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Wireless World

ELECTRONICS
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FORTY-NINTH YEAR OF PUBLICATION

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FRAME GRID VALVES FOR TELEVISION

3

The frame grid valves for television tuners are the PCC89 and PCF86. The PCC89 is a variable-mu r.f. double triode for use as a cascode amplifier. It is the frame grid counterpart of the conventional PCC84, but it has twice the slope. The PCF86 is a combined triode and high-slope r.f. pentode for use in the mixer stage. Its conventional counterpart is the PCF80; but, again, the frame grid valve has about twice the slope of its predecessor, and the increase in conversion conductance is from 2.1mA/V to 4.5mA/V. With such substantial changes in characteristics, it is obvious that the frame grid types cannot be used as plug-in replacements for the earlier types. Tuners will necessarily have to be redesigned with different component values. In addition, the large increase in voltage gain will demand particular care with respect to stability, especially as tuners are progressively miniaturised and printed circuits are introduced.

The design of the r.f. amplifier round the PCC89 will be discussed in a later advertisement. Here we shall outline the special features of a frame grid mixer stage.

STABILITY

In the mixer, stability must be considered primarily at the frequency where the grid tuned circuit and the i.f. transformer most closely approach in frequency; that is to say, on channel 1. The stability of the stage is determined by the effective slope of the mixer valve, which is doubled when a frame grid valve is used. However, the impedances of the grid and anode circuits are likely to be substantially the same for the PCF80 and PCF86. The worst condition for stability is when the primary of the r.f. bandpass filter is detuned with respect to the secondary, feeding the mixer grid; and the impedance of the i.f. bandpass filter (which is usually built into the tuner itself) is at its highest.

In the 40Mc/s region the characteristics of the circuit are such that there is only a narrow margin of stability. In particular, there is very little allowance for stray capacitances. For maximum stability, especially during alignment, it is therefore advantageous to neutralise the anode-to-grid capacitance of the valve. This can be done with either a loop coupled transformer (Fig. 1) or with bottom capacitance coupling (Fig. 2). In either case, the equivalent bridge circuit is as shown in Fig. 3. The value of Cg2 is not particularly critical, since partial neutralisation should be sufficient. However, the normal precautions must be observed: the stage should be carefully wired, the placing of components near the valve-holder should be avoided as far as possible, and the i.f. transformer coil should be kept well away from the mixer grid circuit.

R.F. LOSSES

In the design of the PCF86, special attention has been given to the question of r.f. losses. The triode and pentode cathode pins are internally strapped to minimise cathode lead inductance. They should both be taken straight to ground. Accordingly, in the PCF86 the effective grid-cathode capacitance due to cathode lead inductance rises comparatively little with frequency. Thus at 200Mc/s its value is only 10% above its l.f. value; while in the PCF80 the increase is more like 25%, and the capacitance/frequency characteristic is steep.

The input impedance of the PCF86 pentode has been carefully controlled by a certain amount of screen regeneration which is built into the valve. The inductive component of the screen grid connection produces a negative damping effect in the grid-cathode circuit by virtue of Miller effect; and the total input conductance of the pentode, due to cathode lead and screen lead inductance, is held within narrow limits.

FIG. 1

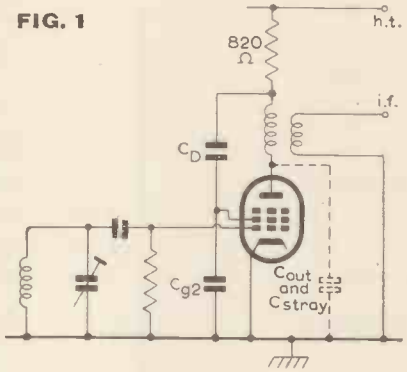


FIG. 2

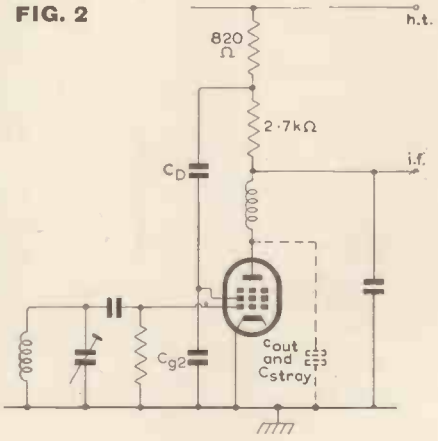
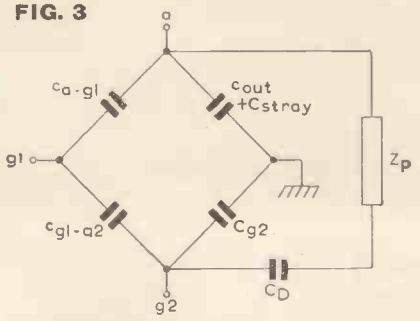


FIG. 3



DECEMBER 1959
Vol. 65 No. 11

Wireless World

Broadcasting Parliament

WE in this journal are interested primarily in the technique of radio communications, and normally we leave it to others to decide for what ends they are used. Nevertheless, when some novel application or extension of function takes place, or is mooted, we are expected to have an opinion and when relevant to express it.

Thus, when broadcasting started we opened our pages to programme matters, both domestic and foreign, as a means of interesting new readers in the benefits and attractions of owning a wireless set, but as the service settled down and acquired a predictable pattern we were content to leave these things to others and to reserve comment for special occasions or any new turn of events.

A recent proposal by Mr. Aneurin Bevan that the Lords and Commons should be continuously televised as a means of increasing public interest in Parliamentary proceedings has again provoked discussion. We say "again" because the idea of broadcasting Parliament is not basically a new idea. As long ago as March 24th, 1926, the following comment appeared in this journal:

> "As we write, the question as to whether or not the Budget speech will be broadcast remains undecided, and very divergent views have been expressed on the subject. If we are asked what our opinion is as to the advisability or otherwise of broadcasting Parliamentary proceedings, we should most definitely state that, in general principle, we are opposed to such a course. In our opinion anything in the nature of regular or frequent broadcasting of Parliamentary debates would tend to convert the House into a stage, where members would always feel that they were being listened to by an audience not always in sympathy with their views and always critical of their powers of oratory. Popularity amongst the public would tend to depend more upon eloquence than upon substance in speeches, whereas it should be remembered that not always the best orators make the best statesmen, and, in fact, the reverse is not infrequently the case. Apart from these points, there are, of course, many other objections which might well be raised against the principle of broadcasting the proceedings of the House as a regular programme feature.
>
> "When, however a special occasion arises, as, for instance, in the case of the Budget speech, the matter might well be viewed somewhat differently. There are millions who may never have the opportunity of listening in the galleries on such an occasion, and from the point of view of national education such an exception might well be made without the creation of a precedent which would ultimately lead to regular or even frequent transmissions of the kind. We should, in fact, welcome Parliamentary broadcasting if carried out very occasionally and in special circumstances such as the present instance, where public interest is so great, in view of the novelty, as to outbalance objections."

As far as the main issues are concerned there is little that can be added to what was said nearly 34 years ago. Technically, it is now perhaps more difficult than it was in 1926 to provide a continuous broadcast from Westminster, for the simple reason, as Sir Ian Jacob has emphasized, that no channel is available. But Sir Ian does not rule out the possibility of televising the best debates as they occur during the course of the year. These would be dealt with as outside broadcasts and would take their place as part of the normal programmes. No doubt Mr. Bevan would object on the grounds that this implies selection, and therefore editing by, to use his own words, "the bureaucrats of Broadcasting House." It would certainly involve recording, for only the leisured few—and M.P.s—can afford the time to attend debates at, say, 11 o'clock in the morning. Unless Parliamentary broadcasts can be brought to the people at normal and, when sufficiently important, peak viewing hours they will fail to conform to the democratic principles which were the mainspring of Mr. Bevan's suggestion. Continuous live broadcasting of Parliament during normal working hours is likely to have an audience very little larger than the circulation of Hansard.

No official assessment of the feasibility of mounting cameras to command views of Members rising to speak in any part of the House has yet been published, but it is not technically impossible, though it is bound to present difficulties. It is much easier to place microphones than cameras, as has already been demonstrated by the sound reinforcement in the new House; but even here skilled supervision by an alert and experienced operator is necessary to switch in microphones adjacent to the appropriate Members during the cut and thrust of a heated debate. Control is simplified by the fact that sound quality is not seriously affected by directional effects. The same cannot be said of sight. Here the angle of viewing is all-important, as every film star and amateur photographer knows. If and when television cameras are installed we foresee a general reshuffling of seats by profile-conscious politicians adjacent to camera positions, though their plans may be brought to nought by telephoto lenses and the remote control devices which have already been developed for other purposes by the B.B.C. It is a thought to daunt even the most extrovert of British M.P.s who may not yet have had the experience of speaking, as have his Antipodean contemporaries, before "the 20 microphones which stand up like tall poppies all over the Chamber to provide the Australian Broadcasting Commission's pitiless non-stop coverage."*

* "Westminster with Differences," by the Canberra Correspondent of *The Times*, November 16th, 1959.

Transistor Switching Speed

REASONS FOR THE LIMITATIONS—AND SOME METHODS OF ACCELERATION

By P. M. THOMPSON and J. BATESON†*

THE early simplication of a phenomenon, necessary for forming a concept, must always be suspect. Such concepts are incomplete and if used in this form as a basis for further investigation will inevitably lead to erroneous ideas. Before further ideas are developed the original concept must be examined carefully. As an example, ideas based on the earlier classification of solids into conductors and non-conductors are now inadequate. Computer switching circuits have been divided into those which do or do not "saturate," and this has led to such erroneous ideas as that collector voltage saturation is the sole cause of carrier storage.

Switching a transistor on or off is governed by the existence of carriers in its base region. Fig. 1 shows a cross-section of a transistor in which the emitter and collector are similar. This is sometimes called a bilateral or, more correctly, a symmetrical transistor. The current it can pass when switched on is governed by the population of carriers in the base region which, in turn, is primarily determined by the rate of recombination and the base current. It is not affected significantly by the collector current, or by the collector voltage being saturated. It can be seen that if there is no base current, the emitter and collector currents must be equal, thus a carrier extracted at the collector must be replaced by one at the emitter immediately, and the only mechanism available for depopulating the base is recombination. When the collector voltage is saturated, not all the carriers which arrive at the collector are collected. Those carriers which are

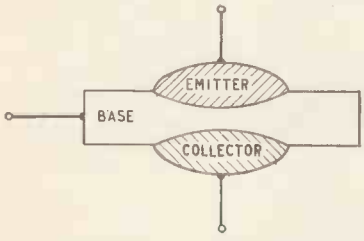


Fig. 1. Cross-section of a symmetrical transistor.

not collected are re-emitted from the collector junction, and those which *are* collected are replaced at the emitter junction. Thus the collector voltage being saturated does not affect the rate of depopulation.

Fig. 2 (a) shows a transistor being switched on and off by a current pulse at the base. The collector current waveform is shown at (b). Such a waveform would be obtained by placing a time constant in the base of a transistor having infinitely high switching speed, as in Fig. 2 (c). The time constant

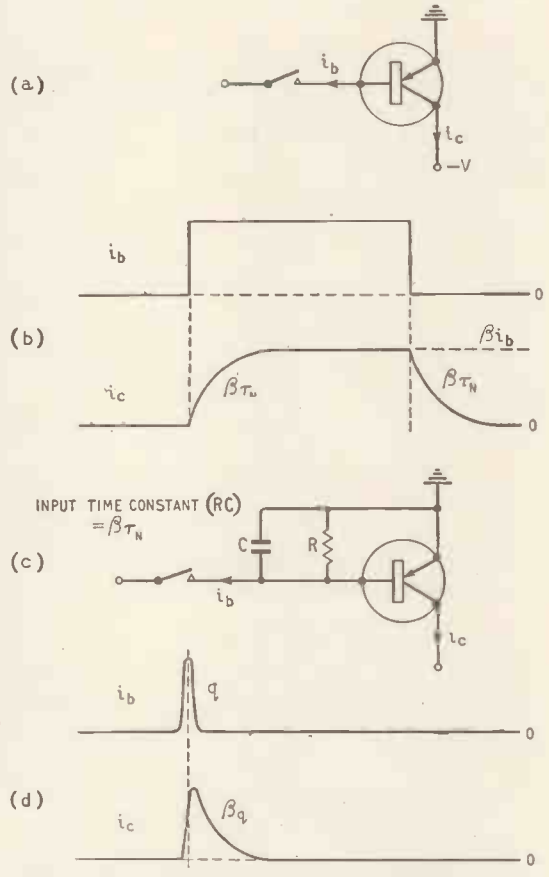


Fig. 2. Derivation of the charge concept in transistor switching: (a) transistor being switched by current pulse, (b) base and collector current waveforms, (c) equivalent circuit for producing the collector waveform, (d) base and collector current waveforms illustrating the charge concept.

would have a value of $\beta\tau_N$, where β is the d.c. current gain and τ_N the time it would take the collector current to rise to equality with the base current.

The presence of the time constant in this equivalent circuit introduces a concept which can be useful in the design of switching circuits. The equivalent capacitor must be charged when the transistor is turned on and discharged when it is turned off; in other words, the base can store a charge.‡ It follows that if we charge the base with a charge (q), β times that charge (βq) will be available at the collector. The current waveforms at the base and

* The Plessey Company, † The Eastern Ontario Institute of Technology, Canada. Both formerly of the Canadian Defence Research Telecommunications Establishment.

‡ The charge-control concept was previously mentioned in "International Transistor Convention and Exhibition," *Wireless World*, July/August, 1959.

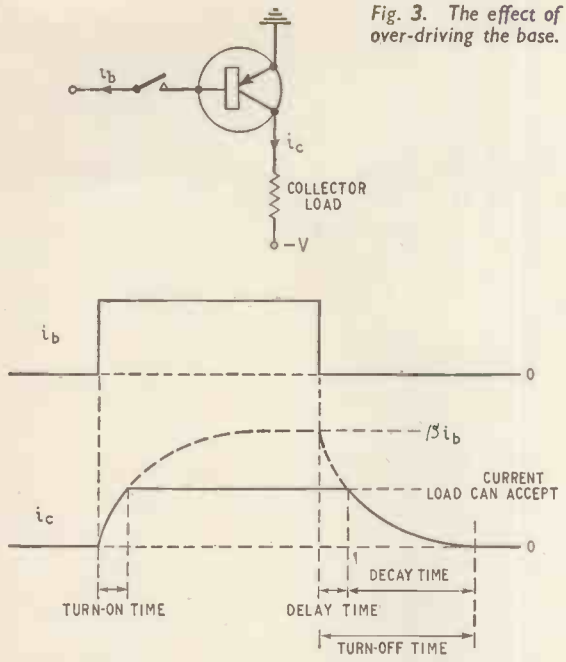


Fig. 3. The effect of over-driving the base.

collector might be very different, as shown in Fig. 2 (d), and it is the total output charge which is β times the total input charge. This is consistent with the d.c. β of the transistor, as can be seen by regarding the base current as the succession of a lot of separate charges, then the collector current is this succession multiplied by β.

In computers both the turn-on and turn-off times can be important. The transistor can be switched on more quickly by increasing the base current. The waveforms of Fig. 3 show a base current which is twice that needed to saturate the collector voltage. Here the base over-drive causes the transistor to turn on more quickly, but it also aggravates the problem of turning it off. The transistor turns off as if it were supplying βi_b, i.e., the current which could be collected; in this case twice that the collector load can accept.

The time lapse between turning off the base current and the start of the actual collector current decay is the time which would be taken for the collector current to decay from βi_b to the current which the collector load can accept. The time lapse, which is somewhat analogous to "lost motion" in relays, is shown in Fig. 3 as "delay time." A diode could be connected to draw the excess current, as in Fig. 4, but still this would not change the delay prior to the decay of i_c. A more profitable direction of investigation would be to consider the method by which the transistor was turned on quickly. The forward, base-current over-drive which turns the transistor on causes more carriers to be emitted into the base than are collected from it, resulting in storage in the base of excess carriers. This suggests a way of reducing the population of carriers in the base, which is to cause more of them to be collected than are emitted. It would follow from this that just as the population was increased by a forward base current it could likewise be reduced by a reverse base current.

The turn-off will be most rapid if no emission is allowed and both the emitter and collector are used as collectors. The maximum switching speed would be obtained from a transistor (see Fig. 5) by first applying a base over-drive to turn it on, then reducing the base drive to that just sufficient to maintain the collector current, and finally applying a large reverse base current to turn it off. This can be considered in terms of the equivalent circuit as follows. First apply a large current to charge the input capacitor, then maintain enough current to balance that flowing through the shunt resistance, and finally apply a reverse current to discharge the capacitor. It must be remembered, incidentally, that there is a limit to the reverse base current, and

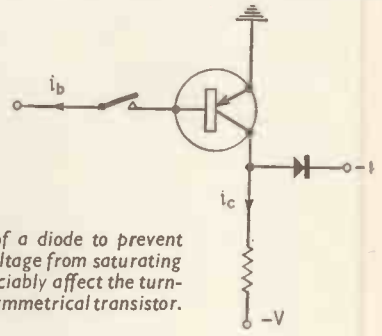


Fig. 4. Use of a diode to prevent the collector voltage from saturating does not appreciably affect the turn-off delay of a symmetrical transistor.

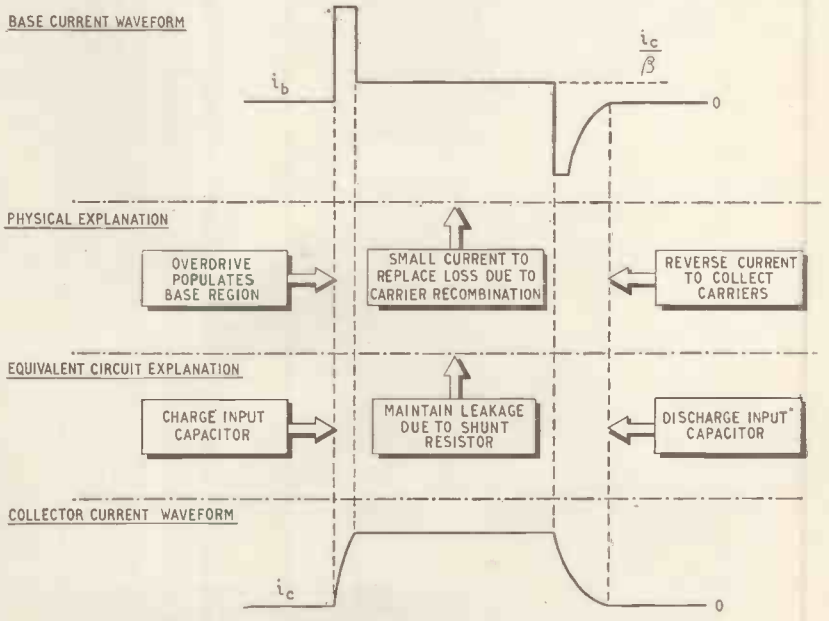


Fig. 5. Diagram to illustrate the accelerated switching of a transistor.

this is set by the rate at which carriers can diffuse to the junctions to be collected.

Up to this point we have considered only the ideal case of a symmetrical transistor. Many transistors used in switching circuits are constructed with their collectors larger than their emitters in order to improve their β and switching speed, and this unsymmetrical geometry modifies the turn-off delay when the collector circuit has been saturated. The advantages of making the emitter smaller than the collector can be seen from considering the fate of carriers emitted from various points of the emitter of the transistor shown in Fig. 1. Carriers emitted at the centre of the emitter will reach the collector much more quickly, on the average, than those emitted at the edge. If the emitter is made small and placed near the centre of the collector, as in Fig. 6, the average transit time will be shorter than in a symmetrical transistor and the number of carriers lost through recombination therefore fewer. When the collector voltage is allowed to saturate, emission will take place at the collector, and since emission takes place over the whole of the collector, carriers from the edges will have long path lengths and the average reverse transit time will be longer.

The asymmetry of construction thus leads to an asymmetry of switching time and the transistor will take longer to turn off. However, this does not detract from the method shown in Fig. 5 of accelerating the switching of a transistor. This switching waveform is approached fairly closely in the first of our two practical examples. The method was developed by R. H. Baker††; the circuit is shown in Fig. 7. Here, the current peak required to switch on the transistor is the difference between the currents through R_1 and R_2. When the transistor is switched on the collector voltage goes positive, and the base current is limited to i_c/β by the combination of silicon and germanium diodes. The collector can go positive until the voltage remaining between the collector and base terminals is the difference between the forward voltages of the silicon and germanium diodes; then the germanium diode conducts and allows the collector, instead of the base, to pass the excess input

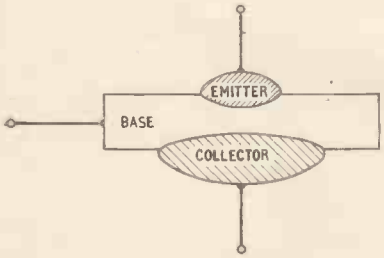


Fig. 6. Cross-section of a high-speed transistor.

current. The transistor is switched off by returning the input voltage to zero and allowing the current through R_2 to depopulate the base.

If, during switching, the change in voltage across the load is appreciable, the collector capacitance assumes some importance. Because it can be considered as being capacitance between collector and base it is sometimes called Miller capacitance and, as such, by applying negative feedback to the base, slows the rise of collector current. This has led to "low level logic," a type of computer-logic circuit

†† "The Design of Transistor Circuits for Digital Computers," by A. I. Pressman. John Rider (1959).

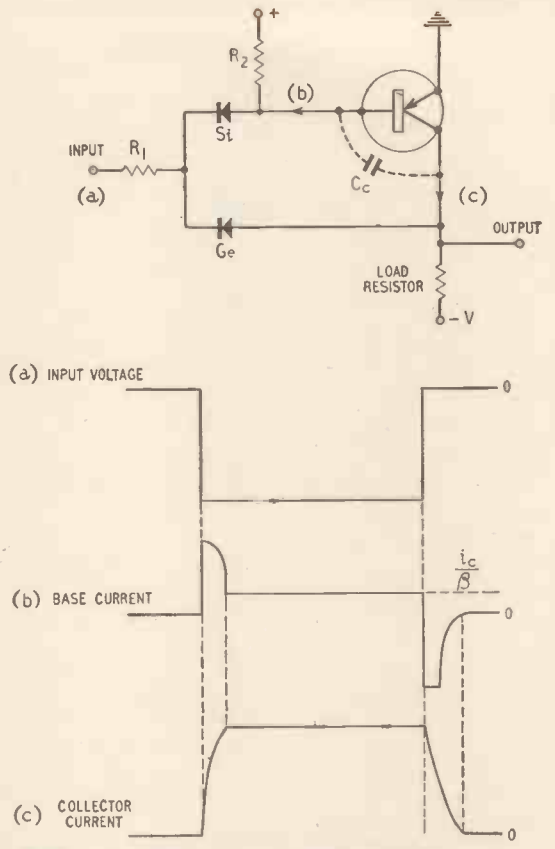


Fig. 7. Circuit for the rapid switching of transistors developed by R. H. Baker.

in which the changes of collector voltage are held to a minimum.

An example of low level logic is shown in Fig. 8, where the input voltage excursion is made just sufficient to switch the diodes between their conducting and non-conducting states. Here, there is no attempt to prevent base over-drive, the transistor being switched from the saturated to the non-saturated condition by the appropriate base currents. The transistor is regarded as being "on" when the base is overpopulated (i.e. when there is an excess of carriers over those required to supply the load current) and "off" when the transistor cannot supply the current the load can absorb.

Consider that the input terminals are all open circuit. Then, since R_3 is small, the currents flowing are determined principally by the values of R_1 and R_2. These are so arranged that i_1 is half the value of i_2, the other half of i_2 being supplied from the base as a forward current. Since the emitter diode is conducting, point X is clamped to earth potential, and the point Y is slightly negative. The base is now overpopulated and the collector effectively connected to earth.

Suppose that one of the input terminals is now connected to earth (this would be done by a circuit similar to that under discussion). Then point Y will be clamped close to earth potential and i_2 will be diverted, its new path being through the input diode from earth. Now i_1 proceeds to depopulate the base and disconnect the collector from earth. When the

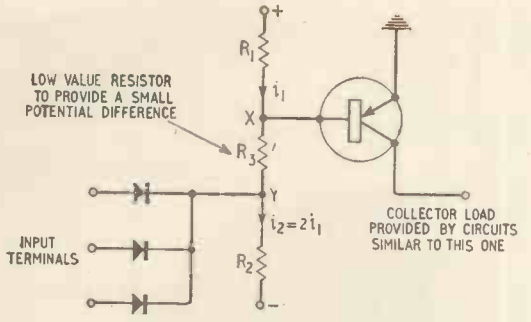


Fig. 8. Example of "low level logic" switching circuit.

base is cleared, all of i_1 flows through R_3 and point X becomes slightly positive. When $i_2 = 2i_1$ the turn-off current is approximately equal to the turn-on current, and the input capacitance is discharged in about the same time as that needed to charge it. Thus the turn-off and turn-on times also are approximately equal.

We should stress that this circuit is not the only way of performing low level logic; for example, Baker's technique may be applied. Also the method of turning the transistor on and off, which we have applied to the low level circuit, may be applied to circuits which are not necessarily low level. The two circuits which have been used here to exemplify the switching principles have been kept simple; however, the techniques may be found in many more complex circuits, a good example being the complementary pair circuits of N. F. Moody§. Furthermore, there are many other circuits which have been developed for fast switching of transistors, but in considering these circuits, an understanding of the true causes of carrier storage can assist the engineer in finding that which is most appropriate for his application.

Finally, the authors would like to thank R. S. Cobbold of the Canadian Defence Research Telecommunications Establishment, for review and criticism of the article.

§ "Controlled Saturation in Transistors and its Application in Trigger Circuit Design," by N. F. Moody, *Electronic Engineering*, 30, March and April, 1958.

New Acoustic Measurement Station

ACOUSTICAL Investigation and Research Organisation (AIRO) Ltd. recently opened in Hemel Hempstead a building in which various acoustic characteristics of materials, machines and electro-acoustic transducers can be measured.

The building contains five rooms—an echo-free (anechoic) chamber, a reverberation chamber, two sound source rooms and a control room. There is also a 40ft long, 3ft square underground duct containing a 20ft long anechoic wedge for simulated field-free measurements from 100c/s down to 20c/s. Alternatively, for standing wave absorption measurements, a reflecting surface may be placed in front of the wedge in the duct.

The walls of the anechoic chamber (see photograph on right) are different from the usual "dragons teeth" construction and consist of "Bondacoust" fibrous absorbent material in strips of various widths between about 1½ and 3ft arranged to form a number of long wedge-like shapes. Five slightly different shapes are used to avoid any resonance effects.

Possible resonance effects are also carefully avoided in the source and reverberation rooms (see photograph of reverberation room below) by breaking up any regularities in reflection by means of rectangular and square reflecting panels hung at various distances and angles from the ceiling, as well as by making the walls slightly out of parallel by about half an inch per foot. Changes in the reverberation time caused by placing a sample of a material in the 10ft square floor space provided enable the absorption of the material to be measured. Alternatively, sound transmission can be measured by placing a sample in an aperture between the reverberation room and one of the source chambers.

Ventilation ducts to the reverberation room are surrounded by Helmholtz resonators tuned to various frequencies so as to provide at least 35dB sound isolation.

Reverberation room (below left) and echo-free room (right) in AIRO acoustic measurement station.

Crystal Calibrator

Battery-operated Spot-frequency Signal Generator

By G. de VISME

THE usefulness of a crystal calibrator to the short-wave enthusiast was pointed out by a colleague, and having seen the one built by him, the writer was inspired to construct one for himself and this article describes its construction, performance and use.

There is nothing in the least original about it, but for anyone interested in constructing an entirely

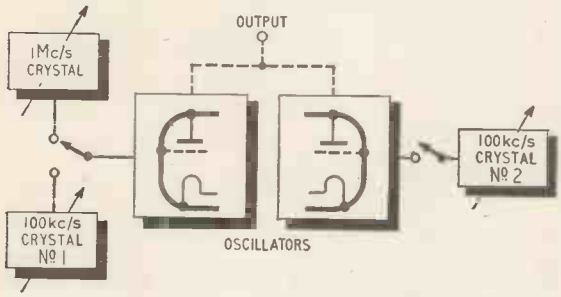


Fig. 1. One of two possible circuit arrangements for the frequency calibrator.

portable source of spot radio frequencies, constant in amplitude, phenomenally accurate in frequency and at low cost, this article may save him the job of working out component values, etc., for himself.

Requirements and Possible Arrangements.—The specifications set were as follows, in order of priority:—

(*i*) Low cost.
(*ii*) Easily detectable spot frequencies up to 30Mc/s.
(*iii*) Portability, i.e., battery-operated and compact.
(*iv*) Low battery consumption.

The first question was whether or not to use transistors. Requirements (*iii*) and (*iv*) certainly favour their use, whilst requirements (*i*) and to a lesser extent (*ii*) suggest miniature double-triodes. The latter alternative was chosen.

Specification (*ii*) implies the ability to amplitude-modulate every spot frequency effectively, and two possible arrangements suggested themselves:—

(*a*) Two 100-kc/s crystals and one 1-Mc/s crystal and one double-triode, used as shown in Fig. 1. The idea here is as follows:

Tune any receiver to the long-wave Light programme, the carrier frequency of which is 200kc/s to a very high degree of accuracy. Switch on the oscillator using crystal 2 (Fig. 1) and tune it to give zero beat with the Light programme. "Modulated" spot frequencies every 100kc/s can then be obtained by switching on the oscillator using crystal 1, and very slightly mistuning it.

For the benefit of readers not familiar with the use of quartz crystals as frequency standards, the following digression explains what is meant by "tuning" and "mistuning" a crystal.

A suitably-cut quartz crystal behaves, by virtue of the piezoelectric effect, as a series-tuned circuit of extremely high "Q," and resonating at a definite frequency. However, the values of the equivalent inductance and capacity of the circuit are altogether outside our experience of normal radio-frequency tuned circuits—for instance, the equivalent inductance might be 3H, whilst the equivalent capacity might be as little as 1/100pF.

Placed in an oscillatory circuit, the crystal will oscillate at a frequency making it either slightly inductive or slightly capacitive, depending on the circuit. In view of the enormous equivalent inductive and capacitive reactances of the crystal—which at resonance exactly balance, of course—the small reactive component required to make the circuit oscillate is attained at a frequency only minutely differing from the resonant frequency of the crystal.

Reactive elements added to the circuit, therefore, only very slightly affect the oscillatory frequency; thus a variable capacitor across the crystal acts as a very fine control of frequency in the immediate vicinity of the crystal's quoted frequency. This is what is meant by "crystal tuning." The crystal is

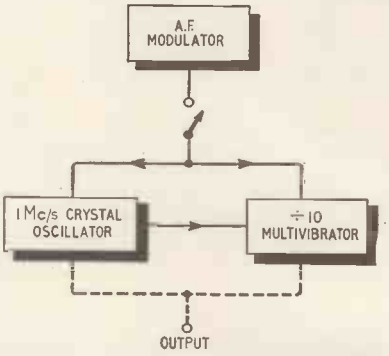


Fig. 2. The alternative circuit arrangement discussed in the text.

said to be "mistuned" when the added reactances in the circuit cause it to oscillate at a frequency differing from its quoted frequency; the greatest degree of mistuning possible, however, is of the order of the crystal frequency divided by the crystal "Q" (upwards of 20,000).

To resume, "modulated" spot frequencies every Mc/s are obtained by substituting the 1-Mc/s crystal for crystal 1. The word "modulated" is in inverted commas because a mere addition of two signals differing in frequency does not give actual a.m., but only beats.

This method worked quite satisfactorily when using the 1-Mc/s crystal, only of course the pitch

of the "modulation" varied with the harmonic selected. The harmonics of crystal 1, however, tailed off in intensity above 4.5Mc/s, so multiples of 100kc/s could only be obtained up to this frequency. Since only one valve is used, the consumption is quite small. However, the idea might be worth further investigation, perhaps using transistors in place of the valve.

(*b*) The standard calibrator arrangement, which was finally adopted, and which is shown in Fig. 2.

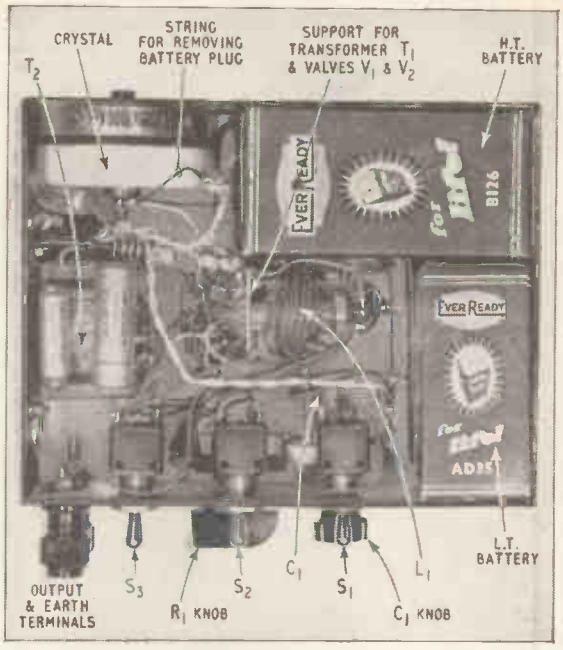
Circuit.—The circuit of arrangement (*b*), shown in Fig. 3, gives very powerfully modulated harmonics of both 1Mc/s and 100kc/s all the way up to 30Mc/s. In fact, harmonics of 1Mc/s could be detected even on a v.h.f. tuner.

The first section of V_1, together with the associated circuitry, comprises the crystal oscillator. The crystal is tuned by means of variable condenser C_1. The h.t. to this stage is drawn through half of the primary winding of transformer T_2, as also is the h.t. to the multivibrator (valve V_2 and associated circuitry).

The second section of V_1, with T_2, R_2, C_3, C_4 and C_5, forms an audio frequency Hartley oscillator. When switch S_1 is closed, this stage becomes operative and bursts into oscillation, and a.f. voltage oscillations appear across the windings of T_2. Thus the h.t. supply to both crystal oscillator and multivibrator is modulated at a.f. when S_1 is closed.

Since both these latter circuits operate non-linearly, variation of their h.t. supply amplitude-modulates their output.

Condenser C_2 and the secondary winding of transformer T_1 couple a very minute portion of the output of the crystal oscillator into the multivibrator, enabling the multivibrator frequency to lock itself to a sub-multiple of the crystal oscillator frequency.



Plan view (with lid removed) of the crystal calibrator. Circuit identifications relate to Fig. 3.

The only features worth drawing attention to are:—

(*i*) Anode modulation of both crystal oscillator and multivibrator is used.

(*ii*) The 1-MΩ variable resistance R_7 across one of the multivibrator grid leaks provides a very fine

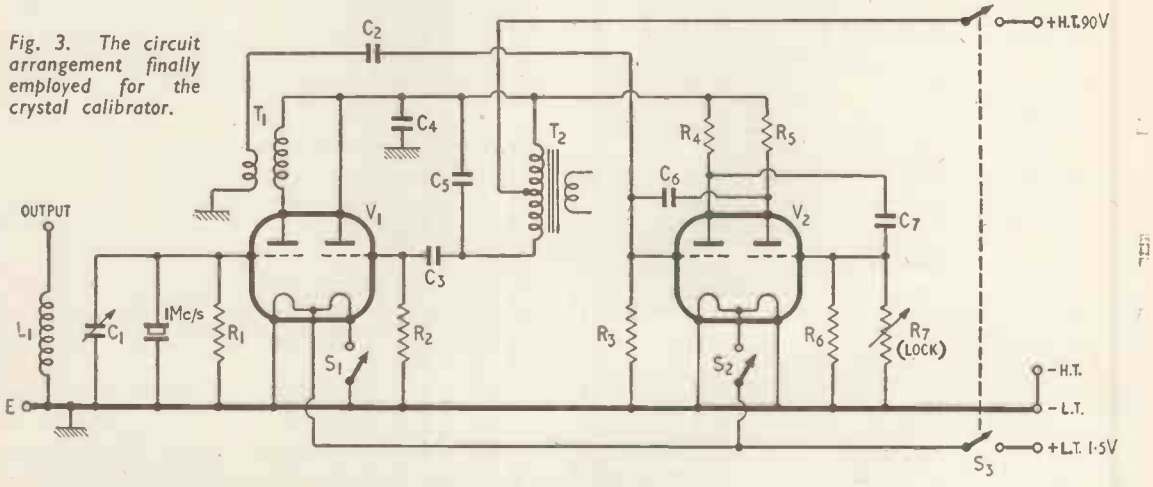


Fig. 3. The circuit arrangement finally employed for the crystal calibrator.

LIST OF PARTS

Capacitors

C_1 = 10-100pF air-spaced variable
C_2 = 3.5pF
C_3, C_5 = 0.01μF
C_4 = 0.05μF
C_6, C_7 = 33pF

Resistors

R_1 = 1MΩ
R_2 = 18kΩ
R_3, R_6 = 62kΩ
R_4, R_5 = 47kΩ
R_7 = 1MΩ variable

Miscellaneous

V_1 and V_2 = Type 3A5 or DCC90 (double triodes).
T_1 = Denco "Maxi-Q" Range 2 coil, Wearite PHF2, or similar type.
T_2 = Small output transformer, centre-tapped primary (R.M. Electric).
Crystal = Surplus P.O. Type PATT 2381A, 1Mc/s, see text.
L_1 = A few turns p.v.c. covered wire wound round T_1, V_1 and V_2
H.T. battery = Ever-Ready Type B126 (90V)
L.T. battery = Ever-Ready Type AD35 (1.5V)
S_1, S_2 = Single-pole on-off switches
S_3 = Double-pole on-off switch.

control of multivibrator frequency in the region of 100kc/s.

(iii) Filament consumption is reduced to a minimum by providing filament rather than h.t. switches in the audio oscillator and multivibrator sections, so that the filaments of these sections may be switched off when not in use.

(iv) The coil L_1 presents such a small reactance across the calibrator output terminals that there is very little extraneous pick-up by the wires connecting the receiver to the calibrator.

Layout and Construction.—The whole circuit and both batteries conveniently fit inside an "Oxo" tin, as shown in the illustrations.

Earth wires are all soldered directly to the tin, for convenience.

Screwing down the lid presented a slight problem; the metal was too thin to permit the use of self-tapping screws, so 6-BA nuts were soldered at suitable intervals inside the rim of the box. To prevent solder from running into the thread of the nut while soldering it into position, it was held on a 6-BA tap, the steel of which effectively resisted the flow of solder. (A match stick might serve equally well.)

Operation.—The instrument is tuned with the aid of the long-wave Light programme (200kc/s) by switching on both the crystal oscillator and multivibrator and making the necessary adjustments, first to the multivibrator lock control (R_7), and then to the crystal tuning control (C_1) so that, from a receiver tuned to the Light programme and at the same time picking up radiations from the calibrator, the signal amplitude remains quite steady.

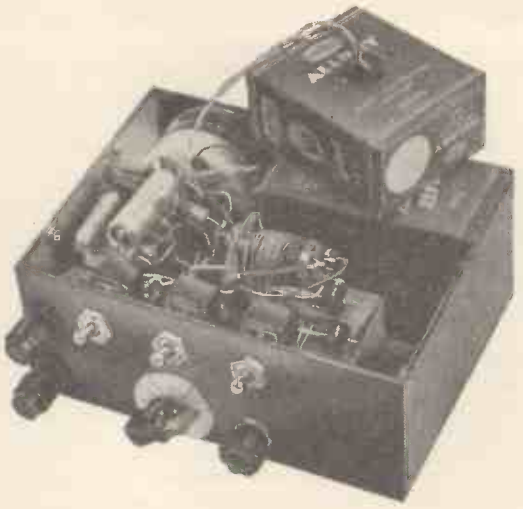
Fig. 4. Calibration of the multivibrator lock control, R_7.

A certain amount of "fiddling" with the coupling between the calibrator and the receiver aerial is needed to bring out the beats between the calibrator output and signal. In fact, it may not even be necessary to connect the calibrator output terminal to the receiver aerial at all—the metal of the calibrator box is thin enough to allow a certain amount of stray radiation. To limit direct radiation from the box the principle of the "common earth point" should be followed when wiring the circuit.

On switching on the audio oscillator, it may be found that the lock is slightly disturbed, for the depth of modulation of the h.t. to the multivibrator is very considerable; however, a small adjustment to the lock control is all that is required. When the multivibrator is locked to a sub-multiple of the crystal frequency (in this case, 1/10 of it)—the audio note in the receiver suddenly purifies itself.

The instrument is now radiating, m.c.w. or c.w. as desired with spot frequencies spaced at 100kc/s all the way up to 30Mc/s and further, and on m.c.w. there is no mistaking the characteristically baleful tone associated with each harmonic!

It will be noticed too that, very conveniently, the one-megacycle harmonics are much more pronounced than the intervening 100kc/s harmonics, so there is no confusion as to which spot frequency



Another view of the calibrator with the l.t. battery withdrawn and showing position of the valves below L_1.

the receiver to be calibrated is actually tuned. It is somewhat unlikely that the receiver calibration will be so far out as to leave doubt as to which megacycle harmonic is which.

Other Spot Frequencies.—In addition to its use as a calibrator the instrument, insofar as it is a source of constant amplitude at any one frequency, may be used to line up i.f. stages, etc.

With the object of providing a very much wider range of spot frequencies, the multivibrator lock control (pre-set, and adjustable by means of a screwdriver on the normal instrument) is brought out to a knob. The locking is so effective that there is literally no position of this control in which the multivibrator is not locked to one or other sub-harmonic of the crystal frequency. The lock control can therefore be calibrated as shown in Fig. 4.

TABLE

÷6	÷7	÷8	÷9	÷10	÷11
167	143	125	111	100	91
(333)	286	250	222	200	182
(500)	428	375	333	300	273
(667)	572	(500)	444	400	364
833	714	625	556	500	455
	857	750	667	600	546
		875	778	700	637
			889	800	728
				900	818
					909

The table indicates the subdivisions of a megacycle obtainable in this way. They are expressed in kc/s.

Once again, since the crystal harmonics stand out so well above the multivibrator harmonics, it is immediately possible, by simply counting the multivibrator harmonics, to know exactly to which multivibrator harmonic the receiver is tuned.

With the resistance values given in Fig. 3, the nearest frequencies to the standard i.f. obtainable are 455kc/s (÷11) or 500kc/s (÷10).

It is perhaps worth noting that, supposing the 41

sub-divisions are uniformly distributed (which of course they are not exactly), the calibrator would give spot frequencies separated by about 25kc/s and no signal would be removed by more than 0.5×25kc/s from one of the calibrator frequencies. This interval is just within the audio range and so, by judicious adjustment of the lock control, an audio beat can be produced with any signal to which the receiver is tuned, and hence, by roughly estimating its pitch, pin down the signal frequency to within, say, 1 or 2 kc/s.

Battery Consumption and the effect of Battery Ageing.—The h.t. consumption, even with all circuits working, is quite small (about 4.5mA.). The l.t. consumption per filament section is 0.11A (at 1.4V), so the drain on the l.t. battery depends very much on which circuits are in use. However, a calibrator is not the kind of instrument which is left on for long periods, and it will normally be months before the l.t. battery requires replacement, and even longer before the h.t. battery is worn out.

Decline in the supply voltage does not affect the frequency accuracy of the instrument at all (naturally enough), but it does alter slightly the calibration shown in Fig. 4. When the supply is greatly reduced, it is difficult to obtain a lock on m.c.w., though on c.w. the multivibrator stops working before it stops locking. These effects give all the indication needed that it is time to replace one or both of the batteries.

How Many M.U.F.s?

*By T. W. BENNINGTON**

FIVE DIFFERENT INTERPRETATIONS RECOMMENDED BY C.C.I.R.

A WELL-KNOWN adage which seems to be particularly applicable in radio technology is that "things are not always what they seem to be". Or should we render it "so simple as they seem to be", for that seems to be the case with the quantity known as the maximum usable frequency (m.u.f.), which is in common use in connection with high-frequency, long-distance transmission by way of the ionosphere.

The m.u.f. for a given distance along the ground is the frequency which corresponds to the critical frequency at vertical incidence, which is the highest frequency which will be reflected by a given layer, and above which the wave will penetrate the layer. Thus the m.u.f. for a given distance and layer may be loosely defined as the highest frequency which will be reflected from that layer at oblique incidence, so as to return to earth at that distance. But this is all very well, except that in practice there seem to be several different conceptions of what *is* the highest frequency to be effectively returned at a given distance, and, consequently, several different ideas as to what constitutes the m.u.f. The matter has become, in fact, so muddled and ambiguous that the C.C.I.R., in their recent assembly at Los Angeles, thought it well to attempt to clarify the situation by a recommendation on the "meaning of m.u.f.", in which they found it necessary to deal with no fewer than five different terms which have been, or might be, used, namely the "classical M.U.F.", the "standard M.U.F.", the "operational M.U.F.", the "theoretical M.U.F." and the "experimental M.U.F.".

In order to clarify our own minds we can, following the lead of the C.C.I.R., concentrate on the differences between the first three of these and dismiss the last two as being applicable only to the cases of particular calculations or experiments. Let us consider the situation for a particular ionospheric layer, for example, the F_2 layer, and for the "ordinary" component of the wave only.

With a given distribution of the ionisation with height in this layer we shall, by the vertical pulse-sounding technique, obtain a curve of virtual height with frequency (an h'-f curve) of a particular shape, as, for example, in Fig. 1(a). In this f_1 is the critical frequency, at which the wave penetrates the layer. The equivalent frequency/height parameters for any oblique angle are obtained by the use of what is known as the modified secant law, which governs radio-wave refraction in a curved medium where the refractive index decreases continuously with height. If we apply this to Fig. 1(a) for a distance of, say, 2,000km, then we obtain a curve of the form shown in Fig. 1(b). We notice that, for any frequency higher than f_2 there are not one, but two, virtual heights shown. Though f_2 has, in fact, been arbitrarily chosen, it is indicated in order to show that, with decreasing frequency, the upper of the two rays becomes, in practice, unobservable owing to absorption. But the two virtual heights shown for frequencies above f_2 do correspond to two separate rays, which will traverse different trajectories in covering the ground distance of 2,000km. The one which returns from the lower virtual height is the "low-

*Research Department, British Broadcasting Corporation.

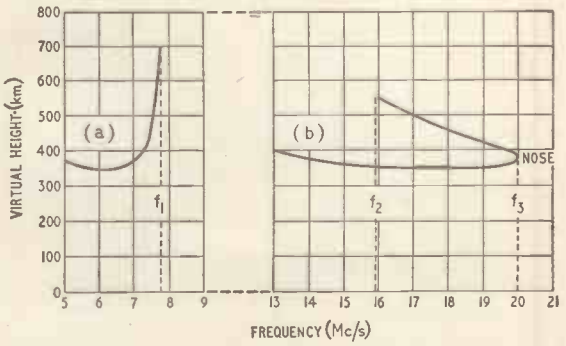


Fig. 1. Variation of virtual height with frequency (h'-f), F_2-layer, ordinary wave only; (a) for vertical incidence; (b) for transmission over a distance of 2,000km.

angle ray" and the other the "high-angle ray", and the situation is shown diagrammatically by the dashed lines in Fig. 2. But, with increasing frequency above f_2 the virtual height corresponding to the high angle ray gets nearer and nearer to that for the low angle ray, until at f_3 the two rays become one, and the situation is as shown by the full-line curve in Fig. 2. At f_3 then, on the "nose" of the curve, a single ray is returned, and on frequencies higher than this, no energy should be returned at all; f_3 is, therefore, the "classical M.U.F.".

All this, however, is something of a diversion (though perhaps a necessary one) from our main theme, which is to explain the reason for the existence of other m.u.f.'s than the classical one. In short-wave propagation work it is impracticable actually to calculate the oblique-incidence parameters from the observed vertical-incidence curves, for a large number of stations and for a mass of observations from each. A graphical method for determining the m.u.f. for any distance from the vertical incidence h'-f curves was long ago developed, but even more convenient in dealing with a large amount of data is that of using the standardised characteristics of the layers for any time and place in conjunction with a set of empirical "distance factors" which permit of calculation of the oblique-incidence m.u.f.'s for any distance from the vertical-incidence critical frequency. Both these methods give an approximation to the "classical M.U.F." of Fig. 1, and this practically determined value of m.u.f. is defined by the C.C.I.R. as the "standard M.U.F.".

Operational M.U.F.

But now we come to the real crux of the whole matter. It has long been found that, in practical communication, it is possible, particularly at certain seasons of year, times of day and in certain directions, to provide good service on frequencies considerably higher than the "classical M.U.F.". In other words the "operational M.U.F." (to use the C.C.I.R. definition) is often considerably higher than the "classical M.U.F.". Furthermore, unlike the "classical M.U.F.", which because it is determined by ionospheric refraction alone, does not vary with transmitted power, the "operational M.U.F." is power-dependent, increasing, within limits, with increasing power. The reasons for this increase in the operational above the "classical M.U.F." are not fully understood, but experiments indicate that usable signals are produced on these higher frequencies by scattering of the energy both

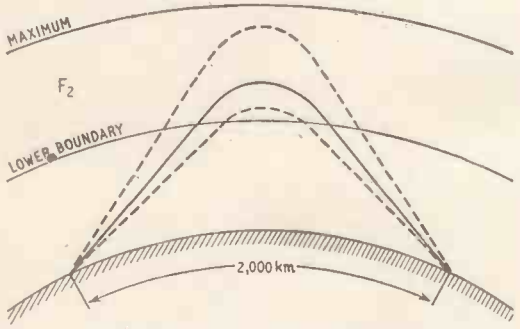


Fig. 2. Dashed-line curve shows high- and low-angle rays at 17Mc/s; full-line curve a single ray at 20Mc/s (see (b) Fig. 1).

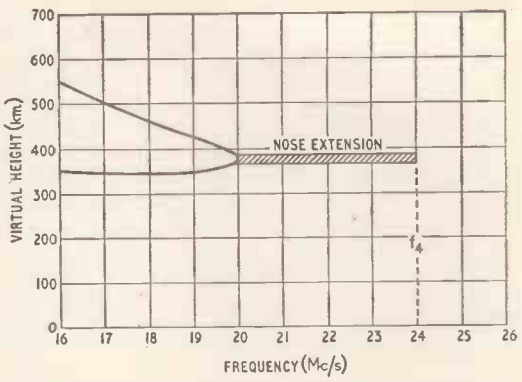


Fig. 3. Part of curve (b), Fig. 1, re-drawn and with a "nose extension" due to scattering and other processes, added for a 2,000-km transmission.

in the ionosphere and on the ground, by lateral deviation of the waves from the great-circle path, and possibly by some "bending" of the trajectories in the troposphere and lower ionosphere. The effect is to extend the nose of the oblique h'-f curve of Fig. 1(b) so that it becomes somewhat like Fig. 3, where f_4 is the "operational M.U.F.". The nose extension can extend to frequencies up to 25% above the "classical M.U.F.", but this extension varies, as has been said, for different seasons, times of day and circuits. It also varies, critically, for different types of service, for as the signals on frequencies above the "classical M.U.F." are due largely to scattering processes, they are unsuitable for services, like some types of high-speed telegraphy, which demand a highly coherent signal for their operation. It is interesting to note that sound broadcasting, which requires a higher signal-to-noise and signal-to-signal ratio than most other services, is less demanding in the matter of coherence of the signal than are the services just mentioned, and so has an "operational M.U.F." which is often well above the "classical M.U.F.".

Specifying M.U.F.

We see therefore that, whilst the classical and standard m.u.f.'s are capable of direct evaluation, the "operational M.U.F." is a more ambiguous quantity, and difficult to specify exactly. The C.C.I.R. has, in fact, left the matter of its specification fairly open, by recommending that "the ratio of the classical M.U.F. to the operational M.U.F. . . . should be determined by a combination of experience and theoretical studies".

There is one further point to bear in mind, so that we may be quite clear of what we are speaking. When we specify an m.u.f.—whether the classical, standard or operational—do we mean the instantaneous value observed at some time at the ionospheric point to which we are referring? If so we should state this fact, but if, as is the more usual case, we mean to specify a median value for some point we should use a clear expression like "the monthly median classical m.u.f." for a given month, time and place, or "the monthly median operational m.u.f. for the London/Johannesburg broadcast circuit" for a given month and time of day. In so doing we shall avoid ambiguity, and prevent the possibility of our specification being misconstrued.

Autumn Audio Fair

SELECTED NEW EQUIPMENT OF INTEREST

THE emphasis on tape recording in new developments was even greater at the Autumn Audio Fair than at other recent exhibitions of sound reproducing equipment.

The American Steelman transistor tape recorder is now being manufactured under licence in this country by Redifon. This recorder retains the capstan drive normal to a mains recorder, though d.c. bias and erase are used. Speeds of $1\frac{7}{8}$ and $3\frac{3}{4}$in/sec are provided, the response at the latter speed being given as from 150 to 7,500c/s. The output is 100mW. Thirteen Mallory RM-12R mercury cells are normally used.

A transistorized version (the L2/TA) of the well-known E.M.I. portable L2 tape recorder was also on show. An equalized playback stage with an output power of 70mW has been incorporated. The tape transport mechanism has also been improved: the wow and flutter is now less than 0.25% at $7\frac{1}{2}$in/sec. Since this instrument is designed for outside recording using new tape, no erase facilities are provided.

E.M.I. also showed their first domestic tape recorder (H.M.V. Type DSR1), a feature of which is the use of separate record and replay heads and amplifiers.

A new Simon recorder, the Minstrelle, incorporates the new Garrard deck and magazine. This recorder is very unusual in that it incorporates a built-in microphone. This is intended for speech recording and is mounted on foam rubber to reduce the effect of vibrations of the tape transport mechanism.

A four-track recorder has already been shown in this country by the Harting-Tandberg groups: two new models were shown at the Autumn Audio Fair by Telefunken and Recording Devices. The Telefunken 76K features a transistorized replay head amplifier and is for single-channel recording. On the other hand, the model shown by Recording Devices is for stereo and is essentially a 4-track version of the Stuzzi Tricorder (briefly described on p. 225 of our May, 1959, issue) with the amplifying equipment for the second stereo channel fitted in a separate cabinet. A stereo microphone comprising two moving-coil elements mounted at right angles to each other is available for use with this recorder.

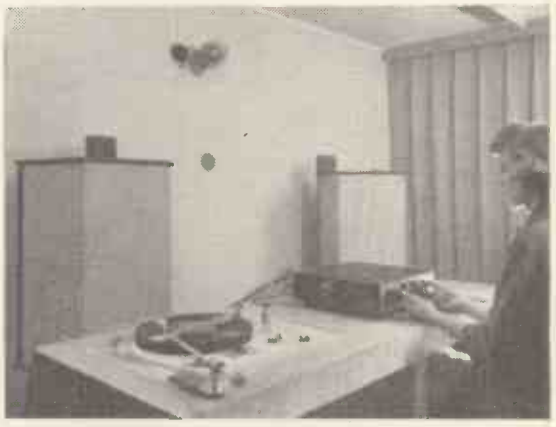
A recorder which can both record and replay stereophonically using the normal twin-track system was shown by Grundig (Model TK60).

Three-channel stereo tape recordings were demonstrated by Rank Cintel using the Ampex 300-3 recorder. Even when the final commercial stereo recording has only two channels, making the original master recording on three rather than two channels offers a number of advantages. The most important of these is that, when widely spaced microphones are used for recording, the "hole in the middle" fault can be readily avoided by using a third microphone in the middle to feed the third channel. Another advantage is that it is easier to adjust the balance between the soloist and orchestra after the recording has been made. This latter advantage also makes it easier to convert stereo to single-channel recordings, since these latter often require a different optimum balance between soloist and orchestra.

Tape suitable for the Ampex video recording system was shown by M.M.M. (Scotch Boy) and E.M.I. Since the direction of travel of the head gap relative to the tape is across its width in the Ampex system rather than along its length, the magnetic particles in such video tape are oriented across its width rather than along its length. Because of the high relative speed between the head and gap, wear and heating problems are important in the design of video tape. It must also be more free from drop outs than ordinary tape.

An inexpensive two-speed ($33\frac{1}{3}$ and 45 r.p.m.) transcription gramophone turntable was introduced by Connoisseur. The wow and flutter are stated to be 0.15% and 0.1% respectively, and the rumble −50dB referred to 7cm/sec at 1kc/s using the R.I.A.A. record playback characteristic. The turntable is driven at the outer, rather than the usual inner, edge.

The sandwich method of loudspeaker cone construction in which the two skins are made of heavier and stiffer material than the filling so as to give a considerable overall increase in the stiffness-to-weight ratio, and which was discussed by D. A. Barlow in our December, 1958, issue (p. 564), was adopted for an experimental bass loudspeaker demonstrated by Leak. A system of magnet design to be described by A. E. Falkus in *Wireless World* was used in two new loudspeakers shown by Fane Acoustics. One of these was a 15-in bass unit with a 3-in-diameter voice coil, a fundamental resonance between 20 and 25c/s, and a 310,000-line magnet field. The other was a 5-in unit which forms the first of a range of speakers to be marketed by this company for set manufacturers.



Over 50% of the production time of Beam-Echo (Avantic) equipment is devoted to testing. The photograph shows the final listening test on an SPA21 stereophonic combined pre-amplifier and 2 x 12-watt amplifier being performed in a near acoustically dead room.

WORLD OF WIRELESS

B.(?)R.E.M.A.

SPEAKING at the annual dinner of the Radio and Electronics Industry (R.I.C. and E.E.A.) on November 18th, E. E. Rosen, chairman of the R.I.C., disclosed that the Registrar of the special court charged with the enforcement of the Restrictive Practices Act had notified the British Radio Equipment Manufacturers' Association that the British Content clause in the conditions of membership of the Association was considered to be an infringement of the Act.

Mr. Rosen pointed out that the purpose of the clause, which, since 1926, has been basic to the constitution of the Association, was to limit by specification the amount of foreign content of labour and material, because there is no mandatory definition which describes what is meant by British Content. He concluded, "Each one of our associations is proud of its British heritage, and B.R.E.M.A. has unanimously decided to contest the Registrar's contention. . . . I am sure it was never the intention that merely being British would be an infringement."

Servicing Exams.

THE highest failure rate since the examination was introduced in 1944 is recorded by the Radio Trades Examination Board in announcing the results of the 1959 servicing examinations. Of the 1,869 entrants for the sound radio examination 1,009 failed, 547 passed and 291 have to retake the practical test.

For the first time the practical test was carried out on the "Trainer-Tester" system and, in the opinion of the Board, proved to be a very satisfactory form of testing fault diagnosis. This system employs a pictorial layout of a receiver, a circuit diagram with component values and a series of fault sheets. Possibly the greatest advantage of the scheme is the uniformity of testing.

A soldering test has always been regarded as an important part of the practical examination for a servicing certificate; in fact, candidates failing in the soldering test have in the past been failed in the whole practical examination. As the new "practical test" is entirely paper work a more elaborate soldering and wiring test has been introduced.

Of the 485 entrants for the Television Servicing Certificate, 209 qualified, 94 have to retake the practical test and 106 failed. The "Trainer-Tester" scheme was not used for the TV exam.

Entries for the 1960 examinations, which will be held in May and June, must be received by the Board, 9 Bedford Square, London, W.C.1, not later than January 15th (television) or February 1st (sound radio).

Next year's examinations will probably be the last in which sound and television are separated. If present plans of the R.T.E.B. materialize future exams. will be taken in two stages. An intermediate examination will be taken at the end of a three years' course which will include television servicing at 3rd-year level, and success in this will be necessary before a candidate can take the final examination and secure the Board's certificate.

Conference on Computers

AT the second "Open Day" held on November 11th at the premises of I.C.T. Ltd., and organized by the Electronic Forum for Industry (E.F.F.I.) to bring together representatives of the suppliers and users of electronic equipment, most of the discussion centred on the applications of computers. C. Metcalfe, C.B.E. (E.M.I.), in opening the proceedings, emphasized the vital necessity of speed in adopting new ideas and methods if the alliance between electronics and industry was to be effective in meeting foreign competition. Early contact between suppliers and potential users was essential so that they could come to a working agreement to think in parallel during the development stage.

Following the showing of three documentary films on computer applications a panel consisting of E. R. Davies (English Electric); S. Gill (Ferranti); J. C. Gladman (A.E.I.); N. D. Hill (E.M.I.); R. L. Michaelson (Elliott Bros.) and L. Lightstone (I.C.T.) ably dealt with searching questions put by representatives of organizations interested in such diverse products as chemicals, footware, food, motor cars, cement and bright steel bars.

The third "Open Day" has been arranged at Olympia during the I.E.A. Exhibition in May and will take as its theme "The Satisfied User".

Servicemen's Pay

INCREASES in the basic rates of pay for servicemen come into operation on January 4th, as a result of an agreement between the R.T.R.A. and the Association of Radio and Electronic Engineers. The increases vary from 5s per week for a 17-year-old apprentice to £1 8s 8d per week for a London holder of the R.T.E.B. Television Servicing Certificate. Similar agreements have already been signed between the A.R.E.E. and the Scottish and Northern Ireland radio retailers' associations.

The figures quoted below are the minimum rates of pay for a 44-hour week (reduced from 46 hours) for servicemen over 21 years old, with the London rate in brackets.

	£	s	d		£	s	d
Servicemen who have served a 5-years' apprenticeship	11	7	4	(	11	16	6)
Holders of R.T.E.B. radio servicing certificate with 5 years' apprenticeship	12	7	6	(	12	16	8)
Holders of R.T.E.B. television servicing certificate with 5 years' apprenticeship	13	7	8	(	13	18	8)
Semi-skilled persons doing general installation and maintenance	9	7	0	(	9	14	4)

The rates of pay for apprentices range from £3 per week at 16 to £7 10s at 20. In addition, those entitled to the R.T.E.B. Radio Service Certificate will receive an additional 10s a week and those entitled to the Television Servicing Certificate a further £1. The secretary of the Association of Radio and Electronic Engineers is W. Criddle, 17 Tottenham Court Road, London, W.1.

V.A.S.C.A.

A NEW U.K. valve manufacturers' association has been formed under the title Electronic Valve and Semi-Conductor Manufacturers' Association

(V.A.S.C.A. for short). It is taking over from the British Radio Valve Manufacturers' Association (B.V.A.) its responsibilities for semiconductors and industrial valves and tubes. The B.V.A. will continue its separate interest in domestic valves and television tubes. The five founder-member firms of the Association are English Electric Valve Co., M.O. Valve Co./G.E.C., Mullard, Siemens Ediswan/B.T.H., and S.T.C.

The chairman of V.A.S.C.A. is G. A. Marriott (G.E.C.) and the secretary *pro tem* is W. R. West (secretary of B.V.A., 16, Jermyn Street, London, S.W.1).

Freeing Imports.—The recently announced removal of most of the controls on imports from the dollar area, Western Europe and many other countries—excluding Japan and the Soviet bloc—is of special interest to the radio and electronics industry. It would appear from the "negative list" included in the Board of Trade's Notice to Importers No. 920 that all radio and electronic apparatus (excluding transistors and parts thereof) and scientific instruments can now be imported from these areas without restriction. This removal of import controls does not affect the import tariffs.

Receiver Sales.—Figures for the despatch by manufacturers to the home trade of sound receivers in September were the highest on record, and those for television receivers the highest for any September. Sound receivers (including car sets) totalled 179,000 and television sets 345,000, bringing the respective totals for the nine months to 1.099M and 1.775M. These totals show increases of 20% and 64% respectively on the corresponding period last year. Radiogramophone despatches totalling 116,000 for the nine months were 3% down on the same period last year.

Radio Show 1960.—The 27th National Radio and Television Exhibition is to be held at Earls Court, London, from August 24th to September 3rd with a pre-view on the 23rd for overseas visitors and invited guests. It is being organized by Radio Industry Exhibitions Ltd., 49 Russell Square, London, W.C.1.

A.P.A.E. Exhibition.—The Association of Public Address Engineers is re-introducing its exhibition next year. It will be held at the King's Head Hotel, Harrow-on-the-Hill, Middx., on March 9th and will be open from 11.30 to 1.0 for members and the Press, 2.0 to 5.0 the trade, and 5.0 to 7.30 the public. Details are available from Alex J. Walker, honorary secretary, 394 Northolt Road, South Harrow, Middx.

P.M.G.'s Presentation.—Rarely, if ever before, has a recipient of the P.M.G.'s Certificate of Proficiency received his "ticket" at the hand of the Postmaster-General. At a ceremony at the Baltic Exchange, London, on November 4th to mark the 50th anniversary of the opening of the Post Office Coast Radio Service, the most recently qualified radio officer, P. N. Baker, received his second-class certificate from Mr. Bevins. Philip Baker is an eighteen-year-old student from Norwood Technical College who operates an amateur station under the call G3NPQ.

Printed Circuits.—A course of six lectures will be given on successive Tuesday evenings by P. G. L. Vivian, head of the chemistry department of Ultra Electric, at the Norwood Technical College, Knight's Hill, London, S.E.27, from January 12th. Fee 10s.

Transistor circuit techniques will be covered in a course of ten lectures to be given at the Medway College of Technology, Chatham, Kent, on Tuesday evenings, beginning January 19th.

"Words, Words, Words"—a correction. In lines 8 and 14 of the right-hand column of page 485 of the November issue, "transistor" should read "thermistor." It is regretted that this aberration passed unnoticed.

Vacuum Science.—The Joint British Committee for Vacuum Science and Technology consisting of representatives of ten societies and institutions has been formed as a result of last April's conference on high vacua sponsored by the Institute of Physics. Its objects are to co-ordinate and help to initiate meetings in the whole field of vacuum science and technology and to act in the collective interest of the constituent bodies by maintaining liaison with the International Organization for Vacuum Science and Technology and with vacuum societies of other countries. The Institute of Physics, 47 Belgrave Square, London, S.W.1, is providing the secretariat.

Relay Services Association.—The number of subscribers to television relay services in this country is increasing by about 100,000 a year. The figure at the end of December, 1958, quoted in the annual report of the Relay Services Association was 196,165, compared with 108,019 for the year before, but at the Association's annual luncheon on November 10th it was announced that the number is now approaching 300,000. The Association represents 95% of the relay services in this country, to which the total number of subscribers—both sound and TV—is over a million.

Brit.I.R.E. Council.—Professor E. E. Zepler, who occupies the chair in electronics at University College, Southampton, has been re-elected president of the British Institution of Radio Engineers. It is his second term of office. The following members have been elected to the council: Air Marshal Sir Raymund Hart (chairman of the Radio Industry Council), Ieuan Maddock (Atomic Weapons Research Establishment), E. K. Cole (Ekco), D. L. Leete (Manchester University) and Sqn. Ldr. W. L. Price (R.A.F., Technical College, Henlow). Dr. A. D. Booth (Birkbeck College, Computational Laboratory) and A. H. Whiteley (Whiteley Electrical) have been re-elected to the Council.

R.S.G.B.—An increase in membership for the third successive year is recorded in the annual report of the Radio Society of Great Britain. The year's increase of 445 brought the total to 9,540 on June 30th. The number of licensed transmitting members increased by 451, making a total of 6,349. The report records that 66% of the 8,463 holders of U.K. Amateur (Sound) Licences in force on June 30th were members of the Society. The number of amateur television transmitting licences in force at that date was 93. A total of 142 societies are affiliated with the R.S.G.B.

Colour Television will be the subject of this year's Christmas Holiday Lecture for secondary school children to be given by G. G. Gouriet. It will be delivered in the Institution's Lecture Theatre, Savoy Place, London, W.C.2, at 3.0 on December 30th and repeated on the following day at the same time. Admission is free but tickets must be obtained from the Institution.

For E. & R.E. read E.T.—With its January issue our sister journal *Electronic & Radio Engineer* changes its title to *Electronic Technology*.

Publication Dates

We apologize to our readers for the inconvenience they may have suffered as a result of our recent delays in publication. These have been due entirely to difficulties arising in the aftermath of the dispute in the printing industry. We are sorry for the irritation this may have caused, and are hoping to produce the next issue of "WIRELESS WORLD" within only a few days of our normal publication date, and to be back to normal by the appearance of the February issue.

If, for any reason, any recent issues have not been obtainable through the normal Trade channels, we would remind our readers that copies to complete their files are available by post from the Publishers.

Personalities

R. Ferguson, O.B.E., general manager since 1947 of the Marconi International Marine Communication Company, which he joined in 1910, has been elected to the board and becomes managing director. In 1919, after service in the Royal Flying Corps, he joined the newly formed Radio Communication Company, and was general manager of that company when, in 1928, the British Wireless Marine Service was formed as the joint service organization of the Marconi Marine and Radio Communication Companies. Mr. Ferguson then became manager of the new organization, and was appointed joint general manager of the Marconi International Marine Communication Company and its subsidiaries in 1929. For ten years from 1934 he was seconded to the Egyptian State Broadcasting as general manager. Mr. Ferguson began his career as a sea-going radio officer and in January, 1911, was granted the P.M.G.'s certificate for wireless proficiency. This he lost when the *Empress of Ireland*, of which he was chief wireless operator, sank in the St. Lawrence in May, 1914. At a ceremony on November 4th to mark the 50th anniversary of the Post Office Coast Radio Service, the Postmaster-General presented Mr. Ferguson with a framed copy of his original certificate.

R. FERGUSON

D. P. FURNEAUX

D. P. Furneaux, M.A., B.Sc., who joined the Marconi organization in 1953 and for the past four years has been a management executive of the company, succeeds Mr. Ferguson as general manager. After taking an honours degree in natural science at Trinity College, Cambridge, he served in the Royal Air Force Technical Branch during World War II. Demobilized in 1946 with the rank of Wing Commander, he held commercial appointments in South Africa before returning to England in 1950 to join the staff at Sheffield University.

F. N. Sutherland, C.B.E., M.A., M.I.E.E., managing director of Marconi's Wireless Telegraph Co., has been elected to the board of Marconi Marine.

John Keir, who joined Marconi's sea-going staff in 1915, is appointed personal assistant to the managing director of Marconi Marine. For some years he was managing director of the associated company, Companhia Marconi Brasileira.

JOHN KEIR

O. W. Humphreys, C.B.E., B.Sc., M.I.E.E., F.Inst.P., director of the Research Laboratories of the General Electric Co. since 1951, and a member of the board of the G.E.C. since 1953, has been appointed Director for Research and Technical Development. He graduated with honours in physics at University College, London, in 1925 and joined the staff of the Laboratories in 1927. He was appointed manager of the Laboratories ten years ago. Mr. Humphreys is chairman of the D.S.I.R. Radio Research Board; chairman of the International Special Committee on Radio Interference (C.I.S.P.R.); chairman of the Postmaster-General's Advisory Committees on the control of radio interference from industrial, scientific and medical equipment and from ignition systems; and chairman of the Guided Weapons Committee of the Society of British Aircraft Constructors.

O. W. HUMPHREYS

L. G. A. Sims, D.Sc., Ph.D., M.I.E.E., who has become professor of electrical engineering at the University of Southampton, had been senior lecturer in the Electrical Engineering Department since 1952. He graduated with first class honours and a Bowen Research Scholarship at the University of Birmingham in 1924. After a period at the G.E.C. Research Laboratories he joined the staff of Birmingham University and founded the electronics laboratory. Professor Sims was head of the Electrical Engineering Department of the Northampton Polytechnic, London, from 1936 to 1939 and has also held senior teaching appointments at the Royal Naval College, Greenwich, and the Royal Aircraft Establishment, Farnborough.

J. C. Simmonds, M.Sc.(Eng.), Ph.D., M.I.E.E., managing director of Airmec, Ltd., has been appointed managing director of British Communications Corporation Ltd., and of Radio & Television Trust Ltd., of which Airmec is a subsidiary. Dr. Simmonds, who is 46, joined Airmec in 1946. For the previous nine years he was a development engineer in the Radio Branch of the Post Office Engineering Department.

P. M. Thompson, co-author of the article on page 530 emigrated to Canada in 1950 at the age of 24 and until recently was in the transistor section of the Electronics Laboratory of the Canadian Defence Research Telecommunications Establishment, where the work he describes was carried out. He has recently joined the Plessey organization. Mr. Thompson took the natural science tripos at Cambridge and after a short while at A.T. & E., Liverpool, returned to the Cavendish Laboratory. For a few years before going to Canada he was with Salford Electrical Instruments.

J. Bateson, who, with P. M. Thompson, writes on the switching speed of transistors in this issue, went to Canada in 1948 after leaving the Signals Branch of the R.A.F. He was until recently in the Radio Propagation Laboratory of the Canadian Defence Research Telecommunications Establishment and is now teaching at the Eastern Ontario Institute of Technology, Ottawa. He is 39.

Sqn. Ldr. G. de Visme, B.Sc., contributor of the article on page 534 on a battery-fed crystal calibrator, graduated in 1942 and ten years later received the diploma in electronics from Southampton University. He was for two years in the G.E.C. Research Laboratories and since 1950 has been in the Education Branch of the R.A.F.

J. F. Coales, O.B.E., M.A., M.I.E.E., F.Inst.P., reader in control engineering at Cambridge University, has been elected a member of the executive council of the International Federation of Automatic Control. He is the only U.K. member. After graduating at Cambridge he joined the Admiralty scientific service in 1929 and from 1940 to 1946 was in charge of the development of naval gunnery radar. In 1946 he joined Elliott Brothers as research director. Six years later he returned to Cambridge University to take charge of post-graduate studies in control engineering.

Wing Cdr. E. W. Anderson, O.B.E., D.F.C., A.F.C., has succeeded **Capt. F. J. Wylie** as president of the Institute of Navigation. He was a schoolmaster for some time before joining the R.A.F. in 1940. For his navigation of the *Aries* on her pioneer polar flights he received the A.F.C. He left the R.A.F. in 1954 as its senior navigator and went to Elliott Brothers but is now with the Sperry Gyroscope Company at their new factory at Bracknell.

Dr. J. C. SIMMONDS
(See opposite page)

Wing. Cdr. E. W. ANDERSON

P. J. Farmer, A.F.R.Ae.S., has been appointed editor of our associate journal *Data Processing* of which he has been acting editor since its introduction at the beginning of the year. He joined our publishers, Iliffe and Sons, in 1954 and in 1957 was appointed assistant editor of *Aircraft Production*. Before joining Iliffe he was engaged in structural design of guided missiles and was associated with the design of the Seaslug and the Firestreak anti-aircraft weapons.

D. E. D. Hickman, who discusses Wien bridge oscillators in this issue, served for five years as an air wireless fitter in the R.A.F. and on demobilization went to the Decca Navigator Co. Since August, 1958, he has been with Solartron Research and Development Laboratories where he is at present engaged on the design of electronic equipment for a digital tape recording machine.

K. R. Simmonds, B.Sc.(Eng.), A.M.I.E.E., has been appointed general manager of the International Rectifier Co. (Gt. Britain) Ltd., of Oxted, Surrey. For the past two years he has been general manager (marketing) of Texas Instruments Ltd., and was previously with Elliott Bros. (London) Ltd., whom he joined in 1948, and was for some time manager of their radar division at Rochester.

K. R. SIMMONDS

G. W. A. Dummer, M.B.E., M.I.E.E., who writes on the miniaturization of components on page 545, joined the Telecommunications Research Establishment (now the Royal Radar Establishment) in 1939 and was associated with the design of the first p.p.i. used in radar. He was at one time in charge of a group designing synthetic radar trainers and later became responsible for component development and panclimatic testing. More recently he has been doing fundamental work on printed and potted circuit techniques and is now in charge of a component development division.

W. H. Clarke, manager of the Studio Recording Division of RCA Great Britain Ltd., has been elected a director of the company with which he has been associated for over 27 years.

OBITUARY

H. W. Allen, who joined the Marconi Company as its first secretary on its formation in July 1897 as the Wireless Telegraph and Signal Company, died on October 7th at the age of 89. He claimed the unique distinction of being the first person to enter the wireless industry. Mr. Allen held various positions in the Marconi group and on the formation of the Imperial and International Communications Co. (now Cable and Wireless) was appointed general manager. He retired in 1930 and resided in Cape Town from 1947 until July this year when he returned to this country.

Dr. J. Zenneck, the German physicist who propounded the theory of groundwave (sometimes called the Zenneck wave) propagation and the effects of the ground on polarization and absorption, died recently at the age of 88. He began his career as a physicist when in 1895 he became assistant to his former teacher, Professor F. Braun, the cathode-ray tube pioneer. Dr. Zenneck, who was at one time editor of *Hochfrequenztechnik und Elektroakustik*, initiated ionospheric research in Germany and set up its first ionospheric research station in Kochel, Bavaria.

News from the Industry

Redifon are supplying a series of single-sideband h.f. transmitters (Type G423) and associated receivers (Type R403) for four Post Office coast radio stations—Land's End, Niton, North Foreland and Anglesey. Redifon are also supplying f.m./a.m. radio-telephone equipment for the Peninsular and Orient S.N. Co.'s fleet of passenger and passenger-cargo liners, the company's London terminal and at Tilbury Docks—a total of 31 installations.

Decca are supplying two high-power radars (TM909 and D808) for the recently launched Orient liner, *Oriana*. The two radars will be installed in the wheelhouse with a slave display in the chart room. The total number of ships for which orders for radar have been received by Decca now exceeds 9,000. Decca state that they have equipped approximately half the world's radar-fitted ships.

The B.B.C. has ordered from Marconi's two 100-kW short-wave transmitters to replace two at Daventry used for its External Services. To facilitate a changeover from one frequency to another each transmitter has two independent r.f. amplifiers with a common modulator. By tuning the standby amplifier to the new frequency the changeover can be carried out in a matter of seconds.

Ampex Electronics Ltd., which earlier this year established a factory in Reading, Berks., to produce Ampex equipment in this country, is now making the FR-100 series tape handler—a multi-channel analogue recorder for laboratory and industrial use. The marketing in this country of this British-made equipment and also certain Ampex products manufactured in the U.S.A. is being undertaken by a recently established associate company, Redwood City Engineering Ltd., also at Reading.

Sony Corporation, the Japanese radio receiver manufacturers, have announced that they are setting up an Irish company—Sony Ltd.—to assemble transistor sets in a factory at Shannon airport.

Marconi's have concluded an agreement with the Government of India for the manufacture under licence in India of Marconi v.h.f. multi-channel radio terminals and repeaters, and ancillary equipment. Marconi's are to supply all necessary technical assistance for indigenous manufacture.

Continental Distributors Ltd., of 121 Earls Court Road, London, S.W.5, have been appointed agents for the Nuclear Chicago Corporation, of the U.S.A. They will handle the Corporation's nucleonic measuring equipment and laboratory counting systems and in the New Year will be able to offer servicing facilities.

"Designing for Diecasting" is the title of a 32-page booklet issued by Fry's Diecastings Ltd., of Merton Works, Prince George's Road, London, S.W.19, for the benefit of designers and manufacturers of equipment. It is one of a series of technical booklets issued by Fry's and covers the basic principles of the diecasting process.

R.E.E. Telecommunications Ltd., of Crewkerne, Somerset, manufacturers of "Telecomm" v.h.f. radiotelephones, have made arrangements for installing and servicing facilities at fourteen centres throughout the country.

Marconi Marine.—Among recent installations of communication and navigational equipment undertaken by Marconi Marine are those in the new cargo liners *Indian Industry* and *Cheshire* and the Grimsby trawler *Ogano.*

Nash & Thompson Ltd., of Chessington, Surrey, have appointed A. R. Bolton & Co., 3a St. Vincent Street, Edinburgh 3 (Tel.: Caledonia 2065) as their sole agents for Scotland.

Philips Electrical Ltd. have opened new and enlarged headquarters for their south-western region at 51 Victoria Street, Bristol (Tel.: 93311). The four-storey building houses offices, stores, showroom and a hearing-aid centre.

Hazeltine Research Corporation, a research subsidiary of Hazeltine Corporation, of New York, is opening a new research and development centre in Plainview, Long Island.

Scope Laboratories, of Australia, manufacturers of the Superspeed soldering irons marketed in the U.K. by Enthoven Solders, and of electronic welding timers, etc., have moved to a new factory at Bulla Road, Airport West, Melbourne.

EXPORT NEWS

Belgium.—An IBM 610 automatic decimal point computer has been installed for the Faculty of Science at Ghent University. It will be used for scientific and engineering work, and in particular for solving problems connected with nuclear physics, astronomy and astrophysics.

West Africa.—Domestic sound and television equipment manufactured by Pye, Ekco, Garrard and Grampian is included in the selection of over 300 consumer goods for the display sponsored by the Design Centre which has been shown in Accra, Ghana, during November, and will be seen in Lagos, Nigeria, from January 11th to 23rd.

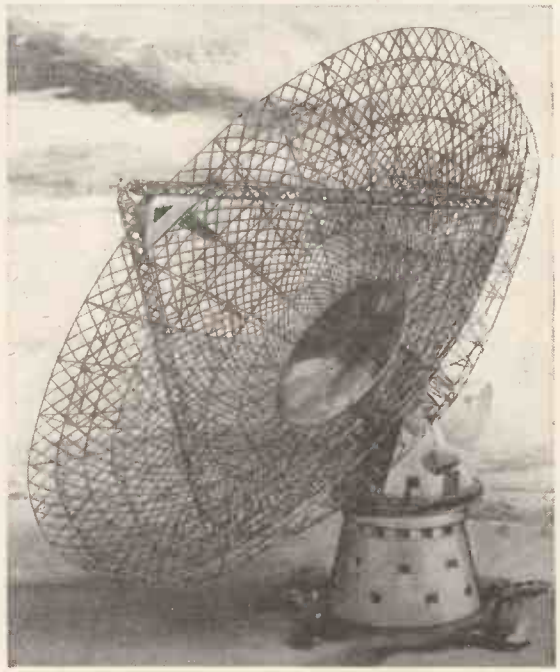
U.S.S.R.—A three-man delegation from the Scientific Instrument Manufacturers' Association visited the Soviet Union in the middle of November to explore the possibilities for an exhibition of British scientific instruments (with lectures and demonstrations) in Moscow in the second half of next year. The delegation consisted of H. D. Binyon (Solartron), F. Hamill (Hilger and Watts) and K. A. Macdonald (Unicam Instruments).

U.S.A.—The Audio Manufacturers' Group of B.R.E.M.A. is organizing a composite exhibit of audio equipment for the British Exhibition to be held in New York next June. The chairman of the group is Major J. F. E. Clarke (Clarke and Smith Manufacturing Co.), the vice-chairman D. A. Lyons (Trix) and the secretary S. E. Allchurch, 49 Russell Square, London, W.C.1.

Middle East.—The Advisory Council on Middle East Trade set up by the President of the Board of Trade in February last year to advise the Government on problems concerning trade in that area, has issued a booklet "Exporting to the Middle East." It outlines the importance of the Middle East markets, the past achievements of British industry there and what the region offers today.

Bulgaria's first television station, which opened in Sofia on November 7th, was designed and built by Pye, Ltd. Equipment supplied includes transmitters, aerial, studio and control equipment, film scanning equipment and an outside broadcast unit.

Switzerland.—Equipment manufactured by Electronic Instruments Ltd. has been included in the special survey trolley designed by the Health Physics Group of C.E.R.N., for use at the Nuclear Research Centre, Geneva.



A.E.I. Electronic Apparatus Division has developed the servo system for the control of the 210-foot radio-telescope to be erected in Australia. We reproduce an artist's conception of the telescope, which is to be built by a German firm for the Commonwealth Scientific and Industrial Research Organization at Parkes, N.S.W. In addition to the servo control equipment, A.E.I. is also supplying the intercommunication system between the master station and its eleven out-stations and some of the electrical gear.

By

G. W. A. DUMMER*

M.B.E., M.I.E.E., M.I.R.E.

Miniaturization and Micro-Miniaturization

NEW TECHNIQUES OFFERING INCREASED RELIABILITY

EXTREME miniaturization (micro-miniaturization) has been made possible by the changeover from valve to transistor circuits and is being increasingly emphasized by new developments in solid-state physics. The two main reasons for developing these techniques are (1) a significant reduction in size and weight, and (2) the possibility of increased reliability. It is this second point which may contain the real value of micro-miniaturization techniques, particularly from the military point of view. The present average failure rate for normal components under laboratory conditions is about five failures per thousand per year. Failure rates are many times higher in Service equipment, depending greatly on environmental conditions.

The effective packaging efficiency of components in sub-miniature equipments is still quite low, mainly because of cooling requirements and the necessity for providing withdrawal space for units or accessibility space for repair. Even in an i.f. "strip" the ratio is about three parts air to one part electronics, i.e., component packaging efficiency is about 25%. The fundamental point is, however, that with present shapes of sub-miniature components it is not possible to pack more components into a given space because of difficulties in soldering them in (even with miniature soldering irons) whilst providing adequate accessibility for repair. The limit of miniaturization has, therefore, been reached. The next logical step in development is to use components in which the actual working element only is used.

In any typical tubular component most of the available volume is taken up by material which plays no part in its electrical performance. In a cracked-carbon resistor the active carbon-film element has a volume of approximately 1/500th of the total component volume. Similarly, in a ceramic capacitor about 1/250th of the volume is effective, the remainder consisting of ceramic tube, case and connections. The heat dissipation of the cylindrical shape component is inefficient because of the low surface-area/volume ratio and an increase in power loading (or a reduction in effective size) could be made by opening out the cylinder and its leads into flat strips, provided that sound connections to the films are made. The comparatively large end connections on tubular components could thus be obviated and to a certain extent individual component-protection techniques may be reduced and the unit protected as a whole.

The miniaturization problem is, of course, aided by the low voltage-rating requirements of transistor

* Royal Radar Establishment.

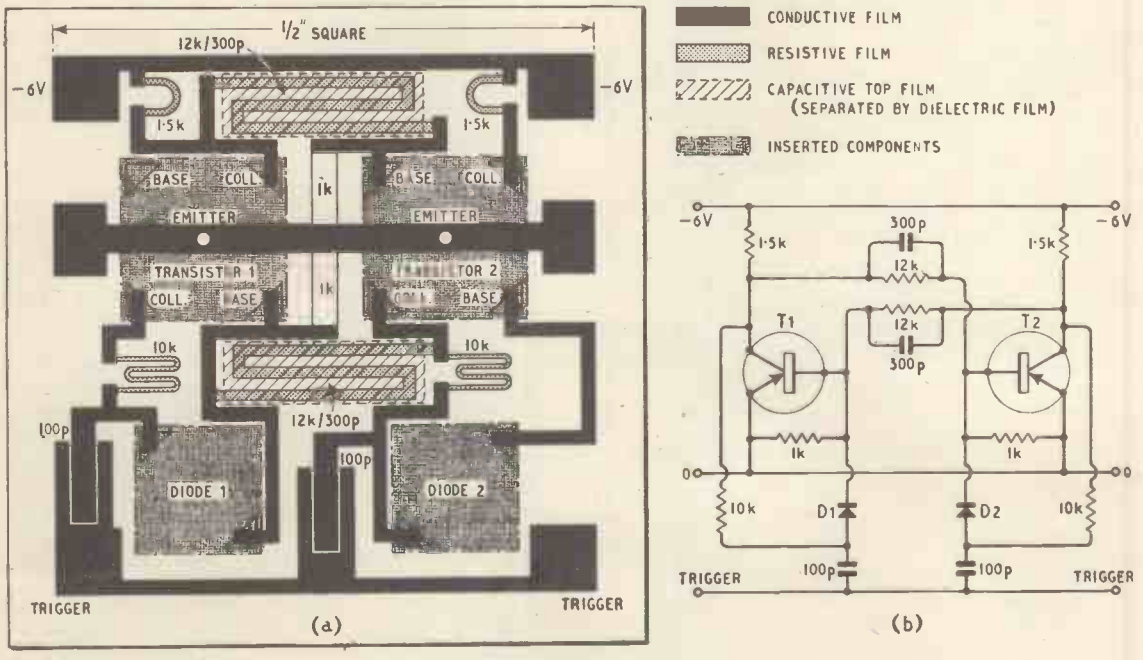


Fig. 1. Proposed layout (a) and (b) theoretical circuit diagram of binary-counter stage of flat-film form.

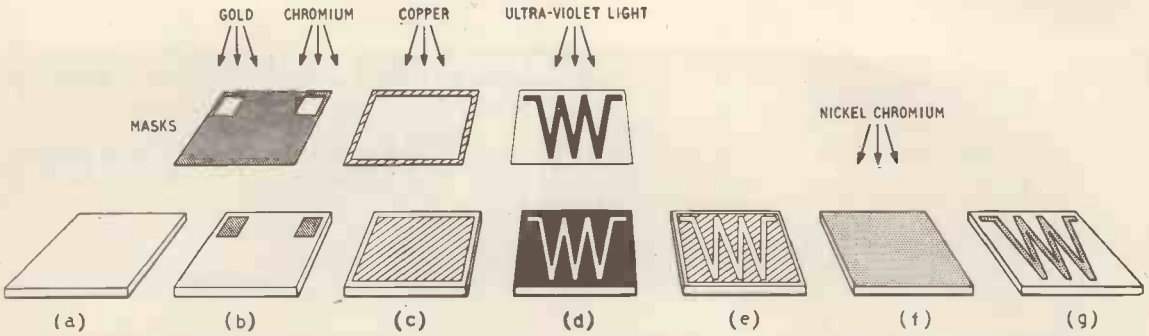


Fig. 2. Stages in production of high-definition film-type resistors with terminals. (a) Substrate is cleaned. (b) Gold/chromium laminated terminals are deposited by evaporation through mask. (c) Temporary copper coating is vaporized onto plate. (d) Plate coated with light-sensitive resist is exposed to ultra-violet light through a mask to render exposed resist insoluble. (e) Unexposed resist is washed away and exposed copper removed by etching. (f) Overall Nichrome coating is deposited by evaporation process and component is annealed at 350°C. (g) Remaining copper is removed by selective etching, leaving only desired meandered nickel-chromium resistor pattern. Steps (b) (e) and (f) are carried out at pressure equivalent to 10^{-4}mm of mercury.

components. Because of these low operating voltages and the low power ratings, it now becomes possible to design components using extremely thin films of resistive, dielectric, magnetic, conductive or semiconducting materials. For instance, resistors can be made by

(1) evaporation of metal alloys such as Nichrome, with end connections of evaporated nickel,
(2) platinum-gold alloy, chemically deposited and subsequently fired, with soldered end connections, or
(3) in tin-antimony oxide with evaporated metal end connections.

All of these show remarkably high potential reliability but some will need more evaluation. In the majority of transistor circuits high values of resistance are not required and 100 kΩ is regarded as a reasonable maximum for most circuit applications. For low-voltage, high-value capacitors, four possibilities exist, namely,

(1) thin plates of high-permittivity ceramic—possibly multilayer,
(2) thin plastics films such as polystyrene, etc.,
(3) anodic films such as tantalum or aluminium oxide, and
(4) evaporated metal-oxide films of many types—e.g., silicon monoxide, alumina, etc.

Magnetic materials are also available as

(1) thin films rolled from powder alloys,
(2) films electro-deposited from alloys, and
(3) films evaporated from alloys.

The three circuit elements of resistance, inductance and capacitance are, therefore, available in film form and the problem is how to use them in conjunction with the transistor itself. An important point is that careful process control during evaporation plays an essential part in forming these films. As with the transistor where very pure materials are essential, the use of accurate process control means higher reliability.

TABLE

Construction	Packing Density (Components per cu. ft.)	Estimated Reliability (Failures/1000hrs)
Pre-war ..	1,000	1.0%
Miniature ..	5,000	0.5%
Subminiature	50,000	0.1%
Micro-module	600,000	0.01%
Circuit plate ..	2,500,000	0.01%
Solid circuit ..	50-100 million	Negligible

It has become common to quote packing densities per cubic foot, and although these figures become somewhat meaningless at the higher packing rates, they are nevertheless used as a method of comparison, and the table shows the comparison rates between packing density and estimated reliability. It should be stressed that this is *estimated* reliability only, as a considerable time will have to elapse before these reliability estimates can be proved.

Assembly Techniques

There are four possible methods of assembly for micro-circuits; these are summarized below:—

1. *Component-assembly or Micro-module System*—single or multiple components on plates, stacked and connected by riser wires.
2. *Circuit Assemblies*—single complete circuit function on a plate.
3. *Solid Assemblies*—true solid circuits consisting of single crystals with controlled resistivity areas, etc.
4. *Sealed Assemblies*—Micro-miniature components sealed in subminiature valve cases.

Micro-module System.—This system is now reasonably well known in Great Britain. Its main advantage is that components can be tested individually before final assembly. The concept hinges around a module 0.31 in square. This is very similar, in principle, to the well known "Tinker Toy" construction. It consists of ceramic plates on which are deposited the various flat circuit elements, including transistors and diodes, mounted one above the other and connected together by riser wires terminating in oversize end plates. The complete assembly is encapsulated in the usual way to produce a non-repairable, rigid assembly capable of withstanding vibration, shock, climatic conditions, etc. At present, some of the components in this assembly are of a tentative nature—that is, carbon-resin resistors and transistors utilizing ceramic wafers cemented together with synthetic adhesive—but it is finally intended to produce all these items in high-stability materials, preferably of an inorganic nature,

e.g., Nichrome resistors, tantalum-oxide capacitors and completely sealed semiconductor elements.

The selection of the 0.31in × 0.31in dimensions for the module was based on a review of component performance, manufacturing capabilities and voltage and power levels. Power dissipations of one to two watts per micro-module, working frequencies up to 100 Mc/s, 75 V maximum levels, and the application to general circuitry (i.f., r.f., a.f., filter, oscillator and computer-logic circuits) were the influencing parameters in the selection of this geometry. The 0.31-in square was the smallest size in which the desired ranges of many components could be accommodated, including glass, electrolytic and high-permittivity capacitors, diodes, ceramic resonators, metal-film resistors and even some electromechanical parts such as potentiometers and trimmer capacitors. This system was sponsored by the U.S. Army Signal Corps Research and Development Laboratory. Whilst R.C.A. act as the main contractor, there are some 170 firms engaged in making the individual component micro-elements. The whole programme is timed to be complete by late 1961 and it should be emphasized that this is a production contract rather than a research and development contract. It will be interesting to see how the reliability of the system proves in practice.

Circuit Assemblies.—The flat plate or substrate is processed to produce conductors, resistors, capacitors, and transistors and diodes are inserted to form a complete circuit function. The construction is almost entirely two-dimensional, using film-type components (which are described later). The technique lends itself to evaporation processes with very closely controlled parameters. The advantage of this system is that only a few connections have to be made between units; but the reject rate of each individual component must be made very low indeed.

Work at the Royal Radar Establishment has been carried out on this system in preference to the component-assembly system, and small, complete circuit functions have been the target. A $\frac{1}{2}$in × $\frac{1}{2}$in module has been chosen and this can be extended in two planes to become $\frac{1}{2}$in × 1in, 1in × 1in, $\frac{1}{2}$in × 2$\frac{1}{2}$in, etc. A simple multivibrator circuit is being constructed initially. This consists of eight resistors, two capacitors, two transistors, and two diodes, and the layout of the $\frac{1}{2}$in-square plate is shown in Fig. 1(a) together with the theoretical circuit (Fig. 1(b)).

The work on resistors, capacitors, etc., will now be described.

Fixed Resistors.—Film resistors have been made for many years as evaporated Nichrome resistors for waveguide loads, and fired platinum-gold solutions as flat-plate resistors. Alternatively, tin-antimony-oxide films have been made which have excellent stability.

It has been decided that for micro-miniaturization work, carbon mix and similar types of resistors should not be used and all the work is aimed at employing inorganic resistive materials. A considerable basic study of the processes and substrates is being made, e.g., special studies of binding energies between films and substrates are being made, particularly for nickel-chromium on glass.

Nickel-chromium work is divided into two processes, one for resistors with line widths above 0.015in, and one for resistors composed of narrower lines. Resistors with "wide" lines are made by evaporating nickel-chromium directly on to a heated subtrate, the final thickness of the Nichrome being approximately 6×10^{-6} mm. Simple pattern meandering is made by mechanical masking and the resistance elements are annealed at 350°C for at least half an hour. Resistors with line widths down to 0.004in are made by deposition of an intermediate layer of copper which is photo-mechanically processed. Deposition of the nickel-chromium on to the heated substrate follows in the usual way and the copper mask is etched away subsequently, lifting the superfluous nickel-chromium with it and leaving the correct pattern. Annealing follows in the usual way. The stages in the development of the high-definition films are shown in Fig. 2.

Capacitors and Dielectrics.—Although thin plastics films have been developed in thicknesses as small as 0.0001in and below, and can be used as also can high-permittivity plates down to 0.001in in thickness, most of the work for this programme has been done on evaporation techniques. Both silicon-monoxide and magnesium-fluoride capacitors have been made experimentally at R.R.E. for low-voltage operation; but again a thorough understanding of the mechanism of adhesion is the prime object of the work, and many research contracts have been arranged to implement this programme.

Glass microscope slides have been employed as substrates, although surface imperfections make these far from ideal. Masks were arranged to allow evaporation of four capacitor specimens on one slide, each specimen having an area of 0.6 cm^2. Aluminium, chromium, gold, copper and silver have all been tried as electrode materials. The most consistent results were obtained with aluminium and this has been used for all later work. Initial experiments were made using magnesium fluoride and zinc sulphide as dielectrics since these were known to be easy to evaporate. It was found that capacitors made with magnesium-fluoride films thicker than 5×10^{-4} mm had a tendency to craze; but this was

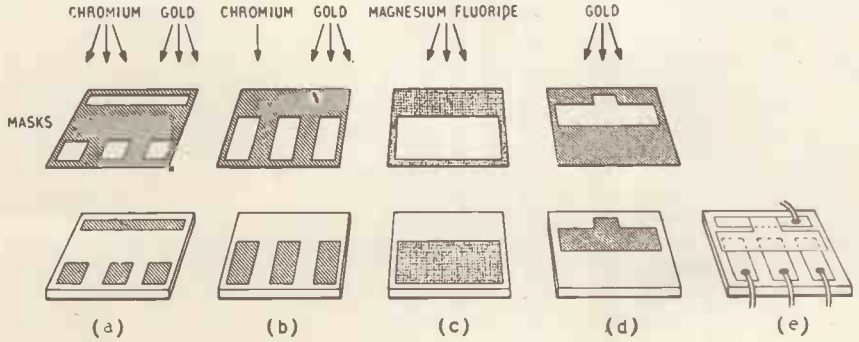


Fig. 3. Stages in production of gold-electrode, magnesium-fluoride-dielectric capacitors. (a) Chromium and gold terminals are applied by evaporation. (b) Gold electrodes are applied over chromium layer to give adhesion to substrate. (c) Magnesium-fluoride dielectric is applied and annealed at 300°C for 30 minutes. (d) Common electrode is applied to form (e) three-capacitor block.

avoided by heating the substrate during deposition. Fig. 3 shows the stages in the process. Zinc sulphide gave surprisingly good results and thick films were easy to obtain: atmospheric moisture, however, caused deterioration over a period of weeks.

Most of the work has been on silicon monoxide. Initially pure, resublimed lump silicon monoxide was used but spitting from the containing boat during evaporation occurred. Mixtures of silicon and silicon dioxide gave improved results. For the best

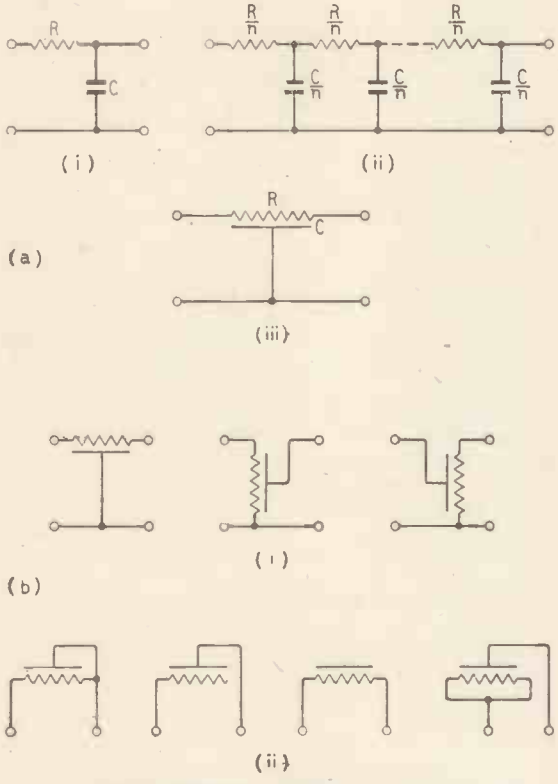


Fig. 4. (a) Evolution from (i) single R-C low-pass four terminal filter through (ii) multi-stage filter ("lumped constants") to (iii) distributed-constant type of low-pass filter. (b) Possible (i) four terminal and (ii) two terminal distributed R-C networks of the simplest type.

electrical properties, slow evaporation rates (10 to 15×10^{-7} mm/sec, heated substrates and a small residual air pressure (1 to 3×10^{-5} cm mercury) were all required. The addition of calcium borate to the mixture in the boat resulted in the disappearance of the straw colour of the film. The substitution of a phosphate gave a deep orange film. This may provide useful information concerning the leakage mechanism by a study of the effects of addition of materials of different valencies.

Mechanical crazing of the film has also been studied. Silicon monoxide shows crazing typical of a compressively stressed film. Crazing is greatly accelerated by storage in a moist atmosphere; but it is very much delayed in a desiccator.

The permittivity of evaporated silicon monoxide films was found to be approximately 5, whilst the leakage measured on films in air showed an exponential relation between current and voltage.

Breakdown voltages of the order of 100 volts/micron can be achieved. Initial breakdowns at weak points in the film can self-heal in air; but not in a vacuum.

Future work will be directed towards the controlled evaporation of mixtures with a view eventually to the exploitation of materials with much higher permittivities such as titania and barium titanate. It is hoped that fundamental studies of breakdown and leakage mechanism will also be continued.

Conductors.—The conductors now used consist of layers of evaporated chromium and evaporated gold, starting with chromium, which adheres to the base. The resistivity is below 0.5 ohms per square. The conductors are evaporated on to the cold substrate using mechanical masking techniques. Lines produced by masking techniques can be as narrow as 0.01in, and the mask apertures are made by etching through copper suitably protected by a light-sensitive temporary coating ("photo resist").

Substrates.—Most of the work has been done to date on microscope slides of glass with a high soda content, because the expansion coefficient of this glass most nearly matches that of the evaporated Nichrome resistors. It is essential to have a flawless surface for high resolution pattern resistors: ceramic substrates have been investigated but do not possess a sufficiently smooth surface. Ion migration in glass should not be a problem as the operating temperature of the substrate is not expected to be above about 80°C when germanium is used and, even for silicon transistors, the temperature will not be above 150°C.

Transistors and Diodes.—The first stage in all micro-miniaturization work is the development of a suitably protected flat-shaped transistor. Many attempts have been made to protect the surface of both germanium and silicon active elements, and although some photo-sensitive solutions and silane (silicon hydride) treatments can be used, the long-term effects have not yet been fully evaluated. A range of small flat-cased transistors (fully sealed) is to be developed which are capable of being let into recesses in ceramic or glass substrates. The size of the sealed transistor is not to exceed 0.125-in square or 0.125-in dia. × 0.040-in thick, with flush electrode contacts. It is emphasized that fully-sealed cases of inorganic materials are required and both glass and ceramic cases are to be investigated. Diode construction would be similar to, and fit the same size specification as, the transistor.

Distributed Component Techniques.—Distributed resistor-capacitor networks can consist basically of sandwiched layers of conducting, dielectric and resistive films, with various connections brought out. Fig. 4(a) shows the extension of a single R-C filter

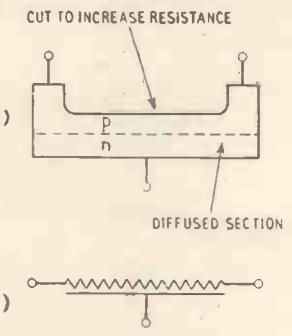


Fig. 5. (a) Appearance and (b) equivalent theoretical circuit of distributed-type element made by diffusion processes for solid-circuit techniques.

through a cascaded filter of the lumped-constant type to the distributed component. By changing round the terminals of the distributed component, different types of four-terminal networks may be achieved, and by open- or short-circuiting the terminals, two-terminal components are possible. Fig. 4(b) shows three possible types of four-pole connections and four possible two-pole connections.

Solid Assemblies.—Experimental work in doping techniques in silicon and germanium crystals has shown that it is possible to control resistivity in parts of the crystal and capacitance can be produced by using p-n junctions. This holds out the possibility of incorporating both active and passive circuit elements in a single block. Provided control conditions are adequate, the intrinsic reliability of such a device should be very high indeed.

In America, Texas Instruments Inc. have made working models of a simple multivibrator and a phase-shift oscillator which they call single-crystal circuits. By diffusion, evaporation, electrolytic and chemical forming, ultrasonic cutting of the crystal and similar processes, a semiconductor wafer is made to perform the function of the complete circuit. External leads are required only for the input and output signals and the power source. The individual components lose their identity because the device as a whole is performing the circuit function.

Doping techniques in silicon are being fully investigated both in the U.S.A. and in this country: a distributed component network has been made in the U.K. by diffusing into a p-type crystal n-type impurities and cutting it to shape as shown in Fig. 5. This shaped crystal formed the basis for a phase-shift oscillator; but as a power gain of 27dB was required for oscillation, a pentode was used as an interim measure in place of a transistor. The amplitude and frequency of oscillation could be altered by changing the bias across the junction. 180° phase change was obtained at 0.5Mc/s.

Oxide masking processes are being investigated for the diffusion techniques. The thickness of the silicon oxide determines the depth of the junction when both p- and n-type impurities are diffused into the silicon block, whilst the shape determines the area of diffusion. These techniques, however, are in the early experimental stages.

Sealed Assemblies.—In this technique individual assemblies of film type components with suitable interconnections are arranged in three-dimensional form in a subminiature-valve envelope, such as that shown in Fig. 6. These use hermetic seals in the case to provide complete protection to the miniature components inside. Using these component assemblies in conjunction with the miniature tubes specially developed for high reliability, complete circuits can be made which take up very little space.

Conclusions.—Micro-miniaturization techniques will undoubtedly have an influence on low-voltage circuitry where high packing densities are required, and it is possible that through this technique the reliability of electronic equipment may be improved. Ideally the aim is to reduce the size of existing subminiature transistorized equipment by a factor of ten, and to improve the reliability by a factor of ten.

It should be remembered that high reliability is a very difficult goal to achieve, and not until production assemblies have finally passed the acid test of operational use can their real reliability be estimated.

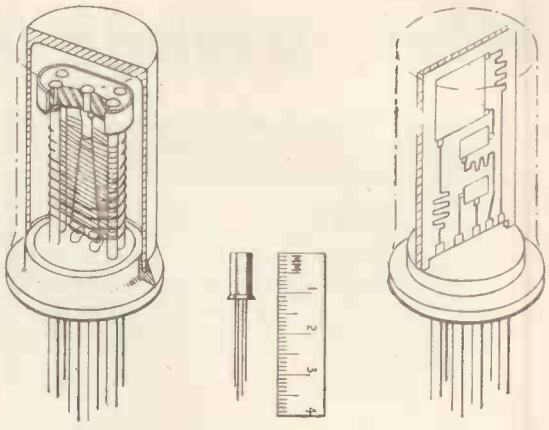


Fig. 6. Comparison of (a) micro-miniature thermionic valve with (b) component-assembly hermetically sealed in similar envelope; also shown (c) is size of envelope relative to scale calibrated in mm.

Nevertheless, there is no doubt that in these techniques lies the only possibility of achieving higher orders of reliability as compared with conventional subminiature components.

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Wien Bridge Oscillators

THEORETICAL ANALYSIS AND PRACTICAL DESIGN

By D. E. D. HICKMAN*

Both the basic equations and normalized expressions for the phase/frequency and amplitude/frequency characteristics of the Wien bridge network are derived. The various sources of frequency drift and errors caused by the parameters of the associated amplifier within the regenerative loop are discussed. Various methods of amplitude stabilization are discussed and their limitations pointed out. Finally a design procedure is presented for a low-frequency Wien bridge oscillator employing thermistor stabilization, and the procedure illustrated by a practical example.

WHERE accurate and stable frequency generation over a wide range of frequencies with low distortion is required, the Wien bridge oscillator has much to recommend it. It is these attributes, together with the inherent simplicity of this type of circuit, which have led to its widespread use in the majority of low-frequency signal generators that are currently available. The Wien bridge oscillator is particularly appropriate for use in decade oscillators since range multiplication may easily be achieved by switching capacitors while fine control of frequency may be covered by switched or variable resistors[1].

Over most of the audio-frequency range and up to several hundred kilocycles per second, the thermistor is the generally favoured method of amplitude stabilization; its advantages being (a) that the power developed in the thermistor is not a function of frequency (since its own temperature time constant is long compared with the period of oscillation) and (b) that no distortion is introduced by the thermistor which is sensitive only to the r.m.s. value of the voltage developed across it.

The author was recently faced with the task of designing a suitable oscillator to run at a constant frequency of 50 c/s at an amplitude of some twenty volts r.m.s. which was to be an inexpensive but reasonably accurate frequency standard for a synchronous hysteresis-type capstan motor of a general-purpose instrumentation tape recorder/reproducer. Consequently a comprehensive analysis was carried out for the Wien bridge circuit and this is given.

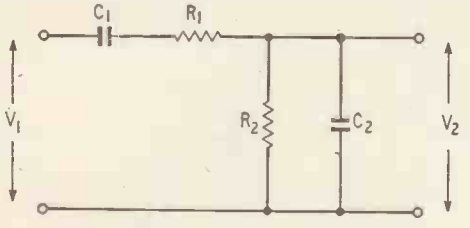

Fig. 1. Reactive section of Wien bridge.

It is felt that, although the particular application for which the design was intended was a specialized one, the analysis and information presented by this paper may be of sufficient general interest to warrant its publication.

Circuit Analysis of the Reactive Section of the Wien Bridge.—Fig. 1 illustrates the frequency determining part of the conventional Wien bridge.

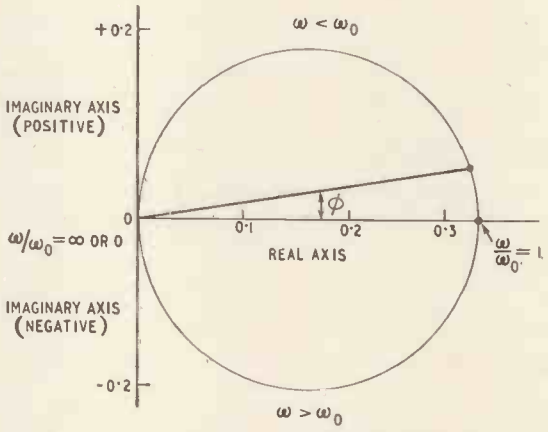

Fig. 2. Transmission of a symmetrical Wien network.

The transmission $T = V_2/V_1$ at any angular frequency ω is obtained from

$$T = \frac{\dfrac{R_2}{1 + j\omega C_2 R_2}}{R_1 + \dfrac{1}{j\omega C_1} + \dfrac{R_2}{1 + j\omega C_2 R_2}}$$

Which simplifies to

$$T = [j\omega C_1 R_2] \div [1 - \omega^2 C_1 C_2 R_1 R_2 + j\{\omega C_1 R_1 + \omega C_2 R_2 + \omega C_1 R_2\}] \quad \ldots \quad (1)$$

Rationalising this expression we have

$$T = [\omega C_1 R_2 (\omega C_1 R_1 + \omega C_2 R_2 + \omega C_1 R_2) + j\omega C_1 R_2 (1 - \omega^2 C_1 C_2 R_1 R_2)] \div [(1 - 2\omega^2 C_1 C_2 R_1 R_2 + \omega^4 C_1^2 C_2^2 R_1^2 R_2^2) + (\omega C_1 R_1 + \omega C_2 R_2 + \omega C_1 R_2)^2]$$

At any given frequency ω rads/sec, the phase shift ϕ of V_2 with respect to V_1 is given by

$$\phi = \tan^{-1} \frac{1 - \omega^2 C_1 C_2 R_1 R_2}{\omega C_1 R_1 + \omega C_2 R_2 + \omega C_1 R_2} \quad \ldots \quad (2)$$

For zero phase shift $\phi = 0$, i.e., $1 - \omega^2 C_1 C_2 R_1 R_2 = 0$. Thus the frequency f_o at which $\phi = 0$ is given by

$$f_o = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}} \quad \ldots \quad (3)$$

It is customary practice to make the resistor

* Solartron Research and Development Ltd

values equal, and also the condenser values equal. Thus, putting $R_1 = R_2 = R$ and $C_1 = C_2 = C$ in equations (1) (2) and (3) we obtain equations for transmission, phase shift and frequency at which the phase shift is zero, respectively as follows

$$T = \frac{j\omega CR}{1 - \omega^2 C^2 R^2 + 3j\,\omega CR} \quad \ldots\ldots\ldots\ldots \quad (4)$$

$$\phi = \tan^{-1}\left(\frac{1 - \omega^2 C^2 R^2}{3\omega CR}\right) \quad \ldots\ldots\ldots\ldots \quad (5)$$

$$f_o = \frac{1}{2\pi CR} \quad \ldots\ldots\ldots\ldots \quad (6)$$

In order to examine the characteristics of the network where $C_1 = C_2 = C$ and $R_1 = R_2 = R$ at frequencies other than f_o it is convenient to derive normalized equations for transmission and phase shift. Thus using equation (6), and replacing CR by $1/\omega_o$ in equation (4), we obtain the following expression

$$T = \frac{j(\omega/\omega_o)}{1 - (\omega/\omega_o)^2 + 3\,j\,(\omega/\omega_o)}$$

Let $\omega/\omega_o = \rho$, then

$$T = \frac{j\rho\,(1 - \rho^2 - 3j\rho)}{(1 - \rho^2 + 3j\rho)\,(1 - \rho^2 - 3j\rho)}$$

$$= \frac{3\rho^2}{(1 - \rho^2)^2 + 9\rho^2} + j\,\frac{\rho - \rho^3}{(1 - \rho^2)^2 + 9\rho^2}$$

Replacing ρ by ω/ω_o, the normalized transmission equation becomes

$$T = \frac{3(\omega/\omega_o)^2}{[1-(\omega/\omega_o)^2]^2+9(\omega/\omega_o)^2} + j\,\frac{(\omega/\omega_o) - (\omega/\omega_o)^3}{[1 - (\omega/\omega_o)^2]^2 + 9(\omega/\omega_o)^2} \quad \ldots \quad (7)$$

From this equation we can deduce the phase shift at any fractional frequency deviation.

$$\tan \phi_{\,\omega/\omega_o} = [1 - (\omega/\omega_o)^2]/3\,(\omega/\omega_o) \quad \ldots\ldots\ldots \quad (8)$$

Fig. (2) shows the theoretical transmission factor of a symmetrical Wien bridge given by equation (7), plotted in the complex plane for values of ω/ω_o from 0 to ∞. It may be shown that the effect of changing the ratios R_1/R_2 and C_1/C_2 from unity is that of increasing or reducing the diameter of the circle diagram for transmission.

From Fig. 2 the modulus of the normalized

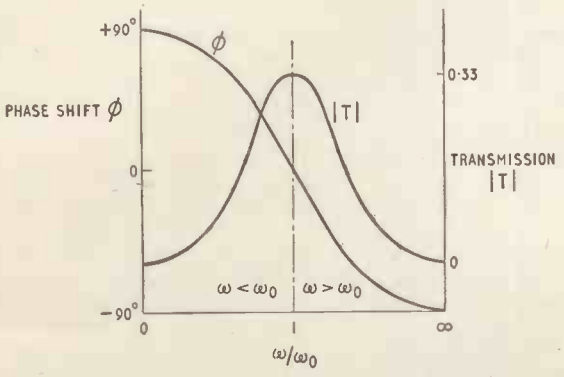

Fig. 3. Normalized transmission modulus and phase shift of a symmetrical Wien network plotted against ω/ω_o.

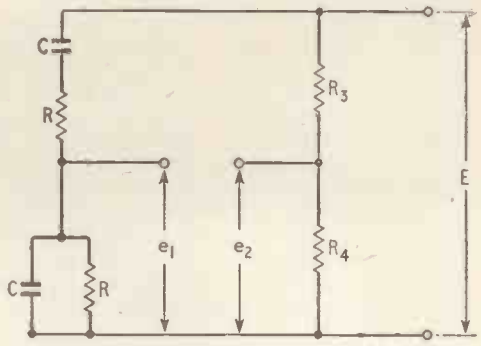

Fig. 4. Complete Wien bridge network.

transmission and phase shift may be plotted with respect to ω/ω_o as the horizontal axis. Fig. 3 shows the result of doing this.

For the Wien bridge oscillator it is desirable for the rate of phase change with frequency to be a maximum at $\omega/\omega_o = 1$, since in this case phase changes due to component variations or any other cause produce a minimum change in oscillator frequency. The curve of ϕ against ω/ω_o verifies that maximum rate of phase change occurs when $\omega/\omega_o = 1$, since this is a point of inflexion on the phase curve.

Complete Bridge.—We have shown that at a frequency given by $f = 1/2\pi\sqrt{C_1\,C_2\,R_1\,R_2}$ the output of the reactive network is in phase with the input. From this point on, we shall only consider the case where $C_1 = C_2 = C$ and $R_1 = R_2 = R$ which are the conditions for what is called a "symmetrical" network. Equation (7) gives the transmission as

$$T = \frac{3\,(\omega/\omega_o)^2}{[1-(\omega/\omega_o)^2]^2+9(\omega/\omega_o)^2} + j\,\frac{(\omega/\omega_o) - (\omega/\omega_o)^3}{[1-(\omega/\omega_o)^2]^2+9(\omega/\omega_o)^2}$$

At the frequency at which ω/ω_o is unity, the imaginary term reduces to zero and the transmission is 1/3. Thus we see that for the bridge of Fig. 4 to be in balance, $e_1 = e_2$, R_3 must equal $2R_4$.

The phase and amplitude discriminating properties of the balanced Wien bridge network may be applied to the measurement of capacity in terms of resistance and frequency. Such measurements can be made with considerable precision since resistance and frequency standards are known to great accuracy[2, 3].

Complete Oscillator.—It is theoretically possible to construct an oscillator using only the reactive branch of the Wien bridge. The output of the network is used as the input of a linear amplifier whose output is connected to the input terminals of the network, and the amplifier gain is adjusted critically to equal +3. However, with this arrangement, it is found that many factors external to the Wien network affect the frequency and it is difficult to achieve a satisfactory waveform. It is common practice therefore to use an amplifier with a gain considerably greater than 3, and to reduce the gain to 3 by a large amount of negative feedback, applied in series with the input. (It is of course necessary to ensure that the amplifier phase shift is zero or an integral multiple of 360 degrees so as to produce oscillation.)

The effect of the application of heavy negative feedback by R_3 and R_4 in Fig. 5 is to complete the bridge circuit and it is convenient to consider the

action in terms of bridge and amplifier parameters. The procedure for achieving undamped oscillations is to apply a small amount of unbalance to the bridge by making R_3 in Fig. 5 slightly greater than $2R_4$, the unbalance voltage then forming the input signal to the amplifier. The gain of the amplifier is then adjusted so that the output is $3e_1$, and oscillation at the frequency $f_o = 1/2\pi CR$ will then ensure.

The negative feedback produced by R_3 and R_4 is very effective in improving the general performance of the amplifier by reducing distortion and improving the bandwidth, and also in making the frequency practically independent of valve and circuit component changes.

In the previous calculations that were made on the Wien bridge network the source impedance driving the network was assumed to be zero. If this is not the case in practice, the frequency at which the bridge offers zero phase shift is modified as is also the transmission of the network.

A cathode follower is therefore often used to drive

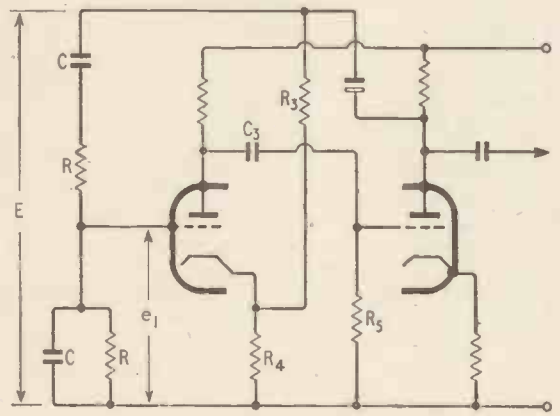

Fig. 5. Basic Wien bridge oscillator circuit.

the bridge from the output of the amplifier. Where more than two a.c. coupled stages are used in the loop, however, difficulty may be experienced due to a component of the feedback becoming positive at some low frequency and thus causing the well-known "hunting" effect. If the anode of the second valve is set to a voltage somewhat less than the h.t. voltage, the cathode follower may be directly coupled to the output of the second valve and hunting should then not occur due to this cause.

An alternative, and simpler, approach is to use a low value of anode load for the second valve and operate this stage at a fairly large anode current. This is the approach chosen by the author in the final design of the oscillator described later in this paper. Under these conditions the majority of the gain is supplied by the first valve which can conveniently be a high slope r.f. pentode.

Effect of the Coupling Time Constant.—It has been mentioned that one of the uses of the negative feedback is to reduce the effect of valve and circuit parameters upon the generated frequency f_o. At low frequencies it is necessary to consider the effect of the coupling circuit C_3 R_5 upon the generated frequency. D. L. A. Smith has derived[4] an expression for the generated angular frequency of a Wien bridge oscillator without negative feedback in which the amplifier phase shift is not negligible. By equating the loop phase shift to zero and solving for ω he obtains

$$\omega = \frac{1}{CR}\left(1 + 2\frac{CR}{C_3R_5}\right)^{1/2} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

where C R is the time constant of the bridge and C_3 R_5 is the time constant of the coupling circuit between the two valves. Assuming C_3 $R_5 > 2C$ R, equation (9) may be expanded to

$$\omega = \frac{1}{C\,R}\left(1 + \frac{C\,R}{C_3R_5} - \tfrac{1}{2}\left(\frac{C\,R}{C_3R_5}\right)^2 + \ldots\right)$$

Thus, to a first approximation

$$\omega \simeq \frac{1}{C\,R} + \frac{1}{C_3R_5} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

He then goes on to use this effect as a means of adjusting the frequency of oscillation over a narrow range, thus providing a simple and effective method of incremental frequency control.

It is normally desirable, however, that the effect of the coupling circuit upon the generated frequency shall be negligible. Consequently it is obviously essential that the coupling circuit time constant should be large in comparison to the period of the generated frequency.

With no negative feedback, the fractional frequency deviation due to the circuit would be $\delta\omega/\omega = CR/C_3R_5$. The error with negative feedback however is reduced in the ratio $1 : (1 + A\beta)$ and for a typical circuit with $\beta = 1/3$ and $A = 90$, the error would be reduced by a factor of 1 : 31. Of course, the greater is A, the more the reduction of the effect of C_3 R_5 upon the frequency of oscillation. For frequencies of the order of a few cycles per second upwards, component values of 0.25 μF and 1M Ω respectively for C_3 and R_5 are quite sufficient for most purposes.

Amplitude Stabilization.—It is well known that if an oscillator output contains harmonics, considerable frequency error may be introduced which makes the generated frequency differ from the predicted frequency[5]. It is therefore desirable that the output waveform should contain little or no distortion. It is also desirable that the output level of the oscillator should remain constant over a wide frequency range, so that some means of automatic amplitude stabilization becomes necessary. It is possible to have a fixed amount of gain and a small adjustment of the negative feedback which will just allow the system to oscillate, but the adjustment is necessarily extremely critical and difficulty is experienced in obtaining just the right conditions of equilibrium where the loop gain is unity. The methods of stabilizing Wien bridge oscillators may be divided into two main groups: (a) Thermal Methods and (b) A.G.C. Methods.

Thermal Methods.—Of these methods (a) is usually the simplest although it tends to suffer from the obvious disadvantage that the amplitude of stabilization is to some extent dependent upon the ambient temperature; although careful choice of component values considerably reduces this limitation. Some years ago, before the invention of the thermistor, it was common practice to use a lamp as the temperature sensitive element[6]. This had the advantage that its operating temperature was normally rather greater than the ambient temperature, though

(*Continued on page* 553)

it suffered from the attendant disadvantage that a fair amount of power was required from the oscillator in order that the lamp should be operating on a suitable part of its resistance/temperature characteristic.

Both lamp and thermistor methods however are extremely useful since they do not introduce distortion, resistance not being a function of frequency (to a first order approximation).

One method of compensating for the drop in output voltage that occurs with rise of temperature is to follow the oscillator with an amplifier whose gain is a function of temperature such that the reduction in output from the oscillator is precisely compensated by an increase in gain of the correcting amplifier. By this means it is possible to achieve a reasonably flat amplitude/temperature characteristic but, in the interests of frequency stability, hum, and noise level, it is desirable that the oscillator itself should run at a nearly constant amplitude.

By operating the stabilizing thermistor in an uncompensated Wien bridge oscillator at a reasonable power level of the order of 40 to 50 milliwatts, the power dissipated in the thermistor due to the current in it is an appreciable fraction of the total dissipation caused by the sum of the electrical power and ambient heating. The latter will then have negligible effect.

A.G.C. Methods.—Briefly, the principle involved in a.g.c. methods of stabilization is to rectify the output waveform and apply the resulting d.c. to the grid of the first stage as a bias voltage which is proportional to the peak value of the output voltage. By choosing a valve with variable mu characteristics, the gain of the first stage is considerably altered by the bias, and stabilization can thus be achieved. If the fraction of input signal excursion to the grid base is small, as it normally is, very good shape and frequency stability can be achieved, although care is necessary in the design to see that the rectifying circuit does not impose a non-linear and complex load on the amplifier, and thus give rise to unwanted phase shifts within the regenerative loop. Even better amplitude stability may be achieved by the use of amplified, delayed a.g.c.

An alternative method of applying a.g.c. has been suggested. Fig. 6 is a diagram of a Wien bridge oscillator with the suggested method of stabilization incorporated. The operation of the circuit is as follows:—

The output voltage appearing across the anode load resistor R_6 is rectified by the diode V3 and the resulting waveform, smoothed by C_5, appears across R_8. R_8 acts as the d.c. load for V3, while the d.c. return path is formed by R_9 via E_B to earth. E_B may conveniently be obtained from a potentiometer connected between h.t. positive and earth, and serves as a fixed delay for V3. V2 is a cathode follower whose grid bias voltage is determined by the rectified d.c. component of the oscillator output voltage. The anode current in V2 determines the mutual conductance of that valve. Over a fairly small range of anode current variation the relationship between mutual conductance and grid voltage is linear, provided that the optimum d.c. operating conditions are chosen for the particular type of valve. However, any non-linearity in the relation between g_m and v_g is of little consequence in this application since V2 is only being used as a regulating device.

The output impedance of the cathode follower is effectively shunted across the lower part of the resistive section of the Wien bridge. The orientation of V3 is such that if the oscillation amplitude tends to increase, the negative bias voltage due to V3 is increased, the anode current of V2 is thereby reduced, the consequent reduction in the g_m of V2 increases the effective shunting impedance as seen from the cathode of V1, and this gives rise to an increase in the feedback fraction. In order to prevent any changes in the d.c. operating conditions of V1 by virtue of the current changes in V2, the cathode of V2 is isolated for d.c. from the cathode of V1 by means of a large capacitor C_4. The large value of capacity is necessary so that its reactance at the frequency of operation is small in comparison to R_7. If this capacity is too small, the effective total impedance of the lower section of the divider chain would have an imaginary component, the frequency of oscillation would alter to bring the output from

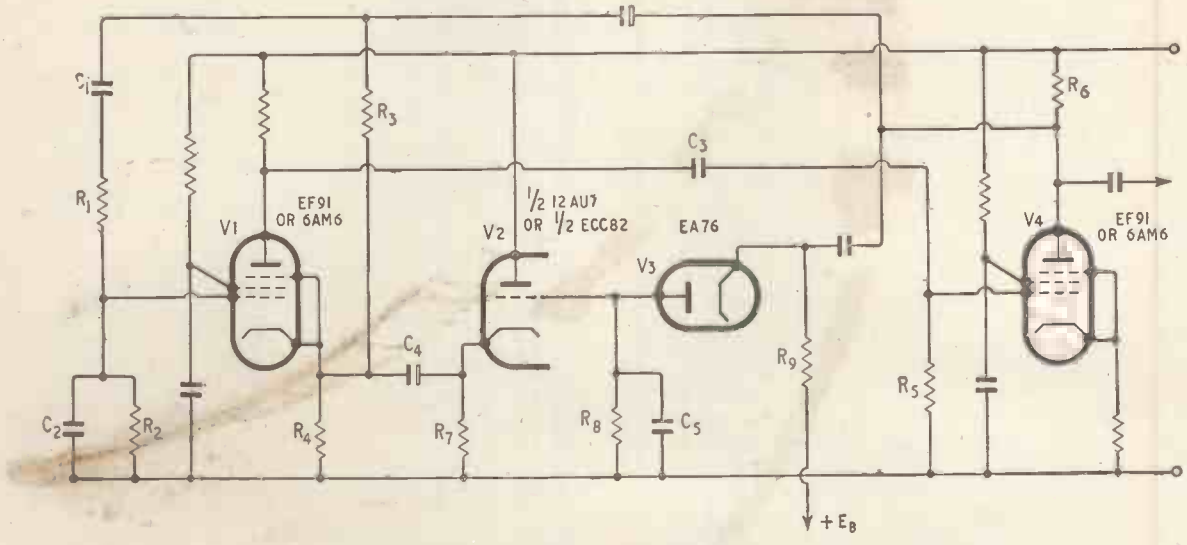

Fig. 6. Possible method of stabilizing the amplitude of a Wien bridge oscillator.

the bridge back into phase with the bridge input, and a frequency error would be obtained.

With very careful design, such methods of stabilizing the output voltage of Wien bridge oscillators by means of amplified a.g.c. can be very effective, but the control circuitry has a tendency to become very complicated if good frequency stability is required.

The most important difficulty involved in the design of a.g.c. controlled oscillators is the choice of optimum filter time constants to give effective smoothing of the control voltage over the working frequency range without introducing the phenomenon of "hunting"—an effect caused by the response time lag of the correcting system allowing the amplitude to grow and then be over-corrected by the controlling voltage.

Various aspects relating to the theory of Wien bridge oscillators have now been discussed with particular reference to the available methods of amplitude stabilization. Using the results of the foregoing discussion a general procedure is now given for the design of a simple thermistor stabilized oscillator.

Design of a Practical Oscillator: Procedure.—Referring to Fig. 7, the first stage in the design is

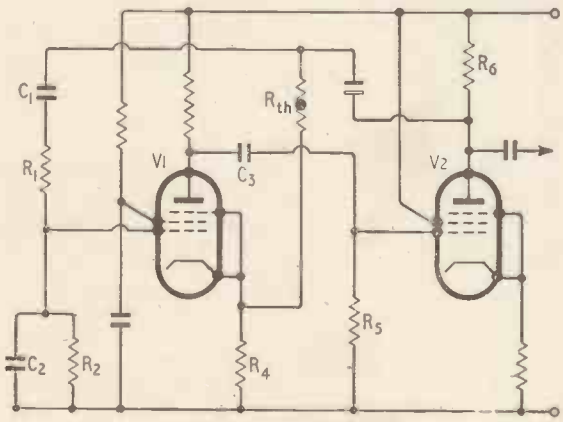

Fig. 7. Theoretical circuit diagram of Wien bridge oscillator used as basis for design procedure.

to work out required values for the frequency determining part of the Wien bridge itself, for the various frequencies involved.

Such values are obtained from equation (3): $f_o = 1/2\pi\sqrt{C_1 C_2 R_1 R_2}$.

Determine from the valve curves the value of cathode resistance R_4 for the first stage that gives satisfactory operation at an anode current of the order of 1 to 2 mA.

The operating value of resistance, R_{th}, of the thermistor must therefore be approximately $2R_4$.

Work out, from the output voltage V_o required, the voltage across the thermistor, V_{th}. This is of course $2V_o/3$. The power dissipated by the thermistor is thus $P_{th} = V^2_{th}/R_{th}$. For satisfactory operation it is desirable that this should be between about 40 and 50 mW. If this is not the case, make small adjustments to the value of the cathode resistor and re-calculate the power developed in the thermistor for the same output voltage and ratio R_{th}/R_4.

From the manufacturer's curves of thermistor resistance plotted against power, select a suitable thermistor that gives the required resistance for the given power dissipation.

Determine the input impedance of the bridge and the current demanded by the bridge. For medium to low frequencies this impedance is sensibly $3\ R_4$ since $R_4 + R_{th} << $ the impedance of C_1, R_1 and C_2, R_2. The current is given by $V_o/3R_4$ where V_o is the output voltage of the oscillator.

Adjust the operating conditions of V2 so as to make the d.c. component of its anode current at least $1\frac{1}{2}$ to 2 times $V_o/3R_4$. This is done by operating V2 with a low value of anode load R_6.

Calculate the open loop amplifier gain of the two stages (A). Determine the amplifier input voltage by dividing the output voltage by the open loop amplifier gain A. The gain should not be so great that the input for the required output voltage is less than say 1 to 10mV as the amplifier would then be more liable to pickup of extraneous hum, etc.

Calculate the feedback factor $1 + A\beta$. In this case take $\beta = 1/3$. From the largest value of CR in the bridge circuit, i.e., that for the lowest frequency, evaluate the smallest permissible time constant for the inter-stage coupling circuit $C_3\ R_5$ that would produce say no more than 0.1% frequency error. $C_3\ R_5 > 10^3\ C_1\ R_1/(1 + A\beta)$. It is usual to make R_5 of the order of 470kΩ to 1MΩ.

This completes the design. If small adjustments of output voltage are required, they can be obtained by inserting a small potentiometer (about 1kΩ) in series with the thermistor.

Design of a Practical Oscillator: Example.—In the practical example shown in Fig. 8, a frequency of 50 c/s was required, at an output of 22V r.m.s.

The first stage is to work out the bridge component values. Using $C_1 = C_2 = C = 8{,}200$pF, $R = 1/2\pi Cf = 10^{12}/2\pi \times 8{,}200 \times 50 = 388$ kΩ. Since this is a non-standard value, the nearest preferred values of 330kΩ and 56kΩ were used in series.

A cathode resistor R_4 of 2.7kΩ was chosen for the first valve to operate this valve at a quiescent anode current of 1.5mA.

The operating resistance of the thermistor must therefore be $2 \times 2.7 = 5.4$kΩ.

The voltage across this is $2/3 \times 22 = 14.7$V. The power developed in the thermistor is then $14.7^2/5.4 = 40$mW. This was considered to be a satisfactory level of power dissipation.

From the appropriate resistance/power curves, a suitable thermistor was selected. In this case the S.T.C. type A5513/100 gives a resistance of about 5.4kΩ when the power dissipation is about 40mW at an ambient temperature of about 35°C.

The bridge input impedance is approximately $3 \times 2.7 = 8.1$kΩ. The bridge current is thus $22\text{V}/8.1\text{k}\Omega = 2.7$mA.

The output stage is therefore operated at about 10mA which is of the order of 3 times as great.

Using a 100kΩ anode load for the first stage and 10kΩ for the anode load of the second stage, the overall gain using an EF86 and EF91 for V_1 and V_2 is obtained from the product of the gains of V_1 and V_2. For the first stage (EF86), taking μ as 1,000, the gain

$$A_1 = \frac{1000 \times 100}{1000 + 100 + 2.7(1001)} = 26$$

For the second stage (EF91) the load impedance is effectively the anode load R_6 shunted by the input

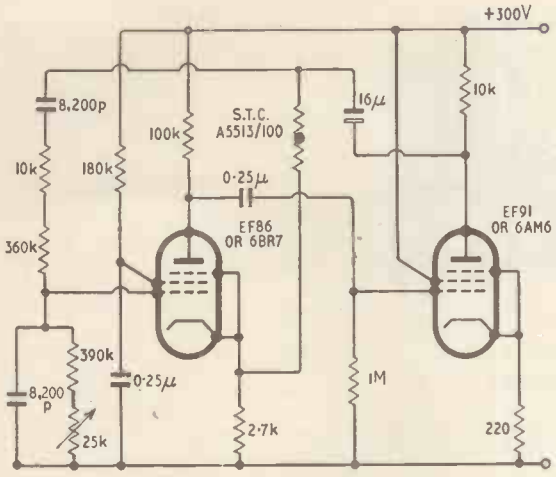

Fig. 8. Practical circuit of a thermister-stabilized Wien bridge oscillator.

impedance of the bridge which in this case is 8.1kΩ. The effective anode load is thus $10 \times 8.1/(10 + 8.1) = 4.5\text{k}\Omega$. The gain of this stage is then

$$A_2 = \frac{7500 \times 4.5}{1000 + 4.5 + 0.22(7501)} = 12.7$$

Therefore the total loop gain (open) $= A_1A_2 = 26 \times 12.7 = 330$. Therefore the input voltage to the bridge $= V_o/A_1A_2 = 22/330 = 67\text{mV}$. This is appreciably above the hum level expected at this point.

For the coupling circuit C_3 R_5 to introduce less than 0.1% frequency change at 50 c/s the following relation must be satisfied:—

$$C_3R_5 > 10^3 \cdot \frac{C_1R_1}{1 + A\beta} = \frac{10^3 \times 386 \times 8200 \times 10^{-9}}{1 + (330 \times 1/3)}$$

$$= 0.03 \text{ sec.}$$

The actual values chosen for the coupling circuit were $C_3 = 0.25\mu\text{F}$; $R_5 = 1\text{M}\Omega$. These give a time constant of 0.25 sec, thus giving an improvement in the reduction of the effect of the coupling circuit time constant upon the generated frequency nearly 10 times better than that stipulated.

A measurement of total harmonic distortion was made on the prototype oscillator using a wave analyser and this was found to be of the order of or less than 0.02%.

The circuit diagram of the practical oscillator to which the design refers appears in Fig. 8. It is seen that in this case the bridge has been made slightly asymmetrical in that R_1 and R_2 are not quite equal. This was to facilitate small changes in the operating frequency so that a number of oscillator units could be set up against a sub-standard frequency during production testing.

Although no new methods have been employed in the design of the practical Wien bridge oscillator it is felt that a satisfactory design procedure has been established and experiments have confirmed that the use of this procedure is satisfactory.

Acknowledgement.—The author wishes to thank Mr. L. V. Mayhead, Assoc. Brit. I.R.E., who gave much valuable assistance and advice during the experimental work carried out in connection with the subject of this paper.

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25 sq ft of Printed Circuit

HOW large is it possible to make a printed circuit? Theoretically perhaps there is no limit, but it might be of interest to learn that Printed Circuits Ltd. (a company within A.E.I. group) is producing what are said to be the largest printed circuits so far made, at least in this country.

The photograph shows part of the latest automatic equipment employed in their Borehamwood factory and in this instance 1,100 separate circuits are being processed on a single board measuring 5ft × 5ft.

This new process should open up new fields of application for printed circuits and it also considerably accelerates the rate of production of smaller units.

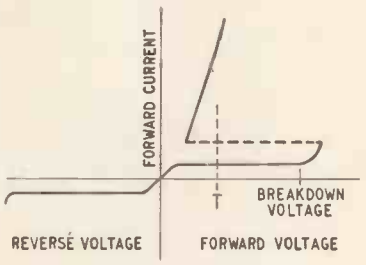
Right: Automatic equipment processing 25 sq ft of printed circuits (Printed Circuits Ltd.).

Technical Notebook

Automatic Dimensional Check of mass-produced parts in factories is given by an electronic device based on a counting system described in the Russian journal *Priborostroienie*, No. 7, 1959. The parts to be checked are placed between the c.r.t. and a photocell, which feeds an electronic counter via a waveform shaping circuit. A coarse raster is traced out on the c.r.t. screen with a horizontal deflection frequency of 1c/s and a vertical deflection frequency of 50c/s. Two thin curved lines are drawn on a transparent material fixed to the screen, one of them representing the upper limit of the contour of the parts to be checked and the other representing the lower limit. Normally, with no parts interposed between the tube and photocell, the light to the cell is interrupted twice by the two drawn lines for each vertical deflection of the scanning spot. As a result two impulses from the photocell are, after shaping, counted by the electronic counter. When a part is being checked, if its contour falls between the two lines, as shown in the centre diagram, the scanning light spot is interrupted twice, as before, and the count of 2 registered by the counter is used as a signal for an automatic control system to accept the part. If the part is too big, as shown in the left-hand diagram, there is only one light-spot interruption and one impulse counted, and this is used to reject the part. If the part is too small, as shown on the right, three impulses are counted,

and again this is used to reject the part. The contour lines on the screen of the c.r.t. are somewhat larger than the actual parts being checked, and an optical focusing system, between the screen and the parts, reduces the image of the lines to the required dimensions.

Silicon Controlled Rectifier, a switching device which can be considered as a semiconductor equivalent of the thyratron (see July/August, 1959, issue, p. 348), is now being manufactured in Great Britain. It is a p-n-p-n structure with three terminals, and can be regarded as two transistors coupled by a common collector junction. It



offers a high impedance (several megohms) in each direction between two of the terminals, but can be triggered into a low-impedance condition in one direction by application of a small signal to the third (control electrode) terminal. The volt-amp characteristic is shown in the diagram. In the reverse direction it is almost identical with that of a simple silicon rectifier. The forward direction is a mirror image of the reverse characteristic up to the breakdown voltage. If a small current (10-100mA) is applied to the control electrode when the forward voltage is below breakdown (e.g., at T in the diagram), the rectifier will remain conducting until the voltage across it falls to almost zero. A common technique used for controlling the output of the rectifier is to change the phase of the trigger current in relation to the a.c. voltage applied to the device. In a range of silicon controlled rectifiers introduced by A.E.I. Electronic Apparatus Division, loads up to 10A at peak inverse voltages between 25V and 300V can be handled. A typical triggering current is 50mA at 2 volts.

Television Frame Interlace Errors due to the difference in the integrated sync pulse waveform on odd and even frames can be reduced by adding a line-timebase waveform component to the integrated sync pulses; also a substantial improvement in regularity of synchronisation in the presence of noise can be achieved, according to a paper by H. W. Proudfoot in *I.R.E. Transactions on Broadcast and Television Receivers* for May, 1959. The practice of adding a differentiated and inverted sync component to the integrated waveform is well-known; however, in the presence of noise, this can result in frame timebase stability worse than that achieved by the simple integrator. Proudfoot's scheme employs a train of twice line frequency "spikes" which are derived from the line timebase by a ringing coil, amplifier, clipper and differentiator. These pulses perform the same function as does the differentiated and inverted sync waveform. The frame oscillator is "primed," so to speak, by the rise in the integrated waveform due to the frame-sync pulse train, then the flyback is actually initiated by one of the spikes. Provided that a reasonable balance between spike and integrated-pulse amplitude is struck, and the spikes have sufficiently sharp leading edges, correct interlace is achieved. In addition, as the locally-generated spikes are free of noise, the performance under noisy-signal conditions is improved—an increase of 15dB, compared with the simpler integrator, in noise rejection was achieved in tests on a typical American monitor unit operating on the 525-line, 60-frame negative modulation system. The circuit given uses a double triode and two semiconductor diodes; but the author suggests that it could be simplified considerably by deriving the spike waveform at high level (i.e. line output stage rather than line-oscillator).

170° Television Tube, with a flat 17-inch screen and a depth of only 5 inches, is reported by *Electronic News* for October 13th, 1959, as a development from Multi-Tron Laboratory in the U.S.A. It is said to weigh only six pounds and to require very low scanning power, thus being suitable for transistorized portable receivers. The extremely wide deflection angle is achieved by what is called "electron optical projection." Another similar tube, with a 160° deflection angle and a length of 6½ inches, has been developed by the firm. This, according to the report, requires a scanning power of only 3½-4 watts, and, since the tube can be used with standard 110° deflector coils, there is thought to be a possibility of incorporating it into existing receiver designs. The 170° tube, on the other hand, apparently needs an entirely new design of deflector coil assembly.

Standard Solar Cells have been introduced by the International Rectifier Co. (Great Britain) for checking the efficiencies of production silicon solar cells. They are intended for calibrating artificial light sources in terms of solar radiation. Accompanying curves show conversion efficiences at different radiation intensities.

Elements of Electronic Circuits

8.—TWO-STATE CIRCUITS

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

CIRCUITS producing abrupt transitions between two electrical states (usually high voltage and low voltage) take many different forms and have many different applications in the field of electronic switching, pulse generation and digital computing. The circuits may be free-running in operation, providing a source of square (or near square) waves, or may have to be triggered from one state to the other by an external voltage, giving an action rather analogous to that of an electromechanical relay. They may have two stable states, or one stable and one unstable state. Some types of circuits use one valve and others use two.

Probably the best-known two-state circuit is the multivibrator. This month it will be considered simply as a waveform generator; next month as a triggered circuit. The multivibrator consists basically of a two-stage RC coupled amplifier which has its output coupled back to its input. Voltage changes within the amplifier, due primarily to the charging or discharging of capacitors, cause the amplifier to change suddenly from a stable state to an unstable state, at regular intervals. Because of this the term "flip-flop" is sometimes applied to this class of circuit. The name "multivibrator" derives from the waveforms produced at the anodes of the two valves, which are approximately rectangular and hence rich in harmonics.

Fig. 1 illustrates the fundamental circuit which,

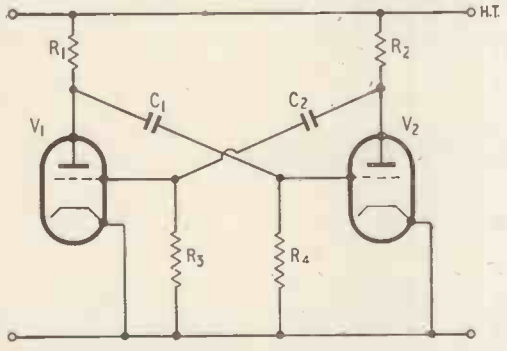


Fig. 1

for simplicity, is shown as consisting of two RC coupled triodes. Advantages can, however, be gained by using pentodes in that (a) cleaner anode waveform pulses can be obtained, and (b) as anode circuits are "electron-coupled" to the remainder of the valve (screen and control grids are shielded from the anode by the suppressor grid) any variation in load does not significantly affect the frequency of oscillation of the circuit.

Now let us consider the action in detail. When the circuit is switched on, both valves conduct and oscillations commence, as shown in the waveform diagram Fig. 2. The sequence of operation is as follows: At stage A the grid voltage of V_1 is assumed

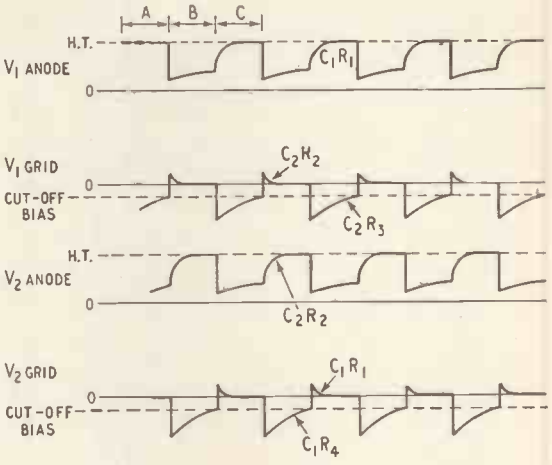


Fig. 2

to be rising towards zero volts. As the grid of V_1 rises through cut-off, V_1 starts to conduct, causing the anode voltage of the valve to drop. This drop in voltage is applied to V_2 grid via the coupling capacitor C_1 and results in a rise in voltage at V_2 anode. The rise is passed back to the grid of V_1 via the coupling capacitor C_2, so causing a further increase in current in V_1. A cumulative action develops, causing V_1 grid to rise to a positive value and V_2 grid to drop to a large negative value (well beyond the V_2 cut-off point).

Note: V_1 grid does not rise as much as V_2 grid falls, because the flow of grid current in V_1 makes the grid/cathode resistance small and hence the voltage developed across R_3 is limited.

The "amplification" stage is now over and the circuit is said to "relax" during stage B (hence the term "relaxation oscillator"). During this lull C_2 *charges* via R_2 and the low-resistance grid/cathode path of V_1, causing V_1 grid voltage to drop to zero with time constant C_2R_2 and V_2 anode voltage to rise to h.t. with the same time constant. Also during stage B, C_1 *discharges* through R_4 and V_2 grid voltage rises to zero through cut-off with time constant C_1R_4. As soon as V_2 starts to conduct the sudden amplifying action takes place all over again and the circuit "flops" into the unstable state once more. Amplification ceases when V_1 is cut-off.

Stage C sees a further quiet or "relaxed" period, during which C_1 *charges* via R_1 and the low resistance grid/cathode path of V_2, causing V_2 grid voltage to drop to zero with time constant C_1R_1 and V_1 anode voltage to rise to h.t. with the same time constant. Also during stage C, C_2 *discharges* through R_3 and V_1 grid voltage rises to zero through cut-off with time constant C_2R_3. When V_1 re-conducts, sudden amplification again takes place and the circuit "flips" into the unstable state once more and the cycle repeats itself.

In order that the rise in anode voltages to h.t

should be rapid, i.e., that the time constants C_1R_1 and C_2R_2 should be short, it is usual to make the anode load resistors R_1 and R_2 fairly low values. Very often, to make the start of each negative-going anode voltage pulse more clearly defined, the grid voltages are caused to rise more sharply through cut-off. This is done by connecting R_3 and R_4 to h.t. instead of to earth, as shown in Fig. 3.

The frequency at which the free-running multivibrator will oscillate is largely dependent on the time constants C_1R_4 and C_2R_3, as well as on the minimum values of grid voltage together with the values of cut-off bias for the chosen valves. For high-frequency circuits account has to be taken of inter-electrode and stray capacitance effects when deriving the formula for frequency of oscillation.

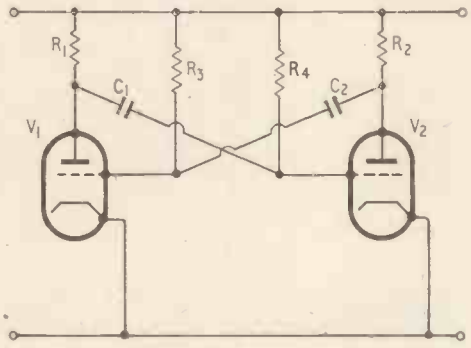


Fig. 3

It can be shown that the period of oscillation is expressed approximately by the following formula:

$$T_{\text{seconds}} \approx C_1R_4 \log_e K_1 + C_2R_3 \log_e K_2$$

where K_1 is the ratio of minimum grid voltage to cut-off voltage for V_1, and K_2 is the ratio of minimum

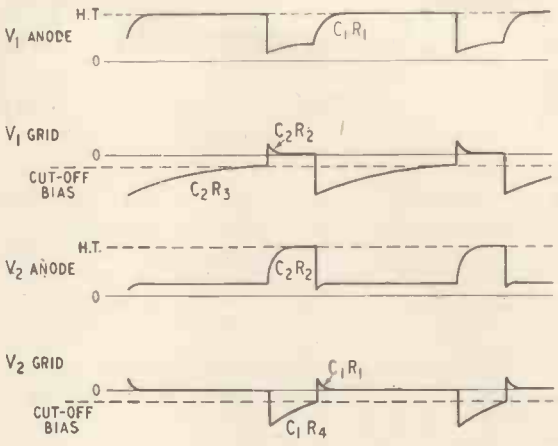


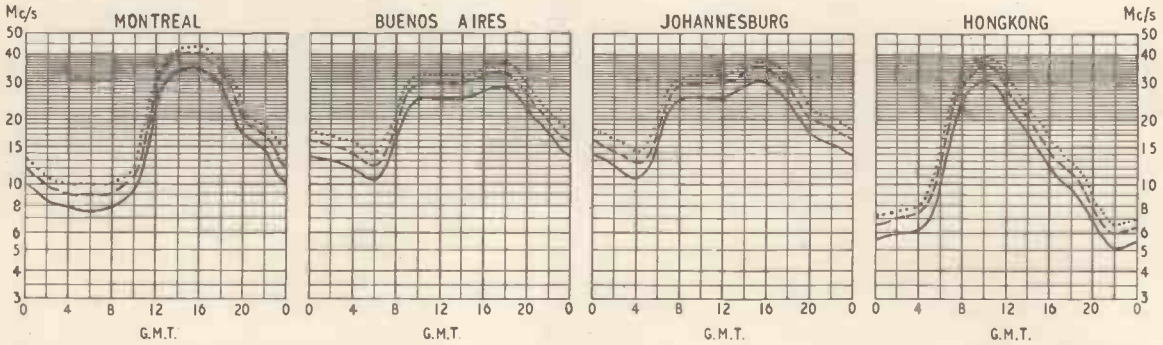
Fig. 4

grid voltage to cut-off voltage for V_2. It should be noted that this relationship will only apply at low frequencies of oscillation where stray and inter-electrode capacitances have negligible effect.

An important point about the circuit action described above is that the duration of the positive and negative going portions of each anode voltage waveform is equal. For this reason the circuit is known as a "symmetrical" multivibrator. It is possible, however, to make the two portions of unequal duration if the time constants C_1R_4 and C_2R_3 are made unequal. This is illustrated in Fig. 4 where, by making $R_3 = 3R_4$, the positive V_1 anode pulse is lengthened to approximately three times the duration of the V_2 anode pulse. Under these conditions the circuit is known as an "asymmetrical" multivibrator. By making R_3 or R_4 variable, pulses of varying width can be produced, i.e., a variable mark-to-space ratio can be obtained.

SHORT-WAVE CONDITIONS

Prediction for December



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

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

•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

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

V.H.F./F.M. Multipath-Propagation Test-Set

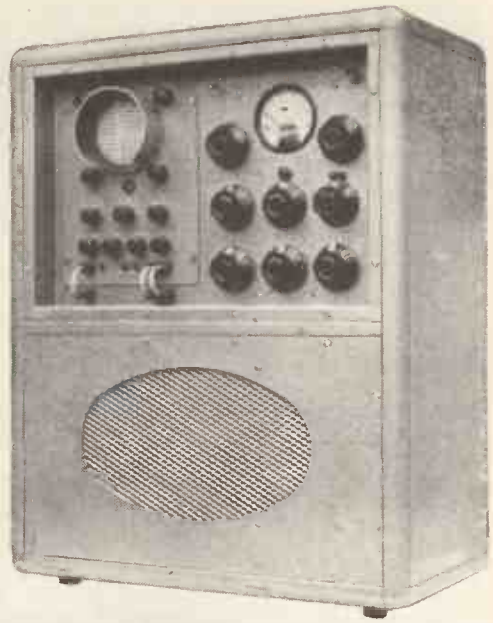
SIMPLE APPARATUS GIVING VISUAL DISPLAY

IN a practical radio-communication system the signal at the receiving site will generally consist of a direct signal from the transmitter and one or more delayed signals which have been reflected from near or distant objects. In the case of a frequency-modulated transmission this multipath propagation causes unwanted phase and amplitude modulation of the carrier, giving rise to perceptible distortion of the reproduced programme if the time delays and relative amplitudes of the reflected signals are sufficiently large. The audible effect produced varies from a noise similar to that of an overloaded a.f. amplifier (when the difference in length of path travelled is small) to a hiss like co-channel interference (large path-length difference). At intermediate path-length differences the distortion closely resembles the effect of something loose in the loudspeaker.

The mathematical analysis of the way in which the delayed signals cause distortion has been recorded.* To ensure satisfactory results from an f.m. receiver, it is clearly essential to reduce to a minimum the distortion caused by multipath propagation. A receiver with good amplitude limiting can remove the a.m. component of this distortion and thus effect a considerable improvement. However the phase-modulation component can only be reduced by careful siting of the aerial to discriminate against the more harmful of the reflected signals. In the case of a receiver with inadequate limiting, where the unwanted amplitude modulation makes an additional contribution to the audible distortion, attention to the aerial is even more important. This is easier said than done because the nuisance value of multipath distortion varies widely with programme material. Distortion which is hardly detectable by listening to, say, speech may be completely intolerable on piano music. What is needed, then, is a relatively simple equipment for obtaining a clear visual display of the characteristics of the received signal to aid the correct installation of aerials: this test-set should also be accurate and consistent enough to allow measurement to be made of the severity of interference at the installation site.

An apparatus complying with these requirements has been developed at the B.B.C. Research Department, Kingswood Warren; it consists of a tuner unit, oscilloscope, a.f. amplifier, loudspeaker and power supply.

Deriving the Display.—As the transmitter frequency deviates, due to modulation, the number of wavelengths travelled by the reflected signal relative to the number of wavelengths travelled by the direct signal also varies. This changes the phase of the reflected signal relative to that of the direct signal, resulting in a variation of instantaneous amplitude (amplitude modulation) of the received signal. Also the number of phase reversals which occur for a given deviation of the transmitter frequency depend on the excess path length travelled by the reflected signal.



Appearance of multipath-propagation test-set developed by the B.B.C. Loudspeaker and a.f. amplifier are fitted to enable use as high-grade demonstration receiver.

Thus the amplitude-modulated component of the f.m. carrier can be used to derive a display indicating the presence of multipath distortion. A simple measurement of the amount of amplitude modulation present is not alone sufficient, because the extra distance travelled by the delayed signal also has an effect on its "nuisance value." For instance, it has been found by listening tests that the amount of audible distortion caused by the presence of a reflected signal of 35 per cent of the main signal in amplitude and excess path length 8km; is the same as that caused by a signal of only 6 per cent of the main signal, but which has travelled over a path 29km longer than that followed by the main signal. Some means, therefore, is required for the evaluation of excess path length travelled by the reflected signal. The test-set is therefore arranged to give a kind of "wobbulator" display with the amplitude of the incoming signal plotted against its frequency deviation. Fluctuations due to phase changes of the reflected signal are thus displayed in such a way that both the depth of amplitude modulation of the signal and the number of reversals of phase for a given change in frequency can be seen.

A block schematic diagram (Fig. 1) shows the way in which the equipment is arranged. The X-deflection voltage for the oscilloscope is obtained from the discriminator output of the tuner, and the Y-deflection voltage from the control-grid potential of the

* See, for instance: "F.M. Multipath Distortion," by M. G. Scroggie, B.Sc., M.I.E.E., *Wireless World*, Dec., 1956, p. 578.

saturated-pentode limiter valve. Both of these circuits are direct-coupled so that l.f. phase distortion is avoided.

Interpretation of the Display.—The vertical deflection from the zero base line of the oscilloscope display represents the instantaneous signal level. The horizontal deflection of the spot indicates the instantaneous frequency of the carrier wave. In the absence of delayed signals the instantaneous amplitude remains constant as the carrier frequency varies and the oscilloscope trace is a horizontal straight line whose length is proportional to the peak deviation. If a reflected signal is received in addition to the direct signal, the phase difference between them, and hence the amplitude of their resultant, varies with the instantaneous frequency, and a trace of the type shown in Fig. 2 is obtained. This is a photograph of the oscilloscope display with an input including one delayed signal of amplitude 20 per cent of that of the direct signal, with a path difference of 8km; the carrier deviation is ±75kc/s at a modulation frequency of 120c/s. The ratio of the amplitudes of the two signals is a/b and the path difference in km

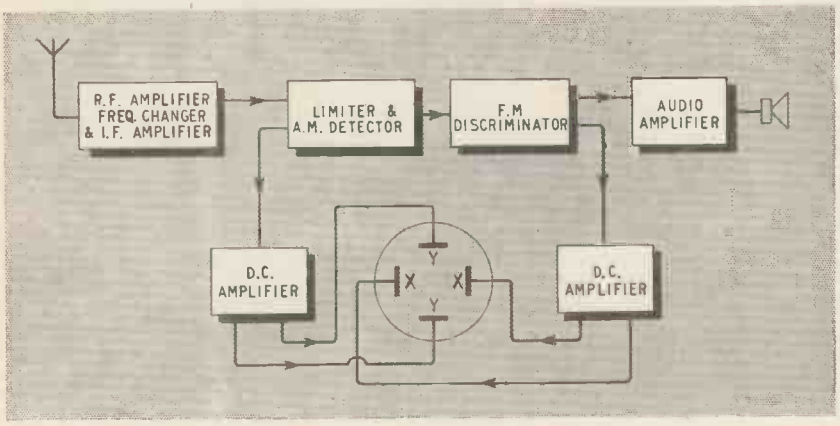


Fig. 1. Block-schematic diagram of equipment for test-set as arranged by B.B.C.

turns out to be equal to 2N, where N is the number of complete cycles of amplitude variation in the total bandwidth of ±75kc/s. In general, several reflected signals are received simultaneously and the shape of the trace is more complicated. Fig. 3, for example, shows the trace resulting from a complex signal containing three delayed signals with path differences of 8km, 16km and 24km. Signals containing even more components and producing more complicated displays may be encountered at sites which are unfavourably situated for v.h.f. reception.

A source of difficulty in interpreting the display is doubling of the trace due to phase shift of the amplitude modulation. The display shown in Fig. 2 represents a low modulation frequency and a comparatively small path difference so that the forward and return traces are almost exactly superimposed. If either the modulation frequency or the path difference is increased, the reflected signal delay becomes a significant fraction of the frequency modulation period, resulting in appreciable de-phasing of the amplitude modulation and a doubling of the trace in the oscilloscope display. An additional cause of differential displacement of the forward and return traces is the inevitable, but small, distortion of the discriminator output which arises from the unwanted phase modulation of the signal due to reflection.

Both of these effects are inherent in multipath propagation and contribute more to the blurring of the display when receiving programme than do small deficiencies in the phase characteristics of the equipment. Despite these limitations it has been found in practice that the display can be interpreted with reasonable accuracy on programme material.

An example of the type of display obtained with programme modulation is shown in Fig. 4 (a). In this case the programme was a news reading and the signal contained five delayed components with the following path differences and relative amplitudes:—1,000 ft, 25%; 2 miles, 10%; 5 miles, 10%; 10 miles, 5% and 15 miles, 5%. Fig. 4 (b) shows the display given by the same complex signal but with the transmission modulated ±75kc/s with 120c/s tone. The complex signals represented in Figs. 2, 3 and 4 were produced with a laboratory multipath simulator which generates the reflected signals artificially using a magnetostriction delay line. One type of reflection which operation on programme may conceal or make difficult to measure is that from a near object. This type of reflection gives rise to a more gradual change of amplitude with a variation of frequency than does a long path-difference reflection, so that only a fraction of a cycle appears on the display, resulting in either a broad maximum or minimum or a tilt of the trace. Fortunately, although this type of reflection may be quite large in amplitude when compared with longer distance signals, it is of little importance from the distortion viewpoint.

When using this apparatus to determine the best position for a receiving aerial the signal from each of the local transmitters should be examined to ensure that good performance on one programme is not obtained at the expense of another.

To aid in the estimation of acceptable levels of multipath propagation a table has been compiled, showing the result of a listening test made by the B.B.C. A high-grade loudspeaker and a receiver having good a.m. suppression (50dB) were used; the programme material—a piano recital—was of a type which is particularly susceptible to the form of distortion produced by multipath propagation. Whilst the reduction of secondary-signal relative amplitude to below the figures shown should result

TABLE

Path difference (miles)	2	5	10	15
(km)	3.2	8	16	24
Amplitude relative to main signal	57%	22%	6%	4%

Relative amplitude of a single secondary signal in multipath propagation giving "perceptible" distortion on a good receiver using critical programme material.

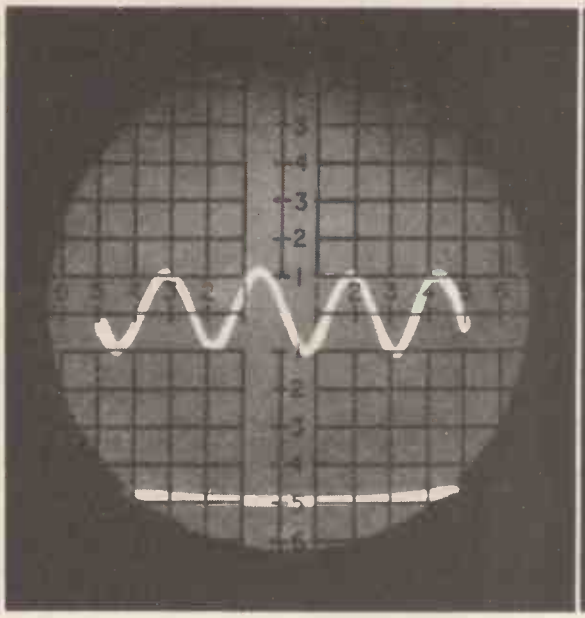


Fig. 2. Photograph of display showing one delayed signal of excess path length 8km, amplitude 20% of direct signal. The base line is recorded by a second exposure.

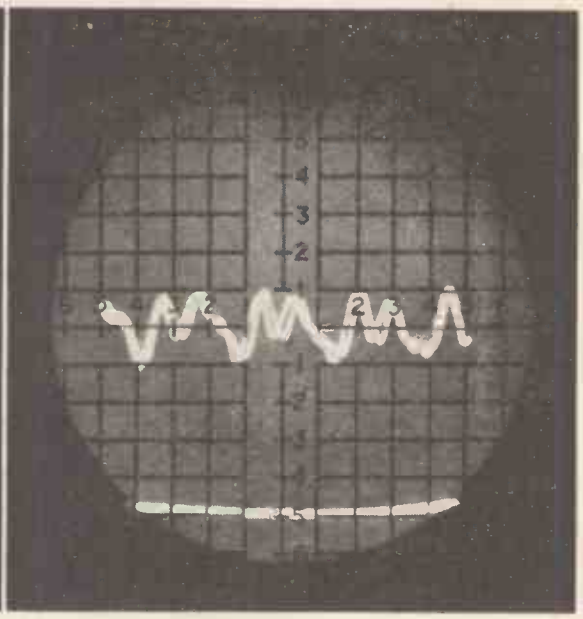


Fig. 3. Display given by complex signal with three delayed signals of path-length differences: 8km, 16km and 24km. Amplitude of each delayed signal is 10% of direct signal.

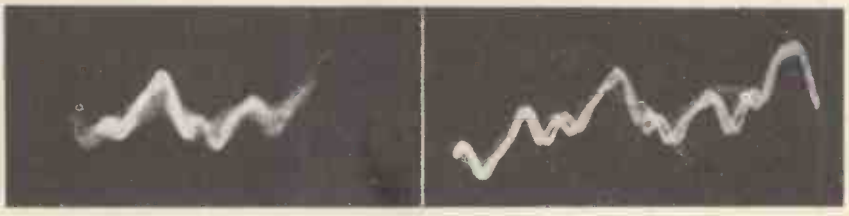
in satisfactory service when using a "good" receiver, these values may have to be halved if a receiver with poor a.m. suppression is used. For speech, on a good receiver, an interfering signal of amplitude twice—or even three to four times in the case of the larger path differences—that of the direct signal may be present before distortion is heard.

Circuit Details

A display of the type required can be produced quite simply with a f.m.-tuner unit which employs a saturated grid limiter and a balanced discriminator together with a small direct-coupled oscilloscope. Some slight modification to the tuner is required to extract the voltages (including the d.c. component) developed at the limiter grid and the discriminator output. However, for accuracy and ease of use, some refinements are desirable and some of those fitted to the B.B.C. apparatus are shown in the "skeleton" circuit of the i.f.-amplifier limiter and discriminator sections of the tuner (Fig. 5.)

The a.m. output to the oscilloscope Y-amplifier is taken from the limiter control grid (V3) through a 100-kΩ "filter" resistor: section (c) of S1 earths this line in the "set-zero" position so that the oscilloscope spot may be set at the bottom of the graticule. Another section (b) of S1 earths the X-input terminal for horizontal centring of the spot, in the "set-zero" position and connects this terminal to a preset potentiometer across the 6.3-V heater supply when set to "calibrate." This potentiometer is set up either with the aid of a signal generator giving an f.m. output of standard deviation, or by comparison with 440c/s continuous tone (deviation ±18kc/s) radiated by the Network Three transmitters before programme transmission starts, to give an output equal to that given by the discriminator when demodulating a ±75kc/s-deviated signal. Thus the X-gain control can be set in the absence of a signal generator. S1(a) earths this calibrating voltage to avoid hum being induced into other circuits in the "use" or "zero" positions. So that this calibration is reliable the tuner must have good static limiting, i.e., the discriminator output must not vary with changes of signal strength.

For the a.m. output from the limiter to be usable amplitude limiting must not occur in the tuner prior to the limiter control grid, i.e., the receiver must accept all input signal strengths which it is likely to encounter and amplify them in a linear manner. If limiting does occur the vertical deflection of the oscilloscope will be distorted, and, to avoid this an a.g.c. circuit is fitted, fed from the limiter grid: the limiter grid current also operates a signal-strength meter. Without the provision of gain-stabilising measures in the tuner this meter can be expected to have a short-term accuracy of about ±6dB. Whilst the a.g.c. circuit is most helpful in obtaining



(a) (b)

Fig. 4. Display of complex signal containing the following delayed signals:— 1,000ft, 25% relative amplitude referred to main signal; 2 miles, 10%; 5 miles, 10%: 10 miles, 5% and 15 miles, 5%. (a) Programme (news reading). (b) Tone (±75kc/s at 120c/s).

a linear display and in reducing the amount of "knob-twiddling" necessary during the setting up of an aerial, it can, under some conditions of propagation, cause the display to jitter in sympathy with the programme modulation. To avoid this a switch (S2) is provided by which the a.g.c. potential may be replaced by manual gain-control bias which is obtained from the 6.3-V heater supply, via a point-contact diode. When operating on manual gain control it is essential that the i.f.-gain-control potentiometer is not set at too high a level, as this may result in overloading of the i.f. amplifier. This can be avoided by first setting-up the receiver on a.g.c., then switching to manual control and adjusting the i.f.-gain control to give the same vertical deflection of the oscilloscope trace. To avoid detuning effects in the first i.f. amplifier when its bias is varied, a 41-Ω unbypassed cathode resistor is used to provide negative voltage feedback.

No firm figure can be set for the maximum gain required prior to the limiter grid, but the gain should be sufficient to ensure that the signal does not drop below about 1V (pk) at this point; because, below this level, detection is markedly non-linear.

Three more requirements for the tuner are a flat i.f. response over the ±75kc/s swept by the f.m. carrier, a highly stable local oscillator and good a.m. rejection. As the vertical deflection of the trace is dependent on the gain of the tuner, any humps in the i.f. response will be displayed on the oscilloscope—$\pm\frac{1}{2}$dB variations are not a nuisance.

Good local-oscillator stability is desirable because it avoids continuous retuning when the receiver is first switched on.

A.F.C. was fitted to the tuner used in the equipment; but it was found to be necessary to increase its time constant to a value of the order of 1 sec. to avoid phase distortion of the display. This makes tuning tedious as a result of the rather sluggish action of the a.f.c. in tending to compensate for tuning adjustments. A switch (S3) has, therefore, been added so that the a.f.c. can be disconnected when tuning. No tuning indicator is needed as the correct horizontal centring of the display indicates the correct tuning point.

The output from the discriminator must not contain a.m. products of sufficient amplitude to be seen in the display. Thus good a.m. rejection is required in the limiter, and this must remain good down to the lowest signal input at which the test-set is required to work. With the component values shown in the circuit diagram and an adequate amount of pre-limiter gain an a.m. rejection factor of 35dB was achieved for a signal input of 30μV, rising to 40dB over the range 100μV to 10mV. It should go without saying that the discriminator must be linear and equally balanced about earth.

One other limitation imposed upon the equipment is by the bandwidth of the Y-amplifier. The amplitude modulation resulting from multipath propagation contains components which are high harmonics of the original modulation frequency. If the bandwidth of the Y-deflection channel is restricted, these components can be severely attenuated when the fundamental modulating frequency is high, particularly if the path difference of the principal delay signals are also large; and this will reduce the apparent depth of amplitude modulation. In the original apparatus, the gain of the Y channel was 3dB down at 13kc/s.

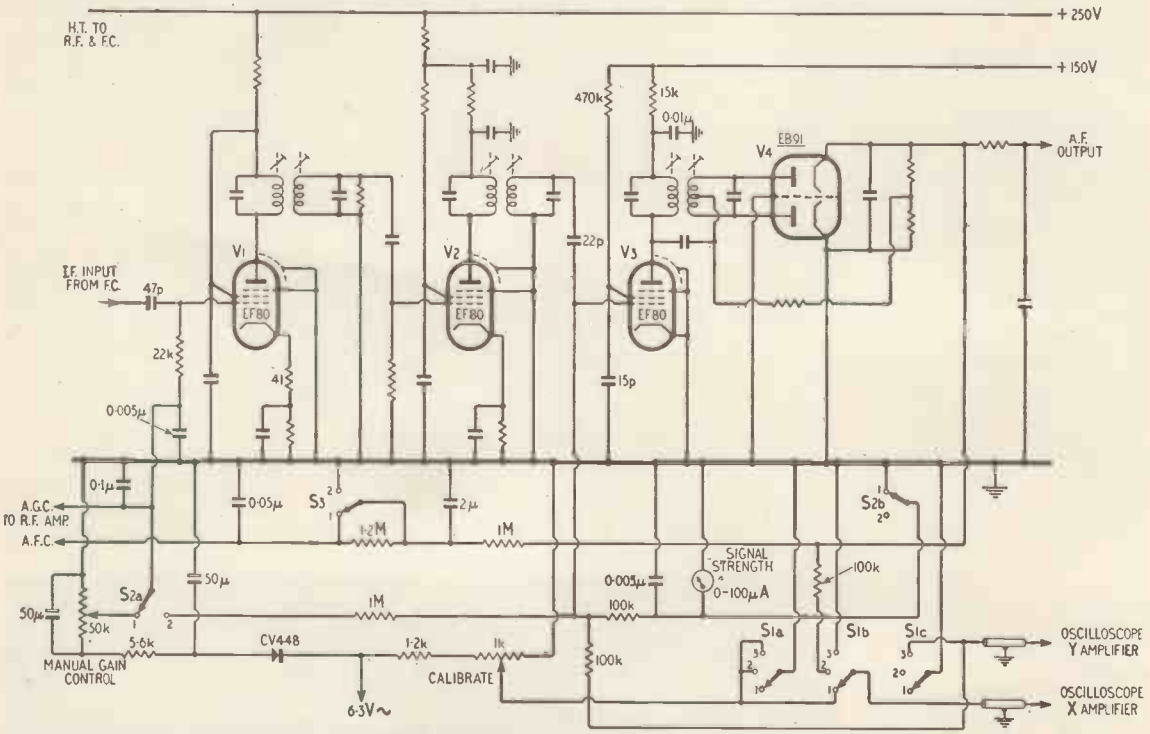


Fig. 5. Skeleton circuit diagram of modifications by B.B.C. to tuner to feed display-tube direct-coupled amplifiers. Switch functions and positions:—S1: position 1, "calibrate"; 2, "operate"; 3, "set zero"; S2: 1, "manual gain control"; 2, "a.g.c." S3: 1, "a.f.c. on"; 2, "a.f.c. off."

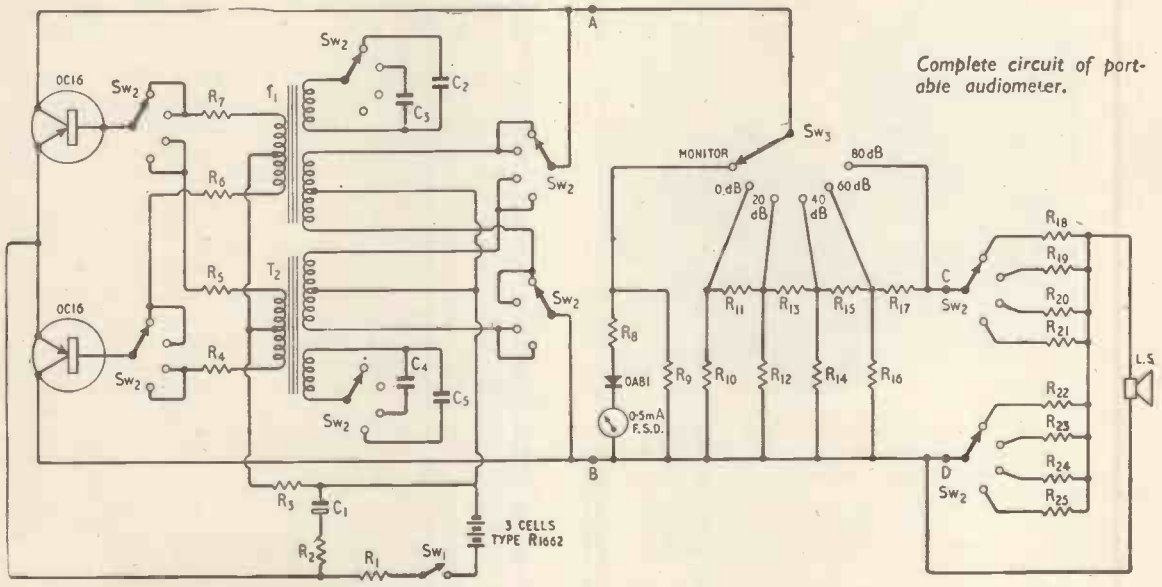
Transistorized Audiometer

Simple Portable Unit for Testing Children's Hearing

By H. J. F. CRABBE and P. DENES, M.Sc., A.M.I.E.E.

WHEN testing the hearing of small children, it is often useful to have an audiometer which is small enough to be carried around the room easily and which does not intimidate the child by its appearance. It must produce a high enough sound intensity at the subject's ear even when held several feet away, because putting the instrument too close to the child would distract it. In addition, it should be possible to operate the controls unobtrusively and to carry the instrument easily in one hand. Since such an instrument would not be used for detailed testing it is sufficient to have only a small number of output intensities and frequencies available. This article describes the construction of an audiometer which fulfils these mechanical requirements and produces sounds at four frequencies—500 c/s, 1 k/cs, 2 kc/s and 4 kc/s—and five intensities—0, 20, 40, 60, 80 dB above normal threshold.

Basic Description.—In essentials, the instrument comprises an oscillator, attenuator and loudspeaker, all mounted in one small box. Assuming the use of transistors in the generating circuit, the lower limits of size and weight are determined by the loudspeaker with its mounting, and the battery for the power supply. The capacity of the battery is in turn dependent on the consumption of the circuit and on the permissible frequency of battery replacement. It was decided to use a 3½-in speaker of standard design, and the unit chosen had the best efficiency and smoothest frequency response compatible with a moderate size of magnet. Using a totally enclosed box, it was found that only 1/10 W was required to produce the 80 dB level at 1000 c/s, and less than this at higher frequencies. At 500 c/s, the efficiency can be maintained by using the restricted air volume behind the cone to raise the resonant frequency of the speaker to approximately 400 c/s. The unit used in the prototype had a free air resonance of



Complete circuit of portable audiometer.

TABLE OF COMPONENTS

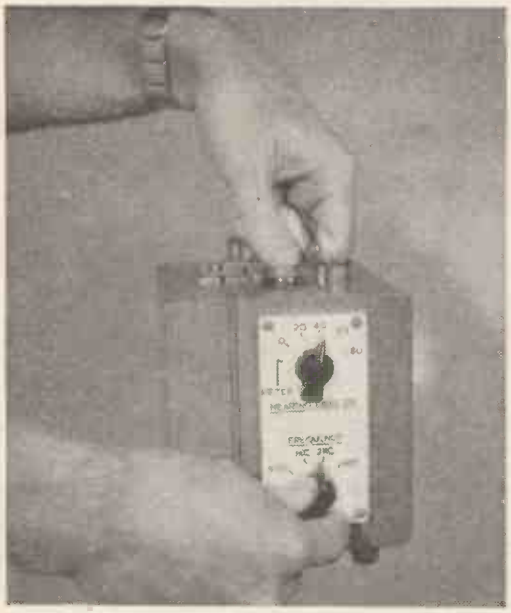
	R_1	10Ω	1W
	R_2	10Ω	½W
	R_3	330Ω	½W
See text	R_4	132Ω	½W
	R_5	132Ω	½W
	R_6	170Ω	½W
	R_7	170Ω	½W
	R_8	1.3kΩ	½W
	R_9	20Ω	½W
	R_{10}	22Ω	½W
	R_{11}	200Ω	½W
	R_{12}	24Ω	½W
	R_{13}	200Ω	½W
	R_{14}	24Ω	½W
	R_{15}	200Ω	½W
	R_{16}	24Ω	½W
	R_{17}	200Ω	½W
See text	R_{18}	5Ω	½W
	R_{19}	10Ω	½W
	R_{20}	15Ω	½W
	R_{21}	15Ω	½W
	R_{22}	∞	
	R_{23}	51Ω	½W
	R_{24}	10Ω	½W
	R_{25}	10Ω	½W

	C_1	500μF, 6V wkg	See text	C_4	0.156μF
See text	C_2	0.188μF		C_5	0.037μF
	C_3	0.044μF		L.S.	Elac 3D/10

T_1 and T_2 are wound on Ferroxcube LA7 pot core assemblies.

T_1 Tuned winding: 900 turns of 40 s.w.g. enamelled (0.55H).
Both c.t. windings: 44 turns of 28 s.w.g. enamelled.

T_2 Tuned winding: 250 turns of 34 s.w.g. enamelled (0.04H).
Both c.t. windings: 16 turns of 24 s.w.g. enamelled.



Two views of the completed audiometer.

230 c/s, and the air volume in the box after the insertion of components was 26 cu in, which brought the peak up to 390 c/s. Allowing for losses in an attenuator and in the components which correct for variations of loudspeaker impedance with frequency, a maximum power of $\frac{1}{4}$ W is needed from the transistor circuit.

Oscillator.—This moderate requirement of $\frac{1}{4}$ W can be met with ease by the simplest of tuned-transformer oscillators, using a push-pull arrangement for a good waveform. The circuit is shown in the diagram, where it will be seen that a pair of OC 16s are used. These are power transistors capable of delivering several watts, but they are employed here to achieve complete reliability and safety, for with continuous oscillation their maximum dissipation is never reached, even at high ambient temperatures. In addition, no heat sink is required, which is a great asset with the rather tight packing of components in the finished unit.

The output of the oscillator appears between the transistor collectors and is fed into the attenuator at points A and B in the circuit. This voltage is also coupled back to the transistor bases by means of the centre-tapped transformer windings, and resistors R_{4-7} are chosen to produce the maximum output consistent with a pure waveform. The frequency of oscillation is determined by the tuned winding on each transformer, and condensers C_{2-5} are adjusted to give 500 c/s, 1 kc/s, 2 kc/s and 4 kc/s respectively. It is not possible to cover the whole range with one transformer, because an inductance which provides a sufficiently high dynamic impedance to avoid shunting the resistive load at low frequencies will be too heavily damped to prevent distortion at high frequencies, and vice versa. The base circuits are returned to the negative line via R_3, and this, in conjunction with the common emitter resistor R_1, provides a high degree of d.c. stability. R_2 and C_1 prevent very rapid changes of the supply voltage as the on/off switch is operated; this ensures a smooth rise and fall for the oscillatory envelope, thus preventing audible " clicks " in the output. This is in conformity with the British Standards Institute specification for audiometers.*

Attenuator and Loudspeaker Circuit.—The attenuator is of the simple ladder variety, with four 20 dB steps, and offers a load of 20 Ω to the oscillator. At this low impedance stray capacity is of no consequence and the whole assembly is mounted on a small Yaxley type switch (Sw 3). An additional switch position connects the oscillator to a monitoring meter, and R_8 is adjusted to provide full scale deflection at 1 kc/s. The meter may be calibrated in dB and is useful for checking the state of the battery as reflected in amplitude of oscillation. The output of the attenuator is fed to the loudspeaker circuit, and the resistors R_{18-25} are arranged to produce the correct level at the loudspeaker terminals at each frequency. As this will vary from one speaker to another, individual adjustment is necessary.

The best procedure here is to mount the speaker and components in the box in their final positions, bringing out a separate pair of wires from the loudspeaker coil. First measure the loudspeaker impedance at the four frequencies. Then at each frequency in turn connect a resistor in series with the speaker which, in combination with the measured loudspeaker impedance, will produce an attenuation of exactly 80 dB. Place the instrument in an anechoic chamber and adjust the input voltage so that the tone is just perceptible at a distance of three feet. If this is repeated with a number of subjects, the mean values of input voltage will approximate to those required at the speaker terminals to produce a signal 80 dB above normal threshold level.

With the attenuator set to 80 dB hearing loss (zero attenuation) and a 22 Ω resistor connected between C and D in place of the loudspeaker network, the output of the oscillator can be measured at each frequency. The difference between these voltages and those ascertained as above represents the attenuation to be introduced by R_{18-25}. It simply remains to choose values producing this attenuation and to ensure that in combination with the loudspeaker impedance they always offer a load of 22 Ω to the attenuator between points C and D. The various figures relevant to this setting up procedure as measured on the prototype are shown in the table,

*B.S. 2980: 1958, " Pure Tone Audiometers."

Frequency (c/s)	Loudspeaker impedance in Ω as finally mounted in sealed box	R.M.S. volts at loudspeaker with 80dB hearing loss	R.M.S. volts between points C and D into 22Ω load with zero attenuation (80dB hearing loss)
500	17.5	1.51	2.00
1000	16.5	1.27	2.32
2000	19.0	0.57	2.00
4000	23.0	0.69	2.14

Table showing, at the four frequencies used, the loudspeaker impedance, the voltage needed at the loudspeaker, and the output obtained from the oscillator, all as measured on the prototype.

and the values of R_{18-25} given are for this particular loudspeaker and pair of transistors.

Construction.—The whole circuit is contained in a wooden instrument case which is approximately a 5-in cube. The loudspeaker is fixed in the side remote from the lid, and its front protected by a suitable decorative grille. The complete unit is shown in the two photographs, and it will be noticed that the attenuator and frequency switches are mounted on one side, and the small monitoring meter on the other. The case is held by the left hand, and the on/off switch (Sw 1) is a bell push operated by the thumb. This leaves the other hand free to adjust the level and frequency. The battery consists of three large $1\frac{1}{2}$-V cells connected in series, and is accommodated in the lid. The main body of the box is completely sealed off to avoid changes in loudspeaker loading when the battery is replaced. The instrument would normally only be used to produce short bursts of tone from time to time, so many months of life could be expected from a set of cells. The consumption is approximately $\frac{1}{4}$ A.

This audiometer has been used successfully in the Audiology Department of a London hospital for some months. The principles of using such a device for testing the hearing of small children and clinical experience with it are described elsewhere.†

† P. Denes and M. Reed, "A Portable Free Field Audiometer," *The Lancet*, Vol. 2 (1959), p. 830, Nov. 14th.

BOOKS RECEIVED

Fundamentals of Radio and Electronics. Edited by W. L. Everitt. Completely revised and rewritten edition of this standard textbook, including much new material on transistors, monochrome and colour television, radar and navigational aids and industrial electronics. There is an introductory chapter on the elementary mathematics of radio and electronics. Pp. 805; Figs. 596. Price 57s 6d. Constable & Co., Ltd., 10, Orange Street, London, W.C.2.

Encyclopédic des Isolants Electriques. Succinct classification in 27 synoptic tables of electrical insulating materials, their physical and chemical properties, behaviour under operating conditions, and precautions to be taken in their application. Pp. 80. Price 22 Swiss francs. L'Association Suisse des Electriciens, 301 Seefeldstrasse, Zurich 8.

Corrosion of Metals by Vapours from Organic Materials, by Vera E. Rance and H. G. Cole. Booklet issued by the Corrosion and Electrodeposition Committee of the Inter-Services Metallurgical Research Council (Admiralty and Ministry of Supply) giving a survey of instances of corrosion, both under laboratory and service conditions, arising from vapours exhaled from woods, glues, varnishes, plastics, etc. The effect of volatile corrosion inhibitors on metals other than steel is mentioned. Pp. 25. Price 2s. H.M. Stationery Office, York House, Kingsway, London, W.C.2.

Fifteen Years of Semiconducting Materials and Transistors. A classified bibliography and author index compiled by N. L. Meyrick. Pp. 75. Price 5s. Newmarket Transistors Ltd., Exning Road, Newmarket.

Mobile Radio Telephones by H. N. Gant, A.M. Brit.I.R.E. A book written primarily for potential users outlining its possible applications and limitations, how to obtain a licence, performance requirements, installation, maintenance and testing. Pp. 125; Figs. 21. Price 21s. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2.

Guide to Mobile Radio, by Leo G. Sands. Handbook of American practice describing systems, transmitters, receivers and maintenance. Pp. 160; Figs. 116. Price $2.85. Gernsback Publications Inc., 154 West 14th Street, New York 11.

Library Services and Technical Information for the Radio and Electronics Engineer. Primarily a catalogue of the books and periodicals available to Brit.I.R.E. members, but contains also useful information on other libraries, translation services, standards and specifications and international bodies concerned with radio and electronics. Pp. 72. Price 2s 6d. The British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1.

Television Servicing, by Alex Levy and Murray Frankel. Illustrated index of typical faults and step-by-step procedures for servicing as applied in American television receiving sets. Pp. 534; Figs. 348. Price 43s. McGraw-Hill Publishing Co., Ltd., 95 Farringdon Street, London, E.C.4.

Principles of Electronics, by H. Buckingham, Ph.D., M.Sc., A.M.I.E.E., and E. M. Price, M.Sc.(Tech.), A.M.I.E.E. Second edition of this textbook for technical colleges includes new chapters on transistors and magnetic amplifiers. Test questions (and answers) are given for each of the 20 chapters. Pp. 419; Figs. 302. Price 17s 6d. Cleaver-Hume Press Ltd., 31 Wrights Lane, London, W.8.

A First Course in Television, by "Decibel." Complementary volume to "A First Course of Wireless" by the same author giving an elementary technical description of the essentials of monochrome and colour television systems and of the basic functions of receiver circuit elements. Pp. 149; Figs. 106. Price 15s. Sir Isaac Pitman & Sons Ltd., Parker Street, London, W.C.2.

Junction Transistor Electronics, by Richard B. Hurley. Exhaustive treatise on the semiconductor triode, its physical action and the design and performance of associated circuits for low and high signal amplification at low and high frequencies, switching circuits and transistor-saturable reactor circuits. Pp. 473; Figs. 240. Price 100s. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2.

The Bomber's Eye, by Group Captain Dudley Saward, O.B.E. Personal account of the development, adoption and operational use of H_2S (airborne plan position indicator). Pp. 265 with 10 plates. Price 21s. Cassell & Co., Ltd., 35 Red Lion Square, London, W.C.1.

LETTERS TO THE EDITOR

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

Early Public Address

REGARDING "Free Grid's" first item in the October issue, you may be interested to learn that my father, Fred Warren, provided p.a. for the General Election of 1922. Besides what could be called "mobile" gear for open-air meetings, he relayed the speeches of the meetings at the Luton Assembly Hall to the crowd outside. One speaker in this campaign was the late George Bernard Shaw.

I am currently engaged in locating as much information as possible on early p.a., for, in my capacity as Hon. Librarian of the A.P.A.E., I intend to have an historic exhibit at the 1960 Exhibition. I have contacted Mr. Peter Jensen, of Forest Park, U.S.A., for he recently wrote of providing p.a. as early as 1910, employing "a heavy duty (carbon) microphone, battery and sensitive receiver on a horn." He relates how this equipment was used for political work immediately after the first World War.

I would welcome any assistance and suggestions in connection with the proposed exhibit. Old gear is very hard to come by; I am trying to locate a copy of the instruction manual for the early Marconi gear, also Western Electric.

88, Wellington Street, Luton, Beds. HAYDON G. WARREN.

"Hum, Rumble and Noise"

IN his excellent article "Hum, Rumble and Noise," in the October issue, Mr. Cooke states that hum due to the stray field from a turntable motor is reduced 2dB when the motor voltage is reduced from 240V to 200V. This is hardly more than the 1.6dB reduction one would expect if the stray-field/motor-current relationship were linear. In any case a reduction in motor power with consequent danger of increased wow and longer run-up time seems rather a high price to pay for such a small improvement in hum level; surely one does not notice a 2dB change at 50c/s. However, if Mr. Cooke's experience shows that this reduction is worth while, perhaps turntable manufacturers will consider increasing the turns on the motor windings to give a reduced stray field.

London, E.C.2. A. R. NICOLL.

The author replies:

Mr. Nicoll is correct in pointing out that the reduction in stray field is little more than that expected for a linear voltage/current/stray field relationship. It is, however, 25% more even with the high-class motor used for the tests. Other motors running well into saturation may well show a more pronounced reduction.

When serious hum is encountered, very possible reduction becomes worth while and a drop of 2dB certainly worth having.

The average synchronous or induction motor is not worried by the slight loss of torque resulting from a 20% reduction in voltage. Other factors, such as slippage between idler and motor shaft, usually have a greater effect.

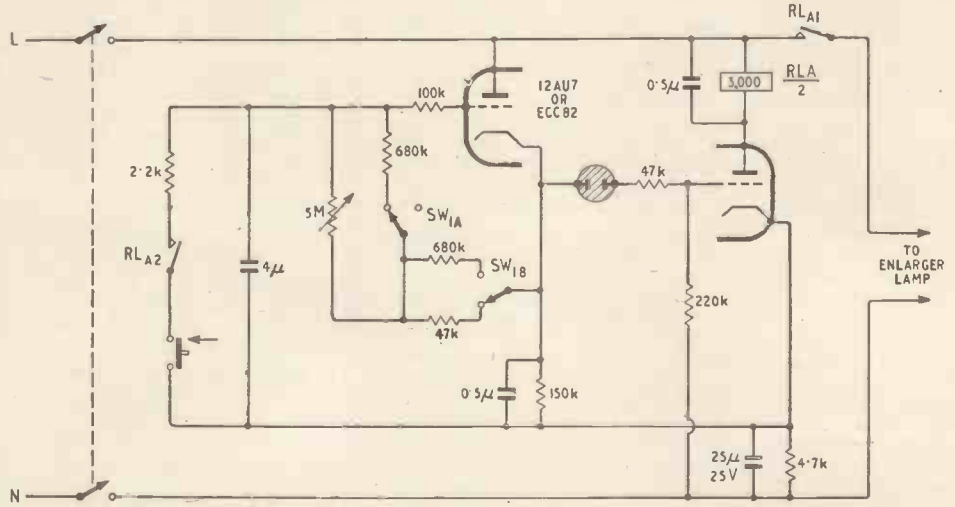
RAYMOND E. COOKE.

"Inexpensive Photographic Timer"

THE problem mentioned by your correspondent H. d'Assis Fonseca in the June, 1959, issue can be overcome in what I regard as a more simple way, by separating the two functions of the circuit (timing and relay closure). One valve is used in a bootstrap charging circuit as before, to raise the cathode potential until the neon strikes. (The type is that used as a panel indicator light, e.g., Hivac CC7L.) This gives clean operation of the relay.

The use of only one valve in the timing circuit will necessitate some rearrangement of the timing components to give similar intervals. An alternative arrangement is shown, giving two ranges (1-10 sec. and 10-100 sec.) on one control knob with a range-change switch.

The second relay contact, in series with the push-button (this is considered preferable to a switch), ensures consistent discharge of the timing capacitor, although it could be omitted if one is prepared to hold the push-button in for a full second or so. This will admittedly allow more complete discharge to occur, permitting the use of lower value resistors in the timing circuit. The basic principle of Mr. Jowett's excellent circuit (August, 1958, issue) remains, whatever detail variations one chooses to use.



Croydon, Surrey. K. HARDISTY.

Electrocussion

MAY I humbly take "Free Grid" to task for seeming to condone careless handling of electrical and electronic equipment? In the Services we are taught that "Electric shocks are not an occupational hazard" and that the receipt of an electric shock should be followed by a post-mortem* to avoid repetiuon.

London. GEORGE M. SMITH.

* [Metaphorically and not literally, we hope. Ed.]

DUMMY AERIALS

Resistive Load with Visual Indicator for Aligning Low-power Transmitters

*By H. B. DENT**

Fig. 1. One of the dummy aerials described in the text.

THE preliminary adjustments to a small radio transmitter often take a considerable time, and under no conditions should they be carried out with the normal transmitting aerial connected to the set. Adjustments can often be made with the d.c. input power to the valves reduced to below damaging "no-load" values, but eventually the time arrives when final adjustments have to be made on full power. Again a radiating aerial is undesirable as such adjustments can take longer than one realizes at the time and until it is required actually to transmit a message, or request a "contact" by means of a CQ call, all testing ought to be effected with a dummy load in place of the aerial.

Probably the most common type of dummy aerial load is an ordinary electric lamp of a wattage suitable for the expected power output of the transmitter. Lamps are all very well in their way and if output powers much over 15 watts are involved they form one of the most economical types of load to employ. However, with output powers under 15 watts, and with resonant aerials such as half-wave dipoles or Yagis, the opportunity is available to use simulated aerial loads which in the writer's experience are far superior to lamps and not unduly costly.

The dummy aerial illustrated in Fig. 1 was made for use with a small mobile v.h.f. transmitter-receiver giving 6 to 7 watts r.f. output, but others capable of dissipating 15 watts or so have also been constructed on similar lines.

As will be seen from Fig. 2 the device consists of a number of carbon-rod resistors connected in parallel and with a small flashlamp bulb, or similar low-current lamp, joined in series with them and with the input cable. The latter is a short length of 75Ω coaxial feeder terminating in a coaxial cable plug.

Fig. 1 shows the actual form of construction adopted and its principal merit perhaps is that in addition to being a convenient form of assembly for a dozen or so resistors, it ensures that no matter how many resistors are used all are equidistant from the common point of attachment of the feeder cable. This can be important at v.h.f. since quite short lengths of wire have appreciable impedance and with connecting wires of different lengths some resistors would be dissipating more than their quota of the available r.f. power. As a result some will tend to become excessively hot if the power dissipated in the load is about the maximum for which it is intended.

The dummy aerial consists of seven 1-watt carbon-rod resistors connected top and bottom to 1½-in diameter rings made from No. 18 s.w.g. copper wire. A short piece of ¼-in diameter copper tube is held centrally in the lower ring by means of four 18 s.w.g. wire arms soldered to the lower ring (see Fig. 1). Through this is threaded the coaxial cable after removing sufficient of the outer insulation to enable it to extend up the centre of the cylinder of resistors as far as the top ring.

The copper braid on the cable is unravelled down to the top edge of the ¼-in tube, twisted into pigtails and soldered to the 18 s.w.g. wire arms positioning the tube. The tube forms an anchorage for the coaxial cable at the same time preserving the symmetry of the assembly.

The indicator is a small flashlamp bulb, its centre pip being soldered to the centre conductor of the coaxial cable and its base ring joined by two short pieces of 18 s.w.g. wire to the top ring of the bank of resistors. It is quite safe to solder the wire supports to the lamp provided reasonable care is taken.

The reason a number of 1-watt resistors is used instead of one large fat resistor of the required wattage is perhaps best explained by reference to an article by Dummer[1] on the characteristics of resistors at very high radio frequencies. As the dummy aerial was primarily intended for use on 145Mc/s and higher, the type of rod resistor which was shown by the data in Dummer's article as being suitable for the purpose was employed.

Briefly stated, at frequencies of 100Mc/s and higher, long, thin carbon-rod resistors have better r.f. characteristics than short, fat ones. Some curves are given by Dummer from which it is possible to assess the effective r.f. resistance over a wide range of very high radio frequencies of different values of carbon-rod resistors of the "long and thin" variety, and

* Amateur Radio Station G2MC.

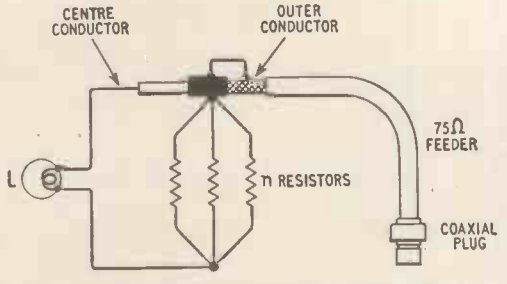


Fig. 2. Theoretical circuit of the dummy aerial.

from these it was deduced that about 85% of the d.c. resistance of a 1-watt resistor under 1kΩ in value would be effective at radio frequencies of the order of 145Mc/s, with a progressively falling percentage at higher frequencies.

In consequence of this, seven 1-watt carbon resistors of 560 ohms each (±5% tolerance) were used for the 7-watt dummy aerial. With all the resistors connected in parallel the d.c. resistance is nominally 80Ω, and 85% of this is 68Ω, which, with the little extra resistance of the series-connected flashlamp bulb, brings the total to close on the nominal 75Ω of the average halfwave dipole and the most common types of coaxial feeders.

As a point of interest, the d.c. resistance of small flashlamp bulbs varies considerably with the temperature of the filament. Some of the 0.3-A type measured showed a d.c. resistance when cold of between 2 and 3Ω, and while a 3.5-V lamp should be 11Ω approximately when taking the full 0.3A, below full brilliance its resistance might be anything from 5 to 11Ω.

Of course, the lamp is only an indicator of power in the dummy load, it is no use for quantitative measurements. However, if a few measurements are made with known amounts of watts (d.c.) dissipated in the load, and the brilliance of the lamp can be memorized, an approximate estimate of r.f. power in the load can often be made.

If exact measurement of power is needed for any purpose the method described in the article "Double Tetrode Oscillator"[2] can always be employed.

REFERENCES

[1] Dummer, G. W. A., "Characteristics of Fixed Resistors," *Wireless World*, June 1956, p. 263.

[2] Andreae, J. H., and Joyce, P. L., "Double Tetrode Oscillator," *Wireless World*, April 1958, p. 173.

Manufacturers' Products

NEW ELECTRICAL EQUIPMENT AND ACCESSORIES

Airborne Engine Analyser

A NEW instrument from Ultra Electric, Ltd., is the Engine Condition Analyser Type UE91, which displays in flight the outputs from temperature- and vibration-sensing elements applied to the engines of an aircraft. Up to 40 thermocouples and eight vibration transducers, shared between four engines, can be used, and the outputs from these are gated sequentially at 2,000 p.p.s. to provide Y-deflection on two cathode-ray tubes—one for temperature, the other for vibration. The X-deflection is a normal timebase, so that a row of square pulses whose amplitudes represent temperature and vibration is seen on the screen of each cathode-ray tube. Detailed examination of the temperatures associated with any one engine is catered for by switching in a "strobe" timebase. One horizontal line on the display gives the normal pulse-base positions for take-off, climb, cruise and descent (selection by front-panel switch) and read-out of any individual temperature is accomplished by lining up another line with the top of the equivalent pulse. The vibration display is of first-order amplitudes of vibration only (those vibrations corresponding to engine-rotation speed) and in this case a horizontal line provides a danger-warning facility.

Ultra engine-condition-analyser display unit.

The equipment uses transistors extensively and it is contained in two "boxes" weighing 23 lb (9.1kg) without cabling. Power consumption is 60VA at 115V, 400c/s.

Precision Digital Turns Counter

A CONTROL which records visibly the whole number and fractions of turns made to a multi-turn component such as, for example, a helical potentiometer, is now obtainable from General Controls, Ltd., 13-15 Bowlers Croft, Honywood Road, Basildon, Essex.

In the model illustrated (CM3) three digital dials engraved with easily-read figures record up to a maximum of 10 turns (3,600° rotation of spindle) the dials showing full turns, tenths and hundredths of a turn respectively. This model has a shaft lock incorporated for a ¼-in spindle.

Digital dials are black with white figures and the overall depth is 1.37in. The accuracy of reading is ±0.002 turn.

General Controls precision turns counter with three digital dials.

Tape Loop Cassette

PHILIPS are now marketing a tape loop cassette, Type EL3963/00, which, though intended primarily for use with their AG8108G tape recorder, can also be used with certain other recorders in which the spool-drive spindle on which the cassette is placed can be locked stationary during recording or playback, and in which, in addition, the tape travels from left to right. The cassette contains 190ft of long-playing tape, and this can be played at 1⅞, 3¾ or 7½in/sec thus giving 10 minutes playing time at 3¾in/sec with proportionate times for the other speeds. Both sides of the tape are coated with magnetic oxide and one side is coated with graphite to reduce friction between adjacent layers of tape. The playing time can thus be doubled by breaking the loop and giving one

end of the tape a 180° twist before resplicing so as to connect together the two sides of the tape. The locked recorder spool spindle has a friction pad placed over it so as to hold still the nylon cassette spindle (which is joined to the upper cassette flange). The cassette

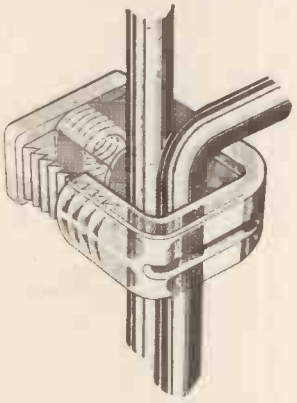
Philips Continuous Tape Cassette.

spindle fits in a hole in a truncated conical nylon collar which is joined to the lower cassette flange. This lower flange and the conical collar rotate as the tape moves; the collar being made conical so as to incline the inner turns of the tape away from the central spindle. The EL3963/00 cassette costs £5, and is marketed by Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

Polystyrene Cable Clamp

THE "Quickclip" is designed for the clamping of bunches of cables or multi-wire harnesses in such a way that the replacement or addition of individual wires can be carried out with the minimum of difficulty.

Moulded from high-impact polystyrene, the clamp is in two parts, a U-shaped top (serrated across the inside of the "legs") and a base which fits into the upper portion. The base carries serrations on the outside edges and can be held in position either by a woodscrew or a bolt, for which the base is threaded. The clamp can be released by working it from side to side, so releasing the grip of the serrations.



Alma Components "Quickclip" cable clamp.

The "Quickclip" is marketed by Alma Components Ltd., of 551, Holloway Road, London, N.19, and is available in sizes suitable for cables from $\frac{3}{16}$-in diameter (14s 3d per 100) to $1\frac{1}{4}$-in (67s 6d per 100).

Safety Mains Connector

THE "Safebloc" is designed for the safe, quick and easy temporary energising of mains-powered apparatus without the bother of fitting a plug. It consists of a moulded plastics box carrying the stationary contacts of a double-pole switch mechanism and three "bulldog-type" colour-coded clips for quick connection to bared flexible-cable ends. In the deep lid are mounted the moving contacts of the switch and clips to accept cartridge fuses to BS1392 (ring-main plug fuses, ratings 2 to 13A) and the lid is so hinged that raising it disconnects from the exposed metal work both live and neutral poles of the mains supply. The unit carries holes for mounting screws and terminals are provided for the connection of the supply, at the rear, under a removable plate. Maximum rating is 250V, 13A, a.c., and the manufacturers are Rendar Instruments Ltd., Victoria Road, Burgess Hill, Sussex.

Safety mains connector with lid open. Closing lid applies power to cable clips.

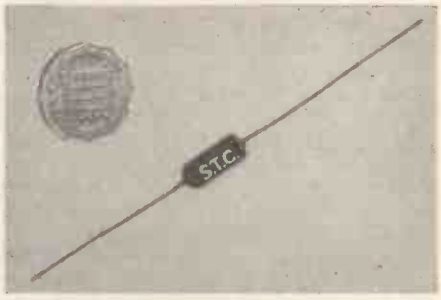
Silicon Resistors

A NEW type of silicon resistor, designated the "Silistor," and having pronounced positive resistance/temperature characteristics should prove particularly useful in transistor circuitry. The law governing its change in resistance with temperature is approximately as follows:—

$$R = R_{25}\left(\frac{273+T}{298}\right)^{2.3}$$

where T is the temperature in degrees C and R_{25} is the resistance at 25°C.

Resistance range at present available is 10Ω to 470Ω.



Standard Telephones "Silistor" a new silicon resistor.

Further details are obtainable from Standard Telephones and Cables, Ltd. (Transistor Division), Footscray, Sidcup, Kent.

Miniaturized Reference-Voltage Unit

DESIGNED for operation from 28-volt d.c. supplies, the miniature reference-voltage unit illustrated provides an output of 9.4V ±5% with a stability within ±1mV for input voltage variations of ±10%. This is achieved by use of a Zener diode regulator and a silicon reference element.

The unit, which is designed for mounting on printed-circuit boards, measures $1\frac{1}{4}$in high and 1in in diameter. It is encapsulated in epoxy resin with wire connecting leads at the base. The price; about £36.

Bulletin SR401, obtainable from the International Rectifier Co. Ltd., Oxted, Surrey, contains full details.

Miniature reference-voltage encapsulated unit for mounting on printed-circuit boards. (International Rectifier Co.)

Mechanical "Circuits"

By "CATHODE RAY"

THE ELECTRICAL ANALOGY IS NOT FOOLPROOF

I FORGET when I first met the idea that there is a precise and complete analogy between electrical and mechanical systems. I suppose our very first lessons in electricity always liken voltage to force or pressure, resistance to friction, inductance to inertia, and so on. Later we learn that the equations stating the general relationships between these quantities are exactly the same for electrical circuits as for mechanical devices. Analogies of this kind between different sciences appeal to me, if only because they reduce the total number of different things to be learnt. And they make a tidy mental pattern. But this one particularly pleased me, because electrical engineers (starting later) have overtaken mechanical engineers to such an extent that it is often worth while translating mechanical quantities into electrical to get the benefit of the highly developed state of electrical circuit analysis and measurement techniques. Since electricity is a comparatively mysterious thing, explained in the first instance by mechanical analogies, this strikes me as pleasantly ironical.

In our own field of sound reproduction, where the key devices are partly electrical and partly mechanical ("electromechanical transducers," as the professionals call them) it is helpful to be able to include everything in one lot of units and equations, and sometimes to find that dodges which are commonplace in electrical circuitry can be used to good effect in their mechanical equivalents. An example of this occurred about 30 years ago, when a mild technical sensation was aroused by the invention of a pickup arm designed as the analogue of a non-reflecting transmission line.

The same idea has been extended to acoustics, so that it is now no surprise to be offered apparatus for measuring acoustical impedance in acoustical ohms. In what follows, "mechanical" should, where the context permits, be deemed to include "acoustical."

Distant View

From a little distance all this looks intellectually and practically satisfying. But then the Editor came along, and, hinting that behind this neat and orderly façade a certain amount of confusion reigned, bade me expound the matter clearly. This I was reluctant to attempt, because to confess the truth the subject had never really progressed in my mind beyond the very-nice-idea stage. I had assumed that since every mechanical quantity has its electrical analogue all one had to do was apply the familiar electrical equations and circuit "know-how" to mechanical systems in which one might happen to be interested. At the same time, however, such equivalent circuits as I had seen didn't look particularly obviously the analogues of the mechanical or acoustical systems concerned. In any case, for causing one's supposed mastery of a subject to melt rapidly away there is nothing like trying (a) to put it to practical use or (b) to teach it.

However, my own self-inductance (or inertance, as the acoustical equivalent is called) having been overcome, Lenz's law will ensure that I carry on relentlessly in spite of all protests.

Disenchantment

The first thing was to "gen up," and having long connected the whole business with the name of Olson, and his book "Dynamical Analogies" having been favourably reviewed both on its first appearance in 1942 and in revised and enlarged form only a few months ago, I turned naturally to that work, especially as a quick glance showed neat comparative tables and lots of diagrams presenting the mechanical and acoustical equivalents of the three primary electrical elements (R, L and C) and almost every typical combination of them.

Even in this conservative country, and even in physics as well as electrical engineering, there has been a general change-over in textbooks from c.g.s. to rationalized m.k.s. units. Our present subject, in which units are vitally important, would seem to be a "natural" for m.k.s. throughout, and to see a book on it coming from America at this late date still adhering to c.g.s. "abamperes," "abohms," etc., was quite a surprise.

Perhaps, however, Mr. Olson is not fully to blame for this, because on consulting British Standard 661 : 1955 (Glossary of Acoustical Terms) I saw with pained astonishment that what is called the acoustical *ohm* is a c.g.s. unit. This term being also an international standard, there would obviously be a difficulty in changing over from it to an m.k.s. unit which would have to bear the same name while being one thousand million times larger. If the c.g.s. unit had been called anything at all, it ought to have been called an acoustical abohm. How silly can people be when they establish standards?

However, that was merely a ripple to disturb the deep sea of confident expectancy with which I approached the reading matter accompanying

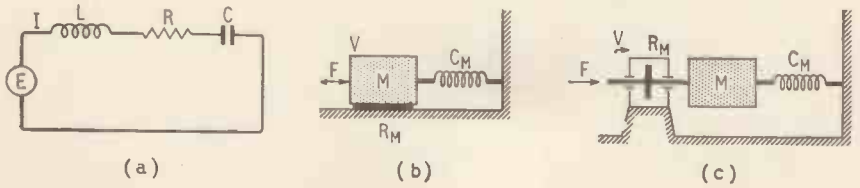


Fig. 1. Electrical series circuit (a) and mechanical equivalent according to (b) Olson and (c) Bloch.

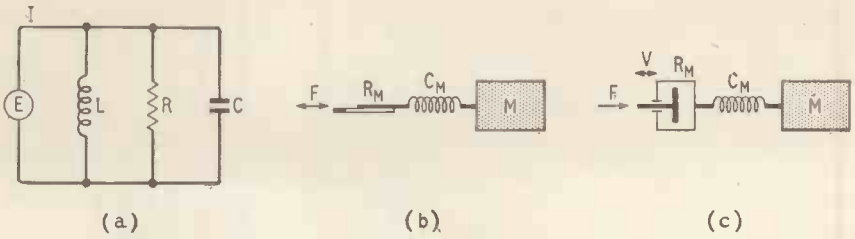


Fig. 2. Electrical parallel circuit (a) and mechanical equivalent according to (b) Olson's conventions and (c) Bloch.

Olson's intriguing comparative diagrams. Anyway, using wholly c.g.s. units is better than the usual horrible mixture, in which various constants appear. Most of Olson's equations would be the same in m.k.s.

In my youthful innocence of long ago, the attractiveness of this analogue idea had lain in the fact that, it having once been established that certain electrical quantities were exact analogues of certain mechanical quantities, and having learnt all the electrical relationships, one would thereupon be in possession of all the mechanical relationships, merely by substituting the appropriate symbols. To take an easy example, suppose it has been established that mass is analogous to inductance, velocity to current, and force to e.m.f. Knowing that the r.m.s. e.m.f. E needed to pass an r.m.s. current I at frequency f through an inductance L is

$$E = j2\pi fLI = j\omega LI \quad .. \quad (1)$$

one thereupon knows without further ado that the force F needed to make a mass M vibrate with r.m.s. velocity V at frequency f is

$$F = j2\pi fMV = j\omega MV \quad .. \quad (2)$$

Results derived from (1) and other electrical equations can be translated into mechanical counterparts merely by changing symbols, for mathematical derivations obviously depend in no way on the symbols that may have been used. An older generation of electrical engineers denoted current by C and capacity (as they called it) by K, but the change-over to I and C respectively didn't make it necessary to establish all their relationships afresh.

Most of "Dynamical Analogies" consists of a fourfold* repetition of statements and equations, down to the smallest detail, only the quantities and their symbols being different. Once the reader has caught on to the analogy idea further repetition seems to me to be, like that practised by the Pharisees, vain. The space that could have been saved might well have been devoted to explaining what was far from obvious to me at least, namely how Mr. Olson arrived at the particular mechanical arrangements he depicts as analogues of the electrical circuits alongside. It would also have been profitable to discuss what one should do in practice about the fact (which I happened to know, but is mentioned) that for the type of friction illustrated the mechanical counterpart of Ohm's law is notably untrue. And in view of the literature which has been reaching me for some time past dealing with the design of transistor equipment as a heat-disposal problem, with "thermal ohms," etc., I'd have liked to see thermal "circuits" included in the new edition. However, this is not supposed to be a book review, and I mention these things merely to exemplify the disappointment the earnest seeker after knowledge can find even with the most highly praised authorities.

At this unsatisfactory moment I turned to a paper by Bloch** who soon convinced me that there is more to this new idea than I had gaily run off with years ago, and that one must really sit down and think it clearly through, especially as regards "rates of exchange" between electrical and mechanical quantities. He also overcame my considerable sales resistance to the recognition and use of a second system of analogues developed by Firestone as long ago as 1933—the inverse of the more popular one which Bloch calls the "direct analogy," and which Olson considered to be the only one worth discussing in his 1943 edition***. In what follows my grateful acknowledgements are due mainly to Firestone and Bloch.

The "direct" or "classical" analogy is the one we are probably all more or less familiar with, in which the analogous quantities are:

Electrical	*Mechanical*
E.m.f.	Force
Charge	Linear Displacement
Current	Velocity
Resistance	Resistance
Inductance	Mass
Capacitance	Compliance
Reactance	Reactance
Impedance	Impedance

Fig. 1 shows Olson's comparison of a simple 3-element series circuit (a) with its mechanical analogue (b) and also (c) Bloch's version of the same. I have taken some liberties with the original letter symbols to facilitate comparison, and for the same reason have turned (c) on its side. The only real difference between (c) and (b) is that Olson shows mechanical resistance as friction between mass and ground, which is very "non-ohmic", whereas Bloch represents his by a dashpot, which does obey the mechanical Ohm's law reasonably well.

It is a pity, of course, that the symbol for inductance looks like a spring, which is the mechanical analogue of capacitance, and that the symbols for a mechanical resistance look like capacitors; but only the simple are likely to be misled by this.

Series or Parallel

At first glance both of these mechanical systems have a series look about them, so one may easily imagine one has got the idea and could recognize any mechanical "series circuit" at sight.

If so, examination of the mechanical equivalents of a parallel circuit, Fig. 2, will prove disconcerting. (Olson unfortunately shows no "direct" mechanical

* Electrical, mechanical rectilineal, mechanical rotational and acoustical.

** A. Bloch. "Electromechanical Analogies and their Use for the Analysis of Mechanical and Electromechanical Systems," *Journal I.E.E.*, Part 1, April 1945, 157-169.

*** In 1952 he added a chapter on the "mobility analogy" (so named by Firestone), which is Bloch's "inverse analogy." He distinguishes Bloch's "direct analogy" as the "classical."

analogue for exactly this circuit, but if he had it would almost certainly have looked like (b). Both this and (c) must be imagined as floating horizontally in space, presumably in an interplanetary vehicle unprovided with artificial gravitation.) Again, both of them look rather like series arrangements. Compared with Fig. 1, the main difference seems to be that the order of the three elements has been altered (M being shifted one place to the right), which to the electrical mind would appear unimportant. There is also an absence of the "earth connections" seen in Fig. 1. Ordinary intellects, at least, may feel that

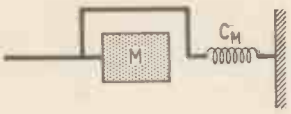


Fig. 3. The mass (M) and compliance (C_M) in Fig. 1 are not, as might be supposed, in series, but in parallel, as can be seen by re-drawing thus.

some explanation is needed to restore confidence in their ability to write down by inspection the electrical equivalent of a mechanical system, or vice versa.

The principle of an electrical series circuit, of course, is that the same current flows through all the elements, but the voltage across each is proportional to its impedance. In a parallel circuit, on the contrary, the same voltage comes across all the branches, but the current through each is proportional to its admittance.

Now the analogue of current is velocity, and in Fig. 1 (b) and (c) it is clear that the to-and-fro velocity being imparted to the mass is the same as the *difference* in velocity between the two "terminals" of the resistance and of the compliance. As one terminal of each of these two elements (in both diagrams) is "earthed", the velocity of the mass is the same as that of the moving end of the resistance and compliance. It is perhaps a little less obvious that the force applied to each element is proportional to its impedance. But if you imagine any one of the mechanical elements to have a relatively very high impedance you will see that little force will be left for the others (and consequently little movement of any of them), just as in the electrical circuit.

Compare Fig. 2. It is easy to see that if any one of the elements has a much greater impedance than the others its velocity (reckoned differentially between the two terminals in the cases of the resistance and compliance) is relatively small, and that more generally the velocity is inversely proportional to the impedance of that element individually, instead of being the same for all as in Fig. 1. That each receives the same force may be less obvious, because one may at first suppose that each element in the string absorbs some of the force. In this we may perhaps have in mind the use of springs and shock absorbers to protect us from the bumps imparted to the wheels of our car by the road. But the function of the springs is not to pass on less force to us than they receive from the road but to reduce the force the road applies, by giving way to it. Also the mechanical circuit of a car is complicated by the large mass of its chassis interposed between ourselves and the road, which, as we shall see, makes its equivalent circuit not wholly parallel. No; the only element which can receive more force than it passes on is mass, and that is in the last position in both (b) and (c). Assuming the other two have no mass at all, any force they receive must be balanced by an equal and opposite force.

The first general conclusion we draw from all this is that whereas in wholly series or parallel electrical circuits any element can be interchanged with any other without making any electrical difference† in mechanical circuits the order in which the elements are connected is vitally important.

This leads to the next conclusion, which is that we electrical people must be very careful about treating the mechanical links between mechanical elements as if they were wires joining electrical elements. Lack of such care would lead us to suppose that all the mechanical circuits shown so far were of the series type.

The startling thing (unless you have been bright enough to run on ahead, or know it beforehand) is that Fig. 2 (b) and (c) *are* series circuits, although their electrical equivalent is a parallel circuit. And the mechanical analogues of the series electrical circuit in Fig. 1 are parallel circuits.

The truth of the latter statement may not spring at once to the eye. But just as a battery cannot apply its e.m.f. to a circuit if only one of its terminals is connected, so a force cannot be brought to bear unless it is "connected" in two places. In Fig. 1 it must therefore be anchored somewhere to the frame or "earth" represented by diagonal shading. Otherwise it would just push itself away. So in both (b) and (c) it is exerted directly across resistance R_M.

The series appearance of M and C_M is also misleading. So far as C_M is concerned, the body of M is acting merely as a mechanical coupling, and the true situation is more clearly shown in Fig. 3, which is essentially identical. The same principle applies to R_M in Fig. 1(c). So the same force applied to

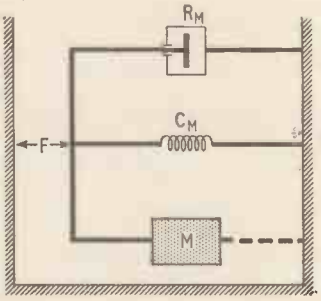


Fig. 4. By re-drawing Fig. 1(c) in this way, the parallel arrangement is quite clear.

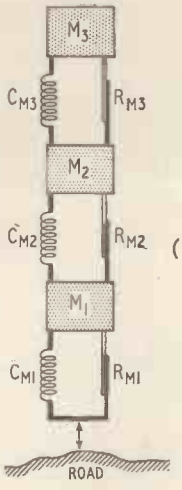
R_M is also applied directly across C_M, which is therefore in parallel.

But what about M? In Fig. 3, as in Fig. 2, it seems to have only one "terminal." And certainly it does seem to be the odd man out, since it can accept a force without passing any on to anything else. It seems almost as if it had some kind of invisible link with "earth." And although it may appear to you a bit of a fiddle to assume such a link and represent it by a dotted line as in Fig. 4, under the more respectable name of "concept" it has the authority of Dr. Bloch, who shows that it is not altogether unjustifiable. Besides, it works.

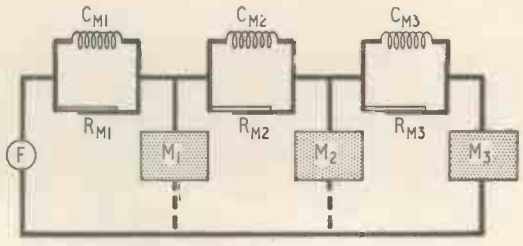
So, just by looking at Fig. 1(b) and (c) a little

(*continued on page 573*)

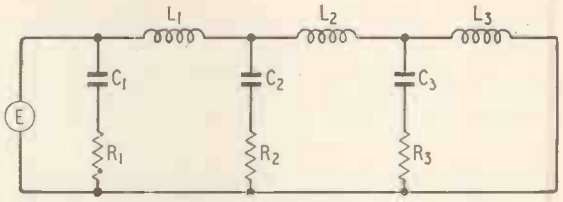
† In practice, of course, real components as distinct from theoretical circuit elements have stray capacitances, which are additional circuit elements and do often give significance to the order in which the components are connected.



(a)



(b)



(c)

Fig. 5. The mechanical contrivances between the road and your body (M_3) when you are motoring are shown in simplified form at (a). Redrawn to bring out the mechanical "circuitry" they appear at (b). (c) is the result of translation into electrical components and connections.

differently, we find ourselves with a parallel mechanical circuit as the analogue of a series electrical circuit.

Duality

Some while ago‡ I dealt with duality—that sort of inverse analogy that exists between the following electrical quantities:

Current, I	Voltage, V or E
Resistance, R	Conductance, G
Inductance, L	Capacitance, C
Reactance, X	Susceptance, B
Impedance, Z	Admittance, Y

If any equation connecting any of these quantities is true, it is equally true if all the quantities in it are replaced by those on the same line in the opposite column. To take the simplest example, Ohm's law is expressed by the familiar equation

$$E=IR$$

Making the exchange as described, we get

$$I=EG$$

which is also true, and is sometimes more useful; for example, in parallel circuits. Each of these two equations is said to be the dual of the other. Moreover, if the same exchanges are made in any circuit, *and series and parallel connections are interchanged,* the result is the dual of that circuit. The advantage of this procedure is that all the equations relating to one circuit can be adapted to its dual circuit by transforming them into their dual equations. This may save a lot of work ("Two formulæ for the price of one") as well as tidying up the whole matter in one's mind.

Now in working out the "direct" analogy between electrical and mechanical circuits or systems, on the familiar basis of voltage being analogous to force and current to velocity, we have arrived at the rather upsetting conclusion that the analogue of an electrical series circuit is a mechanical parallel circuit, and vice versa. Does this mean that all the relationships in an electrical circuit, say, have to be transformed into their duals before they apply to its mechanical analogue? Well, no; we have already checked that Fig. 4 behaves like a series circuit, in spite of its appearance, so that (for instance) adding more resistances apparently in parallel would *reduce* the velocity imparted by a given force, just as adding series resistances in Fig. 1(a) reduces the current imparted by a given e.m.f. So Fig. 4 is a parallel circuit in appearance but a series circuit in behaviour. Whichever it is called is therefore liable to mislead. To avoid such confusion, Bloch calls it "co-resistive," in contrast to Fig. 2(c) which is "co-yielding"—in each case like its electrical analogue.

So far as the algebra is concerned, then, the direct analogy is sound, in spite of the apparent oppositeness of circuit structures.

Simplified Example

There is more to come than we can cram into this month's space, so let us just consolidate the position reached by taking a familiar example, even though it might be reckoned more in the province of *The Autocar* than *Wireless World.* A car is of course a very complicated mechanical system, but for the sake of example let us consider only the parts concerned in the insulation of the inmates from the roughness of the road.

These are represented by the conventional picture symbols in Fig. 5(a). There are first the tyres, which form a compliance (mechanical capacitance) C_{M1} yielding to the vertical forces applied by road bumps. They support the mass of the wheels, axles, etc., M_1. The "tuned circuit" so formed is damped by the frictional and viscous losses in the rubber. These losses, which make the tyres warm up in action, are represented by R_{M1}. On top of this is another similar circuit (but with different magnitudes) formed by the springs, chassis, and dampers. These in turn support the upholstery, with its combined compliance and damping, and lastly you, gentle reader, the mass M_3.

To prepare this diagram for translation into the equivalent electrical circuit, all we need do is draw dotted lines from the masses to the other terminal of the mechanical generator, which in this case being the road is literally "earth." For this purpose it is rather more convenient to rotate the diagram through 90° (b).

The last step is to replace the mechanical circuit

‡ *Wireless World*, April 1952, and "Second Thoughts on Radio Theory," Chap. 35.

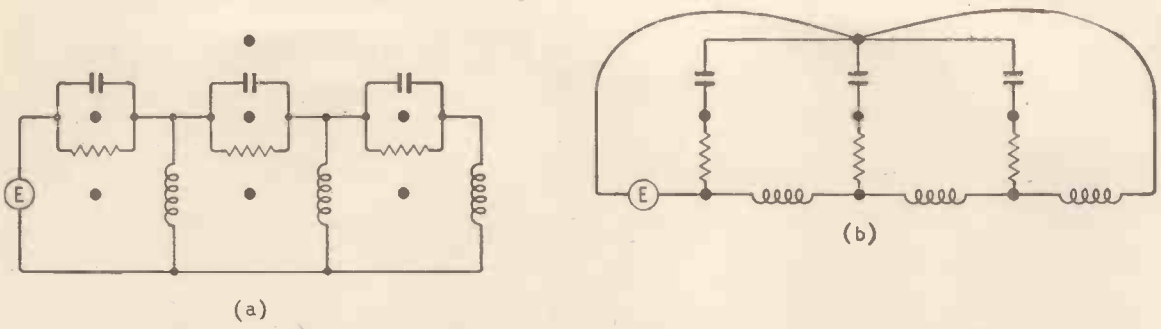


Fig. 6. For the sake of the weaker brethren the metamorphosis from Fig. 5(b) to (c) is here eased by intermediate stepping stones. At (a) the mechanical elements have been changed to electrical with the same (now incorrect) connections. Changing these over from series to parallel and vice versa, with the help of the black dots, we get (b), which in tidier layout is Fig. 5(c).

elements by their electrical equivalents (compliances by capacitances, etc.) and at the same time change series connections to parallel and vice versa. Fig. 5(c) is the result, but in case you are not used to this sort of thing and would like to make the two changes separately, Fig. 6 shows these. At (a) the transformation to electrical elements has been made without any change of "wiring." At the same time I have put a black dot inside each closed mesh of the circuit. That is part of a foolproof scheme for drawing dual circuits. All one has to do is look at each circuit element in turn, note the pair of dots between which it lies, and join those dots with a wire containing the same kind of element. (In a true dual circuit it would have to be the opposite kind of element but here we are only concerned with the connections.) You would do it with ink on a pencil diagram, or with a different colour; but not having that advantage in print I have drawn the second diagram separately around the same dot pattern at (b). This only needs turning upside down and straightening out a bit to be the same Fig. 5(c) that the brighter boys got in one move.

It is now easily recognizable by *Wireless World* readers as a low-pass filter. When we ride over cobblestones or frozen snow ridges our teeth are not likely to chatter, but we may hear some of the lower regions doing so, because of the relatively large high-frequency "current" in the first stage of the "filter."

We can follow this analogy through and perhaps get some bright new ideas as to how cars should be sprung. But to do the thing properly, especially in our own field, we need to know more than just how to draw diagrams. Next time we shall see how to deal with calculations.

Crash Position Indicator

A HIGH-SPEED modern aircraft can be totally destroyed in as short a time as 100msec. This rather frightening fact assumes further importance when it is recalled that search aircraft and ships have passed within short distances of survivors without finding them. The well-known Sarah rescue beacon does much to reduce the risk of such an occurrence but, as it is usually attached to survival equipment within the aircraft, it is possible that it could either be damaged; or the survivors, perhaps unconscious, might not be able to set it in operation.

To make detection more certain, Ultra Electric, Ltd., have introduced a new distress beacon known as "Crash Position Indicator" (C.P.I.). This is constructed over a "plate" aerial and encapsulated in plastics foam which is covered with a laminated-nylon skin. The whole forms a flat section which fits into the aircraft skin, and, when released automatically from a crashing plane, it tumbles through the air to reduce its speed to a value low enough to land without damage. Satisfactory operation occurs even if the C.P.I. lands in water or on marsh, for it floats with 80% of the volume of the unit above the surface.

Transistors are employed in the equipment except in the transmitter which uses two valves in a tuned-line oscillator circuit. An interesting power-economy feature is that the valve heaters are switched on and off by transistors; in this way an operating life of 100 hours is achieved. C.P.I.'s transmissions are completely compatible with the N.A.T.-accepted "Sarah" search and homing equipment.

Ultra C.P.I. (Crash Position Indicator) in and out of its foam-plastics case. Transmitter and switching transistors are mounted on a flat panel backing "plate" aerial, with storage batteries round the edge. Ranges up to 70 miles can be achieved.

DECEMBER 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. Medical Electronics Group.—Discussion on "Nuclear magnetic resonance" opened by Dr. N. Sheppard and Dr. R. E. Richards at 6.0 at Savoy Place, W.C.2.

4th. Television Society.—"Television in Germany" by Dr. Rolf Möller (Fernseh G.m.b.H.) at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

7th. I.E.E.—"Frequency patterns for multiple-radio-channel routes" by B. B. Jacobsen at 5.30 at Savoy Place, W.C.2.

9th. Women's Engineering Society.—"Radar and telecommunications research and development" by Dr. Elizabeth Laverick at 7.0 at "Hope House," 45, Great Peter Street, Westminster, S.W.1.

10th. Physical Society Acoustics Group.—"The architectural design of broadcasting studios" by Alexander Brown at 5.30 at the Imperial College of Science and Technology, Prince Consort Road, S.W.7.

10th. Brit.I.R.E. Computer Group.—"The simulation of nuclear reactors and power plants" by W. J. G. Cox and J. Dowsing at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

11th. Institute of Physics.—"The ultrasonic camera—an alternative approach to ultrasonic testing" by J. F. Sayers (Atomic Energy Research Establishment) at 6.0 at 47, Belgrave Square, S.W.1.

11th. I.E.E. Graduate and Student Section.—"The trends of electrical progress and their implications" by Sir Willis Jackson (president) at 6.30 at Savoy Place, W.C.2.

14th. I.E.E.—Discussion on "Why Hi-Fi?" opened by P. P. Eckersley at 5.30 at Savoy Place, W.C.2.

15th. Institute of Physics.—"Tubes for colour television" by K. G. Freeman (Mullard Research Laboratory) at 5.30 at 47, Belgrave Square, S.W.1.

15th. Brit.I.R.E.—Symposium on "Magnetic recording techniques" at 3.0 and 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

16th. I.E.E.—"The laying of submarine cables" by Capt. W. H. Leech at 5.30 at Savoy Place, W.C.2.

16th. Brit.I.R.E. Medical Electronics Group.—"Measurements in the presence of noise" by Dr. D. A. Bell and Dr. G. D. Dawson at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

17th. British Computer Society.—Discussion on "Conversion between analogue and digital representation" at 11.0 at the Northampton College of Advanced Technology, St. John Street, E.C.1.

18th. B.S.R.A.—"Sound reproduction: things we forget to remember" by Percy Wilson at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

29th. Radar and Electronics Association.—"High-quality sound broadcasting" by Dr. K. R. Sturley (Engineering Training Department, B.B.C.) at 7.30 at the Royal Society of Arts, John Adam Street, W.C.2.

BIRMINGHAM

8th. Brit.I.R.E.—"The development of h.f. tape recording" by P. J. Guy at 7.15 at the Matthew Boulton Technical College, Suffolk Street.

BRISTOL

8th. Television Society.—"The design of experimental tuners for bands 4 and 5, television receivers" by K. H. Smith (Siemens Edison Swan) at 7.30 at the Hawthorns Hotel, Clifton.

17th. Brit.I.R.E.—"The transistor and its use in communication and control equipment" by E. Wolfendale at 7.0 at the School of Management Studies, Unity Street.

CAMBRIDGE

7th. I.E.E.—"Rockets and satellites" by Dr. R. L. F. Boyd at 6.30 at the Technical College.

8th. I.E.E.—"The reliability of components" by G. W. A. Dummer at 8.0 at the Cavendish Laboratory, Free School Lane.

CARDIFF

17th. British Computer Society.—"Mechanical translation of languages" by Dr. J. P. Cleve (University Computation Laboratory, Southampton) at 6.30 at University College.

CHELMSFORD

8th. I.E.E. Graduate and Student Section.—"The bond disc with particular reference to the f.m. regulator" by S. J. Read at 7.0 in the Electricity Showrooms.

CROYDON

17th. Association of Supervising Electrical Engineers—"Electronics in industry" by S. R. Rose (Croydon Electronic Machines) at 8.0 at the Greyhound Hotel, High Street.

EDINBURGH

18th. Brit.I.R.E.—"The digital voltmeter" by J. A. Irvine and D. A. Pucknell at 7.0 at the Department of Natural Philosophy, The University, Drummond Street.

GLASGOW

17th. Brit.I.R.E.—"The digital voltmeter" by J. A. Irvine and D. A. Pucknell at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

LIVERPOOL

10th. Society of Instrument Technology.—"New simple transistorized industrial instruments" by A. Green at 7.15 at the M.A.N.W.E.B. Industrial Development Centre, Paradise Street.

MANCHESTER

9th. I.E.E.—"New amplifying techniques" by C. W. Oatley at 6.15 at the Engineers' Club, Albert Square.

10th. Brit.I.R.E. — "Learning machines" by P. Huggins at 6.30 at the Reynolds Hall, College of Science and Technology, Sackville Street.

NEWCASTLE UPON TYNE

7th. I.E.E.—"Dielectric materials—trends and prospects" by C. G. Garton at 6.15 at the Rutherford College of Technology.

9th. Brit. I.R.E.—"Micro miniaturization" by H. G. Manfield at 6.0 at the Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road.

RANDOM RADIATIONS

By "DIALLIST"

Lunar Television

PHOTOGRAPHING the far side of the moon, developing the pictures and transmitting them over a distance of more than a quarter of a million miles to the earth must be the most remarkable achievement ever accomplished with the aid of wireless. A general account of the whole procedure was given in *Soviet News* of November 5th. The stopping and starting of the "lunik's" rotation, the tilting of its business end first away from the sun and then, more exactly, to face the moon, the triggering of the camera shutter for the various photographs that were taken, the starting, control and stopping of the developing process and finally the actual transmission of the pictures themselves were all done by radio control. The pictures were transmitted in black and white using a flying-spot scanning tube and photo-multiplier in a way similar to that used for films by ordinary television stations but some thousands of times slower. Long- and short-distance transmission were used, both the speed of transmission and the number of lines transmitted being changed according to the transmission distance. The maximum number of lines transmitted was 1,000. The received signals were recorded in as many as four different ways; on film, on tape, on long-persistence tubes and on electro-chemical paper using pen recorders.

Transistor Progress

THE manufacture of transistors has shown such expansion in this country that the British Radio Valve Manufacturers' Association (B.V.A.) is to hand over to a new association, the Electronic Valve and Semiconductor Manufacturers' Association (V.A.S.C.A. for short), its responsibilities for semiconductors and also for industrial valves and c.r. tubes. The B.V.A. is to continue its interest in the valves and c.r. tubes used in domestic sound and television equipment. One hopes that the greatly increased manufacture and use of transistors will lead in due course to even greater reductions in their price. This should happen as better and more efficient methods of making them are developed through the co-operation of members of V.A.S.C.A. It won't, I think, be many years before the valve radio receiver becomes something of a museum piece. Some parts of the television receiver present problems with which only valves can still now deal: I'm thinking in particular of the line and frame scans and of the provision of e.h.t. voltage for the c.r. tube. Still, problems are there to be solved and back-room boys are there to solve them.

V.H.F./F.M. in France

FROM the editorial of a recent issue of the French monthly *Radio Constructeur et Dépanneur* I gather that v.h.f. sound broadcasting is not very popular in France. That's curious when one thinks of how well it's gone down in this country and in Germany. The writer of the article is puzzled by the rarity of the v.h.f. aerials in areas served by f.m. stations and asked various people—retailers, listeners and servicemen—if they could offer any explanation of this lack of interest. Among the reasons suggested is one which comes as a great surprise: listeners in some areas said that the quality of the musical transmissions was very poor, being definitely below the standard of local a.m. broadcasts. If that's really so, one can't wonder that the number of v.h.f./f.m. listeners is small. But I very much doubt if the transmitters are to blame; it seems more likely, don't you think, that the frequency-modulation portion of some French a.m./f.m. receivers is not so good as it ought to be.

Tidying up the Television Receiver

THE use of the short-necked 110-degree cathode-ray tube and of more and more miniaturized components has much improved the appearance of this year's 17-inch and 21-inch television receivers. And as transistors come increasingly to take the place of valves, those of the not-so-distant future will doubtless be still neater and more compact. Ingenuity has largely overcome the difficulty of obtaining dead-sharp definition near the vertical edges of big c.r.t. screens, and it seems to me that the best receivers of to-day give just about as good a picture as it's possible in practice to get with 405-line scanning. But the picture isn't everything in TV reception, and in some of the cheaper mass-produced table models the accompanying sound leaves much to be desired. I'm thinking of sets made not only in this country but in other countries,

too. It costs money to provide good audio output, and to designers of low-priced sets every penny must always be an important consideration. And, too, there's the question of the space available. Reduce the size of your table model cabinet to the smallest possible dimensions and there's hardly room enough for a good-sized loudspeaker. It's different with sets of the console type, for the lower compartment may contain nothing but the output transformer and the loudspeaker. Nor is it so important for the price of a console to be kept as low as possible, for it is to some extent looked on as being in the luxury class of set.

Future of the TV Aerial

EVEN the most dyed-in-the-wool TV enthusiast could hardly claim that the Yagis which now assert themselves so conspicuously on the skylines of our towns and villages are things of beauty. My forecast is that as time goes on they'll gradually become less and less in evidence. I don't mean that there will be fewer TV sets, for that certainly won't happen. I think that new ferrite materials may lead to wider use of indoor aerials in places where signal strength is good and that more and more of the areas troubled by ghosts, interference and weak signals will be served by master aerials placed in trouble-free spots and providing piped TV. Then again, increasing use is likely to be made of communal aerials serving blocks of flats, groups of houses and even whole housing estates. I for one certainly wouldn't mourn the demise of the domestic roof-top TV aerial as we now know it.

Bigger and Bigger Units

WE'RE all familiar with such mega-units as the megacycle and the megawatt. But a prefix which multiplies by a mere million wasn't found big enough to meet all today's needs, and giga (symbol G) with its multiplication by 10^9 appeared some time ago in such terms as Gc/s. Today, in France at any rate, that prefix has been found inadequate for certain purposes. The French Electricity Supply Authority now measures the combined output of its generating stations in TWh, or terawatt-hours, the tera-prefix indicating multiplication by 10^{12}. One can't somehow help wishing that the new prefixes hadn't been such linguistic barbarisms as they are; but that, I suppose, is just one of those things.

UNBIASED

By FREE GRID

Mute Monument

I SUPPOSE that everybody has heard of Karl Marx, and anybody passing his tomb in Highgate Cemetery will not need to be told who he was. It is otherwise, however, with a man buried in the same cemetery whose grave many people must pass each year without realizing what a great debt they all owe to him for so many of the comforts in their homes, which are due to his genius in discovering and investigating electromagnetic induction.

Faraday's simple headstone, although well kept, is in great contrast to the flamboyant bust of Marx, but it tells the passer-by nothing about the benefits his work conferred on the world which, of course, are not limited to the field of electricity.

When I passed it with Mrs. Free Grid a few months ago I paused awhile and remarked to her that I thought few people who enjoyed the comfort of electric lighting in their homes as well as heating, sound broadcasting and television realized they owed it all to him.

To my astonishment she flatly contradicted my statement that Faraday was at the back of all the modern electrical comforts we enjoy. She pointed to the date of his death as recorded on the headstone, and said it was obvious that he could have had nothing to do with radio. She added that she had always understood Edison to be the pioneer of incandescent electric lighting.

Summoning up all my reserves of patience—which as a married man are naturally considerable—I tried to explain that all the electrical comforts we enjoy at home depend on an adequate supply of power from the mains, and that if Faraday had not discovered and investigated the phenomenon of electromagnetic induction there would be no generating stations.

Faraday's simple headstone which is cared for by the Faraday Society.

By this time several people, attracted by the argumentative tone of my voice, had stopped to listen. When Mrs. Free Grid suddenly produced her transistor portable and asked what generating stations had to do with that, there were murmurs of agreement from the women in the little crowd. Why is it, I wonder, that females, despite their dislike of their own sex—so strongly exemplified in canine females—will always rally to each other's side in an argument with a man?

It was useless for me to point out, as I did, that there were many instances of the principle of induction in her little portable. She promptly produced a pocket torch and asked what there was in that for which we could thank Faraday. Eventually I made a dignified retreat on the grounds that a cemetery was no place for wordy warfare.

Radio Relics Club

MY recently expressed opinion that F. H. Haynes pioneered the use of the loudspeaker in politics seems to have been rather wide of the mark as is made quite clear by Haydon G. Warren, of Luton, who in his letter to the Editor (see page 566) states that p.a. equipment appeared in the U.S.A. as early as 1910. It is rather surprising to learn this. I happened to be in Washington and New York ten years later during the presidential election campaign of November, 1920, in which Harding was elected, and I cannot remember seeing any sign of p.a. although ordinary broadcasting was going strongly. I do recollect, however, buying a moving-coil loudspeaker then (the old horn-type Magnavox), which I still have, and also my first electric razor—a murderous device worthy of Sweeney Todd himself.

If the use of p.a. equipment dates from 1910 or earlier, I wonder when the first complete radio receiver—as distinct from components—was offered for sale to the public. Many people might be inclined to say May, 1922, when the P.M.G. of the day made his first public announcement of the forthcoming broadcasting service which commenced regular operation six months later. However, to my own recollection, complete sets were on sale a couple of years after the end of the first World War. Several firms—and in particular that of Leslie McMichael—offered for sale ex-W.D. a.f. amplifiers with detector and tuner added.

But sets were on sale even before the first World War, as I recollect one being marketed and advertised in *Wireless World*. It consisted of a combined magnetic detector and tuner. Its primary purpose was to receive time signals from the Eiffel Tower (call sign FL).

Long before that even, units consisting of a coherer and decoherer, all parts neatly mounted on a baseboard, were on sale. I published a photograph of one of these a few years ago. It certainly had no tuning arrangement, but such a refinement was hardly necessary in those days of shock excitation from a plain-gap and plain-aerial spark transmitter. The earliest set was undoubtedly the resonator ring of Hertz in 1888, but it was certainly not on sale to the public.

Personally I should like to see the formation of a Radio Relics Club which would establish and maintain a central museum for all such relics including literature. There are, of course, radio relics in the Science Museum, but since it caters for *all* branches of science it is impossible for adequate space to be set aside to show any large quantity of radio relics. The Royal Photographic Society sets us an example, as it has a museum for old cameras and other photographiana.

I, for one, have a few old relics such as one of the earliest all-mains sets marketed, which Mrs. Free Grid is constantly threatening to throw out. No doubt many of you are in a similar predicament and would be glad to find a home for your relics.

Technical Adam Wanted

I WISH there could be some official body to regulate the nomenclature of things in the field of radio and electronics as soon as they are invented. I have often felt this, but I am made to feel it more strongly still by reading in an otherwise respectable newspaper all about the working of an instrument which it describes as an encephalogram. This word is usually used for the record which the machine makes. It is not the name of the machine itself, any more than the word oscillogram is the name of an instrument.

What, then, *is* the name of the equipment which produces an encephalogram? On the analogy of an oscillograph we must, I suppose, call it an encephalograph. But a "telegraph" isn't the name of the machine which transmits a telegram; or is it? We need somebody or some body to deal with these matters as authoritatively as Adam did with the naming of the birds and the beasts (Genesis, II, 20); but he was lucky, as his wife was not then in existence to disagree with his names.

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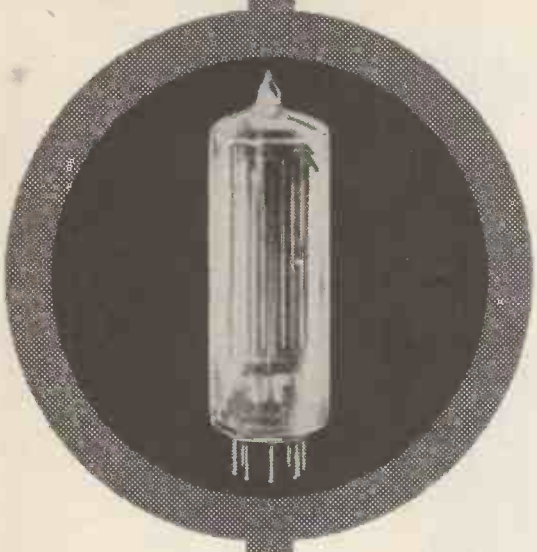

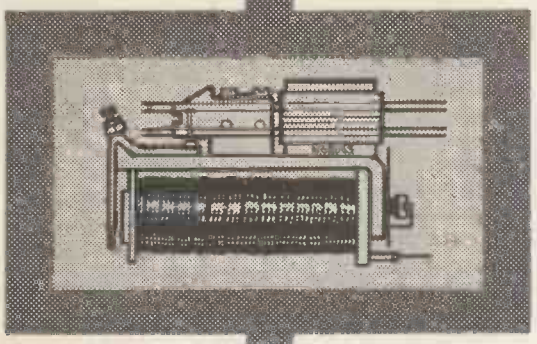

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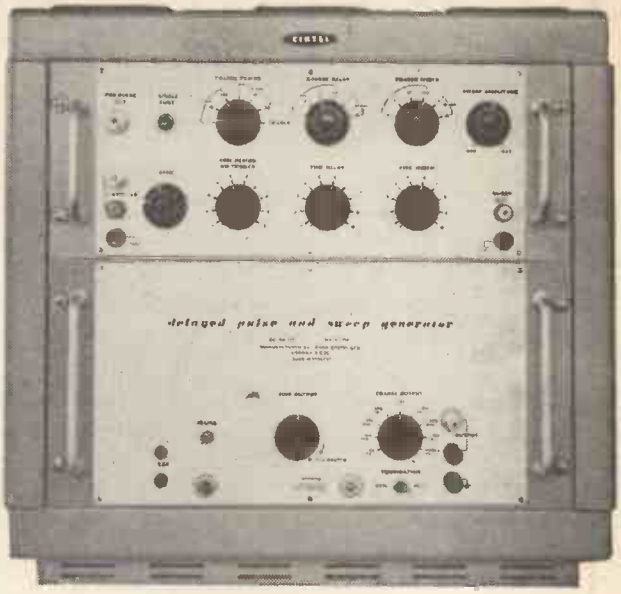
DELAYED PULSE AND SWEEP GENERATOR



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

BRIEF SPECIFICATION

Period

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

Pre-pulse

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

Main pulse

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

Amplitude: Control gives 4:1 attenuation of each of four maximum outputs as follows:
5V max in 75Ω rise time 10mμsec
10V max in 150Ω rise time <20mμsec
25V max in 600Ω rise time <40mμsec
50V max in 1000Ω rise time 50mμsec

Polarity: Positive or negative going.

Accuracy: ±2%.

Delay

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

Sweep

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

Cable pulse

Obtained from short circuited pure line.
One positive and one negative going pulse coincident with main pulse.
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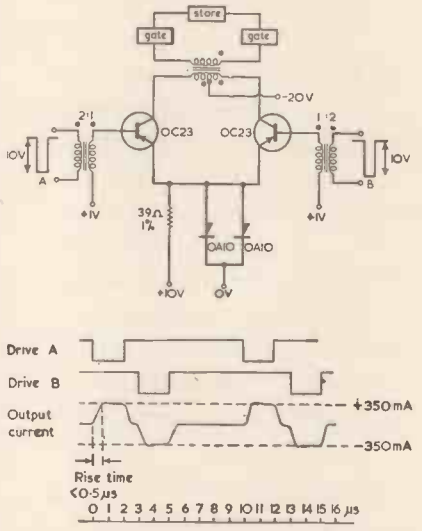
High frequency—High gain

OC23 Computing Transistor

The OC23 is designed and specially tested for driving square-loop ferrite computing elements and storage matrices. Its high f_α and power handling capabilities, however, suit it for a number of additional computing applications.

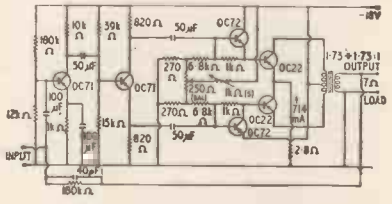
- Ferrite drive transistor providing 1-amp pulses with rise time <0.8 μsec.
- Half and full current pulse generator transistor for ferrite stores of up to 40,000 bits capacity.
- Gating transistor for use with ferrite stores.
- Clock pulse generator transistor for medium speed computers.



Pulse generator circuit for square loop ferrites

OC22 High quality industrial A.F. Transistor

The f_α of 2 Mc/s of the OC22 ensures that the negative feedback used in quality a.f. amplifiers does not cause h.f. oscillation. In addition, the α' gives a generous final gain even allowing for the inevitable reduction through negative feedback, thus reducing the power required from the drive stage. An extremely linear α'/I_c characteristic is yet another reason for using the OC22 in transistorised industrial a.f. equipment where quality is of paramount importance.



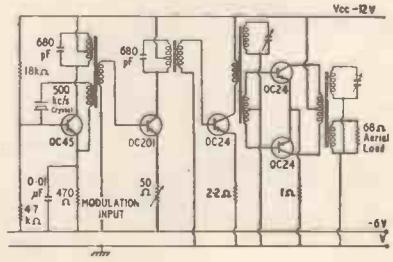
4-watt experimental a.f. amplifier circuit

Total harmonic distortion at 4W output (measured at 400 c/s)	<1.0%
Frequency response (400 c/s ref. level) ...	± 2 dB 20 c/s to 20 kc/s
Feedback factor (with 2.5 kΩ source) ...	20 dB
Sensitivity (input current for full output) ...	30 μA

OC24 Communications Transistor

The OC24 is particularly suited for communications applications. Two of these transistors are, for example, used in the output stage of a marine distress transmitter where they provide 4 watts c.w. at 500 kc/s. The OC24 can, of course, be used for modulated c.w. or telephony.

Another example of the application of the OC24 in the field of communications is a 12 channel telephone repeater amplifier which conforms to the full C.C.I.T. Specification. This amplifier has an output of 0.5 watt at 120 kc/s.



4-watt 500 kc/s Transmitter

Power transistors

10 watts dissipation
2 Mc/s average f_α

High frequency cut-off, high α', high dissipation and low bottoming voltage are all combined in the Mullard OC23—a leading transistor of its kind in the world.

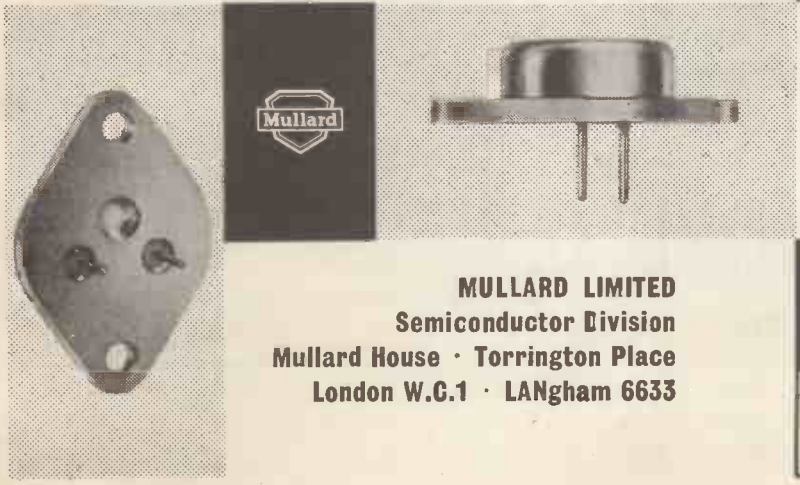
The OC23 and its companion types OC22 and OC24 are now being made by Mullard in extremely large quantities and are immediately available at economic prices. Telephone or write Mullard House for full information and assistance in selecting the type most suited for your particular application.

Germanium P-N-P Alloy Junction Transistors

Characteristics (at $T_{junction}$ = 25°C) for OC22, OC23 and OC24.

		Typical	Max.
GROUNDED BASE			
Collector Leakage Current			
(at V_c = −10V, I_e = 0)	$I_{c(o)}$	30μA	100μA
Emitter Leakage Current			
(at V_e = −10V, I_c = 0)	$I_{e(o)}$	20μA	100μA
GROUNDED EMITTER			
Collector Bottoming Voltage			
(at I_c = 1.0A, I_b = 30mA)	V_{ce}	−400mV*	—
Current Amplification Factor		*Typical*	*Min.*
(at V_c = −2V, I_c = 100mA)	$\bar{\alpha}'$	200	—
(at V_c = −2V, I_c = 1.0A)	$\bar{\alpha}'$	150	50

* −400mV for OC23 and OC24 only. OC22 = −600mV.



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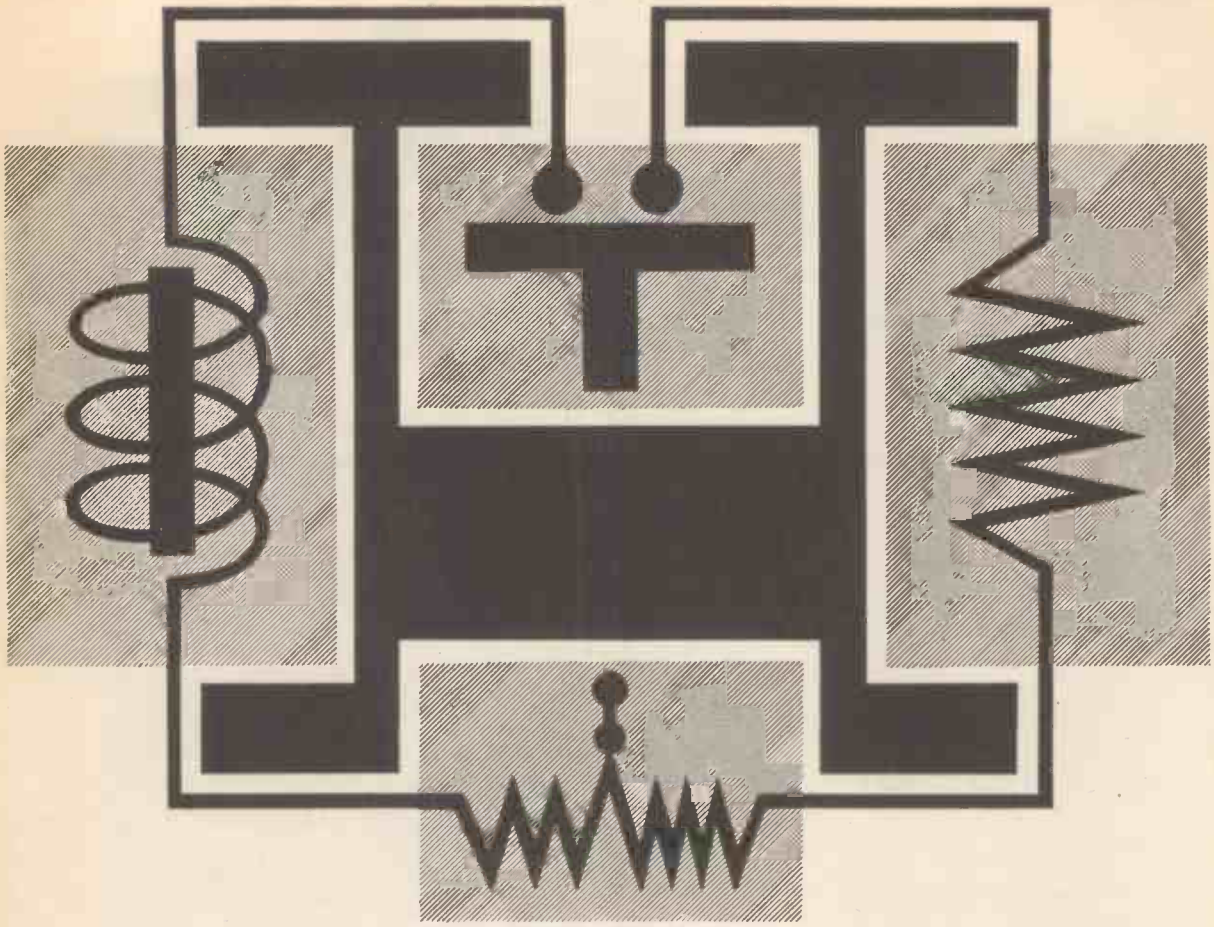

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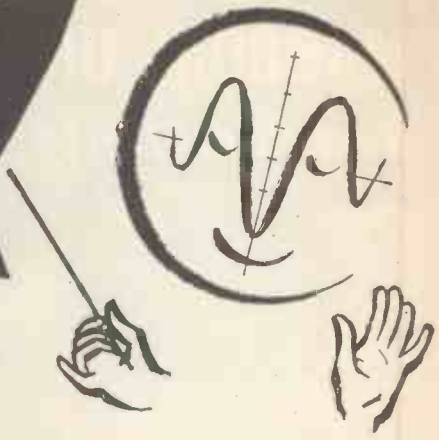


These four Cossor Oscillographs, each designed for an important range of applications, offer first-class performance backed by rigid adherence to published specifications.

MODEL 1065 PULSE OSCILLOGRAPH

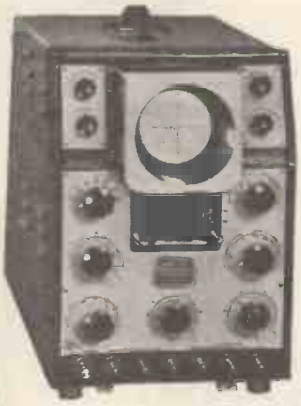
Tube. single-beam, P.D.A.
Bandwidth: d.c. to 15 Mc/s (—50%).
Sensitivity: 250 mV/cm.
Overshoot: less than 3%.
Time-base: triggered or repetitive over range 40 cm/sec to 5 cm/μsec.
X Amplifier: gain 5, continuously variable.
Time-base delay: 2 ranges, continuously variable.
Calibration: voltage and time, by calibrated shifts
Probe: 1.5 MΩ, 12 pF

MODEL 1058 FOR THE TV & RADIO ENGINEER

Tube: single-beam
Bandwidth: d.c. to 6 Mc/s (—50%).
Sensitivity: 250 mV/cm.
Time-Base: triggered or repetitive, over range 30 cm/sec to 1.5 cm/μsec. Special facilities for triggering from TV line or Frame pulses on IV.D.A.P. composite video waveform.
X Amplifier: gain 5, continuously variable.
Calibration: time and voltage calibration facilities.

MODEL 1049 INDUSTRIAL DOUBLE-BEAM OSCILLOGRAPH

Y Amplifier: A1: d.c. to 200 kc/s (—30%) at gain 900: A2: d.c. to 400 kc/s (—30%) at gain 30.
Time-Base: repetitive or triggered in 18 ranges, down to 7.5 sec/sweep.
Intensity modulation: three modes including beam bright-up.
Calibration: time and voltage, by calibrated shift (X and Y1) and multiplier (Y2).



MODEL 1035 GENERAL PURPOSE DOUBLE-BEAM OSCILLOGRAPH

Y Amplifiers: A1: 5 c/s to 5 Mc/s (—30%), Maximum gain 3,000. A2: 5 c/s to 250 kc/s (—30%) at gain 30, with trace inversion facility.
Time-base: repetitive or triggered in 9 sweep ranges from 100 msec to 10 μsec. Time-base delay and pulse bright-up facilities.
X Amplifier: gain 5, continuously variable.
Calibration: voltage and time, by calibrated shifts.

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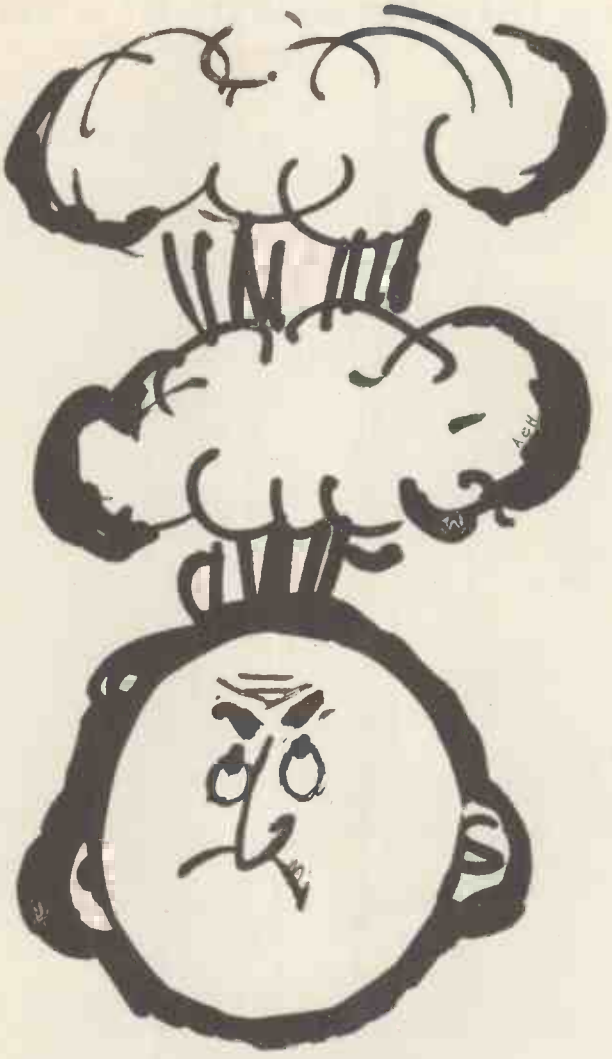

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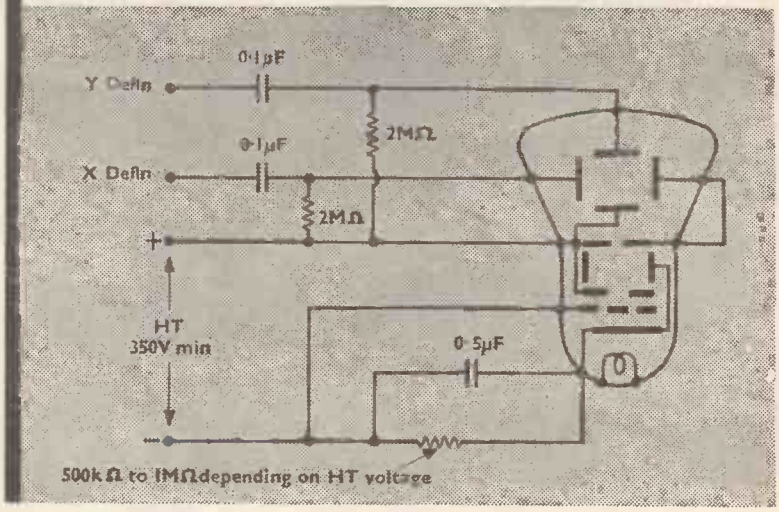

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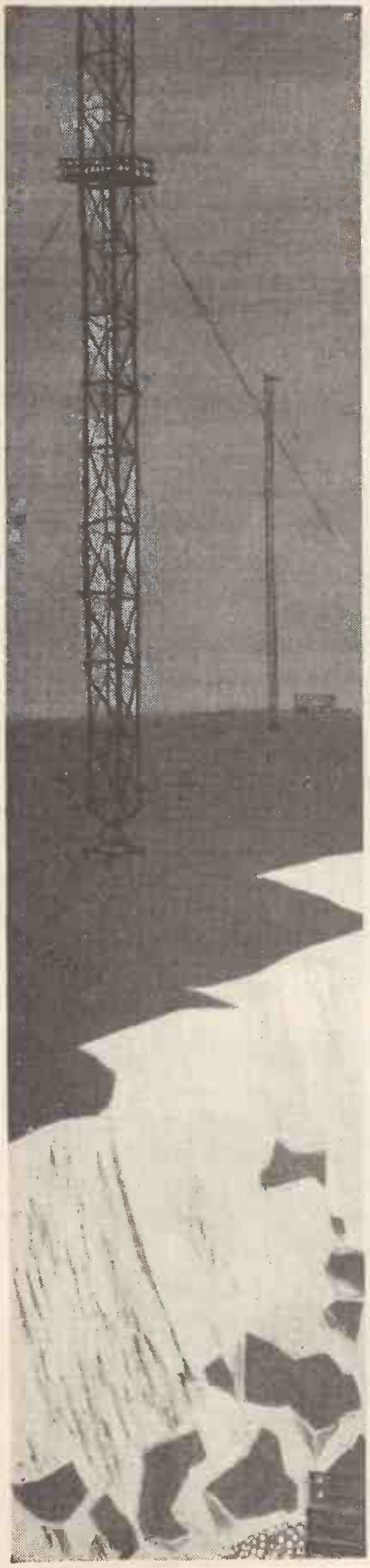

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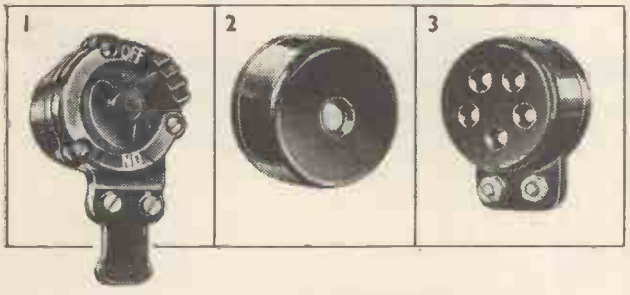

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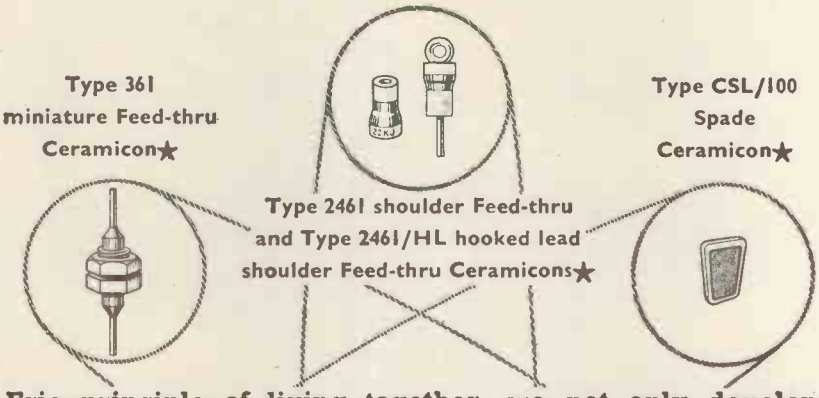

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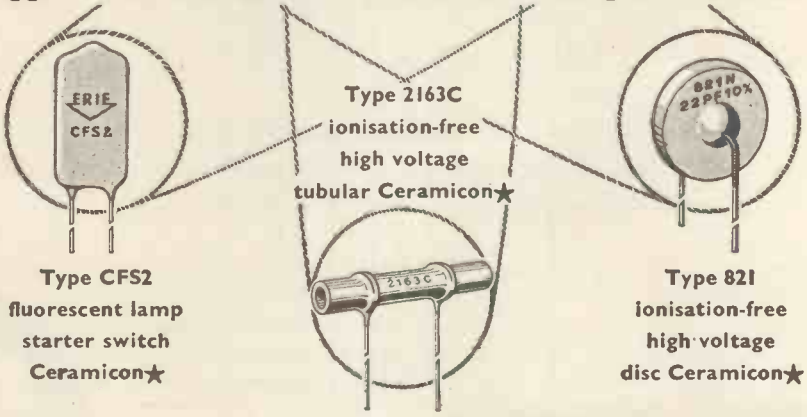

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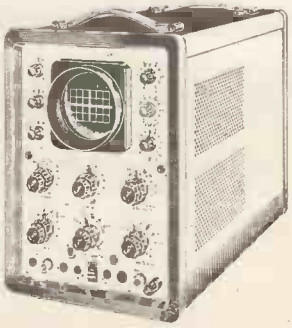
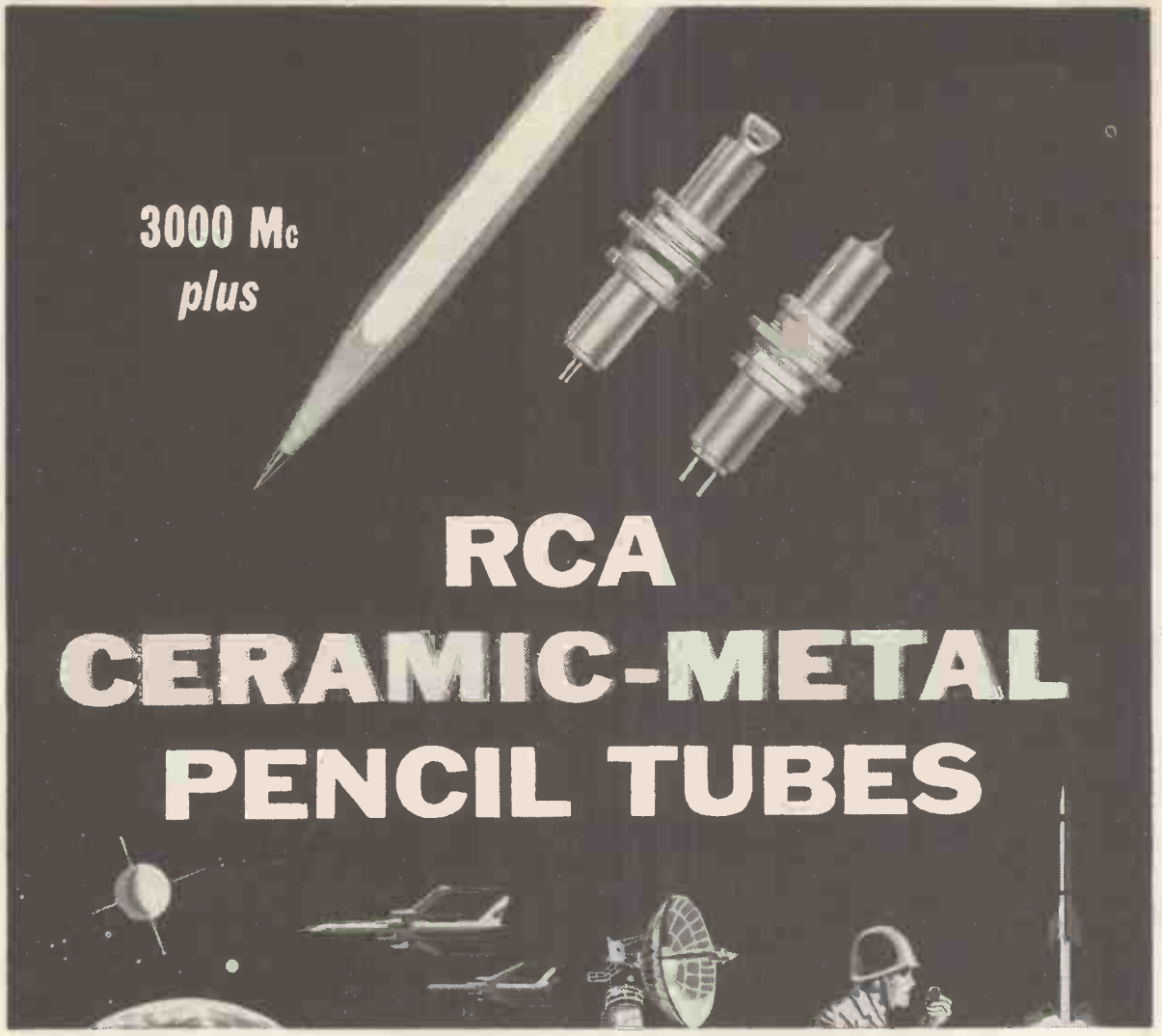
GM 5602

High Frequency Oscilloscope

Cathode Ray Tube: DH 10-78
Flat faced 10 cm tube, EHT - 4 kV
Vertical Amplifier: 3 c/s - 14 Mc/s
(-3 ± 1/2 dB)
Sensitivity 75 mV/cm,
Calibration accuracy 3%
Signal delay line 0.3 μsec.
Time base: 0.2 μsec/cm - 10 msec/cm
Calibration accuracy 3%
Horizontal magnification: x 2, x 5
Cathode-follower probe available.



The price - a pleasant surprise



RCA-7552 and RCA-7554—the first of a dynamic new series of RCA Pencil Tubes for UHF service

RCA—originator of the PENCIL-TUBE and NUVISTOR concepts—again sets the pace in commercial and military UHF tube design with two new ceramic-metal pencil triodes for operation at frequencies up to 3,000 Mc/s and above! Both types utilize coaxial-electrode structures and are designed to operate at altitudes as high as 100,000 feet without pressurization and at plate-seal temperature of 225°C. The generous plate-cylinder surface provided by pencil-tube construction permits fast heat dissipation—a major advantage in miniaturized equipment.

Already incorporated in the design of airborne communications and data-transmission systems and well suited for use in portable field equipment, missile-guidance systems, and satellite-communications applications, RCA ceramic-metal pencil tubes are a "natural" for UHF circuits in miniaturized equipment where low heater power, fast warm-up and high thermal stability are critical. RCA-7552 is a high-mu triode designed for low-noise, class A rf amplifier service. RCA-7554 is a high mu triode intended for class C oscillator, rf power amplifier, and multiplier service. Both types are now in production.

For further information on these types. write Engineer ng Products Sales Departmer t WW.14.

RCA GREAT BRITAIN LIMITED

(An Associate Company of Radio Corporation of America)

Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex.

Telephone : Sunbury-on-Thames 2101.

Check these outstanding Ceramic-Metal Pencil Tube features :

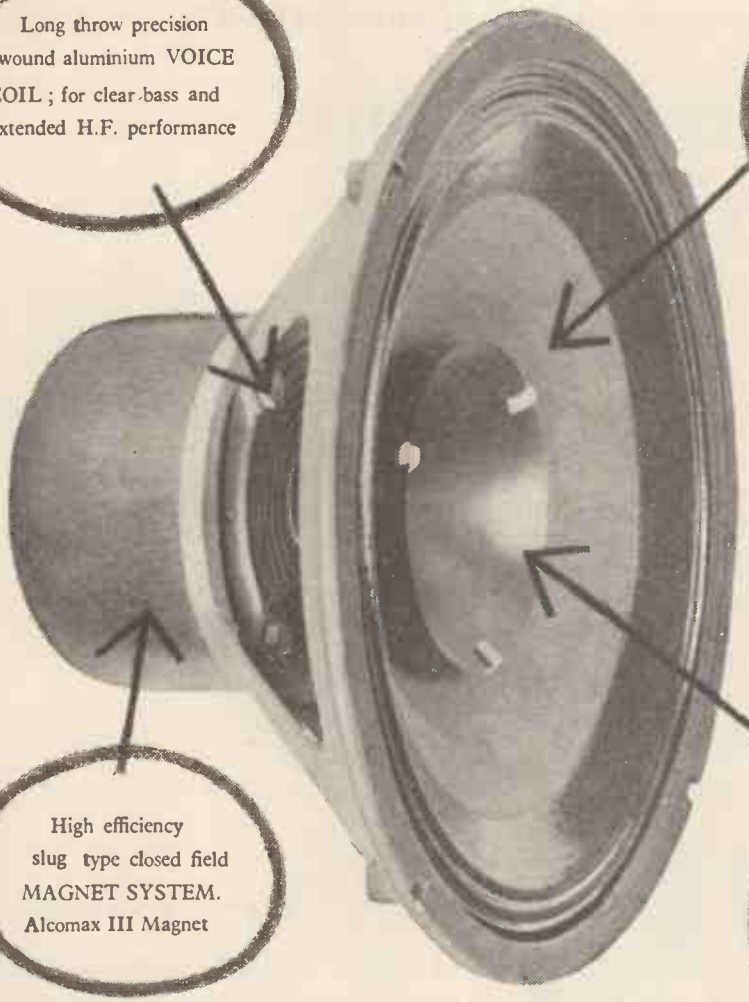
- ★ **Large cathode area: about three times more cathode area for the same heater power than comparable planar types.**
- ★ **Fast warm-up time : only $\frac{1}{3}$ the warm-up time of comparable planar types (12 seconds to reach 90% of dc operating plate current).**
- ★ **Thermal stability: output remains essentially constant over ±10% heater-voltage fluctuations.**
- ★ **Small size: Maximum length 1⅛in.; maximum diameter (at grid flange) 9/16in.; weight only 0.3 oz.**
- ★ **Less affected by nuclear radiation: Evidence indicates that ceramic-metal construction has greater endurance to nuclear radiation than glass-metal construction.**
- ★ **Cantilever arrangement of coaxial elements: has low inter-element leakage, permits good efficiency, and resists shock and vibration.**

C

STILL the best selling 12" High Fidelity Loudspeaker . . .

Long throw precision wound aluminium VOICE COIL ; for clear bass and extended H.F. performance

Vacuum formed controlled edge BASS DIAPHRAGM with plastic termination providing smooth low frequency and mid-range output from 30 c/s.



High efficiency slug type closed field MAGNET SYSTEM. Alcomax III Magnet

HIGH FREQUENCY RADIATOR, automatic mechanical crossover. Fitted with terminators. Controlled low distortion output up to 16,000 c/s.

AXIOM 300

Frequency Range : 30 *c/s.*—16,000 *c/s.*
Fundamental Resonance : 35 *c/s.*
Power Handling Capacity : 15 *Watts.*
Flux Density : 14,000 *gauss. Impedance* : 15 *ohms.*

Price £11. 5. 9

The most advanced twin cone High Fidelity Loudspeaker yet produced

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GOODMANS INDUSTRIES LIMITED Axiom Works, Wembley, Middx.
* *Tel*: *WEMbley* 1200 (8 *lines*) *Grams*: *Goodaxiom, Wembley, England.*
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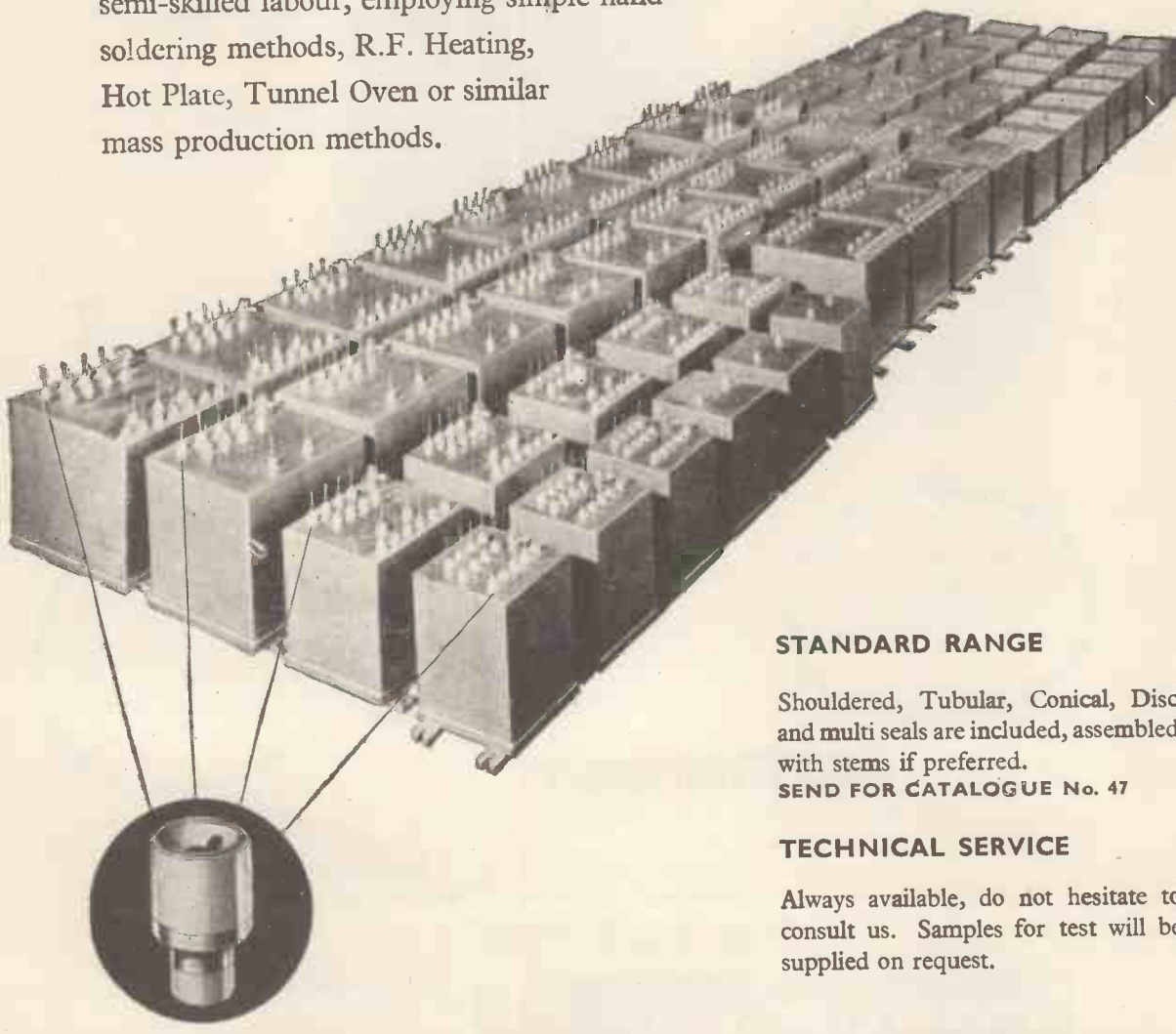
NICKEL METALLISING
Quality Approved (Joint Service R.C.S.C.)
WILL MEET THE MOST EXACTING REQUIREMENTS

METALLISED BUSHES

Perfect Terminations

—made readily without special precautions by semi-skilled labour, employing simple hand soldering methods, R.F. Heating, Hot Plate, Tunnel Oven or similar mass production methods.



STANDARD RANGE

Shouldered, Tubular, Conical, Disc and multi seals are included, assembled with stems if preferred.
SEND FOR CATALOGUE No. 47

TECHNICAL SERVICE

Always available, do not hesitate to consult us. Samples for test will be supplied on request.

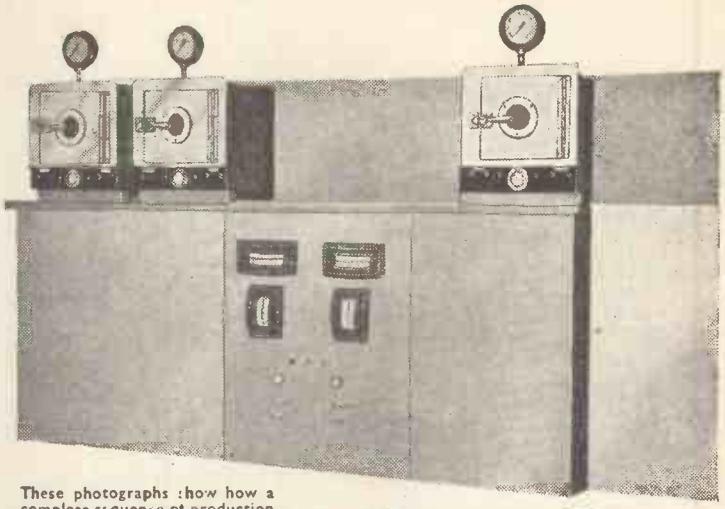
STEATITE & PORCELAIN PRODUCTS LTD.

STOURPORT ON SEVERN, WORCS. **Telephone: Stourport 2271** **Telegrams: Steatain, Stourpor**

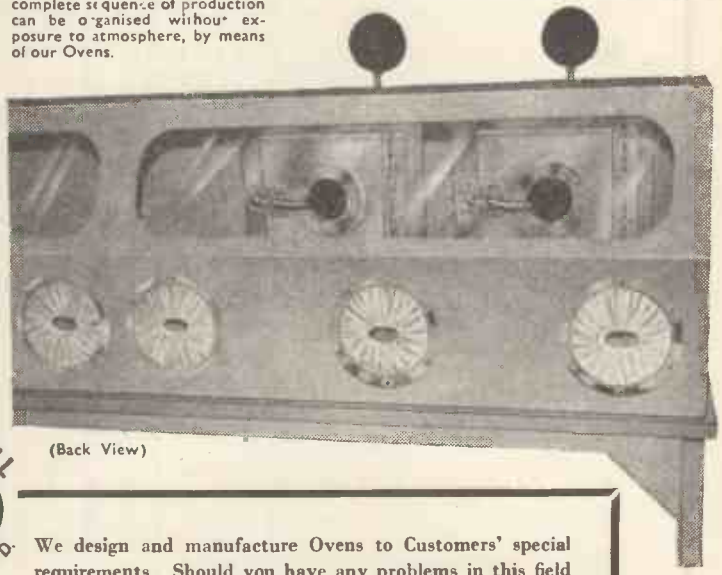
SPI

DOUBLE ENDED STAINLESS STEEL VACUUM OVENS

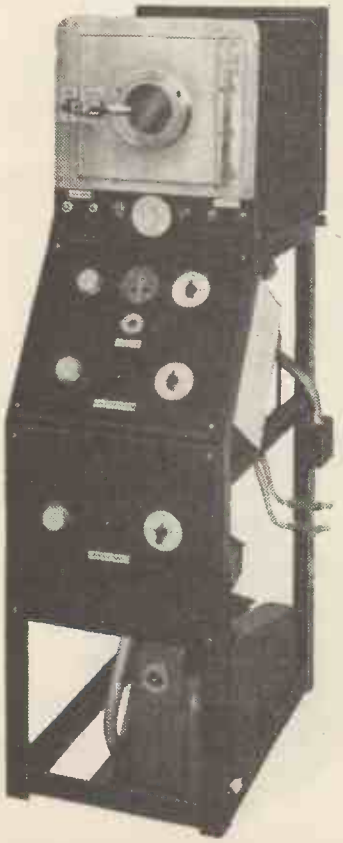
- ★ Made throughout in polished stainless steel.
- ★ Single action door openings.
- ★ Rectangular with shelf spacings to suit.
- ★ Double ended controls.
- ★ Electrical interlocking of air inlet and isolation valves.
- ★ Outer cover hermetically sealed.
- ★ Temperature range 0°-300°C or equivalent F.
- ★ Temperature Control: Normal ±7½°C. Special ±1C
- ★ Internal Spacing 7in. x 8in. x 18in. (can be altered to special requirements).
- ★ Vacuum Range: To 10–4.
- ★ Respective Vacuum Gauges incorporated.
- ★ Automatic air inlet valve on Backing Pump.
- ★ Visual Indicators and fuses on all switches.
- ★ Flanged for fitting into Dry Box.



These photographs show how a complete sequence of production can be organised without exposure to atmosphere, by means of our Ovens.



(Back View)



VACWELL ENG. CO. LTD.

We design and manufacture Ovens to Customers' special requirements. Should you have any problems in this field our Technical Department is always willing to help you solve them.

Vacuum Ovens with temperatures of up to 600°C are also manufactured by us on similar lines but with Sectional Heating and Water-Cooled Ends.

VACWELL ENGINEERING CO. LTD.

WILLOW LANE · MITCHAM · SURREY

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CAMBRIDGE
Centre of Scientific Research

Henry Cavendish

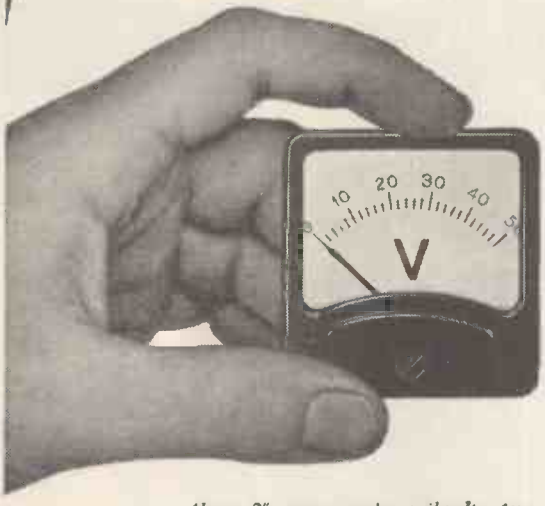
Born in France in 1731, Henry Cavendish entered Peterhouse, the oldest of the Cambridge Colleges, in 1749. He left without taking a degree and devoted the rest of his life to Science. Painfully shy, Cavendish never exploited any of his Scientific discoveries, many of which were not even published in his lifetime; but the name of this great Scientist was commemorated in the Cavendish Laboratory, set up in Cambridge just over sixty years after his death. Pye is fortunate to have been closely associated throughout its own history with this great centre of Scientific research, which has been recognised for many centuries as the home of new ideas. The Scientists and craftsmen at Pye have always drawn great inspiration from this background. At the same time, they are proud of their own contribution to the Science of electronics.

PYE

Pye Limited of Cambridge England

A COMPREHENSIVE RANGE OF

"Miniature" Instruments



Above: 2" square moving coil voltmeter

★ **DESIGNED TO HARMONISE WITH ALL MODERN ELECTRONIC EQUIPMENT**

★ **FIXINGS CONFORM TO ACCEPTED PRACTICE**

★ **PRICES ARE HIGHLY COMPETITIVE**

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

RESISTANCE TO IMPACT SHOCK OF 200g in any plane.

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

OSCILLATORY TEST—up to one million operations.

SPECIFICATIONS B.S. 89–1954 and other international standard specifications, or B.S. 2011/H3 if required.

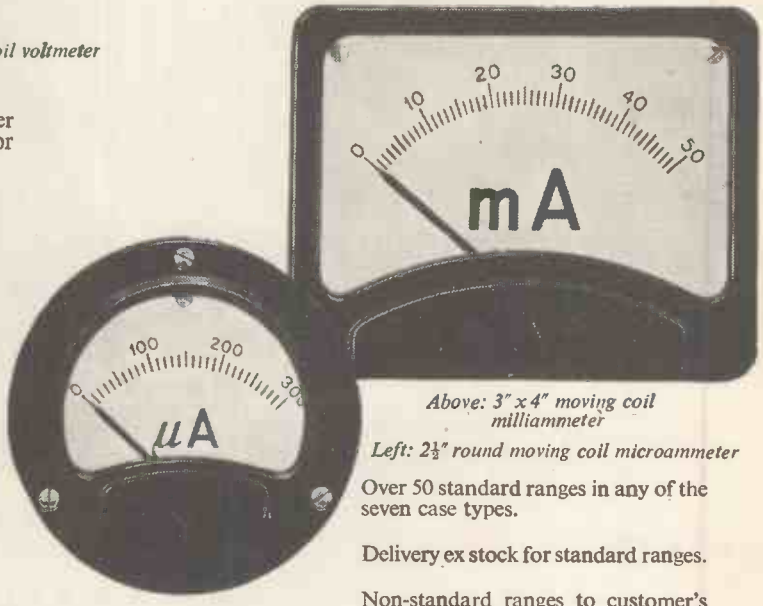
TYPES

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

SIZES

Square: 2", 2½" and 3½" nominal scale length.
Round: 2½" and 3½" nominal scale length.
Rectangular: 5" x 6" or 3" x 4" nominal case size.

Design registrations pending.



Above: 3" x 4" moving coil milliammeter

Left: 2½" round moving coil microammeter

Over 50 standard ranges in any of the seven case types.

Delivery ex stock for standard ranges.

Non-standard ranges to customer's specification within 21 days.

Literature available on request to The ENGLISH ELECTRIC Co. Ltd., Instrument Department, Stafford.

'ENGLISH ELECTRIC'

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

Meter, Relay and Instrument Division, Stafford

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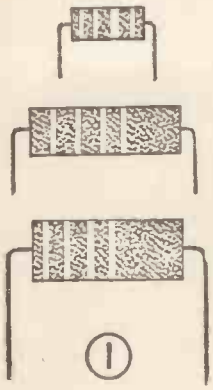
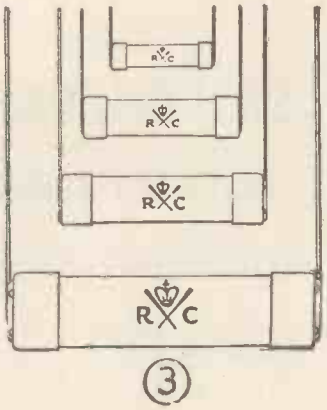
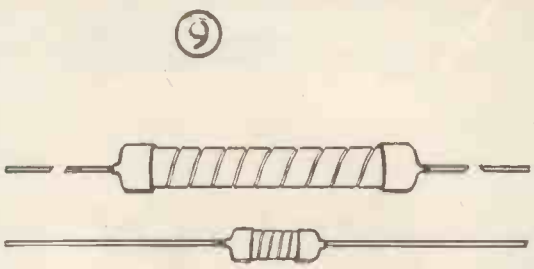
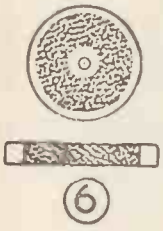
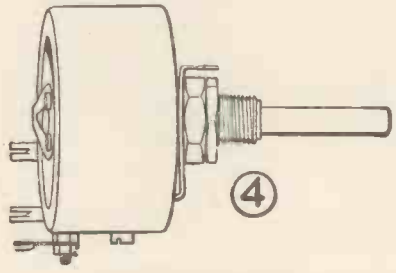










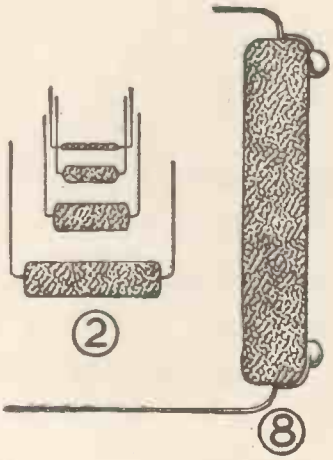
A SERVICE FOR DESIGNERS

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

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

CARBON	WATTS	OHMIC RANGE	TOLERANCES ±
1. Solid	½ 1 and 2	10—10M	5% and 10%
2. Cracked	1/30—20	1—500M	5% and 10%
3. * High Stability	1/10—3	1—50M	0.5% 1% 2% 5%
4. Variable	¼	5K—2M	—
5. V. High Resistance	¼—3	50M—10^{13}	5% and 10%
6. V.H.F.(Rods and Discs)	1/10—1	10—1K	1% and 2%
WIREWOUND			
4. Rheostats	4—500	10—80K	—
9. Metal Oxide	¼—2	100—4.2M	1% 2% 5%
8. Vitreous	3—500	1—150K	1% 2% 5%
7. Cemented	1—15	1—25K	5% and 10%

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



Do you KNOW

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

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

26 YEARS LAB
JUBILEE YEAR OF RESISTOR SPECIALISATION

READ DIRECTLY

1μμa

and

1μv

10 times previous accuracy, drift less than ±2μv, noise less than 0.2μv!

New 425A microvolt-Ammeter

£205

delivered U.K.

Now make these difficult measurements quickly, easily

Engineering—minute dc potentials, difference voltages, nulls; resistances from milliohms to 10 megmegohms (with external dc source). Also use with Esterline-Angus, other recorders

Physics, Chemistry—grid, photomultiplier circuits, vacuum ion levels, thermocouple potentials, voltaic currents in chemicals

Medicine, Biology—voltages in living cells, plants, seeds, nerve voltages

Use of a photoelectric chopper instead of a mechanical vibrator, insuring low noise and drift. Protection against 1,000 volt momentary overloads. New probe minimizing thermocouple and triboelectric effects. Heavy ac filtering.

Above are but a few of the reasons why the new *-hp-* 425A does the work of complex equipment arrays faster, more simply and with 10 times previous accuracy.

In addition to extremely small voltages and currents, Model 425A measures resistances from milliohms to 10 megmegohms, in conjunction with an external constant current.

SPECIFICATIONS

MICROVOLT-AMPLIFIER:

Voltages: Pos. and neg. 10 μv to 1 v full scale. 11 ranges, 1-3-10 sequence.

Current: Pos. and neg. 10 μμa to 3 ma full scale. 18 ranges, 1-3-10 sequence.

Input Impedance: 1 megohm on voltage ranges, 1 megohm to 0.33 ohms on current ranges.

Accuracy: ±3% full scale.

AMPLIFIER:

Frequency Range: dc to 0.2 cps.

Gain: 100,000 maximum.

Output: 0 to 1 v, adjustable.

Output Impedance: 10 ohms, 1,000 ohm shunt.

Data subject to change without notice

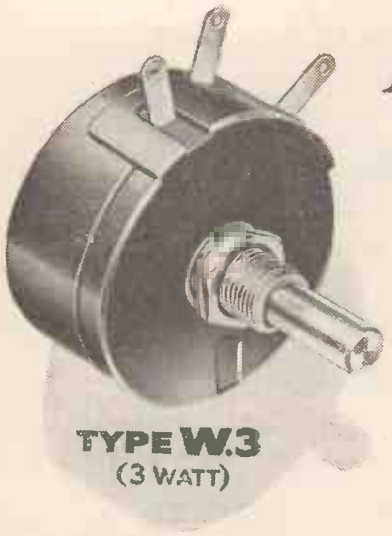
HEWLETT-PACKARD CO.
Represented by

Get complete details today from:-

LIVINGSTON LABORATORIES LIMITED

RETCAR STREET · LONDON · N.19

Telephone: **ARC**hway 6251



This illustration is actual size.

Introducing . . .

ADDITIONAL TO THE RELIANCE RANGE

This latest addition to the Reliance range of Potentiometers has been designed to conform with specification DEF-5121 style RVW 7 & 8 (formerly RAC.RAD) and is fully sealed with integrally constructed moulded cover. A commercial unsealed version, with identical characteristics is also available. Both types can be supplied in ganged form.

BRIEF SPECIFICATION

RESISTANCE RANGES

Linear Law A.....5 to 100,000 ohms
Laws B—G.....50 to 50,000 ohms
Non-Inductive.....50 to 10,000 ohms
(Ayrton Perry)

RESISTANCE TOLERANCE

Standard.....over 100 ohms± 5%
under 100 ohms±10%
Also available (at extra) with tolerance to ±1% and linearity to within ±1%.

ROTATION

Electrical Effective .....280°±5°
Mechanical ..... 290°±5°

MAXIMUM WORKING VOLTAGE

Between spindle and track ..... 1,000 V.d.c.

Full technical details and dimensional drawings in Data Sheet No. 9 available on request.

★ *Also* available, the precision built
TYPE HA2500
providing exceptionally high law accuracy *without cam correction.* Range 100 to 100,000 ohms. Law Accuracy (Absolute) ±0.25% or ±0.10%.
Full details In Data Sheet No, 100.

RELIANCE MANUFACTURING CO. (SOUTHWARK) LIMITED
SUTHERLAND ROAD, HIGHAM HILL, WALTHAMSTOW, LONDON, E.17. Tel: Larkswood 1118/9

GD61

100,000 o.p.v.!

Model '100A' TAYLORMETER

HIGHEST SENSITIVITY IN THE WORLD

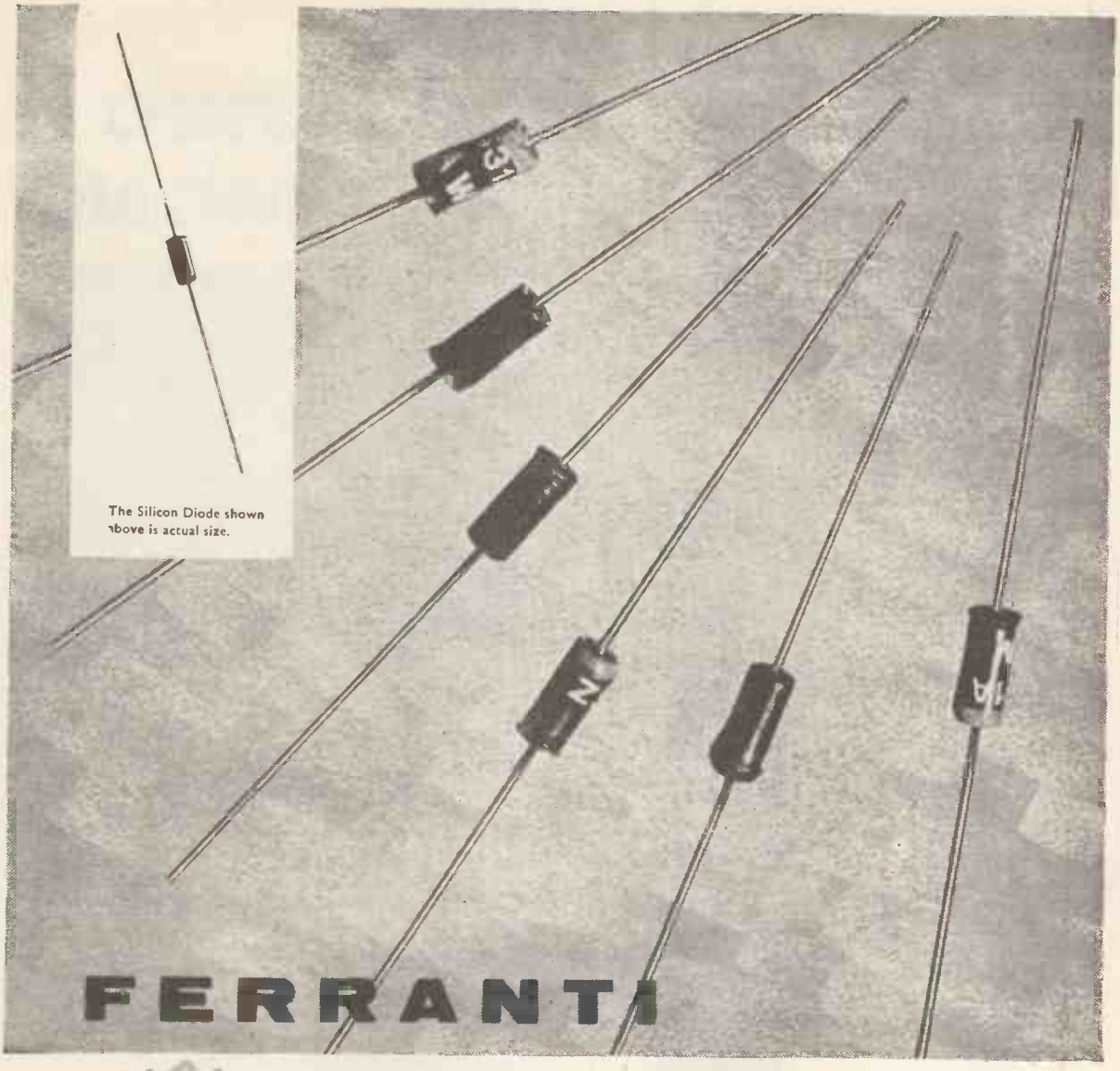
13 STAR FEATURES

- ★ Supersensitive
- ★ Automatic Mechanical Overload Cut-out
- ★ Reverse Polarity Facility
- ★ Lowest current reading—0.2 μA
- ★ 10 Microamps full scale
- ★ Highest current reading—10 Amps DC
- ★ Lowest resistance reading—0.5 ohms
- ★ Highest resistance reading—200 Meg ohms self contained
- ★ Lowest voltage reading—10 mV DC
- ★ Highest voltage reading—25 kV DC
- ★ Very Robust—suitable for everyday use
- ★ Accuracy (2% DC. 3% AC. ohms 5%)
- ★ Portability

LIST PRICE **£31.10.0**
Complete with Instruction Manual and Interchangeable test prods and clips.
High quality leather case, if required, £2.18.0d.
H.V. Probe for 25 KV ... £4.0.. d.

Write for full details and catalogue

TAYLOR ELECTRICAL INSTRUMENTS LTD.
MONTROSE AVENUE, SLOUGH, BUCKS. Telephone: Slough 21381
Cables: Taylins, Slough



Silicon Diodes ZS30 series

for MINIATURIZED Circuitry

SPECIAL FEATURES

- AUTOMATIC WIRING TECHNIQUES
- HIGH POWER TO SIZE RATIO
- HIGH TEMPERATURE OPERATION
- HIGH FORWARD CONDUCTANCE
- HIGH RECTIFICATION EFFICIENCY
- RUGGEDISED CONSTRUCTION

Ferranti Miniaturized Circuit Diodes are designed for automatic wiring techniques. These diodes, in addition to being run at maximum ratings for forty-eight hours, are rigorously tested to satisfy the following conditions:

Vibration	Grade 1 (Aero Engines)
Shock	> 500 g.
Humidity	Class H1
Temperature Range	−70°C to + 135°C.

P.I.V. Range 50-400 Volts : Max. Mean Rectified Current 500mA

FERRANTI

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SILICON
SEMICONDUCTOR
DEVICES

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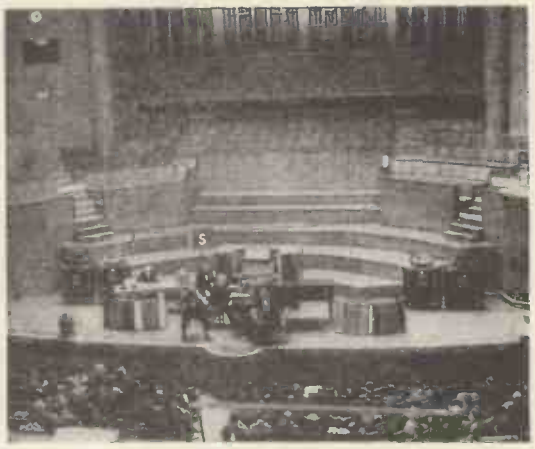
LIVE v STEREO v MONO



String Trio playing in direct comparison with E.M.I. recording in the Colston Hall, Bristol, 9th October, 1959.

At this lecture demonstration given by G. A. Briggs the audience was able to compare both stereo and mono recordings with live performances. A show of hands indicated a majority preference for stereo.

SFB/3s were used to reproduce the voice of Harold Blackburn, principal bass with Sadler's Wells.

For the string trio, two pairs of multi-speaker systems were used, each employing the W15/FS mounted in a 9 cu. ft. sandfilled reflex enclosure.

Richard Hawkins writing in the "Bristol Evening Post," Saturday, October 10th, says:

"*. . . an excellent reproduction on tape of Mr. Harold Blackburn's fine bass voice . . .*"

"*What was delightful was the loudspeakers' handling of the extreme wide variety of tone colour produced during the evening, and their consistently musical tone, particularly kind to strings, which have not always recorded so well since the L.P. era.*"

EQUIPMENT USED

QUAD amplifiers CONNOISSEUR turntable
ORTOFON C mono pickups DECCA stereo
AMPEX 351/2P tape recorder
WHARFEDALE speakers

Emitape

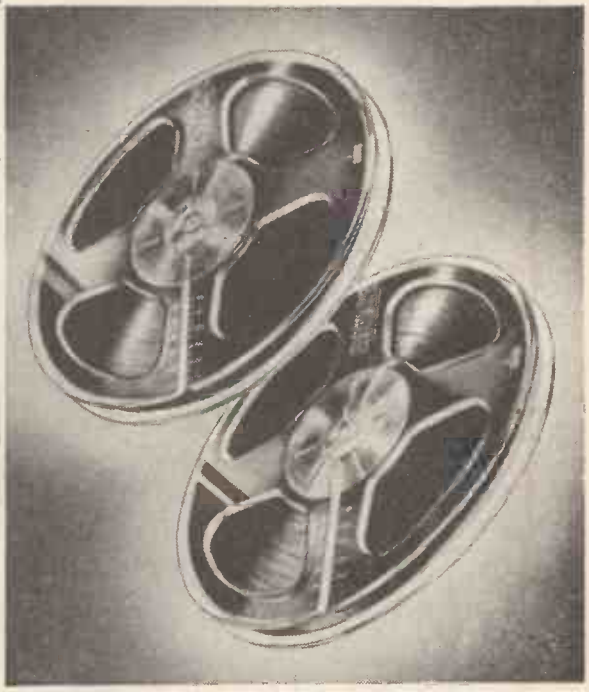
the magnetic recording tape with the highest technical standards

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

"88" GENERAL PURPOSE

"99" LONG PLAY

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



Emicase

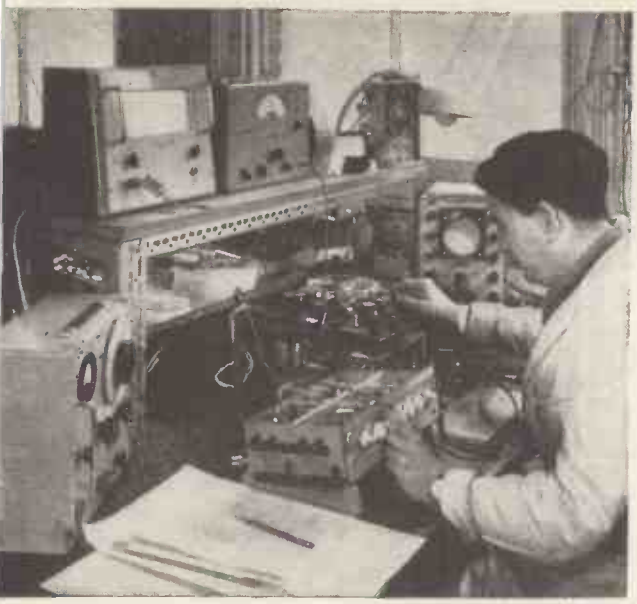
now available separately!

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

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

E·M·I SALES & SERVICE LTD
(Recording Materials Division)
HAYES · MIDDLESEX
Tel: SOUthall 2468

ES/R/46



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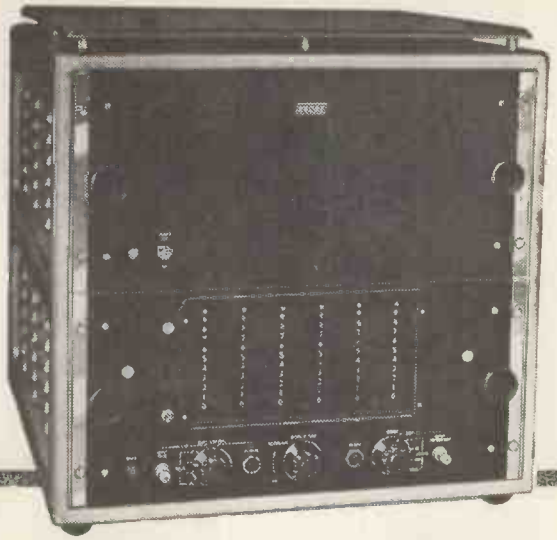

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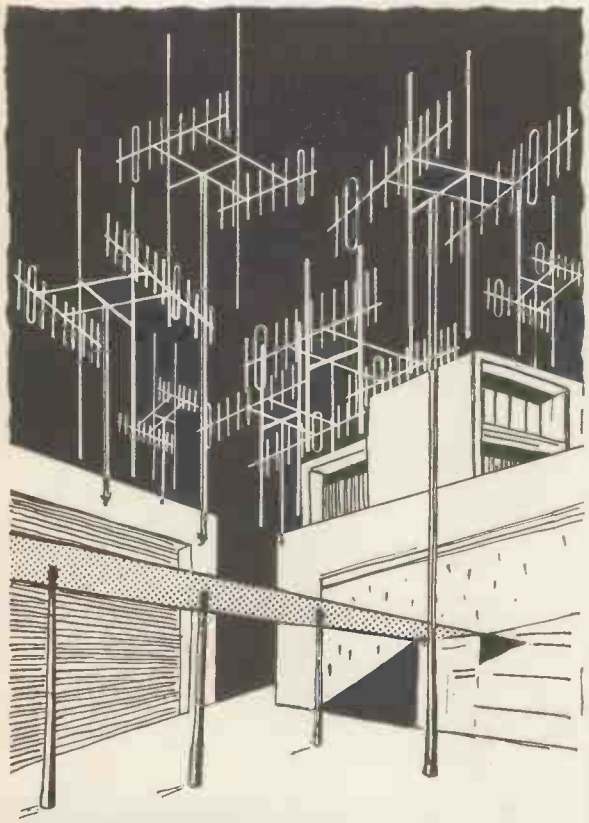

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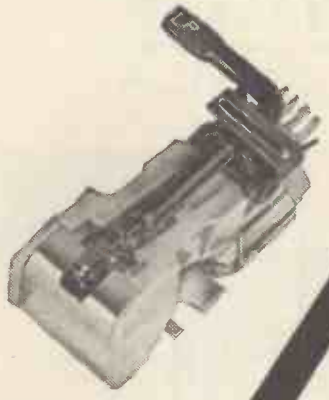

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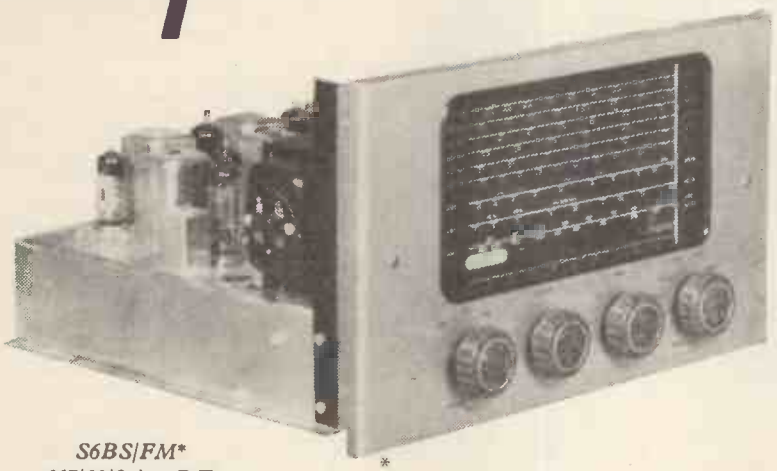

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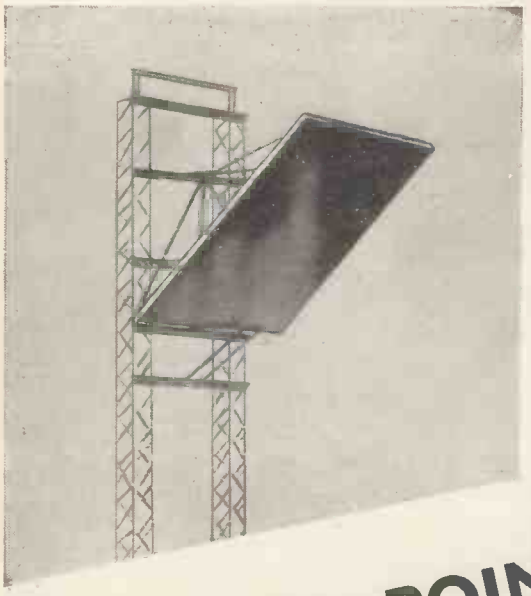

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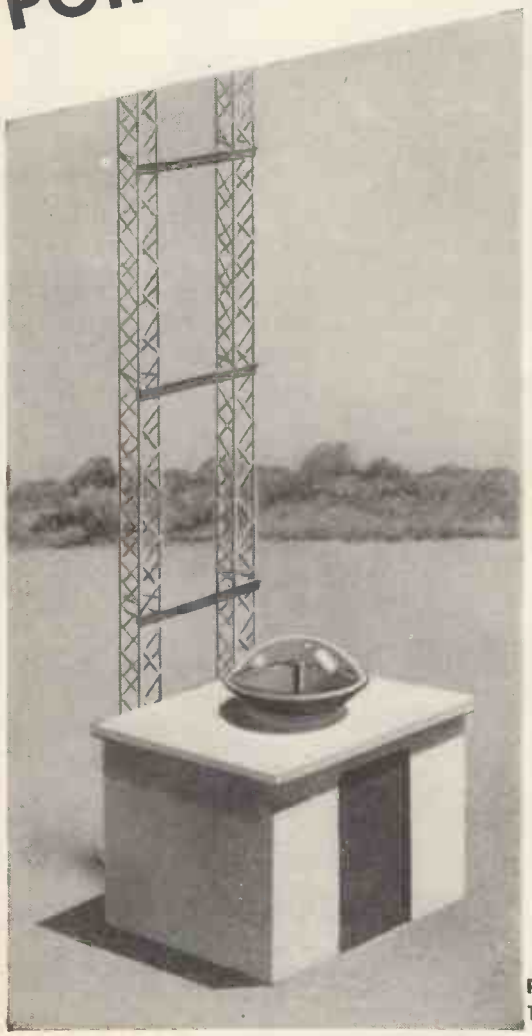

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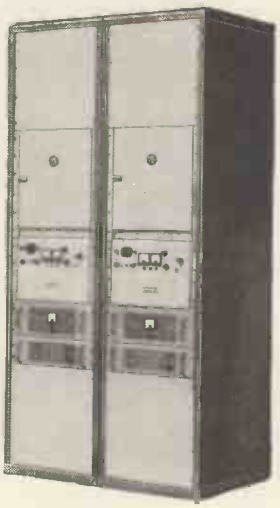

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DECEMBER 1959

VOLUME 65 NO. 11

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FRAME GRID VALVES FOR TELEVISION

3

The frame grid valves for television tuners are the PCC89 and PCF86. The PCC89 is a variable-mu r.f. double triode for use as a cascode amplifier. It is the frame grid counterpart of the conventional PCC84, but it has twice the slope. The PCF86 is a combined triode and high-slope r.f. pentode for use in the mixer stage. Its conventional counterpart is the PCF80; but, again, the frame grid valve has about twice the slope of its predecessor, and the increase in conversion conductance is from 2.1mA/V to 4.5mA/V. With such substantial changes in characteristics, it is obvious that the frame grid types cannot be used as plug-in replacements for the earlier types. Tuners will necessarily have to be redesigned with different component values. In addition, the large increase in voltage gain will demand particular care with respect to stability, especially as tuners are progressively miniaturised and printed circuits are introduced.

The design of the r.f. amplifier round the PCC89 will be discussed in a later advertisement. Here we shall outline the special features of a frame grid mixer stage.

STABILITY

In the mixer, stability must be considered primarily at the frequency where the grid tuned circuit and the i.f. transformer most closely approach in frequency; that is to say, on channel 1. The stability of the stage is determined by the effective slope of the mixer valve, which is doubled when a frame grid valve is used. However, the impedances of the grid and anode circuits are likely to be substantially the same for the PCF80 and PCF86. The worst condition for stability is when the primary of the r.f. bandpass filter is detuned with respect to the secondary, feeding the mixer grid; and the impedance of the i.f. bandpass filter (which is usually built into the tuner itself) is at its highest.

In the 40Mc/s region the characteristics of the circuit are such that there is only a narrow margin of stability. In particular, there is very little allowance for stray capacitances. For maximum stability, especially during alignment, it is therefore advantageous to neutralise the anode-to-grid capacitance of the valve. This can be done with either a loop coupled transformer (Fig. 1) or with bottom capacitance coupling (Fig. 2). In either case, the equivalent bridge circuit is as shown in Fig. 3. The value of Cg2 is not particularly critical, since partial neutralisation should be sufficient. However, the normal precautions must be observed: the stage should be carefully wired, the placing of components near the valve-holder should be avoided as far as possible, and the i.f. transformer coil should be kept well away from the mixer grid circuit.

R.F. LOSSES

In the design of the PCF86, special attention has been given to the question of r.f. losses. The triode and pentode cathode pins are internally strapped to minimise cathode lead inductance. They should both be taken straight to ground. Accordingly, in the PCF86 the effective grid-cathode capacitance due to cathode lead inductance rises comparatively little with frequency. Thus at 200Mc/s its value is only 10% above its l.f. value; while in the PCF80 the increase is more like 25%, and the capacitance/frequency characteristic is steep.

The input impedance of the PCF86 pentode has been carefully controlled by a certain amount of screen regeneration which is built into the valve. The inductive component of the screen grid connection produces a negative damping effect in the grid-cathode circuit by virtue of Miller effect; and the total input conductance of the pentode, due to cathode lead and screen lead inductance, is held within narrow limits.

FIG. 1

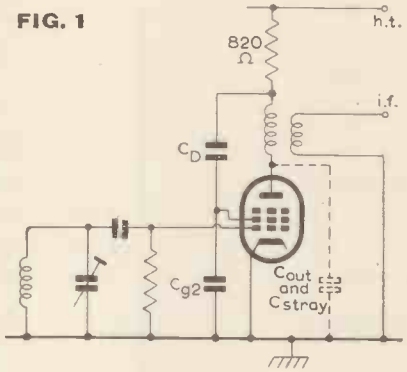


FIG. 2

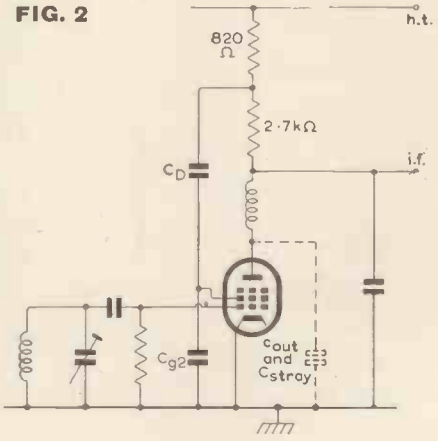
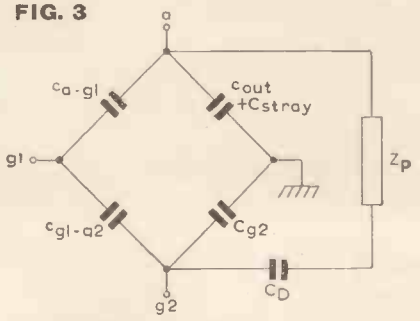


FIG. 3



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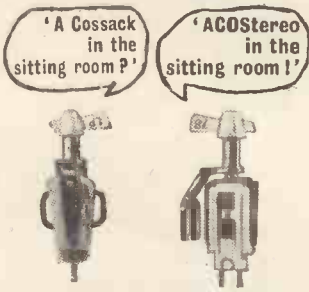

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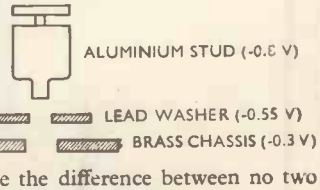
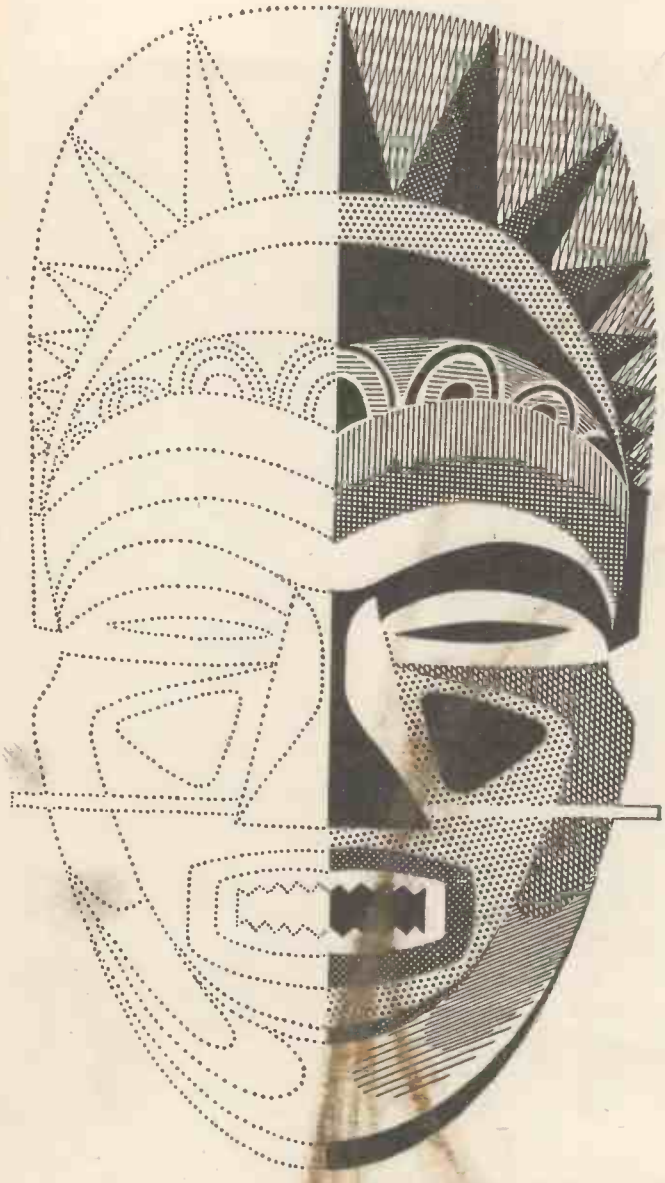
It has been established that different metals in proximity in an electrolyte have different potentials, some higher, some lower. The text book standard is a calomel electrode in sea water, against which the potential of other metals are measured, e.g., zinc is — 1.1 volts, copper is — 0.2 volts, i.e., the potential between copper and zinc is the difference between these two readings which is 0.9 volts. It is the material which has the most negative value that tends to corrode. It is generally considered good practice to keep potentials low, and if normally exposed to weather, 0.25 volts should not be exceeded, but 0.5 volts is tolerable if the equipment is to be used under warm and dry conditions.

The atmosphere itself in certain industrial locations can be very corrosive, so much so that exposed and untreated metal parts have a short life. In such places impurities seep through any but completely sealed containers, and really extensive damage can develop in time if potentials have not been considered. Steps can be taken to reduce the potential difference by electro-plating either or both parts with a metal with the desired potential.

Cadmium is generally recognised as a most useful metal either for the plating of a steel chassis, or for valveholders or other components which have to be mounted thereon. It is also permissible to reduce the potential difference by the introduction of a third metal, say a lead washer (— 0.55 V), the potential of which lies between those in use as shown in the sketch below,



where the difference between no two metals exceeds 0.25 volts.



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Aspects of design

17

FRAME DRIVE CIRCUITS

This is the Seventeenth of a series of special features dealing with advanced problems in television and radio circuit design to be published by Siemens Edison Swan. The Ediswan Mazda Applications Laboratory will be pleased to deal with any questions arising from this or other articles, the eighteenth of which will appear in the January 1960 issue.

The frame drive circuit in a television receiver must be capable of supplying a waveform accurately timed and of sufficient amplitude to drive the frame output valve. Although a typical frame output valve such as the Ediswan Mazda 30PL13 may need only about fifteen volts peak to peak swing on its grid to provide the anode current scanning waveform the drive circuit must usually be capable of providing a much higher output. This is because the signal is attenuated in the shaping circuit which is introduced to produce the correct grid waveform for a linear scan—see Aspects of Design No. 3. The required amplitude from the drive circuit may vary between about fifty volts and as much as a hundred volts according to the type of linearising arrangements used.

The most exacting requirement which the frame drive circuit has to fulfil is that the output waveform should be identical on alternate strokes and should not vary either in amplitude or in timing in relation to the synchronising signal. Any differences in amplitude or timing between odd and even scans will upset the interlace and degrade the picture quality.

The frame drive circuit is synchronised at the end of each stroke by a synchronising signal. This frame synchronising signal is often separated from the composite synch waveform by integration followed by clipping of the integrated waveform. This produces frame synchronising pulses with a small timing error on the leading edge but a considerable timing error on the trailing edge. By correct design the error on the leading edge, which is used to synchronise the drive stage, can be made negligible but the error on the trailing edge remains. Every effort must be made to ensure that this does not affect the operation of the timebase.

Frame drive circuits in general use are (1) blocking oscillator, (2) anode coupled multivibrator, (3) cathode coupled multivibrator and (4) a system of overall feedback in which the drive valve and output valve are connected in a manner similar to an anode coupled multivibrator. Typical circuits are shown in Figs. 1 to 4.

In all cases the output sawtooth is generated by periodically discharging a capacitor which, in the intervals between discharge, is allowed to charge exponentially through a resistor towards H.T. line potential. The choice of circuit is, as usual, governed by the conflicting requirements of performance and economics.

1. The blocking oscillator uses only one valve which may be in the same envelope as the output valve but it also uses a transformer and this may be fairly expensive. It is triggered into conduction by the negative-going leading edge of a synchronising pulse applied to the anode. If a synch pulse with a non-interlaced trailing edge is used and the oscillator conduction time is long then this positive-going edge may terminate the conduction period. Conduction would then be different on odd and even frames and interlace would deteriorate. The oscillator is accordingly designed to have a short conduction time of about 150 to 250μS. This usually results in a fairly low impedance transformer with consequent difficulty in providing sufficient amplitude of synchronising pulse at the anode.

2. The anode coupled multivibrator presents a higher impedance to the synchronising pulse. The negative-going pulse is usually applied to the anode of the non-conducting valve V_2 whence it is fed to the grid of the conducting valve V_1. An amplified pulse is therefore fed to the grid of V_2 which is then easily driven into conduction. In order to prevent termination of the conduction period of V_2 by the trailing edge of the synch pulse, V_1 is usually kept cut off until well after this has arrived. The cut off period of V_1 is accordingly arranged to be about 600 or 700μS. The multivibrator is not capable of providing such high peak currents as the blocking oscillator and this long conduction of V_2 enables the required output voltage swing to be provided without using large valves.

3. The cathode coupled multivibrator offers the advantage of a control grid on V_1 (Fig. 3) which takes no part in the oscillation process. This makes a convenient point for synchronising without danger of a pulse being fed back into the synchronising signal separator. It is often difficult, however, with this circuit, to provide such high peak currents as with the anode coupled circuit.

4. The overall feedback circuit (Fig. 4) is particularly difficult to use because line pulses picked up by the frame deflector coil from the line output stage are fed straight into the coupling components of the oscillator circuit. This results in bad deterioration of interlace. A condenser across the primary of the frame transformer will reduce this effect.

In all cases extreme care must be taken in layout and wiring to avoid coupling line frequency signals into the frame drive circuit. The Ediswan Mazda 6/30L2 and the triode sections of 30PL13, 30PL1 and 30FL1 have been developed to have characteristics suitable for frame drive circuit operation.

FIG 1

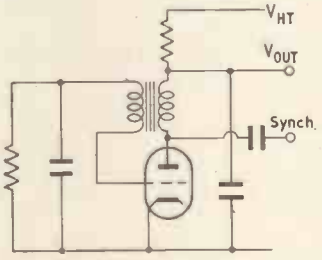


FIG. 2

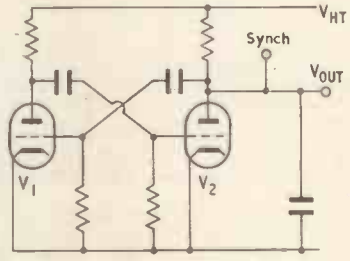


FIG. 3

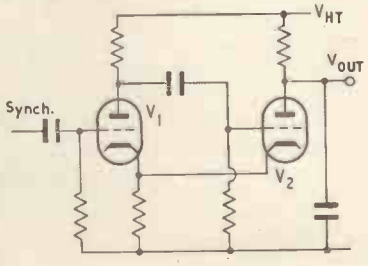
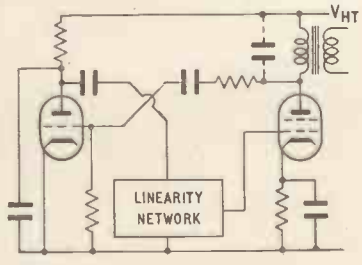


FIG. 4



SIEMENS EDISON SWAN LIMITED *An A.E.I. Company*
Technical Service Department, 155 Charing Cross Rd., London, W.C.2.
Telephone: GERrard 8660. Telegrams: Sieswan, Westcent, London.

EDISWAN MAZDA 10LD12

The 10LD12 is a Triple Diode Triode intended for use in FM and AM/FM a.c./d.c. receivers. The first diode is for AM detection with the second and third diodes designed for use as the FM ratio detector. The high μ triode is for audio amplification.

Heater Current (amps)	I_h	0.1
Heater Voltage (volts)	V_h	28

MAXIMUM DESIGN CENTRE RATINGS

Triode Section

Anode Dissipation (watts)	$P_{a(t)max}$	1
Anode Voltage (volts)	$V_{a(t)max}$	250
Heater to Cathode Voltage* (volts)	$V_{h\text{-}k(t)max}$	150
Cathode Current (mA)	$I_{k(t)max}$	5

Diode Sections

Peak Inverse Voltage (all sections) (volts)	$PIV_{(max)}$	350
Anode Current. Section 1 (mA)	$I_{a'(d)}$	1
Anode Current. Section 2 (mA)	$I_{a''(d)}$	10
Anode Current. Section 3 (mA)	$I_{a'''(d)}$	10

*In order to avoid excessive hum the a.c. component should be as low as possible (less than 30 V rms).

CHARACTERISTICS

Anode Voltage (volts)	$V_{a(t)}$	200
Grid Voltage (volts)	V_g	−2.3
Anode Current (mA)	$I_{a(t)}$	1.0
Mutual Conductance (mA/V)	g_m	1.4
Amplification Factor	μ	70
Ratio Anode Resistance ($\delta v_a/\delta i_a$) Diode 2 to Diode 3	$r_{d''}\text{-}r_{d'''}$	0.65 to 1.5

INTER-ELECTRODE CAPACITANCES (pF)

		*	**	***
Triode Section				
Anode/Earth	$C_{a\text{-}E}$	1.4	1.9	2.6
Grid/Earth	$C_{g\text{-}E}$	1.9	2.2	3.0
Grid/Anode	$C_{g\text{-}a}$	2.0	2.1	2.4
Diode Sections				
Cathode, Diode 2/all	$C_{k''d\text{-}all}$	4.9	5.3	6.4
Anode Diode 3/all	$C_{a'''d\text{-}all}$	5.1	5.6	6.6
Anode Diode 1/h, pin 7	$C_{a'd\text{-}kt,\,k'd,\,k'''d,\,h,\,s}$	0.8	1.1	1.7
Anode Diode 2/h, pin 7, Cathode Diode 2	$C_{a''d\text{-}k''d,\,kt,\,k'd,\,k'''d,\,h,\,s}$	4.8	5.0	5.4
Cross Capacitances				
Anode/Anode Diode 1	$C_{at\text{-}a'd}$	0.08	0.09	0.10
Anode/Anode Diode 3	$C_{at\text{-}a'''d}$	0.05	0.11	0.22
Anode/Cathode Diode 2	$C_{at\text{-}k''d}$	0.006	0.011	0.016
Grid/Anode Diode 1	$C_{g\text{-}a'd}$	0.06	0.07	0.10
Grid/Anode Diode 3	$C_{g\text{-}a'''d}$	0.012	0.021	0.035
Grid/Cathode Diode 2	$C_{g\text{-}k''d}$	0.0025	0.0044	0.0066

*Inter-electrode capacitance in fully shielded socket, without can.

**Inter-electrode capacitance with holder balanced out (using holder quoted below).

***Total inter-electrode capacitance including B9A nylon phenolic holder without skirt or radial shield (Siemens Ediswan Clix holder Type VH19/902).

TYPICAL OPERATING CONDITIONS AS RESISTANCE CAPACITY COUPLED AF AMPLIFIER

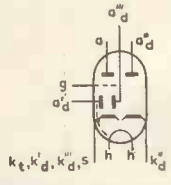
(Grid Current Bias)

Supply Voltage (volts)	$V_{a(b)}$	170	170	170	200	200	200
Anode Load Resistance (kΩ)	R_a	47	100	220	47	100	220
Grid Resistor (Grid Current Bias) (MΩ)	R_{g1}	10	10	10	10	10	10
Anode Current (mA)	I_a	1.25	0.82	0.46	1.6	1.0	0.56
Grid Resistor of following valve (kΩ)		150	330	680	150	330	680
Voltage Amplification		32	42	51	34	44	53
Total Distortion for 3 volts (rms) output (%)		0.6	0.5	0.4	0.5	0.4	0.3
Total Distortion for 5 volts (rms) output (%)		1.1	0.8	0.5	0.9	0.6	0.4
Total Distortion for 8 volts (rms) output (%)		2.0	1.3	1.1	1.5	1.0	0.9

Maximum Dimensions (mm)

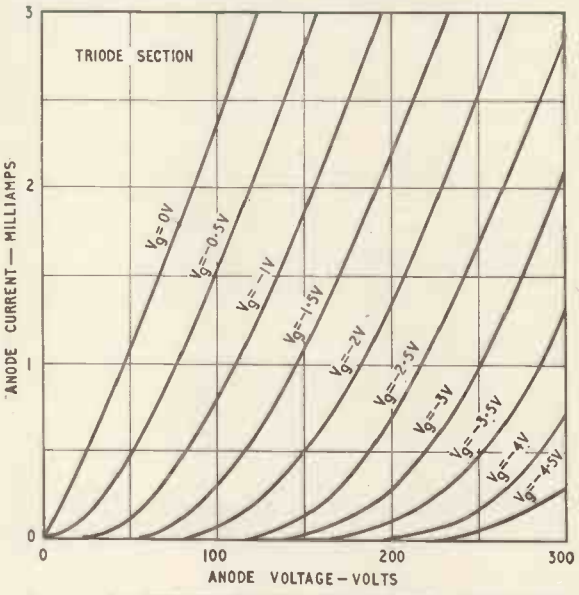
Overall Length	67.5
Seated Height	60.5
Diameter	22.2

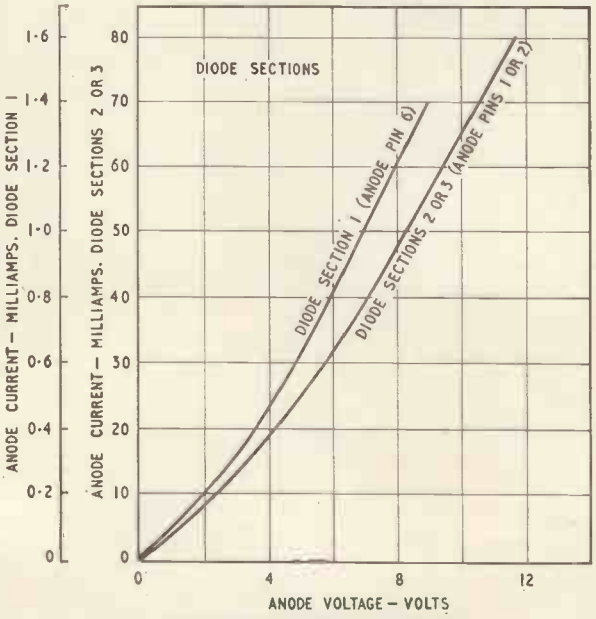
BASE B9A (Noval)



SIEMENS EDISON SWAN LIMITED *An A.E.I. Company*
Technical Service Department, 155 Charing Cross Rd., London, W.C.2.
Telephone: GERrard 8660. Telegrams: Sieswan, Westcent, London.

Characteristic curves of Ediswan Mazda Valve Type 10LD12

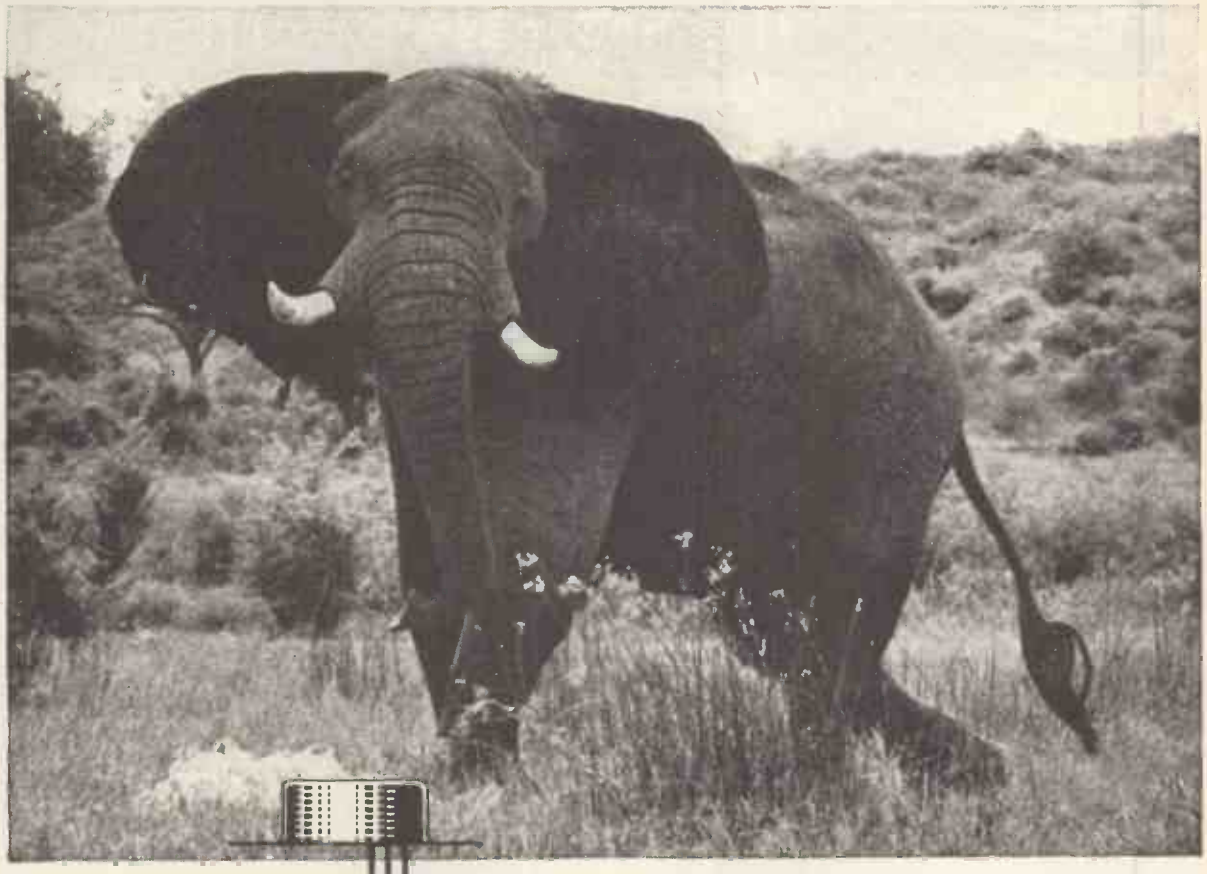




EDISWAN
MAZDA

CRC 15/50

POWER



12A POWER TRANSISTOR
. . . another G.E.C. first!

GET57 Series
G.E.C. have produced a transistor capable of switching up to 12A in d.c. converters or giving 50W output from a class-B push-pull audio amplifier at 45°C. Extremely robust and reliable, these transistors are suitable for use in power amplifiers, servo amplifiers, d.c. converters and many similar applications. Matched pairs are available.

TYPE	Maximum Ratings					Typical Characteristics		
	Peak collector current $i_{c(pk)}$ (A)	Peak collector-base voltage $v_{cb(pk)}$ (V)	Peak collector-emitter voltage (base open-circuited) $v_{ce(pk)}$ (V)	Thermal resistance (Junction to cooling system) (°C/W)	Junction temperature $T_{j(w)}$ (°C)	Large signal current gain h_{FE}	Base-emitter voltage V_{eb} (V)	Collector-emitter voltage V_{ce} (mV) (I_c=12A, I_b=2A)
						(V_{ce}=−1.5V, I_c=12A)		
GET571	12	16	16	2.5	90	15	1.0	160
GET572	12	32	32					
GET573	12	64	40					

G.E.C. **SEMICONDUCTORS**

For full information on these and other devices please contact:
G.E.C. Semiconductor Division, School Street, Hazel Grove, Stockport, Cheshire. Tel: Stepping Hill 3811
or for London area, ring Temple Bar 8000, Ext. 10.

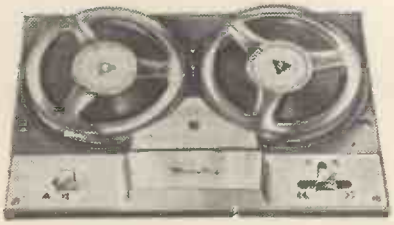
MONARCH UA12
DE LUXE RECORDCHANGER

HATS OFF TO TODAY'S GREATEST ENTERTAINERS

B.S.R. units are made for the man who knows, the man who is not satisfied with second best. Look for the B.S.R. seal before you buy. Monarch Changers and Tapedecks are fitted in the products you can rely on, to give you far better listening for far more years.

. . . IN DESIGN . . . IN PERFORMANCE . . . IN RELIABILITY

BSR are way ahead..!



TAPEDECK T.D.1

MONARCH UA8
STANDARD RECORDCHANGER

BIRMINGHAM SOUND REPRODUCERS LIMITED, MONARCH WORKS, OLD HILL, STAFFS.

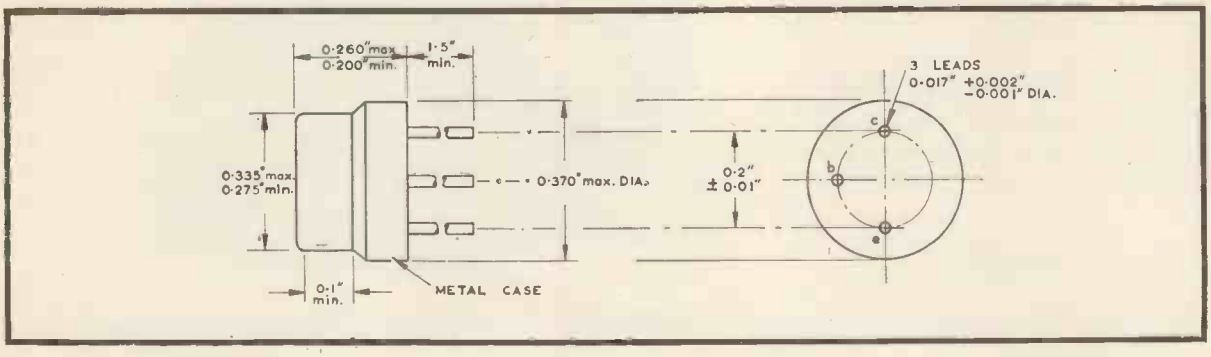
G-

High speed Switching Transistors

TYPES XA141, XA142 and XA143

These germanium p-n-p drift transistors are specifically designed for use in high speed current switching circuits and feature minimum gain/bandwidth products of 20 Mc/s, 40 Mc/s and 60 Mc/s respectively. Full particulars of these and other Ediswan Mazda semiconductor devices will be sent gladly on request.

If you wish to keep up to date with the latest developments in this field, please ask us to add your name to our semiconductor mailing list.



MAXIMUM RATINGS (Absolute Values)

Collector to base voltage (volts)	− 30
Collector to emitter voltage (volts)	− 29
Emitter to base voltage (volts)	− 2
Collector current (mA)	−100
Collector dissipation $T_{amb}=25°C$ (mW)	120
Collector dissipation $T_{amb}=71°C$ (mW)	10

PARAMETER CHARACTERISTICS* ($T_{amb}=25°C$)		XA141	XA142	XA143
Static current amplification at $V_{ce}=-7V$, $I_c=-5mA$ (h_{FE})	Minimum	20	20	20
	Average	45	45	45
Collector to base capacity (pF)	Average	2	2	2
	Maximum	5	5	5
Gain/bandwidth product (frequency for current gain=1) at $V_{ce}=-7V$, $I_c=-5mA$ (Mc/s)	Minimum	20	40	60
	Average	30	50	75

**Typical production spreads*

EDISWAN MAZDA SEMICONDUCTORS

SIEMENS EDISON SWAN LIMITED *An A.E.I. Company.*

Valve CRT and Semiconductor Department, 155 Charing Cross Road, London WC2. Tel: GERrard 8660.

CRC 15/57

Marconi Crystals for stability and precision

The experience gained in manufacturing quartz crystals to the stringent requirements of our own apparatus and of Service equipment enables us to offer a comprehensive range of crystals covering the frequency band 1.0 Kc/s to 62 mc/s at extremely competitive prices.

Years of intensive research and development work guarantee the reliability and quality of this Marconi product.

MARCONI CRYSTALS FOR ELECTRONICS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

Amplifiers that are acclaimed throughout the world

J. C. GILBERT,
F.R.S.A., Assoc. I.E.E.,
M.Brit. I.R.E., F.T.S.

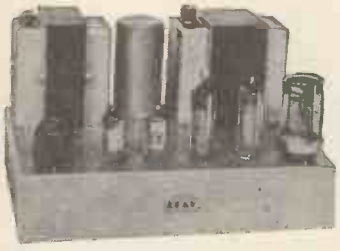
The "Point One Stereo" pre-amplifier is designed so that it can be used with any Leak monaural power amplifier or a combination of any two Leak monaural power amplifiers additionally to its more normal use with the "Stereo 20" or "Stereo 50."

"The 'Point One Stereo' pre-amplifier is probably the most comprehensive unit in existence covering every refinement for stereo tape, disc and radio plus monaural amplification for any form of input signal . . . it is difficult to think of any additional requirement that one would ever wish. The equipment performs with the high performance always associated with the tradition of Leak equipment. It is a fine example of design and construction, and the pre-amplifier can be used with any other Leak main amplifiers. How the pre-amplifier can be sold for as little as £21 can be answered only by Harold Leak. . . . Summing up, therefore, one can highly recommend the Leak stereo system for use with any current monaural or stereo input whether it be from pickup, tape, radio or microphone."

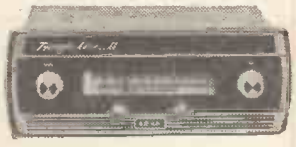
Extract from Test Report by J. C. G. Gilbert reprinted from the Music Trades Review, February, 1959 and in our advertisement in October's "Wireless World". The full two-page Test Report and an illustrated brochure on the amplifiers will be sent to you on request.

£21:0:0 . . . . . *a price made possible only by world-wide sales*

STEREO 20 amplifier 29 GNS



TL/12 PLUS amplifier 18 GNS



Trough-Line F.M. Tuner *(self-powered)* **£25.0.0 plus £8.15.0 tax**

LEAK

Fill in coupon for further information on Leak amplifiers.

Please send me Test Report and Brochures

NAME .....

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. . . the first name in High Fidelity since 1934

H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, LONDON, W.3

Telephone : SHEpherds Bush 1173/4/5 *Telegrams : Sinusoidal, Ealux, London*

Transistor Set Parcel

Cabinet as illustrated—with handle and motifs—2-gang tuning condenser—printed circuit—tuning scale—full circuit diagram showing other necessary parts—separate value £3—will all be sent for 29/6 plus 2/6 post and insurance.

Morganite Potentiometers

Single and 2-gang types available, standard size with good length spindle, all new and boxed. Single types, 1/- each, valves available: 5K, 10K, 25K, 50K1, 100K, 250K, 1 meg., 2 meg., Gang type 3/- each—valves available: 5K + 5K, 100K + 100K, ½ meg. + ½ meg., 2 meg. + 2 meg.

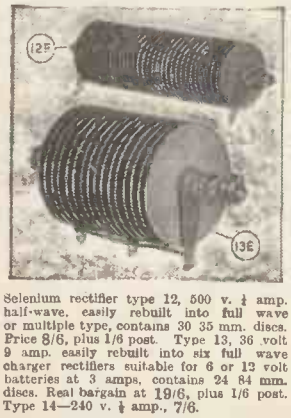
A.C./D.C. Multimeter Kit

Ranges: D.C. volts 0-5, 0-50, 0-100, 0-500, 0-1,000. A.C. volts 0-5, 0-50, 0-100, 0-500, 0-1,000. D.C. milliamps 0-5, 0-100, 0-500. Ohms 0-50,000 with internal batteries. 0-500,000 with external batteries. Measures A.C./D.C. volts. D.C. current and ohms. All the essential parts including metal case, 2in. moving coil meter, selected resistors, wire for shunts, range selector, switches, calibrated scale and full instructions, price 19/6, plus 2/6 post and insurance.

R1155 for Spares

These are less valves but otherwise reasonably complete—ideal for spares—prices £2 to £4 depending on condition. Carr. 7/6.

Rectifier Bargains



Selenium rectifier type 12, 500 v. ½ amp. half-wave, easily rebuilt into full wave or multiple type, contains 30 35 mm. discs. Price 8/6, plus 1/6 post. Type 13, 36 volt 9 amp. easily rebuilt into six full wave charger rectifiers suitable for 6 or 12 volt batteries at 3 amps, contains 24 84 mm. discs. Real bargain at 19/6, plus 1/6 post. Type 14—240 v. ½ amp., 7/6.

INDUCTOR FLUORESCENTS

These represent today's best value in lighting. All models are complete with polyester-filled chokes (so far as we know not available in any other low-priced fittings) all are made from heavy gauge sheet steel, stove enamelled white, all use canister type plug in starters, and all are fitted with interference suppressors. Guaranteed for two years:

Inductor 80 for 5ft. 80-watt lamp	.....	39/6+5/- carriage and ins.
Inductor 40 for 4ft. 40-watt lamp	.....	32/6+4/6 „ „
The Three-Forty: for 3ft. 40-watt lamp	.....	31/6+3/6 „ „
Inductor 20 for 2ft. 20-watt lamp	.....	29/6+3/6 „ „
Circle Light for 40-watt circular lamp	.....	49/6+3/- „ „

Note: Prices do not include tube but these are the latest bi-pin type easily obtainable from your local electrical shop or if you wish direct from us.

Special Offers:
Inductor 40 complete with tube ready to work 39/6+5/6 carriage and ins.
Three Forty complete with tube ready to work 39/6+4/6 „

This Month's Snip

5-valve F.M. receiver kit. Note: This is not just a tuner but a complete receiver with power supplies—made by the famous Co sor Company. Until very recently this cost £15/15/-, but due to a large purchase we are able to offer this at the remarkably low price of £8/19/6, plus 3/6 post and insurance. Complete with full constructional details. The circuit uses five B9A valves and special features are the cascode R.F. stage and the Foster Seeley discriminator. All valves and components, printed circuit, printed dial, 10in. × 6in. elliptical speaker—in fact, everything except the cabinet is supplied. Do not miss this wonderful bargain!

American Receiver C646068

This is a 12-valve receiver originally designed for military operation on the 60-80 Mc band One stage of R.F. and three stages of I.F. with additional stages for noise suppression and A.V.C. make this an extremely versatile receiver, also crystal in oscillator provides highest stability. On the front panel are all controls and moving coil input and output meters. Complete with its own power supplies, these, however, are intended to operate on American voltage 115 v. So with each receiver we supply a step down transformer. A limited quantity only of these offered at the extremely low price of £6/10/-. Plus 12/6 carriage and packing. Size approx. 26in. × 9in. × 17in. Note: These sets are unused but have been in store for some years and may therefore require servicing before being put into operation. At the low price charged we cannot test these nor do we give any guarantee. Complete with valves and one crystal. Circuit diagram and technical notes free with equipment or separately price 2/6.

For the Record Enthusiast

New-four speed playing deck by E.M.I. has the following features:—
Velocity operated auto trip.
Pick-up on switch cannot be damaged.
Remarkably low rumble achieved by single ball thrust and magnetic screen on motor.
Anti-microphony mounting.
The ideal unit to renovate old equipment or to build into new.
Size: 11¾in. wide, 1¼in deep, 2¼in. high, depth 2¼in.
Mains model with stereo cartridge, £7/17/6.
Or with monaural cartridge, £6/18/6, post and ins. 3/6.
H.P. Terms on request.

FOR ADDRESSES SEE OPPOSITE PAGE

Hi-Fi Snip

Infinite Wall Baffle

Nicely veneered and polished. Corner fitting (attaches to picture rail). Takes up no floor space. Gives really fantastic results with only low-priced 8in speaker. Fitting for tweeter. Only 45/- each. Carriage and insurance 3/6.

Speaker Bargain

12in. Hi-fidelity loudspeaker. High flux. Permanent magnet type with standard 3 ohm speech coil. Will handle up to 12 watts. Brand new by famous maker. Price 32/6, plus 3/6 post and insurance.

W.D. Circuit Details

Diagrams and other information extracted from official manuals. All 1/6 per copy, 12 for 15/-.

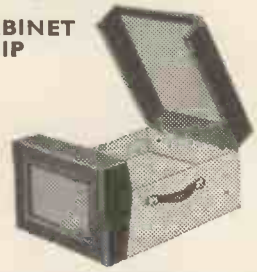
A.1134	R.109
BC.348	HRO Receiver
BC.312	R28/ARC5
R.103A	R1116/A
BC.342	RA-1B
RA-1B	AR88D
R-208	AN/APA-1
R-1155	78
R-1124A	76
R-1132A/R-1481	R.T.18
R-1147	CAY-46-AAM-
R-1224A	RADAR
R-1082	A.S.B.-3
R-1355	Indicator 62A
B.C.1206-A/B	Indicator A.S.B.3
B-455-A (or -B)	Indicator 62
B-454-A (or -B)	Indicator 6K
B-453-N-A (or -B)	R.F. unit 24
Transmitter T1154	R.F. unit 25
Fifty-eight walkie talkie	R.F. unit 26
Frequency meter B.C. 221	R.F. unit 27
	Wireless set No. 19
	Demobbed valves

Medresco Hearing Aid

As supplied by National Health, completely overhauled and in good working order with six months' guarantee. Only £2/15/- plus 2/6 post and ins. Complete with earphone and new ear plug but not batteries. these can be supplied as an extra for 5/- per set.

Instructions showing how to convert to pocket radio available free if requested.

CABINET SNIP



Extremely well made portable amplifier case finished in two-tone and very modern in appearance. Large enough for stereo outfit with tape deck or autochanger. Snip price 59/6, plus 3/6 carriage and insurance.

Radio Stethoscope

This can be slipped into the pocket rather like a fountain pen. With it in most districts a receiver can be checked from the grid of the first valve right through to the output without a signal generator, the stethoscope will operate in both L.F. and R.F. circuits without alteration. It is a complete fault-finder.

All the necessary parts to make this tracer 9/6, post 1/-.

Building a Scope?

3in. oscilloscope tube. American-made type No. 3FP7, octal base 6.3 v. .6 amp. heater, electrostatic deflection, brand new and guaranteed, 15/- each, plus 1/6 post and ins.

Thermostats

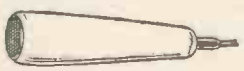
1½ amp.	3/6
2 amp. Q.M.B.	5/6
5 amp.	8/6
15 amp.	15/-
15 amp.—wall mounting	27/6

Note all are skeleton type similar to illustration except the wall mounting type which is encased in metal box with scale and pointer.

Yaxley Switches

1 Pole 3 Way	1/6
1 Pole 5 Way	2/-
1 Pole 11 Way	2/6
2 Pole 2 Way Ceramic	2/6
2 Pole 4 Way	2/-
2 Pole 6 Way	2/6
2 Pole 8 Way	3/6
2 Pole 11 Way	3/6
2 Pole 12 Way	4/6
3 Pole 3 Way	1/6
3 Pole 6 Way	3/6
4 Pole 4 Way	3/-
6 Position Shorting	2/-
6 Pole 3 Way	2/6
6 Pole 3 Way Ceramic	3/6
8 Pole 2 Way	2/-
9 Pole 3 Way	2/6
12 Pole 2 Way	2/-

Crystal Mike by Acos



Model 39/1, this is ideal for tape or general amplifiers, complete with screened lead 39/6, plus 1/- post.

45 r.p.m. Record Player by Cossor

Wonderful present for a teenager. Limited quantity only. Brand new in manufacturer's carton with guarantee card. Only last year these were being advertised at 19 gns. Our price £10 plus 7/6 post and ins.

Here is a present that will be really appreciated

Motorised food mixer with no irksome lead hanging out and which does not have to be plugged into the mains as it works off three 1½ v. cells in its handle. A really useful mixer ideal for kitchen or anywhere about the house and can also be taken on barbecues, picnics, etc. Price 35/- plus 2/6 post and packing.

For Your Service Department

An invaluable tool for working inside a dark cabinet or cupboard. This is a screwdriver with torch and has four interchangeable bits, two for the ordinary slotted screws and two for Philips heads. The torch section operates from 1½ v. batteries in the handle and will save its cost in frayed tempers alone. Why not treat yourself to one of these now? Only 10/6 plus 1/6 post and packing.

SIX USEFUL ARTICLES

Our 1960 catalogue now ready gives constructional hints and circuits for the following items:

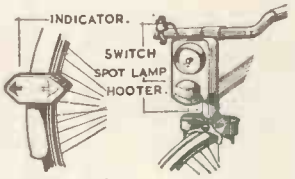
Moisture operated switch
Simple but clever signal tracer
Versatile power pack costing only 10/-
Instantaneous heater for workshop or den
Six transistor pocket superhet
Simple bed warmer
Photo-flood controller

Send for this catalogue today—price 2/6, refundable from purchases.

Components Would Cost More

Car Battery Charger—ready-made high output battery charger in stove enamelled sheet steel louvred case. New, complete and ready to work. Rated at 12 v. 4 amps. and variable rate selector for trickle charging, also a meter to show charging rate. Suitable for 230/250 A.C. mains. Special snip price of 55/-, plus 3/6 post and ins.

For Cycles and Scooters



This three part outfit comprises combined headlamp with built-in hooter and a rear fitting direction indicator and a combined indicator switch and push button. Altogether a well made outfit which will make cycling safer. Price 15/6 complete, plus 2/6 post and packing.

Towards Hi-Fi Perfection

The revolutionary B.J. tweeter unit stands on top of the cabinet and with it the best in the loudspeaker is brought out by top "C" positive and controllable. Frequency responses 2,000 to 18,000 c.p.s. Effective acoustic spread 360°. Dimensions 6¼ x 5in. diameter. Weight 1¼ lb. approx. Finished in sapele mahogany veneer. Price £4/19/1 plus 3/6 carriage and insurance. Fuller technical details available on request.

SPECIAL THIS MONTH

Battery Charger Rectifier—selenium 12-15 v., 5 amp.. 9/6.

Blank Metal Chassis—all 2½in. deep from 18 gauge aluminium. Sizes: 6in. x 2in., 4/6; 7½in. x 5in., 6/-; 13½in. x 9in., 10in. x 7½in., 7/-; 11½in. x 7½in.. 8/-.

Metal Chassis—punched for Mullard 510 Amplifier, complete with inner screening sections and stove enamelled, 12/6 set.

Geiger Counter Tubes—20th century type, Type No. G24, with circuit of geiger counter, 29/6.

Waterproof Heater Wire—suitable electric carpets, electric blanket, hand muffs, foot pads, etc., 7d. per yard.

Twin Twisted Lighting Flex—equivalent 14/36 rubber insulated, cotton covered, 17/6 per 100 yard coil.

Moving Coil Meters

0-500 microamp	2in. flush	17/6
250-0-250 microamp	2½in. surface	27/6
750 microamp	2½in. surface	17/6
5-0-5 microamp	2½in. flush	17/6
0-30 milliamp	2½in. flush	17/6
0-100 milliamp	2½in. flush	15/-
0-300 milliamp	2½in. flush	15/-
0-500 milliamp	2½in. flush	15/-
0-1 milliamp	2½in flush	25/-

Luminous Switch, double pole designed for electric blankets, neon indicators glow when appliance is switched on, 10/-.

Unbreakable Mains Lead type of lead fitted to electric razors makes fine lead for test meters and any other devices where subject to continuous bending. Twin figure eight construction, soft cream p.v.c. covered. Normally costs 2/- per yard. Three 6-ft. leads for 2/-.

Metal Rectifier equivalent RM5, 12/6.

Metal Rectifier, 60/80 mA, 250/300 v., 4/6.

Filament Transformer, 6.3 v., 1½ amps, 6/6. .3 Amp Dropper—tappings marked 200/220/250 3/6.

Output Transformer—standard pentode—4/6, multi ratio, 6/6.

Bi-metal Strip with heavy duty contact—ideal for thermostat, fire lamp, etc., 2/6.

Neon Lamp—midget wire ended, ideal mains tester, etc., 2/-, ex Govt., 1/6.

Philips Trimmers—0-30pF, 1/- each, 9/- doz.

Set of 8 Allen Keys, 3/6.

Heavy Duty Test Prods—red and black with plug-in lead attachments, 8/6.

Install those extra points, 3.029 twin flat T.R.S. cable. Big purchase enables us to sell this at 45/- per 100 yds., carriage 3/6.

Low Resistance Head Phones. Ideal crystal sets, etc., 7/6, plus 2/6.

Goodmans Multi Ratio Output Transformer. 6 watt, 8 ratios, from 12-1 to 72-1. Centre tapped for push/pull, 7/6, plus 1/-. Ditto, unbranded. 6/6, post 1/-.

Cold Cathode Valve CV413. Voltage regulator or trigger switch—unused but ex-equipment. 2/- each.

Tag Panels. Ideal for constructors, experimental circuits, etc., 3 of each of 12 different types, 5/-, post 1/6.

Slydlok Panel Mounting Fuses with carrier, 5 amp, 2/- each, 15 amp, 2/6 each. Belling Lee 2BA fully insulated terminals for mounting through metal panels, 2/- each.

Terminal Heads, insulated 4BA, 2/- doz. .1 mFd. 350 v. Small tubular metal cased condensers made by Dubilier. 2/6 doz. 50 Assorted Resistors. Well mixed and useful values ¼ and ½ watt, 5/- for 50. Ditto, but 1 watt. 6/6 for 50.

Mains Transformer. Standard 230 v. input 250-0-250 at 80 mA., 6.3 v. at 5 A., 12/6.

Toggle Switch. Standard metal body, type with round dolly, fixing ring and on/off indicating plate, 1/3 or 12/- doz.

Metal Rectifier. 250 v. 60-80 milliamps., ideal for mains set or instrument or to replace that expensive valve, 4/6.

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Long, Medium and Short Wave Coil Pack. An exceptionally well made coil pack which covers the standard long, medium and short wavebands for 465 kc 1.F., complete with diagram of connections. 14/6, plus 1/6 postage and insurance—limited quantity only.

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If ordering by post, address your order to the Company nearest to you. *Please include postage.*

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Phone: ARChway 1049.
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Electronics (Manor Park) Ltd.
520 High Street North,
Manor Park, E.12.

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Phone: RUISLIP 5780.
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...there are 7.7 radio-receivers to every metre of the equator

In 1957 there were approximately 309 million radio-receivers all over the world*. If they were to stand along the equator there would be about 7.700 receivers to a kilometre. This seems tremendous to us. Nevertheless, there is every possibility of ensuring a further increase. Above all, the number of double-receivers, portable radio-receivers, car radio-receivers increases rapidly. In the Netherlands 3 million radio-receivers for 2.8 million homes have already been registered. Has the upper limit already been reached thereby?

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Electron-tubes — valuable components in our technical world

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All for 240 V Input, other Supply Voltages as Required
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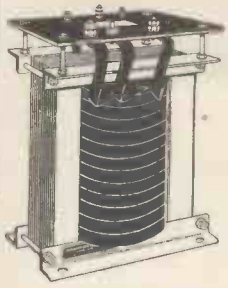

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10 V 300 A	£28
10 V 900 A	£50
12 V 1,000 A	£64
15 V 1,000 A	£75
20 V 800 A	£80
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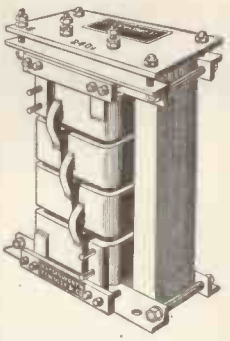
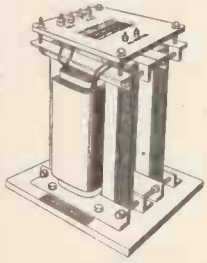


TRANSDUCTORS



Saturable Reactors for controlling AC currents up to 200 A 100 kVA. Available for all standard AC supply voltages. Single phase and three phase. Standard DC control volts; 12, 24, 36, 110 and 240 V.

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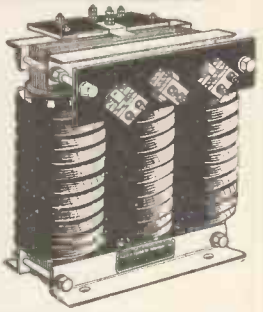

These and other Transformers can be supplied for 3 phase, 6 phase and 12 phase Rectifiers.

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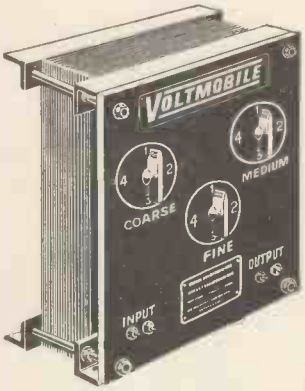
AC and DC Supply Units with infinitely variable or tapped output. Manual or remote control with full instrumentation. The Console illustrated has a stabilized 230 V AC supply as well as several low voltage heavy current sources. Each source is independent of the others, but where called for, interlocking and protection devices can be included.



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VOLTAGE REGULATING AUTO-TRANSFORMERS

Range from zero volts to supply volts in 64 steps. Change per step 1.6% ON LOAD SWITCHING.

VOLTMOBILES can be used by themselves or in the primary of another transformer to give very fine changes of output.

	INPUT 240 V OUTPUT 0/250 V	INPUT 420 V OUTPUT 0/440 V
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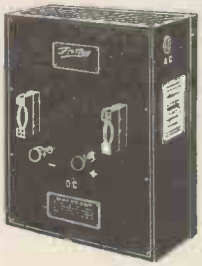

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For 200/250 V AC. Also available for 3-phase supply.

6.3 V DC 13 A	£13
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24 V DC 26 A with stabilizer	£36
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36 V DC 50 A	£51
110/120 V DC 10 A	£34
110/120 V DC 25 A	£25
200/250 V DC 6 A	£39
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200/250 V DC 18 A	£60
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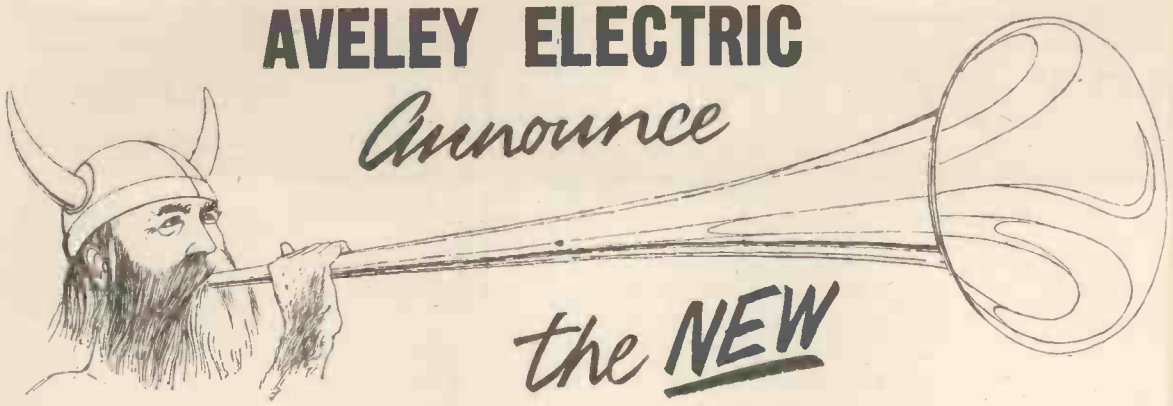

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Unique, patented, 4-pole 4-coil moving iron system. FUNDAMENTALLY correct in principle and geometry for the new stereo disc recordings, provides equal compliance in all directions with high channel separation through the entire frequency range.

Price **£22 . 19 . 0** *inc. P.T.*

★*Precision engineered double gimbal light alloy arm*
Low friction—low mass

★*Tracking pressure 2-4 grams.*

★*Plug-in cartridge—easy change DIAMOND STYLUS*

★*High output—low impedance*
Hum-balanced system

Cartridge fitted with bracket (½in centres) fits most arms. Price **7 gns.** *inc. P.T.*
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TV—Grey Finish 10/- extra.

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360 degree radiation from twin moving coil units facing inwards into bi-conical reflector ensures true stereo from all listening positions. Range 2-20 Kc/s,

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Gaumont-Kalee Fluttermeter Type 1740

Watch that WOW!

with the Gaumont-Kalee FLUTTER METER

Accurate measurement of sound equipment speed deviations

The Flutter Meter measures those components which are commonly described as "Wow" and "Flutter" resulting from speed variations in sound recorders and reproducers. This instrument is equally suitable for use with machines employing perforated film, tape, wire or disc records.

Type 1740 is of entirely new design. More compact, lighter in weight and costing considerably less than ear ier Gaumont-Kalee Flutter Meters, but with the same high performance and facilities.

Dimensions: Height 10¼" 26.04 cm.
Width 12¼" 31.12 cm. Depth 14¼" 36.47 cm.
Nett Weight: 29lb. 13.15 Kilos.

Write for full details to :

Brief Technical Data

Operating carrier frequency 3,000 c.p.s.±5%
Minimum Input signal 50 mV R.M.S.
Input. Impedance 1 Megohm.
Input amplifier bandwidth —3db at 2,500 and 3,500 c.p.s.
Effective limiter range ±10dB.
Meter scaling—"Peak wow" 0 to ±1% (centre zero).
"Wow" and "Flutter" 0 to 1% and 0 to 0.2% R.M.S.
Crossover frequency 20 c.p.s.
"Flutter" meter response —3db at crossover.
—3dB at 200 c.p.s:
"Wow" meter response —3dB at crossover.
—1dB at 0.5 c.p.s.
C.R.O. output frequency response level down to zero frequency —3dB at 200 c.p.s.
3,000 c.p.s. oscillator output level 5V R.M.S. into 0.5 Megohm 100 mV R.M.S. Into 500 ohms.
Accuracy: Meter presentations ±2% f.s.d.
Power consumption 35 watts.
Operation 45 to 60 c.p.s.

Important users of Gaumont-Kalee Flutter Meters include :

B.B.C. Television and Research, Collaro.
Commission Superioreure Technique, Paris.
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New techniques demand new tools. Transistors, printed circuits, sub-miniature components can now be soldered more accurately, with much less effort, without risk of damage to adjacent components with the feather-weight pencil-thin Oryx. Available in seven models for continuous working up to 470°C. Widely used by instrument makers, electronic equipment makers throughout the world. It will pay you to give the Oryx an extended trial on your own production lines.

from 25/- subject

For QUICKER . . . BETTER Joints at less cost!

EXCLUSIVE ORYX FEATURES

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THE RESULT OF FOUR YEARS' PROGRESSIVE DEVELOPMENT

THE STEREO PICKUP

for playing 45/45 records. Miniature ceramic type with replaceable diamond stylus. Constant velocity output approximately 20mV from each channel. Frequency range 20 to 16,000 cycles. Channel separation 20/25 dbs.

(Complete as illus.) £12/19/10
Head only..... £7/19/11
Arm only..... £4/19/11
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STEREOPHONIC AMPLIFIER AND PRE-AMPLIFIER

Twin channel amplifier and pre-amplifier for reproducing monaural and stereophonic sound from disc, radio and compensated tape.
Ultra linear push/pull output giving 7.5 watts peak from each channel.

Amplifier £24 . 10 . 0
Pre-amp. £16 . 10 . 0

BRAND NEW 2 SPEED STEREO TRANSCRIPTION MOTOR

Operates at 33⅓ and 45 r.p.m. Full 12in. turntable.

£16 . 13 . 1
(inc. tax)

VARIABLE 3 SPEED MOTOR TYPE B (illustrated)

Operates at 33⅓, 45 and 78 r.p.m. Non-ferrous turntable. Built-in large stroboscope with internal light source. Precision ground and lapped spindles. Adjustable nylon graphite bearings. Synchronous motor.

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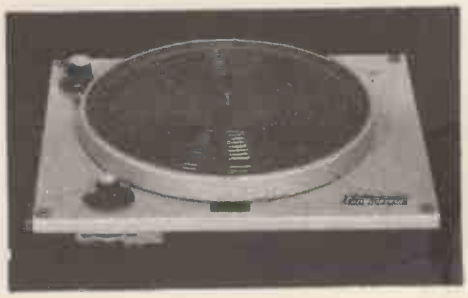
A. R. SUGDEN & Co. (Engineers) Ltd.

Market Street, Brighouse, Yorks. *Telephone 2142*



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SKANTEST is a fraction of the size—and a fraction of the price—of any similar tester available in this country. SKANTEST saves hours of work, increases goodwill.

- **TESTS**
- *Line Output Transformers*
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- **for**
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Also available from leading wholesalers

Export and wholesalers enquiries invited.

THE MOST EFFICIENT LOWEST PRICED TIME BASE COMPONENT SHORTING TURN TESTER

SKANTEST **£7:10:0** *(Nett Trade)*

Subject to quantity discount to wholesalers

Use the DTV Service for all ALL Your TV Component Replacements!

SPECIALISTS IN TIME BASE COMPONENTS

Direct TV Replacements do not just supply Time Base Components, but manufacture and design Time Base Transformers. Improvements introduced by DTV, have in some cases resulted in set makers advising customers to purchase from our company or in the set maker using our Transformers.

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CRM91, CRM92, MW22-7, MW22-14, MW22-14C, MW22-17, MW22-18 **£2/15/-**

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Frustrated export, carriage and insurance 12/6.

MW31-74, MW36-24, 10SK **£7/19/-**

MW43-64 **£8/19/-**

Enquiries welcomed for any tubes not listed. Any new tube can be supplied at standard list price, plus carriage.

PROJECTION T.V.

Optical Unit with MW6/2 Tube
Untested ... ... £3/10/-.
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OZ4	5/6	6BG6G	12/6	6L1	13/6	10C2	12/6	25L6G	6/-	7193	2/-	EBF80	8/6	EL33	9/-
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1A7GT	12/6	6BJ6	6/6	6L7M	6/-	10F1	10/-	25Y5G	9/-	B36	8/6	EBL31	16/-	EL38	12/6
1C5GT	10/6	6BR7	10/6	6L18	9/6	10F9	7/6	25Z4G	7/6	B65	4/9	EC52	3/9	EL41	9/3
1D5	9/6	6BW6	7/9	6L19	11/6	10L14	9/-	278U	16/-	CBL31	24/4	ED90	3/6	EL42	9/6
1H5GT	9/9	6BW7	6/6	6LD3	8/9	10LD3	8/3	30C1	7/9	CCH35	7/-	EC91	4/6	EL84	8/3
1L4	3/9	6BX6	5/9	6LD12	7/9	10LD11	12/6	30F5	7/6	CL33	11/-	ECC31	9/6	EL85	11/-
1N5GT	9/9	6C4	3/6	6LD20	8/6	10LD12	9/-	30FL1	9/6	CY31	9/6	ECC32	3/9	EL91	4/9
1R5	7/-	6C5	5/6	6P15	8/3	10P13	12/-	30L1	7/9	CY32	14/-	ECC33	7/6	EL95	9/6
1S4	9/-	6C6	4/3	6P25	9/-	10P14	12/-	30P4	12/6	D63	1/6	ECC34	9/-	EM34	8/6
1S5	6/6	6C9	9/6	6P28	9/6	10P18	8/3	30P12	11/6	D77	4/-	ECC81	6/9	EM80	9/3
1T4	5/-	6C10	8/9	6Q7G	7/6	12A6	5/6	30P16	7/9	D152	6/6	ECC82	6/6	EM81	9/3
2D21	4/6	6CD6G	18/6	6Q6GT	9/3	12AJ6	8/6	30PL1	13/6	DA30	12/6	ECC83	7/6	EM84	10/6
3A4	6/-	6CH6	9/3	6SA7	6/-	12AT6	8/6	35L6GT	9/6	DA100	25/-	ECC84	8/9	EM85	10/6
3A5	9/6	6D2	4/-	6SD7	9/-	12AT7	6/-	35W4	6/9	DAC32	9/9	ECC85	8/6	EN31	16/-
3Q4	7/6	6D3	9/6	6SG7	5/-	12AU7	6/9	35Z4GT	6/-	DAF91	6/6	ECC91	3/6	EY51	
3Q5GT	8/9	6D6	4/6	6SH7	4/6	12AX7	7/6	35Z5GT	8/6	DAF96	8/3	ECF80	10/6	SMALL	9/6
3S4	7/-	6F1	6/6	6SJ7	5/6	12BA6	8/-	42	7/6	DF33	9/9	ECF82	10/6	EY86	9/6
3V4	7/9	6F6G	6/6	6SK7	5/-	12BE6	9/-	43	7/6	DF91	5/3	ECH42	8/9	EZ35	6/6
5B4G	9/6	6F6M	7/-	6SL7GT	6/9	12BH7	9/6	50C5	10/6	DF96	8/3	ECH81	8/3	EZ40	7/-
5U4G	5/9	6F12	4/-	6SN7GT	4/9	12C8	6/6	50CD6G	16/-	DH63	7/6	ECL80	8/6	EZ41	8/-
5V4G	10/6	6F13	5/9	6SS7	6/6	12E1	12/6	50L6GT	9/6	DH77	7/6	ECL82	11/-	EZ80	6/9
5Y3G	6/6	6F14	9/6	6U4GT	10/6	12J5GT	3/6	53KU	10/6	DK91	7/-	ECL83	14/-	EZ81	7/6
5Y3GT	7/-	6F15	8/6	6V6G	5/9	12K7GT	6/-	54KU	8/6	DK92	8/6	EF36	2/6	GT1C	12/6
5Z4G	9/-	6F16	8/9	6V6GT	6/6	12K8GT	12/-	61BT	11/-	DK96	8/6	EF37	6/6	GZ32	8/6
5Z4GT	11/-	6F19	7/6	6X4	6/-	12Q7GT	6/-	61SPT	11/-	DL35	10/6	EF39	4/6	GZ34	12/6
6A7	9/6	6F33	5/-	6X5G	5/-	12SG7	6/-	77	4/6	DL82	17/6	EF40	13/6	GZ37	10/6
6A8G	8/6	6H6	2/-	6X5GT	6/6	12SJ7	5/6	78	6/-	DL92	7/-	EF41	8/6	HABC80	9/6
6AB8	8/6	6J5	4/3	7A7	11/6	12SK7	6/-	80	5/-	DL94	7/9	EF42	7/6	HL41DD	9/6
6AC7	4/6	6J5G	2/6	7B5	12/6	12SN7GT	8/6	83	9/6	DL96	8/3	EF50-BR	1/6	HVR2	6/6
6AG7	7/6	6J5GT	3/6	7B6	8/-	1487	13/6	90AV	4/6	EA50	9d.	EF50 RED	2/-	KT32	6/-
6AK5	6/6	6J6	3/6	7B7	7/6	19AQ5	7/6	185BT	16/-	EABC80	7/9	EF50 USA	2/6	KT33C	6/6
6AL5	4/-	6JYM	7/6	7B8	12/-	19BG6G	16/-	323A	15/-	EAC91	5/3	EF54	3/6	KT36	9/-
6AM5	4/9	6J7G	5/-	7C5	7/6	20D1	9/6	723A	35/-	EAF42	8/6	EF30	5/6	KT44	9/6
6AM6	4/-	6J7GT	7/6	7C6	7/6	20F2	9/6	80YUSA	6/-	EB34	1/6	EF85	7/-	KT45	8/6
6AT6	7/6	6K6GT	6/9	7H7	7/6	20L1	12/6	807E	3/6	EB41	7/-	EF86	11/-	KT61	9/-
6AU6	9/6	6K7G	2/3	7K7	8/-	20P1	11/6	807USA	5/6	EB91	4/-	EF89	8/6	KT66	15/-
6B7	5/9	6K7GT	5/3	7S7	9/6	20P3	12/6	808	15/-	EBC3	9/-	EF91	4/-	KTW61	5/6
6B8G	3/6	6K8G	6/6	7Y4	7/6	20P4	15/-	813	55/-	EBC33	5/-	EF92	4/9	KTW63	5/6
6BA6	6/6	6K8GT	9/6	7Z4	7/6	20P5	16/-	2050	3/6	EBC41	8/9	EF95	6/6	KTZ63	5/-
6BE6	6/6	6K25	7/6	10C1	9/-	25A6G	8/-	5763	10/-	EBC81	11/-	EL32	4/-	L63	2/9

LN152	8/6	SP6	4/-	UCH81	9/-	PABC80	9/6	PC84	7/9	PC85	9/6	PC88	18/-	PC89	18/-
LZ319	7/9	SP41	2/6	UCL82	12/-	PC84	7/9	PC85	9/6	PC88	18/-	PCF80	7/9	PCF82	9/9
MU14	8/-	SP61	2/6	UCL83	13/6	PC85	9/6	PC88	18/-	PCF80	7/9	PCL82	10/-	PCL83	11/6
N37	11/-	SU25	12/6	UF41	8/9	PC88	18/-	PCF80	7/9	PCL82	10/-	PCL84	12/6	PCL85	12/6
N78	15/-	8U2150A	4/6	UF42	8/6	PC89	18/-	PCF82	9/9	PCL83	11/6	PEN25	5/-	PEN45	7/6
N108	11/-	T41	7/6	UF80	9/6	PCF80	7/9	PCL82	10/-	PCL84	12/6	PEN45	7/6	PEN46	5/-
N152	10/6	TH30C	12/6	UF85	9/6	PCF82	9/9	PCL83	11/6	PEN25	5/-	PEN46	5/-	PEN383	9/-
P41	4/5	U14	8/-	UF86	16/-	PCL82	10/-	PCL84	12/6	PEN45	7/6	PEN383	9/-	PL33	7/6
P61	2/6	U18	9/-	UF89	8/6	PCL83	11/6	PEN25	5/-	PEN46	5/-	PL33	7/6	PL36	13/6
PABC80	9/6	U22	6/6	UL41	7/6	PCL84	12/6	PEN45	7/6	PEN383	9/-	PL38	14/6	PL81	10/6
PC84	7/9	U24	7/6	UL44	12/6	PEN25	5/-	PEN46	5/-	PL33	7/6	PL81	10/6	PL82	7/9
PC85	9/6	U25	12/-	UL46	9/6	PEN45	7/6	PEN383	9/-	PL36	13/6	PL82	7/9	PL83	8/9
PC88	18/-	U26	12/-	UL84	8/3	PEN46	5/-	PL33	7/6	PL38	14/6	PL83	9/6	PL84	9/6
PC89	18/-	U31	7/9	UM80	9/6	PEN383	9/-	PL36	13/6	PL81	10/6	PL84	9/6	PL504	9/6
PCF80	7/9	U33	11/-	UU6	9/6	PL33	7/6	PL38	14/6	PL82	7/9	PL504	9/6	PL505	16/-
PCF82	9/9	U35	8/6	UU7	9/6	PL36	13/6	PL81	10/6	PL83	8/9	PL505	16/-	PL508	16/-
PCL82	10/-	U37	26/6	UU8	16/6	PL38	14/6	PL82	7/9	PL84	9/6	PL508	16/-	PL509	16/-
PCL83	11/6	U43	9/6	UU9	7/-	PL81	10/6	PL83	8/9	PL504	9/6	PL509	16/-	PL802	16/-
PCL84	12/6	U50	6/6	UY41	6/6	PL82	7/9	PL84	9/6	PL505	16/-	PL802	16/-	PY31	8/6
PEN25	5/-	U52	6/3	UY85	7/3	PL83	8/9	PL504	9/6	PL508	16/-	PY31	8/6	PY32	11/-
PEN45	7/6	U76	6/-	UY1N	11/-	PL84	9/6	PL505	16/-	PL509	16/-	PY32	11/-	PY80	7/-
PEN46	5/-	U78	6/-	VR150/30	7/-	PL504	9/6	PL508	16/-	PL802	16/-	PY80	7/-	PY81	7/-
PEN383	9/-	U107	6/6	W17	5/3	PL505	16/-	PL509	16/-	PY31	8/6	PY81	7/-	PY82	7/6
PL33	7/6	U191	9/6	W61	9/9	PL508	16/-	PL802	16/-	PY32	11/-	PY82	7/6	UBC41	8/-
PL36	13/6	U281	8/6	W76	6/6	PL509	16/-	PY31	8/6	PY80	7/-	PY83	8/6	UBC81	12/-
PL38	14/6	U282	22/7	W77	4/9	PL802	16/-	PY32	11/-	PY81	7/-	PZ30	8/6	UBF89	8/6
PL81	10/6	U301	9/6	W81	5/6	PY31	8/6	PY80	7/-	PY82	7/6	R18	12/6	UCC85	8/9
PL82	7/9	U329	12/6	X61M	12/6	PY32	11/-	PY81	7/-	PY83	8/6	R19	12/6	UCF80	16/-
PL83	8/9	U403	9/6	X63	8/6	PY80	7/-	PY82	7/6	PZ30	8/6	R52	11/-	UCH42	8/-
PL84	9/6	U404	9/6	X65	11/-	PY81	7/-	PY83	8/6	R18	12/6			UCH81	9/-
PL504	9/6	U801	16/-	X66	11/-	PY82	7/6	PZ30	8/6	R19	12/6			UCL82	12/-
PL505	16/-	UABC80	9/-	X76M	9/6	PY83	8/6	R18	12/6	R52	11/-			UCL83	13/6
PL508	16/-	UAF42	9/-	X78	15/-	PZ30	8/6	R19	12/6					UF41	8/9
PL509	16/-	UB41	8/-	X79	15/-	R18	12/6	R52	11/-					UF42	8/6
PL802	16/-	UBC41	8/-	Y63	6/-	R19	12/6							UF80	9/6
PY31	8/6	UBC81	12/-	Z14	9/9	R52	11/-							UF85	9/6
PY32	11/-	UBF89	8/6	Z63	5/-									UF86	16/-
PY80	7/-	UCC85	8/9	Z77	4/-									UF89	8/6
PY81	7/-	UCF80	16/-	Z152	5/6									UL41	7/6
PY82	7/6	UCH42	8/-	Z719	5/6									UL44	12/6
PZ30	8/6	UCH81	9/-											UL46	9/6
R18	12/6	UCL82	12/-											UL84	8/3
R19	12/6	UCL83	13/6											UM80	9/6
R52	11/-	UF41	8/9											UU6	9/6
		UF42	8/6											UU7	9/6
		UF80	9/6											UU8	16/6
		UF85	9/6											UU9	7/-
		UF86	16/-											UY41	6/6
		UF89	8/6											UY85	7/3
		UL41	7/6											UY1N	11/-
		UL44	12/6											VR150/30	7/-
		UL46	9/6											W17	5/3
		UL84	8/3											W61	9/9
		UM80	9/6											W76	6/6
		UU6	9/6											W77	4/9
		UU7	9/6											W81	5/6
		UU8	16/6											X61M	12/6
		UU9	7/-											X63	8/6
		UY41	6/6											X65	11/-
		UY85	7/3											X66	11/-
		UY1N	11/-											X76M	9/6
		VR150/30	7/-											X78	15/-
		W17	5/3											X79	15/-
		W61	9/9											Y63	6/-
		W76	6/6											Z14	9/9
		W77	4/9											Z63	5/-
		W81	5/6											Z66	7/-
		X61M	12/6											Z77	4/-
		X63	8/6											Z152	5/6
		X65	11/-											Z719	5/6
		X66	11/-												
		X76M	9/6												
		X78	15/-												
		X79	15/-												
		Y63	6/-												
		Z14	9/9												
		Z63	5/-												
		Z66	7/-												
		Z77	4/-												
		Z152	5/6												
		Z719	5/6												

G73: Signal generator and wavemeter, 100 kc/s. 1 meg. crystal calibrator, precision attenuator. Top make 79/-

SIGNAL GENERATORS

B.S.R. LO50A. L.F. 30 c/s.-18 kc/s £9/10/-. Carr. 5/-.

TBS9: Transmitters £6/10/-. Receivers £4/10/-. £9/10/- pair. Carr. paid. 808s modulating 808s. 100-150 M/cs. Ideal for conversion to 2 metres.

MIRROR GALVANOMETERS

By Evershed and Vignoles. Sensitivity 1,375 MMS per micro-amp. at 100 CM scale distance 45 second period. Brand new, boxed with spares. Ideal for school laboratory **£3/19/-**

SCR522: Transmitter receivers. U.S.A. standard aircraft type. 100-140 Mc/s., less valves 25/-. Carr. 5/-.

POWER PACKS

Input 230 volts A.C., 2 separate double smoothed outputs of 375, 350 or 620 v. at 200/250 mA. and 6.3 v. 5 a. 4 5U46 valves. Complete in transit case. £7/10/-. Less valves £6/10/-.

L.T.V. CONVERTORS WITH INTERNAL POWER PACK. Well-known make, at a very competitive price, completely enclosed. Finished in hammered gold. Very compact. Can be put inside practically all T.V.s. Gain and Trimming controls. Listed at £7/7/-. Carr. 3/6. **£3/10/-**

100 RESISTORS A Useful Assortment **7/6**

VALVES ALL GUARANTEED 3 MONTHS:—

PL81 SOILED AMAZING VALUE AT ONLY **7/-**
EY51, U25 SHORT ENDS **7/-**

SEND 6d. FOR COMPLETE LIST OF ITEMS

AMAZING OFFER

DUE TO A FORTUNATE PURCHASE WE ARE ABLE TO OFFER A FULL 13 CHANNEL TELEVISION SET WITH AN INTERNAL CONVERTER FITTED, AT THE FOLLOWING AMAZINGLY LOW PRICES.

ALL FAMOUS MAKES INCLUDING FERGUSON, PYE, ETC. BUT UNTESTED.

12in. TABLE MODEL **£3.19.0**

14in. TABLE MODEL **£7.10.0**

Will be carefully packed and forwarded Post & Packing FREE at customers risk

STEREO:

Famous make single player. Stereo equipped. Unrepeatable at this price **£6/19/-** Carr. 3/-

100 CONDENSERS 10s.

A most for your spares box. A well-balanced assortment of miniature silver mica and ceramic condensers. 3-10,000 PF. List value over £5.

RADIO:

The best buy of he season. Receivers, complete with valves, speaker and 6-volt vibrator pack. 6K7, 6K8, 6Q7, 6V6. Suitable for adaption as car radio. Ideal for workshop Carr. 5/-. **29/-**

COLLARO "CONQUEST"

Hi-Fi 4-speed, 10 record Autochanger. Brand new, unused. **£6/19/6** Limited Quantity

or Carton containing 2 Players **£13/-/-**

P.M. SPEAKERS:

Standard 3 ohm Tested top makes —performance guaranteed.
6½in. **7/-** 5in. 7 8in. **11/-** 10in. 10×6in. **13/-**
6½ in. Speaker — 69/- per Doz.
(Post & Packing Free)

CO-AXIAL CABLE:

Semi-air spaced, low loss. 50 yard drums 22/6 carr. 2/-. 6 drums 125/-, carr. 5/-. 100 yard drums £2.

TRANSISTORS AND DIODES. XA103 12/6; XA104 15/-; XB104 9/-. V15/10P "Goltop" Power Transistor 19/-. GET15 Power 19/-; Matched pair 38/-. Diodes, General Purpose 9d.; 8/- doz. Equivalent to GEX44 3/6.

1 WATT TRANSISTOR PUSH-PULL OUTPUT

STAGE KIT. Can transform your existing Transistor Receiver or Amplifier into a really high volume set. Two matched GET15 Power Transistors, correct Push-Pull input and 3 ohms output transformers. Instructions. £2/19/- Post 2/-.

CRYSTAL PICK-UPS

STAAR GALAXY. Single hole mounting, light-weight adjustable needle pressure. For any 3- or 4-speed turntable. Amazing value.
1. With latest Steig and Reuter or Sonotone cartridge. Interchangeable with and similar to the Acos GP65. Excellent reproduction 17/6
Cartridge only 15/-
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ACOS HPG37 Cartridge 25/-
"SONODE" (by Plessey) 19/6
Cartridge only 17/-

TRADE ENQUIRIES INVITED

SPECIAL TERMS AVAILABLE ON ALL VALVES IN HEAVY TYPE

25, 50, 100 per Type or Mixed Parcels

Post: 2lbs. 1/6, 4lbs. 2/-

All items less 5% and free in dozens

TECHNICAL TRADING CO.

P.O. BOX 21 (W)
350-352 FRATTON ROAD, PORTSMOUTH

W.W.—B4

R.S.C. HI-FI TAPE RECORDER KIT

Build a high quality recorder in the £70 class for only **29½** GNS. Carr. 17/6

OR DEPOSIT 3 GNS. and 12 monthly payments of 53/9.

Cash price if settled in 3 months.

INCORPORATING THE LATEST MK. IV COLLARO TAPE TRANSCRIPTOR. THE LINEAR LT45 HIGH QUALITY TAPE AMPLIFIER. A HIGH FLUX 7 × 4in. LOUDSPEAKER, 850ft. Reel of Best Quality L.P. TAPE. Spare Tape Spool, a Portable Cabinet, size approx. 18 × 13 × 9in., finished in Veneered walnut or Sapele, and connection diagram for wiring amplifier to transcriptor.

FEATURES INCLUDE

★ 3 SPEEDS. ★ FREQUENCY RESPONSE 50-11,000 c.p.s. ★ SWITCHED NEGATIVE FEEDBACK EQUALIZATION FOR EACH SPEED. ★ OUTPUT 4 WATTS. ★ MAGIC EYE RECORDING LEVEL INDICATOR. ★ TWIN TRACK OPERATION. Both bottom and top tracks can be recorded or played back without removing tape. ★ INSTANTANEOUS CHANGES can be made from one track to another. Fast rewind in either direction. ★ TAPE MEASURING AND CALIBRATING DEVICE. ★ TAKES FULL 7in. DIAMETER REELS OF TAPE. ★ NEGLIGIBLE HUM. ★ ENTIRELY EFFECTIVE ERASURE.

Full descriptive leaflet supplied on receipt of S.A.E.

HI-FI 8 WATT AMPLIFIERS

Last Opportunity—Few now remaining

SPECIAL PURCHASE DUE TO CANCELLED EXPORT ORDER **£4-19-6** Carr. 7/6

For 200-250 v. A.C. mains.

A REMARKABLE OPPORTUNITY

Push-pull output. Latest high efficiency B.V.A. valves. Dual separately controlled inputs for mike and gram. Separate bass and treble controls. High sensitivity. Output for 15 ohm loudspeaker. Guaranteed brand new, tested, and in perfect working order.

VALVES!

Full range at really competitive prices. All guaranteed!

REPANCO CONSTRUCTIONAL ENVELOPES AND COMPONENTS ALWAYS IN STOCK

All parts for: One Transistor Receiver 25/-; Two Transistor Receiver 42/-; 3 Dee 3 Transistor Receiver £3/19/6; Mini 7 Seven Transistor Pocket Portable Receiver £9/19/6: Major 7 Seven Transistor Portable Receiver 15 gns. Only Mullard, Ediswan, or Brimar Transistors supplied for Mini 7 and Major 7 Receivers.

Constructional Envelopes. 3 Dee 9d., Mini 3 Pocket Portable 1/3, Mini 7 1/6, Major 7 1/6.

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. mains. L. and M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated or walnut veneered type. It employs valves 6K7, 6P61, 6F6 and is specially designed for simplicity in wiring. Sensitivity and quality are well up to standard. Point-to-Point wiring diagram. Instructions and parts list 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batterie 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 × 5½ × 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 H.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.

COSSOR V.H.F. F.M. RADIO RECEIVER KITS

Brand New Boxed with valves, 10in. × 6in. Goodmans Speaker, and printed circuit. Normal price 15 Gns. Only £3/19/6

R.S.C. TR2 PORTABLE TAPE RECORDER

A fully assembled unit housed in attractive two tone rexine covered portable cabinet.

- ★ Single Speed 3¾in. per sec.
- ★ Negative Feedback Tone Compensation.
- ★ Excellent Frequency Response.
- ★ Takes 5¾in. Tape Reel.
- ★ Fast rewind.
- ★ Magic Eye Recording Level Indicator.

Complete with Reel of best quality Tape, Spare Spool, and Microphone. **19** Carr. 10/6 GNS.

H.P. TERMS, DEPOSIT 2 Gns. and 12 monthly payments of 33/6.

- ★ Twin Track.
- ★ Automatic Erasing.
- ★ High Sensitivity.
- ★ High Flux 7 × 4in. P.M. Speaker.
- ★ Output 3 watts.
- ★ For 230/250 v. 50 c.p.s. A.C. mains.

ACOS HI-FI CRYSTAL 'MIKES'

33-1 hand or Desk type **35/9** (Listed 50/-)

39-1 Stick type **39/6** (Listed 5 Gns.)

Limited number.

R.S.C. TRANSFORMERS

FULLY GUARANTEED

INTERLEAVED AND 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., 5 v. 2 a.	17/6
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a. suitable for Mullard 510 Amplifier	33/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	35/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a., c.t. 5 v. 3 a.	49/9

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9

ELIMINATOR TRANSFORMERS
Primaries 200-250 v. 50 c/s.

120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v. 250 mA.	9/11

FILAMENT TRANSFORMERS

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.	17/6
0-4-6.3 v. 2 a.	7/9	12 v. 3 a. or 24 v. 1.5 a	17/6
12 v. 1 a.	7/9		

OUTPUT TRANSFORMERS

Midget Battery Pentode 66: 1f or 3S4, etc	3/9
Small Pentode 5,000 Ω to 3 Ω	3/9
Standard Pentode 5,000 Ω to 3 Ω	5/9
Standard Pentode 8,000 Ω to 3 Ω	5/9
Push-pull 8 watts 6V6 to 3 ohms	8/9
Push-pull 8 watts EL84s to 15 ohms	8/9
Push-pull 10-12 watts 6V6 to 3 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 ohms	17/9
Push-pull Ultra Linear for Mullard 510	27/9
Push-pull 15-18 watts, sectionally wound, 6L6, KT66, etc., or 3 or 15 ohms	23/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT66, etc. to 3 or 15 Ω	47/9

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 LT type	6/6

EXTENSION SPEAKERS

Limited number in handsome Walnut veneered cabinets. 2-3 ohms speech coils, 6½in. 29/9. 8in. 35/9. 10in. 56/9.

DRY SHAVERS. Brand new in carrying case. Operation from 3 U2 batteries, fitted in case. Just the thing for travel. Only 59/6 (approx. half price).

RECORDING TAPE. GEVASONOR Best quality 600ft. 5in. 14/9, L.P. 5in. 850ft. reels 22/6, 7in. 1,700ft. reels 35/-. Less than wholesale price.

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 is £4/15/-. Point-to-Point wiring diagrams and instructions 2/6.

LITTLE STAAR BATTERY OPERATED RECORD PLAYING UNITS. Complete with Pick-up to take 45 r.p.m. records. Used by leading manufacturers in Transistorised Record Players. Require 6 v. battery. Only £3/19/6. Carr. 3/6.

COLLARO JUNIOR 4-SPEED RECORD PLAYER with separate pick-up having dual point sapphire stylus. Brand new, cartoned. For 200-250 v. A.C. mains only. Only £3/15/-. Post 3/6.

B.S.R. MONARCH AUTO-CHANGERS

Type UA8, 4 speed, T/O Pick-up with sapphire stylus £6/19/6. Carr. 4/6.

Collaro AC4/564 4-speed single players with hi-fi turnover crystal pick-up head £6/12/6. Carr. 4/6.

R.S.C. AI2 STEREO AMPLIFIER KIT

A complete kit of parts to construct a good quality 3 + 3 watt (total 6 watt) stereo amplifier providing really life-like reproduction. Suitable for use with all stereo, pick up heads at present available. Gauged volume and tone controls. Preset balance control. Outputs for matched 2-3 ohm speakers. For 200-250 v. A.C. mains. Astonishing value. **£3-19-6** Carr. & packing 7/6

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS

HF1012, 10 watts 15 ohms (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance. £4/10/9. Please state whether 3 ohm or 15 ohm required.

AM/FM RADIOGRAM CHASSIS, HIGH QUALITY. PUSH-PULL. 6-8 WATT OUTPUT. Current manufacture. 12 months guarantee. For 200-250v. mains. Covers L. and M. wavebands plus F.M. Includes 8 latest type miniature B.V.A. valves. Only 22 gns. plus 7/6 carr. Or deposit £2/12/- and 9 monthly payments of £2/12/-.

E.M.I. 4-speed Single Players with hi-fi T/O crystal pick-up head for Stereo and Monaural. £7/15/-. Carr. 4/6.

GARRARD 4-SPEED AUTO-CHANGERS

Type RC/120H. Limited number of £9/19/6. (approx. half price). Carr. 5/6. Brand new.

PHILCO F.M. RADIO TUNERS

With self-contained power pack. A 6-valve de-luxe unit housed in beautiful walnut veneered cabinet. For 110-200-250 v. A.C. mains. Magic eye tuning indicator **12½** Carr. 5/- GNS.

30 WATT AMPLIFIER
R.S.C. A.10 ULTRA LINEAR

HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. EF86, EF86, ECC83, 807, 807, GZ34. Tone Control Pre-amp. stages are incorporated. Sensitivity is extremely high. Only 12 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. An extra control input with associated vol. control is provided so that two separate inputs such as "mike" and gram. etc., etc., can be simultaneously applied for mixing purposes. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF** 300 v. 20 mA. and 6.3 v. 1.5 A. **FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams.

Only **11 Gns.** Carr. 10/-

Or Factory built with 12 months' guarantee **£13/19/6.** TERMS ON ASSEMBLED UNITS. DEPOSIT 24/9 and 12 monthly payments of 24/9.

Cover as illustrated 18/9 extra.

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/cs. Tone Controls ± 12 D.B. at 50 c/cs. ± 12 D.B. to — 6 D.B. at 12,000 c/cs., hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-250 v. 50 c/s. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS OR OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES,** etc., etc. We can supply Microphones, Speakers, etc., at keen cash prices or on terms with amplifiers. **EXPORT ENQUIRIES INVITED.**

LINEAR "DIATONIC" 10 WATT HIGH FIDELITY AMPLIFIER. A compact attractively finished unit. 12 gns. Cash. Send S.A.E. for leaflet. H.P. Terms. Dep. 22/3 and twelve monthly payments of 22/3.

LINEAR LI/10 10 WATT HIGH FIDELITY AMPLIFIER, with 3 position equalisation switch 13 Gns.

LINEAR L5/5 HIGH QUALITY STEREO AMPLIFIER. Total output 10 watts. Handsome Perspex Facia Plate. All controls ganged. Only 11 Gns.

LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER. Suitable for use with any record playing unit and most microphones. Negative feedback 12 D.B. Bass and Treble controls. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves. Size only 8 × 5 × 5½in. high. Chassis fully isolated from mains. Guaranteed 12 months. Only **£5/19/6** Or Deposit 22/- and 6 monthly payments of 22/-. Send S.A.E. for leaflet.

L63 MINIATURE 3 WATT GRAM AMPLIFIER

For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 6½ × 4½ × 2½in. Fitted vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changing unit. Output for 2-3 ohm speaker. Guaranteed 12 months. Only 57/9.

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER. Spec. exactly as A5 below with exception of output wattage. Complete kit of parts, diagrams and instructions £3/15/-, carr. 3/6.

R.S.C. A5 4-5 WATT HIGH GAIN AMPLIFIER

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. 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/cs. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/- or assembled ready for use 25/- extra, plus 3/6 carriage. Or Deposit 22/- and five monthly payments of 22/- for assembled unit.

P.M. SPEAKERS. 2-3 ohm 2½in. Perdio 21/9. 5in. Goodmans 17/9. 7 × 4in. R.A. Elliptical 19/9. 6½in. Rola 19/9. 8in. Rola 19/9. 8in. Goodmans 21/9. 8 × 6in. Elac with high flux magnet 25/9. 10in. R.A. 28/9. 10 × 6in. Elliptical Goodmans 29/9. 12in. R.A. 29/11. 12in. R.A. 3 or 15 ohms, 10 watts, 12,000 lines, 59/6.

TWEETERS. 4in. Plessey, 3 ohms, 18/9.

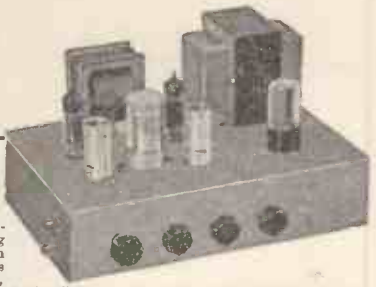
COLLARO CONQUEST 4-SPEED AUTO-CHANGERS. With studio pick-up with turnover head. BRAND NEW. Cartoned latest model. For 200-250 v. A.C. mains. £7/19/6. Carr. 4/6.

ACOS Crystal Microphone Inserts. Brand new. Only 5/11 ea. Ex. Equip. 4/11 ea.

ACOS HGP59 Hi-Fi Crystal Cartridges. (Turnover type, with sapphire stylus.) Standard replacement for Garrard and Collaro. Only 19/9. B.S.R. Full-fi 19/9. Garrard GC2 19/9.

HIGH FIDELITY 12-14 WATT AMPLIFIER TYPE AII

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PREAMP STAGES



Twoinput sockets with associated controls allow mixing of "mike" and gram. as in A10. High sensitivity. Includes 5 valves, ECC83, ECC83, EL84, EL84, 5Y3. High Quality sectionally wound output transformer specially designed for Ultra Linear operation, and reliable small condensers of current manufacture. **INDIVIDUAL CONTROLS FOR BASS AND TREBLE** "Lift" and "Cut" Frequency response ± 3 D.B. 30-30,000 c/cs. Six negative feedback loops. Hum level 60 D.B. down **ONLY** 23 millivolts **INPUT** required for **FULL OUTPUT.** Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs. For **STANDARD** or **LONG PLAYING RECORDS.** For **MUSICAL INSTRUMENTS** such as **STRING BASS, GUITARS,** etc. **OUTPUT SOCKET** with plug provides 300 v. 30 mA. and 6.3 v. 1.5 a. For supply of a **RADIO FEEDER UNIT.** Size approx. 12-9-7in. For A.C. mains 200-250 v. 60 c/cs. Output for 3 and 15 ohms speakers. Kit is complete to last nut. Chassis if fully punched. Full instructions and point-to-point wiring diagrams supplied. (For factory built 45/- 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 18/9, and 12 monthly payments of 18/9. Send S.A.E. for illustrated leaflet detailing Ready-to-assemble Cabinets, Speakers, Microphone etc., with cash and credit terms.

R.S.C. PORTABLE GUITAR AMPLIFIERS

JUNIOR 5 WATT. High Quality Output. Separate Bass and Treble "cut" and "boost" controls. Sensitivity 15 m.v. High Flux 8in. l/speaker. Input sockets for Radio/Tape or Gram Pick-up and Mike /Instrument Pick-up. Handsome strongly made cabinet (Size approx. 14 × 14 × 7in.). Finished in satin walnut and fitted carrying handle.

£8/19/6 Carr. 7/6. Or Deposit £1 and nine monthly payments £1.

Send S.A.E. for leaflet.

SENIOR 10 WATTS. High Fidelity Push-Pull output. Separate Bass and Treble "cut" and "boost" controls. Twin separately controlled high gain inputs so that two instruments such as Guitar and String Bass can be used at the same time. Two Loudspeakers are incorporated, a 12in. P.M. for Bass notes, and a 7 × 4in. elliptical for Treble. Cabinet is well made and finished satin walnut. Size approx. 18 × 18 × 8in. 13 gns. Plus 10/- carr. H.P. TERMS. DEPOSIT 23/6 and 12 monthly payments 23/6. Both models for 200-250 v. A.C. mains.

STAAR GALAXY 4-SPEED MIXER AUTO-CHANGERS. Brand New, cartoned. Turnover sapphire styli. Many exclusive features. Unique design motor virtually free from rumble. For 200-250 v. A.C. mains. Limited number tested and guaranteed £5/19/6. Carr. 4/6.

PORTABLE CABINETS

For Record Players or Tape Recorders. Rexine covered. Wide selection of attractive designs and colour combinations PRICES FROM **15/9**

12in. 10 WATT HIGH QUALITY LOUDSPEAKER IN POLISHED WALNUT FINISHED CABINET

Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only £4/19/6. Carr. 5/-.
Terms: Deposit 11/- and 9 monthly payments of 11/-.
12in. 20 WATT 15,000 line l/speakers 15 ohms, in Cabinet finished as above. Size 18 × 18 × 8in. £7/19/6 or Deposit 13/10 and 12 monthly payments 13/10.

PORTABLE CABINETS. Attractive design. Two-tone rexine covered. Will take Collaro, B.S.R., Garrard or Staar Auto-Changer, amplifier and 7in. × 4in. or 5in. speaker. Slightly soiled. Only 49/6.

ACOS HIGH FIDELITY PICK-UPS. GP54 with HGP59/52 Cartridge. Turnover sapphire Styli, cream finish. Limited number at approx. half price. Only 29/11.

SPECIAL OFFER

Above cabinet Staar Changer, Gram amplifier, and 8in. or 6in. × 4in. speaker £9/19/6. Carr. 10/-. Or with B.S.R. changer in lieu of Staar, 11 Gns. Carr. 10/-.

PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A11 or any similar amplifier. Rating is 10 watts. Gauss 12,000 lines. Price only £5/17/6. Or Deposit 10/6 and 12 monthly payments of 10/6

R.S.C. MANCHESTER, LEEDS & BRADFORD

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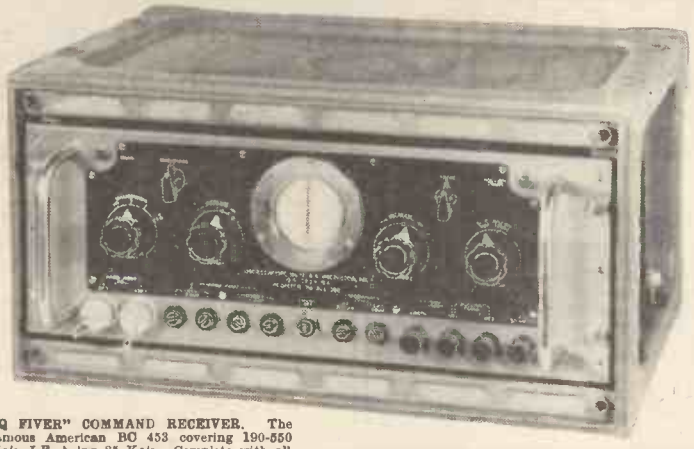
TERMS: C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on all orders under £2, 2/9 extra under £5 unless carriage stated. Trade supplied. Post orders to **Mail Order Dept., 29-31 Moorfield Road, Leeds, 12.**



OSCILLOSCOPE No. 11

Made for Anti-Aircraft Command by A. C. Cossor in 1952, this is a First Grade L.F. Oscilloscope incorporating a Hard Valve Time Base, with existing speeds of 1-5-40 milliseconds, but is easily converted at a cost of a few shillings to produce speeds of 3 cycles per second to 30 kc/s. Has High Class Amplifier with Fine and Coarse gain controls, plus Brightness and Focus controls, and X and Y shifts. Conservatively rated Mains Power Pack is for nominal 115 v. and 230 v. input, and is adequately fuse protected in all circuits. Tube employed is 2½in. ACR10. Will make up into an ideal workshop or servicing oscilloscope. Has grey and black engraved front panel size 19in. × 7in., depth of unit being 12in. Illustrated in heavy steel transit case in which it can be used, or removed for standard 19in. rack mounting. Complete with leads and suggested modification data. BRAND NEW, ONLY **£12/10/-**, (carriage 15/-).

"Q FIVER" COMMAND RECEIVER. The famous American BC 453 covering 190-550 Kc/s, I.Fs being 85 Kc/s. Complete with all 6 valves and circuit. Size 11 × 5½ × 5ins. **BRAND NEW IN MAKERS CARTONS. ONLY 89/6** (Post 3/6).

POWER UNITS TYPE 234. Primary 200/250 v. 50 cycles. Outputs of 250 v. 100 mA., and 6.3 v. 4 amps. Fitted double smoothing. For normal rack mounting (or bench use) having grey front panel size 19in. × 7in. **BRAND NEW. ONLY 59/6** (carriage, etc., 7/6).

MARCONI SIGNAL GENERATOR TF-517-F/L. Cover 10-18 Mc/s., 33-58 Mc/s. and 150-300 Mc/s. In good, used condition, with charts. Checked before despatch. Complete with power pack for normal A.C. mains. **ONLY £12/10/-** (carriage, etc., 20/-).

TAPPED TRANSFORMER. Normal primary, delivering 30 v. 2 amps., which is tapped to obtain 3 v., 4 v. 5 v., 6 v., 8 v., 9 v., 10 v., 12 v., 15 v., 18 v., 20 v., 24 v., **ONLY 20/-.**

12 VOLTS AMERICAN DYNAMOTOR. Delivers 220 volts at 100 mills. Size 5½ × 3½in. diameter. Ideal for running Radio or Electric Shaver, etc. from car battery. **ONLY 32/6.**

EHT TRANSFORMERS. 5.5 kV. (Rect. with 2 v. 1 a., **79/6.** 7 kV. (Rect.) with 2 v. 1 a., **89/6.** 2.5 kV. (Rect.) with 2-0-2 v. 1.1 a., 2-0-2 v. 2 a. (for VCR 97 tube etc.), **47/6** (postage 2/- per trans.).

6 v. VIBRATOR PACKS. Output approx. 130 v. at 30 mA., fully filtered and smoothed. Complete, **ONLY 12/6.**

HIGH FREQUENCY A.C. VOLTMETER. A First Grade Moving Iron Instrument with 6in. Mirror Scale, reading up to 150 volts A.C. at 400 and 1,200-2,400 cycles. In substantial Oak case with removable lid, overall size 8½in. × 8½in. × 5½in. Recently made for the Air Ministry, by Everett Edgcumbe, and in perfect order. Brand New and Unused. **ONLY £7/10/0.** Can be, supplied modified for 50 cycles, use either 0-150 or 0-300 volts, 20/- extra.

TCS TRANSMITTERS

The renowned American TCS Model designed by the Collins Company for static or mobile use. Covers 1.5-12.0 mc/s. in 3 bands, and is complete with 7 valves, employing 2 of 1625 in P.A. Stage, 1 each of 1625 in Buffer and Modulator Stages, and 3 of 12A6 in Oscillator Stage. Provision for VFO or Crystal Control. 4 Crystal positions. Radio Telephone or Radio Telegraph. Has Plate and Aerial Current Meters. Power Requirements 12 v. LT and 400 v. HT. In black crackle case, size 11 × 13 × 11 in. New Condition internally, but externally store soiled. ONLY **£7/19/6** (Carr., etc. 15/-).

We can also supply the TCS RECEIVER, which matches the Transmitter in size and appearance, and covers similar frequencies. Complete with 7 valves, 1 each of 12SA7 and 12SQ7, 2 of 12A6 and 3 of 12SK7. Power Requirements 12 v. LT and 225 v. HT. In first class Condition. **ONLY £10/10/0** (carriage etc., 15/-).

The double Dynamotor Power Unit, Type 21881B for 12 volts operation, delivering 400 v. for Transmitter and 225 v. for Receiver, is available at **£12/10/-** (carriage, etc., 15/-).

RCA AR 88 RECEIVERS

Re-conditioned and in perfect working order. "LF" Model, covers 75-140 kcs. and 1.2-30 mcs., **ONLY £50.** "D" Model, covers 500 kcs-31 mcs. **ONLY £55** (Carriage etc., 25/-).

CRYSTAL CALIBRATOR No. 10

A superb Crystal Controlled Wavemeter just released by the Ministry of Supply. Has directly calibrated dial for nominal coverage of 1.5-10.0 Mc/s. but may actually be used from 500 Kc/s. up to 30 Mc/s. Complete with 500 Kc/s. Crystal, 2 valves type 1T4, 1 or 1R5 and 1 of CV286 (Neon Stabiliser), and Instruction Book. Size 7in. × 7½in. × 4in., weight 5lbs. Used but in first class condition. **ONLY £2/19/6.** Carr. 3/6.

TRIPLETT UNIVERSAL TEST METER. Made by the famous American meter manufacturers. Size 7½ × 6½ × 6½in., and incorporates a unique tilting bakelite container size 5½ × 3½in., which has two meters, a 25,000 ohms per Volt moving coil for D.C. measurements, and a first grade moving iron for A.C. Reads Resistance up to 40 Megohms, A.C. & D.C. Volts to 1,000, D.C. Current to 250 mA., and also has 0-50 Microamps range. Facilities for measuring Condenser Capacity etc., and Audio Output. Completely portable, with protective face cover. Complete with leads, batteries, and instructions. Fully re-conditioned. **ONLY £12/10/-** (post, etc. 5/-).

RCA 8in. P.M. **SPEAKER,** in heavy black crackled metal case, designed for use with AR 88 Receiver, or any set with 3 Ohms Output. **BRAND NEW IN MAKERS CARTONS. ONLY 45/-** (Post 3/6).

CANADIAN MOVING COIL PHONES. Low-resistance, fitted noise excluding chamois ear muffs, and leather covered head-band. Lead terminates to jack plug. **BRAND NEW. ONLY 19/6** (Post 1/6).

MAINS ISOLATING TRANSFORMER. Manufactured by Vortexion. Fully shrouded. Will provide true 1 : 1 Ratio from nominal 230 v. Primary. Rated at 100 watts. **BRAND NEW. ONLY 22/6** (post 2/6).

AIRBORNE TRANSMITTER, RECEIVER TYPE 1938. A Mobile 10 Channel Crystal Controlled V.H.F. TX/RX covering 124.4/156 Mc/s. I.F. Bandwidth 23 Kc/s. Complete (less external attachments) in metal case, with all valves and 24 volts Rotary Power Unit. Used, but in first class condition, with circuit. **ONLY £6/19/6.** Carr. etc., 10/6.

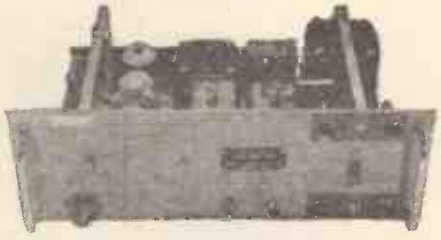
HETERODYNE FREQUENCY METERS

TYPE LM14

Designed and built to United States Navy specification, these Crystal Controlled instruments combine all the advantages of the well known BC.221 Frequency Meter, plus many additional features which increase their usefulness.

- ★ Frequency range 125–20,000 kc/s. in 2 bands.
- ★ Accuracy better than .02% in 125–2,000 kc/s. band, and better than .01% in 2,000–20,000 kc/s. band.
- ★ Voltage stabilisation circuit ensures accuracy not affected by power supply fluctuation.
- ★ Separate power switches allow standby filament operation without HT supply.
- ★ Modulation switch enables instrument to be used as a Signal Generator.
- ★ Has corrector for WWV.
- ★ Supplied with removable shock protection mounting.
- ★ Size only 8½in × 8in. × 8½in. Weight 11½lb.
- ★ Brand New and Unused. Further details on application.

AMPLIFIER N24



Manufactured for the Admiralty in 1952 by Burndept, this utilises 4 valves, 1 each 5Z4G, 6V6G, 6J7G, 6J5G, and high quality components such as "C" Core Transformers and Block Paper Smoothing Condensers. Has A.C. Mains Pack for nominal 110/230 volts. Provision for 600 ohms or High Impedance Input, and has Output to 600 ohm Line. For normal use only requires changing Output Transformer. Can be used for Speech or Music, giving High Quality Reproduction. Output approximately 4 watts. Enclosed in metal case, and designed for Standard 19in. Rack Mounting, having grey front panel size 19in. × 7in. with Chromium Handles. All connections to rear panel, front having "On/Off" Switch, Gain Control, Indicator Light, Fuses and Valves Inspection Panel. **BRAND NEW IN MAKER'S PACKING. ONLY £4/9/6** (carriage 10/6).

Cash with order please, and print name and address clearly

PLEASE ADD POSTAGE OR CARRIAGE COSTS ON **ALL** ITEMS

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Open until 1 p.m. Saturdays. We are 2 mins. from High Holborn (Chancery Lane Station) and 5 mins. by bus from King's Cross

CRYSTAL CALIBRATORS No. 10

An extremely useful instrument providing the following facilities: 1, Xtal controlled osc. giving fixed frequency signals of 500 kc/s and harmonics to 30 Mc/s; 2, an additional switched oscillator (250-500 kc/s) enabling all intermediate frequencies from 500 kc/s to 10 Mc/s to be produced. Compact size, 7 × 7½ × 4in. Utilises 2-1T4, 1R5 and CV286 valves and 500 kc/s Xtal. Supplied with instructional hand book. 59/6 each. P/P 3/6.

VORTEXION PORTABLE AMPLIFIERS

Operation from 200/250 volts A.C. or 12 volts D.C. Separate inputs for microphone or gram. Output matched to 7.5, 15, 250 or 500 ohms. incorporates volume control and full switched tone control. Valve line-up; 6Q7, 6J5, 6V6, 6V6, 5Z4. Size 8½ × 6½ × 17½in., not brand new but supplied in perfect working order, fully tested. £10/10/- each. P/P 6/-.

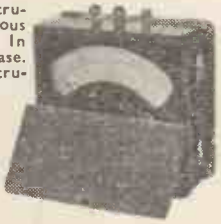
DON Mk. 5 FIELD TELEPHONES

ideal for all inter-communication. Buzzer calling. Supplied fully tested, complete with batteries and instructions. 39/6 each. P/P 3/6 ea., 5/- pr.

SOUND POWERED INTER-COM-SYSTEM

Ideal for office, home or workshop. Comprises 2 sound powered telephone handsets and 72ft. of twin connecting flex. No. batteries required, just speak and listen. COMPLETE. ONLY 35/-. P/P 3/-. Additional flex 2½d. yd. extra.

PORTABLE PRECISION VOLTMETERS



Brand new instruments by famous manufacturer. In polished teak case. Moving iron instrument reading A.C. or D.C. volts on 2 ranges 0-160 v. or 0-320 v., 8in. mirror scale. Accuracy within 2%. £5/19/6 ea. P/P 3/6.

SURPLUS HEADPHONES

RCA chamois padded, moving coil. 100 ohms, fitted jack plug, 19/6 pr. P/P 1/6. American HS/30 super lightweight, 50 ohms. 15/- pr. P/P 1/6. 4,000 ohm light duty, 12/6 pr. P/P 1/6.

CR.100 SPARES KITS

Contains 15 valves, resistors, pots, condensers, o/p trans., etc. All brand new, 59/6 set. P/P 3/6.

ADVANCE CONSTANT VOLTAGE TRANSFORMERS

190 to 260 volts input. Constant 230 volts output, 150 watts. Brand new boxed, £8/10/- each. P/P 5/-.

MODEL 7 UNIVERSAL AVOMETERS

Reconditioned, perfect order with leads £12/19/6 each. P/P 3/6.

12 VOLT 45 AMPERE NIFE ACCUMULATORS

£4/19/6 each. P/P 7/6.

PERMEKO TABLE TOP TRANSFORMERS

Input 230 volts. Output 620/550/375/0/375/550/620 volts 250 mA. Also 2-5 volt 3 amp. windings. Size 6¾ × 6½ × 5½in. New boxed, 45/- each. P/P 5/-.

MUIRHEAD PRECISION STUD SWITCHES

4 bank, 4 pole 24 positions. New boxed, 17/6 each. P/P 1/3.

R.1294 V.H.F. COMMUNICATION RECEIVERS

500 to 3,000 mc/s. Perfect condition with handbook, £25 each. P/P 10/-.

MARCONI TF-517 SIGNAL GENERATORS

10 to 18mc/s; 33 to 58 mc/s; 150 to 300/mcs. 200/250 volts operation. Perfect order, £12/10/- each. P/P 10/-.

110/230 VOLT AUTO TRANSFORMERS

15/20 w., 9/-; 50 w., 12/6; 150 w., 18/6; 500 w. 65/-. Please add postage.

24-VOLT ROTARY CONVERTORS

Input 24 volt D.C. Output 230 volt A.C. 50 cycles, 100 watts. Housed in metal case with inlet/outlet plugs. Brand new, 92/6 each. P/P 7/6.

GARRARD VARIABLE SPEED GRAM MOTORS

0-to 45 r.p.m. 200/250 v. A.C. With turntable, 22/6 each. P/P 2/6.

DYNAMO EXPLODER UNITS

For detonating explosive charges. Hand generator operation. Brand new, 29/6 each. P/P 3/6. Hide leather cases 19/6 extra.

POST OFFICE TELEPHONE HANDSETS

Std. type, new boxed, 12/6 each. P/P 1/6.

CRYSTAL MIC. INSERTS

4/6 each. P/P 6d.

REVERSIBLE MODEL MOTORS

12/24 volts D.C., 8/6 each. P/P 1/-.

FERRANTI FILAMENT TRANSFORMERS

Two types, both 200/250 v. input. Type 1. 6.3 volt ct., 5.6 amp., 6.3 volt, ct., 4.8 amp., 6.3 volt, ct., 1 amp., 19/6; Type 2. 6.3 volt, ct. 3.3 amp., 6.3 volt, ct., 1 amp., 6.3 volt ct., .9 amp., 6.3 volt, ct., .6 amp. 15/6. P/P 2/- each type.

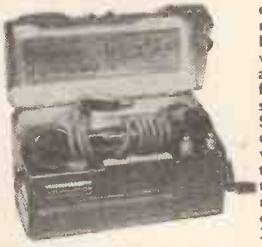
HALLICRAFTER S.27 U.H.F. COMMUNICATION RECEIVERS.

F.M. or A.M. coverage 27 to 143 mc/s. on 3 bands. Incorporates S meter, variable sel. b.f.o. a.n.l. etc. Output for phone or speaker. Operation 110 or 230 volts A.C. Supplied in good working order, £27/10/- each. P/P 10/-.

ROTARY CONVERTERS

12 v. D.C. input. 230 volt A.C. 150 watts 50 cycles output. Housed in wooden case and fitted with voltage control slider resistance, switch, plugs and A.C. mains voltage output check meter. Supplied in perfect condition, individually tested £9/19/6 each. P/P 10/-.

FIELD TELEPHONES TYPE L.



Generator bell ringing. Light and very portable. Ideal for all installations. Supplied complete with batteries, fully tested. As new, 59/6 each. P/P 3/-. 5/- pr.

FERRANTI TESTMETERS TYPE Q

D.C. VOLTS	A.C. VOLTS	D.C. Current	Ohms
3 v.	15 v.	7.5 ma.	25,000
30 v.	30 v.	30 ma.	
150 v.	150 v.	150 ma.	
600 v.	060 v.	750 ma.	

500 ohms per volt on all ranges B.S.S. first-grade accuracy on all self contained ranges. Supplied in perfect working order complete with leads, battery, instructions and rexine covered carrying case. Price 52/6 each. P/P 2/6.

BATTERY CHARGING OR MODEL RECTIFIERS AND TRANSFORMERS

Rectifiers. All full wave and bridged. 12/18 volt 1.5 amp. 4/3; 12/18 volt 2.5 amp., 6/9; 12/18 volt 4 amp., 9/9; 12/18 volt 6 amp., 18/6; 24/30 volt 1 amp., 12/6; 24/30 volt 4 amp., 22/6; 24/30 volt 15 amp., 62/6.

Transformers. All primaries tapped 200/250 volts. 3.5, 9 or 17 volt 1 amp., 9/9; 3.5, 9 or 17 volt 2 amp., 14/3; 3.5, 9 or 17 volt 4 amp., 16/6; 9 or 17 volt 6 amp., 26/-; 3, 4, 5, 6, 8, 10, 12, 15, 18, 20 ,24 or 30 volt 2 amp., 18/6. Please add postage on all above items.

HOURS OF BUSINESS: 9 A.M. TO 6 P.M. THURSDAY 1 P.M. OPEN ALL DAY SATURDAY. SEND S.A.E. FOR LISTS.

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

Wilkinsons EST. 1921

METERS GUARANTEED

F.S.D.	Size	Type	Price
50 Microamps	2½in.	MC/FR	70/–
100 Microamps	3½in.	MC/FR	70/–
500 Microamps	2in.	MC/FR	25/–
500 Microamps	2½in.	MC/FR	37/6
1 Milliamp	2in.	MC/FS	27/6
1 Milliamp	2½in.	MC/FR	35/–
30 Milliamps	2½in.	MC/FR	12/6
100 Milliamps	2½in.	MC/FR	12/6
200 Milliamps	2½in.	MC/FR	12/6
500 Milliamps	3½in.	MI/FR	30/–
5 Amperes	2in.	MC/FS	27/6
15 Amperes	2in.	MC/FR	10/6
25 Amperes D.C.	2½in.	MI/FR	7/6
50-0-50 Amp.	2in.	MC/FS	12/6
30-0-30 Amp.	2in.	MC/FR	15/6
20 Volts	2in.	MC/FS	10/6
40 Volts	2in.	MC/FS	10/6
300 Volts	2½in.	MI/FR	25/–

CROSS POINTER METERS. 2 separate 100 microamp movements, **22/6.**
MICROAMMETER. 250 F.S.D. 3½in. F.R. Sangamo Mod. S.37. Scaled for valve voltmeter. Circuit available free. **5/–.**
Postage 1/6 extra for above meters.
CATHODE RAY TUBES. 2AP1 **25/–**, 139A **35/–**, 5BP1 **55/–**. Post 3/-.
TEST PRODS. Retracting points, fused, flex and terminals, **5/6.** Post 6d.

RELAYS P.O. TYPE 3000

Build to your own specification

Keen Prices

Quick Delivery

Contacts up to 8-Changeover

SPECIAL OFFER. YOKES for Type 3000 Relays **30/-** doz. Armatures **9/-** doz. Armatures (adjustable) **18/-** doz.

MINIATURE RELAYS:

Siemens High Speed Sealed.			S.T.C. and G.E.C. Sealed.			
2.2Ω+2.2Ω	H96A	15/6	2Ω	2 C O	4184GA	18/6
145Ω+145Ω	H96C	19/6	700Ω	2 C O	418GD	19/6
500Ω+500Ω	H96D	22/6	2500Ω	1 make	HD4186EE	22/6
1700Ω+1700Ω	H96E	25/-	2700Ω	2 C O	4184GE	21/6
Simens High Speed Open.			180Ω	2 m 2 b	M1087	19/6
100Ω+100Ω	H85N	15/-	670Ω	4 C O	M1092	21/6
1000Ω+1000Ω	H95A	17/6	2500Ω	1 C O	M1022	22/6
1700Ω+1700Ω	H85L	17/6	5000Ω	2 C O	M1052	25/–

Comprehensive range available from stock.

SWITCHES. 1 hole fixing, 3 amp. 250 volt. **1/6** each, **12/-** doz.
RACKS—POST OFFICE STANDARD. 6ft. high with U-channel sides drilled for 19in. panels, heavy angle base, 4ft. 10in. in stock.

SOLENOIDS. 12 volt D.C. with 3½in. lever. Ideal for remote control, model railways. **5/- ea.**, post 1/6. Unit of 26. **£4/6/8.** Cge. 15/-.
NIFE BATTERY. Nickel cadmium. 6 volts 75 amp., crated and connected. Alkaline filled. Brand new, **£7/10/-.** Carr. 15/-.
LOUDSPEAKERS. P.M. Elac 5in. round **15/6**, post 1/6. Axiom 150 dual cone 12in. 15 watts 15 ohms, fully dustproof, **£7/19/6**, post 7/6. Pye 10in. portable 3 ohms **50/-**, carr. 7/6.

3 IN. ROUND PLESSEY SPEAKER, SEALED TYPE WITH PROTECTIVE GRILL . . . . 19/6, POST 1/6

JACK PLUGS. Cylindrical bakelite screw-on cover, 2 contact **2/6**, post 6d.

SOCKETS. One hole fixing for above, **3/6.** Post 6d.
TELEPHONE PLUGS TYPE 201 with headphone cord. **3/-** each, post 1/-. Large quantities available from stock.

TERMINAL BLOCKS. 2-way **4/-** doz. or box of 50 for **15/-**, 3-way **6/-** doz., 50 for **22/6.** Post 1/6.
AIR BLOWER. 230 volt A.C. 15in. fan. Volume of free air at max. r.p.m. is 1,250 cu. ft. per min. At maximum efficiency 900 cu. ft. per min. Brand new **£25.** Carr. 20/-.
XPELAIR EXTRACTION FANS. 7½in. blades, Baffle outlet **190/-.** Cge. 5/-
HEADPHONES. Balanced armature type DLR5. **10/6** pr., post 1/6.
HEADPHONES. High resistance 4000 type CHR, **12/6** pr., post 1/6.
HEADPHONES. Balanced armature type DHR, **17/6** pr., post 1/6.
LOUDHAILERS RE-ENTRANT TYPE all-metal **15in.** diameter with mounting bracket **£6/10/0**, carr. 10/-. Easco 15 ohms 8in. diameter with mounting bracket, **£5/10/-**, carr. 10/-., 18in. long by 12in. dia. with mounting bracket, **£5/10/-**, carr. 10/-.
AVO TEST BRIDGES. 220/240 volt A.C. Measure capacities from 5 pf. to 50 mfd. and resistances from 5 ohms to 50 megohms. Valve voltmeter range 0.1 to 15 volts and condenser leakage test. BRAND NEW. Full working instructions supplied with instrument. **£9/19/6.** Post 3/-.
OSCILLOSCOPE. Type 43. With 3½in. C.R.T. 138A, 4—617, 3—VR54, 5Z4, VU120. Brand New with usual controls, power pack and leads. Suitable for 230 volts, **£10/10/-**, carr. 12/6.

A LARGE AND COMPREHENSIVE STOCK OF WIRELESS AND ELECTRONIC COMPONENTS

TELEPHONES

Easy to Fix
Wiring Diagram Free

TELEPHONE SET TYPE "A" Ringing and speaking both ways on a 4-core cable. Very loud and clear over any distance. The handsets are as illustrated and the set is complete except wire. 4-core at **8d.** per yard or 2-core at **3d.** per yard extra. Price **75/-** set, post 3/6.
SET B. Two headphones connected to breast microphones, with leads, plugs and fitted carrying cases. Join instruments together with two wires and 1½ volt battery for a super Intercom., **25/-**, post 3/6.
SET "C". Similar to Set "A". Instead of P.O. Type handsets, two P.O. Desk Type Instruments are supplied with usual drawer in base. Complete ready for use. Price **150/-**, post 7/-.

10 AMP BATTERY CHARGER

HERE IS YOUR CHANCE TO PURCHASE A BRAND NEW UNIT WORTH £40! FOR OUR SPECIAL PRICE £17.10.0
Carriage 20/-.
Input 200/250 v. A.C. 50 cy. Output 10 amps., 22 volts D.C. Controlled by two 4-position switches for fine and coarse control which enables 6 to 24 volt batts. to be charged. Brand new with 0/12 ammeter. Fused A.C./D.C.
ROTARY CONVERTERS. Input 12 D.C. Output 230 A.C. 50 cy. 135 watts. In fitted case with variable resistance, 0/300 voltmeter. The ideal job for television where A.C. mains are not available. **£10.** Carr. 15/–. Special connectors, one fitted with 6ft. heavy duty flex and clips for D.C. side. **10/-** set, post 1/-. **CONVERTORS ONLY,** 12 volt or 24 volt. **£8/10/-.** Carr. 7/6.
BATTERIES. Portable Lead Acid type, 6 volts 125 ampere hours. In metal case 16in. × 8in. × 11in. (Two will make an ideal power supply for our 12 volt Rotary Converters). Uncharged **£6/10/-** each, carriage 15/-. 24 volt 85 ampere **£15/-/-** each, carriage 15/-.
UNI-PIVOT GALVANOMETER by Cambridge Instruments, 50-0-50 micro-amps., dia. 4in. Knife pointer, mirror scale. Complete with leather carrying case. Ideal for laboratory use. **£10,** carriage 3/-.
FLIGHT TO GROUND SWITCHES. 5C/2828 as used on aircraft. Very robust, will carry a very heavy current **25/-** each; or in pairs with auxiliary switch **50/-**, post 3/-.
SIGNAL GENERATOR TYPE 52A. Input 230 volt 50 cycles, complete with leads, dummy antenna. Brand new in transit case. 6 to 52 Mc/s. inclusive in 4 bands with calibration charts. Coarse and fine attenuators. Int. and ext. mod. Output 0.5 volt to 100mv., impedance 70 and 100Ω. **£10.** Carriage 10/-.
MOTORS. 12 volts D.C. Reversible. 2in. × 1¼in. Spindle ⅛in. × ⅛in., **10/6** each, post 1/6.
SYNCHRONOUS MOTOR. 200/250 volts A.C. 60 r.p.m., suitable for electric clocks, etc., **25/-**, post 2/6.
MAINS MOTORS. Capacitor 230 v. A.C. 1/40th hp 1,400 r.p.m. **55/-**, post 3/-.
MAINS TRANSFORMER WITH RECTIFIER mounted on top. Giving a D.C. output of approx. 30 to 40 volts 1 amp. Price **27/6** each, post 2/6.
VARIAC TRANSFORMER. Input 230 volts. Output infinitely variable 0–230 volts and 0–270 volts. 9 amp., bench or panel mounting. **£15,** carr. 12/6.
SELENIUM METAL RECTIFIERS.

Charging Rectifiers. Full Wave Bridge.			
12 Volts 1 Amp	8/6 each	24 Volts 1 Amp	13/– each
12 Volts 2 Amps	13/6 each	24 Volts 2 Amps	24/– each
12 Volts 3 Amps	16/6 each	24 Volts 3 Amps	28/– each
12 Volts 4 Amps	20/– each	24 Volts 4 Amps	36/– each

Discounts for quantities of above charging rectifiers.
MAINS TRANSFORMERS to suit above rectifiers.

12 Volts 1 Amp	12/6 each	12 Volts 4 Amps MT5	25/– each
12 Volts 2 Amps	24/- each CT109	12 Volts 4 Amps CT107	29/6 each
12 Volts 2.5 Amps	22/- each MT5B	24 Volts 3 Amps	25/– each

RESISTORS EX STOCK IN QUANTITY WIRE WOUND, HIGH STABILITY CARBON ETC., BEST MAKES AT LOWEST PRICE.

ELECTRO-MAGNETIC COUNTERS
COUNTING UP TO 9999
Type 16A
2,300 ohms 75/230 v. D.C., **15/-** each. Post 1/6.
Type 17A
3 ohms 2/6 v. D.C., **15/-** each. Post 1/6.
VEEDER-ROOT MAGNETIC COUNTER. General purpose type with zero re-set. 800 counts per minute up to 999999. 48 volt D.C. **55/-**, post 2/6.
THERMOSTAT SATCHWELL, 12in. stem 0/250 volt A.C./D.C. 15 amps A.C. 10 to 90 degrees cent. **25/-**, post 2/6.
ROOM THERMOSTAT. Adjustable between 45 and 75 deg. Fahr., 250 v. 10 amp. A.C. Ideal for greenhouses, etc., **35/-**, post 2/-
THERMOSTAT. For frost protection, on at 34 deg. F., off at 49 deg. F., 1½ amps. at 250 volts, adjustable, **4/6**, post 1/-.
SIMMERSTAT BY SUNVIC Plug-in type with knob control, 15 amps 3-pin, 200/250 volts, **35/-**, post 2/-.

L. WILKINSON (CROYDON) LTD.
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MULLARD DESIGNS

Still by far the finest value

COMPLETE KIT OF PARTS

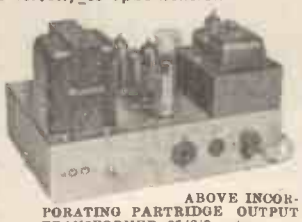
Designed by MULLARD—presented by STERNS strictly to specification

MULLARD "5-10" MAIN AMPLIFIER

For use with the MULLARD 2 stage preamplifier (described below) with which an undistorted power output of up to 10 Watts is obtained. This combination is thoroughly recommended for "Hi-Fi" enthusiasts who contemplate a versatile and very high quality home installation. We supply SPECIFIED COMPONENTS AND NEW MULLARD VALVES including PARMEKO MAINS TRANSFORMER (which has extra Power available to drive Radio Tuner) and the choice of the latest Ultra-Linear PARMEKO or the PARTRIDGE Output Transformer.

Price: COMPLETE KIT (Parmeko O/put Trans.) **£10.0.0**

Alternatively we supply ASSEMBLED and TESTED **£11.10.0**



ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER £1/6/0 extra.

MULLARD'S PRE-AMPLIFIER TONE CONTROL UNIT

Employing two EF86 valves, and designed to operate with the Mullard 3-3 and 5-10 MAIN AMPLIFIERS, but also perfectly suitable for other makes.

Our kit is strictly to MULLARD'S SPECIFICATION and incorporates:

- Equalisation for the latest R.I.A.A. characteristics.
- Input for Crystal Pick-ups, and variable reluctance magnetic types.
- Input. (a) Direct from High Imp. Tape Head. (b) From a Tape Amplifier or Pre-Amplifier.
- Sensitive Microphone Channel.
- Wide range BASS and TREBLE Controls.

PRICE: COMPLETE KIT OF PARTS **£6.6.0** Alternatively we supply ASSEMBLED AND TESTED **£8.0.0**

(Carriage and Insurance 5/- extra).

MULLARD 3-3 MAIN AMPLIFIER

Based entirely on the very popular "3-3" model and designed to operate with the 2-stage PRE-AMPLIFIER (shown here) thus providing all the facilities associated with the more expensive "Hi-Fi" equipment. We recommend it as the IDEAL SMALL HOME INSTALLATION where very high quality is desired at the lower volume level (up to 3 watts).

We supply completely to MULLARD'S SPECIFICATION INCLUDING the latest PARMEKO Output Transformer, specified Valves and Components. Has Power available to drive a Radio Tuning Unit.

Price for COMPLETE KIT OF PARTS **£7.0.0**

Alternatively we supply ASSEMBLED AND TESTED **£8.0.0**

(Carriage and Insurance 5/- extra).

COMPLETE MULLARD 5-10 AMPLIFIER

The popular and very successful complete "5-10" incorporating Control Unit providing up to 10 Watts high quality reproduction. Input channels for high output pick-ups and all modern Radio Tuning Units only.

Specified Components and new MULLARD VALVES are supplied including PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE ULTRA Linear Output Transformers. Adequate power available to drive Radio Tuner. Price: COMPLETE KIT, Parmeko Transformer **£11.10.0**

Partridge Transformer **£13.10.0**

Alternatively we supply ASSEMBLED and TESTED .....

Hire Purchase (Assembled Amp. only). Deposit £2/14/-, 12 months at 19/10.

ABOVE incorporating PARTRIDGE OUTPUT TRANSFORMER £1/6/0 extra.

COMPLETE MULLARD 3-3

THE COMPLETE ASSEMBLY MANUAL AVAILABLE FOR 1/6.

A VERY HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-VALVE 3-WATT AMPLIFIER DESIGNED IN THE MULLARD LABORATORIES.

Price for COMPLETE KIT OF PARTS **£7.10.0**

(Plus 6/6 carriage and insurance).

Alternatively supplied ASSEMBLED and FULLY TESTED (Plus 6/6 carriage and insurance) **£8.19.6**

H. P. Terms Deposit £2 and 8 monthly payments of £1.

Our kit is complete to the MULLARD specification including supply of specified components, valves and PARMEKO OUTPUT TRANSFORMER. We also include switched inputs for 78 and L.P. records plus a Radio position. Extra power to drive a Radio Tuning Unit is also available.

SPECIAL PRICE REDUCTIONS

(a) The COMPLETE KIT OF PARTS to build both the "3-3" Main Amplifier and the 2-Stage Pre-Amplifier Control Unit **£12.10.0**

(b) The "3-3" and the 2-Stage Pre-Amplifier both Assembled and Tested **£15.0.0**
H.P. TERMS: Deposit £3 and 12 months of £1/2/-.

(c) The COMPLETE KIT OF PARTS to build both the "5-10" Main Amplifier and the 2-Stage Pre-Amplifier Control Unit **£15.15.0**

(d) The "5-10" and the 2-Stage Pre-Amplifier both Assembled and Tested **£18.18.0**
H.P. TERMS: Deposit £3/16/- and 12 months of £1/7/8.

(e) The COMPLETE KIT OF PARTS to build the Dual Channel "3-3" Amplifier and the Dual Channel Pre-Amplifier Control Unit **£21.10.0**

(f) The Dual Channel "3-3" Amplifier and the Dual Channel Pre-Amplifier Control Unit both Assembled and Tested **£25.0.0**
H.P. TERMS: Deposit £5 and 12 months of £1/16/8.

(g) The COMPLETE KIT OF PARTS to build one "5-10" Main Amplifier (Parmeko Transformer) and the Dual Channel Pre-Amplifier Control Unit **£21.10.0**

(h) One "5-10" Amplifier (Parmeko Transformer) and the Dual Channel Pre-Amplifier both Assembled and Tested **£25.0.0**
H.P. TERMS: Deposit £5 and 12 months of £1/16/8.

(i) COMPLETE KIT OF PARTS to build Two "5-10" Main Amplifiers (incorporating Parmeko Output Transformers) and the Dual Channel Pre-Amplifier Control Unit **£31.0.0**

(j) Two "5-10" Amplifiers (Parmeko Output Transformers) and the Dual Channel Pre-Amplifier Control Unit both Assembled and Tested **£36.0.0**
H.P. TERMS: Deposit £7/4/- and 12 months of £2/12/0.

Carriage and Insurance 7/6 extra

Prices quoted are subject to £1/6/- extra for Partridge Trans-

MULLARD—STERN STEREO DESIGNS

Model 3-3 M/S

DUAL "3-3" MAIN AMPLIFIER

Comprises two "3-3" MAIN AMPLIFIERS (described above) on one chassis and is designed to operate with our DUAL CHANNEL PREAMPLIFIER for both STEREOPHONIC or MONAURAL operation.

Price: COMPLETE KIT OF PARTS **£10.0.0**

Alternatively ASSEMBLED AND TESTED **£11.15.0**

H.P. Terms Deposit £2/7/0, 12 months at 17/4.

Its output power is 6 Watts (3 Watts per channel) and together with our PREAMPLIFIER provides a very acceptable STEREO installation.

COMPLETE STEREO AMPLIFIER

A thoroughly recommended design that very effectively meets the many requests for a low priced but good quality DUAL CHANNEL STEREOPHONIC AMPLIFIER.

PRICE COMPLETE KIT OF PARTS **£8.10.0**

Alternatively ASSEMBLED AND TESTED **£10.10.0**

Two Mullard ECL 82 Triode Pentode Valves are incorporated in the design, they form a "CLASS A" single ended output stage in each channel. The input sensitivity is 300 m/volts, therefore when used with most STEREO Crystal Pick-Ups, or Radio Tuning Units, an output of 2 Watts per channel is achieved; or similarly when switched to MONAURAL Pick-Up position a combined output of 4 Watts is produced.

DUAL CHANNEL PRE-AMPLIFIER

This model incorporates two 2-Valve Pre-Amplifiers (described above) combined into a Single Unit enabling it to be used for both STEREOPHONIC or MONAURAL operation. It is designed primarily to operate with our range of MULLARD MAIN AMPLIFIERS but will also operate equally well with any make of Amplifiers requiring an input of 250 m/v.

PRICE COMPLETE KIT OF PARTS **£12.10.0** Alternatively ASSEMBLED AND TESTED **£15.0.0**

H.P. Terms £3 Deposit and 12 months of £1/2/0.

Perfectly suitable for MONAURAL Only operation, with one "3/3" or one "5/10" MAIN Amplifier to which the second Main Amplifier can at any time be added thus very easily providing for both STEREO or MONAURAL reproduction.

Recommended combination for STEREO operation.

(a) The DUAL CHANNEL PRE-AMPLIFIER together with the Dual "3/3" MAIN AMPLIFIER.

(b) The DUAL CHANNEL PRE-AMPLIFIER together with two "5/10" MAIN AMPLIFIERS. Assembly Manual is available for 3/- or send S.A.E. for Descriptive Leaflet.

When ordering please advise MAKE and MODEL OF AMPLIFIER in use.

Only New **HIGH GRADE** Specified Components and MULLARD VALVES are supplied in all these models.

Please enclose S.A.E. if ILLUSTRATED and DESCRIPTIVE LEAFLETS are required . . . alternatively the COMPLETE ASSEMBLY MANUALS containing component Price Lists and practical Drawings, etc., are available at 1/6 each.

STERN RADIO LTD.

109 & 115 FLEET ST., LONDON, E.C.4

Telephone: FLEET STREET 5812/3/4

Stern's "fidelity" TAPE RECORDERS

Each Model incorporates the highly successful HF/TR3 Amplifier (described opposite), thus ensuring truly "Hi-Fi" record and playback facilities

All prices quoted provide for the COMPLETE RECORDER including CRYSTAL MICROPHONE and 1,200ft. Spool of Tape.

There are no "better value for money" Tape Recorders on the market—if you can't call and hear them—send S.A.E. for fully descriptive leaflets.

BEFORE YOU BUY—YOU SHOULD HEAR THESE RECORDERS—THEY ARE COMPARABLE TO THE MUCH HIGHER PRICED MODELS

MODEL CR3/S. Incorporates the New COLLARO "STUDIO" TWIN TRACK 3-speed Deck **£41.0.0**
H.P. Terms: Deposit £8/4/- and 12 months of £3/0/2.

MODEL CR3/T. Incorporates the very popular 3-speed COLLARO Mk. IV "TRANSCRIPTOR" Deck, which has both upper and lower tape tracks **£49.10.0**
H.P. Terms: Deposit £9/18/- and 12 months of £3/12/7.

MODEL TR3/Mk. VI. Incorporates the New TRUVOX Mk. VI TWIN TRACK 2-speed Tape Deck **£49.10.0**
H.P. Terms: Deposit £9/18/- and 12 months of £3/12/7.

! ! RECORD PLAYERS ! !

The LATEST MODELS are in Stock. Many at REDUCED PRICES!!!
Send S.A.E. for ILLUSTRATED LEAFLET

B.S.R. MONARCH UA8 4-spd. Mixer Autochanger with Crystal Pick-up. **£6.12.6**

The COLLARO "CONQUEST" 4-spd. autochanger Studio "C" Pick-up. **£7.10.0**

The latest COLLARO "CONTINENTAL" 4-speed MIXER Autochanger, Studio "C" Pick-up..... **£8.10.0**

The NEW COLLARO model RP594, 4-speed Single Record Player, Studio Cartridge **£9.18.9**
The COLLARO model 4 564 4-speed Single Record Player, Studio Pick-up **£6. 6.0**
THE NEW B.S.R. model UA12 is in stock. A 4 "SPEED" MIXER AUTOCHANGER **£8. 7.6**
UA12 is also available incorporating the B.S.R. STEREO Pick-up plays L.P. and 78 records **£10.10.0**
GARRARD RC121/4 4-speed Autochanger fitted with latest Crystal Pick-up **£10. 0.0**
The latest GARRARD TRANSCRIPTION MOTOR "301" with Stroboscopically marked turntable **£23.18.4**
The new GARRARD Model 4HF High Quality Single Record Player fitted with the latest T.P.A. 12 Pick-up arm and G.C.S. Crystal Cartridge **£18. 7.6**
GARRARD Model TA/MK. II Single Record Player fitted with high output Crystal Pick-up, detachable head..... **£8.10.0**

HIRE PURCHASE TERMS available on all units £8/19/6 and over
Carriage and Insurance on each above 5/- extra.

STERN'S MK II "fidelity" F.M. TUNING UNIT

(Plus 5/- carr. and ins.)
HIRE PURCHASE: Deposit PRICE £2 and 12 months at £1/0/9. **£14.5.0**
Incorporates the latest MULLARD PERMEABILITY TUNING HEART and the corresponding MULLARD VALVE LINE UP comprising ECC85, 2 type EF85s (or EF89s), EM84, Tuning Indicator, plus 2 type O.A. 79s Germanium Diodes. A really first-class Tuner very attractively presented and comparable to many offered at much higher prices. Power consumption is only 1.5 amps at 6.3 volts and 25 m.a. at 250 volts.

HOME CONSTRUCTORS !

YOU CAN BUILD THIS TUNING UNIT FOR ONLY **£10.10.0**
(Plus 5/- carr. and ins.)
Please send S.A.E. for fully descriptive leaflet, or the Assembly Manual is available for 1/6.

! ! HOME CONSTRUCTORS ! !

A RANGE OF "EASY TO ASSEMBLE" PREFABRICATED CABINETS
Designed by the W.B. "STENTORIAN" COMPANY for "Hi-Fi" Loudspeaker systems or to accommodate high-quality equipment. The acoustically designed Bass Reflex Cabinets containing the very successful "Stentorian" Speakers give really first-class reproduction and are well recommended. Models are also available to accommodate high-quality Amplifiers, Preamplifiers, Tuning Units, Record Players, etc. All models are very easily assembled, in fact only a screwdriver is required.
Fully illustrated leaflets are available including complete specifications of the various STENTORIAN LOUDSPEAKERS. Please enclose S.A.E.

CAR BATTERY CHARGER

A COMPLETE KIT OF PARTS FOR ONLY **£2.19.6**
Will charge 6 or 12 volt batteries at max. 2½ amps. The design incorporates Reliant Resistor and Fuse and we supply complete with Metal Box container. EASY-TO-FOLLOW ASSEMBLY INSTRUCTIONS ARE INCLUDED.

SPECIAL CASH ONLY BARGAIN

A bulk purchase enables us to offer this very useful INTERCOM SET or BABY ALARM *For only* **£5.5.0**

Consists of MASTER UNIT (illustrated) and one EXTENSION, providing 2-way TALK-LISTEN facility. Complete in polished wood cases, size of each only 7½ x 4½ x 6in. high.

! ! RADIOGRAM CHASSIS ! !

ARMSTRONG MODEL A F 208 ..... **£23.2.0**
Complete AM/FM chassis producing 5 Watts. Separate Bass and Treble controls.

ARMSTRONG "STEREO TWELVE" **£37.16.0**
The most complete A.M./F.M. unit yet produced. For Stereo, giving 6 watts high fidelity push-pull output on each channel, 12 watts for Monaural.

ARMSTRONG "JUBILEE" **£29.8.0**
An AM/FM chassis with nine valves and with push-pull output stage providing 6 watts.

ARMSTRONG AM/FM "STEREO 44" **£28.7.0**
Provision is made for Stereo and Monaural playback from pick-up or tape. Outputs provided for Stereo or Monaural tape recording.

RADIO TUNING UNITS

The JASON "MERCURY" Switched F.M. TUNER PRICE ASSEMBLED AND TESTED **£13.10.0**
Complete Kit of Parts £9/19/6.

DULCI Model FMT/2 ..... **£19.17.6**
A complete self-powered FM Tuner incorporating automatic frequency control

ARMSTRONG "S.T.3" AM/FM Tuning Units **£27.6.0**
A self-powered high fidelity tuner covering full VHF, medium and long wavebands with automatic frequency control on VHF.

DULCI "H4/T" AM/FM Tuning Units **£23.15.8**
A 4-waveband self-powered high fidelity tuner covering the VHF/FM transmissions plus the long, medium and short wavebands.

NEW HIRE PURCHASE TERMS are available on all above. Illustrated leaflets available—send S.A.E. (Carr. & Ins. 5/- extra)

Hi-Fi LOUDSPEAKERS

WE HAVE IN STOCK THE COMPLETE RANGE BY GOODMANS-WHARFDALE-W.B.

And will be pleased to send you Illustrated and Priced Leaflets.

Recommended Types are:

GOODMANS "AXIOM 300". The best 12in. Seller. 15 ohms, V/Coil' Freq. Resp. 30 c/s, 16,000 c/s **£11.5.9**
GOODMANS "AXLETTE" 8-inch (as illustrated). 3 or 15 ohms. Freq. Resp. 40-15,000 c/s **£6.12.0**
W.B. "STENTORIAN" H.F.816, 8in., 3 or 15 ohms. Freq. Resp. 50-15,000 c/s **£6.10.6**
W.B. "STENTORIAN" H.F.1016, 10in. 3 or 15 ohms. Freq. Resp. 30-15,000 c/s **£7.12.3**
W.B. "STENTORIAN" H.F.1214, 12in. 15 ohms. Freq. Resp. 25-14,000 c/s **£9.15.6**
WHARFDALE "SUPER 8 FS/A1", 8in. 3 or 15 ohms..... **£6.19.11**
WHARFDALE "GOLDEN FSB". 10in. 3 or 15 ohms Voice Coil **£7.13.3**
WHARFDALE "W12/Fs", 12in. 15 ohms. Voice Coil **£10.5.0**
WHARFDALE "SUPER 12/FS/AL". 12in. 15 ohms. Voice Coil **£17.10.0**

LOUDSPEAKER ENCLOSURES—TWEETER UNITS—CROSSOVER UNITS *are also available*

SPECIAL CASH ONLY OFFER !!

This very attractive PORTABLE AMPLIFIER CASE together with a good quality GRAM AMPLIFIER and a matched P.M. SPEAKER. ALL FOR ONLY **£8.7.6** (plus 7/6 carr. and ins.). The Amplifier consists of a 2-stage design incorporating the 3 modern BVA valves and has separate BASS and TREBLE CONTROLS. The Portabel Case will also accommodate almost any make of Autochanger and is attractively finished in Grey colour Rexine—WE ALSO SUPPLY SEPARATELY:—
(a) The 2-stage (plus Rectifier) AMPLIFIER £4 2 6
(b) The PORTABLE CARRYING CASE £3 17 6
(c) 6½in. P.M. SPEAKER 18 9
Carriage and insurance 4/- extra)

STERN RADIO LTD. 109 & 115 FLEET ST., LONDON, E.C.4
Telephone: FLEET STREET 5812/3/4

C.R.T. ISOLATION TRANSFORMERS

For Cathode Ray Tubes having Heater/Cathode short circuit and for C.R. Tubes with falling emission. Full instructions supplied.

Type A. Low Leakage windings. Optional Boost 25% and 50%. Tapped mains primaries.

2 volt	12/6 each
4 volt	12/6 each
6.3 volt	12/6 each
10.8 volt	12/6 each
13.3 volt	12/6 each

OUR LATEST SUPERIOR PRODUCT. Type A2. High Quality. Low capacity, 10/15 pf. Optional boost 25%, 50%, 75%. **16/6** each

Type B. Mains input. Low capacity. Multi Output 2, 4, 6.3, 7.3, 10 and 13 volts. Optional boost 25% and 50%. Suitable for all Cathode Ray Tubes, 21/-.

RESISTORS. All preferred values. 20% 10 ohms to 10 meg., ½ w. 4d.; ¼ w., 4½d.; ½ w., 6d.; 1½ w., 8d.; 2 w., 1/-.

HIGH STABILITY. ¼ w., 1%, 2/-. Preferred values 100Ω to 10 meg. Ditto 5%, 9d., 100Ω to 5 meg.

5 watt, 10 watt, 15 watt } WIRE-WOUND RESISTORS 25 ohms—10,000 ohms { 1/3, 1/6, 2/-

15,000 ohms—50,000 ohms 5 w., 1/9; 10 w. 2/3

WIRE-WOUND POTS, 3 w. Pre-set Min. T.V. type Knurled Slotted knob. All values 25 ohms to 25K. 3/- ea., 30 K., 50 K., 4/-. Ditto, ½ w. Carbon Track 30 K. to 2 Meg., 3/-.

WIREWOUND POTS, 4 w. Standard size Pots, long Spindle High Grade. All values 100 ohms to 50 K., 6/6; 100 K., 7/6. W/W EXT. SPEAKER CONTROL 10Ω 3/-.

O/P TRANSFORMERS. Heavy Duty 50 mA., 4/6. Multi-ratio push-pull, 7/6. Miniature 3V4, etc., 4/6. Hygrade Push-pull 10 watts, 15/6. MULLARD "510" 6k. or 8k 30/-. L.F. CHOKES 15/10H 60/65 ma., 5/-. 10H 85 ma. 10/6. 10H 150 ma. 14/-.

MAINS TRANSFORMERS 200/250 v. A.C.

STANDARD 250-0-250, 80 mA., 6.3 v. 3.5 a. tapped 4 v. 4 a. Rectifier 6.3 v. 1 a., tapped, 5 v. or 4 v. 2 a. Ditto 350-0-350 ..... 22/6

MINIATURE 220 v. 20 mA., 6.3 v. 1 a. 10/6

MIDGET, 250 v. 45 mA., 6.3 v. 2 a. 15/6

SMALL, 250-0-250 100 mA., 6.3 v. 3.5 a. 19/6

STANDARD, 250-0-250, 65 mA., 6.3 v. 3.5 a. 17/6

HEATER TRANS., 6.3 v. 1½ a. 7/6. 3 amp. 10/6

GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 A. 22/6

ALADDIN FORMERS and cores, ⅛in. 8d.; ¼in. 10d. 0.3in. FORMERS 5937 or 8 and Cans TV1 or 2, ¼in. sq. × 2¼in. or ⅜in. sq. × 1½in. 2/- with cores.

SLOW MOTION DRIVES. Epicyclic ratio 6:1, 2/3.

TYANA. Midget Soldering Iron, 230 v. 40 w., 16/9.

REMPLOY INSTRUMENT IRON. 230 v. 25 w., 17/-.

MAINS DROPPERS. 3 × 1½in. Three Adj. Sliders, .3 amp. 750 ohms, 4/3. .2 amp., 1,000 ohms, 4/3.

LINE CORD. .3 amp., 60 ohms per foot, .2 amp., 100 ohms per foot, 2 way, 6d. per foot, 3 way, 7d. per foot.

CRYSTAL MIKE INSERT by Acos 6/6

Precision engineered. Size only ¾ × 1⅜in.

ACOS CRYSTAL DESK MIKE. Bargain. 35/-.

MIKE TRANSF. 50:1, 3/9 ea.; 100:1 Potted, 10/6.

LOUDSPEAKERS P.M. 3 OHM. 5in., Rola 17/6. 6in. × 4in. Rola, 18/-. 7in. × 4in. R.A. 21/-. 10in. × 6in. Rola, 27/6. 8in. Plessey, 19/6. 6½in. Rola, 18/6. 8in. Rola, 21/-. 10in. R.A., 30/-.

HI-FI TWEETERS, 4in. 25/-. 12in. Plessey, 30/-. 12in. Baker 15 wt. 3 ohm and 15 ohm models, 105/-. 12in. Baker foam suspension 15 w. 15 ohm, £8. 12in. 15 ohm Plessey 10 wt., 45/-.

I.F. TRANSFORMERS 7/6 pair

465 kc/s. slug tuning miniature can 2½ × 1 × 1in. High Q and good bandwidth. By Pye Radio. Data sheet supplied.

Wearite M300 I.F. Miniature 465 kc/s. 12/6 pair.
Wearite 550 I.F. Standard 665 kc/s., 12/6 pair.

CRYSTAL DIODE G.E.C. 2/-. GEX34, 4/-. 40 Circuits, 3/-. H.R. HEADPHONES, 4,000 ohms, brand new, 16/6 pair. SWITCH CLEANER Fluid, squirt spout, 4/3 tin.

TWIN GANG CONDENSERS. 365 pf. Miniature, 1⅛in. × 1⅛in. × 1½in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers, 8/-. Midget, 7/6; Single 50 pf., 2/6; 100 pf., 150 pf., 7/-. Solid dielectric 100, 300, 500 pf., 3/6.

VALVE HOLDERS. Pa. int. Oct., 4d. EF50, E.50, 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, 7 pin, 1/-.

MOULDED Mazda and Int. Oct. 6d., B7G, B8A, B8G, B9A, 9d. B7G with can, 1/6; B12A, 1/3. B9A with can, 1/9.

CERAMIC, EF50, B7G, B9A, Oct., 1/-. B7G, B9A Cans 9d.

SPEAKER FRET. Gold Cloth 17in. × 25in., 5/-, 25in. × 35in., 10/-. Tygan 54in. wide 10/- ft. 27in. wide, 5/- ft. Samples, S.A.E.

WAVECHANGE SWITCHES.

2 p. 2-way, 3 p. 2-way, short spindle	2/6
5 p. 4-way, 2 wafer, long spindle	6/6
2 p 6-way, 4 p. 2-way, 4 p. 3-way, long spindle	3/6
3 p. 4-way, 1 p. 12-way, long spindle	3/6

Wave change "MAKITS" 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer 16/-; 4 wafer 19/6; 5 wafer 23/-; 6 wafer 26/6.

TOGGLE SWITCHES. S.P., 2/-; D.P. 3/6; D P.D.T., 4/-.

MORSE KEYS, good quality, 2/6.

SUB-MINIATURE ELECTROLYTICS (15 v.), 1, 2, 4, 5, 8, 25, 50 mfd. 3/- each.

EDISWAN TRANSISTORS JUNCTION TYPE P.N.P.

AUDIO XB102, for amplifiers, and output stages up to 250 milliwatts in push-pull. PRICE **10/-**

R.F. XA104 frequency changer up to 4 Mc/s. **18/-**

XA103 IF amp. up to 2 Mc/s. **15/-**

Goltop Power V15/10P, up to 10W with heat sink 20/-

1959 RADIOGRAM CHASSIS

THREE WAVEBANDS S.W. 16 m.—50 m. M.W. 200 m.—550 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, 4.2 watts. Chassis 13½in. × 5½in. × 2½in. Glass Dial Size 10 × 4½in. horizontal or vertical. 2 Pilot Lamps. Four Knobs. Walnut or Ivory, aligned and calibrated. Chassis isolated from mains.

BRAND NEW £9. 10. 0 Carr. 4/6.

TERMS: Deposit £5/5/- and 5 monthly payments of £1. MATCHED SPEAKERS 8in., 17/6; 10in., 25/-; 12in., 30/-.

SUPERIOR FM-AM MODEL

Six Mullard Valves, ECC85, ECH81, EF89, EABC80, EL84, EZ80. V.H.F. 108-87 Mc/s. Med. 190-550 m. Long 1000-1900 m. Gram input. Ready for use. A.C. Mains 200/250 v. Isolated chassis. Output point for use as Hi-Fi Tuner. 12 month guarantee. Circuit supplied. Leaflet S.A.E.

£18. 19. 6. Carr. 5/6

★ GARRARD 4-SPEED RECORD CHANGERS RC121/D MKII MODELS ★

Brand new and fully guaranteed 12 months.

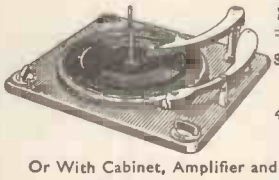
AUDIO PERFECTION

Designed to play 16, 33, 45, 78 r.p.m. Records 7in., 10in., 12in. With plug-in NORMAL HEAD.

OUR PRICE **£10. 10. 0** STEREO HEAD £2 extra

LATEST COLLARO AUTOCHANGER

£7.19.6



STUDIO 'O' Pick-up

4 Speeds—10 Records

Or With Cabinet, Amplifier and Speaker

£11.19.6. Carr. 5/6.

B.S.R. MONARCH UA8 4-SPEED AUTOMATIC RECORD CHANGERS

Brand new and fully guaranteed 12 months.

OUR PRICE **£6. 19. 6** post free

STEREO MODELS UA8, £7/19/6, UA12, £10/10/-.

AUTOCHANGER ACCESSORIES

Suitable player cabinets (uncut boards) 49/6
Amplifier player cabinets with cut boards 63/-
2 valve amplifier and 6½in. speaker for above 79/6
3 valve amplifier and 6½in. speaker for above 95/-

Wired and tested ready for use.

★ GARRARD 4-SPEED SINGLE RECORD PLAYER 4SP ★

£7.10s. | **AUDIO PERFECTION** | POST FREE

MODEL TA MK II £8 - 10 MODEL 4 HF £18 } Stereo Heads £2 extra.

BATTERY-MAINS POWER PACK

Same size as batteries B126 and AD35, 90 v. H.T., 1½ v. L.T. only 1/- a year to run on A.C. 200/250 v. Made by COSSOR. List 63/-, our price 39/6.

THE HI-GAIN BAND 3 PRE-AMP

Cascode circuit using Valve ECC84. 17db gain. Kit 29/6 less power; or 49/6 with power pack kit. Plans only 6d. Also Band 1 version same prices.

LATEST "E.M.I." 4 SPEED SINGLE RECORD PLAYER

Acos 73 Hi-Fi Stereo and normal xtal pick-up for 7in., 10in. and 12in. records. Silent motor, heavy turntable.

Special offer £6/19/6. Post 3/6.

VOLUME CONTROLS

Midget size: Long spindle. Guaranteed 1 year. All values 5 K. ohms up to 2 Meg., No Switch. D.P. Sw. 3/- 4/9 Linear or Log Tracks.

80 ohm Cable Coaxial

Semi-air spaced, ⅛in. dia. Ideal Band III Losses cut 50% **6d.** yd. Post 1d. per yard

FRINGE QUALITY AIRSPACED .... 1/- yd.

COAXIAL PLUGS .....1/- LEAD SOCKETS 2/-
PANEL SOCKETS .....1/- OUTLET BOXES 4/6
BALANCED TWIN FEEDER per yd. 6d., 80Ω or 300Ω.
TWIN SCREENED BALANCED FEEDER 1/6 yd., 80 ohm.

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled with 4 sides, riveted corners and lattice fixing holes, with 2½in. sides, 7 × 4in., 4/6; 9 × 7in., 5/9; 11 × 7in., 6/9; 13 × 9in., 8/6; 14 × 11in., 10/6; 15 × 14in., 12/6 and 18 × 3in., 16/6

BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, 8 colours, single or stranded, 2d. yd.
NEON MAINS TESTER SCREWDRIVERS, 5/-.
CORED SOLDER RADIOGRADE 4d. yd., ½lb. 2/6.
PAXOLIN 1/16in. 8in. × 10in., 1/6. ION TRAPS 5/-.

"GEVAERT GEVASONOR"

50% Extra Long Play Plastic Tape.
1,700ft. 7in. Reel 35/-, 850ft. 5in. Reel 21/-
SUPERIOR 1,200ft. 7in. Plastic Tape 24/-
600ft. 5in. 15/-. All Spare Reels 3/- each.
LONG PLAY 5½in. 1,200ft. 28/-. 3in. 225ft. 7/6.
"INSTANT" Bulk Tape Eraser and Head Demagnetiser: 200/250 v. A.C. 27/6.

MAINS TYPE. RM1, 125 v., 60 mA., 5/-; RM2, 100 mA. 6/-; RM2, 120 mA., 8/-; RM4, 250 v. 275 mA., 16/-.

MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 mA., 7/6; 60 mA., 8/6; 85 mA., 9/6; 200 mA., 21/-; 300 mA., 27/6; Full Wave 120 mA., 15/-.

COILS. Wearite "P" type, 3/- each. Osmor Midget "Q" type adj. dust core from 4/- each. All ranges.

TELETRON. L. and M. T.R.F. with reaction, 3/6.

FERRITE ROD AERIALS. M.W., 8/9; M. & L., 12/6.

T.R.F. COILS, A/HF, 7/- pair. H.F. CHOKES, 2/6.

JASON F.M. TUNER COIL SET, 26/-. 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 kit with Jason Calibrated dial and 4 valves .... £6/15/-. With new Jason Cabinet, 20/- extra.

CONDENSERS. New Stock. .001 mfd. 7 kV. T.C.C. 5/6. .20 kV., 9/6. .1 mfd. 7 kV. 9/6. 100 pf. to 500 pf. Micas, 6d. Tubular 500 v. .001 to .01 mfd., 9d.; .05 .1 1/-; .25 1/6; .5 1/9; .1/350 v., 9d.; 1/1,000 v., 1/9; 0.1 mfd., 2,000 v. 3/6; .001 mfd. 2,000 v., 1/9.

CERAMIC CONDS. 500 v., .3 pf. to .01 mfd., 9d.

SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-; 600 pf. to 3,000 pf., 1/3.

CLOSE TOLERANCE (±1 pf.) 1.5 pf. to 47 pf., 1/6. DITTO 1% 50 pf. to 815 pf., 1/9; 1,000 pf. to 5,000 pf., 2/-.

TRIMMERS. Ceramic, 30, 50, 70 pf., 9d.; 100 pf., 150 pf., 1/3. 250 pf., 1/6. 600 pf., 750 f., 1/9. Phillips, 1/- ea.

NEW ELECTROLYTICS. FAMOUS MAKES

TUBULAR		TUBULAR		CAN TYPES	
1/350v.	2/-	64/350 v.	5/6	8/500 v.	3/-
2/450 v	2/3	100/25 v.	2/-	16/500 v.	4/-
4/450 v	2/3	250/25 v.	1/-	32/350 v.	4/-
8/450 v.	2/3	500/12 v.	3/-	100/270 v.	5/6
8/500 v.	2/9	8+8/450 v.	4/6	2,500/3 v.	4/-
16/450 v.	3/6	8+8/500 v.	5/-	6,000/6 v.	5/-
16/500 v.	4/-	8+16/450 v.	5/-	8+16/500 v.	7/-
32/450 v.	5/6	8+16/500 v.	5/6	32+32/450 v.	6/6
25/25 v.	1/9	16+16/450 v.	5/6	50+50/350 v.	7/-
50/25 v.	2/-	16+16/500v.	5/-	64+120/350v.	11/6
50/50 v.	2/-	32+32/350v.	4/6	100+200/275v.	12/6

FULL WAVE BRIDGE/SELENIUM RECTIFIERS. 2, 6 or 12 v. 1½ amp., 8/9; 2 a. 11/3; 4 a. 17/6; 6 a. 22/6.

CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v. 1½ a. 15/6; 2 a., 17/6; 4 a. 22/6

Charger circuit free. AMPMETERS, 4 a. and 5 a., 14/6

VALVES

NEW and boxed				90-day guarantee			
1R5	8/6	6L6G	10/6	EA50	1/6	EY51	12/6
1S5	8/6	6N7M	7/6	EABC80	10/6	EZ81	8/6
1T4	8/6	6Q7G	10/6	EB91	6/6	HABC80	12/6
2X2	2/6	6SA7M	10/6	EBC33	8/6	HVR2A	7/6
3S4	8/6	6SJ7M	10/6	EBC41	10/6	MU14	10/6
3V4	8/6	6SN7	8/6	EBF80	10/6	P61	6/6
5U4	8/6	6V6G	7/6	ECC84	12/6	PCC84	12/6
5Y3	8/6	6X4	7/6	ECF80	11/6	PCF80	11/6
5Z4	10/6	6X5	7/6	ECH42	10/6	PCF82	11/6
6AM6	8/6	12A6	8/6	ECL80	12/6	PCL82	11/6
6BE6	7/6	12AT7	10/6	ECL82	12/6	PEN25	6/6
6BH6	10/6	12AU7	9/6	EF39	7/6	PL82	10/6
6BW6	10/6	12AX7	9/6	EF41	10/6	PY80	8/6
6D6	7/6	12BA6	9/6	EF50	5/6	PY81	10/6
6F6G	7/6	12BE6	9/6	EF80	10/6	PY82	8/6
6H6GT	3/6	12K7	8/6	EF86	14/6	SP61	5/6
6J5M	6/6	12Q7	8/6	EF92	5/6	UBC41	10/6
6J6	7/6	35L6	9/6	EL32	5/6	UCH42	10/6
6J7G	8/6	35Z4	9/6	EL41	10/6	UF41	10/6
6K6GT	6/6	80	10/6	EL84	10/6	UL41	10/6
6K7G	5/6	807	6/6	EZ40	8/6	UY41	8/6
6K8G	8/6	954	1/6	EZ80	8/6	U22	10/6

A HAPPY CHRISTMAS TO ALL READERS OF "WIRELESS WORLD"

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE RD., WEST CROYDON

POSTAL SERVICE 1/-. OVER £2 FREE. C.O.D. 1/6 (EXPORT C.W.O. POST EXTRA.) Wed. 1 p.m. Catalogue 1/6. THO. 1665. Buses 133 or 68

CABY MULTI-RANGE TEST METER. Freshly Imported Guaranteed Model A-10. A.C./D.C. Voltages, sensitivity 2,000 ohms per volt. Ranges: 10, 50, 250, 500, 1,000 v. Resistance: 10K ohm and 1 megohm. D.C. Current: 0.5 mA., 25 mA., 250 mA. Decibel range. Accuracy: 2 to 3%. Price £4/17/6 P. & P. 1/6. Ask for leaflet fully illustrating and describing this and other models.

FRESHLY IMPORTED MINIATURE CONTACT COOLED RECTIFIERS

Half-Wave Type

Max. A.C. In. 125 v. D.C. Out. 80 mA.	4/-
Max. A.C. In. 250 v. D.C. Out. 50 mA.	7/-
Max. A.C. In. 250 v. D.C. Out. 85 mA.	8/6

Television Type

Max. A.C. In. 250 v. D.C. Out. 300 Ma.	18/6

Full-Wave Bridge Connected

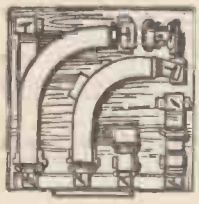
Max. A.C. In. 250 v. D.C. Out. 75 mA.	9/6
Max. A.C. In. 250 v. D.C. Out. 150 mA.	15/-

SPECIAL OFFER. LIMITED QUANTITY.

GENERAL PURPOSE CATHODE RAY OSCILLOSCOPE

The famous model 160-B C.R. 'Scope, manufactured by R.C.A. of U.S.A. Best general purpose instrument of its kind, complete with 6in. cathode ray tube. Unused, guaranteed perfect. For operation on 110 v. A.C. Price £22/10/-. Carr. 10/-.
Step-down transformer to enable the above to operate on 230 v. Price 19/6.

SYNCHRONOUS MOTOR, one rev. every 24 hours. 110 v. or with resistor (supplied) 230 v. Price 27/6. P. & P. 2/-.



WAVE GUIDE 3 cm, mounted on a carrying board consisting of: (1) directional coupler. (2) 90 degree bend. (3) co-ax to wave guide adaptor type N. (4) British to W.916. (5) Co-ax to wave guide adaptor circular flange. (6) Circular to American adaptor. Complete in carrying case with coaxial cable. Price 60/-. Carr. 10/-.

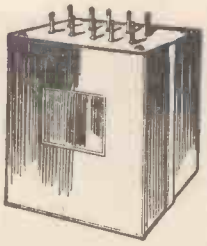
AERIAL AS ILLUSTRATED. Ideal for Car. Overall length 33in., khaki, with flexible shaft which enables the aerial to be fixed firmly in any position. Price 8/6, plus P. & P. 1/6.

NEW WIRE WOUND RHEOSTAT ON CERAMIC. 58 ohms, 50 watt, complete with instrument knob. Price 8/6. P. & P. 1/6.

W. W. RHEOSTAT. New. 3.5K, 25 watts. Price 7/6. P. & P. 1/6.

W. W. RHEOSTAT. New. 5K, 25 watts. Price 7/6. P. & P. 1/6.

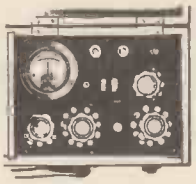
SLIDER RESISTANCE, 44 ohm, 1½ amp. Price 18/6. P. & P. 2/-.



POTTED TRANSFORMERS. Type 2762 C Core: Input 230 v. 45/65 cycles. Output 350-0-350 at 375 mA. 25 v. at 1 amp., 21 v. at .5 amp., 6.3 v. at 1 amp., 6.3 v. at 5 amp., 5 v. at 4 amp. Price 65/-. Carr. 6/6

Type 2759 C Core Input 230 v. 45/65 cycles. Output 361-0-361 at 200 mA. 361-0-361 at 65 mA. 5.16 v. at 4 amp., 5.16 v. at 3 amp., 3.25-0-3.25 at 2 amp., 6.5 v. at 5 amp., 3.25-0-3.25 at 5 amp. Price 65/-. Carr. 6/6.

Type 2669 Oil filled Input 230 v. 45/65 cycles. Output 0–70 v. 75 v., 80 v., at 4 amp. Price 42/6. Carr. 3/6.



WHEATSTONE BRIDGE UNIT. 4-stud switches 0–10, 0–100 ohms, galvanometer centre zero, F.S.D. 2.5 mA. In oak carrying case 16 × 7½ × 6in., 40/- each. P. & P. 3/6.

EVERSHED AND VIGNOLES. Circuit testing Ohms Meter, pattern "S" complete with testing prods, inst. book etc. Two ranges: 0–3 and 0–30 ohms. Brand new, guaranteed perfect, as illus. Offered at fraction of maker's price. £4/17/6 each. P. & P. 2/6.

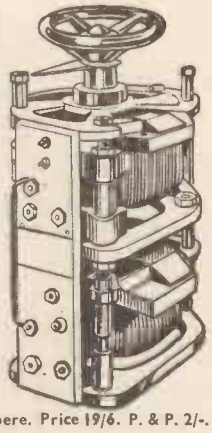
BRIDGE MEGGER, Evershed and Vignoles Serles II, 250 volt. Condition as new, guaranteed perfect. Price £22. Carriage pald. Leather case available 20/- extra.

TRIPLE RANGE VOLTMETER. 0–5 25–250 v. D.C. M/C 3½in. meter 3in. scale, mounted in bakelite carrying case 7½in. × 4½in. × 3in. complete with handle and test leads. 27/6 each. P. & P. 2/-.

12 v. D.C. AMPLIFIER, as new, for operation on 12 v. car battery, 10 watts undistorted output, with 6L6 valves in push-pull. Mike/Gram input, tapped output 7½, 15, 62, 100, 250 or 500 ohms. £12/10/- each. Carr. 15/-.

MIDGET ROTARY TRANSFORMERS. 2½in. dia. × 4½in. Input 11.5 volt. Output 310/365 volts at 30 mA. Brand new. 12/6 each. P. & P. 1/6.

VARIABLE VOLTAGE TRANSFORMER



500 cycles, maximum input 180 v. Output variable from 0 to 180 v. at maximum 15 ampere. Brand new in original manufacturers cases. Price £10. Carr. 12/6.

FRESHLY MANUFACTURED TRANSFORMERS Ideal for model makers. Input tapped 200/250 v Output multi-tapped from 3 to 30 volts at 2 ampere. Price 19/6. P. & P. 2/-.

MERCURY SWITCH, 10 amp. contacts, Single pole, New. Price 3/6. P. & P. 6d.

METERS GUARANTEED PERFECT

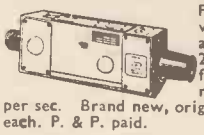
Charging Types	
2½ amp. D.C. M.I. 2in. fl. rnd.	7/6
5 amp. D.C. M.I. 2½in. fl. rnd.	11/6
7½ amp. D.C. M.I. 3½in. proj. rnd.	12/6
9 amp. D.C. Hot Wire W.R. 2½in. fl. rnd	6/6
Voltmeters	
12 v. D.C. M.C. 2½in. proj. rnd.	8/6
20 v. D.C. M.C. 2in. fl. sq.	9/6
25 v. D.C. M.C. 2in. fl. rnd.	7/6
30 v. M.I. 3in. proj. rnd.	10/6
40 v. M.C. 2in. fl. sq.	9/6
150 v. D.C. M.C. fl. rnd. 2½in.	10/6
250 v. A.C. rectified moving coil linear scale 3½in. fl. rnd.	35/-
300 v. A.C. M.I. 2½in. fl. rnd.	22/-
400 v. A.C. M.I. 4½in. fl. rnd.	35/-
Milliammeters	
2 mA. M.C. 2½in. fl. rnd.	14/6
5 mA. M.C. 2in. fl. square	12/6
10 mA. M.C. 3½in. fl. rnd.	30/-
30 mA. M.C. 2½in. fl. rnd.	9/6
50 mA. M.C. 2in. fl. sq.	8/6
200 mA. M.C. 2½in. fl. rnd.	9/6
500 mA. M.C. 2½in. fl. rnd.	9/6
Microamp	
50 microamp. scaled 0-100, M.C. 2½in. rnd. fl.	42/6
200 microA. M.C. 2½in. rnd. fl. (calibrated 0–50)	29/6
50 microA. 2½in. square, sidefitting 3 scales	35/-
500 microA. M.C. 2in. rnd.	16/6

Postage on all meters 1/- each.

NEW UNCHARGED UNFILLED 12 VOLT ACCUMULATOR 9 ampere In unspillable plastic cases Comprises 6 × 2 v. separate cells connected by terminal strips. 6 × 5½ × 4½in. over terminals. Price 19/-, plus P. & P. 2/9. Wooden carrying case for same with lid and strap price 3/6.

MINIATURE P.M. MOTOR. 12/24 volt, reversible. 1½in. dia. New. Price 9/6 each. P. & P. 1/-

AIRCRAFT CINE CAMERA G45B Mk. III.



Fully modified, fitted with f/3.5 triple anastigmatic lens, takes 25ft. of 16 mm. film, fitted with 24 v. motor. 16 exposures per sec. Brand new, orignal packing, £4/10/- each. P. & P. paid.

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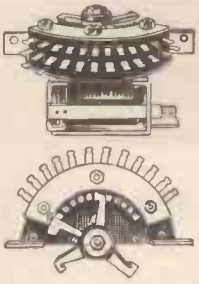
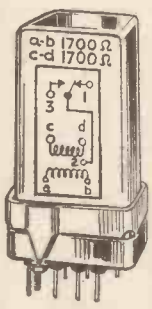
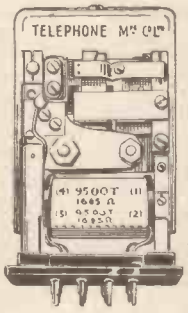


MINIATURE UNISELECTOR SWITCH. two banks of ten plus home contacts one bank continuous of normal. 30 ohms coil for 24 volt operation. Brand new, manufacturer's packing. Price 22/6 each. P. & P. 2/6. As illustrated.



SIEMENS H.S. RELAY. Very latest type, sealed. H96E. 1,700 ohms plus 1,700 ohms, single C.O. contacts. Brand new with fixing clip. In maker's cartons. Price 16/6 each, plus 1/- P. & P.



NEW CARPENTER'S TYPE POLARISED RELAYS. 2 × 9,500 turns at 1,685 ohms. Price 22/6 each. P. & P. 1/-

MINIATURE MOVING COIL DIFFERENTIAL RELAY. Two coils 350 ohms each.

Operating current minimum 140 microamp, nominal 400 microamp, maximum 8 milliamp. One pole two way, or, centre stable. Two way contact current 100 mA at 50 V. A.C. or D.C. Size 1½ × ⅞ × ¾in. Price: 22/6 each.

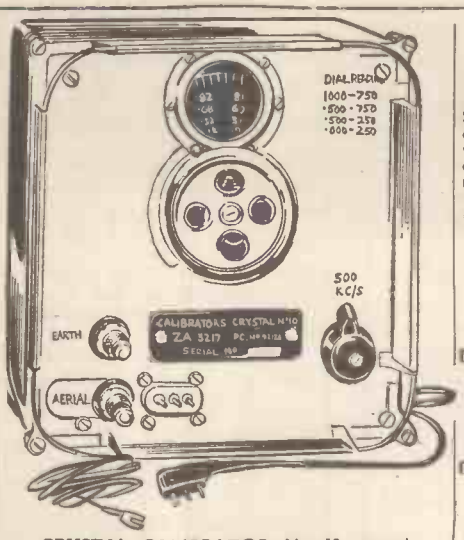
HIGH SPEED RELAY. Siemens, two bobbins, 1,000 ohms each. New, 10/6 each P. & P. 1/-.

SOLENOID OPERATED MAGNETIC RELAY. Type S. 5CW/3942 with 4 make, 4 break 25 Amp. contact, D.C. coil resistance 160 ohms, 24 v. operation. Housed in metal screening can 2⅜in. × 1in. × 1¾in. Brand new. 7/6 each. P. & P. 6d.

U.S.A. 27-volt 4-pole CHANGE OVER RELAYS. Brand new and boxed, 10/6 each. P. & P. 6d.

FAST ACTING ROTARY RELAY, 12 volt. Heavy duty change-over contacts and one low current for externa lcircuit, plus one break set that extends coil winding to reduce initial energizing current to 50 mA for holding. Price 7/6. P. & P. 1/6.

VENNER 8-day clockwork Time Switch. Contacts 1 amp. 230 volt. 24 hour phase, ¼ hour divisions, allows setting for one make and one break to be made every 24 hours, complete with key. Used but guaranteed perfect. Price 27/6 each. P. & P. 1/6.



CRYSTAL CALIBRATOR No. 10 crystal controlled 4-valve high-grade instrument in the same category as the famous B.C.221. Directly calibrated, does not require cross reference or charts—functions as follows:

(1) A crystal controlled oscillator which provides fixed frequency signals of 500 KC and all harmonics of 500 KC to beyond 10 Meg. and up to 30 Meg.

(2) A variable oscillator from 250 KC to 500 KC, this enables all intermediate frequencies between 250 Kc/s. and 30 Meg. to be produced and modulated.

The instrument Is supplied complete with 3 spare valves, all leads and maker's instruction book in carrying haversack. The complete outfit is brand new—repeat NEW. Price: £4/19/6. Carr. 3/-.

MUIRHEAD PRECISION, 4 bank, 1 pole, 24 position Stud Switch. Heavy duty contacts, brand new, original boxes. Price 17/6 each. P. & P. 1/-.

CERAMIC PRECISION SWITCH. 2 pole, 6 way, 4 banks. New in manufacturer's boxes. Price 10/6 each. P. & P. 1/6.

20 WAY STRIP containing standard Post Office telephone Jack Sockets, overall size 11 × 3½ × ½in. New. Price 15/- each. P. & P. 1/6. **10 WAY STRIP** standard Post Office telephone Jack Sockets, spacing allowing Igranic Jack Plugs. New. Price 10/-. P. & P. 1/6.

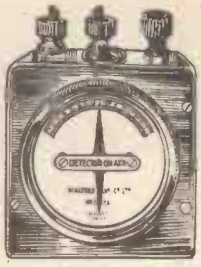
LATEST MOST MODERN TYPE OF EX W.D. MINIATURE HEADPHONES As illustrated. Brand new, low impedance. Price: 10/6 plus P. & P. 1/6.

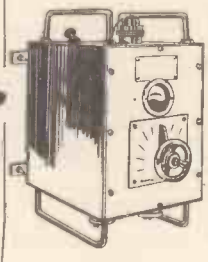
NEW MOVING COIL HEADSETS. Complete with Tannoy carbon hand microphone, with plug suitable for No. 19 set. Price: 12/6 each, plus P. & P. 2/-.

AUTO TRANSFORMERS. Step up, step down, 110-200-220-240 v. Fully shrouded. New. 300 watt type £2/2/- each. P. & P. 2/6. 500 watt type £3/3/- each. P. & P. 3/9. 1,000 watt type £4/4/- each. P. & P. 6/6. Also 60 watts, 19/6 each. Plus P. & P. 2/-.

MARCHING COMPASS Mk. I. Brand new ex W.D. Price 14/6. P. & P. 1/-.

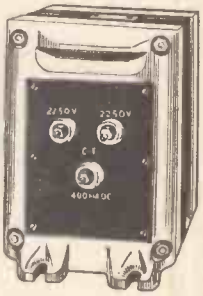
NEW GALVANOMETERS Solid brass, 3in. dial, in polished wooden case. 70 degree scale, 35 mA either side. 100 ohm coil. Price 12/6 each. P. & P. 1/6.

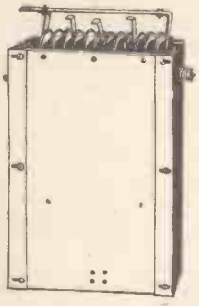




L.T. TRANSFORMER. Input 230 V. Output 50 V. 50 amp. Adjustable by regulator switch on primary. Steel case with mains switch. Will take 100% overload. Weight 150lb. Wound at 800 amps per sq. inch. Brand new. Price: £15. Carr. £1.

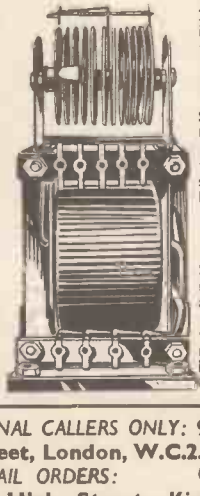
PLATE TRANSFORMER of very best U.S.A. make, brand new, original manufacturer's cases. Input tapped at 190/210/230/250 V. Output 2250-0-2250, centre tapped 400 mA. Nett weight 76lb., size 13in. × 9in. × 6½in. Price £6/10/- each, plus carr. 10/-.





BRAND NEW SELENIUM FULL WAVE BRIDGE TYPE RECTIFIERS, in manufacturer's original packing. D.C. output 36 v. 10 amp., made up of 12 × 110 mm. dia. plates. These fitted in cooling funnel (removable). Size 11⅛in. × 8in. × 4¼in. Price 45/-. P. & P. 3/3.

TWELVE PLATE F.W. BRIDGE CONNECTED RECTIFIER mounted on 200/250 volt A.C. input transformer. Output 36/40 volt D.C. at 1.2 amps. New, perfect. Price 16/6. P. & P. 3/6.



SPRING LOADED FUSED TEST PRODS, complete with wire leads and spade terminals. Price 4/6 per pair. P. & P. 1/-.

MUIRHEAD VERNIER DRIVE. Scaled 0-180 degrees, ratio 31/1, dia. 3in., as fitted to R.F.26 units. Complete with lampholder. In manufacturers' original packing. New. 8/6 each. P. & P. 1/6.

WE ARE EXPERTS AT OVERSEAS PACKING & SHIPPING!

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PERSONAL CALLERS ONLY: **9 Little Newport Street, London, W.C.2.** *Tel: GER 0[illegible].* *(Early Closing Thursday)*

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COSSOR KITS! *A unique opportunity to obtain a first-class amplifier and/or the latest type VHF/FM receiver at the most reasonable price ever.*

COSSOR AUDIO AMPLIFIER KIT 562K. This excellent amplifier supplied in kit form in manufacturer's original presentation carton comprising: Pre-assembled printed-circuit board, valves: 6V4, 6BQ5, EF86 output transformer, two loud-speakers, 4in. circular and 10 x 6in. elliptical, wiring wire, nuts, bolts, attractive escutcheon and control knobs, mounting brackets and fully illustrated assembly instructions. With negative feedback incorporated, and the high performance loudspeakers provided, a really high quality output is assured. Suitable for use with radio tuners, microphone or gramophone units. For A.C. 200/250 v. operation. **BRAND NEW AND COMPLETE AT ONLY £5/19/6 plus 3/6 P. & P. (List price £9/15/-).**

COSSOR VHF/FM RECEIVER KIT 701K. A first-class receiver of the latest type for the reception of B.B.C. VHF/FM programmes, and suitable for use on A.C. or D.C. mains supply, supplied in kit form, in manufacturer's original presentation carton, comprising: printed circuit (with all connections clearly marked), 6 valves: UCC85, UF89, UF89, UABC80, UL84, UY85. All necessary components including nuts, bolts, wiring wire, solder, etc., and an excellent quality Goodmans 10in. x 6in. elliptical loudspeaker. A fully illustrated step-by-step instruction book is provided with the aid of which the receiver can be completed in approx. 9-10 hours. **BRAND NEW AND COMPLETE AT ONLY £8/19/6 plus 3/6 P. & P. (List price £15/15/-).**

RECORDER AMPLIFIER

(Well known manufacturer's surplus.) This is a brand new amplifier designed for use with a famous wire recorder. A simple modification is all that is required to make this unit ideal for use with any **Tape Deck.** Specifications: Valve line-up 7C5, 2AU7, 6BR7, 6BR7, 6X4. Neon Record Level Indicator. Controls: Volume/Record Level. Tone Control, Record/Playback Switch. High and Low level inputs for Mike and Radio. External Speaker Socket. Built-in 5in. Loudspeaker with High Flux magnet: Separate Power Pack. Dimensions: Amplifier 5¾in. H. x 11¾in. W. x 2¼in. D. Power Pack; 6¾in. x 6in. x 5in. High (overall). Full modification details are supplied. Price **£6/19/6.** P. & P. 3/6.

A SPECIAL HIGH QUALITY PUSH-PULL AMPLIFIER

By famous manufacturer

Limited stocks only of this really wonderful quality amplifier employing 4 valves: 2-EL84, ECC83, EZ80. Separate Bass and Treble Controls mounted with Volume Control upon loose panel with flying leads. Excellent quality components employed throughout. Overall dimensions: (Main chassis) 12½in. x 4in. x 5in. high. Control panel: 6in. x 2¾in. Input to match standard high impedance crystal or magnetic pick-up. Output approx. 8 watts max. WHILST STOCKS LAST ONLY, **£6/19/6** plus 3/6 P. & P.

EXTRA SPECIAL OFFER!!

A small three-valve **PORTABLE RECORD-PLAYER AMPLIFIER** mounted on baffle 12 x 7in. with High Flux 6½in. Loudpseaker, Valve line-up ECC83, EL84, EZ80. Incorporates separate bass and treble controls. Max. output 3 watts. Will match all types of high impedance pick-up. Ready to use, **£5/12/6** plus 3/6 P. & P.

NEW STYLE CABINET finished in two-tone Leatherette. Will accommodate above Amplifier and Baffle without modification, also most types of Ancillary Equipment. Overall size 18 x 13½ x 8½in. Fitted with carrying handle, **£3/9/6** plus 5/- P. & P. **NOTE. If both items purchased together they will be supplied at a special inclusive price of £8/7/6 plus 6/6 P. & P.**

RECORD PLAYERS →

A QUALITY RECORDER FOR 39 GNS.

Collaro Mark IV Tape Transcriptor Deck.....	£17	19	6
Special amplifier.....	£14	14	0
8 + 6in. loudspeaker...	£1	10	0
De Luxe Cabinet with gilt fittings	£4	10	0
CollaroMike(orsimilar)	£2	5	0
1,200ft. EMI tape	£1	15	0
TOTAL	£42	13	6

OUR SPECIAL INCLUSIVE PRICE ONLY 39 GNS. if all items purchased together. Terms: **£4/19/-** dep. and 12 monthly payments of **£3/6/-.** C. & P. 15/- extra. Full assembly instructions provided. Note: We shall be pleased to wire the tape deck switches at extra charge of **£1.** Send stamp for further details.

GARRARD 4S.P. Single-record 4-speed unit complete with GC2 turnover crystal head and sapphire styli. Limited quantity. Brand new and fully guaranteed. **£6/9/6** plus 3/6 P. & P.

COLLARO JUNIOR. 4-speed turntable and pick-up complete with crystal cartridge and sapphire styli. **SPECIAL OFFER** at only **75/-** plus 2/6 P. & P. or **TURNTABLE** and **MOTOR** only at **52/6** plus 2/6 P. & P. **PICK-UP** only at **27/6** plus 1/6 P. & P.

E.M.I. 4-SPEED STEREO SINGLE RECORD UNIT. Complete with Stereo Head and Sapphire Styli. Brand New and Fully G'teed. ONLY **£6/19/6** plus 3/6 P. & P. whilst stocks last.

NEW! FOR THE CONSTRUCTOR

SUPER 1-VALVE SHORT WAVE RADIO

World Wide Coverage at most reasonable cost. Covers 40-100 metres with the coil supplied. Can be extended to cover 10-100 metres. Provision is also made for the addition of two extra valve stages. Employs the famous Acorn type 954 valve. All necessary components can be supplied complete with full assembly instructions at ONLY **35/-** plus 2/- P. & P. Send 2/- for point-to-point wiring diagram and price list.

SUPER PERSONAL PORTABLE

A wonderful little set that you can take anywhere. Ideal for camping, picnics, etc. Detachable aerial rod supplied. Covers Medium Waveband 200-500 metres. Can be built in approx. 1 hour. All necessary components available at the following SPECIAL INCLUSIVE PRICES: 1-Valve Version ONLY **35/-.** Super 2-Valve Version ONLY 41/-. Plus 2/- P. & P. Send for point-to-point wiring diagram and parts price list, 2/- post free.
Extra for use with the above DLR5 balanced armature headphones, 7/6 pr.

TWO-TRANSISTOR PERSONAL PORTABLE

This is an amazing little receiver with built-in aerial, and small enough to be held in the palm of the hand. Medium wave reception at wonderful volume. Supplied with drilled chassis and colour coded components. Easily assembled with the aid of the easy-to-follow assembly instructions provided. Total cost of all necessary components, including transistors, Deaf-aid type earpiece, wiring wire and even solder, ONLY **69/6** plus 1/6 P. & P. Parts price list and Easy Lay-out Plans 2/- post free.

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First delivery Famous American Ferrodynamics Acetate Base High Quality Recording Tape. An enthusiast's "must". Brand new (NOT SUB-STANDARD), 7in. 1,200ft. on plastic spool, **25/-**; 7in. 1,800ft. on plastic spool, **35/-.** Post free.

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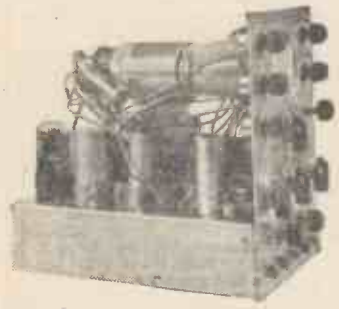
The following equipment of top quality is now available for home construction.

AUDIO GENERATOR AG10. Covers from 10c/s. to 100 Kc/s. in four ranges. Max. output 10 volts. Min output 100 microvolts. Square wave output with excellent rise time makes this generator very useful for checking all Audio equipment. Housed in attractive metal shelf mounting case measuring 11½in. x 6½in. x 5½in. high. All necessary components available, including valves, at a Special Price of £14/5/-, plus 3/6 p. & p.
Fully descriptive booklet with comprehensive assembly instructions available at 2/- post free.

OSCILLOSCOPE OG10. This is a general purpose Oscilloscope based on a "Mullard" circuit employing a DG7-32 3in. cathode ray tube. A sensitivity of 100 microvolts per c.m. with a band width of 2 c/s. to 2.5 mc/s. makes this a useful unit for T.V. servicing as well as audio amplifier checking. Housed in smart metal case complete with carrying handle. All necessary components available. including valves, at a Special Price of £22/10/- plus 5/- p. and p. Fully descriptive booklet with comprehensive assembly instructions available separately at 3/6 post free.

CLYNE CATHODE RAY OSCILLOSCOPE for Home Construction



The latest addition to our comprehensive stocks of quality equipment for the constructor. This is an exceptionally sound and robust instrument of the most versatile type, that will be a boon to the seriously minded amateur, serviceman or constructor. Specifications: 8-Range Time Base, switched from 20 c/s. to 160 Kc/s. Y-Plate Amplifier has a sensitivity of 50 mV. and frequency response of 20 c/s to 600 Kc/s with a gain of 150. A calibrating voltage of 6.3 v. 50 c/s is provided. Employs ECR 30 2½in. Cathode Ray Tube and 4 valves: 2/ECF80, 1/EF91, 1/EZ35, 6X5. Controls: X-shift, Y-shift, Focus, Width, Brilliance. ON/OFF. Time Base Frequency (Fine) Time Base Frequency (Course). Sync. Selector. Sync. Amplitude. Y-input Selector. X-input selector. Amplifier Gain. Operates from 200/250 v. or 110 v. A.C. Mains. All required components for the construction of this wonderful instrument, including comprehensive assembly instructions, available at a SPECIAL INCLUSIVE PRICE OF ONLY £12/19/6 plus 5/- carriage and packing.

A HIGH QUALITY 5-WAVEBAND AM/FM CHASSIS
(By famous manufacturer). BRAND NEW.
A really first-class AM/FM Chassis, which is in great demand by the discerning enthusiast. Brief spec.: 9 valves, ECC85, ECH81, EF89, EABC80, 2/EL84, ECC83, EZ81, EM34. Covers Long, Medium, 2-Short and FM Wavebands. Power pack and output stage (Push-Pull) mounted on separate chassis. Independent Bass and Treble Controls. Volume Control on flying lead. Available with Vertical or Horizontal edge lit dial. Flywheel tuning. Facilities for quality tape playback. Pick-up and extension speaker sockets provided. PRICE WHILST STOCKS LAST, ONLY £17/19/6, plus 7/6 p. and p. Terms: Deposit 39/6 and 12 monthly payments of 29/4.

A.M. GRAM CHASSIS SPECIAL! (By famous manufacturer)
This special offer chassis is being offered for a limited period only and represents the best possible value for money. Spec.: 3 wavebands, Long, Medium and Short. 5 miniature valves—6C7, 6F15, 6LD20, N108, U107. Attractive vertical glass dial (13in. × 3½in.) in red, green and gold on black background. Two-speed dial drive. Full range tone control. Output approx. 4 watts to match 3 ohm speaker. For A.C. mains 110/250 v. Overall size 13in. × 6½in. × 6½in. high. WHILST STOCKS LAST, £7/19/6 ONLY, plus 7/6. P. & P.

VALVES. We have perhaps the most up-to-date valve stocks in the trade. New imported valve types fully guaranteed and P.T. paid and all the usual surplus types at special prices. We also carry a comprehensive stock of all B.V.A. types at current list prices. Send stamp for NEW list now available. Note: Certain other American special purpose types can be supplied. Enquiries invited.

RE-GUNNED CATHODE RAY TUBES. (As new.) Guaranteed 12 months. 12in., 14in., and 15in., £5/10/-; 17in., £6; 21in., £7/19/6, plus 10/- c. and p.

VISIT OUR FULLY EQUIPPED HI-FI SHOWROOM AT TOTTENHAM COURT ROAD FOR DEMONSTRATION OF THE LATEST HI-FIDELITY EQUIPMENT BY ALL LEADING MANUFACTURERS.
i.e., Leak, Quad, Armstrong, Dulci, Ferrograph, Vortexion, Linear, Wharfedale, Grundig, Goodmans, W.B., Rogers, etc., etc.
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BARGAIN! REPLACEMENT PICK-UP INSERTS. All brand new and fully guaranteed. Complete with Sapphire Stylii. **PHONOFLUID** 21/- each. B.S.R. TC 8 (less bracket) 15/- each. B.S.R. Hi-G with bracket, 18/- each. B.S.R. Hi-G (less bracket) 15/- each. E. V. POWER POINT In Garrard plug-in shell, 18/6 each. E. V. CARTRIDGE only 11/6 each. All plus 9d. P. & P.

A COMPACT TEST METER FOR HOME CONSTRUCTION. This is a very sensitive multi-range test meter (500 micro-amp basic movement) covering the following ranges: A.C./D.C. voltage: 0-10 v., 0-50 v. and 0-500 v. Current: D.C. 0-10 ma., 0-50 ma. and 0-500 ma. Resistance (on internal battery) 2 K.ohm. to 100K. ohm. Housed in a smart grey stove enamelled case measuring 3¾in. x 7in. x 1¾in. overall. Brand new best quality components and High Stability resistors are used throughout, resulting in a thoroughly reliable, accurate instrument.
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(To build yourself)
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These pocket size multi-range test meters are of excellent quality and cover all the most useful ranges (A.C. Volts, D.C. Volts, resistance and current). Supplied complete with test prods, instruction book and batteries.
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A most versatile test meter covering 15 ranges. 3,333 o.p.v. basic movement. Ohms ranges: 0-20K., 0-2 Meg. Volts: A.C. and D.C. 6 v., 12 v., 60 v., 300 v., 1,200 v. Current: D.C. 300 micro-amps, 30 mA., 300 mA. Size only 3½in. × 5in. × 1⅞in. overall. Supplied complete with instructions and test prods. ONLY £5/19/6 plus 2/6 P. & P.

ACOS MIC 39-1. Crystal stick microphone with stand. List price 5gns. Our price 39/6 plus 1/6 P. & P.

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HIGH IMPEDANCE LIGHT-WEIGHT HEADPHONES. Brand new imported type finished in cream. Complete with leads, 15/-, plus 1/6 P. & P.

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WHITE SPOT, R.F. up to 2.5 Mc/s. ..... 7/6 ea.

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METERS. We carry large stocks of Meters from 25 microamps to 1,500 v. A few of the most popular types are:— 25 microamps 2½in. Flush Round, 65/-; 100 microamps 2½in. Flush Round Moving Coil at 45/-; 500 microamps 2in. Flush Round Moving Coil at 18/6; 1 mA. 2in. Flush Square Moving Coil "Elliott" 1954 man., 25/-; 50 mA. 2in. Flush Square Moving Coil 8/6; 1 mA. 2½in. Flush Round 35/-. Send stamp for complete list. We shall be pleased to quote for special meters to your own specification.

AERIAL TUNING UNIT ZA0841. This well made ex-W.D. unit contains a host of useful components including: 1 mA. 2in. flush round M/C meter 1 mA. Westinghouse full wave meter rectifier, 5 pole 5 way heavy-duty silver plated wave change switch, 3in. dia. silver plated rotary tuning indicator, 350 pF. tuning condenser with insulated coupler and 3in. calibrated dial (0–180 deg.) etc., etc. Contained in strong metal carrying case 9in. × 9in. × 8in. with hinged lid. ONLY 27/6 plus 5/- C. & P.

No. 38 AFV WALKIE-TALKIE. A wonderful offer. This famous transreceiver unit, with relay operated SEND/RECEIVE switch, covering 7.4–9 Mc/s band, range approx. 5 miles. In new condition. ONLY 22/6 plus 2/6 P. & P. per unit (less accessories). Quantity Export inquiries welcomed.

No. 17 Mk. II TRANSMITTERS RECEIVER. Built into strong wooden cabinet 15in. × 14in. × 9in. Complete with headphones and microphone. Range 5-8 miles with simple aerial.
Freq. range 44-61 mc/s. (5-7 metres) Uses standard 120 v. H.T. and 2 v. L.T. batteries. Brand new. Complete with full operating instructions, 45/-, (Second hand 30/-). Batteries not supplied.

12in. BAKERS SELHURST LOUDSPEAKERS 15 ohms, 15 watt, 30-14,000 cps. Brand new, £4/10/-. P. & P. 3/6.

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Readers will no doubt be pleased to know that our working model of this amazing organ for home construction, may now be heard and seen, at our Hi-Fi Showroom in Tottenham Court Road, W.1. For the benefit of constructors all components, keyboards, chokes, etc. are available ready made. Full constructional details are available in book form at 15/- plus 1/6 p. and p. We shall be happy to forward a complete price list on receipt of a stamp. Please address all organ enquiries for the attention of Mr. L. Roche.

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THE COMPONENT SPECIALISTS
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ALPHA FULLY GUARANTEED VALVES

All tested before despatch

AC/P	7/6	KT63	7/6	1A5GT	6/–	6X5G	7/–
AC6PEN	6/6	KT66	17/6	1A7GT	12/6	6X5GT	7/–
ACVP1/5	10/–	KT88	22/6	1C2	11/6	6/30L2	12/6
ATP4	3/6	KTW61	6/6	1C5GT	12/6	7B6	10/6
AZ1	10/–	KTW63	7/6	1D5	12/6	7B7	8/6
AZ31	10/–	KTZ41	3/6	1D6	12/6	7B8	8/–
AZ41	13/11	MH41	7/9	1H5GT	9/6	7C5	8/–
B36	15/–	ML4	8/6	1L4	6/6	7C6	8/–
CL4	12/6	MSP4/5	7/6	1LD5	3/6	7D6	13/6
CL33	19/3	MSP4/7	7/6	1N5	10/6	7H7	9/–
CY31	16/7	MVS/PEN	10/–	1R5	7/6	7Q7	9/–
CY1	18/7	OZ4	5/6	1S4	10/6	7S7	9/6
CV73	6/–	P61	3/6	1S5	6/6	7Y4	8/6
C36A	6/6	PABC80	13/11	1T4	6/–	8D2	2/9
DAF96	8/9	PCC84	9/–	2C26	1/6	9D2	3/6
DF96	8/9	PCC85	14/7	2X2	4/6	10C1	17/3
DH63	9/–	PCF80	9/6	3A4	7/–	10D2	12/–
DK96	8/9	PCF82	12/6	3A8GT	6/–	10F1	15/–
DL96	8/9	PCF84	16/7	3D6	5/–	12A6	6/6
DM70	7/6	PCL82	12/–	3Q4	8/–	12AH8	10/–
EA50	1/6	PCL83	14/6	3Q5GT	9/6	12AT6	10/6
EABC80	9/–	PL38	17/6	3S4	7/6	12AT7	7/6
EAF42	10/6	PL36	15/–	3V4	8/6	12AU6	8/–
EB34	2/–	PL81	12/6	4D1	3/–	12AU7	8/–
EB41	8/6	PL82	8/6	5R4GY	9/6	12AX7	8/–
EB91	6/6	PL83	11/6	5U4G	6/6	12BA6	9/–
EBC33	6/9	PL84	12/7	5V4	11/6	12BE6	9/–
EBC41	9/6	PL820	18/7	5Y3G	8/–	12C8	9/–
EBC81	11/4	PX25	12/6	5Y3GT	8/–	12H6	3/6
EBC90	12/7	PY31	16/7	5Z4G	9/–	12J5GT	3/–
EBC91	12/7	PY32	17/11	5Z4M	10/–	12J7GT	10/6
EBF80	9/9	PY80	7/6	6A7	11/–	12K7GT	7/6
EBF89	9/6	PY81	8/6	6A8G	9/–	12K8GT	13/6
EC31	7/6	PY82	7/–	6AC7	6/6	12Q7GT	7/6
ECC81	8/–	PY83	8/6	6AG5	5/6	12SG7	7/6
ECC82	7/6	PZ30	19/11	6AK5	6/6	12SH7	6/–
ECC83	9/–	PEN4VA	15/–	6AL5	5/–	12SJ7	6/–
ECC84	10/–	PEN25	6/–	6AM5	12/6	12SK7	6/–
ECC85	9/6	PEN46	7/–	6AM6	5/–	12SL7	8/–
ECF80	12/–	PEN220A	4/–	6AQ5	7/6	12SN7GT	15/–
ECF82	13/–	PENA4	15/–	6AT6	8/6	12SQ7	8/6
ECH42	9/6	PM12M	8/–	6AU6	10/6	14S7	17/–
ECH81	9/–	QP21	5/–	6B8G	4/–	15D2	7/9
ECH83	13/11	SP41	3/–	6BA6	7/6	12AQ5	9/9
ECL80	10/–	SP61	3/–	6BE6	8/–	25A6G	10/6
ECL82	12/6	SP4/5	10/6	6BH6	9/–	25L6GT	10/–
ECL83	19/3	SP4/7	10/6	6BJ6	9/–	25Z4	9/6
EF22	8/6	TDD13C	7/6	6BR7	12/6	25Z5	8/–
EF36	5/–	U10	10/6	6BW6	9/–	25Z6	10/–
EF37A	15/–	U14	8/6	6BW7	8/6	27SU	19/11
EF39	5/9	U16	12/6	6C4	5/–	30C1	10/6
EF40	14/6	U22	8/–	6C5GT	6/6	30F5	10/6
EF41	9/9	U25	14/–	6C6	5/–	30FL1	10/6
EF42	11/–	U45	15/–	6C31	7/6	30P4	20/7
EF50	4/–	U50	8/–	6CD6G	29/10	30P12	12/6
EF50SYL	7/–	U76	8/–	6D6	5/–	30P16	9/6
EF54	6/–	U191	11/6	6CH6	10/6	30PL1	12/6
EF55	10/–	U339	12/–	6F6G	7/6	35L6GT	10/–
EF80	7/6	U404	11/4	6F6M	7/6	25Y5	9/9
EF85	7/6	UABC80	10/–	6FI	14/–	35W4	7/6
EF86	13/–	UAF42	9/6	6FI3	14/–	35Z4GT	8/–
EF89	8/9	UBC41	9/–	6FI5	14/–	42	8/–
EF91	5/9	UBC81	11/4	6FI8	15/3	35Z5GT	9/–
EF91(BVA)	9/–	UBF80	9/6	6F23	18/7	50C5	11/6
EF97	13/3	UBF89	13/11	6F33	17/6	50L6GT	8/6
EF98	13/3	UC92	13/3	6H6	2/6	75	11/6
EL32	5/6	UCC84	10/11	6H6GT	2/6	77	7/6
EL33	14/–	UCC85	10/6	6J5GT	5/–	80	8/6
EL34	15/–	UCF80	16/7	6J5M	6/6	142BT	3/6
EL38	26/6	UCH42	10/6	6J6	6/–	210DDT	4/6
EL41	10/6	UCH81	10/6	6J7G	6/6	210VPT	3/6
EL42	10/6	UCL82	16/7	6J7M	9/–	83	10/–
EL81	16/7	UCL83	12/6	6K7G	4/–	301	10/6
EL84	9/–	UF41	9/–	6K7M	6/9	302	10/6
EM34	9/6	UF80	13/11	6K8G	7/6	304	10/6
EM80	10/–	UF85	9/–	6K6GT	7/–	305	10/6
EM81	10/6	UF89	9/–	6K7GT	5/9	306	10/6
EY51	9/6	UL41	10/–	6K8GT	10/–	807	6/6
EY81	13/3	UL84	9/–	6K25	19/11	954	2/–
EY86	10/–	UY1N	12/6	6L6G	8/–	955	4/–
EZ40	7/6	UY41	7/6	6L6M	9/6	956	3/6
EZ41	7/6	UY85	7/–	6L7G	7/6	5763	11/6
EZ80	7/–	VP13C	3/6	6L18	11/6	9004	5/6
EZ81	7/–	VP133	15/–	6N7GT	7/6	9006	5/6
EZ90	7/6	VR22 (PM2A)	3/–	6P28	26/6		
E1148	2/–	VP23	6/6	6Q7G	7/6	**DIODES**	
FC13	6/6	VP41	8/6	6Q7GT	9/6	OA70	4/–
FW4/500	10/–	VR105/30	8/–	6SA7GT	8/–	OA79	4/–
GZ32	12/–	VR116	4/–	6SG7	7/6	OA81	4/–
H30	5/–	VR150/30	7/6	6SH7	6/–	CG6E	4/–
H63	10/–	VU120A	3/6	6SJ7	8/6	CG12E	4/–
HL23DD	8/6	VU39(MU12/14)8/9		6SK7	6/–		
HL22	6/6	VU111	2/6	6SL7GT	8/–	**TRANSISTORS**	
HL41	3/6	W76	7/6	6SN7GT	7/6	OC45	23/–
K40N	9/–	W77	8/6	6SQ7	9/3	OC66	25/–
KF35	8/6	W729	10/6	6U4GT	12/–	OC70	14/–
KT2	5/–	X78	16/–	6U5G	8/6	OC71	14/–
KT24	5/–	Y63	9/–	6U7G	8/6	OC72	17/–
KT33C	8/6	Z309	7/6	6V6G	6/–	XB102	10/–
KT55	11/6	Z359	7/6	6V6GT	7/9	XB104	10/–
KT61	13/6	1A3	3/6	6X4	7/6		

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★ All brand new. ★ Note Special Prices. ★ All Permanent Magnet 3 ohms Impedance.

5in. Units by Plessey, Goodmans, Lectrona ... each 17/6
6½in. Plessey ... each 18/6
8in. Goodmans ... each 19/6
10in. Elac, Plessey each 25/6
6in. × 4in. Plessey each 19/6
7in. × 4in. Goodmans each 19/6
7in. × 5in. Goodmans each 19/6
8in. × 5in. Goodmans each 25/6
10in. × 6in. Plessey each 25/6

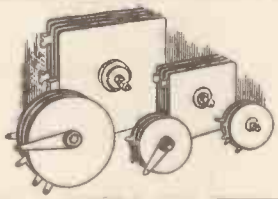
8in. Loudspeaker Units 3 ohms Impedance with a Matching Output Transformer suitable for 6V6. Brand new but soiled, offered at a Special Price of 11/6 each, postage 2/-.

AUTOMATIC CHANGER UNITS

The latest Collaro Conquest, 4-speed auto-changer, in cream with Studio "O" insert. Brand new, fully guaranteed. £7/19/6, plus packing and post 3/6.

Collaro 4-speed single player unit with automatic stop, cream, turnover crystal cartridge, brand new and guaranteed, £6/19/6.

Garrard Automatic Record Changer, 4-speed, type RC120/D/Mark I. Price £8/17/6, packing and post 3/6.



RECTIFIERS FOR BATTERY CHARGERS

12 v. 1 amp. 4/3
12 v. 2 amp. 7/–
12 v. 3 amp. 10/6
12 v. 4 amp. 12/–
12 v. 5 amp. 14/6

ACOS PICK-UP ARM

Type GP54/2 complete with turnover crystal cartridge and crystal styli HGP37/1 or HGP59/5C, 29/6 complete.

CHARGER TRANSFORMERS

Tapped Primary 200/240 v., Secondary 3.5 v., 9 v. and 17 v., 2 amp. type 13/6, 4 amp type 21/-, postage 1/6.

MAINS TRANSFORMERS 3-WAY MOUNTING TYPE

MT1 Primary 200/250 v., Secondaries 250-0-250 v. 80 mA 0-6.3 v. 4 A. 0-4 v. 2 A., both tapped at 4 v., 21/9 each.

MT2 Primary 200/250 v., Secondaries 350-0-350 v. 80 mA 0-6.3 v. 4 A. 0-5 v. 2 A., both tapped at 4 v., 21/9 each.

MT3 Primary 200/250 v., Secondary 30 v. 2 A. Taps at 3 v., 4 v., 6 v., 8 v., 9 v., 10 v., 15 v., 18 v., 20 v., 24 v., 21/9 each.

Postage and packing please add 2/- per transformer.

Mains Dropping Resistors SMD6 and SMD7 as used in Ultra Twin 50 5/3 each.

TELEVISION BAND III CONVERTORS

INVICTOR. 13 Channel Adaptor for Models 118, 119, 120. Listed £7/19/6. OUR PRICE 59/6.

WOLSEY TC 165 Convertor Aerial Convertor. Listed £9/19/6. OUR PRICE £3/19/6.

ACOS MICROPHONES

Acos Mic 39/1. Crystal Stick Microphone for use as a hand, desk or floor stand units, for high quality recording, broadcasting and public address work. List price £5/5/0. OUR PRICE 39/6, with Stand 47/6, with floor stand adapter 52/6, postage 1/6.

Acos Mic 40, as supplied with most modern tape recorders, with folding rest and 8ft. lead, response 40-6000 c.p.s. Listed at 35/-. OUR PRICE 25/-.

RECORD PLAYER UNITS

BSR Monarch, Model UA8. 4 speed, 10 records capacity, Ful-Fi turnover crystal cartridge. £6/19/6.

CYLDON TURRET TUNERS

Types E10H, E10L. For chans. 2/10 only. Brand new and boxed. Complete with fitting instructions, etc. Listed £7/7/- each. OUR PRICE 55/- or less valves 35/-.

TELENG TURRET TUNERS

10 Megs. 100 M/A heaters fitted B8A plugs, available for chans, 5/10. 300 M/A heaters fitted B9A plugs, available for chans. 5/10, 2/9/10, 2/10, 4/8. PRICE COMPLETE, 45/- each.

CATALOGUE

Our 1960 catalogue is now available, please send 1/- in stamps for your copy. Trade Catalogues also available, please attach your Business Letter Heading.

ALPHA RADIO SUPPLY CO.

103 LEEDS TERRACE
WINTOUN STREET
LEEDS 7

TERMS: Cash with order or C.O.D. Postage and Packing charges extra, as follows: Orders value 10/- add 1/-; 20/- add 1/6; 40/- add 2/-; £5 add 3/- unless otherwise stated. Minimum C.O.D. fee and postage 3/-.
For full terms of business see inside cover of our catalogue.
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REPLACEMENT RE-BUILT T.V. TUBES

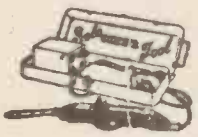
£8-10-0
CASH PRICE
12 months' full guarantee

All sizes except 10in. Completely re-built gun assembly, new cathode heaters, etc., giving the high standard required for long picture life, quality and value. Carr. and Ins. 15/6.
OR Yours for 8/6 initial payment (plus carr. & Ins.) and 19 weekly payments of 8/6.

★ **EXPRESS DESPATCH SERVICE** ★

Please 'phone to confirm Tube in stock. Send Telegraph Money Order. Tube despatched Passenger Train same day. This service only available with remittance by a Telegraph Money Order and cash sales, not terms.

SOLO SOLDERING TOOL 12/6



110 v., 6 v., or 12 v. (special adaptor for 200/250 v. 10/- extra). Automatic solder feed including a 20ft. reel of Ersin 60/40 solder and spare parts. It is a tool for electronic soldering or car wiring. Revolutionary in design. Instantly ready for use and cannot burn. In light metal case with full instructions for use. Post 3/6.

13 CHANNEL TURRET TUNER 65/-
Brand new. Well-known manufacturer. 38 Mc/s. Complete with valves PCF80 and PCC84. .3 series line up and channel coils covering channels 1, 2, 3, 4, 5, 8 and 9. Carr. & Ins. 3/6.

T.V. AERIALS 23/6
For all I.T.A. channels. Outdoor or loft. 3 elements. P. & P. 2/6

AERIALS 15/6
B.B.C. indoor type. Folded dipole with 12ft. co-ax cable fitted. Post 1/9.

T.V. AERIALS 7/9
For all channels. Complete with co-ax cable. For use indoors or in the loft. Postage 1/3.

CO-AX CABLE 6d. yd.
Good quality. Cut to any length. 1/6 postage on 20 yds.

COLVERN PRESET POTENTIOMETERS 2/9
Brand new. 200 ohms. 10K. and 20 K. P. & P. 9d.

EOCUS MAGNET 9/9
Brand new. 38mm. Incorporating picture shift control. P. & P. 1/3.

SCANNING COILS 10/6
Low impedance. 38mm. Brand new. P. & P. 1/3.

SCANNING COILS 15/9
Wide angle 90 deg. 38mm. Low impedance. P. & P. 1/3.

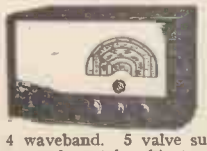
ELECTRIC CONVECTOR HEATER 99/6
Illuminated grille. Bronze finish. A.C./D.C. Size 26 × 18 × 7¼in. deep. Ins. carr. 10/6.

GANG CONDENSERS 1/9
Salvage guaranteed. Standard size two gang. .0003 and .0005. All tested and guaranteed. P. & P. 1/3.

INSULATING TAPE 1/6
Finest quality tape 75ft. × ½in. wide in sealed metal container. Post 9d.

T.V. MASKS 7/9
21in., as above. Post 2/3.

T.V. MASKS 2/9
Gold plastic for 15in. tubes. Post 1/3.



SUPER SUPERIOR RADIO 89/6

4 waveband. 5 valve superhet radio. 2-tone covered metal cabinet size 24¼ × 12 × 10in. deep. 4 control knobs. Positions for gram., p.u. and extension speaker. A.C. only. Ins. carr. 8/6

TRANSFORMERS

MAINS TRANSFORMER 5/9
Primary 200–250. Secondary 0–100–250, 150 mA. Suitable for small amplifier with .1 series valves. 2¾ × 1¾in. P. & P. 1/9.

OUTPUT TRANSFORMER AND SMOOTHING CHOKE COMBINED 4/9
2¾ × 1¾in. Suitable for EL84's in single or push-pull output. P. & P. 1/9.

MAINS TRANSFORMER 7/9
Primary 200–250. Secondary 300–0–300. 6 v. 3.3 amps. P. & P. 1/9.

MAINS TRANSFORMER 3/9
Primary 200–250. Secondary 250–0–250. 6.3 at 3 amps. 5 volts at 2 amps. P. & P. 2/3.

FRAME OUTPUT TRANSFORMER 1/9
500 ohms primary. 18 ohms secondary. P. & P. 1/6.

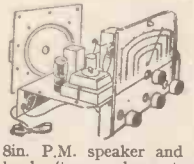
SMOOTHING CHOKE 250 mA. 5/9
2nd 40 ohms D.C. Res. New. P. & P. 1/6.

BAKELITE CABINETS 5/9
Brand new. Colour brown. Attractive design. Size 12 × 7 × 5½in. Ideal for small receivers, converters etc. P. & P. 3/9.

NODARK OVERLOAD CUT-OUT SWITCH 8/9
This will stop the search for that illusive fuse wire and the annoyance of repairing the fuse. Accidental crossing of wires or faulty connections will automatically throw the switch of the Nodark cutting the current to the fuses. It now only remains to rectify the fault and switch on the Nodark. 200–250 v. Maximum load, 2–5 amps. A fraction of the list price. P. & P. 1/6.

A COMPLETE AND WORKING 17" T.V. CHASSIS 24 GNS.

Latest chassis, including 17in. tube, permanent magnet speaker, 13-channel Turret Tuner (any two selected channels fitted). Other channels supplied on request at 7/6 each.
13 valves. Line up as follows: 5–EF80s; 1–ECC84; 1–ECF80; 2–ECL80s; 1–PL81; 2–EB91s; 1–EY51. Chassis and valves guaranteed for 3 months. CRT for 12 months' full guarantee. Sound I.F. 19.5 Mc/s. Vision 16 Mc/s. A.C. only. Ready and working to fit into your own cabinet. Carr. & Ins. 25/-.
As above with 14in. tube, complete and working. **£19/19/-.**



SUPER CHASSIS 79/6

5-valve Superhet chassis including 8in. P.M. speaker and valves. Four control knobs (tone, volume, tuning, w/change switch). Four wavebands with position for gram p.u. and extension speaker. A.C. Ins., carr. 5/6.

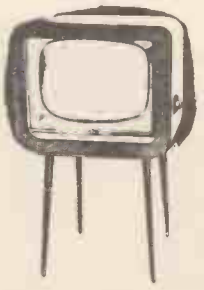
★ **T.V. CHASSIS at Clearance Prices** ★

THE POPULAR 12in. PLESSEY CHASSIS 9/6
A bargain for anyone wanting to make up their own T.V. at a very low cost. A chassis in one unit. Less valves and tube. Chassis size 12 × 14½ × 11in. I.F.s 10.5–14 Mc/s. Can be adapted for a 12-channel Turret Tuner and modified to take a larger tube. Carr. & Ins. 10/6.

CHASSIS 1/-
6 or 8 valve latest type midget valve design for A.M. or F.M. Brand new. Cadmium plated. Size 12¼ × 7½ × 2½in. P. & P. 1/9.

DUKE & CO.

Send for FREE Catalogue



17" T.V. 19 Gns

(CASH PRICE)

OR 20/7 initial payment and 19 weekly payments of **19/11.**

OR 11/1 initial payment and 35 weekly payments of **11/1.**

(4 WEEKLY PAYMENTS IN ADVANCE plus 30/- Ins. and Carr.).

★ FEATURES ★

★ Beautiful latest finish cabinet in contemporary style covered and washable.

★ Polished legs 18in. optional extra for **25/-.**

★ 17in. Rectangular Tube. Guaranteed fully for 12 months.

★ 12 channels. "Turret Tuned"—ITV/BBC Extra coils at only 7/6 a pair (with order).

★ Chassis. 14 B.V.A. valves—salvaged but re-conditioned and guaranteed 3 months.

Due to overwhelming demands, some delay may occur. Please enquire when ordering.

SOUND/VISION and I.F. STRIP 7/9
Plessey. I.F.s 10.5 Mc/s sound. 14 Mc/s vision. 8 valve holders. Less valves. Size 8½ × 5 × 4½in. Circuit incl. The tuner unit plugs directly into this chassis. P. & P. 2/6.

SOUND/VISION and I.F. STRIP 2/9
Salvaged. Complete sound and vision strip. 8 valve holders. Less valves. I.F.s 16-19.5 Mc/s. Size 8½ × 4½ × 4½in. Drawings free with order. P. & P. 2/6.

TIMEBASE 2/9
Containing scanning coils, line transformer, etc. less valves. Drawings free with order. P. & P. 2/6.

I.F. TRANSFORMERS 1/- per pair
465 Kc/s. All tested and guaranteed. Post 1/-.

RECTIFIERS 2/9
250 v. 100 mA. Full or half wave. Salvage guaranteed. P. & P. 1/3.

R.F. E.H.T. COIL 7/9
7–10 Kv. R.F. frequency approx. 22 Kc/s. Uses 6V6 or P61 as osc., suitable for Ultra model V600, 700 and many other sets or replacing E.H.T. mains transformers. Ideal when using a larger tube. Size 4¾ × 2in. dia. Base 4 × 4½in. Circuit drawings available with order. P. & P. 2/6.

GENERATORS 1/9
24 volt in. Less brushes. Size approx. 4 × 4in. P. & P. 1/9.

CAR AERIALS 6/9
Whip antennae. Plated. 50in. long collapsing to 11in. One hole fixing. Post 1/-.

IDEAL RADIO CHASSIS 39/6
5-valve Superhet. A.C. Radio or Radiogram chassis. 3 waveband and gram switched 8in. P.M. speaker included. Valve line up: 6K8; 6K7; 6Q7; 6V6; 5Z4 (not included). Chassis size 19¼ × 7½ × 9in. Knobs 2/- extra. Set of valves 45/9 extra. Complete £4/5/-. Ins. carr. 5/6

HOME RADIO 79/6

AC/DC Universal mains 5-valve octal superhet. 3 waveband receiver can be adapted to gram p.u. In attractive wooden cabinet. 9¾ × 18½ × 11¾in. Ins. carr. 4/6.

PRACTICAL SUGGESTIONS FOR XMAS PRESENTS—ON INTEREST FREE CREDIT TERMS TOO!

RECORD PLAYER CABINETS

29/6 R.P.6

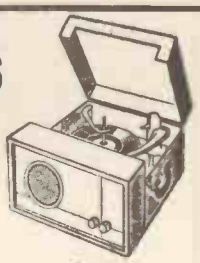
Elegant cabinet, cloth covered in grey or red with sunken control panel and speaker fret. size 13 × 17 × 8in. deep. Takes a B.S.R. Monarch 4-speed Autochanger; 7 × 4in. elliptical speaker and most of the modern portable amplifiers. Carr. & Ins. 4/6.

R.P.2 **69/6**

A beautifully styled cabinet. Made by a famous manufacturer. In polka dot cloth with clipped lid and carrying handle. Size 16 × 14½ × 8½in. deep. Will take a B.S.R. Monarch 4-speed Autochanger and 7 × 4in. elliptical speaker and most of the modern portable amplifiers. Carr. & Ins. 4/6.

R.P.3 **69/6**

A delightful looking cabinet 14¾ × 17¾ × 8¾in. in 2 tone leatherette. Will take a B.S.R. Monarch 4-speed autochanger and 6½in. round speaker. Carr. & Ins. 4/6.



R.P.4 **79/6**

Stylish cabinet by famous manufacturer. Cloth covered in contrasting colours (red and grey). Grilled front controls panel. Size 15 × 19 × 8¾in. deep. Beautifully made —a cabinet of which you can be really proud. Takes 4-speed B.S.R. Autochanger, 6½in. round of 7 × 4in. elliptical speaker. Room for any amplifier of your own choice. Carr. & Ins. 4/6.

The New CONTINENTAL TYPE RECORD PLAYER CABINETS

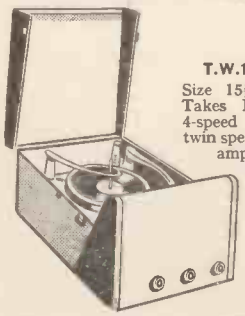
in gay two-tone colours as follows:—

P.L.10 CABINET 39/6

Size 14⅜ × 12½ × 6in. Takes B.S.R. T.U.9 4-speed record player unit. 8 × 3in. elliptical speaker. Single control amplifier. Carr. & Ins. 4/6.

C.H.1. CABINET 69/6

Size 14⅜ × 16⅞ × 8½in. Takes B.S.R. U.A.8 4-speed autochanger. 7 × 4in. elliptical speaker; most of the modern portable amplifiers. Attractive speaker grille and recessed control panel. Carr. & Ins. 4/6.



T.W.1. CABINET

Size 15⅜ × 19¾ × 10⅜in. Takes B.S.R. U.A.8. 4-speed autochanger; twin speakers. 3 control amplifier. Carr. & Ins. 4/6.

79/6

B.S.R. UL-FI Crystal turnover cartridges 19/6

Brand new. Including sapphire needles for L.P. and Standard, giving fullest range and finest tone obtainable for any player. Can be fitted to all standard pick-up arms. P. & P. 9d.

STEREOPHONIC CABINET 99/6

Continental style cabinet including extra clip on speaker cabinet. 15⅜ × 10⅜ × 24¾in. deep. Takes B.S.R. 4-speed stereo autochanger. Printed circuit amplifier. Two 8in. speakers. Carr. & Ins. 12/6.

AMPLIFIERS 12 Months Guarantee

PORTABLE AMPLIFIER Mk. D.1 59/6
Brand new. Latest design with printed circuit. Dimensions 7 × 2½ × 5in. A.C. only. Mains isolated 2-3 watts output. Incorporating EL84 as high gain output valve. Volume and tone controls. Knobs 2/6 extra. P. & P. 3/6.

PORTABLE AMPLIFIER Mk. D.2 79/6
Printed circuit. Latest design. Dimensions 7 × 2½ × 5in. A.C. only. Mains isolated. 3-4 watts output. Incorporating the latest ECL82 triode pentode output valve giving higher undistorted output. Volume and tone controls. Knobs 2/6 extra. P. & P. 3/6.

PORTABLE AMPLIFIER Mk. D.3 89/6
De-luxe model. Printed circuit. Latest design. Dimensions 7 × 2½ × 5in. A.C. only. Mains isolated. 3-4 watts output. Incorporating the latest ECL82 triode pentode output valve giving higher undistorted output. Volume, treble and bass control. Knobs 3/6 extra. P. & P. 3/6.

PORTABLE AMPLIFIER Mk. D.5 39/6
Simple circuit employing ECL80 triode pentode output valve giving 2-3 watts output. A.C. only. Mains isolated. Single control for volume and on/off switch with knob. P. & P. 3/6.

3 TRANSISTOR AMPLIFIER 79/6
9 volts. 1 control. P. & P. 3/6.

STEREOPHONIC AMPLIFIER £7.19.6
Beautifully made for portable stereophonic record players. Latest design with printed circuit. Dimensions 3 × 5½ × 9¾in. A.C. only. Mains isolated. Twin amplifiers each side giving 3-4 watts output. Incorporating ECL82 triode pentode valve. Full tone, volume and balance controls. Complete and ready to fit. Knobs 3/6 per set extra. P. P. & Ins. 3/6.

World's Finest Autochangers—

U.A.8 B.S.R. MONARCH 4-SPEED AUTOCHANGER £6-19-6

U.A.12 LATEST B.S.R. MONARCH 4-SPEED MIXER £8/9/6

COLLARO CONQUEST 4-SPEED AUTOCHANGER £6/19/6

COLLARO CONQUEST STEREO AUTOCHANGER 11 Gns.

P. & P. on all the above 5/6.

Deferred terms to suit all pockets

Monthly credit terms at weekly easy payments

Details on request:—

DUKE & CO.

(Dept. C12)

621/3 ROMFORD ROAD, MANOR PARK, E.12

Telephone: ILFord 6001/3

EXTENSION SPEAKERS 19/9

Polished oak cabinet of attractive appearance. Fitted with 8in. P.M. speaker W.B. or Goodmans of the highest quality. Standard matching to any receiver (2-5 ohms.) Switch and flex included. Ins. carr. 3/9.

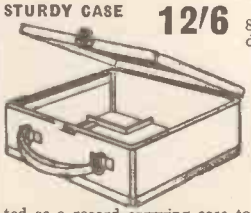
IDEAL FOR STEREOPHONIC SOUND

8in. P.M. Speakers 8/9
With O.P. transformer fitted 10/–
Postage 2/6.
7 × 4in. Elliptical Speakers 19/6
9½ × 4½ Elliptical Speakers 22/6
Postage 2/9.

PHOTOGRAPHIC SLIDE CASE (List price £2/10/0) 17/6

Size 8 × 12¾ × 2¾in. deep. Will hold 150 of those expensive coloured transparencies in separated partitions. This is the answer to that aggravating search for that particular photograph and will, of course, keep them safe from damage. P. & P. 2/6.

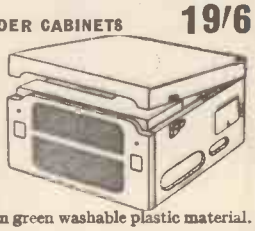
STURDY CASE 12/6



8½ × 7½ × 3½in deep. Covered in burgundy and grey washable rexine. Strong clasp, hinges and handle. Ideal for portable radio chassis or Transistor set. Can be adapted as a record carrying case to hold 18 seven-inch long playing records. P. & P. 2/6.

A "must" for the build-your-own tape recorder enthusiast:—

TAPE RECORDER CABINETS 19/6



Suitable for the Truvox Tape Recording Desk. Less front cast speaker panel. Size 13¾ × 15 × 8½in. deep. Detachable lid with compartment for spare tape. Covered in green washable plastic material. P. & P. 4/6.

AMERICAN VALVE VOLTMETER

R.C.A. TYPE 165-A

D.C. ELECTRONIC VOLTMETER.
6-Ranges. 3–10–30–100–300 and 1,000 volts. Input res: 11-meg. constant on all ranges. Sensitivity: 3,666,666 ohms per volt on 3v. scale.

A.C. VOLTMETER.
5-Ranges. 0–10–30–100–300–1,000 volts. Sensitivity: 1,000 ohms per volt.

ELECTRONIC OHMMETER.
6-Ranges, from 0.1 ohms to 1,000 megohms.

Movement. 200 microamperes. D.C. accuracy ±2%.

COMPLETE WITH INSTRUCTION BOOK AND TEST PRODS, BRAND NEW.

Input 110–250 volts A.C.

ONLY £12/10/- P.P. 3/6

SPECIAL PURCHASE - LIMITED STOCKS BUY NOW

T/X TYPES AND SPECIAL PURPOSE VALVES

EF91 ... 5/-	2C43 ... 50/-	872A ... 15/-	8582 ... 15/-	5829 ... 10/-
EF92 ... 5/-	725A ... 35/-	2K25 ... 65/-	1B38 25/-	5839 ... 35/-
813 ... 65/-	726A ... 15/-	19G3 15/-	1632 ... 6/-	5840A 30/-
832 ... 30/-	726B ... 15/-	WL860 30/-	1644 ... 12/6	5852 ... 22/6
832A ... 35/-	723A/B 55/-	TZ40 35/-	5638 ... 15/-	5932 ... 30/-
829B ... 40/-	2J54 ... 35/-	CV129 45/-	5692 ... 30/-	5931 ... 35/-
QVO4/7 15/-	803 ... 22/6	CV2161 25/-	5703 ... 8/6	6004 ... 17/6
TT15 ... 45/-	805 ... 35/-	CV100 15/-	5722 ... 17/6	9005 ... 15/-
446A ... 12/6	35T ... 15/-	CV85 15/-	5726 ... 8/6	CK5785 8/6
446B ... 12/6	807 ... 7/6	1625 ... 5/-	5800 ... 45/-	
705A ... 15/-				

VOLTAGE STABALIZERS

OA2 ... ... 8/-	VR150/30 ... ... 6/-	QS1208 ... ... 10/-
OB2 ... ... 8/-	QS75/20 ... ... 10/-	STV/280/40 ... 15/-
VS70 ... ... 6/-	QS105/45 ... ... 10/-	STV/280/80 ... 25/-
VS110 ... ... 6/-	QS150/15 ... ... 10/-	OD3W 10/-
VR105/30 ... ... 6/-	QS1207 ... ... 10/-	

Over 600 commercial and industrial valve types in stock. Send for free lists.

V.H.F. TRANS/RECEIVER TYPE TRI920

★ **9.72 MC/S IF** ★ **4-CHANNEL CRYSTAL CONTROLLED**
★ **40 KC/S BANDWIDTH** ★ **100 to 120 MC/S COVERAGE**

Unit complete with 21 valves; crystal; 24 volt rotary power unit, etc., in metal case. In new condition with full circuit diagram.

£6/10/-, carr. 10/6. Circuits separately, 1/9 post free.

V.H.F. TRANS/RECEIVER TYPE 1986

★ **9.72 MC/S IF** ★ **10-CHANNEL CRYSTAL CONTROLLED**
★ **23 KC/S BANDWIDTH** ★ **124.5 to 156 MC/S COVERAGE**

Sub-units	Type	With valves	Less valves	P.P.
TRANSMITTER	81	60/-	25/-	2/6
RECEIVER	114	25/-	7/6	2/6
IF Amplifier	476	32/6	12/6	2/6
Modulator...	105	20/-	—	2/6
24 v. Rotary unit	3	15/-	—	2/6
10-way Control unit	382	6/-	—	9d.

All the above are in absolute new condition. Full circuits available, 1/9 post free.

MARCONI No. 19 SET CRYSTAL CALIBRATOR

CRYSTAL CONTROLLED OSCILLATORS: 10 Kc/s, 100 Kc/s and 1 Mc/s. On/OFF MODULATOR. With handbook. Unused. ONLY 79/6. P.P. 2/6.

DYNAMOTORS

24 volt D.C. to 230v. A.C. 50 c/s. 100 watts. £5. 10. 0. P.P. 7/6.
28 volts D.C. to 250 volts 60mA 12/6. P.P. 2/6.
12 volts D.C. to 220 volts 165 mA 32/6. post free.

SCR522 TRANSMITTER RECEIVER

All complete in new condition less valves.

Comprises BC624A and BC625 **15/-** P.P. 5/-

SMITHS 8-DAY CLOCKS

BRAND NEW SEALED CARTONS, 6in. dial 8-day clock with detachable adjustable time switch.

ONLY 95/- P.P. 5/-

QUARTZ CRYSTALS

FROM 5/- EACH

From 6 Kc/s–47 Mc/s. FT243, FT241, 10XJ and B7G.
All types for all purposes.
Send for Free List

WALKIE/TALKIE TYPE 38 TRANSMITTER/RECEIVER

Complete with 5 valves. In new condition. These Sets are sold without Guarantee, but are serviceable. (7 to 9 Mc/s.) 22/6 P.P. 2/6. Headphones 7/6 pair, Junction Box, 2/6. Throat Mike 4/6. Canvas Bag 4/-. Aerial Rod, 2/6.

R.C.A. SPEAKER

6in. P.M. in crackle cabinet. For AR88 and all communications receivers. **45/-** P.P. 2/6.

PACKARD BELL AMPLIFIER

(Low Imp. Mic. Pre-amp). Complete with screened case with 6SL7GT; 28D7; relay, leads, jack plugs; handbook, etc. Sealed in carton. Low impedance mic. pre-amp.

ONLY **12/6** P.P. 2/-.

182A INDICATOR UNIT

COMPLETE. INCLUDES VCR97 with Mu-metal screen; 3—EF50; 4—SP61; 5U4G; POTS; TRANSFORMERS, etc. **67/6** P.P. 5/-.

SURPLUS EQUIPMENT

New Free List of Units, Meters, Generators and Equipment, including Vibrators, Radar Units, RX/TX etc.

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Army Type 17 Mk. II

Complete with Valves, High Resistance Headphones, Handmike and Instruction Book and circuit. Frequency Range 44.0 to 61 Mc/s. Range approximately 3 to 8 miles. Power requirements: Standard 120 v. H.T. and 2 v. L.T. Ideal for Civil Defence and communications.

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44–61 Mc/s. Calibrated Wavemeter for same, 10/- extra. P.P. 2/-.

1933 RECEIVER CONTROL UNIT

BARGAIN OFFER 18 MINIATURE VALVES!!!! 8-EF91; 6-EF92; 2-EB91; EL91; IF's; RELAYS, ETC., ETC., IN CASE.

95/- P.P. 3/6

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0–20 v.	2in.	M.C. (DC) F.S.	7/6
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0–500 UA	3½in.	M.C. (DC) F.R.	59/6
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0–1 mA	2½in.	M.C. (DC) F.R.	22/6
2½–0–2½ mA	2½in.	M.C. (DC) F.R.	12/6
0–30 mA	2in.	M.C. (DC) P.	7/6
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0–10 mA	2½in.	M.C. (DC) F.S.	10/-
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0–750 mA	2in.	T.C. (RF) P.	6/-
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0–12 amp.	2½in.	T.C. (RF) P.	10/-
0–20 amp.	2in.	M.C. (DC) P.	7/6
0–30 amp.	2in.	M.C. (DC) F.S.	7/6
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FREE COMPLETE LIST ON REQUEST

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3-channel U.H.F. Receiver; uses plug-in crystals (not supplied): operating on 332.6; 333.8; 335 Mc/s. Unit contains 7—6AJ5; 28D7; 2—12SN7; 125R7; Relays etc. BRAND NEW and boxed: a bargain at **59/6** P.P. 5/-

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A self-contained Portable unit comprising the latest Collaro 4-speed Auto Changer Record Player, incorporating the famous High Fidelity Studio "O" Xtal Pick-up with Turnover Cartridge and fitted with L.P. and 78 Sapphire stylii. An internal 2 valve amplifier of modern design with variable tone and volume controls is fitted. This, together with a quality 6in. P.M. speaker, ensures a high standard of reproduction. The whole is housed in a robust wooden cabinet attractively styled in a maroon contemporary leather cloth with contrasting polka dot relief. A fortunate bulk purchase enables us to offer this commercially styled Player at the following attractive breakdown Unit prices:

Collaro 4-speed autochanger, **£6.19.6** + 4/6 carr.

2-valve, 2-stage amplifier, ready wired, complete with speaker, etc., **£3. 7.6** + 2/6 carr.

Cabinet with mounting board, etc. Size 18¼in. – 13¾in. – Ht. 8½in. **£2.12.6** + 3/6 carr.

This is a recommended bargain buy and when present stock is exhausted cannot be repeated. Originally built to be sold at 17 gns.

This complete 3 unit "Do-it-yourself" Record Player Kit offered at amazing bargain price of

£12.19.6

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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 stylii. Auto stop and start. A fidelity unit and bargain buy at only £6.19.6.

SINGLE PLAYERS. BSR (TU9), 90/-; COLLARO (4/564) 6 gns.; GARRARD (4SP) £7.10.0.. Carr. and ins. 3/6.

AUTOCHANGERS. BSR (UA8), £6.19.6., COLLARO £7.19.6; GARRARD (RC121 4D Mk. II) plug-in head, stereo adapted, 10 gns. Stereo head £2 extra.

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Contemporary styled 18in. × 13in. × 8in., 3gns. Carr. and ins., 3/6.

2-VALVE 2-WATT AMPLIFIER

Twin stage ECL82 with vol. and neg. feedback. Tone controls AC. 200/250 v. with double-wound Mains trans. Complete with knobs, etc., ready wired to fit above cabinet.

£2.17.6 P. & P. 1/-.

6-in. Speaker and matching trans., 22/- P. & P. 1/6.

COSSOR VHF/FM CONSTRUCTORS KIT (Model 701K).

This is a 6-valve (UCC85, 2UF89, UABC80, UL84, UY85) FM Radio Kit of high quality design and superb reproduction, with pre-aligned coils and printed circuit complete with Power Pack for AC/DC 200/250 v. operation. Kit includes High Performance 10in. × 6in. Goodmans Speaker for quality response. Complete in every detail, including calibrated Tuning Dial, Slow Motion Drive and Pilot Lamp and comprehensive instruction details and circuit diagram this Kit is a genuine recommended buy.

BARGAIN OFFER

Listed at 15gns. **Only £8.19.6**

Carr. and Ins. 4/6

TRANSISTOR 'ONE-WATT' AMPLIFIER

6 v. Battery operated

Latest Push-Pull, 4 Transistor circuit giving full 1 watt Output into standard 3 ohm speaker. Good sensitivity and improved freq. response. Neg. feedback. Var. Tone and Volume Controls. Chassis Size 6¾in. × 3¾in. × 1¾in. Current consumption 10 mA quiescent—250 mA at 1 watt.

2 matched GEC GET15 Transistors 42/- pr.
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Driver Trans. 8/6
Output Trans. (to 3 ohms)..... 10/6
Complete Kit of Parts incl. circuit etc., less speaker, ONLY **99/6** P. & P. 2/6.

Circuit and instruction booklet 1/6 *post free*

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4 valve, Med. & L.W., l'tweight battery Radio. Size only 8in. × 5¼in. × 4in. Weight 3¼lb. with battery :— P. & P.
Complete receiver component kit 57/6 1/6
Set 4 miniature valves (96 series) 35/- 9d.
5in. Speaker & O/put Trans..... 21/- 1/6
Cabinet, Dial and Knobs, etc.... 22/6 2/-
Latest superhet circuitry, delayed AVC and A.F. Neg. feedback.

Complete kit—BARGAIN—only £6.10.0, post free

Terrific performance—Remarkable size—Staggering Value

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6K8	8/6	EF80	9/6	PL81	12/6
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DAF96	9/-	EL41	10/6	PY80	7/6
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SPECIAL PRICE PER SET

IR5, IT4, 185, or 384 or 3V4, 27/6.
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COAX 80 OHM CABLE.

Stand ¼in. diam. Low Loss Semi-Air Spaced Aeraxial.

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MULLARD "3-3" AMPLIFIER

Quality built to Mullard's specification, with special sectionalised O/P Trans.
Complete kit with front panel only £6.19.6. P. & P., 3/6.

2 WAVEBAND CAR RADIO KIT

12 v. operation Med. & Long Waves

Modern development of the famous Brimar Hybrid vibratorless car radio circuit. Five latest type Brimar low voltage valves and power transistor. R.F. stage and permeability pre-aligned Cyldon Tuner Unit provide extremely good sensitivity and signal/noise ratio. Printed circuit for easy construction and 7 × 4in. elliptical speaker for fidelity output. Self-contained in neat metal cabinet 8 × 7 × 2½in. with attractive calibrated dial. Speaker and power transistor stage mounted separately, approx. 8 × 5 × 3in.

Recommended Buy *Complete Kit. Bargain Price* **£12.19.6**

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New improved types—mains prim. 200/250 v. tapped

All Isolation Transformers now supplied with alternative *no boost, plus* 25% and *plus* 50% boost taps at no extra charge.

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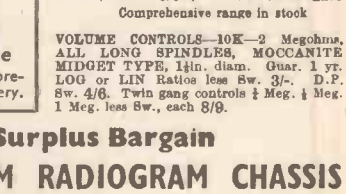
VOLUME CONTROLS—10K—2 Megohms, ALL LONG SPINDLES, MOCCANITE MIDGET TYPE, 1¼in. diam. Guar. 1 yr. LOG or LIN Ratios less Sw. 3/-. D.P. Sw. 4/6. Twin gang controls ¼ Meg. ¼ Meg. 1 Meg. less Sw., each 8/9.

Manufacturer's Surplus Bargain

7 VALVE AM/FM RADIOGRAM CHASSIS

Valve Line-up: ECC85, ECH81, EF89, EABC80, EL84, EM81, EX80



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Complete with 4 Knobs—walnut or ivory to choice.
Three ohm P.M. speaker only required. Recommended quality speakers.
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Post & Pkg. 1/6

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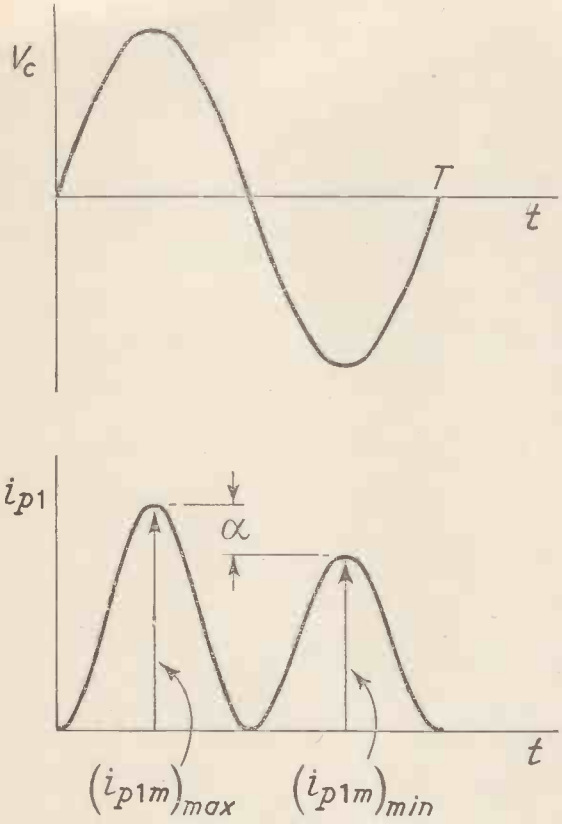

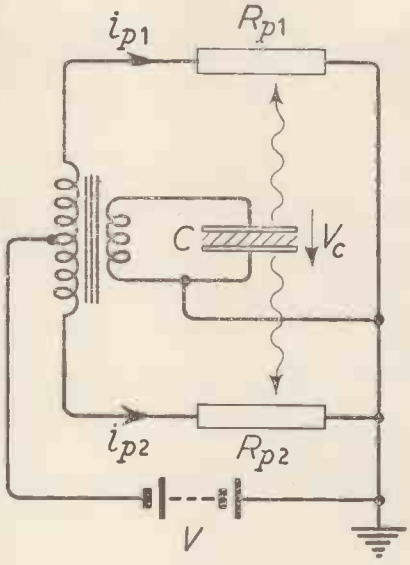

Electroluminescent Cell Applications

An article in the November issue of *Electronic & Radio Engineer* describes an experimental investigation of electroluminescent-cell applications in amplifiers and multivibrators. Experimental and theoretical results of circuits using a combination of El-cells and photoconductors are given.

OTHER ARTICLES IN THE NOVEMBER ISSUE INCLUDE:

Magnetic Measurements with Bridged-T Networks
This article describes how the bridged-T network can be usefully employed for the measurement of magnetic loss and a.c. permeability under different conditions of excitation in the core.

Cathode-Coupled Push-Pull Output Stage
The operating conditions of the cathode-coupled push-pull stage as a power amplifier are discussed in this article. It is shown, among other things, that there is an optimum value for the common cathode resistor for minimum distortion.

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

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PRECISION SERIES 834-S. (U.S.A.). Multi range tester for A.C./D.C. volts, ohms and milliamps. Basic movement 400 microamps. Housed in wooden box with carrying strap. Overall size 7½ × 7in. × 5in. Complete with test prods, batteries, etc. Ready to use, **£4/19/6.** Post 2/6.

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HEAVY DUTY LT TRANSFORMERS. 230 v. 50 cycles pri. 17 v. sec. at 35 amps., capable of carrying 25% over actual rating. Perfect condition. ONLY **115/-** each, either type. Carr. 5/-.

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MARCONI SIGNAL GENERATOR. TYPE TF517-F/1. Covering 10-18 Mc/s. 33-58 Mc/s. 150-300 Mc/s. Used but in very good condition. Complete with full technical data and instructions. Limited quantity. Unrepeatable at only **£12/10/-.** Carr. 20/-.

ALSO MARCONI SIGNAL GENERATOR TYPE TF390G for 200-250 v. A.C. mains input. Frequency range 4-16 Mc/s. and 32-100 Mc/s. indirect calibration. Output 1 uV to 100 M/V. 400 c/s internal modulation. In good order. Only **£12/10/-.** Carr. 20/-.

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CONDENSERS. Mixed parcel, good assortment of types and values. 50 for **10/-.** P. & P. 1/-.

TELEPHONE DIALS. Standard (G.P.O.) Pattern. 0-9. Brand New. **30/-.** P. & P. 1/-.

ACCUMULATORS 12 v. 25 A.H. New and unused. Housed in strong wooden case for extra protection, **45/-.** Carr. 7/6. **2 v. 100 A.H.** 75 actual. Ex Govt. New and unused. Complete with carrying handle. Size 6½ × 6½ × 3½in., **15/-** each. Carr. 3/6. 3 sent for **50/-**, or 6 for **£5**, carr. paid. Ditto **16 A.H., 5/-.** P. & P. 2/-; 6 for **24/-.** P. & P. 10/-. Ditto **14 A.H.,** less handle, **5/-.** P. & P. 2/-; 6 for **24/-.** P. & P. 10/-.

IDEAL XMAS GIFT!

"AGFA" Long-play Tape 1,800ft. on 7in. spools. Brand New. Special Xmas Price. **32/-** each. 2 for 3 gns. P. & P. 1/-.

Send S.A.E. for money-saving price list of other tape bargains!

TRUVOX TANNOY LOUD-HAILERS With 180 ohm line transformer and condenser. Impedance 7½ ohms, handling capacity 8 watts. Complete in slope-front wooden case. Brand new and unused. **18/6.** P. & P. 3/6 2 for **42/-.** Post paid

SELENIUM METAL RECTIFIERS, FULL BRIDGE

6 or 12 v. 1 amp. **7/6**;	24 v. 1 amp. **18/6**;		
12 v. 2 amp. **10/–**;	24 v. 2 amp. **20/–**;		
12 v. 2½ amp. **15/–**;	24 v. 2½ amp. **25/–**;		
12 v. 4 amp. **16/6**;	24 v. 4 amp. **30/–**;		
12 v. 6 amp. **23/6**;	24 v. 6 amp. **35/–**;		
12 v. 10 amp. **40/–**;	24 v. 10 amp. **80/–**.		

RE-ENTRANT LOUD HAILERS (Ex-Govt.) Heavy duty 20 watts all-metal 15 ohms. Diameter 15in., length 15in. (approx) Good condition. **£6/10/-.** Carr. 10/-. Ditto. Brand new. **£8.** Carr. 10/-.

BAKER'S SELHURST SPEAKERS

12in. P.M. 15 ohms 15 watts, 30-14,000 c.p.s. Our price **£4/10/-.** HH

"AUDITORIUM" 12in. 15 ohms 1 2watts, 35-16,000 c.p.s. Flux density 14,500. OUR PRICE, **£7/10/-.**

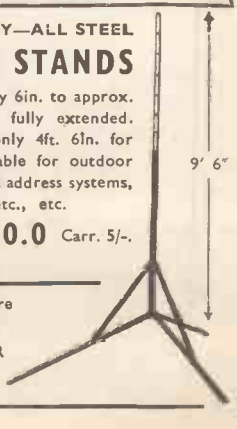
"SUPER-HI-FI 25" 12in., 15 ohms, 25 watts 25-20,000 c.p.s. Flux density 17,600. OUR PRICE, **£9/9/-.** All the above speakers are Brand new and full descriptive specification is available.

HEAVY DUTY—ALL STEEL

TRIPOD STANDS

Adjustable every 6in. to approx. 9ft. 6in. when fully extended. (Folds up to only 4ft. 6in. for storage). Suitable for outdoor speakers, public address systems, floodlighting, etc., etc.

OUR PRICE **£3.10.0** Carr. 5/-.



These stands are ideal for our RE-ENTRANT LOUD HAILER as described above.

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 3/6.

CRYSTAL CALIBRATOR No. 10 A crystal controlled heterodyne wavemeter covering 500 K/cs. to 10 Mc/s. (Harmonics up to 30 Mc/s.) Requires 15 m/a. and 12 v. 0.3 A. d.c. but can be easily modified for 120 v. and 1.4 v. working. Size 7×7½×4in. First class condition, complete with valves, crystal, instruction manual and circuit. ONLY **59/6.** Post 3/6.

CHOKES. Parmeko 5 H. 200 m/amps., **6/6.** HRO chokes, 17 H., 80 m/amps., **7/6.** AR-88 chokes, 15 H., 90 m/amps., **8/6.** Parmeko 8 H, 100 m/amps., **7/6.** Postage any type, **1/6.**

Q'SER (BC-453) This Command Receiver covers 190-550 Kc/s.-(I.F. 85 Kc/s.) and is ideal for double superhet conversion etc. Supplied BRAND NEW in original cartons, with all 6 valves and CIRCUIT. **89/6.** Post 3/6.

SELENIUM BRIDGE RECTIFIERS. Funnel cooled. A.C. input 45 v. RMS. D.C. output 30 v. 10 amps. BRAND NEW. Boxed. **45/-.** Post 3/6.

HEAVY DUTY L.T. TRANSFORMERS. (Gresham.) Latest type potted, oil filled, Pri. 230 v. 50 c/s. Sec. 0-70-75-80 v. 4 amps. Size 5½×4½×6½in. high. Wt. 19 lb. BRAND NEW. **42/6,** carr. 5/-. Gardner's Transformer. Tapped mains input. Secondary 12 volts RMS. (C.T.). 30 amps. Housed in sheet metal case 9¼×8½×6½in. high. BRAND NEW. **72/6,** carr. 7/6.

DUAL PURPOSE TRANSFORMERS (Gresham). Pri. 230/250 v. Secs. 240-0-240 v. 1.5 amps., 5 v. 12.5 amps. 5 v. 1.75 amps. Ideal for ISOLATING TRANSFORMER, to obtain TWO 240 v. 360 watt lines. Potted, oil-filled, 7×7½×10½in. high. Wt. 50 lb. **BRAND NEW. £3/10/-.** Carr. 10/-.

ADVANCE CONSTANT VOLTAGE TRANSFORMERS. Input 190-260 v., 50 c/s. A.C. mains. Output 230 v. 250 watts. **10 Gns.** Carr. 7/6.

STANDARD TRANSFORMERS. Vacuum impregnated, interleaved, E.S. screen, universal mounting. Size 4×3½×2½in. ALL BRAND NEW. **18/6** each. Post 1/6.
Type 1. 250-0-250 v. 80 m/a., 6.3 v. 3 A., tapped at 4 v., 4 A., 6.3 v. 1 A. tapped at 4 v. and 5 v. 2 A.
Type 2. As above, but 350-0-350 v. 80 m/a.
Type 3. 30 v. 2 A., tapped at 12, 15, 20 and 24 v., to give 3-4-5-6-8-9-10 v., etc. Ideal for models, trains, etc.

6-VOLT VIBRATOR PACKS. HRO type, 180 v. D.C., 65 m/amps. BRAND NEW. **29/6,** post 3/6. Type PU2, 200 v. D.C. 100 m/amps., with OZ4 rectifier. **BRAND NEW. 25/-.** Post FREE.
CRYSTALS. 200 Kc/s. American GEC, **10/-** each. 100 Kc/s. RCA bars, **15/-.**

ADMIRALTY HT TRANSFORMERS Pri. 230 v. 50 c/s. Secs. 620-550-375-0-375-550-620 v. (620 and 550 v. 200 m/amps., 375 v. 250 m/amps.), plus two 5 v. 3 Amp. rectifier windings. Total rating 278 VA. Upright mtg. Wt. 25 lb. Made 1953. **BRAND NEW.** Original boxes. **45/-.** Carr. 5/-.

INSTRUMENT TRANSFORMERS. 230 v. A.C. input. Outputs 0-65-130-195 v. 85 m/amps., 6.3 v. 5 amps., 6.3 v. 0.3 amps. Shrouded. Size 3½×3½×3¾in. high. **15/-,** post FREE.

AR88D MAINS TRANSFORMERS. Input 110-240 v. Output 345-0-345 v. 125 m/amps., 6.4 v., 4.5 amps., 5 v. 2 amps. 4¾×4½×5½in. high. Wt. 12 lb. Potted. Tag ends. RCA BRAND NEW. Boxed. **29/6,** post 3/6.

MARCONI CR100

Completely overhauled. In perfect working order. LOOK LIKE NEW. **£21.**
Later model with Noise Limiter, **£25.**
Carr. Eng. and Wales 30/-. Send S.A.E. for full details.

RCA AR-88 SPEAKERS

A high quality 3 ohm unit fitted into heavy gauge black crackled steel cabinet, size 10½×11½×6in. Fitted with rubber feet and 6ft. lead. Ideal for extension speaker, CR100, etc. In original cartons. BRAND NEW. **45/-.** Post 3/6.

CR150 COMMUNICATIONS RECEIVERS

Covers 2–60 Mc/s. in 5 ranges. Double superhet, with 2 EF50 R.F. stages, 500 Kc/s. crystal calibrator, H.T. stabiliser, "S" and valve-check meter, audio filter, etc. Variable selectivity, using TWO double-crystal band-pass filters. External power supply required, 300 v. D.C. 65 m/Amps, and 6.3 v. 3.7 Amp. Size and appearance similar to CR100. In superb condition and working order, **£45.** Carr. 30/-.

LOUD HAILER EQUIPMENT

IDEAL FOR CROWD CONTROL, FACTORIES, FETES, ETC. CONSISTS OF 4 SPEAKER UNITS AND CONTROL UNIT, COMPLETE WITH MICROPHONE, HEADPHONES, AND SPARES. OPERATES FROM 12 VOLTS D.C. (OR 6 VOLTS D.C. WITH SLIGHTLY REDUCED OUTPUT), CONSUMING ONLY 3 AMPS. OUTPUT POWER 8 WATTS. ALL TESTED AND WORKING, BUT SLIGHTLY SOILED. A GENUINE BARGAIN. **£4/19/6.** CARRIAGE **25/6.**

MORE METER BARGAINS

Range	Type	Size		Price
25 Microamp.	D.C. M/C	2½in.	Flush Circ. Scale "Rontgens"	69/6
25 Microamp.	D.C. M/C	2½in.	Proj. Circ. Scale "Röntgens"	59/6
50 Microamp.	D.C. M/C	3½in.	Flush Circ. Scale "Tolerance"	79/6
50 Microamp.	D.C. M/C	2½in.	Flush Circ. scaled 0–100 v.	59/6
100 Microamp.	D.C. M/C	3½in.	Flush Circ. Scale 0–50/0–1,000 v.	62/6
100 Microamp.	D.C. M/C	2½in.	Flush Square	42/6
1 Milliamp.	D.C. M/C	3½in.	Flush Circular	50/–
1 Milliamp.	D.C. M/C	3½in.	Flush Squ. Scaled 0–250v.	69/6
200 Milliamp.	D.C. M/C	2½in.	Flush Circular	10/6
1 Amp. Thermocouple		2½in.	Projecting Circular ...	6/9
300 Volts	A.C. M/I	6in.	Flush Circular. Made 1955	79/6
300 Volts	A.C. M/I	2½in.	Flush Circular	25/–
500 Volts	A.C. M/I	2½in.	Flush Circular	25/–
40 Amperes	D.C. M/C	2in.	Flush Circular	7/6

METAL RECTIFIERS. Full wave bridge. BRAND NEW. Salford 1 mA. 8/6, 5 mA. 8/6. STC 2 mA. 5/6.

MINIATURE 373 IF STRIPS. For FM tuner described in "Practical Wireless." Complete with 3 of EF91, 2 of EF92 and 1 of EB91. A fresh release enables us to offer these once again. BRAND NEW. Complete reprint of conversion instructions and circuit supplied free. **35/–.** OR less valves, **12/6.** Post, either 2/6.

DECADE RESISTANCE BOXES. Type 750L. Manufactured by Daven Co., U.S.A. Five decades 1Ω to 111, 110Ω. In oak cases with aluminium top and copper lining. BRAND NEW. **£10/10/-.** Post 3/6.

MINIATURE RELAYS (ALL BRAND NEW AND BOXED)
G.E.C. sealed, wire ends, 670Ω, 2 H/D makes, M1099 ... 15/–
G.E.C. sealed, wire ends, 670Ω, 4 C/overs, platinum, M1092 19/6
G.E.C. sealed, wire ends, 5000Ω, 2 C/overs, platinum, M1052 17/6
Siemens High Speed, 1K+1KΩ, 1 C/over 10/6

HRO SENIOR RECEIVERS

Complete with ALL NINE general coverage plug-in coilsets for 50 Kc/s. to 30 Mc/s. Instruction booklet, and circuit, but less external power supply unit. Table models, as new condition, **21 GNS.** Rack mounting, 18 GNS.. Packing and carriage 22/- extra. Send S.A.E. for further details.
HRO POWER PACKS. 115/230 v. A.C. mains input. Tested, and in good condition. Table or rack, 69/6, post 4/-.

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One minute from Leicester Sq. Station (Up Cranbourne St.)
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SANGAMO-WESTON VOLTMETERS S61. Dual range 0-5 and 0-100 v. D.C. FSD 1 m/A. 3in. scale. Recent manufacture. Ideal for schools. Complete in super quality canvas carrying case, with test prods and leads. **BRAND NEW.** Boxed **27/6.** Post 2/6.

SANGAMO-WESTON ANALYSER E772. A useful multi-range meter in rexine covered carrying case. Thoroughly overhauled and in perfect working order. For full details see previous adverts. **£7/19/6.** Carr. 4/6.

AVO LC & R BRIDGES. 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. For use on A.C. mains. Tested and guaranteed. **£8/10/-.** Post 3/6.

HICKOCK 1-177 VALVE TESTERS. Checks dynamic mutual conductance, shorts, emission, gas, and noise. For UX4, UX5, UX6, UX7, Octal, Loctal, B7G, and Acorn types. Portable, in wooden carrying case 15½×8×5½in. Wt. 13½ lb. BRAND NEW. Complete with instruction book and valve testing charts. For 117 v. A.C. 10 gns. Carr. 7/6. Matching auto. transformers for 230 v. A.C. **12/6.**

MARCONI TF987/1 NOISE GENERATORS. Range 100 Kc/s. to 200 Mc/s. Determines noise factor of AM and FM receivers. Fully stabilised H.T. supply. A.C. mains operation. Brand new and in original boxes. **£25.**

MARCONI SIGNAL GENERATORS 85 Kc/s. to 25 Mc/s. A.C. mains operation. In fair condition and good working order. TF144F. **£40.** TF144G. **£50.**

MARCONI TF.340 OUTPUT METERS. Perfect working order. **£19/10/-.**

SCR522 TRANSMITTER/RECEIVERS. 100-150 Mc/s. Comprises BC624A rec., and BC625 trans. with valves, and in good condition. BC624A, less relay **19/6.** With relay, **25/-.** BC625 **22/6.** These two, on rack **47/6.** Carr. 7/6.

MOVING COIL PHONES. Finest quality Canadian, with chamois ear-muffs and leather-covered headband. With lead and jack plug. Noise excluding and supremely comfortable. **19/6.** Post 1/6.

INVICTA LOUDSPEAKERS. Good quality 10in. unit (impedance 3 ohms). In wooden cabinet 17×17×6in. Complete with 50ft. lead and jack plug. BRAND NEW. **39/6.** Carr. 5/6.

VITAVOX PRESSURE UNITS TYPE N. 20 watts. P.M. Heavy duty. BRAND NEW, boxed. **89/6.** Carr. 5/6.

RESISTORS
Morgan "T" (½ watt) and "R" (1 watt). Latest types, all BRAND NEW. 100 assorted, 10/-. Post 1/-.

HEAVY DUTY SLIDER RESISTORS. 1.25Ω 20 A., **12/6,** post 3/6. 1Ω 12 A., 8/6. Zenith adjustable 25Ω 4 A., **8/6,** post 2/6.

PRECISION RESISTORS. 1 megohm 1% 1 watt wire wound. Ex-U.S.A. BRAND NEW. **10/6** per dozen.

DC/AC CONVERTERS. Input 12 v. D.C. Output 230 v. 50 c/s. A.C. at 135 watts. Fitted with 0-300 v. A.C. 2½in. meter and slider resistor for voltage adjustment. In stout wooden carrying case with lid. Perfect working order, **£9/19/6.** Carr. 10/6.
24 v. Input 230 v. A.C. 50 c/s. 100 watts output. In grey metal case. BRAND NEW. **92/6.** Carr. 7/6.

RADIATION METERS. Portable dose-rate meter, containing modern type rectangular 50 microAmp meter, CVX494 electrometer valve, etc. BRAND NEW. In canvas carrying case. **£3/19/6.** Post 2/6.
For details of other equipment, see our previous adverts.

D.C. OSCILLOSCOPE

A.C. MAINS 200-250 VOLTS

SIMPLIFIED SERVICING PROBLEMS WHEN USING THE 'TESTGEAR' SCOPE

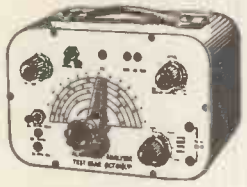
3in. D.C. OSCILLOSCOPE

Engineered to precision standards, this high-grade instrument is made available at the lowest possible price, incorporating the essential features usually associated with luxury instruments. This "SCOPE" will appeal particularly to Service Engineers and Amateurs. A high gain, extremely stable differential Y-Amplifier (30 mV/C.M.). Provides ample sensitivity with A.C. or D.C. inputs. Especially suitable for measurement of transistor operating conditions where maintenance of D.C. levels is of paramount importance. Push-pull X amplifier; Fly-back suppression; Internal Time-base Scan Waveform available for external use; pulse output available for checking T.V. Line O/P Transformers, etc.; Provision for external X I/P and CRT. Brightness Modulation. Size 10in. high, 6¼in. wide, 9in. deep. Wgt. 11½lbs. £15.15.0 plus P. & P. 7/6, or 30/- deposit, plus P. & P. 7/6 and 12 monthly payments of 26/6.

FULL 12 MONTHS' GUARANTEE INCLUDING VALVES AND TUBE

ALIGNMENT ANALYSER TYPE MC12

A.C. MAINS, 200/250 volts. Provides:—"WOBBULATOR" (SWEPT FREQUENCY) OPERATION, for FM/TV alignemt linear frequency sweep up to 12 mc/s. From 400 kc/s.—80 mc/s. CAPACITANCE MEASUREMENT. Two ranges provided 0—60 pf and 0—120 pf. SPECIAL FACILITY enables true resonant frequency of any tuned cct, I.F. transformer etc. to be rapidly determined. Cash price £6.19.6 and 5/- P. & P. H.P. terms, 25/- deposit and 5/- P. & P. and 6 monthly payments of 21/6.



B.S.R. MONARCH UA8 with FUL-FI HEAD

4-speed plays 10 records 12in., 10in., or 7in. at 16, 33, 45 or 78 r.p.m. Intermixes 7in., 10in. and 12in. records of the same speed. Has manual play position; colour brown. Dimensions: 12½in. × 10½in. Space required above baseboard 4¾in., below baseboard 2¾in. Fitted with Full-Fi turnover crystal head. £6.19.6 Plus 5/- P. & P.

STEREO HEAD £7.19.6 Plus 5/- P. & P.

PLAYER CABINET

Finished in 2-tone leatherette, will take B.S.R. UA8, with room for amplifier and 7in. × 4in. speaker. Overall size 15½in. × 13½in. × 9½in.

Similar to the above in POLISHED WALNUT, will take Collaro.

39/6 Plus 5/- P. &P.

CHANNEL TUNER

Will tune to all Band I and Band III stations. BRAND NEW by famous manufacturer. Complete with P.C.C. 84 and P.C.F. 80 valves (in series) I.F. 16-19 or 33-38. Also can be modified as an aerial convertor (instructions supplied). Complete with knobs, **22/6** Plus 3/6 P. & P.

HEATER TRANSFORMER to suit the above, 200-250 v., 6/- Plus 1/6 P. & P.

AC/DC POCKET MULTI-METER KIT

Comprising 2in. moving coil meter, scale calibrated in A.C./D.C. volts, ohms and milliamps. Voltage range A.C./D.C. 0-50, 0-100, 0-250, 0-500. Milliamps. 0-10, 0-100. Ohms range, 0-10,000 Front panel, range switch, wire-wound pot (for ohms zero setting), toggle switch, resistors and rectifier. Basic movement, 2mA. In grey hammer finish case.

19/6 Plus P. & P. 1/6. Built and tested 7/6 extra

point-to-point wiring diagram 1/- free with kit.

MAINS TRANSFORMERS

All with tapped primaries 200-250 volts.

0-160, 180, 200 v., 60 ma. 6.3 v. 2 amps, 10/6. 320-0-320 v. 75 ma., 6.3 v., 2.5 amp., 5 v., 2 amp., 10/6. 280-0-280, 80 ma., 6.3 v., 2 amp., 6.3 v., 1 amp., 10/6. Postage and packing on the above 3/-.

SIGNAL GENERATOR

Covering 100 Kc/s-100 Mc/s. on fundamentals and 100 Mc/s. to 200 Mc/s. on harmonics. Metal case 10in. × 6¾ in. × 5¼in. grey hammer finish. Incorporating three miniature valves and Metal Rectifier. A.C. Mains 200/250 v. Internal Modulation of 400 c.p.s. to a depth of 30%. Modulated or unmodulated R.F., output continuously variable 100 millivolts C.W. and mod. switch, variable A.F. output. Incorporating magic-eye as output indicator. Accuracy plus or minus 2%.

£6/19/6 Or 25/- deposit and 6 monthly payments of 21/6 Post & Packing 5/- extra.

SIGNAL GENERATOR

Coverage 120 Kc/s—230 Kc/s., 300 K/cs.—900 Kc/s., 900 Kc/s.—2.75 Kc/s., 2.75 Mc/s.—8.5 Mc/s., 8 Mc/s.—28 Mc/s., 16 Mc/s.—56 Mc/s., 24 Mc/s.—84 Mc/s. Metal case 10in. × 6¾in. × 4¼in. Size of scale 6¾in. × 3¾in. 2 valves and rectifier A.C. mains 230-250 v. Internal modulation of 400 c.p.s. to a depth of 30 per cent. modulated or unmodulated R.F., Output continuously variable 100 millivolts C.W. and mod-switch variable A.F. output and moving coil output meter. Grey hammer finish case and white panel. Accuracy plus or minus 2%. **£4/19/6**

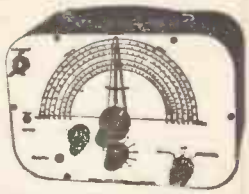
Or 25/- deposit and 4 monthly payments 21/6. P. & P. 5/- extra.

SIGNAL & PATTERN GENERATOR

£6/19/6 P. & P. 5/-

Or 25/- deposit. P. & P. 5/- and 6 monthly payments of 21/6.

Coverage 7.6 Mc/s.-210 Mc/s. in five bands, all on fundamentals., slow motion tuning audio output. 8 vertical and horizontal bars, logging scale. In grey hammer finished case with carrying handle. Accuracy ±1% A.C. mains 200-250 v.

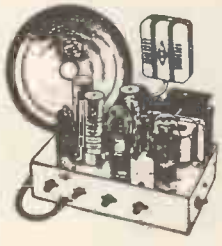


F.M. TUNER UNIT

Permeability tuned by famous German Manufacturer. Coverage 88—100 Mc/s Complete with ECC85. Size 4in. × 2in. × 2in.

25/- Plus P. & P. 1/6 Circuit diagram free with unit. **1/-**

10.7 Mc/s. I.F. and Discriminator Coil 2/6 pair.



8 WATT PUSH-PULL AMPLIFIER

COMPLETE WITH CRYSTAL MIKE AND 8in LOUDSPEAKER

A.C. mains 200/250 v. Size 10¼in. × 6¼in. × 2¼in. Incorporating 6 valves, H.F. pen., 2 triodes, 2 output pens, and rectifier. For use with all makes and types of pick-up and mike. Negative feed-back. Two inputs, mike and gram., and controls for same. Separate controls for Bass and Treble lift. Response flat from 40 cycles to 15 Kc/s, ±2 db: 4 db. down at 20 Kc/s. Output 8 watts at 5%, total distortion. Noise level 40 db down, all hum. Output transformer tapped for 3 and 15 ohm speech coils. For use with Std. or L.P. records, musical instruments such as Guitars, etc.

£4.19.6 Plus P. & P. 7/6

Or £1 deposit, plus P. & P. 7/6 and 4 monthly payments of 23/-

6 watt PUSH-PULL AMPLIFIER

A.C. mains 220/250 v. incorporating 4 valves and metal rectifier, 2 inputs, high and low, and controls for same. Separate controls for Bass and Treble lift. Size of chassis 11in. × 4½in. × 2½in.

59/6 P. & P. 5/- Plus

2-TRANSISTOR POCKET RADIO

Plus Germanium diode, fully tuneable over medium and long waves. Size 3¼in. × 4in. × 1¾in. Complete set of components including case, 2 transistors and earpiece (less batteries), Point to point wiring diagram 1/6. (Free with kit).

Plus **19/6** P. & P. 1/6.

PUSH-PULL OUTPUT STAGE

Inclusive of transistors with input and output transformers to match 3 ohm speech coil, suitable for use with the above kit. Complete kit of parts including transistors. Point to point wiring diagram 1/6. (Free with kit.).

Plus **19/6** P. & P. 1/6.

RADIO AND T.V. COMPONENTS (ACTON) LTD.

23, ACTON HIGH STREET, LONDON, W.3

GOODS NOT DESPATCHED OUTSIDE U.K. ALL ENQUIRIES S.A.E.

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Readers are warned that Government surplus components and valves which may be offered for sale through our displayed or classified columns carry no manufacturers' guarantee. Many of these items will have been designed for special purposes making them unsuitable for civilian use, or many have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such items purchased.

NEW RECEIVERS & AMPLIFIERS

AM/FM stereo chassis, 6w. output with 2 speakers, only £20.— Bel Sound Products, Marlborough Yard, N.19. [0182

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

AR88D, excellent condition, complete, speaker, handbook, table mounting, £50 cash.—Box 5854.

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

T.V. RECEIVERS—SURPLUS AND SECONDHAND

MULLARD Optical Unit, 30/-; Philips Projection Chassis, working, £7/10/0.—Hall, 24 Nevern Mansions, Warwick Road, S.W.5. Fremantle 9631. [8817

TRANSMITTING EQUIPMENT—SURPLUS AND SECONDHAND

TEN Signals Vans fitted complete with R 10 units, 2 Wireless senders, 2 Reception sets, 2 Power supply, 1 Unit Pulser, 1 Monitor, Auto Transformer 1.6 kVA. 50 cycles 130/25 volts. Offers for whole or part.—Broadbent Bros. (Nottm.) Ltd., Dalesde Road, Nottingham. Telephone 53927. [8703

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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. [0056

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ALL types of valves British or American, transmitting and receiving; keenest cash prices paid. What have you to offer?—Write or call Lowe Bros., 9a, Diana Place, Euston Rd., N.W.1. Tel. Euston 1636-7. [8494

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A PROMPT cash offer for your surplus brand new valves, speakers, components, test instruments, etc.—R.H.S., 155, Swan Arcade, Bradford, 1. [0190

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Service, Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [0163

URGENTLY wanted, manuals or instruction books, data, etc., on American or British Army, Navy or Air Force radio and electrical equipment.—Harris, 93, Wardour St., W.1. Gerrard 2504. [8550

WANTED BC614E or H. Special Amplifiers (£17/10/-), Junction Boxes J.B.70 (£10); also B.C.610 Hallicrafters and E.T.4336 Transmitters and spare parts for all above.—P.C.A. Radio, Beavor Lane, Hammersmith, Riverside 8006. [0079

WANTED, good quality communication RYS tape recorders, test equipment, domestic radios, record players, amplifiers, valves, components, etc., estab. 18 years.—Call, send or 'phone Ger. 4638, Miller's Radio, 38a, Newport Court, Leicester Square, W.C.2. [8563

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e vacancies at the Jodrell Bank Experimental Station for Instrument Makers and Electronic Technicians to work on the instrumentation of British Artificial Satellites. Salaries to be negotiated according to rates applicable in these trades.
APPLICATIONS should be sent to The Director, Jodrell Bank Experimental Station, Lower Withington, Macclesfield, Cheshire. [8819

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WE need electronic and mechanical engineers at all levels to work in this new and developing sphere. There is plenty of scope for originality and thought. The working conditions are good, the atmosphere is friendly, we pay you well and we pension you off if you would rather not die in harness. We could also do with a good circuit engineer, familiar with transistors.
IF you are interested, please write or telephone: Michael Cohen, B.Sc. (Hons.), Chief Engineer, ARDENTE Acoustic Laboratories Ltd., 8/12, Minerva Rd., North Acton, London, N.W.10. ELGar 3923. [8786

MIDDLESEX COUNTY COUNCIL Education Committee.
BRUNEL COLLEGE OF TECHNOLOGY Woodlands Avenue, Acton, W.3.
GRADUATE Assistant (Research Student).
THERE is a vacancy for a Graduate Assistant in the Department of Electronics to undertake a research project in the field "Radio Receiving Techniques and Aerials", covering the frequency range from 100 Mc/s to microwaves. A GRANT of £400 per annum is available. The Assistant may prepare for a Higher Degree.
APPLICATION forms from the Registrar [8802

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REQUIRE at once for work on High-Class Audio Equipment, Male Fault Finders and Testers.
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APPLY as above or ring Hainault 4151 for interview. [8794

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TECHNICIAN required for maintenance of electromedical apparatus. Qualification at least to Ordinary National Certificate. Knowledge of mechanical engineering an advantage. Salary (at age 26+) £620 rising to £730.
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12 POSTS for men fully skilled and experienced in the trade, able to teach it and to supervise trainees. Appropriate O.N.C., C. & G. Certificate or equivalent qualification desirable. Selection by trade test and interview. Starting salary £615 (at age 21)—£750 (at age 26 or over), rising to £925 (National Rates). Write for details to C.E.P.O., Personnel Lines, Catterick Camp, Yorkshire. Closing date 15th December, 1959. [8772

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APPLICANT must be prepared to work on own initiative without supervision. Starting salary, according to age and ability with a possibility of rising to £1,000 per annum.
APPLY: Electronics Department, Fringevision Limited, Marlborough, Wilts. [8701

HI-FI and Tape—Vacancy for engineer with good technical knowledge. Permanency to right person—wage according to experience. Berry's Radio, 25 High Holborn, W.C.1. [0028

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A SOUND training in electronics is essential. EXPERIENCE in current Army Radar or Control Equipments and teaching ability would be advantageous.
SALARY: Approximately £727.
WRITE: O.C., 5 Trg. Bn., R.E.M.E., Hazebrouck Barracks, Arborfield, Berkshire. [8811

TELEVISION bench and field engineers required at all times for vacancies in most parts of the British Isles; permanent positions with highest salaries plus bonus for suitable applicants, 5½-day week.—Box 1757. [0251

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CANDIDATES should hold a University Degree or equivalent. Some practical experience is desirable but not essential.
APPLY in writing giving full particulars to S. G. Brown Limited, Shakespeare Street, Watford, Herts. [8751

MINISTRY OF AVIATION requires a Technician at Coventry to assist in supervision of contractor's inspection at large electrical works, with particular responsibility for ground radar equipment.
QUALS. Electrical or electronic engineering apprenticeship or equiv. training in an appropriate field e.g. radar. Sound knowledge of electronics, and some experience on mechanical work involving precision gearing an advantage. O.N.C., appropriate C. & G. Finals or equiv. qual. desirable.
SALARY. £875 (age 30)—£1,053 p.a. Application forms from Manager (P.E. 2380) M.O.L. & N.S., Professional & Executive Register, Atlantic House, Farrington Street, London, E.C.4. [8784

SMART man required as Radio & TV Engineer for branch shop. Able to drive. Good wages and prospects. Accommodation provided. State age and details of experience to Fells Ltd., Head Offices, Ravenshaw Buildings, Chapel Street, King's Lynn. [8813

RADIO Servicing Dept. Manager required for Ceylon to take charge of about 20 local technicians. Young single man preferred. Good pay and allowances.— Write brief details previous experience: B, Rigold & Bergmann, Ltd., 54, Old Broad St., London, E.C.2. [8810

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TECHNICAL Assistant required for Acoustical Laboratory. Experience in radio or audio engineering essential. Possession of O.N.C. or equivalent standard desirable.—Full details of age, experience, etc., to Electro Acoustic Industries Ltd., Broad Lane, Tottenham, N.15. [8791

DEVELOPMENT Engineer of H.N.C. standard with experience in the design of Audio Equipment required in South West London area; some knowledge of relays and methods of remote control would be an advantage. Pension Scheme.—Write giving full particulars of experience and qualifications to Box No. 5270.

ENGINEERS with some five years' practical experience of radio frequency design work required for interesting new project in Laboratory situated in South West outskirts of London. Some experience of cables an advantage. Pension Scheme.— Write giving full particulars of experience and salary required to Box No. 5078. [8711

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TEST engineers; applications are invited from senior 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. [0024

PHYSICIST/Electronics Engineer wanted for work on problems associated with Mechanisms and Electro chemistry. Suitable applicants should have H.N.C. or equivalent plus several years experience in audio and sub-audio work. Applications in writing giving full details of experience, qualifications and salary required to the Chief Research Chemist, Wilmot Breeden Laboratories, Umberslade Park, Hockley Heath, Solihull. [8769

TV/RADIO field or bench service engineer required immediately; experience essential, must be capable of maintaining high standard of service to the public; excellent working conditions; loyalty and enthusiasm will be rewarded with permanent position and a salary in the range of £700 to £950 p.a.—Apply for interview, The Secretary, Leytonia Radio Ltd., 784-8 High Rd., Leyton, E.10. Telephone LEY 1396. [8702

ENGINEERS and Assistant Engineers are required by a Company in the London area specialising in Videotape and Telerecording. Applicants should have a good technical background a knowledge of pulse techniques and electronic servo-mechanism. Experience of T.V. broadcasting would be an advantage. Salary range £997—£1,260. Apply Technical Manager, Alpha Television Services (London) Ltd., 18, Ogle Street, London, W.1. [8783

TECHNICAL Assistants grade 3 reqd. for R.E.M.E. Training Centre, Arborfield. Qualifications O.N.C. (Mech. Eng.) or have passed an Artificer Course in R.E.M.E. Post involves supervision of vehicle maintenance. Previous exp. in both mech. and elect. work on transport essential. Salary £727 approx. Apply in writing to O.C. 5 (Radar) Trng. Btn. R.E.M.E. Hazebrouk Barracks, Arborfield, Berks, or to any Employment Exchange quoting Order No. Reading 3075. [8780

SENIOR Scientific Assistant required by the United Kingdom Atomic Energy Authority at Dounreay Experimental Reactor Establishment, Thurso, Caithness, Scotland, to join a group concerned with setting up and operating experimental low power nuclear reactors and to specialise in reactor control circuitry, nuclear counting equipment and physical instrumentation generally. The duties include fault finding investigational work and some control circuit design work.
APPLICANTS should possess a General Certificate of Education in at least four subjects at ordinary level including English language and a mathematical or scientific subject, or have equivalent qualifications.
FAMILIARITY with electronic and testing methods and good experience, preferably in a research or development laboratory, is required. Some workshop experience and ability to read mechanical drawings would be an advantage. Normal minimum age 27 years.
SALARY between £810 and £1,085 p.a. according to qualifications and experience.
CONTRIBUTORY superannuation. Staff housing scheme. Hostel accommodation available.
SEND postcard for application form, quoting reference 115/J48, to Personnel Manager at above address.
CLOSING DATE: 7th December, 1959. [8776

LABORATORY Technicians for Department of Electrical Engineering. (a) To assist in research laboratories, setting up and maintenance of light current equipment and recording experimental readings. Salary £610–£670 p.a. (b) To assist in Electrical Machines laboratory, installation and maintenance, and setting up experimental equipment. Salary £610–£670 p.a. (c) Construction and maintenance of experimental electronic apparatus for teaching and demonstration. Salary £545–£610 p.a. (d) (Male or Female) for photographic work, filing and keeping of records. Salary £485–£545 p.a. 44 hour week. Superannuation scheme. Application forms from Registrar, Room 40 (X), College of Advanced Technology, Gosta Green, Birmingham 4, on receipt of stamped addressed envelope. [8775

SITUATIONS VACANT

CIRCUIT Designers and Circuit Laboratory Engineers required for design and testing of automatic telephone exchange systems and other similar projects. Candidates should have had previous experience of this work and preferably have at least an O.N.C. or an intermediate grouped C. & G. certificate. Knowledge of Crossbar Switching or totalisators would be an advantage. Good salary paid to selected applicants. Pension scheme after qualifying period.
WRITE giving full details of qualifications and experience to the Personnel Manager, Ericsson Telephones Limited, Beeston, Nottingham quoting Ref. DA/1. [0160

CLARENDON Laboratory, University of Oxford, requires an electronic engineer to design and build equipment for a research group. This appointment is for three years only in the first instance. Applicants must possess at least H.N.C. in electrical engineering or equivalent and several years experience. Salary appropriate to age, qualifications and experience. Good holidays and pension scheme. Write giving full details of education and career to the Administrator.—Box 5787. [8797

TEST Engineers required for communications equipment. Interesting positions for men with good background of Alignment, test and fault-finding, preferably with U.H.F. and R.F. experience. Preference will be given to men with formal theoretical training through C. & G. O.N.C. or relative forces experience. Good working conditions including pension and life assurance scheme. etc. S.W. Middx. Area.—Please write full details of experience to Personnel Manager, Box No. T.E.1397, A.K. Advertising, 212a, Shaftesbury Ave., London, W.C.2. [8805

CHARGEHAND (Male or Female) age 25-35 required to supervise a production line of female operators. Applicants should be accustomed to this type of responsibility and have had several years experience of electronic prototype/production wiring. Amenities include non-contributory pension, life assurance and sickness pay scheme. Five-day week of 42 hours. Holidays increasing from 2 to 3 weeks in five years. Company cafeteria, etc.—Please apply to The Personnel Officer, The Solartron Electronic Group Ltd., Queens Rd., Thames Ditton, Surrey. [8795

WIRELESS Operator required by Falkland Islands Dependencies Survey for service at the W/T Station Port Stanley. Commencing salary according to age in scale £540 rising to £600 a year. Three-year tour. Full board accommodation available at about £14 a month. Candidates must be single and be capable of transmitting and receiving plain language and code at minimum speed of 20 w.p.m.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2A/50809/WF. [8793

TECHNICAL Grade II vacancy exists at War Dept. establishment in Hampshire. Duties: To assist in trials of telecommunications equipment and associated experimental work. Quals.: H.N.C. or equiv. desirable. Experience in telecommunications essential, some knowledge of service conditions of use of telecommunications equipment an advantage. Salary: £850 (age 30) —£1,005. Applicants of lower age groups and women have proportionate rates.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1., quoting D.512/9A. Closing date December 11th, 1959. [8789

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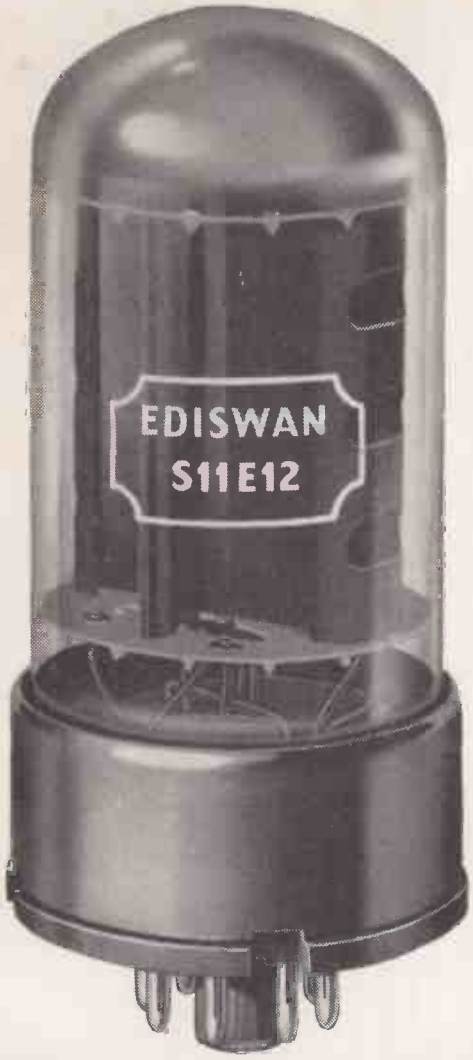

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