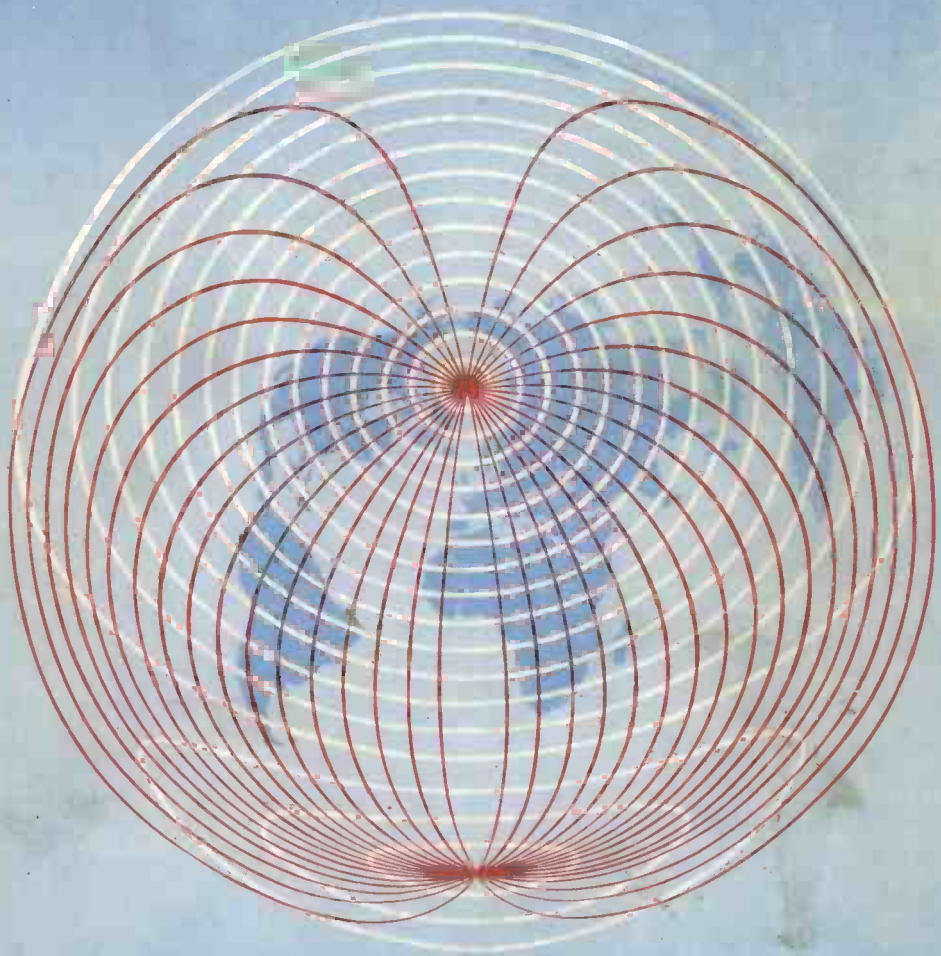
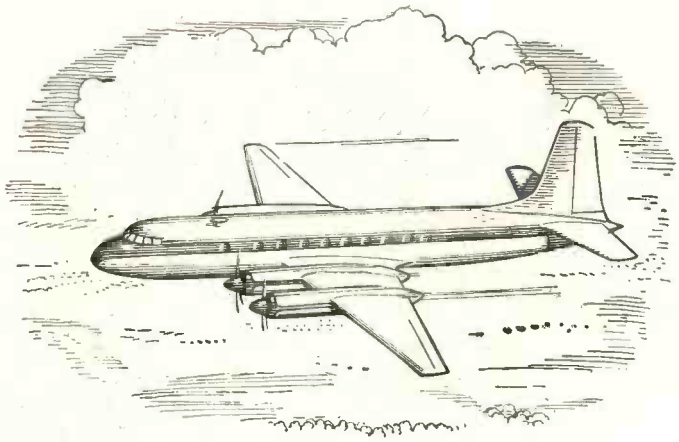
Wireless World

NOVEMBER 1953 · TWO SHILLINGS



RADIO, TELEVISION AND ELECTRONICS



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Wireless World

RADIO, TELEVISION AND ELECTRONICS

43rd YEAR OF PUBLICATION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: H. F. SMITH

NOVEMBER 1953

In This Issue

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Wireless World

NOVEMBER 1953 VOL. 59 No. 11

Speeding Up the Telegrams

WRITING in a rather pessimistic mood just over a year ago, we expressed the view that radio was failing to attune itself to the tempo of modern travel; in other words, we were failing in our task of keeping up with the Comet. These strictures were particularly directed towards radio telegraphy, but, as wire and wireless are now so closely integrated, they might better have been applied to telegraphy as a whole. The inland telegraph service, conducted at a heavy financial loss, is predominantly wire-borne, and so, perhaps, is not quite our concern. At home the telegram has almost acquired an antiquity value, and by its rarity rather than its speed, compels attention where other means of communication fail to do so.

Overseas Commonwealth telegraphic communications are fortunately in a healthier state, but clearly every advantage must be taken of technical developments if the transit time of telegrams is to beat by a sufficiently wide margin the speeds of modern jet aircraft. And speeds of other kinds of transport are going up as well.

The present state of Commonwealth telecommunications was ably surveyed recently by J. A. Smale, Engineer-in-Chief of Cable and Wireless, the new Chairman of the Radio Section of the I.E.E., in his inaugural address. Most of the developments foreshadowed by Mr. Smale were in the direction of faster service. For instance, he envisaged a direct sender-to-addressee service for telegrams, comparable with the existing telephone system. Many of the developments envisaged are those applicable to submarine cables rather than to radio circuits, but the radio man can take heart in the thought that they will be essentially of a radio-like or electronic nature.

Mr. Smale said: "It is a firmly held belief among old telegraphers that the biggest fool in the world sits at the other end of his circuit." In that light-hearted way he introduced a very serious plea for common executive control of all the ends of the Commonwealth circuits. Freedom from errors and delay could, he maintained, best be attained by those means. He expressed the belief that "force of circumstances will eventually produce agreement among the self-governing nations of the Commonwealth to compromise with sovereignty to the extent necessary to bring their telecommunications systems under unified control of a body possessing the confidence of all."

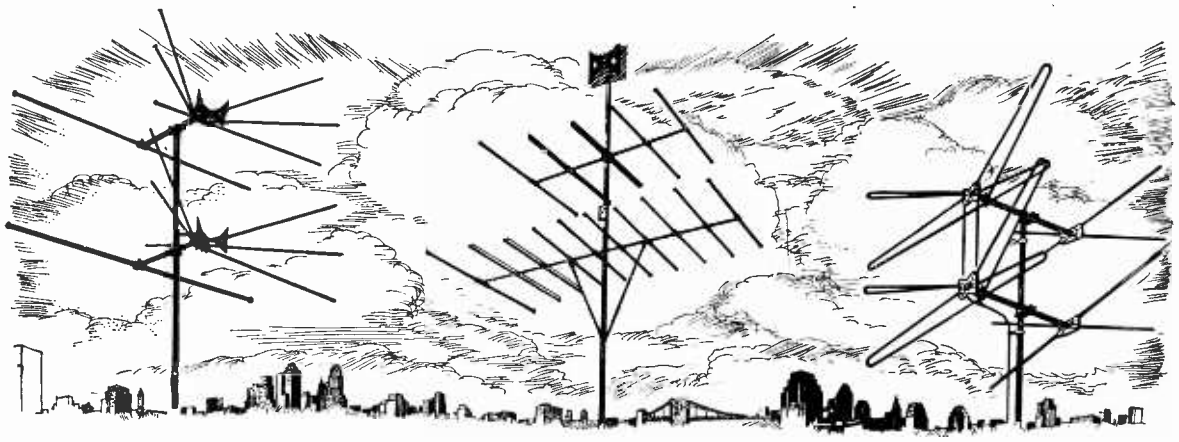
B.B.C. Progress

THE B.B.C. compels our admiration by the way in which it refuses to be shaken by the gusts of political controversy of which it is the storm centre. In spite of long-drawn-out uncertainty as to the way in which the Government will exercise powers of control over its future, the Corporation is calmly going ahead with plans for engineering extensions.

A useful survey of recent developments and of the existing state of broadcasting was recently given by Harold Bishop, director of technical services of the B.B.C., in his inaugural address as President of the Institution of Electrical Engineers. Mr. Bishop then went on to discuss proposed developments, first explaining at some length the present limitations on the medium-wave services. He admitted that reception of the Home programme was difficult or impossible during the hours of darkness for some 5M listeners. The position is deteriorating and such palliatives as can be used could not apparently be expected even to maintain the *status quo*.

Mr. Bishop then briefly outlined the B.B.C.'s plan for providing v.h.f. sound coverage by a system comprising 51 f.m. transmitters at 19 sites. This, presumably, would be the first stage of the Stockholm Plan, described in detail elsewhere in this issue. The first stations to be installed would be in those districts where medium-wave reception is bad. This is all subject to approval by the Government.

Few will quarrel with the general idea of reinforcing our present sound service in this way. We cannot imagine at this stage there will be very much support for the idea that the proposed v.h.f. service will come too late, and, with television growing at the present rate, will be outmoded before it starts. All this takes us into the sphere of prophecy rather than intelligent anticipation, and it would be indeed rash to hazard any guess as to the future position of sound *vis à vis* television.



Television Aerials of the Future

—*Not Forgetting V.H.F. Sound Broadcasting*

By F. R. W. STRAFFORD,* M.I.E.E.

ULTIMATELY the outcome of the Television Advisory Committee's first report will take the form of a mixture of politics, economics, and techniques and it is not the purpose of this article to gaze into the crystal ball, but to assume that all five bands internationally allocated to television and v.h.f. sound broadcasting will eventually be used.

To refresh the reader's memory, these bands are split up as follows:—

Band No.	Frequency Range (Mc/s)	Proposed use
1	41–68	Television
2	87.5–100	Sound broadcasting
3	174–216	Television
4	470–585	Television
5	610–960	Television

The United States are operating television in Bands 1, 3 and 4 and v.h.f. sound broadcasting in Band 2. The frequency range is in the ratio of about 10 to 1. Because the stations are not transmitting a common programme, receivers are expected to tune continuously through all channels and the aerial system must therefore be effective over the receiver tuning range. It is not the purpose of this article to deal in detail with the various types of American wide-band aerials excepting to point out that they appear to be inefficient compared with single-channel optimized aerials, and take various forms. The title illustration, which depicts only a few of the dozens of variants, leaves the rest to the reader's imagination.

One significant fact must be observed, namely: that all television and v.h.f. sound transmissions in the U.S.A. are based on *horizontal polarization*, which at least gives the designer some common basis upon which to engineer his broad-band aerials.

It is with some dismay that one notes that the T.A.C. recommendations for Band 3 television envisage the use of vertical and horizontal polarization, according to the siting of the transmitter. This can only complicate the aerial design and render it more bulky than its U.S.A. counterpart unless some outstanding development is forthcoming.

The use of vertical and horizontal polarization for two television transmitters is confined to the case in which they operate on a common frequency channel (shared-channel operation), and is based upon evidence (so far as Band 1 is concerned) that, during anomalous propagation† a greater freedom from mutual interference results.

This technique may be fully justified on Band 1, where all stations are radiating a common programme, and no one minds a single aerial installation whether vertically or horizontally disposed. But consider the case of a viewer situated so that he is within range of one station in Band 1 and, say, four stations in Band 3, each radiating its own programme. The viewer will naturally require that his receiver be capable of selecting individual programmes and the aerial must be efficient at the frequencies involved.

Providing a common polarization is used, whether vertical or horizontal, it is not difficult to devise the necessary wide-band aerial, but on the present recommendations these four stations in Band 3 can all be vertically polarized, or horizontally polarized, or can be a mixture of both. Clearly, the only solution in this event is a pair of broad-band arrays, one erected vertically and the other horizontally, which just doubles

* Belling and Lee, Ltd.

† *Wireless World*, March 1953.

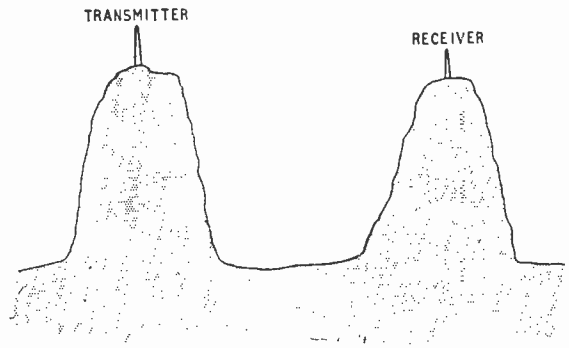


Fig 1. Example of practical "free space" conditions on the ground.

the total amount of equipment required for any one aerial installation!

Bearing in mind the fact that the frequency of Band 3 is, on the average, four times that of the Band 1, it is suggested that ample experimental evidence must be furnished that mixed polarization on shared-channel operation is an advantage before it is adopted. This is really the crux of the whole matter.

Clearly, it is impossible to enter into a detailed discussion on aerial design until this basic problem is fully resolved, but there are certain fundamental aerial concepts which may be discussed with advantage.

It is usual in theory to refer to "free space" conditions and, mathematically, this is essential in order to get exact solutions for wave-energy equations. But it may be taken that, at the frequencies concerned, a transmitting and receiving site respectively located on the peak of two mountains as shown in Fig. 1, and in direct line of sight, will approximate very closely to ideal "free space" conditions.

Assume that the transmitter is Alexandra Palace on channel 1 (45 Mc/s), and that a conventional "H"-type receiving aerial is used. Now scale the transmitting aerial down by a factor of 10 so that it is a resonant system at 450 Mc/s (which places it in Band 4) and energize it with exactly the same power. The field strength at the receiving site will be unaffected. Now scale down the receiving aerial by a factor of 10 so that it is again a resonant system at 450 Mc/s. The amount of energy received by the aerial will be only one-hundredth of the original, even though the field strength at the aerial has remained constant. This is because the effective height of the aerial is proportional to the wavelength. Thus if the wavelength is reduced by a factor of 10 the induced e.m.f. in the aerial is reduced by the same factor, so that the energy, which is proportional to the square of the e.m.f., is reduced one-hundredfold.

It is obvious that something must be done to compensate for this very high loss, and it is satisfactory to know that quite a lot of signal may be recovered. If the space originally occupied by the transmitting aerial is filled with 450-Mc/s dipoles, all correctly phased and the same is done in the space previously occupied by the receiving aerial, then there is, theoretically, a net gain.

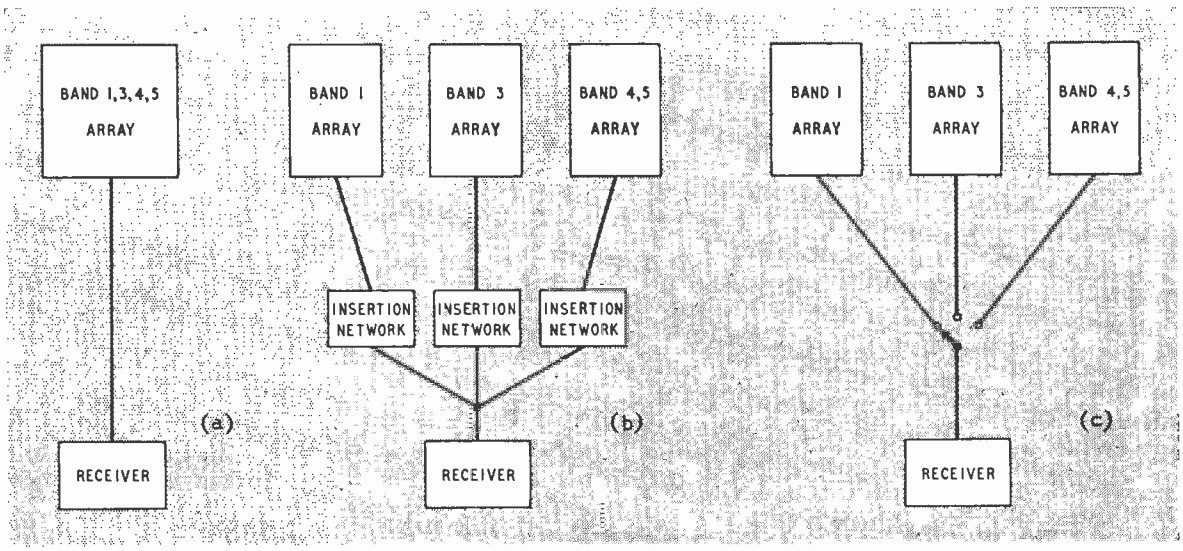
In practice there are certain difficulties on the transmitting side, and there is insufficient space to spare on the receiving side, bearing in mind that Bands 1, 2 and 3 aerials may also be required.

Even in the ideal case of the transmitting and receiving sites being located within line of sight and under "free space" conditions the net result is not likely to be better than that which would have been obtained at 45 Mc/s.

The problem is worsened in practice where the average receiving installation is on the usual type of undulating terrain and is surrounded by other buildings and structures. In these circumstances there are greatly increased propagational losses at 450 Mc/s due to diffraction and ground reflection effects and increased absorption of energy from intervening objects. In addition, there must be included the greater difficulty of exciting the transmitting aerial with anything like the same amount of radio-frequency power, and the higher noise-factor and lower conversion-efficiency of detectors employed in the receiver.

It is difficult to be hard and fast about the overall result of these added problems, but they all add up to a greatly reduced range, and an increased number

Fig. 2. Three basic designs for a multi-band v.h.f. aerial.



of pockets of low field strength within a given area as compared with a service on a lower frequency radiating the same power.

The same remarks apply to Band 3, but here the average frequency is only four times greater than that of Band 1; hence the effects are not so serious. Nevertheless, for a given system the results to be expected, so far as coverage is concerned, will be less than on Band 1.

From all this we may deduce one important point. If we neglect the Band 2 aerial, which is for sound-broadcast reception only, and assume that three separate aerials will be required for Bands 1, 3, 4 and 5 their respective heights should be in the same order—that is, the Band 4 and 5 aerial should be at the top of the mast, with the Bands 3 and 1 aerials progressively lower.

Forgetting the problem of mixed polarization, and assuming that everything is either vertically or horizontally polarized, the design of a suitable all-band aerial may be attacked in three ways.

First, an attempt may be made to devise a single multi-element array which will respond efficiently over all the bands. So far all that has been done has resulted in inefficient systems particularly as regards front-to-back ratio which is very important when "ghosts" are present. It must be remembered that the "ghost" problem is likely to increase as the wavelength is decreased because of the greater reflectivity of surrounding structures.

A second method is to devise a moderately broad-banded array for each channel and feed into a single transmission line via suitable isolating filter networks so that impedance matching may be maintained.

A third method is identical with the second, excepting that the isolating filters are removed and a separate and switchable feeder is used with each aerial.

These arrangements are depicted (in block diagram form) in Fig. 2. Obviously method (a) is ideal if it is capable of achievement. Method (c) would be frowned upon by receiver manufacturers and installers on the grounds of cost, so that the problem resolves itself into either (a) or (b) or some combination of both, but that is a matter which must be left to the ingenuity of the aerial designer and cannot be disposed of prematurely. It is sufficient to note that the U.S.A. has made varied attempts to solve this problem, and the reader is again referred to the title illustrations.

Aerial Feeder

The question of feeders can now be discussed. The popular type at present employed in this country on Band 1 is of coaxial construction and, typically, has a loss when matched of about 3.5 db per 100 ft. The average suburban installation uses about 50 ft of this feeder so the loss (1.75 db) is not serious. It is well known that this loss increases as the square root of the frequency; hence, it is doubled on Band 3 and more than trebled on Bands 4 and 5. Bearing in mind the progressive deterioration of reception with increasing frequency there is a strong suggestion that the existing type of feeder is just about acceptable up to, and including, Band 3 but is completely unacceptable so far as Bands 4 and 5 are concerned.

An examination of data for coaxial feeders shows that a feeder for use at 500 Mc/s (Band 4) will require an outside diameter of nearly 1 in if its loss is not to exceed that at present accepted on Band 1 installations with the conventional feeder. The cost of such a

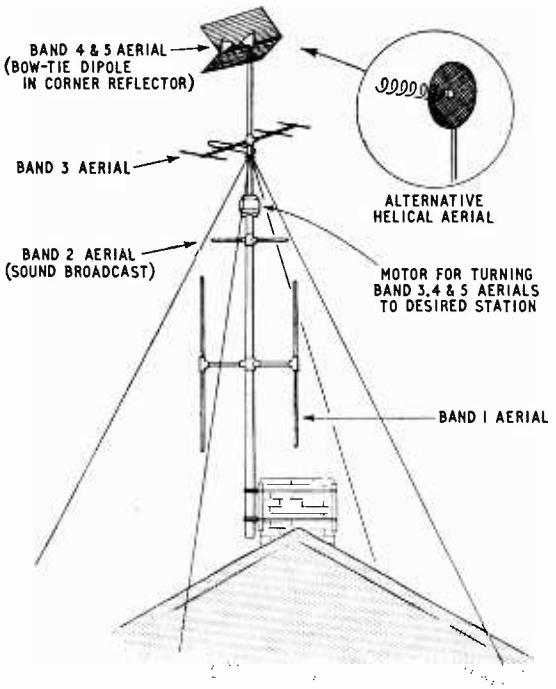


Fig. 3. A multi-band television and v.h.f. broadcasting aerial system might conceivably take this form.

feeder rises alarmingly and can far exceed the cost of the aerial, particularly on Bands 4 and 5 where the material content of the aerial may be fairly small.

Further, the matching of a single wide-band aerial to a feeder is rendered more difficult when the characteristic impedance is low (say 80 ohms), and it is difficult to design a low-loss coaxial feeder of higher impedance—in fact, anything greater than 100 ohms becomes economically impossible.

The Americans have long recognized this fact, and for this reason have almost invariably adopted 300-ohm twin feeders. It is a simple matter to design these for a characteristic impedance up to 400 ohms. They have the advantage of being much cheaper than an 80-ohm coaxial feeder for the same loss and a typical example will consist of a pair of parallel conductors of 7/30 s.w.g. copper wire separated about 0.4 in by a web of low-loss flexible insulating material such as polythene. The characteristic impedance is 300 ohms and the lost at 450 Mc/s (when dry) is about 3 db.

The disadvantage, due to the open construction of this (so-termed) ribbon feeder is that it must be spaced a few inches from walls and other semi-conducting surfaces, or the inherent attenuation loss increases, and the characteristic impedance decreases, thereby causing additional mis-match losses.

Measurements have shown that the installation of 300-ohm ribbon feeder in close proximity to a conductive surface doubles the inherent attenuation loss and reduces the impedance to about 240 ohms. Also, ribbon feeders, on account of their open construction, are very susceptible to nearby interfering fields unless they are electrically balanced; in practice this is difficult, if not impossible, to attain over a wide frequency range.

For a given conductor size the inherent attenuation

is almost inversely proportional to the characteristic impedance. By closing the spacing so that the conductors are separated by about 0.1 in the characteristic impedance will fall to about 150 ohms. This feeder is cheaper because less insulation is used, but the loss will be double. At some increase in cost the conductors may be increased in diameter and the losses reduced somewhat, so, at about the same overall cost, a twin feeder may be converted from 300 to 150 ohms with about 30½% increase in loss.

What is more important, however, is that it is far less influenced by proximity effects. It can be installed without stand-off insulators (these are always used in U.S.A.) and the loss, under the most adverse conditions when routed close to a conductive surface, will increase by only 20 % and the impedance will fall by about 10 %. This is confirmed by experiment. Additionally, its susceptibility to local interference is reduced and the balancing problem is simplified somewhat. It is hoped that designers of converters, or broad-band receivers, will give these suggestions careful consideration.

Some idea of the shape of things to come may be gleaned from Fig. 3. In accordance with the best technical ethics the Bands 4 and 5 aerial will be at the top of the mast. A typical broad-band aerial may consist of a "bow tie" dipole (already popular in the U.S.A.) located in a wire mesh corner-reflector. Alternatively, a bowl-type reflector may be used, or the helical aerial, with reflector mat, as devised by J. D. Kraus of Ohio State University (see inset). Bearing in mind the increased propagation losses and other sources of inefficiency in the receiver, and the increased "ghosting" problems, it is unlikely that anything so simple as a dipole or even "H" type array will be satisfactory in Bands 4 and 5, excepting line-of-sight conditions. Even then "ghost" elimination may require highly directional arrays, and for wide-band operation the usual parasitically excited rod elements can only work over a fairly restricted frequency band and must be replaced by a surface such as a corner reflector, bowl or mat.

The Band 3 aerial may take the form of a multi-element Yagi with folded dipole to provide the necessary frequency coverage, which is beyond the capabilities of the simple dipole array. The centre impedance of a folded dipole is of the order of 300 ohms, but by the time the parasitic reflector and director elements have been added this will be reduced and is another good reason why a 150-ohm feeder is to be preferred. There will be variants of this aerial (see title illustration) but it cannot be pointed out too strongly that, in the present state of the art, the gain of an aerial is uniquely related to the space it occupies, and that increasing gain without increasing physical size is as impossible as pouring a quart from a pint pot.

The Band 2 aerial is not very ambitious because it is required for sound-broadcast reception and there are no "ghosting" problems, and very little directional effect is likely to be required. At extreme ranges it may need the addition of a reflector and, perhaps, director elements, in which case it will look like a larger version of the Band 3 aerial.

There follows, finally, the conventional (and largest) aerial for Band 1. For reception of the horizontally polarized transmitters (e.g., Belfast) it may be combined with Band 2 and 3 aerials to provide a much more presentable installation occupying far less space. Fig. 3 has, however, been drawn purposely to bring out this point in considering vertical polarization on Band 1. Bearing in mind that the present plan envisages mixed polarization in Band 3 the earlier remarks on the effect on aerial design may be added (in imagination) to Fig. 3!

Fig. 3 also shows a motor drive located above the Band 2 array so that Band 3, 4 and 5 arrays may be rotated for the purpose of selecting the desired alternative programme, or finding one that is free from "ghosts" (a typical U.S.A. practice, incidentally). This expensive motor drive could be eliminated if the various services had their transmitting aerials on the same site, a point which should not be overlooked in future planning.

The U.S.A., with horizontal polarization throughout and plenty of experience, have achieved nothing by way of compact aerial design beyond what can be seen from the title illustration. In the present circumstances it must be concluded that the British problem is far more difficult. Suggestions for simplifying this may be in conflict with problems relating to transmitter and receiver design and may contain much which lies within the confines of politics—a subject which the author wishes to avoid. For this reason the article must close without drawing any conclusions, but enough has been said to indicate that the problems are not simple, and need weighty considerations from all directions.

Overlapping Television Channels?

NOW that the allocation of television channels is becoming such a problem in the small amount of ether-space available for them, technical people are getting rather worried by the inefficient nature of the television system as a means of conveying information. Measured against Shannon's formula giving the maximum capacity of a communications channel, a television channel consumes far too much bandwidth for the amount of information it conveys.

This subject came up for discussion recently at a Brit. I.R.E. meeting when D. A. Bell gave a lecture on "The Impact of Information Theory on Television." Dr. Bell put some emphasis on the fact that whereas the frequency spectrum of a television transmission was usually represented on paper by the pass-band characteristic of the transmitting and receiving equipment, the actual distribution of sideband energy in the signal tended to fall off quite rapidly away from the carrier frequency in an exponential curve. This suggested that the outer sidebands of two adjacent television channels could be overlapped without serious interference, so that less space would be occupied in the band.

The idea had already been tried out in France and it was also helpful in the N.T.S.C. system of colour television (see page 524) for reducing interference between the two sets of interlaced sidebands. Several speakers were of the opinion, however, that the principle was not very good because the exponential curve of sideband energy was only an average one and in practice the outer sidebands often contained large peaks of energy which could cause mutual interference.

Apart from this, Dr. Bell thought that the shape of the sideband energy curve could be exploited in

another direction. The best way to secure error-free transmission was to distribute the signal over the frequency band in the same way as the interfering noise—that is, more or less evenly. This suggested that some form of "pre-emphasis" should be used at the transmitter to lift the outer, high-frequency sidebands of the signal to the same amplitude as those near the carrier frequency. Then at the receiver "de-emphasis" could be used to restore the energy distribution to its original form.

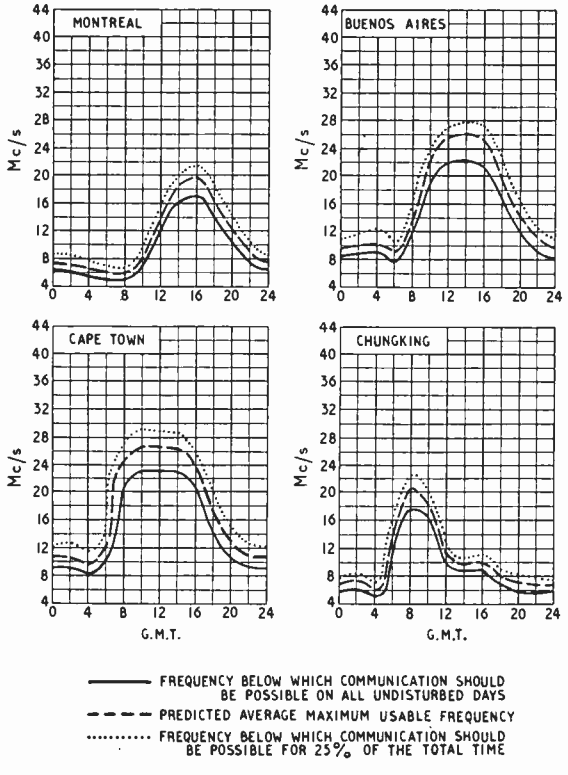
The lecturer considered that synchronizing pulses were a very redundant feature of the television signal because of their repetitive nature. Nevertheless, a large frequency band was required to transmit them properly. All we really needed in principle for synchronizing was a single sideband frequency, with an apparatus at the receiver which would work from a sine wave instead of pulses. In view of the experience that had already been gained with flywheel synchronization this would not be very difficult to arrange.

Short-wave Conditions

Predictions for November

THE full-line curves given here 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 November.

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



BOOKS RECEIVED

Fundamentals of Electronic Motion, by Willis W. Harmon. Mathematical treatise on the interaction between electrons and electric and magnetic fields with practical illustrations of their application in electron optics, travelling wave amplifiers, linear accelerators, etc. Pp. 319+x; Figs. 252. Price in U.K., 46s 6d. McGraw Hill Publishing Company, 95, Farringdon Street, London, E.C.4.

Principles of Electronics, by L. T. Agger, B.E. Elementary textbook on vacuum and gas-filled valves and their associated circuits. Pp. 340; Figs. 307. Price 18s. Macmillan and Company, St. Martin's Street, London, W.C.2.

A First Course in Wireless, by "Decibel." Revised third edition of a collection of articles reprinted from *World Radio*. Pp. 231+vii; Figs. 93. Price 12s 6d. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2.

Magnetic Amplifiers, by George M. Ettinger. Broad survey of principles and applications with an 82-item bibliography. Pp. 88+viii; Figs. 48. Price 6s 6d. Methuen and Company, 36, Essex Street, London, W.C.2.

Measurements of Radio Interference in the Frequency Range 0.15 to 30 Mc/s. Technical Report M/T116 "A Portable Measuring Set," by S. F. Pearce and D. C. G. Smith. Pp. 9; Figs. 5. Price 10s 9d by post; and Technical Report M/T117 "A Mains Isolating Unit," by J. Miedzinski and S. F. Pearce. Pp. 7; Figs. 11. Price 12s 10d. Both designs in accordance with performance characteristics prescribed in British Standards Specification BS.727. The Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

Traité Pratique des Antennes, by E. Rolin. Elementary theory of short-wave aerials (10-100 metres) for reception and transmission, including directional aerials and their orientation for great circle paths. Pp. 216; Figs. 104. Price 1,380 francs. Dunod, 92 rue Bonaparte, Paris VI.

CLUB NEWS

Birmingham.—A demonstrated talk on "Some Experiments in the Application of Cold Cathode Tubes" will be given by A. B. Watt (G2DRG) to members of the Slade Radio Society on November 13th. The annual general meeting of the club will be held on November 27th. Meetings are held at 7.45 on alternate Fridays at the Church House, High Street, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Cleckheaton.—At the meeting of the Spen Valley and District Radio and Television Society on November 18th, E. A. Smith, of the Post Office, will talk on microwave radio links. Meetings are held on alternate Wednesdays at 7.30 in the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds.

Hounslow.—Meetings of the Hounslow and District Radio Society are held on alternate Thursdays at 7.30 at Grove Road Junior School, Grove Road, Hounslow. The next meeting will be on November 12th. Sec.: R. J. Parsons, 16, Cypress Avenue, Whitton, Twickenham, Middx.

Nottingham.—The Nottingham and District Short Wave Club meets every Monday and Thursday at 7.0 at Woodthorpe House, Sherwood, Nottingham. A basic radio course occupies part of Monday evenings and morse practice is given on Thursdays. Sec.: N. D. Littlewood, 129, Standhill Road, Nottingham.

Two-Call Club.—Membership of the British Two-Call Club, which is restricted to British amateurs having been allocated a call in two or more countries, continues to increase. New members include P. R. Golledge (G3EDW, VQ2W, D2DW), D. R. Wilde (G3EBA, DL2BA), R. D. Raley (G3IDR, DL2SR) and C. W. Liversidge (G3ERF, Y12GQ). The president of the Club is Major D. A. MacDonnell (G8DK), who is in the six-call section. Sec.: G. V. Haylock (G2DHV), 63, Lewisham Hill, London, S.E.13.

Point Contact Germanium Rectifiers

Principles of Operation and Their Relation to Performance and Reliability

By R. T. LOVELOCK,* A.M.I.E.E.

THE point-contact germanium rectifier, consisting of a springy metal wire making end-on contact with a germanium surface, has been available in commercial quantities for several years. During that period some manufacturers have used it very successfully in a variety of electrical equipments, while others have been disappointed in its performance. Failure to obtain satisfactory performance can be attributed either to an imperfectly developed component, which was still suffering from faults not realized by the manufacturer, or to lack of comprehension by the user of the fundamental characteristics of the rectifier, with consequent failure to adopt an optimum circuit design for its inclusion.

In the historical development of the rectifier, the various faults experienced have often led to a better appreciation of the conduction mechanism. However, to obtain a clearer grasp of the faults and limitations of the component, it is better to depart from the historical order and first to outline such principles of operation as will assist understanding of its performance, then to note the electrical characteristics of the rectifier, and finally to examine the major faults of manufacture which may cause premature failure in an equipment. For obvious reasons the treatment must be general, and specific constructions cannot be cited. An appreciation of the possible weaknesses, however, will enable an intending user to devise tests which will discriminate between the good and bad examples of design which may come into his hands.

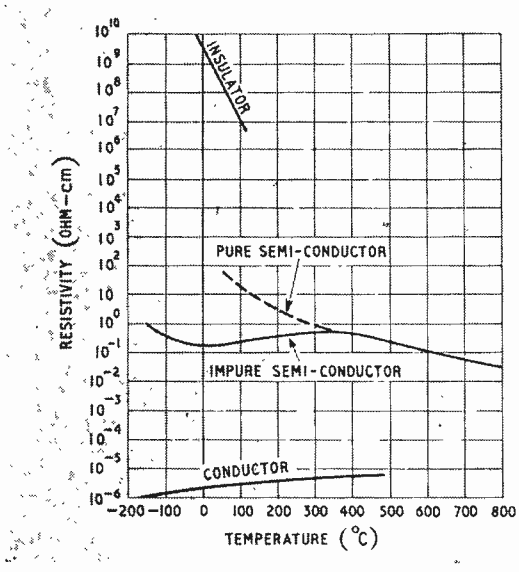
Electrical Conduction in Solids.—In a solid material the atoms are bonded together by forces resulting from a sharing of electrons in the outermost orbits by two or more atoms. In some materials the arrangement of electrons is such that a large number are free to move at random within the volume occupied by the atomic lattice, and they form an assembly analogous to a gas in a closed container. If an electric field be established within the material, a steady component of drift velocity will be superimposed upon the random thermal movement, and electrical conduction will occur: materials which possess this type of structure are called electrical conductors. There are other forms of material in which all the electrons are bound within the vicinity of their parent nuclei, and no general drift is possible upon application of a potential gradient, but only a certain straining of the system from its passive distribution, which we interpret as a "dielectric constant." Such materials are insulators, and the small leakage current which they do exhibit is due to the drift of a very small number of free electrons which are present as slight imperfections in the material structure.

The behaviour of these two types of material with variation of temperature is radically different. Increase of temperature in a conductor causes an insignificant increase in the number of electrons able to conduct, but the increase in thermal energy reduces the mean free path of an electron within the volume. Resistivity is inversely proportional both to the number of electrons and also to the mean free path, and the decrease of mean free path greatly outweighs the increase of electrons, resulting in an increase of resistivity with increasing temperature. In an insulator however, the very small number of electrons present causes the decrease in mean free path to be insignificant compared with the increase of available electrons, and the resistivity falls with rising temperature.

A semi-conductor, as its name implies, is a material intermediate in type between the two extremes: it has many more mobile charges than an insulator, but several orders less than a conductor. In a pure material in the crystalline form the number of free charges available for conduction increases rapidly with increase of temperature, and resistivity falls; the resulting flow of current is said to be due to "intrinsic conduction."

If, in the crystal lattice of the semi-conductor, a very

Fig. 1. Typical variation of resistivity with temperature.



* Murphy Radio, formerly General Electric Company.

small percentage of the atoms are an impurity material possessing either one less or more electron in the outermost orbit than does the semi-conductor, such impurity atoms will each be capable of contributing one free current-carrying charge to the material; these charges will be liberated by the impurity at a much lower temperature than will those of the semi-conductor, and over the temperature range in which the major component of conduction is provided by the impurity charges, conduction is said to be "extrinsic."

Hence, over the low temperature range in which the number of charges liberated by the impurity is rapidly increasing with rising temperature, the material will exhibit a negative temperature coefficient; when the majority of such charges have been liberated, and those provided by the semi-conductor are still only an insignificant fraction of the total, further increase of temperature, by reducing the mean free path without significant increase of free charges, will result in a positive coefficient; when, once more, the number of charges liberated by the semi-conductor becomes comparable with that from the impurity, the increase in number will once more mask the decrease in free path, and the coefficient again becomes negative. Typical behaviour of all four types of material is illustrated in Fig. 1.

An impurity with one more electron in the outermost orbit is said to be a donor type impurity, since it is capable of donating one extra electron to the assemblage, and the mixture is said to be an "*n*" (negative) type of semi-conductor. An impurity with one less electron is said to be an acceptor impurity, since it results in a space (positive hole) into which an electron can fall (or be accepted): conduction can occur due to the successive falling of bound electrons into these holes, and they behave as though they were free current-carrying agents with a positive charge. Such a material is said to be a "*p*" (positive) type material. By a critical temperature processing of a semi-conductor it is possible to produce a lattice imperfection (cause a small percentage of spaces in the crystal lattice which should be occupied to become vacant) and such imperfections act as if they were a "positive hole" and result in a behaviour similar to that of *p*-type material; such behaviour is not identical with that resulting from the presence of acceptor impurity, but differs from it in several important ways, not perfectly understood as yet. It is probably this possibility of modifying the behaviour of a material by deforming the lattice which makes possible the construction of the high-reverse-voltage type of point-contact germanium rectifier.

The Germanium Rectifier.—During the last few years the germanium rectifier has sprung into prominence as one of the most important applications of the semi-conducting elements. The intrinsic resistivity of pure germanium at 20°C is between 60 and 100 ohm-cm, but in the high-reverse-voltage type of rectifier it is usually employed with sufficient donor impurity to reduce this to 10 ohm-cm. For making the low-impedance type of rectifier it is used with about a thousand times this impurity concentration. The two contents represent 0.1 parts per million, and 100 parts per million respectively.

If a bar of germanium be prepared in which one end consists of high-resistivity *n*-type material, and the other of low-resistivity *p*-type material, and a low-resistance contact be attached to each end of the bar so that current may be caused to flow across the inter-face where the two types meet, the bar will behave as a rectifier, and this form is known as a *p-n* junction rectifier. It may be shown on theoretical grounds that the static characteristic of the junction, ignoring the bulk resistance of the bar, can be expressed at 20°C by the law :—

$$i = I_o\ (1 - e^{39V}) \quad .. \quad .. \quad .. \quad (1)$$

where I_o is a constant and V is the applied voltage.

Rectifiers have been constructed which exhibit very close agreement with this theoretical law. The junction type of rectifier is being very actively developed in this country, but is not yet available in production quantities.

The point-contact type of rectifier, which has been freely available for some years, consists of a small block of *n*-type germanium, to one side of which is attached a low-resistance contact, and on the other side it is contacted by a pointed springy wire, pressed firmly against it. This device also exhibits a rectification characteristic, but a characteristic which does not agree exactly with that forecast on theoretical grounds for the plain contact between metal and germanium.

Recently, when experiments in connection with the germanium transistor had thrown considerable new light on the mechanism of conduction at a metal-germanium contact, it was realized that the reason for failure to agree with the older theoretical law was because that law had not taken into account the modification to the germanium material which occurs due to the passage of current through the contact. American workers in the Bell Telephone Laboratories have now established that passage of a heavy current pulse through the contact, such as is used to "electroform" the rectifiers, so modifies the germanium in the immediate vicinity of the contact that it exhibits *p*-type characteristics. It is presumed that this modification occurs partly due to the creation of lattice defects in the material, and although the matter is still controversial Fig 2 shows the most likely form which the point-contact rectifier takes in practice. During manufacture the whisker point is pressed firmly against a specially etched surface of germanium, and a heavy pulse of current passed which serves to form a semi-weld between the metal and germanium, and to produce a small volume of *p*-type germanium between this weld and the bulk *n*-type germanium. Thus a *p-n* junction will be formed at the inter-face, which will be "shunted" by any conducting layer of oxide residues which may be formed on the surface during heating of the contact by the current.

The Rectification Characteristic.—In Fig. 3 are shown typical characteristics of representative rectifiers. Both current and voltage scales are shown proportional to the cube root of the parameter as a convenient means of opening out the scale of small values while still allowing the zero point to be plotted. Experiment has shown that the body life of free charges is not greatly affected by variation of impurity content over the range used for the rectifiers plotted, and it follows from this fact on theoretical grounds that if two rectifiers with different impurity content but identical low-frequency capacitance be chosen, the characteristics of the *p-n* junctions formed will be nearly identical, except for the lower breakdown voltage of the one with higher impurity content. In Fig. 3 the characteristics of two point-contact rectifiers are plotted with equal capacitance, but widely differing impurity content, and also the theoretical

characteristics of the junctions formed under the whisker points.

The forward current is seen to be less than that of the junction, and the reverse current greater: the forward current of the low-resistivity rectifier is nearer to that of the junction than is that of the high-resistivity component, but this relationship is reversed in the case of the inverse currents. Although it is very difficult to devise and control experiments to prove the matter, an obvious explanation of this divergence from the theoretical form is that the rectifier comprises a complex system such as that shown in Fig. 4. Such a system could account for all the departures from the junction characteristic, including the rather puzzling negative resistance slope exhibited by the high-reverse-voltage types. Although it must be emphasized again that this matter is still controversial, this explanation will be adopted for simplicity in the following treatment as a suitable framework on which to erect a picture of rectifier behaviour.

Cyclic Temperature Coefficient.—As the temperature of the germanium block varies, the characteristic undergoes major changes of shape; such variations may or may not be cyclic and reversible. In this section only those which are cyclic will be considered, leaving those which are not to be considered later as faults. When negligible power is being dissipated in the rectifier, the temperature of the contact is that of the ambient conditions, but when appreciable power is dissipated a considerable temperature rise above ambient may occur, due to the small physical size, and should be allowed for. If, therefore, a slow variation with time, which is not related to the variation of ambient temperature, is observed, this effect

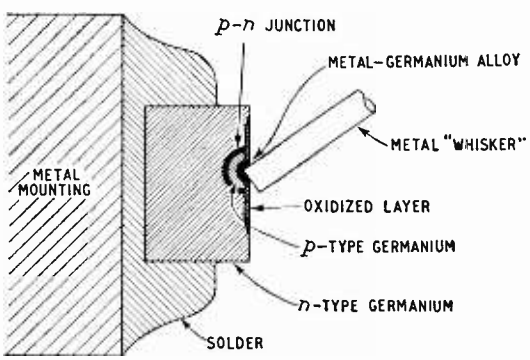


Fig. 2. Diagrammatic representation of point-contact type rectifier.

should be suspected, and when measuring rectifiers care should be taken to avoid it.

Over the temperature range -40° C to $+100^\circ$ C the effect of increasing temperature on the germanium rectifier is to increase both the forward and reverse current at a given potential, and also to decrease the "turn-over" voltage or the breakdown voltage. Germanium at a temperature of $+20^\circ$ C has already released all charges from the impurity centres, and over the range of impurity concentrations used in commercial rectifiers the number of charges released by the germanium itself at that temperature is sufficient to ensure that as temperature increases from $+20^\circ$ C to 100° C the resistivity falls rapidly. Below $+20^\circ$ C, however, the behaviour depends to a certain extent on the impurity concentration and the state of the germanium material: all rectifiers will show a greatly reduced rate of increase as temperature falls below this limit, while some may even be showing a slight tendency to fall again as temperature falls from -20° C to -40° C. This major variation of resistivity with temperature is a basic feature of germanium material, and it is impossible to make a rectifier using germanium which will not exhibit it: the only solution to the problem of obtaining a more stable rectifier is to utilize another semi-conducting material in which the major transition from extrinsic to intrinsic conduction occurs over a higher temperature range. Such a material is silicon, and considerable effort is being made to develop a high-reverse-voltage silicon rectifier, in which there is a possibility of obtaining an impedance as high at 100° C as is given by the germanium at 20° C.

The attempt to forecast the variation with temperature is fraught with complexity in the case of the point-contact type. It is comparatively easy to forecast the variation of the theoretical junction characteristic but the other two components causing departure from this characteristic are not subject to close control in manufacture, and will be present in varying degrees in commercial rectifiers of a given type. As a result of this, there will be a considerable spread of temperature coefficient among any given batch of components, and the only method of specifying it is for the manufacturers to measure a percentage of each day's production and to supply the user with information concerning the distribution of coefficients for the rectifier type being used.

The variation of junction current is fairly simple. In equation (1) the exponent or index (39 at $+20^\circ$ C) will vary inversely with absolute temperature (degrees Kelvin) decreasing to 31 at 100° C. The coefficient I_o

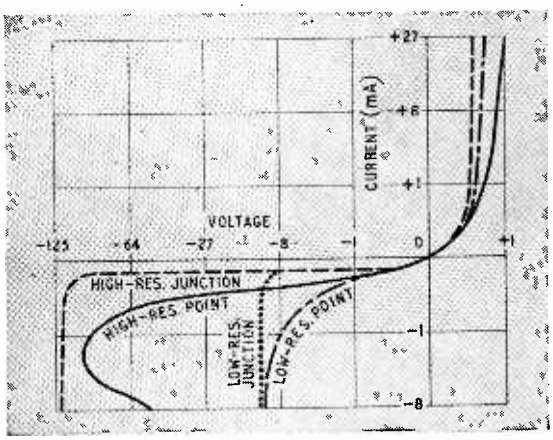


Fig. 3. Typical germanium rectifier characteristics.

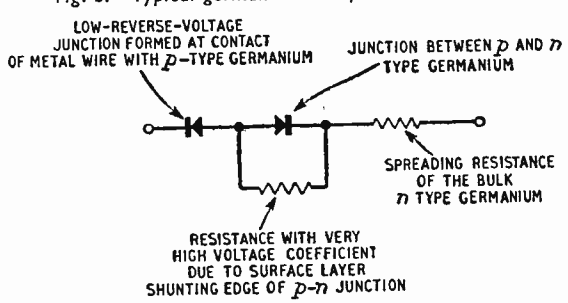


Fig. 4. Suggested equivalent circuit of point-contact germanium rectifier.

has a variation depending mainly on three factors; it is directly proportional to absolute temperature, it is inversely proportional to the overall conductivity of the germanium-impurity alloy, and it is directly proportional to the square of the intrinsic conductivity of pure germanium. The latter term increases so rapidly over the range from 20° C to 100° C that it is the major factor causing the large increase observed, and as a very rough approximation one may consider I_o as increasing a little more rapidly than the conductivity of pure germanium. In the forward direction the current will increase less rapidly than I_o due to the decrease in value of the exponent. In the reverse direction I_o represents a saturation current which will flow at all values of voltage between 0.5 and the breakdown level.

The forward current of the point-contact rectifier is less than that of the junction due to potential drop both in the spreading resistance of the germanium, and also in the reversed rectifier formed by the metal-germanium contact; both these sources will give a smaller fall in potential for a given current as the temperature rises, and in consequence the increase in forward current in the overall rectifier is a little greater than would be that of a junction type. The reverse current will consist of two components, that through the junction, and that through the non-linear leak shunting the junction. Analysis of practical characteristics indicates that increase of the leakage component

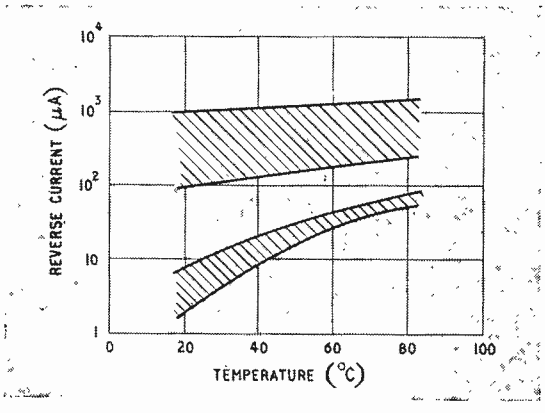


Fig. 5. Typical temperature characteristics of two germanium rectifier types.

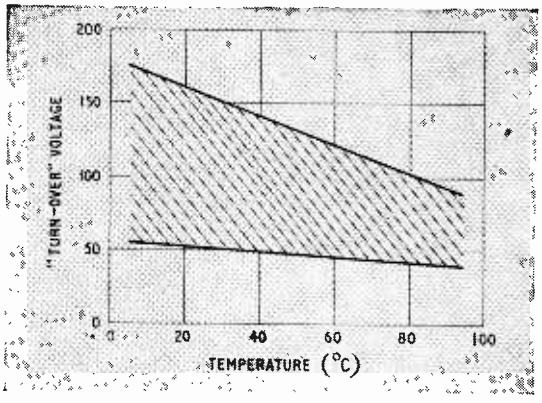


Fig. 6. Variation of "turn-over" voltage with temperature for typical germanium rectifier.

is less rapid than that of the saturation component, and in consequence the overall increase of reverse current is not so great as that of a junction. The leakage component can be analysed into two sub-components, one of which increases linearly with increase of voltage (ohmic) and the other which increases as a power (approximately two) of the voltage. The ohmic component decreases slightly as temperature increases, but the squared component increases and overweighs the ohmic, giving an overall increase of current for increasing voltage. Hence the temperature coefficient of the whole leakage component varies widely between samples due to the variation of ratio between ohmic and non-linear sub-components.

For a given impurity concentration the value of I_o will be directly proportional to the low-frequency capacitance, and as this capacitance varies by as much as four to one over a batch of typical rectifiers, it follows that the value of saturation current will vary by at least as much. An even greater variation of the leakage component is encountered which is not directly related to I_o and it follows that the value of reverse current at any particular voltage is no guide to the value of temperature coefficient. Three general rules may be stated, however, for the guidance of the user: —

(a). The more nearly horizontal the reverse characteristic between −1 and −50 volts, the greater will be the ratio of junction current to leakage current, and the greater will be the overall temperature co-efficient for a given value of reverse current.

(b). For a given value of capacitance, the greater the reverse current at a given voltage the greater will be the leakage component and the smaller the temperature coefficient.

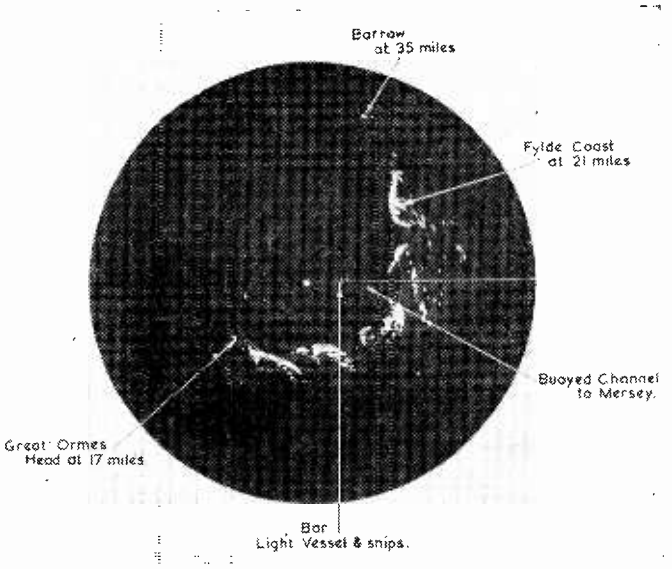
(c). For a given capacitance and a given reverse current at a particular voltage, the greater the concavity of the characteristic the greater will be the ratio of non-linear to linear leakage, and the greater will be the temperature coefficient.

Since the capacitance is controlled within certain limits during manufacture, and the *average* value will remain fairly constant for any large batch, it follows that the *average* value of temperature coefficient for a given batch will be smaller the greater the average value of reverse current; in designing circuits to use these rectifiers it is necessary to design for the average value of coefficients, and allow for the spread of these throughout a representative batch. Typical spread of reverse characteristic for two types is shown in Fig. 5 where it will be seen that the one with highest current has lowest temperature coefficient.

The fall of "turn-over" voltage with rise of temperature is a composite phenomenon, due both to changes in the junction and also in the leakage shunting it. The theory of the negative resistance slope has not been fully evaluated yet, and the only reliable information comes from measurements on production rectifiers. Due to variation of ratio between junction and leakage currents the performance of a rectifier having a given value of "turn-over" voltage at 20° C will vary between the individuals in a batch, and the spread of a typical production batch is shown in Fig. 6. It will be noted that the average fall for a given batch will be less the smaller the average value of "turn-over" voltage, but no rules can be stated for the individual rectifier, and the batch must be considered as having a value which may lie anywhere inside the shaded area in the figure.

(To be concluded)

Display showing responses on the 50-mile range from a vessel bound for Liverpool.



Long-Range Marine Radar

Features of the New Kelvin-Hughes Type 2C Equipment

NORMALLY, marine radar sets are provided with a maximum range of 25 miles, which covers all targets within the ship's horizon. On some trade routes it is an advantage in hazy weather to get an early fix from high land which is "visible" to the radar at much greater distances, and to meet this demand Kelvin and Hughes (Marine), 99, Fenchurch Street, London, E.C.3, have produced an equipment with a 50-mile scale in addition to those normally available.

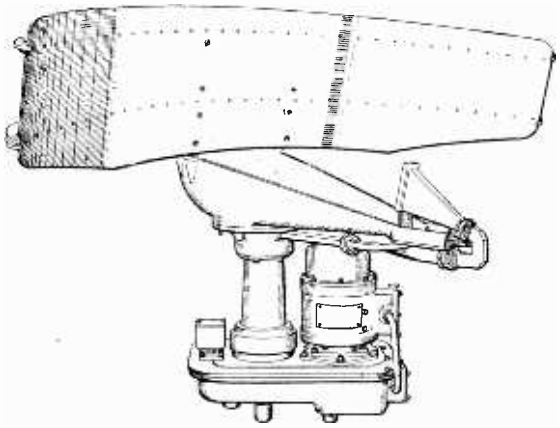
Increased power in the transmitted pulse is necessary, as well as the highest possible receiver sensitivity, in order to make the 50-mile range effective, and in the Type 2C the peak power is 60 kW with a pulse width of 0.2 μsec. The accompanying photograph shows that the waveguide "plumbing" has been cleaned up and now gives a straight outlet, and the layout has been sectionalized in "book" form giving ready access to components for servicing.

Another feature of this new model is the aerial system, which is of parabolic cylindrical form, and is fed on the focal line from a horn termination on the waveguide.* The reflector is tilted forward so that the horn feed is removed from the main reflected beam, with a consequent reduction of interference and side-lobe generation in the polar diagram of the aerial.

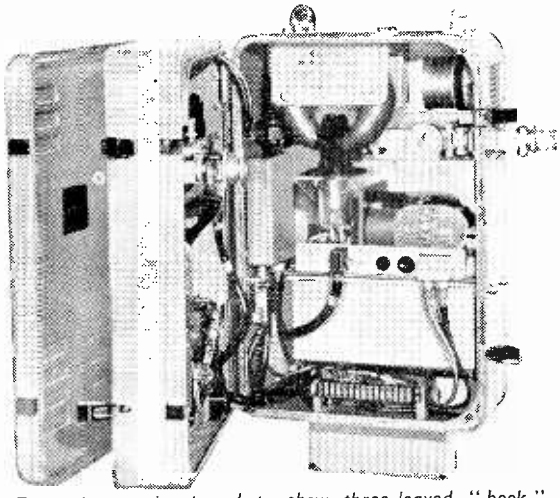
The display unit, which incorporates all the principal controls, uses a 12-in cathode-ray tube. In addition to an adjustable range calibration ring, fixed concentric rings can be superimposed at intervals of 8 miles on the 50-mile range, 4 miles on the 25-mile range, 2 miles on the 10-mile range and $\frac{1}{2}$-mile on the 1-5 mile range. The last is continuously variable, so that the optimum range can be chosen for pilotage in congested waters. Range discrimination and minimum range are 40 yards, while the bearing discrimination claimed is 1.3 degrees.

Monitoring is effected by a cavity-resonator of high-Q, mounted aft in the blind angle formed by the masts and funnels. This resonator "rings" and gives a narrow lobe-like response on the display, the length of which is a measure of the overall efficiency of the equipment, and so gives early warning of any incipient faults.

The price of the new Type 2C long-range equipment is £2,200.



Tilted parabolic cylindrical reflector in the scanner gives an increased gain and reduction of side lobes in the polar diagram by removal of the feed horn from the main axis of the beam.



Transmitter unit opened to show three-leaved "book" construction for ease of inspection and servicing.

A Valve Megohmmeter

The Measurement of Resistance Up to More Than a Million Megohms

By M. G. SCROGGIE, B.Sc., M.I.E.E.

IN a previous article* some of the special precautions necessary when measuring very high resistances were explained, expecially the guard-ring technique. Details of an instrument suitable for measuring such resistances will now be given. It is assumed that the desired range of resistance extends from one megohm to one million or perhaps even ten million megohms—a range that opens up a new and fascinating field of study to any one hitherto equipped only with the ordinary type of ohmmeter or bridge. Moreover the instrument is a valve voltmeter with exceptionally high input resistance and therefore suitable for very-low-current or " open-circuit " investigations.

Nearly all ohmmeters are based on the principle of measuring the current flowing through the unknown resistance when a certain voltage is applied. The difficulty with very high resistances is the extreme smallness of the current. With 500 V applied to a million megohms it is one two-thousandth of a microamp. It is possible to buy a galvanometer sensitive enough to measure this, but such an instrument is expensive and delicate—what would happen if the thing being measured accidentally short-circuited does not bear thinking about—and involves a vibrationless mounting and optical accessories for projecting a moving spot of light, to say nothing of a shunt box to control the sensitivity. A cheaper and more convenient alternative is to measure the current as a voltage drop across a known standard resistance. Obviously the voltmeter ought not to shunt this standard resistance sufficiently to affect its value appreciably ; in other words, it should pass negligible current compared with that flowing through the unknown. Assuming that d.c. is used, it might be supposed that a valve voltmeter would easily fulfil this requirement, for it is often stated that the d.c. input of a valve provided with suitable grid bias is negligible. And so it may be for most purposes, but not for this one. Supposing for the moment that the grid current is allowed to be 2% of the current used for the test (which is 0.0005 μA as suggested above) it would have to be limited to 0.00001 μA ($=10^{-11}$A). In general the grid current of a valve under working conditions is vastly greater than that.

Fig. 1 shows a simple method of measuring grid current. With S closed, adjust the grid bias to the proposed working point, observed by the anode microammeter ; then open S, putting into circuit the high resistance R_g. To exclude any leakage other than via R_g, S is a clip lead and R_g is air mounted. It is also desirable to screen the grid lead and R_g from stray fields. Next, eliminate the resulting change in anode current by adjusting the grid bias ; the amount of adjustment needed is equal to the voltage drop in R_g. Supposing for example, that R_g were 10,000 MΩ ($=10^{10}\Omega$) and the change is bias needed to restore the original anode current were -0.2 V, the grid current would be $-0.2/10^{10} = -2 \times 10^{-11}$ A.

If the space between grid and cathode in the valve behaved as an ordinary ohmic resistance, the value of grid current thus measured and the value of grid bias at which it was measured would indicate the amount of that resistance, which could be allowed for when reckoning the effective value of the standard resistance. Fig. 2 however, which is a typical grid-current/grid-voltage graph, shows that it is nothing like an ohmic resistance (which of course would be represented by a straight line through the origin as shown dotted). This very non-linear characteristic is a combination of several distinct types of current. The peculiarity that a relatively large positive current flows when the voltage is zero is due to some of the electrons emitted from the hot cathode landing on the grid without any positive invitation and flowing back to the cathode via the external circuit. Something between one and two volts negative is needed to suppress this current completely, and the working bias must be not less. If it is more negative, a negative current flows; but instead of increasing with voltage it reaches a maximum not far from the cross-over point and then decreases. The reason is that most of this current is due to ions liberated by electrons on their way to the anode, and increasing negative bias reduces anode current and hence ionization. Other causes of negative grid current are internal and external leakage, and grid emission due to heat and light from the cathode and light from outside. In some types of valve, leakage from anode to grid may be serious.

Leakages are minimized by using a suitable type of valve. A top-cap grid connection is obviously a safeguard, but not absolutely essential if the valve is otherwise well insulated. The most important cause of current is then ionization, which can be tackled by reducing anode voltage and current to the lowest practicable. One type of valve in which grid current can be reduced to something like the right extent is the EF37 or EF37A, grid-current data for which have been given by K. D. E. Crawford**. It can be kept down to about 10^{-11} A by restricting anode voltage and current to below 50 V and 0.1 mA respectively, and in these circumstances it is allowable to reduce grid emission by running the heater at 4.5-5 V. Also the valve should be kept in the dark Not all samples of this type are equally suitable and some selecting may be necessary ; or alternatively

* " Measuring High Resistance," *Wireless World*, June 1952, p. 236.

** " H.F. Pentodes in Electrometer Circuits," *Electronic Engineering*, July 1948, p. 227.

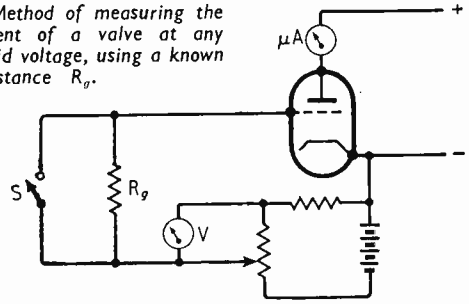


Fig. 1. Method of measuring the grid current of a valve at any desired grid voltage, using a known high resistance R_g.

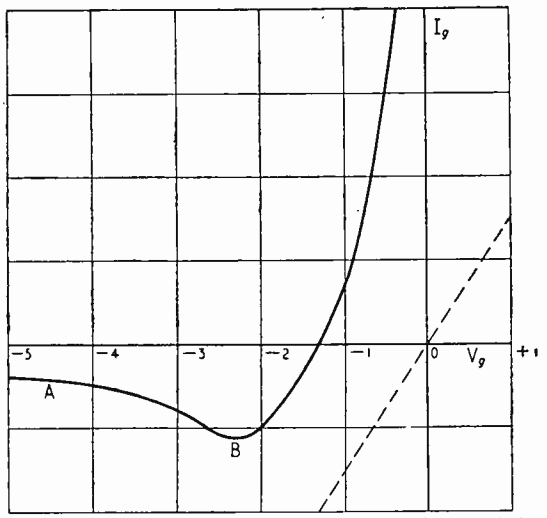
one may prefer to make sure of a grid current below 10^{-11} A by paying rather more for a ME1400 valve which is a special low-I_g version of the EF37A.

Fig. 2 shows that the grid current measured at any one bias voltage is not sufficient information to indicate the corresponding error in resistance measuring. In fact between A and B, where the working point is normally found, the grid-cathode resistance is negative. Instead of reducing the input voltage by its shunting effect, the valve would actually increase it. What happens is that when the grid voltage is made, say, less negative the resulting increase in anode current causes an increase in grid current, which flowing through R_g reduces the bias more, causing I_a to increase further, and so on. R_g has only to be sufficiently large and the system is unstable, so that the working point cannot stay on the negative slope AB but jumps straight to one end or the other.

Though the Fig. 1 method does not enable the grid-current error to be predicted, it does show how much the zero setting of the megohmmeter will be displaced by grid current, and, on the assumption that the greater the measured grid current the greater the error, it can be used for roughly comparing one valve with another. On the whole however it is better to test valves for grid current in the actual megohmmeter circuit.

With regard to that circuit: first, the tendency to instability can be nearly eliminated by using the valve as a cathode follower, because this keeps I_a much more nearly constant relative to V_g. In doing so, of course, it makes the changes in I_a more difficult to read directly, so a stage of current amplification is advisable. The general scheme thus turns out as in Fig. 3. The current passed by a known test voltage through the unknown resistance R_x is passed also through a known standard resistance R_s, and the resulting voltage drop is indicated by the two-valve voltmeter. For the sake of calibration stability the second valve (V_2) is also run as a cathode follower. The more sensitive the meter, the greater the resistance that can be used in series with it and the less the effect of changes in the characteristics of V_2, but the greater its cost. A 0-1 mA meter was chosen as a suitable compromise: the valve is then only about one-fifth of the total series resistance, and if the anode voltage is kept constant by stabilization the calibration drift is not likely to be appreciable for a long period of normal use.

To be precise, the full test voltage ought to be maintained across R_x alone, but as the standard British voltage for measuring insulation resistance is 500 and the input to V_1 need not be more than 5 V the error caused by not doing so is at most 1%. Moreover, the higher the value of R_s the more costly and inaccurate it is likely to be, and in any case the maximum value is limited by grid current. Experience with the EF37 class of valve suggests that there is no difficulty with 1,000 MΩ (1 kMΩ), across which a drop of 0.5 V is obtained through 10^{12} Ω (1 MMΩ); and with care the grid-current error need not be excessive even with 10 kMΩ, enabling at least rough measurements to be made up to 10 MMΩ. High-stability resistors of these values are obtainable, but if the price is to be reasonable a considerably wider tolerance than 1% will have to be accepted; 20%, say. Because resistances high enough to be measured therewith are likely to vary widely with the slightest changes in humidity, and for other reasons, there is not much point in attempting high absolute accuracy—in fact, above a few thousands of meghoms it is usually enough to determine the order of magnitude correctly—but the comparative accuracy is of course much better.



Right: Fig. 2. Typical shape of grid current characteristic, compared with that of a linear resistance (dotted).

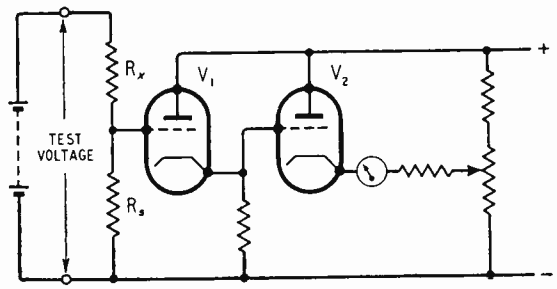


Fig. 3. General scheme of the megohmmeter described.

If the valves are set to give full-scale deflection with no input, and the test voltage is connected so as to make the grids more negative, then accidental excess input cannot over-deflect the meter; on the other hand, it is desirable to pass the least anode current through V_1—and thus have least grid current—when the highest resistances are being measured, and since meter protection is obtained by other means it was decided to use positive test voltage, which is more convenient in practice.

If the resistance being measured is shunted by capacitance—whether or not what is being tested is

actually a capacitor—this capacitance causes any fluctuations in test voltage to be applied in almost full measure to the grid of V_1. Fluctuations of one or two volts, which would be quite harmless if reduced in the ratio R_x/R_s, thus become intolerable, and as such fluctuation is only a fraction of 1 % of the whole test voltage it is clear that if the voltage is derived from the mains it must be stabilized. Extensive smoothing is not a solution, because it can be shown that its time constant would have to be large compared with that of R_s in conjunction with the capacitance across R_x, and that is likely to be impracticable. Moreover a slowed-down drift of the reading is even more troublesome than rapid fluctuations.

The stabilizing system, shown in the full circuit diagram (Fig. 4), is conventional in principle,*** and serves not only the test voltage source but also the valve voltmeter, the anode supply for which is taken from across the stabilizer tube V_5. The total current does not exceed 8 mA, so comes within the ability of the 16HT series of metal rectifiers. The only disadvantage of a metal rectifier here is that it has no time delay, so during the warming-up period the valve V_4 has to bear an anode voltage of the order of 900. Any risk attaching to this unorthodox practice could be avoided by using a slow-heating valve rectifier, but no reasonable type rated to include 770 V, 8 mA output appears to be available. No trouble has actually been experienced with V_4, which can be almost any old medium triode one happens to have left over from the days when plain single triodes were the mainstay of the valve list; but it would be prudent not to pick on one with a high g_m in relation to heater current, achieved by reducing electrode clearances as much as the designer dared. Another reason for avoiding a small heater wattage will appear presently. A μ of about 20–35 is suitable.

Since the cathodes of V_2 and V_3 differ less than 100 V in potential these valves can be a double triode, but with a cathode at + 500 V V_4 needs a separate heater supply. An ordinary 350-0-350 receiver transformer does all that is needful—the h.t. winding provides about 740 V end-to-end at this load current, and its rectifier heater winding is available for V_4—but if its unnecessary size and weight are embarrassing a special transformer suitable in the alternative half-wave rectifier circuit shown, can be obtained from the Majestic Winding Co., 180 Windham Road, Bournemouth.

V_5 can be a Mullard 85A1 or 85A2 or Osram QS83/3, but these are unnecessarily precise for the job, and the Mullard 90C1 or 7475 or Osram ST11 are suitable. The main thing—which should be checked by noting that there is no jerkiness in the meter reading as the input to V_1 is varied steadily through its full range—is that there are no "steps" within the working range of current caused by sudden redistribution of glow. The value of resistance in series has been chosen so that of the total of about 6 mA V_5 takes about 2 mA at zero reading. As the reading increases, V_2 takes more current at the expense of V_5: if too much of the test voltage reaches the grid terminal, the meter current is limited to little more than this 2 mA; after which V_5 goes out and the stabilizer begins to reduce the test voltage. If "+ H.T." is dead-shorted to "GRID," the meter reading may actually be *less* than full-scale: this is a very comforting thought. Risk to V_1 and V_2 is excluded by series grid resistors, and risk to the metal rectifier and the operator by 1 MΩ (R_1) is series with the test voltage. This means that 1 MΩ must be deducted from the reading, but it confers the advantage that there is no definite lower limit to the range of measurement—all that happens is that below about 1 MΩ the accuracy of reading begins to fall off steadily. The anode voltage to V_1 is reduced to 45–50 V by means of a potential divider.

For some purposes a test voltage of 500 may be too high, so it is convenient to be able to switch over to the voltage across V_5. With the high-stability types this is usually between the limits 83–86 V, and the 90C1 86–94, but the 7475 or ST11 may be anything from about 88 to 105, so if one is lucky enough to get one running at 100 it is very convenient for

*** "Stabilized Power Supplies," *Wireless World*, Oct., Nov. and Dec. 1948.

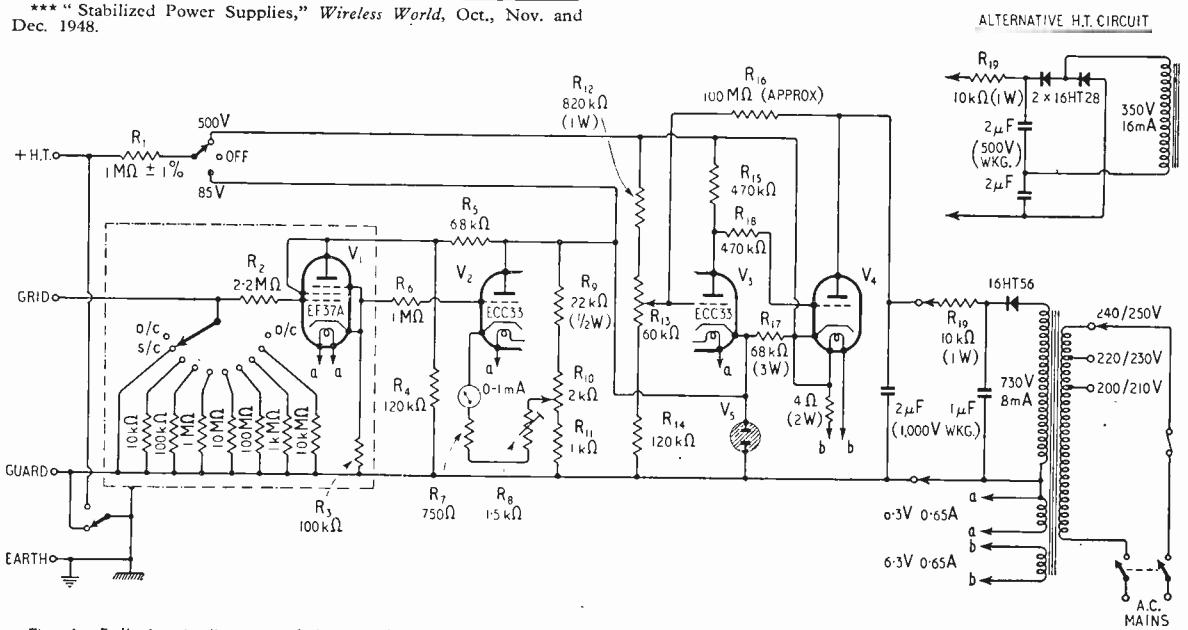


Fig. 4. Full circuit diagram of the megohmmeter. An old-type triode, as explained in the text, may be the most suitable for V_1.

calculation. The possible error due to drop across R_s is of course greater than with 500 V, but for most purposes still tolerable (and in any case can be corrected). A considerable discrepancy between the values obtained for R_x with the different test voltages is not necessarily a cause for despondency; it is quite usual for the resistance of semi-conductors to vary with voltage, contrary to Ohm's Law.

When checking the circuit operation it is advisable to begin with the power unit and stabilizer, temporarily substituting a 25-kΩ resistor for the valve-voltmeter portion. Using a high-resistance voltmeter direct to cathode of V_4, check that the test h.t. can be set by R_{13} to 500 V, with some margin for adjustment. Next, reduce the mains voltage from normal by 10 % and see that the h.t. remains practically constant. Very close stabilization can be obtained by adjusting R_{16}, which may be made by pencilling across between two terminals on a small strip of bakelite until the best results are obtained—a technique familiar to early practitioners in radio. If meanwhile the system behaves in a manner that appears to contradict basic electrical principles the explanation is likely to be spurious oscillation, but with common-sense layout and R_{18} this ought not to occur.

The valve voltmeter should next be restored in place of the temporary load resistor, and R_8 and R_{10} adjusted alternately until with the " GRID " terminal at zero volts relative to " GUARD " the meter reads 0.1 mA and with + 5 V it reads 1.0 mA. Fig. 5 shows two alternative methods for calibrating the meter in volts; in the second of these the 500 V and the 1 MΩ in series (R_1) must be reliable and the 0–10 kΩ is a decade box or the equivalent, and of course the range switch must be set to open-circuit. If there is room on the meter dial a resistance scale can be added, and the range switch marked with the factors by which the scale readings must be multiplied. It is wise to have a reminder on the panel that 1 MΩ must be deducted from the reading, if it is appreciable.

To guard against at least the less extreme onslaughts of load shedding and other occasions of low mains voltage, sufficient rectified voltage is provided to stand a 10 % reduction. In the original set-up, in which an EBC33 was used for V_4, it was found that 10 % reduction in voltage from the h.t. winding alone had negligible effect; 10 % reduction in heater voltages alone reduced the " zero " deflection of the meter slightly, and when this was adjusted by R_{10} the calibration was correct; but 10 % reduction in both caused the stabilization to fail and the calibration to be upset. This situation was overcome by slightly over-running the heater of V_4 at normal mains voltage, but it was rightly judged that if a valve with a more substantial heater was used it would not arise at all, and an old Tungsram HL4+ has proved entirely satisfactory. Low mains voltage is indicated by displacement of the meter zero, and when this is adjusted the calibration is practically correct.

At this stage it is a good idea to check the maximum possible meter overload by temporarily substituting a higher-range milliameter and increasing the input voltage indefinitely.

Lastly the input circuit. Obviously special care must be taken to keep the leakage resistance from the grid lead of V_1 large compared with the highest standard resistance. The only places (apart from the valve itself) where there need be any leakage at all are the input terminal and the range switch. The original instrument failed on the top two ranges, and this was traced to a ceramic stand-off terminal that looked impressive but was found to be too conductive. At that juncture Belling & Lee came to the rescue with two new types of terminal specially made for this kind of job; the smaller, with a resistance of 3.6 million megohms, is quite good enough, and there is a larger one with 20 million megohms. The switch is more difficult; but an ordinary ceramic type was found to have a resistance from moving contact and one fixed contact to all other contacts and metal parts of about 180 kMΩ, and this was considered just about tolerable in relation to the highest R_s—10 kMΩ ± 20 %.

To check that the error due to grid current and switch leakage is small enough, the input voltage calibration process (Fig. 5) should be repeated with the highest standard resistance inserted in *series* with the grid as in Fig. 1. This test is equivalent to the unpractical one of checking the calibration by means of an accurately known 0-10 MMΩ variable resistance between " +H.T." and " GRID " terminals, with R_s (max.) in its normal position (see Appendix). This is so, even although the valve is a non-ohmic resistance. First of all the test should be done with the range switch disconnected from the grid, so as to confine attention to the valve. R_s is first shorted by a clip lead, and the meter zero set with zero input. If R_s is 10 kMΩ the zero is likely to shift slightly when it is unshorted. If the shift is more than slight, the excess may be due to stray field. V_1 and its grid lead should always be screened. The screening having been checked, any remaining zero shift is presumed to be due to grid current, and if the valve is reasonably good should certainly be less than 0.3 V. The magnitude of the shift is not necessarily a measure of the error it imposes on readings, for, as already explained, the grid current is usually relatively constant over the range of input voltage, and when the zero has been reset the error should be quite small. If not, try another valve.

Next, connect the switch and set it to the highest range; the resistor for that range will not be present, of course, for it has been placed in series with the

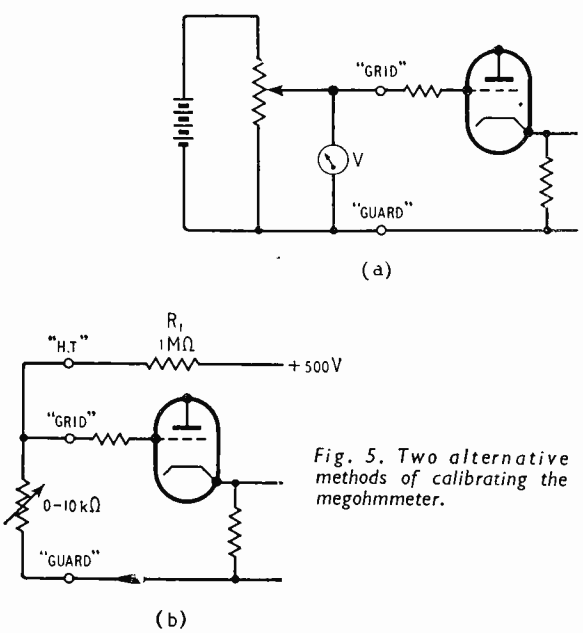


Fig. 5. Two alternative methods of calibrating the megohmmeter.

calibrating voltage, and the only effect of connecting the switch is to shunt its leakage resistance across the valve input (Fig. 6). Repeat the previous test, noting the effect on the calibration of unshorting R_s. It may well be that both zero shift and calibration error are less than before, because of the positive leakage resistance offsetting the negative valve input resistance. If however the error at first is distressingly large there is no need to lose heart. Leave the instrument on for about half an hour, or longer in damp weather, preferably in its box so as to raise the temperature throughout, and the story may be quite different. (Whenever the instrument is used on its upper ranges, and especially after it has been out of use for some time and has not been kept in a dry warm place, it is essential to have it on for perhaps an hour or so beforehand). If after all precautions the leakage error on the top range when tested as just described much exceeds 10% it may be necessary to clean the switch with methylated spirit.

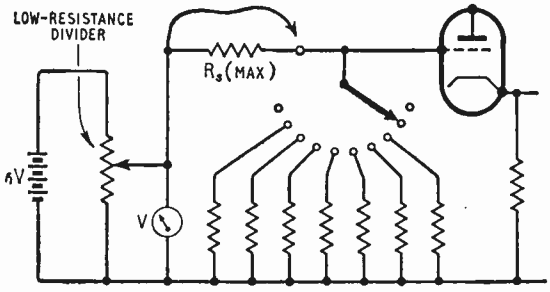


Fig. 6. Adaptation of the Fig. 1 method, for measuring the influence of grid current and switch and " GRID " terminal leakage on any range, especially the highest. Note that the appropriate range resistor is removed from its position in the switch and placed in series.

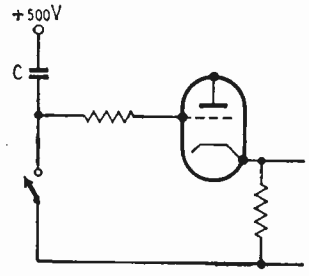


Fig. 7. Alternative method of measuring input resistance and checking calibration.

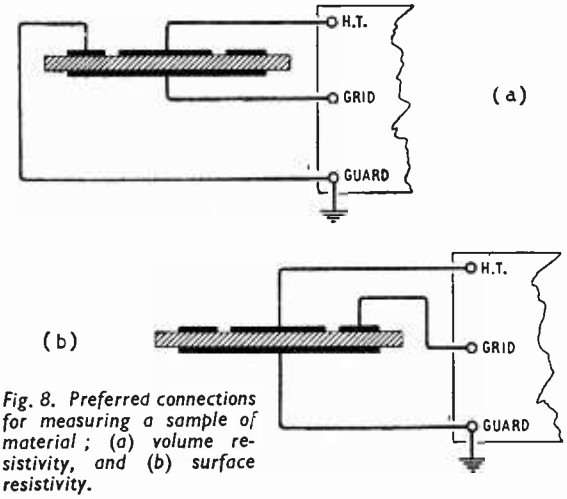


Fig. 8. Preferred connections for measuring a sample of material ; (a) volume resistivity, and (b) surface resistivity.

The method used to measure the switch leakage resistance may be of interest, as it affords an additional means of checking the megohmmeter calibration on the upper ranges. Provided that a capacitor with really high leakage resistance can be found, it is extremely simple. The capacitor is connected as shown in Fig. 7, the grid being short-circuited for obvious reasons. When the short circuit is removed the capacitor discharges through its own leakage and the grid potential slowly rises. There is no other leakage except that due to the valve, which should previously have been found to be satisfactory. The rise in voltage should be practically linear with time and quite slow if the capacitor is a good one. Since a charge often takes some while to " soak in," the test should be repeated until consistent results are obtained. A 4,000-V 0.01-μF capacitor was found to discharge at 15 seconds per volt ; and since this initial discharge rate, if maintained, would completely discharge it in CR seconds, R in this case is indicated as 750 kΩ. With the appropriate switch leakage paths connected across the capacitor the rate quickened to 2.9 secs per volt, indicating 145 kΩ for the combination, and therefore 180 kΩ for the switch.

In measuring very high resistances the question of guarding usually arises, as explained in the earlier article. It will be noticed that the instrument as a whole is insulated from earth, so that either positive (+H.T.) or negative (GUARD) terminal can be earthed. If the resistance to be measured (R_x) has one terminal earthed, then that terminal should be connected to " +H.T." and it must not be forgotten that " GUARD " is 500 V below earth. Leakage resistance between the negative side of the instrument and earth, together with any leakage between the earthed end of R_x and " GUARD " comes across the h.t. supply, and unless excessive should be harmless. Leakage between the other end of R_x and " GUARD " comes across R_s, and care should be taken to see that its resistance is large compared with the R_s in use. If neither end of R_x is earthed, " GUARD " should be earthed, and the end of R_x having the higher leakage resistance to this point should be connected to " GRID," in the hope that it will be large compared with R_s and that the leakage resistance from the other end to earth will not be so low as to cause trouble when connected across the h.t. As an example, Fig. 8(a) shows how to connect a sample of insulating material for measuring volume resistivity. Compared with the connections shown in the earlier article, the " +H.T. " and " GRID " connections have been interchanged, because in exceptional cases in which surface resistance is relatively low the resistance of the short path between upper electrode and guard ring may be low enough to shunt the appropriate R_s appreciably and cause a misleadingly high volume resistivity to be indicated. The surface resistivity connections shown in Fig. 8(b) are the same as previously ; as mentioned then, this measurement is of little value unless it is possible to control ambient humidity.

The following British Standards specify in detail the procedure for tests of this nature, except that a sensitive galvanometer is shown in place of this valve instrument :

BS488 : 1948 *Moulded Insulating Materials for General Electrical Purposes.*

BS771 : 1948 *Synthetic Resin (Phenolic) Moulding Materials.*

BS903 : 1950 *Methods of Testing Vulcanized Rubber.*

A standard practice is to take the reading after the h.t. has been applied for one minute. It need hardly be mentioned that until the h.t. has been switched on, the range switch should be at the short circuit position to which position it should be returned after taking the reading. On the upper ranges the instrument is very sensitive to small changes in capacitance to grid, and one's hands should be kept well away while taking a reading.

APPENDIX

Validity of method shown in Fig. 6 for measuring megohmmeter error due to input current.

In Fig. 9(a), V_t is the h.t. voltage, normally 500; V_1 is the input voltage that would exist if leakage and grid current were nil; V_2 is the actual input voltage, the non-linear input resistance being denoted by R_i.

Then $V_1 = V_t R_s/(R_x+R_s)$; but since in the instrument described, with $V_t = 500$, R_s is never more than 1% of R_x it can be neglected in comparison, and $V_1 \simeq V_t R_s/R_x$. On the same basis,

$$V_2 \simeq V_t \frac{R_s R_i}{R_x(R_s+R_i)}$$

To set up the voltage V_1 at the input, using the circuit Fig. 9(b)—which is essentially the same as Fig. 6—with the switch closed, V_3 must be made equal to V_1, and if this is taken as $V_t R_s/R_x$ then

$$V_4 = V_t \frac{R_s R_i}{R_x(R_s+R_i)}$$

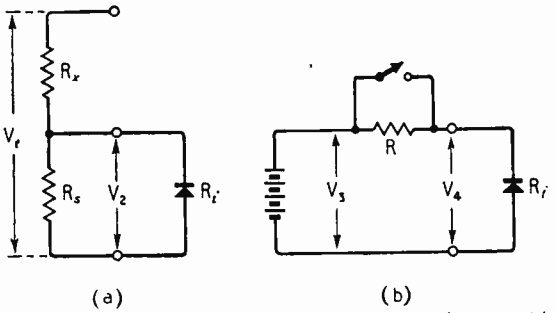


Fig. 9. Theoretical representation of input conditions, with (a) ohmmeter circuit, and (b) calibration circuit (Fig. 6).

Except for the negligible difference already mentioned, this is the same as V_2, and therefore the value of R_i—even if considerably non-linear—is the same in both cases, and the Fig. 6 calibration circuit correctly simulates the effect of leakage and grid current in the ohmmeter circuit, but without actually having to provide a known very high-valued resistance R_x.

If the instrument zero is reset on any range that has a perceptible zero error due to R_i, the effective error at any scale reading is the *difference* between the error measured at that reading and the error measured at zero.

SWISS RADIO SHOW

International Exhibition of Broadcast Receivers and Sound Reproducing Equipment

By G. H. RUSSELL, Assoc. Brit.I.R.E.*

THE twenty-fifth Swiss radio exhibition was held in the Kongresshaus Building, overlooking the lake, in the city of Zürich, from August 29th until September 5th. This year, the exhibition coincided with the commencement of regular transmissions from the first television transmitter in Switzerland. This is situated on high ground at Uetliberg, a few miles from Zürich. The transmissions are broadcast on European channel 3, using the C.C.I.R. standard of 625 lines, with a power of 5 kW.

As Switzerland manufactures only a small proportion of her electronic needs, a great deal has to be imported from abroad. The exhibition, therefore, tends to be of a far more international character than its equivalents elsewhere. Countries represented were Austria, Denmark, Germany, Great Britain and the United States of America, but the majority of the exhibits were of German origin.

Apart from radio and television sets, tape-recorders, amplifiers, measuring instruments, components, valves, aerials and gramophone records were displayed in abundant variety. Altogether, there were over fifty stands, many of them displaying goods from several manufacturers.

Television.—The main focus of interest was, quite naturally, on television. The majority of the receivers shown were tuneable over bands 1 and 3. All receivers were of the direct-viewing type, and tubes varied from 14 to 27 inches. British firms represented were Bush, Ferguson and Pye. Amongst the American exhibits were table and floor models with 21-in tubes by RCA, and a 27-in console model by Philco. From Germany there were 14-in, 17-in and 21-in receivers in great variety. One German "prestige" model contained a 21-in television receiver, all-wave radio, three-speed gramophone, tape-recorder, gramophone-record storage space and cocktail cabinet, all in one unit of truly massive proportions.

There did not appear to be anything revolutionary in the circuitry of these receivers. Some sets used continuous tuning, but the majority were switch tuned. Intercarrier sound was a very popular feature, but flywheel sync, on the other hand, was only used by a few of the manufacturers.

Sound Broadcasting.—Switzerland, being situated

* Bush Radio, Limited.

in the centre of Europe and surrounded by large numbers of high-power stations, must of necessity use broadcast receivers which are highly selective. As there is only one station for each language group within Switzerland, a great deal of foreign listening is indulged in, which makes the selectivity of a receiver of even more importance than it might otherwise be.

One interesting method of coping with this selectivity problem is the "ferrite aerial," one example of which was shown by the Swiss firm of Sondyna. It consists of two lengths of Ferroxcube rod, on which are wound the medium- and long-wave aerial coils. These are screened in all directions but two. The whole unit is mounted well above the chassis on a rotating shaft, which is controlled by means of an external knob. Indication of orientation is given by a rotating device on the dial. Discrimination ratios of the order of 30 db and over are claimed for this aerial, not only against "off-beam" signals, but also against local electrical interference. It is further claimed that the directional properties of this aerial are far greater than can be obtained with a frame.

Because of the public desire for foreign listening, and because of propagation difficulties in such a mountainous country, wire broadcasting is extensively used. Until recently, this has been of the audio-frequency variety, but radio-frequency wire broadcasting is now coming increasingly into use. This provides at least three foreign stations, as well as two of the home programmes; the quality of reproduction is excellent. A channel spacing of 33 kc/s is used. A number of receivers were shown which make provision for the reception of these programmes, the bandwidth being automatically adjusted to take advantage of the improved frequency response.

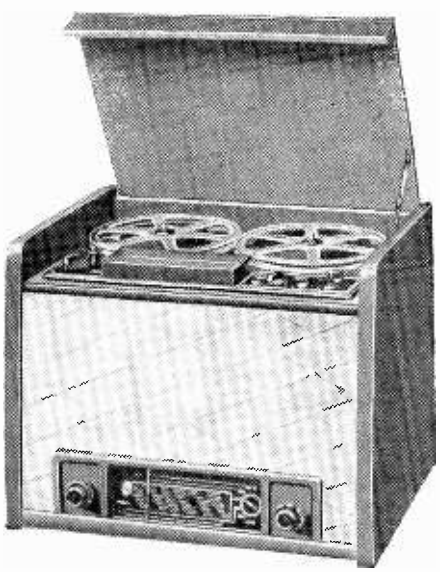
The fact that one of the German f.m. stations is receivable in the German-speaking area of Switzerland has made the public there very v.h.f.-conscious. As nearly all German receivers incorporate a v.h.f. band as a matter of course, and as the medium and long wave selectivity of these receivers is adequate for Swiss needs, German radio tended to dominate the exhibition. A popular circuit line-up is: self-oscillating mixer, two i.f. amplifiers and ratio-detector. One Swiss firm showed an f.m. converter housed in a small wooden cabinet, the appearance being similar to that of an American midget receiver of pre-war days. Sondyna provide a v.h.f. adapter as an optional facility for their receivers. Permeability tuning is used, and this is operated by means of an eccentric drum attached to the receiver tuning spindle. The unit is built on a flat chassis, measuring about 4½in by 3½in, and is constructed so as to fit above the receiver tuning condenser. The valve line-up is: 6BK7, cascode r.f. stage; 6J6, mixer and oscillator; two 6BH6 i.f. amplifiers and 6AL5 ratio detector. It is claimed that full limiting takes place with an input of 30 μV. The ratio detector seems to have become a standard part of these f.m. receivers, and, with it, an intermediate frequency of 10.7 Mc/s.

Radio-gramophones were all provided with two or three-speed motors, and crystal pickups were universally employed.

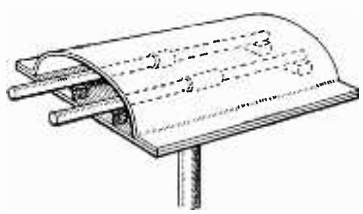
Tape Recorders.—A great variety of tape recorders were displayed, including the British Ferrograph model. The Swiss firm of Revox showed their recorder housed in what can best be described as, a table radiogram cabinet, complete with radio and "wired wireless" receivers. Another Swiss manufacturer, Perfectone, demonstrated recorders which included the following features: twin-track recording with automatic track-change-over at the end of the reel, providing two hours continuous playing time, automatic stop at the end of the reel; automatic stop in the event of tape breakage; and instantaneous track-change-over at any point.

Test Gear and Components.—Among the test instruments shown were a wide selection from Advance Components and some of the Marconi Instruments range. American and German instruments were strongly represented. One of the General Radio exhibits was a very compact absorption wavemeter covering the range 250 to 1,200 Mc/s without switching. From the Danish company Radiometer was an f.m./a.m. standard signal generator with a frequency coverage of 54 to 216 Mc/s, with variable deviation from 0 to 300 kc/s. A piston attenuator is used and the output voltage reading is claimed to be 10% ± 1 μV. Frequency calibration is claimed to be within 0.5% of the dial reading. An additional instrument which converts the above signal generator to the range 100 kc/s to 55 Mc/s is available. These two instruments together, therefore, provide a continuous f.m./a.m. signal source ranging from 100 kc/s to 216 Mc/s.

In the components field, British products were reasonably well represented, but as far as could be ascertained, all aerials were of German manufacture. They were invariably of the 300-ohm folded dipole type, and some very imposing arrays were shown, such as a triple aerial system covering bands 1, 2 and 3, complete with reflectors and directors.



Three-band radio receiver, provision for receiving wire-distributed programmes and a tape recorder are combined in this Swiss domestic sound unit, made by Revox and costing about £130.



Ferrite-rod directional aerial for two-band reception.

Colour Television for Britain

Will a Compatible System be Too Difficult and Too Dear for Us?

THE Federal Communications Commission of the U.S.A. is now in the process of considering the proposed standards for colour television submitted to it earlier in the year by the National Television System Committee, a body representing most of the well-known American radio manufacturers. These standards are based on a system of compatible colour television (described on the following page) which has been devised more or less as a counterblast to the old non-compatible C.B.S. frame-sequential system. If the standards are accepted—and it seems fairly certain that they will be—it follows that this system will form the basis of design for all colour transmitting and receiving equipment in America.

At such an important point in the history of American development it is appropriate that some comment should come from this country about our own position. So far, the Television Advisory Committee has recommended that any future British system should be a compatible one. If this proposal is accepted by the Government it is probable that we shall adopt something similar to the N.T.S.C. system. There are, however, a good many problems that would have to be solved before such a system could be made suitable for use in Britain.

Critical Timing

Some of the limitations of the N.T.S.C. system that would make things difficult for us were discussed recently by F. C. McLean, Deputy Chief Engineer of the B.B.C., at a British Association meeting in Liverpool.* To begin with he placed a good deal of emphasis on the critical timing and phase relationships of the various components of the signal. It would be necessary, for example, to lock together the colour sub-carrier frequency, the line and frame frequency and the timing of any colour synchronizing signal. This would mean that the present practice of tying the line frequency to the mains frequency would have to be abandoned. From the transmitting point of view this would cause very little difficulty, but it might give trouble in some existing receivers which would be required to take a monochrome signal from the colour transmissions.

Referring to the distribution of the signal to the various transmitters, he pointed out that a system like the N.T.S.C.'s implies that "a very close tolerance must be maintained on the timing of the various carriers and pulses, and hence all parts of the transmission system must have a very small distortion in terms of amplitude and phase delay over the whole of the video band." Similarly the phase and amplitude distortion introduced by the transmitters themselves would have to be made negligible. All this would result in increased difficulty and cost.

Mr. McLean also thought that a simultaneous sub-carrier system might affect the range of transmitting stations by reducing the useful service areas within which satisfactory reception could be obtained. This limitation might be caused by differential fading or attenuation of the various components of the picture, and at distances of about 50 miles the colour information might be seriously distorted. To cover a given area would, therefore, require more transmitters and hence more channels. This could prove a serious matter for the establishment of a nation-wide colour service.

As for the question of our narrower channel widths in this country, he said it still remains to be decided whether all the colour information can be transmitted within the limitations of a 5-Mc/s channel, or whether such information will have to be sent outside in another channel.

On the subject of receivers, Mr. McLean said that there are likely to be some problems of even greater difficulty than those met by the N.T.S.C. in America. He pointed out, for example, that in this country the sound channel is amplitude modulated, so that separation of the colour sub-carrier might be more difficult than in the U.S.A. where the sound carrier is frequency modulated. Discussing the more general aspects, he said that a colour television receiver requires much greater stability of circuits, components and receiving conditions. We still do not know what effect any variations of these will have on faithful colour reproduction, since all receiving tests so far have been carried out under laboratory or restricted field-test conditions. Colour receivers would cost a good deal more than our present ones and their greater complexity would probably put up the servicing costs as well.

Interference Problems

One other problem which Mr. McLean did not mention but which has troubled a number of engineers is the possibility of the colour signal producing an interference pattern on the black-and-white picture. Although the N.T.S.C. system employs various tricks to reduce this effect it seems that they are not completely effective. It is felt, too, that the process of interlacing the sidebands of the monochrome and colour signals is not entirely foolproof because in practice there are sometimes large instantaneous peaks of energy occurring at frequencies outside the normal distributions and these can cause interference between the two signals.

These, no doubt, are some of the technical difficulties which Sir Ian Jacob, Director-General of the B.B.C., had in mind when he said that "neither here nor in America is there yet a system which has been developed to the point at which it can be confidently adopted."

* "The Application of Colour Television to Broadcasting", a paper read before Section G (Engineering) of the British Association.

American

Principles of the N.T.S.C.

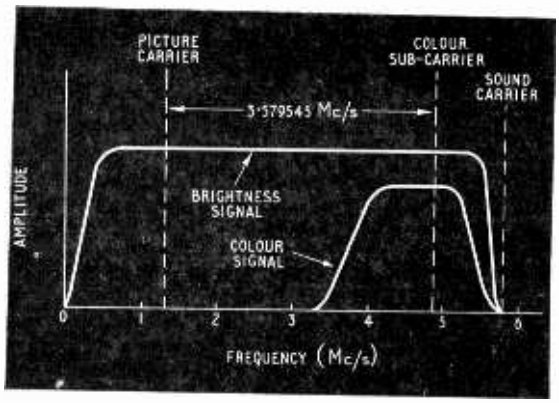
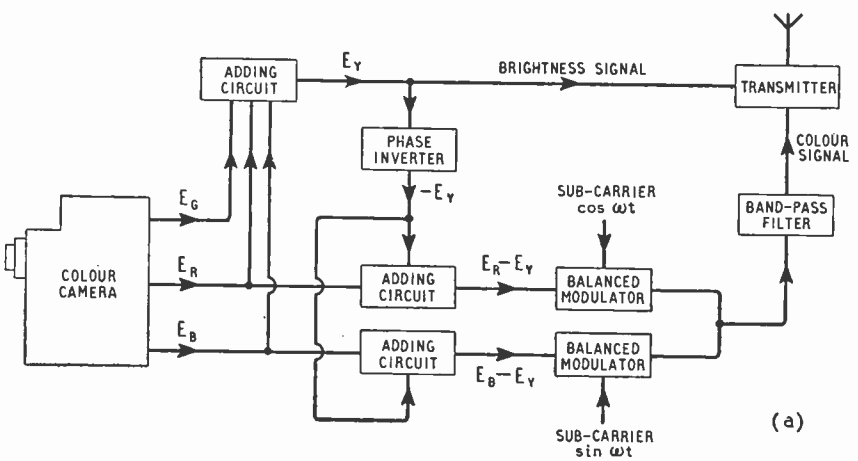


Fig. 1. Frequency characteristic of the N.T.S.C. colour transmission in its 6-Mc/s channel. The vestigial sideband system is used for both the picture carrier and the colour sub-carrier.

WHEN the National Television System Committee first set about the task of devising a colour television system for the United States they were faced with two main technical requirements. The first was that the system should be compatible, that is, the pictures should be receivable in black and white on existing receivers without any degradation from normal quality. The second was that the frequency band of the transmissions should be kept within the present American channel width of 6 Mc/s—in other words, all the vision information would have to be transmitted within a band of about 5 Mc/s. The system which has now been evolved satisfies first of all the compatibility requirement by taking the brightness information of the colour picture and transmitting it as a black and white picture which can be reproduced on existing receivers. The bandwidth requirement is satisfied by transmitting the colour information on a sub-carrier, of approximately 3.58 Mc/s, in such a way that the signal is kept within the normal vision band and yet does not interfere with the black and white picture. This is done by a process known as frequency interlacing. Fig. 1 shows the complete frequency characteristic of the transmission. Note that the vestigial sideband system is used and that the colour signal only occupies just over 1 Mc/s of the whole channel.

This idea of transmitting the picture in the form of two sets of information, brightness and colour, seems rather strange when one thinks of the classical method, evolved from colour photography, of transmitting it in terms of three colour components, usually the primary colours, red, green and blue. The reason for it is, of course, that a separate brightness component is needed to provide the normal black and white picture. It would be possible, of course, to transmit this brightness component in addition to the three colour components, but that would be very wasteful of bandwidth because the colour components would already contain the brightness information and it would be transmitted twice. In the N.T.S.C. system this duplication is avoided by removing the brightness information from the three colour components. The remaining colour information on the sub-carrier then consists of hue (e.g. red, brown, yellow, purple) and saturation (i.e. the extent by which the hue is pure and not diluted by white light).

This method of specifying a colour picture in terms of brightness, hue and saturation instead of in red, green and blue components is rather unfamiliar, but the relationships of the three quantities can be illustrated quite well graphically as in Fig. 2, using the well-known colour triangle. At the corners of the triangle are the three primary colours, while in between are the secondary colours produced by mixing them additively. In the middle, where all the colours are mixed, is pure white. With this arrangement two of the quantities can be represented by a vector rotating about the centre of the triangle. The angle of the vector specifies hue, while its length (or the distance away from white) gives saturation. The third quantity, brightness, can be represented by another vector perpendicular to the plane of the paper and passing through the centre of the triangle. Along the length of this vector the white in the centre gradually changes through grey to black, or zero brightness. Thus, while the picture is being transmitted the colour vector can be imagined as rotating to specify the hue and lengthening and shortening to specify the saturation. (This is, in fact, the way in which the actual electrical vector of the colour signal specifies the information—the hue modulates the phase angle of the sub-carrier and the saturation its amplitude.) At the same time, the perpendicular vector (not shown) can be imagined as lengthening and



Colour Television

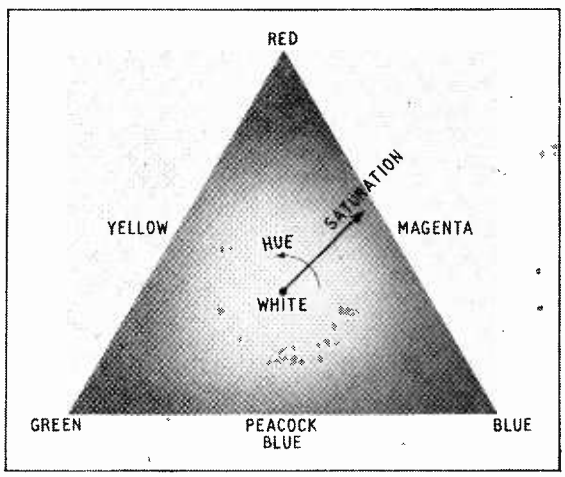
Simultaneous Compatible System

shortening according to the brightness information, and in this way it represents the normal amplitude modulation of the carrier. When there is no colour in the picture at all the rotating vector and the colour signal disappear completely.

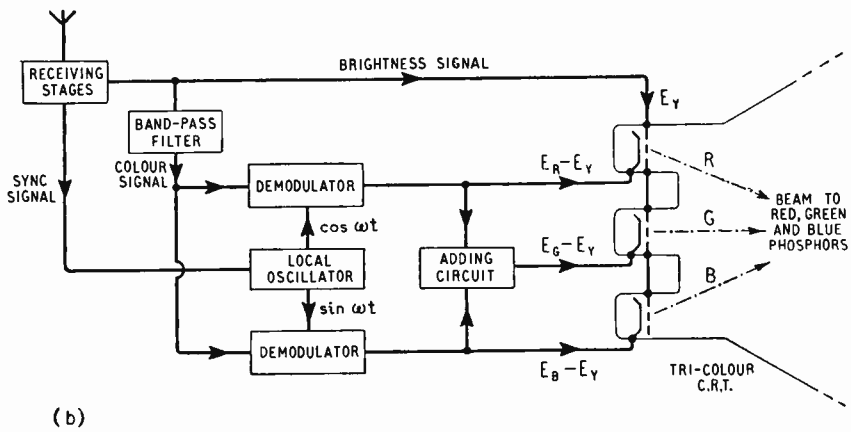
As well as subtracting the brightness information from the three colour components it is possible to make a further saving in colour-signal bandwidth by removing one of the colour components entirely. The reason for this is that all three components are already being transmitted in the form of white light by the brightness signal, so that if only two colour components are transmitted by the sub-carrier they can be subtracted from the brightness signal at the receiving end to recover the third one. Actually it is the green component that is removed and recovered in this way. Thus in Fig. 2 one can imagine the rotating colour vector as being restricted in movement to the right-hand side of the triangle and not having to go through the green corner at all.

Yet another reduction in the amount of colour information to be transmitted is made by taking advantage of certain characteristics of human vision. It is a well-known fact that the eye is insensitive to fine detail in colour and can only see it in black-and-white form. Obviously, then, there is no point in transmitting this fine detail on the colour signal as long as it is carried by the brightness signal. Thus the information-content of the colour signal can be very much smaller than that of the brightness signal and consequently its frequency band can be limited to something quite narrow—just over 1 Mc/s, in fact. This characteristic of human colour vision is, of course, a gradual thing. With slightly larger detail, for example, the eye still cannot distinguish between blue and yellow—they both appear grey—or between brown and crimson or blue and green, but it can between red and green. In the N.T.S.C. system, therefore, the bandwidth requirements of the transmitted colour components are graded accordingly. Those which can be distinguished in medium detail are given the full colour bandwidth of just over 1 Mc/s while those which can only be seen in broad areas are restricted to about 500 kc/s.

The broad functioning of the system can now be followed from the simplified block diagram Fig. 3. At the transmitting end (a) the colour camera analyses the picture and produces three signals representing the red, green and blue colour components, E_R E_G and E_B. These components are recombined in an adding circuit to produce the brightness signal, E_Y, or black-and-white picture, which is sent straight to the transmitter and radiated in the normal bandwidth. The red and blue components are also fed to two circuits where they are added to the signal $-E_Y$ produced by a phase inverter—in other words the redundant brightness component is subtracted from them, as explained above. (The green component is simply ignored as that is also redundant for reasons stated above.) The two resultant signals, E_R-E_Y and E_B-E_Y, now contain all the essential hue and saturation information that has to be modulated on the colour sub-carrier. As mentioned above, the hue information is conveyed by phase modulation and the saturation



Above: Fig. 2. Colour triangle with rotating vector representing the two quantities hue anr saturation. A second vectod representing brightness can be imagined as perpendicular to the plane of the paper and passing through the centre of the triangle.



Left: Fig. 3. Simplified block diagram of the system, with the transmitter at (a) and the receiver at (b). Note how the brightness signal (black and white picture) is shunted round the colour channel.

information by amplitude modulation. The actual method of doing this is to split the sub-carrier into two components, one leading the other in phase by 90°, and modulate the leading component with the $E_R - E_Y$ signal and the lagging component with the $E_B - E_Y$ signal, as shown by the vector diagram Fig. 4. The two parts are then recombined and the resultant vector in Fig. 4 represents the modulated sub-carrier as finally transmitted.

One can now see exactly how the hue and saturation are represented respectively by the angle (phase modulation) and length (amplitude modulation) of this resultant. The E_R and E_B colour-component signals from the camera vary in amplitude according to the hue of the picture, and as a result the two vectors $E_R - E_Y$ and $E_B - E_Y$ vary in length and produce corresponding changes in the phase angle of the resultant. Thus we have the angle of the electrical vector specifying the hue in much the same way as the rotation of the vector in Fig. 2 specifies it in graphical form. Similarly, the E_Y brightness component in Fig. 4 varies in amplitude according to the saturation of the hue, since it represents the amount of white-light dilution. This causes the lengths of $E_R - E_Y$ and $E_B - E_Y$ to vary and consequently the length of the resultant vector. Again, we have the electrical vector lengthening and shortening to specify saturation in the same way as the Fig. 2 graphical vector.

This process of modulating the two components of the sub-carrier is actually done by balanced modulators (Fig. 3) so that the sub-carrier itself is suppressed. The components are then combined and the complete colour signal is fed through a band-pass filter (giving the characteristic shown in Fig. 1) to the transmitter.

At the receiving end of the system (b) the carrier is demodulated and the whole signal is fed into the brightness channel; it is also applied to a band-pass filter which passes only the band containing the colour signal. The brightness signal then modulates all three grids of a tri-colour cathode-ray tube. In the colour channel the two modulating voltages $E_R - E_Y$ and $E_B - E_Y$ are recovered from the colour signal by a process of synchronous detection. This involves heterodyning the incoming signal with two sine waves, each of which has the same frequency and phase as the desired component. Thus, the local oscillator producing these sine waves must be locked in phase to the colour sub-carrier, and for this purpose a synchronizing signal consisting of several cycles of sub-carrier frequency is transmitted during the back-porch period following each line sync pulse.

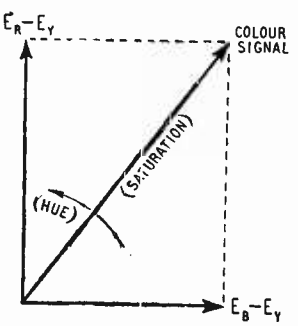


Fig. 4. Vector diagram showing how the two colour-difference signals modulate two components of the colour sub-carrier in quadrature. When these are combined (Fig. 3) the final colour signal is represented by the resultant vector, which carries hue information by phase modulation and saturation information by amplitude modulation.

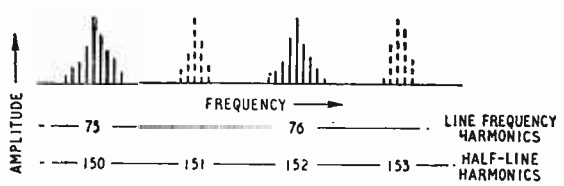


Fig. 5. Illustrating the technique of interlacing the monochrome and colour sidebands. The monochrome sidebands are shown as full lines and the interleaved colour sidebands as broken lines.

From the two colour-difference signals thus recovered the third one, $E_G - E_Y$, is derived by adding suitable fractions of them together. The three are then applied in a negative sense to the three cathodes of the tri-colour c.r. tube, and the E_Y brightness components that were subtracted at the transmitter are put back by the E_Y signal applied to the grids. In other words, the $-E_Y$ voltages at the cathodes become $+E_Y$ as a result of being applied in a negative direction, and as E_Y is fed to the grids in the same phase the two cancel out. This leaves E_R E_G and E_B, the original three colour-component signals, applied between the grids and cathodes of the tube. Thus, the three electron beams and the three sets of coloured phosphor elements on the screen are modulated according to the three output signals of the colour camera.

An ordinary monochrome receiver tuned to the transmission cannot, of course, do anything with the information on the colour sub-carrier, so it simply responds to the brightness signal and reproduces from this a black-and-white picture in the normal way.

It was mentioned earlier that the colour sub-carrier is transmitted in the same band as the brightness signal (Fig. 1), without interfering with it, by a process known as frequency interlacing. This principle takes advantage of the fact that the sideband frequencies of a television transmission tend to be grouped in clusters around harmonics of the line scan frequency, leaving open spaces in between. The idea, then, is to interleave the sideband clusters of the colour signal between the sideband clusters of the brightness signal, so that neither set interferes with the other, although they are all within the same band. This is done in the N.T.S.C. system by arranging the colour sub-carrier to lie exactly half way between two harmonics of the line frequency—in other words by making it an odd multiple of half the line frequency. The interlacing process then works out as shown in Fig. 5 at line and half-line frequency harmonics.

Although the colour signal does not interfere directly with the brightness signal it will nevertheless get into the vision channel of an ordinary receiver, so that one might expect it to appear as an interference pattern on the black-and-white picture. Actually it does not. The reason is that the intensity modulation of the c.r. tube beam by the colour signal reverses in phase along each line in successive picture periods—blacks become whites and whites become blacks. So, whereas the light modulation produced by the brightness signal is summated in time by the storage effect of the screen and the viewer's persistence of vision in the normal way, that produced by the colour signal tends to cancel out. In practice the cancellation is not complete because the light storage is not long enough. However, the visibility of the interference is kept to a minimum by making the colour sub-carrier frequency as high as possible (see Fig. 1), so that the pattern produced on the screen is a very fine one.

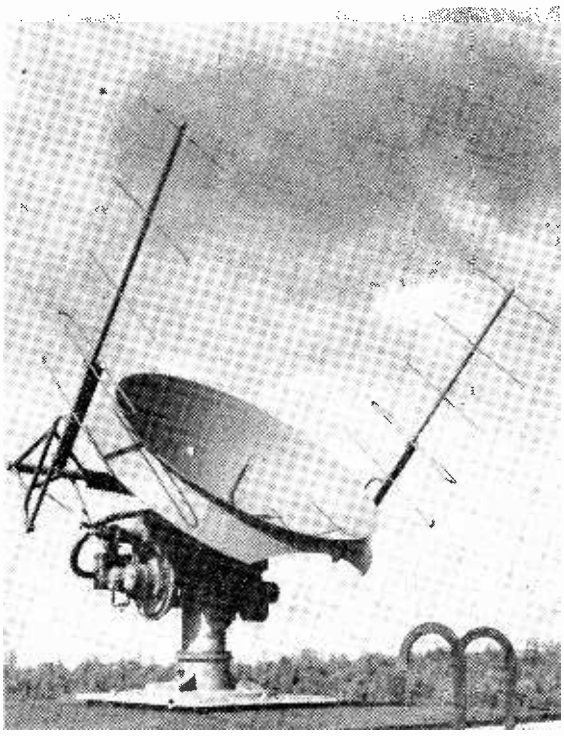
Radar Wind Measurement

New Meteorological Station Using the "Radar Sonde"

WHILE the main purpose of the balloon-borne radio sonde is to transmit meteorological data to the ground, it is also used nowadays for giving information on the speed and direction of the winds which carry it along. Hitherto the system has been to equip the sonde with a reflector and follow it about with a radar set on the ground. Changes in its range, bearing and elevation are then used to compute the required wind information. Unfortunately, this primary radar system is restricted in range to about 40 miles, so the latest step has been to use secondary radar, with a transponder instead of a reflector on the balloon. This increases the range to about 100 miles.

The original secondary radar system, or "radar sonde," was devised some years ago by T.R.E.* Now, an engineered version of it has been developed by Mullard and installed at a new meteorological station near Crawley in Sussex. A feature of this equipment is that it is completely automatic in operation. The radar aerial follows the course of the sonde automatically and gives range, bearing and elevation information from which the wind information is continuously com-

* "The Radar Sonde," *Wireless World*, April, 1951, p.155.



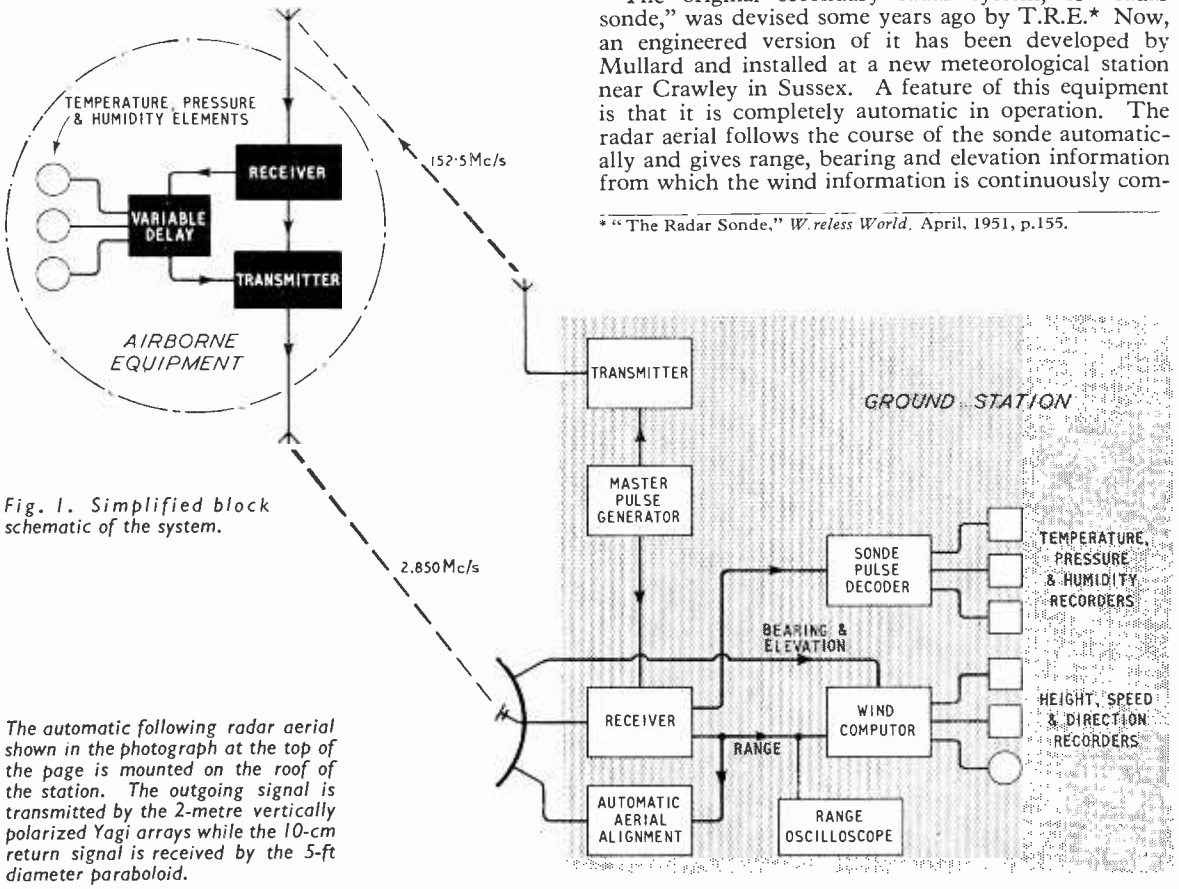
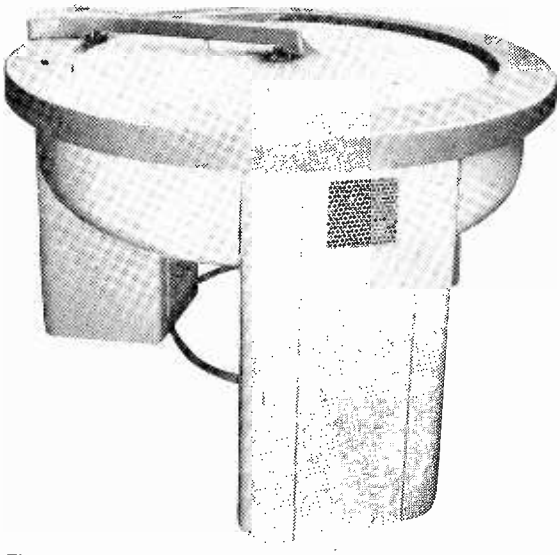


Fig. 1. Simplified block schematic of the system.

The automatic following radar aerial shown in the photograph at the top of the page is mounted on the roof of the station. The outgoing signal is transmitted by the 2-metre vertically polarized Yagi arrays while the 10-cm return signal is received by the 5-ft diameter paraboloid.



This unit houses the wind computor and carries the 4-ft diameter rotating polar chart which records the wind direction. A pen slowly traversing from the outside to the inside of the chart represents the time the sonde is in flight, while rotational movements of the chart represent changes in the wind direction with respect to the initial direction at launching.

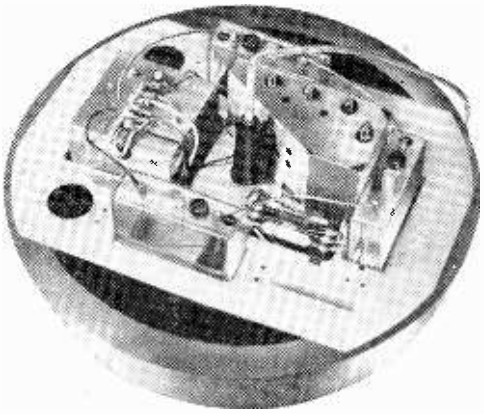
puted and recorded. At the same time the straightforward telemetering of other meteorological data is done through the channel provided by the returning radar signals, and the results are presented continuously by pen recorders.

Fig. 1 is a simplified block schematic of the system. Pulses of 2 μsec duration are transmitted at a repetition rate of 404 per second with a peak power of 50 kW on a frequency of 152.5 Mc/s. They are received by the airborne transponder and arranged to trigger its 30-W transmitter, which sends back pulses on 2,850 Mc/s to the receiving paraboloid. The transit time of the pulses gives the range of the sonde and this information is displayed on a cathode ray tube and fed to the wind computor.

The system for keeping the receiving paraboloid continuously trained on the sonde makes use of a dipole which is offset from the axis of the reflector and rotates in such a way that the aerial beam traces out a cone in the sky. If the paraboloid is pointing in a slightly wrong direction and the sonde is to one side of the cone, the received signal fluctuates in strength as the beam swings around, at a frequency corresponding to the rotational speed of the dipole. The fluctuation frequency is then used as an error-signal to correct the alignment of the paraboloid. If the paraboloid is properly aligned and the sonde is exactly in the centre of the cone the signal strength remains constant and no error-signal is produced. From the positioning of the paraboloid the bearing and elevation of the sonde are obtained and the information is fed into the wind computor.

In the computor the speed and direction of the wind is derived from the rates of change of the range, bearing and elevation information. Wind direction is recorded on a polar chart, while speed and height (which is also computed) are registered on standard pen recorders.

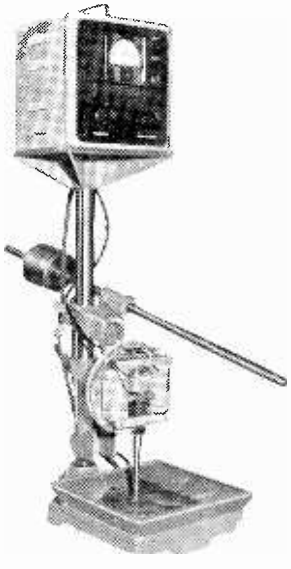
Some of the balloons which are sent up carry just



An airborne unit with its cover removed. The miniaturized equipment is mounted in a light thermally insulating container and is suspended from the balloon by the quarter-wave receiving aerial. The transmitting aerial projects from the bottom. Power is supplied by 6.5-V batteries and h.t. is obtained by means of a vibrator.

a transponder for wind measurements only, while others have in addition meteorological elements for measuring temperature, pressure and humidity. The system for transmitting these additional measurements on the radar return signal makes use of a second pulse delayed slightly from the main one. The three meteorological elements are selected in sequence by a motor-driven switch and arranged to control the spacing between the two pulses. In the ground equipment the two pulses are used to trigger the front edge and the back edge of a square pulse, so that the duration of this square pulse represents the value of the meteorological measurement. An electronic chronometer then measures the duration of the pulse and gives the answer in the appropriate meteorological terms.

ULTRASONIC DRILL



IN this experimental machine, made by Mullard and shown recently at the Institution of Electronics Manchester exhibition, vibrations at about 22 kc/s are generated by a magnetostriction transducer and transmitted to a drilling tip by a tapered metal stub, which acts as a velocity step-up transformer. The box on top contains an amplifier, which forms part of an oscillatory circuit with the magnetostriction device below. Rapid drilling and cutting of most brittle materials is possible when a paste of carbide abrasive is fed to the tip. The use of the machine was demonstrated recently in the television programme "Science Review."

LETTERS TO THE EDITOR

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

Ignition Interference in U.S.A.

IN his letter in the October issue, Malcolm S. Morse states that "in the U.S.A. our television sets operate in the midst of millions of motor cars, all unsuppressed, yet never have I seen a case of ignition interference or even heard of anyone troubled by it."

Mr. Morse must have been singularly fortunate in his choice of viewing sites. If he will refer to an American book published this year ("Principles of Television Servicing," by Carter V. Rabinoff and Magdalena E. Wolbrecht: McGraw-Hill) he will find that the authors have quite a bit to say about it on pp. 432-434. Indeed, they say "some years ago an appeal was made to the automobile industry by the F.C.C. to study and if possible develop ways and means of eliminating ignition interference. The industry has been and still is co-operating by extensive research along these lines."

In spite of Mr. Morse's remarks about "poorly designed British sets" the fact remains that it is not possible by any known means to suppress ignition interference at the television set, but it can be done easily and cheaply on the car itself. Certain measures to reduce the interference can be taken in the receiver, it is true, such as by using limiters. In spite of the sets being so "poorly designed," all current British sets include them. They are such a normal fitting that they are taken as a matter of course.

London, N.14. W. T. COCKING.

"Television Interference"

I WAS very interested to read the note on page 320 of your July issue on this subject, as I am one of the "suffering amateurs" operating on the 2-metre band.

Our particular trouble is caused by 2nd harmonics of local oscillators on about 72.5 Mc/s. They sound rough and unstable and some are weakly modulated, probably by a microphonic valve. Similar trouble has been reported by Scottish amateurs.

There are wider issues involved than interference to amateurs, which in all conscience is bad enough already. 72 Mc/s, the fundamental frequency, is used by business radio and certain users are, I understand, already being inconvenienced during TV hours. Our 2-metre band is shared with one of the armed forces, apparently, and whilst their stations are not at present likely to be troubled, an increase in this form of interference might give them cause for complaint. Another problem may arise when new TV channels open up, with the possibility of interference by higher-order harmonics, admittedly weaker but there all the same.

It seems to me that unless something is done now, things will get worse. I realize that TV receiver designers already have a lot to worry about, but in future I think they should give more attention to the "front end," making every effort to reduce unnecessary (and possibly illegal) radiation. This will apply also to converters, of course.

Until now, the v.h.f. bands, both commercial and amateur, have been fairly "clean" and free from the kinds of interference which plague the lower frequencies. Let us keep them that way!

Worthing, Sussex. R. B. FORGE (G3FRG).

Technical Qualifications

AS a holder of the City and Guilds Full Technological Certificate I have followed the correspondence regarding this qualification with a spectator's interest. However, the letter by M. L. Barton in your October issue provokes a reply. It might well have been written by a sworn enemy of the Institute—or a disappointed candidate!

The reference to the mathematics standard is accurate but unfair. Surely Mr. Barton does not think that Inter. B.Sc. maths. would equip one to sit the fourth and fifth year examinations in Telecommunication Principles? Whether specifically examined in mathematics or not, the C. and G. candidate has to reach the standard required to pass these examinations—which, like all advanced electrical papers, are exercises in higher mathematics.

The phrase "telecommunications as understood by Post Office engineers" is just trite nonsense. One imagines "Post Office" electrons rolling down the wire, painted engineer green and stamped G.P.O., while "Barton" electrons saunter along, varicoloured and with a look of independence. The Post Office has done as much work with super frequencies as any other large British organization—and the C. and G. fifth year syllabus is in a large part devoted to the technique of their use.

Mr. Barton finishes his letter with a backward somersault in supporting the Brit.I.R.E., apparently ignorant of the fact that this institution grants the holder of a full technological certificate complete exemption from the technical and maths. sections of its graduateship examination.

If these arguments are the best that can be advanced in criticism of the C. and G. Full Technological Certificate it is no surprise to me that the Ministry by which I am employed (Supply) recognizes the qualification. Might it not be that they, the Admiralty and the B.B.C. are the ones in step?

Farnborough, Hants. P. B. HAYES.

"Meter Overload Protection"

THE mechanical overload tests on microammeters described by J. de Gruchy (September issue) are liable to be misleading unless account is taken of the "transit time" of the meters concerned, a factor which depends not on meter damping alone, but also, in certain cases, on the load in which they are worked.

By transit time is meant the time the pointer takes, with current suddenly applied, to reach any steady reading up the scale, and, for a dead-beat condition, is independent of the magnitude of the deflection.

A normal microammeter of the type mentioned, if used in a high resistance circuit, will have a transit time of about one second. Subjected to a sudden overload of 250 times its full scale current, it will endeavour to maintain its transit time; i.e., the pointer tip will be given an acceleration such as to enable it to reach a point 250 times the scale length in one second. If the scale is 1.5 inches long, the distance it is attempting to travel is 1.5×250 inches per second, an average speed of more than 20 miles an hour!

The kinetic energy released at the top stop, and hence the damage done, will be lessened if the transit time is increased.

The transit time of a microammeter will begin to increase if the resistance of the circuit in which it is worked is taken below ten times its own internal resistance. Maximum transit time, which is considerably more than the open circuit value, occurs, as would be expected, at practically short-circuit conditions.

Therefore, a microammeter used heavily shunted, as, for instance, in a multi-range test set, will withstand more sudden actual meter current overload than one of the same type used in a high resistance circuit.

High Wycombe, Bucks. T. H. FRANCIS.

Lamp Interference

REFERRING to W. B. Mansell's statement in your August issue that gas-filled filament lamps are also responsible for generating interference, I have made a number

of enquiries to find support for this view, but so far as I can determine from my friends and colleagues in the interference and lamp manufacturing fields there is every reason to believe that only vacuum lamps are responsible.

It is, however, a fact that, in the past, some few lamps labelled "gas filled" have in fact been vacuum, and have given rise to conflicting reports.

The lamps causing the majority of the trouble are 40-, 60- and 100-watt "rough service" types. The 15- and 25-watt vacuum lamps which are the only sizes normally available to the public are only responsible in rare cases.

Enfield, Middx. A. HALE.

I AM indebted to your correspondents for their helpful comments on the lamp interference problem raised in my letter published in your May issue.

They may be interested to know that the interference in question was ultimately traced to a vacuum lamp in my own home! It was, in fact, a 15-watt domestic type, purchased from a chain store, and was normally kept on all night in the children's bedroom. The interference, however, was not continuous during the time it was in use, but usually occurred some two or three hours after the lamp was switched on.

It appears that the oscillations arose as the result of a fault, since the lamp failed a week or so after the interference was first reported. Furthermore, they were probably mains-borne, because they were being generated inside a metal-clad pre-fab. which would undoubtedly be a big deterrent to direct radiation. The attenuation of incoming signals produced by these houses is sufficient, in this locality at least, to make portable receivers an impracticable proposition without an outdoor aerial.

Weymouth, Dorset. K. ROBINSON.

"*D.C. Restoration in Television*"

W. T. COCKING, in his article in your March issue, analyses the simple case where the resistor of the RC coupling is connected directly in parallel with the diode (his Fig. 6). He makes no mention of more modern arrangements where the resistor is no longer so connected. At the time I anticipated that there would be a further article discussing such circuits. Since none has been forthcoming, and since such an eminent authority as Donald Fink makes no mention of them in the 1952 edition of "Television Engineering," I have made it my business to examine several current receiver designs; in no case has the improved circuitry been applied. I feel therefore that these circuits may not be as widely known as I had imagined, and would like to draw attention to them.

Referring again to Fig. 6 of Mr. Cocking's article, it is apparent that the mean circuit flowing in R_2, the resistor in question, is a function of average picture brightness. This current can therefore vary, as Mr. Cocking points out, between very wide limits and, since the diode mean current must equal this current, the datum to which the sync pulse tips are "restored" will also vary with average picture brightness. This undesirable effect can be eliminated if we can maintain a constant current in the resistor.

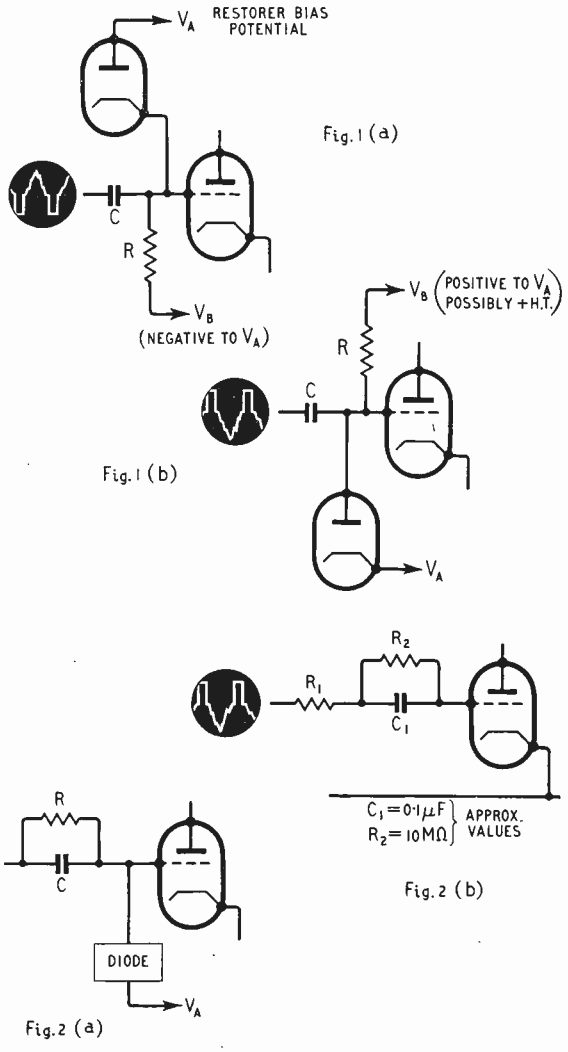
One method which partially achieves this result is to connect the remote end of the resistor to a point of which the d.c. potential differs by a margin of several times the signal amplitude from the mean d.c. potential at the coupling. This is illustrated in my Figs. 1(*a*) and 1(*b*) for the two cases of negative-going and positive-going sync pulses. The potential V_A is chosen to give the desired range of signal excursion at the amplifier grid. V_B is a potential differing from V_A by an amount many times the amplitude of signal applied to C, being positive or negative to V_A, as required to cause the diode to conduct. It is obvious that the current in R (and in turn the diode current) is almost entirely dependent on the p.d. V_A-V_B and only to a small degree on the variations in signal applied. This gives a close approximation to the desired condition and much improved restoration results.

Another method of attack is to connect R to a point in the circuit where the same signal excursion exists as that applied to C. The p.d. across R must then be constant, making the current in it constant. The p.d. across R must again be in correct sense to cause the diode to conduct. One simple embodiment of this idea is shown in my Fig. 2(*a*) where R is connected in parallel with C; it can only be used when the p.d. across C is in the correct sense. The sync separator circuit illustrated in Mr. Cocking's article (Fig. 2) can be greatly improved by this method. This is shown in my Fig. 2(*b*), the grid cathode circuit of the valve forming the diode and R_2 and C_1 being connected to a source of signal positive to the cathode (via R_1).

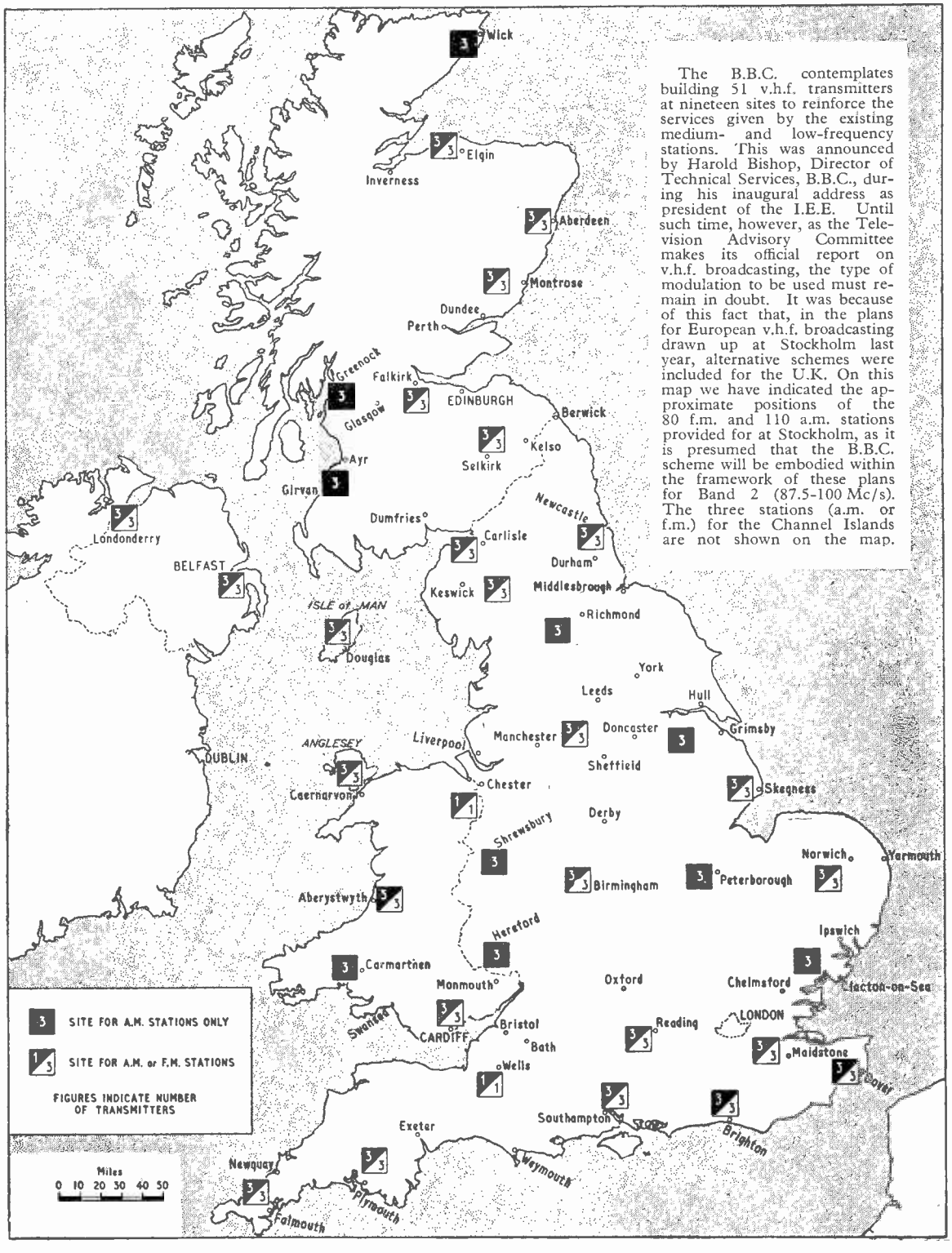
In all these circuits, suitable values of C will be the same as those normally employed in restored coupling (say 0.1 to 0.5μF). R must, however, be very much larger, (10 to 22 megohms), and is chosen to give about the same average current in the diode as obtains in the simple circuit.

I must point out, however, that while these arrangements alleviate one defect of the d.c. restorer, they do not appreciably reduce the other defect discussed by Mr. Cocking—the variation in signal datum which occurs during the frame sync pulse.

Chelmsford, Essex. J. E. NIXON.



V.H.F. Broadcasting: Plans for U.K.



The B.B.C. contemplates building 51 v.h.f. transmitters at nineteen sites to reinforce the services given by the existing medium- and low-frequency stations. This was announced by Harold Bishop, Director of Technical Services, B.B.C., during his inaugural address as president of the I.E.E. Until such time, however, as the Television Advisory Committee makes its official report on v.h.f. broadcasting, the type of modulation to be used must remain in doubt. It was because of this fact that, in the plans for European v.h.f. broadcasting drawn up at Stockholm last year, alternative schemes were included for the U.K. On this map we have indicated the approximate positions of the 80 f.m. and 110 a.m. stations provided for at Stockholm, as it is presumed that the B.B.C. scheme will be embodied within the framework of these plans for Band 2 (87.5-100 Mc/s). The three stations (a.m. or f.m.) for the Channel Islands are not shown on the map.

International Technical Questions

Summary of C.C.I.R. London Meeting

AFTER five weeks' deliberations the 7th Plenary Assembly of the International Radio Consultative Committee (C.C.I.R.) ended on October 7th. The C.C.I.R., which is one of the four permanent bodies of the International Telecommunication Union, is charged with the study of technical radio questions and operating questions of a technical character. To facilitate the study of the questions tabled at each plenary assembly fourteen study groups have been formed and it is the task of these international groups to consider and report on the findings of their national counterparts. A list of the British study groups and their chairmen was given in our September issue (p. 396).

Some 300 representatives from 41 countries participated in the meetings, the findings of which will eventually be published by the C.C.I.R.

During the Assembly's protracted deliberations in London, some three or four hundred documents were considered and a vast number of recommendations approved. At this stage we can do no more than summarize a few of the recommendations which will be submitted to the I.T.U., and some of the study programmes to be undertaken before the next plenary assembly (to be held in Warsaw in 1956).

The approved recommendations of the study group concerned with both sound and vision receivers cover questions of stability, selectivity and sensitivity. In the recommendation regarding receiver stability it is pointed out that in cases where economic considerations prevent the use of effective frequency stabilizing devices attention should be paid to the stability of inductors and capacitors and of the oscillator circuit (including the valve and its power supply). It also recommends the use of temperature compensating components. Tables giving the single-signal and two-signal selectivity characteristics of various classes of receiver (W/T, R/T, domestic broadcast and television) are included in the recommendation that uniform methods of measurement of receiver selectivity be adopted. The same study group has drawn up a programme of investigation into the methods of measuring and expressing the amplitudes of undesired emissions from sound and vision receivers and also of means of suppression. It also calls for a study of the question of the choice of intermediate frequencies.

Three study groups are concerned with propagation—tropospheric, ionospheric and ground wave, respectively. The outstanding subject so far as the ionospheric group was concerned was probably the question of atmospheric radio noise. Study programmes have been agreed upon and one recommendation calls for the setting up of a world network of lightning recorders. It is also proposed to produce a new set of noise curves which can be used internationally in place of the theoretical data at present used.

The 1947 Atlantic City Conference entrusted the C.C.I.R. with the task of studying the establishment of a world-wide standard-frequency and time service. A report on the services provided by the existing stations in Washington, Hawaii, Tokyo, Rugby, Johannesburg and Turin was adopted, together with recommendations for improving the service. The possibility of employing the two-independent-sideband method of transmission for the standard frequency service is to be studied.

Standards for magnetic-tape recording of programmes for international exchange were recommended and approved, although not unanimously. The recommended tape speed is 15 inches per second with alternative speeds of 30 and $7\frac{1}{2}$ in/sec. Single-track recording is recommended and standards are given for tape, spools, frequency response and recording heads. In view of the increasing interest in the interchange of filmed television programmes it has been agreed that an investigation should be undertaken to find out what method or methods should be used for the recording of the accompanying sound for TV programmes intended for international exchange.

Short-wave broadcast receiver manufacturers will soon have to include the 26-Mc/s band in the coverage of their sets if a resolution passed at the meeting is acted upon. This called for the use of this band for long-distance broadcasting because of the very low atmospheric noise intensity in that part of the spectrum.

The vocabulary study group recommended the abolition of all adjectives and superlatives in describing frequency bands and the substitution of numbers as given in the following table, which it is intended should take the place of the table in the Atlantic City Radio Regulations. The lower limit of the frequency range is excluded and the upper limit included in each case. The formula is : Band "N" extends from 0.3×10^N to 3×10^N c/s.

Band Number	Frequency Range		Metric subdivision
4	3 to	30 kc/s	Myriametric waves
5	30 to	300 kc/s	Kilometric waves
6	300 to	3,000 kc/s	Hectometric waves
7	3,000 to	30,000 kc/s	Decametric waves
8	30 to	300 Mc/s	Metric waves
9	300 to	3,000 Mc/s	Decimetric waves
10	3,000 to	30,000 Mc/s	Centimetric waves
11	30,000 to	300,000 Mc/s	Millimetric waves
12	300,000 to	3,000,000 Mc/s	Deci-millimetric waves

To facilitate the preparation by the International Telecommunication Union of an international list of telecommunication terms, definitions and symbols, the C.C.I.R. is to produce a "provisional list of terms and definitions peculiar to the work of the C.C.I.R." which, it is intended, shall serve as a basis for the radio-communications section of the proposed I.T.U. vocabulary.

WORLD OF WIRELESS

International Conferences ✦ Television and Amateur Shows ✦ R.I.C. Awards ✦ R.T.E.B. Exams.

European Broadcasting Conference

A SERIES OF MEETINGS of the European Broadcasting Union is being held at Monte Carlo from November 3rd to 14th. The main meeting is the 1953 General Assembly of the E.B.U., which will be held on the 13th and 14th. This will be preceded, as usual, by meetings of the Technical Committee, Legal Committee, Television Study Group and of the Administrative Council.

The Technical Committee, under its chairman, E. L. E. Pawley of the B.B.C., will review the activities of its various working parties and of the E.B.U. Technical Centre in Brussels for the past year and will fix the programme of work to be undertaken during the following twelve months. The working parties, which are composed of specialists of member organizations, have during the past year been considering indirect-ray propagation on medium-waves, unattended broadcast transmitting stations, the implementation of the Stockholm v.h.f. plans and the standardization of equipment and operational procedure in tape recording. It is possible that the Technical Committee will, in conjunction with the Television Study Group, also review the development of international television exchanges in Europe.

Interference : International Agreement

APPROXIMATELY 60 delegates from 18 countries and various international organizations attended the meeting of the International Special Committee on Radio Interference (C.I.S.P.R.), held in London in the middle of October. The chief aims of the committee are to obtain international agreement on limits which should be imposed on the production of "man-made" interference, methods of measurement and safety considerations involved in the use of suppressors on electrical appliances.

As a result of the meeting, agreement was reached on interference limits in respect of certain classes of electrical equipment. The general adoption of the recommendations made would considerably benefit international trade. At present exporting manufacturers are confronted with a variety of specifications

Among the items referred to national delegations for further study and consideration are: interference limits in the v.h.f. band; interference between receivers (from oscillator and line time-base circuits); interference from high-tension cables and from industrial, scientific and medical r.f. equipment.

TV Show

SOME 40 EXHIBITORS will be participating in the annual exhibition of the Television Society, which will be held from January 7th to 9th in the Electrical Department, King's College, Strand, London, W.C.2. The exhibition is not, of course, concerned only with domestic reception, but will also cover industrial television and television in research.

On the first day, the show will be open from 6.0-9.0 for members and the press only. On the second day it will be open at 12 noon and on the last day at 10.0, and will close on both days at 9.0. Admission will be by ticket obtainable from members of the society or the secretary, 164, Shaftesbury Avenue, London, W.C.2.

Amateur Radio Show

THE SEVENTH Annual Amateur Radio Exhibition, organized by the Radio Society of Great Britain, will be opened at the Royal Hotel, Woburn Place, London, W.C.1, at 12 noon on November 25th by Rene Klein, a founder-member and vice-president of the Society. Mr. Klein, who is now managing director of McMichael Radio, was instrumental in the founding of the Society as the London Wireless Club in 1913.

In addition to the equipment exhibited by manufacturers there will be a wide range of home-constructed gear and a display of amateur television equipment arranged by the British Amateur Television Club.

At the time of going to press the following will be exhibiting: Air Ministry, Avo, Cosmocord, Denco, G.E.C., David Godwin, Grundig, Panda Radio, Philpotts Metalworks, Salford, Siemens, *Short Wave Magazine*, *Telecraft* and *Wireless World*.

The exhibition will be open daily (11-9) until November 28th. Admission 1s.

B.B.C. Tuning Notes

OUR REFERENCE in the September issue (page 409) to the "B.B.C. 1,000-c/s tuning note (not the Third Programme 440 c/s)" was not strictly accurate. There is actually a 1,000-c/s tuning note for the Third Programme. It is radiated for five minutes before the ten-minute 440-c/s note which immediately precedes the opening of the Third Programme.

Incidentally, the degree of accuracy of the radiated audio frequencies has recently been improved and is now ± 5 parts in 10^8.

Writing Prizes

IT WILL be recalled that two years ago the Radio Industry Council launched a scheme to encourage, by the award of premiums, the writing and publication of technical articles to increase the prestige of the British radio industry. Last year five 25-guinea premiums were awarded and two additional £10 awards were made.

The panel of judges, which this year includes Dr. Willis Jackson (late Professor of Electrical Engineering, Imperial College), P. D. Canning, W. M. York, C. E. Strong and Vice-Admiral Dorling, will be meeting shortly to consider articles accepted for publication by journals on sale to the public between January and December this year. They should be submitted to the Secretary of the R.I.C., 59 Russell Square, London, W.C.1, by the author or editor not later than November 30th.

Do You Know?

HOW LONG should the radiator be for a dipole for the reception of the Wrotham v.h.f. transmissions ?

Where does one apply for an amateur transmitting licence ?

What are the base connections for an X81 ?

What is the value of a resistor coloured orange all over ?

What is the address of the Television Society ?

The answers to these and very many other questions can readily be given by the possessor of a 1954 *Wireless World* Diary which includes, in addition to the usual week-at-an-opening diary pages, an 80-page reference section.

The Diary is obtainable from booksellers and newsagents, price 5s 10d (morocco leather) or 4s 1d (rexine), including purchase tax.

Servicing Exam. Results

OF THE 309 ENTRANTS for the Radio Servicing Certificate Exam. in May, 126 (40 per cent) qualified for the certificate—including 30 candidates who passed the practical test only, having been referred last year. A further 87 candidates were successful in the written paper, but were referred in the practical tests. As mentioned last month, the next exam. will be held on May 4th

and 6th for the written papers and May 15th for the practical test. The closing date for entries is February 1st.

The percentage of successes in the 1953 Television Servicing Certificate Exam. was higher than in the Radio Exam.—48 per cent. Of the 135 candidates, 64 were successful; including 24 who were referred in the practical test last year. Thirty-six passed in the written papers and may sit again next year for the practical test. The next exam. for the Television Servicing Certificate will be on May 10th and 12th and June 19th, for which the closing date for entries is January 15th.

Particulars and entry forms for both examinations are obtainable from the Radio Trades Examination Board, 9, Bedford Square, London, W.C.1.

PERSONALITIES

Professor F. C. Williams, of Manchester University, has been awarded the ninth Charles Vernon Boys Prize by the Physical Society in recognition of his "invention of the storage system for use in digital electronic computers." The award will be made at the Society's meeting at 5.0 on November 20th in the Lecture Theatre of the Science Museum, London, S.W.7, when Professor Williams will deliver a lecture on "Cathode-ray Tube Storage for Digital Electronic Computers."

Dennis McMullan, M.A., Ph.D., who for the past four years has been undertaking post-graduate research work at the Cambridge Engineering Laboratory, where he developed the scanning electron microscope, is going to Canada as head of the Simulator and Field Equipment Section of the Canadian Armament Research and Development Establishment in Quebec. He graduated from Cambridge in 1944 and went to Bush Radio under the Hankey scheme for the development of Services equipment. Dr. McMullan left Bush in 1946 and, before returning to Cambridge, was for two years with Cinema Television where he worked on high vacuum techniques and for a short while at Sperry Gyroscope designing analogue computors.

H. Walker, O.B.E., A.M.I.E.E., becomes Assistant Superintendent Engineer (Television Studios), B.B.C. He joined the engineering staff of the Corporation in 1931 and transferred to the Television Service in 1936. After war service in the R.A.F. in which he attained the rank of Wing Commander, he returned to the Television Service in 1945 and was appointed assistant engineer-in-charge at Alexandra Palace the following year. In 1950 he became engineer-in-charge of the London station and for the past eighteen months has been head of Technical Operations, Television Studios.

W. D. Richardson has been appointed Assistant Superintendent Engineer (Television Outside Broadcasts), B.B.C. He joined the B.B.C. as a maintenance engineer at Brookmans Park in 1930 and became senior maintenance engineer at Alexandra Palace in 1938. Throughout the war he served in the B.B.C.'s Planning and Installation Department and since 1946 has held various posts in the Television O.B. Department.

Wallace Rubin, B.Sc.(Hons.), Ph.D., who joined Multicore Solders a year ago, has been appointed chief chemist of the Research Laboratories in succession to Dr. P. M. Fisk, who has left after nine years' service with the company.

M. G. Hammett, M.I.E.E., A.M.I.Mech.E.,, who joined Murphy Radio as chief engineer of the Electronics Division at the beginning of September, held a similar position with E. K. Cole's Electronics Division at Malmesbury for some time. He has taken over responsibility for all electronic development and design at Murphy's works at Welwyn and Ruislip.

H. J. Leak, M.Brit.I.R.E., managing director of H. J. Leak & Company, went to the United States to attend the Audio Fair in New York (October 14th-17th) where the company's new products were demonstrated.

H. A. Hartley has gone to the United States to devote himself exclusively to the interests of his American company (H. A. Hartley Co. Inc., of 521, East 162nd Street, New York 51). The sole rights of manufacture and selling in the United States and its possessions are vested in the American company, but for the rest of the world these rights will remain with H. A. Hartley Co., Ltd., 152, Hammersmith Road, London, W.6.

OBITUARY

Allen Longstaff, who was for over 20 years the representative of Amalgamated Wireless (Australasia), Ltd., in London, died in Sydney, N.S.W., on September 19th. It was in 1925 that Mr. Longstaff first came to this country; he was then engaged in experiments being conducted preparatory to the establishment of the Anglo-Australian wireless telephone service. He attended the International Radiotelegraph Conference in Washington as A.W.A.'s representative in 1927 and immediately afterwards was appointed as European Representative of the company. He returned to Australia in 1946.

IN BRIEF

Broadcast Receiving Licences totalling 13,056,689 (including 2,539,103 for television and 196,161 for car radio sets) were current in Great Britain and Northern Ireland at the end of August. The number of television licences increased by 59,649 during the month.

Faraday Lecture.—This year's Faraday Lecture of the I.E.E. will be given by O. W. Humphreys, B.Sc., and will be entitled "Electric Process Heating—An Aid to Productivity." The lecture tour opens at Birmingham Town Hall on November 30th and continues at Leicester on December 3rd, Cardiff (February 1st), London (February 16th), Southampton (February 18th), Manchester (March 23rd), Liverpool (March 25th), Leeds (April 12th), Sheffield (April 14th), Newcastle (May 4th) and Glasgow (May 6th). Admission to the lectures is by ticket and application must be made to the honorary secretary of the I.E.E. Centre concerned, except in the case of London, when application must be made to Savoy Place, London, W.C.2.

Brit.I.R.E. Membership was 4,383 on March 31st—an increase of 365 on the previous year. This was recorded in the annual report given at the meeting on October 21st. In the course of the review of the past year it was stated that a report is being prepared on the use of primary materials in the radio industry. The first part will cover ceramics, constructional metals, magnetic materials and crystals.

Blind Operators.—Donations totalling nearly £540 were received at the Earls Court Radio Show by the United Appeal for the Blind (London) as a result of the demonstration of blind operators assembling components. It will be recalled that the demonstration was provided by Philips who employ about 20 blind operators at their Mitcham Works.

Trans-American Radio.—Radio equipment is being installed in the Sunbeam Alpine car which, with a caravan-trailer, is being driven from Alaska to the Strait of Magellan by a three-man team. The radio installation, which has been supplied by the British Communications Corporation, Ltd., Wembley, includes a 5-watt crystal-control transmitter for c.w. operation in the 20-40-metre amateur band. The operator, Marco McClintock, of Cleveland, Ohio, will use his own call W0DXT. The car will also carry v.h.f. transmitting and receiving equipment supplied by B.C.C.

Sponsored TV ?—The organizers of the recent Nottingham Radio and Television Exhibition (the Nottingham Centre of the Radio and Television Retailers' Association) arranged for a series of commercial television programmes to be transmitted on a closed circuit to receivers in the main hall of the exhibition. The majority of the exhibitors at the show were local retailers.

"Old N'Ions."—The annual dinner and reunion of past students of the Northampton Engineering College, Clerkenwell, will be held on November 27th at the Connaught Rooms, Gt. Queen Street, London, W.C.2. Tickets are obtainable from A. F. Thompson, 10, Milborough Crescent, Lee, London, S.E.12.

"Navigation To-day," the exhibition being held at the Science Museum, South Kensington, will remain open until January 17th. It shows the various types of navigational instruments and equipment (including radar and other radio aids) used in navigation in the air, on land and at sea. The museum is open on week-days from 10 to 6 and on Sundays from 2.30 to 6. Admission is free.

C.C.I.R. BANQUET.—Delegates to the London meetings of the International Radio Consultative Committee (C.C.I.R.) were entertained by the Marconi Company at a dinner and dance at the Dorchester Hotel. Dr. Balth. van der Pol, director of the C.C.I.R., is on the right in this view of the head table. Sir George Nelson, chairman of the Marconi group of companies, is on the right of the microphone and H. Faulkner, who was chairman of the plenary assemblies, is next to him.

New Norfolk Transmitter.—As part of its plan to improve the coverage of the Home Service, the B.B.C. is building a new 2-kW transmitter at Hampstead, near Cromer, Norfolk. For technical reasons it will use the same wavelength and radiate the same programme as the Northern Home Service, 434 metres (692 kc/s). Its directional aerial will give a good service in the Sheringham, Cromer, North Walsham and Reepham area without affecting reception of the Moorside Edge transmissions in north-west Norfolk.

R.A.E. Reunion.—The first reunion of those who worked in the Wireless (10) Department of the Royal Aircraft Establishment, Farnborough, between 1922 and 1939, was held at Farnborough on September 25th. Dr. James Robinson, who was the first head of the department after it was moved from Biggin Hill, was the guest of honour. Others present included Air Commodore A. L. Gregory, the first serving R.A.F. Officer to take charge of the department, F. S. Barton (principal director of electronics research and development, M.o.S.) and Dr. J. S. McPetrie, present head of the R.A.E. Radio Department.

Marine I.F.F.—Development models of a device to ensure the identification of ships when seen on a radar p.p.i. are undergoing tests in the United States. The equipment has been devised by a committee of the American Radio Technical Commission for Marine Services to enable a port radar operator to know which of the numerous ships shown on the p.p.i. he is talking to.

Radio-control Equipment fitted in the target model aircraft exhibited by M.L. Aviation at the S.B.A.C. Exhibition (to which we referred on page 464 of our October issue) was made by Beme Electronic and Marine Equipments, Ltd., of Hythe, Hants. It was designed and developed under a M.o.S. contract.

R.A.M.A.C.—The thirteenth conference of the Radio Marine Associated Companies, which is an association of twenty-five marine radio operating companies in nineteen countries, was recently held in the London offices of the British member company—Marconi International Marine Communication. R.A.M.A.C. co-ordinates research and the exchange of technical information on marine radio communication and navigational aids among its members.

Fire !—The incidence of fires caused by television receivers decreased from 6.4 per 10,000 sets in 1947 to 1/10,000 in 1951. The incidence for sound receivers during the same period remained at approximately 1/40,000. These figures are given in "Fire Research, 1952," published by H.M.S.O. for the D.S.I.R., price 3s.

E.I.B.A. Ball.—The annual dinner and ball in aid of the Electrical Industries Benevolent Association will be held at Grosvenor House, Park Lane, London, W.1, on November 13th. Tickets, price 2½ guineas, are obtainable from the Association, 32, Old Burlington Street, London, W.1.

B.I.F.—Plans are already well advanced for the 1954 British Industries Fair, which will be held simultaneously in London and Birmingham from May 3rd-14th.

Non-ferrous Metals being used extensively in the radio industry, we draw readers' attention to the "Metal Industry Handbook and Directory, 1953," which is issued annually to subscribers to the weekly journal *Metal Industry*. A large section of the 456-page Handbook, which is in its 42nd year of publication, is devoted to general properties of metals and alloys, and there are sections covering standards and finishing processes and a directory of producers.

Plastics.—A 44-page booklet listing all the more important plastics materials produced in Great Britain has been prepared by the British Plastics Federation of 47-48, Piccadilly, London, W.1. Each of the 17 classifications of materials listed in the booklet is prefaced by a short note on its uses. The booklet, which is obtainable from the B.P.F. price 2s, also includes lists of manufacturers and trade names.

Association of Plastic Cable Makers has been formed with the objects of promoting and advancing the interests of the industry and the establishment of standards of quality for plastic cables. James, Edwards & Co., 381, Salisbury House, London Wall, London, E.C.2, have been appointed secretaries to the association.

BUSINESS NOTES

"Tape Deck."—In a recent case in the Chancery Division Truvox, Ltd., were the defendants in an action brought against them by Wright and Weaire, Ltd., concerning the use of the trade mark "Tape Deck." Judgment was given for Truvox, on the grounds that the plaintiffs had failed to proceed with their original case. We understand that as a result of these proceedings an application will be made to expunge the term "Tape Deck" from the Register of Trade Marks.

Switzerland has ordered from Marconi's a complete mobile television outside broadcasting unit comprising three image orthicon cameras and associated sound and vision equipment.

E.M.I. are to provide three complete Emitron mobile television microwave links to the Swiss Post Office for O.B. work. Switzerland recently started experimental transmissions from a station on the Uetliberg, near Zurich.

Valve Shrouds.—One of the two machines shown by Heenan and Froude, Ltd., of Worcester, at the recent European Machine Tools Exhibition in Brussels, was a strip-forming machine tooled for the manufacture of valve shrouds.

Hadley Sound Equipments, Ltd., of Smethwick, have advised us that the School Broadcasting Council has approved their new 5-watt amplifier with baffle-mounted loudspeaker as suitable for use in schools. The PR5 amplifier will, therefore, be added to the Council's "List of Approved Apparatus" to which we referred in our May issue.

International Aeradio, Ltd., are to provide and install radio and meteorological equipment at the Fiji Airways base, Nasouri, on the main island. Similar equipment will be installed at the other four airfields, Lambasa, Lautoka, Taveuni and Savu Savu. The company has also been given the contract by the

Government of Iraq for the provision of radio and radar engineering services and the establishment of an electronics training school in Baghdad.

Tanker Radio.—Six new 26,640-ton tankers on order for the Esso Petroleum Company are to be supplied with radio communication equipment and navigational aids by the Marconi International Marine Communication Company.

R.F. Dielectric Heater for the production from glued strips of wood of boards up to $80 \times 40 \times 2$ inches thick has been produced by the General Electric Company and Fielding & Platt, Ltd. R.F. power for this edge-gluing machine, which incorporates a pneumatically operated press, is provided by a G.E.C. 25-kW r.f. generator.

Tannoy in Canada.—To facilitate the distribution and maintenance of Tannoy equipment in North America, Tannoy (Canada), Limited, has been formed with offices in Toronto. F. A. Towler, who was for many years sales manager in London, is the resident executive.

Nera of England, Limited, is the new name adopted by Aren (Radio and Television), Limited, of Jeffries Passage, High Street, Guildford, Surrey. In addition to producing projection television receivers and TV components, the company is manufacturing electronic instruments.

Gillon Electric, Limited, Rockstone Works, Rosemary Lane, Camberley, Surrey (Tel.: Camberley 481), has been formed by G. D. Gilbert and A. L. Leeson (until recently with Allen Components, Ltd.) for the manufacture of radio and television components.

Truvox-Rola-Celestion.—The sale, distribution and service of Rola and Celestion loudspeakers and Truvox p.a. loudspeakers will in future be undertaken by Rola Celestion, Ltd., and not, as hitherto, by Truvox. All enquiries, correspondence, orders and units for service should be addressed to Rola Celestion, Ltd., Thames Ditton, Surrey.

The Sales office of the **Aluminium Wire and Cable Company** is now at 30 Charles II Street, St. James' Square, London, S.W.1. (Tel.: Trafalgar 6441).

Dupley Electronics, Limited, makers of transformers and battery chargers, have moved from Ealing to Athlon Road, Manor Farm Road, Alperton, Wembley, Middlesex (Tel.: Perivale 9126).

Glasgow Branch of W. T. Henley's Telegraph Works Company is now at 149/153, North Street, Glasgow, C.3. (Tel.: Central 1771.)

Aerialite, Ltd., have increased their factory accommodation at Stalybridge, Cheshire, by an extension to the factory giving a further 20,000 square feet of floor space.

MEETINGS

Institution of Electrical Engineers

Discussion on "Safety Precautions in Electronic Apparatus, with Particular Reference to Medical Applications," opened by H. W. Swann and W. Grey Walter, M.A., Sc.D., at 5.30 on November 12th.

Radio Section.—"Some Aspects of the Design of V.H.F. Mobile Radio Systems" by E. P. Fairbairn, B.Sc., at 5.30 on November 11th.

"Loudspeaker Systems—Recent Trends in Design" by Major A. E. Falkus, B.Sc.(Eng.), at 5.30 on November 23rd.

Education Discussion Circle.—Discussion on "What are the Requirements of Electrical Engineering Textbooks?" opened by Instr.-Cdr. D. K. McCleery, M.Sc., at 6.0 on November 9th.

All the above meetings will take place at Savoy Place, London, W.C.2.

Cambridge Radio Group.—Address by J. A. Smale, B.Sc., chairman of the Radio Section, at 6.0 on November 3rd at the Cambridgeshire Technical College, Cambridge.

Mersey and North Wales Centre.—"Radio Telemetering" by J. Walsh, B.Sc., at 6.30 on November 2nd at the Liverpool Royal Institution, Colquitt Street, Liverpool.

"Telemetering for System Operation" by R. H. Dunn, B.Sc., and C. H. Chambers, at 6.30 on November 16th at the Town Hall, Chester.

North-Eastern Radio Group.—"A Method of Designing Transistor Trigger Circuits" by Prof. F. C. Williams, D.Sc., D.Phil., F.R.S., and G. B. Chaplin, M.Sc., at 6.15 on November 16th at King's College, Newcastle-upon-Tyne.

North-Western Radio Group.—"Some Aspects of the Design of V.H.F. Mobile Radio Systems" by E. P. Fairbairn, B.Sc., at 6.30 on November 25th at the Engineers' Club, Albert Square, Manchester.

North Scotland Sub-Centre.—"Electronic Telephone Exchanges" by T. H. Flowers, B.Sc., at 7.30 on November 11th at the Caledonian Hotel, Aberdeen, and at 7.0 on November 12th at the Royal Hotel, Dundee.

South-West Scotland Sub-Centre.—"Electrotechnical Ceramics—a Survey of Compositions, Manufacturing Methods and Properties" by W. G. Robinson, B.Sc.Tech., and E. C. Bloor, B.Sc., at 7.0 on November 4th at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

South Midlands Centre.—"Printed and Potted Electronic Circuits" by G. W. A. Dummer, and D. L. Johnston, B.Sc. (Eng.), at 7.15 on November 19th at the Winter Gardens Restaurant, Malvern.

Faraday Lecture "Process Heating" by O. W. Humphreys, B.Sc., at 6.0 on November 30th at the Town Hall, Birmingham.

South Midlands Radio Group.—"Printed and Potted Electronic Circuits" by G. W. A. Dummer and D. L. Johnston, B.Sc.(Eng.), at 6.0 on November 23rd at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Reading District.—"Sound Recording" by G. F. Dutton, Ph.D., B.Sc.(Eng.), at 7.15 on November 30th at the George Hotel, Reading.

London Students' Section.—"Scanning Generators" by Lt. M. J. Wyatt and 2/Lt. P. D. Gibbons at 7.0 on November 10th at the R.E.M.E. Depot, Arborfield, Berks.

"Metallic Resistance at High Frequency" by A. D. Stevens at 7.0 on November 17th at the Public Library, Chelmsford. Essex.

British Institution of Radio Engineers

London Section.—"A High-Definition General-Purpose Radar" by J. W. Jenkins, J. H. Evans, G. A. G. Wallace and D. Chambers, B.Sc. (Cossor), at 6.30 on November 11th at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Scottish Section.—"Vibration Generators—Their Ancillary Equipment and Application" by H. Moore (Goodmans), at 7.0 on November 5th at the University, Edinburgh.

Merseyside Section.—"Multi-Channel Tuners for Television" by S. L. Fife and W. E. Hosey, B.Sc. (English Electric), at 7.0 on November 5th at the Merseyside and North Wales Electricity Centre, Whitechapel, Liverpool.

North-Eastern Section.—"Principles of Electronic Computing Machines" by Dr. B. V. Bowden (Manchester College of Technology), at 6.0 on November 11th at the Institution of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

West Midlands Section.—"Remote Control Devices and Servomechanisms" by A. E. W. Hibbitt (Muirhead), at 7.15 on November 24th at the Wolverhampton Technical College, Wulfruna Street, Wolverhampton.

Physical Society

"Some Magnetic Measurements—Techniques and Applications" by Prof. W. Sucksmith; and "Cathode Ray Tube Storage for Digital Computers" by Prof. F. C. Williams, D.Sc., D.Phil., F.R.S., at 5.0 on November 20th at the Science Museum, London, S.W.7.

Television Society

Discussion on "Competitive Television" at 7.0 on November 13th.

"Converters for V.H.F. or U.H.F. Television" at 7.0 on November 26th.

Both these meetings will be held at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Leicester Centre.—"Fly Wheel Synchronizing" by S. E. Gent, B.Sc. (Eng.), (Ferguson Radio), at 7.0 on November 30th at the College of Art and Technology (Room 45), The Newarkes, Leicester.

British Kinematograph Society

Film Production Division.—"Stereophonic Sound Systems" by A. W. Watkins, at 7.15 on November 18th.

Television Division.—"Medium Screen Television" by H. Ibbotson, B.Sc., at 7.15 on November 25th.

Both meetings will take place at the Gaumont-British Theatre, Film House, Wardour Street, London, W.1.

Radio Society of Great Britain

"The Television Society's new TV Station" by H. de L. Banting, D. N. Corfield, D.L.C. (Hons.), and E. A. Dedman, at 6.30 on November 20th at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Institute of Practical Radio Engineers

Midlands Section.—"Television and Radio Suppression in Vehicles" by H. Harrison (Joseph Lucas, Ltd.), at 7.30 on November 2nd at the Crown Hotel, Broad Street, Birmingham.

SKIN EFFECT

By "CATHODE RAY"

Why High-Frequency Currents Tend to Flow on the Outside of Conductors

IN connection with microwave valves, two months ago, I happened to mention that at such high frequencies it was better to use sheet than wire, because most of the current flowed at the surface—a peculiarity known as skin effect. With such a picturesque name, it could hardly fail to be known. But I wonder if it is *understood*. I suspect that many reasonably knowledgeable technical people regard it as one of the sweet mysteries of r.f. life that are better not inquired into too closely. There is some excuse for this attitude, because the books that do deal with it thoroughly make very heavy mathematical weather of it, full of special Bessel functions, wave propagation, and suchlike. Consequently the simpler treatises tend to laugh it off by hinting that you must be a fool if you can't see that it is in the nature of very high-frequency currents to keep to the surface. The thing is "skin effect," so—well, there you are!

For those who are not honours graduates, but nevertheless have inquiring minds, some of the books strike a happy medium. But the said inquiring minds may perhaps be a little troubled by the fact that several apparently quite different explanations of skin effect exist. There is, however, no cause for alarm; skin effect is one of those things that can be approached by different routes; some people may find one way easier, some another.

Basic Principles

Personally I think the best starting point for any expedition of this kind is with the basic principles of electricity. A bit more thought may be needed to work it out from there, but every time one does it makes those principles clearer in the mind. However, there is no reason against—in fact every reason for—supplementing this approach by views from other positions, which, although established from fundamentals indirectly, may be more familar in practical work. For instance, one way of explaining skin effect is in terms of eddy currents. To anyone who has studied eddy currents and knows all about them, this may be a convenient short cut; but if one's understanding of eddy currents is itself rather shaky it is clearly not a sound proposition.

The simplest conductor to consider is a long straight round-section wire made of a non-magnetic material, say copper, and far enough away from other conductors for their effects to be neglected. When d.c. flows it does so uniformly over the cross-section, so that if the wire were imagined to be divided up into equal thick parallel strands each would be carrying the same current. Since each strand has the same e.m.f. between its ends and the same resistance, it could hardly be otherwise. What calls for some explanation is the fact that with a.c. it *is* otherwise. If the frequency is sufficiently high, the strands around the circumference are found to be carrying nearly all the current, and those in the middle hardly any. Consequently the resistance of the wire as a whole is higher for a.c. than for d.c.

Students of the elementary books that try (regrettably) to make things easier by introducing reactance as a kind of resistance may need to be assured that this increase in resistance is quite apart from the increase in impedance due to the inductance of the wire as a whole. Such an assurance may be especially necessary because inductance does come prominently into my explanation. But not the inductance of the wire *as a whole*. May I emphasize, then, that there is an increase in actual *resistance* of the wire when the current becomes unevenly distributed from any cause whatever, whether by making the current alternate or by substituting Eureka for some of the copper.

Presumably it is obvious that the resistance of a wire is greater if current ceases to flow altogether through some portion of its cross-section, because that is the same thing as making the wire narrower. But anyone who does not find it obvious that *any* departure from uniform distribution of current flow increases the resistance should try calculating the total power dissipated in two parallel resistors when a given total current is shared between them in various proportions. Suppose, for example, that the resistors are each 10 ohms, representing (say) the core and outer parts of a 5-ohm length of wire (Fig. 1) and that the total current is 4 amps. If this is shared equally, each path takes 2 A and the power dissipated in it (I^2R) is $2^2 \times 10 = 40$ watts: total for both path 80 watts. Now suppose one path takes 3 A and the other 1 A. Dissipation in the 3 A path is 90 watts an in the other 10 W; total 100 W. Of course the voltages across the two paths are now unequal (assuming the current is d.c.), which is impossible if the paths are in parallel. But not with a.c. For if the low-current path has more inductance in series with its resistance than the other path, it is quite possible for the voltage across it to be the same as across the other.

But, you may say, surely all strands of a single wire have the same inductance, especially if (as we are supposing) the division of the wire into strands is only imaginary? Even when one takes two separate wires with which to wind a coil, if they are

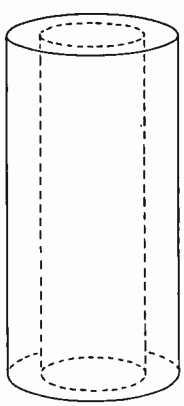


Fig. 1. A short sample (highly magnified) of a long solid wire, divided longitudinally by imaginary boundaries into two "strands," one inside the other, having equal cross-sectional area.

twisted together throughout their length the inductive coupling between them is very nearly 100%; any difference between two longitudinal halves of a single wire must be quite negligible! Regarding the inner and outer parts of the wire as separate strands, with boundaries as in Fig. 1, they obviously have the same length (and, if wound into a coil, the same number of turns), so assuming 100% coupling between them they could be represented electrically as in Fig. 2. At zero frequency the inductance would have no effect, so only the lower part of the diagram would apply, and the e.m.f. to pass 4 A (2 A through each path) would have to be 20 V. Since the wire is supposed to be stretched out straight, its inductance would presumably be quite small, so the d.c. conditions would not be much affected if the e.m.f. alternated at a low frequency, say 50 c/s. Very little more than 20 V would be needed to maintain the total current at 4 A. At high frequencies, however, the back e.m.f. generated by the flux set up by the current would become appreciable compared with 20 V, and a greater generator voltage would be needed to maintain the current. At a sufficiently high frequency, the inductance would become the dominating partner, swamping the resistance. But on the assumption of equal inductance and 100% coupling, the impedances of the two strands would be equal, whatever the frequency, so the currents in them would remain equal.

But now let us see if this representation—which at first sight might seem to be at least a close enough approximation to the truth—is justified. And this is where we get down to the bedrock of basic principles. One of the most important of them is that the magnetomotive force around any loop is proportional to the current enclosed (or linked). In the m.k.s. system it is actually equal to the number of ampere-turns; in the c.g.s. system it is 0.4π times the amp-turns. Our wire, being straight, has only one "turn," so the m.m.f. around any loop embracing it when it is carrying 4 A is (in the m.k.s. system) numerically equal to 4, or, in the c.g.s. system, 5.03. The path of the magnetic field at any point caused by current in a straight wire is a coaxial circle, and its strength is equal to the m.m.f. divided by the circumference of the circle. So just outside the wire, around its surface, the field strength (H) is m.m.f. πD, where D is the diameter of the wire. If D is, say 0.4 cm, H due to 4 A is 4 oersteds. The flux density B is equal to H multiplied by the permeability, μ, and in the c.g.s. system the μ for air is practically 1; so in our example B would be 4 gauss (or lines per sq. cm). In the m.k.s. system it would work out at 0.0004 weber. But for our present purpose numerical values are only of incidental interest, so there is no need to worry about systems of units—they do not affect the basic facts, namely, that the m.m.f. is the same in every concentric path around the wire, because all enclose the same current, and the field strength and flux density are therefore inversely proportional to the diameter, as shown in Fig. 3.

The same principles apply inside the wire itself, but of course we have to allow for the fact that the current enclosed, and therefore the m.m.f., progressively diminishes as the diameter of the path is reduced. The current, uniform distribution being assumed, is proportional to the cross-sectional area, and therefore to the *square* of the diameter. So the field, being proportional to the diameter squared, divided by the diameter, is simply proportional to the diameter and we can complete the field/diameter diagram as in Fig. 4.

The one essential thing to grasp out of all this is that current flowing down the centre of the wire is linked with more flux than current in the outer "skin." The difference is the flux in the wire itself; this flux is proportional to the total current through the wire, but is independent of its gauge. This may seem rather surprising, but if you remember that the maximum flux density (which is at the surface of the metal) is inversely proportional to D, while the area through which it passes is directly proportional to D, you will see that D cancels out when calculating flux = flux density × area.

Now if the current is alternating, the whole of the flux it produces is alternating, and therefore is inducing an e.m.f. in the wire. Other things being equal—frequency and length of wire—the e.m.f. induced is proportional to the peak flux. Since, as Fig. 4 shows, the flux linked with the core of the wire is greater than that linked with the skin, we see that more e.m.f. is induced in the core than in the skin. But the generator e.m.f. applied across all strands of the wire is the same, so after the induced e.m.f.s have been deducted there is less to spare for driving current through the resistance of the core than through the resistance of the skin. Consequently the effect of the unequal flux

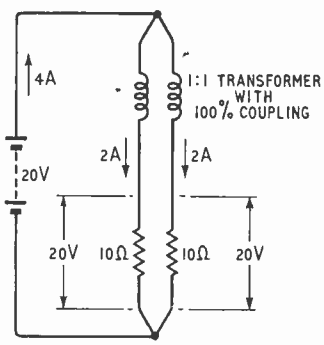
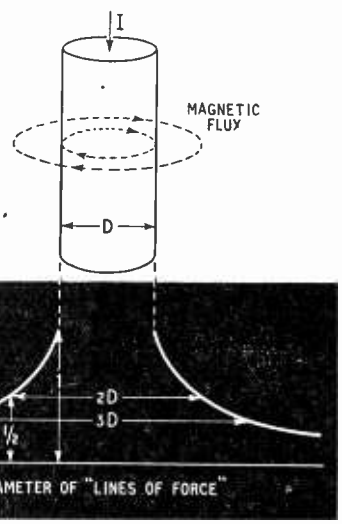


Fig. 2. If the resistance of the wire is taken as 5 ohms, the two "strands" can be represented by two 10-ohm resistances in parallel. Their inductances are also in parallel and very closely coupled; on the assumption that they are equal they are shown as making up a 1 : 1 transformer. At zero frequency the inductance has no effect, and an e.m.f. of 20 volts is sufficient to maintain a current of 4 amps, divided equally between the strands.

Fig. 3. The density of magnetic flux paths ("lines of force"), two of which are shown around the wire, falls off inversely as their length (which is proportional to their diameter) as shown in the lower part of the diagram. D is the diameter of the wire.



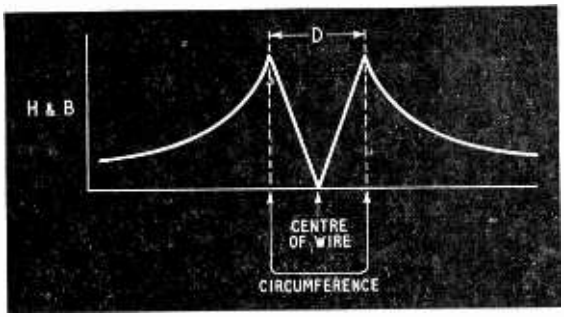


Fig. 4. To the field and flux density diagram for the field outside the wire is here added the portion applying to the field inside the wire, assuming the current is uniformly distributed. This diagram takes no account of the sign (direction) of the field.

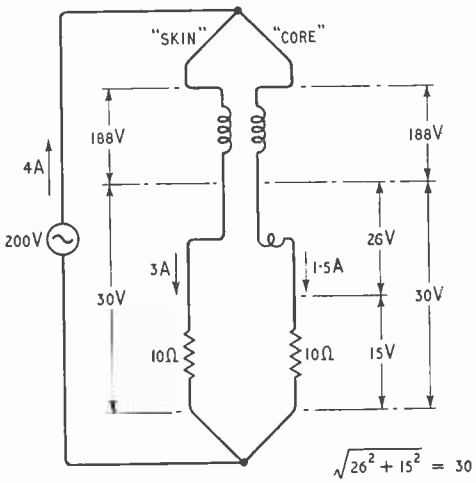


Fig. 5. This is Fig. 2 modified to apply to a frequency high enough for the reactance of the wire to be greater than its resistance. The fact that (as shown in Fig. 4) there is more flux outside the core of the wire, linked with it, than there is outside the skin, causes the core to have a higher inductance, so that less voltage is left to drive current through its resistance, and less current flows through it.

is to divert current from the core to the skin, and the resistance of the wire as a whole is increased.

Using conventional circuit symbols, this state of affairs can be shown as in Fig. 5, where the little extra coil in the "core" path represents the extra inductance corresponding to the flux inside the wire. The important point is that this inductance is not coupled to the "skin" path. Its back e.m.f. constitutes an extra voltage drop in the core path, and to make the situation clearer some figures are given on the diagram. For comparison with Fig. 2 the generator voltage has been raised sufficiently to maintain the total current at 4 A. The voltages across the two "windings" of the transformer *must* be equal and in phase, because the ratio is 1:1 and the coupling 100 per cent, so the voltages across the rest of each path must also be equal. But because of the extra inductance the current in the core path is not only less than the skin current but lags it in phase. In this case the phase difference is nearly 60°, which accounts for the fact that although the current in one branch has gone up by 1 A it has gone down in the other by only 0.5 A. So here is another cause of increased resistance. If you compare Fig. 5 with Fig. 2 you will find that the power dissipated, for the same current, has risen more than 40 per cent, equivalent to a rise in resistance from 5 Ω to more than 7 Ω. Note that a large diversion of current has been caused by a relatively small difference between the inductances of the two paths.

One result of the diversion of current from the core is to modify Fig. 4. The field outside the wire (being determined only by the total current) remains unchanged, but there is less inside. This tends to reduce the excess of voltage induced in the core. The diversion therefore takes place only so far as is necessary to bring about a balance, such as that shown in Fig. 5. But if the frequency is very high indeed, and the resistance of the wire is very low (as it would be if made of heavy gauge copper), practically the whole of the applied voltage is used in overcoming the inductance. In other words, the voltage induced in all strands of the wire must be practically the same. This cannot happen if some strands are linked with more flux than others, so current ceases altogether except at the surface. Then there is no flux inside the wire and all parts of the wire are linked by the same flux, (i.e., the flux outside the wire). And the resistance of the wire is many times greater than it was. The resistances of the various "strands" are still the same as before; it is just that fewer of them are being used. Directly the resistance rises so much as to absorb an appreciable part of the voltage applied to the outermost skin, it makes possible a slightly greater induced voltage in the inner layers, which means that some current, though small, can flow there.

The thicker the gauge of the wire, the lower its d.c. resistance in proportion to its inductance, and the greater the skin effect. This fact sometimes makes unthinking people jump to the conclusion that at very high frequencies a thick wire has a greater resistance than a thin one. Actually, of course, the thick wire has the lower resistance, however far skin effect is developed, for it has more surface. It is true that *in proportion to the amount of metal used* its resistance is greater, because that goes up as the square of the diameter whereas the surface goes up in simple proportion to the diameter. So to obtain the lowest resistance with a given amount of metal it should be in the form of a thin-walled tube. It is also true that a coil wound with thick wire may have a higher r.f. resistance than a coil of the same dimensions wound with thinner wire. But if so it is not because of skin effect but because the lower resistance of the thick wire is being more than offset by greater dielectric losses in the insulation between the turns.

A moment or two ago we saw that skin effect brought about a reduction of magnetic flux inside the wire, the flux outside (for a given current) remaining the same. So the total flux produced by a given current is reduced, or in other words the inductance of the wire is reduced. The inductance of any circuit depends to some extent on frequency: it is greatest at zero frequency, when Fig. 4 holds good; it falls as skin effect comes into play; but there is a limit to the fall, for however high the frequency the circuit cannot lose more than all the flux inside the wire, and that is usually quite a small proportion of the whole. So at very high frequencies the inductance curve levels out again, towards a slightly lower figure than the d.c. value. The more refined formulæ for calculating inductance provide a frequency correction.

We have already seen that skin effect is more pronounced with thick solid wire than with thin, in the sense that a given frequency multiplies its resistance by

a larger factor, though it never becomes so high as that of the thin wire. It should also have been clear that wire made of low-resistance metal develops skin effect at a lower frequency than high-resistance metal. Study of Fig. 5c shows that the lower the resistance of the wire—whether because it is thick or because it is made of low-resistance material, or both—the lower the frequency at which its inductance is large compared with its resistance, causing the current to crowd towards the skin in order to reduce the internal flux and thus equalize the inductive voltages in all strands. So a thick copper wire shows skin effect at a comparatively low frequency; a thick resistance wire or a thin copper wire is similarly affected only at a much higher frequency; and a thin resistance wire maintains its resistance within close limits up to a much higher frequency still. Finally, a wire made of iron or other magnetic material, though higher in resistance than copper and therefore less subject to skin effect, has an enormously higher permeability than copper, so the internal flux is multiplied accordingly, and the net skin effect is far greater even than with copper.

Skin effect is therefore increased by the following: conductance per unit length, permeability, and frequency. The exact calculation of the increase in resistance is, as I said, a matter for the brighter mathematicians, and practical people like ourselves fall back on tables or graphs. While it is easy enough to use these to find the increase for an infinitely long straight wire with no other conductors anywhere near, no real circuit answers to that description. Even if one takes a practical view of "infinitely long" (in some circumstances a foot or so may be indistinguishable from infinitely long) there must be a return path somewhere if there is to be any current. However, if this is outside the more intense parts of the wire's magnetic field, it can be disregarded for purposes of calculating skin effect. But most often one is interested in r.f. resistance as it affects coils, transmission lines and other circuits that do not even roughly conform to the above description. Take a coil, for instance. The flux inside the wire forming any of the turns is caused not only by the current in that turn but also by the same current in other turns. So Figs. 3 and 4 do not hold good, and the explanation based on them falls down. But its conclusion does hold good if it is expressed more generally. What we really found was that when the frequency is high enough for the inductance to predominate over resistance in the impedance *the current tends to flow where it makes the inductance least.* In a straight wire, this is at the circumference of the cross-section; in short, the skin.

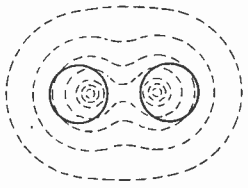


Fig. 6. When two wires carrying the same current are close together, their combined magnetic flux is distributed something like this (a), and the h.f. current consequently tends to flow where shaded (b).

Fig. 6 shows a section through two adjacent wires carrying current in the same direction. Assuming their returns are relatively far away, the flux pattern will be somewhat as shown at (a). The parts of the wire linked with least flux are those farthest apart, so the greatest current density will be through them, as shown by the shading at (b). This modified distribution is sometimes given a separate name, *proximity effect*, but basically it is the same as skin effect. In a single-layer coil, the tendency is for the current to flow along the inside surfaces of the wire. Abacs for calculating r.f. resistance of coils are in *Radio Data Charts*.

Then there is the coaxial line. It is no surprise to learn that current through the inner conductor tends to flow at the outer surface, as in simple skin effect. But it may seem rather contradictory that the current through the outer conductor tends to keep to the *inner* surface. Yet it follows from the same sort of reasoning as we used for the isolated wire. If in Fig. 7 we work from the axis outwards, calculating the m.m.f. due to the zero-frequency current enclosed, and dividing by the length of the field path or "line of force," everything is as before until we reach the inside diameter of the outer conductor. Here we start to enclose a current flowing in the opposite direction, so the net m.m.f. decreases. By the time we reach the outside diameter we are enclosing no net current at all, because the currents in the inner and outer conductors are equal and opposite. So from here outward there is no magnetic field—which of course is one of the advantages of this type of cable. Looking at the possible current paths, we see that a path down the core of the inner conductor, and up the outer skin of the outer, links with all the flux there is, both in the space between the conductors and in the metal, so has maximum inductance. The path of *least* inductance, and therefore most popular with high-frequency current, is along the surfaces enclosing the space between the conductors.

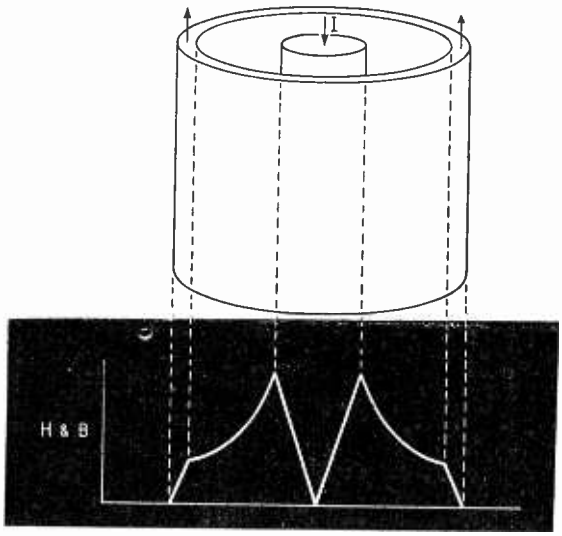


Fig. 7. This is Fig. 4 modified to apply to a coaxial line, where the external field is cancelled out by equal and opposite currents in the two conductors.

The only metal having a lower resistivity than copper is silver, so where low r.f. resistance is worth the extra cost it is customary to silver-plate the surfaces where the current flows. But the resistivity of silver is only about 5 per cent lower, and it has been found* that plated surfaces are microscopically rough,

* "Attentuation and Surface Roughness of Electroplated Waveguides," F. A Benson, *Proc. I.E.E.*, Part III, July 1953, p. 213.

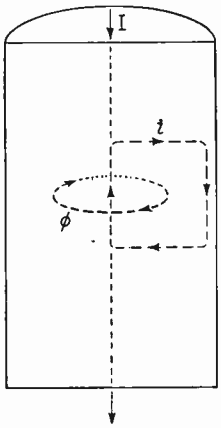


Fig. 8. In this wire, shown in section, the alternating flux (represented by the single line of force, ϕ) induces current around paths such as the square one marked. When all such paths are taken into account, the net result is skin effect.

and the extra distance the current has to go, up and down all these little hills, may more than swallow up the slight advantage.

For the sake of anyone who would like an alternative approach to simple skin effect, Fig. 8 shows a longitudinal section of our piece of wire with current flowing down it. Consider any closed path in a vertical plane inside the metal, such as the square one shown dotted. Provided that it is not exactly in the centre, such a conducting loop as linked with some flux, represented by the single coaxial line of force marked "ϕ". As the current in the wire alternates, so does this flux, which therefore induces an alternating e.m.f. around the loop (and around all others like it), and because the loop conducts a current flows around it. According to Lenz's Law, the direction of current must be such as to oppose its cause; so inside the flux loop it must be opposite to the current that set up the flux, which means that nearer the surface of the wire it must be in the same direction as the current there (which was *not* responsible for the flux). In other words, the current near the axis of the wire is weakened, and the current near the surface is strengthened; in still fewer words —skin effect.

Some time ago, when discussing Energy (January 1952, to be precise) I mentioned that the electrical energy travelling along a resistanceless wire existed solely in the space around, in the form of electric and magnetic fields; it was only in so far as the wire has resistance that energy enters into the wire, there to turn to heat. In saying this I neglected the magnetic field inside the wire, but this was reasonable, for at most it is a small proportion of the whole, and, if a wire really could be devoid of resistance, skin effect would be full developed even at the lowest frequency and there would be no current or flux inside. Supposing now the wire *has* resistance, energy from the fields must enter it from the outside inwards, being dissipated as it goes. One would expect, therefore, the greatest dissipation to be at the surface, and (since energy must travel at a finite speed) the dissipation nearer the axis of the wire to be not only less intense but also delayed in time. This is exactly what we have already found: the current inside the wire being less, the I^2R loss is less than at the surface; and since the inductance is greater it lags in phase.

An interesting point is that when d.c. is switched on, the magnetic field around the circuit has to grow, so there is a transient skin effect as well as a transient inductive effect, and the current in the wire starts flowing in the skin first and spreads to the inner parts later, before finally becoming uniformly distributed.

The "strands" we have spoken about hitherto have been distinguished only by imaginary longitudinal boundaries in the solid wire. What if we were to make up the wire of a number of actual separately insulated strands? This idea would occur at once to anyone who viewed skin effect as a manifestation of eddy currents, as in Fig. 8, because the way to minimize eddy currents in iron cores is to break up the current paths by using insulated stampings. It might seem that the insulation of the strands would in the same way interrupt the eddy currents where they pass horizontally from axis to circumference. But in fact these currents do not exist anyway! The current path marked in Fig. 8 is by no means the only one; there is another above it, and its lower horizontal portion carries current equal and opposite to the upper portion of the first, so cancelling it out. And so on for other paths. The only places where the current can be regarded as flowing at right angles to the axis of the wire is at each end (where there must be a conducting path there if the strands are to be electrically in parallel!).

So stranding alone does not overcome skin effect. The way to do so is to arrange that equal flux links every strand. This can be done by organizing the strands so that each occupies inside and outside positions in the same proportion. Stranded wire so organized is known as litzendraht, or more commonly as litz, and by its use the r.f. resistance of coils of given dimensions can be considerably reduced. But not only is this wire itself much more expensive than solid, it must be handled carefully and connected with great care and trouble, for if there are short-circuits between some of the strands, or every strand is not soundly connected at the ends and unbroken throughout its length, the result falls considerably short of expectation. In fact, a badly made litz coil may be even worse than if the wire were solid. The higher the frequency, the more difficult it is to obtain the benefit of litz, for apart from defects of workmanship the capacitance between strands increasingly nullifies its purpose.

I.E.E. PREMIUMS

THE Kelvin Premium (£25) has been awarded by the I.E.E. to Dr. W. Culshaw (T.R.E.) for his paper on "A Spectrometer for Millimetre Wavelengths" which was read during the Symposium on Insulating Materials.

Many of the Radio Section awards are for papers read at last year's Convention on "The British Contribution to Television." The Duddell Premium (£20) went to D. C. Birkinshaw (B.B.C.) for his paper "Television Programme Origination: the Engineering Technique," and the Ambrose Fleming Premium (£10) to D. A. Wright (G.E.C.) for "A Survey of Present Knowledge of Thermionic Emitters."

Premiums valued at £10 have been awarded to the following for the papers quoted: H. Cafferata, C. Gillam and J. F. Ramsay (Marconi's), "Television Transmitting Aerials"; E. McP. Leyton, E. A. Nind and W. S. Percival (E.M.I.), "Low-Level Modulation Vision Transmitters, with special reference to the Kirk o'Shotts and Wenvoe Stations"; Prof. F. C. Williams and G. B. B. Chaplin (Manchester University), "A Method of Designing Transistor Trigger Circuits."

The following received £5 premiums: G. R. M. Garratt (Science Museum) and A. H. Mumford (Post Office), "The History of Television"; Dr. B. G. Pressey, G. E. Ashwell and C. S. Fowler (D.S.I.R.), "The Measurement of the Phase Velocity of Ground-Wave Propagation at Low Frequencies over a Land Path"; P. A. T. Bevan (B.B.C.), "Television Broadcasting Stations"; W. R. Piggott (D.S.I.R.), "The Reflec-

tion and Absorption of Radio Waves in the Ionosphere"; H. E. Holman and W. P. Lucas (E.M.I.), "A Continuous-Motion System for Televising Motion-Picture Films"; Dr. E. C. Cherry (Imperial College) and G. G. Gouriet (B.B.C.), "Some Possibilities for the Compression of Television Signals by Recoding"; Dr. A. J. Biggs (G.E.C.) and E. O. Holland (Pye), "The British Television Receiver"; L. C. Jesty (Marconi's), "Television as a Communication Problem"; Prof. H. E. M. Barlow, Dr. A. L. Cullen and A. E. Karbowiak (University College, London), "Surface Waves" and "An Investigation of the Characteristics of Cylindrical Surface Waves."

The premiums were awarded at the opening meeting of the session on October 8th.

B.R.I.T.I.R.E. AWARDS

THE premier award of the British Institution of Radio Engineers—the Clerk Maxwell Premium (20 guineas)—has been given to Dr. Charles Süsskind of the Microwave Laboratory at Stanford University for his paper "Obstacle-Type Artificial Dielectrics for Microwaves."

I. A. Harris (M.o.S.) has received the Heinrich Hertz Premium (20 guineas) for his paper "A Systematic Method of Linear Small-Signal V.H.F. Analysis for Valve Circuits." The Louis Sterling Premium (15 guineas) was made to Dr. R. T. Theile and H. A. McGhee (Pye) for their paper "The Application of Negative Feedback to Flying Spot Scanners." The award for the most outstanding contribution on aids to aircraft safety—the Brabazon Premium (15 guineas)—went to P. L. Stride (E. K. Cole) for his paper "Search Radar for Civil Aircraft."

The first award of the A. F. Bulgin Premium (15 guineas)—for a paper from a member of the Armed Services—was made to Lt.-Col. J. P. A. Martindale (formerly of the Royal Military College of Science) for his paper "Lens Aerials at Centrimetric Wavelengths." V. J. Cooper (Marconi's) received the Marconi Premium (10 guineas) for the paper "New Amplifier Techniques." The Leslie McMichael Premium (10 guineas) went to J. A. Hutton (Murphy) for his paper "The Focusing of Cathode Ray Tubes for Television Receivers." The Dr. Norman Partridge Memorial Award (5 guineas) was made to K. R. McLachlan and R. Yorke (University of Southampton) for their paper "Objective Testing of Pick-ups and Loudspeakers."

The awards were made at the annual general meeting on October 21st.

TECHNICAL TRAINING

THE central feature of the Technical Training Display at the Show, provided by a number of colleges under the ægis of the Radio Industry Council, was a map indicating the types of training available at educational establishments throughout the British Isles. This information, which was provided by the Ministry of Education, is tabulated below. The initials against the name of the town or the college indicate the type of training provided: A, telecommunications engineering; B, servicing; C, Higher National Certificate with electronics or telecommunications; D, B.Sc. degree with electronics or telecommunications; and E, Higher N.C. in applied physics.

Angus
- Dundee (A, B, C)

Bedfordshire
- Bedford (A)
- Luton (C)

Berkshire
- Maidenhead (B)
- Newbury (A)
- Reading (A)

Buckinghamshire
- Bletchley (A)
- High Wycombe (A)
- Slough (A)
- Wolverton (A)

Caernarvonshire
- Bangor (A)

Cambridgeshire
- Cambridge (B, C)

Cheshire
- Chester (A)
- Crewe (A, B)
- Stockport (A, B, C)

Cornwall
- Camborne (A, B)
- Falmouth (B)

Cumberland
- Carlisle (A, B)
- Whitehaven (A)

Denbighshire
- Wrexham (A, B, C, D)

Derbyshire
- Chesterfield (A)
- Derby (A, B)

Devon
- Barnstaple (A)
- Exeter (A, B, D)
- Plymouth (A, B, C)
- Torquay (A, B)

Dorset
- Weymouth (A, C)

Durham
- Darlington (A)
- South Shields (A, B)
- Stockton (B)
- Sunderland (D, E)
- West Hartlepool (A, B)

Essex
- Chelmsford (C, D)
- Dagenham (A, B, C)
- East Ham (C)
- Southend (B, C)
- Walthamstow (A, C)
- West Ham (A, B)

Fifeshire
- Cowdenbeath T.C. (B)

Glamorganshire
- Cardiff (A, B, C, D)
- Rhondda T.I. (A)
- Swansea (A, B, C, D)
- Treforest (A, B, E)

Gloucestershire
- Bristol (A, B, C, D)
- Cheltenham (A, B)
- Cinderford (B)
- Gloucester (A, B, C)
- Stroud (A)

Hampshire
- Bournemouth (A, B, C, D)
- Portsmouth (A, B, C, D)
- Southampton University College (A, B, C, D)

Herefordshire
- Hereford (A, B)

Hertfordshire
- Hatfield (A, B)
- Letchworth (A, B)

Kent
- Canterbury (A, B)
- Dartford (A, B, C)
- Dover (A)
- Folkestone (A)
- Medway (A, B)
- Thanet (A)
- Tunbridge Wells (A)

Lanarkshire
- Coatbridge T.C. (B)
- Glasgow
  - Stow Eng'g. Col. (A, B)
  - Allan Glen's (A, B)
  - Royal T.C. (C, D)
- Hamilton (B)

Lancashire
- Blackburn (A, B)
- Blackpool (A, B)
- Bolton (A, B, C)
- Bootle (A)
- Burnley (B)
- Lancaster (A)
- Liverpool
  - College of Technology (A, E)
  - Old Swan T.I. (A)
  - Riversdale T.C. (A, B)
- Manchester
  - Col. of Technology (C, D)
  - Openshaw T.C. (A, B)
- Oldham (B)
- Preston (A, B, C, D, E)
- Salford (A, B, C, D, E)
- Southport (A)
- Wigan (A, B, C, D)

Leicestershire
- Leicester (B)
- Loughborough (B, C, D)

Lincolnshire
- Lincoln (A, B)

London
- Battersea P. (A, C, D)
- Deptford (S.E. London T.C.) (A, B, C, E)
- Finsbury (Northampton P.) (A, C, D, E)
- Islington (Northern P.) (A, B)
- Lambeth (Norwood T.C.) (A, B)
- Paddington (B)
- Poplar (B)
- St. Marylebone (Regent St. P.) (A, B, C, D)
- Southwark (Borough P.) (A, C)
- Woolwich P. (A, C, D)

Middlesex
- Acton (A, C, D)
- Enfield (B, C)
- Hendon (C)
- Southall (B, C)
- Willesden (A, C)

Midlothian
- Edinburgh
  - Heriot-Watt (A, B, C, D)
  - Leith T.C. (B)

Monmouthshire
- Crumlin (C)
- Newport (A)

Norfolk
- Gt. Yarmouth (A)
- Norwich (A)

Northamptonshire
- Peterborough (A)

Northumberland
- Newcastle-on-Tyne (A, B, C, D)

Nottinghamshire
- Nottingham (A, C)

Oxfordshire
- Oxford (A, E)

Renfrewshire
- Greenock Watt Memorial Sch. (A, B)
- Paisley T.C. (C, D)

Shropshire
- Shrewsbury (A, B)

Somerset
- Bath (A, B)
- Taunton (A, B)

Staffordshire
- Burton-on-Trent (A, B, C)
- Stafford (A)
- Stoke-on-Trent (A, B)
- Walsall (B)
- Wolverhampton (A, B, C, D)

Stirlingshire
- Stirling High Sch. (A)

Suffolk
- Lowestoft (A, B)

Surrey
- Croydon (A, B, C)
- Richmond (B)
- Wimbledon (A, B, C)

Sussex
- Brighton (A, B, C, D)
- Hastings (B)

Warwickshire
- Birmingham (A, B, C, D, E)
- Coventry (A, C, D)
- Leamington (A)
- Rugby (A C, D)

Wiltshire
- Chippenham (A, B)
- Salisbury (A, B)
- Swindon (A)

Worcestershire
- Gt. Malvern (C)
- Kidderminster (A)
- Worcester (A)

Yorkshire
- Bradford (A, B)
- Castleford (Whitwood) (B)
- Doncaster (A, B)
- Halifax (A)
- Huddersfield (A, B, C)
- Kingston-upon-Hull (A, B, D)
- Leeds (A, B, C, D)
- Middlesbrough (A, B)
- Rotherham (A, B, C, E)
- Scarborough (A)
- Sheffield (A, B)
- Wakefield (B)

EIRE
- Dublin (B)

NORTHERN IRELAND
- Belfast (B)

Abbreviations: P., Polytechnic; T.C., Technical College; T.I., Technical Institute.

TRANSISTORS

10.—*Analogue, "Field-Effect," and Tetrode Transistors : Junction Photocells*

By THOMAS RODDAM

IN the first eight articles of this series the discussion related to the conventional transistors, the ones which are in production in America and elsewhere. Three types have been mentioned, the point type and the two polarities of junction transistor : in essence, as we have seen, these reduce to only two basic types, the point type with a current gain of more than unity and the junction type with a current gain of less than, though very close to, unity. A modified version of the junction transistor, the symmetrical unit, was mentioned in the ninth article. This month I want to describe some of the other members of the transistor family which have been constructed. Which of them will prove important is anyone's guess, but they serve to show the lines along which transistor development is proceeding.

The group of transistors to be described first is the general class of unipolar transistors. The most easily appreciated types of unipolar transistors are the analogue transistors, which are called by this name because they really are very analogous to ordinary triodes. Externally, it is true, the usual junction transistor is quite valve-like, but of course any fairly linear three-element system must be rather like some sort of triode. The analogue transistors are fundamentally like a valve. The description of these transistors follows closely that given by Shockley. To begin with, consider two electrodes in a vacuum —a vacuum capacitor, in fact. Assuming that a battery is connected to the two plates, there will be a potential difference between them, an electric field in the space between the plates, but no charge in the gap, because the emission is negligible. A very similar structure can be realized with semi-conductors by arranging an intrinsic semi-conductor, one which is absolutely pure, with a *p*-region at one end and an *n*-region at the other. Provided that the *n*-region is connected to the positive terminal of the battery and the *p*-region is connected to the negative terminal, very few carriers will enter the intrinsic region in the middle, and there will be a concentration of charge along the two boundaries. Of course, if the polarity is reversed the majority carriers in the two "doped" regions will flow into the middle.

In an ordinary valve the electric field is distributed so that it tends to pull electrons out of the grid and cathode, and to catch them at the anode. This is obvious when the valve is cold, and when the cathode is hot the main change is that electrons come out from the cathode very easily, while the field at the cathode is reduced by space charge.

An analogue transistor can have the structure shown in Fig. 1, in which the "cathode" and "anode" are made of *n*-germanium, the "grid" of *p*-germanium, and the "vacuum" of pure germanium. At the "cathode" the electric field will tend to extract electrons, and these will form a space charge round the "cathode." As the "grid" is negative with respect to "cathode," the electrons will not flow into the "grid," and the "grid wires" will be surrounded by what Shockley calls depletion regions. As the "grid" potential is varied the number of electrons which slip through the gaps between "grid wires" will vary. The behaviour is thus very much the same as in an ordinary valve.

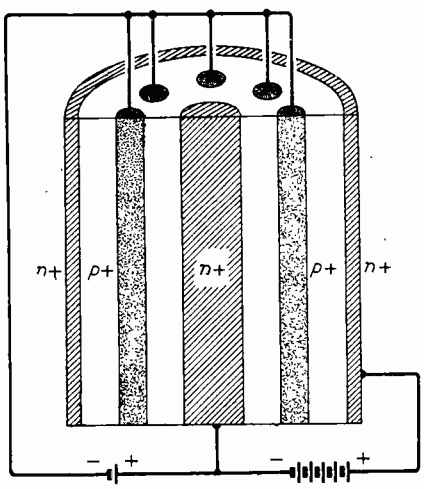


Fig. 1. Transistor analogue of a triode valve. The space between "electrodes" is pure (intrinsic) germanium.

The analogy is not absolutely exact, of course. For one thing, the electrons do not flow in a stream, bouncing together like billiard balls and obeying the law of conservation of momentum. In consequence there may be no "grid" current even if the "grid" is positive with respect to "cathode," so long as the field at the "grid" is electron extracting.

The important distinction between the analogue transistor and the ordinary transistors lies in the fact that there is no emitter in the analogue transistor. In the junction transistor the controlled current and the controlling current both flow in the base region, so that input and output are mixed up together. In the point transistor, both holes and electrons are involved, and the injection of holes at the emitter is an essential feature of the operation. An electron-flow analogue transistor may have a small saturated flow of holes, just as the ordinary valve may have a small current due to ions, but the essential working depends on one kind of current carrier only. For this reason the new kind of transistor is called a unipolar transistor to distinguish it from the bipolar transistor we have met previously.

There is a second variety of unipolar transistor, the field-effect transistor, which differs from the analogue

transistor by having unbalanced chemical impurities in the " vacuum " region. But first we must introduce some terminology. It seems obvious that we should follow Shockley,[1] and this is what he says :

" Since the role of emitter is not played in the normal way in the unipolar transistor and since the collector also functions somewhat differently, it appears advantageous to introduce new terminology for the electrodes in the unipolar types. The choice proposed for the electrodes is as follows : *Source* for the electrode from which the carriers enter the region of relatively high electric fields ; *drain* for the electrode at which they arrive and out of which they flow ; in the analogue transistor the control electrode will be called the *grid* because of its close analogy with vacuum-tube structures. In the field-effect transistor it is proposed to call the control electrode the *gate*. The fact that gate and grid have the same initial letter leads to the use of a common subscript for these two similarly functioning electrodes. The choice of these names has been based partly on an attempt to find names which describe functions and partly on the value of the names from a phonetic and abbreviational point of view. It should be noted that none of the new subscripts are the same as those encountered in bipolar transistors. Furthermore, it may be noted that the names selected are all monosyllabic."

The typical structure of the unipolar field effect transistor is shown in Fig. 2(a). It is a triode, and is constructed from a sandwich of *p*-material between two layers of *n*-material, the latter being heavily doped so that it can be described as $n+$ material. The actual " space current " is carried by holes moving from left to right, and the current electrodes are made up of heavily doped *p*-material ($p+$) shown as 1 and 2. The *p-n* junctions are biased back, since both 1 and 2 are negative with respect to the earthed $n+$ plates 3. Space charge regions near the *n* plates are formed, and in these regions there are very few carriers. All the carriers flow through the central channel.

The width of the channel is, of course, a function of the relative bias on the gate electrodes. If 2 is more negative than 1, the bias will be greater near 2 so that the channel will be narrower at the right-hand end than at the left. The approximate theory shows that if this effect is sufficiently pronounced the channel will be closed completely. In more detailed analysis we find there is a point known as the *extrapolated pinch-off point* or *expop*. The distribution of space charge is shown in Fig. (2)b, and the actual shapes and sizes of some experimental units in Fig. 2(c).

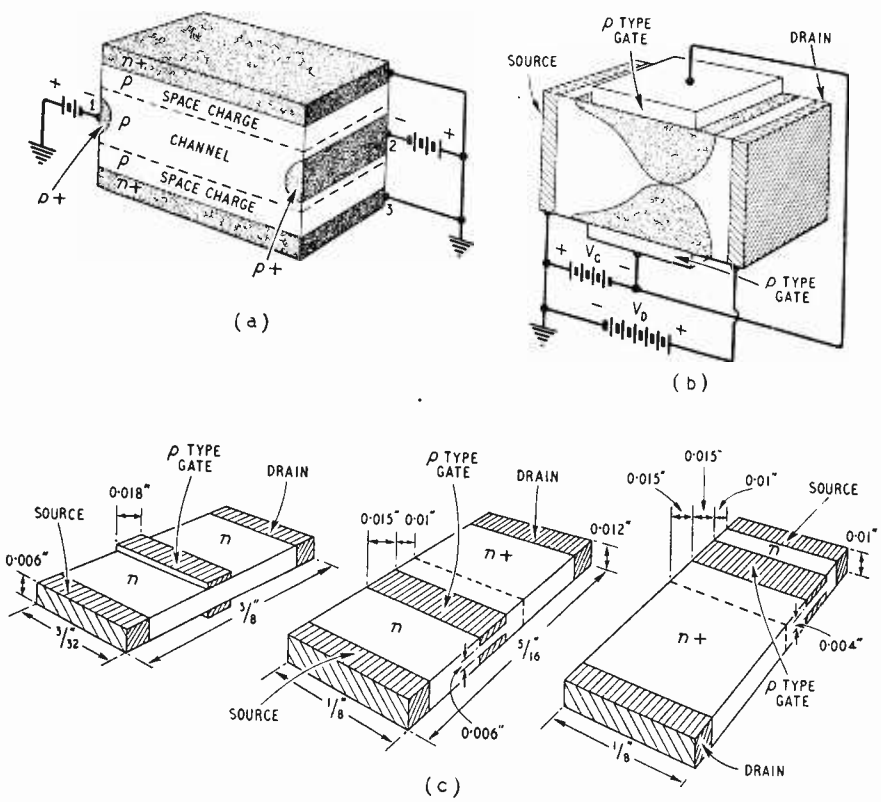
Quite obviously the hole current in the channel can be controlled by varying the potential of the gate. Analysis and computation lead to the conclusion that gain can be obtained at frequencies as high as 10 Mc/s in a device which has all the predictability of the junction class of transistors. This is of very great importance, because the point transistors still seem to present considerable difficulty to the manufacturers.

The actual experimental units had mutual conductances up to 0.3 mA/volt and flat responses up to 3 Mc/s. Important among their properties are high input and output impedances. Unfortunately the noise figure is high, and under particular conditions one unit had a noise figure of 68 db. Dacey and Ross[2] state that using 17 ohm-cm germanium it should be possible to get a mutual conductance of 24 mA/V and an upper frequency limit of 140 Mc/s.

Another field controlled device is the junction " fieldistor " described by Stuetzer.[3] This is shown schematically in Fig. 3. The *p-n* junction is biased in the non-conducting direction and a control electrode is mounted very close o the surface. As a biasing potential is applied to the control electrode, there is a surface effect at the germanium junction, and the back resistance varies. In this form the mutual conductance is only a few microamps per volt.

By adding a liquid of high polar moment in the

[1] *Proc. I.R.E.*, Vol. 40, p. 1313, Nov. 1952.



[2] *Proc. I.R.E.*, Vol. 41, p. 970, August 1953.
[3] *Proc. I.R.E.*, Vol. 40, p. 1377, Nov. 1952.

Fig. 2. (a) Structure of a unipolar field-effect transistor triode. (b) Distribution of space charge. (c) Dimensions of some experimental field-effect transistors.

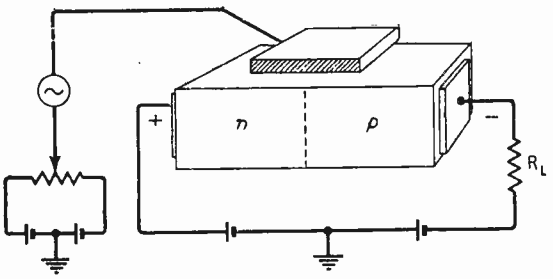


Fig. 3. In the "fieldistor" a liquid polar dielectric between control electrode and junction increases mutual conductance.

Right: Fig. 4. p-n-p-n junction transistor and its equivalent circuit.

space between electrode and germanium the device is completely transformed. The mutual conductance changes sign and becomes fairly large, the output impedance drops, and the frequency response, which without the liquid extends up to some hundreds of kilocycles per second, starts to droop at audio frequencies. A mutual conductance of some milliamps per volt, already well down at 1000 c/s, can be produced.

This device seems to be one which has not much future. A study of its mode of action shows that it is a surface device, not a volume device, and it has one value. It shows why we must be careful in choosing the material if we want to embed a diode in wax. Polar waxes would be fatal.

The next type to be considered is the *p-n-p-n* junction transistor. Schematically this is shown in Fig. 4, and according to the early terminology this is a *p-n-p* transistor with a "hook" collector on the right. The effect of the hook collector is to increase the current gain, and as a result values of α of the order of 50 can be obtained. As we have seen earlier, in an ordinary junction transistor the value of α does not exceed unity.

The mechanism of operation of this type of transistor is, perhaps, too complicated for this series. It is, however, possible to carry out experiments connected with this type of transistor, since it can be simulated by connecting an *n-p-n* transistor and a *p-n-p* transistor together in the way shown in Fig. 5. Notice that the terminal on the right is marked ϵ_2 and is an emitter, not a collector. Used as an earthed-base hook collector transistor B is left disconnected and the equivalent circuit takes the form shown in Fig. 6. The value of α can be reduced by connecting a resistance between B and ϵ_2. In an even more complicated arrangement a diode is connected here, and by building out r_{ϵ_2} with 22 ohms and using a *p-n*-diode between B and ϵ_2 an almost constant value of α over a range of 0.01 to 1.0 mA of I_{ϵ_1} has been obtained. The α was just under 3.

These *p-n-p-n* transistors are likely to be very hard to produce. It is anyone's guess whether other forms will be found to do the job before the production difficulties are solved.

A four-electrode junction transistor of another kind is the one described by Wallace, Schimpf and Dickten.[4] This is a normal *n-p-n* transistor with an additional

[4] *Proc. I.R.E.* Vol. 40, p. 1395, Nov 1952.

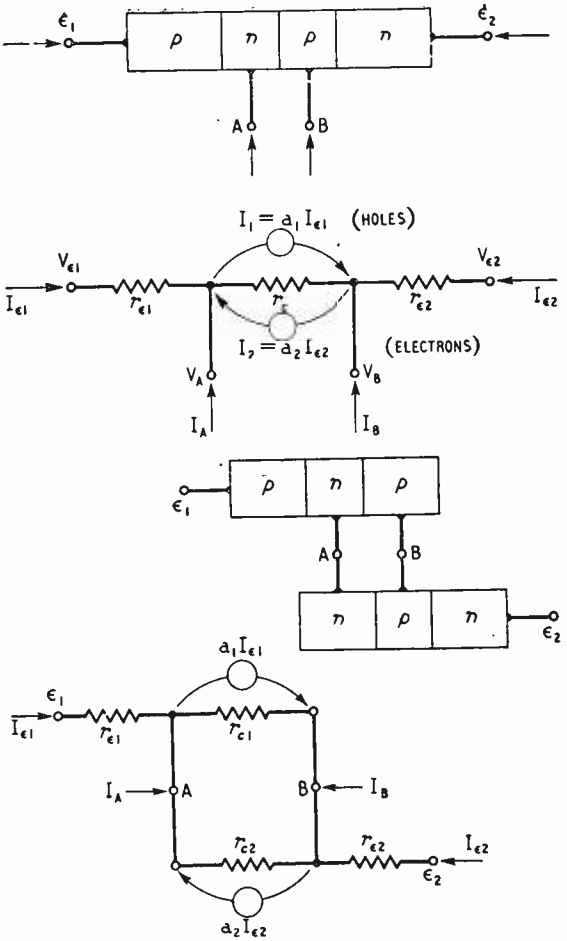


Fig. 5. Combination of p-n-p and n-p-n junction transitors.

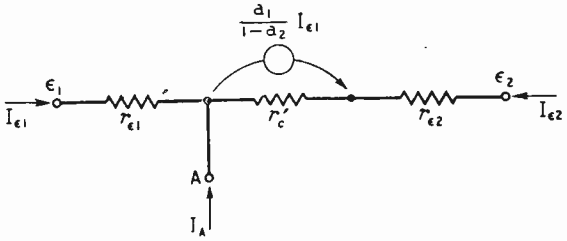


Fig. 6. Equivalent circuit of a "hook" collec or transistor.

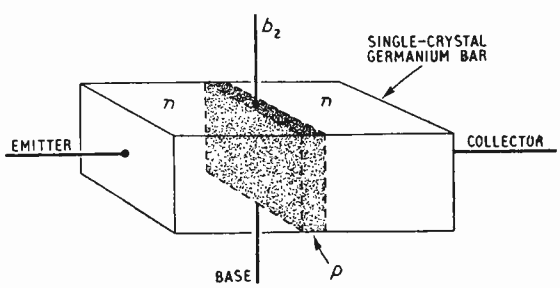


Fig. 7. Tetrode transistor with fourth connection b_2.

connection made to the p-layer. The advantage of this type is its excellent high-frequency response. Even the first few experimental models oscillated at frequencies up to 130 Mc/s. A video amplifier with a gain of 22 db up to 5 Mc/s and a 15 db amplifier with a 9-Mc/s bandwidth centred on 32 Mc/s are examples of its first use. The structure of this tetrode is shown in Fig. 7. The actual thickness of the p-layer is rather thinner than in the ordinary n-p-n transistors: this helps to keep the cut-off frequency of α high. Another factor favouring high-frequency performance is the use of a smaller collector area, and in the units described this was only about 10^{-4} sq in.

The fourth electrode, b_2, is fed with a bias current which corresponds to a negative potential at b_2 of about -6 volts. As the emitter is at about -0.1 volt with respect to base, the top of the emitter junction is biased negatively and does not emit electrons into the p layer. Only near the base electrode will there be any emission: excluding all other currents the bottom 1/60th will have a p-layer positive with respect to the n-layer of the emitter contact. This could be achieved equally by cutting away the top 59/60ths of the bar, but this would actually mean making a bar only 1/6000 inch thick. With this very low effective thickness the base resistance will clearly be very low, and measurements show that a very practical value of I_b, -2 mA, results in a reduction of base resistance to 40 ohms from an initial value of 1100 ohms for $I_{b2} = 0$.

Unfortunately, at the same time as r_b is reduced, α is reduced, and in one example given α falls from 0.99 to 0.75. The frequency characteristic of α tends to flatten out a little, although the roll-off point is much the same. For these junction tetrodes α is about 3 db down at 15–20 Mc/s.

It is shown by Wallace, Schimpf and Dickten that the gain of an earthed-base transistor amplifier will be 3 db down at a frequency given by

$$\frac{f}{fc\alpha} = 1 - \frac{\alpha_0 r_b}{r_e + r_b + R_G}$$

where $fc\alpha$ is the frequency of cut-off of α and R_G is the internal resistance of the input generator.

When $r_b = 0$ the response is 3 db down at $fc\alpha$, which in this case is 15–20 Mc/s. For an example discussed in their paper, the gain with the fourth electrode inoperative is 3 db down at $f = 0.055\,fc\alpha$, or about 1 Mc/s, while with the bias current flowing into the fourth electrode the gain is 3 db down at $f = 0.603fc\alpha$. This is up in the region of 10–12 Mc/s. Gains of the order of 20 db are obtained under these conditions: a gain of 20 db, flat up to 10 Mc/s, with resistive terminations is a very useful thing for any video amplifier designer.

The television designer is interested in getting his gain in bandpass amplifiers. A circuit using the junction tetrode is shown in Fig. 8: this gives 15 db gain over a 9-Mc/s band centred at 32 Mc/s, and the response curve is shown on the right-hand side of Fig. 9. The other two curves are the responses of amplifiers of the same basic type, but designed for narrower bandwidths and lower frequencies.

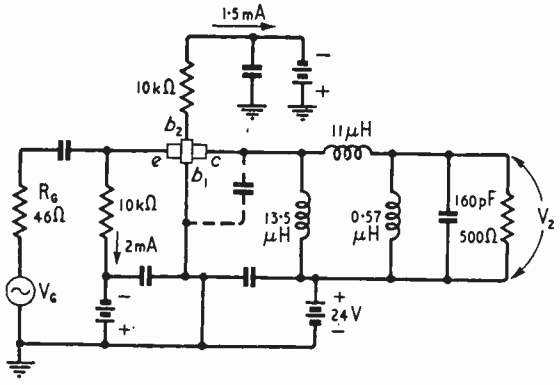


Fig. 8. Typical bandpass amplifier stage using the transistor tetrode.

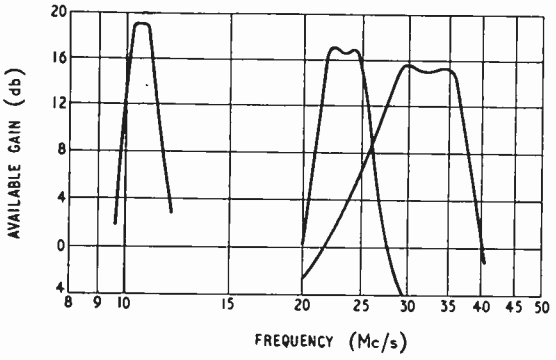


Fig. 9. Response curves of tetrode transistor amplifiers.

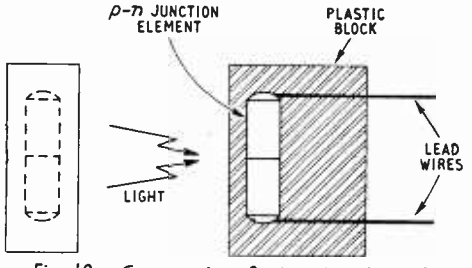
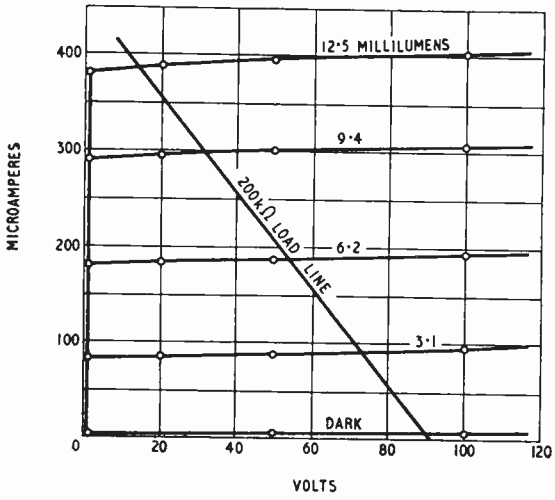


Fig. 10. Construction of a junction photocell.

Below: Fig. 11. Characteristics of the M-1740 junction photocell (average of ten).



In an oscillator, one transistor of this type gave an output of 0.25 mW at 100 Mc/s.

Another tetrode, quite different from this modified junction triode, is the new Sylvania point-contact tetrode, type 3N21. This is a point-type transistor with twin emitters and a single collector, the purpose of which has not been revealed. A transistor of this kind was made experimentally elsewhere some years ago, and could be used as a push-pull detector with gain, analogous to two triodes with the grids connected in push-pull and the anodes connected in parallel. Sylvania are promising a pentode, which will be provided with three emitters, and a common collector.

The general family of transistors must, I think, be considered to include the junction diodes, of which the *p-n* junction photocell is certainly entitled to be called a transistor. Fig. 10 shows diagrammatically the form of the Bell, M-1740 junction photocell, while Fig. 11 shows its characteristics. The photocell can be regarded as the base and collector of an *n-p-n* transistor, and it is connected with the *n*-electrode, the collector, positive with respect to the *p*-electrode, the base. When a light shines on the junction, hole-electron pairs are generated and these produce the "transistor conduction" effect at the rectifying barrier. This type of photocell is, of course, very small, and its other advantages are low dark current at room temperature, high speed of response, high sensitivity and low noise. At the recent Radio Exhibition a photo-transistor (Type P50A, made by Standard Telephones) was shown operating an ordinary P.O.3000 type relay. The maximum operating current of this particular type of cell was 2.5 mA and the maximum operating frequency 50 kc/s.

The junction technique has also been applied to power rectifiers, and two types are now appearing in this country. The great feature of these rectifiers is that the drop in the forward direction is very small, about 0.5–0.7 volt, although they will give an output current of up to 500 mA at up to 100 volts. The home-produced variety has not yet reached these ratings, but the smaller type, with a maximum input of 100 V RMS and a d.c. output current of 30 mA, weighs only 0.0017 ounce (0.75 gm).

By the time this article appears there may be some more new types of transistor, as well as those I have overlooked.

"A slow sort of country!" said the Queen. "Now, *here*, you see, it takes all the running *you* can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

That is just what you would expect, since the transistor is a valve, through the looking glass.

NEW AIRFIELD RADAR EQUIPMENT

A COMPACT, mobile and easily operated surveillance radar giving a medium-range coverage for a small airport or Service airfield has been developed by Decca. Known as the Type 424, it employs much of the circuitry and technique which has been developed for their marine radar equipment and it is claimed that by utilizing some of the existing and well-tried practices a considerable saving is effected in the price of the apparatus. This new radar gear, while giving most of the facilities offered by a full-scale G.C.A. (Ground Controlled Approach) equipment, costs only £5,000.

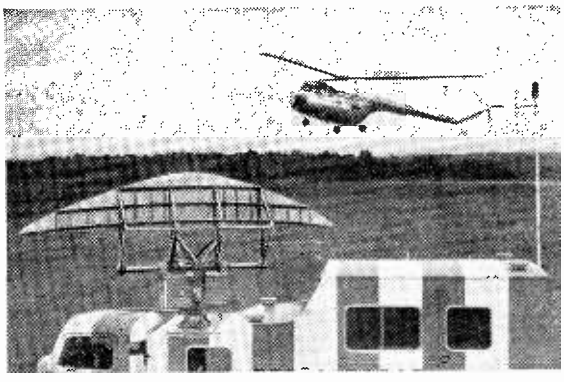
Its initial function is a Service one and it was conceived primarily for speeding up the landing of modern jet fighter aircraft which, owing to the very high fuel consumption, especially at low altitudes, must be brought down on to the airfield with the least possible delay.

Recent experience with the equipment has shown that it has definite applications in civil aviation and a complete set has, in fact, been ordered for use at one of the municipal airports in the north of England.

The Type 424 can be supplied in mobile, static or air-transportable forms, the latter being of particular interest to military air forces. It comprises the following basic units:—

Scanner:—The parabolic cylinder-type scanner measures 14 ft across and gives a beam-width of 0.750 deg in the horizontal plane and 3.80 deg in the vertical. The scanner rotates at 24 r.p.m. and provision is made to tilt it between −2 deg and +20 deg to meet operational requirements.

Radio-frequency Head:—Immediately below and rotating with the scanner is a radio-frequency head containing a pulsed magnetron generator giving an r.f. output to the scanner on 9,375 Mc/s (3.2 cm). A peak pulse output of 30 kW is available with two pulse lengths of 0.1 μsec and 0.5 μsec respectively. Contained also in the radar head are the detector and early stages of the receiver.

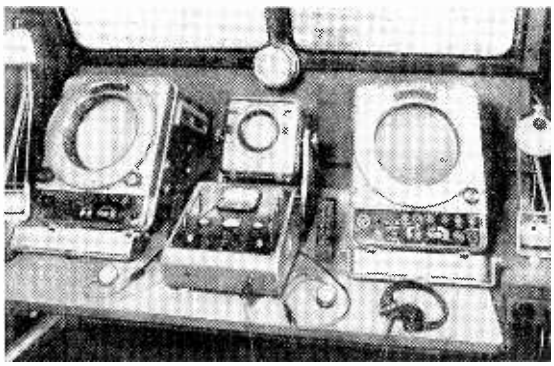


Horn-fed scanner and radar head of the Decca airfield radar forming part of a mobile control unit. A helicopter "talked-down" and about to land is seen in the background.

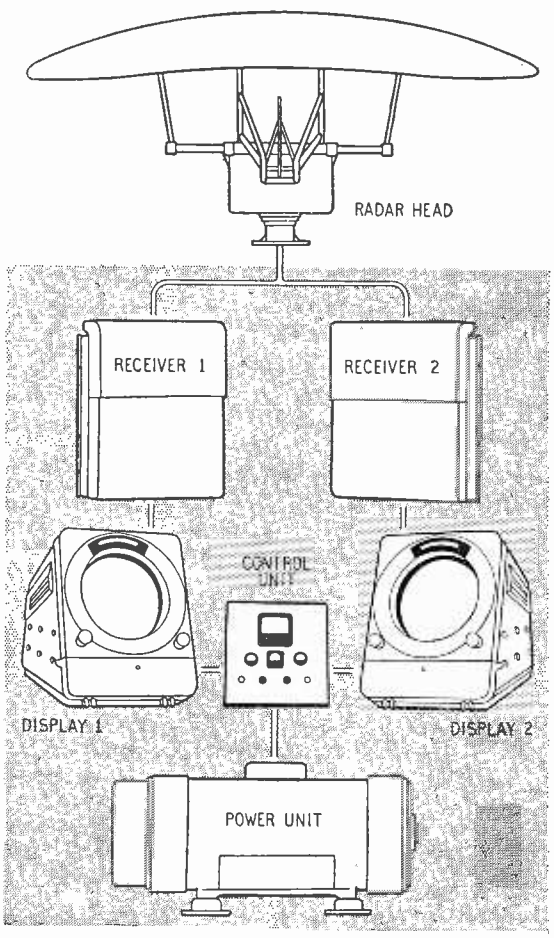
Receivers:—The output from the radar head is split and fed to two identical and independent receivers and these in turn feed two independent PPI (Plan Position Indicator) display units fitted with 12-in c.r. tubes. For normal operation one display unit would be used for marshalling aircraft from the limit of range of the equipment (20 to 25 miles) into 5 miles or so and the second display unit would take over the actual runway approach and landing control. Instructions to pilots are given over the normal v.h.f. radio-telephone equipment. Two controllers, one

handling the approach and marshalling and the other the actual landing, can thus be employed.

Each display unit has range adjustments for coverages of 0.5, 1.0, 2.5, 5.0, 10 and 25 miles radius with the radial scanning trace based on the centre of the tube.



Layout of the controller's position showing two airfield display units, miniature CRDF display, control box and v.h.f. radio telephone control units.



Schematic layout of the various units comprising the Decca airfield radar Type 424.

An illuminated marker line can be projected directly on to the c.r. tube showing the approach path for the airfield runway in use and on this line are projected range markers. This is said to obviate any likelihood of parallax error in positioning an aircraft on the approach line, such as might arise when the runway approach path and other airport features are displayed on the glass screen of the PPI unit.

Control Unit:—This is situated normally between and slightly to the rear of the two display units and carries all the controls including a remote indicator for tilt angle of the scanner.

Additional equipment developed for use with this radar is a miniature CRDF (Cathode Ray Direction Finder) display unit which operates in conjunction with the Standard Telephones v.h.f. D/F equipment and is intended for identifying the aircraft seen on the Decca display units.

Identification is, however, quite possible without this extra aid by adopting the familiar controller's technique of instructing each aircraft it is required to identify to embark on a particular manœuvre, usually an abrupt change in course for a short distance.

Power Supply:—The equipment operates at 80 volts, 1,000 c/s from a rotary converter; consumption is about 4.5 kW.

During the course of a demonstration aircraft were picked up unmistakably at the maximum range of 25 miles, the characteristic bright "hyphen" on the PPI tube being of excellent definition. Its flight path under v.h.f. radio control was clearly followed, the speed of scanning (20 r.p.m.) keeping the response well illuminated right up to the touch-down point.

In bad visibility this radar can quite obviously be used to bring aircraft safely in to the airfield and exactly on to the end of the runway without any additional navigation aids.

INTERNATIONAL STANDARDS

A BRIEF summary of the results achieved by the various technical committees of the International Electrotechnical Commission during the meetings in Yugoslavia in July has been issued by the British Standards Institution. About three hundred delegates, representing seventeen countries, participated; the largest delegation being from the United Kingdom —43 in all.

A document on the procedure for applying basic climatic and mechanical robustness tests to radio components was approved for publication. A colour code for ceramic capacitors and a specification for fixed paper capacitors were passed for circulation to the National Committees for approval. Agreement was also reached regarding a group specification for ceramic capacitors and for carbon resistors which will be used in the drafting of detailed specifications.

The Committee on Insulating Materials has been considering the standardization of methods of test for specific properties, and at the recent meeting it reviewed in detail the tests for tracking, volume and surface resistivity, and heat resistance.

As the result of comments on a specification for valve bases, a number of additions and modifications to the text were made at the meeting and a revised draft will be circulated. The dimensions of subminiature valves were also discussed and a draft specification is to be prepared.

Neon Tube Measuring Device

Applications as a Microammeter and High-resistance Voltmeter

By H. E. STYLES, B.Sc.

THE neon gas discharge tube has become well established as a device for providing stabilized d.c. voltages, but little attention seems to have been given hitherto to the application of such tubes to the detection and measurement of minute electric currents. In a recent article[1] the author showed how measurement of high resistances may be effected by means of a neon tube shunted with a capacitance, and this application provides a good illustration of the fact that such discharge tubes can be employed for detecting and assessing the magnitude of extremely small currents.

Experience with the instrument described in that article has shown that the circuit of Fig. 1 produces in the telephone receiver a very clearly audible click every five seconds or so. As the mean potential of the capacitance in this circuit approximates to 100 volts, it follows that the average current passed by the resistance must have a magnitude of the order of only 0.01 microampere.

Despite the smallness of this current the device not only renders it readily detectable by ear but does so in a manner which enables quantitative measurements to be made. Furthermore, a current of 0.01 microampere by no means represents the limit of sensitivity obtainable as not only can a lower discharge frequency correspond to a lower mean current but, given a sensitive telephone receiver, the shunt capacitance may be reduced considerably without rendering the discharge pulses inaudible.

It is evident, therefore, that this simple circuit provides an extraordinarily sensitive device for the detection and measurement of electric currents. If, however, the utmost sensitivity is not required, an even simpler circuit may be employed, as, with pulses of sufficient magnitude, a telephone receiver is unnecessary; the flash of the discharge can be clearly seen.

Elimination of the telephone receiver not only represents a simplification, but may be regarded as highly desirable if measurements are being made in very high voltage circuits. It has been found that a CV188 tube shunted with a capacitance of 0.01μF produces flashes which can be seen with reasonable facility, but for most purposes a shunt capacitance of 0.1μF is better.

With such a capacitance the neon discharge is sufficiently intense to be easily visible in daylight whilst the capacitance is small enough to permit measurement of currents well below one microampere. For higher currents, of course, a larger value of capacitance may be required.

The mechanism whereby the neon oscillator circuit is able to render minute currents detectable is, of course, quite simple. The circuit merely integrates the more or less steady current flowing through the resistance over an appropriate period of time and subsequently releases the stored energy in precisely regulated pulses of sufficient magnitude to render them evident to the sense of hearing or sight according to the method of detection adopted, the former providing the greater sensitivity.

There are certain limitations to this method of current measurement consequent upon the fact that sufficient electromotive force must be available to raise the potential of the shunt capacitance above the striking potential of the discharge tube. The device is thus restricted to circuits associated with relatively high voltages and resistances, but within these limitations it can prove very useful.

Experimental Investigations.—Experiments to assess the potentialities of a neon oscillator as a current measuring device were made with the circuit of Fig. 2,

[1] "Inexpensive Megohmmeter," *Wireless World*, Oct., 1953, p.484.

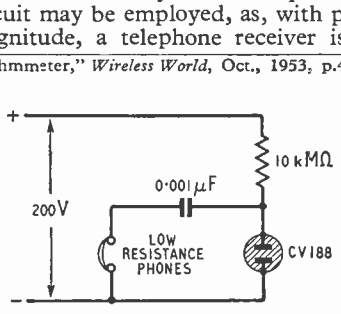
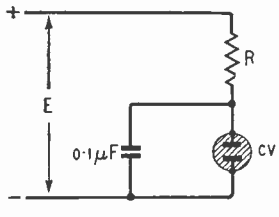
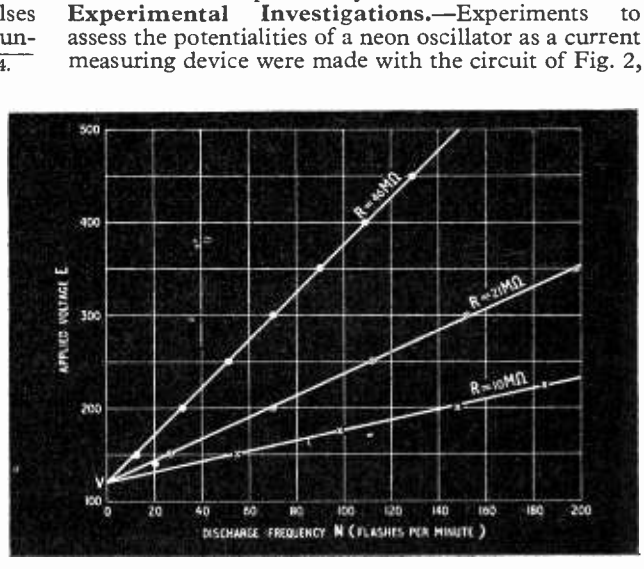


Fig. 1. Circuit giving audible response for current of 0.01μA.



Left: Fig. 2. Flashing oscillator used for experimental investigations.



Right: Fig. 3. Experimental results with circuit of Fig. 2.

the behaviour of which was observed over a range of applied voltages with various values of resistance R. The observed data are presented graphically in Fig. 3 from which the following conclusions may be drawn.

(a) For any particular value of series resistance R, the relationship between applied voltage E and discharge frequency N is linear, as would be expected on theoretical grounds.

The relationship may thus be expressed in the form $E = AN + V$ where A and V are constants.

(b) For all values of series resistance the lines pass through a single point on the axis of zero discharge frequency. Hence V in the foregoing equation must be of fixed value whatever resistance is employed. The value of V is evidently numerically equal to the mean potential assumed by the shunt capacitance during the charge and discharge cycle and lies somewhere between the striking and extinction potentials of the particular neon tube employed.

(c) It follows from (b) that the difference E-V corresponds to the mean voltage across resistance R. Hence the mean current flowing through the resistance must be given by the expression $\frac{E-V}{R}$. Since $E - V = AN$, it follows that if I be the current flowing through the resistance, then

$$I = \frac{AN}{R}$$

(d) Provided that there is no significant leakage across the capacitance, and/or the neon tube when the latter is not in its conducting condition, it is obvious that the whole quantity of electricity passing as a current through R must correspondingly pass in the form of pulses through the neon tube. The magnitude of these pulses, however, is maintained constant at a value dependent solely upon the size of the shunt capacitance and the characteristics of the neon tube. Hence the frequency at which the discharge pulses occur must be directly proportional to the magnitude of the mean current flowing through the resistance. This implies that the ratio $\frac{A}{R}$ should itself be a constant and that this is in fact the case is shown by the experimentally derived data :—

Value of R Megohms	Value of A	Value of $\frac{A}{R}$
10	0.56	0.056
21	1.17	0.056
46	2.55	0.055

This fresh constant $\frac{A}{R}$, which may conveniently be termed K, is numerically equal to the mean current corresponding to a discharge frequency of one per minute and, in the case of the circuit experimentally investigated, had a value of 0.056 microampere. With lower values of shunt capacitance a correspondingly lower value of K would be obtained and *vice versa*. Strict proportionality between the values of shunt capacitance and K may conceivably not be obtained as it is possible that the striking and extinction characteristics of the neon tube may be slightly influenced by the intensity of the discharge pulses. This point has so far not been investigated but is regarded as of no great importance as empirical calibration must of necessity be employed owing to the inherent variance of individual discharge tube characteristics.

(e) From what has already been said it is evident that the relationship between applied voltage and discharge frequency can now be expressed as follows

$$E = KRN + V$$

where K is a constant depending upon the value of shunt capacitance employed.

For a fixed value of E it follows that if N_1 and N_2 are the discharge frequencies obtained with resistances R_1 and R_2 then $KR_1N_1 = KR_2N_2$

Hence $\frac{R_1}{R_2} = \frac{N_2}{N_1}$ which is the relationship upon which the design of the megohmmeter described in the article referred to previously was based.

Alternatively, since A, the slope of the voltage-frequency line, equals KR, it is evident that the ratio of the slopes of lines obtained with different resistances will be the same as the ratio of the resistance values themselves. If one of the latter is known the other can be derived from the slope ratios.

(f) If frequencies N_1 and N_2 correspond to two voltages E_1 and E_2 with a fixed value of resistance R and a particular shunt capacitance then

$$E_1 = KRN_1 - V \text{ and } E_2 = KRN_2 - V$$

$$\text{Hence } E_1 - E_2 = KR(N_1 - N_2)$$

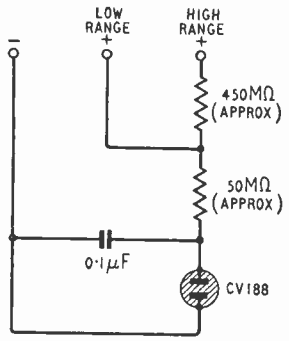
$$\text{or } K = \frac{E_1 - E_2}{R(N_1 - N_2)}$$

Thus if R is of known value the value of K can be determined without having to take an elaborate series of measurements. For a shunt capacitance of 0.1 μF a resistance value of about 20 megohms is convenient for determining discharge frequencies at 200 and 300 volts.

(g) One final conclusion can be drawn from Fig. 3 which, though having no great bearing upon the immediate problem, is nevertheless worth noting. It has already been mentioned that the mean potential V across the shunt capacitance must be less than the striking potential of the neon tube. In practice, therefore, it is not physically possible to obtain discharge frequencies corresponding to applied voltages lying between V and the striking potential (about 140V). A glance at Fig. 3 will quickly show that this frequency gap is greater the lower the value of the series resistance so that if, for any purpose, it be desired to generate a very low frequency discharge, a very high value of series resistance must be employed. The desired result cannot be obtained by using a lower applied voltage in conjunction with a lower value of series resistance though this is possible at frequencies of higher order.

Practical Applications. Having established the foregoing essential facts concerning the behaviour of neon oscillator circuits it becomes possible to consider the practical applications of the device. These would seem to be as follows :—

(1) *Measurement of High Resistances.* One method has already been described in reference (1); this possesses the advantage of requiring no measuring instruments of normal type and may still be regarded as the best method of using a neon oscillator for resistance measurement. It is evident that, since the neon oscillator can be made to serve as an extremely sensitive microammeter, such an oscillator, once calibrated, could be employed in conjunction with a



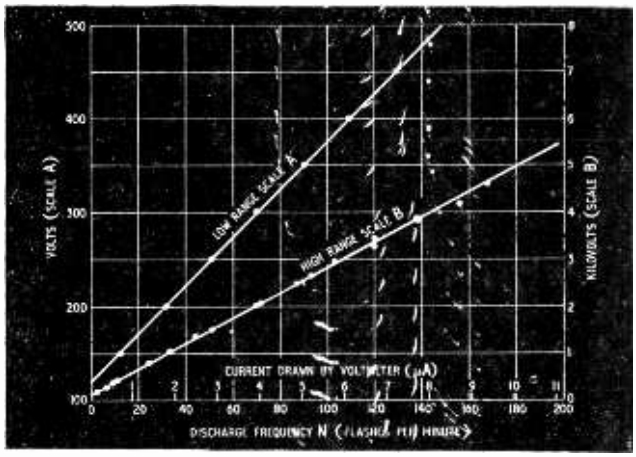


Fig. 4. Two-range neon voltmeter with maximum current of 10 μA
Right : Fig. 5. Voltmeter calibration curves

voltmeter (neon or otherwise) for resistance measurement. In such case, in order to eliminate the possibly unknown effect of the potential drop across the shunt capacitance of the neon microammeter, resistance determination should be based upon the difference in current produced by a known change in applied voltage.

(2) *Measurement of High Voltages.* In radio and television work a need frequently arises for a means of measuring the voltage in circuits of high impedance or of sources of limited power output, e.g., r.f. oscillator e.h.t. generators. For such purposes it normally proves necessary to employ either extremely sensitive moving-coil meters or some form of valve voltmeter, though electrostatic instruments can be used for voltages in the kilovolt range.

All such instruments suffer from one or more of the drawbacks of high cost, delicacy and relative complexity, but the circumstances under consideration are precisely those for which it has been shown that the neon circuit is pre-eminently suited. Fig. 4 shows the circuit of a two-range neon voltmeter and it is difficult to imagine a cheaper, simpler or more robust instrument.

Experimentally determined calibration curves for this instrument are given in Fig. 5, from which it will be seen that the linear relationship between applied voltage and discharge frequency is well maintained with series resistances of the order of 500 megohms. The instrument covers voltage ranges of 150 to 500 and 150 to 5,000 with a maximum current of about 10 microamperes in both ranges. This corresponds to some 100,000 ohms per volt which far exceeds the figure obtainable with straightforward moving-coil meters and is likely to be adequate for most purposes. If necessary, however, the sensitivity could be greatly improved by reduction of the shunt capacitance, but this introduces some difficulty in obtaining the extremely high values of series resistance which must then be employed.

An upward extension of the voltage range can be obtained either by increasing the series resistance or by increasing the shunt capacitance, though the latter will involve an increase in the "full scale" current. It should, perhaps, be noted that for high-voltage work the series resistance should comprise a chain of resistors of lower resistance value in order to restrict the voltage drop across individual components. The author uses twenty such resistors, each of approximately 25 MΩ; high-stability components should be employed if possible. The shunt capacitor has only to withstand the striking potential of the neon tube, but must possess the highest possible leakage resistance to avoid error from voltage drop.

The high-voltage calibration points shown in Fig. 5 were obtained by means of a 2,000 ohms per volt moving-coil meter used in conjunction with an r.f. oscillator e.h.t. supply, and it is of interest to note that removal of the moving-coil voltmeter load resulted in an increase from 4,600 to 5,300 volts at the maximum setting of the oscillator. Deviations of individual calibration points from the straight line in Fig. 5 can be attributed to difficulties encountered in maintaining an entirely steady output from the e.h.t. supply.

(3) *Measurement of Leakage Currents at High Voltages.*

As a microammeter, the neon oscillator becomes inoperative at voltages below about 140 and this precludes its use for a number of purposes for which microammeters are needed. No such drawback applies in testing high-voltage television components, etc., for leakage at working potentials and for work of this character the neon oscillator has definite advantages apart from its great sensitivity.

The author employs an r.f. oscillator as a source of adjustable e.h.t. for tests of the kind in question and originally employed a moving-coil microammeter for measuring leakage currents. It was thought that the limited output available from the e.h.t. generator would automatically protect the meter from damage in the event of a breakdown in the insulation of a component undergoing test, but this proved to be a costly miscalculation. It was observed that when such breakdown occurred a spark discharge sometimes took place within the meter despite its low coil resistance and the fact that it was "earthed" on one side. This was attributed to the inductance of the coil offering a high reactance to the current surges produced by insulation breakdown, but the destructive nature of the spark discharge was not appreciated until eventually the coil became open-circuited. This unhappy experience has convinced the author that moving-coil meters are quite definitely unsuitable for high-voltage leakage tests, whereas the neon oscillator is able to withstand breakdown surges without damage.

The circuit of Fig. 6 indicates how a single neon

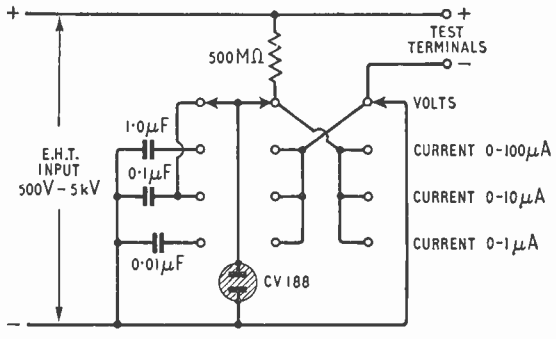
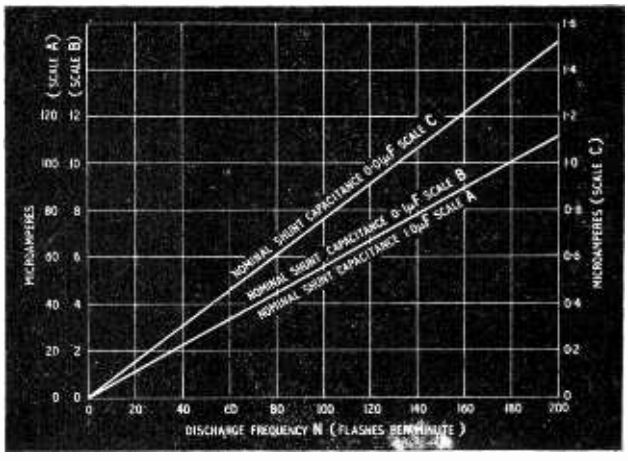


Fig. 6. Circuit for high-voltage leakage tests



Right : Fig. 7. Microammeter calibration curves

tube may be employed for both voltage and current measurements, the switching being such as to permit a choice of shunt capacitances for current measurement purposes. These capacitances can, of course, be calibrated at lower voltages in the manner already described and Fig. 7 shows curves which were thus obtained for capacitances of the values given in Fig. 6. The fact that the curves for the 1.0 and 0.1-μF capacitances are superimposed in Fig. 7 is purely fortuitous, no special selection of capacitors having been made, though this could be done if considered necessary. The 0.01-μF capacitor was evidently of higher capacitance than its rating compared with the other two.

A word of caution may perhaps not be amiss at this point regarding the dangers associated with high-voltage equipment. Whilst an e.h.t. generator of the radio-frequency or fly-back type may itself be quite safe by virtue of small storage capacitances and low power output, such a device can charge circuits of high capacitance with potentially dangerous amounts of energy. Very great care should therefore be exercised in such circumstances, bearing in mind the fact that high voltages can spark across gaps which would be quite safe at lower voltages. A golden rule is to keep one hand in a pocket when working with live equipment ; this at least ensures that a shock is not taken from one hand to the other via the chest.

Finally, there is one feature of neon discharge tubes which has to be taken into consideration in the design of equipment based upon them. The striking potential of a particular tube may be increased considerably if the tube is completely screened from light as the latter radiation serves to promote ionization of the neon gas within the tube. It is important therefore to design the equipment so that the tube itself is subjected to light radiation though a moderate amount of shading is permissible. Other components should preferably be housed in a well-closed box in order to obviate as far as possible the accumulation of surface deposits which may cause undesirable changes in the values of series resistors, or may give rise to leakage across capacitors or tube holder.

HIGH PULSE-RATIO RADAR

Methods of Range Extension in the Decca "45"

THE new Decca marine radar, Type 45, is a modified version of the Type 12 in which range scales having maxima of $\frac{1}{2}$ and 45 miles have been added to the existing ranges of 1, 3, 10 and 25 miles. The minimum range and range dicrimination remain at 25 yards (with a pulse width of 0.1 μsec), and the new $\frac{1}{2}$-mile range gives an effective scale of 168 yards to the inch.

The 45-mile range, which has been added at the request of shipowners to enable earlier landfalls to be made, would not be effective without a substantial increase of power and/or overall efficiency, compared with that required for the 25-mile range which has hitherto been regarded as an adequate maximum. Decca have achieved this partly by increasing power 2.5 db (from 10 to 18 kW peak in the pulse), but chiefly by increasing the pulse length to 1.0 μsec in the longest range, and by general improvement in the aerial and receiving circuit efficiency.

Specifically, the increased power output has been obtained with a more efficient type of magnetron and the power supply conditions are substantially unchanged, so that externally the appearance is the same as the Type 12, and the advantages of compactness, and ease of installation and maintenance have been retained. The aerial scanner aperture has been increased and the width is 6ft, giving a beam width of 1.2 deg compared with 1.6 deg in the Type 12—an effective increase of 4.5 db in gain. The increased energy returned from a 1-μsec pulse is supplemented by an increase in receiver efficiency, since a narrower bandwidth can be used. An overall gain of 8 db results from the use of this long pulse. In the mixer and pre-amplifier circuits an improvement of 3 db in noise factor has been effected, bringing the total gain improvement of the Type 45 over the Type 12 up to a total of 18 db. This is a maximum theoretical figure, but in practice 15 db (measured) is consistently achieved. To obtain a comparable performance solely by increasing power would require 320 kW in the pulse compared with the original 10 kW. This may seem a big increase for an extension of only 50 per cent in range, but it must be borne in mind that the range in radar is proportional to the fourth root of the power employed.

In the interest of long life, the h.t. supplies to the relatively expensive cathode-ray tube and magnetron are now controlled by a separate stand-by switch.

The price of the Type 45 is £1,900, compared with £1,750 for the Type 12 which will still be made.

Reflex Push-Pull Receiver

Two-valve Local-station Set

By G. J. POPE

A SMALL self-contained receiver forms a useful addition to the home as it can be taken from room to room which is not always convenient with a larger set. It is also invaluable in the case of illness. The set described here has three valves only, two being SP61 war-surplus type and the third is an EA50 diode. It is a t.r.f. set with the unusual feature that the r.f. valve forms one half of a push-pull output stage using a reflex circuit. This arrangement was particularly attractive since a ready means of achieving the necessary phase reversal between the output valves' grids suggested itself.

Considering the circuit diagram, Fig. 1, it will be seen that a conventional series diode detector feeds V_2 via the gain control. A common cathode return circuit is arranged to give the correct Class A bias condition for both valves. At r.f., V_1 cathode is bypassed adequately by C. An a.f. signal appears across R which is approximately half that available between V_2 grid and earth. This relationship may be shown to hold if the amount of negative-feedback occurring is calculated.

The gain of a feedback amplifier is given by the formula,

$$\text{Gain} = \frac{A}{1 + A\beta}$$

where : A = gain in absence of feedback
and β = fraction of output fed back

The feedback circuit is shown in Fig. 2, where series current feedback occurs due to a fraction $\frac{R_k}{R_k + R_l}$ of the output acting in opposition to the input signal voltage e_g. Now since V_2 is a pentode, its gain is given by :—

$$g_m R_l \text{ approximately}$$

The optimum load for the SP61 is 20 kΩ, hence gain without feedback

$$= 9 \text{ ma/V} \times 20{,}000$$
$$= 180 \text{ times.}$$

$$\text{With feedback, gain} = \frac{180}{1 + 180 \times \frac{100}{20{,}000}} = \frac{180}{1.9}$$
$$\simeq 95 \text{ times}$$

It will thus be seen that the gain is reduced by approximately 6 db. The voltage across R_k will be :—

$$\frac{1}{200} \times 95 \simeq \frac{e_g}{2}$$

Since this voltage acts in opposition to e_g, the grid cathode voltage of V_2 is also $= \frac{e_g}{2}$

Since the cathode circuits are common, V_1 acts as a cathode driven push-pull stage, its grid being at earth potential to a.f. Approximately the same ratio of cathode volts to grid drive volts is obtained if the anode load is varied over wide limits, so that the exact value of anode load is

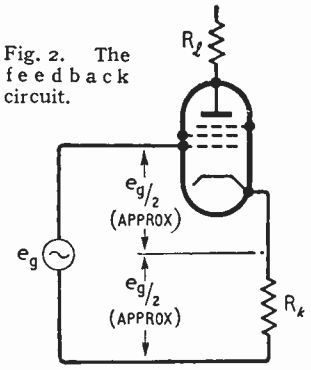


Fig. 2. The feedback circuit.

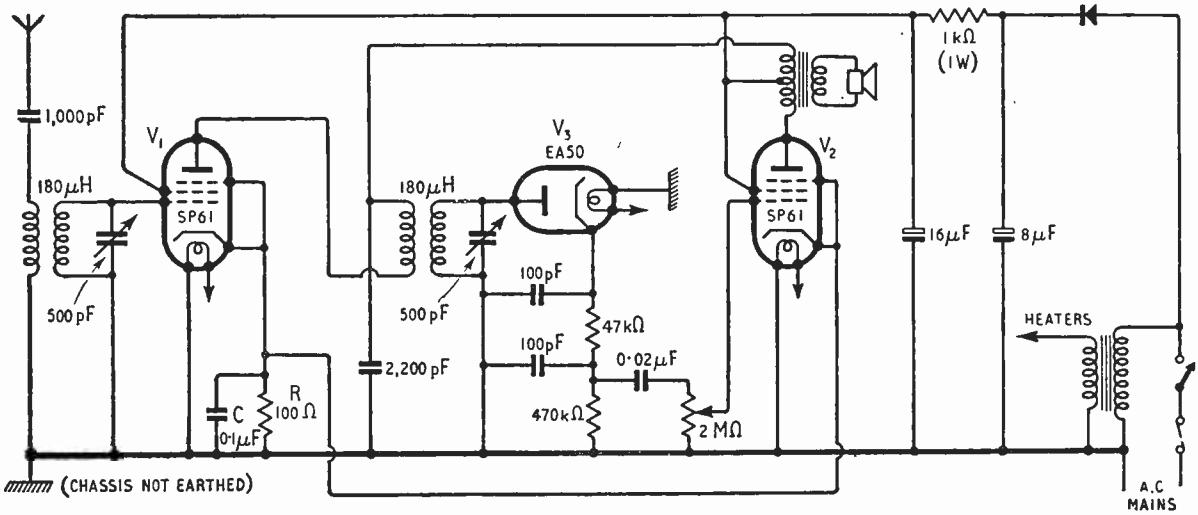


Fig. 1. Circuit diagram of the receiver, with the r.f. valve forming one half of a push-pull output stage using a reflex circuit.

unimportant on this account. This may be an advantage if a standard push-pull component only reflecting somewhat lower loads is available. The value of C at a.f. is insufficient to materially affect the response. The connection of this form of a.f. drive to the second valve causes 6-db drop in sensitivity as mentioned above, but a 3-db increase results from the added output stage, so that the final arrangement is 3-db less sensitive. The receiver is, however, capable of giving an extra 3 db output power, that is, twice that of a single valve. Since the receiver is built for local-station use the question of sensitivity is relatively unimportant, ample output being obtained on about 10 ft of aerial in London.

The push-pull circuit allows the use of a small output transformer since the core flux due to each valve's anode current cancels out. In practice for a given size component this means better low-frequency response. The writer uses a midget component and the bass response is very good. Another small advantage push-pull has is that a common un-bypassed cathode resistor can be used, so saving a low-voltage electrolytic capacitor which would otherwise be necessary. The omission of the bias by-pass capacitor from a power amplifier of this kind is usually not recommended, but no serious distortion has been apparent.

The author's model employs switched station selection which was considered adequate and possibly simpler for the rest of the household to handle. When operated in the London area it may be found advantageous to make the aerial connection switchable from the primary side of the aerial transformer to the grid connection, so that the sensitivity may be increased for the reception of weaker stations. This was found necessary for Third Programme reception with a short aerial and connections may obviously be adjusted to fit individual geographical locations.

Any coil with a tuned winding "Q" of approximately 100 and inductance of 180 μH or so may be used in both positions, but for constructors not in a position to make their own, Osmor Q-type QA11 and QHF11 are suitable for aerial and intervalve transformers respectively.

There is no reason why a germanium crystal should not be used for the detector but in this case the value of the diode load should be dropped to about 100 kΩ. This may result in some loss of selectivity, but it is not likely to be troublesome.

With the output stage and loudspeaker matched to give an anode-to-anode load of 20 kΩ an output of about 0.75 W is provided. If a lower load figure is taken the output will be correspondingly reduced.

MANUFACTURERS' LITERATURE

Tubular M.C. Microphone of unobtrusive appearance, 1in in diameter and weighing 9oz. Leaflet giving brief specification and frequency response curves from Standard Telephones and Cables, Connaught House, Aldwych, London, W.C.2.

Rotary Switch Wafers with improved fixing of contact clips on stators to avoid loosening during soldering. Engineering data sheet on type DH and DM "Oak" sections from NSF, Keighley, Yorks.

Television Aerial Feeder Cables, coaxial solid, coaxial semi air-spaced, balanced screened twin and unscreened twin. A leaflet giving characteristics and dimensions from The Edison Swan Electric Company, 155, Charing Cross Road, London, W.C.2. Also new data booklets on Mazda receiving valves and c.r. tubes and Ediswan industrial and transmitting valves.

Crystal Microphones made by Ronette. A new illustrated catalogue giving technical specifications of the complete range is available from the Mail Order Supply Company, 33, Tottenham Court Road, London, W.1.

High-Voltage Capacitors, tubular paper types, suitable for smoothing television e.h.t. supplies, with working voltages of 20 kV and 25 kV. Technical bulletin No. 40 from The Telegraph Condenser Co., North Acton, London, W.3.

Small Soldering Iron, $\frac{5}{16}$in diameter and 9$\frac{1}{2}$in long, with four interchangeable bits and designed to operate from a 20-V bus-bar installation. Leaflet from the Electrical Remote Control Co., East Industrial Estate, Harlow New Town, Essex.

Dry Electrolytic Capacitors and others, with ratings, sizes and prices, listed in a booklet intended for the servicing trade. From A. H. Hunt (Capacitors), Bendon Valley, Garratt Lane, Wandsworth, London, S.W.18.

Sound Reproducing Equipment, a leaflet giving brief descriptions and prices of the products of Grampian Reproducers, Hanworth Trading Estate, Feltham, Middlesex.

Portable P. A. Equipment with vibrator power pack working from a 12-V battery. Descriptive leaflet from Easco Electrical, Brighton Terrace, London, S.W.9.

Interference suppressors for various types of electrical apparatus. A booklet describing the models available and methods of fitting them from Belling & Lee, Cambridge Arterial Road, Enfield, Middlesex. Also a booklet describing their sound, television and anti-interference aerials and accessories and a catalogue of components and accessories.

Coaxial Connectors, American military types for 50Ω and 72Ω and for various cable diameters between 0.2in and 1in Also a leaflet giving information on how to connect cables to them. From Besson and Robinson, 6, Government Buildings, Kidbrooke Park Road, London, S.E.3.

Accessories and Electro-mechanical Devices, a list of Government surplus equipment from A. T. Sallis, 93, North Road, Brighton, Sussex.

A.C. Voltage Stabilizers for regulating mains voltages, including heavy-duty types for currents of 30A to 130A. Full descriptions in a supplement to their "Variac" catalogue V549 from Claude Lyons, 180, Tottenham Court Road, London, W.1.

"Moulded Plastics for Industry," an illustrated booklet describing the moulding processes carried on by the G.E.C. works at Witton and listing some typical products. From the General Electric Company, Magnet House, Kingsway, London, W.C.2.

P-N Junction Crystal Diodes with similar characteristics to standard American types. A leaflet giving general features and prices from Detectron, 25, rue de Toulon, Bordeaux, France

Television Aerials with elements already assembled but folded up. Single and multiple types described in leaflets from Antiference, Bicester Road, Aylesbury, Bucks.

Components and Accessories, tools and test gear; a comprehensive illustrated catalogue of 150 pages from Rudolph Schmidt, Gl. Kongevej 64, Copenhagen, Denmark.

Preferred Valves List, second edition, 1953. Takes into account greater range of miniatures now available and includes American and military equivalents. Full data and base diagrams are given. Available from the Scientific Instrument Manufacturers' Association, 20, Queen Anne Street, London, W.1, price 3s 6d, post free.

Valve Voltmeter for measuring the maximum amplitude of transient phenomena having a duration of at least 1 millisecond. It has a range of 0-20V and an input impedance of 33kΩ and there are two meters to cater for positive and negative peaks. Explanatory booklet with diagrams from Standard Telephones and Cables, Transmission Division, North Woolwich, London, E.16.

Aerials and Accessories for sound and television reception. A 1953/54 comprehensive catalogue from Aerialite, Castle Works, Stalybridge, Cheshire.

Pressure Transducers, one type for measuring static pressures in ranges from 0-25 to 0-4,000lb per sq in and another for fluctuating pressures in ranges from 0-250 to 0-50,000lb per sq in. Also a dynamometer for measuring tensile loads in ranges from 0-50 to 0-10,000lb. Descriptive leaflets from J. Langham Thompson, Springland Laboratories, Bushey Heath, Herts.

Small Motor Blowers with weights between 2lb and 40lb and power consumptions between 33 and 440 watts. Leaflet from Air Control Installations, Ruislip, Middlesex.

Glass Marking Colour, suitable for writing on valves, available in black, white, red, orange, yellow, green and blue. Leaflet from George T. Gurr, 136, New King's Road, London, S.W.6.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Output Transformer

THE illustration shows one of the latest type of push-pull output transformers now produced by Partridge Transformers, Roebuck Road, Tolworth, Surrey, using grain orientated strip-wound cores (generally known as "C" cores).

This model is the Type P3064 having a power handling capacity of 20 watts for less than 1 per cent distortion. The maximum d.c. per half-primary is 100 mA and a 20 per cent out-of-balance current can be tolerated. The d.c. resistance of each half primary is 100 ohms.

Four separate secondary windings are provided which by series or parallel connection give correct operating conditions with a primary loading impedance of 10,000 ohms for

Partridge Type P3064 push-pull transformer giving the choice of several output impedances.

loudspeakers of 0.95 ohm, 3.8, 8.5 and 15 ohms impedance respectively.

With the equivalent of 10,000-ohms resistive load on the primary the frequency characteristic is virtually flat having a deviation of ±0.5 db only over the range 30 c/s to 30 kc/s. The leakage inductance is claimed to be less than 8 mH.

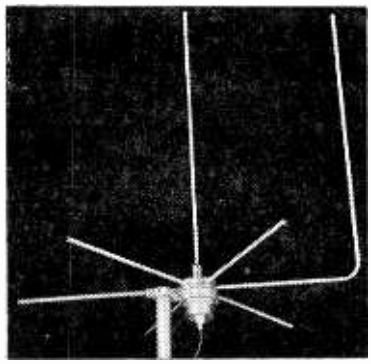
This transformer measures $2\frac{7}{8} \times 2\frac{7}{8} \times 3\frac{1}{4}$ in, weighs $2\frac{1}{4}$ lb and costs £4 18s.

Television Aerial-Amplifier Unit

A NEAT and workmanlike way of obtaining a good television signal with a simple aerial in fringe areas is shown in the illustration. It consists of a ground-plane aerial with reflector and in the centre hub of the system is housed a two-stage head amplifier. One valve is a neutralized triode amplifier, the other is a cathode follower.

The vertical elements of the aerial are a quarter-wavelength long and the horizontal members, which serve as an artificial "earth," measure a half-wavelength from tip to tip. It is reasonably light in weight and can be mounted on the usual 2-in o.d. tubular mast.

The necessary heater and h.t. supplies are fed to the amplifier along a two-core screened cable which is



Spencer-West Type AC8 television aerial embodying a head amplifier.

also the feeder for signals from the aerial to the receiver. A small power supply unit is required and is mounted close to the receiver.

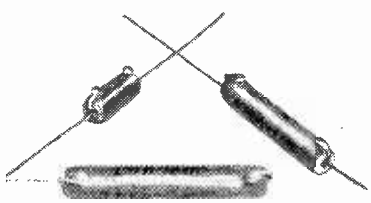
The aerial system can be fitted with a relay for automatically switching on the head amplifier when the main receiver is switched on.

The makers are Spencer-West, Quay Works, Great Yarmouth, and the aerial, known as the Type AC8, costs £33 15s including 65 ft of feeder and a power supply unit.

Vitreous Resistors

A RANGE of vitreous-enamelled resistors wound with nickel-chrome resistance wire on ceramic formers is now in production by Labgear, Ltd., Willow Place, Cambridge. They are at present available in $4\frac{1}{2}$-, 6- and 10-watt types, these being the commercial ratings, but for Service equipment the ratings are lower at 3, 4.5 and 6 watts respectively.

All three types have the same outside diameter of $\frac{1}{4}$ in approximately, but differ in length, the smallest being $1\frac{3}{8}$ in and the largest $1\frac{3}{4}$ in. The resistance ranges are as follows: 4.5-W, 10 to 12,000 ohms; 6-W, 5 to 33,000 ohms and 10-W, 5 to 47,000 ohms. The normal tolerance is ±5 %.



Labgear range of vitreous-enamelled wire-wound resistors in $4\frac{1}{2}$-, 6- and 10-watt types.

RANDOM RADIATIONS

By "DIALLIST"

Oh for V.H.F.!

THIS COUNTRY'S v.h.f. sound broadcasting service can't come into being too soon for me; or, I expect, for a good many others who are growing very tired of the interference on the medium- and long-wave bands. Myself, I can seldom receive the Light Programme even reasonably well. To bring in the medium-wave transmission without interference from one or more stations selectivity must be pushed up until there is a marked decline in quality: on the long waves there is too often a poisonous heterodyne whistle. The Home Service from Brookmans Park is also liable to heterodyne troubles, while at times some foreign station provides an annoying background. I'm coming to rely more and more on the 90-Mc/s transmissions from Wrotham with their almost entire freedom from interference. The snag is that Wrotham sends out only one programme at a time; and too often it isn't the one I want.

It Shouldn't be Long

I haven't a doubt that f.m. will win the day for the official service. To two important points I can testify without reserve. The first is that, given a.f.c. (which you must have, anyhow, to look after oscillator drift) the f.m. receiver isn't the tiniest bit more difficult to tune than the a.m. The second is that f.m. is not just a little more effective than a.m. against impulsive interference: it's *vastly* better than a.m., even with a limiter. Once the modulation question is decided, it shouldn't take long to get the services going. Note that I say services in the plural, for the slot aerials below the dipole arrays on the mast of every television transmitting station can transmit two v.h.f. programmes on different carrier frequencies. It would seem hardly necessary to build giant transmitters, to begin with, at any rate. The 18-20 kilowatts of the now well-proved Wrotham transmitter appear to give a service area quite as large as that of either of the medium-wave Brookmans Park giants. I'm speaking, of course, of the f.m. transmissions with which the minimum necessary field strength is much smaller than with a.m. The signal need only be strong enough to work the limiter to give you all that's going.

A New Contributor

TURNING THROUGH the pages of a learned American journal, I was electrified by finding in it a reference to a recent *Wireless World* article "by R. W. Hallows and M.A. Cantab." The latter belongs, of course, to the *coterie* of writers which includes such authorities as B.A. Oxon, M.D. Lond., D.D. Dunelm and M.B. Leeds amongst its English members. Well-known Scottish members of it are the Mac Antabs and Mus. B. Edin.

They Have a Word for it

I REALLY CAN'T swallow without many grains of salt Malcolm S. Morse's statement in the October correspondence columns that motor car ignition interference with television reception is unknown in the U.S.A. Nor can I accept for a moment his suggestion that American sets, though used in a veritable welter of radiation from millions of unsuppressed cars, provide undisturbed pictures because they are so much better designed than ours. There's no mystery about the design of the sets made on the other side of the Atlantic. They incorporate nothing in the way of anti-interference devices that our manufacturers don't know and use. There may be differences in the ways in which we use them, but these are due to our positive modulation. I suspect that Mr. Morse's "unsuppressed" means that the owners of the cars haven't deliberately had suppressors fitted. No need to do so if your new car has already been treated as a matter of course before delivery. But there must be noticeable interference, or one wouldn't read so many references to "auto-ignition static."

Useful Jobs of Work

THE SUBMARINE television camera is destined to play a very useful part in salvage operations. A diver working in deep water uses a cable with a heavy weight at its lower end, known as the shot-rope. It used to be impossible to tell whether the shot-rope had been put into the right position until the diver went down to find out. He can't move more than a foot or two from it with safety; if it is wrong, he must come up and another attempt must be made. You'll see that this can be a very slow business; a whole tide may, in fact, be wasted. With the TV camera it's just too easy. The camera goes down and the shot-rope is moved until it is seen on the receiv-

ing screen to be in exactly the right place. The diver then goes straight to his job. His partnership with the TV camera doesn't end there either. He can telephone for the camera to be moved to where he needs it when he wants to show observers above something of special interest that he has found. They can then make a permanent record by means of photographs or ciné films of the screen.

Not So Hot

MANUFACTURERS of television receivers can be pretty badly let down when their sets are installed by careless or inefficient service-men. The other day a non-technical friend told me he was a bit disappointed in the set (his first) which had cost him a tidy sum. When I dropped in to see how it was performing, I wasn't surprised. The first thing that struck me was that on the 14-inch screen the image was barely 10 inches in width. The aspect ratio was nothing like 4:3; the image appeared badly distorted, and this was confirmed when I tried the set on Test Card C a few mornings later. Though the set was in a back room, the aerial had been fixed to a chimney stack at the front of the house where it brought in the maximum amount of interference from every unsuppressed motor vehicle. Had it been mounted on a convenient high chimney at the back, the dipole would have been 40ft further from the road and probably outside the ignition interference zone. Luckily, one doesn't often see sorry jobs of that kind; it's sad that one should ever come across them.

Taxi!

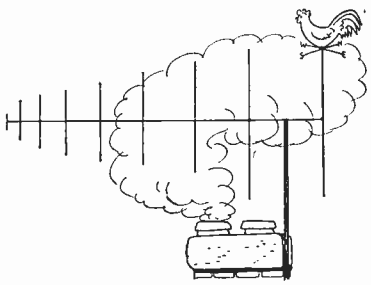
WHEN I WAS just on the point of sending off the manuscript of this month's jottings the postman brought a letter from a reader in the W.9 district of London. In the early part of last year he made a tape recording on his own machine. On playing it back, he was amazed to hear two voices: his own and that of a taxi driver speaking to his headquarters. He now sends me a cutting from September 20th issue of *The Observer* describing a similar occurrence (except that on this occasion a voice speaking from headquarters and not the taxi man's was recorded). I haven't had time before writing this to think of an explanation of this queer business. Can any reader suggest one?

UNBIASED

By FREE GRID

Strange TV Aerials

TRAVELLING to the wilds of East Anglia recently I was struck by the changing character of the TV aerials as the train receded from London. At first there was nothing but the familiar "H" type to be seen among the chimney pots, with here and there a plain dipole. As we drew nearer to that part of the country made famous and hallowed by Hereward the Wake and St. Etheldreda respectively the aerials began to assume strange shapes; weird and wonderful multiple arrays sprouted up here and there in an



Xylophone TV aerials

endeavour to catch the ever more elusive signals from the transmitter.

Eventually we passed the lofty West Tower of Ely Cathedral soaring majestically over the flat fen country surrounding it—surely a veritable gold mine for the Dean and Chapter if and when commercial television eventually goes a site-seeking. Beyond Ely the only TV aerials to be seen were what I can only describe as the xylophone or dulcimer type which I have endeavoured to illustrate in my sketch.

I subsequently had cause to visit Alexandra Palace and expected to see the aerials become less and less conspicuous until in the vicinity of the transmitter they disappeared altogether as being unnecessary. To my surprise, however, I found that in one district bordering on the Palace they seemed more conspicuous than in remoter suburbs.

I naturally suspected the existence of some inexplicable pocket of low signal strength and I dropped in to a local dealer's place to discuss the matter. He shook his head, however, and pointed out that signal strength was so great that an attenuator rather than an aerial was needed. He went on to say that the people in the district were so afraid the neighbours would think they couldn't afford TV that they always demanded an aerial; in fact, one of his customers who had the largest car and the most beminked and bejewelled wife in the district insisted on his erecting a mast having not an H but the letters TV at the top so that there could be no misunderstanding.

Etheric Anarchy

THERE HAS BEEN a lot of talk about the difficulties of clearing Band 3 of such things as business radio in order to make it safe for television. In my opinion, however, if v.h.f. communication goes on spreading at the rate it is doing at present TV will eventually be squeezed out of the ether altogether. I feel rather strongly on the matter as I have some personal experience of what is going on.

It so happened that a few weeks ago my eye was caught by a remarkable shop-window display of the potential and actual uses of business radio. One of the chief features of the display I saw was an errand boy on a bicycle with a v.h.f. "X-eiver" in his bicycle basket, and headphones over his ears, receiving instructions from his employer. I cannot tell you where this remarkable display was—and probably still is—as the Editor won't have any suggestion of advertising in these columns. However, when I tell you that it was in a part of London with street names recalling the past glories of the de Vere family you obviously only need to ring up the Editor of Burke or Debrett in order to find out where I mean.

In a foolish moment I told Mrs. Free Grid all about it and then promptly dismissed the matter from my mind until a couple of weeks later I observed a friend of hers pushing a pram and apparently talking to herself. Closer observations revealed dainty hearing-aid type earphones, a mike and a neatly mounted rod aerial. The set, I discovered, was under the baby; a place where I should have thought it would be subject to a heavy damping effect.

This was not all as I presently encountered Mrs. Free Grid herself, complete with pram, grandchild and "X-eiver," and also several others of her coterie all busy chattering away nineteen to the dozen and spoiling good ether. If this sort of thing is allowed to spread we shall be faced with etheric anarchy.

The "Elevated Electrode"

I WAS TALKING the other day to a friend who had been attending the meetings of the C.C.I.R. in London and he was telling me of the weighty matters which had been occupying its attention. One incidental question which cropped up was the correct form of the plural for antenna. There can be no doubt that it is antennæ but some delegates seemed to favour antennas as is used in America. It was, moreover, pointed out that "aerials" was also used in some of the official documents. After some discussion, the delegates agreed to accept the ruling of the *Concise Oxford Dictionary*.

This apparent climb-down on the part of the Yanks rather surprised me as the *Concise Oxford* says without any equivocation that "antennæ" is the plural and it has no truck with "antennas." The *Concise Oxford's* big brother, *O.E.D.*, is far more tolerant of the weaknesses of human nature and gives "antennas" as a permissible alternative.

"To what base uses . . ."

AVO REG. TRADE MARK

WIDE RANGE Signal GENERATOR

REMEMBER HF POPPY DAY

An inexpensive yet precision instrument designed especially to meet the exacting needs of the modern service engineer and laboratory technician. With six frequency ranges covering 50 Kc/s. to 80 Mc/s., its accuracy is better than ± 1% of the scale reading.

50Kc/s.-150Kc/s.	1.5Mc/s.-5.5Mc/s.
150Kc/s.-500Kc/s.	5.5Mc/s.-20Mc/s.
500Kc/s.-1.5Mc/s.	20Mc/s.-80Mc/s.

Scale sub-divisions provide more than adequate discrimination for use in television circuits. Note the starred features below, which combine to maintain a minimum signal of less than 1μV up to 20 Mc/s. and less than 3μV between 20 Mc/s. and 80 Mc/s.

★OUTPUT 1
Co-axial socket for attenuated output. Force socket located totally within H.F. compartment.

MAINS TRANSFORMER 2
Marked tagboard for inputs of 100-130 V. and 200-260V., A.C. 50/60 c/s.

★CAST ALUMINIUM H.F. COMPARTMENT and CHASSIS 3
Large number of fixing holes for H.F. compartment cover ensures excellent electrical bonding and good screening.

FUSE 4
Easily accessible when replacement is necessary.

VALVES 5
Standard types run at a rating to ensure long life.

TURRET COIL SWITCHING 6
Standard "AVO" practice.

★ATTENUATOR SYSTEM 7
Employs close tolerance, high stability midget carbon resistors, low reactance rotary potentiometer modified for H.F. operation with carefully designed screening.

Other features include:

ILLUMINATED SPOT RANGE SELECTOR
Gives rapid identification of operational band with intensified lighting round precise frequency. Fine hair line gives close discrimination, particularly on high frequencies.

STOPS
Separate stops prevent turning of dial with respect to condenser.

★MAINS FILTER SYSTEM
This is screened from main electrical assembly.

BUSHING PLATES
provide additional rigidity for rotary controls.

SLOW MOTION DRIVE
substantially free from backlash.

MAINS MODEL 100—130 V. and 200—260 V. A.C., 50—60c/s.
OR BATTERY MODEL.....£30

Sole Proprietors and Manufacturers:

The AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.
WINDER HOUSE • DOUGLAS STREET • LONDON • S.W.1 *Telephone: VICTORIA 3404/9*

S. G.2

A

"From time to time in the past we have attempted to make recordings, both on wax and by tape, in our Band room and we have failed most miserably. Commercial recording companies have also made valiant attempts but with as little success as we had previously... after experiments with many microphones we finally made tests with your D.104 and at once *the quality of the recordings improved*, certainly *not less than sixty per cent* and by the very nature of the tests made, we are forced to the conclusion that the secret of the very successful recordings does, without doubt, rest with the particular microphone made by you."

"... quality of the recordings improved... not less than 60%..."

says Mr. ALEX MORTIMER, *Musical Director of the Black Dyke Mills Band when writing of the new Rothermel D.104 Microphone.*

—the New ROTHERMEL D.104 Microphone

This 'quality' microphone D.104 has been considerably improved since it was first introduced and is ideally suited to all uses which require a sensitive high impedance instrument. It is available in three forms:

- Complete hand microphone with white handle and 6 ft. of high quality shielded cable **£6.0.0**

  Head only with three-pin plug and socket stand connector with side cable outlet—less cable **£5.10.0**

  Head only with screw eyes for suspension ring mounting, with 6 ft. of high quality shielded cable **£5.5.0**

The 2AD56 model is a low-priced, general purpose microphone that has become a firm favourite for use with tape recorders and many other applications because of its wide range and even response. Available as a hand microphone (without base) at £3. 3. 0, or with desk base as illustrated at 10/6 extra.

Ask to see these Rothermel Microphones at your local dealer.

Full details and illustrated leaflets free on request from

ROTHERMEL LTD

9 STRATFORD PLACE · LONDON W.1 · Tel: MAYfair 4234

A NEW HIGH PERFORMANCE FREQUENCY CHANGER

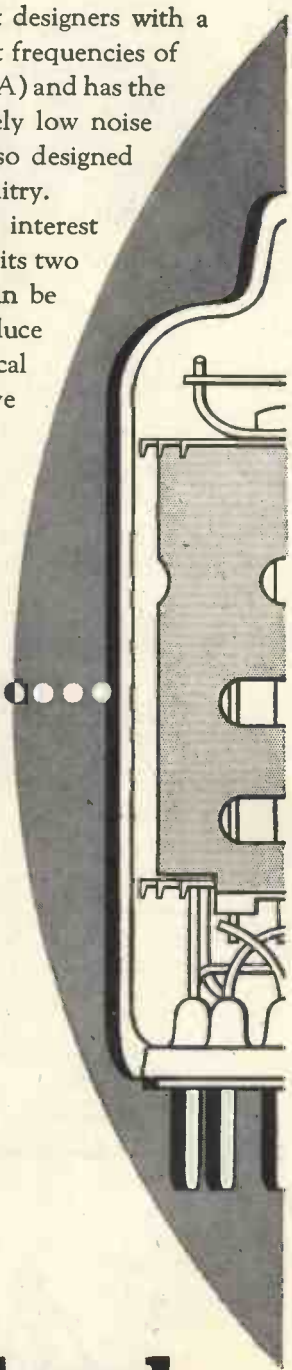
on a Services' Preferred base (B9A)

The new Mullard triode heptode, ECH81, provides equipment designers with a high performance frequency changer that will work efficiently at frequencies of up to 100 Mc/s. It is constructed on a Services' Preferred base (B9A) and has the important advantages of high conversion conductance, extremely low noise factor, and robust construction. Furthermore, the ECH81 is so designed that it enables maximum results to be obtained from existing circuitry.

A special feature of this valve that should prove of particular interest to designers of FM and AM/FM communication receivers is that its two sections may be operated independently. In FM circuits, it can be used as an R.F. or I.F. amplifier, or oscillator and thereby reduce the number of different valve types employed. Brief technical details of the ECH81 are given below. More comprehensive information will gladly be supplied on request.

ACTUAL SIZE

ECH81



PRINCIPAL CHARACTERISTICS

HEATER Suitable for series or parallel operation A.C. or D.C.

Vh	6.3 V
Ih	0.3 A

TYPICAL OPERATING CONDITIONS OF HEPTODE SECTION AS A MIXER

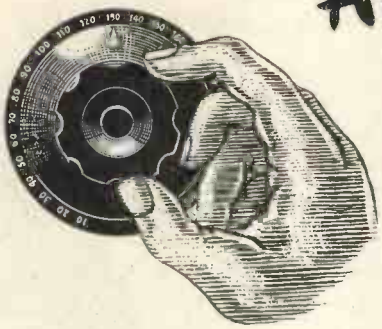
Va=Vb	250 V
Rg2+g4	22kΩ
Rg3+gt	47kΩ
Ig3+gt	200μA
Vg1	−2.0 V
Vg2+g4	103 V
Ia	3.25mA
Ig2+g4	6.7mA
gc	775 μA/V
ra	1.0MΩ
Vg1 for 100:1 reduction in gc.	28.5 V

CHARACTERISTICS OF TRIODE SECTION

Va	100 V
Vg	0 V
Ia	13.5 mA
gm	3.7 mA/V
μ	22

BASE B9A

Mullard



Adjustable-Stabilized A.C. Voltage

WITH HARMONIC FILTER

This new Advance Constant Voltage Transformer is designed for use when an adjustable but closely regulated source of constant A.C. voltage is required. The "Volstat" is ideally suitable for the most exacting industrial applications as well as for general laboratory work.

It provides a portable, simple to handle instrument for such duties as instrument calibration and testing and many other operations involving factors that are sensitive to wave form and voltage.

Full technical details on Leaflet S19/W

- Output "A," variable 0-260 volts stabilised ± 1%.
- Output "B," 230 volts ± 1%.
- Total Harmonic Distortion less than 5%.
- Maximum Output 170 watts.

Advance 'VOLSTAT'

ADVANCE COMPONENTS LIMITED, BACK ROAD, SHERNHALL STREET, LONDON, E.17

Telephone : LARkswood 4366/7/8 *Telegrams : Attenuate, Walt, London*

THIS UNIQUE STELLATE CORE IS THE SECRET OF FAULTLESS FLUXING

. . . because it gives six points of rapid solder collapse and the flux is liberated *immediately* heat is applied. The correct amount of activated flux is always present in Superspeed, thus eliminating dry or H.R. joints. The stellate core is featured only in the Enthoven range of cored solders which ensures perfect soldering.

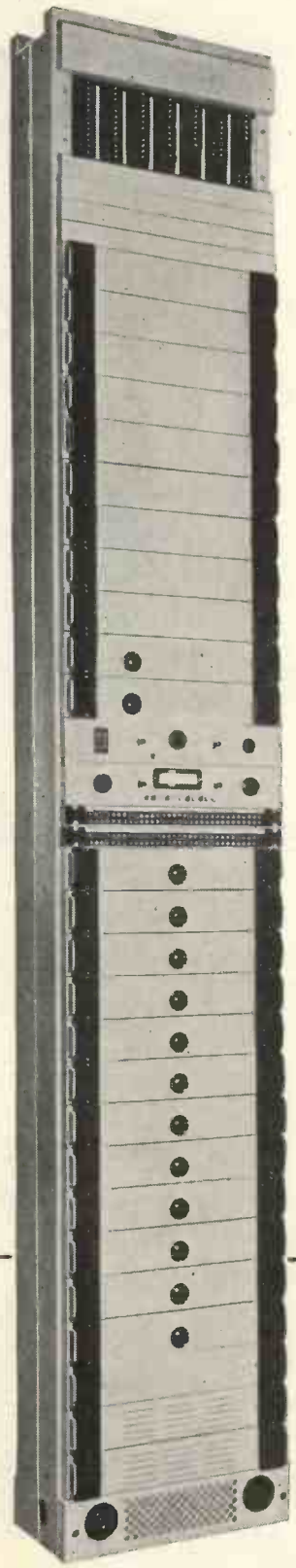
Superspeed

ACTIVATED ROSIN CORED SOLDER

for all Radio, T.V. electronic and telecommunication soldering. Complies with M.O.S. Specification DTD. 599 and is approved by the A.I.D., G.P.O. and R.C.S.C. Superspeed is available in a wide range of alloys and gauges. Samples together with comprehensive literature gladly sent on request. Technical advisers are available for consultation.

MANUFACTURED BY THE ENTHOVEN GROUP

Marketed by Enthoven Solders Ltd., Enthoven House, 89, Upper Thames Street, London, E.C.4. Telephone: Mansion House 4533



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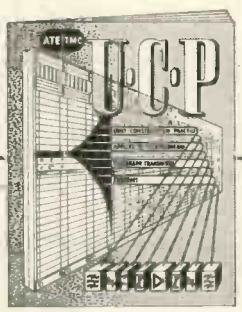
Designed for *Continuous* Service

ATE/TMC Transmission equipment is designed to offer an operating administration the maximum facility in the performance of maintenance routines. Jack-in panel frames fitted with quickly detachable functional units ensure the most rapid form of servicing yet devised. You are invited to apply for a copy of "Unit Construction Practice" which describes the technique employed.



AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.

Radio and Transmission Division

STROWGER HOUSE · ARUNDEL STREET · LONDON, W.C.2.

Telephone: TEMple Bar 9262. · *Cablegrams: Strowgerex London.*

Manufacturers:— AUTOMATIC TELEPHONE & ELECTRIC CO. LTD., Liverpool & London

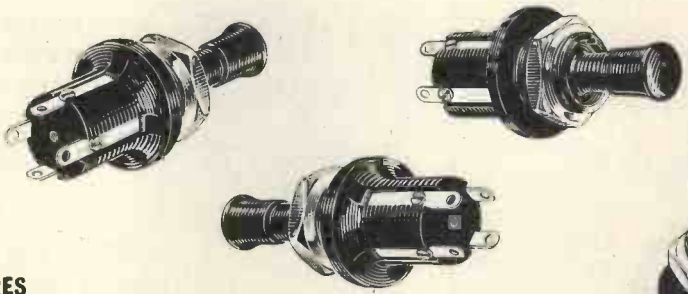
TELEPHONE MANUFACTURING CO. LTD., St. Mary Cray, Kent.

ATM

AT8511-BX105

PAINTON

By Appointment to the Professional Engineer



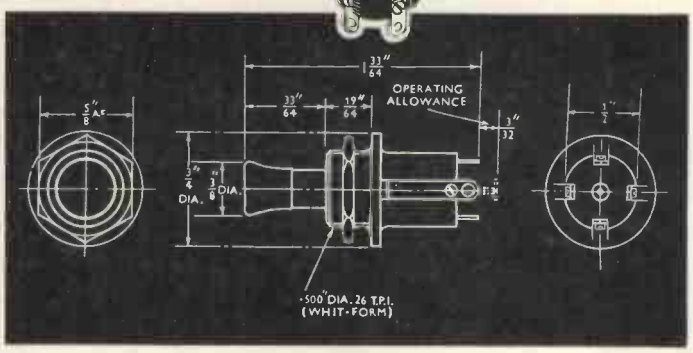
MINIATURE PUSH BUTTON SWITCH

FEATURES

RATING: 0.1 Amp., 250 v. A.C./D.C.
CONTACT RESISTANCE: 0.01 ohm.

The new Painton Push Button Switch is an efficient and reliable miniature component combining safe electrical operation with robust mechanical action. The highest electrical grade material is used for the knob, shaft and inner body, which are produced as one solid moulding. The design of the contacts ensures minimum fatigue, and the retention of low contact resistance over a long period and under wide variation of atmospheric conditions.

The non-locking version is particularly suitable for metering, monitoring and also inter-communication system applications.



Cat. Number	501404	501405	501406	501407
Mechanical Action	Non-Locking	Locking	Non-Locking	Locking
Electrical Action				
501404 / 501405	Switch in normal position: Contacts 1 and 2 made, Contacts 3 and 4 open. Switch operated: Contacts 1 and 2 open, Contacts 3 and 4 made. (By cross connection of the contacts, single pole changeover operation may be obtained).			
501406 / 501407	Switch in normal position: Contacts 1, 2, 3 and 4 open. Switch operated: Contacts 1, 2, 3 and 4 commoned.			

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Northampton England

ATTENUATORS AND FADERS • STUD SWITCHES • FIXED AND ADJUSTABLE WIREWOUND RESISTORS WIREWOUND POTENTIOMETERS • MIDGET R.F. CHOKES • HIGH STABILITY CARBON RESISTORS • TERMINALS PLUGS AND SOCKETS • KNOBS, DIALS AND POINTERS • TOGGLE SWITCHES • PUSH BUTTON SWITCHES

★ ★

it's NEW... and it's NEWS!

The tape Recording SENSATION of the SEASON is now available. With an operating height of only just over 5 INCHES the Editor is the smallest MAINS OPERATED, FULLY AUTOMATIC tape recorder on the market. The Editor is EASY TO CARRY, EASY TO OPERATE and EASY TO LOOK AT. For the finest value and quality in any portable recorder we give you . . .

The Remarkable

★ **Editor**

SUITCASE TAPE RECORDER

—The REALLY portable tape equipment ! Covered in high quality leathercloth in various attractive colours.

H.P. TERMS

£15 . 15 . 0 Deposit, 12 monthly instalments of 60/-.
Or 18 monthly instalments of 42/-.

CREDIT TERMS

Send only £6 to secure with 8 further monthly payments of £6.

ACCESSORIES

The "Editor" is supplied complete and ready for use with the famous Burgoyne crystal desk microphone made specially for this equipment by RONETTE. The Coronation microphone can be supplied as an alternative if desired.
A 1,200ft. reel of high coercivity BURGOYNE tape is also issued with every recorder.
This tape is especially recommended and is available at 35/- per 1,200ft. reel or 21/- per 600ft. reel.

***it's perfect at only* 45 gns**

200-250V. A.C.

SPECIFICATION:—

★ Tape speed 7½in. per second. ★ Miniature valves. ★ Twin track heads. ★ Three high grade specially designed recording motors provide fast forward run and 50sec. rewind without unlacing tape. ★ Independent Bass and Treble Controls for recording and playback. ★ Negligible wow and flutter. ★ Overall negative feedback. ★ 1,200ft. reel of tape will provide ONE hour playing time. ★ High fidelity Record head. ★ Special high grade speaker. ★ Provision for external speaker. ★ Positive servo braking on all functions. ★ Amplifier may be used for high quality record reproduction. ★ Extremely high output and brilliant reproductions. ★ Compact size for ease of handling. ★ Magic eye recording indicator. ★ Size only 16¾" × 12" × 7" (with lid) ★ Weight only approx. 40 lbs.

See it and hear it at the Radio Centre

M·O·S MAIL ORDER SUPPLY COMPANY

The Radio Centre, 33 Tottenham Court Road, London, W.1. *Telephone : MUSeum 6667*

★ ★

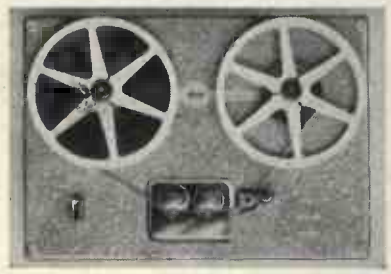
Come to the Radio Centre

Where you can choose from BRITAIN'S most comprehensive display of TAPE RECORDING equipment. Order in confidence through the mail if you are unable to call. All our merchandise is fully guaranteed. Send for latest lists.

We recommend

★ THE LANE TAPE TABLE

incorporating several new features ensuring even better reproduction and simple handling.



- ★ Three Motors
- ★ Positive Servo braking
- ★ Twin track
- ★ High fidelity heads
- ★ 7½in. per sec.
- ★ Size 11⅛in. x 16⅛in.
- ★ For 200-250 v. A.C.
- ★ Only two controls

£17 : 10s. CARR. PAID. H.P. Terms £5/16/8 deposit 12 monthly payments of 22/-, OR ON CREDIT TERMS.

We recommend these Motors for Recording

★ **B.S.R.** F.P. 10 clock or anti-clock. 1,400 R.P.M. 4 pole 3in./.03 Torque. **38/-.**

★ **COLLARO** "S" clock or anti-clock — latest release. Specially designed recording motor, **45/6.**

We recommend

★ BURGOYNE

high impedance half track Recording and Erase heads. Built-in tape guides. Single hole fixing.

only **37/6d** *each*

ACTUAL SIZE

ALL MAKES OF TAPE AVAILABLE *from stock e.g. :—E.M.I. ; Scotchboy ; G.E.C. : Agfa, B.A.S.F. ; Ferrovoice Sound Mirror and BURGOYNE.*

and you can choose from the latest releases of the famous—

COLLARO — B.S.R. — GARRARD

makes of Gramophone Equipment

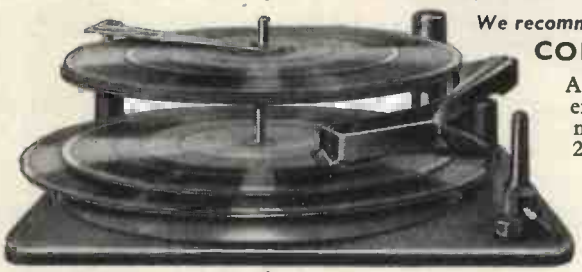
We recommend

The B.S.R. MONARCH AUTOCHANGER at £16 10s.

H.P. terms £5/10/- deposit, 12 monthly payments of 21/8.

and the B.S.R. REGENT

(G.U.4) 3 speed motor unit with lightweight P/u. **£9/4/-.** monthly payments of **13/3.** TERMS available.



Deposit **£3/1/4** and 12 9 MONTH CREDIT

We recommend the very latest

COLLARO Release

A Transcription unit at an extremely low price, which must sweep the market. In 2 versions.

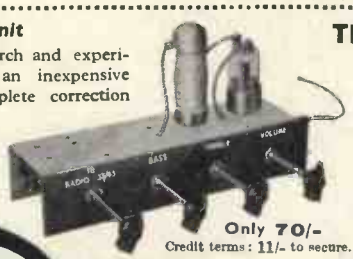
(A) 3 speed Transcription unit on Banjo, less P/u., **£13/9/6.** H.P. terms **£4/10/-** deposit and 12 monthly payments of **18/-.**

(B) As above but on Rectangular Plate with Studio P/u. **£18/4/9.** H.P. terms **£6/1/9** deposit and 12 monthly payments of **23/6**—undoubtedly the finest unit of its kind.

We recommend for the Connoisseur of sound reproduction (a) Leak Vari slope Pre-amplifier, **£12/12/-.** (b) Leak Point One TL/12 amplifier, **£28/7/-.** (c) Leak Radio Tuner, **£35.** H.P. terms available separately or on the 3 items together at **£25/6/4** deposit and 18 monthly payments of **65/-.** Also available on 9 month credit terms. Send **£9/14/-** only to secure.

We recommend this unit

Considerable time in research and experiment was spent to find an inexpensive method of providing complete correction for all recording characteristics as well as compensation for deficiencies in broadcas transmissions.



Only **70/-**
Credit terms: 11/- to secure.

THE BURGOYNE TONE CONTROL PRE-AMPLIFIER

This unit provides a wide range of bass and treble control without the need to readjust the main volume control when bass or treble are altered. The use of continuously variable controls is most necessary when dealing with unknown characteristics, for compensation of these can only be done by ear. As the characteristics of the human ear vary with intensity, the compensation required is a function of the loudness of reproduction. With a badly designed tone-control amplifier, the critical listener will find himself indulging in an orgy of knob twiddling which cannot be rationalised. This unit not only avoids introducing distortion into the reproduction, but precisely and easily overcomes the defects of the signal fed into it. The unit is supplied completely assembled and tested. A three-position input switch is incorporated :— RADIO 78-33/45.

M·O·S

MAIL ORDER

Telephone : MUSeum 6667. ***THE RADIO CENTRE.***

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We are now able to offer selected merchandise on easy payment terms by means of which equipment can be obtained on payments of only ONE-NINTH of the total purchase price. Payment is spread equally over NINE months.

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M.O.S. A1	£5 12 6	14 0
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Leak Varislope	£12 12 0	£1 12 4
Leak Point One	£28 7 0	£3 12 0
Acoustical Quad	£35 0 0	£4 9 0
Goodsell Williamson	£36 0 0	£4 11 6
Rogers Baby De Luxe	£14 0 0	£1 15 6
GRAMOPHONE UNITS		
Connoisseur 3-speed	£21 7 3	£2 14 2
Garrard 201B5	£22 11 8	£2 17 3
Garrard RC 80 (Motor and Arm only)	£15 11 0	£1 19 6
Monarch Auto	£16 10 0	£2 2 0
Regent GU4/TOH	£9 4 11	£1 4 9
MU10 BSR 2-speed	£3 18 7	12 0
MU14 BSR 3-speed	£6 8 6	18 0
MU15 BSR	£3 0 0	10 0
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Burgoyne RGI	£23 2 0	£2 19 0
Leak Radio Tuner	£35 0 0	£4 9 0
Chapman 85	£21 6 8	£2 14 2
Goodsell S.P. Tuner	£19 5 0	£2 9 2
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Lane Table	£17 10 0	£2 2 10
Truvox Table	£23 2 0	£2 19 0
Wearite Deck	£35 0 0	£4 9 0
The Editor Recorder	£47 5 0	£6 0 0

ITEM	CASH PRICE	TO SECURE SEND ONLY
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Plus A Gram Table Model, 3-speed Auto.	£28 16 9	£3 12 0
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Decca 33B	£8 19 6	£1 4 0
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12in. Mullard	£16 13 8	£2 2 2
14in. Mullard	£19 9 3	£2 9 2
17in. Mullard	£23 12 8	£2 19 10
12in. Brimar	£17 14 6	£2 4 0
14in. Brimar	£20 10 0	£2 13 2
17in. Brimar	£24 13 6	£3 2 0
16in. English Elec.	£22 4 10	£2 17 0

This is only a selection from our available stock on easy Credit or H.P. payment terms. Send us your order for whatever your requirement may be. Add sufficient for carriage and packing at the rate of 6d. per £1.

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Signal Generator, Mains or Battery	£30 0 0	£10 0 0	£1 19 0
Universal Bridge	£34 0 0	£12 0 0	£2 2 0
Electronic Test Meter	£40 0 0	£13 6 8	£2 10 0
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45BValve Tester	£25 10 0	£8 10 0	£1 12 6
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72A Universal Meter 1,000 opv.	£16 0 0	£5 6 8	£1 1 2
75A Universal Meter, 20,000 opv.	£15 0 0	£5 0 0	£1 0 6
77A Universal Meter, 20,000 opv.	£15 0 0	£5 0 0	£1 0 6
85A/P Universal Meter, 20,000 opv.	£19 10 0	£6 10 0	£1 6 0
88A Universal Meter	£21 10 0	£7 3 4	£1 7 9
90A Universal Meter	£15 15 0	£5 5 0	£1 1 6
110C Bridge	£14 10 0	£4 10 0	£1 0 0
120A Universal Meter, 20,000 opv.	£9 0 0	£3 0 0	13 4
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170A Electronic Test Meter	£24 0 0	£8 0 0	£1 11 6
190A Audio Oscillator	£22 10 0	£7 10 0	£1 9 0
240A Pattern Generator	£14 0 0	£4 13 4	19 0
260A T.V. Wobbulator	£36 15 0	£12 5 0	£2 6 0
COSSOR Tele-check	£27 0 0	£9 0 0	£1 15 0
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EVERSHED Wee-Megger	£20 14 0	£6 18 0	£1 6 8
HUNTS Bridge	£14 14 0	£4 14 0	£1 0 0
PULLIN Universal Test Meter	£11 11 0	£2 0 0	£1 0 0
PULLIN RC Bridge/Valve Volt-meter	£40 0 0	£10 0 0	£2 17 6
AMPLION D.C. Test meter	£5 0 0	£1 0 0	10 0
B.P.L. Foundation Meter 1 m/a. F.S.D. 3½in. (flush mtg.)	£3 10 0	£1 3 4	7 0
B.P.L. 0-500 Microamps 3½in. meter (flush mtg.)	£3 10 0	£1 3 4	7 0
B.P.L. Universal Meter	£5 10 0	£1 10 0	10 0
RADAR Kilovolter	£3 17 6	£1 6 0	7 6

LOUDSPEAKERS BY :—	CASH	DEPOSIT	12 MONTHLY PAYMENTS
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Audiom 60	£8 12 6	£2 17 6	12 11
Axiom 102	£9 18 0	£3 6 0	14 4
Axiom 150	£10 5 6	£3 8 6	14 9
W.B.			
Tweeter Unit	£3 15 6	£1 5 0	7 6
Concentric Duplex 10in., with transformer	£10 15 6	£3 12 0	15 4
Less transformer	£9 7 6	£3 2 6	13 9
Concentric Duplex 12in. With transformer	£23 16 0	£7 19 0	£1 10 9
Less transformer	£22 11 0	£7 10 4	£1 9 6
High Fidelity Units: 6in. HF 610	£2 10 6	16 10	6 0
8in. HF 810	£3 0 6	£1 0 2	6 6
9in. HF 912	£3 7 0	£1 2 4	6 11
10in. HF 1012	£3 13 6	£1 4 6	7 3
Extension Speakers in cabinets: Senior	£7 17 6	£2 12 6	12 1
Junior	£7 3 9	£2 7 11	11 4
Cadet	£6 2 3	£2 0 9	10 1
Baby	£3 14 3	£1 4 9	7 3
Windsor	£2 15 0	18 4	5 10
Stuart	£3 6 0	£1 2 0	6 10
Tudor	£3 19 6	£1 6 6	7 6
Twin Corner Reflex Console	£23 14 9	£7 18 3	£1 10 9
WHARFEDALE			
W5	£2 0 0	—	—
Super 5	£6 13 3	£2 4 5	10 9
Bronze 8	£3 3 11	£1 1 4	6 6
Bronze 8 A/L	£3 10 8	£1 3 7	6 11
Super 8	£5 13 3	£1 17 9	9 7
Super 8cs	£6 6 7	£2 2 2	10 1
Super 8csal	£6 13 3	£2 4 5	10 9
Bronze 10in.	£4 12 8	£1 10 11	8 2
Golden 10in.	£7 13 3	£2 11 0	11 10
Golden 10csb.	£8 6 7	£2 15 6	12 7
W10CSB	£12 6 6	£4 2 6	16 11
W12CS	£9 15 9	£3 5 0	14 2
Super 12 CSAL	£16 0 0	£5 6 8	£1 1 2
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W15CS	£16 0 0	£5 6 8	£1 1 2

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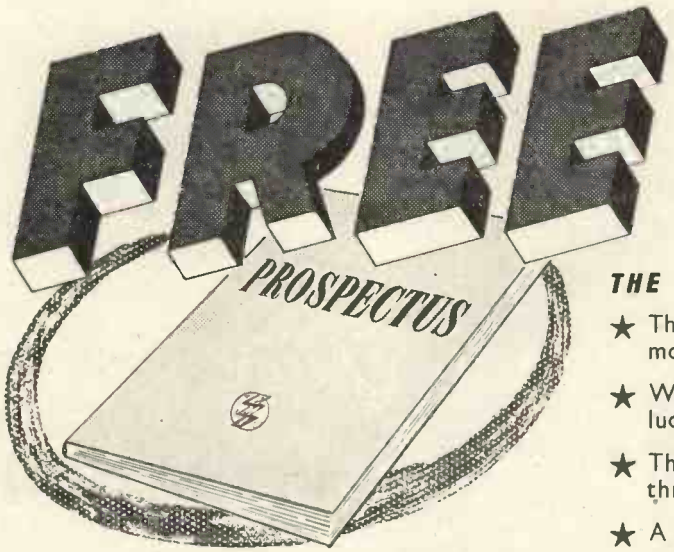

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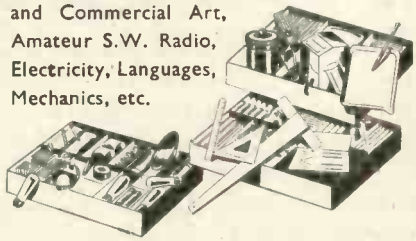

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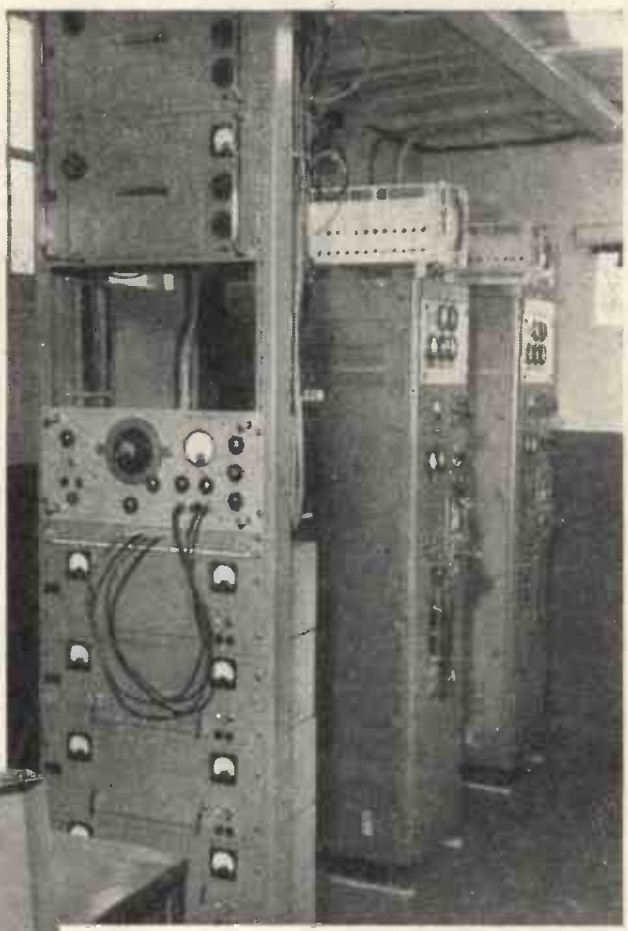
10 KC/S—10 MC/S

An outstanding feature of the Wayne Kerr Video Oscillator Type O.222A is a thermistor bridge circuit stabilising the amplitude. Once set the output level will remain constant within 0.5 db while the oscillator frequency is varied over its full range of 10 kc/s to 10 Mc/s. *Another advantage* is its special facility for indicating the modulus of the load impedance to which the instrument is connected.



General view of the duplicate transmitters, distribution amplifiers, and testing equipment in the temporary television station at Truleigh Hill, near Brighton. The Wayne Kerr oscillator is used for checking the response characteristics of the vision transmitters over their full bandwidth.

Photograph by courtesy of the B.B.C.

In transportable case £155, *or for standard* 19″ *Rack mounting* £148.

SPECIFICATION

Frequency Range:	10 kc/s—10 Mc/s in 6 ranges
Frequency Stability:	better than 1 in 10^3 in 1 hour
Frequency Accuracy:	1%
Output Range:	+10 db to −50 db on 1V p-p.
Output Level:	Constant to ± 0.5 db at any frequency [setting
Output Impedance:	75 ohms
Total Harmonic Content:	less than 1%

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Switch unit	37/6
Tape Holder assembly	22/6
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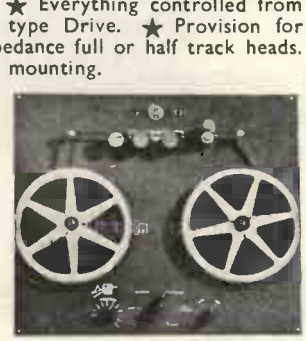
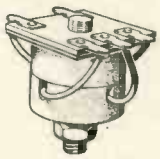
Brake assembly	16/6
Capstans—7½in., 7/- ; 15in.	7/6
Motors, each	38/6

(Send S.A.E. for detailed list)



THE "LINCOLN" OSCILLATOR COIL



Completely enclosed in "Neosid" former ensuring minimum external field. Unusually good waveform with maximum amplitude at 45 Kc/s. Lettered tag panel connections and one-hole fixing.

Overall size, 1½in. x 1½in. x 1in. PRICE 12/6. (Post 6d.).

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Made of finest quality magnetic steel laminations, precision machined to fine limits. Full or half track. High or low impd. Record/Playback or Erase. **37/6**

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A novel arrangement in this amplifier permits connection of output valves as either TRIODES or TETRODES with outputs of 3 or 10 watts. Bass and Treble lift and cut. Negative feedback.

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is an ideal instrument for the determination of tuned circuit resonant frequency, tuning transmitters without application of power, for the determination of coil, mutual and stray inductances and both fixed and stray capacitances. Covers 1.5 to 300 Mc/s in eight ranges. PRICE: 12 Gns. Complete.

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When we showed our new High Fidelity units at the Radio Show, we knew we had something exceptional to offer — the experts who had tested these speakers had been most enthusiastic about their merits.

But — we did not anticipate such an overwhelming response from the public, far in excess of any reaction we have experienced in the past 27 years. Without exception, visitors to our Stand were amazed that a performance of so high a quality could be made available at popular prices.

This new range has been developed to take full advantage of the television sound transmissions and high fidelity recordings now available. The cone is made from uncured cambric and bonded pulp, the whole being completely cured together and made into one composite cone by a new manufacturing process.

The bass resonance is substantially lower than that using the conventional cone, and all coloration is therefore removed from the lower frequencies. No tiring or fatigue of the surround takes place. The high frequencies are well maintained, which, together with the extended bass response, provides a well-balanced overall response. The speakers are all fitted with high flux density Alcomax magnets and are completely dustproof.

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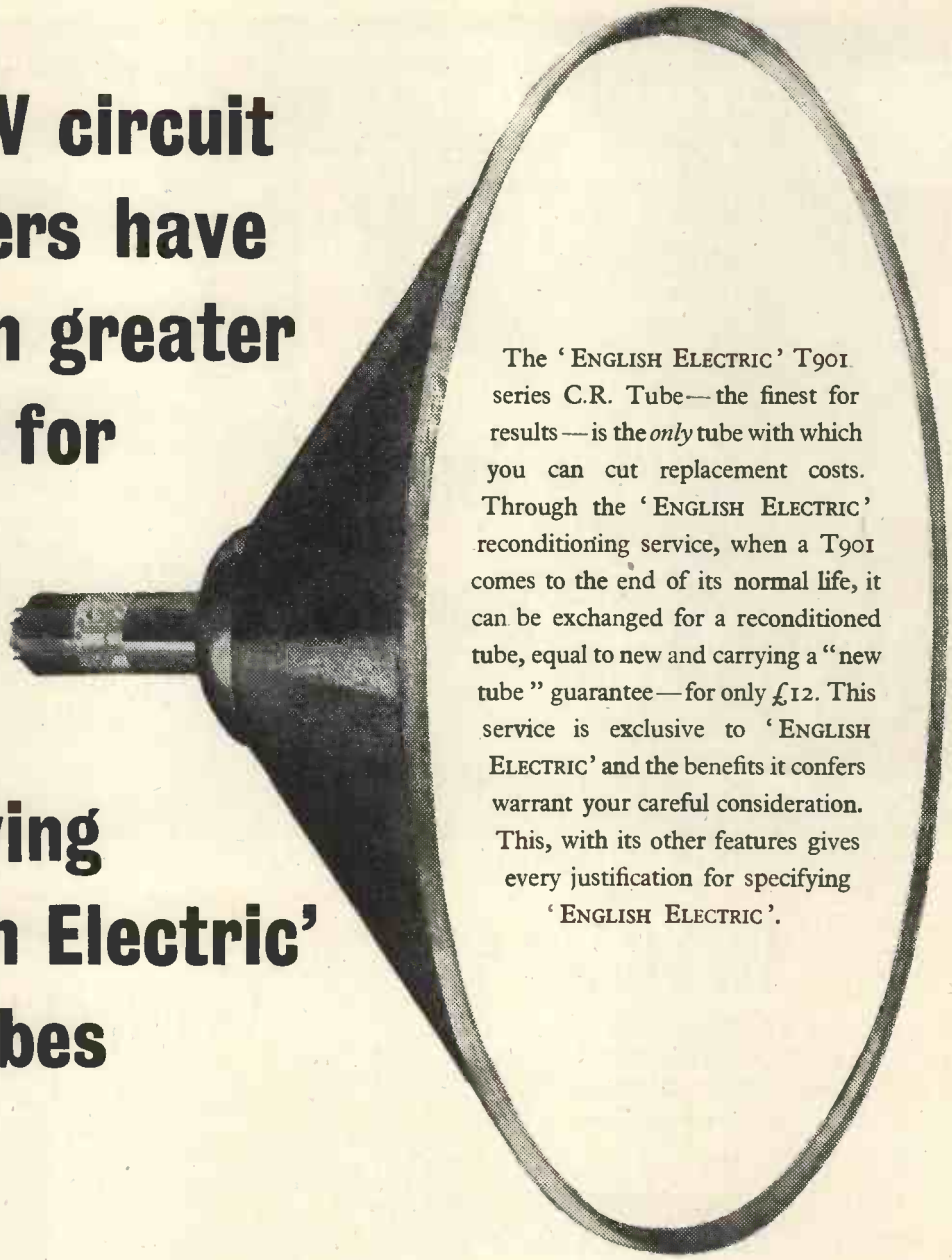

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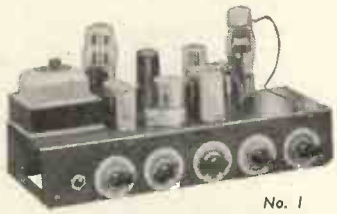

No. 1

No. 1 "SYMPHONY" AMPLIFIER is a 3-channel 5-watt Gram/Radio Amplifier with astonishingly flexible tone-control. You can lift the treble, the bass, or—and here is the unique feature—the middle frequencies to suit your own ear characteristics and the record or radio programme being heard. It is thus possible to arrange the frequency-response of the amplifier to a curve equal and opposite to the resultant curve of the other items in the chain so that what finally registers in the brain is as per original. This flexibility of control is far more important than mere nominal linear response of the amplifier, as the pickup, speaker, etc., are not linear. Independent Scratch-Cut is also fitted and special negative-feedback circuit employed. The Amplifier can accommodate a wide variety of records from old 78's to new LP's Input is for all types of pickup of 0.2v. output or more and there is full provision (and power) for Radio Tuner. It is available to match 2/3 or 15 ohms speakers. Price : 10 gns. (carriage 5/-). Fitted In Portable Steel Cabinet 35/- extra.

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REGD. DESIGN

Remote Control Panel ▶

"SYMPHONY" AMPLIFIERS with REMOTE CONTROL. Both the above model Amplifiers are available with all controls on a separate Control Panel with up to 4 feet flexible cable which simply plugs into the amplifier. Enables the Amplifier proper to be sat in the bottom of a cabinet whilst the controls are mounted conveniently higher up. Extra cost 2 gns.

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GARRARD 3-SPEED GRAM UNITS model TB, in stock at last ! ! This beautifully engineered unit sets a new standard in quiet operation. Special drum (not rim) drive. Micro. adjustment of stylus pressure between wide limits. Complete with two separate Acos high-fidelity crystal P.U. Heads, £11/17/6 or with two Decca XMS Magnetic Heads, £13 7/6. Post 2/6. Extra head for thorns 25/- to 35/-. Also available as Complete Record Player in de luxe rexine-covered Portable Case £4 extra.

"SYMPHONY" BASS REFLEX CABINET KITS 30in. high, consist of fully-cut ¾-in.-thick, heavy, Inert, non-resonant patent acoustic board, deflector plate, felt, all screws, etc., and full instructions. 8in. speaker model, 85/- ; 10in. speaker model, 97/6 ; 12in. speaker model, £5/7/6. The design is the final result of extensive research in our own laboratory and is your safeguard of optimum acoustic results. Carriage 7/6. Ready built, 10/6 extra, also available fully finished in figured walnut veneer as illustrated, 8" £10/10/0, 10" £11/0/0, 12" £11/10/0. Treble baffle to match, 45/-.

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GOODMANS CORNER CABINETS (left) for the AXIOM 150 Mark 2 manufactured by us to Messrs. Goodmans own design. Price : complete kit in plain board with felt, 8 gns. Price ready built, 10 gns. Finished in figured walnut, 16 gns. Other veneers to order. Carriage extra.

STANDARD PORTABLE RECORD PLAYER CASES, strongly constructed of ⅜in. thick ply, rexine-covered, measure internally 15in. by 12½in. by 6½in. Uncut motorboard. Will take any of the Garrard, Decca, B.S.R. or Collaro single-record units. Makes a de luxe Player. Price 57/6. Post 2/6.

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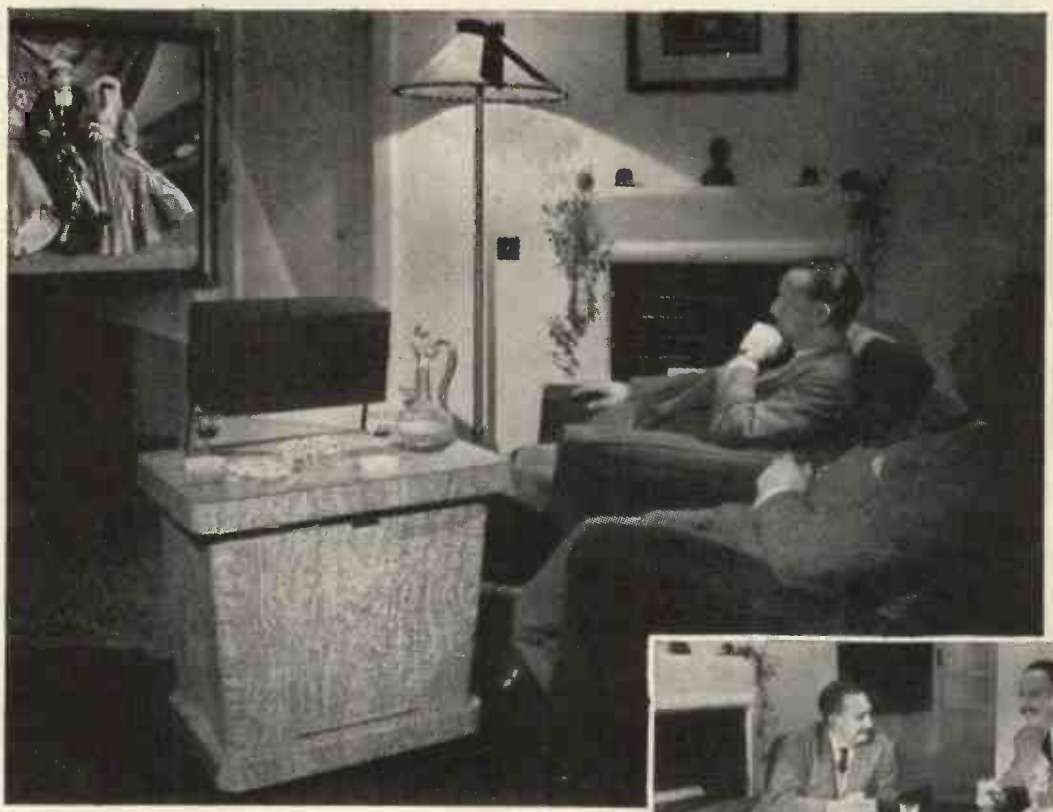

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See that coffee table? Who would guess that when television time comes round, it converts in a few seconds into a projection television receiver and transforms your room into your own private picture theatre? Open the cabinet doors . . . lift up the optical unit (so finely counterbalanced that it swings into position at a touch) . . . and switch on. Sit back with your family and friends and all enjoy the comfort and clarity of BIG television on a screen that measures no less than FOUR FEET wide. Enjoy pictures that are needle-sharp, rock-steady and distortion-free from any angle. Furnish your home with TELEMAX television and enjoy a lifetime of inexpensive entertainment.

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★ *Twin speeds 3¾in./sec. and 7½in./sec.*
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★ *4 watts output.*
★ *Hi Fi amplifier. Twin feedback loops.*
★ *Radio, Gram and Mic. inputs.*
★ *Freedom from "wow" and "flutter."*
★ *15 ohm output (3 or 7.5 ohm available).*
★ *Total distortion less than 2 per cent.*
★ *Magic eye level indicator.*
★ *7½in./sec.—30-9,500 C/s. 3¾in./sec.—30-4,000 C/s., both ± 3 db.*

These are a few of the features of this new high fidelity tape recorder. The MUSICMASTER SENIOR tape recorder embodies all the desirable features of simplicity of operation, single slot loading, twin track, two speed recording, three motor drive, freedom from "wow" and "flutter," fast forward and rewind without tape unlacing, and a new design amplifier and oscillator that give a very high standard of reproduction and low noise level. Irrespective of price the MUSICMASTER SENIOR has a performance equal to the best. It is a recorder that the discriminating purchaser cannot overlook and which the critical will purchase.

48 GNS
Carr. extra
Special transit case £2 (refunded on return).

Including one 1,200ft. reel of tape, take-up spool, microphone and mains lead. Warranted for 18 months.

P R 7 TAPE RECORDER

★ *Recording to professional standards.*
★ *Tape speeds of 7½in. or 15in. per sec.*
★ *Up to and including 2,400ft. spools.*
★ *Twin track recordings.*
★ *Built-in mixer unit.*
★ *Separate Treble and Bass controls.*
★ *High impedance output.*
★ *3, 7.5 and 15 ohm outputs.*
★ *10in. x 6in. Elliptical speaker built-in.*
★ *Monitor channel.*
★ *Meter level indicator.*
★ *7½in./Sec.—30-10,000 C/s. ± 3db.*
★ *15in./Sec.—30-17,000 C/s. ± 3db.*

£72
Carr. extra
Special transit case £2 (refunded on return).

P R 7 TAPE DESK

★ *Twin track recordings.*
★ *Fast Forward and Rewind.*
★ *Single slot loading.*
★ *15in./Sec. or 7½in./Sec.*
★ *Up to and including 2,400ft. spools.*
★ *Complete freedom from "wow" and "flutter."*

£25 **Carr. extra**

MUSICMASTER SENIOR TAPE DESK

★ *As used in above recorder.*
★ *Twin speeds. Twin track.*
★ *Single slot loading.*
★ *Fast Forward and Rewind.*
★ *Three motor drive.*

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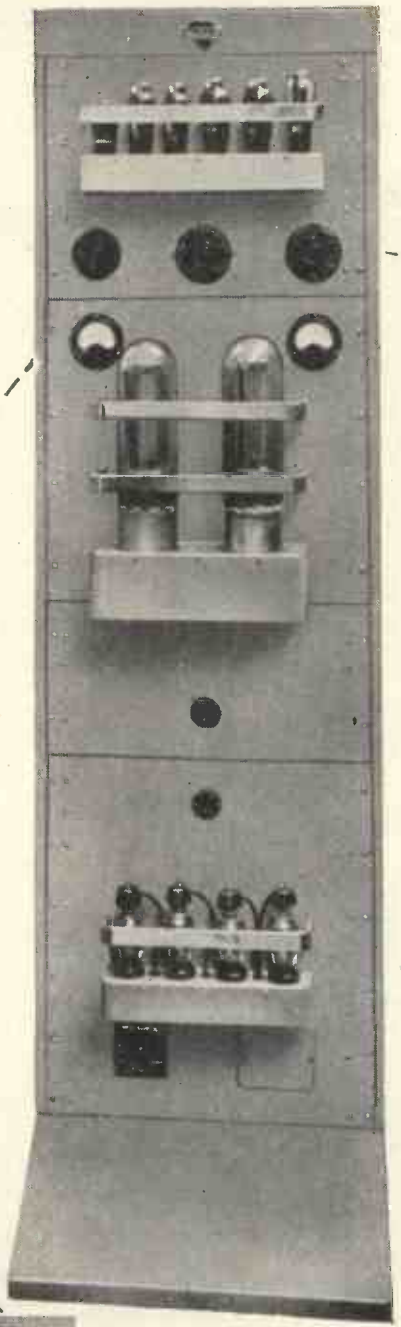
OFFICES & SHOWROOM: **196 KINGSLEY ROAD, HOUNSLOW, MIDDX. (HOUnslow 7947)** *WORKS:* **TWICKENHAM, MIDDX.**

Ultrasonic Power for Industry



L.F. Ultrasonic Generator type E.7590

MULLARD, pioneers in the application of ultrasonic power to industry, now make available the first of a range of h.f. and l.f. ultrasonic generators that provide from 50W — 1kW ultrasonic power at frequencies in the range 15 kc/s to 2 Mc/s.

These equipments are already being successfully applied to such processes as the tinning of aluminium and its alloys, the rapid cleaning of small engineered parts that are either inaccessible or that require delicate treatment, and the dispersion of particles in liquid media.

In addition to these proved applications, high power ultrasonics offers interesting possibilities in research projects where cavitation phenomena or high particle velocities are required.

Research workers and development engineers wishing to investigate the application of ultrasonics to their own particular problems are invited to take advantage of the Mullard advisory service on ultrasonics at the address below.

H.F. Ultrasonic Generator type E.7562

Mullard

SPECIALISED ELECTRONIC EQUIPMENT

Mullard Ltd., Equipment Division, Century House, Shaftesbury Avenue, W.C.2

REMEMBER POPPY DAY

Sound Appreciation

Here is an appreciation of high quality Sound reproduction, typical of many we receive from enthusiasts all over the world who own or have listened to a Goodmans High Fidelity or good quality Commercial Loudspeaker.

Berkeley, Glos.
September 7th, 1953

Dear Sirs,

On Wednesday last, the opening day of the Radio Show at Earls Court, I attended one of your sound demonstrations, and right now, please let me say how much I enjoyed it. I was greatly impressed, and in my humble opinion (Just an ordinary person who enjoys high quality) considered the results from your new 8" speaker – STUPENDOUS.

The speaker which attracted me most of all was your Axiom 150 MK.II. 12" in the specially designed cabinet, and could you please send me details of how such an identical cabinet can be constructed

AXIOM 150 MK. II

BRIEF SPECIFICATION

Frequency Coverage	30/15,000 c/s
Fundamental Resonance	35 c/s
Max. Power Capacity	15 watts peak A.C.
Flux Density	14,000 gauss
Finish	Grey Rivelling Enamel
Price	£10 : 5 : 6 (Tax free)

Dimensional drawings of this specially designed Corner Reflex Cabinet measuring approximately 46" x 29" x 19", and illustrated literature covering the full range of Goodmans Loudspeakers will be sent on request.

This is but one of the numerous unsolicited testimonials which are continually reaching us, the originals of which are available for inspection.

A TRADITION OF EXCELLENCE FIDELITY EFFICIENCY

GOODMANS

GOODMANS INDUSTRIES LIMITED
AXIOM WORKS, WEMBLEY, MIDDLESEX

Telephone : WEMbley 1200 Cables : Goodaxiom, Wembley, England

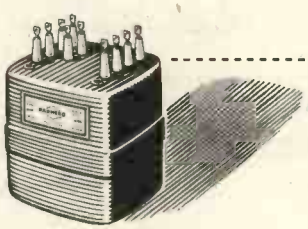
C

"Precision on Patrol"

"Hello KLN 3...attend R.T.A....A.6...6 miles from..."

Briefly—precisely—instructions are given and the patrol car is on its way. That the police are so quickly on the scene of action is due to the efficiency of their system, the skill of their men, and the dependability of their equipment.

Only the highest possible performance by its many components enables shortwave equipment to succeed in its task. Parmeko are proud of the part played by their transformers, whose absolute reliability is shown by their continued use, not only by the police and all brances of H.M. Services, but in every branch of industry



PARMEKO *of* LEICESTER

Makers of Transformers for the Electronic and Electrical Industries

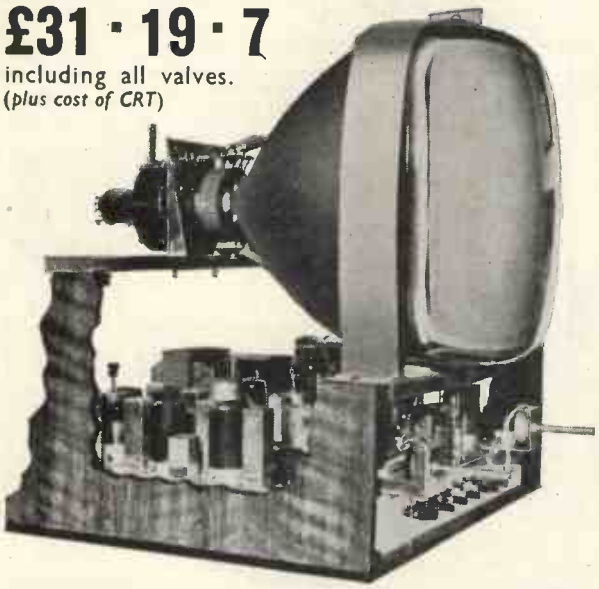
*Photograph by kind permission of The Chief Constable, Leicestershire and Rutland Constabulary

PREMIER RADIO COMPANY

MAY BE BUILT FOR

£31 · 19 · 7

including all valves.
(plus cost of CRT)



The NEW
PREMIER TELEVISOR

Three years ago we gave you the 6in., 9in. and 12in. Televisors which achieved tremendous popularity. Now after a considerable period of research our Technical Staff have designed a very worthy successor to these original Models.

Brief Technical Details are as follows:
19 valves (plus tube) Superhet Receiver, tunable from 40-68 Mc/s without coil or core changing. Wide Angle scanning Flyback EHT giving 14 kV, Duomag Focaliser permanent magnet focussing with simple picture centering adjustments, suitable for any 17in. or 14in. wide angle Tube, may also be used with a 12in. Tube with very minor modifications.

VISION CIRCUIT. Common RF Amplifier, single valve frequency changer, two IF stages, Video Detector and Noise Limiter followed by special type of Video Output Valve. ALL COILS PRE-TUNED ASSURING ACCURATE ALIGNMENT AND EXCELLENT BAND-WIDTH.

SOUND CIRCUIT. Coupling from anode of frequency changer, two IF stages, Double Diode Triode detector and first LF Amplifier, Diode Noise Limiter and Beam type Output Valve, feeding a 10in. Speaker. ALL COILS PRE-TUNED.

TIME BASES. 2 valve sync. Separator, giving very firm lock and excellent interlace.

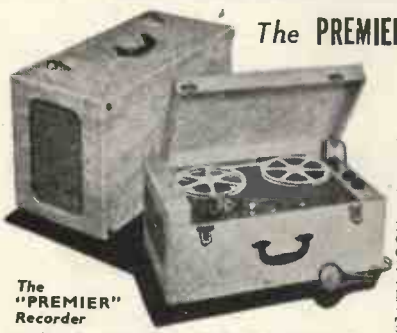
LINE TIME BASE. Blocking Oscillator using a pentode driving a high efficiency output stage comprising Ferroxcube Cored Output Transformer with Booster Diode.

FRAME TIME BASE. Blocking Oscillator driving a Beam Output Valve coupled through a Transformer to the high efficiency FERROX-CUBE Cored Scanning Coils.

POWER PACK. Double wound Mains Transformer supplying all L.T. and H.T. using two full-wave Rectifiers.

THE COMPLETE TELEVISOR IS SAFE TO HANDLE, BEING COMPLETELY ISOLATED FROM THE MAINS BY A DOUBLE WOUND MAINS TRANSFORMER. ALL PRESET CONTROLS CAN BE ADJUSTED FROM THE FRONT, MAKING SETTING UP VERY SIMPLE.

The Televisor may be constructed in 5 easy stages: **(1) Vision, (2) Time Base, (3) Sound, (4) Power Pack, (5) Final Assembly.** Each stage is fully covered in the Instruction Book, which includes layout, circuit diagrams and point-to-point wiring instructions. The Instruction Book also includes full details for converting existing Premier Magnetic Televisors for use with modern wide angle tubes. All components are individually priced. *Instruction book* **3/6** *post free.*



The **"PREMIER"** *Recorder*

The PREMIER De Luxe PORTABLE MAGNETIC TAPE RECORDING KIT

PRICE £37 : 4 : 0
(Plus 15/- Pkg., Carr. & Ins.)

★ *Including ALL parts, Valves, Portable Cabinet, 8 in. Loudspeaker, Tape-Table, Reel of 'Scotch Boy' Tape and Rewind Spool, and Microphone.*

THE 7-VALVE AMPLIFIER IS SPECIALLY DESIGNED FOR HIGH QUALITY REPRODUCTION

Brief Specification: **VALVE LINE-UP:** EP37A First Stage, 6SL7 Second Stage and Tone Control; 6V6 Output 6X5 Rectifier; VT501 Bias and Erase Oscillator; 7193 Record Level Amplifier; 6U5 Magic Eye Record Level Indicator. **OUTPUT:** 4 Watts. **FREQUENCY RANGE:** 50 c.p.s. to 9,000 c.p.s. **CONTROLS:** Volume; Record/Playback Switch; Treble Boost; Bass Boost—on/off.

A VISUAL MAGIC EYE Record Level Indicator is incorporated. The unit is housed in a superbly finished rexine covered portable cabinet which incorporates a compartment for the Microphone when not in use. Weight complete 35lb. Dimensions: 2in. long, 12½in. deep, 9½in. high.

The RECORDER incorporates an entirely NEW VERSION of the famous LANE TAPE TABLE. Brief Specification: Made to high standards and incorporating features ensuring low level of "Wow" and "Flutter" throughout the full length of tape.

FAST REWIND. Provision for fast rewind and forward run in less than 1 min. in either direction. WIND AND REWIND WITHOUT UNLACING OF TAPE. INSTANTANEOUS BRAKING. THREE MOTORS obviating friction drive.

HIGH FIDELITY RECORD PLAYBACK (1 HOUR APPROX. PLAYING). The Table is fitted with high fidelity record playback head of new design wound to high impedance and a separate A.C. Erase Head. The Heads are half-track size allowing approx. 1 hr. playing from standard 1,200ft. Reel of Tape.

TAPE SPEED: 7½in. sec. **For use on A.C. 200/250, 50 cycles mains only.**

MICROPHONE: Crystal—specially designed for Premier by famous manufacturer.

This Recording Outfit has been designed for use with M.C.-3-111 "SCOTCH BOY" Magnetic Tape. With this new and improved high-quality tape a frequency of 50 c.p.s. to 9,000 c.p.s. at tape speed of 7½ in./sec. can be readily achieved. Additional reels of 1,200ft. can be supplied at 35/-

INSTRUCTIONAL BOOKLET . . . 2/6
This is credited if a complete kit of the Tape Recorder is ordered.

As is usual in all PREMIER KITS, every single item down to the last nut and bolt is supplied. The Chassis is punched and layout diagrams and theoretical circuits are included. When completed the PREMIER PORTABLE TAPE RECORDER compares MORE than favourably with any other make at double the price.

SEPARATE UNITS CAN BE SUPPLIED AS LISTED BELOW

AMPLIFIER KIT (including 8in. Speaker)... **£11 0 0** *plus* 5/- *pkg./carr.*
AMPLIFIER (already built, wired and tested) **£14 15 0** *plus* 7/6 *pkg./carr.*
LANE TAPE TABLE & REWIND SPOOL £16 10 0 *plus* 7/6 *pkg./carr.*
PORTABLE CABINET (rexine covered)... **£4 19 6** *plus* 5/- *pkg./carr.*
MICROPHONE ..... **£2 19 6** *plus* 1/- *pkg./carr.*
REEL OF NEW M.C.-2-III "SCOTCH BOY" TAPE (1,200ft.) ..... **£1 15 0** *plus* 1/- *pkg./carr.*

To those unable to build this PORTABLE TAPE RECORDER we can supply it completely wired, tested and ready to plug in at **39GNS** *Plus 1 gn. pkg./carr.*

CRYSTAL MICROPHONE
An entirely insulated crystal microphone which can be safely used on A.C./D.C. amplifiers. High impedance. No background noise, really natural tone. The ideal Mike for tape, wire and sound projectors. Price 22/6.

MICROPHONE STAND BASE
Heavy Moulded Black Base fitted with Standard thread adaptor. Dimensions: 7½in. across, 2in. deep. Weight: 1½lb. Post paid 3/11.

MOVING COIL MICROPHONE
Low impedance. Incorporates press-to-talk switch. Housed in strong black bakelite case. Dimensions: 2in. wide, 2½in. high, 1¼in. deep.

Plus 1/6 post and packing. **19/6**
A matching transformer for high impedance can be supplied at 3/6 extra.

MICROPHONES
LUSTRAPHONE: Moving Coil; High Impedance. Stand Type: **£5/15/6**—Hand Mike **£6/6/0.**
RONETTE—Crystal Mike; Incorp. the Filter Cell Insert; High Imped. Ball Type: **£3/19/6.**
CRYSTAL MICROPHONE — Rothermel 2AD56. Especially recommended. **£2/19/6.**
Table stands for all the above 10/6 and 17/6.

PREMIER RADIO COMPANY

WHY PAY MORE?

WILLIAMSON AMPLIFIER KIT 15gns.

plus 7/6 post, pkg. & ins.
This kit is absolutely complete and all components are guaranteed exactly to author's specification.

WILLIAMSON OUTPUT TRANSFORMER

(author's spec.), 3.6 ohms. sec. £4.4.0

MAINS TRANSFORMER SP425A (with

additional 6.3 v. 3a. and capable of supplying an extra 50 mA. for Pre-amp. or Feeder Unit) £3.7.6

PREMIER MAINS TRANSFORMERS

All primaries are tapped for 200-230-250 v. mains 40-100 cycles. All primaries are screened. All LTs are centre tapped.

SP175B, 175-0-175, 50 mA., 4 v. @ 1 a., 4 v. @ 2-3 a. 25/-
SP301B, 300-0-300, 120 mA., 4 v. @ 2-3 a. 4 v. @ 2-3 a. 4 v. @ 3-5 a. 28/-
SP350A, 250-0-250, 100 mA., 5 v. @ 2-3 a. 6.3 v. @ 2-3 a. 29/-
SP351, 350-0-350, 150 mA., 4 v. @ 1-2 a. 4 v. @ 2-3 a. 4 v. @ 3-6 a. 36/-
SP352, 350-0-350, 150 mA., 5 v. 2-3 a. 6.3 v. 2-3 a. 6.3 v. 2-3 a. 36/-
SP375A, 375-0-375, 250 mA., 6.3 v. @ 2-3 a. 6.3 v. @ 3-5 a. 5 v. @ 2-3 a. 55/-
SP501, 500-0-500, 150 mA., 4 v. @ 2-3 a. 4 v. @ 2-3 a. 4 v. @ 2-3 a. 4 v. @ 3-5 a. 47/-
SP501A, 500-0-500, 150 mA., 5 v. @ 2-3 a. 6.3 v. @ 2-3 a. 6.3 v. @ 2-3 a. 50/-
SP425A, 425-0-425, 200 mA., 6.3 v. @ 2-3 a. 6.3 v. @ 3-5 a. 5 v. @ 2-5 a. 67/6
250-0-250, 80 mA., 6.3 v. @ 4 a. 5 v. @ 2a. 19/6
350-0-350, 80 mA., 6.3 v. @ 4 a. 5 v. @ 2 a. 19/6
200-230-250, output 3 v.-30 v. @ 2 a. .. 17/6
Charger, 2-6-12 v. @ 1.5 a. 12/6

SPECIAL OFFER

DOUBLE WOUND AUTO-TRANSFORMER 250 watts.

Input/Output 100, 110, 200, 210, 220, 230, 240, 250 volts. Output/Input 110, 113, 116, 119, 122, 134, 146 volts.

With the two windings connected in series a vast number of voltage tappings are available.

Plus 2/6 Pkg. and Carr. Price 35/-

PREMIER VARIABLE IMPEDANCE "MATCHMAKER" M.O.I5 OUTPUT TRANSFORMER

Designed to meet the demand for an efficient variable ratio Output Transformer. 11 ratios from 13 : 1 to 80 : 1 all centre tapped and can be used to match any output valves either single- or push-pull. Class "A" "AB1" "AB2" or "B" to any low impedance speech coil or combination thereof. Primary Inductance 60 henries 15 watts audio 100 mA. Price 45/-.

WEYMOUTH MINIATURE I.F. TRANSFORMERS

465 Kc/s., iron cored, permeability tuned, 10/6 pair.

WEYMOUTH MINIATURE COIL PACK

Covering Med./Long/Short wave bands. Iron cored coils, gram position on switch. Dimens.: Height, 1¾in. Length. 3¼in. Width 2¾in. Spindle length 2in. Price 19/6.

MINIATURE TUNING CONDENSERS

2 gang .0005 mfd. with trimmers 6/9

CHARGER TRANSFORMERS

Input 230 v. A.C. Output 12 v. at 1 amp. Completely shrouded. Price 9/11

BATTERY CHARGERS

200-250 v. A.C. Will charge 2 v., 6 v. and 12 v. Car Battery at 1 amp. Housed in strong metal casing. Finished in Green hammered enamel. Size: 6in. long, 3½in. wide, 3¼in. high. Guaranteed 12 mths. The above unit is manufactured by PREMIER and does not contain ex-Govt. components. Plus 2/6 post and pkg. 39/6

BATTERY CHARGER KITS

All incorporate metal rectifiers. Transformers are suitable for 200/250 v. A.C. cycle mains.

Cat. No.
2002 Charges 6 volt accumulator at 1 amp. Resistance, supplied to charge 2 v. accumulator 21/-
2003 Charges 12 volt accumulator at 1 amp. 22/-
2004 Charges 2, 6 and 12 v. accumulators at 1 amp 24/6

H. T. Eliminator *Ex. Govt.*

By famous manufacturer

NEW & UNUSED. Input 200/250 v. A.C., Output 120—at 30 mA., housed in strong metal box size 10in. long, 7in. wide, 6¼in. deep.

37/6

Plus 2/- pkg. and carr.

H.T. ELIMINATOR AND TRICKLE CHARGER KIT

All parts to construct an eliminator to give an output of 120 volts at 20 mA., and 2 volts to charge an accumulator. Uses metal rectifier, £2.

C.R. TUBES

VCR516
9in. Blue picture, Heater volts 4 Anode 4 Kv. In manufacturer's original carton.
£3/19/6. Plus 5/- pkg., carr., ins.

VCR517C
6½in. picture. This tube is a replacement for the VCR97 and VCR517. Guaranteed full size picture.
Price 35/- Plus 2/6 pkg., carr., ins.

ALL BRAND NEW

AUTO TRANSFORMER, 50 watts

Input/Output 0-110-210-220-230-240-250-volts. Plus 1/- P. & P. 7/6

Famous Set Manufacturer's surplus of

ELECTRIC 'GRAM UNITS

Two-speed, 33⅓ and 78 r.p.m. For playing Standard and L.P. recordings. Complete with Turntable. For use on 200-250 v. A.C. mains. Each unit is in its original manufacturer's carton and is fully guaranteed. Limited quantity only available at approx. half list price.

£4 · 2 · 6

Plus 2/6 pkg., carr., ins.

SPECIAL OFFER

THE FAMOUS "CHANCERY" HIGH FIDELITY MICROCELL PICK-UP—TYPE GPX *for Standard and Long Playing*

The Chancery Light Weight GP.X Pick-up which has a sapphire stylus which is precision ground and semi-permanent. With two cartridges 1 L.P. and 1 Standard. Price 52/6. *Additional L.P. or Standard Cartridges can be supplied from stock at* 19/6 *each.*

QUALITY CRYSTAL PICK-UP ROTHERMELL TYPE U48 26/-

plus 1/6 Pkg. and Carr.

PORTABLE GRAMOPHONE UNIT

Ready to plug into Radio or Amplifier. Fitted with B.S.R. 2-speed motor 33⅓ and 78 r.p.m. and Chancery high fidelity microcell pick-up type G.P.X. with L.P and Standard Cartridges. Assembled in rexine covered cabinet. Height 5½"; Length 15½"; Depth 13¾". Price £7 . 7 . 0 plus 7/- Pkg. & Carr.

Cabinets can be obtained separately at 29/6 plus 2/6 Pkg. & Carr. Carrying handle and clips are supplied free.

THE COLLARO RC3/521 3-SPEED AUTOMATIC RECORD CHANGER

Magnetic Studio head transformer included. Motor suitable for 100/125v. or 200/250v. Play either 7" or 10" or 7" and 12" not mixed.

Price £9 . 19 . 6

Plus Pkg. and Carr.

GARRARD Type 75A. Latest 3-speed Autochange Unit complete with 2 Acos High Fidelity G.P.19 Pick-up Heads. 1 L.P. and 1 Standard. £14.19.6

GARRARD Rim Drive 78 r.p.m., complete with magnetic pick-up and turntable ... £5.19.6

COLLARO 3-speed single-gram. unit, complete with head for L.P. and Standard recordings £6.19.6

Packing and carriage on each of the above units 2/6.

PLESSEY 3-SPEED AUTO CHANGER UNITS

Brand new in maker's cartons, complete with mounting instructions.

This unit will auto change on all 3 speeds, 7in., 10in. and 12in. Fitted with separate sapphires for L.P. and STD., which are moved into position by a simple switch. Price 10 Gns.

5/- Pkg. and Carr. for each of above.

"MASTERADIO" VIBRATOR PACK

6 v. input; 150 v. 60 mA. output; complete with valve rectifier and leads. 49/6. Plus 5/- pkg., carr.

ACCUMULATORS

Lead Acid Celluloid Non-Spill, 2v., 7 amps 8/6
2 volt 10 amp (by famous maker)..... 4/11

RECTIFIERS

E.H.T. Pencil Type S.T.C.

Type K3/25	650 v.	1 mA.	4/7
,, K3/40	3.2 kV.	1 mA.	6/-
,, K3/45	3.6 kV.	1 mA.	8/2
,, K3/50	4 kV.	1 mA.	8/8
,, K3/160	12 kV.	1 mA.	21/6

H.T. Type S.T.C.

Type RM1	125 v.	60 mA.	4/-
,, RM2	125 v.	100 mA.	4/6
,, RM3	125 v.	125 mA.	5/6
,, RM4	250 v.	250 mA.	18/-

L.T. Type Full Wave

6 v. 1 amp.	4/-
12 v. 1 amp.	8/-
12 v. 2 amp.	10/9
12 v. 4 amp.	12/6

A.C.R. I.C.R. TUBES

5¼in. screen. 4 volt Heater. This Electrostatic Tube is recommended as eminently suitable for Television 15/- plus 2/6 Pkg., carr. and ins. Data sheets supplied

SUPER QUALITY TELEVISION MAGNIFYING LENS

5in. lens suitable for 6in. 18/6
6in. lens 25/-
10in. lens £2/10/-
12in. lens £3/10/-

ALUMINIUM CHASSIS 18 s.w.g.

Substantially made from Bright Aluminium, with four sides

7 × 5½ × 2in.	4/-
7 × 3½ × 2in.	3/9
9½ × 4½ × 2in.	4/3
10 × 8 × 2½in.	5/6
12 × 9 × 2½in.	7/-
14 × 9 × 2½in.	7/6
10 × 9 × 3in.	7/-
12 × 10 × 3in.	7/9
14 × 10 × 3in.	7/11
16 × 10 × 3in.	8/3
16 × 8 × 2½in.	8/-

ALUMINIUM PANELS 18 s.w.g.

7 × 6in.	1/3	7 × 4in.	1/-
9½ × 6in.	1/8	9½ × 4in.	1/5
10 × 9in.	2/2	10 × 7in.	1/11
12 × 9in.	2/8	12 × 7in.	2/5
14 × 9in.	3/2	14 × 7in.	2/11
16 × 9in.	3/9	16 × 7in.	3/5
20 × 9in.	4/8	20 × 7in.	4/5
22 × 9in.	5/2	22 × 7in.	4/11

LOUDSPEAKERS

ELAC—2½in. dia., Moving Coil, 15 ohms imp. 15/-
PLESSEY—3in. dia., Moving Coil, 3 ohms imp. 15/-
ELAC—3½in. dia., Moving Coil, 3 ohms imp. 15/-
ELAC—5in. dia., Moving Coil, 3 ohms imp... 14/6
E.M.I.—6in. Elliptical, 15 ohms imp. 27/6
PLESSEY—8in. dia., Moving Coil, 3 ohms imp. 14/6
PLESSEY—8in. dia., Mains Energised, 3 ohms imp. (600 ohms field), with Pentode Transformer 22/6
PLESSEY—8in. dia. Mains Energised, 3 ohms imp. (600 ohms field) 19/6
PLESSEY—10in. dia. Moving Coil, 3 ohms imp. 23/6
GOODMANS—12in. dia., Moving Coil, 15 ohms £8/8
Plus 5/- packing and carriage.
VITAVOX—K12/20 12in. dia., Moving Coil, 15 ohms imp. £11/11
Plus 5/- packing and carriage.

SPECIAL OFFER

A 12in. TRUVOX P.M. SPEAKER

(2-3 ohm Voice Coil) For only
These are brand new in Maker's Cartons 49/6
Plus 2/- Pkg. and Carr.

METERS

Large stocks available, a few of which are enumerated below :—

Full Scale Deflection	Scale Length in.	External Dimensions in.	Movement	
25 A	1½	2½ round ..	R.F. Thermo ..	7/6
3.5 A	1½	2½ × 2½	R.F Thermo ..	7/6
4 A	1½	2½ × 2½	R.F. Thermo ..	7/6
20 A	1½	2½ round ..	M/C	8/6
40 A ..	1½	2½ round ..	M/C	8/6
1.5 mA ..	1½	2½ round	.....	12/6
5 mA..	2	3½ round	.....	7/6
6 mA...	2	3½ round	.....	16/9
50 mA ..	1½	2½ × 2½	M/C	7/6
20 V	2	2½ × 2½	M/C	8/6
40 V	1½	2½ × 2½	M/C	8/6
1 mA ..	2	3½ round ..	M/C	25/-

MOVING COIL METER

A super quality Moving Coil Meter basic movement 2 mA Scale dimensions 2½in. Overall dimensions 2½in. dia. 1½in. deep. Bakelite Case projecting type. At present scaled 1 amp. R.F. By removing thermo couple, reversing scale and recalibrating the meter, a high grade test instrument with any range above the basic F.S.D. may be built up. Price 4/9

1 mA METER IN PLASTIC CASE

The movement is 1 mA mounted in a case 3½in. square and 3½in. high. The scale is 2½in. long and the dial is 2½in. diameter. There is ample room in the case for a switch and multipliers. Internal Resistance 100 ohms. Price 27/6

Germanium Crystal Diodes. G.E.C. wire ended, 2/6, 24/- doz.

Great Britain's Valve Mail-Order House

RADIO **BULLS** VALVES
246 HIGH ST., HARLESDEN, N.W.10

SERVICE SHEETS

The one you require enclosed if available in a dozen assorted of our best choice. **10/6**

Q-MAX

Chassis Cutters with keys.

The easiest and quickest way of cutting holes in sheet metal.
The cutter consists of three parts: A die, a punch and an Allen screw. The operation is quite simple. Prices:
⅜in. 12/4; ½in. 12/4; ⅝in. 13/4; 1in., 1¼in. and 1½in., 16/- each; 1⅝in. and 1¾in. 18/- each; 1⅞in., 19/9; 2 3/32in., 31/9; 2½in., 36/9; 1in. square, 24/3. Post 1/-.

TYANA TRIPLE THREE

Small Soldering Iron. Latest development. Complete with detachable bench stand, 19/6. Post 1/-.

Adcola Irons, 25/6.

HOME BROADCASTER

Connects to radio or gram. Talk over your own radio, room to room. Easy to fix. Two mikes makes 2-station house phone in your own home. Order to-day,

12/6 post 1/6.

MORSE BUZZER OUTFITS

Consisting of a buzzer, a morse key and a battery compartment, all mounted on a polished baseboard. All parts high grade ex-Air Ministry. An excellent gift for a boy. Post free

6/-

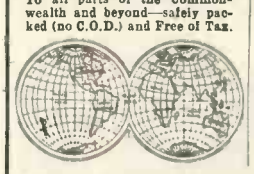
B.T.H. GERMANIUM CRYSTAL DIODE

Complete with Blueprint and operating instructions

3/-

EXPORT

To all parts of the Commonwealth and beyond—safely packed (no C.O.D.) and Free of Tax.



TRUVOX TAPE DESK MARK III.

Incorporating high impedance mu-metal twin-track heads. Two-speed capstan for tape speeds of 7½ and 3¾ inches per second. Three heavy-duty motors allowing for fast forward and rewind facilities without tape handling. All controls operated by electrically and mechanically interlocked push buttons. Price £23/2/-. FREE carriage.

TAPEMASTER RECORDING COMPONENTS

Suitable for use with either Hartley or Culpitts Circuits.

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71A	12 10 0	1 17 6	1 4 0	13 17 6
72A	16 0 0	2 8 0	1 10 8	17 14 8
77A	15 0 0	2 5 0	1 8 8	16 11 8
88A	21 10 0	3 4 6	2 1 2	23 16 2
110C	14 10 0	2 3 6	1 7 9	16 1 0
120A	9 0 0	1 7 0	17 3	9 19 6
130A	15 0 0	2 5 0	1 8 8	16 11 8
170A	24 0 0	3 12 0	2 5 11	26 11 2
190A	22 10 0	3 7 6	2 3 0	24 17 6
240A	14 0 0	2 2 0	1 6 9	15 9 6
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*Type 17/9	5	0		3/32 15"	21	17	11	
				TA10 10"	14	18	11	
				TA10/J 10"	14	18	11	
				TA15 15"	21	17	11	
				TA15/J 15"	21	17	11	
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				MW36/22 14"	19	9	3	
				MW36/24 14"	19	9	3	
				MW41/1 16"	22	4	10	
				*Moulded bases ea.	B	1	2	A 6

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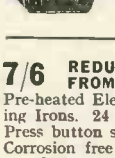

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101	Quad, with control unit	35	0	0
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103/2	Goodsell MA.5	13	10	0
103/3	Goodsell Williamson	33	0	0
104	Rogers Baby de-luxe	14	0	0
105	Lowther B.5F	21	0	0
105/1	Lowther A.10F 7.5 watts	35	0	0
PRE-AMPLIFIERS				
150	Leak "Vari-Slope"	12	12	0
151	Goodsell Type U/TC	8	15	0
151/1	Goodsell Type F/U/TC	12	12	0
151/2	Goodsell Type P/FA	22	10	0
152	Rogers Junior de luxe Mk. II	9	0	0
153	Lowther Pre-Amp. and Tone Control Unit	20	0	0
TONE-CONTROLS, FILTERS, ETC.				
200	E.M.G. Infinitely Variable Steep-cut Filter	4	10	0
201	Leak Steep-cutting Filter	5	10	0
203	Wharfedale Microgroove Equaliser MG.1	2	17	6
203/1	Wharfedale Cross-over Unit, 1,000 c.p.s., 7-16 ohms	3	12	6
203/2	Wharfedale Cross-over Unit, 3,000 c.p.s., 7-16 ohms	2	18	6
204	Lowther Independent Bass and Treble Corrector B.T3	9	9	0
204/1	Lowther 9 Kc Whistle Filter	3	3	0
RADIO UNITS COMPLETE (Supplied in chassis form for building into cabinets.) *Broadcast and Shortwave*				
250	Leak	34	19	0
251	Quad, for use with Quad amp	24	10	0
252	Rogers	24	16	0
255	Lowther Straight Tuner LEI.2	22	7	9
256	Grundig (for use with T/R)	21	0	0
257	Chapman S.4	16	0	0
259	Armstrong EXP.73 Superhet	23	13	0
259/1	Armstrong RF.41	31	19	8
259/2	Armstrong EXP.119	55	19	4
259/3	Armstrong BS.125	70	12	6
VHF, AM, FM Units				
280	Lowther VHF "Wrotham" AM Unit	6	10	0
280/1	Lowther AM/FM	22	0	0
WHARFEDALE SPEAKER				
600/9	Golden 10in.	7	13	3
601/1	W.10/CSB	12	6	6
601/2	W.12	9	5	0
601/3	W.12/CS	9	15	0
601/4	Super 12in./CS/AL	16	0	0
601/5	W.15	15	10	0
GOODMAN SPEAKERS				
603/1	Audiom 70 12in.	13	15	0
603/2	Audiom 80 15in.	22	10	0
603/5	Axiom 22 12in.	14	14	0
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LOWTHER VOIGT				
607	LOWTHER VOIGT PM/2 Drive Unit	35	0	0
607/1	LOWTHER VOIGT PM/4 Drive Unit	48	0	0
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608	Voigt P.M. Pressure Unit	42	0	0

(Continued on next page)

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703	ACOUSTICAL Corner Ribbon	95	0	0
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509	Tapemaster Oscillator Coil		10	6
511	Tapemaster Recording Head	1	19	6
512	Tapemaster Snr. Play/Record Head	2	5	0
512A	Tapemaster Erase Head	2	5	0
513	Wearite Head Lift Transformer Type 977	1	10	0
514	Wearite Oscillator Coil Type 579		7	6
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520	Collaro Clock and Anti-clockwise	1	18	6
523	B.S.R. Model F.P.10	1	18	0
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584	Motek	16	10	0
585	Lane, Mark IV	17	10	0
586	Truvox, Mark III	23	2	0
587/1	Wearite, Type 2A	35	0	0
588/1	Bradmatic, Type 5 /6RP	41	0	0
588/2	Bradmatic, Type 5C	45	10	0
591	Reflectograph	39	10	0
952/1	Lane Amplifier Kit	13	10	0
592/2	Lane Amplifier, assembled	15	10	0
593/1	Elipco Junior Amplifier	16	16	0
593/2	Elipco Senior Amplifier	24	0	0
595/1	C.J.R. Professional Type P.A.I.	94	0	0

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Complete set of parts for building the Sound Master tape desk		13	13	0			
					13	13	0

		£	s.	d.	£	s.	d.
W.B							
Amplifier Chassis	WB201	1	15	0			
Power Unit Chassis	WB202	1	11	6			
Brackets, Pillars abd Screens	WB203		11	2			
Mains Transformer 1	WB204	3	7	6			
Smoothing Choke..	WB205		19	6			
Output Transformer	WB206		12	0			
Bias Rejector Coil..	WB207		6	0			
Loudspeaker, New Type 610 with Cambric Cone	WB208	2	10	0			
Soundmaster Cabinet	WB209	6	0	0			
					17	12	8
MULLARD VALVES							
2—EF40's at 22/9		2	5	6			
1—EL41			17	3			
1—EM34			17	3			
1—ECC40		1	2	9			
1—EZ40			13	11			
					5	16	8
					£62.0.10		

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VALVES, TUBES & CIRCUITS

11. PRE-AMPLIFIER PENTODE TYPE EF86

In most audio amplifier applications it is necessary to provide at least one stage of voltage amplification in which any hum, noise or microphony which could be introduced by the valve must be reduced to a minimum. This is particularly important in the early stages of high-gain amplifiers, in microphone pre-amplifiers and in magnetic tape recording applications.

These requirements have been specially considered in the design of the Mullard voltage amplifying pentode type EF86 which is recommended for all audio-frequency applications where low levels of hum, noise and microphony are essential. This valve is in the miniature all-glass range having a single-ended construction and a B9A (noval) base. Its heater, rated at 6.3V, 0.2A is suitable for series or parallel operation with either a.c. or d.c. Typical conditions of operation are given in the accompanying table of data.

HUM

In the design of the EF86 special precautions have been taken to reduce possible sources of hum in the valve. A bifilar heater construction minimises the effect of hum due to the magnetic field of the heater. Effective internal screening assists in reducing hum due to both internal capacitances and external fields. In addition the internal control grid lead is surrounded by a guard ring which is connected to pin 7 and is normally earthed. This reduces leakage to the grid across the base of the valve and also reduces the capacitance between grid and heater.

When used as a normal voltage amplifier with a line voltage of 250V, an anode load of 100 kΩ and a grid resistor of 470 kΩ the maximum hum level of the valve alone is 5 μV, the average value being about 3 μV when operated with one side of the heater earthed. This can be further reduced by centre-tapping the heater to earth. Under these conditions the maximum hum level is 1.5 μV.

The low levels of hum attained with this valve can be completely masked by an unsuitable choice of valve-holder in which leakage and capacitative coupling between pins can introduce considerable hum. For most applications it is found that a low-loss type of holder such as nylon-loaded phenolic or P.T.F.E. is adequate.

NOISE

The low-frequency noise generated by a valve is most conveniently specified as an equivalent voltage on the control grid for a specific bandwidth. For the EF86 under normal conditions, *i.e.* line voltage of 250 V and an anode load of 100 kΩ, the equivalent noise voltage is approximately 2 μV for the frequency range 25-10,000 c/s.

MICROPHONY

Care in the design of the valve to ensure that the electrode structure and its mounting are as rigid as possible has reduced the microphony of the EF86 to a very low level. There are no appreciable internal resonances at frequencies below 1,000 c/s. At higher frequencies the effect of vibration is usually negligible on account of the damping provided by the chassis and the valve-holder. In high-gain applications such as tape recording care should be taken in siting the valve, particularly when a loudspeaker is present in the same cabinet or when a motor is mounted on the same chassis. In such cases a flexible mounting for the valve-holder or a separate weighted sub-chassis is advisable.

VALVE DATA

HEATER		
V_h	6.3	V
I_h	0.2	A
CAPACITANCES		
C_{out}	5.5	μμF
C_{in}	4.0	μμF
C_{a-gl}	0.025	μμF
C_{gl-h}	0.0025	μμF
LIMITING VALUES		
V_a max.	300	V
p_a max.	1.0	W
V_{g2} max.	200	V
p_{g2} max.	0.2	W
I_k max.	6.0	mA
V_{h-k} max.	100	V
BASE	B9A	

CHARACTERISTICS		
V_a	250	V
V_{g3}	0	V
V_{g2}	140	V
I_a	3.0	mA
I_{g2}	0.6	mA
V_{gl}	-2.0	V
g_m	1.8	mA/V
r_a	2.5	MΩ
DIMENSIONS		
Max. seated height	49	mm
Max. over-all length	56	mm
Max. bulb diameter	22.2	mm

TYPICAL OPERATING CONDITIONS AS R.C. COUPLED A.F. AMPLIFIER.

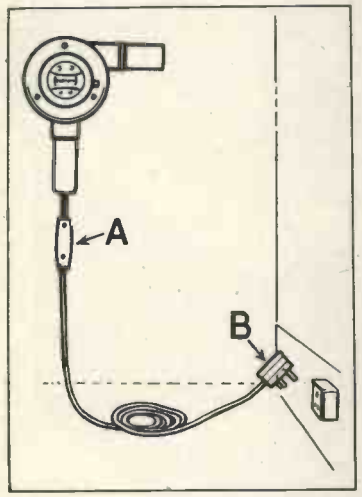
V_b (V)	R_a (kΩ)	I_k (mA)	R_{g2} (MΩ)	R_k (kΩ)	$\frac{V_{out}}{V_{in}}$	V_{out} (V)	D_{tot} (%)	R_{g1}* (kΩ)
PENTODE CONNECTION.								
300	100	2.45	0.39	1.0	116	64	5.0	330
250	100	2.05	0.39	1.0	112	50	5.0	330
200	100	1.65	0.39	1.0	106	40	5.0	330
150	100	1.0	0.47	1.5	95	22	5.0	330
300	220	1.1	1.0	2.2	188	54	5.0	680
250	220	0.9	1.0	2.2	180	46	5.0	680
200	220	0.75	1.0	2.2	170	36	5.0	680
150	220	0.55	1.0	2.7	150	24.5	5.0	680
TRIODE CONNECTION.						†		
300	100	1.5	—	2.2	28.5	50	3.8	330
250	100	1.25	—	2.2	28	39	3.7	330
200	100	1.0	—	2.2	27.5	27.5	3.3	330

**Grid resistor of following valve.*
†V_{out} at commencement of grid current.

THE "BELLING-LEE" PAGE

Providing technical information, service and advice in relation to our products and the suppression of electrical interference

Split Suppression for T.V. Interference



Split suppression is the name given to a technique which is coming into more general use with the advent of TV flex lead suppressors.

It implies suppression in two stages; TV suppression "A" at one point in the appliance, and broadcast frequency suppression "B" at another.

It is well known that a suppressor must be fitted near the appliance to be effective; this is particularly important at TV frequencies, and if for any reason a TV suppressor has to be fitted in a flex lead, it must be within a few inches of the appliance. See "A." At broadcast frequencies some concessions to this can often be made, and provided that the flex is not too long, a broadcast frequency suppressor will work well at the mains outlet socket "B," possibly forming an integral part of the socket or plug. (There is much to be said for the latter arrangement, since this means that the appliance is suppressed when plugged into any socket.)

TV suppressors are inherently smaller than broadcast frequency suppressors, and "Split Suppression" takes advantage of this by providing a very compact TV suppressor "A" in the flex lead near the appliance, together with a suppressed mains plug "B" to take care of the long and medium wavebands. This is essentially an arrangement for the sake of convenience, and is of obvious value for appliances normally held in the hand, where a bulky suppressor would be a nuisance.

"Split Suppression" is therefore recommended for hairdryers, electric razors, electric drills, etc., with leads not greater than 6 feet. It is not suitable for vacuum cleaners and other appliances with long trailing flexes, but here a rather larger all-wave suppressor can be fixed to or near the appliance without causing inconvenience.

Electric sewing machines can be dealt with by either method.

Flex Lead Suppressor

L.799 is an Inductor and Capacitor suppressor indicated at "A" in sketch (see first column). The inductors are wound for 2 amp. To be effective at TV frequencies it must be fitted not further than 6 inches from the connectors of **the motor in the appliance.**

Plug Point Suppressor

L.1308 is the capacitor filter indicated at "B" in sketch. The capacitors are built into a 3 pin 5 amp. plug. Whilst the plug by itself provides ample suppression in most cases, on long and medium wavebands, it is only effective at TV frequencies when used in conjunction with L.799.

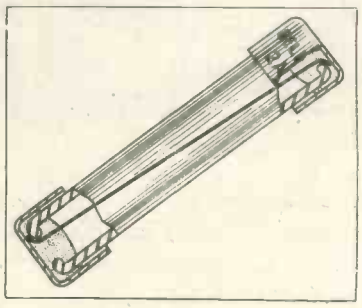
RADIO SHOW
This Year's Funny Story.

The visitor who thought that the folding of a dipole was to facilitate packing.

Improved Method of Fuse-Link Production

No more loose caps, they are locked to the glass, caps and filament as one. The glass will shatter before a cap can move. Mechanically and electrically this is a better fuse-link, and one that is less likely to deteriorate in use. The element is placed diagonally as a means of combating the bad effect of a sagging wire, which might touch the glass, cool off, and thereby defeat its purpose. Other features of the new "lock-cap" assembly are—

1. Fuse markings on caps are not lost.
2. Even extreme vibration cannot harm the element which is secured against breakage.
3. Hermetic sealing of the element against moisture and corrosion, prevents "perspiration" and sweating of the fuse.
4. Protection against rapid and extreme temperature changes—heat to cold and vice versa.
5. No external solder blobs on end caps—resulting in better end contact.
6. Strain relieved hard glass tube gives much greater strength and resistance to fracture on high current rupture.



7. More accurate dimensions and alignment and higher finish.
8. Element straight and more visible.

Written 30th September, 1953.

E·M·I

RECORDING EQUIPMENT

Made by E.M.I. — with their unrivalled knowledge and experience of sound recording — the Emicorda combines quality of recording and reproduction with simplicity of operation (which is so important to the non-professional user).

The Emicorda is the home version of the E.M.I. Tape Recorders used by the leading broadcasting and recording organizations.

The

EMICORDA

PRICE 90 GNS. *Model 2301 (right)*

FOR BETTER RECORDINGS

Emitape is the outcome of 50 years of research in the science of sound recording by the E.M.I. Group (H.M.V., Columbia and Parlophone). Available for all types of tape recorders, the Standard High Coercivity tape is made in two lengths — 600ft. (Type H60/6), 21/-, and 1,200 ft. (Type H60/12) 35/-.

EMITAPE

Emidiscs are the supreme lacquer recording blanks noted for free cutting and low background noise, allied with excellent frequency response and anti-static properties. Available in four grades, and wide range of sizes.

EMIDISCS

Send today for full details :

E.M.I. SALES & SERVICE, RECORDING EQUIPMENT DIVISION, HAYES, MIDDLESEX

SOUTHALL 2468 ES26L

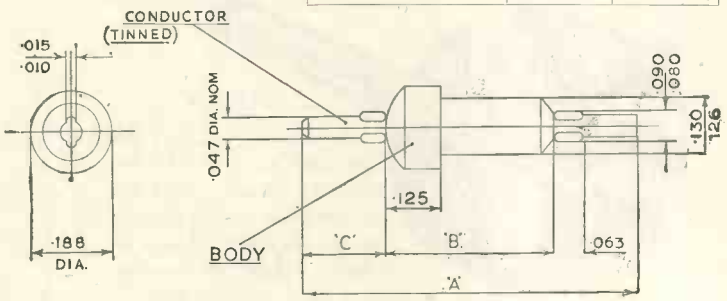
POLYTAGS...lead-through and stand-off insulators

Polytetrafluoroethylene (P.T.F.E.) is an outstanding insulator. It is tough, durable and will not crack or arc. Its dielectric properties are substantially constant over a frequency range of 60 c.p.s. to at least 300 Mc.p.s. and are unaffected by temperature changes between minus 100°C. and plus 288°C. It has zero moisture absorption and is water repellent. It is, therefore, a most suitable material for stand-off and feed-through insulator terminals and has been chosen by Ediswan for this purpose. Ediswan Polytags are available in five types as illustrated below.

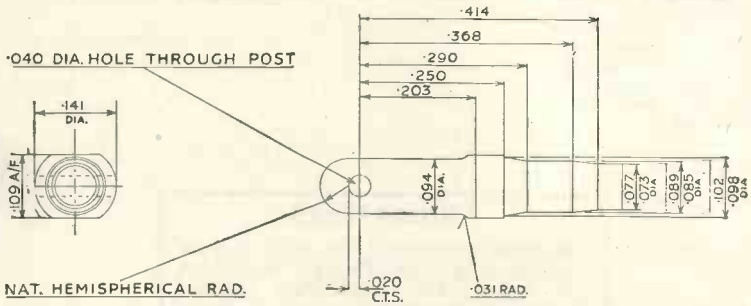
PT 1 & 2. Lead-through

PT 3 & 4. Stand-off

	A	B	C
PT 1	.750	.375	.188
PT 2	.875	.500	.188
PT 3	.563	.375	—
PT 4	.688	.500	—



PT 5. Component mounting



Fixing: Polytags are primarily designed for fixing with a 5 B.A. nut—PT 1—4 or an 8 B.A. nut PT 5. They are self-tapping.

We are equipped to produce components fabricated or moulded in P.T.F.E. to individual specifications and enquiries will be welcomed.

EDISWAN

CLIX

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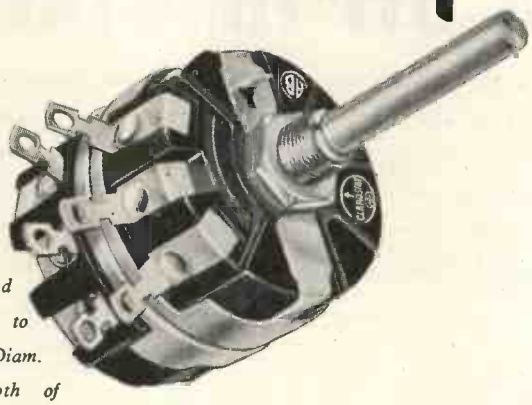
F

Introducing

Further additions to the range of

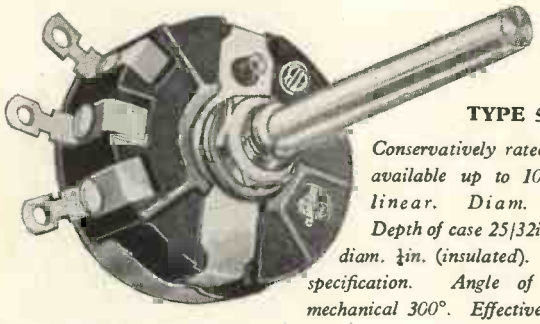
Clarostat† WIRE-WOUND Controls

All Clarostat controls are manufactured with high grade Bakelite cases of rugged construction. Solder tags are heavily silver-plated and of special design, removing all danger of turning or loosening under operating conditions. The controls are fitted with metal dust covers which are firmly keyed into the Bakelite casing and connected to the fixing bush, thus providing automatic earthing of cover. Samples available on application.



TYPE 58 (Dual)

Two controls in tandem operated by a common spindle. Each control wound to any resistance up to 100,000 *ohms linear. Diam. 1.21/32in. Total depth of case 1.9/16in.*



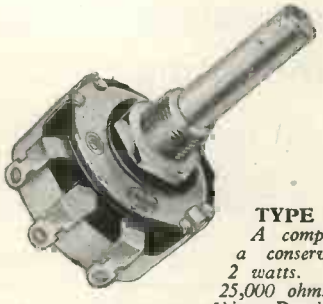
TYPE 58

Conservatively rated at 3 watts: available up to 100,000 ohms linear. Diam. 1.21/32in. Depth of case 25/32in. Spindle diam. ¼in. (insulated). Length to specification. Angle of rotation, mechanical 300°. Effective 280°.

All controls can be supplied with special windings and closer tolerances to specification. Can also be supplied fitted with single or double pole mains switch if required.

TYPE 43 (Dual)

Any two controls of specified value can be mounted in tandem operated by a common spindle. Diam. 1⅛in. Total depth of case 1.3/16*in.*



TYPE 43

A compact control with a conservative rating of 2 watts. Available up to 25,000 ohms linear. Diam. 1⅛in. Depth of case 19/32in. Spindle diam. ¼in. (insulated). Length to specification. Angle of rotation, mechanical 300°. Effective 280°.

WHOLESALERS

Clarostat wire-wound Potentiometers are supplied with a spindle 2½in. long with full length flat, individually packed in sturdy two-colour cartons. Delivery is prompt. Write for details of very attractive trade terms.

† *Regd. Trade Mark*

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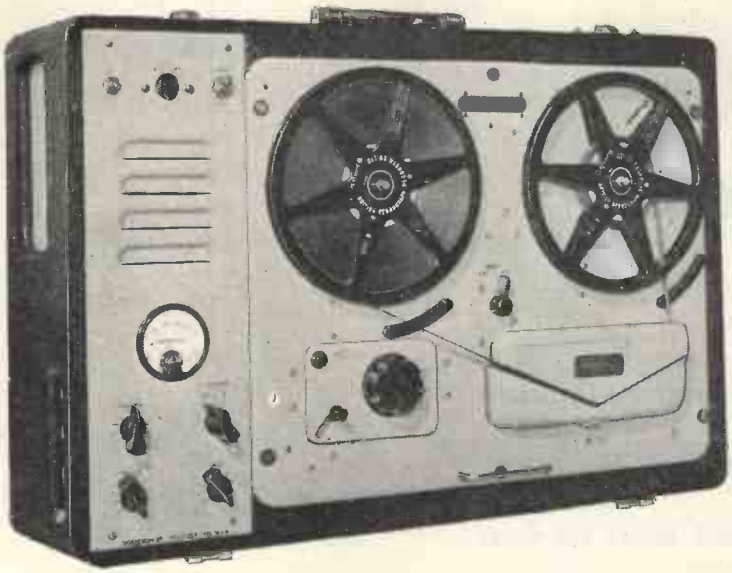
Phone: GROsvenor 5206/7

VORTEXION TAPE RECORDER



The amplifier, speaker and case, with detachable lid, measures 8¼in. x 22½in. x 15¾in. and weighs 30 lb.

PRICE, complete with WEARITE TAPE DECK £84 0 0

★ The noise level is extremely low and audibly the hum level and Johnson noise of the amplifier and deck are approximately equal. Only 25% of this small amount of hum is given by the amplifier alone.

★ Extremely low distortion and background noise, with a frequency response of 50 c/s.—10 Kc/s., plus or minus 1.5 db. A meter is fitted for the measurement of signal level and bias level.

★ Sufficient power is available for recording on disc, either direct or from the tape, without additional amplifiers.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.s, microphone or radio inputs.

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ Facilities are provided for using the amplifier alone and using power output or headphones while recording or to drive additional amplifiers.

★ The unit may be left running on record or play back even with 1,750 ft. reels with the lid closed.

POWER SUPPLY UNIT to work from 12 volt Battery with an output of 230 v., 120 watts, 50 cycles within 1%. Suppressed for use with Tape Recorder. **PRICE £18 0 0.**

FOUR CHANNEL ELECTRONIC MIXER

is almost essential for the professional or semi-professional where a number of different items have to be mixed on one tape recording.
It is recommended by a number of tape recorder manufacturers for this purpose.
Any normal input impedance can be supplied to order, balanced or unbalanced, the standard being 15-30 ohms balanced.
The normal output is 0.5 volt on 20,000 ohms or less, but 600 ohms is available as an alternative.
The steel stove enamelled case is polished and fitted with an engraved white panel suitable for making temporary pencil notes.
An internal screened power pack and selenium rectifier feed the five low noise non-microphonic valves.
Used in many hundreds of large public address installations and recording studios throughout the world.

PRICE
£36.15.0

Manufactured by

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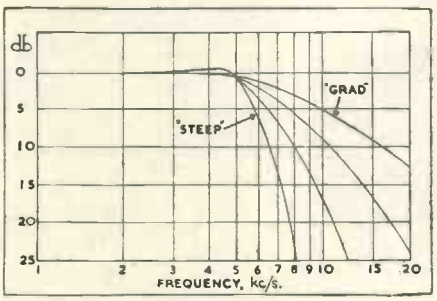
Telephones: LIBerty 2814 and 6242.3 Telegrams: "Vortexion, Wimble, London."

LEAK *equipment is* ***unique***—

It is acceptable to professional communications engineers for recording and broadcasting. The B.B.C. use several hundreds of the TL/12 Amplifier, and 1,000 are used by other Broadcasting Corporations.

The Vari-Slope

Representing a unique feedback circuit development, the "Vari-Slope" pre-amplifier gives audibly better reproduction. This advance consists of variable-slope "electronic" low-pass filters operating on negative voltage feedback principles. No Inductors ("Chokes") are used, and their disadvantages are completely eliminated. The turnover frequencies are 5kc/s, 7kc/s, and 9kc/s, and the slopes of attenuation are continuously variable over the range 5db to 50db per octave.



Frequency amplitude curves for the "TREBLE-3" position (5kc/s turn-over). Curves of the same slopes are obtained on the other two positions turning over at 7 kc/s and 9 kc/s ("—2" and "—1" positions).

The filters consist essentially of Twin-T resistor-capacity networks inserted in the return circuit of a single-loop feedback amplifier. The more obvious advantages of this electronic feedback method over conventional choke filters include :—

(a) Improved transient response characteristics (due to absence of chokes having self-capacitance) and the consequent reduction of "ringing."
(b) Extremely low harmonic and inter-modulation distortion due to negative voltage feedback action.
(c) No discontinuities in the rates of slope when the slope control is operated, and no change in signal level at frequencies below turnover. (Both these faults occur in variable-slope choke filters due to the slope control altering the terminating impedance and the insertion loss.)
(d) No chokes to cause magnetic hum pickup.
(e) Smaller size, lighter weight, greater uniformity in production.

LIST PRICE IN BRITAIN **12 Gns.**

Point-One TL/12

Triple Loop Feedback Amplifier

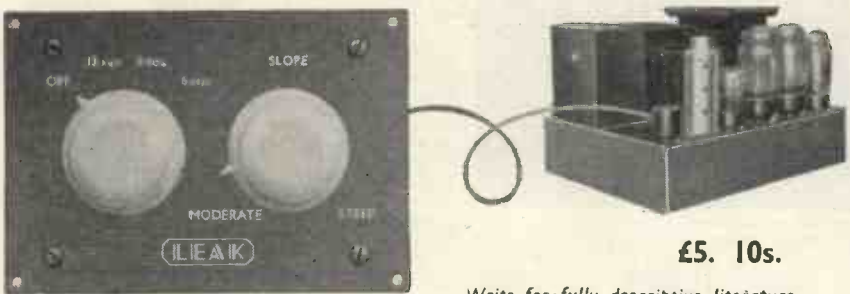
Used with the "Vari-Slope" pre-amplifier and the best available complementary equipment, the TL/12 power amplifier gives to the music-lover a quality of reproduction unsurpassed by any equipment at any price.

For laboratory use as a stabilised-gain audio frequency power amplifier. For the highest possible standard of disc recording. For the highest possible quality of reproduction from Pickup, Radio, Microphone, Film and Magnetic Tape. For use as a driver amplifier in the speech modulator chain of broadcast transmitters.

27 Gns.

The "Point-One" TL/12 Amplifier is built to a tropical specification and used throughout the world, including :

The British Broadcasting Corporation.
The South African Broadcasting Corporation.
The Swedish Broadcasting Corporation.
The Swiss Broadcasting Corporation.
The Italian Broadcasting Corporation.



£5. 10s.

Steep-Cutting Filter

For use with the TL/12 power amplifier and pre-amplifiers preceding the Vari-slope. This filter unit is of particular interest to the record enthusiast.

Write for fully descriptive literature.

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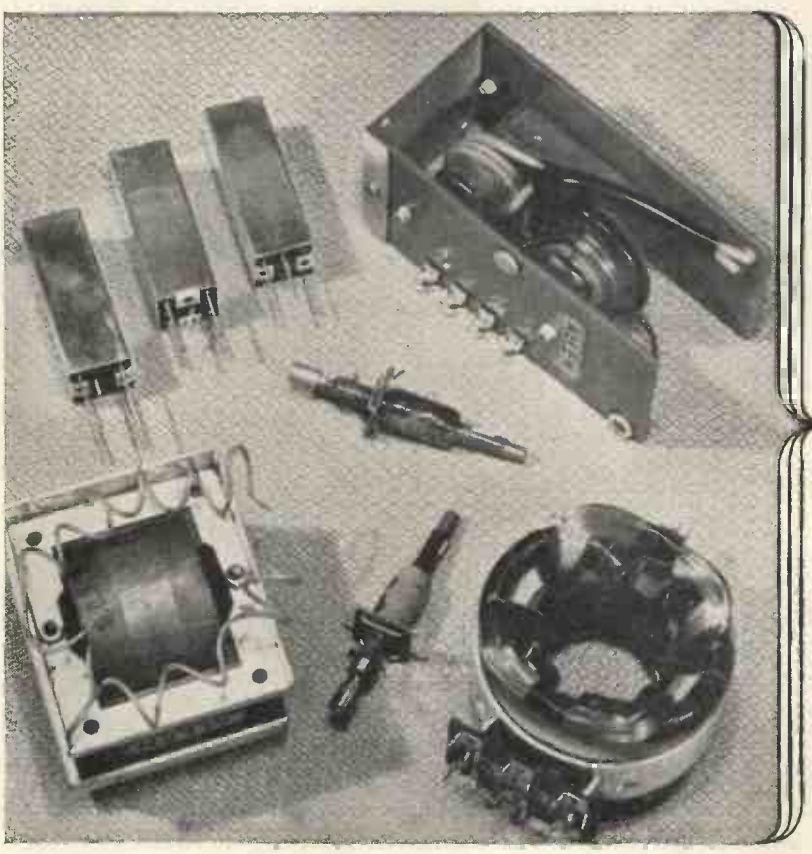

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Also for the conversion to 14" or 17" C/R tubes of all popular home-built televisors

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The "TELE-VIEWER"

5 CHANNEL TELEVISOR

A Design of a Complete 12 in. or 9 in.

SUPERHET T/V RECEIVER FOR THE HOME CONSTRUCTOR

This receiver has been developed after most careful research and affords a high standard of Television entertainment by producing a picture of *really outstanding* quality.

We confidently believe that not only have we achieved a T.V. Receiver that surpasses in efficiency any other designed for the home constructor, but that successful construction, even by the most inexperienced, is assured by the step by step wiring detail and diagrams provided, and at about half the cost of the nearest comparable commercial receiver.

Here are some of the features which combine to make this such a fine receiver.

- The Superhet circuit *easily* tuned to any of the five channels, i.e., LONDON, SUTTON COLDFIELD, HOLME MOSS, WENVOE and KIRK-O-SHOTTS. (The extreme ease of tuning is accomplished by the provision of pre-aligned I.F.T's.)
- A lifelike, almost stereoscopic, picture quality made possible by the following factors:
  a. Excellent band width of I.F. circuits.
  b. A really efficient video amplifier.
  c. C.R.T. Grid modulated from low impedance source.
  d. High E.H.T. voltage (approx. 10 kV.).
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- All pre-set controls are mounted on side of chassis enabling all adjustments to be carried out whilst facing the C.R. Tube.

We can sometimes supply New Mullard 12in. C.R.T. at the specially reduced price of

£13/17/6

These, when available are for purchasers of the Televiewer only.

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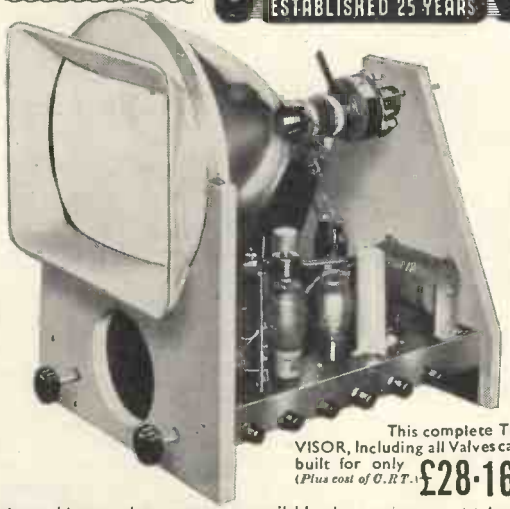
ESTABLISHED 25 YEARS

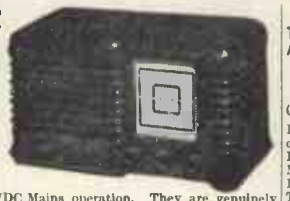


This complete TELEVISOR, Including all Valves can be built for only (*Plus cost of C.R.T.*) **£28·16·4**

As no hire purchase terms are available the receiver can be bought in five separate stages (practical diagrams and circuits are provided for each stage) thus enabling hire purchase interest rates to be avoided. The complete set of ASSEMBLY INSTRUCTIONS is now available, price 5/-. The instructions include really detailed PRACTICAL LAYOUTS, WIRING DATA AND COMPONENT PRICE LIST.

ALL COMPONENTS ARE AVAILABLE FOR INDIVIDUAL PURCHASE. A CABINET WILL ALSO BE AVAILABLE.

SURPLUS TO AN EXPORT ORDER
A 5 VALVE SUPERHET RECEIVER



covering the COMPLETE MEDIUM WAVEBAND and TWO SHORT WAVEBANDS. ENTIRELY COMPLETE and CONTAINED IN ATTRACTIVE BAKELITE CABINET. (Plus 10/- Carr. and Ins.) **£6'19'6**

- INCORPORATING THE LATEST RANGE OF B.V.A. MINIATURE VALVES. UY.41, UL.41, UBC.41, UF.41 and UCH.42 AND A 5 INCH P.M. SPEAKER.
- Complete Waveband Coverage 13-35, 35-100 and 195 to 550 Metres.
- We have a limited number only, some being for A.C. Mains and some AC/DC Mains operation. They are genuinely BRAND NEW, being surplus to an export order recently completed.

ANOTHER REDUCTION ! !

The COLLARO Model A.C. 514 Record Player

£3/19/6

(Plus 5/- carr. and ins).

RIM DRIVE 78 r.p.m. complete with the COLLARO Plug in type MAGNETIC HEAD and 10 inch TURNTABLE. These are COMPLETE BRAND NEW UNITS for A.C. Mains 200-250 Volts.

!! The TRUVOX TAPE UNIT !!

We can now offer this very successful Unit ex stock. Price **£23/2/0**
(Plus 5/- carr. and ins.)

A really good class TAPE AMPLIFIER is also available. Price **£16/16/0**
(Plus 5/- carr. and ins.)

The combination of these two Units provides a really first-class complete TAPE RECORDER. Send S.A.E. for complete details.

One of the best known makes ! !
A 3 SPEED AUTOCHANGE UNIT

COMPLETE WITH THE TWIN STYLUS CRYSTAL PICK-UP **£13/15/0**
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- These Units will autochange on all three speeds, an adaptor, price £1/0/7, being required for the 45 r.p.m. Records.
- They have separate sapphires for L.P. and 78 r.p.m. which are moved into position by a switch on the pick-up head.

These Units are one of the best made today, they are brand new, complete with mounting instructions, etc.

HIGH FIDELITY PICK UP

Incorporating the famous CONNOISSEUR Light Weight Moving Iron Head and including the Connoisseur matching Transformer **39/6**
(Plus 1/- carr. and ins.)

THE FAMOUS "SHAFTESBURY" RIBBON MIKE

Incorporating internal line transformer having transformation ratio from ribbon impedance up to 500-600 ohms . . . reduced from 10 gns. to £6. A special line to grid, 500-600 ohms transformer also available for 25/-.

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For charging either 2, 4, 6 or 12 volts at 1 amp. Complete in metal case, and incorporating a limiter resistor. Size 5½in. x 5½in. x 4½in. Complete and ready for use, 39/6.

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Accuracy better than 2 per cent on all ranges. Coverage 100 Kc/s to 70 mc/s. (on fundamentals), modulated on CW output. 500 c/s A.F. source. Has large clearly calibrated scale. Price £8/10/-. (Plus 5/- carr. and ins.)

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Including a 5in. P.M. SPEAKER and VALVES.

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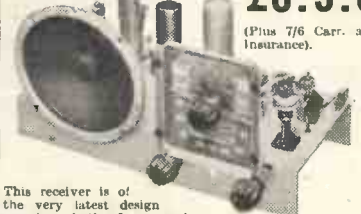


This receiver is of the very latest design covering both Long and Medium Wavebands, and includes the modern BVA miniature valves. The line up being 12 BA6- 12AT6-12A6-35W4. It incorporates Permeability Tuned Coils thus ensuring excellent selectivity and sensitivity.

The overall size of the complete chassis including speaker is 10½in. x 4½in. x 6½in.

An attractive Bakelite Ivory finished Cabinet size 11½in. x 5½in. x 6½in. is available for 16/6 (plus 2/6 carriage and insurance).

!! STOP PRESS !!

A COMPLETELY ASSEMBLED CHASSIS OF A 3 WATT A.F. AMPLIFIER WITH SELECTIVE FEEDBACK

For A.C. Mains Operation. **£4/9/6** (Plus 5/- carr. and ins.)

- Designed for good quality Gram. reproduction up to a maximum output of 3 Watts.
- The selective feedback circuit incorporates separate Bass and Treble Controls.
- New Valves are used, the line up comprising the new Mullard types EF.40, EL.41, EZ.40.

Suitable P.M. Speakers are available at 16/-, 18/9, 25/- and 34/4.

MICROPHONES FOR THE HOME CONSTRUCTOR

The Lustraphone Model LX55 Crystal mike. Designed for use as either a hand mike or desk type. Price £2/10/-. Model C51 Dynamic mike, low impedance £5/5/-, or high impedance £5/15/6. Carr. and ins. on each of above 2/-.

GOODMANS' SPEAKERS

5in.	3 ohm. with trans.	21/-
5in.	3 ohm. less trans.	16/-
8in.	3 ohm. less trans.	19/6
8in.	3 ohm. with trans.	25/-
10in.	3 ohm. less trans.	25/-

HALF-WAVE H.T. RECTIFIERS

250 Volts 150 m/a 12/9; 250 Volts 250 m/a. 16/9.

BATTERY CHARGER TRANSFORMER

for 2, 6 or 12 Volt Charging. Input 200 to 240 volts. Output 17 volts tapped 11 and 17 Volts at 1½ amp., 11/6.

AMPLIFIERS

TWO COMPLETE KITS OF PARTS

A 4-VALVE QUALITY "PUSH-PULL" 6-8 watt AMPLIFIER for A.C. mains. Incorporating Negative Feedback, Filter Input Circuit and employing 6V6's in Push-Pull. A simple arrangement is provided to enable either a magnetic-crystal or lightweight pick-up to be used, and is suitable for use with Standard or long-playing records. A tone control is incorporated, and the 10-watt output transformer is designed to match 2 to 15 ohm speakers.

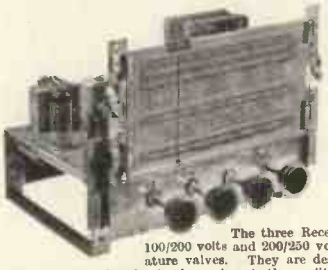
The overall size of the assembled chassis is 10in. × 8in. × 7½in. high, and full practical diagrams are supplied. Price, including drilled chassis and valves, of complete kit, **£6/17/6**. Price of assembled chassis, supplied ready for use, **£8/12/6**. Full descriptive leaflets are available separately for 1/-.

A 12-watt **HIGH FIDELITY "PUSH-PULL"** AMPLIFIER designed for A.C. mains 200 to 250 volts, employs 6 valves plus rectifier, with negative feedback, and comprises a main amplifier chassis and a remote controlled Preamplifier and Tone Control Unit, incorporating four controls—bass, treble, main volume or mixing control, and a radio, gram, microphone, selector switch. This control unit measures only 7 × 4 × 2in. The measured frequency range of the amplifier with this unit shows an excellent response from 14,000 cycles down to 20 cycles, the bass and treble controls allowing independent control of gain at both ends of the frequency range from zero to a gain of 50. It can be seen, therefore, that ample correction is provided to suit any type of pick-up with any type of recording. Input voltage for maximum output is 70 mV. 6.3 volts at 2 amps and 30 mA. H.T. is provided for tuning unit, etc. Price of complete kit, including drilled chassis and valves, £14. Complete specification and layout, 2/-. We can also supply completely assembled and ready for use at £17.

THIS AMPLIFIER COMPARES WELL WITH THE WILLIAMSON AND SIMILAR DESIGNS AT A FRACTION OF THEIR COST.

THREE COMPLETELY ASSEMBLED ALL-WAVE SUPERHET CHASSIS

- Model B.3. A 5-valve 3-waveband Receiver.
- Model B.3.P.P. A 6-valve 3-waveband Receiver with PUSH-PULL OUTPUT.
- Model B.3.P.P./R.F. A 5-valve 6-waveband (4 Bandspread) Receiver.



The three Receivers are for operation on A.C. mains 100/200 volts and 200/250 volts, and employ the very latest miniature valves. They are designed to the most modern specification, great attention having been given to the quality of reproduction which gives excellent clarity of speech and music on both gram and radio, making them the ideal replacement chassis for that "old Radiogram," etc.

Brief specifications: **Model B.3.**—Valve line-up, 6BE6, 6BA6, 6AT6, 6BW6, 6X4—waveband coverage, short 16-50 medium 187-550, long 900-2,000 metres. Controls: (1) volume with on/off; (2) tuning (flywheel type); (3) wavechange and gram; (4) tone (3-position switch operative on gram and radio). Negative feedback is employed over the entire audio stages. Chassis size: 11 × 7½ × 8½in. high. Dial size: 9½in. × 4½in. Price complete and READY FOR USE, excluding speaker, **£12/12/-** (carr. and Ins. 7/6 extra). Model B.3. P.P. This model is the B.3 Receiver but incorporates two 6BW6 VALVES in PUSH-PULL, resulting in really excellent quality reproduction up to approximately 6 watts. Price **£15/15/-** (plus 7/6 carr. and ins.).

Model B.3. P.P./R.F. This model is similar in appearance and has same waveband coverage as the Model B.3, but in addition it incorporates an R.F. STAGE together with PUSH-PULL OUTPUT, employing a total of 7 valves with two type 6BW6 in Push-Pull. This makes for a really sensitive receiver with genuine quality reproduction. Price **£18/18/-** (plus 7/6 carr. and ins.).

MODERNISE YOUR OLD RADIOGRAM FOR

£25

(plus 10/- carriage and insurance)

with the very latest equipment. We will supply the 3 waveband chassis on the left with the 3-speed auto changer on the right, complete with 10in. speaker for £25 (£28/7/6 with the Model B3P.P. Or £31/5/- with B3P.P R.F.) This is less than half the price of comparable commercial three speed auto radiograms.

A GENUINE SPECIAL OFFER!

3-SPEED AUTO CHANGE UNITS BY A FAMOUS MANUFACTURER

(Normal price is £16/10/-). **£11/14/6** (plus 7/6 carr. and insurance).

Brand new in Maker's Cartons, complete with mounting instructions.

- These units will auto change on all three speeds, 7in., 10in. and 12in.
- They play MIXED 7in., 10in. and 12in. records.
- They have separate sapphires for L.P. and 78 r.p.m., which are moved into position by a simple switch.
- Minimum baseboard size required 16in. × 12½in. with height above 5½in. and height below baseboard 2½in.

A bulk purchase enables us to offer these BRAND NEW UNITS at this exceptional price.

ANOTHER SPECIAL OFFER!!

THE COLLARO 3RC/521 3 SPEED AUTOCHANGE UNIT

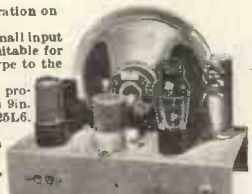
(Normal Price £18/10/0) **£9/19/6** (Plus 7/6 carriage and insurance)

- With separate crystal heads for standard and LP records.
- Incorporating pick-up weight adjustment.
- Will autochange on 7in., 10in. and 12in. records not intermixed.
- Minimum Base plate size 15in. × 12½in., with height above 4½in. and below baseplate 3in.
- Brand new in Makers Cartons, complete with Mounting instructions.

WE OFFER This autochanger complete with the Model B3 3 Waveband chassis, also advertised, and together with a 10 inch PM speaker for **£23/0/0** (plus 10/- carriage and Insurance) or with B3PP Model for **£26/-/-**, (plus 10/- C. and I.), or with Model B3 PP/RF for **£29/10/0** (plus 10/- C. and I.).

A COMPLETE KIT OF PARTS TO BUILD A 3-4 WATT HIGH GAIN AMPLIFIER

For operation on A.C. or D.C. Mains, 200-250 volts.



This amplifier will give 3 watts output for the small input voltage of only 75 millivolts, and is therefore suitable for use with any type of pick-up from the crystal type to the miniature H/F Magnetic type.

A tone control is incorporated and the quality produced is excellent. The overall size of chassis is 9in. × 5in. × 7in. and valve line-up 25Y5-bsH7-25L6. Price of complete kit, including drilled chassis and valves, £4/2/9, plus 6½in. P.M. (which fits on chassis), 16/-, or 8in. P.M., 18/9.

Price of fully assembled chassis ready for use, £5/5/- (plus cost of speaker).

Copy of assembly instructions and components price list available for 1/3.

S.T.C. RECTIFIERS

TYPE K3/15	4/5	TYPE K3/60	9/8
K3/25	5/8	K3/70	11/-
K3/30	6/-	K3/80	12/4
K3/35	6/10	K3/90	13/6
K3/40	7/6	K3/100	14/8
K3/50	8/8	K3/160	21/6

The DENCO M.T.O.I. MODULATED TEST OSCILLATOR

£3/15/0

(Plus 2/- carr. and ins.) Has Frequency range continuously variable from 170-475 Kc/s and 550-1,600 Kc/s. Battery operated and thereby completely self contained.

GENUINE REDUCTION!

The COLLARO MODEL 3RC/514. 3 SPEED NON-AUTOCHANGE RECORD PLAYER

(Normal Price £12 6 7) **£6 / 19 / 6** (Plus 5/- carr. and ins.)

Incorporating the New Ortho Dynamic Hi Fi Magnetic head fitted with Twin alloy stylus and matching transformer, together with pick-up weight adjustment.

These units are quite new and contained in the makers original cartons complete with Mounting Template.

BATTERY CHARGER KITS

All Kits are for A.C. Mains 200-250 Volts. They comprise of a Metal Rectifier and Transformer, tapped for 6 or 12 Volt charging, and a tapped Resistor, with Selector Switch, to enable the charging rate to be varied.

For 6 or 12 volt batteries at max. 1 amp.	£1/17/6
For 6 or 12 volt batteries at max. 2½ amp.	£2/5/3
For 6 or 12 volt batteries at max. 4 amp.	£3/2/6

An easily followed Wiring Diagram is included with Each Kit.

VARLEY HEATER TRANSFORMER

Input 200-250 volts. Output 4 volts (centre tapped) 5 amps. **14/9** (1/- postage).

When submitting orders, please include post and packing charges.

STERN RADIO Ltd.

109 & 115, FLEET STREET, E.C.4

Tel.: CENTRAL 5812-3-4

THE TELE-KING

A practical 5-channel

SUPERHET TELEVISION RECEIVER

16" 17"

Using the new 16 and 17 inch cathode ray tubes and wide angle components for the home constructor.

Complete instructions, wiring diagrams and 32-page descriptive booklet.

6/- POST FREE

ALL COMPONENTS IN STOCK
WRITE FOR LIST

ALLEN WIDE ANGLE COMPONENTS

D.C. 300 latest type Ferroxcube Coils 39/6
GL.16 Coil 7/6
GL.18 Coil 7/6
Focus Coil 31/-
FO.305 trans. 21/-
Frame B.O. transformer 15/-
Line EHT. transformer, 40/-

CHASSIS

Power pack Sound-vision and Scan chassis. PRICE 11/- each. All other metal work available from stock.

CONDENSERS

All condensers. As specified. Manufacturers surplus £3/16/-.
COILS 13 all exactly as specified. Price 44/6.

RESISTANCES. 72 Resistances, all exactly as specified, 18/-.

CABINET

Walnut veneer, £8/10/-, plus carriage 12/6 extra. As illustrated here.

WIDE ANGLE CATHODE RAY TUBES

14in. MW36-22....	£19	9	3
14in. C14B.....	£20	10	1
16in. MW41-1....	£22	4	10
16in. T901.....	£22	4	10
17in. MW43-64....	£23	12	8
17in. C17BM.....	£24	13	0

Carriage and insurance extra.

OUTPUT TRANSFORMERS

40 mA Multi ratio.....	4/11
80 mA Multi ratio.....	14/11
80 mA Pentode.....	12/6
60 mA Plessey, 6,000 ohms	5/11
Standard pentode.....	4/11
Pentode	3/6
Midget Pentode.....	3/6
Miniature Pentode, 3S4, 1S4	4/6
PX4 Intervalve.....	8/6
5 : 1 Intervalve	5/11

P.M. LOUDSPEAKERS

All with 3 ohm speech coil.

2½in.	15/-	6½in.	13/6
3in.	12/6	8in.	15/-
4in.	9/6	10in.	17/6
5in.	14/6		

NOW AVAILABLE 12 inch Goodmans heavy duty speaker. Capacity 15 watts, 15 ohms speech coil impedance.
LASKY'S PRICE £5/19/6. Car. 3/6 ex. All loudspkrs. offered are first grade and of highest quality construction. Many other type in stock. Send us your reqts.

THE "UNIVERSAL" LARGE SCREEN AC/DC TELEVISOR

By A. S. Torrance, A.M.I.P.R.E., A.M.T.S.

A 28 page booklet giving full instructions for building a large 17 inch screen televisor.

* A.C. and D.C. mains.
* P.M. focussing.
* Mullard valves and c.r. tube.
* 5-channel superhet.
* Table model.
* Convertible into radiogram console.
* Incorporates all latest developments.

3d. POST FREE.

COIL PACKS

Medium and 2 short wave bands. Price 16/-.

COIL PACKS

Long, medium and short wave bands. 29/6.

LASKY'S LINE TRANSFORMER

RF.EHT for line fly back. 6-8Kv, with EY51 heater winding. Suitable for home construction T/V 25/-.

INTERCOM UNITS

4-station operation. For use on A.C./D.C. mains 200-250 volts. Supplied complete, with 3 new valves, ready for immediate installation. Fitted in attractive plastic cabinet.
Suitable for use as baby alarm.
MASTER UNIT **£5 . 19 . 6**
Carr. 5/- extra.
Extension Units. Price 21/- each complete. Carriage 2/- each extra.

DUOMAG FOCALISER

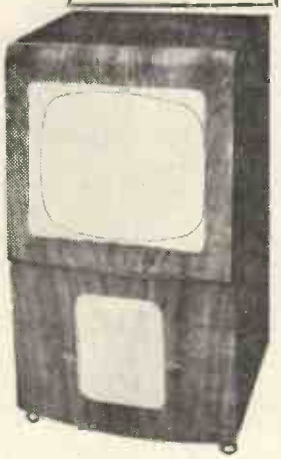
Low Flux....	37/6
Med. Flux....	39/6
High Flux....	42/-

POSTAGE STAMP TRIMMERS

Paxolin. Up to 100pf. 6d. each. 5/- per doz.
Ceramic. Up to 100pf. 9d. each. 7/6 per doz.
350 and 550pf. Ceramic 1/- each. 10/6 per doz.

Duodecal (B12A) bases. VCR139 c.r.t. bases. 1/- each. 10/6 dozen.

Alexandra Palace,
Sutton Coldfield,
Holme Moss,
Wenvoe,
Pontop Pike,
Belfast,
Kirk o'Shotts.



SPEAKER FRET

Expanded Metal. Silver Finish.

12in. × 12in.....	3/11
12in. × 18in.....	5/11
Plastic White, 12in. × 5in.	2/-
Wire, Bronze, 11in. × 8in.	2/-

LASKY'S T.V. CONSTRUCTORS PARCEL

All brand new components by Igranic. Comprises E.H.T. flyback line transformer, 7-10Kv. with ferroxcube core and rectifier heater winding; scanning coils; frame output transformer; Elac focus unit with vernier adjuster, U37 E.H.T. rectifier and brand new 12 inch cathode ray tube with ion trap, mask and glass.
LASKY'S PRICE FOR THE COMPLETE PARCEL £15/19/6. Carriage and insurance 15/- extra.
The Constructors Parcel as above, but less the cathode ray tube and ion trap.
LASKY'S PRICE 79/6. Carr. 3/6 extra.

LASKY'S RADIO

NOTICE TO ALL PURCHASERS OF THE ENGLISH ELECTRIC 16 inch C.R.T. TYPE T.901
The first and only reconditioning service. By English Electric. A reconditioned 16in. metal tube costs £12 and carries maker's full guarantee. Write for further details.

MAINS TRANSFORMERS

All 200-250 v. 50 c.p.s. primary. Finest quality, fully guaranteed.
MBA/3. 350-0-350 v. 80 mA., 6.3 v. 4 a., 5 v. 2 a. Both filaments tapped at 4 volts. An ideal replacement trans. Price 18/-.
MBA/6. 325-0-325 v. 100 mA. 6.3 v. 3 a., 5 v. 2 a. With mains tapping board Price 22/6.
MBA/7. 250-0-250 v. 80 mA., 6.3 v. 3 a., 5 v. 2 a. Both filaments tapped at 4 volts. Price 18/-.
AT/3. Auto transformer. 0-10-120, 200-230-240 volts 100 watt. Price 17/6.

FILAMENT TRANSFORMERS

6.3 v. 1.5 a., 5/9.
6.3 v. 3 a., 9/6.
6.3 v. tapped at 4 v. 2 amps., 7/9.
Special Transformer. 2 amps., with the following tappings: 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24 and 30 volts. Price 17/6.

SMOOTHING CHOKES

20 mA 40 H.....	3/6
40 mA 8 H.....	3/6
40 mA 10 H.....	4/3
100 mA 10-20 H.....	7/3
250 mA 10 H.....	18/6

WIRE RECORDERS

BRAND NEW AND UNUSED

By a very well known British Manufacturer. Original list price £69/10/-. Records from Records, Microphone, Radio.
Includes a Garrard pick-up arm, and can be used as a record player complete with its own amplifier.
Supplied in perfect working order, with 7 valves, full operating instructions, circuit diagram and spool of recording wire.
Fitted with tone control and magic eye recording level indicator.
In attractive wood cabinet with roll top. Medium walnut finish.
LASKY'S PRICE **£27 . 10 . 0**
Carriage 25/- extra.

RECORDING WIRE. 1 hour spool 32/6. ½ hour spool 17/6.
Moving Coil Insert. Ideal for use as a microphone with the above wire recorder. **PRICE** 5/-.

RADIO

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485/487 Harrow Road, Paddington London, W.10
1979 and 7214. All Departments.
TERMS: Pro Forma, Cash with order, or C.O.D. on post items only. Postage and package on orders value £1—1/- extra, £5—2/- extra. £10—3/6 extra Over £10 carriage free. All goods fully insured in transit.

R.S.C. MAINS AND OUTPUT TRANSFORMERS

Fully Guaranteed, Interleaved and Impregnated

FILAMENT TRANSFORMERS
Primaries 200-250 v. 50 c/cs.

6.3 v. 1.5 a.	5/9
6.3 v. 2 a.	7/6
6.3 v. 3 a.	9/6
0-4-6.3 v. 2 a.	7/9
12 v. 1 a.	7/11
6.3 v. 6 a.	17/6
0-2-4-5-6.3 v. 4 a.	16/9
12 v. 3 a. or 24 v. 1.5 a.	17/6

CHARGER TRANSFORMERS
All with 200-230-250 v. 50 c/s. Primaries: 0-9-15 v. 1.5 a., **14/9** ; 0-9-15 v. 3 a., **16/9** ; 0-9-15 v. 6 a., **22/9** ; 0-4-9-15-24 v. 3 a., 22/9 0-9-15-30 v. 3 a., **23/9.**

TOP SHROUDED DROP THROUGH TYPE
Primaries 200-230-250 v. 50 c/s.

250-0-250 v. 70 mA., 6.3 v. 2.5 a.	12/11
260-0-260 v. 70 mA., 6.3 v. 3 a., 5 v. 2 a.	14/11
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 3 a., 4 v. 2.5 a.	14/11
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 v., 4 a., c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v.-4 v. 4 a., c.t. 0-4-5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a....	29/11
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	29/11

E.H.T. TRANSFORMERS. 2,500 v. 5 mA., 2-0-2 v., 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517 or ACR2X 35/-
5,000 v. 5 mA. 2 v. 2 a. 39/6

Primaries 200-230-250 v. 50 c/cs.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a., Midget type 2½-3-3in.	16/9
350-0-350 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.....	18/9
300-0-300 v. 60 mA., 12 v. 1.5 a., c.t.....	18/11
250-0-250 v. 100 mA., 6.3 v.-4 v. 4 a. c.t., 0-4-5 v. 3 a.	25/9
250-0-250 v. 100 mA, 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion	29/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a. c.t., 0-4-5 v. 3 a.	25/9
350-0-350 v. 100 mA., 6.3-v.-4 v. 4 a. c.t., 0-4-5 v. 3 a.	25/9
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.	33/9
350-0-350 v. 160 mA., 6.3 v. 6 a., 6.3 v. 3 a., 5 v. 3 a.	45/9
350-0-350 v. 250mA., 6.3 v. 6a., 4 v. 8a., 0-2-6 v. 2 a., 4 v. 3 a., for ElectronicEng. Televisor	67/6
425-0-425 v. 200 mA., 6.3 v.-4 v. 4 a. c.t., 6.3-4 v. 4 a., c.t., 0-4-5 v. 3 a., suitable Williamson Amplifier, etc.	49/9
425-0-425 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a.	65/6

SMOOTHING CHOKES

250 mA. 7-10 H. 200 ohms	16/9
250 mA., 3 H. 50 ohms	11/9
100 mA., 10 H. 175 ohms	7/6
80 mA., 10 H. 350 ohms	5/6
60 mA., 10 H. 400 ohms	4/11
50 mA., 40 H. 1,000 ohms Potted...	10/9

ELIMINATOR TRANSFORMERS
Primaries 200-250 v. 50 c/s.

120 v. 40 mA.	7/11
90 v. 10 mA., 8-0-8 v. 250 mA.	9/11

OUTPUT TRANSFORMERS

Midget Battery Pentode 66 : 1 for 3S4, etc.	3/6
Small Pentode, 5,000Ω to 3Ω	3/9
Small Pentode, 8,000Ω to 3Ω	3/9
Standard Pentode, 5,000Ω to 3Ω	4/9
Standard Pentode, 8,000Ω to 3Ω	4/9
Standard Pentode, 10,000 ohms to 3 ohms...	4/9
Multi-ratio 40 mA. 30 : 1, 45 : 1, 60 : 1, 90 : 1, Class B Push-Pull	5/6
Push-Pull 8 watts 6V6s to 3 ohms	7/11
Push-Pull 10-12 Watts 6V6 to 3Ω or 15Ω...	15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω	16/9
Push-Pull 15-18 Watts to match 6L6, etc., to 3Ω or 15Ω Speaker	22/9
Push-Pull 20 Watts high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9
Williamson type, exact to author's specification	85/-

MICROPHONE TRANSFORMERS
100 : 1 ..... 5/9

SILVER MICA CONDENSERS. 5, 10, 15, 20, 25, 30, 35, 50, 100, 120, 150, 180, 200, 230, 300, 330, 400, 470, 500, 1,000pfd. (.001μF), .002 mfd. (2,000 pfd.). All at 5d. each ; 3/9 dozen one type.

DIAL BULBS, M.E.S., 8 v. 0.15 a., 6/9 doz.

VOLUME CONTROLS with long spindles, all values less switch, 2/9 ; with S.P. switch, 3/9.

WIRE WOUND POTS : 20 ohms, 30 ohms, 1,000 ohms, 5K, 50K (medium length spindles), 2/9.
220 ohms, 2K, 10K, 20K, 50K Preset type, 1/9 ea.

AMMETERS. Moving coil. G.E.C. 0—5 amps., 2in. scale, 12/6.

ELECTROLYTICS (Current production. NOT ex-Govt.).

Tubular Types		Can Types	
8μF 450 v.	1/11	16μF 450 v.	2/9
8μF 500 v.	2/9	24μF 350 v.	2/11
16μF 350 v.	2/3	32μF 350 v.	2/11
16μF 450 v.	2/9	32 mfd. 450 v.	4/9
16μF 500 v.	3/9	40μF 450 v.	4/9
24μF 350 v.	3/3	64 mfd. 450 v.	4/9
32μF 350 v.	3/9	8-8μF 350 v.	3/9
32 mfd. 500 v.	5/9	8-8μF 450 v.	3/11
8-16μF 500 v.	4/11	8-16μF 450 v.	4/6
25μF 25 v.	1/3	16-16μF 450 v.	4/11
50μF 12 v.	1/2	16-16 mfd. 500 v.	5/9
50μF 50 v	2/3	16-32μF 350 v.	4/9
Can Types		32-32μF 350 v.	4/9
8 mfd. 450 v.	2/3	32-32μF 450 v.	5/11
8 mfd. 500 v.	2/11	64-120 mfd. 350 v.	7/6
16 mfd. 350 v.	1/11	3,000 mfd. 6 v.	5/9

MISCELLANEOUS EX-GOVT. ITEMS
Slydelock Fuses, 15 amp., 1/9. Bulgin panel mounting Fuseholders (ex-equipt.), 11d. Bulgin octal type moulded Bakelite, 5-pin or 7-pin Plugs and Sockets, 1/11 pr. Earphones (Single), low resistance, 1/3.

EX-GOVT. ACCUMULATORS with non-spill vents. Unused and guaranteed. 2 v. 16 A.H. Size 7½—4—2in., 4/9 ea. Or set of 3 wired for 6 volts in wood carrying case 9—7—5in., 13/9, plus 2/6 Carr.

P.M. SPEAKERS. All 2-3 ohms. 5in., Goodmans, 14/9, 6½in. Elac., 14/11, 6½in. Plessey with Pentode Trans., 14/11, 8in. Plessey, 15/9, 8in. R.A. Heavy duty, 18/9, 10in. Goodmans, 31/-, 10in. Plessey, 18/6, 10in. Rola with Trans., 29/6, 12in. Truvox, 49/9.

M.E. SPEAKERS. All 2-3 ohms, 6½in. Rola field 700 ohms, 11/9, 10in. R.A. field 600 ohms, 23/9. 10in. R.A. field 1,500 ohms, 23/9. 10in. R.A. Field 1,000 ohms, 23/9.

BAKELITE AND WALNUT VENEERED CABINETS

Size approximately 12in. × 6½in. × 5in. Bakelite type available in Brown or Cream. Price of Cabinets 17/6 ea., carr. 2/6.

Suitable fully punched T.R.F. 3-valve and rectifier chassis	3/9
Suitable fully punched superhet chassis (4 valves and rect.)	4/9
Dial Scales, 2 colour, 2 waveband, station named, glass	1/6
Dial Scales, 3 colour, 3 waveband, station named, glass	1/9
Suitable coloured Metal Backplates	1/3
"Push-on" Pointers	6d.
T.R.F. Coils, 2 waveband with circuit	6/9
Drum Drives, complete	2/6
Constructional Envelope of an All Mains 2 wave T.R.F. Receiver (3 valves and rectifier) which can be built in any of above cabinets for approximately £4/15/-	2/6

SELENIUM RECTIFIERS

L.T. Types		H.T. Types H.W	
2/6 v. ½ a. h.w.	1/11	70 v. 20 mA.	2/11
F.W. Bridge Types		90 v. 20 mA.	3/6
6/12 v. 1 a.	5/9	120 v. 40 mA.	3/11
6/12 v. 2 a.	9/9	250 v. 50 mA.	5/9
6/12 v. 4 a.	17/9	350 v. 50 mA.	7/9
6/12 v. 6 a.	22/9	250/350v. 80 mA.	8/9

EX-GOVT. E.H.T. SMOOTHING CONDENSERS

.02 mfd. 5,000 v. Bakelite Tubulars	1/6
.02 mfd. 8,000 v. Cans	1/11
.1 mfd. 2,500 v. Cans	3/6
.1 mfd. plus .1 mfd. 8,000 v., large blocks (common negative isolated)	9/6

SPECIAL PURPOSE EX-GOVT. VALVES (GUARANTEED)
VR91, 5/9, SP61 (VR65) 2/9, VR56 3/11, AC6Pen 5/3, 80, 6/11, 7193 1/3, 6J6 10/3, 954 1/11, 955 3/9, 6SH7Met 6/11, 12SC7GT 6/11, RK34 2/6, VU120A 2/9, SP41 (VR65A) 1/11.

EX-GOVT. WIRE WOUND POTS.
(Ex-equipt., insulated spindles).
Bakelite type, spindles approx. 1in. 2K, 2.5K, 5K, 15K, 20K, 50K, 100K, 2/3 ea.

EX-GOVT. AUTO TRANSFORMERS 50 c/cs

15-10-5-0-215-235 v. 200 watts...	25/9
Double wound 10-0-200-220-240 v. input, 10-0-270-290-310 v. output 200 watts	27/9

EX-GOVT. MAINS TRANSFORMERS.

All 230 v. 50 c/cs input. 48 v. 1 a. output	9/6
Outputs 250-0-250 v. 40 mA., 6.3 v. 2 a., 5 v. 2 a.	10/9
350-0-350 v. 150 mA. 5 v. 3 a.	17/6

VALVE SCREENING CANS. International Octal 3 piece, 10/6 doz., 1/3 each.

EX-GOVT. SMOOTHING CHOKES

250 mA., 10 H. 50 ohms. Potted type	14/9
250 mA., 40 H. 200 ohms. Trop. type	17/6
250 mA. 20 H. 250 ohms. Tropicalised	13/9
250 mA. 10 H. 100 ohms	12/9
250 mA. 5 H. 100 ohms. Potted type	9/6
250 mA. 3 H. 50 ohms Potted	7/6
150 mA. 10 H. 50 ohms	10/11
100 mA. 10 H. 100 ohms	6/11
100 mA. 15 H. 450 ohms. Tropicalised	5/9
100 mA. 5 H. 100 ohms. Tropicalised	4/6
50 mA. 50 H. 1,250 ohms. Potted type	8/11

EX-GOVT. T.V. TYPE TRANSFORMERS. All 230 v. 50 c/s input.

610-0-610 v. 150 mA., 300-0-300 v. 150 mA., 1,250 v. 250 mA.	19/9
2 v. 3 a., 2 v. 3 a., 2 v. 3 a., 2 v. 3 a.	8/9
375-345-0-345-375 v. 250 mA.	22/6
6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a., 5 v. 3 a., 4 v. 3 a.	22/6
278-0-278 v. 80 mA.	7/9
350-0-350 v. 160 mA., 6.3 v 6 a., 5 v. 3 a....	27/6
400 v. C.T. 150 mA. 4 v. 6 a., 6.3 v. 6 a., 6.3 v. 0-6 a., 4 v. 6 a., 4 v. 3 a., 4 v. 3 a., 4 v. 3 a., 5 v. 2 a.	22/9

EX-GOVT. BLOCK PAPER CONDENSERS

4 mfd. 500 v., 2/9	4 mfd. 1,000 v. 3/11
4 mfd. 750 v., 3/3	4 mfd. 2,000 v., 5/3
	8 mfd. 500 v. 4/9

EX-GOVT. HEAVY DUTY FIL. TRANS.
All for 230 v. 50 c/cs. input. 6.3 v. 10 a., 17/6, 22-23-24 v. 5 a., 19/6.

EX-GOVT. CATHODE RAY TUBES
VCR517 (guaranteed full picture) (carr. 5/-) 29/6 ea.
ACR2X (guaranteed full picture) (carr. 5/-) 12/6 ea.

SPECIAL OFFERS. Germanium Crystal Diodes 1/11. Midget Mains Transformers (size approx. 2½ × 3 × 2½in.). Screened Primary 220/240 v. 50 c/s. Output, 250-0-250 v. 60 mA. 6.3 v. 2.5 a. Only 11/9.

CO-AXIAL CABLE. 75 ohms ½ in., 9d. yard. Twin screened feeder, 8d. yard.

EX-GOVT. CATHODE ISOLATING FILAMENT TRANSFORMERS. 6.3 v. to 6.3 v. c.t., 3/9 ea.

R.S.C. 25 WATT "PUSH PULL" AMPLIFIER

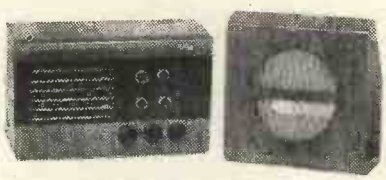
Now firmly established and proving extremely popular, our AII Quality Amplifier we consider to be the best value in amplifiers offered to-day. The volume of its high fidelity reproduction is completely controllable, from the sound of a quiet intimate conversation to the full glorious volume of a great orchestra. Its sensitivity is so high that in areas of fair signal strength it can be operated straight from a crystal receiver. Entirely suitable for standard or long playing records in small homes or in large auditoriums. For electronic organ or guitar or for garden parties or dance bands.

The kit is complete to the last detail, and includes easy to follow point-to-point wiring diagrams.

Twin volume controls with twin input sockets allow SIMULTANEOUS INPUTS for BOTH MICROPHONE and GRAM, or TAPE and RADIO. SEPARATE BASS and TREBLE CONTROLS giving both LIFT and CUT. FOUR NEGATIVE FEEDBACK LOOPS with 15 db in the main loop from output transformer to voltage amplifier. Frequency response ± 3 db. 50-20,000 c.p.s. Hum and distortion LESS THAN 0·5 per cent. measured at 10 watts. This is comparable with some of the highest priced amplifiers. Six B.V.A. valves, Marconi/Osram KT series output valves. A.C. only, 200-230-250 v. 50 c/cs. input. 420 v. H.T. LINE. Paper reservoir condenser. Compact chassis. Matched components. OVERALL SIZE 4-10-9in. approx. Output impedances for 3 and 15 ohms speakers.

Available in kit form at the amazingly low price of **9 gns.** Plus carriage 5/-

Or ready for use 50/- extra.



R.S.C. MASTER INTERCOMM. UNIT, with provision for up to 4 "Listen—Talk Back Units" individually switched. A high gain amplifier enables speech and other sounds emanating from the rooms containing remote control units to be heard at the master control. The unit is in kit form and point-to-point wiring diagrams are supplied. A walnut veneered wood cabinet is included. Mains input is 200-250 v. 50 c/s. H.T. line 300 v. CHASSIS IS NOT "ALIVE." Ideal also for use as "Baby Alarm." Sound amplification 4 watts. Price only **£5/19/6.** "Listen—Talk Back Unit" as illustration can be supplied at **27/6** each. Full descriptive leaflet **1/-.**

The Master Unit can be supplied assembled and tested for **27/6** extra.

R.S.C. BATTERY CHARGER KITS. For mains input 200-250 v. 50 c/s. To charge 6 v. accumulator at 2 amps., **25/9.**

To charge 6 v. or 12 v. accumulator at 2 amps., **31/6.**

To charge 6 v. or 12 v. accumulator at 4 amps. **49/9.**

ABOVE KITS CONSIST OF BLACK CRACKLE STEEL CASE, MAINS TRANSFORMER, FULL WAVE METAL RECTIFIER, FUSES, FUSE-HOLDERS AND CIRCUIT. Due to careful design the use of resistors for regulation of charge has been obviated. The mean charging rates are as indicated above, and complete safety is ensured by fusing of both input and output. Chargers supplied assembled and tested for **6/9** extra.

A PUSH-PULL 3-4 WATT HIGH-GAIN AMPLIFIER FOR £3/12/6, plus carr. 2/6. For mains input 200-250 v. 50 c/s. Complete kit of parts including point-to-point wiring diagrams and instructions. Amplifier can be used with any type of feeder unit or pick-up. Output is for 2-3 ohm speaker. (We can supply a very suitable 10in. unit by Goodmans at **31/-.**) The amplifier can be supplied ready for use for **25/-** extra. Full descriptive leaflet **9d.**

COLLARO 3-SPEED AUTOMATIC RECORD CHANGERS (brand new), type RC521, complete with 2 plug-in P.U. heads. Mains input 200-250 v. Limited number available at only **£9/19/6.**

COLLARO GRAM MOTORS, TYPE AC37. Governor controlled at 78 r.p.m. Mains input 110-200-230-250 v. Shaded pole type, **35/-.**

COLLARO TAPE DESK MOTORS. Shaded pole type. Clockwise or anti-clockwise. Mains input 110-200-250 v., **31/6.**

PERSONAL SET BATTERY SUPERSEDER KIT.

Complete with case. Supplies 90 v. 10 mA. and 1.4 v. 250 mA. fully smoothed, from normal 200-250 v. 50 c/s. mains. For 4-valve superhet receivers. Price with circuit **35/9.** Or ready for use **42/6.** Size of unit 5-4-1⅛in.

BATTERY SET CONVERTER KITS. All parts for converting any type of battery receiver to all mains. A.C. 200-250 v. 50 c/s. Kit will supply fully smoothed H.T. of 120 v. 90 v. or 60 v. at up to 40 mA., and fully smoothed L.T. of 2 v. at 0.4 a to 1 a. Price complete with circuit and instructions only **48/9.** Supplied ready for use for **7/9** extra.

H.T. ELIMINATOR AND TRICKLE CHARGER KIT. Consists of h.t. and l.t. transformer, h.t. and l.t. rectifiers, smoothing electrolytic, choke, and steel case. For mains input of 200-250 v. Output 120 v. 40 mA. and 2 v. ½ a. Price with circuit **29/6.**

Or in working order, **37/6.**

WILLIAMSON AMPLIFIER KIT. Complete set of parts (exact to author's specification) for construction of the original amplifier.

PRICE COMPLETE **14 gns.**

R.S.C. TONE CONTROL-PRE-AMP. UNIT. A complete set of parts for the construction of a very efficient but simple pre-amplifier and tone control unit. Suitable for use with any amplifier and pick-up. Fil. supply is self-contained. Overall size is 7½-5-5½in. approx. Full descriptive leaflet **9d.**

PRICE INCLUDING WIRING DIAGRAMS **37/6.**

Or ready for use. **15/-** extra.

CHASSIS

18 s.w.g. undrilled aluminium amplifier type (4 sided)

12in. × 9in. × 2½in.	6/11
14in. × 9in. × 2½in.	6/11
14in. × 10in. × 3in.	7/11
16in. × 10in. × 3in.	8/3
18 s.w.g. aluminium, receiver type. 6in. × 3⅝in. × 1½in.	1/11
7½in. × 4½in. × 2in.	2/9
10in. × 5½in. × 2in.	3/3
11in. × 6in. × 2½in.	3/11
16 s.w.g. aluminium, receiver type, 12—8—2½in.	5/3
16in. × 8in. × 2½in.	7/6
20in. × 8in. × 2½in.	8/11
16 s.w.g. aluminium, amplifier type, 4 sided.	
12in. × 8in. × 2½in.	7/11
16in. × 8in. × 2½in.	10/11
20in. × 8in. × 2½in.	13/6
14in. × 10in. × 3in.	13/6

RADIO SUPPLY CO. (LEEDS) LTD.

32 THE CALLS, LEEDS 2

Terms C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/1 extra under £1, 1/9 extra under £3. Full Price List 6d. Trade List 5d.
Open to Callers: 9 a.m. to 5.30 p.m. Saturdays until 1 p.m.

Prices slashed at Clydesdale

R1155 RECEIVER UNIT
Communications, D.F. and "Ham" 20, 40, 80, 5 ranges 18-7.5 Mc/s, 7.5-3 Mc/s, 1500-600 kc/s, 500-200 kc/s and 200-75 kc/s. Complete with 10 valves. SM drive, ME tuning, BFO, etc., in metal case 16½ x 9 x 9in. External Power Supply required. APPEARANCE AS NEW ASK FOR X/E6
£8.19.6 CARR. PAID
APPEARANCE GOOD ASK FOR X/H916 **£6.19.6** CARR. 7/6 EXTRA.
APPEARANCE ROUGH ASK FOR X/H898 **£5.19.6** CARR. 7/6 EXTRA
Circuit 1/3.

T1154B TRANSMITTER UNIT
Medium/High powered, for C.W.-M.C.W.-R/T. 3 Ranges 10-5.5 Mc/s, 5.5-3 Mc/s, 500-200 kc/s. Complete with 4 valves, etc., in metal case 14 x 16½ x 8½in. External Power Supply required.
ASK FOR X/E5A **39/6** Each CARRIAGE 7/6 EXTRA **Circuit 2/3**

POWER UNITS for T1154/R1155 UNITS
Types 33 or 33B. Input 24 v. D.C. 16 a. Output 1,200 v. D.C. 200 mA.
ASK FOR X/E7A.
Types 35 or 35A. Input 18 v. D.C. 12 a. Outputs 7.2 v. D.V. 13 a. and 225 v. D.C. 110 mA.
ASK FOR X/E8A.
Each a Motor Generator Unit, smoothed, etc., in metal case 16 x 7½ x 6in.
LOOSE STORED
ANY UNIT **42/6** Each CARRIAGE PAID

VISUAL INDICATOR TYPE 1. Ref. 10Q/2.
Dual reading Left/Right DF meter for R1155. 2¾in. Scale, Overall dim.: 3¼ x 2½in. In used condition.
ASK FOR X/H862A **12/6** Each POST PAID

LOOP AERIAL TYPE 17 10D/16950.
NOT designed for R1155, but could be used. NO Housing, scaled 0-350 degrees. Wgt. 2½lb.
ASK FOR X/H938 **21/-** Each POST PAID

RECEIVER CHASSIS, RANGE 150-200 mcs. Contains: 1 Transformer prim 85M. henries, sec. 155M. henries, 5 coil in cans, 3 957 acorn valves, 4 acorn valve bases, 9 1.0 Valve-bases, 1 25pf. miniature tuning condenser with knob and coupling, 4 co-ax. sockets. On metal chassis size 8in. x 13in. x 5in. Wgt. 8¼ lbs.
ASK FOR X/H940 **21/-** Each POST PAID

EGG INSULATOR TYPE H6, 10B/153
Standard, medium, large, insulator finished in brown. 3in. long, 2 in. max. dia.
ASK FOR X/E192 **1/9** Each POST PAID
Box of 4 for 5/6. Gross lots for £7/4/-.

SUPPLY UNIT RECTIFIER for No. 43 Transmitter
Ex. Cdn. Army in original wood case.
Input 110 volts A.C. 50/60 c/s. 1.7K. V.A. Output (HT1) 2,100V. 375mA. (HT2) 500V. 400mA. plus HT Lines, 450V. 275V., also 383V. regulated and neg. bias 250V. 150V. 80V. Making 3 complete power supplies all fed via double choke, condenser. Input circuits. Valves are 4/866A/866, 5Z3, 6SJ7, 2/6A3, VR150/30 (Stab.) and 1V. (Time Delay). The complete unit mounted in metal case with lid shock mounted. Dim.: 2ft. 6in. x 1ft. 6in. x 1ft. Finish olive drab. Wgt. 420 lbs.
ASK FOR X/H26 **£25** Each CARRIAGE PAID

SELSYN MOTOR TYPE 5J/2512
Ref.: No. W.325A.
230 volts A.C. input single phase, torque transmission value 45 lb./ins. with ⅜in. long, ¼in. shaft. Overall 12½ x 7 ins. diam. With fixing base.
ASK FOR X/H83 **39/6** Each CARRIAGE PAID

POWER UNIT TYPE 266 in Transit Case Input 80V 1.5K cps. A.C. Outputs HT 120V. D.C. bias 3 and 9V. L.T. 2V. Smoothed and Stabilized. Complete with 5U4G valve VS110 stabilizer. 12V. 1A metal Rectifier, etc., etc., in attractive metal case with handles. Dim.: 11 x 9¼ x 7½ ins.
ASK FOR X/E870 **22/6** Each CARRIAGE PAID

TEST SET SE2 PATTERN NO. W5799
Brand New
Contains:—Wavemeter, oscillator and noise generator working on frequency of 180 to 220 mcs. Valves are 1/6X5, 1/655, 1/L63, 2/EA50, 1/EC52, 1/E1468. Mains Transformer 80V., 180V., 230V., 50-2,000 cps., 10-500 microamp meter. All sections are separately screened with their own brass boxes, which are silver plated. Complete with leads and attennuator in wooden case. Grey finish. Size 20 x 10 x 11 ins. Wgt. 55½ lbs. Calibration chart on lid of box.
ASK FOR X/H937 **£3.19.6** Each CARRIAGE PAID

OSCILLATOR (SIGNAL GEN.) TYPE 35
Ex. Admiralty. Robustly constructed Signal Generator with frequency coverage 15-600 kcs. 0.8-25 mcs. in 11 switched bands, 200-1 ultra S.M. Drive. Input 200V. D.C. H.T. and 250V. A.C. or 12 V. D.C. for valve heaters, L.T. Supply. Shorting strips for altering heater circuit beneath valves. Valve types KTW61 and 2/DL63 or equiv. **NOT SUPPLIED.** Chassis and Panel construction in steel and finished in grey and black. Dim.: 28 x 7½ x 12 ins. Wgt. 71 lbs. **LESS VALVES.**
ASK FOR X/E787 **£6.19.6** Each CARRIAGE PAID

A UNIVERSAL ELECTRIC MOTOR.
For 200/250 v. A.C. or D.C. Mains. By simple external wiring, full data supplied. New method gives better than 1/6th h.p. Using Ex-R.A.F. Motor Generator, dim.: 11 x 5½ x 5½in.
TYPE 29. ASK FOR X/E880.
TYPE 28. ASK FOR X/E880A.
EITHER UNIT **25/-** CARRIAGE PAID

Or giving slightly less power, ⅛ h.p. Motor Generator Type 30.
ASK FOR X/H488 **19/6** Each CARRIAGE PAID

ROTARY TRANSFORMER TYPE 44, Ref.: 10KB/409.
Input 18 v. D.C. 3.13 a. Output 450 v. D.C. 0.05 a. Spindle extended each end. Dim.: 8½ x 3¼ x 3⅛in.
ASK FOR X/H845 **12/6** Each POST PAID

STARTER MOTOR TYPE FE-1 CA4750.
Heavy Duty 24 v. D.C. Starter Motor, as used in Aircraft, with recessed splined spindle, 6 hole end etg. dim.: 8¼in. long 4¼in. dia.
ASK FOR X/H870 **10/-** Each CARRIAGE PAID

STILL AVAILABLE
As detailed in September Issue.

JEFFERSON-TRAVIS UF 2
Transceiver Chassis. (U.S.A. made)
Less valves, partly stripped by the M.O.S.
ASK FOR X/H518 **17/6** Each CARRIAGE PAID
Circuit 2/6.

BC-456 SPEECH MODULATOR UNITS.
ASK FOR X/E42 **27/6** Each CARRIAGE PAID
Circuit 1/3.

S-440-B VHF TRANSMITTER CHASSIS.
Less valves, partly stripped by the M.O.S.
ASK FOR X/H517 **15/-** Each CARRIAGE PAID
Circuit 1/3.

MODULATOR 169.
BRAND NEW. In original wood case.
ASK FOR X/H713 **21/-** Each CARRIAGE PAID

WS-18 RECEIVER CHASSIS
ASK FOR X/H22 **25/-** Each POST PAID

WS-18 TRANSMITTER-RECEIVER CHASSIS.
Partly stripped by M.O.S.
ASK FOR X/H349 **33/6** Each CARRIAGE PAID

GYRO ANGLING POWER UNIT 9/2201.
ASK FOR X/E874 **12/6** Each POST PAID

MONITOR CRYSTAL TYPE 2 10T/11390.
Less valves and Crystals.
ASK FOR X/H872 **5/-** Each POST 1/- EXTRA

FLUXMETER TYPE 1. WY 0023.
ASK FOR X/H361 **55/-** Each CARRIAGE PAID

RECORDER MK. II 24 VOLTS.
ASK FOR X/H88 **27/-** Each POST PAID

MAGNETIC MARCHING COMPASS Mk. I
ASK FOR X/H406 **12/6** Each POST PAID

PUMP, DESSICATOR, Adm. Patt. No. 12128 for Telescopes and Binoculars.
ASK FOR S/H358 **£3.10.0** Each CARRIAGE PAID

ROTARY CONVERTER TYPE 195.
ASK FOR X/H914 **£5.19.6** Each CARRIAGE PAID

AMPLIFIER A1363.
For Battery operation.
ASK FOR X/E898 **8/6** Each POST PAID

GUN SIGHT PROJECTOR UNIT TYPE 30
ASK FOR X/H882 **19/11** Each POST PAID

THROAT MICROPHONE. Ref. ZA.13935.
ASK FOR X/E14 **3/11** Each POST 6d. EXTRA

THROAT MICROPHONE. Ref. ZA.19374.
ASK FOR X/H955 **4/11** Each POST 6d. EXTRA

THROAT MICROPHONE.
(U.S.A. made.)
ASK FOR X/H57 **3/11** Each POST 6d. EXTRA

MICROPHONE. Ref. 10A/14381.
(Flying Helmet Type.)
ASK FOR X/E16 **3/11** Each POST 6d. EXTRA

CARBON HANDSET MICROPHONES
No. 8 Ask for X/H480.
No. 4A Ask for X/E13.
EITHER UNIT **7/6** Each POST PAID

CARBON POWER MICROPHONE.
And Moving Coil Headphone Assembly. Ref. ZA17604. In Original Carton.
ASK FOR X/E13 **15/-** Each POST PAID

CANADIAN R.E.L. BINOCULARS

Brand New and guaranteed optically perfect. Individual eye-piece focussing (dioptar setting) and variable inter-ocular setting, leather neck-strap.

In original cartons
Magnification 6 x 30.

ASK FOR X/H920 **£8.19.6** Each POST PAID

In fitted Leather Case.
Magnification 7 x 50.

ASK FOR X/H921 **£21.10.0** Each POST PAID

PLOTTER FIELD Mk. IV, Ref. OS.739A

A precision made Protractor Unit, first-class condition. With 2 scales 0-180 deg., moving crossarms, scaled 21-65 each 12⅞in. long. Straight edge base scaled 0-3500 length 25in. fully extended. In soiled leather case 16 x 5¼ x 2in.

ASK FOR X/H864 **9/11** Each POST PAID

ELECTROSTATIC KILOVOLTMETER.

Range 0/2 kV. 2½in. round mld. case, drilled flange.

ASK FOR X/E333 **27/6** Each POST PAID

500 MICROAMP METER REF. ZN2106

For WS-18 Transmitter.

2In. round, clip mounting case. Res. 500 ohms.

ASK FOR X/E303 **15/-** Each POST PAID

WALNUT-FINISH WOOD RADIO CABINET.

Dim.: Internal 8½ x 15⅝ x 7⅞in. approx. External 9½ x 17 x 8in. approx.

ASK FOR X/H394 **12/6** Each POST PAID

Or **Cabinet** as above with 3 waveband glass dials, expanded metal L.S. Grill, 3 knobs 1¼in. dia. fluted type.

ASK FOR X/H945 **17/6** Each POST PAID

PLASTIC RADIO CABINET.

Dim.: Internal 11 x 6½ x 4¾in. approx. External 12 x 7½ x 6⅞in. approx.

ASK FOR X/H720 **12/6** Each POST PAID

AERIAL SYSTEM TYPE 62.

U.H.F. Antenna on streamlined moulding with VR92 (EA50) untuned detector stage. Overall dim.: 13½ x 4¾ x 2¾ Antenna 22.5 cm.

ASK FOR X/H496 **3/6** Each POST 9d. EXTRA

Circuit 1/3.

AERIAL ROD.

15in. lengths, copper plated steel tube, ferruled to interlock and an Aerial of desired length.
⅛in. dia.: Ask for X/H709.
¼in. dia.: Ask for X/H710.

EITHER SIZE **5/6** Doz. Lengths POST 6d. EXTRA

RADAR REFLECTOR AERIAL MX-137/A.

Spider Web mesh Aerial in original moisture proof carton, with assembly instructions.

ASK FOR X/E175 **4/11** Each POST 9d. EXTRA

STAINLESS STEEL AERIAL WIRE

7/.015 in reels of approx. 1,600ft. made by Temco.

ASK FOR X/E143 **25/-** Per Reel CARRIAGE PAID

DINGHY TELESCOPIC MAST.

Aluminium Telescopes from 14½in. to 7½ft. Seven sections, base dia. ⅝in., top dia. ⅞in. Wgt. 4 oz.

ASK FOR X/H489 **4/6** Each POST 6d. EXTRA

MORSE PRACTICE BOARD ONLY.

Comprises Key, buzzer, and phone terminals on board 6½ x 6½ x ½in. with battery clamps.

ASK FOR X/EIX **5/6** Each POST 9d. EXTRA

Further Reductions

CALIBRATOR UNIT R.D.F. No. 1 ZA.14401.

In Original Wood Case.

Complete with valves 2/VR65 (SP61), 2/VR66 (P61), 2/VR92 (EA50) 5Z4G and VGT128 (GTK) 80 v. 400 c/s Power Supply, condensers, resistors etc. Dim.: 13 x 7½ x 9½ln.

ASK FOR X/H829 **21/-** Each CARRIAGE PAID

TEST OSCILLATOR TS-24/ARR-2.

(U.S.A. made.)

For alignment of TBX Aircraft Receivers. H.F. Osc. signal of 245 Mc/s. L.F. Osc. tuned 540-830 kc/s. 2/955 acorns, safety time switch, calibrated dial, etc. Complete less batteries. In metal box 9¾ x 7½ x 7in.

ASK FOR X/H364 **21/-** Each CARRIAGE PAID

TEST OSCILLATOR TS-24A/ARR-2.

(U.S.A. made.)

As TS-24/ARR-2 but having additional tone modulation section, with further 955 acorn, this provides optional Audio Signal Switch controlled.

ASK FOR X/H364A **27/6** Each CARRIAGE PAID

TEST SET TYPE 102.

A 250 v. A.C. 50 c/s Test Set emitting 25 c/s and 50 c/s synchronising pulses. Amplitude calibrated 0/2 a. and 1.4 watts for output lamp. Complete with valves, 6J5 and CV18 (double triode) photometer type comparitor, spare lamps, output cable, etc., in steel box 11 x 9 x 10in., with carrying handle.

ASK FOR X/H561 **21/-** Each CARRIAGE PAID

AMPLIFIER AI271. Ref.: 10U/549.

Used with T/R's 1133, 1143, 1143A, 1430, 1464, and Aerial System type 62. With valve VR56 (EF36) Relay, Transformers, etc., in metal case, dim.: 5 x 5 x 4¾in.

ASK FOR X/H532 **4/11** Each POST 1/-

Circuit 1/3.

F24 AIRCRAFT CAMERA

in Transit Case

Lens 5 inch F/4, with internal iris diaphragm stops to F/11, fixed focus set at infinity, screw in housing projects 5½in. Focal plane shutter speeds 1/60th to 1/1,000th of a second and time, fitted

in film magazine designed for 5¾in. wide film, picture size 5½ x 5¼ins. Shutter release and rewind spindle fits standard spanner. Hand operated as it stands. Net. wgt. 17 lbs. Packed in fitted transit case 42 lbs. Dim.: body 6½ x 9 x 9¼ ins. overall incl. lens housing 11¾ x 9 x 9½ins. Provision for external motor drive (not supplied). Lens housing grooved for fitting to aircraft camera port. A precision Air Survey Camera, could be adapted for Laboratory, Industrial or Portraiture uses.

ASK FOR X/H302 **£4.19.6** CARRIAGE PAID

14 INCH F/5.6 LENS FOR F/24 CAMERA

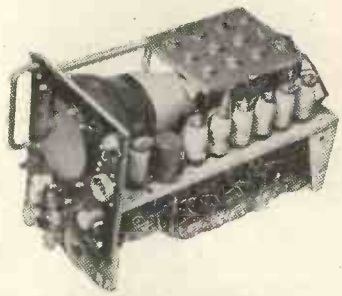
Complete with Iris, Filter, Mount and Extension in Transit Case.

ASK FOR X/H563 **£9.19.6** Each CARRIAGE PAID

INEXPENSIVE T.V.

INDICATOR UNIT TYPE 62A with EF50's Containing VCR-97 Tube and Valves. 12-VR91 (EF50) 4-VR65-CV118 (SP61) 3-VR92 (EA50) 2-VR-54 (EB34), etc., etc., in metal case 18 x 18¼ x 11½ ins. Used, good condition.

ASK FOR X/H868 **79/6** Each CARRIAGE PAID



INDICATOR UNIT TYPE 62.

Used, good condition.

ASK FOR X/E774 **49/6** Each CARRIAGE PAID

INDICATOR UNIT TYPE 6.

In original wood case.

ASK FOR X/H524 **89/6** Each CARRIAGE PAID

INDICATOR UNIT TYPE 6H.

In Original Wood Case.

ASK FOR X/E777 **89/6** Each CARRIAGE PAID

INDICATOR UNIT TYPE 305

Brand New. Ref.: 10QB/6504

Contains :—VCR524A-VCR525, 7 EF50, 2 VR54, 6 EA50, 2 .01 high voltage condensers, 3 relays 4 make, 4 break, 500 ohm. coil. Numerous condensers, Pots., and Resistors. Dim.: 12 x 7 x 18 ins. Wgt. 30 lbs

ASK FOR X/H943 **£3.19.6** Each CARRIAGE PAID

5CP1 CATHODE RAY TUBE.

In Original Carton.

6in. Electrostatic type, Heaters 6.3 v. 0.6 a.

ASK FOR X/H529 **19/6** Each POST PAID

Ion Trap Magnet Assembly. Mfg. Surplus. Type IT/6 by Elac for 35 mm. tube neck.

ASK FOR X/H919 **2/6** Each POST 3d. EXTRA

IF/AF AMPLIFIER UNIT R1355

In transit case.

With valves, IF frequency 7.5 mcs. Dim. 18x 8½ x 7½ ins. Used, good condition.

ASK FOR X/E770A **37/6** Each CARRIAGE PAID

ALSO STILL AVAILABLE

R1355 as above but loose stored.

ASK FOR X/E770B **22/6** Each CARRIAGE PAID

R.F. Unit Type 24. In Original Carton. Switched tuning 20-30 Mc/s with valves, etc.

ASK FOR X/H850 **22/6** Each POST PAID

R.F. Unit type 25. In Original Carton Switched tuning 40-50 Mc/s with valves, etc.

ASK FOR X/H847 **22/6** Each POST PAID

R.F. Unit Type 27. With broken dial. Variable Tuning 65-85 Mc/s with valves, etc. Used, good condition.

ASK FOR X/E771 **39/6** Each POST PAID

THE POWER UNIT TYPE 285

Ready made for T.V.

A.C. mains Input 230V. 50 cps. Outputs E.H.T. 2K.V. 5mA. HT. 350V. 150mA. LT 6.3V. 10A and 6.3V. 5A. Fully smoothed and rectified with valves VU120, 5U4G, VR91 (EF50) plus cond., Resistors, etc.

ASK FOR X/H947 **£4.19.6** Each CARRIAGE PAID

"UNITELEX PRIMA" PORTABLE TAPE RECORDER: We are appointed stockists for this recorder, Features include ultra-modern cabinet design, giving exceptional lightness and portability without sacrifice of quality. Push-button control on mechanical side, twin-track heads, dual-speed (7½in. and 3¾in. per sec.), giving up to two hours playing on one reel of tape; latest type miniature valves used; genuine 10 kcs. response; separate bass and treble controls; magic eye recording level indicator; provision for use as straight playback amplifier from record players or changers; 4-watts output to internal 10in. elliptical high-flux speaker, with provision for feeding two external speakers or amplifiers. Price, complete with filter cell microphone housed in recorder, and with 1,200ft. reel of high coercivity tape, 57 guineas. H.P. terms 19 gns. deposit, 12 monthly payments of £3/11/6. Send 2½d. stamp for illustrated brochure.

GARLAND AMPLIFIER ACIV. A high-fidelity gramophone or microphone amplifier with a maximum output of 11.5 watts. The exceptionally wide frequency range (20–30,000 cs. ± 1 db.) and extremely low harmonic distortion (0.5 per cent. at 1,000 cs. for 8 watts output) are unusual among amplifiers in this price bracket. Separate high and low gain inputs, bass, treble and volume controls. Output to 150 ohm or 3 ohm. speaker. Standard valves throughout. Price 15 guineas, plus 15/- carriage, etc. Weight 20 lb.

SPECIAL OFFER. COLLARO RC 3/521 3 SPEED AUTO-CHANGER with 2 plug-in heads. £9/19/6.

COLLARO 3 SPEED RECORD PLAYER DESKS with 2 plug-in ortho-dynamic heads. £6/8/6. Limited stock only.

MAGNETIC RECORDING COMPANY PORTABLE TAPE RECORDER, single speed (7½in.), twin track; magic eye recording level indicator, 3 watts output provision for mixing. Price complete 48 guineas.

BELLING AND LEE PLUGS AND SOCKETS. 5 way, 2/-; 7 way, 2/3 complete.

JONES PLUGS AND SOCKETS, 6 way, 1/9; 8 way 2/- complete.

GOODMANS H6 OUTPUT TRANSFORMERS. Rated up to 30 watts push-pull; ten-section wound on silicon steel laminations with primary inductance of 100 H and negligible leakage inductance and capacitance. Primary 10,000 ohms C.T. Secondary 3.75 plus 3.75 ohms. Price £3/3/-, plus 2/6 p. and p.

TAMSA TYPE 100 TAPE RECORDING HEADS. As used by the leading commercial tape recorder manufacturers. Housed in chromium plated brass case on adjustable mounting. Record/playback heads have ½-thou. gaps and erase heads have 2.5 thou. gaps. These heads are of high impedance. Price 45/- each.

VARLEY MAINS TRANSFORMERS. Primary 10-0-200-220-240 volts. Secondary 300-0-300 volts at 150 mA., 5 volt at 3 amps., 6.3 volt at 4 amps., 6.3 volts at 1 amp. Open type construction. Price 45/-, post 2/6.

BRENETTE MICROPHONES. Large sales of these popular microphones has enabled us to make substantial reductions in the prices. The following range is available: **Type 9ND:** Multi-directional ball-type, in black and chrome, £2/2/-, post 2/-. **Type 7D:** Directional type, for instrumental or vocal use; black and chrome, £3/15/-, post 2/6. **Type 11A:** A wide-frequency-response microphone, in brown cast case with chrome grille, £5/5/-, post 2/6. **Type 13U:** A highly sensitive studio microphone with outstanding frequency characteristics. Flexible mounting enables it to be used directionally or not as required. Black and chrome finish, £6/6/-, post 3/6.

TWO GANG TUNING CONDENSERS. 0.0005 mfd., with fixing feet. Price 7/9 each.

THYRATRONS. Type NGTI (CV1141), 4 volt heater. Price 5/6 each.

E.H.T. PLUGS AND SOCKETS. 1/- complete.

PYE ¾ COAXIAL PLUGS AND SOCKETS. 1/- per pair, complete.

4-WAY MOULDED PLUGS AND SOCKETS. 2/6 per pair.

L.F. CHOKES. 10 Henry, 70 mA. Price 4/9 each.

ENGRAVING TOOL. For 200-240 v. A.C. mains. Suitable for use on metals or plastics. Price 10/- each.

COAXIAL CABLE. Stranded centre conductor, ¼in. diameter, 80 ohms, 4/6 per ½ doz. yds.

CONDENSER CLIPS. Vertical mounting 1in., 4d.; 1⅛in., 4½d.; Horizontal mounting, 1⅛in., 4d.; Double, ⅞in., clips, 4d. Minimum order 3/-.

CATHODE-RAY TUBES. Type 5CP1. 5in. green screen, electrostatic focussing and deflection. Callers only. Price 22/6 each.

PAXOLIN PANELS. 3½in. x 1½in. x 3/32in. 5/- per 100. 2½in. x 2in. x 1/16in., 6/- per 100 Many thousands available.

CRYSTAL DIODES. Germanium Vacuum sealed glass type with wire ends, 2/6 each or 24/- per dozen.

CARBON RESISTORS. ¼-½ watt, 3/6 per doz. (minimum). Virtually all standard values in stock. Nearest value supplied, unless otherwise stated.

SILVER MICA OR CERAMIC CONDENSERS (pFs). 2, 4, 10, 15, 27, 30, 50, 75, 100, 160, 200, 220, 300, 330, 350, 500, 1,000, 2,000, 4,500, 4,700. All at 4/- per doz. (minimum quantity).

MOULDED MICA CONDENSERS. .01 mfd. 500 v., 5/- per doz. (minimum quantity).

EHT CONDENSERS. .001 mfd., 5kV. A.C. Test, 1/6 each or 15/- per doz. .02 mfd., 5kV, D.C. working, 1/6 each or 15/- per doz.

Garland Bros

GARLAND AMPLIFIER ACII. Self-contained general-purpose amplifier, providing 3.5-watts output. All power supplies derived from mains transformer, ensuring isolated chassis. Standard valves throughout. Volume and Tone Controls incorporated. Negative feedback loop. Price £6/12/6 plus 5/- carriage, etc. Weight 10 lb.

THE LATEST LANE TAPE TABLE. Incorporating three heavy duty Lane motors; fast rewind and wind-on without tape handling; automatic braking; high impedance half-track heads; hub locking device. Tape speed 7½in. per second. Price £17/10/-. Carriage 10/-.

OUTPUT TRANSFORMERS. Standard pentode matching to 2/4 ohms. Price 4/6 each.

ROTARY TOGGLE SWITCHES. 4 pole bunching. Price 1/6 each.

EXTENSION SPEAKER CABINETS, modern design in walnut. For 6½in. speaker 19/6; for 8in. speaker 21/-.

CV73 A HEAVY DUTY BEAM TETRODE for pulse operation, also used in stabiliser circuits. 5/- each.

MR COMPANY AMPLIFIER, only suitable for use with Lane, Motek or other high impedance desks. £15.

MAGNETIC TAPE. Now available, the new Scotch Boy High Coercivity Tape MC2-III, with higher output and signal-to-noise ratio. Price 35/- per 1,200ft. reel. Still available: Scotch Boy MCI-III: 1,200ft., 35-; 600ft., 21/-; 300ft., 12/3. Spare 7in. spools, 4/3. Ferrovoice, the new kraft-based medium coercivity tape: 1,200ft., 22/6. Spare 7in. spools, 4/6. Magnetophone Tape: £2 per 1,200ft. reel.

ZINC PLATED CHASSIS. 13½ x 6 x 2½in. drilled for five valves, 2/6.

DUMMY AERIAL LOADS. Tapped at 20, 10 and 5 ohms, 100 watts. British 5-pin base. Callers only, 1/6 each.

PLASTIC SPEAKER CABINETS. Louvred for 5in. speaker. Callers only. Price 10/- each

IGNITION SWITCHES. Low voltage, high current, in bakelite case. Price 9/- per doz.

S.W. TUNING CONDENSERS. 160 pF. with fixing feet. Price 2/3 each.

FLEX CONNECTORS. 2½ x ½in., for 250 v., 1/- complete.

TRIMMERS. 50+50 pF, 100 + 100 pF, 100 + 500 pF, 500 + 500 pF, ceramic mica, 9d. each; 250 pF, 1,000 pF, 9d. each; 50 pF, 75 pF, airspaced pre-set, 1/3 each; 75 pF, air-spaced, 2in. spindle, 2/- each. 33⅓ per cent. discount in dozen lots.

LINE CORD. 3-way, 0.3 amp., 60 ohms per foot, 1/9 per yard.

ELECTROLYTIC CONDENSERS. These are current production, not surplus stocks. 32 mfd., 450 volts, 250 mA. ripple, can., 4/6; 8 mfd., 450 v., 1/9; 8 + 8 mfd., 450 v., 3/3; 8 + 16 mfd., 450 v., 4/-; 8 + 32 mfd., 450 v., 4/6; 16 + 16 mfd., 450 v., 5/-; 32 + 32 mfd., 350 v., 3/6 mfd., 25 v., 1/9; 50 mfd., 12 v., 1/9.

MAINS DROPPERS. Standard 0.2 and 0.3 amp. Price 3/9 each.

HEATER TRANSFORMERS. 230 v. input, 6.3 v., 1.5 amp. output, 6/- each.

MOULDED BAKELITE ESCUTCHEONS. 8⅛in. x 2⅜in. with opening 6⅜in. x 1⅛in., 4/6 per ½ doz.

MINIATURE LIGHT WEIGHT RELAYS. 270 ohm, 18 v. Single pole on-off. Ex-American equipment. Price 2/9 each, 13/6 per half-dozen.

MICA "POINT ONES." Actual value 0.108435 ± 0.5 per cent. Suitable for use on A.C. mains voltage. Special offer at 1/- each, 9/- per doz. or £3 per 100.

ELECTROLYTIC CONDENSER OFFER. Tubular cardboard cased, with wire ends, 8 mfd., 450 v. wkg., 525 v. surge, 2/- each, 21/- per doz. Current production.

TRUVOX TAPE DESK MARK III. Incorporating high impedance mu-metal twin-track heads. Two-speed capstan, for tape speeds of 7½ and 3¾ inches per second. Three heavy-duty motors allowing for fast forward and rewind facilities without tape handling. All controls operated by electrically and mechanically interlocked push buttons. Price £23/2/-. Send S.A.E. for full particulars. Plus 10/- carriage, etc. Delivery from stock. Send 2½d. stamp for details of this and of suitable amplifier.

AERIAL AND OSCILLATOR COILS. For medium and short waves. Price 5/- per set of 4 coils.

HEADPHONES. 4,000 ohms, per pair, 11/-.

SWITCH SOCKETS. Flush mounting 250 volt, 3 pin, 5 amp., bakelite. Price 3/6.

POTENTIOMETERS
Ex-Govt. or Manufacturers Surplus.

Value	Track	Watt-age	Spindle length	Price
33	Carbon	1	1in.	1/9
2.2k	W/W	5	5in.	3/9
3k	C/Trop	2	¾in.	1/6
3k	W/W	5	Preset	2/3
5k	,,	2	¾in.	2/6
8k	,,	5	¼in.	2/3
10k	C/Trop	2	¾in.	1/9
10.4k.....	W/W	5	¼in.	3/-
20k	,,	3	Preset	1/9
20k	,,	5	1in.	3/-
20k	C/Trop	2	¼in.	1/3
25k	W/W*	5	¾in.	3/-
25k	C/Mini	½	Preset	9d.
50k	W/W*	3	¾in.	2/6
50k	C/Mini	½	¼in.	9d.
100k	,,	½	¼in.	9d.
200k	Carbon	1	¾in.	1/3

All new and unused. Spindle diam. ¼in. in all cases. * are earthed slider.
Above prices less 20 per cent. in dozen lots, less 33 1/3 per cent. in 100 lots.

RECTANGULAR KNOBS. Size 1¼in. x ¾in., with gold indicating spot ; to fit standard ¼in. spindles. Price 5/- per doz., 37/6 per 100.

BOOKS FOR RADIO ENGINEERS.

Mullard Valve and Service Reference Manual	5/-
Mullard Amateurs Guide to Valve Selection	1/6
Osram Valve Manual, Part I	5/-
Brimar Radio Valve and Teletube Manual	5/-
Wireless World Radio Valve Data, 3rd edition	3/6
Radio Valve Guide. By W. J. May	5/-
The Williamson Amplifier Manual, latest edition	3/6
Wireless World High Quality Amplifier Manual	2/6
T.V. Fault Finding	5/-
Television Faults	5/-
Television Explained (Miller)	5/-
Viewmaster Envelope (state transmitter for which required)	7/6
Tele-King Envelope	6/-
The Oscilloscope Book	5/-
Magnetic Recording (Quartermaine)	4/6

(Add 3d. to price in all cases for postage.)

TYANA SOLDERING IRONS. Lightweight, 40 watt irons with easily interchangeable elements and 3/16in. diameter bits. Voltage ranges, 6 v., 100/110 v., 200/220 v. and 230/250 v. Price 16/9. "The iron that makes soldering a pleasure."

LARGE DIAMETER SLEEVING. Transparent plastic, ¼in. diameter, 6/- per doz. yards.

LITZ WOUND INDUCTORS. 199 micro Henry, wound on Aladdin ¾in. coil former (no iron dust core). Price, 2/6 per half dozen, 4/6 per dozen, 30/- per 100.

TOGGLE SWITCHES. Black bakelite. SPCO 1/- each, 9/- per doz. DP on-off 1/3 each, 12/- per doz. Suitable for use on mains voltages.

L.F. CHOKES : Tropicalised 8H 120 mA., 8/6 each ; 40 mA midget type, 3/- each.

CLEARANCE OF EX-GOVT. MOTORS, Rotary Transformers, etc. Many different types available. All one price to clear, for callers only, 6/6 each.

MINIATURE MUMETAL TRANSFORMERS. Auto-wound, giving approx. 2/1 ratio. Ideal rewind as head lift transformer, or lams can be used for recording heads, 2/6 each or 11/- per half-doz.

CONNECTION BLOCKS. 3-way on porcelain base, 6/- per dozen.

cut your costs

INSTRUMENT WIRES. Enamelled, silk and cotton covered, available in upwards of 2 oz. reels. Send S.A.E. for list of lowest prices.

AMPLION TESTMETER. 10 ranges A.C. and D.C. up to 500 v. Resistance up to 200,000 ohms. 1/800 ohms per volt A.C. and D.C. Price £5.

HIGH WATTAGE WIRE WOUND RESISTORS. Capped end type, porcelain covered, at the following prices : 20 watt, 1/- ; 40 watt. 1/3 ; 80 watt, 1/6 ; 100 watt, 1/9 ; 200 watt, 2/6 ; 3 ohm, semi-variable, 20 watt ; 4 ohm, 40 watt : 13.852 + 1.352 + 8.352 ohm, 40 watt ; 80 ohm, 40 watt ; 350 ohm, 40 watt ; 430 ohm, 200 watt ; 5 k, 40 watt ; 7.5 k, 40 watt ; 12 k. + 2 k, 80 watt ; 20 k, 80 watt ; 50 k. 100 watt ; 75 k, 40 watt ; 100 k, 200 watt. Packing and carriage extra on all of these resistors. 20 per cent discount dozen lots, 33⅓ discount 100 lots.

TWIN SCREENED CABLE. Suitable for carrying currents of up to 5 Amps. Cotton covered, 9d. per yard. Ditto uncovered, 8d. per yard. Minimum order 6 yards.

WALNUT VENEERED CABINETS. Size 12in. x 7in. x 5¼in. Suitable for housing a T.R.F. receiver or inter-com. Complete with back, chassis, dial and clips. Price, to callers only, 22/6.

MAINS TRANSFORMERS. All at 19/6 each.

MT1. 250-0-250 v., 80 mA, 0-4-5 v., 2 A., 0-4-6.3 v. 3 A.

MT2. 350-0-350 v., 80 mA, 0-4-5 v., 2 A., 0-4-6.3 v. 3 A.

MT3. 0-30 v., tapped to give 3 v., 4 v., 5 v., 6 v., 8 v., 9 v., 10 v., 12 v., 15 v., 18 v., 20 v., 24 v., 30 v., all at 2 amp.

MT4. 4 v., 4 amp. ; 10 v. 4 amp. ; 20 v. 3 amp., for battery chargers.

MT5. Auto ; 0-10-120-200-230-250 v., at 100 watt.

VALVE HOLDERS. B3G, pax, 4d ; Do., with spring retainers, 1/- ; B5, pax, 4d. ; B5, bakelite, 6d. ; B5, baseboard, 6d. ; B7, pax 6d. ; B7, amphenol, 1/- ; B7G, amphenol, 6d. ; Int. Octal, amphenol, 6d. ; B8A, amphenol, 9d. ; B8G (loctal), amphenol, 6d. ; B9, pax, 6d. ; B9A, amph., 9d. ; B9G, pax, 6d. ; B9G, ceramic or siliconised polystyrene, 6d. ; B12A, pax, 9d. ; UX4, pax, 6d. ; UX4, amphenol, 9d. ; UX5, pax, 6d. ; UX5, amphenol, 9d. ; UX5, ceramic, 1/- ; UX6, pax, 4d. ; UX7, pax, 4d. ; UX7, medium (for 1625, RK34, etc.) ceramic, 1/-.

NEON LAMPS. 85 volt striking, S.B.C centre contact base. Price 2/6.

GOODMANS OUTPUT TRANSFORMERS. 10 watts push-pull to match into 10,000 ohm., with two 3.75 ohm. secondaries for 3 or 15 ohm. speaker. Price 14/9.

MINIATURE LIGHT WEIGHT RELAYS. 270 ohm, 18 v. Single pole on-off. Ex-Amercan equipment. Price 2/9 each, or 13/6 for 6.

COMMERCIAL POTENTIOMETERS. All usual values. Less switch, 2/3 ; with single pole switch, 3/6 ; with double pole switch, 4/-.

CARTRIDGE FUSES. All usual values in 1¼in., 5d. each. Other sizes 6d. each.

SWITCHBOARD METERS. 6½in. scale, 0-5 v. A.C./D.C. full scale. Price 30/-.

GARLAND TAPE RECORDER OSCILLATOR UNITS. With valve, for use with high impedance heads only. Price 35/-.

TYANA SOLDER GUNS. Weight 30 oz., for 220-250 v. A.C. mains only ; consumption 100 watts. The low voltage bit can be easily bent to reach into corners and is insulated from the earthed case. Price 3 guineas.

WINDSOR SAPPHIRE NEEDLES. Available in the following three patterns : trailer type for magnetic or heavyweight pick-up ; straight type for crystal pick-up ; midget type for lightweight or high fidelity pick-up. Price 2/6 each.

MIDGET 2-GANG CONDENSERS. American manufacture, 500 pF., 6/- each.

VARIABLE RESISTORS. 50 ohm, 1 amp., with calibrated very fine worm drive. Price 7/6.

RADAR REFLECTORS. Type MX139/-A. These consist of 6—2ft. x ¼in. dural tubes covered with fine wire mesh. The whole assembly can be used as an omni-directional aerial, and the mesh has many horticultural applications. Price 3/9 each, post 9d. ; 36/- per doz., carr. paid. Type MX137A : similar to above, but also include a telescopic aerial rod, extending from 11in. to 3ft. 6in. approx. Price 4/9 each, post 9d. ; 45/- per doz. or £15 per 100, carr. paid.

TELEVISION MAGNIFYING LENSES. 6in. clear, 19/6 ; 9in. clear or filter, 50/- ; 12in., clear or filter, 70/-. Please state which and add 5/- for carriage and packing.

WHANDA WIRE AND CABLE STRIPPERS, to take all size flexes and cables up to ⅜in. diam. with 3 alternative heads and triple screw adjustment. These are brand new and boxed, and the original price was 15/- each. Our price 5/- each, post paid.

AERIAL RODS. These popular rods, of tough steel, copper-plated, are 12in. long, and fit into each other to make any length. Many hundreds of thousands sold to T V aerial manufacturers and to the public. Price 3/6 per doz. or £1 per 100, post paid. £10 per box of 1,800 carriage paid U.K.

DECALS. 500 ¼in. high white transfer letters and words for marking electronic equipment. Price 4/9 per book. The new Decals book for the amateur now available. 29 words per page, 4 pages radio and audio, 4 pages T/V and Scope, 2 pages misc. incl. Tx. and Tape Recording, 3/6 per book, post 3d.

H.F PENTODES. Type 6SH7, 6.3 v. 0.3 a. heater, int. octal base, high slope. Special offer, 5/6 each, 27/- per half-dozen, £20 per 100.

SMALL PAPER CONDENSERS. In tubular metal cases with wire ends. 0.25 mfd., 250 v., ¼in. diam. x ¾in., 1/- each ; 1 mfd. 150 v., ⅜in. diam.x 1¼in., 1/3 each ; 2 mfd. 250 v., ⅜in. diam. x 2¼in., in Neoprene sleeve, 1/9 each. Above prices less 25 per cent. in dozen lots.

WIRE WOUND RESISTORS. Open, cement coated or vitreous enamelled. 4 watt, 50, 90, Price 1/- each. 6 watt, 30, 145, 270 10 k., 15 k. Price 1/6 each. 10-15 watt, 5, 90, 100, 120, 170, 175, 200, 400, 700, 950, 1 k., 3.5 k., 4.5 k., 4.7 k., 11 k., 15 k., 25 k., 1/9 each. 15 watt, 650 ohm. Price 2/-.

CERAMIC SWITCHES. Single pole, eight-way, 3/6 each.

T.R.F. COILS. Medium and long wave, aerial and H.F., 6/- per pair ; with reaction winding, 6/9 per pair.

BRIMISTORS. Non-linear resistors to protect valves from current surges : CZ1, 0.3A, 3/6 ; CZ2, 0.3A, 2/6 ; CZ3, 0.2A, 1/6 ; CZ4, 1.25A, 5/- ; CZ6, 0.45A, 3/6.

MOULDED BROWN BAKELITE CABINETS. Suitable for fitting Decca 3-speed gram. motor, amplifier or loudspeaker. Outside dimensions (closed) 15¼in. x 10in. x 5¼in. ; thickness of wall, ¼in. Price, 22/6, to callers only.

TAPE RECORDER OSCILLATOR COILS. 6.3 mH, 45 kc/s, for high impedance heads only. Price 6/9 each.

DIAL BULBS. 6-8 v. 0.3 amp., M.E.S. fitting. Price 6 for 3/6.

MANSBRIDGE CONDENSERS. 0.01 mfd., 500 v., 6d. ; 0.01 mfd., 750 v., 6d. ; 0.25 mfd., 500 v., 6d. ; 1 mfd. 400 v., 6d. ; 1 mfd. 500 v., 9d. ; 1 mfd. 600 v., 1/- ; 1 mfd. 800 v., 1/3 ; 3 mfd., 750 v., 1/9. Minimum order 5/-.

OIL FILLED CONDENSERS. 1 mfd. 600 v., 3/-

ADMIRALTY TRANSFORMERS. 36 vA. 500/1,000 c. Pri. 0-80-180 v. Sec. 0-900-2,400 v Can be used in reverse on 50 c., 3/9.

DIMMER SWITCHES 5C/725. Wire-wound. approx. 300 ohms, with off position, 6/- per ½ doz.

METAL RECTIFIERS. RM1, 125 v. @ 80 mA., 3/11. RM2, 125 v. ± 100 mA., 4/3. RM4, 250 v. @ 250 mA., 17/- 14D/972, 250 v. @ 25 mA., 6/6. 12 v. ¾ a., 6/-. 25 v. 1 a., 4/6. 12 v. 2 a., 12/6. 12 v. 2½ a., 16/6. 12 v. 4 a., 21/-.

ELECTRO - MAGNETIC CONTACTORS. Energised at 9-14 volt, ½ amp. ; maximum switched current, 40 amps. In bakelite case. Price 2/9 each or 25/- per doz.

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ROTARY TRANSFORMERS. Midget type. 11.5 volt input 365/310 volt 30 m.a. output. Brand new **15/-** each, post 1/-.

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JONES SOCKETS. 8-way Chassis Mounting, **7/6** doz. 8-way with covers **9/-** doz. 2-way with covers, **4/6** doz.

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ACCUMULATOR CUT OUTS. 12 volt and 24 volt 60 amp. Type 'D' Suitable for using on battery chargers etc., **10/-,** each, post 9d.

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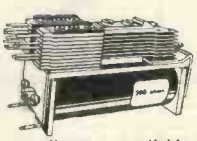

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1155 POWER PACK AND OUTPUT STAGE complete with U50 and KT61 valves (not surplus) Black crackle case 12 x 8 x 5in. built-in 5in. pm Speaker and phone jack. 200-250 v. A.C. All connections terminate in Jones plug which enables instant operation of recelver **without any modifications whatever.** Matches in appearance with receiver. Made to "Wireless World" specifications. Built entirely from top grade new components, **£7/10/-** plus 3/6 carriage.

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TRAWLER BAND BATTERY RECEIVER R1224A

A 5-valve superhet receiver covering 30 to 300 metres in 3 wavebands with no gaps. I.F. 465 kc/s. Valve line-up: R.F. (VP23), F.C. (FC2A), I.F. (VP23), Detector 210LF, output 220 P.A. For headphone output but data supplied for speaker operation. Receiver contained in grey wooden cabinet, size 14½in. x 10in. x 9½in. MUIRHEAD slow motion dial. Brand new in original carton or case, complete with valves and air-tested. Requires 2 v. L.T., 120 H.T., 9 v. G.B. Circuit diagram included ; for **79/6**, plus 7/6 carriage.

COMMUNICATION RECEIVERS

SKY CHAMPION S2OR. This super Hallicrafter receiver covers 550 kc/s to 45 Mc/s (550 to 6½ metres) without gaps. Has bandspread tuning. R.F. stage, two I.F. stages, etc. Built-in power-pack for 200/250-volts 50 cycles A.C. mains operation. Complete with all nine valves, built-in speaker and ready for operation. Each set tested prior to despatch and demonstrated to callers. In case size 18in. x 8½in. x 10in. Price **£21**, plus 10/- carriage and packing.

SKY RIDER DEFIANT SX24 is similar to above but includes crystal I.F. filter and S meter, etc. Complete with valves and crystal for **£27/10/-**, plus 10/- carriage and packing. For further details send S.A.E.

COMMUNICATION RECEIVER R1155 for world-wide reception. Can be heard at any time during shop hours. Air tested prior to despatch. Brand new at £11/19/6. A few slightly used at £7/19/6.

TRAWLER BAND. R1155N, with super slow motion drive, available at **£17/19/6. Carriage in original transit cases 10/6 extra on all models. Send 1/3 for full details and circuit.**

A.C. MAINS POWER PACK OUTPUT STAGE enables the R1155 to be used to operate speaker from 200/250 volts A.C. without ANY MODIFICATIONS WHATEVER. **All our Power Packs have heavy duty transformers, are complete with leads and Jones plugs and are guaranteed for 6 months.**

Type A. In neat black box, size 8½in. x 4½in. x 6½in. Less speaker. Price **£4/10/-**, plus 3/6 carriage.

Type B. With built-in 5in. speaker in black case, size 13½in. x 5½in. x 7½in. Price **£5/5/-**, plus 3/6 carriage.

Type C. With 8in. R.C.A. speaker, built in R.C.A. speaker cabinet as described below. Price **£6/10/-**, plus 3/6 carriage.

SAVE £££££££'s Deduct 10/- when purchasing any R1155 and power pack together.

VISUAL INDICATOR TYPE 1 Ref. 10Q/2—the cross-over Left/Right indicator for D.F. operation and Loop Aerials Type 4, ref. 10B/420. Both Brand new and boxed. We have these items in stock and those interested in complete D.F. installations should contact us for quotations.

R.C.A. SPEAKER. 8in. P.M. unit in beautiful black crackle cabinet. Size 11½in. x 10½in. x 6in. A de Luxe job. Brand new at **45/-**, plus 2/6 carr.

U.S.A. DYNOMOTOR. 12 volts D.C. input, 250 volts 60 mA. output. Weight 2¾ lbs. Size 4½in. x 3in. diameter. Ideal for car radio, mobile amplifiers, small transmitters, etc. All tested prior to despatch. ONLY **22/6**, post paid.

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The R1132A receiver covers 100-124 Mc/s with variable tuning. Very easily altered to other frequencies. Complete with all 11 valves. Requires only 250 volts and 6.3 volts when it is ready to operate. Complete circuit supplied. Only **45/-**, plus 7/6 carriage. BRAND NEW. Will operate from our standard R1155 power pack using special lead, price 10/- extra.

POWER PACK NO. 3. Standard 19in. rack-mounted power packs for 200/250 volts mains operation. Paper smoothing, two heavy duty chokes, VU39 rectifier. Output 250 volts D.C. 100 mA., 6.3 volts 4 amps. Two types : Mark I with H.T. current meter at £4/4/- ; Mark II with H.T. current and voltmeters at **£4/10/-**, carriage 5/-. Suitable for use with P48, R1132, R1481, R1392, R1155, etc. Lead for any specified set with Jones plugs, 10/- extra. All power packs guaranteed in working order.

OSCILLATOR BEAT FREQUENCY No. 5 manufactured by Furzehill for the Admiralty. Range 0-10,000 cycles. Complete with seven valves—push-pull 6V6 output giving 2 watts into 600 or 10 ohms. The output is monitored by moving coil meter. For operation on A.C. mains 100-250 volts. Contained in handsome metal instrument case, size 17½in x 9in. x 11in. With circuit diagram and operating instructions. In perfect condition and tested prior to despatch. A laboratory instrument for ONLY **£12/10/-**, plus 10/- carriage.

VARIACS TYPE 100L. Rated 2 kVA continuously adjustable from zero to mains voltage. Price **£12.**

VARIACS semi-variable. Rated .8 kVA, oil filled. Adjustable for 30 volts above and below the mains input. Price **£5.**

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UNIVERSAL AVOMETERS MODEL 40—very little used, thoroughly checked and tested. First-class multi-range test meter for **ONLY £9/19/6.**

1 Milli-amp. 2½in. square panel mtg., **15/-.**
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All the above meters are brand new and boxed.

BLOCK CONDENSERS

4 mfd. at 1,000 volts. Size, 4¾in. x 4in. x 1¼in., 5/-. New and boxed.
10 mfd. at 1,000 volts D.C. test, will work at 600 volts. Size, 2in. x 3in. x 3in. New and boxed. SPECIAL PRICE at 3 for **10/6.** .25 mfd. at 1,500 volts. Size, 2¼in. x 2in. x 1¾in. Price, 3 for **4/6**, post paid. All the above are metal cased with paper insulation and fixing feet. .04 mfd. 12.5 kV. ONLY **6/-** each.

BATTERY CHARGERS. Contained in black crackle case, size 6in. x 7in. x 12in., includes a heavy duty transformer, metal rectifier, 0-5 ammeter, on/off mains switch and 2 Slydlock fuses. 230 volts 50 cycles input ; output 4 amp., 6 or 12 volt battery. The transformer, etc., is conservatively rated and the whole unit is of sturdy construction and super quality. Made to a very stringent specification, this equipment is well worth the price of **£4/19/6**, plus 5/- carriage and packing. **In brand new unused condition.**

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Selenium 230 volts 60 mA. at 5/- ; 250 volts 100 mA. at **7/6** ; RM2 at 4/3, or two for 8/- ; RM4 at **17/-**. 12 v. 4 a. full wave bridge, **15/-** ; 12 v. 1 a., F.W.B. **6/6.** 6 v. 3 a. F.W.B., **10/6.** All types in stock. Heavy duty Westalite with square fins, size 8½in. x 4in. x 4in. Two units in full wave bridge give 48 volts 10 amps. D.C. BRAND NEW at **£5** per pair

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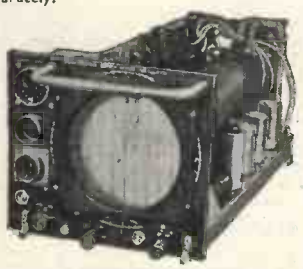
contains 3 EF50, 1 5U4G, 4 SP61 and a 6½in. C.R.T. type VCR517. This tube will replace the VCR97 without any alteration, is completely free from cut-off and has a more pleasant tube colour. Contains in addition a very large assortment of pots, resistors, condensers, etc. Tubes demonstrted. Supplied BRAND NEW (less relay) for only **79/6**, plus **7/6** carriage in original transit cases. **Original circuit supplied FREE with each order, or 1/6 separately.**



INDICATOR UNIT 182A

INDICATOR UNIT 62A, containing VCR97 C.R.T., complete with mu-metal screen. Valves : 12 EF50, 4 SP61, 3 EA50, 2 EB34. Otherwise as above. BRAND NEW in original transit cases. ONLY **£4/19/6**, plus **10/6** carriage.

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6in. MAGNIFYING LENS for the VCR97, etc. First grade, oil filled. Now ONLY **17/6**, plus 2/6 postage.

CO-AXIAL CABLE. Brand new 70/80 ohm with stranded inner conductor. Not ex-Govt. Price 1/- per yard. Minimum per post dozen yards at **10/-.**

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Transformers of current manufacture. Two types, both standard tapped primaries. Universal mounting. (1) 350-0-350 volts 80 mA., 0-4-6.3 volts 4 amps, 0-4-5 volts 2 amps. (2) 250-0-250 volts 80 mA., 0-4-6.3 volts 4 amps., 0-4-5 volts 2 amps. Both these transformers are new and boxed, fully guaranteed at 18/- each, post paid.

30 VOLT TRANSFORMER standard primary. Secondary 30 volts 2 amps., tapped to give 3, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24 volts. Has countless uses. Price **17/6.**

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12-watt high quality amplifiers, bass and treble boost; £12/15; lists.—Broadcast & Acoustic Equipment Co., Ltd., Tomb and, Norwich. [0065

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RECEIVERS, AMPLIFIERS—SURPLUS AND SECONDHAND

MULLARD TV projection unit; £25.—Box 1153. [1934

HALLICRAFTER SX28 receiver, excellent, £45 or offer.—Ilford 2668. [1928

HALLICRAFTERS SX24, perfect order, best offer over £20.—Box 1129. [1917

MARCONI type CR.100, 12-valve tuner amplifier B.35; £20 o.n.o.—Box 1040. [1887

EDDYSTONE 740, as new; nearest £28.—Parnell, 67, Holderness Rd., Hull, Yorkshire. [1859

EDDYSTONE 740 plus speaker, £35; within guarantee, little used; carriage paid N.W. —Box 1131. [1919

EDDYSTONE receiver 750; £40 or exchange good 670.—Williams. 107, Riverview Rd., Ewell, Surrey. [1865

SX28 unmodified and in good order; £40 or near offer.—Judd, 68, Mayfield Ave., Orpington, Kent. [1941

BC348L, £25 or offer; RF24, 26, 27, price 12/-, £2, £2.—Howe, 108, Monkleigh Rd., Morden, Surrey. [1942

EDDYSTONE 640 receiver, medium speaker, Brown's phones, all as new; £24, or near offer.—Tel. Cro. 5708. [1826

COMMUNICATIONS receiver R1116A 8-valve double superhet 7-band 2KC-20MC, complete, offers ?—Box 1130. [1918

ARMSTRONG EXP83, 8v 10 watts chassis, speaker, in Bush cabinet; offers around £14.—Platts, 1a, Croxted Rd., London, S.E.21. [1890

35-watt quality amplifier (a.c.) by sound sales, with set spare valves; little used; £15.—Cryselco, Ltd., Kempston Works, Bedford. [1935

FERROGRAPH, model I.D., walnut, factory overhauled, guaranteed as new; £55, seen London.—Industrial Engineering, Ltd., 23, Albemarle St., W.1. [1812

HRO Rx's and coils in stock, also AR88, BC348R, CR100, etc.—Requirements please to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0053

FOR sale, Savage audio amplifier, 1kW output; £100.—Hornchurch Broadcast Relay Co., Ltd., 30, Victor Gardens, Hornchurch, Essex. [1841

AR880, AR77E, SX28A, SX42, in perfect condition; new Garrard RC80 changer with astatic turnover pick-up; what offers for lot or separately?—Box 1118. [1911

ARDENTE high fidelity 10 watt amplifier, pre-amplifier stage and tone control, input for microphone and gramophone, new condition; £14, or nearest offer.—Box 0820. [1837

LOUDSPEAKERS—SURPLUS AND SECONDHAND

HORNS.—12 new exponential 4ft long, 3ft sq mouth, 7in throat with 1¼in flange, 18g. M/S painted; 50/- each.—Box 1115. [1907

LOUDSPEAKERS—SURPLUS AND SECONDHAND WANTED

WANTED, Acoustical corner ribbon or similar quality loudspeaker for Leak amplifier; send full details and price.—Box 1128. [1916

WANTED horn speakers, complete, any type; offers to—Radioquipment Co., Brook St., Raunds, Wellingborough, Northants. [1949

TEST EQUIPMENT—SURPLUS AND SECONDHAND

TF144G, attenuator, coil turret, variable condenser, output meter, new; offers; Cossor 3339 oscilloscope, perfect condition, £25.—Box 1102. [1898

TEST EQUIPMENT—SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, valve voltmeters, frequency meters, multi-range meters in stock; your enquiries are invited.—Requirements to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0056

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BATTERY chargers, 4 models, 2-6-12v, 1-2-4 amp D.C.; any mains voltage; also larger types special transformers, chokes, test gear, interior car heaters, etc.—The Banner Electric Co., Ltd., Hoddesdon, Herts. [0112

ALL types of rotating electrical machinery up to 20kva available, including rotary converters, rotary transformers, motors, petrol and diesel-engined generating plants, alternators and d.c. generators. We are also in a position to quote for power transformers; as actual manufacturers we will be glad to quote for any quantity for home or export.
DIESEL Electric generating plants, 3kva, 230v, with push-button remote control, starting equipment, ready for use; £225.
CHAS. F. WARD, Lordscroft Works, Haverhill, Suffolk. Tel. 253. [0039

THE Pearce new model diesel alternator plant, on welded steel frame 230/1/50 3kva plus 32v 15a d.c., Petters latest AVA1, air-cooled diesel engine, alternator, self-energised automatic-voltage control by winding arm stator d.c. output charges lighting and starter battery up to 15amps, 24v lighting is used when plant is not in use, remote control push-buttons, complete with main switch and fuses, battery cables: £255.
SEND p.c. for full description and photographs.
ALSO above plant fitted Lister slow-speed water-cooled diesel and electric flywheels.
ALTERNATORS, 230/1/50, 400VA, self-energised, 3,000rpm, ball bearing, £23/15 del., also special television model same price; voltage regulator 30/- extra.
J.A.P. No. 2A 1.2hp petrol engine, air-cooled, 4-stroke, starting rope, tools; £17/10 delivered for above alternators.
SPECIAL rotary converters, guaranteed interference free, fitted radio and television filters, wt. 60lb, d.c. input 12v 200va, out. 24v. 32v. 50v, 110v, 230v d.c. to 230v. out. 250va. £28/10 del.; also converters for radiogram and general use, inputs, outputs and prices as above; the above also supplied without smoothing. £25 del. immediate despatch; trade supplied.
AT a purchaser's home 60 m.s. S.W. of Sutton Coldfield a 24v.
TELEVISION converter was tested on Ekco television, 12in tube, stated consumption 135 watts d.c. current from battery only 9½amps, picture and sound were perfect and completely free of interference or flutter.
THE above are the latest products of British manufacture, and are guaranteed for one year; fullest details of plant, alternators or 400VA alt. or rotary converters, by return post; state which required; terms c.w.o., pro forma invoice c.o.d. (post goods only).
T. W. PEARCE, 66, Great Percy St., W.C.1 (near Angel). [0013

DYNAMOS, MOTORS, ETC.—SURPLUS AND SECONDHAND

TRUVOX tape desk, as new, dem. London. £18.—Box 1127. [1914

H.F. alternators, 80v, 25a, 1,500 cycles; also hot wire ammeters, 0-1, 2 amps.—E.W.S. Co., 69, Church Rd., Moseley, Birmingham. [1613

TWO ex-Admiralty generators, 220 d.c. to a.c. 230/50/200 watts, rating will take 100% overload, weight 100lb; £5/15 each, £10/10 two. —Gummer, Frinton-on-Sea 712. [1939

LISTER 1¼kw 110v D.C. petrol gen. set with auto switchboard, batteries, lamps, exhaust pipe, etc., all good condition, £50; Weston batt. signal gen. less instruction book, £3; electro-dynamic 230 D.C. in 230 A.C. 150w out. with silence cabinet, smoothing good cond., £7; another 230 D.C. in 6 to 12 D.C. 2-amp out. silence cabinet, £2.—Hill, Elect. Eng., Tadcaster 2253. [1929

NEW GRAMOPHONE AND SOUND EQUIPMENT

RECORDING equipment to the trade.
WEARITE tape decks and special parts, disc recording machines.
BLANK discs, Scotch-boy tape, Emitape.
RADIO feeder units, microphones, etc.
ALL from stock—Sound Discs (Supplies), Ltd., 179, Bispham Rd., Southport, Lancs. [1087

SOUNDMASTER kits available, amplifiers built to spec., £30; or our 4-watt amp. to suit, 21gns.
AMPLIFIERS for Wearite 2A decks, 21gns.; mi. valves (Z729, etc.), meter lev. indicator and output feed for leak etc.; fre. res. 30-12 kc/s; special pre-amp/rec. units, with meter ind., for use with leak, etc.; £15.
TRUVOX, Lane, Motek, 12 watts p.p. amps. to suit, £21; 3 input channels, m. eye ind., bass and treble, var. bias, etc.; others from £12.
ALL our amplifiers are handmade and will give years of good service.
HARDING ELECTRONICS, 120a, Mora Rd., London, N.W.2. [1858

NEW GRAMOPHONE AND SOUND EQUIPMENT

FERROGRAPH magnetic tape recorder, model 2A now available; price 76gns.; demonstration daily by appointment.
SOUND DISCS (SUPPLIES), Ltd., 178, Bispham Rd., Southport. Tel. 88153. [1802

HIGH-FIDELITY FM, the very best RF signal converted to AF. See display advert.—Bel Sound Products Co., Marlborough Yard, N.19. [0185

C.J.R. ELECTRICAL & ELECTRONIC DEVELOPMENT, Ltd., manufacturers of high quality portable and console magnetic tape recorders for professional and amateur use; full details on application.
BICKFORD Rd., Witton, Birmingham, 6. East 0822. [9968

CINE-VOX disc recording equipments, type C7J for high-quality recordings from existing microphone equipment; price from 28gns; also available as a complete channel inclusive of mic., amplifier and playback equipment, at 70gns; type C7, for highest quality professional requirements—recorder mechanism at 48gns, or complete channel at 110gns; demonstrations arranged in London.
PLEASE write for details to K.T.S., Ltd., 60, Aylward Rd., London, S.W.20 (Liberty 2426). Callers by appointment only. [0209

POLLOCK lightweight m/c pick-up, response 40cs to 20 kc/s, h.f. resonance 25 kc/s approx.; complete set of parts for constructing head, 25/-, plus 1/- postage and packing; building instructions, 5/-; sapphire stylus .001in or .0025in, 7/6; model also for thorns; 100:1 input trasformer, steel case, 20/- plus 1/- post, etc. —S.a.e. for details to A. M. Pollock, 14, Broomfield Lane, Hale, Cheshire. [1857

PICK-UP arm/pvt for Pollock m.c. pick-up head now available as a kit, price 26/-, post free; s.a.e. for details as above.—A. M. Pollock, 14, Broomfield Lane, Hale, Cheshire. [1901

MAGNETIC recorders, all types, new and secondhand for sale; hire service in greater London area only; mechanical and electronic repairs carried out by specialists: "Magnegraph" limpet telephone pick-ups, suitable for all types of recorders, 25/-; tape storage racks for 12 reels, 37/6; B. & H. recording wire, new and used, from 15/- reel; tape, accessories, etc.; full details s.a.e.—The Magnegraph Recording Co., Ltd., 1, Hanway Place, W.1. Tel. Langham 2156. [0236

GRAMOPHONE AND SOUND EQUIPMENT —SURPLUS AND SECONDHAND

PYE gram, £50 o.n.o, cost £90.—Tel. Hil. 4204. [1873

SIMON tape recorder, Model Ia, new June, '53, less mic.; £65.—Frankton, 22, Barleycroft, Welwyn Garden City, Herts. [1874

H.M.V. radiogram table model (automatic change), in new condition; £25, or exchange good tape recorder.—Box 0821. [1838

GRUNDIG two-speed reporter, as new, complete tape, mike, list £84; £65.—Taylor, 125, Manchester Rd., Denton, M/C. [1880

SOUNDMIRROR T411 mic 22/2, perfect, must sell, going abroad; £55, o.n.o.—Swales, Airport Club, Northolt Airport, Ruislip. [1803

BRADMATIC model 5 tape deck, £29; Wearite, £28; both as new.—Plant, Asfordby, Melton Mowbray. Tel. Asfordby 241. [1842

WEARITE tape deck type "B," three heads, synchronous capstan motor, nearly new, perfect order; £30, London area.—Box 1041. [1888

6FT G.P.O.-type relay rack, two amplifiers, three power packs, mixer unit, r.f. tuner, etc., oscilloscope, reproducing equipment, other bargains, odds and components; s.a.e. list.—3, Coombe Gdns., New Malden, Surrey. [1947

1 Complete public address unit, comprising: 3 constant speed turntables by Garrard, 1 amplifier and power pack, 2 large speakers plus extra B.T.H. speakers, 4 large baffle boards; bargain.—Vicar, St. Sepulchre's Church, E.C.1. [1828

CROWN magnetic recording wire, type 302 Nilstain .0036, unused on metal bobbins, average net weight 1.1lb, as used in Chicago Webster recorders, ohms per yd 115-122; £2/5 each.—Robinson, 847, Kingsway, Manchester, 20. [1904

FERROGRAPH magnetic tape recorder, £60; 10 spools Emitape, unopened, 23/- each; M.S.S disc recording machine, 1953, £48; B.S.R. Monarch self-changer (unopened), £12; Wharfedale 10in speaker (unopened), £3; Reslo ribbon mike and stand, £7; Leak amplifier and prestage, as new, £30.—Box 0405. [1761

ANY of you tape types building your own? Although we deal primarily in sub-standard cine equipment, it's quite possible that our "Bits and Pieces" list might be useful; s.a.e. please. We also wish to buy tape desks, recorder components, etc.—Burgess Lane & Co., Block J, Sunleigh Works, Sunleigh Rd., Wembley. Tel. Wem. 2378. [0253

VALRADIO converter, tape or TV, etc., £7/15; E.M.I. cutterhead, £5; groove locator and Hi-Fi pick-up, £4/15; radio feeder, £6; 25-watt p.p. amplifier, £17; M.S.S. studio console disc recorder, £65; sound-cell mike, £4; moving-coil mike, 30/-; C.J.R. tape recorder, £80; 10in Wharfedale speaker in reflex cabinet, £7; 40 assorted gram records, £3; exponential horn speaker, £4; several amplifiers, mikes, recording equipment, blanks, transformers, etc.; exchanges considered; s.a.e. please.—Matthews, Bentworth Priors, Tower Hill, Dorking. Tel. Dorking 3426. [1885

NEW COMPONENTS

(This advertisement contd. from previous page)

Rectifiers Type K3/25 at 5/3, K3/40 at 7/6, K3/45 at 8/2, K3/50 at 8/8, K3/100 at 14/8, K3/160 at 21/6 and K3/200 at 26/-. Meter Rectifiers. 1m/a by G.E.C. at 11/6, also 5m/a by Westinghouse at 8/6. Introducing L.T. Rec-range of selenium rectifiers fully guaranteed for 12 months from date of purchase. No Govt. surplus materials used in their production. At present available are 6v 1a C.T. at 5/-, also full-wave bridge types, 12v 2a at 11/3, 12v 3a at 12/6 and 12v 4a at 15/-. Wholesalers, retailers and manufacturers are invited to apply for trade terms. Watch future advertisements for further additions to this range. Ex-Govt. meters in stock, include 2in square 0-5m/a thermo-couple at 4/6, 0-5m/a m/c at 7/6, 0-50m/a at 7/6, 0-500m/a at 17/6 (round), 0-1m/a 2½in desk-type at 27/6. Many others in stock.

WE also offer very limited supply of ex-Naval all-purpose test meters by Everett, Edgecumbe. These instruments are not brand new, but all have been serviced and guaranteed 100 per cent condition. Complete in strong wooden case. Size 9in×6in×5½in. Leather carrying handle. 3½in Scale—1,000 ohms per volt—Measures 0-1,000 volts A.C./D.C.—Capacity .02mfd—16mfd—Resistance to 10 megs. While stocks last—Price £7/19/6 only!

ALSO in stock, descriptive envelopes for "Viewmaster," "Tele-King," and "Soundmaster." All components for these circuits are available, and note that we are demonstrating a fully assembled "Soundmaster" tape-recorder at 18, Tottenham Court Rd., W.1, situated 50 yds. from Tottenham Court Rd. Tube. Don't forget the new name in retail radio—CLYNE RADIO, Ltd.! Clyne Radio, Ltd.! Clyne Radio, Ltd.!

WE nearly forgot to mention it. We have in stock, tape decks by Motek, Wearite and the Truvox Mk. III. All at current list prices. One last word. If you require a packet of 8BA nuts and screws, or a ¼lb reel of enamelled copper wire from 16 swg to 42 swg. We have that too! Don't forget for this month only we are supplying all items post free. Money-back guarantee, prompt service, quality goods, at CLYNE RADIO, Ltd., 18, Tottenham Court Rd., W.1. Museum 4539/2453. Shop hours Mon.-Fri., 9-6 p.m. Saturday 9 a.m.-1 p.m Clyne Radio, Ltd. Why not pay us a visit??? [1883

CRYSTAL microphone inserts (Cosmocord Mic —6), guaranteed brand new; 15/6 post free.—Radio-Aid, Ltd. (Retail Dept.), 29, Market St., Watford. [0036

COIL sets for TV converter. May issue "Wireless World." 12/6, post free; money-back guarantee.—C. O. Preston & Son, Healey Lane, Batley, Yorks. [1688

COIL packs, miniature 3-wave, 22/6; t.r.f. coils, 4/6 pair; w/reaction, 5/6; i.f. tran's 465 K.C. miniature, 9/- pair; stamp bargain list spare and components.—Channon Electric, 84, Hazellville Rd., London, N.19. Tel. Archway 5208. [1948

TELEVISION screens, lilac tinted, laminated safety glass, 15⅛in×11⅞in, at 5/- each, postage 2/6 extra; also television plastic, lilac tinted. 12in×10½in, at 2/- each, postage 6d extra.—Dubar Safety Glass Co., Ltd., Darwin Rd., W.5. Ealing 4960. [1900

NEW, the "High Q" C.5 TRF matched L and MW coils are now available; we claim the finest made for the price of 8/- per pair. Inc. battery and mains circuit diagrams; if unobtainable locally send direct to: Cretton Radio, 349, Copnor Rd., Portsmouth. [1899

TELEVISION—New ¾in canned formers 2/3 ea., coil sets, EE, VM, PT, etc., from 18/6; FM. Rx. coil sets 75/-; 6mm cored formers 7/- do., 8mm 10/-; 3W4B min. switches 15/- doz. —Bel Sound Products Co., Marlborough Yard, N.19. Arc. 5078. Trade supplied. [0186

FOR really good results you can do no better than use Osmor coils and coilpacks, ask anyone of experience! Send 5d (stamps) today for beautifully-drawn free circuits, our new coil-data leaflets, and latest lists of matched radio components. A speedy mail order department is at your service, and remember, all Osmor lines are guaranteed. (Trade enquiries invited.) Dept. C.W.1.

OSMOR RADIO PRODUCTS, Ltd., Bridge View Works, Borough Hill, Croydon. Tel. Croydon 5148-9. [0046

FLUORESCENT 80 watt 230v complete ballast unit, 39/6; 80w brick choke and starter lamp, 14/6; 40 watt complete ballast 230v, 28/9; complete fluorescent fittings from 45/-; metal rectifiers, 12v 4amp f/w bridge, 13/9; suitable charger transformer, 16/6; 0-4 ampmeter, 8/6; brand new small radio cabinets, 16/6; multi-ratio output transformers, Goodmans, 7/6; Diamond H switches, 4/6; 4-pole cooker switches, 5/-; charge your dry cell batteries with our special charger from mains, complete unit, 14/9; new G.E.C. ½hp electric motors, 230v S/p, £4/16.—Malden Transformer Supplies, Rear of 5, Coombe Rd., New Malden, Surrey. Mal. 2655 (Longside of Malden S.R. Station). [0038

COMPONENTS—SURPLUS AND SECONDHAND

6in TV kit, mostly constructed; £18.—Fox, 91, Showell Green Lane, B'ham, 11. [1906

G. A. RYALL, "Utopia," Mayfield Rd., Herne Bay (Kent); please refer to previous adverts. [0205

SOUTHERN RADIO SUPPLY, Ltd., 11, Little Newport Street London, W.C.2. See our displayed advertisement, page 154. [0014

COMPONENTS—SURPLUS AND SECONDHAND

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188. ELECTROLYTICS, capacity, voltage, size, type of mounting, price post paid; 400, 6v, 1×2in, lug, 1/9; 250+250, 6v, 1×2in, lug, 2/-; 500+500, 6v, 1×3, lug, 2/6; 40+40, 150v, 1⅛×2, clip, 2/9; 40, 150v, 1×2, clip, 2/6; 20+20, 275v, 1×2, lug, 3/3; 16+32, 275v, 1×2, lug, 3/3; 16+16, 275v, 1×2, clip, 3/3; 32+32, 275v+50mf 25v, 1×3, lug, 3/6; 60+100, 275v, 1⅜×3, lug, 4/6; 100, 275/350v, 1⅛×3, clip, 3/6; 32+12, 350v, 1⅛×2, clip, 4/-; 16+16+16, 350v, 1⅜×2 clip, 1⅛×2, 4/9; 40+40+20, 350v, 1⅜×3, lug, 5/-; 16, 350v, ¾×2, lug, 1/9; 40+40, 300v, 1×3, lug, 3/6; 10, 450v, ¾×2, lug, 1/6; 16, 450, ⅞×2, tag, 2/9; 20, 450v, 1×2, lug, 2/3; 32, 450/525v, 1⅜×2, clip, 3/9; 32+32, 450v, 1⅜×3, clip, 5/6; 30+30, 450v+20mf 25v, 1⅜×3, lug, 5/-; 15+15, 450v+20mf 25v, 1⅛×3, lug, 4/6; 200, 6v, ⅝×1¼, clip, 1/6; 100, 12v, ⅝×1¼, clip, 1/9; 8, 450v, 1×2, clip, 2/-; 50, 12v, ¾×1⅝, tag, 1/6; 150, 25v, ¾×1¾, clip, 2/-; 250, 12v, ¾×1¼, wire, 2/3; 350, 25v, 1×2¼, clip, 2/6; 16+16, 450v, 1⅛×2, clip, 4/-; 40+40, 275v, 1⅜×2, clip, 3/3; 16+32, 450/525v, 1⅜×2, clip, 5/-; 24+24+16, 350/425v, 1⅜×2, clip, 4/9; 60+200, 275/350v, 1⅜×4½, clip, 6/6; 4, 150v, ⅝×1¾, clip, 1/1; 500, 12v, 1⅜×2¾, clip, 2/-; 8, 350v, ¾×2 clip, 1/9; 6,000, 12v, 1⅜×4½, lug, 4/6; 100+200, 275/350v, 1⅛×4¼, clip, 6/6; 100+175, 275/350v, 1⅜×4¾, clip, 6/6; 32+32, 350/425v, 1⅜×2, clip, 5/-; 8+16, 450/525v, 1×2, clip, 4/-; 2, 450/525v, ⅜×1¾, tag, 1/6; 2, 350v, ⅜×1¾, tag, 1/3; 1,000, 6v, 1×2¾, clip, 2/9; 3,000 6v, 1×3, clip, 3/6; 8, 450v, ¾×2, clip, 1/9; all all cans, some with sleeves all voltages WKG, surge where marked, new stock, guaranteed.

TELEVISION! Set of 3 components, comprising line output trans., with E.H.T. winding to give 7kV, using EY51 (heater winding for EY51 also included), and fitted with width control scanning coils, low impedance line and frame, focus coil (res, 10,000Ω, current approx, 20 mA); the set of 3 for 42/-, plus 2/- post, diagram of line trans, supplied.

PERSONAL receivers, 3 valve T.R.F. using 1T4s, contained in handsome bakelite case with lift-up lid, size 7×6½×5in with lid closed, plastic carrying handle, fram, AE in lid, these receivers cover the medium waveband and operate from self-contained dry batts., standard types, W1435 and U2, output to a pair of lightweight 'phones (H.R.), controls, SM tuning and reaction, opening lid switches on, supplied brand new, with valves, batteries, 'phones, an ideal set for invalids hos, patients, etc., these receivers are not Govt, surplus and are offered ready to play; carr, paid £4/10.

UNIVERSAL amplifiers, 8-valve 20watt A.C./D.C., black crackle chassis, and black and chrome cover, overall size 15½in×7½in×7in. First-class components (Partridge O.P.T., and driver, Gardner choke, A.E.E. Mu-Metal input trans, for mike). Valves, 2×EF37, 4×CL33, 2×UR3C. Switched input for high or low imp., top cut and bass cut switches, V.C., mains switch, mains plug and socket, 220-250v, isolated chassis, 15Ω output. Wired and tested, ready for use, with valves, brand new, £10/19/6, carr, paid. T.V. control panels, 5 adjustable res. on pax, panel 4in×3in, 3 wire wound (1K, 5K, 10K), 2 carbon (50K), Welwyn res., slider type, complete with slider knobs, 6/- each, post paid.

5 mA meters, moving coil, Bakelite case, 2in square, flush mounting, new, boxed; 8/- post paid.

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188. [0015

PARMEKO H.T. transformers.—Prim 100-250 V sec 1300-0-1300 V 250 MA, potted type, size 59/6, carr. 5/-; Parmeko LF chokes 10 H 250 MA, potted type, 15/-, carr. 2/-; heavy duty LT transformers, Prim 230 V sec tapped 4-6-11 V, 200 amps, ideal for welding or soil heating, £7/10, carr, 7/6; British electric heavy duty pots, 6-in dia., 1,800 ohms 200 watts, with 3in skirted knob, 22/6, carr, 1/6; 4in dia 2000 ohms 0.22 amps, with 3in skirted knob, 15/-, carr, 1/6. The above items are surplus to a manufacturer's requirements, as new and in perfect condition.—J. Hallett, 19, Upper Richmond Rd., London, S.W.15. [1913

RECEIVER type W spot tuned to 600 metre SOS band, easily adapted to B.B.C., 3×VP23 valves, waterproof cabinet, frame aerial in lid, uses 2v LT 45v HT, in cabinet size 11in×10in×8in, 25/-; 72v HT to suit above set, 4/6; radar chassis, 19in×10in×3in, contains 6×VR65, VR54, toggle switch, 5 pots, jack socket, 22 condensers, 42 resistors, etc., 25/-; power unit type 297, input 24v 3A, output 200v 50 MA 13v 1.8A, rotary converter, P.M. field, V.S.110 stabilizer, relay, chokes, condensers, etc., all in metal case 12in×8in×5in, 12/6; motor, 50v 3-phase, A.C., 1/40bhp, supplied complete with resistor, condenser, and circuit diagram to convert to ⅛hp for use on 240v single-phase A.C. mains, speed 2,600 rpm, weight 8lb, size 4in×4¼in×6¼in, shaft extends 5/16in×1½in, foot mounting, 22/6, or motor only 15/-; steel louvred cabinet and chassis with I.O. valveholders, cut and drilled for Vortexion type portable amplifiers, size 18in×8¼in×6½in, 10/-; transformers, all 230v 50c input, output 350-0-350v 100 MA, 4v 4.5 A, 4v 2.5 A, 5v 2.5 A, 11/6, or minus 5v winding, 10/-; 80v 200 MA, 6.3v 2 A, 7/6; 155v 200 MA, 155v 200 MA, 7/6, 275-0-275v, 4v 5A, 4v 2.5 A, Potted type, 14/-; 265-0-265v, 250 MA, 6.7v 7 A, 4v 2.5 A, 16/6; smoothing choke 200 MA, 7/6 morse tapper, 3/-; condensers, .1 uf 1,000v, D.C., 4/- dozen; over 4,000 valves in stock, any type sent c.o.d.—Logan's Radio Mecca, Grove Rd., Hitchin, Herts. [0258

COMPONENTS—SURPLUS AND SECONDHAND

SUPREME RADIO, 746b, Romford Rd., Manor Park, London, E.12. Tel. Ilf. 1260. Est. 17 yrs.
ALWAYS "supreme" for good quality components at the keenest prices.
LOOK!! Just arrived. Mains trans., drop-thro. fixing, primary: 200-210v, 220-230v, 240-250v, on voltage adjusting panel. Secondary, 250-0-250v 60m/a with 6.3v 3amp winding tapped at 5v, small size, length 3¼in, width 2½in, stack thickness 1⅝in, our price, 11/6 ea.
VERY popular mains trans. by "Parmeko," universal fixing, primary tapped 0-200-220-240v, sec. 290-0-290v, 80m/a, 6.3v 3amp, and 6.3v tapped at 4v 2amp with screen—our price, 15/11 ea. inc. p.post.
FILAMENT trans.: primary 0-250v, sec. 6.3v at 1.5a, 5/11 ea., or 6.3v at 3amp, 8/11 ea.
SMALL vol./controls: 1meg or ½meg, with 1/ spindle and D/P switch, our price, 3/- ea.
ALSO ½meg or 2meg v/controls less switch 1/6 ea., or 15/- doz.
2-pole, 2-way w/change switches, 1/- ea. or 10/6 pr. doz.
TWIN bal. feeder, 800hm, for television, 4d pr. yd.
NEW stocks electrolytic cond., tub/card, w/end, 8mfd, 450v, 1/11 ea.; also drylitic 8mfd 500v t/card, w/end cond. 2/9 ea.
METAL can 16+16mfd 350v, small, 2/3 ea.; 32+32+16mfd, 350v, small metal can cond., 3/6 each; 60+150mfd, 275v d.c. wkg. at 4/11 ea.; tub/card w/end 100mfd 12v bias cond. 1/6 ea.
DROPPERS: .1 amp, 2,000ohms, cement coated with 2 sliders, 3/9 ea.; .15amp, 1,500ohms c/coated, 2/sliders, 3/9 ea.
TWIN-GANG .0005mfd tun/cond. with detachable fixing bracket feet, 5/11 ea.
P.M. Speakers, good quality at bargain prices, all 2-30hm v/coil less trans., 10in, 17/6 ea.; 8in p.m., 12/11 ea.; 6½in type, 11/6 ea.; 5in, 10/6 ea.
SPECIAL bargain line in speakers—only a few left, 8in p.m., 2-3ohm v/c., with out/trans. for 7K ohms load, 13/6 inc. p/packing.
MANY other bargain lines in stock.
TERMS: c.w.o., no c.o.d.; send 9d extra for postage orders under £5; 2½d s.a.e. all enquiries and list. [0021

METADYNE generators, 45v, 60a, 2.7kW, totally enclosed, type MD70EX, new; £28.
SELSYN motors, B.T.H. type SM1406, 230v ac Standard model, as new; £9 pair.
CONSTANT frequency units, G.E.C., 100 Kc crystal controlled, two multivibrator units with jack points for 10Kc, 1Kc, 250c, 50c power unit, 230v ac, all mounted in standard rack 56in high with heavy angle base, enamelled finish, plated fittings, complete with crystal, 27 valves, circuit diagrams, etc., new; £45.
MAGSLIP sine-cosine resolvers, 3in AP 10861, new, each in maker's tin; 45/-.
AMMETERS, 5in, 0/14 amps, MI ac/dc, Grade 1 Proj. E.A.C., Ltd., new, boxed; 25/-.
P. B. CRAWSHAY, 166, Pixmore Way, Letchworth, Herts. Tel. Letchworth 1147. [0251

FREE to W.W. readers!—Send 5d postage for 4.BA. nutdriver and lists of radio, electrical, etc., goods; this amazing offer for November only; one nutdriver per customer only.—Annakin, 25, Ashfield Place, Otley, Yorks. [1950
GUARANTEED goods; o/trans. stnd. pent 5,000 ohm, 4/11; multi-ratio p/pull, 5/11; mains trans., 350-0-350, 6v, 5v, 4v, 4v, 80 m/A, 21/6; chokes, 7H-65 MA, 4/11; C.R.T. Iso-trans. air-spaced, 2v at 2 amp, 9/6; Collaro RC521, 3-speed a/changers, with twin X/tal heads, £9/19/6; Strad Uni-mains 5-valve chassis, £9/5, tax paid; inter-com. unit, Master unit, £5/19/6; stations 25/6 each; date available; new valve and component list; stamp please.—Radio Unlimited, Elm Rd., London, E.17. Tel. Key 4813. [0062

CABINETS

LEWIS RADIO have the best selection and finest finish.—See page 114. [0224
WALNUT radiogram cabinets; details.—Cabinetware, 1a, Heyes St., Blackburn.
WALNUT radiogram and television cabinets, soundly constructed; stamp for details.—R. Shaw, 69, Fairlop Rd., Leytonstone, E.11.

WANTED, EXCHANGE, ETC.

VHF test equipment.
TS47AP, TS174, TS175/U, TS148 or TSX-4SE; analysers; BC221 freq. meters, TS69, and any U.S.A. test gear; Klysrons type 723/AB, 2K33 2K39 2K41; receiver, APR4 and units TN16 17-18-19; RCA AR88D, S27 and SX28s and S27CA; microwave equipment; highest offers given by return.—Ger. 8410, Universal Electronics, 27, Lisle St., Leicester Square, London, W.C.2. [0229
45/- each offered for 813 type valves.—Write Box 7050. [1073
WANTED, Wilcox Gay V.F.O. units in new or modified condition.
McELROY-ADAMS MFG. GROUP, Ltd., 46, Greyhound Rd., London, W.6. Tel. Fulham 1138/9 [0194
WANTED, receivers A.P.R.4, also T.N. 16, 17, 18, 19, etc., and any radio test gear.
LESLIE DIXON & Co., 214, Queenstown Rd., Battersea, S.W.8. Macaulay 2159. [0176
COIL winders urgently required, Douglas No. 6 preferred.—Radiomart, Cirencester, Glos.
WANTED, test sets No. 98; this is a grey box approx. 6in. cube containing a milliameter reading 0-1.
STARAVIA, Blackbushe Airport, Camberley, Surrey. [1690
WANTED, HRO coils, Rxs, etc., A.R.88s, BC348s, S27s, etc.—Details to R.T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0163

WANTED, EXCHANGE, ETC.

WANTED, R.C.A. transmitters, all types or any R.C.A components, including chassis and metal work.
McELROY-ADAMS MFG. GROUP, Ltd., 46, Greyhound Rd., London, W.6. Tel. Fulham 1138/9 [0196

WANTED TCS/6 or TCS/12 transmitters in mint condition; also control boxes for same.
McELROY-ADAMS MFG. GROUP, Ltd., 46, Greyhound Rd., London, W.6. Tel. Fulham 1138/9. [0195

REQUIRED immediately, 25 ex-W.D. Selsyns. —Please send offers immediately to Box 0741. [1833

WANTED, RCA 4331 transmitters.—P.C.A Radio, Cambridge Grove, Hammersmith, W.6. Tel.: Rivers:de 3279 [0093

WANTED, service manuals, sheets for Ekco TRC 1124, G.E.C. BC 4247, Bush AC11. —Nickeas, Ebnal Cottage, Pentre, Queensferry; Chester. [1915

WANTED, power supply units for no. 33 transmitters (Z.A.10729); call or ring.—P.C.A. Radio, The Arches, Cambridge Grove, W.6. Riv. 3279. [0081

WANTED, set manufacturers' or ex-Government radio equipment, large or small quantities of valves, electrolytics, speakers, meters, also components.
LOWE BROS., 5, Fitzroy St., London, W.1. Tel. Museum 4389. [9745

WANTED, BC-610 Hallicrafters, RCA ET-4336 transmitters SX-28, AR-88, S-27 HRO receiver and spares parts for above; best prices.—P.C.A. Radio, The Arches, Cambridge Grove, W.6. [0080

WANTED, power units type P.U.176 (vibrator type); grey box approx. 10in×6in×3in; Ref. 10K/485 (similar in shape and size to a radio H.T. battery).
STARAVIA, Blackbushe Airport, Camberley, Surrey. [1689

WANTED, RCA speech amplifiers, type MI-11220 J or K, and aerial tuning units BC 929A.—Offers, stating quantity and price, to P.C.A Radio, The Arches, Cambridge Grove, W.6. [0079

WE purchase all types of domestic or ex-Government radio receivers and equipment: send full details or call and collect cash; large or small quantities.—Walton's Wireless Stores, 48, Stafford St., Wolverhampton. [0146

ALTHAM RADIO Co. pay highest prices in the trade for all American equipment, including test sets, transmitters, receivers, teleprinting gear, etc.—Jersey House, Jersey St., Manchester, 4. Tel. Central 7834-5-6. [0228

WANTED, AN/APR-4 receiver, any units; any other good quality U.S. surplus radio and radar tubes, test sets; laboratory equipments, etc.; give condition and price in first letter.—Engineering Associates, 434, Patterson Rd., Dayton, 9, Ohio, U.S.A. [0234

WANTED, good quality communication rxs., domestic radios, test equipment, etc.; top prices paid; established since 1937.—Miller's Radio, 38a, Newport Court, 1 min. from Leicester Sq. Tube. Tel. Ger. 4638. Call, write or send. Hours of business 10-6 p.m. Open all day Saturday. [0199

WANTED, signal generators types 30, 31, 51, 53, 54, 56 and 101; also any American test equipment with prefix TS or BC. American receivers types AR88, APR4 or similar.—Send price and details to Hatfield Instruments, Ltd., 175, Uxbridge Rd., Hanwell, W.7. Tel. Ealing 0779/9857. [0037

WANTED: we will pay 10% more for the following American equipment; test sets with TS prefix, BC221, APR4 receivers, APR4 tuning units, BC342, BC312, power units No. 15 and PE98, teleprinter equipment.—Altham Radio Co., Jersey House, Jersey St., Manchester, 4. Tel. Central 7834-5-6. [0227

WANTED, ex-Govt. mine detectors, type 4 or 6, also parts including test unit ZA28857, voltmeters 3v D.C., connectors, leads, various types, lamps signal office WB3312, mountings and aerials for SCR522, refs. FT488, 10h14207, switchboards U.C. YA4920, dummy aerials, ear cushions, chamois type, parts for radio T/Rs 12, 18, 19, 22, 33, 66T, 107, etc.; also telephone material.—Rodwell's, 20, Drapers Rd., Enfield, Middx. Tel. Enfield 4389. [1735

REPAIRS AND SERVICE

ARMATURE re-winding service to the trade. VACUUMS, drills, grinders, hood dryers, dental motors, vacuum cleaner armatures replaced from stock; 24-hour service; every job guaranteed; all vacuum cleaner parts, hoses, etc., in stock for any make.
REGAM ELECTRIC, 95, Park Lane, Leeds, 1. [1905

MAINS transformers rewound, new transformers to any specification.
MOTOR rewinds and complete overhauls; first-class workmanship; fully guaranteed.
F.M. ELECTRIC Co., Ltd., Potters Bldgs., Warser Gate, Nottingham. Est. 1917. Tel. 47898. [0113

TRANSFORMER rewind service, mains, E.H.T. transformers and chokes, prompt delivery, range of replacement types ex stock or manufactured to your specification.
METROPOLITAN RADIO SERVICE Co., 75, Kilburn Lane, London, W.10. Ladbroke 2296. [0200

AUDIO.—Bernard J. Brown is again able to undertake the design/manufacture/repair of any type audio equipment, disc, tape or film recorders, etc.—Write 33, Goldhawk Rd., London, W.12. Tel. She. 6079. [1903

REPAIRS AND SERVICE

MAINS transformers, E.H.T. line outputs, chokes and field coils, etc., promptly and efficiently rewound or manufactured to any specification; 12 months' guarantee. LADBROKE REWIND SERVICE, Ltd., 820a Harrow Rd. Kensal Rise. N.W.10 Lad. 0914. [0222

REPAIRS.—E.H.T. mains and O.P. transformers, field coils and chokes; also armatures and motors; new transformers designed to any specification; all work fully guaranteed. WILLESDEN TRANSFORMER Co., Ltd., 2a, Frithville Gdns., Shepherds Bush. London W.12. Tel. Shepherds Bush 5819. [0076

ELECTRICAL test instruments repaired and standardized, all types British or American, ammeters, voltmeters, ohmmeters. DC/AC multirange meters, etc.; meters converted to specification. THE ELECTRICAL INSTRUMENT REPAIR SERVICE, 329, Kilburn Lane London, W.9. Tel. Lad. 4168 [1134

REWINDS and conversions to mains and output trans, pick-ups, fields, clock coils, etc., from 4/6; PP equipment a speciality; all work guaranteed.—N.L. Rewinds, 173, High Rd., Willesden Green, N.W.10. Tel. Wordsworth 7791. [1938

24-HOUR service, 6 months' guarantee, any transformer; rewind, mains outputs and l.t.s., etc.; all types of new trans., etc., supplied to specification; business heading or service card for trade prices.—Majestic Winding Co., 180, Windham Rd, Bournemouth. [6520

AS professional sound recordists and members of the Association of Professional Recording Studios, we are particularly well qualified to give advice and service on all aspects of sound recording and reproduction. Design of tape equipment a speciality. Circuits designed, repairs and modification carried out quickly. Advice freely given. See also below:—COMPREHENSIVE service to trade and amateur; design, manufacture and repair of electronic equipment carried out by specialists; equal attention given to small or large orders. See also below:—Autochangers, 48-hour service, cleaning and adjusting at fixed price of 35/- plus carriage; also all repairs carried out; trade enquiries invited.—Ariel Sound, 57, Lancaster Mews, London W.2. Tel. Paddington 5092 (2 lines) [1630

MISCELLANEOUS

NEW and unused enamelled copper wire with one layer of artificial silk, available ex-stock as surplus to requirements.
700LB SWG 41 on 1045 bobbins.
70LB SWG 40 on 95 bobbins.
15/- (fifteen shillings) per lb to clear.
APPLY Box 0866. [1850

HEAVY current transformer, 230v input, 4-6-11v output, 200a, £4; carriage extra (56lb). —Box 1101. [1897

CABLES, wires and flexibles P.V.C. covered at clearance prices.—R. Lowther, Ltd., 90a, St Vincent St. Ancoats. Manchester, 4 [0223

WINDER, Douglas No. 3, motorised, portable, inserter, column, v-speed, spares, material; £55.—72, Leopold Ave., Birmingham 30. G.R.E.2070. [1876

METALWORK, all types cabinets, chassis, racks, etc., to your own specifications; capacity available for small milling and capstan work up to 1in bar.
PHILPOTT'S METAL WORKS, Ltd., (G4BI), Chapman St., Loughborough. [0208

A HIGH vacuum impregnation unit or single or batch coil impregnation service to R.I.C. specification 214 or individual requirements.—Blickvac 505, Lordship Lane, S.E.22. Tel. Forest Hill 7089. [0310

PLYWOOD—Hardboards. Send s.a.e. for free price lists and samples, including ¾6in mahogany ply 10d sq. ft, sheets 72in×36in; hardboard all sizes, from 6d sq. ft; free delivery (100 miles).—N. Gerver, 2-10, Mare St., London, E.8. Amherst 5806. [1742

PLATED nuts, screws washers, bolts, soldering tags, hank-bushes, self-tapping screws, grub-screws, socket-screws, wood-screws; large quantities or gross cartons; stamp for list.—Sinden Components, Ltd., Dept. B, 117, Churchfield Rd, Acton, W.3 Acorn 8126 [1415

YOUR own recorded tapes to disk; 78 and LP Ferrograph recorders supplied; microphones, tape, etc., complete recording service. —"Eroica" Recording Services, Peel St., Eccles, Manchester. Tel. Eccles 1624. Musical Dir., Thurlow Smith, A.R.M.C.M. [1933

ENGRAVING amateurs and trade could take the opportunity of engraving problems in the future by getting in touch with A.G. Engraving, 19a, Windmill Rd., London, S.W.18. Bat. 5793. Brass, bronze, erinoid, Perspex dials; one knob or repetition equally entertained. [0034

COPPER wires enamelled, tinned. Litz. cotton, silk covered, all gauges; B.A. screws, nuts, washers, soldering tags, eyelets, ebonite and laminated bakelite panels, tubes, coil formers; Tufnol rod; headphones flexes, etc.; latest radio publications, full range available; list, s.a.e.; trade supplied.—Post Radio Supplies, 33, Bourne Gardens, London, E.4 [0138

DECALS labels for marking radio and electronic equipment, clear permanent lettering ⅛in high, no background, easily applied, permanent, Govt. approved; available in book form each book containing approx. 750 titles, covering all aspects of radio and electronic equipment; price 4/9 plus 3d post, in black or white.—Alexander Equipment, Ltd., Childs Place, Earls Court, London, S.W.5 [0243

MISCELLANEOUS

CHASSIS, 18 swg, aluminium, 4-sided, 8in×5¼in×2in, 3/8; 9in×7in×2½in, 4/6; 13in×10in×2½in, 6/4; 16in×8in×3in, 7/3; plus 8d postage; prices in proportion for special sizes; also panels, ec.; estimates free; punching charges, valve holes 3d each; transformer cut-outs, 6d. other holes 2d; please send sketch of your requirements.—Wood and Toy, 51, Whinfield Rd., Claines, Worcester [1891

SITUATIONS VACANT

The engagemen of persons answering these advertisements must te made through the local office of the Ministry of Labour and National Service, etc., if the applicant is a man aged 18-64 or a woman aged 18-59 inclusive, unless he or she or the employer is excepted from the provisions of The Notification of Vacancies Order 1952.

SERVICE or Maintenance Engineer.

A FIRST-CLASS engineer is required for the maintenance of electronic instruments and control equipment used in the Research Laboratories of D. Napier & Son, Ltd.; experience of this type of work is essential, radio and television servicing is not sufficient qualification. —Applications, giving details of education, qualifications, experience and salary required, to Dept., C.P.S., 336/7, Strand, W.C.2, quoting ref. 1187. [1866

RADAR technician required by the NIGERIAN Government, Meteorological Department, for one tour of 12 to 24 months in first instance with option of appointment (a) on agreement with prospect of permanency with salary, etc., in scale £750 rising to £1,175 a year or (b) on contract with salary, etc., in scale £807 rising to £1,269 a year; outfit allowance £60 free passages for officer and wife and assistance towards cost of children's passages or their maintenance in this country; liberal leave on full salary; candidates must be competent radar mechanics and must be able to maintain GL III radar equipment and to take charge of a radar wind station; established Civil Servants should submit their applications through departmental channels. WRITE to the Crown Agents, 4, Millbank, London, S.W.1; state age, name in block letters, full qualifications and experience and quote M2C/30169/WF. [1879

ASSISTANT Signals officer required by the GOVERNMENT OF NIGERIA for the Aviation Department for one tour of 18 to 24 months in the first instance. Salary, etc., either (a) in scale £750 rising to £1,315 a year with prospect of permanency, or (b) in scale £807 rising to £1,453 a year, on a temporary basis with gratuity at the rate of £100 a year. Outfit allowance £60. Free passages for officer and wife, and assistance towards cost of children's passages, or their maintenance in the United Kingdom. Liberal leave on full salary. Candidates must have a knowledge of the fundamental principles of electricity and magnetism and of radio engineering with experience in the maintenance of aeronautical radio transmitters and receivers, direction finders tes equipment and small petrol and diesel engine generator sets. Workshop experience and a knowledge of radar will be of advantage. Minimum examination qualifications are C. & G. Certificate in radio communications or technical electricity, or satisfactory pass in M.C.A. radio mechanics course.
WRITE to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/29637/WF. [1856

JOSEPH LUCAS (Gas Turbine Equipment), Ltd.
INVITE applications for
ELECTRONIC engineers.
SOME knowledge of servo mechanisms would be an advantage. Should have university degree.
THESE appointments are pensionable and offer good prospects to individuals with initiative and technical ability.
SALARY will be in accordance with experience and qualifications.
DETAILS of experience and qualifications should be sent to:—
PERSONNEL Manager, Joseph Lucas (Gas Turbine Equipment), Ltd., Shaftmoor Lane, Hall Green, Birmingham. [1927

FERRANTI, Ltd. have immediate vacancies for:—
(a) MEN with electrical engineering qualifications for the advanced testing of naval anti-aircraft fire control equipment involving electronics and servo mechanisms either in factories or on board H.M. ships in home ports; normal expenses plus a generous allowance when working out.
(b) MEN with electrical engineering qualifications for production testing of aircraft gyroscopic flight instruments.
SALARY in accordance with age and experience between £356 and £650 per annum; previous experience, though desirable, is not essential
PERMANENT staff appointments with pension benefits.
FORMS of application from Mr. R. J. Hebbert, Staff Manager, Ferranti, Ltd., Hollinwood, Lancs. Please quote reference HGN (a) or (b). [1819

A FIRST-CLASS radio and television engineer required for Coventry; excellent conditions and salary.—Apply Sutton & Jones, Ltd., 36, Cross Cheaping, Coventry. [1830

SITUATIONS VACANT

WIRELESS Station Superintendent required by the NIGERIA GOVERNMENT Posts and Telegraphs Department for one tour of 18 to 24 months in the first instance. Commencing salary according to experience in scale £864 rising to £1,392 a year. Gratuity £100/£150 a year. Outfit allowance £60. Free passages for officer and wife and assistance towards cost of children's passages or their maintenance in the U.K. Liberal leave on full salary. Candidates must have had wide practical experience of modern radio techniques and equipment, in particular V.H.F. equipment, and preferably also V.H.F. multi-channel equipment.
WRITE to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/28927/WF. [1855

SIGNALS assistant inspectors of police required by the GOVERNMENT OF KENYA for one tour of two years, extending to three years by mutual consent and with possibility of permanency; commencing salary, etc., according to previous experience in scale £796 rising to £1,134 a year; gratuity (at least £162 after two years' service) payable on satisfactory final completion of service; outfit allowance £30, uniform allowance £10 a year; free passages, liberal leave on full salary; candidates aged 20-35 should be at least 5ft 7in without footwear, have normal vision without glasses and be of good education; they should possess a sound knowledge of the installation and maintenance of modern low- and medium-powered V.H.F., static and mobile equipment, H/F transmitters and receivers, petrol generators and diesel electric sets; previous police experience not necessary. APPLY in writing to the Crown Agents, 4, Millbank, London, S.W.1, stating age, name in block letters, whether married or single, full qualifications and experience and quote M1/35931/WF. [1920

WIRELESS and telegraph supervisor required by the NIGERIA Government Railway Department for one tour of 18 to 24 months in first instance; option of appointment either (a) on agreement with a prospect of permanency with salary, etc., in scale £750 rising to £1,175 a year or (b) on contract with salary, etc., in scale £807 rising to £1,269 a year and gratuity of £100/£150 a year; outfit allowance £60; free passages for officer and wife and assistance towards cost of children's passages or their maintenance in this country; liberal leave on full salary; candidates must have a sound knowledge of International wireless operating, of telegraph working, and of the general running and supervision of a telegraph and wireless office; they should have experience of the working and handling of traffic over wireless and telegraph networks, together with technical knowledge of modern H.F. radio transmitters and receivers and of telegraph circuits; candidates employed by the General Post Office should apply through departmental channels.
WRITE to the Crown Agents, 4, Millbank, London, S.W.1; state age, name in block letters, full qualifications and experience and quote M2C/30187/WF. [1878

VACANCIES are available in the Transmission Department for:—
(1) Development Engineers experienced in the design of multi-channel carrier telephone systems or in allied techniques, including amplifiers, filters and radio;
(2) Equipment Engineers with such knowledge of modern line communication practice as will enable them after training in the company's methods to prepare detail specifications of equipment requirements and to develop arrangements for rack-mounting of the apparatus;
(3) Draughtsmen to work with the engineers, preferably having experience in the telecommunications industry. The positions available are permanent, on full established staff status, with contributory pension fund and usual staff conditions.—Please write to Personnel Manager, Automatic Telephone & Electric Co., Ltd., Liverpool, 7, giving full details of experience, qualifications, age and approximate salary sought. [1912

MINISTRY OF SUPPLY, Radar Research Establishment, Malvern, Worcs, requires ELECTRICAL Engineers and Physicists for research and development work on radio and electronic equipment. Work ranges from fundamental research on circuitry and physics of the solid state, to devising and developing in collaboration with industry electronic devices for the Army, R.A.F. and Naval Aviation. Ample scope for initiative and originality over very wide field concerned mainly with electronics. Salaries according to age, qualifications and experience within the following ranges:—Scientific Officer, £417—£781 (F.S.S.U. benefits may be available); Experimental Officer (min. age 26), £649—£799; Assist. E.O., £264 (age 18)—£576. Women somewhat less. Posts unestablished. Qualifications: S.O.—First or second class honours degree or equivalent in Physics or light Electrical Engineering; E.O. and A.E.O.—minimum of Higher School Cert. (Science) or equivalent but further training in Physics or Electrical Engineering to standard of H.N.C., degree, etc., may be an advantage.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting A.254/53/A. Closing date November 13, 1953. [1852

SHOP foreman wanted for sub-assembly dept. of factory manufacturing communications equipment in East Anglia.—Box 0813. [1834

SITUATIONS VACANT

INSTITUTE of Cancer Research: Royal Cancer Hospital, Fulham Rd., London, S.W.3. TECHNICIAN (male) required in the Physics Department; applicants should be capable of constructing, wiring, and initial testing of experimental electronic apparatus from theoretical circuit diagrams; salary £410×15—£470 plus London Weighting.—Applications, giving the names of three persons to whom reference can be made, must be received by the Secretary not later than November 10th, marking the envelope "Technician—Physics Department." [1875

RADIO/TV Engineer reqd., top wages paid.—Coynes Stores, 105, Talbot Rd., Bayswater. Bay. 4860. [1844

MINISTRY OF SUPPLY, R.A.E. (Guided Weapons Dept.), Farnborough, Hants, requires
EXPERIMENTAL Officers and Assistant Experimental Officers for work on design, development and performance of new weapons and associated guidance and control systems; instrumentation of flight trials and investigation of trials results. Experience in any of following fields desirable: Light engineering development; hydraulic and servo mechanism design; electrical control devices; centimetric radar techniques; design of light electrical, electronic or optical mechanisms; aircraft design, ballistics or aerodynamics; scientific computing or design of high-speed computing machines. Minimum of Higher School Cert. (Science) or equivalent required, although further qualifications in mechanical, electrical or electronic engineering, physics or mathematics may be an advantage. Salaries within ranges: Experimental Officer (Min. age 26) £649—£799, or Assistant Experimental Officer, £264 (age 18)—£576.
WOMEN somewhat less. Appointment unestablished. Application forms from M.L.N.S., Technical & Scientific Register (K), 26, King Street, London, S.W.1, quoting A232/53/A. Closing date 10th November, 1953. [1807

THE FAIREY AVIATION Co., Ltd., invite applications from the following for work of outstanding interest and opportunity:—
ELECTRONIC Engineers to become Section Leaders of small teams responsible for the preparation, testing in the field and further laboratory development of guided weapons; applicants should normally have at least H.N.C. and 5 years' experience in either the microwave, pulse or communication field.
ASSISTANT Engineers to form such teams either (a) with a similar background to the above or (b) having considerable experience of developing and testing small prototype electromechanical instruments.
THE vacancies are at the Research and Armament Development Division at Heston Aerodrome, Middlesex Periods of work away from this base at outstations in the U.K. are covered by subsistence allowances and week-end leave privileges. Good salary with bonus. Pension scheme.—Details of experience and qualifications should be sent to the Assistant Manager (A), Dept. W., The Fairey Aviation Co., Ltd., Heston Aerodrome, Hounslow, Middx. [1931

RADIO and television engineer required, fully experienced all makes, for bench and outside; good driver, clean licence; good salary, references.
ELECTRICAL SERVICE (EDGWARE), LTD., 117, Edgware Rd., W.2. Pad. 2342. [1726

ELECTRONIC Engineers required by The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry, in their Development Laboratories, for work on:—
(a) TRIALS Team in connection with guided weapons; 1 senior engineer, also 3 engineers.
(b) SERVO-MECHANISMS; 1 engineer.
(c) PULSE circuitry; 3 engineers.
(d) MICROWAVE circuits; 1 engineer.
(e) TEST equipment; 2 engineers.
(f) GENERAL radar circuit development; 2 engineers.
APPLICANTS, preferably with a degree or an equivalent qualification, should have had at least two years' experience in the development and engineering of service equipment as well as experience in one of the above.
HOUSES on the outskirts of Coventry, near our laboratories, are now available for offer to successful applicants and this offer can only remain open for a few months. Applicants' holiday requirements will receive special attention.—Reply, stating age, qualifications and experience, to the Personnel Manager, Ref. R.G. [1882

EXPERIENCED TV engineers required for retail service; permanent positions at good salary.—Full details to Shenstones (op. Town Hall), Leyton, E.10. Ley. 1362. [9266

KEEN young radio improver required (facilities, given for learning television); excellent prospects.—Write or call Morgan Radio, Ltd., 89, St Albans Rd., Hatfield, Herts. [1805

TELEVISION Engineer required, Waltham Cross area; must be capable driver; accommodation available to right man.—Write, Teleradio, 18, Turnpike Lane, N.8. [1863

RADIO service mechanics required by Smiths (Radiomobile), Ltd., for all parts of the country.—Write details of experience and qualifications to Personnel Officer, Goodwood Works, North Circular Rd., London, N.W.2. [0342

TRANSFORMER designer required by old-established company (South London area); candidates must be fully conversant with the design of all types of transformers up to 100 K.V.A. rating; progressive and permanent appointment; salary according to experience.—Box 1132. [1924

KEYING RELAYS. As used in 1154 Transmitter. These contain 5 sets of change over contacts and 2 sets of make contacts and have two 24v. coils. Brand new in maker's carton. Price 7/6. Post 1/3.
TELESCOPIC MASTS. 4 section, each 3ft. long, ¾in.-½in. diameter. 2 aerials fitted in 3 foot canister. Price 7/6. Carriage 3/6.
REV. COUNTERS BY SMITHS LTD. 3½in. dial. Scaled 10 to 5,000 revs. per minute. Luminous pointer. Flexible metal drive. Approximately 12in. long. Brand new and boxed 29/6. Postage 1/6.
POST OFFICE TYPE RACKS. For equipment 19in. 5ft. 6in. high for accommodating amplifiers, transmitters, receivers, etc., 39/6. Carriage 5/6.
MINE DETECTOR. For the detection of ferrous or non-ferrous metals, underground, under water or in animals, timber or chemicals, etc., etc., Originally intended for detecting mines. This equipment has never been used. The equipment comprises a 3 valve battery amplifier in a steel case, a shoulder haversack and a long counter balances search coil, short search coil, headphones, junction box operating instructions and circuit diagram. As we have to clear our store, we offer these at a very low figure of 39/6 carriage 7/6. These Mine Detectors were tested and in working order before being stored, but, in view of the very low price, we can give no guarantee other than of completness. Batteries not supplied.
AIR RAID WARNING CONTROL UNITS.
TYPE "A." DC Bias unit consisting of 230 v. mains transformer auto type tapped at 210 volts, twin coil polarised relay 50 ohms with 2 sets of break contacts, indicator light, two toggle switches, both 2 way 2 pole buzzer and housed in black bakelite case 4½in. × 3½in. × 6½in. deep. Price 15/-. Postage 2/-.
TYPE "B." Operated by audio frequency consisting of tuned relay with two reeds which in turn operates a 10 amp mercury switch through a train of gear wheels by means of a ratchet. A frequency of 396 C.P.S. applied will operate switch to off position and a frequency of 427 C.P.S. will operate the switch to the "ON" position. Made by G.E.C., and contained in a waterproof case iron box 5½in. × 5½in. × 4in. deep. Complete with terminal block. Price 17/6. Postage 2/6.
TYPE "C." DC Bias. Similar to Type "A" but consisting of transformer buzzer and small relay with single pole make contacts. Short flexible lead 2 pin 5 amp universal plug, unit 3½in. × 4in. × 6in. deep. Price 9/6. Postage 2/6.
SERIES BOOSTER—5U2712. New 12 v. input, 24 v. output, or in reverse. Price 15/6. Postage 2/6.
CHASSIS AND COVER. Steel Chassis 7½in. × 10in., front panel with handles 9in. × 8in., suitable for mounting new front panel as existing one is over drilled. Cover 8in. × 7½in. × 10½in. deep. Very clean condition. Price 3/-. Postage 1/6.
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In Every Ship of the Royal Navy

SITUATIONS VACANT

RADIO and television manufacturers require technical assistant for development work; city factory, 5-day week; staff canteen.—Full details of experience and salary required to Box 0724. [1829

TELEVISION/RADIO service engineer, competent and experienced man reqd. by H.M.V., Murphy, Pye dealer, W. London; able drive.—Write fully Box 149, c/o Gosden's, 76, Strand, W.C.2. [1922

SENIOR mechanical and electrical design engineers required for television transmission equipment, salary between £900 and £1,500 per annu.m—Apply Technical Director, Pye, Ltd., Cambridge. [1820

WORTHING district, television and radio service engineer required; state qualifications, experience and salary required.—Bowers & Wilkins, Ltd., 1, Becket Buildings, Littlehampton Rd., Worthing. [1815

SERVICE engineer required for recording equipment, thorough knowledge of audio engineering necessary, should be able to drive service van.—Apply to Personnel Dept., E.M.I., Ltd., Blyth Rd., Hayes, Middx. [1814

THE Brown's Lane Engineering Division of the G.E.C. Stanmore Laboratories urgently quires first-class experienced men to undetake pre-production engineering development work in the following fields:—
1. Gyroscopically stabilised aerial systems.
2. Servo-mechanisms and Magnetic Amplifiers.
3. Microwave Transmitters and Receivers.
4. Pulse Circuits.
THE right men can expect very attractive salaries. There is also a number of less senior positions open to men with less experience.
REPLY to Personnel Manager, Brown's Lane Division, G.E.C. Stanmore Laboratories, The Grove, Stanmore Common, Stanmore, Middlesex, quoting ref. WW/BLS/E4. [1851

ALUMINIZING Engineer, thoroughly familiar with aluminizing techniques as applied to Cathode ray tubes, for responsible position with leading United States independent manufacturer of Cathode Ray tubes.
LOCATION in New York suburban area.
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UNBEATABLE working conditions.
CONGENIAL, progressive associates; top executives who extend every concelvable co-operation that makes for mutual success.
INTERVIEWS will be held in London; to arrange for an appointment, at your convenience, please send complete details of experience to—Box 0851, c/o Wireless World. [1848

JUNIOR and Senior circuit engineers required capable of building and proving performance of specialised equipment; applicants should state age, qualifications and experience.—Box 1006. [1871

VENNER, Ltd., require a production supervisor with practical experience of electronic assemblies.—Applications to Personnel Manager, Venner, Ltd., New Malden, Surrey (Malden 2442). [1870

ELECTRICAL and radio installation draughtsmen required for design work on new aircraft and guided weapons projects.—Apply Employment Manager, Vickers-Armstrongs Ltd. (Aircraft Section), Weybridge, Surrey. [1892

COILWINDING.—Location near Rickmansworth; new concern requires engineer to control transformer, general coilwind and assembly shop; commencing salary £750 rising as business increases in size.—Box 1133. [1925

U.H.F. and TV engineer for the development of components and accessories; wide experience with variety of receivers (e.g., from servicing) essential; East London area; state age, salary, experience, qualifications.—Box 8886. [1661

RADIO testers and inspectors required for production of communication and industrial electronic equipment.—Apply Mr. D. J. Lewendon, Winston Electronics, Ltd., 1, Park Rd., Hampton Hill, Middx. Tel. Molesey 2985. [1645

TECHNICAL representative. A vacancy of unusual scope exists with old-established London company marketing acoustic correction and sound reinforcement equipment; applicants should have good technical background in radio or audio engineering.—Reply Box 0693. [1827

FIRST-CLASS radio and television engineers required by old-established, expanding business; good salary and prospects; permanent; all leading agencies, including Murphy, Bush, Pye, Ekco, etc.—E. P. Fox Ltd., East Molesey, Surrey. Molesey 2721. [0442

ELECTRONIC Engineer required to work on development projects in small organization situated on South Coast; experience on design of communications receivers essential; H.N.C. standard; write full details and salary expected. —Box 8840 [0251

ELECTRONIC development engineers required for work in laboratory on instrumentation, industrial electronics and guided weapons; must have sound knowledge and experience of electronics and be capable of working on own initiative; salaries up to £1,000 p.a. depending on experience; excellent opportunities for capable men to progress in rapidly expanding organisation.—Apply Technical Director, Winston Electronics, Ltd., 1, Park Road, Hampton Hill, Middx. Tel. Molesey 2985. [1644

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TELESONIC 4-Valve Battery Portable. Complete with 4 Hivac Valves. In Metal Carrying Case. Easily convertible to Personal Portable. £2 including conversion Sheet.
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SITUATIONS VACANT

SERVICE engineer reqd. by S.W. Lond. dealers; full TV exp. essential; only first-class men interested in their own future with a directorship in the business need apply; applicants must write, giving full details of prev. exp., etc.—Box 1150. [1930

SENIOR draughtsman required to work with minimum supervision on electric switches and devices, plastic/porcelain moulding, press-work, etc.; good salary for experience; West London area; 5-day week; canteen.—Write, giving full details of experience, to Box 8923. [1672

AIRCRAFT radio mechanics skilled in workshop practice or aircraft installations to work at Stansted Airport, Essex; hostel accommodation available; minimum hourly rates 3/9.—Write to the Personnel Manager, Skyways of London, 7, Berkeley St., W.1. [0019

EXPERIENCED radio testers and inspectors required for production of communication and radio apparatus, also instrument makers, wirers and assemblers, for factory test apparatus.—Apply Personnel Manager, E. K. Cole, Ltd., Ekco Works, Malmesbury, Wilts. [0238

TECHNICAL writer.—Decca Radar, Ltd., invites replies from young engineers interested in the preparation of technical literature concerning radar and associated systems; a sound knowledge of electronic techniques is essential.
APPLICANTS must be of British nationality and completed their National Service.—Replies to J. M. Decca Radar, Ltd., Research Laboratory, 2, Tolworth Rise, Surbiton, Surrey. [1818

FERRANTI, Ltd., Edinburgh, have a vacancy in their laboratories for a first-class engineer for interesting development work in connection with a control project involving digital computors, data recording and servo-mechanisms.
APPLICANTS should possess a B.Sc. degree and experience in some, or all, of these fields.
PERMANENT appointment, offering excellent prospects in a pleasant and desirable part of Scotland. Staff Pension Scheme.
APPLY, giving full details of training, qualifications, and experience in chronological order and quoting Ref. E/AL, to the Personnel Officer, Ferranti, Ltd., Crewe Toll, Edinburgh, 5. [1889

TELEVISION engineer required by leading radio and television dealers for servicing department at Halesowen, Birmingham; must be fully qualified; rates in excess of R.T.R.A. min. will be paid; write, giving full details of experience, age, etc., to—Box 1029. [1881

RADIO frequency service engineer for Radyne R.F. equipment in Midlands, must have had previous experience in this or similar type of work.—Apply by letter, giving fullest particulars, including slary expected, to T. W. Wall & Son, Ltd., 79, Church Rd., Moseley, Birmingham, 13. [1884

LAYOUT engineers required for design of industrial electronic equipment; excellent opportunities for capable men to progress in rapidly expanding organisation.—Apply Technical Director, Winston Electronics, Ltd., 1, Park Rd. Hampton Hill, Middx. Tel. Molesey 2985. [1647

FERRANTI, Ltd., require electronic equipment testers, radio diagnosers and radio mechanics for their North and South Manchester factories; standard rates of pay and excellent working conditions.—Write giving age and details of experience, to Labour Manager, Ferranti Ltd., Moston, Manchester, 10. [1728

ENGINEER with layout and small-batch production experience required to initiate and take charge of small assembly section for medical electronic equipment.—Write fully stating age, experience and salary required, to Box 86, Aldridge Advertising, 1, Whitefriars St., London, E.C.4. [1836

DEVELOPMENT engineer required by established firm manufacturing wire-wound components and electronic equipment; ability to work on own initiative essential; write, giving details of age, experience and salary, to: Dagnall & Kendall, Ltd., Cranfield, Nr. Bletchley, Bucks. [1895

BERRY'S (SHORT WAVE), Ltd., have vacancy for counter sales assistant; must have had previous retail experience of quality amplifiers and tape recording equipment; also bright lad for general work.—Write only stating age, past experience, salary required, to 25, High Holborn, London, W.C.1. [1835

RADIO and television engineers required by well-known manufacturer, interesting and varied work for skilled men, good rates of pay and conditions, five-day week, canteen facilities, pension scheme, employment Perivale district.—Write, giving details of experience, etc., to Box 0596. [1811

TELEVISION aerials.—Vacancies occur with well-known manufacturers for practical technical riggers capable of supervising multi-point installation in London and provinces, good pay and prospects for suitable applicants, must hold clean driving licence and be prepared to travel.—Box 0595. [1810

E.M.I. Eng. Dev., Ltd., have an interesting progressive vacancy for a circuit engineer to work with a small section on transistor applications; applicants should have at least five years' experience on circuit development associated with wide range of electronic equipment.—Write, giving full details and salary required, to ED/133, Personnel Dept., E.M.I. Eng. Dev., Ltd., Hayes, Middx. [1821

SITUATIONS VACANT

ELECTRONIC engineers to inspect and service A.A. equipment; O.N.C. or equivalent qualifications necessary; salary £550 (age 28 or over) and £20 to £628; generous paid annual leave.—Application forms from O.C., 1 A.A. Group Wksp. R.E.M.E., Shrapnel Barracks, London, S.E.18. [1869

DEVELOPMENT engineer (electronics) required for work on radio communications and sound recording equipment; London area; practical experience essential; ample scope for advancement.—Apply in writing, giving age, previous experience and salary required, to Box 1005. [1868

DRAUGHTSMAN wanted for a small drawing office engaged in design of electronic equipment; good opportunity for man with initiative in rapidly expanding organisation.—Apply Technical Director, Winston Electronics Ltd., 1, Park Rd., Hampton Hill, Middx. Tel. Molesey 2985. [1646

ELECTRONIC Engineer with experience of special amplifier and test equipment design, degree desirable but not essential, salary according to qualifications and experience.—Apply Personnel Officer, Louis Newmark, Ltd., Prefect Works, Stafford Rd., and Purley Way, Croydon, Surrey [1945

ASSISTANT transformer designer required by established firm manufacturing wire-wound components and electronic equipment; the position offers excellent prospects for a keen engineer; write, giving details of age, experience and salary, to: Dagnall & Kendall, Ltd., Cranfield, Nr. Bletchley, Bucks. [1894

TECHNICAL Writer, experienced in compiling matter for publication in Radio and Television Service Manuals, Instruction leaflets, etc., required for engineering department; reply stating age, qualifications, etc., to—Employment Manager, Ferguson Radio Corporation, Ltd, Gt. Cambridge Rd., Enfield, Middx. [1864

ENGINEER required to undertake the development of electronic instruments; the successful applicant must be capable of working substantially on his own initiative; salary will be in accordance with qualifications and experience; degree or equivalent preferred.—Apply in writing to Advance Components, Ltd., Back Rd., Shernhall St., London, E.17. [1909

A GOOD opportunity exists for a man with common sense, patience and organising ability to take charge of a small but expanding section in modern factory in N.W. London, work is concerned with assembly of precision electro-mechanical products and offers permanent employment and a good salary.—Write Box W.W.701, c/o, 191, Gresham House, E.C.2. [1809

DECCA RADAR, Ltd., have vacancies for men with a sound knowledge of radio and/or radar as installation engineers, the work is interesting and varied and in all cases specialist training given.—Write in the first instance, giving details of past experience and salary required, to the Manager, Decca Radar, Ltd., 50, Southwark Bridge Rd., London, S.E.1. [1813

JUNIOR electronics engineer required to assist in the development of an analogue computer; previous development experience is essential and a knowledge of d.c. amplifiers would be advantageous; applicants, who should be 21-24 years of age and hold the Higher National Certificate, should write, quoting full particulars, to—The Personnel Officer, E. Cowes, Isle of Wight, ref.: W.W./C.3. [1719

THE ENGLISH ELECTRIC Co., Ltd., want a senior graduate familiar with computing techniques (analogue and/or digital) to undertake development work on high priority defence project; must possess initiative and originality; permanent progressive post; salary according to age and experience.—Applications, quoting ref. 862E, to Dept. C.P.S., 336-7, Strand, London, W.C.2. [1754

SENIOR and junior engineers required for responsible work in radio and television laboratories; applicants for senior position should be able to undertake development work with minimum supervision; excellent conditions and salary available for applicants who are accepted.—Apply in first case to Personnel Manager (Dept. R.D.), McMichael Radio, Ltd., Wexham Rd., Slough. Applicants must be of British Nationality. [1527

McMICHAEL RADIO, Ltd., require senior and junior engineers in their equipment division laboratory at Slough; training and experience in the field of applied electronics (including communications) and experience of working with Government Departments are the chief qualifications required.—Write, stating age and full details of training, qualifications and experience, to the Chief Engineer, Equipment Division, McMichael Radio, Ltd., Slough, Bucks. [0198

ELECTRONIC engineers interested in the testing of radar and microwave equipment in a new production establishment are required by an old-established leading electrical company; sound technical knowledge and a wide experience of testing techniques and equipment are necessary; positions of responsibility are available to suitably qualified applicants, with further openings and scope for advancement arising in a South Coast area; salary will be according to experience and ability.—Please reply, giving full details of experience, qualifications and age, to Box 1116. [1908

SITUATIONS VACANT

PARTRIDGE TRANSFORMERS, Ltd., have vacancy for post of chief engineer; applicants must possess university degree or equivalent and have had considerable experience in the design and development of all types of audio and power transformers.—Written applications to Managing Director, Partridge Transformers, Ltd., Tolworth, Surrey. [1923

EXPORT manager required by leading firm of electronic components manufacturers to work under jurisdiction of sales manager; essential qualifications, similar previous experience, working knowledge of foreign languages, and thorough knowledge of radio and television from the manufacturing angle; must also be free to travel; write full details and salary required.—Box 0692. [1817

TEST gear design engineers and maintenance engineers required with practical experience of this class of work, based on sound knowledge of electronic principles; these vacancies are permanent and progressive; a company pension scheme in operation; London area.—Please write in confidence, quoting reference WW/758, giving full details of qualifications, to Box 0631. [1816

FIRE-SETTERS required for electronic valve production unit with at least two years' experience (valves or lamps) on sealing-in machines and other automatic glass working equipment; all applications will be treated in confidence.—Write stating age, salary required and giving details of experience to Personnel Officer, Ericsson Telephones, Ltd., Beeston, Nottingham. [1854

EXPERIENCED electronic technicians required for work on Service radar and gun control equipments in the North-west, West Midlands and South Wales areas, in the grade Technical Assistant Grade III; salary at age 28 approximately £520 p.a.×£20—£600 p.a.—Apply, quoting age, qualifications and experience to ADME, HQ 4 AA Group, Peninsula Barracks, Warrington. [1853

ELECTRONICS Test Engineer; a vacancy exists for an engineer to take charge of a new test room dealing with final testing of electronic and microwave instruments, in conjunction with design laboratories; salary in the range £500 to £650 at start depending on qualifications and experience.—Apply to Chief Engineer, W. H. Sanders (Electronics), Ltd., Bedwell Lane, Stevenage, Hertfordshire. [1843

BUSH RADIO, Ltd., require experienced senior design draughtsman for work in connection with developments on commercial radio and television receivers and electronic units for the services; apply giving full particulars of ags and experience to the—Personnel Manager, Bush Radio, Ltd., Power Rd., Chiswick, W.4. Tel Chi. 6491. Interviews may be arranged for Saturday mornings. [1804

DRAWING office staff required, draughtsmen and drawing office clerk, to take charge of print room and drawing office records, for a well-established firm, situated within half an hour of Waterloo Station; draughtsmen should have workshop experience and preferably a knowledge of electronics; good salary paid to suitable applicants; 5-day week.—Apply D.O., Box 1709, 15, Hill St., London, W.1. [0246

FACTORY engineers are required for Cathode Ray tube factory in North London area; previous knowledge and experience desirable but not essential; applicants should have at least Higher National Certificate in Electrical Engineering and some knowledge of chemistry; they must be capable of investigating and solving manufacturing problems on their own initiative.—Box 0982. [1867

ELECTRONIC engineer required by a large food organisation centred in London, for the construction and maintenance of specialised factory electronic equipment, and to assist in the development of new apparatus; applicants should possess initiative and be capable of working without undue supervision; salary according to age and experience.—Write Box W.W.785, c/o 191, Gresham House, E.C.2. [1937

JUNIOR test assistant with some telecommunication knowledge required by Company, S.E.10; a young man studying for City and Guilds Telecommunications Course in Engineering would be considered; experience of cable test at audio and carrier frequencies desirable but not essential; all welfare facilities; 5-day week; salary according to age and qualifications.—Apply Staff Officer, Telcon Works, Greenwich, S.E.10. [1893

HIGH-DEFINITION FILMS, Ltd., require Junior Engineers and Technical Assistants for development and operation of studio electronic equipment; preference will be given to applicants who have had previous experience in the development and/or operation of television studio equipment; candidates must have completed their National Service.—Write, giving full details, to Personnel Manager, 98, Highbury New Park, N.5. [1926

BELLING & LEE, Ltd., Cambridge Arterial Rd., Enfield, Middlesex, require research assistants in connection with work on electronic components, fuses, interference suppressors and television aerials; applicants must be graduates of the I.E.E. or possess equivalent qualifications, together with similar laboratory experience; salary will be commensurate with previous experience; 5-day week; contributory pension scheme.—Applications must be detailed and concise, and will be treated as confidential. [0230

SITUATIONS VACANT

SENIOR engineer and a junior are required by a small but progressive firm of electronic instrument manufacturers in Surrey for interesting development work on important projects; scope for initiative and self-expression; applicants should possess a degree in physics or the equivalent and should have industrial experience and a practical mind; both salary and prospects will be good for the right men. —Apply Box 8964. [1676

DRAUGHTSMEN required, seniors and juniors, preferably experienced in light mechanical engineering, as applied to radio and radar equipment; knowledge of workshop practice essential; applicants should possess Ordinary National Certificate or the equivalent; salary, A.E.S.D. rates and over, according to ability; 5-day week; canteen facilities.—Write, giving full particulars, to R.D.J., Decca, Ltd., 2, Tolworth Rise, Surbiton, Surrey. [0247

RADIO service engineers. Selfridges, Ltd., have vacancies for radio Service Engineers. Applicants must have experience of all makes of radio and television sets and must be able to drive a car. Good starting salary and generous increases to men who show ability. Posts are permanent and pensionable to men under 43 yrs.—Apply between 9 a.m. and 11.30 a.m., Monday to Friday, to Personnel Manager, Provision Building, Somerset St., W.1. [1839

DEVELOPMENT engineer required to carry out work in connection with improvements to direct writing pen oscillographs; the position is a responsible one in which the applicant will be required to deal with technical correspondence and contacts with customers; a good knowledge of light mechanisms under vibrating conditions is required together with the ability to calculate the behaviour of and subsequently design such mechanisms.—Apply, giving full details of previous experience, to Box 0903. [1860

ELECTRONIC engineer, over 28 years of age, with degree in physics or engineering, and some practical mathematical ability. At least 6 years' experience in a development laboratory working on problems involving VHF techniques and subminiaturization. Must be familiar with problems of design for production, in small or large quantities, of small complex electronic units, and able to lead a small team of engineers and draughtsmen.—Applicants write with full details to ED/134, Personnel Dept., E.M.I., Eng. Dev., Ltd., Hayes, Middx. [1822

BRITISH EUROPEAN AIRWAYS require engineers for overhaul and maintenance of electronically operated flight simulators at London Airport; applicants should possess thorough knowledge of electronics and have had maintenance experience on apparatus using servo-mechanisms actuating repeater instruments; commencing salary between £10/19 —£13/19 p.w. according to qualifications.—Written applications to Personnel Officer, Flight Operations, B.E.A., Keyline House, Ruislip, Middlesex. [1806

ENGINEERS with radio and radar installation and maintenance experience are required for interesting work which will involve working in various parts of Great Britain; applications will be welcomed particularly from ex-Service men who have had extensive experience in this field; these positions offer good prospects in a large flourishing company which operates a generous pension scheme.—Applications, which will be treated in confidence, should be addressed to Box WW 626, L.P.E., 110, St. Martin's Lane, W.C.2. [1946

ELECTRONIC engineer required by new division of prominent engineering company in Northern Ireland for development work on guided weapons and other projects; degree or equivalent in electrical engineering or physics, with good practical experience, preferably of d.c. amplifiers, electronic computation, pulse techniques, or miniature equipment; good salary and prospects for man with initiative; pension scheme, assistance with housing.—Send full particulars of age, qualifications and experience, and salary required, quoting E.E.2, to Box 8888. [1663

MINISTRY OF CIVIL AVIATION. Radio technicians required at aerodromes and radio stations. Special training courses for keen technicians with basic quals. Interesting work in progress providing electronic aids to navigation. Prospect of permanent pensionable posts. Rates of pay (London) from £330 p.a. at age 19 to £445 at 25 rising, subject to qualifying test to £540. Slightly lower for provinces. Candidates aged 19 or over with practical experience in maintenance of radio or radar equipment should apply to Ministry of Labour and National Service, Barnsbury Rd., London, N.1, quoting Order N. 576. [1823

AUSTRALIA.—Engineers and technical assistants required for guided weapons trials organisation at the Long-Range Weapons Establishment, Salisbury, near Adelaide; posts are available for electronic, electro-mechanical and hydraulic engineers as well as for those who wish to gain experience subsequent to graduation or apprenticeship. For the more senior posts experience with servo-mechanisms would be an asset; suitable service in the Armed Forces will also be taken into consideration in assessing suitability; initial period of training for some months near London; passages for employees and family, assistance in obtaining accommodation.—Apply with full details quoting No. 1424, to Personnel Manager, Sperry Gyroscope Co., Ltd., Great West Rd., Brentford, Middx. [1773

SITUATIONS VACANT

JUNIOR and Senior Radio and Television Engineers required in production, sale and service (field) departments of manufacturers in South West London; applicants should have thorough knowledge of modern receiver technique. Salaries according to position and qualifications.—Write Box 0852. [1849

ELECTRONIC engineers are invited to apply for senior posts of exceptional interest and opportunity with Decca Radar Ltd., to work in their laboratories on an extensive and expanding programme of microwave-link and radar development; applicants must have had several years of responsible development experience in the electronic field; posts are permanent and pensionable; British nationality essential.—Write, quoting reference S.E., to The Research Director, Decca Radar, Ltd., Research Laboratory, 2, Tolworth Rise, Surbiton, Surrey. [0248

ELECTRONIC technician required to construct and maintain electronic equipment; duties are not solely of this nature as the unit is small; satisfactory qualifications are, for example, National Certificate together with five years' experience in the electronic field, or Inter. B.Sc. together with three years' experience; good prospects exist for further education, formally or informally; minimum salary £450 p.a.—Reply, stating age, qualifications and experience, to Dr. H. D. Darcus, M.R.C. Unit, Department of Anatomy, University Museum, Oxford, by November 9, 1953. [1944

THE GENERAL ELECTRIC CO., LTD., Brown's Lane, Coventry, require Senior and Junior Electronic Development Engineers for work on Guided Weapons and like projects, particularly in the field of Microwave and Pulse Applications. Mechanical Development Engineers, Designer Draughtsmen and Draughtsmen, preferably with experience of radar type equipments, also required for the above projects: salary according to age, qualifications and experience; houses available to selected senior staff.—Apply by letter stating age and experience to the Personnel Manager (Ref. R.G.). [0259

ENGINEER required for laboratory of manufacturers of radio frequency magnetic materials; the work includes the development and application of these materials; applicants must be versatile and resourceful; sound theoretical training and several years industrial experience in design and development in the electronic field is essential; salary commensurate with qualifications and experience.—Write, stating age and full details of training and experience to the Managing Director, Neosid, Ltd., 33, Hyde Way, Welwyn Garden City, Herts. All applications will be treated in confidence. [1921

B.B.C. requires engineer of recognized professional standing (Hons. Degree engineering/physics preferred) for television section of designs department to take charge design of major items of equipment used in television studios and mobile control rooms; will be expected to produce original work. Direct personal experience design of modern electronic television equipment closely related techniques essential; knowledge optics advantage. Starting salary £1,000 (higher if qualifications exceptional) by annual increments to £1,330 max.—Detailed applications to E.E.O., B.B.C., London, W.1 quoting reference E.782. [1825

DECCA RADAR, Ltd.—There are vacancies in the technical publications department, either for experienced technical writers or for engineers whose qualifications and experience fit them to take on this work; the work involves the preparation of technical, installation, and operational instruction manuals in draft form from original data provided by other departments of the organization; salary scale £10 to £14 per week according to experience and qualifications.—Reply, by letter only, to Decca Radar, Ltd., Installation Department, 50, Southwark Bridge Rd., London, S.E.1, quoting reference RWD/GP. [0249

TELECOMMUNICATIONS Engineers required on overseas shore staff of Cable and Wireless, Ltd., applicants must have technical knowledge and practical experience of maintenance and operation of wireless telegraph plant, and possess C. & G. Radio II certificate or equivalent; desirable age limit 29; basic commencing salary £324 (age 22) to £456 (age 29) per annum; free accommodation or allowance in lieu; foreign service and expatriate allowances (up to £240 and £550 p.a. respectively) additional; tax paid; permanent and pensionable positions for suitable candidates.—Apply in writing, giving experience and qualifications to Managing Director, Cable and Wireless, Ltd., Electra House, Victoria Embankment, London, W.C.2. [1840

THE MULLARD RADIO VALVE Co., Ltd., Mitcham Junction, Surrey, has a number of vacancies for production engineers; applicants should hold a degree or equivalent qualifications in physics electrical engineering or mechanical engineering. Whilst previous experience would be an advantage, it is not essential. The company has production departments manufacturing receiving valves, cathode ray tubes, gas-filled valves, U.H.F. valves, transmitting valves and most other electronic tubes, and successful applicants would be required to join one of these departments on work connected with valve technology and the technical and organisational control of production. The salaries offered vary with experience and age; good opportunities of advancement exist in this expanding industry for men of ability.—Applications in writing should be addressed to: Personnel Officer, Mullard Radio Valve Co., Ltd. New Rd., Mitcham Junction, Surrey, quoting ref. W.1.C [1932

SITUATIONS VACANT

SENIOR and junior electronic engineers are required for interesting and varied work in the Nelson Research Laboratories; applicants should have sound workshop experience, some knowledge of drawing office procedure, qualifications, Higher National Certificate minimum; duties involve responsibility for the engineering design and development of prototype electronic equipment from the experimental stage to the issuing of manufacturing information to the Laboratories' workshops; these posts offer scope for advancement to young men with initiative and ability; salary according to qualifications and experience comparable with present-day levels.—Write, giving full details, quoting ref. 1051A, to Dept. C.P.S., The English Electric Co., Ltd., 336/7, Strand, W.C.2.

ADMIRALTY, Royal Naval Scientific Service. Engineers and Physicists (particularly with electronics) required for appointments in (a) Senior Scientific Officer and Scientific Officer grades (Ref. A246/52A) and (b) Experimental Officer and Assistant Experimental Officer grades (Ref. A247/52A) in experimental establishments in London, Portsmouth, Weymouth areas and Scotland. Candidates, British subjects, for (a) must possess first or second class honours degree in Physics or Engineering, or high professional attainments such as corporate membership of appropriate professional institution with suitable experience and responsibility and for (b) should possess one of following qualifications: University degree in Science, Engineering or Mathematics, Graduate membership of appropriate professional institution, Higher National Certificate, Final Certificate of five-year grouped course in relevant subject at City and Guilds of London Institute or comparable institution, Higher School Certificate with Mathematics, or Science as principal subject or equivalent qualification. S.S.O.'s at least 26 years of age with at least three years' approved experience, London salary (men) £917-£1,075 per annum; S.O.'s at least 21 years, £440-£812; E.O.'s at least 26 years, £681-£838; A.E.O.'s at least 17½ years, £274-£607. Rates for women and posts in provinces somewhat lower. Starting salaries above minima may be granted according to age and experience. All appointments unestablished (with F.S.S.U. for S.S.O. and S.O.) but with some opportunities to compete for established posts.—Application forms from M.L.N.S., Technical and Scientific Register (K), Almack House, 26, King St., London, S.W.1, quoting appropriate reference. [1824

SITUATIONS WANTED

EXPERIENCED tracer requires private work; could also undertake some circuit draughting.—Box 1156. [1943

WORKS Manager, qualified, considerable experience of miniature electronics and all aspects of works management, requires progressive appointment.—Box 1154. [1940

OFFICIAL NOTICE

THE trade marks set out below were assigned on the 23rd day of June, 1953, to Pamrex, Ltd., of 41, New Bond St., London, W.1, without the goodwill of the business in which they were then in use:—
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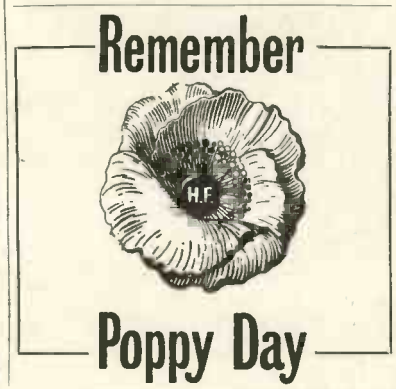

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