Wireless World

RADIO · ELECTRONICS · ELECTRO-ACOUSTICS

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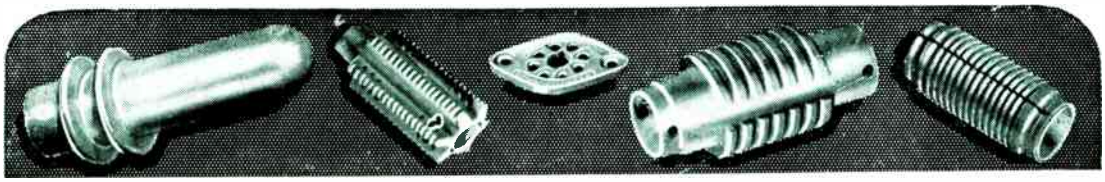

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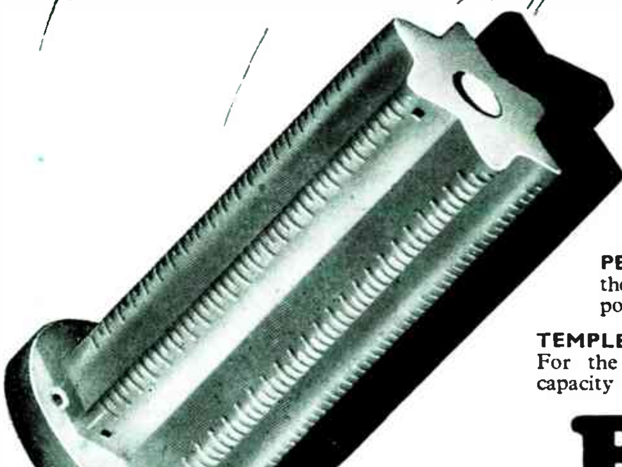

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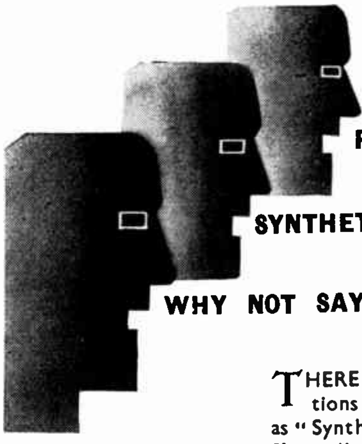

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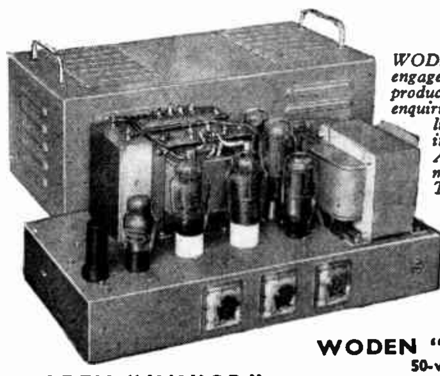

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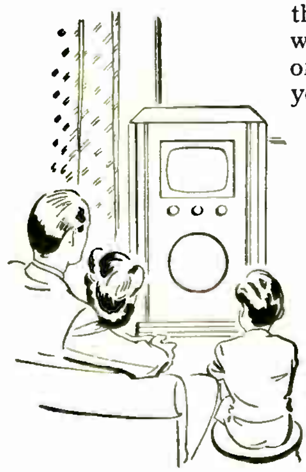

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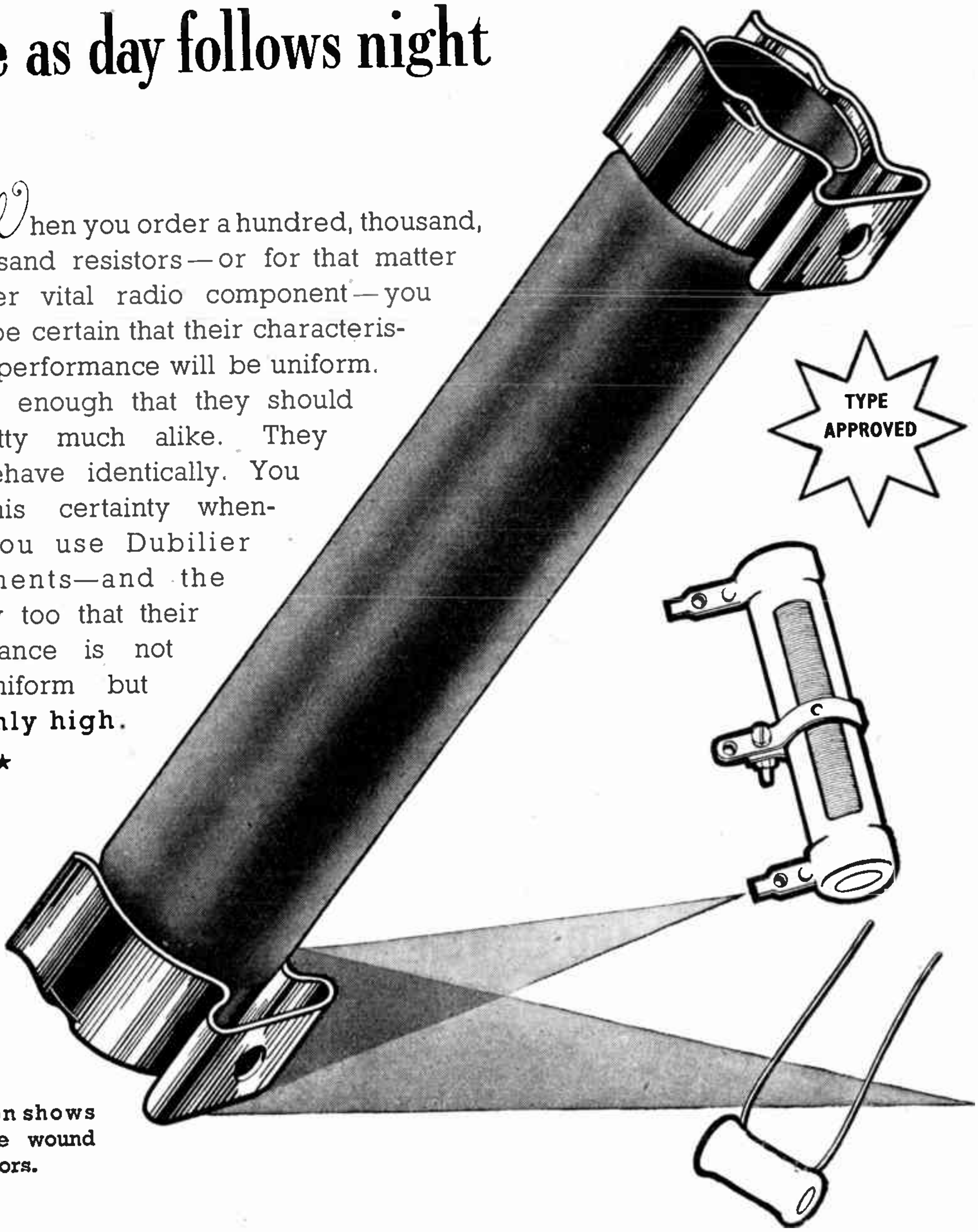

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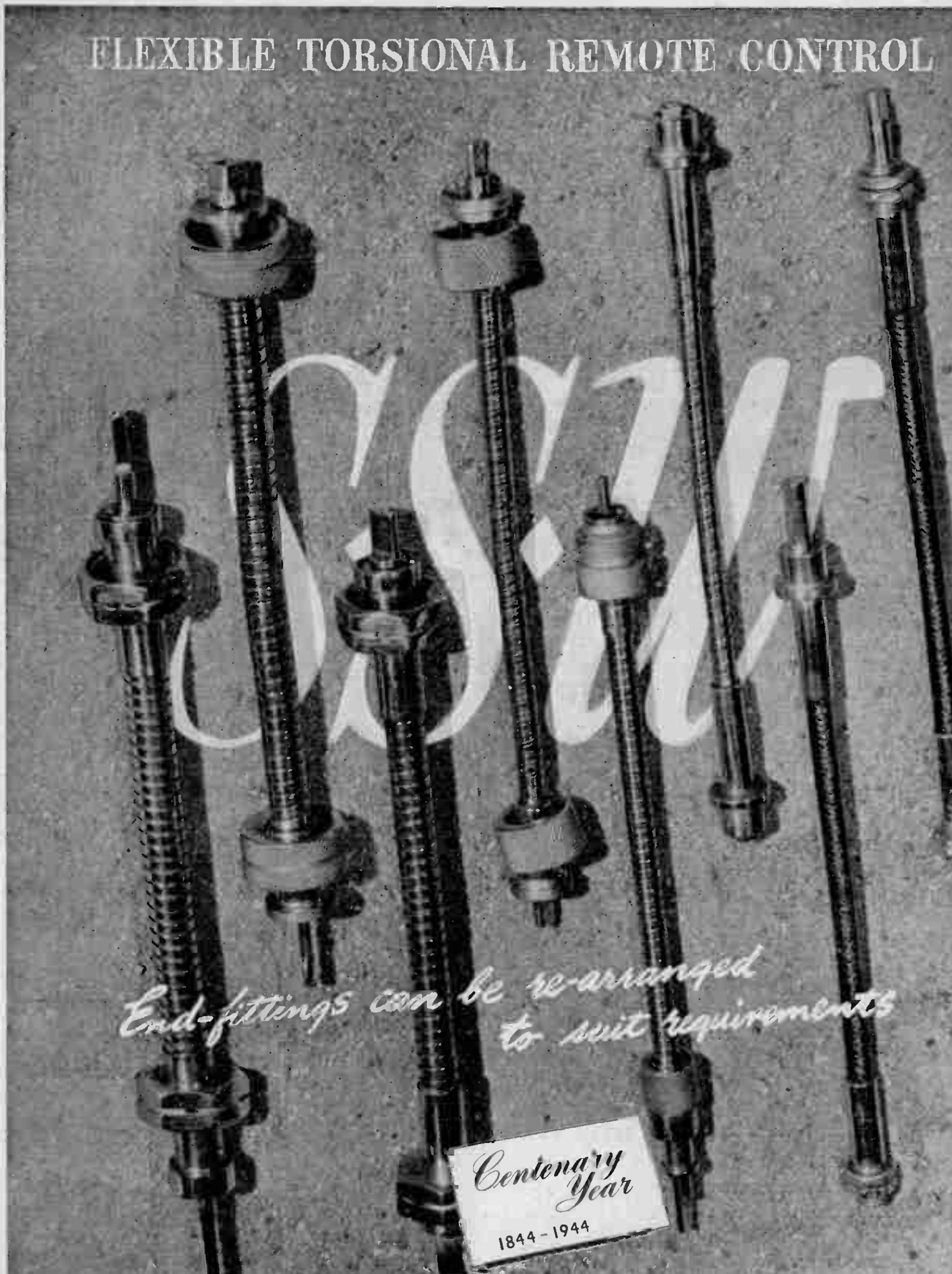
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Wireless World

Radio · Electronics · Electro-Acoustics

Vol. L. No. 8 | AUGUST 1944 | Price 1s. 6d.

Monthly Commentary

International Broadcast Organisation

MOST people concerned with the technicalities of wireless must often have experienced, during the years preceding the war, a feeling of intense disappointment at the failure of broadcasting in improving international relations. Going a little farther, the more critically minded among us must have suffered under a sense of frustration in the belief that politicians and sociologists had failed to turn to better account a medium of such obvious potentialities for the general betterment of the world. We have given them the tools; have they seriously tried to make use of them?

What is spoken into the microphone is, it may be argued, no concern of the technician. But it will certainly be his function to provide not only the means but also the technical organisation for the kind of service that, we dare to hope, will one day enable broadcasting to play a far greater part than hitherto. Influenced by considerations such as these, we publish elsewhere in this issue details of a proposed scheme for an international broadcasting system. It is believed to be the first attempt, worked out in considerable detail and on a large scale, to devise a broadcasting service on a truly international basis.

The proposed European Broadcasting Alliance aims at establishing a service under international control which will provide every listener in Europe with a good signal, quite apart from anything he may receive from his own national service, which would be virtually unaffected by the scheme. To secure this object, and to make possible the reception of the service with cheap and simple receivers, the normal long-wave band (1130-1935 m.) would be devoted exclusively to this service.

The political aspects of the matter, to say nothing of the task of devising programmes acceptable to all the diverse tastes of Europe, presents a problem that cannot profitably be discussed here. But it is clear that some kind of organisation broadly on the lines of that under discussion is essential if international broadcasting is ever to become established as a real force in human affairs. The European Broadcasting Alliance provides at least the nucleus of a scheme that might be made to work—always provided that someone can find the right kind of modulation to impress on the carriers of its transmitters. That, after all, is the work of others, and Messrs. Hubert, Eckersley and Tenenbaum, the sponsors of the plan, are to be congratulated on working out a practical scheme of distribution.

Electric Motor Interference.—It is probably true that the most widespread source of interference with broadcast reception is the small "universal" AC/DC commutator motor, so largely used in vacuum cleaners and countless other domestic electrical appliances. Contributors to this journal have suggested that much of this interference could be avoided by substituting, where possible, AC induction motors. This suggestion was considered at some length in our July issue, and the conclusion was reached that the single-phase induction motor is strictly limited in its applications, though no doubt its somewhat wider use would improve matters.

Another suggestion for reducing interference from motors is made in a recent article in *The Electrician*, from which we print extracts on another page. It concerns the use, in domestic appliances, of three-phase AC motors, which are free of many of the objections of the single-phase induction type, and are equally interference-free. Unfortunately, three-phase supplies are not available, under existing regulations, to domestic consumers, the voltage between conductors being limited to 250. It is argued, however, that this regulation is archaic, and that there is no valid reason, on grounds of safety, why it should not be amended.

Although the widespread provision of three-phase supplies to domestic premises would involve considerable changes in our system of electrical distribution, the proposal should not be ruled out on that score, as, after the war, there will be many opportunities for making such changes.

MAGNETIC RECORDING

A Simple Exposition of the Principles Involved

By G. L. ASHMAN

RECORDED items now play an increasing and recognised part in sound reproduction, and though many systems have been developed, most of these aim at producing permanent results. In certain fields, however, a permanent record may not be necessary or may be uneconomical, and it is then a great advantage to be able to "erase" the record and so use the same sound carrier repeatedly. Many instances arise where a topical event occurs at an inconvenient time for immediate reproduction, but may not justify the making of a permanent record. The magnetic recorder has already proved its worth in the battle zones of North Africa and Italy,[14], [15], and for this type of work it offers the great advantages of being extremely robust and practically unaffected by vibration; it can operate in almost any position, and recordings of considerable length can be made without breaks. A portable recorder has been developed by General Electric in the United States which operates from batteries, weighs only nine pounds, and has been successfully used in aircraft. Magnetic recording machines have also been used for the dictation of correspondence and instructions.[2], [6].

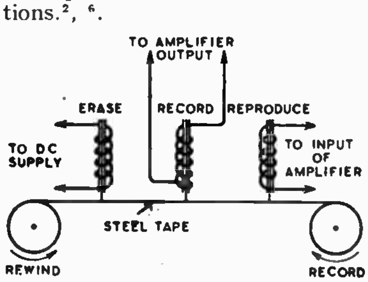

Fig. 1. Essentials of a magnetic recording system.

The principles of magnetic recording have been known for many years, and the original "Telegraphone" (patented by Poulsen in 1900) was based on them.[1] Since then the development of this system for recording speech or music appears to have been neglected for a considerable time, and only during the past twelve years is any record of noteworthy progress to be found. Much experimental work has been carried out on the Continent during this time, but little information on the subject has appeared in this country, and the following outline of the system may therefore serve as an introduction.

Referring to Fig. 1, it will be seen that the steel tape or wire is drawn past three "heads" in succession. These "heads" consist of coils with soft iron cores, the latter being held in contact with the tape and providing the link between the recording medium and the amplifier. Variations in the current flowing through the "recording" coil cause changes in the local magnetic condition of the tape which retains them for a considerable time. When the tape passes the "reproducing" head the varying magnetic flux set up by the moving tape induces small EMFs, which are then amplified in the usual way. The coil of the "erasing" head is fed with steady direct current, and by bringing the tape up to the magnetic saturation point removes traces of previous recordings. It will be obvious that all the heads are not in use at the same time, suitable switching being used to connect those actually required. One notable disadvantage common to any tape system is that the tape must be rewound before reproduction is possible.

Let us now consider the magnetic process in some detail. The magnetising force set up by a current is proportional to the strength of the current, and is measured in dynes per unit pole, usually denoted by the symbol H. The intensity of the resultant field is represented by lines of force per square centimetre being denoted by $B = \mu H$, where μ is the permeability of the material through which the lines pass. In air μ is taken as unity so that $B = H$, but in paramagnetic material such as iron, steel and most ferric alloys, the induced field has many more lines per unit area than the inducing field; in other words, B is much greater than H, the ratio B/H being equal to μ the permeability.

If a curve is plotted of the variation of B with H for the complete cycle of magnetisation, the familiar hysteresis loop is obtained, which is characteristic of the material being examined (Fig. 2). Commencing with the magnetic material in an unmagnetised condition, a steadily increasing magnetising force H will give rise to an induction B in the material along the branch A of the curve.

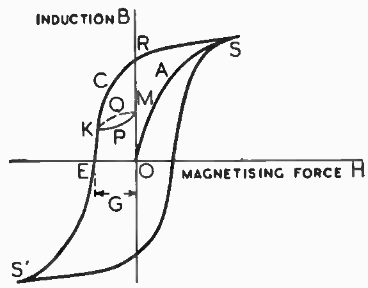

Fig. 2. Typical hysteresis loop.

This induction increases until the magnetic saturation point of the material is reached at S, and thereafter any further increase in H produces no further increase in B. If, however, the magnetising force is reversed, the induction no longer follows curve A, but will instead trace the branch C of the hysteresis loop. It will be noticed that when the magnetising force reaches its zero value a certain amount of induction R (called the residual induction) still remains in the material, and to restore the material to the point E where the induction is zero requires a magnetising force in the opposite sense to the original known as the coercive force G. A further increase in this reverse force will cause saturation of the material with opposite polarity at the point S'. Completion of the hysteresis loop is obtained by again reversing the direction of the magnetising force.

S. J. Begun has shown[13] that if at some point in the cycle, such as K the magnetising force is reduced to zero, the induction in the material does not retrace the curve along C to R, but follows the ascending curve P to the point M and also that this minor curve cannot be retraced by the application of a reverse magnetising force but that the curve Q will be traced instead. From this it is readily seen that the magnetic processes are not reversible and that the result of subjecting the material to a magnetic flux is determined by its previous magnetic treatment.

If the magnetic circuit is not completely closed demagnetisation occurs and the induction in the material is greatly reduced. This effect is most marked in magnets whose length is small compared with their cross-sectional area, and since the coercive force is a measure of the ability of the material to resist demagnetisation, it is obviously very desirable to use magnetic materials with a high coercivity when very short magnets are involved. This requirement can be met by using steel tape of high carbon content or a special tungsten-steel alloy.

Pole Piece Design

Since the pole pieces form the connecting link between the tape and the reproducing amplifier, the material to be used and the form these should take are of great importance. A material having low hysteresis loss is essential, as during reproduction the pole pieces are subjected to a rapidly varying magnetic flux; and as the latter is quite weak the reproducing pole pieces should have the lowest possible reluctance. During the recording process the pole piece must handle a considerable induction if the full magnetic range of the tape is to be utilised. Practical experience by workers in this field has shown that laminated pole pieces of Mumetal or Permalloy are satisfactory, especially when they have a larger cross-section towards the middle of the coil.[13] Ths construction is more effective, as, owing to the presence of leakage flux during the recording process, the intensity at the pole tip is different from that nearer the middle of the coil.

Referring now to the actual recording operation, it will be recalled that the tape is magnetically saturated at the "erasing" head, its condition after leaving this head being as shown in Fig. 3, where OR represents the residual magnetism in the tape. This diagram corresponds to part of the complete loop of Fig. 2. As pointed out by Begun, the process of recording may be compared with the action of a Class A amplifier, and, as in that case, it is essential to operate about a point as near the middle of the straight part of the characteristic as possible in order to avoid distortion due to non-linear operation. To bring about this condition the signal current is superimposed upon a polarising current, the field from the latter being represented by OP. If now any point A on the curve traced by the recording current is considered it will be seen that this current takes the magnetic condition of the tape to the point B. The tape now leaves the recording head and since the magnetising force is reduced to zero, the induced magnetism rises through the minor loop to C, this being the final condition of that particular point on the tape. Every point on the curve representing the recording current may be similarly plotted, and in practice it is found that the

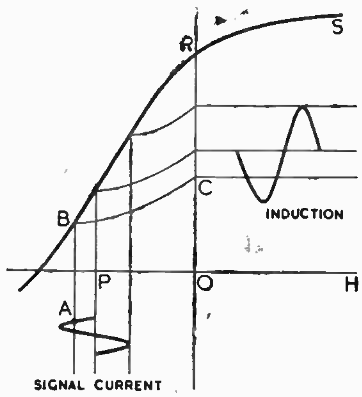

Fig. 3. Recording characteristic showing minor ascending loops.

distortion introduced by the minor loops is negligible. It is obvious that the material used for the tape should have a hysteresis loop with a long straight portion to provide a wide working range with little distortion.

It will be realised that the foregoing discussion only applies when a small part of the tape is subjected to only one momentary value of magnetising force. This condition is not attained in practice since a small area of the tape is under magnetic influence for a finite length of time, determined by the thickness of the pole pieces, the speed of the tape, and the magnetic focusing effect.

In the case where two pole pieces are used exactly opposite to each other on either side of the tape (perpendicular recording) the small area of the tape receives a continuous magnetic influence all the time it is in contact with the pole pieces. As mentioned previously, the magnetic processes are not reversible and this causes the final induced magnetism in the tape to be determined by the highest magnetising force to which it is subjected, rather than by its position relative to the pole pieces. This results in a "blurring" of the recorded signal which is worse for the higher frequencies, and is one factor limiting the frequency range of this method of recording.

In longitudinal recording the pole pieces are offset and there is then a focusing of the magnetic flux along the tape (Fig. 4). In this case the distortion just mentioned is governed more by the offset of the pole pieces than by their thickness.

We now have to examine the reproducing process, the case of a perpendicular recording being considered first. The external magnetic flux from the tape induces EMFs in the coils surrounding each pole piece, the voltages produced being proportional to the rate of change of magnetic flux through the pole piece. If we assume that during the recording the maximum flux density has been maintained at a constant value irrespective of frequency, the voltages induced in the coils should increase by 6 db. per octave until the point is reached where the width of the pole piece is of the order of the recorded wavelength. In spite of the fact that the external flux pattern is modified somewhat by the presence of the pole pieces, it has been found in practice that for the longer wavelengths a 6 db. increase per octave does actually exist. It can be shown that in longitudinal recording the (recorded) external flux increases by 6 db. per octave, consequently the voltage induced in each coil under ideal conditions should increase by 12 db. per octave.

Magnetic Recording—

Owing to the varying lengths of the recorded magnets and the offset of the pole pieces, the relative phases of the induced voltages vary with the recorded wavelength, and if two coils are being used for reproduction a phase control network is necessary to achieve the best results. Begun states that satisfactory results may be obtained when two pole pieces are used if the coil is omitted from one of them, this arrangement ensuring better penetration of the flux through the "active" pole piece. Such pole pieces would be offset when reproducing longitudinal recordings.

The theoretical increase of 12 db. octave for this type of recording only appears to be obtained in practice at very low frequencies. The two main reasons for this are the tendency for shorter signal magnets to become demagnetised and the reduced flux penetration of the pole pieces at higher frequencies. It has already been mentioned that the finite dimensions of the pole pieces introduce a form of distortion, and it can be shown that during the reproducing process this may to some extent be compensated if the tip of the pole piece is of the same order of thickness as that used when recording, or as the offset in the case of longitudinal recording.

Practical design details are obviously outside the scope of this introduction, but there are one or two points that should be mentioned in concluding. Either wire or tape may be used; wire has the great advantage of only needing a small space when coiled but special mechanical arrangements are required to ensure even coiling. Difficulties also arise

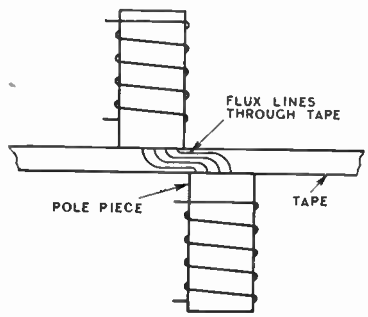

Fig. 4. Distribution of flux in longitudinal recording.

from excessive wear on the pole pieces. Tape, on the other hand, occupies more space, but does not require any special "feed" arrangement when being wound. It has the added advantage that a definite relationship is maintained between the pole pieces and the sound carrier. As with any other system of recording, it is most essential to keep the speed as constant as possible to reduce "flutter" to the minimum.

It is hoped that those sufficiently interested to pursue the subject further may find the appended selection of references useful. Some of these have already been specifically mentioned, the paper by Begun in particular having been drawn upon for much of the foregoing information,[13] while the others are of general interest.

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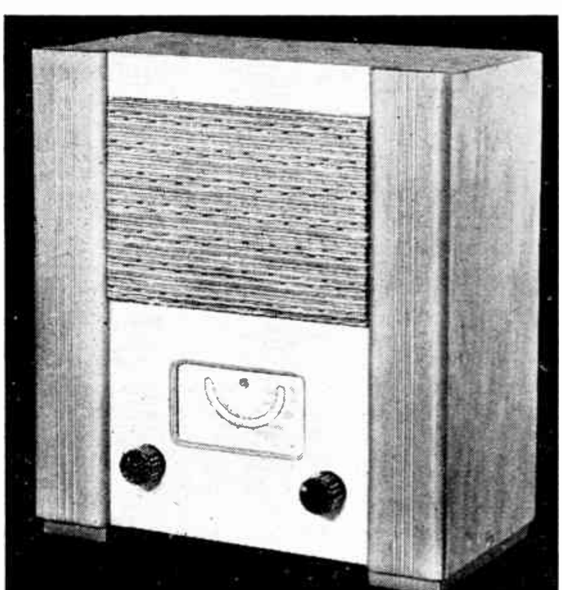


STANDARD WARTIME SETS

Details of "Civilian" Broadcast Receivers

ACCORDING to a statement from the Radio Manufacturers' Association, a quarter of a million of the long-promised "standard" broadcast sets are to be made during the next twelve months. There will be two models of the Wartime Civilian Receiver, as it is officially called; an AC set costing £12 3s. 4d. complete and a battery version at £10 19s. exclusive of batteries. Prices include purchase tax, and distribution will be through normal trade channels, but, as the sets are produced by co-operative action of the industry they will not bear the names of their individual makers.

Both sets cover the 200-560-metre waveband only, and are fitted with 6½in. permanent-magnet speakers. The AC model, for 195-250v., 50 c/s only (shown in the accompanying illustration), has a 3-valve (plus rectifier) circuit, with frequency-changer, IF amplifier, a Westector as second detector and pentode output. Delayed AVC is included. In the battery version, 2-volt valves are used throughout; the first two function as frequency-changer and IF amplifier, while the third is a double-diode-triode providing rectification, AVC and AF amplification; the output valve is a pentode.

It should perhaps be noted that, as the receivers are subject to purchase tax, the popular practice of referring to them as "Utility" is incorrect.

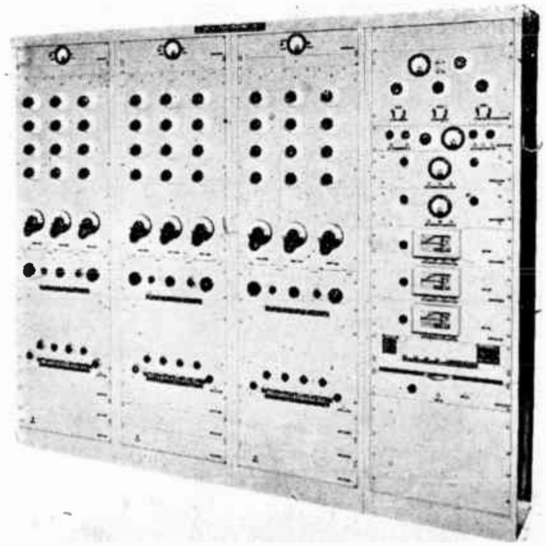
RADIO-TELEGRAPH RELAYS

Automatic Re-transmission of Signals

By J. A. SMALE,
A.F.C., B.Sc., M.I.E.E.
(Assistant Engineer-in-Chief, Cable and Wireless Ltd).

THERE are very few long-distance radio-telegraph links on which communication can be maintained throughout the day; there are usually periods of interruption which vary considerably in length, due to a variety of causes. Such interruptions may occur when the optimum frequency for the route is changing so rapidly that it is not practicable to provide additional frequencies for short periods of communication. In other cases the interruption may be due to the fact that there is no single frequency which will cover the route owing to diverse conditions of daylight and darkness. In addition to the foregoing predictable breaks, there are also interruptions caused by ionospheric storms.

Interruptions in communications often occur at times when the traffic load is light and may not be sufficiently long to warrant special measures; there are, however, instances where the interruptions occur at times of peak loads and cause serious delay to telegraph traffic.



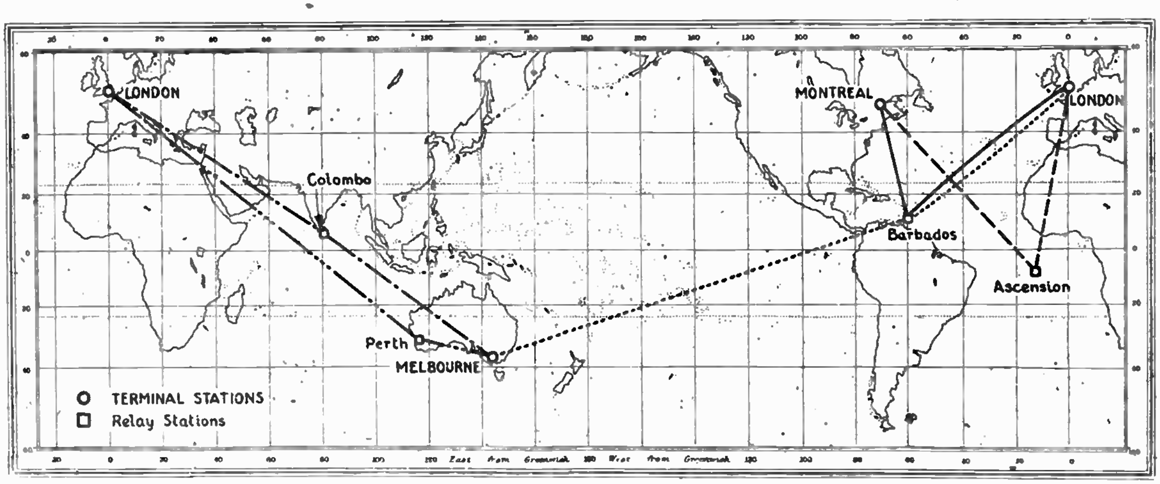
A Marconi short-wave triple diversity receiver, as used at automatic relay stations.

Such conditions will be found on circuits between the Antipodes where, for long periods daily, direct communication is impossible because of the widely different frequency requirements on various parts of the route. Long interruptions of a more random nature are often experienced on routes which pass near to the magnetic poles and are affected to a much greater extent by ionospheric storms.

While breaks in continuity of communication can be minimised by the provision of additional frequencies there are some cases where the only palliative is the use of relaying stations which either divide the route into sections on each of which the optimum frequency is used, or, alternatively, provide quite different routes which avoid the disturbed regions.

In the world-wide network of communications operated by Cable & Wireless, Ltd., the temporary interruption of a radio link is normally covered by a cable link; equally it is a normal procedure to cover a cable interruption by a direct wireless link.

However, there are now cases when such cable interruptions are of long enough duration to overlap the interruption of direct wire-



World map, reproduced from the July issue of *Wireless World*, showing radio-telegraph relay circuits discussed in the test.

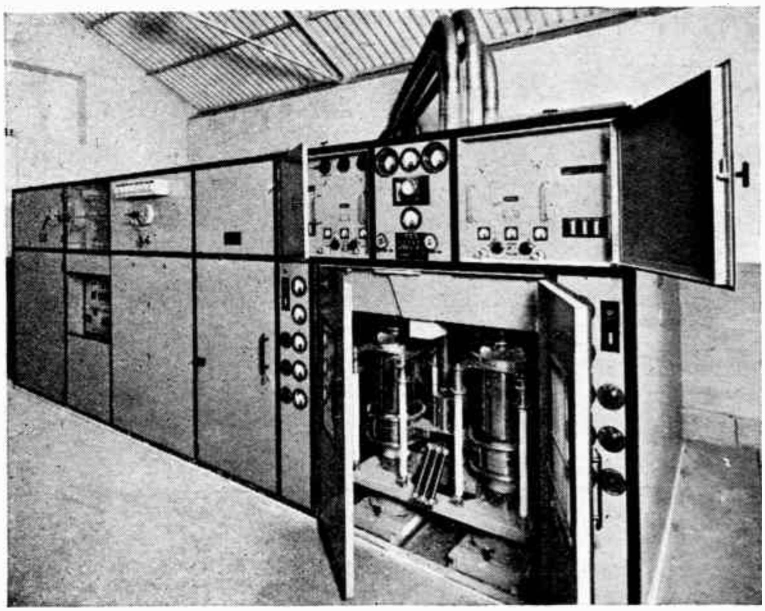
Radio-Telegraph Relays—
less links, and when the load of traffic is too great to be handled over other and more circuitous cable routes.

In these cases it has been necessary to provide alternative high-speed wireless routes *via* relay points. The idea is not new and has developed naturally from the radio control of apparatus. For instance, in 1925, when an interruption occurred due to political disturbances, the Marconi long-wave transmitter at Clifden, in Galway, Ireland, was controlled by a long-wave transmitter at Ongar, 20 miles from London.

Since 1930 the Marconi short-wave beam circuit between London and Montreal and between Montreal and Melbourne, have been inter-connected on occasions to provide a relay circuit between London and Melbourne when the direct London-Melbourne beam has been interrupted. But, unfortunately, the London-Montreal route is itself one of the least reliable, due to its proximity to North Magnetic regions. Accordingly, in 1939 a relay station was set up at the cable station on Ascension Island, in the South Atlantic, and the London-Montreal circuit provided by two substantially North-South routes instead of by one across the North Atlantic. These routes are shown on the accompanying map.

The success of this scheme was so marked that further possible relay sites were examined. An installation at Singapore was interrupted by war events, but plans were immediately laid to provide relay stations at Barbados, West Indies and Colombo, Ceylon.

The war in the Far East and the loss of cable routes in that area made it important to improve the radio links between England and Australia.



Modern short-wave transmitter designed for unattended automatic operation on four spot frequencies. This Marconi gear has an aerial output of 20 kW; the two output pentodes can be seen through the open doors.

The first step was to transfer the Australian terminal during certain hours from Melbourne to Perth and connect the latter by landlines to Melbourne and Sydney; later the landlines were replaced by radio and Perth became a radio relay station.

As was stated in the July *Wireless World*, the following relays are now available:—(a) London-Melbourne, relayed at either Perth, Montreal, Barbados or Colombo. (b) London-Montreal, relayed at Ascension or Barbados.

The programme of working these circuits is approximately as follows, the times being GMT throughout: On the London-Melbourne circuit, during the Northern Hemisphere winter, direct working is possible from 0700 to 1200 on 11.5 Mc/s. on the long Great Circle route; i.e., the route *via* the West Indies. At 1200 the route is changed to the short one *via* Russia and the Dutch East Indies, still on 11.5 Mc/s.

At about 1900 the frequency becomes too low for the Melbourne end, which is coming into Summer daylight and too high for the Winter darkness approaching at the London end; both direct routes are therefore interrupted until 0700.

A London-Perth circuit is available on 9 Mc/s until 0100, when it gets too light at Perth, and the Perth-Melbourne circuit is worked on 11 Mc/s.

Barbados Relay

At 0100 the route between Barbados and Melbourne opens on 15 Mc/s, changing later at 11.5 Mc/s and the London-Barbados circuit, already working on 8 Mc/s completes the relay, changing later in the night to 5 Mc/s.

During summer (Northern Hemisphere) conditions are reversed; from 1600 to 2400 the direct circuit is worked *via* the short route, and from 2400 to 0800 on the long route, both on 11.5 Mc/s. From 0800 to 1600 the London end is too light on either routes, while the Melbourne end will not permit a higher frequency.

The Barbados-Melbourne link is workable from 0800 on 8 to 11 Mc/s, but the frequency requirement on the London-Barbados circuit is changing too rapidly to permit a satisfactory circuit until about 1000, when the relay becomes possible. A circuit is available London-Perth on 18 to 14 Mc/s and the Perth-Melbourne circuit on 11 to 8 Mc/s completes the relay.

The programme *via* Colombo is somewhat similar to that *via* Perth.

The difficulty on the London-Montreal route is not one of conflicting frequency requirements along its course, but is due to severe geomagnetic disturbances in the northern latitudes at the Canadian end.

These disturbances are more

frequent during the period of maximum sunspot activity and lead to the use of lower frequencies; but in winter during the present part of the sunspot cycle the optimum frequency is already low so that there is no margin for decrease of frequency.

Consequently most winter nights and, if there is sunspot activity, many winter days, present impossible conditions.

By working south from Montreal much improvement results. The London-Ascension circuit is workable on 18 Mc/s in daylight and 9 Mc/s at night except for the period 0600 to 0900. The Ascension-Montreal circuit is workable on 13 to 14 Mc/s during the day and 8 to 9 Mc/s at night for a similar period.

The 0600 to 0900 period can be covered on the London-Barbados-Montreal relay using 5 Mc/s.

The effectiveness of relay working on the London-Montreal circuit can be judged from the fact that, for January and February, 1944, the hours of no communication were reduced from 57 per cent. to 26 per cent. by means of the Ascension relay, and when the Barbados relay started in March a further 6 per cent. reduction was obtained.

Relay "Mechanism"

At relay stations the plant provided is similar to that installed at the terminal stations; relaying is accomplished by feeding the output of the receiving equipment into the transmitter which is working into the second leg of the complete radio link. In other words, the received signal, which would normally be passed over a landline channel to the radio-telegraph office to operate a telegraph printer or a high-speed morse recorder, is used instead to actuate a telegraph relay which controls the radio transmitter. The general arrangement is shown in Fig. 1.

The equipment is of conventional pattern, the transmitter having an aerial power of 10 to 30 kW and being connected to a directional aerial. The receivers are of the diversity type with two or three spaced directional aerials.

In diversity reception advantage is taken of the fact that fading will not usually be simultaneous on aerials spaced about 10 wavelengths apart; by combining the signals from two or three aerials so spaced it is possible considerably to improve the ratio between signal and noise as compared with a single aerial. The signals from the spaced aerials are fed *via* coaxial cables into separate radio receivers, the output circuits of which are brought together in a combiner and fed to a recording unit which operates a telegraph relay. The combiner is arranged as an automatic switching device to select the stronger signal and reject noise and signals of lower amplitude.

"Commercial"-type receivers are employed; these are rather elaborate and are usually assembled in groups of two or three for diversity reception. Each receiver has an individual radio-frequency amplifier for each range to be covered, the total frequency range being 3 to 24 megacycles in three stages. The provision of individual amplifiers obviates coil switching and permits a better layout than would be possible with several ranges incorporated in a single amplifier. The intermediate-frequency amplifier has a midband frequency of 450 kc/s, crystal filters being used for the narrower bands required for telegraphy; additional wider bandwidth filters are provided for telephony. The normal telegraph filter bandwidth is 1000 or 2000 cycles; bandwidths less than about 1000 cycles would cause distortion of the signals by attenuation of the signalling sidebands. Among the auxiliary functions provided on the receiver group is automatic tuning control to compensate for any variations of frequency in the transmitter or receiver oscillator.

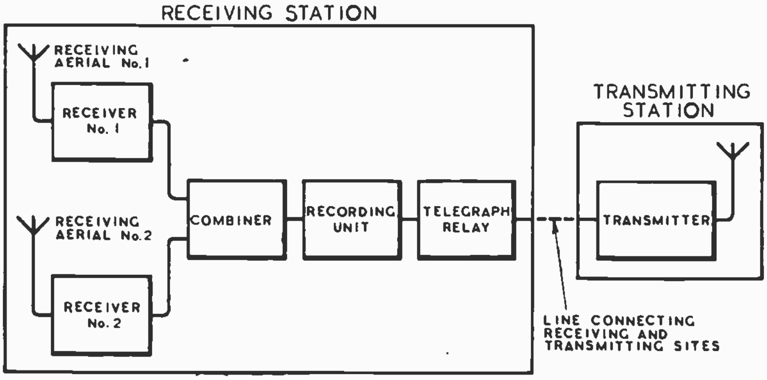


Fig. 1. Block diagram showing typical arrangement of an automatic relay station.

The intermediate-frequency signal is fed into the combiner unit, where the strongest signal is selected and passed to the recording unit. One function of these units is to correct the distortion introduced during propagation of the radio signal. The transmission of radio signals usually takes place *via* a number of different paths and considerable distortion of the received signal is brought about by the differing arrival times of the various signals. For example, the signal may be transmitted simultaneously by single, double and treble reflections from the F layer, each reflected signal arriving at the receiving aerials at different angles, having traversed paths of different lengths. Differences in arrival time between successive rays may exceed one millisecond, and in the event of three rays being received the telegraph signal may be elongated by two milliseconds or more. A morse dot at a medium speed of 125 w.p.m. has a duration of 10 milliseconds, and the distortion may therefore amount to a 20 per cent. increase in its length. The effect is known as multiple or multigraph reception.

Corrector Circuits

The combiner unit incorporates a diode signal rectifier and a diode control rectifier, the control diode providing a steady bias to the signal rectifier which is in opposition to the signal. The result is that the recording unit receives a signal which is a fixed percentage of the original signal peak voltage, and as successive reflections of the signal also suffer more attenuation it is possible to arrange for most of the multiple

Radio-Telegraph Relays—

signals to fall below this percentage and, in effect, receive one reflection only. This will apply during stable propagation conditions, but for long periods daily conditions exist where the amplitude relation of the various rays is extremely variable and only partial correction is achieved. However, the control diode does effect the rejection of the lower order amplitude signals and, of course, assists in reducing the effects of noise.

The recording unit is a special form of DC amplifier where circuits are provided which limit the amplitude of the signal irrespective of the degree of fading and also correct the signal by removing any time increment introduced by the multiple reception which may not have been corrected by the combiner unit. Limiting is carried out by a triode valve the feed of which is reduced to zero by the signal, any further increase of signal having no effect. A variable time constant circuit permits of the adjustment of the signal time to compensate for the multiple distortion. The basic circuit of the combiner and recording unit is illustrated in Fig. 2.

When the percentage distortion is constant the requisite amount of correction is applied, but unfortunately it is sometimes extremely variable, and despite the provision of the special correcting circuits there will often be an irreducible variable distortion on the telegraph signals which is applied to the radio transmitter at a relay station.

Multiple Relays

Distortion on relay links is additive; it is not possible to relay the signals indefinitely and usually a single relay is all that can be attempted. Similarly with fading and interference, the effects on each link are additive, and poor working over one link of a relay system can only be tolerated if the remaining link is working well. It does happen that either link can be operated with occasional repetition for errors, but if the two links are joined the aggregate deterioration is sufficient to prevent the complete circuit being worked. Under such conditions the solution is to operate each link separately and relay traffic by ordinary retransmission.

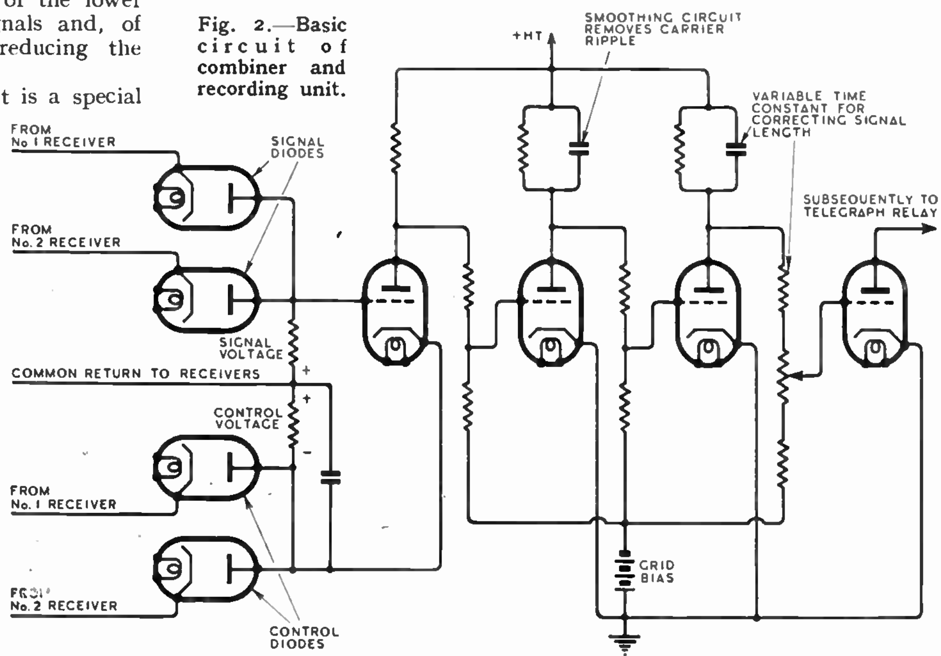


Fig. 2.—Basic circuit of combiner and recording unit.

This method has other advantages; for example, it may happen that although onward transmission may not be immediately possible, it will be possible before the direct circuit recovers, and consequently traffic can be stored at the relay station for a short time. This system is particularly useful if the relay station is able to receive by automatic means instead of by morse recorder or undulator. Not only can these automatic systems produce a printed slip of the messages, but they also produce a perforated tape ready for use in a forwarding transmitter. The London-Barbados circuit is worked on this principle, the one radio channel providing two telegraph channels with either printers or perforators on each.

At Barbados the perforated slip is used to forward the messages by cable to various points in the West Indies and Jamaica, to South America also by cable and by wireless to Montreal; one of the two channels is, when necessary, devoted entirely to traffic going to Montreal; if not immediately, then when the Barbados-Montreal circuit is re-established.

The possibilities of radio relaying are many; unfortunately there occur too frequently such devastating ionospheric disturbances that cannot be overcome even by relaying. It is then that the same technique developed to provide automatic relaying between cable and radio becomes a powerful tool in the preservation of long-distance communications.

100 YEARS OF MORSE

IN the *Wireless World* booklet "Learning Morse" we say: "It is a tribute to the genius of Samuel Morse that . . . the code he devised in 1832 has survived for over 100 years. True, the original 'American morse' has undergone modifications, but the basic conception remains."

Although the Morse system of telegraphy was conceived in 1832, it was not until 1844 that, thanks to a grant from Congress in 1843, the inventor was able to demonstrate it over a line between Washington and Baltimore. The centenary of this event has now been celebrated in America by the dedication by Congress of a plaque to Morse's memory in the building that constituted one terminal of the line. Commenting on the event, *QST* says: "His was the first successful telegraph, the first successful code, and from his work have flowed many of the marvels of to-day's communications structure."

Reducing MACHINE-MADE INTERFERENCE

Three-phase Motors for Domestic Use?

In recent issues of this journal contributors have discussed the possibility of reducing interference with radio reception by the substitution, in domestic appliances, of the conventional universal commutator motors by those of the induction type. But, although it is agreed that for some applications single - phase induction motors might be more widely used, it was pointed out in our July issue that they have many limitations.

Eliminating "Universal Motors"

In *The Electrician* for June 2nd, "Supervisor" discusses the question of interference from domestic appliances, and makes some interesting suggestions as to the post-war use of three-phase motors which are free of many of the objections of both the commutator and single-phase induction types. He says: "One of the root causes of severe radio interference is the employment of the single-phase series-wound motor for domestic appliances of the vacuum cleaner class. This type of machine will always cause serious interference to radio reception except possibly under expert local attention and at considerable expense for the necessary equipment. An opportunity seems to have arisen at this time, when the whole matter of domestic installations is under review, to consider the elimination of this type of motor, and its replacement with a simple three-phase motor for post-war equipment; consideration might be taken as far as making the domestic ring main a three-phase circuit. Apart from the important matter of freedom from interference with radio and television reception, and the later short-wave services visualised . . . this step would result in cheaper appliances and greatly reduced maintenance costs.

"What is the objection to the introduction of three-phase supplies into domestic premises? It is held that the presence of 400V constitutes an added danger for the consumer, but is this really the case? There is small chance of a shock between phases for the average consumer, and the possibility of shock to earth remains exactly the same as with 230V single-phase supplies. In fact, it might be claimed that the latter risk is reduced, in that more robust apparatus is employed, in the shape of a three-phase motor instead of a single-phase motor with flimsy brushgear and wound armature; insulation failure of our present type of domestic motor may be said to be fairly frequent.

"If the presence of 400V is the stumbling block, this could be reduced to some lower pressure without difficulty. For instance, there are devices on the market for the operation of three-phase motors from single-phase supplies, and a domestic form could no doubt be developed. Alternatively, a double-wound transformer might be installed, reducing the pressure to the three-phase ring main to 230V between phases; portable lamps would be wired to tap two phases only. The presence of the double-wound transformer would eliminate the possibility of earth shock, and sockets would remain three-pin as at present. The cost of the transformer might constitute an objection, but this would cost little more than semi-efficient interference suppression; the transformer need not be of large size, as a 3kW radiator would provide a load of 1kW on each phase.

Greater Reliability

"The objection to 400V can hardly be sustained, however, and it has to be remembered that most supplies to domestic premises in Germany have been 220/380, with three-phase circuits to the very smallest motors, including turntable motors for radio-gramophones. The utmost reliability is obtained, and radio interference almost unknown; certainly it does not exist in the acute form suffered in this country. The problem is not amenable to piecemeal attention—it is little use one consumer correcting his own equipment if he is still subjected to interference from his neighbour—and in the best interests of electrical equipment, both for first cost and for reliability, three-phase domestic circuits should now receive serious consideration."

After discussing the advantages of a three-phase supply for quick heating of hotplates in domestic cookers, which can be connected through a switch across two phases for the warming-up period, "Supervisor" goes on to stress the advantages of three-phase motors in refrigerators. He concludes by saying that the installation and use of three-phase domestic circuits would provide the most complete answer to the problem of interference. "Objections to this step would appear to result from prejudice rather than technical considerations."

LIP MICROPHONE

The illustration on the front cover of this issue shows the miniature microphone, developed in collaboration with the U.S. Army Signal Laboratories, being worn by a member of the American Forces. Whilst permitting the clear transmission of speech the "lip mike," as it is called, shuts out all ambient noises and reverberations. It is said to have a frequency response substantially flat from 200 to 4,000 c/s and is unaffected by temperature variations from -40° to 185° F.

The bakelite case measures only 1.25in. square by 0.4in. thick and can, therefore, be used when an operator is wearing an oxygen mask or respirator. A synthetic rubber membrane 0.0004in. thick over the apertures protects the diaphragm and buttons from moisture. Manufactured by the Electro-Voice Manufacturing Company of Indiana, the microphone, complete with harness, cord and plug, weighs less than 2 oz. Miniature hearing-aid type headphones complete the equipment.

REAL INTERNATIONAL BROADCASTING

Proposals for a European Alliance

ALL wireless men expect—and with some justification—that the medium of communication with which they are associated will play a worthy part in consolidating peace and healing the scars of war. The potentialities of broadcasting in that direction are particularly obvious, but it will be agreed that few serious and large-scale attempts have ever been made to use it for the cultivation of international goodwill and understanding. At any rate, there have been few detailed proposals for the creation of a purely international organisation to carry out broadcast transmissions, and a plan for such a scheme that has recently been worked out will be studied with interest.

"The European Broadcasting Alliance," as it is called, aims, in the words of its sponsors, at making radio play its part in composing the claims of the rival European groups when the war is over. It is urged that many problems would be resolved if every European could be made conscious of his status as a European—a member of a nation within a group of nations. The plan has been introduced by A. V. L. Hubert, P. P. Eckersley and B. Tenenbaum. Monsieur Hubert, a Belgian at present in this country, has a more than usually international background. In addition to his association with the S.A.I.T. (the Belgian wireless operating company) he is President of the International Radio Maritime Committee and an honorary member of the Union Internationale de Radio-diffusion. P. P. Eckersley, former Chief Engineer of the B.B.C. and "father" of the Regional scheme, needs no introduction. The third joint author, a Polish radio engineer, completes a truly international team.

It is proposed to confine this description mainly to the more technical aspects of the Plan. In brief, the aim is to establish and operate an international European broadcasting network parallel to, but quite separate from, the various national systems, though the authors urge that the international service should have precedence. Preliminary organisation of the scheme would be effected by an Inter-allied Commission; after the war, the European neutral countries would be invited to join the Alliance; later, the defeated countries could take part.

Long-wave Transmitters

From the technical point of view the Plan hinges on the use of the existing long-wave broadcasting band (155-265 kc/s) for the European network, with synchronised transmitters as an essential part. The aim is to provide good reception, with a simple receiver, of at least one station at any point in Europe. A list of proposed stations, with their frequencies, is given on p. 246.

There are available in the long-wave band a total of 12 channels, allowing for 10 kc/s separation; these channels would be distributed equally between three groups of stations. Each of these groups would be controlled from an International Radio-diffusion Centre. It is suggested that these centres should be in Brussels, Berne and Vienna. Land-lines from each Centre to the associated group of stations would carry frequency controlling impulses as well as modulation for the transmitters, though it is not envisaged that all programmes should originate at the Centres. As will be seen from the map facing this page, there is provision for land-line interconnections between the three centres, and so it would be possible to transmit a single programme to the whole of Europe. Alternatively, as the authors stress the flexibility of the Plan, it would apparently be possible for any station to take a programme from a group other than that to which it belongs.

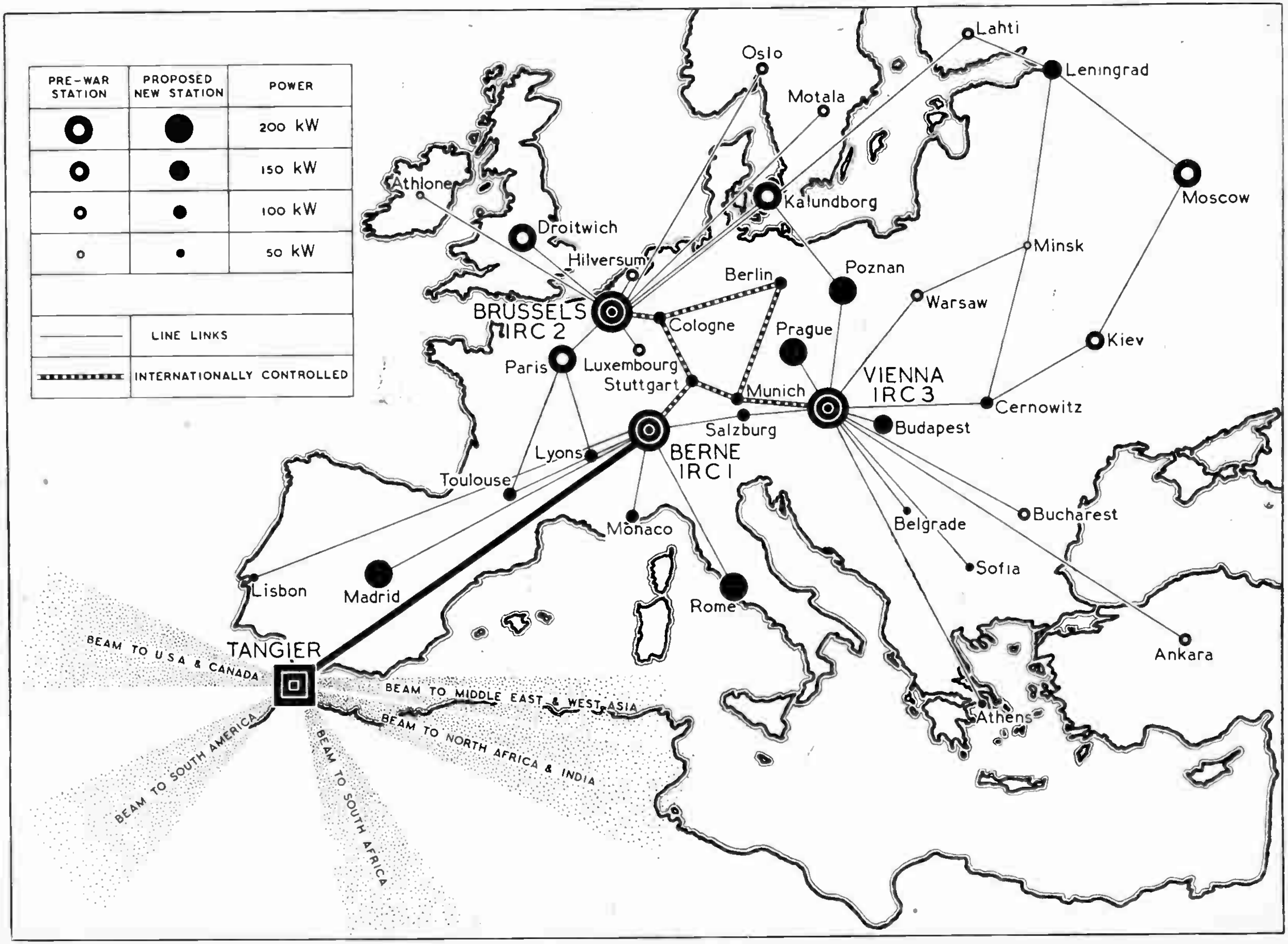
What is known as indirect synchronisation is proposed for the groups of stations working on a common frequency. The method is based on automatic correction of divergencies of frequency by the action of a standard pilot oscillator common to all the transmitters, to which it would be connected by line. In addition, provision is made in the design of the system for equalising the modulation phases as applied to the various stations of a network. This is to compensate for the fact that the line connecting the various stations to the sources of the programme may be of widely differing lengths. An artificial audio-frequency delay would thus be introduced into the shorter lines.

In spite of these precautions, there remains the possibility of interference between the radiation of two synchronised stations; there will be a "mush area" between two transmitters where reception is bad. Various methods of overcoming this disability are discussed, and it is stated that it would be possible to provide zones subject to serious interference with a supplementary transmission on a frequency different from that of the synchronised stations.

World Extensions

A supplementary short-wave transmitting centre at Tangier is proposed; the site has been chosen not only from considerations of geography and wave propagation but because Tangier is already an international zone. Selected programmes of the European networks would be retransmitted through these beam stations and distributed throughout the whole world.

With regard to the financing of the Plan, the capital cost would be met by the countries concerned, while the conduct of the broadcasting service would presumably be paid for by contributions from each country, derived from listeners' licence fees. With so many encouraging examples before us of the operation of new-style financial measures, such as Lend-lease, the authors see no insuperable financial difficulties in the way of the Plan. They admit, however, that the language difficulty does, at first sight, appear to be a serious obstacle. However, it is thought that the spread of Basic English, or possibly of another auxiliary world language, will do much to overcome this disability.


PRE-WAR STATION
PROPOSED NEW STATION
POWER
200 kW
150 kW
100 kW
50 kW
LINE LINKS
INTERNATIONALLY CONTROLLED
Lahti
Oslo
Leningrad
Motala
Athlone
Kalundborg
Moscow
Droitwich
Minsk
Hilversum
Berlin
Poznan
BRUSSELS
IRC 2
Cologne
Warsaw
Prague
Kiev
Paris
Luxembourg
Stuttgart
Munich
VIENNA
IRC 3
Cernowitz
Salzburg
Budapest
Lyons
BERNE
IRC I
Toulouse
Bucharest
Belgrade
Monaco
Sofia
Lisbon
Madrid
Rome
Ankara
TANGIER
BEAM TO U.S.A. & CANADA
BEAM TO MIDDLE EAST & WEST ASIA
BEAM TO NORTH AFRICA & INDIA
Athens
BEAM TO SOUTH AMERICA
BEAM TO SOUTH AFRICA

AESTHETICS OF SOL

Designing a Radiogramop

By H. A. HARTLEY

THE circuit of the complete instrument is shown in Fig. 3. The switch S1 provides the change-over from radio to gramophone. The radio receiver is a simple TRF and detector circuit with manually controlled RF gain. As there is no volume control on the main amplifier, R15 is the only controller of volume on radio. This calls for a detector which is free from distortion on widely different RF inputs, and the conditions are fulfilled by the so-called infinite impedance or negative feed-back detector. This type of detector has the additional advantage of imposing little damping on the tuned circuit preceding it, and adequate selectivity can be obtained from only two tuned circuits, one of which, the grid circuit of V1, is heavily damped by the aerial. C10 and C14 are, of course, ganged. T2 and T3 are identical and are the usual RF transformers. No wave-band switching is provided, and if there are long-wave windings on the transformers and they are not going to be used, they should be short-circuited. Nowadays, it is rather a waste of time to try to perfect the radio receiver, as so many of the B.B.C. programmes consist of home-made recordings of execrable quality compared with direct studio transmissions. However, the simple arrangement shown gave excellent results in pre-war days. It will, no doubt, be appreciated that the rejector circuit L1L9 can be used to suppress heterodyne whistles.

Tone Control : Bass Compensation.—The gramophone tone-control amplifier, which includes V1 and V2 is quite interesting. I have tried almost every arrangement of tone controlling that has been published, and find it impossible to recommend any circuit which includes inductances. There is no cheap way out of the problem, and tuned resonant circuits in tone-control stages, used as boosters, introduce the very defects we are trying to eliminate. We must compensate for the reduced amplitude of bass frequencies on standard records, and the only satisfactory way of doing this is to waste the middle and top somewhere and push up the overall amplification. The network R5R6C4R7 reduces the middle and upper frequencies gradually and to such an extent that the increased amplification provided by V1 (or V2) gives, in effect, the requisite bass increase, 6 db. per octave, with the values quoted. A very good exposition on tone control is given in F. Langford Smith's "Radio Designer's Handbook."

Pick-ups.—The pick-up is one of the most critical components in the whole outfit. The usual heavy types with a needle pressure of about 120 gm. are quite unsuitable for serious work, and the type of pick-up which gives a large output in the bass by virtue of tone arm resonance (and therefore has excessive needle point reactance) will make a steel needle plough its way through the groove of a deeply modulated record, or knock the point off a fibre needle. By hook or by crook the reader should try to get one of the lightweight sort, using miniature needles or a jewelled stylus I use the H.M.V. "Hyper-sensitive" needle armature type. This pick-up has a very low impedance, and requires a high-ratio step-up transformer, T1. Actually, the present arrangement has more gain than is absolutely necessary, and it is possible that the output of V1 might be adequate with the pick-up connected directly across R1. Every precaution must be taken to avoid introducing hum into the grid circuit of V9, and T1 should be enclosed in a mu-metal box ; if this is not obtainable and an ordinary steel box has to be used, the transformer should be carefully orientated into the position of minimum hum pick-up. The motor winding and the mains

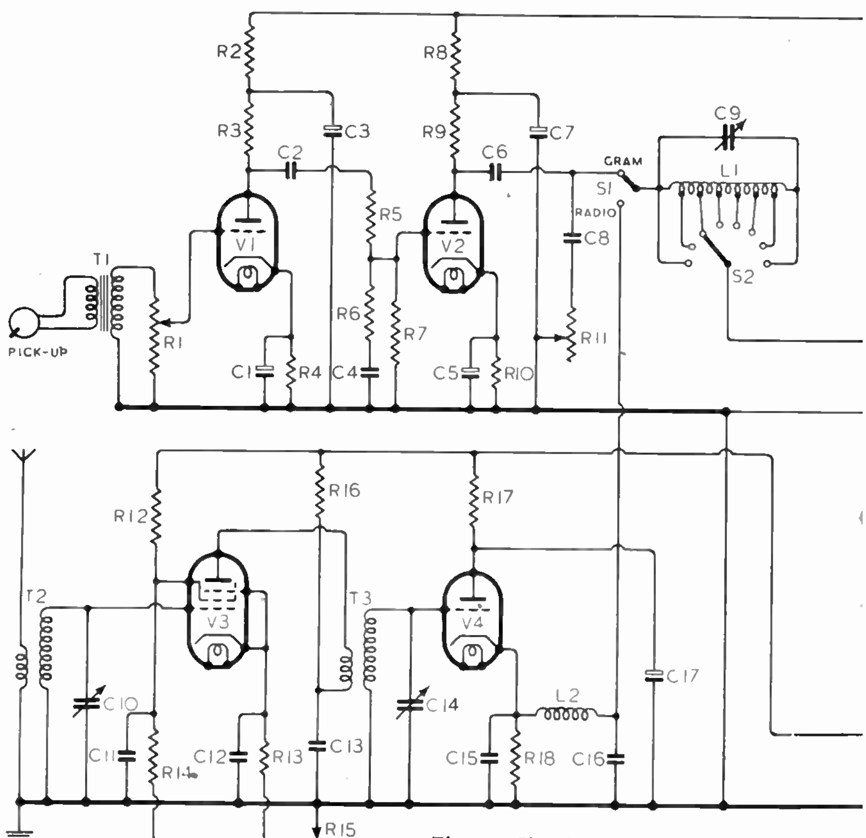


Fig. 3. Circuit diagram of complete radio g

ND REPRODUCTION

hone for Musical Synthesis

(*Continued from page 202 of the previous issue*).

transformer are the usual sources of induced hum. For some obscure reason many gramophone motors fitted on unit plates with automatic brakes are so arranged that the motor field (and commutator) is just below the pick-up when it is resting on the record. A low impedance pick-up under these conditions will give very bad hum. The cure is to turn the motor through 180 degrees in a horizontal plane. The automatic brake should be set so that it trips only on the run-off. Sideways pressure on the needle while playing is fatal to good results

The H.M.V. pick-up can develop a defect peculiar to itself. The small needle is not held by a screw, but rests in two V grooves opposed to each other, at the top and bottom of the armature proper. If the needle is too slack when in position it will rattle on loud passages, causing a distressing buzz in the music. The armature should grip the needle so tightly that it can only be changed by using a small pair of pliers. If the needle is slack, the top of the armature should be squeezed gently until the end of the needle fits tightly.

There can be no doubt that a diamond or sapphire stylus is the best needle. A chromium-plated needle becomes almost useless, from a musical quality point of view, after about ten 12-inch sides, in spite of the claims in the advertisements; the wear is clearly discernible even with a low-power magnifying glass. Fibre needles are a snare and a delusion. Not only is it impossible to get any "top" with fibres, but they ruin good records through excessive wear *of the records*. It is impossible to get all the dust out of the grooves, and what is left gets embedded in the needle, converting it into a first-class abrading instrument. Ideally, the friction between the needle and the record should be non-existent, and the nearest approach to this is reached by a well polished jewel. A jewelled stylus in an undamped pick-up causes negligible record wear.

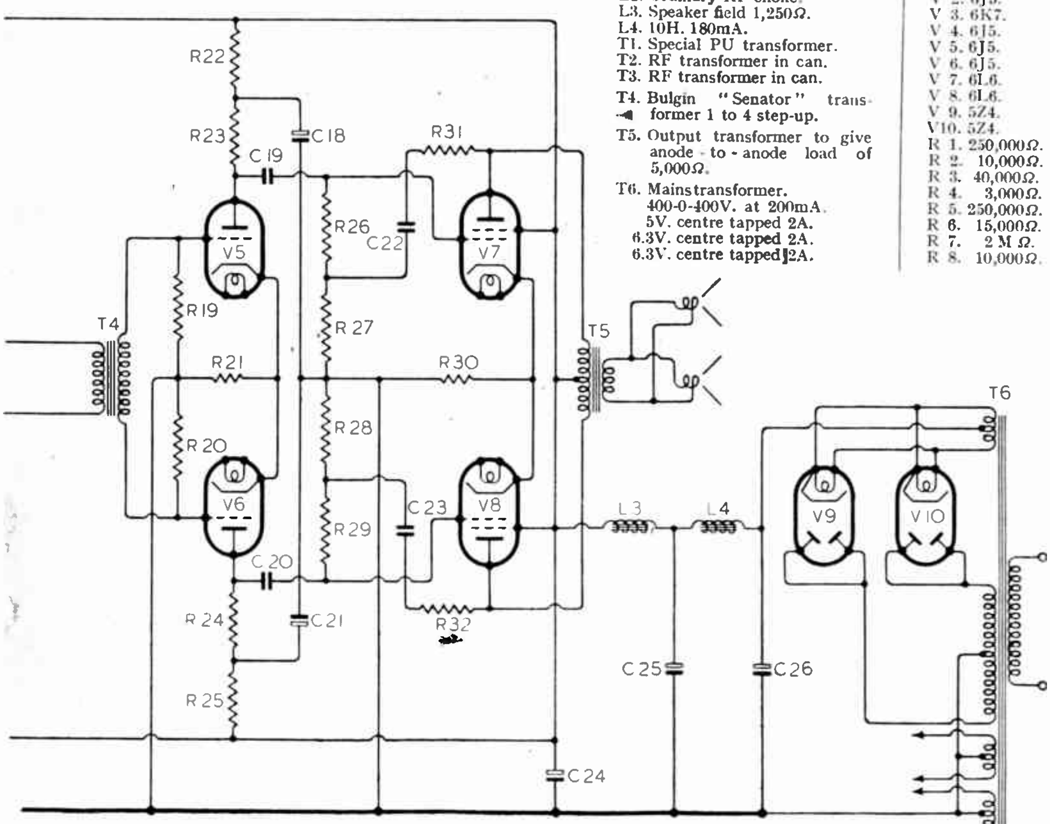
The Main Amplifier.—The main amplifier is fairly conventional. Phase splitting is done by a small mu-metal cored transformer, the secondary being loaded with the two equal resistors, R19 and R20, which also provide the centre-tap. The transformer could drive the output stage and save V5 or V6, but I have a pet theory that small transformers of this type

COMPONENT VALUES FOR FIG. 3.

L1. 3H. air-cored.
L2. Ordinary RF choke.
L3. Speaker field 1,250Ω.
L4. 10H. 180mA.
T1. Special PU transformer.
T2. RF transformer in can.
T3. RF transformer in can.
T4. Bulgin "Senator" transformer 1 to 4 step-up.
T5. Output transformer to give anode-to-anode load of 5,000Ω.
T6. Mainstransformer.
400-0-400V. at 200mA.
5V. centre tapped 2A.
6.3V. centre tapped 2A.
6.3V. centre tapped 2A.

V 1. 6J5.
V 2. 6J5.
V 3. 6K7.
V 4. 6J5.
V 5. 6J5.
V 6. 6J5.
V 7. 6L6.
V 8. 6L6.
V 9. 5Z4.
V10. 5Z4.
R 1. 250,000Ω.
R 2. 10,000Ω.
R 3. 40,000Ω.
R 4. 3,000Ω.
R 5. 250,000Ω.
R 6. 15,000Ω.
R 7. 2 M Ω.
R 8. 10,000Ω,

R 9. 40,000Ω.
R10. 3,000Ω.
R11. 100,000Ω.
R12. 25,000Ω.
R13. 300Ω.
R14. 60,000Ω.
R15. 10,000Ω.
R16. 10,000Ω.
R17. 5,000Ω.
R18. 50,000Ω.
R19. 500,000Ω.
R20. 500,000Ω.
R21. 1,500Ω.
R22. 10,000Ω.
R23. 40,000Ω.
R24. 40,000Ω.
R25. 10,000Ω.
R26. 100,000Ω.
R27. 10,000Ω.
R28. 10,000Ω.
R29. 100,000Ω.
R30. 125Ω.
R31. 90,000Ω.
R32. 90,000Ω.
C 1. 50μF. 12V.
C 2. 0.25 μF.
C 3. 8 μF. 350V.
C 4. 0.05 μF.
C 5. 50 μF. 12V.
C 6. 0.5 μF.
C 7. 8 μF. 350V.
C 8. 0.02 μF.
C 9. 0.0005μF.
C10. 0.0005 μF.
C11. 0.1 μF.
C12. 0.1 μF.
C13. 0.1 μF.
C14. 0.0005 μF.
C15. 0.0003 μF.
C16. 0.0003 μF.
C17 8 μF. 350V.
C18. 8 μF. 350V.
C19. 0.25 μF.
C20. 0.25 μF.
C21. 8 μF. 350V.
C22. 0.25 μF.
C23. 0.25 μF.
C24. 8 μF. 350V.
C25 and C26 are each 2-32 μF 350V. wet electrolytics in series, giving 16 μF. at 700V.



nophone. Component values are given in the table.

Aesthetics of Sound Reproduction— should not be called on to handle large AF voltages. A phase-splitting valve could be used but seems unnecessary.

The output stage consists of two 6L6 tetrodes in Class A. With 250 volts on anodes and screens they will give 14 watts AF output with an anode-to-anode load of 5000 ohms. With a reasonably sensitive speaker this is as much as can be borne in a medium-sized room. Negative feed-back is applied across the output stage. The push-pull arrangement looks after second harmonic distortion, and negative feed-back takes care of the third harmonic. Feed-back also improves the electrical damping on the speaker and makes the valves behave more like triodes. The feed-back condensers, C22 and C23, are normally 0.25 μF; if reduced to about 0.05 μF a rise of about 6 db. will occur at the lower end of the response curve, as shown in Fig. 4, curve A. This rise is useful in helping to correct the "finiteness" of the speaker baffle without losing the benefits of feed-back in the treble, where it is most needed.

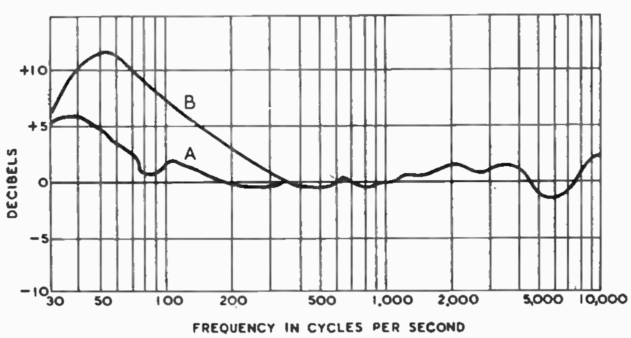


Fig. 4. Response curves of pick-up and amplifier: Curve A, amplifier with restricted negative feedback in the bass; Curve B, amplifier with tone-correcting stage.

Fig. 4, curve B, shows the overall response of pick-up, tone-correcting amplifier and main amplifier, the circuit being given in Fig. 3. It should be realised that the speaker may be damaged with large inputs, unless the diaphragm-voice coil assembly is freely mounted with a permissible excursion of about ⅜in.

These curves were taken by measuring volts on the output transformer secondary, the speaker being connected, when the pick-up was laid on a set of constant frequency records. The usual corrections were made from the information given on the record labels and the curves plotted. A check was then made on a gliding tone record, and the output was found to be substantially constant at all frequencies. The rejector circuit was out of action when the curves were taken.

The response of the complete equipment from pick-up needle to actual sound output is shown in Fig. 5. The decibel scale has been exaggerated to make the curve look as bad as possible, yet it is not a bad curve. With one small exception of a narrow dip at 450 cycles, it falls within the generally recognised limits of $\pm$5 db. for minimum perceptible change of output level. The valley from 70 to 90 cycles, if it really exists, is probably due to some peculiarity of layout inside the cabinet.

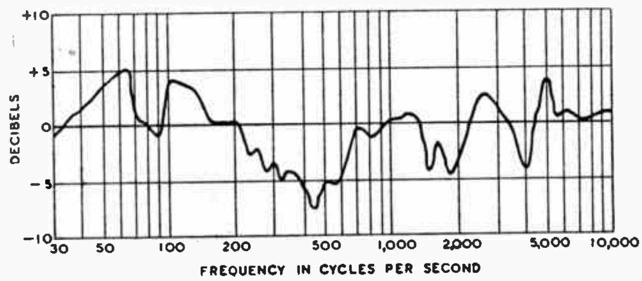


Fig. 5. Response curve of pick-up, amplifier and speaker.

The Loudspeaker.—The speaker is a new unit of my own design not yet placed on the market. The energised field is represented in Fig. 3 by L3 and has a resistance of 1,250 ohms, dissipating 40 watts. The field-magnet gap is quite small, and this gives a very intense field in the gap, absolutely essential for good transient reproduction. The speaker is mounted on a very small baffle-board which is then tilted, completely insulated by sponge rubber and held by a framework against the front of the cabinet. This entirely eliminates acoustic feedback through the turntable.

The cabinet is constructed of walnut-faced 1in. thick block board lined with half-inch wall-board. The various parts of the equipment are irregularly disposed in the cabinet, and there is absolutely no trace of bass resonances due either to speaker, cabinet or air-column. The dip at 70 cycles, already referred to, is not perceptible.

The two speakers shown in Fig. 3 are of identical design. The second was added when it was found that the music was unbalanced in certain parts of the room. The cabinet speaker is near the floor, and the best place for the other was found to be near the ceiling, tilted downwards, and in a corner 90 degrees away from the corner where the cabinet stood. The improvement in depth and realism was very great. A battery of specialised speakers might be better, but the very greatest care has to be taken to get the right cross-over point between treble and bass speakers. If properly done, it is likely to prove too costly for domestic use. If carried out in a slipshod way, with speakers of indifferent performance, the results are usually atrocious.

The listening room has a thick carpet, thick curtains, the usual "three-piece" type of easy chairs, books lining the walls up to a height of about three feet, and the upper parts of the walls left fairly highly reflective. Some reflection is needed.

Envoi: I am afraid I cannot tell the whole story here; the subject is too vast. I have tried to make it clear that the scientist just cannot design, say, a radiogram, hand it over to the factory to produce, and then let the sales department plug the product without some regard for its æsthetic possibilities. If a manufacturer is concerned only with making money, then there is nothing more to be said. But if he is also trying to appeal to the artistic senses of his customers, he cannot get away with selling a high-fidelity instrument and leaving it to take care of itself, for the musician, as explained by Dr. Sargent, will have none of it. Nor, if it comes to that, will he take the ordinary low-fidelity instrument as anything more than a sort of noise box that emits news bulletins at specified times. Something has got to be done for the musically minded listener; and as the musician has not got the skill to produce what he wants, the scientist must add artistic sensibility to his technical accomplishments.

In a crude sort of way I have made a first contribution to this new concept of home music *via* broadcasting, records and an electrical device in the home itself. Others will do much better than I have been able to do when they realise that better will have to be done if " electronically synthesised music " is to take its place among the arts. Apart from the receiving side, a great deal will also have to be done at the studio end, but on that aspect I have no space to write.

If any of my readers can construct a radiogram such as I have described, and care to acquire the art of distorting the response curve to gain artistic ends, they will, if they love the *art* of music, find new pleasure, not in making imperfect copies of the original performance, but in creating music of their own. It is not given to all of us to be able to make music with musical instruments, but we can try and make music out of the raw material which we can tap when we like, the raw material of records and broadcasting. There is no art in sitting passively while a machine churns our music out for us. We must be up and doing for ourselves.

I conclude by offering a few suggestions for raw material-records I have bought during the last year or two, and which are well recorded and well played. They are all " cheap " records, the 4/- discs of pre-war days, for these are the only ones I can afford. Doubtless, many readers gaze wistfully at the " red labels " as I do, and look forward to the days when the Purchase Tax is buried for ever.

Selected Record List

Beethoven: The Archduke Trio. Op. 97. H.M.V. C7588 to 7592.
Beethoven: Razoumovsky Quartet. Op. 59. Col. DX8173 to 8177.
Berlioz: Roman Carnival Overture. Col. DX982.
Bizet: L'Arlesienne. Suite No. 1. Col. DX1085 to 1087.
Bizet: L'Arlesienne. Suite No. 2. H.M.V. C3021 and 3022.
Bliss: Piano Concerto. H.M.V. C7583 to 7587.
Wm. Boyce: Ballet, " The Prospect Before Us." H.M.V. C7547 to 7549.
Dvorak: The Dumky Trio. Col. DX8156 to 8159.
Liszt: Hungarian Fantasia for Piano and Orchestra. H.M.V. C3132 and 3133.
Mozart: Quartet No. 17, " The Hunt." Col. DX8160 to 8162.
Mozart: Horn Concerto No. 4. Col. DX1123 and 1124.
J. Strauss: Die Fledermaus Overture. Col. DX1065.
Szostakowicz: Piano Concerto. Col. DX1049 to 1051.
Tchaikovsky: Swan Lake Ballet. Col. DX8132 to 8135.
Walton: Belshazzar's Feast. H.M.V. C7572 to 7576.
Walton: Façade. Suite No. 1. H.M.V. C2836 and 2837.
Walton: Façade. Suite No. 2. H.M.V. C3042.

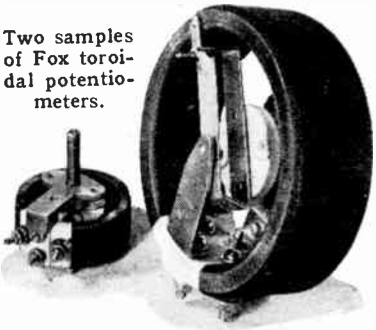
Numbers are given for automatic couplings whenever obtainable.

FOX TOROIDAL POTENTIOMETERS

THE foundation for the resistance element in these heavily built components is a continuous ring of ceramic material over which the oxidised resistance wire is wound.

A substantial cast metal bracket supports the ring and is drilled to form a long plain bearing for the ¼in. steel spindle. The contact arm is insulated from the spindle by a ceramic disc and a point contact on a separate bracket connects the spring blade to its terminal.

The potentiometers, which are available in a wide range of values with ratings of 25, 50, 100 and 200 watts, are made by P. X. Fox, Ltd., No. 2 Factory, Hawksworth Road, Horsforth, Yorks.



Two samples of Fox toroidal potentiometers.

BOOK REVIEW

Introductory Magnetism and Electricity, by T. M. Yarwood, B.Sc. (Hons.). Pp. 159. Published by McMillan & Co., Ltd., St, Martin's Street, London, W.C.2. Price 2s. 6d.

THIS little book, which the author has written for the benefit of those who are approaching the subject for the first time, gives an account of the elements of magnetism and electricity and leads up to an elementary treatment of the triode valve.

In the first chapter on Ohm's law the author makes no mention of the electron theory of matter and regards electric currents as a flow from points of high to lower potential. He next deals with parallel and series networks of resistances and cells. Magnetism and electromagnetism and their various applications come next, followed by a chapter on the heating and lighting effects of an electric current. Chapter V deals with electrolysis and accumulators, and is followed by a further chapter on electromagnetism dealing exclusively with the moving coil meter and the electric motor. The subject of measuring instruments is further developed in Chapter VII, and we find here some details of potentiometers and meggers.

Electromagnetic induction and its chief application, the dynamo, follow in Chapter VIII. An interesting section on the telegraph and telephone come next and the author goes on then to deal with condensers and capacitance. This is introduced by way of the electron theory, a knowledge of which is also essential to the proper understanding of the valve, which follows in the next chapter. One cannot help remarking that it would have been less confusing and more logical to mention electron theory in the first chapter instead of the old-fashioned view of current flow. Chapter XI deals with the use of valves as rectifiers, detectors, amplifiers and oscillators. Wave-motion, CW and radio-telephony are described in the final chapter.

The book is remarkable for the enormous amount of material packed between its covers; in particular, the amount of space devoted to applications of scientific principles is both noteworthy and praiseworthy. The diagrams throughout are good, though not numbered, and there is an obvious error in the diagram of the valve base on p. 126.

The book represents excellent value for money and can be confidently recommended to beginners in radio such as Air Training Cadets, for whose benefit it was written.

S. W. A.

UNBIASED

By

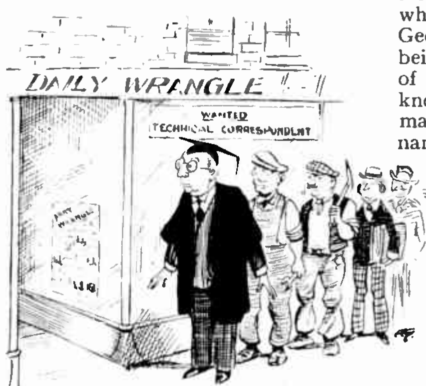
FREE GRID

The Hidden Hand Again

STRANGE things are happening in Ireland, according to the technical correspondent of a well-known daily journal; so strange indeed that it has set me wondering by what manner of means the editor chose his technical correspondent from the queue of applicants which must have stood outside his journal's offices when the job last fell vacant.

According to this luminary of the technical world, the inhabitants of the distressful country have yet another cause for grievance, although at the same time they should be proud to have earned distinction as the only country in the world where there is a shortage of electrons. It appears that the hours of broadcasting of Radio Eireann are to be curtailed owing to the "shortage of electricity."

I have given the matter very careful thought and the first conclusion I arrived at was that this filching of electrons must be Adolf's secret revenge weapon No. 2, designed for the purpose of stirring up some sort of trouble between ourselves and the inhabitants of the Emerald Isle, as it would be only natural that they should cast the eye of suspicion on their nearest neighbours when valuable property like this was missing.



Queue of Applicants

My conclusions have, however, been drastically revised, and I am now of the opinion that it is the technical correspondent (who is most probably a Nazi agent) who is trying to stir up trouble, for careful enquiry has revealed to me that there are just as many electrons in the aerial system of Radio Eireann (and indeed everywhere else) as there ever were, and what is lacking is the necessary fuel to stir them into action and set them surging to and fro. I telegraphed my conclusions to the editor of the journal in question as soon as I had completed my enquiries and at the same time I voiced my suspicions about his technical correspondent and offered my services in his place.

At the moment, however, I have received no reply, and it looks as though he has embezzled the ninepence represented by the unused reply which I prepaid.

Radio Maximo Arvo

I MUST confess that, for once, I feel myself in hearty agreement with "Diallist" when he protests against the pedantry of rendering the plural of *radius vector* as *radii vectores*. I myself am a great stickler for accuracy and always writhe inwardly when I hear wild misstatements like that of a recent speaker in the General Forces Programme who started sentimentalising about what he termed "the good old British name of George."

Actually, there is scarcely a name which is so definitely of Hellenic origin. It did not become very popular in this country until the latter part of the eighteenth century when the well-loved "Farmer George" sat upon the throne, he being so named from his habits of life and not because of any knowledge on the part of the majority of his subjects that his name did indeed mean a "tiller of the soil" (γεωργος). No doubt the B.B.C. speaker imagines that Virgil's *Georgics* consist of poems about a man called George.

However, as "Diallist" rightly implies, there is a limit beyond which meticulous accuracy becomes mere pedantry, and on this point I stand four-square behind him. But I do think that in our own profession and industry of radio we have been less guilty either of pettifogging pedantry or glaring inaccuracy than other classes of the community; such, for instance, as the horticulturists. They will at one moment use the horrible word *croci* pedantically and accurately as the plural of crocus, and yet a moment later they will inaccurately refer to a fuchsia as a "fooshia" instead of a "fooksia" thus completely ignoring the fact that the name was formed by tacking the Latin termination "ia" on to the surname of the good Herr Fuchs, who kept a sort of stud farm for flowers in the Fatherland.

However, we in the world of wireless are not entirely free from one of the things which "Diallist" is rightly jibbing at when he says that he would have voted for *radii vectores* if it had been good Latin which would have conveyed some sort of intelligible meaning to Cæsar or Cicero. How much more so is this the case when we come to the motto of the Radio Manufacturers' Association, *Radio Maximo Arvo*, officially translated as "Broadcasting to the Farthest Shore."

Faber Meae Fortunae

The acid test of a good Latin motto, in the opinion of myself and of other people who matter, is that it should if possible be "slick," even to the extent of a clever piece of punning if need be, without departing from the canons of good Latin. In other words, it should at least be understandable as a plain statement of fact by Cicero or Cæsar as "Diallist" implies, even if they could not understand the joke, pun or double meaning contained in it. One of the cleverest examples of this is *Faber meae Fortunæ*, the motto adopted in the last war by a brilliant member of the great Smith family who, like myself, did indeed become smith of his own fortunes.

In the case of *Radio Maximo Arvo*, however, the admittedly "slick" idea of using the initials R.M.A. seems to have excluded all other considerations and to Cicero and Co. it would have been entirely meaningless. Some time ago when I raised this point with an official of the R.M.A. he pointed out to me quite gravely that Cicero and Co. were definitely not members of the Association and their views on the matter could not therefore be considered; furthermore, he believed they were a non-British firm and so ineligible for membership.

By the way, what will be the motto of the Radio Industry Council?

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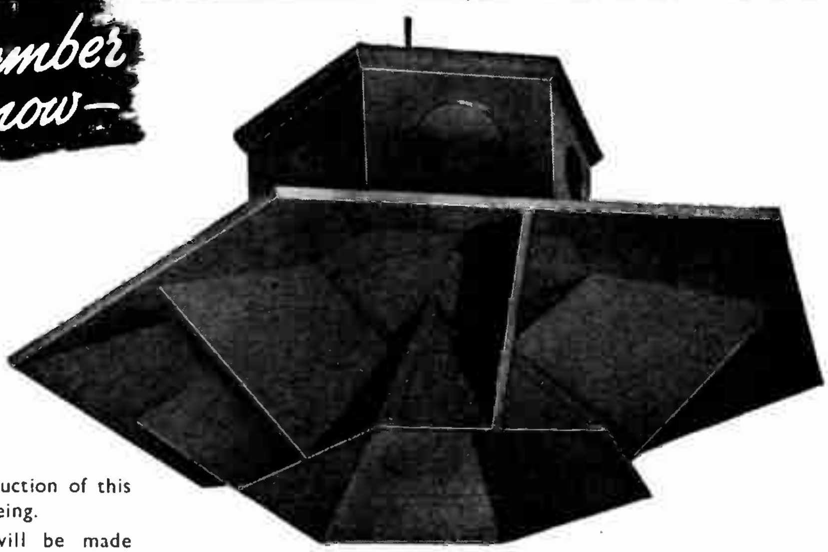

We regret to announce that the very limited supplies of the Concentric Diffuser Loudspeakers have now all been disposed of. Due to the heavy demands made on us by the Services for special Loudspeakers and Telephone Apparatus, we have been obliged to discontinue production of this popular model for the time being.

A further announcement will be made immediately we are able to recommence production.

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Dual Purpose TRANSITRON OSCILLATOR

Uses as a Signal Source and for Dynamic Resistance Measurements

By F. P. WILLIAMS

THE instrument to be described was designed in the first instance for the purpose of measuring the dynamic resistance R_D of tuned circuits and was afterwards modified so that it could also serve as a screened oscillator for general purposes, including rough measurements of amplifier gain.

In using the transitron it is important to understand clearly the operating conditions if good wave-form and fine control are to be obtained. It is assumed, however, that readers of this journal are already acquainted with the general principle of operation*, so the following description will deal only with the way correct operation is ensured in this particular case, using an EF50 valve.

Fig. 1 shows how screen current I_{SG} varies with suppressor grid volts V_{SPG} for various values of control grid volts V_G and screen volts V_{SG}. The negative slope with V_{SPG} constant and equal to A varies from about 1700ω at $V_G = 0$ to almost a megohm at $V_G = -1.5$, but variations of V_{SG} affect it but little. The general shape of the curves also indicates that it is undesirable to allow the suppressor grid to derive its bias from grid current voltage drop in the resistance to cathode. With the suppressor grid resistance returned to cathode there is normally a small negative bias on this grid. Suppose V_G is now made less negative to a point B where the negative resistance slope is just equal to the dynamic resistance R_D of the circuit connected to screen. Oscillation starts and is rectified at the suppressor grid, almost the peak value appearing as extra negative bias, which shifts the working point up the curve where the negative slope is greater. The amplitude of oscillation therefore gets greater until limited by the top bend on the one hand and heavy grid current on the other. V_G must now be made considerably more negative than its initial value, to bring oscillation back to manageable proportions.

* *Wireless World*, March, April, 1943.

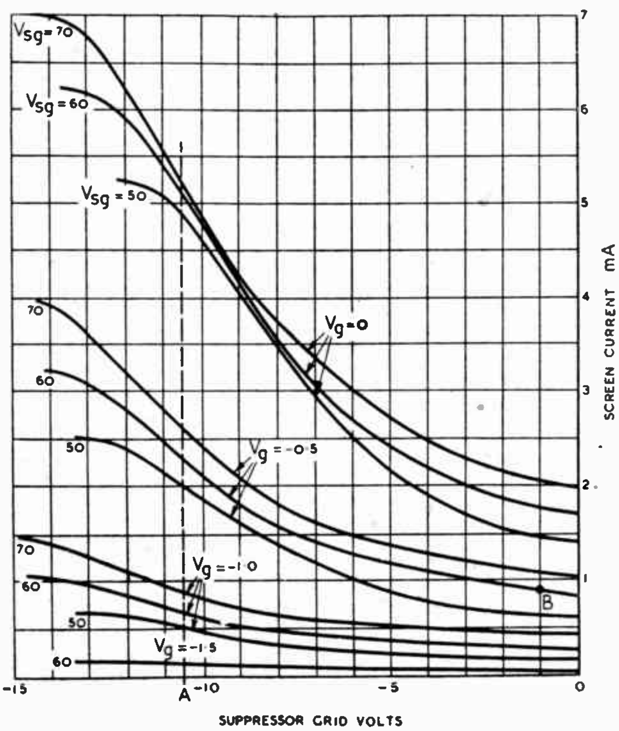


Fig. 1. Relation between screen current and suppressor grid volts in the EF50 for various values of control and screen grid volts.

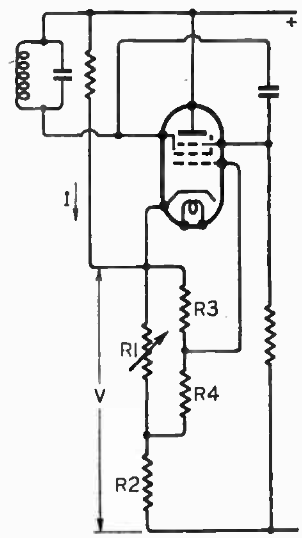


Fig. 2. Basic circuit of transitron oscillator avoiding the use of a potential divider for suppressor grid voltage control.

To avoid this state of affairs the suppressor grid bias must be pinned down to some suitable value such as A (Fig. 1), allowing a peak signal of about 2 volts on an almost straight working characteristic. To obtain this constant bias without using a heavy-current potential divider, the circuit shown in Fig. 2 was devised. The cathode current I_C varies from a maximum value I'_C to approximately zero as R1 is adjusted between zero and a maximum value of R'1.

As the voltage drop across R1 may be more than is required for this purpose, only part of it is applied to the grid by means of

R3 and R4. V is the steady bias needed for the suppressor grid and I the current fed in from the + HT line. R1 may be any value between 100 and 1,000 ohms : the lower it is the more constant will V remain, but I will be larger. For any chosen value of R1, I and R may be found to satisfy the conditions.

$$(I + I'_c)R2 = V$$
$$I(R'1 + R2) = V$$

from which

$$I = \frac{I'_c\left[\sqrt{1 + \frac{4V}{R'1\, I'_c}} - 1\right]}{2}$$

For the purposes of the calculation R'1 is taken to be the net value of R'1 in parallel with R3 and R4 in series.

Incidentally when R1 is zero, R3 and R4 are in parallel between cathode and control grid.

Grid current flows through them, so it is necessary to limit their parallel value to about 500 ohms in order that the condition $V_G = 0$ may be closely approached. In this case R1 is 300ω, I'_c = 6mA, V = 10 volts, and the maximum negative V_G = 1.5 volts; giving the values shown in the complete circuit Fig. 3.

The power supply required is 70 volts on load and should have good regulation.

When measuring R_D, the LC circuit is connected to terminals T1 and T2 outside the screening box, S1 being open and R1 adjusted until oscillation just starts. For use as a screened oscillator or signal generator, if one may stretch the term sufficiently, T1 and T2 are covered with a special screen and the L and C to give the required frequency or band of frequencies (a variable air condenser is incorporated for this purpose) are connected to the internal terminals T1 and T2 ; S1 being closed.

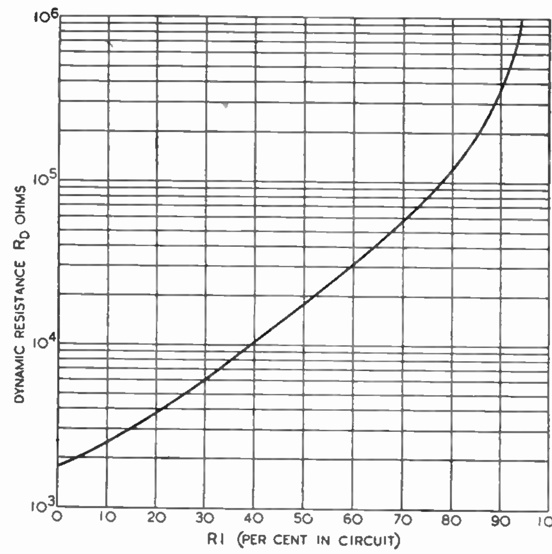


Fig. 4. Typical calibration curve showing dynamic resistance in the terms of the setting of R1 (Fig. 3.)

Owing to the low resistance of the potential divider and the low output impedance of the cathode follower, the distribution of voltage on the former is not likely to be seriously disturbed by any circuit that may be connected to the output. Terminal T3 is provided for checking the voltage across the whole output resistance, which should be not more than two volts.

The calibration of R1 in terms of negative resistance may be accomplished very simply by connecting phones between negative HT and the HT bypass condenser and then inserting various resistances in turn between T1 and T2 (S1 open). The resistances should be of the carbon type and cover the range 1,500ω to 1MΩ.

When R1 is adjusted so that the negative slope is equal to the total positive resistance, the circuit is unstable and a peculiar squawk will be heard in the phones.

Plotting the value of resistance against the relative value of R1 on paper ruled log in one direction gives a curve similar to Fig. 4 : from this the scale of R1 is marked off direct in ohms (negative).

With values over 100,000 ohms it is sometimes better to have the phones in the lead from T2 to HT +.

The drop in screen voltage due to the calibrating resistances causes very much less error than might be supposed, but for the highest accuracy the screen voltage may be temporarily boosted by an amount equal to I_{SG} . R.

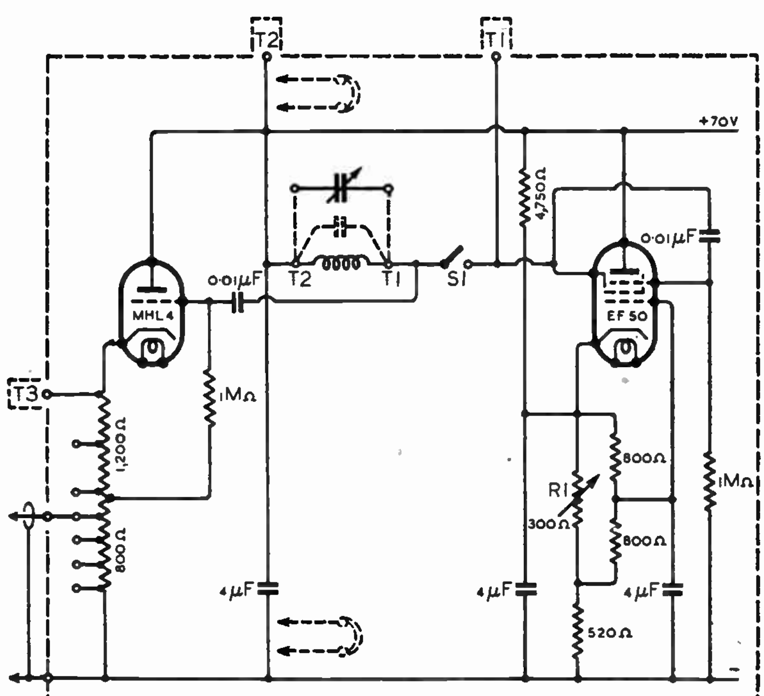


Fig. 3. Complete circuit diagram of oscillator with values.

VARIABLE CONTRAST EXPANSION

Control of Contrast Range Without Change of Average Level

By W. E. INGHAM, B.Sc., and A. FOSTER, B.Sc.

THE various advantages and disadvantages of audio-frequency volume expansion have been lately discussed in these pages, and it would seem that most writers agree that some expansion is desirable to overcome the shortcomings of present-day sound reproduction. No one would, however, deny that expansion should be treated as a temporary expedient until the day when compression is no longer necessary; but in the meantime there is little doubt that a correctly adjusted and operated expander does greatly enhance most recorded orchestral items and also some similar radio programmes.

Many systems have been put forward in the past for obtaining expansion, but the importance of a correct method of controlling the degree of expansion does not seem to have been given the same attention.

The general expansion circuit discussed here is the now well-known one using two pentodes of the AC/SPI or SP2220 type in push-pull. These valves are specially designed for suppressor-grid control of the signal grid/anode mutual conductance, and will handle a tolerably large signal without distortion. No more will be said here about this part of the circuit as the authors' system of control has been applied with success to the circuit described by D. T. N. Williamson in the issue of this journal dated September, 1943.

Expansion Range Required

The figure usually quoted for the possible volume range encountered in the studio is 70db. The range of a symphony orchestra in the concert hall will not be very much less. The maximum range permissible on an average lateral cut disc depends on the physical properties and dimensions of the disc and associated system, and is approximately 25-40 db. This, therefore, needs a maximum compression of 30-45 db. In modern pre-war broadcasting the compression required did not exceed this figure.

A maximum of, say, 30-45 db expansion should therefore be *available* in the reproducer although clearly the value used will vary with the programme, as the compression would be much smaller with, for example, a light orchestra. If the expansion can be continuously varied from zero to 30 db the optimum setting can be used for each type of programme.

The usual method of varying the degree of expansion is to connect a variable potentiometer to control the audio frequency input to the control rectifier. This method is unsatisfactory as it has the undesirable effect of altering the *average* level of the programme when the control is operated. There is also the disadvantage that at "zero expansion" much of the available valve gain is wasted.

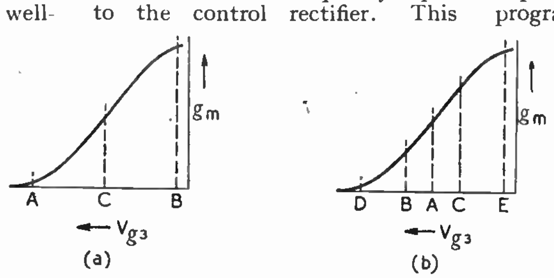


Fig. 1. Variation of mutual conductance with suppressor grid voltage, showing conditions of operation (a) in normal volume expansion circuits and (b) with the system of dual control suggested by the authors.

The shape of the mutual conductance (g_m)—control grid to anode—and suppressor grid (V_{g3}) volts characteristic of the AC/SPI as shown in Fig. 1 (a). The usual method applies a fixed negative bias (A) to V_{g3}, the positive control voltage altering this from A to B on maximum signal (maximum expansion setting), and from A to some intermediate point C (on maximum signal) for some lesser setting of the control. Thus, by simply altering the expansion from zero to maximum the average level would appear to alter from A to C.

It has also been suggested in the past that the expansion may be controlled by altering the fixed bias only. This is, of course, correct but only if the characteristic is non-linear over at least part of its range. This system is less satisfactory than the former as the average level will still alter, and linear expansion at all settings of the control is now impossible.

Constant Average Level

The arrangement proposed utilises both variation of the gain of the control amplifier *and* of the fixed negative bias to give linear expansion and constant average programme level at all degrees of expansion from zero to maximum.

The valves are initially biased to A, Fig. 1 (b), and at zero expansion the bias is fixed at this point, the signal control voltage being zero.

As the expansion is increased, the negative bias is increased, and the control voltage (positive) also increased, with the result that at, say, half maximum expansion, the working range is from B to C. The average level thus remains at A and is completely unchanged. On maximum expansion the control range is from D to E—once again average at A.

It will be noticed that with the expander set to "zero expansion" (i.e. "off")—as it will be for many types of programme—the gain is still reasonably high. This is quite an important consideration. The expansion is linear at all settings of the control.

It may be mentioned that a "delayed" expansion characteristic can be used by arranging to work in a similar way but with the point A almost at the foot of the characteristic. If this is done a valve must be used in which g_m does not fall quite to zero before

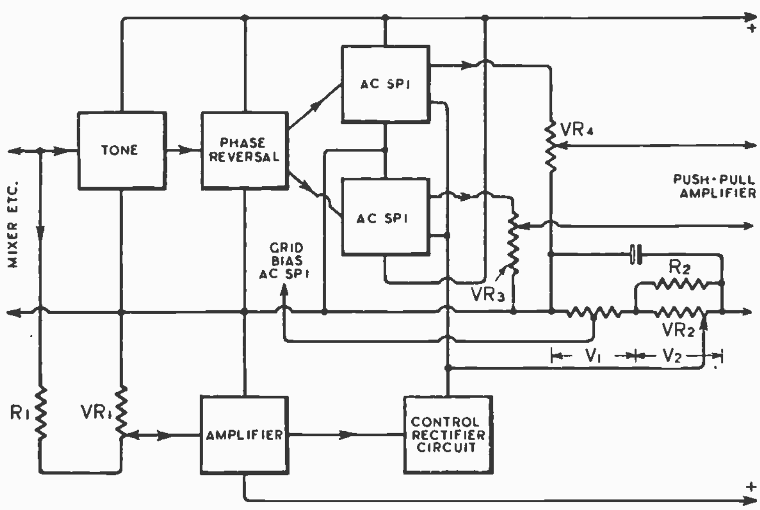


Fig. 2. Schematic diagram of modified contrast expansion circuit giving constant average volume with variable expansion range.

the characteristic becomes level (or of less slope). With this arrangement there will be little or no expansion until the signal level reaches the average level A, and linear expansion above this point. Although this characteristic is thought to correspond more nearly to the type of compression (manual) now in use in broadcasting technique, it is not recommended as much gain is sacrificed in the zero expansion setting. The expander will very likely be used for record reproduction in any case.

Whichever characteristic is decided upon, it will be maintained for all settings of the expansion control, and will not vary as the control is altered.

Practical Arrangement

To obtain the above result, two non-graded (i.e., linear) ganged volume controls are used. One is arranged to vary the DC bias and the other the signal applied to the control rectifier.

A semi-block diagram of the control circuit as applied to the expansion circuit is given in Fig. 2.

The resistances in the negative power lead are used to provide the fixed bias voltages. These may be stabilised by a bleeder circuit (also feeding the screen grids) if necessary.

Potentiometers VR1 and VR2 (ganged) form the expansion control.

Component values should be chosen to suit individual circuit requirements.

Adjustments

The value of the resistance R1 must be adjusted so that on maximum signal the rectifier control voltage is just equal to DE, Fig. 1 (b). This will be about 12 volts for the AC/SPI. The resistance R2 is adjusted (in conjunction with the value of VR2) to give V2 equal to about AD in Fig. 1 (b) or 6 volts for the AC/SPI. V1 should also be about 6 volts.

It is well known that as the expander should have a short time of rise of expansion, the sudden rise of anode current in the controlled valves may give trouble. This can be prevented from affecting the loudspeaker by the push-pull arrangement shown—the anode current change being in phase for each valve. The push-pull circuit also tends to reduce even harmonic distortion in the usual way. There still remains the difficulty that it may cause the following valve grids to block for a short interval, especially as the amplifier may have a good low-frequency response. This trouble can be minimised by using a tone control *before* the expander and by using a volume control *after* the expander. At all volume control settings except that for nearly maximum output the cure will be complete.

It will be noted that because of the push-pull arrangement ganged controls must be used for the main volume control (VR3 and VR4). These should be accurately matched. The average level should be fixed by the mixer or some equivalent stage and no volume changes effected before the expander as this would alter the control voltage.

As the gain at low frequencies may be boosted above the normal level to compensate to some extent for output transformer and speaker losses, the expander control voltage should be taken from a point before the tone control stage (see Fig. 2).

In conclusion it may be mentioned that the arrangement described above, has been in use for some considerable time and has been found to be very satisfactory. There is no audible amplitude distortion and the transient response with a horn - loaded speaker working in conjunction with a labyrinth speaker is good. The apparent reduction in noise level caused by the expansion is appreciable and the greater depth given to an orchestral recording is most satisfactory.

MORSE AND PSYCHOLOGY

IN America, the teaching of morse has become a matter for serious study by psychologists. That elevation of status is a result of wartime demands for wireless operators and the consequent need for intensive training. A number of papers on the subject, recently published in the American journal of *Experimental Psychology*, are summarised in a statement issued by the U.S. Office of War Information.

Some of the findings of workers in this field are indefinite and even contradictory, but at least one clear-cut result is claimed. A "highly reliable" list of the "order of difficulty" in learning the various letters of the alphabet has been prepared. The kind and amount of confusion between characters was determined, and it was shown that most confusions occur "between characters that are identical with each other except for their final element." That presumably means that G and O, W and R, K and D, etc., are commonly confused. It is doubtful whether the experience of morse instructors in this country would agree with that finding.

VOICE - CONTROLLED DEVICES

Electro-mechanical Analysis of Words of Command

By

M. L. TELCS,

Ph.D.

ONE of the most spectacular of recent developments in electro-acoustics is the utilisation of human voice sounds for the control of machinery. The endeavours of the American inventor Dudley, to render a typewriter entirely voice operated (American Patents, 2,195,081 and 2,238,555) give an impressive picture of the inherent possibilities of this latest branch of sound engineering. If the pace of the present research work can be kept up, it is quite possible that by the end of the present war a means for replacing manual operations by voice actuation can be put at the disposal of the disabled. In fact, the desire to provide for the needs of disabled war casualties seems to have given a powerful impetus to this development and a great number of patents concerning voice actuated electro-mechanical devices has been filled since 1940, mainly in the United States.

One of the most remarkable of these devices is an automatic telephone exchange system, developed in the laboratories of the Western Electric Company. The frequency composition of the words " one," " two," " three," etc. is utilised to generate the energising impulses for a uniselector or other type of telephone relay system, so that the dialing action is entirely replaced by the use of spoken words. This system obviously lends itself to all sorts of experiments on the " robot " line, as the switch contacts thus operated could be associated with electric devices other than telephones.

To explain the action of these devices it will be necessary to make a short reference to the composition of speech sounds as explored by the research work of Sir Richard Paget in England and I. Crandall, Sacia and others in the United States. It has been shown, that a vowel sound consists of a group of frequencies, bearing no simple harmonic relationship one to the other and being characteristic for the vowel itself, while a single additional frequency, varying with different individuals accounts for the variations in voice pitch. The characteristic frequency group, as the majority of authors agree, contains, as a rule, two frequencies only, though a third frequency occurs, according to Crandall, in the American pronunciation of " er " as in part. The following table gives some of the characteristic vowel frequencies according to Paget.

	English		American	
	f_1	f_2	f_1	f_2
a (talk) ...	558	886	645	1,024
oo (pool) ...	383	724	431	861
e (teem) ...	332	2,434	431	2,435
o (tone) ...	430	790	724	1,218
a (father)...	790	1,254	861	1,149

A detailed list of English and American vowel components (for which the reader is referred to Paget, *Human Speech*, Kegan Paul, 1930) shows that the separation between adjacent frequencies is 5 to 7 per cent. throughout the vowel scale. Thus selective separation of these components by tuned LC circuits does not offer in itself too great difficulties. To type a vowel sound on a speech-operated typewriter it is necessary to apply that sound to a suitable microphone or other sound sensitive device, single out one of the characteristic frequencies appearing in the output of the device and guide the currents or voltages thus obtained, by means of a set of reactive elements, to the controlled section of the apparatus. This consists, in Dudley's system of a set of small electromagnets, each associated with one of the tuned circuits and actuating levers of the typing mechanism. The magnets are fed with impulses of unidirectional currents, obtained from small metal rectifiers which are situated between the resonant circuits and the windings of the magnets. Valve rectifiers to ensure a sufficiency of energising current for the electromagnets and an automatic gain control to eliminate amplitude differences in the sound input as a controlling factor, will, as a rule, also be incorporated in the device.

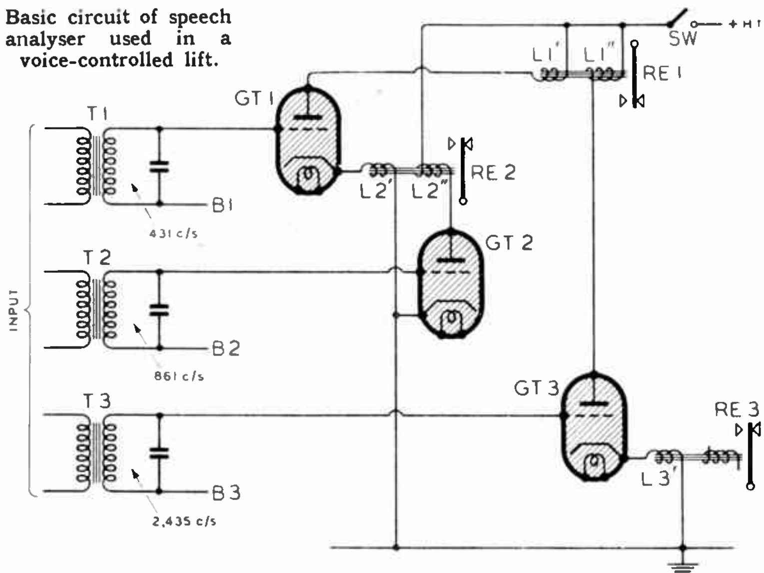
The use of consonants for voice actuation is a more difficult proposition. The elements entering the frequency make-up of a consonant sound are very numerous and it appears, that the frequencies themselves are of less importance than is their rate of change in time. While it is quite possible to " tune in " to frequencies contained in vowel sounds, it is a more difficult task to provide a circuit responsive to the time derivatives of varying frequencies, irrespective of their initial and final values. Further, no definite statement can be made even as to the value of $\frac{df}{dt}$ for a given consonent sound, as this value also depends on the nature of the vowel sound preceding the consonant. " L " in " eel " is characterised by a drop of frequency from 2,298 to 1,722, while in " all " a rise from 912 to 1,366 takes place (Paget). Consonant sounds cannot thus be handled by simple LC arrangements and more complex circuits have to be designed to deal with consonents and vowel-consonant combinations. Much work remains to be done in this direction.

The final stage of a circuit for lift-control as used by the author on a passenger lift in London is shown in the figure. The lift, which has been put at the author's disposal for the purpose of the experiments by Marryat and Scott, was of the usual " call button " controlled type, the buttons operating floor relays, which, in conjunction with other, automatic arrangements determine the movements of the car.

Both vowel components contained in the words " two " (for

Voice-controlled Devices—
calling the lift to the second floor) and " three " for the third floor respectively are utilised. The final relays (RE1, RE2, etc.) are, accordingly, of such construction, that they do not close their contactors unless both of their coils (L1'L1" and L2', L2" respectively) are energised. The circuit shown is, in principle, the same as was used in the experiments in London, though, as can be seen, it represents an adaptation for American accent and its action is as follows.

Basic circuit of speech analyser used in a voice-controlled lift.



Suppose that the word " two " which, it will be recalled, has component frequencies, 431 and 861 in its frequency make-up, is spoken into the microphone, circuits marked 431 and 861 being resonant to these frequencies will build up and apply alternating potentials to the gas-filled discharge tubes GT1 and GT2. Points B1, B2 and B3 are connected to a source of bias supplying the necessary negative potential for cut-off, in the usual manner. The positive peaks of the potentials obtained from the resonant circuits overcome part of the standing negative bias applied to the grids, and tubes GT1 and GT2 strike. These two tubes pass current, the former through winding L1' and L2' of relays RE1 and RE2, and the latter through winding L2" of RE2. Only relay RE2 has current in both its windings and therefore onlyht is relay operates. RE2 is wired in parallel with the call button switch for the second floor and will therefore actuate the floor relay system in such a way as to bring the car to rest at floor two.

The action of the circuit on reception of the sound input " three " is similar, RE3 being then the actuated relay. The further winding L3' shown in the cathode circuit of tube GT3 may be used in conjunction with similar arrangements to those just described to call the lift to the fifth floor in response to the word five, frequency 861 being also a component of the vowel sound " i." Switch SW is common to all anode circuits and is momentarily opened and closed whenever the car is in motion, so as to put the gas-filled discharge tubes out of action and then enable them to receive further calls. This switch may be operated by a ramp mounted externally on the side of the lift car, in much the same way as are the shaft direction switches of electric lifts.

The actual input frequencies to the windings of T1, T2 and T3 are not necessarily identical with those picked up by the microphone. It is a better idea to convert the input frequencies in such a way as to increase their separation $\frac{f_1 - f_2}{f_1}$, otherwise noises generated by the presence and activities of the speaker may cause serious interference. (Laughter and coughs are sources of the worst complications, the latter invariably causing the lift to proceed to the ground floor !) A suitable conversion is described by the function $F = Af - B$ which, as simple calculation shows, will increase the separation of adjacent frequencies f_1 and f_2 from

$$\frac{f_1 - f_2}{f_1} \text{ to } \frac{F_1 - F_2}{F_1} = \frac{f_1 - f_2}{f_1 - B/A}$$

which is greater than $\frac{f_1 - f_2}{f_1}$.

A distorting valve generating the Ath harmonic of its grid input and a frequency changer in conjunction with a local oscillator of a frequency output B is then needed to obtain the conversion referred to.

For experiments with household " robots " it is a good idea to employ a two-step relay (such as Types LQA/FS or LF/FS as manufactured by Londex, Ltd.) which closes contacts on a first excitation of its coil and opens them again on a second excitation. This will enable the experimenter to use the same voice input for putting on or extinguishing an electric fire for instance and will, of course, greatly simplify the associated circuits. When it is required to actuate a mechanism on complete words (preferably code words, to avoid unwanted actuation by conversations carried on in the room) a number of relays, with their contacts connected in series and their coils to various tuned amplifiers, will have to be employed.

PROPOSED STATIONS FOR THE EUROPEAN NETWORK (see page 234)

		kc/s			kc/s			kc/s
Ankara ...	—	—	Kiev	F9	165	Oslo	F5	175
Athens ...	F9	165	Cologne ...	—	—	Paris	F5	175
Athlone ...	F5	175	Lahti ...	F5	175	Poznan ...	F10	185
Belgrade ...	F9	165	Leningrad ...	F9	165	Prague ...	F10	185
Berlin ...	—	—	Lisbon ...	F2	235	Rome ...	F1	155
Berne ...	F2	205	Luxembourg...	F8	265	Salzburg ...	F4	245
Brussels ...	F6	195	Lyons ...	F5	175	Sofia	F11	215
Bucharest ...	F11	215	Madrid ...	F1	155	Stuttgart ...	—	—
Budapest ...	F9	165	Minsk ...	F9	165	Tangier ...	F1	155
Cernowitz ...	F11	215	Monaco ...	F3	235	Toulouse ...	F7	225
Droitwich ...	F7	225	Moscow ...	F11	215	Vienna ...	F12	225
Hilversum ...	F7	225	Motala ...	F7	225	Warsaw ...	F9	165
Kalundborg ...	F6	195	Munich ...	—	—			

WORLD OF WIRELESS

UNITED NATIONS RADIO

WITH the Allied advance in Italy the voice of the United Nations is being heard through an increasing number of broadcasting stations. The latest schedule of transmissions issued by the U.S. Office of War Information includes broadcasts from the stations at Bari, Naples, Tunis, Rabat, Sardinia, Palermo, Catania and the UNR transmitter at Algiers.

The capture of Rome has placed at the disposal of the Allies the extensive international short-wave centre at Prato Smeraldo, which, when opened just prior to the war, consisted of six transmitters; the most powerful being 100kW.

B.B.C. WAR REPORTING

THE Chief Engineer of the B.B.C., in his review of the technical side of reporting as it has developed during the war, points out that it presents two major problems. The first is the provision of a medium by which war correspondents can record their impressions whilst actually at the scene of military operations, and the second, the transmission of the impressions or recordings back to Broadcasting House.

It has already been stated in these pages that the mobile recording equipment has been used successfully in all the campaigns from 1940 to 1944. Its major failings are, however, its weight—450 lb.—and the fact that it requires a recording engineer to operate it.

It was realised some time ago that lighter equipment, capable of being carried and operated by the correspondent, was necessary. The B.B.C. Research Department has, therefore, produced the Midget Disc Recorder, weighing only 35 lb., described in the May issue of *Wireless World*. B.B.C. correspondents who have given such vivid descriptions of the Normandy invasion are using these recorders.

To overcome the delays and difficulties of conveying discs back to Broadcasting House, correspondents now have the facilities of a low-power mobile transmitter in Normandy. This station, which is one of a number and is capable of transmitting on medium and short waves, is installed, complete with engine-generator set, aerial, masts, communication receiver and microphone equipment, in a three-ton Army lorry.

In addition, a mobile studio is being provided which can work either in conjunction with the mobile transmitter or feed programmes by line to the station should the most accessible point for the correspondent not be the site of the transmitter. This studio will be fitted with microphones and reproducing equipment for "dubbing" correspondents' recordings.

THE LATE DR. N. PARTRIDGE

IT is with great regret that we announce the recent death, by enemy action, of N. Partridge, Ph.D., M.I.E.E., M.Brit.I.R.E. As an authority on audio-frequency transformers, Dr. Partridge was, in his own particular sphere, without an equal. As a musical executant of ability, he brought a sympathetic outlook to all problems of sound reproduction.

Dr. Partridge has been a contributor to this journal for many years, and his powers of exposition and lucidity of style made his writings of exceptional value. We —and our readers—are the losers by the fact that a new series of articles was still in the embryonic stage at the date of his untimely death.

The transformer manufacturing business of N. Partridge, which he founded, is being carried on without interruption by his partner, A. L. Bacchus.

LICENCES RECORD

THE number of wireless licence holders in Great Britain and Northern Ireland has now reached the record total of 9½ millions.

The Post Office, however, points out that there are still a number of wireless sets in use for which no licences are held, and reminds listeners that each householder using a wireless receiver, including those rented or hired, should have a licence. Tenants of separate flats or sub-let premises in the same building are not entitled to share the benefits of one licence nor may extensions be made from a licensed set whereby the occupants of other houses, flats, etc., may listen without taking out separate licences.

"JUNGLE-PROOF" SETS

THE maintenance of radio equipment in the severe climatic conditions in the Pacific Islands and Burma presented a problem to designers which, according to a report in the *New Zealand Standard*, has been successfully tackled by New Zealand technicians, who have produced a set which is "jungle proof."

Every component liable to be affected by heat or moisture is coated with a protective film of wax or petroleum jelly. The set was subjected for six hours to a temperature of 140 deg. F. at a

World of Wireless—
humidity of 100 per cent.—a combination in which no human being could live—and still functioned.

The complete transmitter-receiver, although designed for use in armoured vehicles, can be carried by two infantrymen.

A.B.S.I.E.

THE second medium wavelength allocated to the American Broadcasting Station in Europe,

NEWS IN ENGLISH FROM ABROAD

Country : Station	Mc/s	Metres	Daily Bulletins (BDST)
Algeria			
UNR (Algiers) ..	9.535	31.46	1015, 1300, 1600
	9.610	31.21	1300, 1600
America			
WLWK (Cincinnati)..	6.080	49.34	0700, 0800
WKRD (New York)..	6.100	49.18	0600, 0700
WOOC (Wayne) ..	6.120	49.03	04)0, 0500, 0800, 0900
WCBX (Brentwood)	6.170	48.62	0800
WGEX (Schenectady)	6.190	48.48	0400, 0500, 0600, 0700
WGEA (Schenectady)	7.000	42.86	0600
WLWO (Cincinnati)	7.575	39.61	0700, 0800, 0900
WOOW (New York)..	7.820	38.36	0400, 0500, 0800, 0900
WCBN (New York) ..	9.490	31.61	0900
WGEA (Schenectady)	9.530	31.48	1000, 1100, 1200, 1300
WGEX (Schenectady)	9.550	31.41	0000, 0200, 2300
WBOS (Boston).. ..	9.570	31.35	1000, 1100
WCRC (New York) ..	9.590	31.28	1000, 1100
WOOC (New York) ..	9.650	31.09	0200, 0300
WNBI (New York) ..	9.670	31.02	1000, 1100, 1200, 1300
WRUS (Boston) ..	9.700	30.93	0900, 1200
WLWO (Cincinnati)..	11.710	25.62	2100, 2200, 2300
WRUW (Boston) ..	11.730	25.57	1400, 1500
WCRC (Brentwood) ..	11.830	25.36	1300, 1530, 1630, 2100, 2145
WGEA (Schenectady)	11.847	25.32	1800, 2000
WGEX (Schenectady)	11.847	25.32	1200, 1300, 1400, 1500, 1600, 1700
WOOW (Wayne) ..	11.870	25.27	0200, 0300, 1400, 2100, 2200
WBOS (Boston) ..	11.870	25.27	1200
WRCA (New York) ..	11.893	25.22	1100, 1200, 1300, 2100
WRUS (Boston) ..	15.130	19.83	1400, 1500, 1600, 1700, 1800, 1900
WNBI (New York) ..	15.150	19.80	1600, 2100
WOOC (Wayne) ..	15.190	19.75	1400, 2100, 2200
WLWL1 (Cincinnati)	15.200	19.74	0000, 0100, 1200, 1300, 1400, 1500, 2300
WBOS (Boston) ..	15.210	19.72	1500, 1600
WLWL2 (Cincinnati)	15.230	19.69	0000, 0100, 1200, 1300, 1400, 1500, 1800, 2300
WLWK (Cincinnati)..	15.250	19.67	1500, 1600, 1745, 1900, 2000, 2100, 2200, 2300
WCBX (Brentwood)..	15.270	19.65	1300, 1530, 1630, 2100, 2145
WGEO (Schenectady)	15.330	19.57	1500, 1745, 1900, 2100, 2200
WRUL (Boston) ..	15.350	19.54	1600, 1900
WRUW (Boston) ..	17.750	16.90	1700
WRCA (New York) ..	17.780	16.87	1600
WLWO (Cincinnati)..	17.800	16.85	1400, 1500, 1600, 1745, 1900, 2000
WCBN (New York) ..	17.830	16.83	1530, 1630, 2100
WGEX (Schenectady)	17.880	16.78	1800, 2000, 2200
WLWL1 (Cincinnati)	17.960	16.70	1800, 2000
Australia			
VLI4 (Sydney) ..	7.240	41.45	1615
VLG (Melbourne) ..	9.580	31.32	1615
Belgian Congo			
Leopoldville	15.167	19.78	1300
Brazil			
PRL8 (Rio de Janeiro)	11.715	25.61	2130†
China			
XGOY (Chungking) ..	9.635	31.14	1600, 1800, 2230
Ecuador			
HCJB (Quito) ..	12.455	24.09	0100, 2130

Country : Station	Mc/s	Metres	Daily Bulletins (BDST)
Egypt			
Cairo	7.510	39.94	1945, 2200
French Equatorial Africa			
FZI (Brazzaville) ..	11.970	25.06	2045, 2245
India			
VUD3 (Delhi) ..	7.290	41.15	0900, 1400, 1650
VUD4	9.590	31.28	0900, 1400, 1650
VUD8	9.630	31.15	0900, 1650
VUD6	11.790	25.45	0900
VUD9	11.870	25.27	1650
VUD3	15.290	19.62	1400
Iran			
EQB (Teheran) ..	6.155	48.74	2325
Mozambique			
CR7BE (Lourenco Marques)	9.830	30.52	2150
Newfoundland			
VONH (St. John's) ..	5.970	50.25	0015
Palestine			
Jerusalem	11.750	25.53	1715
Portugal			
CSW6 (Lisbon) ..	11.040	27.17	2100
Spain			
EAQ (Aranjuez) ..	9.860	30.43	2150†
Sweden			
SBU (Motala) ..	9.535	31.46	2320†
SBP	11.705	25.63	1800
Switzerland			
HER3 (Schwarzenburg)	6.345	47.28	2250
HER4	11.775	25.48	2250
Syria			
FXE (Beirut).. ..	8.035	37.34	1835
Turkey			
TAP (Ankara) ..	9.465	31.70	1900
U.S.S.R.			
Moscow	7.300	41.10	0000, 1900, 2000, 2100, 2200, 2300
	7.322	40.92	1900
	8.940	33.56	1340
	9.480	31.65	0200, 0300
	9.860	30.43	1340
	10.445	28.72	0645, 1340
	11.830	25.36	1700
	11.950	25.11	0047, 0200, 0300, 1300, 1340, 1420
	12.190	24.61	1340
	12.260	24.47	1320
	15.040	19.85	0047
	15.230	19.70	0047
	15.750	19.05	1800
Vatican City			
HVJ	5.970	50.25	2115

	kc/s	Metres	
Algiers	1,176	255	1300, 1600
Athlone	565	531	1440†, 1945, 2310 (Sun. 2300)
Tunis	823	365	0000, 0100 2300

It should be noted that the times are BDST—**two hours** ahead of GMT. † Sundays excepted.

that of 267.4 metres (1,122 kc/s), is now being used for the transmissions which are radiated from 1730 to 0200 BDST. This wavelength was originally used by the Stagshaw (N.E. Regional) station.

In addition to the two medium wavelengths, A.B.S.I.E. is now transmitting on four short wavelengths: 49.92, 41.75, 31.17, and 25.42. The call letters are GRB, GRK, GWO, and GWH, respectively. To give additional coverage for certain transmissions they are also radiated by B.B.C. short-wave transmitters.

FREQUENCY DISTRIBUTION

ACCORDING to the Bureau of the International Telecommunications Union 45,648 frequencies had been notified as being used by the world's wireless stations at the end of 1943. This figure is an increase of over a thousand on the previous year. A large proportion of this increase is recorded in the two frequency bands between 3 Mc/s and 20 Mc/s. The increase in the 3—6-Mc/s band was 360, and in the 6—20-Mc/s band 482.

The following table shows the number of notified frequencies in each band and in the last column the increase recorded during the year.

Frequency Band kc/s		
10 to 100	414	12
100 to 550	4,944	12
550 to 1,500	2,760	13
1,500 to 3,000	3,951	140
3,000 to 6,000	13,187	360
6,000 to 20,000	17,391	482
22,000 to 30,000	1,623	89
30,000 to 300,000	1,354	12
Above 300,000	24	1

SOUTH AFRICAN BROADCASTING

WHAT is believed to be the only FM transmitter in use in the British Commonwealth is being operated experimentally by the South African Broadcasting Corporation. This fact is learned from the annual report of the Corporation, which stresses the need for making immediate provision for the establishment of a television service in the Union after the war.

Considerable development of the existing system of transmitting programmes by wire to the native compounds is envisaged in the report.

IN BRIEF

Invasion News.—Over 7½ million words of Second Front news was transmitted by Cable and Wireless to all parts of the world during the first four weeks of the invasion. Biggest Empire traffic was to Australia, whose total was 1,092,972 words, whilst 1,388,814 words were transmitted to the United States. The fifteen phototelegraph circuits were also kept busy, nearly 1,950 pictures being transmitted in the four weeks ending July 3rd.

B.V.A.—W. R. West became secretary of the British Radio Valve Manufacturers' Association on July 1st, in place of W. P. Wheeldon, who recently resigned to take up other work, having held office for ten years. J. R. Hughes, a *Wireless World* contributor, has been appointed technical secretary. J. W. Ridgeway (Ediswan) has been re-elected chairman, and C. W. Eve (S.T.C.) elected vice-chairman. The Association is now temporarily at 157-159, Regent Street, London, W.1. Tel.: Regent 2712.

R.M.A.—At the recent annual general meeting of the Radio Manufacturers' Association it was agreed to re-elect *en bloc* the existing council and officers to bridge the period of two or three months before the Radio Industry Council is legally constituted when the R.M.A. will be disbanded.

M.B.E.s.—Four radio officers received the award of the M.B.E. in the recent supplementary honours list "as an expression of commendation for their brave conduct." They are First Radio Officers A. J. Franklin, E. Hodgson, G. Walker, and Chief Radio Officer W. H. Hackworthy.

Swedish Radio.—Two new 100-kW short-wave transmitters are included in the plans drawn up to increase the efficiency of radio in Sweden. One is designed for home use and the other for directional transmissions, principally to Swedish nationals abroad. The present SW transmitters at Motala are only 12-kW each.

Canadian Broadcasting.—Dr. Frigon, acting general manager of the C.B.C., recently stated that effective coverage of Canadian broadcasting would be impossible without the co-operation afforded by the privately owned local stations. Only 10 of the 89 broadcasting stations in Canada are Government owned, he said. The combined system made it possible for the C.B.C. to reach 90 per cent. of the population of Canada—this represented 96 per cent. of all set owners in the Dominion. He also explained the part played by the Canadian National and Canadian Pacific Railways in carrying programmes by wire for re-broadcasting.

Another Premium.—In addition to the three I.E.E. Wireless section Premiums enumerated in last month's issue a fourth, the Webber Premium, was awarded to C. P. Edwards, M.Sc.Tech., for his paper on "Enemy Airborne Radio Equipment."

Prize for Invention.—A prize of £50 is again offered by the Royal Society of Arts, as trustees of the Thomas Gray Memorial Trust, to any person of British or Allied nationality who may bring to their notice an invention, publication, diagram, etc., proposed or invented by himself, which is considered by the judges to be an advancement in the science or practice of navigation. Proofs of claim, etc., must be forwarded to the R.S.A., John Adam Street, Adelphi, London, W.C.2, between October 1st and December 31st, 1944. Last year's prizewinning invention was associated with radar.

I.E.E. London Students' Section.—Officers recently appointed for the year 1944-45 for this section of the Institution of Electrical Engineers include: C. C. Barnes, chairman; H. Shorland, B.Sc., vice-chairman; R. G. Stefanelli, hon. secretary.

Demonstrating TRANSMISSION LINE PRINCIPLES

Slow-motion Models with Exaggerated Circuit Constants

By
C. STOKES
B.Sc., A.M.I.E.E.
(Coventry Technical College)

THE following models may help in the understanding of some of the properties of transmission lines. The usual analysis of a transmission line as a "ladder" of series impedances and shunt capacitances can be conveniently illustrated by the following circuits in which the line constants have been grossly exaggerated.

"RC" Line Model. — The arrangement shown in Fig. 1 demonstrates the finite time taken by a wave to travel along the line due to the progressive charging of the shunt capacitances.

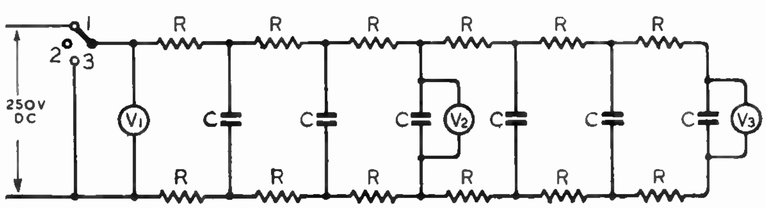


Fig. 1. "RC" line model demonstrating finite time of travel of waves and reflection effects. Twelve to twenty sections should be used with R=100,000 ohms and C=2μF.

The "input," as shown by the voltmeter V1, is a 250-V square wave, obtained by rocking the switch by hand between positions 1 and 3. Half-way along and at the end of the line there are two electrostatic voltmeters V2 and V3, for which purpose Ferranti 300-V instruments are very suitable. These show the progress of the wave, no longer square, along the line, and the time taken for it to cover the whole distance may be anything up to about 10 seconds. A longer time can be obtained by using higher values for R, but owing to the conductance the condensers put across the line, the voltage at the end becomes only a small fraction of that at the beginning. For demonstrations, about two to three seconds is suitable and R=100,000 ohms gives this.

By throwing the switch from position 1 to 3, pausing at 3 for about half a second, then returning to position 2, when the voltage shown on V3 is approaching its full value, "reflection" due to the backward surging of the charge may be shown. For this test only, V1 should be electrostatic also; for the other tests the heavier damping of a moving coil instrument is an advantage.

By deliberately timing the operation of the switch so as to give the correct frequency to the waves, the 180-degree phase shift in a half wavelength of resonant feeder may be shown. However, this point is better demonstrated by the "LC" line model.

Of course, it is technically wrong to use resistances to simulate the series impedance of a line, and after the model has served its limited purpose, this point should be made clear.

"LC" Line Model.—This is extremely useful but has one drawback: With 12 sections of L=20H and C=0.25μF, a time lag of about $\frac{1}{50}$ second is obtained, so that phase shift, nodes, etc., must be observed on a cathode ray oscilloscope, preferably of the double-beam type.

To show phase shift and decay of amplitude in a non-resonant feeder, the line model must be terminated at about 10,000 ohms. One beam of the CRO is deflected by the input voltage to give a datum wave, and the other is made to show the voltage across each section in turn down the line. It will usually be necessary to find the correct terminating resistance by trial to ensure that the amplitude continues to decrease right to the end.

By open-circuiting or short-circuiting the end of the line, standing waves can be produced, but for success two precautions must be taken; the frequency must be adjusted to fit the line exactly, and the good waveform of the input voltage must be preserved by not over-running the iron of the

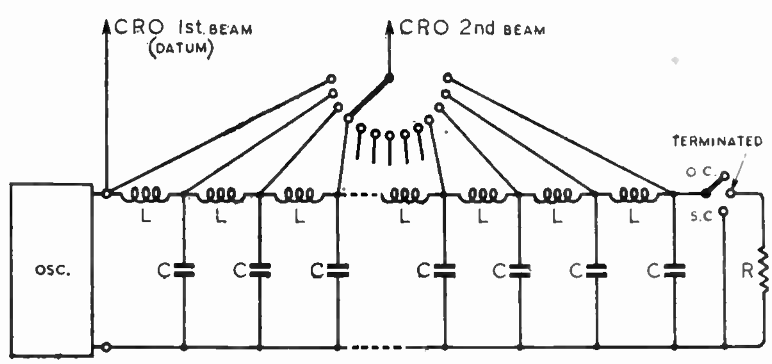


Fig. 2. "LC" model to show, with the aid of a cathode ray oscilloscope, phase shift and standing wave effects along a transmission line. Twelve is a convenient number of sections, L should be 20H; C, 0.25μF and R, about 10,000 ohms.

chokes. About 1V RMS appears to be the maximum for 20H chokes with iron cores ½ in. square. The adjustment of frequency and voltage is best carried out by observing a voltage node, when the harmonics show up on what should be a straight line.

"Input Impedance" Model.—This simple piece of apparatus is useful in demonstrating that the input impedance of a long line settles down to a limiting value after the first few "sections," a point with which some students find difficulty. By using resistances to represent the series and shunt impedances of the line the problem is really over-simplified, since the reactive properties of the line impedances are not represented at all. Nevertheless, from the behaviour of this resistance ladder, one may infer the likelihood of a real line having a limiting value of input impedance.

The input resistance is measured, preferably by ohmmeter, and the following values are obtained as the sections are switched in: 2000, 1666, 1625, 1619, 1618, 1618 ohms, etc. Finally, the end may be short-circuited or left open without any discernible change in the input resistance, and this covers all possible values of the "remainder of the line."

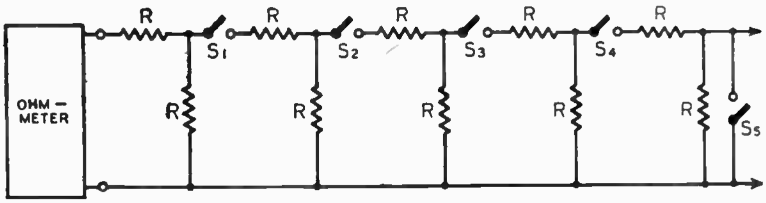


Fig. 3. Resistive "input impedance" model with a minimum of five sections to demonstrate that the resistance of the line settles down to a limiting value after the first few sections are switched in. R=1,000 ohms.

THE UBIQUITOUS JEEP—in this case a wireless-equipped version—just after it has been landed from a glider.

New Output Stage • Valve Load

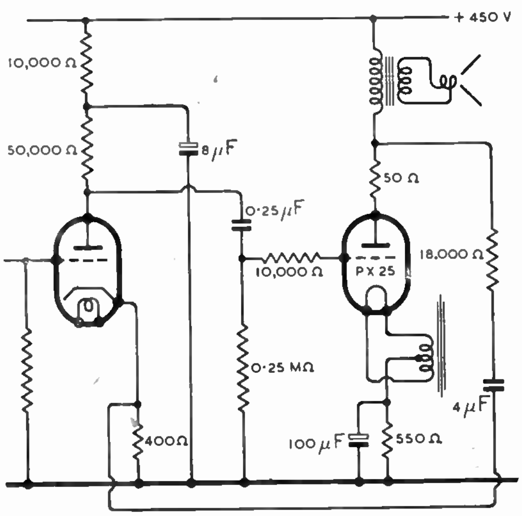
Cathode-follower Output Stage

THE recent contributions on this subject have testified to the remarkable improvement in quality which results when the loudspeaker is fed from a source of relatively low output resistance. I have felt for some years that this is perhaps the greatest advantage to be obtained from the use of negative feedback in audio-frequency amplifiers, and that the improvement in quality which results when feedback is applied to a pentode output stage is more often due to the improved loudspeaker damping than to the reduction of harmonic content which also occurs. This is especially true with the cheaper grade of loudspeaker, which usually has rather prominent resonances.

Messrs. Mitchell and Baker connect the output stage as a cathode-follower to obtain a low output - resistance. This seems to have some disadvantages. The input signal to the stage must be somewhat greater than the output voltage across the load impedance, and as this is usually of the order of 200V at maximum output, considerable output is required from the previous stage. An output of this order can only be obtained with difficulty and at the expense of considerable distortion, and may necessitate transformer coupling. The heater of the output valve must have a separate, well insulated transformer winding, and a pentode cannot be used as a cathode-follower, as it is automatically triode-connected. These latter disadvantages restrict the use of such a stage to equipment intended for AC operation.

All the disadvantages may be overcome by feeding back over two or more stages, the performance being unimpaired, or even improved if desired. To illustrate this, a circuit of this type is shown in the accompanying figure. A single PX25 is used in the output stage: the penultimate stage is a valve of the AC2/HL class. Under normal conditions the output is some 6 watts into a load of 3,200Ω, the output resistance being 1,265Ω. Connected as a cathode-follower the PX25 has an ouput resistance of about 120Ω and requires a grid swing of some 230V peak for full output.

With the component values shown in the figure the output resistance of the PX25 is about 100Ω and the input signal for full output is 5V peak. The penultimate stage only has to provide the normal swing of 35V peak to the PX25. All forms of distortion will be reduced to extremely small proportions by the heavy feedback, which in this case is taken from the anode of the output



valve. If a push-pull output stage is used, the feedback voltage could with advantage be taken from the output transformer secondary.

It seems unlikely that any material advantage will be secured by reduction of the output resistance below one-tenth of the load impedance, a value which is easily arranged even with a pentode output stage.

D. T. N. WILLIAMSON.
London, W.14.

Optimum Load

THE formally correct result derived by Dr. Sturley (your May issue) and your correspondent Mr. Date (July issue), optimum $R_l = 2R_a$, is true only for the arbitrary condition of fixed mean anode voltage (E_o) and with any value you like for the mean adone current (I_o).

Now within certain limits the most important condition for working a power output valve is that the standing anode dissipation ($E_o \times I_o$) should not exceed the stated maximum value. Using this more practical condition it will be found that at higher values of E_o greater power can be obtained with R_l considerably greater than $2R_a$. This has been shown by Prof. Howe in an interesting and lucid Editorial in *Wireless Engineer*, February, 1943.

E. F. GOOD.
Malvern Link, Worcs.

Television Priority

MAKING proposals for the future of television is an amusing pastime for those of us who are interested in the technicalities; and when so much of current radio work is veiled in official secrecy, no one need grudge the space devoted to this topic in *Wireless World* and elsewhere. But, although I have indulged in this pastime myself (hoping that when we do get British television again it will not be on an obsolete system and the lowest definition in the world), I have also said that I do not seriously consider that television should be given a high priority in the immediate post-war period (discussion on Edwards' I.E.E. paper, 23/2/44). Most of Europe will be lacking both the personnel and equipment for training the coming generation of scientists, and will be short of factory capacity of every description; the rehabilitation of the devastated countries, many of which Britain claims as Allies, should then have first call on our trained scientists and manufacturing facilities rather than luxuries such as television. I hope, therefore, that when the report of the Television Committee is issued, it will be accompanied by a statement from the Minister of Reconstruction showing clearly what degree of priority is to be given to television and indicating what other work is to be allocated to the radio and communications industry.

D. A. BELL.

London, N.21.

Standardisation of Resistors

As far as we are informed, standardisation of radio resistances has been brought about by dividing the range between 10^n and 10^{n+1} ohms into 12 parts so that the ratios of consecutive resistance values are approximately equal. Thus the values between 10 ohms and 100 ohms are:

10, 12, 15, 18, 27, 33, 47, 56, 68, 82, 100

with a ratio varying between 1.18 and 1.25.

Was it really necessary to take the number 12 as the basis of this standardisation? Choosing 10 intervals instead of 12 corresponding to the values,

10, 12.5, 16, 20, 25, 31.6, 40, 50, 63, 80, 100,

would result in the following advantages:—

(1) The series of values corresponds to the decibel system with which most communication engineers are already familiar.

(2) The series contains round values such as 20, 25 and 50, which were used before the "standardisation."

(3) To every resistance value there is twice the value and half the value in the series.

(4) The ratios of consecutive resistances differ less from each other (variation 1.25-1.28).

(5) Every resistance can be characterised by two figures, the first indicating the "sub-series" in which the value occurs (0 for 1-8 ohms, 1 for 10-80 ohms, 2 for 100-800 ohms, etc.), and the second indicating the position within this sub-series (0 for 1, 10, 100 . . ., 1 for 1.25, 12.5, 125 . . ., 2 for 1.6, 16, 160 . . ., etc.). Written with a decimal point, these two numbers are very nearly equal to the logarithm of the resistance value. For example, 4.3 represents a resistance of 20,000 ohms, this value being No. 3 in sub-series No. 4, and log 20,000 equals 4.3. The same scheme could also be used for a simplified system of colour coding requiring only two dots for the whole range from 1 ohm (0.0) to 8,000 megohms (9.9).

W. BOWEN.

Bowen Instrument Company, Leeds.

BOOK RECEIVED

Classified Radio Receiver Diagrams. By E. M. Squire. An analysis in diagrammatic form, with explanatory text, of the various sections of typical receivers. A start is made with aerial input circuits, passing on through RF and IF amplification, detection and frequency changing to the various forms of AF and output stages. Auxiliary sections, such as power supplies and tone controls, are included, but not complete receiver circuits. Pp. 164, 332 figs. Sir Isaac Pitman and Sons, Parker Street, Kingsway, London, W.C.2. Price 10s. 6d.

RANDOM RADIATIONS

By "DIALLIST"

The Rectifier Problem

LAST month I gave a problem, sent in by a reader, concerning a mercury arc rectifier of the bi-phase type supplying 100 amperes. It was this, if you remember: The current in each anode lead is in the form of square pulses of 100 amperes. As the frequency of the AC supply is 50 c/s, the pulses have a duration of 0.01 second and the interval between pulses is also 0.01 second. Would 50-amp cable be permissible for the anode leads? Here is what my correspondent says: "At first sight the proper rating of each cable would appear to be half the value of the total current, i.e., 50 amps.; but from the heating point of view we must consider the RMS value. Over half a cycle the square of the current is 10,000 amps; therefore, over the whole cycle it is half of this and the heating value of the current in each lead is $\sqrt{5,000}$, or 70.7 amps. The consequences of using cable just capable of carrying 50 amps. might therefore be serious. The effect is even more surprising in a polyphase rectifier, where the gaps between pulses are longer than their duration."

□ □ □

Motors and Interference

READERS would, I am sure, be grateful to N. F. T. Saunders for his able article on induction motors in last month's issue. The subject is one which is poorly dealt with in not a few electrical text-books. I am convinced by what he writes that this type of motor is not suitable for certain kinds of domestic appliances; but there are many domestic gadgets in which it could be used, but is not. Where the commutator motor is the only one that will fill the bill designers of apparatus know perfectly well that, unless it is provided with some form of suppressor, it is certain to cause interference with radio reception. I blame them, therefore, and the firms for whom they work for not taking the necessary precautions. What does seem to me the height of folly is this: you have big electrical manufacturing concerns turning out for the domestic market many kinds of appliances, including wireless receiving sets. Interference from their sewing machines, cocktail mixers and what not spoils the performance of their radio receivers; yet they seem content to go on producing interfering machinery and spoiling their own market. And in the shops you will find the same queer state of affairs. The man whose main trade is in the sale of wireless sets—and who hopes to do good business in television receivers after the war—supplies and urges his customers to buy household apparatus which is bound to make a nuisance of itself. It would be little more of an incongruity if the motor car manufacturers and the garage proprietors banded together to do all they could to make the roads as bad as possible for motorists! So long as the radio industry goes on fouling its own nest no real solution of the interference problem is in sight.

□ □ □

Jelly-acid Accumulators

UNTIL recently I have had little practical experience of the jelly-acid breed of secondary cell, having always used those with honest liquid electrolyte. But my better half invested in a couple of "jellies" for the battery-operated portable that is dear to her heart, and when I came home on leave I was invited to see whether all was well with their health. The twain, by the way, are not used as a pair in the set; whilst one is doing its stuff there, the other is being slowly refilled by a trickle charger. Examination showed that neither was all that it should be. There was some bulging of the celluloid case and the jelly within looked dried up and showed cracks in places. I gave both a good topping up with water and that seems to be the great tip. Now they get it regularly and it's surprising how much they drink. I'd be grateful for any hints on looking after these things from any reader who has had practical experience of their little ways.

□ □ □

"Civilian" Sets

I HAVEN'T yet had the chance of putting one of the new War-time Civilian Receivers through its paces, but from what I have read and heard of them I gather that they will do satisfactorily all that is needed in wartime reception. The great point is that there are to be receivers available to replace some, at any rate, of those now so ancient that not even the most skilled and willing of servicemen can keep them in working order. The simple standard design, involving the use of comparatively few types of components and valves, will ease manufacturing difficulties, and it is good to learn that ample supplies of replacement parts will be available. These sets cover only the medium-wave band, but that is of no great moment to-day, for there is nothing on the long waves likely to attract the average listener. Nor, I think, will he feel the miss, as the Irish say, of the kind of short-wave gear that was provided in the typical medium-to-low-priced sets of pre-war days. With the crude tuning arrangements with which these were fitted reception of any but the easiest and most loud-voiced of short-wave stations called for far more skill and patience than their owners normally possessed. Hence, after the first week or two the short-wave range was seldom, if ever, used. The only thing I don't like about the new sets so far is their price. Even when purchase tax is taken into consideration, the figures fixed by the powers-that-be do seem rather on the high side for single-range mains or battery receivers.

□ □ □

Down, but Not Out

GOING out into the garden after breakfast the other morning, I found my aerial wire lying in loops and coils on the lawn. There had been during the night one of those tearing winds that have been such a feature of this war and that had proved too much for the supporting wire at the far end. Well, it had not done badly. I put it up nearly six years ago and as I have been away, except for the usual all-too-brief leaves, all the war, it has had no attention at all. I was surprised to find that the enamel covering the phosphor-bronze strands of the aerial itself was as good as new—not a chip or a bare patch to be found anywhere. What had given under the strain was the badly corroded steel supporting wire. Well, one's always learning. When I put that aerial up again on my next leave I will use enamelled phosphor-bronze wire for suspending purposes as well as for the aerial itself; it seems to be entirely weatherproof.

□ □ □

Valve Multiplicity

THE absurd number of valve types that there are in use to-day in domestic wireless receivers was brought home to me the other day when I was talking to one who deals in them. "In my small shop," he said, "I've over 1,500 in stock and I've nothing like one of each." It does seem a pity that we can't decide to standardise a comparatively small number of types and to turn our attention to producing these cheaply and with high quality. The actual types needed for producing good domestic receivers at all prices are very few indeed. Add communications receivers and sets designed for high-quality reproduction and the number of really necessary valve types remains quite reasonably small. Yet we go on producing new kinds, many of which hardly justify their existence, and continuing to manufacture old-fashioned types, whose production should have ceased long ago. Some day, I suppose, we'll come to our senses. Then valve prices will come down with a run and the big efficient set will become popular, for purchasers will no longer be deterred by the nightmare cost of possible valve replacements. Nor shall we find people putting up with the horrid performance of worn-out valves for the very good (or very bad !) reason that to replace them would come to more than the present value of the receiver.

□ □ □

Good Neighbours !

ONE of the many attractive qualities of my nearest neighbours is that they are old-fashioned folk, who are rather afraid of electricity and won't have it in the house. That, you may exclaim, is a nice thing for one who makes his living out of electricity to say ! At first sight it is ; but wait a moment. One friend of mine, a burning radio enthusiast, moved some time before the war to the country. Almost the first thing he did to the jolly little house he bought was to install electric lighting and power. A little later, when he had got to know his neighbours, he urged them to banish the smells and the dirt of gas lighting and to do likewise. Fired by his words, they did. As time went on, they became even more enthusiastic about electricity than he was. The husband showed him with pride an electric razor ; the lady of the house indulged in an orgy of spending, putting in a vacuum cleaner, an egg whisk, a refrigerator, a hair-dryer and goodness knows what else. Gone was my friend's peaceful enjoyment of his communication receiver. As he put it, whenever the husband wasn't shaving or his wife drying her hair, the cook appeared to be beating eggs or the housemaid vacuum-cleaning. Yes, things being as they are in the matter of interference, *my* neighbours can't be too fond of gas or too shy about electricity for my liking !

GOODS FOR EXPORT
The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

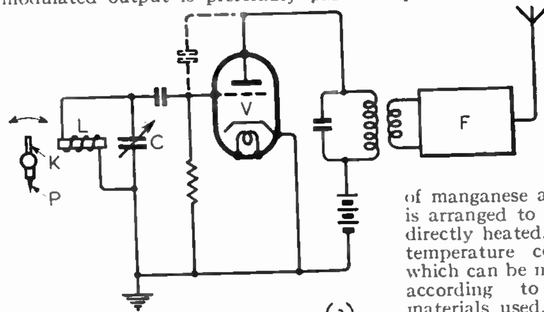
RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

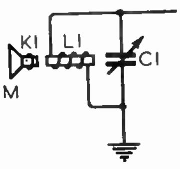
FREQUENCY MODULATION

DIAGRAM (a) shows an arrangement in which frequency modulation is produced by the action of a gramophone pick-up on the tuned grid circuit of a valve oscillator V.

A single short-circuited coil K, mounted on the upper part of the pick-up P, is vibrated by the stylus relatively to the coil L, so as to vary the tuning of the grid circuit LC, and therefore the prevailing frequency of the oscillations generated by inter-electrode feedback. The frequency-modulated output is preferably passed



(a)



(b)

Electro-mechanical frequency modulation (a) with a gramophone pick-up and (b) with a moving-coil microphone.

through a frequency multiplier F to increase the available bandwidth before the signal is radiated.

In diagram (b) the pick-up is replaced by a microphone M resembling a small loudspeaker, the apex of the diaphragm being provided with a small short-circuited coil K1 which serves, as before, to vary the instantaneous tuning of the input circuit L1 C1.

Philco Radio and Television Corpn. (Assignees of R. B. Albright). Convention date (U.S.A.) June 13th, 1941. No. 558680.

MUTING CIRCUIT

IN a known arrangement for shutting out "inter-station" noise during the process of tuning, the cathode of a diode rectifier is given a positive bias sufficient to block the passage of any signal below a certain threshold value. For signals above this level of strength, reception is normal.

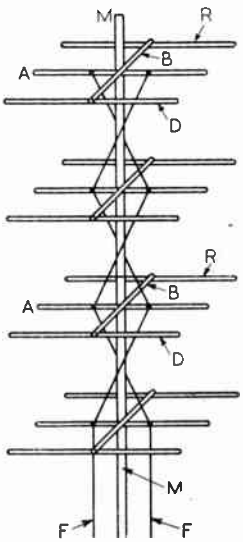
A circuit of this kind is now modified by including a thermally sensitive device, or Thermistor, in series with the potentiometer from which the cathode bias of the rectifier is taken. The heating element of the Thermistor is coupled to, and energised by, the output from the AF amplifier. Initially the circuit operates to exclude background noise, as explained above. However, as soon as a worthwhile signal starts to pass through, a part of the AF amplifier output is fed back to heat the Thermistor. The effective resistance of the latter is thus reduced, so that the original bias on the rectifier-cathode falls and the AF output rises to supply still more heat to the Thermistor, the cycle being repeated until a state of equilibrium is reached. A desired signal is thus sharply lifted to normal strength, and any tendency to distortion is reduced.

The sensitive element of a Thermistor usually comprises a mixture of manganese and nickel oxides, which is arranged to be either directly or indirectly heated. The device has a high temperature coefficient of resistance, which can be made positive or negative according to the proportions of materials used.

Standard Telephones and Cables, Ltd.; P. K. Chatterjea and C. T. Scully. Application date July 9th, 1942. No. 558598.

DIRECTIVE AERIALS

A SHORT-WAVE aerial system is designed to combine the directional properties of the ordinary stacked array with those of the known Yagi arrangement of reflectors and directors and to give better directional qualities with simpler mechanical construction.



Directional aerial array.

Four units are mounted, one above the other, on a single mast M. Each unit comprises an energised dipole A which is backed by a reflector R and faces a director D, both the latter being energised by radiation alone. The units may be spaced apart vertically by half a wavelength, in which case the separate limbs of each dipole are connected to crossed feeders F as shown; or the units may be separated by a wavelength and supplied by parallel feed lines.

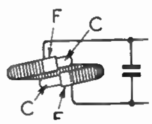
The reflectors and directors are supported at their centres by cross brackets B, all carried by the same mast. Several such stacks are erected side by side to form a complete array, and are energised in phase for directional radiation.

Marconi's Wireless Telegraph Co., Ltd., and E. Green. Application date May 21st, 1942. No. 558852.

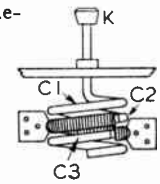
PERMEABILITY TUNING

THE inductance coil is wound over a hollow former F, diagram (a), of insulating material, made in the shape of one complete helical turn, through which the solid core C slides. As compared with a fully closed toroidal winding, the separation between the two ends of the inductance is stated to be advantageous because

Toroidal-type permeability tuners.



(a)



(b)

it reduces the overall distributed capacity of the coil, and so improves its "Q" factor. At the same time, the magnetic reluctance of the air gap is comparatively small. An inductance variation ratio of 11:1 is claimed for this form of construction.

Diagram (b) shows an arrangement in which the sliding core is made in three sections, each of different material. The middle part C2 consists of powdered iron (or of magnetite for short-wave working); whilst the outer part C3 is made of copper, to ensure a higher inductance change towards the limit of the tuning range. The part C1 is of insulating material, and serves to transmit the thrust from a control knob K. Using a magnetite core, the arrangement is stated to cover twice the tuning range given by a straight solenoid winding of equal size.

Marconi's Wireless Telegraph Co., Ltd. (Assignees of R. L. Harvey). Convention date (U.S.A.) May 31st, 1941. No. 559330.

The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

NEW RECEIVERS AND AMPLIFIERS

30-WATT ac amplifiers, precision built instruments, input and output channels to requirements; early deliveries.—Below.

150-WATT racks, comprising 5 amplifiers as above intercoupled, fitted for remote control for industrial installations; send for full details and illustrations; complete equipment, including speakers and microphones, etc., available.—Below.

18-WATT ac/dc amplifiers, mixing input channels, bass and treble controls, input and output transformers; 18gs.—Below.

DANCE and stage transportable equipment, comprising 18-watt amplifier as above, m/c mike, adj. stand, 2 speakers, cables; 36gns. —Broadcast & Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich. [2024

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H.P. RADIO SERVICES, Ltd., offer Philips 11v television chassis, complete with mains equipment and scanning assembly, no valves (ex 100gns receiver), £12/10; new radio chassis, comprising 7 screened coils, 31 condensers, 30 resistors, 8 octal valve holders, volume control, etc., 29/6; 5-watt ac/dc amplifier, 3-valve chassis type, including valves, £6/10; new Crosley 2-waveband car radio, all suppressors, etc., 16gns; Ward under car aerials, 18/6; Meico moving coil microphones, 5gns; Meico microphone transformers, 12/6; Dubilier 2mfd 650v block condensers, 4/-; volume controls, all values available, with switch 5/6, without 3/9; high grade mains transformer replacement bobbins, 4v or 6v, 19/6; mains transformers, reliable make, 30/-; specify 4v or 6v heaters, 8in P.M. speakers, 19/6 (limited supply); car radio distributor suppressors and plug suppressors, each 2/6; dynamo condensers, 3/-; bell transformers, 5/11; 1,000-watt kettle immersion elements, 19/6; list 1d.; s.a.e. with enquiries; prompt attention.—H.P. Radio Services, Ltd., 55, County Rd., Liverpool, 4 (Est. 1935). Tel. Aintree 1445. [2929

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HALLICRAFTER SX.17, with matching speaker, practically unused, in perfect condition, spare set of valves available; offers invited.—Box 3170. [2905

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GOOD short wave battery set; would trade H.M.V. Autochange record player, ac.—Millard, 42, Carr Lane, Hull. [2894

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NEW Broadcast P.M. loud-speakers, 3 models: 12in 12watt 15,500 lines, 1¾in dia, voice coil; 12in 25watt 18,000 lines, 1¾in dia, voice coil; 15in 40 watt 18,000 lines, 2½in dia, voice coil; machined and precision built instruments, Ticonal magnets, detachable diaphragms, die-cast chassis, uniform response, superior standards in fidelity, sensitivity, accuracy, tonal quality, appearance and finish; prompt deliveries; specifications and illustrations upon request.—Broadcast & Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich. [2537

£5/15 only.—Brand new Baker super Quality 12in Auditorium permanent magnet speaker with triple cone, manufactured by Bakers Selhurst Radio, the pioneer manufacturers of moving coil speakers since 1925, wide frequency range, even response, ideal for quality reproduction, fitted with magnet having exceptionally high flux density in the air gap, suitable for public address equipment when quality reproduction is first consideration; send 2½d. stamp for leaflet giving details of above and constructional details of a new acoustic chamber designed to extend loud speaker frequency range; also constructional details of an infinite baffle cabinet; every music lover interested in realistic reproduction should write for leaflet.

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Wanted

VOIGT cornerhorn cabinet wanted (not home constructor).—Box, 3162. [2872

EPOCH Domino, or 99½K or Rola G.12. 15 ohms, s. coil, energ. 1,000-1,500 field.—Crabb, Goonhavern, Truro. [2934

WANTED privately, Baker triple cone, 10in dia. approx. 2,000 ohm field, speech coil, 2.5 ohm.—Kaye, 34, Leyborne Park, Kew Gardens, Surrey. [2803

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ALL types of rotary converters, electric motors, battery chargers, petrol-electric generator sets, etc., in stock, new and second-hand; supplied against priority orders only. WARD, 37, White Post Lane, Hackney Wick, E.9. Tel. Amherst 1393. [1988

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ROTARY converters in stock: edc, 32v, 50v, 110v and 230v dc inputs, 230v ac 250 watts output, £12/10 each; Janette 110v dc/ac, 500 watts, £15; Crypto 200/110v dc/ac, 500 watts, £15; Crypto 75/230v dc/ac, 1,500 watts, £25; Crypto 250/110v dc/ac, 1,500 watts, £25; Crypto 200/100v ac/dc, 100 watts, £5; 100/70v ac/dc, 70 watts, £4; 110/6/8v 14 amps dc/dc, £5; several others available; lists available, stamp please; also dynamos, motors and lighting sets.—Harris, Strouds, Bradfield, Berks. [2924

Wanted

WANTED, rotary converter, any size.—Hull, 221, City Rd., London, E.C.1. [2428

WANTED, rotary converter, input 110 volts dc, output 250 volts ac at 120 watts.—Write Box 3175. [2931

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AVOMETER, Model 40, brand new, in case; best offer secures.—Box 3169. [2903

HUNTS capacitor analyser, £16; Avo valve tester, £18; Radiolab valve and set tester, £18.—Horwood, 4, New Houses, Headcorn, Kent. [2917

FOR sale, contents of radio laboratory, including specially made test benches, multi-range meters, signal generators, etc., all virtually unused.—Box 3165. [2898

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Wanted

AVOMINOR Universal required, in good condition.—Box 3179. [2937

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AVOMETER, Model 7, urgently wanted, new preferred, second-hand if guaranteed; state price.—Box 3167. [2901

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VORTEXION mains transformers, chokes, etc., are supplied to G.P.O., B.B.C., L.P.T.B.; why not you? Imitated but unequalled; orders can only be accepted against Government contracts.

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MORSE practice equipment for class-room or individual tuition; keys, audio oscillators for both battery or main operation.—Webb's Radio, 14, Soho St., London, W.1. Tel. Gerrard 2089. [2291

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PRICE list 1d.; unequalled range; example, Yaxley 4-bank 6-way switches, 5/6.—Taylor, Macaulay St., Huddersfield. [2907

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INVISIBLE RAY CONTROL Photo cell Raycraft Set with bakelite selenium bridge, 10,000 ohm sensitive Relay, megostat, etc., with booklet. 42/-.

EMERGENCY CRYSTAL SETS, all first class and aerial tested.

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TAPPING KEYS. Bakelite, 5/-. Wood base B2, 9/6. Operators' plated on mahogany, 9/6. American type swan neck, 8/6. Galvo. Keys, Gambrell single, 10/-.

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MICROPHONE capsules by Standard Telephones, 3/9 ea.; Centralab vc, less switch, long spindles, 5,000ohms, ½meg, 3/9 ea.

INPUT strips, 2in×¾in, 2-way, 2/6 dozen; with terminal screws, 3/3 dozen; anchor or mounting strips, 2/3 dozen, 5-way.

SPECIAL offer T.C.C. double mica cond. 0.0001×0.0001 five (ten condensers) for 1/3; Hunts 0.01 mica cond., 1/- ea.; hf chokes on ebonite bobbins, 5,000ohms, 1/3 ea.

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CELESTION speakers 10in p.m., with trans., £2; 8in p.m., less trans., 21/-; 6½in p.m., with trans., 27/6; 6in Goodman, less trans., 22/6; mains energised 2,000 ohm field, with trans., 30/6.

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TUNING condensers.—0.0005, 3-gang American, 8/6; 4-gang, 8/6 (large screened type); wavechange switches, Yaxley type, 2-pole 4-way, 2-pole 3-way, 4-pole 2-way, 3/6 ea.

VALVEHOLDERS.—British, 5, 7 and octal, American 4, 5, 6, 7 and octal, 7/6 doz.; grid connecting clips, 1/- doz; tinned copper wire, 16swg, 18, 20 and 22, 2/6 per ½lb reel; twin screened sleeving, 2ft lengths, 1/- ea.; wander plugs, red and green, 2/6 doz; spade terminals, red and black, 2/9 doz.

MAINS droppers, with var. taps and feet, 850 ohms, 0.3 a, 5/6; 1,000 ohms, 0.2, 4/6; Little Maestro type (no feet), 5/6; the three for 12/6; Telsen loudspeaker units, 5/-; Telsen S.M. disc drives, 2/-; assorted Mansbridge condensers, 600v test, 6/- doz.

THIS month's special offer.—Screened h.f. chokes, resistance 200 ohms, ex Ekco, 1/- ea. For volume controls, tubular and mica condensers, etc., see advts. June and July issues. Terms: cash or c.o.d. over £1.—Charles Britain Radio, (temp. address) "Eureka," Surrey Gardens, Effingham, Surrey.

LONDON CENTRAL RADIO STORES.—See our displayed advert., page 14, this issue.—London Central Radio Stores, 23, Lisle St., London, W.C.2. Ger. 2969. [2359

NICHOLSON RADIO, 95, Upper Bristol Rd., Weston-super-Mare, offer the following goods: Mains transformers, condensers, resistors, volume controls, cathode ray tubes, speakers, etc.—Send s.a.e. and 1d. stamp for full list. [2921

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100% British Design **100% British Made**

Answers all OHM'S LAW problems—for example:

What will be the voltage when current I flows through resistance R?
What will be the voltage with watts value W and I current flowing?
What is the current flowing where watts value is W and voltage is E?
What current will flow through R resistance where voltage is E?
What will be the resistance where current I flows at voltage E?
What will be the resistance where watts W is at voltage E?
What will be the resistance where watts W is at current I?
What is the wattage at voltage E through resistance R?
What is the wattage of current I through resistance R?
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The scales read from 1 millivolt to 1,000 volts. From 1 ohm to 1,000,000 ohms. From 1 milliamp to 10 amperes. From one-tenth of a milliwatt to 10,000 watts.

FULL INSTRUCTIONS WITH EACH INSTRUMENT.

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Order at once whilst deliveries are good

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Small 2 mfd. block paper Condensers, 700 v.w., at 2/6 each.

THIS MONTH'S SPECIAL OFFERS

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SPECIAL BARGAIN FOR SET BUILDERS

Grey cellulosed steel radio chassis, including 27 mica condensers, 30 resistances, tubular condensers, 8 mfd. 500 v. condenser, 8 octal valve holders, volume control and screened coils, with trimmers, etc., etc. Size, 8in. x 12in. x 1½in. Price £1 9s. 6d., plus postage.

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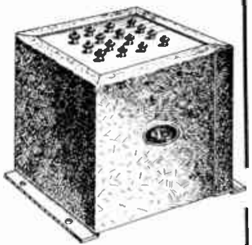

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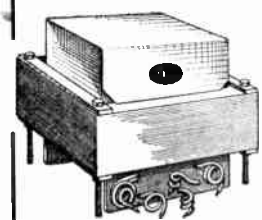

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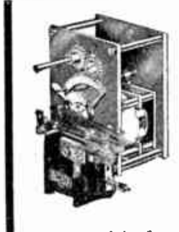

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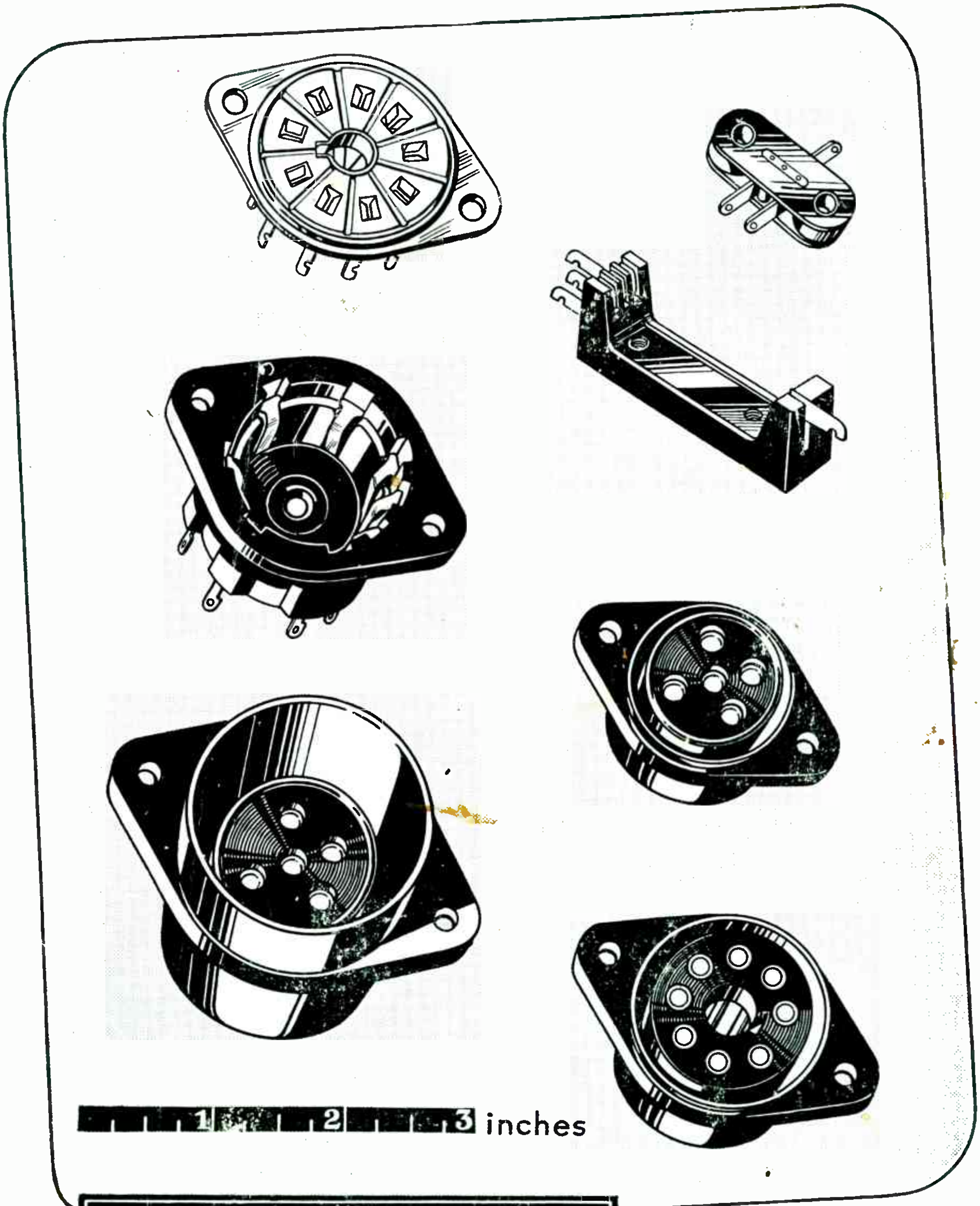
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