructions. **SEND NOW!!**

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5ft. 6in. Angle Uprights, **£4/10/-.** Carr. 15/-.
6ft. Channel Upright, **£6.** Carr. 20/-.
7ft. Channel Upright, **£7.** Carr. 20/-.
All with Heavy Duty Base.

COLLARO "STUDIO" TAPE TRANSCRIBERS. Brand new in original cartons. 3 speeds, 1 1/2, 3 1/2, 7 1/2 i.p.s. 3 motors, digital counter, etc. Complete with 7in. spools, instructions and fixings. A.C. 200/250 v. operation. **SPECIAL PRICE 10 GNS.** Carr. paid.

BARGAIN OFFER !!
TELEFUNKEN HI-FI STEREO AMPLIFIER

110/250 v. A.C. input 5 watt undistorted, output (10 w. nominal). Size 12 x 9 x 2in. Weight 9 lb. Complete with spec. and instructions. **£5/19/6** Carr. 5/-.



Also Model S82 similar spec. but with balance control. **£6/19/6**. Carr. 5/-.

6 TRANSISTOR AND DIODE SUPERHET

A first class 2 waveband transistor superhet in kit form. ● Printed circuit panel (size 8½ x 2½in.) ● 3 pre-aligned. I.F. transformers. ● High-gain Ferrite rod aerial. ● First-grade G.E.C. transistors. ● Car aerial winding. ● Push-pull output. ● All parts supplied with simple instructions. **ONLY £4.5.0** P. & P. 2/6



All parts sold separately. 2½in. 35 ohm speaker **10/6**; 3½in. 35 ohm speaker **16/6**; 35 ohm Sin. P.M. **18/6**; 7 x 4in. 35 ohms speaker **21/-**. P. & P. 1/6 per speaker.

PORTABLE CABINET

Size approx. 9½ x 6½ x 3½in. Suitable for above using 3½in. speaker, **25/-**. P. & P. 2/-.

COIL AND TRANSFORMER SET FOR TRANSISTOR SUPERHET

3 I.F. transformers, one oscillator coil, one driver transformer and wound Ferrite aerial (med., long and aerial coupling), **28/6** complete, post 1/- 6 transistor printed circuit, board to match, **8/6**, post 9d. Circuit diagram 1/6 extra.

MARTIN RECORDAKITS

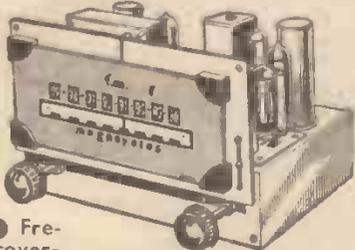
Tape Amplifier for B.S.R. deck. **£8.8.0** P. & P. 3/6.
Cabinet with 7 x 4in. speaker for above, **£4/4/-**. Carr. and ins. 5/-.
Tape Amplifier for Collaro Studio deck, **£11/11/-**. P. & P. 3/6.
Cabinet with 9 x Sin. speaker for above, **£5/5/-**. Carr. and ins. 5/-.
Tape Pre-Amplifier, complete with power supplies, **£8/8/-**. P. & P. 3/6. Full easy-to-follow instructions supplied. Send S.A.E. for leaflet. Full range of Microphones and Tape always in stock.

RECORDING TAPE

P.V.C. base, full frequency L.P. tape. 7in. 1,800ft. (normally 50/-), **27/6**; 5½in. 1,200ft. (normally 35/-), **18/9**. P. & P. 1/- per spool. Ideal for 2- or 4-track recorders.

HARVERSON'S F.M. TUNER MARK I

● F.M. tuning head by famous maker. ● Guaranteed non-drift. ● Permeability tuning. ● Frequency coverage 88-100 Mc/s. ● OAB1 balanced diode output. ● Two I.F. stages and discriminator. ● Attractive maroon and gold dial (7 x 3in. glass). ● Self powered, using a good quality mains transformer and valve rectifier. ● Valves used ECC85, two EF80s and EZ80 (rectifier). ● Fully drilled chassis. ● Size of completed tuner 8 x 6 x 5½in. ● All parts sold separately. **£5/19/6** plus 8/6 P.P. and ins. Circuit diagram and illustrations 1/6 post free.



Mark II Version, as above, but complete with magic eye, front panel and brackets. **£6/12/6**. P. & P. 8/6.

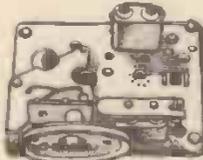
Mark III Version, as Mark I but with output stage (ECL82) and zone control. **£7/7/-**. P. & P. 8/6.

HANDSOME METAL CABINET in choice of grey, black or green. To fit Mark I, **25/-**. P. & P. 2/6. To fit Mark II, **17/6**. P. & P. 2/6.

SPECIAL OFFER!

GÖRLER F.M. TUNER HEADS.
10.7 Mc/s. I.F., 15/-, plus 1/9 P. & P. (ECC85 valve 8/6 extra.)

F.M. TUNER HEAD



A permeability tuned tuner head by a famous maker, supplied without valve (ECC85) and drum and spindle, **18/6**, plus 1/9 P. & P. Valve 8/6 extra. Drum and spindle 3/6 extra.

SPECIAL PURCHASE!

Brand new and unused **TURRET TUNERS**

By famous maker Complete with PCC84 and PCF80 valves. 34-38 Mc/s. I.F. Biscuits for Channels 1 to 5 and 8 and 9. Circuit diagram supplied. **25/-** each. P. & P. 2/6

FURTHER HUGE PURCHASE enables us to offer the

E.M.I. 4-speed Player and P.U.

NOW ONLY 67/6 P. & P. 4/6.



Heavy 8½in. metal turntable. Low flutter performance 200/250 v. shaded motor with tap at 45 v. for amplifier. valve filament if required. Turn-over LP/78 head.

4-SPEED PLAYER UNIT BARGAINS

Single Players. B.S.R. TU/12. **£3/10/-**. Carr. 3/6.

Auto. Changers. B.S.R. UA14. **£6/2/6**. Latest B.S.R. UA16. **£7/2/6**.

Carr. 5/- on each. Latest Garrard "Auto-Slim," **£6/17/6**. Carr. 5/-

LOUDSPEAKER

SILKS Heavily woven in champagne & brown 48" wide. Originally 35/- per yard. Our Special Price 12/- per yd. length. P. & P. 1/6. Also Red rexine, dark grey and oatmeal fabrics for cabinet covering. 54in. wide. 13/6 per yard length. P. & P. 1/6.

TRANSISTOR PERSONAL RADIOS

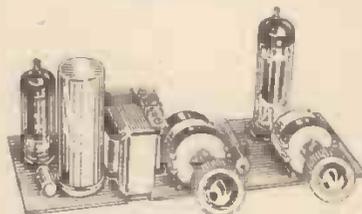
Complete with leather case, personal earphone and PP3 battery. Will receive Luxembourg etc., loud and clear. **SIX TRANSISTOR TYPE £5.9.6** Size 4" x 2½" x 1½"
EIGHT TRANSISTOR TYPE £6.9.6 Size 4½" x 2½" x 1½"
Both plus p. & p. 2/6 each

B.S.R. MONARDECK

(Single speed) 3½in. per sec., simple control, uses S½in. spools, **£6/15/-** plus 5/6 carr. and ins. (Tapes extra.)

COLLARO STUDIO DECK £10/10/- plus 5/6 carr. and ins. (Tapes extra.)

AMPLIFIER ON PRINTED CIRCUIT BOARD



Two valve. UY85, UL84 with O.P. trans., use with 80 volt tap off motor. **39/6**. P.P. 2/6 on above. Dropper res. for filaments if required, 2/6.

B.S.R. AUTO UNITS

160 v. Suitable for use with above. (Slightly soiled) **£4/4/-**. P. & P. 5/-.

LARGE CABINET

Suitable for above B.S.R. Auto Unit and amps. Complete with 3 ohm speaker. **£3/9/6**. Carr. 5/-

Superior Cabinet. Similar to above to take 8 x Sin. speaker, with motor board, will accommodate BSR UA14 or UA16. **£3/9/6**. Carr. 5/6. Speaker 15/- extra. P. & P. 1/6 extra.

SPECIAL BARGAIN OFFERS:

MAINS TRANSFORMER. Impregnated and fully shrouded. Size 4½ x 3½ x 2½in. Weight 6lb. Tapped primary 205, 225, 245v. Electrostatic screen. Output 360-0-360v. at 120 m/a D.C. plus 1050v. half wave at 3 m/a D.C., 6.3v. at 3.5 amps., centre tapped Sv. at 2½ amps. and 6.3v. at .6 amps. **PRICE ONLY 21/-** each. P. & P. 5/-.

CARBON MIKE INSERTS. Brand new 2½in. dia. 5/- P. & P. 9d.

ELECTROSTATIC H.F. TWEETERS. Type L.S.H. 7S. Size 3 x 3in., 2/6 each, plus 9d. P. & P.

MIDGET 2-GANG CONDENSERS. Capacity 195 and 100 PF. Polystyrene case with built-in trimmers. Size ½ x ½ x ½in. Not used but removed from P/C Boards. 2 for 9/- Plus 1/- P. & P.

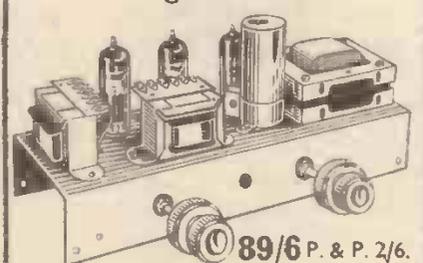
ACOS CRYSTAL MIKES. Hi-imp., Stick type 25/- P. & P. 1/6.

TRANSISTOR DRIVER and O/P TRANSFORMERS. (Tapped 3 ohm and 15 ohm o/p), plus 4 suitable Transistors giving approx. 1 watt o/p. 30/- P. & P. 2/-.

MAINS TRANSFORMERS. Tapped Primary, ½ wave or Bridge Rectifier. Secondary 250 v. at 75 m/a. 6.3 volts at 2 amps. 7/6. P. & P. 3/-.

3 PUSH-BUTTON TRANSISTOR SWITCH D.P.—D.T. Each Switch 5/6 plus 1/- P. & P.

STEREO AMPLIFIER Bargain Offer



★ 4 watts per channel.
★ Full tone and volume controls.
★ Complete with sockets, etc.

QUALITY RECORD PLAYER AMPLIFIER

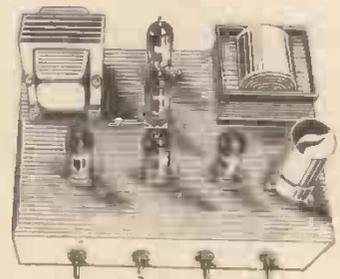
A top-quality record player amplifier. This amplifier (which is used in a 29gn. record player) employs ECC83, EL84, EZ80 valves. Bass, treble and volume. On/off controls. Price **69/6**. P. & P. 3/6.

DITTO. Mounted on board with output transformer and 6½in. speaker. Complete at **89/6**. P. & P. 4/6.

RECORD PLAYER AMP.

2 valve, A.C. mains, 3 watts output, ready built, tested and complete with valves and output transformer. Size 7" w. x 2½" d. x 5½" h. **55/-**. P. & P. 3/-.
Suitable Speakers, 6" 15/- or 10" x 6" **22/6**. P. & P. 1/6 on each.

10/14 W. HI-FI AMP. KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded ultra output transformer (to match 3-15Ω speaker) and 2 independent volume controls. and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. **Only £6/19/6**. P. & P. 6/6. All parts sold separately. Simple instruction booklet 1/6. (Free with parts.)

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GETIS (Matched Pair) 15/-
OC71 5/- PXA101 6/6
OC72 6/- XA103 6/6
OC76 6/- V1S/10p ... 12/6
Set of Mullard 6 transistors **25/-**.
Set of G.E.C. 1,874; 2,873; 3, S1 or GET114 20/-. All Post Free.

BRAND NEW 3 OHM LOUDSPEAKERS

2½in. 12/6; Sin. 12/6; 6½in. 15/-; 10in. 21/-; 12in. 27/6
E.M.I. 2½in. tweeter 10/6
Goodmans Sin. tweeter 10/6
Goodmans 10in. x 6in. 22/6
E.M.I. 13½in. x 8½in. high flux **32/6**
Rola Celestion approx. 9in. x 6in., middle register speaker 10/6
Also 15 ohm, 12in. 30/-
P. & P. 1/6 per Speaker.

HARVERSON SURPLUS CO. LTD.

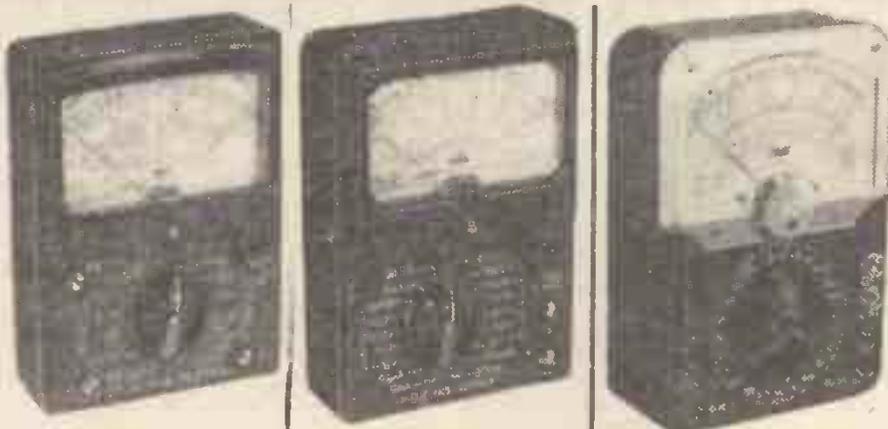
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A few minutes from South Wimbledon Tube Station.

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TESTMETERS FOR EVERY PURPOSE



2,000 OHMS PER VOLT
MODEL TP-10. Reads A.C. and D.C. volts up to 1,000; D.C. current to 500 mA. Resistance to 1 Meg.; Capacitance to 1 μ F; Decibels from -20 to +36; Output jack for Audio measurements. Size 3 $\frac{1}{2}$ x 5 x 1 $\frac{1}{2}$ in. **£3/19/6.**

20,000 OHMS PER VOLT
MODEL TP-58. Reads voltages up to 1,000 D.C. at 20,000 ohms per volt, and A.C. at 10,000 o.p.v.; D.C. current to 500 mA.; Resistance to 10 Megs.; Capacitance to 0.1 μ F; Decibels from -20 to +36. Size 3 $\frac{1}{2}$ x 5 $\frac{1}{2}$ x 1 $\frac{1}{2}$ in. **£5/19/6.**

30,000 OHMS PER VOLT
MODEL 500. Reads voltages up to 1,000 D.C. at 30,000 ohms per volt, and A.C. at 15,000 o.p.v.; D.C. current to 12 amps.; Resistance to 60 Megs.; Decibels from -20 to +36; Incorporates internal buzzer for audible warning of direct shorts and blocking condenser for AF output measurements. Size 3 $\frac{1}{2}$ x 6 $\frac{1}{2}$ x 2 $\frac{1}{2}$ in. **£8/19/6.**

All instruments supplied with test leads and prods, instructions and internal batteries, and carry 6 months' guarantee backed by full service facilities. Further details on request.

HRO SENIOR TABLE MODEL RECEIVERS. Complete with 9 coil sets covering 50 Kcs to 30 Mc/s. Used, very good condition, aerial tested. **ONLY £17.10.0** (carriage, etc., 30/-). A few late Model 5T with I.O. valves, **£22.10.0.**, plus carriage.

PCR COMMUNICATIONS RECEIVERS

Manufactured by Pye and Phillips. One of the Army's most versatile and sensitive sets. R.F. stage and 1 of I.F., using 6 British I.O. valves. Large 180 degree illuminated and calibrated Dial, Flywheel Tuning with locking device, Aerial Trimmer, Tone and Volume controls, Band Switch, front panel jacks for speaker or phones. In black metal case. Size 17 in. L. x 8 in. H. x 10 in. D. Model PCR covers 6-18 Mc/s., 200-250 metres and 830-2,000 metres, and has internal 5 in. speaker. **£6/19/6.**

Model PCR 2 has similar Long and Medium Waveband coverage. Short wave 6-18 Mc/s. but no speaker. **£5 19/6.** Model PCR 3. As PCR2 but has 2 Short Wave Bands 2.0-7.0 Mc/s. and 7.0-23.0 Mc/s., and Medium Wave Band 190-550 metre. **ONLY £8/8/-.**

All receivers used but excellent condition, aerial tested before despatch. Add 10/6 carriage all models. S.A.E. for illustrated leaflet.

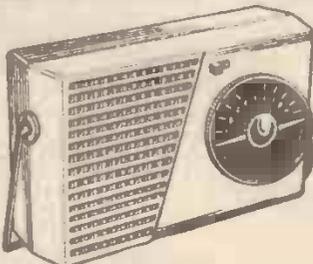
Designed to operate from bulky EXTERNAL power supply, but any set can be fitted with BRAND NEW COMPONENTS INTERNAL PACK for 200/250 v. A.C. at an extra cost of £2.

RCA PLATE TRANSFORMERS. 190/250 volts Primary 50/60 cycles. Secondary 1,500-0-1,500 volts OR 2,000-0-2,000 volts at 500 mA. BRAND NEW AND BOXED. **ONLY £8/10/-** (carr. at cost).

TELESCOPIC AERIAL. 8 sections 30 in. open, 5 in. closed, with 1 in. projection. Chromium plated and ideal for a variety of uses. **ONLY 10/6.**

LAVOIE U.H.F. WAVEMETER MODEL 105. Coverage 373/725 Mc/s. Complete with correct Calibration Chart. First class condition. Battery operated and portable. size 11 x 8 x 7 $\frac{1}{2}$ in. **ONLY £3/19/6** (carriage 7/6).

"POCKET 4"
TRANSISTOR RECEIVER



Uses miniature speaker, proper tuning condenser and volume control. Built-in aerial makes unit efficient and portable. Ideal for the beginner. Full medium wave coverage. All components and case for only **42/6** (p. & p. 2/6). Ten-page constructional book free with parts or separately 1/6. S.A.E. for parts price list.

HIGH FREQUENCY A.C. VOLTMETER.

A first-grade moving iron instrument with 6 in. 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 8 $\frac{1}{2}$ in. x 8 $\frac{1}{2}$ in. x 5 $\frac{1}{2}$ in. Recently made for the Air Ministry by Everett Edgcombe Ltd., and in perfect order. Brand new and unused. **ONLY £7/10/-.** Can also be supplied for 50 cycles use, either 0-150 volts of 0-300 volts, same price.

COMBINED VIBRATOR/MAINS UNIT.

The Power Pack of the Army R107 Receiver. Has Vibrator for 12 volts D.C. operation and Mains Transformer for 100/250 volts A.C. Output 12.6 volts 3 amp. L.T. and 250 volts 100 mA. H.T. Complete with vibrator, 6X54 rectifier, and connecting data. Ideal for driving TCS or Type 52 Receivers, etc., or mobile equipment. **BRAND NEW IN MAKER'S CARTONS. ONLY 45/-** (carr. 5/-).

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Another purchase of Type CV 1596, equivalent to Cossor 09D as used in Oscilloscopes by Cossor (339 series) and Hartley & Erskine (13 series). Listed £12.

25/-
 (carriage 5/-)

Brand new in maker's crates.

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 £20** (carriage 15/-).

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AVOMETERS MODEL 7, re-conditioned and in perfect order, with Leads, internal batteries, and instructions. **ONLY £11** (Regd. post 5/-).

AVOMETER MODEL 7 LEATHER CASES, fitted with carrying handle and long strap. **BRAND NEW. ONLY 32/6** (post 2/6).

6 TRANSISTOR COMBINED PORTABLE AND CAR RADIO



THE "GOOD COMPANION" Mk.II

Using TRANSFILTERS instead of I.F.T.s the latest manufacturing technique to save lining-up problems.

The finest Transistor Portable ever designed for the constructor.

- ★ 750mW Output.
- ★ 6 Transistors plus 1 Diode.
- ★ Covers 540-1,640 Kc/s. (180-550 metres) and 160-285 Kc/s. (1,050-1,880 metres).
- ★ Latest printed circuit technique.
- ★ Very fine tuning with calibrated dial.
- ★ Internal high gain aerial with car aerial socket.
- ★ Brilliantly styled 2-colour cabinet size 11 in. x 8 in. x 3 in.

Technical knowledge is not required to build this set, the easy-to-follow illustrated data which can be purchased for 3/6 making construction simplicity itself.

TOTAL COST INCLUDING CABINET AND DATA (battery 3/6 extra).

£9.19.6

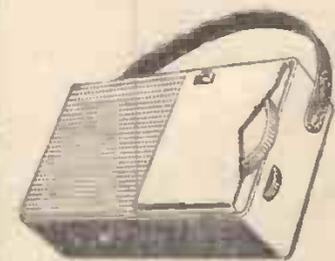
With alternative luxury cabinet using 7 x 4 in. speaker. **£10/19/6.** All parts sold separately, detailed list on request.

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 8 $\frac{1}{2}$ in. x 8 in. x 8 $\frac{1}{2}$ in. Full information on request.

COSSOR TYPE 1036 DOUBLE BEAM OSCILLOSCOPES A few only of these modern scopes, overhauled and in perfect order **ONLY £45.** Further details on request.

"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 NEW STYLE CABINET £7/19/6.**

Cash with order please, and print name and address clearly
 PLEASE ADD POSTAGE OR CARRIAGE COSTS ON ALL ITEMS

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RELAYS P.O. TYPE 3000

Built to your own specification
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Cylindrical Bakelite screw-on cover, 2 contact, 2/6, post 6d. Large quantities available.



2 1/2 in. Moving Coil Flush Round
0/1 amp.; 0/3 amp.; 0/5 amp.; 0/10 amp.; 0/20 volts;
0/30 volts; 0/40 volts, all at 35/- each.

2 in. Moving Coil Flush Round
0/1 milliamp.; 0/5 milliamp.; 0/10 milliamp.; 0/20
volts; 0/30 volts; 0/40 volts, all at 27/6 each.

24 volt D.C. MOTORS. 1/25th h.p. Cont. rat. 1,000
r.p.m. 35/-

ROTARY CONVERTER. Input 24 v. D.C. Output 230 v. A.C., £17/10/- ea.

HOUR COUNTERS. 200/250 v. A.C. 3 1/2 in. diam. Smiths 1SC431, 170/- ea.

HOUR METERS. 5-dial type. 4 in. flush round, "Synclock," 90/- ea.

KEY SWITCHES (Low Capacitance)

Stop/2 change over. Locking 7/6 ea.

Stop/4 change over. No lock 10/6 ea.

6C Lock/2 change over. Lock 17/6 ea.

8 change over. Optional lock. Muirhead 17/6 ea.

TRANSUDERS. £20 p.s.i. S.E. Labs. No. 152A, with transformer, £15 ea.

FERROXUBE TRANSFORMER ASSEMBLIES. Type 25LAI, 10/- ea.

TRANSFORMERS. 230/115 volts, double wound, heavy duty, 1 KVA, £15;

2.5 KVA, £22/10/-; and 5 KVA, £30 ea.

SLIDING RESISTANCE. 500Ω 1.5 amp. Twin tube, worm drive, 50/- ea.

TRANSFORMERS. Input 230 v. Output 12 v. 1 amp. In switch fuse,

and resistance for use as safety supply for two 6 v. 6 watt lamps, 35/- ea.

BARTLETT ELECTRIC DRYING OVENS. Internal dimensions 20 in. x

20 in. x 20 in. 250 volts A.C. with adjustable thermostat giving auto-

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LEDEX SOLENOID-DRIVEN WAFER SWITCHES. Operating from 24 v.

with standard size wafers. Available in 4-bank, 14-bank, 24-bank, all

1 pole, 11-way, from 90/-.

We are disposing of stocks which must be cleared regardless of cost.

Qty.	Description	Price
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10,000	SLYDLOK FUSES Type MM. 60 amp., complete with studs, nuts and washers	2/6 ea.
1,750	INSPECTION LAMPS fit on forehead leaving hands free. Takes box battery 1215 and is supplied complete with battery container which fits on belt. In 35 cases containing 50 in each at 175/-	3/6 ea.
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184	FIELD TELEPHONE SETS Type F. 2-line connection. Generator bell ringing. Wood carrying case	40/- ea.
90	BATTERY CHARGER WESTINGHOUSE TYPE BC3. Charges 3 cells at 15 amps.	£8/10/- ea.
42,000	SCREWS 4 B.A. x 1 in. bright steel round head	3/6 per 100
	7 cases of 6,000	or £8 per case
24,000	BOLTS UNF hexagonal and countersunk, cadmium plated, passivated, etc. Sizes from 3/4 in. to 4 1/2 in.	Lot £85
5,674	SWITCHES. Toggle, double pole on/off with twin fork, dolly dia.	6d. ea.
2,500	LOUDSPEAKERS ELAC 5 in. Round, 9,700 Gauss 3Ω	11 6 ea.
5,500	LAMPS. SBC 6 volt 36 watt. 216 in case 12/- per doz.	£7 per case
2,550	Pairs TEST PRODS with fuse and self-retracting points, fully insulated with red and black ends on 34 in. flex, with spade terminals in packets of 10 pairs	Per pkt. 15/-
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5,000	CONDENSERS. Tubular paper 0.1 mfd. 250 volt	3d. ea.
500	CATHODE RAY TUBES. 2 1/2 in. 189a	25/- ea.
3	SIMULATOR CABINETS on wheels with cooling fan, containing 35 useful items including POWER UNITS, open chassis type +600 volts, 250 milliamps, and +300 volts 250 mA, -300 volts, 450 mA. A MONITOR OSCILLOSCOPE with supply unit, DISPLAY units etc. Cost thousands of pounds, will take very low price to clear. Further details on application.	
78	BATTERY CHARGER (American). Output 12 volts 5 amps. D.C. Input 105/125 volts A.C. in neat crackle finish case. Relay with overload reset push Ref. RA-63B	60/- ea.
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10WT SOUND REINFORCEMENT

THE PORTABLE PUBLIC ADDRESS SET WITH HI-FI STANDARDS.

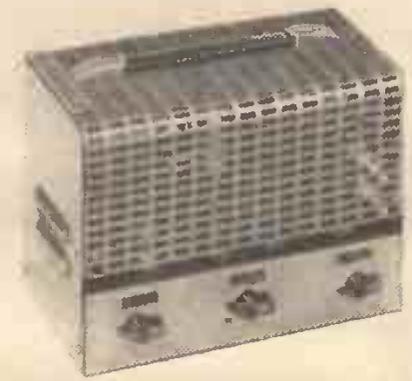
ULTRA LINEAR OUTPUT (MAX 12WT) FOR 3, 7 or 15Ω.

INDIVIDUAL INPUTS WITH SEPARATE GAIN CONTROLS FOR MICROPHONE AND GRAM.

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HF5/HZ - £17 5s. 0d. - HAVING TWO MICROPHONE INPUTS.

FULL DETAILS OF THIS & OTHER MODELS BY RETURN.



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AC/P4	6/-	EB91	3/9	G1/236G	9/-	QP21	6/-	IW4/500	6/-	6K7GT	4/9	12SK7GT	3/-	957	5/-
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BT9B	20/-	EF39	4/-	LP2	10/-	U12/14	8/-	5Z4	8/6	65K7	5/-	76	5/-	9006	2/6
BT83	22/6	EF50	1/6	MH4	3/6	U17	5/-	5Z4G	7/-	65L7GT	6/6	77	6/-	C.R. Tubes:	
CV54	5/-	EF54	3/3	ML4	4/-	U18	6/6	6AB7	4/-	65N7	4/6	78	7/-	ACR1	15/-
CV71	3/-	EF70	4/-	ML6	6/-	U27	8/-	6AC7	3/-	65O7	6/-	80	5/6	ACR11	15/-
CV102	1/-	EF73	6/-	MS/PEN	6/-	U52	5/-	6AG5	3/-	65S7	3/-	81	9/-	ACR13	50/-
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DAF91	6/-	EL42	8/-	PEN25	4/6	VP41	5/6	6BA6	5/6	7V7	5/-	715B	60/-	Photo Tubes:	
DAF96	7/6	EL44	8/-	PEN25A	3/-	VR99	8/-	6BR7	12/-	7Y4	5/-	717A	8/6	CMGB	9/-
DD41	4/-	EL91	4/6	PL36	10/6	VR105/30	5/6	6C4	2/6	7Z4	4/6	801	6/-	GS16	12/6
DET5	15/-	EM80	8/-	PL81	9/-	VR150/30	6/-	6C5GT	6/-	8D2	2/6	803	22/6	Special Valves:	
DET19	3/6	EM84	9/-	PL82	8/-	VT4C	25/-	6C6G	3/-	9D2	3/-	805	30/-	2J31	45/-
DET20	2/-	EN31	10/-	PL83	8/-	VU39	6/-	6C8G	5/-	12A6	2/6	607 (Selected)	5/6	3A/1481	45/-
DF39	4/-	EP71	6/6	PL84	8/-	W31	7/-	6CFG	4/-	12SH7	5/-	807BR	5/-	3J/92/E	£37/10
DF72	7/6	EP72	5/-	PL88	8/-	X66	8/-	6D6	3/-	12AT7	5/6	808	8/-	4J31	£35
DF91	4/-	ESU208	6/-	PL89	8/-	Y63	5/-	6F5G	5/3	12AU6	9/-	810	80/-	4J50	£35
DF96	7/6	EY51	8/-	PL89	8/-	Y65	4/-	6F5GT	5/9	12AX7	7/-	813	60/-	5D21	£3
DK96	7/3	EY86	8/-	PT25H	7/6	Y66	8/-	6F6G	4/6	12C8	3/-	815	40/-	723A/B	50/-
DL92	6/-	EY91	3/-	PX4	19/-	Z31	6/-	6F7	5/-	12E1	20/-	816	30/-	725A	30/-
DL946	6/-	EZ40	7/-	PX25	9/-	IA3	3/-	6F8G	5/-	12H6	2/-	829A	30/-	726A	27/6
DL96	7/6	EZ41	6/9	PY32	12/-	IA5GT	5/-	6F12	4/6	12K7GT	4/6	829B	50/-	ACT6	£8
EA50	1/6	EZ80	6/-	PY80	6/9	IC5GT	7/6	6F13	5/-	12K8M	7/6	832	15/-	CV193	30/-
EABC80	7/3	EZ81	6/9	PY81	7/-	ID8GT	6/-	6F33	2/6	12K8MT	3/6	832A	35/-	CV238	70/-
EAC91	3/6	FW4/500	6/6	PY82	7/-	IE7G	7/6	6G6G	3/6	12J5GT	3/6	843	7/4	CV980	3/-
EB34	1/6	GI20/IB	9/-	PY83	7/3	IG6GT	6/-	6H6M	1/6	12Q7GT	4/4	866A	14/-	KR6/3	70/-
				PZ1-35	9/-	IL4	3/-	6J5	3/6	12S7	7/-	930	8/-	LS7B	30/-
						ILD5	5/-	6J5G	3/-	12SA7	4/-	954	4/-	WLI47A	15/-
						IR5	6/-	6J6	3/6	12SG7	3/-	955	2/5		
						IS4	5/-	6J7G	5/-	12SH7	3/-	956	2/-		
						IS5	5/6	6K6GT	6/-	12SK7	3/6				
						IT4	4/-	6K7G	2/-						

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"CONNECT AND FORGET CANNOT OVERCHARGE" "ESSTRON" MARK I AUTOMATIC BATTERY CHARGER

Initial charging rate 6-7 amps. The charging rate automatically adjusts itself to the charge in the battery. Automatic current and voltage control. Patented application of magnetic amplification to battery charging. Indicator lights show battery fully charged, receiving charge, incorrectly connected or faulty cells. Mains voltage 200/250 v. Built for 6 or 12 v. batteries. Measurements 7 x 5 x 5 1/2 in. Weight: 8 1/2 lb. Price £7/19/6. P. & P. 3/6.

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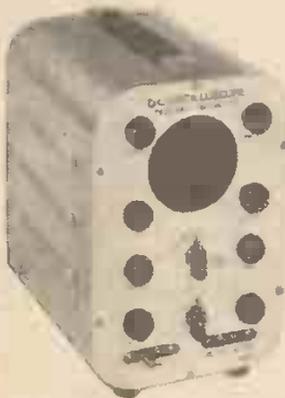
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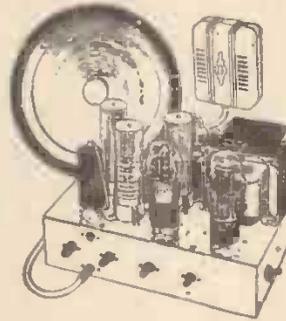
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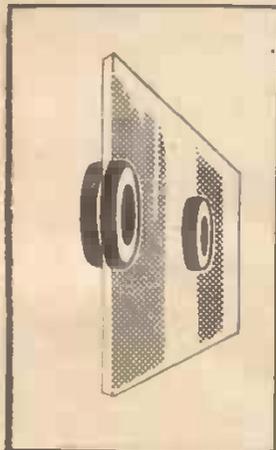
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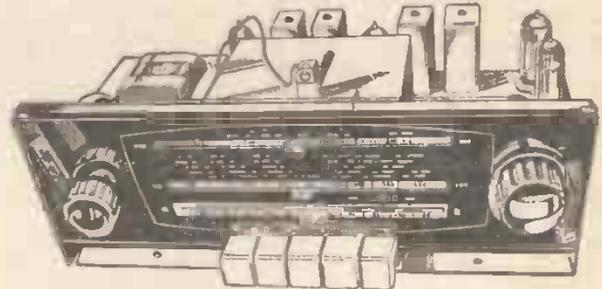
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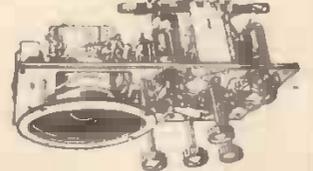
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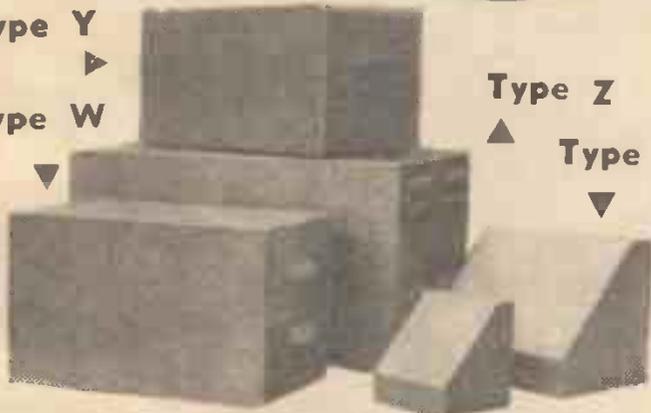


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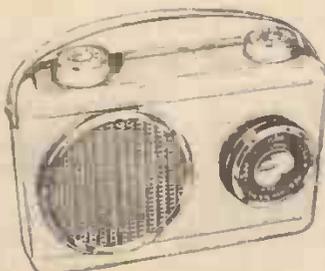
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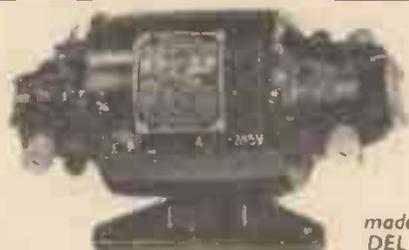
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HEAVY DUTY SLIDING RESISTORS. Suitable for charging boards, etc. 250 watts at 25 amps., 4 ohms, OR 125 watts at 12 amps., 1 ohm, 12/6. Post 3/-

LOUD-HAILER with hand-powered microphone. Operates on either 12 v. D.C. or 24 v. D.C. Output 6 watts. Weatherproof and extremely strong. Easily mounted on vehicle or boat. Complete—ready to work, 90/-, Carr. 10/-

BARGAIN OFFER. Paxolin with foam rubber backing. Approx. 12 in. x 8 in. Paxolin 1/2 in., foam rubber 1/4 in. 1001 uses. 6 sheets, 7/6. Post 2/6.

DEPENDABLE RADIO SUPPLIES LTD.

12a TOTTENHAM STREET, LONDON, W.1

Tel.: Langham 7391/2

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LARGE SELECTION OF COMPONENTS AT GIVE-AWAY PRICES TO CALLERS

Z. & I. AERO SERVICES LTD.

Head Office: 14 South Wharf Road, London W.2

Tel.: AMBassador 0151/2

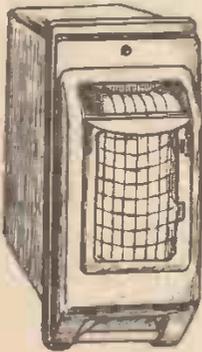
Cables: ZAERO, LONDON

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RETAIL BRANCH (personal callers only): 85 TOTTENHAM COURT ROAD, W.2 Tel.: LANGham 8403

Please send all enquiries, correspondence and Mail orders to Head Office

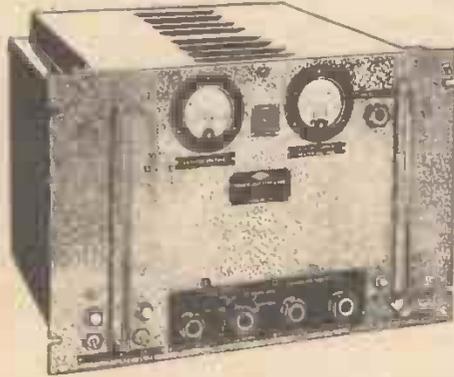
ELLIOTT FLUSH MOUNTED RECORDING MILLIAMMETERS TYPE 230



Range: 1 mA. direct-to-movement, D.C., and 1.1 mA. A.C. through internal rectifier. Curvilinear trace. 3 1/2 in. wide strip chart. Two-speed electric chart drive (230 v. A.C.) at 1 in. and 6 in. per hour. Two limit contacts provided for high and/or low current alarm.

PRICE, fully overhauled and guaranteed, complete with two charts ... £37 10 0
Packing and carriage 15/-.

KLYSTRON POWER SUPPLY UNITS Type 698B



Fully regulated and stabilized rack mounted (19 in.) mains operated power unit providing the following facilities:

- Cathode volts -1.0 kV. to -2.4 kV.
- Grid volts 0 to -220 V.
- Reflector volts 0 to -500 V.
- Cathode current 18 mA. max.
- L.T. supplies 4.0 v. to 1.4 A.

INTERNAL GRID OR REFLECTOR MODULATION: Square wave: 2-4 kc/s., 70 v. peak-to-peak. Sawtooth: 150-600 c/s.; 0 to 30 v. peak.

PRICE, fully overhauled and guaranteed, £60.
Packing and carriage £2.

TRANSFORMERS

CHARGER TRANSFORMERS. 200-250 v. input:—		
MT3AT, output 12-15-20-24-30 v. at 2 a.	25/6	
MT21AT, ditto at 4 a.	38/-	
MT16AT, output 24 v. at 5 a.	38/6	
STEP-DOWN AUTO-TRANSFORMERS. 0-115-200-230-250 v., 150 watts		
	25/6	
Packing and carriage 5/-.		

HIGH VOLTAGE CAPACITORS

.0005µF	20 kV. Visconol	15/-
.001µF	12.5 kV. Visconol	7/-
.0025µF	5 kV. Visconol	8/-
.005µF	5 kV.	5/-
.01µF	5 kV.	8/6
.02µF	5 kV.	6/6
.1µF	5 kV.	5/-
.1µF	10 kV.	10/-
.25µF	7.5 kV.	30/-
.5µF	2.5 kV.	5/-
.5µF	5 kV.	15/-
1µF	2.5 kV.	17/6
2µF	2.5 kV.	15/-
8µF	2.5 kV.	25/-
Packing and carriage 1/- per capacitor.		

HIGH STABILITY CARBON RESISTORS

We have in stock most of the standard values in 1/2 w., 1 w., 2 w., 1 w. and 1 1/2 w. Prices: 5% 6d.; 2% 9d.; 1% 1/- each.

4-DECADE RESISTANCE BOXES

Total range 0-100,000Ω in 10Ω steps. High stability Resistors used throughout. Accuracy better than 1%.
PRICE ... £11 19 6
Packing and carriage 10/-.

MARCONI TF934 DEVIATION TEST SET



Fundamental frequency range 2.5-100 mc/s. basic; range can be extended to 500 mc/s. by using harmonics. Deviation range 0-5, 0-25 and 0-75 kc/s. in the modulation range of 50 c/s. to 15 kc/s. Sensitivity better than 55µV. Power supplies 100-150 and 200-250V. A.C. Price fully overhauled and guaranteed—reduced to .. £85 0 0

BOONTON RADIO F.M. SIGNAL GENERATOR TYPE 152A

Frequency range 1 to 5 mc/s. and 20-28 mc/s. directly calibrated, Vernier dial adjustment ±150 kc/s. Internal modulation at 100, 400, 1,000, 4,000, 10,000 c/s.; F.M. deviation range 0-35 kc/s. and 0-100 kc/s.; A.M. modulation depth 30%. Pre-emphasis circuit. Sync. output terminal. Complete with external Power Supply Unit for 230 V. A.C. mains. Fully overhauled and guaranteed. ... £42 0 0

AN/APR-4 RECEIVING EQUIPMENT

For detection and measurements of comparative signal strengths of signals in the range of 38 mc/s. to 4,000 mc/s. Receiver is essentially a 30 mc/s. five stage I.F. Wide Band Amplifier with associated Audio and Video stages. I.F. Bandwidth can be selected at 4 mc/s. (wide) and 800 kc/s. (narrow). Various ranges are obtained by means of interchangeable R.F. Tuning Units which plug-in into the receiver unit. The Tuning Units are available in the following ranges: 38-95 mc/s., 74-320 mc/s., 300-1,000 mc/s., 1,000-2,200 mc/s. and 2,200-4,000 mc/s. I.F. sensitivity of the receiver is approximately 38-56µV. Video output socket is provided on the receiver for C.R. display of the received signal. Internal power supply unit for operation on 115 v. A.C. Step-down transformer for working off 230 v. mains supplied if required. Prices and further details on application.

PULSE GENERATORS

Measurements Corporation Type 79B

Pulse output: 150V. minimum peak-to-peak, with width variable from .5 to 40µsec., at repetition speeds of 60 to 100,000 per second. Synchronizing pulse 35V. peak-to-peak, 3µsec. wide max., delayed by half period. Carrier input socket for pulse modulating of external signals up to the limit of 200 mc/s. 115V. A.C. Mains Operation. Dimensions 14 in. x 10 in. x 10 in. Fully overhauled and guaranteed. ... £35
Packing and carriage £1.

CIRCUIT MAGNIFICATION METERS

MARCONI TF329; oscillator frequency 50 kc/s. to 50 mc/s. ±2%; Magnification Range 10 to 500 in two bands; measurements accuracy approx. ±5%; Tuning capacitor range 40-450 pF.; Vernier capacitor range ±3pF.

£85 0 0

MARCONI TF866A, V.H.F.; oscillator frequency 15 to 170 mc/s. in two bands ±2%; Magnification range 00-180, 150-450, 400-1,200; measurements accuracy ±10%; Tuning capacitor 12-35 pF. with Vernier scale.

£85 0 0

Both instruments are fully overhauled and guaranteed.

"COMMAND" MODULATOR UNITS BC 456

Contains Tone Oscillator 12J5GT, Speech Amplifier and Modulator 1625, Voltage Regulator VR150, Microphone Transformer for Carbon Microphone Input and Modulation Transformer for Screen Grid Modulation of two 1625 valves. As new, without Dynamotor. 25/-, P.P. 5/6.

EX P.O. MAGNETIC COUNTERS

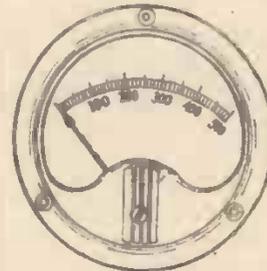
500Ω Coil, energized by 24 V. D.C., four digit electromagnetic fast acting counters (non-cancelling type) counting up to 9999. Perfect condition. 8/6. P.P. 1/6.

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All Brand New

1 M. at 1 a., 6,500Ω coil	10/6
2M. +1B. at 1 a., 8,800Ω coil	12/6
2B. at 500 mA., 2,000Ω coil	10/6
4 C.O. at 500 mA., 2,000Ω coil	12/6
2M. +2B. at 500 mA., break before make, 6,000Ω coil	13/-
3 C.O. at 500 mA., 500Ω coil	13/6
1M. at 500 mA., 2,000Ω coil	10/-
Postage and packing 9d. per relay.	

METERS

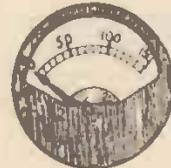


AMERICAN WESTINGHOUSE SERIES 35
2 1/2 in. dia. scale; 2 1/2 in. dia. body; 3 1/2 in. dia. flange. Open scale, clear and accurate calibration.

MOVING COIL METERS

1 mA. FSD, calibrated from -5 to +8 db.; 0 db. at .773 v. into 600Ω. Internal resistance 50Ω	35/-
1 mA., calibrated 0-100	35/-
1.5 mA., 10 mA., 25 mA. or 50 mA.	30/-
100 mA., 200 mA., 250 mA., 300 mA., 500 mA.	25/-
10 v., 350 v., 500 v. D.C., 1,000Ω/V.	30/-
1,000 v., 1,500 v., 2,500 v. D.C., 1,000Ω/V., all with series resistors	35/-
MOVING IRON METERS:—	
5 v. A.C., 7.5 v. A.C., 15 v. A.C.	22/6
THERMOCOUPLE METERS:—	
10 A. E.F., 15 A. R.F., calibrated for use from 25 c/s. to 20 mc/s.	22/6
Electrostatic 2 1/2 in. Round Plug-in, 1500v.	17/6

MINIATURE METERS



GENERAL ELECTRIC 1 1/2 in. Round flush clip mounted Moving Coil Meters:
1 mA. D.C. ... 30/-
25 mA. D.C. ... 25/-
75, 100, 150 mA. D.C. ... 20/-

"INTERNATIONAL" SUBMINIATURE "PENNY SIZE" METERS, 1 in. Round Flush ring nut mounted, 1 mA. D.C. Moving Coil, 30/-.



HIGH FREQUENCY THERMOCOUPLE METERS

(see also above)

200 mA. 2 in. Round Plug-in	12/6
350 mA. ditto	12/6
4 amps. 2 in. Rd. Fl. Mtd.	20/-
12 Amps. 3 1/2 in. Rd. Proj.	20/-

SANGAMO WESTON 3 1/2 in. SCALE ROUND FLUSH MOUNTED SEALED METERS, 100µA F.S.D., internal resistance 1,000Ω, inverse square law calibration (in VSWR). 23.

"ELECTRON" OUTDOOR ROD AERIAL



3 strong tubular light alloy screw-in section 3ft. long each mounted on an insulated base. Bracket, hardware and down-lead supplied with the aerial. Suitable for wall or window sill mounting. 15/- P.P. 5/-.

VENNER 8-DAY TIME SWITCHES

For plug-in mounting. 1 make and 1 break every 24 hours. 24-hour dial with night and day marking. Contacts capacity 1 a. at 250 v. Complete with key. Second-hand, guaranteed. ... 20/-, p.p. 3/6. Ditto 5 amp capacity ... 30/-, p.p. 3/6.

PLUG-IN COILS FOR EDDYSTONE Type 358 and 358X RECEIVER

All ranges from 40 kc/s. to 31 Mc/s. covered in units as follows: 40-90 kc/s.; 90-150 kc/s.; 150-300 kc/s.; 300-600 kc/s.; 600-1,250 kc/s.; 1.25-2.1 Mc/s.; 2.1-4.5 Mc/s.; 4.5-9 Mc/s.; 9-22 Mc/s.; 22-31 Mc/s. PRICE 17/8 per coil. Post free. Full set of 10 coils, £5/10/- Post free.

OUR NEW CATALOGUE OF FULLY SERVICED TEST EQUIPMENT IS NOW AVAILABLE FREE TO INDUSTRIAL USERS, EDUCATIONAL INSTITUTIONS AND BONA FIDE TRADE USERS. Private customers 2/6 per copy. Also available new price list of valves supplied free on receipt of stamped and addressed envelope.

MODEL MAKERS' MOTORS

12 v. D.C. reversible miniature motor; output 5 watts at 7,000 r.p.m. Dimensions 1 1/4 in. dia. x 1 1/4 in. long. Shaft .077 in. dia. x .4 in. long. Centre of reversing switch; pre-lubricated bearings. 15/6 post free.

TRANSISTORS

MULLARD: OC44 7/6; OC45 6/8; OC78 7/-; OC78D 7/-; OC81 7/-; OC810 7/-; pair of matched OC78 or OC81 13/-; set of two matched OC78 and one OC78D or two matched OC81 and one OC81D. 18/- EDISWAN; XC101A, equivalent to OC72. 8/- R.C.A.; 2N410 equiv. to OC45 5/-; 2N412 equiv. to OC44. 5/- WHITE SPOT: 12 v. H.F. 2/8; RED SPOT: 12 v. L.F. 2/8 YELLOW SPOT: 6 v. L.F. 1/10; GREEN SPOT: 3 v. L.F. 1/6

BELLING LEE 3-AMP. MINIATURE TERMINAL BLOCKS

Two-way, 1/2 x 1/2 in. high. 4d. each Four-way, 1/2 x 1/2 x 1/2 in. high. 8d. each Orders accepted for not less than 3 terminal blocks. Packing and postage 6d. Orders for 12 or more post free.

GEIGER-MULLER COUNTER TUBES

G24H—Halogen quenched tube for Gamma radiation. Average operating voltage 370 v.; Plateau length 100 v. min.; Slope 3% per 100 v.; Background count 150 per minute. Dimensions: 23 mm. dia. x 260 mm. long. Suitable for geological surveys. 15/-

G10H—Background count 90 per minute. Dimensions: 28 mm. dia. x 195 mm. long. Suitable for general applications, otherwise similar to G24H. 15/-

BL2H—Halogen quenched thin glass wall beta-gamma (dipping) counter; typical operating condition as G24H. Count up to 80,000 per minute. 200 mm. long x 35 mm. dia. 45/-

G80E (CV2149)—organic quenched tube for cosmic ray research. Average operating voltage 1,300 v.; Plateau length 200 v.; Slope 3% per 100 v.; Dead time less than 300 μsec; Dimensions 36 mm. dia. x 740 mm. long 55/-

G24E—Generally similar to G80E, for cosmic ray and gamma count. Dimensions: 22 mm. dia. x 270 mm. long. 35/- Packing and postage 5/- per tube.

BY100 SILICON RECTIFIERS

Half-wave silicon diode, 700 p.i.v. at 450mA D.C. 8/-, p.p. 1/6

KLYSTRONS

2K45 £7; 2K25 £4; VA249 £30. Further details of these and other Klystrons and Magnetrons supplied on request.

CATHODE RAY TUBES

Table listing various cathode ray tubes with their respective prices, including models like 2AP1, 3DP1A, 3RP1, etc.

Table listing various electronic components and their prices, including models like OA2, OA3, OB2, etc.

FULLY GUARANTEED VALVES IMMEDIATE DELIVERY

Large table listing a wide variety of vacuum tubes and valves with their prices, including models like 12AH7GT, 12AX7, 12AU7, etc.

Table listing various electronic components and their prices, including models like KT63, KT66, KTW61, etc.

PLEASE OFFER US YOUR SURPLUS VALVES AND TUBES. URGENTLY REQUIRED KLYSTRONS 723A/B OUR ORGANISATION HAS BEEN APPROVED BY THE AIR REGISTRATION BOARD FOR INSPECTION AND RELEASE OF ELECTRONIC VALVES

Z. & I. AERO SERVICES LTD.

RETAIL BRANCH: 85 TOTTENHAM COURT ROAD, W.2 Tel.: LANgham 8403

Please send all correspondence and Mail Orders to our

Head Office: 14 SOUTH WHARF ROAD, LONDON, W.2 Tel.: AMBassador 0151/2

ERSIN



SOLDER

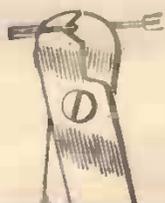
**IN THE NEW
SAVBIT DISPENSER**



Easy to find in the tool box—simple to use. The new Multicore dispenser will stand up or lay on the bench without rolling off. The solder is in a continuous coil which can be used direct from the handy dispenser—in fact, it is virtually a third hand for those tricky soldering jobs. Containing 15 feet 5-core 18 s.w.g. Ersin Multicore Savbit alloy—the world-famous copper-loaded alloy that saves the soldering iron bit.

2/6 each (Subject)

Bib Wire Stripper and Cutter



This efficient tool strips insulation, cuts wires cleanly and splits plastic twin flex. It is adjustable to most wire thicknesses.

3/6 each (Subject)

See also MULTICORE advertisement on back cover

If you have difficulty in obtaining any of these items, they will be sent post free.

**MULTICORE SOLDERS LIMITED
HEMEL HEMPSTEAD, HERTS**
CMMS. 6

NEWS

from
Partridge

New star of the Partridge Range is the P4200 "C" Core U.L. Transformer. Representing the very best in transformer construction, this 12 watt version of the famous P4160 maintains the standard of excellence and faultless performance inherent in all Partridge Equipment.

General Information:

This is a C-core transformer. Resin Potted in a deep drawn seamless steel case. Designed for inverted mounting.

Power Rating:

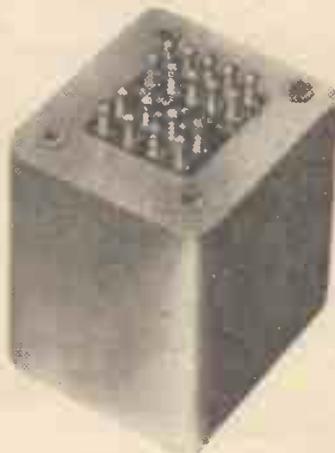
12 watts 20 cps. to 40 Kc/s;
15 watts 25 cps. to 30 Kc/s.

Frequency Response:

-0.5 db 20 cps. to 70 Kc/s.
-3 db 12 cps. to 100 Kc/s.

P4200

the
best
we've
ever
made!



Post the coupon below for full information and illustrated literature.

**To Partridge Transformers Ltd.,
ROEBUCK ROAD CHESSINGTON SURREY**
Full details of P4160 & P4200 Please.

NAME
ADDRESS

WW3/63

**STOCKTAKING SALE
SPECIAL OFFERS**

LIMITED QUANTITIES in oak, walnut and mahogany
NO INTEREST TERMS for H.P.

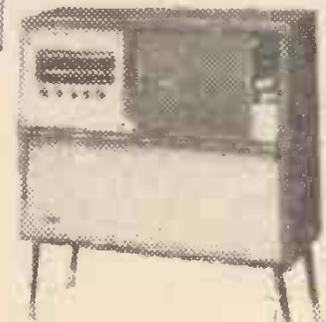
3ft. wide. Deck 15½ x 15. Control panel 15 x 15. Grille 35 x 7 or polished front £12/12/- or 24/- dep., 12 by 19/-.



SP3 34in. high. Deck 15 x 13. Control panel 15 x 14. Baffle 15 x 12. £10/10/-, or 24 dep. 12 by 15/6.



SP4. 3ft. wide. Deck 17 x 14. Control 15½ x 15. Grille 34 x 13. £14/14/-, or 30/- dep., 12 by 22/-.



SP5 45½ wide. Deck 18 x 15½. Control panel 13½ x 15½. Amplifier compartment 9½ x 15½. £14/14/-, or 30/- dep., 12 by 22/-.



SP6A 46 x 16 Deck. SP6B 46 x 18½ Deck. SP6A £19/19/-, or 39/- dep., 12 by 30/-. SP6B £21/15/-, or 39/- dep., 12 by 33/-. Delivery 15/- per cabinet.



B2ES 46in. x 16in. DECK
B2EXS 46in. x 18½in. DECK

Write for lists of Hi-Fidelity Equipment and Enclosures.

**A. L. STAMFORD LTD. (Dept. E.4.),
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CLASSIFIED ADVERTISEMENTS

Rate 8/- for 2 lines or less and 4/6 for every additional one or part thereof, average lines 6 words. Box Numbers 2 words plus 1/-. (Address replies: Box 0000 c/o "Wireless World" Dorset House, Stamford St., London, S.E.1.) Trade discount details available on application. Press Day April 1963 issue, Thursday, February 28th. No responsibility accepted for errors.

SITUATIONS VACANT

AN overseas career

INTERNATIONAL AERADIO LIMITED.
 TO meet the requirements of constant growth and expansion we invite applications from technicians and engineers for an overseas career in North, West and East Africa, the Mediterranean area, the Caribbean, the Arabian Gulf and the Far East. If you have recently completed service in a trade such as Ground Wireless Fitter in the R.A.F. or Radio Electrical Artificer in the Royal Navy or have other experience in the maintenance of HF and VHF communications, RTT and navigational aids, we should be interested to hear from you. **SUCCESSFUL** candidates would normally spend six weeks at our Radio Training School, Southall, Middlesex, before proceeding overseas, but in some cases staff with suitable qualifications and experience may be offered immediate posting. Overseas staff receive a tax-free salary with married and child allowances if appropriate and accommodation. Bachelor or married, is provided free; other benefits include generous U.K. leave and membership of an excellent pension and life assurance scheme. **WRITTEN** applications, please, to Personnel Officer, 40, Park St., W.1 [0263]

RADIO Technicians.

VACANCIES for Radio Technicians, aged 19 or over, at airports and radio stations throughout the United Kingdom, maintaining radio communications and electronic navigational aids. Sound knowledge of radio and practical experience required for entry. Training given on equipment in use. Salary at age 25 £876, rising to £1,006; 31 1/2 weeks' holiday with pay. Paid sick leave. Facilities to study for higher qualifications. Good prospects of permanent pensionable posts and promotion to Telecommunications Technical Officer.—For further details apply to the Ministry of Aviation, EST.5(a)1, Room 754, The Adelphi, John Adam Street, London, W.C.2. [2293]

POST Office Executive Engineers.

PENSIONABLE posts in London and provinces for Mechanical, Electrical and Electronic Engineers (male) at least 21 and normally under 35 on 1.9.63, to develop and design communications systems and postal services. Candidates must normally have (or expect to obtain shortly) a degree, or Dip. Tech. in engineering or physics. Exceptionally, evidence of very high professional attainment may be accepted in lieu. Starting salary (inner London) £790-£1,368, according to age; scale maximum £1,633; promotion prospects.—Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S 322.. (3.) [2265]

CENTRAL ELECTRICITY GENERATING BOARD.

APPLICATIONS are invited for the following appointment:—

ASSISTANT Maintenance Engineer Instruments—West Thurrock Generating Station (Grays, Essex). (S.V. No. 1859.)

SALARY range £1,200-£1,500 p.a. **SUITABLE** candidates must have a thorough knowledge of general electronics with an emphasis on pulse circuit technique. An understanding of instrumentation and/or transistors will be an advantage. Practical training should be preferably either an apprenticeship with a major radio firm, or ex Royal Air Force radar mechanic. Technical qualifications would be an advantage.

APPLICATIONS, quoting reference S.V. No. 1859, stating age, qualifications, experience and present position should be sent to the Assistant Regional Personnel Officer, Central Electricity Generating Board, South Eastern Region, North Thames Division, West Fram Place, Chalk Lane, Cockfosters, Barnet, Herts, to arrive not later than 16th March, 1963.

F. W. SKELCHER, Assistant Regional Director. [2292]

RADIO technician required for development work and prototype construction of test instruments, audio equipment, etc.; neat workmanship essential; good long-term prospects for man capable of undertaking increasing responsibility for design; small laboratory with precision equipment.—Box 5190. [2287]

TEST engineers.—Applications are invited from test engineers with previous industrial experience of testing radio communications, receivers and transmitters; successful applicants will be offered positions on the company's permanent staff; starting salaries commensurate with qualifications and experience.—Apply in writing, giving full details to Personnel Officer, Redifon, Ltd., Broomhill Rd., S.W.18. [0252]

ENGLISH ELECTRIC VALVE COMPANY LTD

TECHNICAL SALES ENGINEER

An attractive opening exists for a qualified Engineer or Scientist to increase the sale of the Company's specialised valve and tube products at home and overseas. This is a senior appointment based on Chelmsford, Essex, and carries a commensurate salary. Relevant experience backed by sound technical knowledge of microwave and transmitting valves is essential and a command of foreign languages would be an advantage.

Please address applications giving full details of qualifications and experience to:

Group Personnel Services,
 English Electric House,
 Strand, London, W.C.2.

quoting reference WW.1597P.

TEST ASSISTANT

Required for our Test Laboratory to maintain and design electronic test equipment associated with control and safety equipment for both aircraft and industrial uses.

Applicants should possess H.N.C. (Elec.) and a sound working knowledge of electronics in these fields.

Excellent conditions of service and a good commencing salary are offered.

Applications to:—

Personnel Officer,
 Wilkinson Sword (Colnbrook) Limited,
 Colnbrook, Nr. Slough, Bucks.

PILOT RADIO (S.A.) (PTY.) LIMITED

DEVELOPMENT ENGINEER

Due to rapid expansion the radio laboratory requires a Senior Engineer for interesting work on receiver development.

Engineers must have previous experience in the development of valve and transistor AM, FM receivers and FM Tuner Units through to production level.

A B.Sc. degree, or similar qualifications would be an advantage, but is not essential. Preferred age 27 to 37 years.

Salary commensurate with experience and qualifications, in the range of £1,200 to £1,800.

Written application detailing experience and qualifications enclosing copies of testimonials and a recent photograph if possible, should be addressed to:

PILOT RADIO (S.A.) (PTY.) LIMITED,
 P.O. Box 9076, Johannesburg,
 SOUTH AFRICA.

PILOT RADIO (S.A.) (PTY.) LIMITED TRANSFORMER PRODUCTION

Applications are invited from suitably qualified engineers for the position of **DESIGN PRODUCTION ENGINEER**. Applicants must have had several years' experience of both audio and power transformer design, and be capable of controlling production. Written application detailing experience and qualifications, enclosing copies of testimonials and a recent photograph, if possible, should be addressed to:

**PILOT RADIO (S.A.) (PTY.) LIMITED,
P.O. Box 9676, Johannesburg,
SOUTH AFRICA.**



Field Engineers for electronic data processing equipment

THERE ARE attractive vacancies in our Field Engineering Section for electronic engineers to maintain I.C.T. electronic calculators and computers installed on our customers' premises in the Greater London area.

Applicants should be aged between 24 and 32 years of age and possess experience in the maintenance and repair of pulse technique equipment either in industry or H.M. Forces. They should also have the ability to handle bench tools and instruments and an appreciation of the effects of electrical and electronic circuits on complex mechanisms.

A National Certificate (Electrical) or a City and Guilds Certificate in Telecommunications would be an advantage. Applications from men with experience of radar equipment in H.M. Forces will be welcomed.

These are permanent, salaried positions which offer plenty of scope for advancement. The conditions of service are excellent.

Write, giving full details of experience, etc., to the Manager, Field Engineering Staff Group, International Computers and Tabulators Limited, Putney Bridge House, London, SW6 (Tel: Renown 3322), quoting reference FE/3.

UNIVERSITY OF ST. ANDREWS.

APPLICATIONS are invited for the post of Electronics Technician, to be responsible for the construction and maintenance of electronic equipment in the University Observatory and in other departments in St. Salvator's College. Applicants should have had experience in the design, construction and maintenance of photo-electric equipment, stabilised voltage supplies and d.c. amplifiers. Fixed salary within the range £900 to £1,135 per annum; pension and life assurance scheme.—Applications, stating age, qualifications and experience, with testimonials or the names of two referees, to be sent as soon as possible, to the Secretary of the University, College Gate, St. Andrews. [2266]

CENTRAL ELECTRICITY GENERATING BOARD.

SOUTH Eastern Region.
NORTH Thames Division.
(CENTRAL Radiochemical Laboratory.)
THE undermentioned vacancy will shortly occur at the above situated at Hornsey, North London, and applications are invited from suitably qualified persons.
THE successful candidate will join a team which provides a radiochemical monitoring service for the Board's nuclear generating stations. Part-time day release for further study in appropriate subjects will be granted to the applicant appointed if aged under 21 years.

JUNIOR Electronics Assistant (S.V. No. 1846). SALARY N.J.C., General Clerical Grade £230-£665 + London weighting £25-£40 p.a. CANDIDATES should have G.C.E. ("O" level) passes in physics, mathematics and English. The work requires an interest in electronics and provides an opportunity for instruction in the servicing and operation of complex electronic equipment.
A higher salary range will be considered for applicants with some appropriate experience, together with educational standard at least equal to O.N.C.

APPLICATIONS quoting S.V. Reference No. 1846, stating age, details of education, examinations passed, experience and present position should be sent to the Assistant Regional Personnel Officer, Central Electricity Generating Board, North Thames Division, West Farm Place, Chalk Farm, Cockfosters, Barnet, Herts., to arrive not later than 4th March, 1963.
F. W. SKELCHER, Assistant Regional Director. [2269]

CITY OF BELFAST COLLEGE OF TECHNOLOGY.

PRINCIPAL: D. H. Alexander, O.B.E., F.C.G.I., M.Sc., Wh.Sch. M.I.Mech. E.
DEPARTMENT of Electrical Engineering.
APPLICATIONS are invited for the position of Assistant Lecturer, Grade A, in Marine Radio and Radar Maintenance in the Marine Radio School.

APPLICANTS should hold the Postmaster General's Certificate of Competency in Radio Telephony and Telegraphy, First-Class, and the Ministry of Transport Certificate in Radar Maintenance. Recent seagoing experience is essential.

SALARY will be in accordance with the scales of the Ministry of Education for Northern Ireland.

FURTHER particulars and form of application may be obtained from the Principal, College of Technology, Belfast, with whom completed applications must be lodged not later than Friday, 15th March, 1963.

CANVASSING is strictly forbidden and will disqualify.

J. STUART HAWNT, Director of Education. [2272]

YOUNG development engineer required for expanding TV rental and distribution chain.—Box 5168. [0181]

LONDON HI-FI dealer seeks part-time catalogue copy writer; mail order experience advantage.—Box 5192. [0139]

EXPERIENCED TV engineers wanted for Manchester area; house or modern flat available.—Box 5195. [2300]

RADIO and Television Testers and Engineers for city factory; good rates, 5-day week.—Alba (Radio & Television), Ltd., Tabernacle St., London, E.C.2. [0011]

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An internationally known Company require Technical Advisor for internal telephone systems.

Applicants should have considerable experience of surveying, quoting, estimating, installing and servicing, be prepared to travel throughout U.K., have H.N.C. or equivalent and be in the age range 25/35 years. This position carries a Non Contributory Pension Scheme and Life Assurance.

Write giving details of age, education, previous experience, present position and salary envisaged to Box 5189.

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A New Service to Engineers of All Grades

If you are thinking of changing your job, we can be of considerable assistance to you. We will undertake on your behalf the task of searching the Electronics Industry in any district of the Greater London area for vacancies that are available compatible with your qualifications and experience. The cost of this service is borne entirely by the employer and is offered to you in the strictest confidence.

Electronics Appointments Bureau,
Gloucester Mansions,
Cambridge Circus,
London, W.C.2.

Phone: Covent Garden 0280.

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Senior and Assistant

TECHNICAL ILLUSTRATORS

Senior and Junior

We are expanding our Technical Publications Section and a number of vacancies are now open and others will occur within the next six months. Successful applicants will work on one of the following projects—

- Airborne Radar
- Industrial Nucleonics
- Medical, Research and Reactor Nucleonics

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JUNIOR ILLUSTRATORS: preferably with some D.O. experience.

Write, in confidence, giving fullest details of experience, training, age, etc., to:—

Personnel Manager,
Ekco Electronics Ltd.,
Southend-on-Sea.

WEST HAM COLLEGE OF TECHNOLOGY.
Romford Rd., Stratford, E.15.
APPLICATIONS are invited for appointment as
College Electronic Instrument Technician.
APPLICANTS should have had wide experience
in the maintenance and repair of modern trans-
istorized apparatus and be capable of develop-
ing circuitry.
SALARY scale: £785 to £855 per annum, plus
London Weighting (£25 to £40).
FURTHER information may be obtained from
the Principal of the College to whom letters
of application should be sent as soon as
possible.
R. OPENSHAW, M.A., Chief Education Officer.
[2281]

SOGENIQUE (ELECTRONICS), Ltd., Newport
Pagnell, Bucks.
ELECTRONICS Engineers.

TWO development engineers are required by
this company which manufacture precision
linear and circular measuring equipment for
the scientific and machine tool industries.
ONE engineer is required to develop new
designs and carry out work on the basic limita-
tions of the systems at present in use.
A second engineer is wanted to produce fully
engineered designs from prototype and experi-
mental equipments.

THESE positions carry good remuneration,
pension fund and life assurance scheme. Write
in first instance, stating age, education and
salary required. [2299]

YOUNG development engineer required to
investigate problems associated with 625/
405 line television conversion.—Please apply in
writing, stating qualifications, etc., Box 5164.
[0180]

SOUND recording studio requires an Assistant
Engineer, knowledge of electronics required,
preferably some experience of recording speech
and mixing music tapes from discs.—Write
stating age, qualifications, experience and
salary required, to Box 5186. [2274]

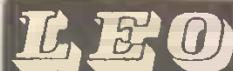
PUBLIC school leaver required as an elec-
tronic trainee to assist in the design and
construction of industrial controls for use in
the manufacture of glass fibre products; start-
ing salary £520.—Write giving details of educa-
tion and interests to Fibrelite Industries, Traf-
ford Hall, Chester. [2276]

AIRCRAFT Radio Engineers and Mechanics
with specific workshop experience in one
or more of the following: VHF, HF/MF, ADF,
ILS, VOR, X Band Radar; 42-hour week;
salary according to ability; pension scheme
after 12 months, overtime and bonus system.—
Apply Managing Director, Air Transport
(Charter) (C.I.) Ltd., 7 Willow Road, Poyle
Trading Estate, Colnbrook, Slough, Bucks. The
inexperienced need not apply. [2268]

DATA processing.—BP. has a career appoint-
ment in its data processing develop-
ment team for, preferably, a graduate
widely experienced in operating and pro-
gramming computers and associated communi-
cations equipment; in addition to its responsi-
bilities in head office, the team liaises with
overseas companies on selection of data pro-
cessing techniques and equipment; conditions
of employment are commensurate with the
importance of this appointment.—Applicants,
aged 30 to 40, should write, giving full details,
quoting reference H.5983A, to Box 7194, c/o
Hanway House, Clark's Place, E.C.2. [2291]

WESTMINSTER HOSPITAL physics Dept.
Senior Electronic Technician, post vacant
on 1st April, 1963; the appointee will assist
in research and the development of specialized
electronics and electrical apparatus used in
various medical research projects. Applicants
preferably with an H.N.C. and some experience
of medical electronics must be able to work
on their own initiative although the projects
are supervised by the Electronics Physicist
from whom further particulars may be ob-
tained. Whitley Council salary scale (under
review) £710 rising to £905 plus London
Weighting allowance.—Applications giving de-
tails of age, education, qualifications and ex-
perience and the names of two referees to
Development Secretary. [2264]

Audio circuit engineer—
valves and transistors — for
development of electro/musical
devices. Qualifications should
include experience and original
ideas. Progressive South
London Company. Write in
first instance, Box No. 5187,
c/o "Wireless World"



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Expansion of our business has created openings in the maintenance of computers and their associated equipments. Vacancies exist at various levels and applications are invited from men with any of the following backgrounds:—

- (1) Qualified men with a degree of H.N.C. in Electrical Engineering or Physics.
- (2) Engineers with experience of electronic circuitry and pulse techniques.
- (3) Men who have served a mechanical engineering apprenticeship and have experience of maintaining light electro-mechanical equipments.
- (4) Young men with a mechanical aptitude and a knowledge of D.C. theory.

Full training will be given and our training scheme provides the means whereby men of ability can advance to more senior positions. Good starting salaries will be paid and further increases will be awarded quickly whenever individual merit warrants recognition.

Write giving details of career to date to:—

**The Personnel Manager (Code 650), Leo Computers Limited,
Hartree House, Queensway, London, W.2.**



ELECTRONIC TEST ENGINEERS

EMI Electronics Ltd. has a number of interesting vacancies for Test Engineers and Assistant Test Engineers to be engaged on the wide range of ministry equipment developed and manufactured by the company.

Applicants must have previous experience of electronic inspection techniques or of the inspection of electronic components. An O.N.C. (electrical) would constitute a distinct advantage but is not essential. These posts are of staff status and are located at Hayes and Feltham, Middlesex.

Please write, quoting reference WWE/9/B9 to:

**Group Personnel Manager,
04213/PF,
EMI Electronics Ltd.,
Hayes, Middlesex.**

SMITHS Radiomobile

BRITAIN'S CAR RADIO SPECIALISTS

invite applications for the following posts:

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These appointments hold out very definite prospects of advancement for those with the right experience and ability.

Applicants should apply to:

The Service Manager, S. SMITH & SONS (RADIOMOBILE) LTD.,
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or telephone for an appointment, GLAdstone 0171.

(Near Staples Corner)

TEST Engineers.—Due to internal promotions and to increasing business in the TV broadcast equipment field, Pye T.V.T., Ltd., have a continuing requirement for engineers to work on the setting up and proving of a wide range of high-grade equipment including transmitters, studio and control equipment, outside broadcast equipment, closed circuit systems and transistorized studio equipment. The Chief Inspector is always interested in hearing from engineers with a sound basic electronics training who would like to consider employment in this field.

WORKING conditions are pleasant and friendly and the prospects of advancement extremely good.

ENQUIRIES may be made in person to the Chief Inspector, at the York St., Cambridge, factory or in writing to the engineering Personnel Officer, Pye T.V.T., Ltd., St. Andrew's Rd., Cambridge, quoting "TTE." [0014

MECHANICAL, Electrical and Heating and Ventilating Engineering Draughtsmen, pensionable posts in Government Departments for men and women aged at least 20 on date of application with not less than 3 years' training (including adequate practical experience with relevant technical study) and at least one year's full-time drawing office work. Appropriate O.N.C. required; starting salary (inner London) £640 (at 20) to £996 (at 28 or over); scale maximum £1,093; promotion prospects.—For application form and details of vacancies and types of work available, write Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/68. (3). [2267

SITUATIONS WANTED

RADIO operator, 1st class P.M.G., seeks post abroad, francois, español.—Box 5177. [2268

COMMUNICATION Electronic Engineer, 41, based mid-Devon, seeks position, 27 years world wide experience all aspects radio communication L/F to V H/F, 100kw to 1 watt, mobile nets Simplex/Duplex, V H/F Multiplex, carrier, teleprinter, R.T.T., diversity, telemetry, surveys, systems planning, U/G cables O/H lines, budgets, personnel, training, admin, etc., available at short notice.—Box 5185. [2270

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WEBB'S log-book for recording signals heard and worked, 112 pages, 9 1/2 x 8 in, approved format, semi-stiff covers, excellent value, 6/-, post free, or callers, 5/4.—Webb's Radio, 14, Soho St., London, W.1. [0021

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RESEARCH AND DEVELOPMENT CRAFTSMEN

RADIO MECHANICS for the maintenance and installation of radio communication receivers and equipment.

TELEPRINTER MECHANICS for the maintenance of teleprinter and cypher machines and associated telegraph equipment.

WIREMEN for prototype sub-assembly layout, wiring and testing of radio and computer type chassis.

BASIC PAY: £10 4s. 2d. per week plus merit pay in the range of 10/- to 100/- per week. Merit pay will be assessed at interview based on ability and the necessary basic qualifications.

Opportunities for eventual permanent and pensionable posts.

Five-day 42-hour net week.

Good working conditions.

Apply in writing to:

Recruitment Officer (RDC/3), G.C.H.Q. "A" Block, Oakley, Priors Road, Cheltenham, Glos.

NEW RECEIVERS AND AMPLIFIERS

TELECOMM 10 valve v.h.f. communication receivers, 3 separate models tuning 65/125 mc/s or 78/175 mc/s or 96/225 mc/s, built-in speaker and A.C. mains power supply, brand new, limited quantity at £100.—Radio Communications Co., Telecomm Works, Crewkerne, Somerset. [2284

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx's, etc., AR88, CR100, BRT400, G209, S640, etc., etc. in stock.—R. T. & I. Service, Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [0053

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HEATHKITS can now be seen in London and purchased on easy terms; free brochure.—Direct TV Replacements, Ltd., Dept. W.W. 25/3, 138, Lewisham Way, S.E.14. Tideway 6666. [9240

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A good starting salary will be paid to men with either a basic knowledge and experience of electronic circuits or education to O.N.C. or G.C.E. "A" level in Maths/Physics. There are excellent staff benefits in operation.

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4-transistors miniature amplifiers, 6 volt/1 watt or 9 volt/1.5 watt price each 35 sh. for 500 pcs. per order. Contact us for further information.

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The Director, Huddersfield Training College, Holly Bank Road, Lindley, Huddersfield.

The Principal, Garnett College, "Downshire House," Roehampton Lane, London, S.W.15.

The Principal, Wolverhampton Technical Teachers' College, Wulfruna Street, Wolverhampton.

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WIRELESS SET B.44. Double super-heterodyne TxRc. RF output 4 watts. 16 valves, amplitude modulation, crystal controlled. 65.90 mc/s. 12 volts battery operation. Man-portable. Speaker, phone and loud hailer outputs contained in one unit. TxRc and PSU. Keen prices for export, etc., with or without operating kits. Full particulars and prices on application.

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AR.88D from £35. R.1475 £10. PCR from £5 9 6. V.H.F. 1392D 90-155 mc/s. 1132A, 100-124 mc/s., many others, all carriage extra. **NO19 TxRc Mk. II and III**, sets from 50/-, complete stations from £7/10/-.

RF Units. Section of the R.209 1-20 mc/s., complete dial and logging dial. 3 valves, dial lights, size 7 x 7 1/2 x 7 1/2. **Brand new 59/6.** Post 3/-. Ditto for the R.107 1.2-17 mc/s., 47/6. Carr. 5/-.

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ASDIC type echo sounders, new, fully portable, 7.5v, 0-100ft, suitable for all craft: £20 complete, leaflet available.—Teleradio below.
RADIO control equipment, send for lists of available equipment for boats and aircraft.
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SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc. in stock.—R. T. & I. Service, Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986 [0058

EVERSHED recorders, milliammeters, dual chart speeds, £25; Tinsley mirror galvanometers, £10; B.S.R. BFO 0-16 KC one Watt 6000 output, £14; X band signal generator with 3in CRT and spare Klystron, £30; electronic instruments pH meter model 23A probes extra. £22; Cambridge Unipivot centre zero microammeter, £9; all items in perfect condition.—Altair Electronics, Ltd., 76, High St., Queenborough, Kent. Tel. Sheerness 2181. [2296

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MICROPHONES by Reslo, Lustraphone, S.T.C., Gramplan, A.G.G. All tapes and accessories. **GOOD quality equipment** welcome in part exchange.

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- ★ Metro-Vickers Metrovac Pumps, 230 v. A.C. £17 10
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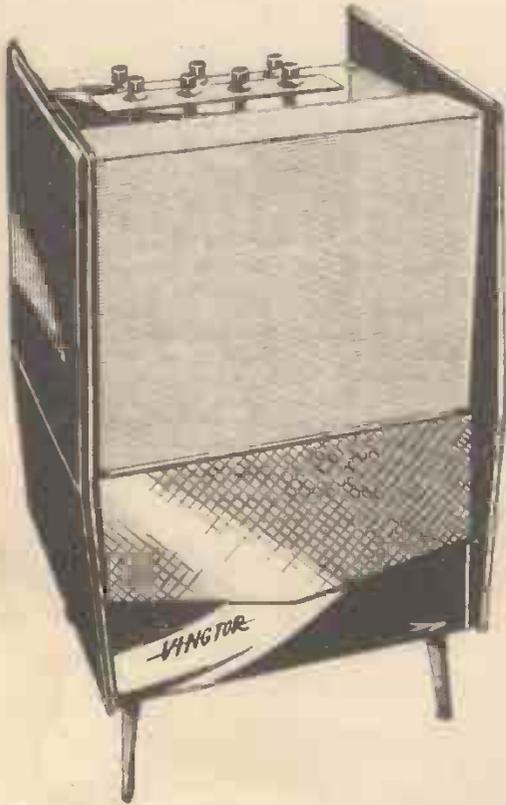
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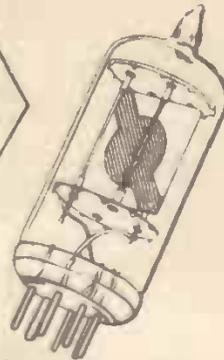
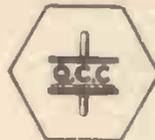
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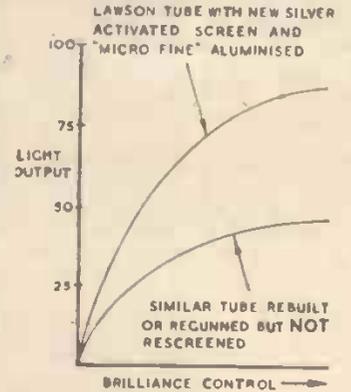
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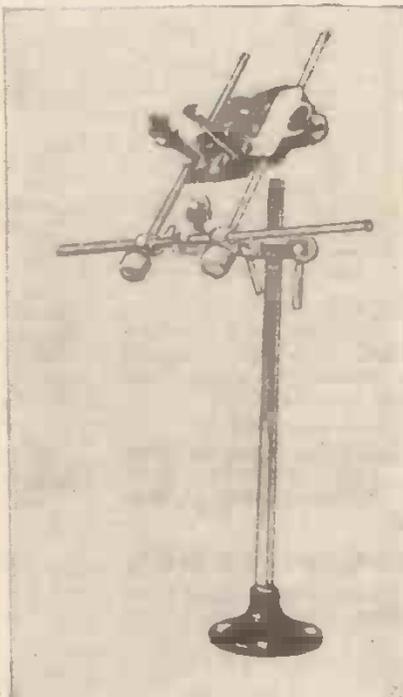
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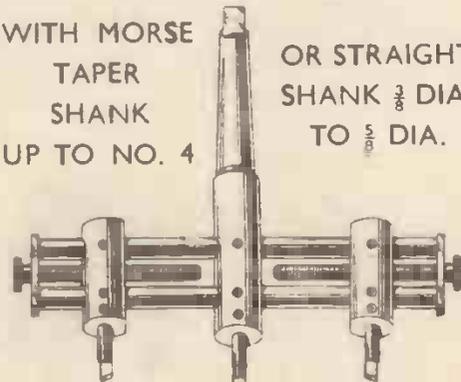
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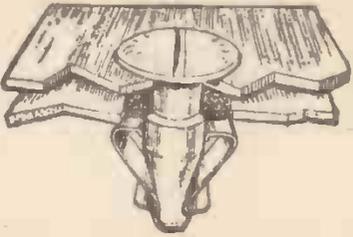
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INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 125 to 128

	PAGE		PAGE		PAGE
Acoustical Mfg. Co., Ltd.	43	Goodmans Industries, Ltd.	25	Quartz Crystal Co., Ltd.	130
Adcola Products, Ltd.	Cover iii	Goodwin, C. C., (Sales), Ltd.	118		
Advance Components Ltd.	26, 27, 34, 51, 68, 79	Gramplan Reproducers, Ltd.	131	Radford Electronics	36
Aeon Laboratories	121	Hall Electric, Ltd.	35	Radio & Electrical Mart	120
Akurate Eng. Co.	132	Harmsworth Townley & Co.	21	Radio & T.V. Components (Acton), Ltd.	116
Alpha Radio Supply Co., Ltd.	107	Harris Electronics (London), Ltd.	113	Radio Clearance, Ltd.	99
Amplivox, Ltd.	55	Harris, P.	129	Radio Component Specialists	92, 93
Anders Electronics, Ltd.	5	Harverson Surplus Co., Ltd.	112	Radio Exchange Co., The	120
A.N.T.E.X., Ltd.	50	Henry's (Radio), Ltd.	104	Radiospares, Ltd.	130
A.P.T. Electronic Industries, Ltd.	59	H.P. Radio Services, Ltd.	58	Radio Supply (M/c), Ltd.	96, 97, 98
Arcoelectric Switches, Ltd.	52			Rank Cintel, Ltd.	23
Armstrong Wireless & Television Co., Ltd.	72			Rank Kalee, Ltd.	44
Avo, Ltd.	1			Redifon, Ltd.	67
		Iliffe Books Ltd.	119, 121	Relda Radio, Ltd.	101
		"Industrial Electronics"	110	Reproducer & Amplifier, Ltd.	29
Batey, W., & Co.	90	International Audio Fair	90	Ritherdon & Co., Ltd.	78
Bentley Acoustical Corpn.	108	International Correspondence Schools	119, 121	Rollet, H., & Co., Ltd.	132
Berry's Radio	121	Interplas	14		
Brenell Engineering, Ltd.	39	Irongate (M.O.) Co.	103		
Britain, Chas., (Radio), Ltd.	91			Salford Elec. Insts., Ltd.	46
Brookes, Crystals, Ltd.	72	Keyswitch Relays, Ltd.	7	Samsons (Electronics), Ltd.	105
Bulgin, A. F., & Co., Ltd.	153			Service Trading Co.	88, 89
Bullers, Ltd.	50			Servo & Electronic Sales	119
		Lasky's Radio, Ltd.	82, 83, 84	Servomex Controls, Ltd.	54
		Lawson Tubes	131	Sifam Electrical Instrument Co., Ltd.	132
Canadian Westinghouse, Ltd.	57	Leak, H. J., & Co., Ltd.	71	Smith, G. W., (Radio), Ltd.	102
Castle Products	116	Ledon Instruments, Ltd.	108	Smith, H. L., & Co., Ltd.	118, 133
Chance Pilkington, Ltd.	66	Levell Electronics, Ltd.	22	Sontronic, Ltd.	42
Clark, A. N. (Engineers), Ltd.	36	Lewis Radio Co.	37	Southern Radio Supply, Ltd.	131
Clyne Radio, Ltd.	94, 95	Lexor Electronics, Ltd.	56	Southern Technical Supplies	121
Cole, R. H. (Overseas), Ltd.	90	Light Soldering Developments, Ltd.	56	Spears Engineering Co., Ltd.	132
Collett Terminals	80	Linear Products, Ltd.	38	Stamford, A. L.	124
Cooper, R. J.	81	Lionmount & Co., Ltd.	114	Standard Telephones & Cables, Ltd.	4
C.R.E.I. (London)	32, 33	London Central Radio Stores	133	Steatite & Porcelain Products, Ltd.	2
Crystals & Components, Ltd.	88	Lyons, Claude, Ltd.	75, 77	Stern Radio, Ltd. & Premier Radio Co.	86, 87
				Stratton & Co., Ltd.	76
Dartronic, Ltd.	28	Mailplan	106	Suflex, Ltd.	64
Davies, A., & Co.	130	Marconi Instruments, Ltd.	15, 41	Sugden, A. R., & Co. (Engineers), Ltd.	78
Daystrom, Ltd.	9, 10, 11	Marconi's Wireless Telegraph Co., Ltd.	65	Sweetman & Bradley, Ltd.	80
Denco (Clacton), Ltd.	40	McMurdo Instrument Co., Ltd.	42		
Dependable Radio Supplies	120	Metrimpex	48	Tannoy, Ltd.	131
Drake Transformers, Ltd.	38	Mills, W.	118	Technical Trading Co.	117
Drayton Controls, Ltd.	3	Modern Book Co.	120	Telemechanics, Ltd.	78, 81
		Modern Electrics (Retail), Ltd.	98	Telequipment, Ltd.	60
E.A.D., Ltd.	128	M.R. Supplies, Ltd.	58	Tele-Radio (1943), Ltd.	56
E.I.R. Instruments, Ltd.	133	Mullard, Ltd.	62	Thompson, A. J.	129
E.K. Electronics, Ltd.	114	Multicore Solders, Ltd.	124, Cover iv	Thorn-A.E.I. Radio Valves & Tubes, Ltd.	70
Ekco Electronics	46			T.R.S. Radio	100
Electro-Winds, Ltd.	118	Newmark Transistors, Ltd.	76		
Electronic & Mechanical Eng. Co., Ltd., The	99	Nombrex, Ltd.	80	Universal Book Co.	132
Electronic Precision Equipment, Ltd.	73			Vacuum Electronics, Ltd.	80
Electronics (Croydon), Ltd.	73	Oddie Bradbury & Cull, Ltd.	133	Valradio, Ltd.	52
Electronics (Flinsbury Park), Ltd.	73	Oliver Socket Screw, Ltd.	121	Vectron, Ltd.	74
Electronics (Manor Park), Ltd.	73			Vestfold Radio-Elektro A/S	128, 130
Elliott Bros. (London), Ltd.	98	Painton & Co., Ltd.	47	Vitality Bulbs, Ltd.	118
English Electric Valve Co., Ltd.	13	Parker, A. B.	81	Vortexion, Ltd.	69
Enthoven Solders, Ltd.	49	Partridge Transformers, Ltd.	124		
		P.C.A., Ltd.	6	Watts, Cecil E.	129
Fane Acoustics, Ltd.	81	P.C. Radio, Ltd.	115	Webber, R. A., Ltd.	118
Fenham Radio	116	Pembridge College of Electronics	40	Webb's Radio	130
Ferranti, Ltd.	Cover ii	Philco International, Ltd.	24	Wellington Acoustic Laboratories, Ltd.	130
		Philips, N. V.	30, 31, 53	Weymouth Radio Mfg. Co., Ltd., The	48
Gardners Transformers, Ltd.	44	Plezo, Ltd.	114	Wharfedale Wireless Works, Ltd.	8, 76
Garrard Eng. Mfg. Co., Ltd., The	45	Pitman, Sir Isaac & Son, Ltd.	58, 133	Whiteley Electrical Radio Co., Ltd.	12
Gee Bros. (Radio), Ltd.	111	Plastronics, Ltd.	56	Wilkinson, L., (Croydon), Ltd.	114
Gilfillan, R., & Co., Ltd.	108	Plessey Co., Ltd.	17, 18, 19, 20	Wirecomp Electronics	109
Gilson, R. F., Ltd.	72	Post Radio Supplies	133		
Gladstone Radio	117	Proops Bros., Ltd.	85		
Glaser, L., & Co., Ltd.	129	Pye Telecommunications, Ltd.	63		
		Pye TVT, Ltd.	16	Z. & I. Aero Service, Ltd.	122, 123

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