Wireless World

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Television in the Cinema

COMMENTING on the Beveridge Report, which was issued just before our last issue appeared, *Wireless World* expressed general approval of the basic findings of the Committee. We have since seen no reason to change that opinion, but there are one or two secondary matters that have been accorded unsatisfactory treatment. These should be discussed before the Report is debated in Parliament.

The worst case is that of television in the cinema. Here the issue has been confused to such an extent that, unless we believed that everyone concerned had been actuated by the best motives, we would be tempted to say that the majority of them have been party to a conspiracy to fog the real issues. The real point, made by a correspondent whose letter appears on another page, is that basically cinema television has nothing to do with broadcasting, the B.B.C. or, for that matter, the Beveridge Committee. It is mainly a matter of point-to-point communication, either by wire or wireless, and so comes under the monopoly of the Postmaster General.

One might expect at least that the Post Office evidence would have helped to dispel the fog. On the contrary, it goes a long way to make it more dense, though the extremely cautious memorandum submitted by the G.P.O. to the Committee sets out to explain the issues under discussion. As an example, we may cite the Post Office description of a hypothetical radio system comprising a station feeding a group of cinemas in a fair-sized town. It is stated that such a system "would, in effect, amount to something very like broadcasting." We can find in the Final Acts of the Atlantic City Conference no justification for that view, and contend it is no more like broadcasting than, say, the service conducted for passenger liners, which transmits news bulletins by radio telegraphy to a designated group of ships which subscribe to the service. In fact, it is less like broadcasting, in any sense of the term, as the hypothetical television station mentioned would confine itself to a 10-degree beam.

The Post Office then raises in its memorandum the bogy of unauthorized interception by the public of cinema television transmissions. This has been swallowed hook, line and sinker by the Beveridge Committee. In the Report it is said "there is nothing wrong in allowing a member of the public to catch (*sic*) at home if he can a transmission directed to a cinema." As to whether it is right or wrong raises ethical issues that we cannot discuss here, but it is certain that it would be illegal and contrary to the terms of the broadcast licence, which allows only the reception of authorized broadcasting stations. Undue fear of the bogy of interception would spell the end of all radio development.

In our view, the cinemas do not make out a good case for their natural desire to stake a claim in television, nor does the B.B.C. in its equally natural desire to avoid what it clearly (but we think wrongly) considers to be an encroachment on its monopoly. Of all the contributions to the evidence, that of Sir Robert Watson Watt (given on behalf of Paramount) stands out above the rest. After pointing out how the real problems have become confused, he goes on to say that "the B.B.C. has no *locus* as judge or negotiator in the claim that the Postmaster General should issue licences [to the cinemas]."

In spite of the large amount of space given to the subject of cinema television in the Report, the final recommendation does not, we feel, amount to very much; it certainly lacks the air of realism. The recommendation is that the P.M.G. should, if channels can be made available, grant licences to responsible bodies to transmit pictures for public showing. The pictures thus transmitted would have to be made available to the B.B.C. and others on terms approved by the P.M.G. This seems to be a very unattractive arrangement from the point of view of the cinemas, and unlikely to introduce any real competitiveness in the field of television.

We do not hold any special brief for the cinemas in the matter of television; our sole concern is that unnecessary barriers should not be placed in the way of development of what may well become an extremely important extension of the radio art.

Stereophonic Sound

By J. MOIR,* M.I.E.E.

A Review of the Basic Principles Involved

IT is difficult to decide whether Mother Nature has provided us with two ears as an insurance against total disablement through damage to a single organ, or whether she finds justifiable advantages in the additional information obtained as a result of the duplication. Whatever the reason for their presence the possession of two ears enables a sound field to be sampled at two points spaced apart by the width of the head (about 21 cm) and this facility does undoubtedly have some advantage both practically and æsthetically. Without philosophizing as to whether the two ears are the result of the advantages they bestow or *vice versa*, attention will be concentrated on the limitations of our present "one-eared" reproducer systems and the possibility of overcoming them.

The advantage of two ears that is immediately apparent is that they are of immense help in locating the position of a sound source, giving the same three-dimensional significance to our acoustic environment as our two eyes give to the visible environment. Unless one has had the opportunity to listen monaurally and binaurally it is difficult to indicate the sacrifice that is made in accepting a monaural system, so recourse will be made to quoting some typical opinions by workers in the field. Thus J. P. Maxfield, of Bell Telephone Laboratories, has said, "I would rather hear 2-channel reproduction good to 6 kc/s than single-channel reproduction good to 15 kc/s. It is more pleasing, more realistic, more dramatic." Other engineers have suggested cut-off frequencies between 4 kc/s and 8 kc/s as the binaural channel bandwidth equivalent to a 15-kc/s monaural channel. However, it should be stressed that the difference is not really one that can be adequately expressed in terms of bandwidth, my own impression being that a monaural channel compresses a hemispherical world of action into a tunnel, cramping and confining the room dimensions.

Before proceeding it should be noted that for reasons that will become clear in later discussion, the limitations of a monaural channel cannot be assessed by stopping one ear with the finger.

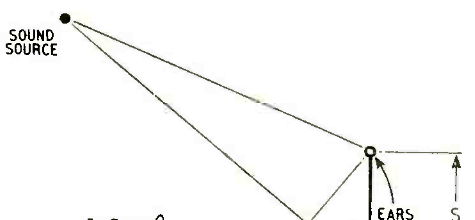

Fig. 1. Calculation of path length difference between source of sound and the two ears.

The differences, worth while or otherwise, between a monaural and a binaural (or stereophonic) system arise because the two ears sample the sound field at two points spaced apart by that obstruction known as the head. Sound from any source not situated in the vertical plane passing through the centre of the head will therefore reach the two ears with a time difference given by

$$t = l/34{,}300 \text{ secs.} \qquad (1)$$

where l is the difference (cm) in path length between the two ears and the source. This path length difference l, obtained as shown in Fig. 1, is given by $l = s \cos \theta$ where s = ear spacing and θ = angle to line through ears. The path difference is obviously a function of the displacement of the sound source from the median plane. This difference *and the presence of the head as an obstruction in the sound field* increase the information supplied to the brain in the following respects.

(1) For impulsive or transient sounds the initial wave front will strike the two ears with a time difference given by equation (1). The maximum time difference will occur when the sound source is in line with one ear and will be approximately equal to 0.00063 sec.

(2) For a repetitive signal such as a single musical note the instant at which the peaks of the waves strike the two ears will differ by the same time interval as for an impulsive noise, but if we assume (somewhat diffidently) that the ear cannot distinguish one peak from another only time differences corresponding to less than one cycle of the incident wave frequency will be significant. In this case it is conventional to refer to this as a phase difference between the sound reaching the two ears, one complete cycle being 360 degrees or 2π radians, though it should be noted that the differences listed as (1) and (2) are really manifestations of the same thing, a time difference.

(3) For any type of sound there will be a loudness difference between the sound reaching the two ears, this difference being due to the increased attenuation of the longer path to the farther ear.

(4) While the loudness difference due to (3) is not large, significant differences in loudness do occur when the sound is pure tone at frequencies over about 1,000 c/s or when the incident sound is complex and contains high frequency components. This loudness difference arises because the two ears are separated by the mass of the head, which introduces diffraction effects which are a function of the incident sound frequency.

Diffraction is a universal phenomena, which may be briefly explained as follows. A wave in water, air or any other medium will on meeting an obstruction "bend round" the obstacle to some extent, but in all cases the obstruction will cast a shadow on the side remote from the incident wave. The

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* British Thomson-Houston Company.

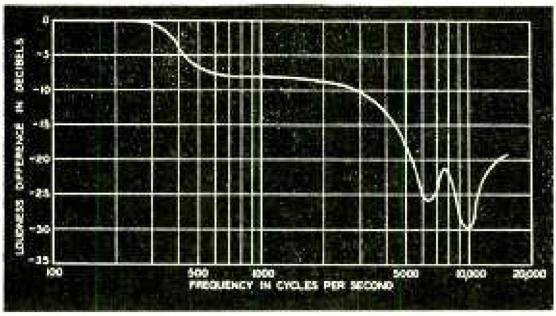


Fig. 2. Loudness difference produced in the right ear when a source of sound of pure tone is moved from the right to the left of an observer.

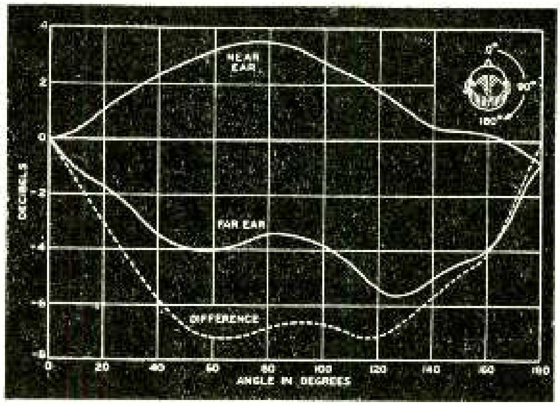


Fig. 3. Variation in loudness as a speech source is rotated in a horizontal plane around the head.

"depth of the shadow," i.e., the decrease in intensity of the wave, is a function of the ratio, obstacle-diameter/incident-wavelength, and is small when the obstacle has dimensions small compared to the wavelength. Where the obstacle is several wavelengths in diameter a strong shadow is cast. An exact calculation of the field distortion is a matter of extreme difficulty, but as in this instance the diffraction effect round an average head is our only interest, an experimentally determined curve Fig. 2* is of interest as showing the order of the loudness difference that results in the two ears as a source of tone is moved round the head.

The everyday sounds are mainly complex and the resultant loudness difference will therefore depend upon their frequency composition, but Fig. 3 indicates the sort of result that is obtained when a source of speech is rotated round an observer's head from front to back.

(5) As the diffraction effects are a function of frequency, the frequency characteristic as well as the loudness of a complex sound differs at the two ears. With experience monaural location is possible with one ear only, presumably due to these changes in character.

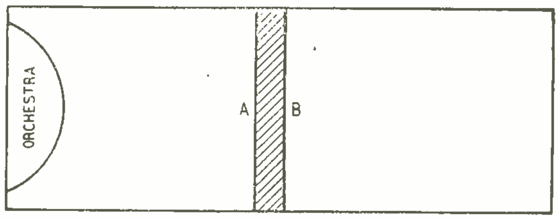
It was noted earlier that these differences vanish for sound sources lying in a vertical plane through the centre of the head, as all points in this plane are equidistant from the two ears, though some differences in character occur between sound arriving from straight ahead and straight astern due to diffraction effects from the ear lobes. The precision of location in the vertical plane is therefore rather low, though possible when the head is free to make some exploratory movements.

There are, therefore, at least five ways in which right ear sound may differ from left ear sound, and from these differences and some experience the brain is enabled to reconstruct the acoustic scene with surprising accuracy.

Current radio broadcast and recording techniques are almost exclusively monaural, using a single microphone and transmission channel. Spatial information on the sound source is almost entirely absent and angular localization impossible though localization in depth is still possible. Depth localization is almost entirely dependent upon the ratio of the reverberant to the direct sound reaching the ears and is largely independent of the possession of two ears. This ability is presumably the result of long experience and it is well confirmed by experiment.

* This figure, together with Figs. 3 and 5, are reproduced from *Bell System Technical Journal*, Vol. 8, April 1934.

Fig. 4. One method of stereophonic reproduction might be equivalent to picking up the original sound field existing at side A of a soundproof wall by a number of microphones, and reproducing it through a complementary series of loudspeakers on side B.



It should be noted that the use of two microphones connected in series or parallel at the studio end is of no value as an aid to stereophony, as the individual signals, though they may differ in phase and amplitude, lose their separate identity in the single electrical circuit. If this individuality is to be preserved, there must be two completely separate channels between the microphones and the listener's ears and this leads fairly easily to the simplest method (in some ways) of achieving stereophony. Two microphones, preferably non-directional, are mounted in a dummy head, the leads being carried back through separate amplifiers to separate earpieces worn by each member of the audience. This effectively transports each listener to the point in the sound field at which the dummy head has been placed and there is no doubt that the realism that can be secured by this means is really remarkable. The wearing of headphones is a habit that is unlikely to return and other means of achieving stereophony must be found if it is to be commercially successful.

Instead of transporting the audience to the sound field existing in the microphone position, the alternative approach of transporting the sound field to the audience would appear to have advantages. Referring to Fig. 4, showing a long hall divided by a transverse wall assumed to be soundproof, the problem would appear to be one of reproducing the sound field existing on side A, at side B. At a prohibitive level of expenditure, this end could be achieved if wall A were covered with microphones, spaced perhaps at one-foot centres, each individually connected through its own amplifier to a speaker located on wall B opposite the microphone. While this might be feasible if wire lines were the only connecting link it is obviously impossible where the sound must be recorded or a radio link must be used, and it is therefore necessary to consider means of simplification.

It was noted earlier that localization in the vertical plane is poor and this suggests that transmission of "vertical" information is perhaps unnecessary. On these grounds all but one horizontal row of microphones and speakers might be removed, a very considerable simplification that proves entirely successful. Pursuing a similar line, though possibly without the same soundness of reasoning, it is found that three channels can give very good stereophony, and even two channels can be made to give good results. Two or three channels are approaching commercial feasibility and it is therefore important to make an experimental verification of the limitations of each method. Bell Telephone Laboratories have studied these problems in some detail and Fig. 5, taken from a paper[1] by Steinberg and Snow, summarizes the results on some of the possible 2- and 3-channel systems.

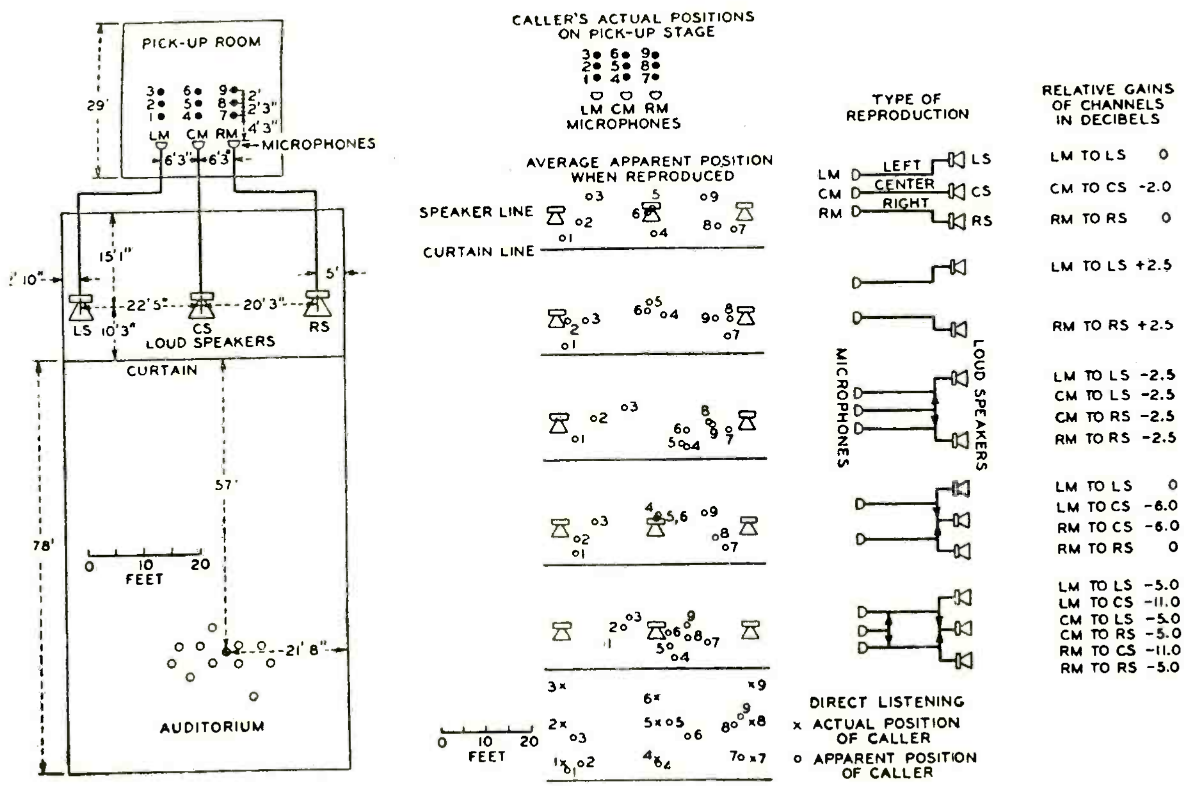
On the left is an outline of the test set up, the microphones being placed in a room 29ft square, the loudspeakers being placed on the stage in a small auditorium and concealed from the audience by a thin curtain. In all the tests a caller occupied fifteen positions on the stage in a random order, but always including the nine positions shown at the top, while the audience, seated in a group in the rear third of the auditorium, marked on a stage plan the apparent position of the caller on the virtual stage. As a final check the caller moved over to the auditorium and repeated his calling positions behind the curtain while the group attempted to locate his position, no electro-acoustic link being involved.

In the first test a straightforward 3-channel system was used, the results indicated opposite the system diagram near the top showing that localization was good, though the apparent width and depth of the stage were slightly reduced by the 3-channel link.

In the next test a straightforward 2-channel system was substituted, but the accuracy of localization decreased appreciably. Reduction in the number of channels has obvious commercial advantage and the three following tests were designed to evaluate the performance that might be obtained if the amount of equipment was reduced. In the simple 2-channel system it will be noted that the centre position suffers most, whereas the centre position is probably the most important of all in practice. The alternative layout tests were therefore mainly designed to pull the centre position forward into prominence. It will be seen that though none of the alternatives approach the performance of the 3-channel system, they do effect an improvement, but they do not represent all the possible alternatives, so it might be unwise to assume from these tests that there is no future in a 2-channel system.

[1] "Auditory Perspective—Physical Factors" by J. C. Steinberg and W. B. Snow, *Electrical Engineering*, Jan. 1934, and *B.S.T.J.*, April 1934.

Fig. 5. Diagram of arrangement (left) for sound localization tests and (right) the results obtained.



Two or three channels are a feasible proposition using magnetic recording on ¼-in tape to give two or three parallel tracks, and two tracks are possible on discs, using lateral modulation for one channel and vertical modulation for the second channel. The problem of radio transmission is a little more troublesome, largely due to the international difficulties, and it would appear that 2-channel transmission might only be possible in the medium-wave band if two stations were transmitting the same programme simultaneously. This is current practice and it would only require minor modification to radiate left ear programmes from, say, London, and right ear programmes from the Midland Regional station. For e.h.f. broadcasting stations the problems are less difficult; and there is the possibility of simultaneously modulating a single carrier with a number of channels. Without difficulty p.c.m. (pulse code modulation) could be adopted to provide two or three channels and in view of its high overall efficiency this would seem to merit particular attention.

As it is not the purpose of this article to go into details of the equipment but to concentrate on the fundamental of stereophony it will be concluded with a return to the question, "What makes it stereophonic?" Earlier it was shown that the two spaced ears or microphones produced signals which differed in at least five respects, and it is interesting to speculate on the relative importance of the individual contribution to the overall result. It is all the more interesting because there appears to be singularly little agreement on the subject, some authority could be quoted to show that the main factor is any one of the five points discussed, so readers may justifiably feel that the next section lacks precision.

Considering first the response to pure tones, there can be little difference in the amplitude of the left and right ear signals in the low-frequency range. The head represents an obstacle only a small fraction of a wavelength long at, say, 100 cycles, so diffraction differences must be insignificant. If the brain cannot distinguish the peak of one cycle from another, wave-point differences would appear to contain no useful information and the brain is left to estimate position from the phase difference at the two ears. There appears to be no reason why this should not be at least partially satisfactory.

With increase in frequency a point is approached at which the ear spacing is one wavelength and just beyond this the ears may each have the same signal phase but displaced by exactly 2π radians, i.e., the two ears are "on" the same points on successive cycles. Ambiguity will occur between this frequency and a half this value, and, as the mean ear spacing is approximately 21 cm, phase would appear to be of doubtful value as an information carrier above perhaps 700-800 c/s. However, it is just in this region that diffraction effects are commencing to produce significant intensity differences, as reference to Fig. 2 will show, and thus it would appear that on single tones phase is important in the low-frequency range, up to 700-800 c/s, with intensity difference playing the significant role above this frequency.

The more common noises do not have the simplicity of a single-frequency tone and on complex sounds, other factors are probably of importance.

Loudness differences at the two ears will be greatly magnified owing to the large reduction in the intensity of the high-frequency components at the far ear, while the character of the sound at the two ears will also differ appreciably due to the same cause.

On transient sounds, the time of arrival of the wave front at the two ears will also show significant differences, and, as sharpness of wave front indicates the presence of high-frequency components, intensity and character differences will also be produced.

It would appear that all the five effects listed may make significant contributions to the localization of the more usual sound sources, the contribution due to phase difference at the lower frequencies probably being of the least importance.

Further improvement in the quality of reproduced music due to improvement in frequency response seems remote, and it may prove that more acceptable improvements are achieved by diverting our efforts to the problems of stereophony.

Electronic Photography

Image Converter Tubes Used for High-Speed Phenomena

UNTIL now, much of the fame of the image converter tube has rested on its ability to see in the dark objects which are illuminated only by infra-red radiation, and this ability has been exploited in various ways in war-time to enable observations to be made at night without the aid of a tell-tale searchlight. The photocathode of an image converter, unlike the human eye, is sensitive to infra-red radiation, and when the infra-red image is focused on to it electrons are released in a corresponding pattern. These are focused into a beam either electrostatically or electromagnetically and are accelerated, after which they impinge on a fluorescent screen and so create a visible reproduction of the original invisible image.

A further possibility inherent in the tube is that the electron beam can be deflected and chopped, and this is now being utilized in high-speed photography for doing electronically what mechanical devices have so far failed to do. With the normal cameras for photographing high-speed motion, writing speeds of up to 2,000 metres per second have been achieved, but with the use of the image converter, this upper limit can be increased to as much as 100,000 metres per second. J. A. Jenkins, of the Mullard Electronic Research Laboratories, described two methods of application in a lecture he gave at the Engineering Centre, Glasgow, last September. In one, the phenomenon to be photographed is seen from behind a narrow slit, an image of which is focused on to the photocathode of the converter tube. The resultant electron image of the slit is then broadened out into a rectangle by back-and-forward deflection, as given by the time-base of an oscilloscope, so that a time axis is applied to the phenomenon and the tube screen presents a two-dimensional picture which can easily be photographed. In the other method a series of separate pictures are produced on the screen by deflecting the electron image from one position to another and, during movements, shutting off the electron beam by suitably pulsing the tube voltages. The screen of the converter is photographed by an ordinary camera in both methods.

Magnetic Recording Tape

Characteristics Considered in Relation to the Recording Process

By H. G. M. SPRATT,* B.Sc., M.I.E.E.

WHILE it is necessary to go back to the beginning of the century to trace the origins of magnetic recording, modern technique, which exploits the advantages of high-frequency bias, can be said to date from the development of the German "Magnetophon" equipment during the last war. From that time onwards, one outstanding advance alone has taken place, namely the introduction of higher-coercivity materials. This article will try to give as comprehensive a description of magnetic tape as is possible in the space available and will not only cover the subject as a whole, but also explain the advantages arising from recent developments.

Most equipments of present-day design can utilize tape of standardized dimensions. A plastic or paper base, of thickness about 0.0015in and width 0.25in, is provided on one side with a coating containing magnetic iron-oxide powder to give a thickness not greater than 0.0024in. On passing the tape over the air gap of an electromagnetic circuit, known as the recording head, in which a varying magnetic flux is generated by a.f. currents in the windings, corresponding alternate north and south poles are set up in the coating by virtue of the leakage field at the gap. Because of the coercivity of the magnetic material, these form open permanent magnets, each pair of poles with its own associated flux field. Accordingly, if the tape is then passed over the air gap of another magnetic head or circuit provided with a pick-up winding, an e.m.f. will be set up in this winding which, after suitable amplification and equalization, will reproduce with more or less fidelity the original signals applied to the recording head. The words "more or less" are used advisedly, for a bare system on these lines would result in distressingly low fidelity. Fidelity in a communication system implies absence of distortion, low noise level, and a level frquency response. None of these essential features comes naturally. They have to be achieved.

To return to the general description, however, an erase head is generally located before the recording head. This unit is similar to the others, but is fed with a steady a.c., preferably of the same frequency as that used for the h.f. bias described later. Its function is to wipe out existing signals on the tape prior to recording. Thus, if desired, all three heads can be in operation together, the first erasing existing signals, the second recording new signals, and the third reproducing them. The air-gap lengths vary from 0.25×10^{-3}in for a pick-up head to $2–3 \times 10^{-3}$in for an erase head. Standard tape operating speeds are 30, 15, 7½, and 3¾in/sec. The first speed will probably soon be obsolete, but an additional one of 1⅞in/sec shows signs of coming into use.

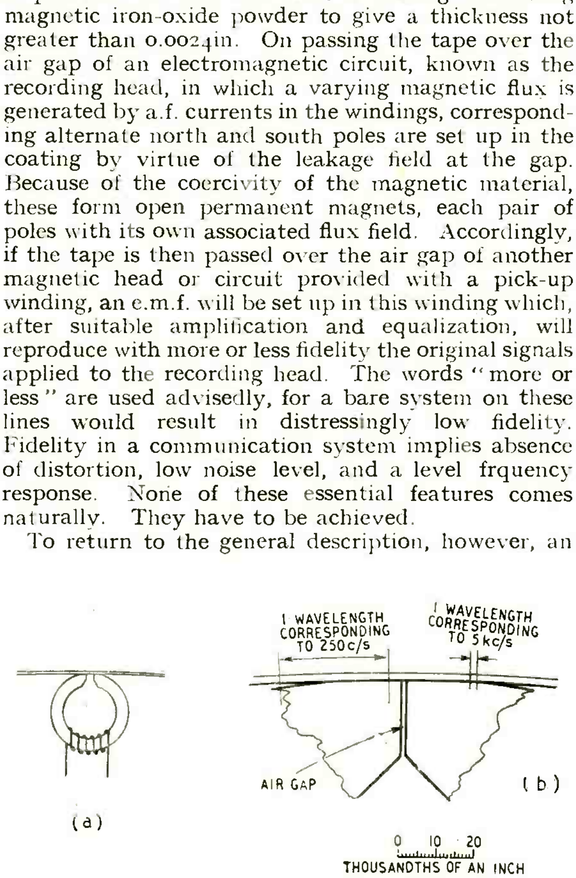


Fig. 1. (a) Conventional illustration of tape and head. (b) Tape and air-gap region of head, drawn to scale.

Before proceeding to details, it is rather important to present a more realistic picture of the tape and the gap over which it passes. For the sake of simplicity this is invariably depicted in technical literature somewhat similarly to Fig. 1(a) and as such cannot fail to give an incorrect picture of the relative dimensions involved. For a coating thickness of 0.0007in, a gap length of about 0.001in, and a lamination depth at the gap of 0.020in, the enlargement at Fig. 1(b) is a more faithful representation. To complete the picture, the wavelengths for a 250 c/s and for a 5 kc/s signal at a tape speed of 7½in/sec have been included. It is interesting to attempt to envisage the relative strengths of the leakage fields at one or two thousandths of an inch away from the tape surface at such wavelengths.

Basic Frequency Characteristic

As Fig. 1(a) suggests, the function of the reproducing head is to provide a low-reluctance return path for the leakage flux from the tape and to bring about flux linkages with the pick-up coil. The instantaneous recording current i will be given by the exprsssion $i = I_m \sin \omega t$, where I_m is the peak value of the current. If demagnetization effects and changes of flux distribution with frequency are ignored, the corresponding leakage flux ϕ from the tape will be proportional to this current. Furthermore, as long as the air gap is small compared with the wavelength on the tape, the instantaneous voltage e set up in the pick-up coil will be proportional to the rate of change of this flux, and is evaluated by differentiating, i.e., $e = k\omega\phi \cos \omega t$ and the r.m.s. value E will equal $k_1\omega\phi$. For constant-current recording, i.e., constants ϕ, E will be proportional to the frequency, rising 6 db per octave. With rising frequency, however, the ratio wavelength/air-gap decreases and an effect analogous to the slit effect in light recording appears. This modifies the expression for the voltage giving $E = k_1\phi \sin (\pi l/\lambda)$,

* Durex Abrasives Ltd.

where l is the air-gap length and λ the wavelength. Fig. 2 shows the resulting curve for pick-up voltage versus frequency, the latter expressed in the normalized form l/λ and also in kc/s for a speed of $7\frac{1}{2}$in/sec and an effective gap of 0.0005in, constant-current recording being assumed. This curve shows that, after rising steadily to a maximum value at a frequency corresponding to a wavelength twice that of the gap, the voltage output falls sharply to zero at $\lambda = l$. With a further increase in frequency the voltage again rises to a maximum and then again falls to zero at $\lambda = \frac{1}{2}l$ and so on. If this gap effect alone had to be considered, the successive voltage peaks would be equal in magnitude. Two other effects, however, cause a gradual fall with frequency, one, the demagnetization effect, which also is dependent on the wavelength and is discussed later, and the other, the iron losses in the pick-up head, a smaller effect dependent on frequency.[1] The quantity l was given as the *effective* gap length, which is not the same as, but is often considerably greater than, the physical gap. The discrepancy arises from the great difficulty in producing a gap to the required mechancial precision.

Magnetization

An explanation of the magnetization process taking place in the coated material demands a return to elementary magnetism. Fig. 3(a) shows a typical BH curve and hysteresis loop for the type of magnetic material employed in magnetic tapes. The first is a static curve of magnetization taken up to saturation, but the loop is of a shape and symmetry such as are reached only after several cycles have been experienced. These curves are, therefore, not really appropriate for studying the induction occurring in the magnetic material, but they can at least be employed to refresh our memory on the general principles of magnetization for high-coercivity materials. Incidentally, it must be admitted that because of their familiarity they are almost universally used for comparison purposes and for relating performances. With the application of a magnetizing field to a material in a completely unmagnetized state, the induction will rise from O following the curve OA and will reach some such peak value as A, depending upon the strength of the field. During subsequent reversals of the field, hysteresis loops will be traced out which take on the final form ABCDEFA when a steady state has been reached. If then at any instant the magnetizing force is removed, the iron will be left magnetized with an amount of remanent induction depending upon the point in the cycle at which the removal or switch-off takes place. Thus, if the switch-off takes place at P, when the magnetizing force is falling, the resulting remanent induction will be OB. If, however, it occurs when the magnetizing force has exactly the same value, but is rising, i.e., at Q, the remanent induction will be OQ_1. Again, for the sake of simplicity, demagnetization effects have for the time being been entirely disregarded.

By contrast with Fig. 3(a), Fig. 3(b) shows the curve followed in the initial cycle of magnetization by a field insufficiently strong to cause saturation. The lines PP_1 and QQ_1 indicate that the remanent induction bears a relation to the loop similar to the one above. It will be observed that both branches AB and BA_1 show appreciable curvature, although admittedly without the points of inflexion associated with saturation. For all that, the whole curve is asymmetrically disposed about the horizontal axis and, as suggested above, will not become symmetrical until several cycles have passed. Bearing in mind the fact that the magnetizing force is a measure of the recording input and the remanent induction a measure of the output, one might reasonably conclude that linear operation was out of the question and fidelity of reproduction impossible. Nevertheless, a closer examination of the loop reveals more or less linear portions in each branch following the "bottom bends," e.g., LA_1. If operation could be restricted to these portions, there would be a chance of an approximation to linear working. The introduction of supersonic bias makes this restriction possible.

The recording head is provided not only with the normal coil carrying the signal current, but also with an additional coil fed with a steady current of frequency some 4 to 7 times that of the highest-frequency signal to be recorded. The optimum current—for maximum amplitude and freedom from distortion—of this supersonic bias, as it is called,

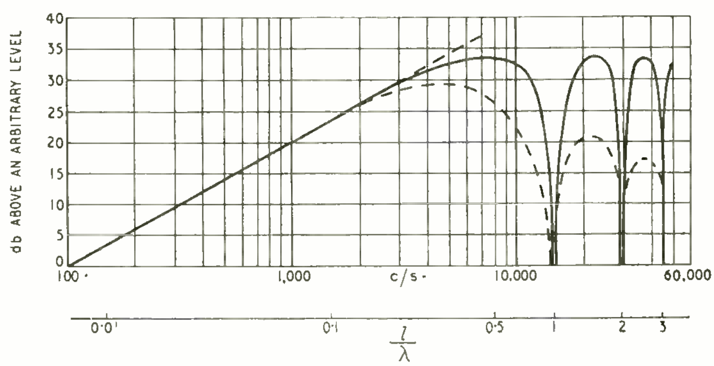
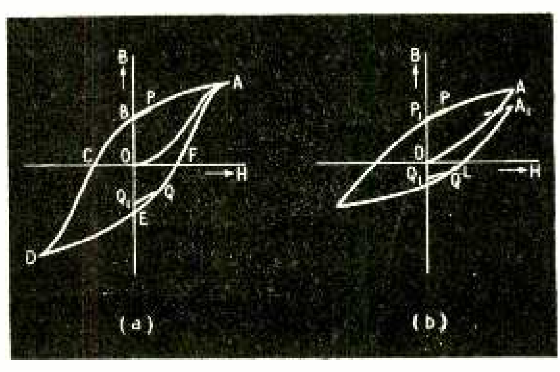


Fig. 2. Voltage output from pick-up head, using tape recorded at constant current. The output falls to zero when the gap length equals any integral number of wavelengths.

Fig. 3. (a) Typical BH curve and hysteresis loop for magnetic tape material. (b) Initial loop for H less than saturation value.



[1] "Overall Frequency Characteristic in Magnetic Recording" by P. E. Axon. *B.B.C. Quarterly* 5 (No. 1) 1 8 (1950).

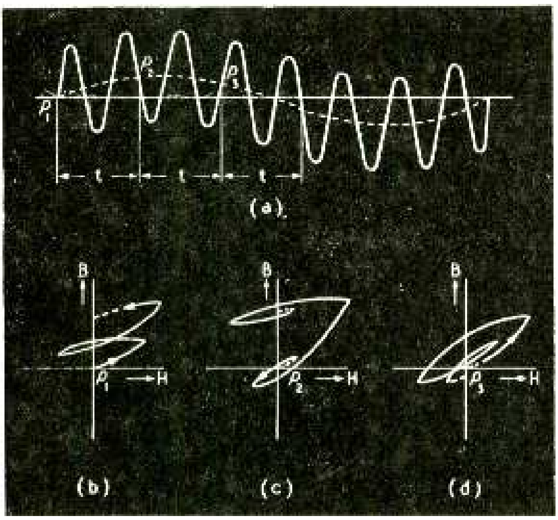


Fig. 4. Graphical presentation of magnetization by an a.f. signal with supersonic bias.

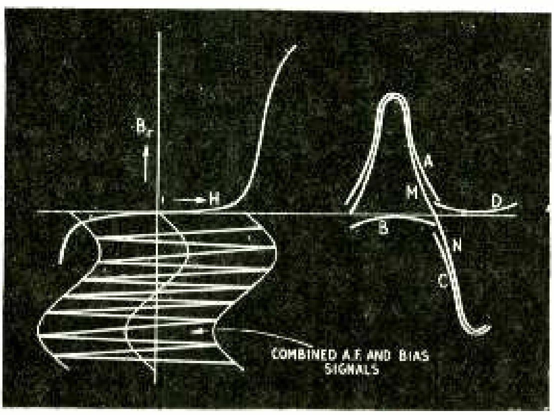
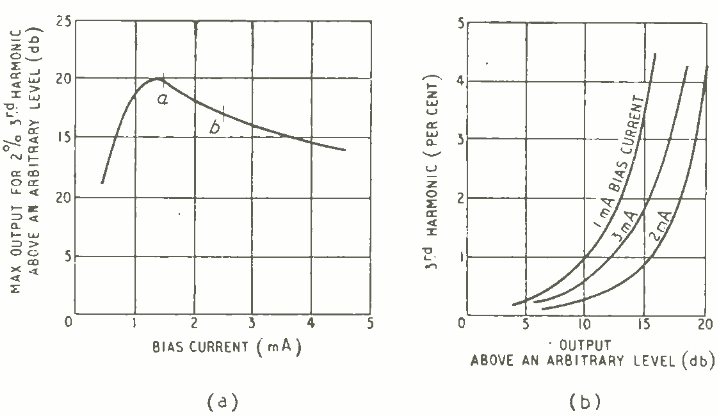


Fig. 5. Construction of output characteristic for a.f. signal with supersonic bias, using the remanent induction curve, B_rH.

Fig. 6. Relationship between bias, output and harmonic distortion.



has to be established by adjustment, but is usually about three times that of the maximum signal current. The signal and bias currents, it should be realized, are mixed in the recording head and not intermodulated.

Two graphical constructions introduced by Holmes and Clark[2] show clearly from different viewpoints the action of supersonic bias which are depicted and described below. Fig. 4(a) shows the combined supersonic bias and a.f. signal. Let us assume that a magnetic element approaching the gap is quite unmagnetized, is entirely uninfluenced by a magnetizing field both before and after passing the gap, and—for simplicity—experiences about 1½ h.f. cycles only during the passage. Actually, the number is more likely to be about five, but even so a steady state will not be reached. Then Figs. 4(b), (c) and (d) indicate the magnetization cycles experienced by elements entering the gap at points p_1, p_2, and p_3, t representing the transit time across the gap. It is interesting and gratifying to find that: first, elements at points such as p_1 and p_2, associated with positive signal excursions, are left with a positive remanent induction, while a point such as p_3 tends to receive negative induction; secondly, the remanent induction is, at least qualitatively, proportional to the signal amplitude at the instant of leaving the gap; and thirdly, the smaller a.f. signals obviously influence the remanent induction value far more than the h.f. bias does.

The second construction, Fig. 5, is reminiscent of the construction used to determine the dynamic characteristic of two valves in push-pull when biased just above the bottom bend. The curve corresponding to the static I_a-V_g line is the remanent induction curve, i.e., one obtained by plotting the remanent induction B_r against the magnetizing force H. As is usual, the "input," i.e., the combined a.f. and bias signals are plotted as abscissae while the B_r values corresponding to the points on the input envelopes are projected to give two pairs of "output" curves A, B, C, and D. Substraction of B from A, and D from C give two further curves M and N which combine to produce one complete cycle of approximately sinusoidal form, the output characteristic. Although this last construction will not stand up to a rigid investigation, it does in fact give results similar to those actually obtained. It should be mentioned at this point that small traces only of the bias signal will be left on the tape owing to demagnetization effects, as is explained at some length below. The bias has in fact already served its purpose by shifting the a.f. signals out of the initial magnetization region of the BH curve into the linear portion beyond the bottom bend.

Provided the frequency of the bias is made sufficiently high to avoid serious interaction with the third harmonic of the highest a.f. signal to be transmitted, its value is not critically important, although it has been suggested[3] that the higher the frequency, the less the noise. Ignoring this last factor, we can safely adopt 50 kc/s as a suitable frequency

[2] "Supersonic Bias for Magnetic Recording," by L. C. Holmes and D. L. Clark. *Electronics*, July 1945.

[3] "Some Distinctive Properties of Magnetic-Recording Media," by R. Herr, B. F. Murphy and W. W. Wetzel, *J. Soc. Mot. Pict. Engrs.*, 52, 77-88, Jan. 1949.

for a.f. recording. The choice of bias amplitude is, a different matter, since on its value depends the slope on the BH curve at which the a.f. signals work and the extent of the linear portion available for them. It is, accordingly, not surprising to find two quite different optimum values of bias current, one corresponding to maximum sensitivity, e.g., ratio of output to input, and the other to maximum distortionless output. It is fortunate that in general the sensitivity versus bias current curve, after rising sharply to a maximum value, tends to fall off slowly, since not infrequently the optimum value for distortionless output lies above that for sensitivity. Figs 6(a) and (b) show curves which confirm this. Needless to say, the operating point would be chosen somewhere between *a* and *b* in Fig. 6(a), the region corresponding to maximum distortionless output. Apart from all this, however, where a choice exists, preference should be given to a low rather than to a high value. This is because the higher current will have the combined effect of recording signals which are subsequently harder to erase, and at the same time of partially erasing the higher a.f. signals.

(*To be concluded*)

How Reliable is a Radio Valve?

IN giving an answer to this question, it is important that the radio valve should be considered against the background of its various applications, for obviously there is a greater need for reliability in some than in others. On this basis an opinion was expressed recently by Dr. G. H. Metson, who considered that the valve was quite reliable enough for present-day entertainment purposes, hardly adequate for serious industrial use, and quite inadequate for aircraft equipment or for those who sank their hopes in subaqueous telephony. He was opening a discussion meeting at the I.E.E. on this same subject, and among the important side-issues he raised were such topics as the possibility of devising some quantitative yard-stick as a measure of reliability and whether it was feasible to manufacture "reliable" valves for special purposes as distinct from "ordinary valves."

Several speakers gave information on specific valve types. It was mentioned, for instance, that C. S. Cockerell had obtained a broad average indication of reliability from some tests he had done on the valve types CV131, CV136, CV138 and CV140. Out of 18,700 samples, 697 had either developed faults during a 50-hour test on stationary racks or had been found to be faulty when drawn from stores. One speaker stated that the average life of 27 valves in a certain civil aircraft equipment during one year's operation was only 1,600 hours, and he added that, of the 17 per cent of aircraft delays ascribable to radio failures, 60 per cent could be put down to faulty valves. A Post Office engineer complained that valves were not so rigorously tested as other components, and stated that the number of telephone faults traced to valves was comparable to that caused by all other associated components.

Miniature valves were mentioned by several speakers as not having yet achieved a satisfactory average life, and the comment of one speaker was that the manufacturers were tending to make the ratings too high, so that a greater performance was demanded than valves of such a size could give. He had found that if the valves were operated at 80 per cent of their specified ratings, a more reasonable life could be expected.

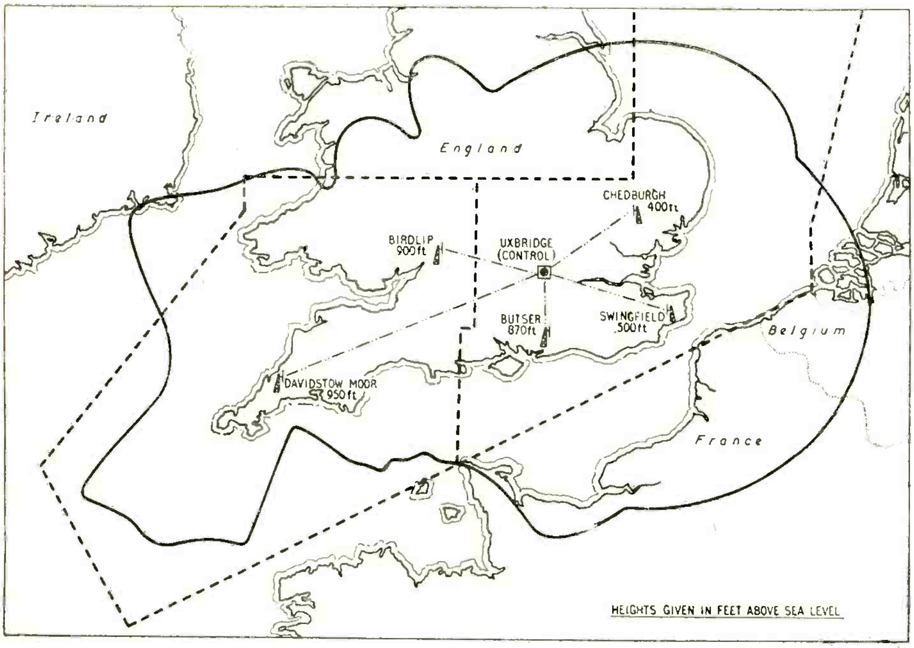
It was pointed out by other speakers, however, that the figures given appeared pessimistic, and the meeting was reminded that most of the valves mentioned were broadcast-receiving types. Current experience with miniature valves appeared to indicate that the number of "catastrophic" failures did not exceed 1 per cent, and that these valves would last for thousands of hours if they were run under proper conditions.

The causes of valve failures were also discussed, and one suggestion was that valve designers worked to an accuracy that did not allow for possible overloading caused by the wide tolerances of related components generally found in practice. There was a difference of opinion on whether the switching on and off of heaters was detrimental to the life of a valve. Further causes of failure mentioned were insufficient control of heater voltage; mechanical defects, such as loose spacers; vibration; clumsy insertion of valves into their sockets; and badly designed sockets which strained the valve pins. It was also pointed out that sometimes a valve was replaced in an equipment in which the running conditions had already been upset by the failure of the original valve, so that the replacement was at once overloaded.

A significant topic that arose was the necessity for a distinction between valve reliability and life. Although most people looked for long life as a part of reliability, one was not necessarily a criterion of the other. Dr. Metson pointed out that reliability was mainly governed by mechanical faults, which were usually revealed very early in the life of the valve, whilst longevity was largely a matter of cathode processing. The first aim of manufacturers should be to give reliability, since this was a basic necessity for all valves; then longevity could be provided for if required.

Statistics were mentioned as a means of calculating the probability of survival during any period and so indicating when replacements were advisable. It was generally agreed that they would give some idea of the probable further life of the large number of valves already in existence, but a more analytical study of individual specimens was necessary to determine the actual reasons for the failures.

It was generally agreed that the cost of faulty valves was not so much that of the replacements themselves but that of having to keep spare equipments in readiness—and, of course, the loss of goodwill.



(Left) Fig. 1. Map of the country served by the southern chain of v.h.f. stations used for communication with civil aircraft. All five operate as a multi-carrier system on one channel in the band 118 to 132 Mc/s. Theoretical coverage at 10,000 ft.

(Right) Fig. 2. The wide-band vertical dipole aerial used at the M.C.A. stations.

(Extreme right) Fig. 3. View of the transmitting hall at Butser, showing the eight T1131A transmitters and, facing them, a crystal comparator unit for checking the frequency of crystals.

Map and Photos: Courtesy Ministry of Civil Aviation.

Multi-Carrier Air Communications

V.H.F. Wide Coverage Scheme for Civil Aviation

RADIO telephony in the v.h.f. band 118-132 Mc/s is now almost the sole means of communication with aircraft over relatively short distances and in the vicinity of aerodromes. Transmissions on lower frequencies, though accepted, are being discouraged in favour of the higher frequencies.

With the higher speeds reached by modern aircraft it was realized some time ago that the range covered by a ground station of 50 watts or so, which is the normal power of equipment in general use, was inadequate when large numbers of aircraft tended to converge on to a busy airport.

In looking for a way of extending the coverage obtainable with v.h.f. the Ministry of Civil Aviation has been experimenting with the multi-carrier idea whereby a number of transmitters are installed at strategic sites and all modulated from a common source. These appeared so promising that a full and comprehensive scheme was worked out for the complete coverage of the British Isles and its regular air approaches by v.h.f. radiotelephony.

Actually the communications network is part only of a much larger plan, which involves the use of radio beacons of various kinds to guide aircraft into a number of air lanes, or "airways" as they are called, and to enable them to navigate these airways by means of radio marker beacons located at known points.

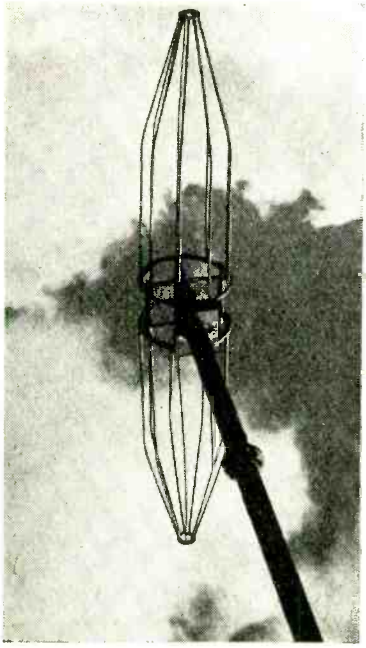
Since aircraft fly in both directions along the airways, constant communication between air and ground is essential for safe flying and this is where the v.h.f. radiotelephone finds its principal use.

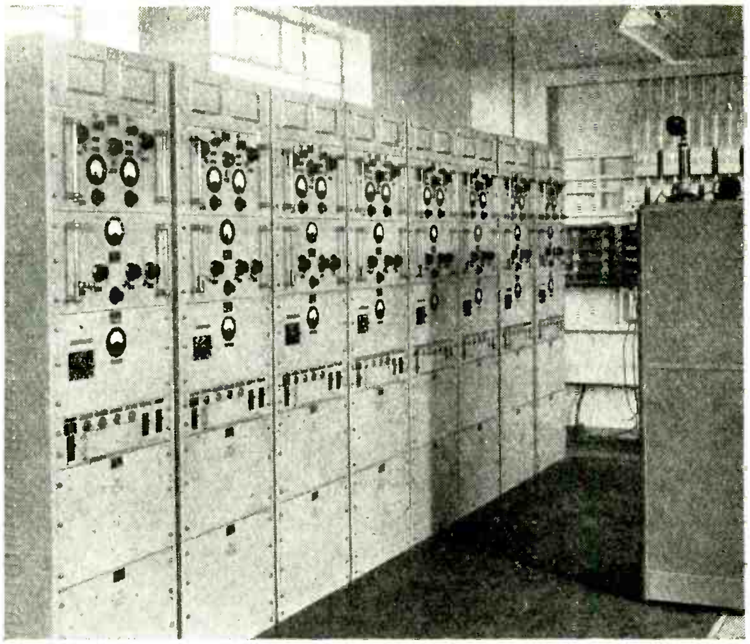
In order to bring aircraft into airports like Heathrow, Northolt and Prestwick, for example, radio contact has to be made with the aircraft well over a hundred miles from its destination and, if necessary, slow down its progress to avoid dangerous congestion over the aerodrome. In order to effect this the country is divided into four main radio control areas, termed Flight Information Regions.

The F.I.R. radio controllers direct aircraft into the airways, guide them along at specified heights and eventually pass them into an inner control zone, which may be under the airport controller, or to an intermediate control such as exists in the London area.

The two southern flight information regions are for the most part acting as a single region with the control centre at Uxbridge, but there is a control at Gloucester for handling aircraft using the aerodromes situated in that part of the country. Other control centres are at Preston and at Prestwick.

Whilst the various regions differ in the actual number of transmitting and receiving sites employed, the basic system of operation is the same throughout and it will thus suffice if a description is given of one only. The combined south-eastern and south-western was selected as the control centre at Uxbridge and one of its stations, Butser, just north of Portsmouth, were conveniently situated for a visit.





Disposed throughout the two southern regions are five combined transmitting and receiving stations, the sites being chosen at Chedburgh, near Bury St. Edmunds, Birdlip, near Gloucester, Davidstow Moor, near St. Eval, Butser, near Portsmouth and Swingfield, near Folkestone. They are thus very widely spaced geographically and an elaborate system of land lines is needed to link them to Uxbridge and provide for remote control of the transmitters. Lines, which are mainly for carrier current operation, are supplied and maintained by the Post Office.

Each of these stations will be able to send and receive simultaneously on four different channels, although at the time of our visit two only were ready for immediate operation.

One transmitter at each of these stations is allotted to a single channel on about 126 Mc/s. Three have a 10-kc/s frequency separation and the most widely spaced pair (Davidstow Moor and Chedburgh) share a common frequency. Together the five stations give an estimated coverage over an area enclosed by the full-line boundary on the map in Fig. 1. It represents approximately all that country south of a line drawn from the Humber to the Mersey, but excluding North Wales and Anglesey. It takes in the southern approach to the St. George's Channel, the south-east tip of Eire, covers the Scilly Isles and part of the French coast from Cherbourg north-eastwards to the Schelde in Holland. Aircraft flying over French, Belgium or Dutch territory are, of course, subject to control of those countries. The nominal separate jurisdiction of the two southern flight information regions is shown by the broken-line boundaries.

As already mentioned two transmitting channels are in operation at each station, but all five are not operating on the same alternative channel. The one centred on 126 Mc/s gives a general coverage and the alternatives are arranged, at present, to give a more localized service. For example, Chedburgh, Birdlip and Davidstow Moor form a three-station chain on 122 Mc/s covering the north and north-western approaches, while Butser operates on a single frequency covering the south and south-west, and Swingfield provides a third channel for local coverage to the east and south-east. Thus there are four communication channels available in this area although individual stations at present operate on two only.

The locations of the stations are all on high ground as the elevation figures on Fig. 1 testify. At each site there is a 120-foot wooden tower supporting four wide-band vertical dipoles taking the form shown in Fig. 2. Each aerial is sensibly flat over the band 118 to 132 Mc/s and the arrangement is that two are earmarked for transmitting and two for receiving, but one only of each pair is in use at a time.

This policy of duplication of equipment is followed throughout the entire radio chain. For example, there are, or will be, eight transmitters at each station, one for each of four operating channels with a reserve alongside and with automatic change-over switching. Heater current is supplied to all valves in the reserve transmitter, and the crystal oscillator, which is in a temperature-controlled oven, is kept at the operating temperature for immediate use. In Fig. 3 is shown an imposing row of eight modified T1131A transmitters installed at Butser. The nominal output of this set is between 40 and 50 watts in the band 118-132 Mc/s.

An interesting feature of the transmitter layout is the provision of a frequency comparator which enables each crystal oscillator to be compared in frequency with its stand-by and also with a third acting as a spare. All these are checked regularly and the differences noted. The aim is to keep all three crystal units within a few cycles of each other so that whenever the reserve transmitter comes into operation it is substantially on the same frequency as the other.

At present one receiving and one transmitting aerial only is in use at each station. This means that each aerial is operating simultaneously on two frequencies, either sending or receiving. The system employed was originally developed by the Admiralty and is known as "Common Aerial Working." A form of automatic trap is included in the lead from the aerial feeder to each transmitter, which effectively bars the passage of the r.f. output from one transmitter to the other and directs it into the aerial. The same process, but in reverse, takes place for receiving.

The simultaneous use of one aerial for two transmitters close in frequency makes use of two well-known characteristics of resonant lines. One is that a quarter-wave section of line, or feeder cable, short-circuited at one end exhibits an extremely high impedance at the opposite end, and the other is that a high "Q" resonator has a high non-reactive impedance at the frequency to which it is tuned, but for all practical purposes is a short circuit off tune.

By connecting a quarter-wave section of line in series with a resonator (cavity resonators are employed) in the branch feeder to each transmitter, or receiver, as shown in Fig. 4 entire independence of operation is achieved. To a signal at frequency F_1 arriving at the junction A the system takes on the appearance of Fig. 5. Since the resonator Res_2 is tuned to a different frequency it is virtually a short circuit to frequency F_1, and as Q_1 is resonant also at F_1 its end at point A offers a very high impedance to the signal and diverts it into Q_2, which being non-resonant at F_1, does not affect the behaviour of Res_1, which appears as a very high impedance across the line to R_{x1} at frequency F_1. At frequency F_2 Res_1 becomes the short circuit and Res_2 the high impedance so that signals are thus diverted into receiver R_{x2}.

The same system is employed for transmission, and to follow the operation it is only necessary to reverse the order and regard the transmitters as the source of signals, whereas the aerial was so taken for the explanation of the principles.

When more than two transmitters, or receivers, are employed a compromise adjustment of the quarter-wave line sections (Q_1 and Q_2 in Figs. 4 and 5) is necessary, and they are then made on electrical quarter wavelength at the mid-band frequency.

The advantages claimed for the common aerial system are that in the first case fewer aerials are needed—two instead of eight excluding reserves—and one mast suffices as the aerials can be arranged so that the receiving one is in the minimum field of the transmitting aerial. For this reason the aerials as seen at Butser are mounted in a line vertically (vertical polarization is employed), and while this leads to a small reduction in height of some, it avoids undesirable complications elsewhere. It is said that the system leads to a saving in site space and also to some economy in telephone lines and terminal equipment.

For receiving, a modified version of the R1392A ground receiver is used. It is a 15-valve superhet designed for fixed-frequency operation in the band 100-150 Mc/s, and it has a crystal-controlled oscillator and a chain of frequency multipliers. There are two r.f. stages and three i.f. Eight of these receivers, each with a separate power unit, will be installed in a fully screened room to prevent interference from harmonies of the adjacent transmitters. Four will be active and four on immediate reserves. The receivers at Butser are shown in Fig. 6, the four seen in this view serving for the two channels at present in operation and there is space alongside for four more. Their power units can be seen below the writing shelves.

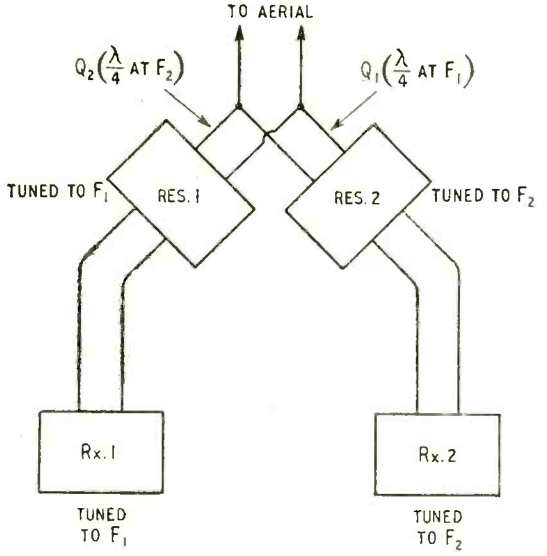
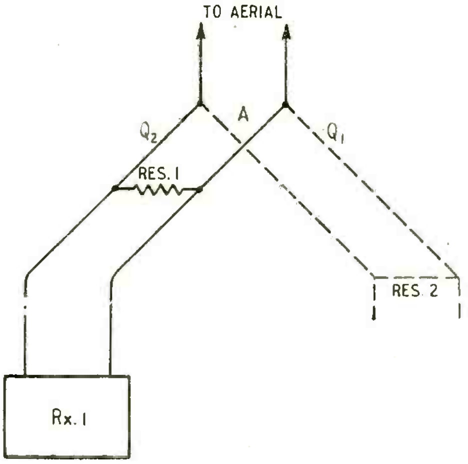


Fig. 4. Schematic arrangement of the common aerial system of operation showing position of quarter-wave lines and resonators for operation on two channels which should have a minimum spacing of 2 Mc/s.

Fig. 5. Equivalent circuit for Fig. 4 as seen by a signal arriving at the point A at a frequency of F_1.



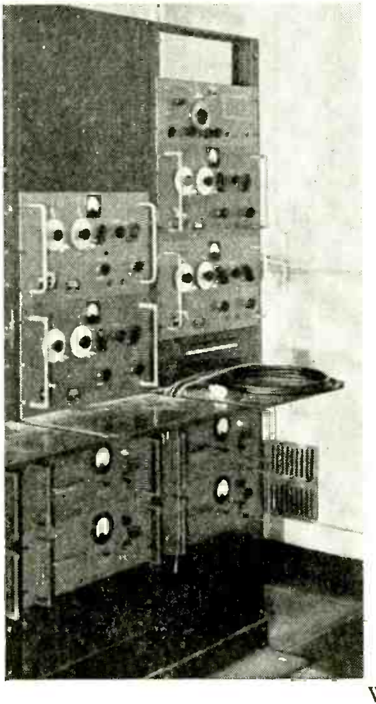


Fig. 6. Corner of a receiving room showing four R1392A receivers in position—two active, two reserve—with power units below the writing shelves. (*Photo: Courtesy of Ministry of Civil Aviation.*)

Vector Diagrams

By "CATHODE RAY"

3.—*Enter the Valve*

THIS final chapter in the series was actually the original starting point. If you remember, a demand had arisen for some light on a subject which appears to have been illuminated seldom and not always helpfully—vector diagrams of valve circuits—but when I came to look into the matter I found that a large part of the trouble was due to varying and confused practices in connection with vector diagrams in general, and—even more basically—in the specifying of circuit currents and voltages.

The main conclusions so far have been that the usual methods of referring to voltages as "V_1," etc., aided perhaps by one or two arrows, leave room for doubt as to what exactly is meant; in particular, it is quite easy to arrive at opposite conclusions about the direction or polarity of a voltage. And that the double-subscript notation ("V_{ab}") obviates all this, provided that there is agreement to work throughout in either rises or falls of potential. And that those who adopt this notation often seem to work in falls, which is a pity because the reverse has certain advantages, not the least being that it enables the same notation to be applied in a particularly neat and foolproof manner to the vector diagram also.

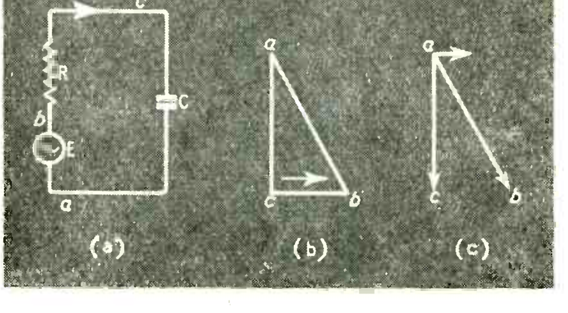
Just as a reminder, Fig. 1 shows an example of this technique. (a) is the circuit diagram, with the component junctions lettered and an arbitrary direction of current marked by a broad arrow head. (b) is the corresponding "generalized" vector diagram, with a broad arrow to indicate the arbitrary phase of the current. The whole diagram is supposed to be rotating anticlockwise. In the position shown, with the I vector pointing to 3 o'clock—the conventional zero—the current is just about to begin its positive half-cycle. The position of *a*, vertically above *c*, means that point *a* in the circuit is then at its maximum positive voltage relative to *c*. And so on. The whole situation can be visualized quite easily and unmistakably. The effect of tying any point in the circuit to earth or zero potential is represented by pinning the corresponding point in Fig. 1(b) to the table, so making it the centre of rotation. If one particular circuit point is known to be earthed, that fact can be indicated in the vector diagram by converting it into the "particular" form, which for earthed *a* would be Fig. 1(c). Note how clear and free from unnecessary labels both circuit and vector diagrams are. No voltage labels are needed, but any voltage can be precisely referred to in either direction; the voltage driving current through R, for example, (reckoned in the same direction round the circuit as the current) is V_{cb}.

The first thing to decide when bringing in the valve is whether to treat it as a real valve, with electrons flying across a vacuum under the influence of anode and grid bias voltages as well as of any alternating ("signal") voltages that may be superimposed on them, or whether we are going to substitute an imitation valve made of ordinary circuit components like those in Fig. 1(a). When studying the thing for the first time it is quite essential to adopt the first method, if only to be sure that the second method, when we come to use it, gives nearly enough the same answer. But the first method calls for a good deal of concentrated thought, on lines outside ordinary LCR electrical theory, and once we have learnt the reality of the matter we can save ourselves a vast amount of effort on many subsequent routine calculations by neglecting the features of the valve that have only a slight effect on the result, so enabling an artificial valve to be substituted, reducing the work to ordinary circuit calculation. It is rather like the necessity for an engineer to have learnt the principles of multiplication and division and logarithms at some time or other, even though in practice he does nearly all his calculations mechanically on a slide rule.

If you object on principle to "mathematical abstractions," then by all means do it the hard way every time and good luck to you. But don't complain that it *is* hard and that lengthy arguments arise if you try to fit the real valve into simple Ohm's Law. It won't go. The only sure way of dealing with an actual valve is according to its own behaviour as found by experiment. If you attribute to it an anode resistance, then it has to be a variable resistance controlled by the various electrode voltages.

On the other hand if you have no conscientious objection to making use of the short-cut "valve equivalent generator," remember (a) that it is only a fake, capable of giving answers near enough if used intelligently within its limitations, but very misleading outside them; and (b) that it relates to a.c. only, so h.t. batteries and other accessories necessary to the proper functioning of the real valve are as superfluous to it as a cup of tea would be to a robot.

Fig. 1. A simple sample of the recommended technique: (a) the circuit diagram; (b) the general form of the vector diagram; and (c) the particular form of vector diagram corresponding to point *a* in the circuit being kept at zero potential. In all three diagrams a thick arrow head denotes current.



Since vectors also refer to the a.c. component only, there is obviously a good argument in favour of using them in conjunction with the imitation valve. As is well known, in its simplest and most usual form this substitute consists of a generator developing an e.m.f. equal to $-\mu V_g$ volts, and having a resistance in series, the so-called incremental or a.c. anode resistance, denoted by r_a.

There have been lengthy disputes in high places over the minus sign. I am one of those who favour using it, on the ground that it is necessary if the imitation valve is to imitate the actual performance of the real valve, assuming (as most people do most of the time) that the anode and grid voltages are both reckoned relative to the cathode. Those who reckon the grid voltage relative to the cathode and then prefer to stand on their heads and reckon the cathode voltage with respect to the anode are rewarded for their effort by being able to dispense with the minus. Their main objection to the minus, apparently, is that if the e.m.f. of the generator in the imitation valve is regarded as acting from cathode to anode the positive direction of the signal current caused by it in the anode circuit is opposite to the steady feed current caused by the h.t. supply. Why that should worry anybody, seeing that the h.t. supply has nothing to do with the imitation valve, and should have been sent away along with the real valve, I don't know, but apparently it does.

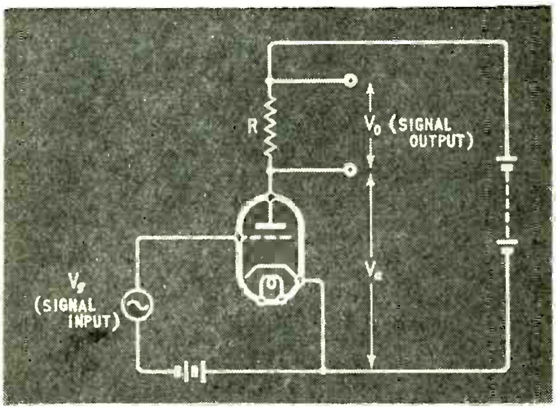
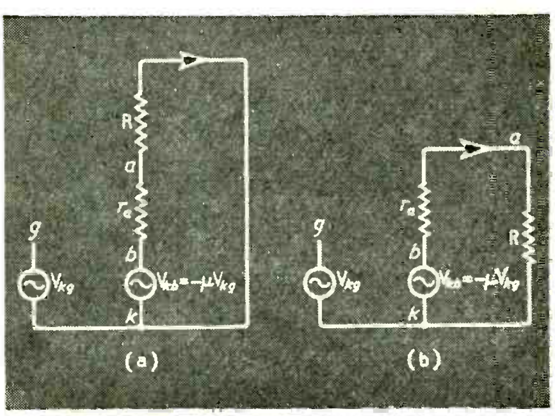


Fig. 2. Circuit diagram of a simple resistance-coupled amplifier.

Fig. 3. "Equivalent" imitation valve substituted for the real valve in Fig. 2. The only difference between (a) and (b) is in the layout of the drawing.



Readers who did not see, or have forgotten, the last instalment may be wondering what use a minus sign has in a purely a.c. system anyway. If μV_g were the only driving voltage in the system there would be no sense in putting a minus in front of it; but actually one of the most important things to be taken into account is the phase relationship between the anode voltage and the signal voltage at the grid, V_g. The experimental fact is that in a resistance-coupled amplifier the output voltage, at the anode, is opposite in phase to the input voltage, at the grid. Unless ordinary circuit calculations performed on the circuit containing the imitation valve give the same result, then our imitation valve is no good and we had better throw it away. The minus sign is the simplest way of ensuring the right phase relationship.

Resistance-coupled Amplifier

But all this should be easier to follow if we try an actual example, Fig. 2. This is a conventional circuit diagram of a real valve arranged as a resistance-coupled amplifier. V_g and V_0 refer only to the alternating parts of the voltages at grid and anode. V_0 is being caused by the current from the h.t. battery varying due to the resistance of the valve being varied by V_g, so varying the voltage dropped across R. Beginners sometimes get into difficulty about the relationship between V_0 and V_a. I have even known a self-styled teacher "explain" the phase-reversal in the valve amplifier by using a diagram like this to show that V_a is opposite in phase to V_0. What he did not appear to perceive is that V_0 is identically the same alternating voltage as V_a, and it is merely the way the diagram is drawn that encourages one to reckon it in the opposite direction round the circuit. Without altering the *alternating* voltages in any way, the upper terminal of V_0 can be slid along the connecting wire and past the h.t. battery to the cathode side. V_0 and V_a then coincide and it is no longer possible not to see that they are the same. Reckoning the same voltage in opposite directions round a circuit and discovering that the results are 180° out of phase doesn't prove anything about valves; it leads to nothing more interesting than the not unfamiliar fact that $-(x) = -x$. The phase reversal is actually a result of the nature of the valve, explained in any book on it. And seeing that its nature is somewhat complex and not within the scope of elementary circuit arithmetic we now regretfully turn it out, along with the h.t. battery, the grid bias battery, the filament heater, the valve holder, and any other details of the equipment, and substitute our ersatz valve (Fig. 3) which requires none of these things.

Both (a) and (b) are the same diagram; the only difference is that (a) is laid out as like Fig. 2 as possible, for the benefit of the less experienced readers, whereas (b) is a little neater. The comparison provides another opportunity of getting used to the fact that the alternating voltage across the coupling resistor R is the same voltage as the one from anode to cathode. Note that although there is now no real valve in the circuit—so no grid or anode—the lettering has been chosen to remind us of the corresponding terminals of the real valve—*g* for grid, *a* for anode, and *k* which is the standard symbol for what classical scholars like "Free Grid" call the kathode. Terminal b in the imitation valve doesn't exist in the real valve, so one can't use it. If you want a mnemonic, b can be thought of as locked away inside the "bottle". The input signal voltage is now called V_{kg} to make quite clear that it is acting in such a way as to raise the potential in the direction k-to-g. If, as is customary, we reckon the anode voltage also with reference to cathode, then the signal anode current must be shown flowing in that direction, and to get the phase reversal the valve "generator" voltage must be minus relative to V_{kg}.

Now at last we get to the valve vector diagram. So much care having been taken over the preliminaries, there is nothing to it. We have a perfectly ordinary circuit, labelled in our foolproof manner, and the problem is actually simpler than Fig. 1. Draw the arbitrary current vector (Fig. 4). Then a line ka parallel to it, proportional in length to R, to represent the voltage (from the imitation valve) driving current through R. Then an extension ab, proportional in length to r_a, to represent the voltage driving current through r_a. So now we have kb representing V_{kb}, the imaginary generator e.m.f., and need only draw a line $1/\mu$ times as long and in the opposite (minus) direction to represent V_{kg}. The voltage amplification is, of course, V_{ka}/V_{kg}, and the phase shift is seen from Fig. 4 to be 180° (as if we didn't know it! But it is nice to find that our substitute gives us the right answer). If we work out V_{ka}/V_{kg} by arithmetic from Fig. 4 we find it agrees with the familiar formula $\mu R/(R + r_a)$.

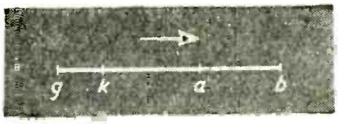
This circuit, with its entire absence of reactance, is so easy to do by arithmetic that the only purpose in drawing the vector diagram is to get used to the technique. Incidentally, in this type of amplifier it is usual to earth the cathode (directly, or through a large by-pass capacitor) so if you like you can mark "k" in Fig. 4 with a little circle and draw arrow heads pointing away from it at g, a, and b. But one of the merits of the generalized diagram is that you can use it to see what happens when you earth any point you like. Suppose we try turning it into a cathode follower. In a cathode follower the anode is kept at earth potential, so far as signal voltages are concerned, so all we do is make Fig. 4 rotate about a instead of k. The output voltage is now drawn from the cathode, and is V_{ak}, while the input voltage is V_{ag}. So the output voltage is in phase with the input and is inevitably less than the input. Which again agrees with what actually happens with a real valve.

And by sticking the pin through g we can study the earthed-grid (or, as the Americans among us say, "grounded-grid") amplifier.

For the sake of practice you might care to try the "concertina" phase-splitting circuit, made from Fig. 3 by inserting a resistance equal to R between k and the common earth line (which you might label e). Although V_{kb} is still $-\mu V_{kg}$, the input voltage is of course V_{eg}, which, if you have drawn the diagram correctly, is larger than V_{ek} and in phase with it, while the other output voltage, V_{ea}, is equal to V_{ek} but in opposite phase.

Next, let us see what happens if the original amplifier is used at such high frequencies that the capacitance from anode to cathode (C_{ak}) provides a relatively low-impedance path (Fig. 5). This confronts us for the first time with a parallel circuit and therefore with the necessity for making a current

Fig. 4. Generalized vector diagram relating to Fig. 3.



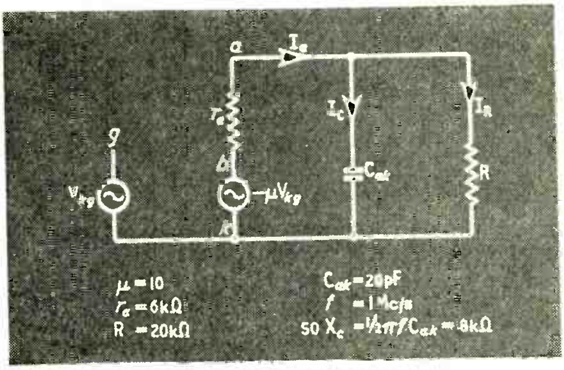


Fig. 5. Equivalent circuit diagram corresponding to Fig. 2 at radio frequency, taking account of the stray capacitance between anode and cathode.

Fig. 6. (a) Current vector diagram in anode circuit of Fig. 5. The voltage diagram is completed in (b).

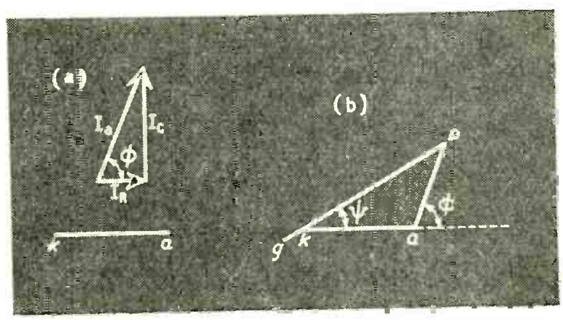


diagram. Hitherto the golden rule has been to start with the current, because in a purely series circuit that is the one thing common to all its components, and the voltages are easily calculated from it. Now there are different currents flowing through R and C_{ak}. But there is a common voltage across them (V_{ka}) so we start with that. We know I_R is in phase with it, and that I_C leads it by 90°. And that I_R is equal to V_{ka}/R and I_C is equal to V_{ka}/X_C. To make the thing more definite let us suppose that the component values are as listed below Fig. 5.

We begin by drawing a vector to represent V_{ka}, the required output voltage (say 50), at any convenient phase and to any convenient scale, Fig. 6(a). The I_R vector must be parallel to it and pointing in the k-to-a direction. As I_R is $V_{ka}/R = 50/20 = 2.5$ mA, its length should represent that to any convenient current scale. The I_C vector must lead ka by 90°, and its length must represent $V_{ka}/X_C = 50/8 = 6.25$ mA. The length of the I_a vector—the vectorial sum of I_R and I_C—will then tell us that I_a is 6.73 mA.

Since the I_R vector is parallel to ka, we now know the angle, ϕ, by which the anode signal current leads the output voltage. It is just over 68°. So we can proceed to complete the voltage diagram, Fig. 6(b)

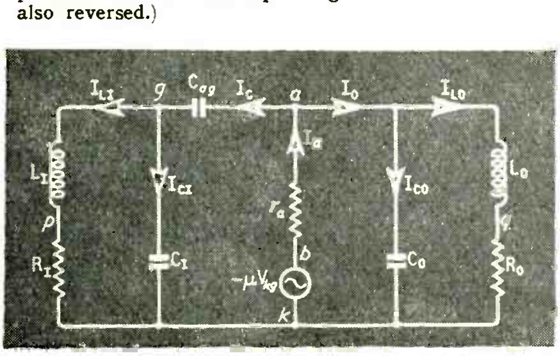
We already have ka; and ab, representing the voltage V_{ab} applied to r_a, being in phase with I_a, must be drawn parallel to the I_a vector. It is equal to $I_a r_a$, which is 40.4 volts. That fixes the line kb, the length of which tells us that V_{kb} is 75 volts. V_{kg} is $1/\mu$ times as large (7.5 volts) and in the opposite direction. One effect of C is now seen to be to make the output voltage lag more than 180° behind the input, but this increase, ψ, is less than ϕ—actually 30°. The amplification—given by the ratio of ka to kg—is $50/7.5 = 6.7$. Without C_{ak}, or at low frequencies, it would be $10 \times 20/(20 + 6) = 7.7$. Considering how heavily C_{ak} shunts R, the drop in voltage amplification that it causes is not as much as one might have expected before drawing the diagram.

Let us now take the plunge and tackle the notoriously difficult tuned-anode tuned-grid oscillator circuit. It can be represented reasonably accurately by the "equivalent" circuit shown as Fig. 7. Here L_I and R_I are the inductance and loss resistance of the grid tuning coil, and C_I the grid tuning capacitance (including the grid-to-cathode capacitance of the valve); L_O, R_O, and C_O are the anode tuning ditto; and C_{ag} is the anode-to-grid capacitance of the valve.

The difficulty about analysing this circuit is that it seems to consist of a set of interlinked vicious circles! Of course the working-out depends a good deal on how much one is given or assumes and what one is setting out to find or prove. If all the component values and the frequency are given, then one can tackle it bit by bit in the same way as Fig. 5. gradually building up the complete voltage and current diagrams. If the result makes $V_{kb} = -\mu V_{kg}$, then oscillation will take place at that frequency. But it would be an incredible fluke if values at random turned out that way; so perhaps it will be better if we assume likely values for all except the anode tuning coil, and then see if the impedance required there to sustain oscillation is physically possible.

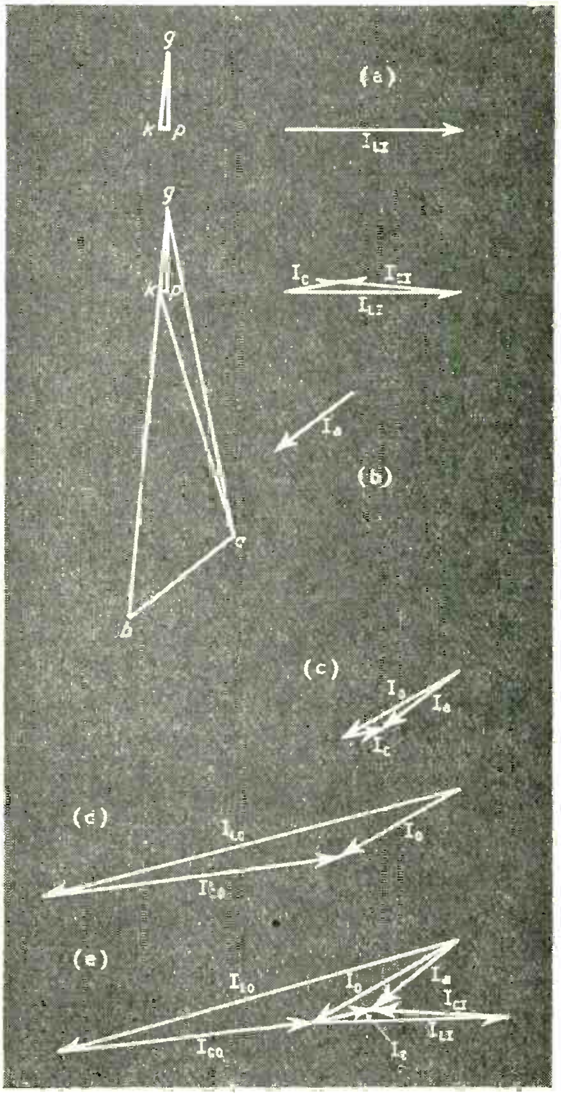
Having explained the previous examples in such detail, I hope it will be enough to give a summary of one possible sequence. Remember that with the rise-of-potential convention I have been using, the voltage required to drive current through any impedance has to be reckoned in the direction of the current through the source of the rise; not through the impedance itself, which of course is a fall. So if we begin by assuming I_{LI}, the voltage across it is V_{kp}, not V_{pk}. Provided that care is taken over this there should be no mistakes. So here goes.

Fig. 7. Equivalent circuit diagram of tuned-grid tuned-anode oscillator, with arbitrary current directions marked. (Any of these directions could be reversed, provided that the corresponding current vector was also reversed.)



Assume I_{LI}. That gives V_{kp} (in phase) and V_{pg} (90° leading) and hence (by addition) V_{kg}. Remember that normally the reactance of L_I will be many times greater than R_I, so I_{LI} will be found nearly 90° behind V_{kg}, as in Fig. 8(a). Then draw I_{CI} leading V_{kg} by 90°, and if you take my tip you will choose a frequency that makes the reactance of C_I rather higher than that of L_I, so that I_{CI} will be less than I_{LI}. Adding the two currents gives I_C, and V_{ga} must lag it by 90°. Normally C_{ag} will be small, so make V_{ga} quite large. You now have V_{ka}, and also $V_{kb}(= -\mu V_{kg})$. And so V_{ab}, and, in phase with

Fig. 8. How the vector diagram for Fig. 7 is built up bit by bit: (a) the assumed I_{LI} and the grid tuning coil voltage diagram derived from it; (b) adding the grid tuning capacitance current gives the phase of I_C and enables the voltage diagram to be completed; (c) I_O is the difference between I_a and I_C; (d) I_{CO} can be calculated, leading to I_{LO}, which corresponds to a typical tuning coil worked slightly below the resonant frequency; and in (e) the foregoing portions of the current diagram are put together.



it, I_a (Fig. 8(b)). Not knowing I_0, you will have to assume a length for I_a. One would expect it to be such as to make I_0 (the difference between I_a and I_c) a good deal larger than I_C (Fig. 8(c)). I_{CO} follows from the known V_{ka} and C_0, leading V_{ka} by 90°; and deducting it (vectorially, of course) from I_0 gives the I_{LO} necessary for this whole system to operate (Fig. 8(d)). If the values chosen elsewhere have been at all suitable, it should be found that I_{LO}, driven by V_{ka}, can be fulfilled by an inductive reactance somewhat smaller than the capacitive reactance of C_0, without calling for a negative value of R_0. You may remember that an essential condition for oscillation in this type of circuit is that the anode load must be inductive, that is to say, I_{LO} must be larger than I_{CO}, so that the resultant I_0 lags the anode voltage V_{ka} by nearly 90°.

If any readers are grieved because I have spent most of the time introducing a new-fangled type of vector diagram instead of explaining at length the more orthodox kind I used in "Miller Effect"* I am sorry, but I really think it is an improvement. However, if you don't like it, you can fix your earthed point every time, and draw the arrows pointing away from it, as in Fig. 1(c), and attach the current vector there, and label the vectors with any notation you like, so long as it avoids the ambiguities I pointed out.

It may be as well to mention, as a postscript, that the imitation valve used here is only one of two kinds—the more commonly used one, known as the equivalent voltage generator. The other, which gives the same answer rather more easily in parallel anode circuits fed from high resistance valves like pentodes, is a constant current generator $-g_m V_g$, with r_a in parallel.

*August, 1949, p. 307.

SHORT-WAVE CONDITIONS

January in Retrospect : Forecast for March

By T. W. BENNINGTON (*Engineering Division, B.B.C.*)

DURING January the average daytime maximum usable frequency for these latitudes was somewhat higher, and the night-time m.u.f. about the same, as during the previous month. Not much seasonal change in m.u.fs would have been expected as between December and January, and the higher daytime m.u.f. during the latter month may have been due to a decreased amount of ionospheric storminess.

Day and night working frequencies conformed more nearly to expectations than they have of late, in fact, they seemed to fit the curves given in the December *Wireless World* very well. Early and late in the month there was some transatlantic communication on 28 Mc/s, but during most of it the highest daytime m.u.f. was below this—in the vicinity of 22-25 Mc/s. Night-time m.u.fs were generally low, being usually below 8 Mc/s after about 2200 g.m.t., though towards the end of the month higher frequencies did remain usable later than this.

Very little Sporadic E was observed during the month On the 30th, however, this phenomenon was noticeably present. Sunspot activity was, on the average, slightly lower than during the previous month.

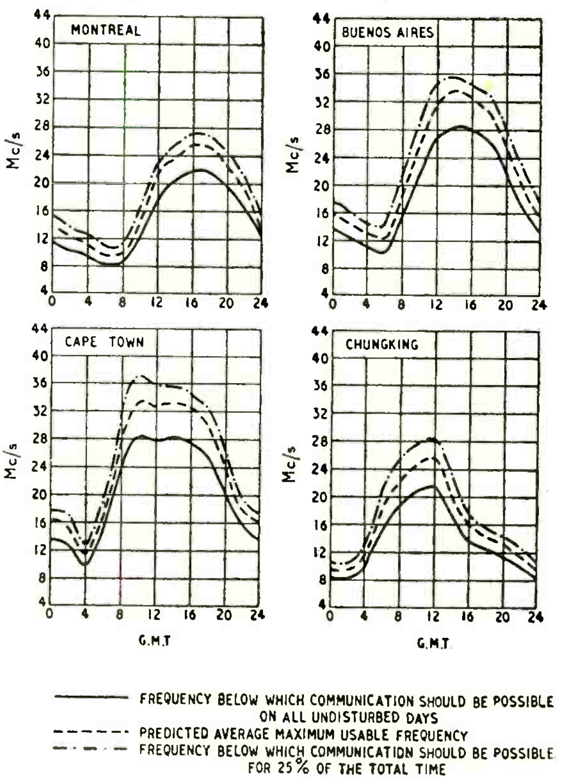
Conditions were relatively undisturbed during January, the 13th-14th and the 22nd-25th being the only really disturbed periods. A very minor storm occurred during the period 17th-19th. One Dellinger fade-out, severe in its intensity, took place at 1627 g.m.t. on January 22nd.

Forecast.—During March, it is expected, there will be a decrease in the daytime m.u.fs for these latitudes, whilst the night-time m.u.fs will continue to increase.

The net effect of the ionospheric variations on long-distance working frequencies should be that those for east-west circuits should decrease slightly during the daytime, whilst those for north-south circuits should show an increase. Frequencies as high as 28 Mc/s should become frequently usable over the latter path but not over the former. Moderately high frequencies should be usable for a considerably greater part of the day than during February over all circuits, and night-time working frequencies should be generally higher, those up to 9 Mc/s remaining of use for the greater part of the night over many circuits.

There is unlikely to be much Sporadic E capable of sustaining propagation on very high frequencies. Over medium distances the normal E layer may control transmission for a short daily period only. There is often an increase in the amount of ionospheric storminess around the equinoxes, so some periods of severe disturbance are likely during March.

The curves indicate the highest frequencies likely to be usable over four long-distance circuits from this country during the month.



Transatlantic Tests

Memorial to the First Amateur Station to Span the Atlantic on "Short Waves"

WHEN the term "short-wave" was used thirty years ago to describe the transatlantic tests organized between amateurs in the U.S. and the U.K. it conjured up in readers' minds wavelengths no shorter than 200 metres.

Whereas at the end of the first world war long-range overseas radio communication was conducted on wavelengths of thousands of metres, to-day, of course, the same, and greater, distances are covered on wavelengths of less than 40 metres. What was probably the first step in the change from long to short waves for long-distance communication was the series of transatlantic tests between British and American amateurs conducted in 1921 under the auspices of this journal and the American Radio Relay League. It was in February of that year—just thirty years ago—that arrangements were made for a number of amateur stations to radiate morse transmissions in an endeavour to establish transatlantic communication using no greater power than that permitted by the licensing authority in each country. In the U.K. it was 10 watts, whereas in the U.S. 1 kW was permitted. It was for this reason that it was decided the American amateurs should transmit and the British endeavour to receive the signals.

Twenty-five amateur stations in the States and some 250 amateurs in this country participated. Although thirty or more logs were received by *Wireless World*, not one entrant received a single word or signal which could unquestionably be attributed to an American amateur station.

Three of the original operators of station 1BCG, including Major Armstrong (left), and Paul Godley (second from right) who operated the receiving gear in Scotland, were present at the dedication of the memorial.

Commenting on the results in *Wireless World* of 5th March, 1921, we wrote "The two main difficulties with which the entrants had to contend, apart from the weakness of the signals, were (1) harmonics from high-power stations on long wavelengths . . . and (2) jamming from other entrants, who in spite of urgent requests, and contrary to the conditions of their licences, persisted in using self-heterodyne receivers, which radiated and completely spoilt the reception for any other amateurs in the vicinity."

This disappointing result did not act as a deterrent from further effort and arrangements were made for another attempt in December of the same year. So great was the enthusiasm shown by American amateurs that the A.R.R.L. invited one of its members—Paul F. Godley—to set up a receiving station in this country "to supplement the efforts of the British amateurs."

Early in December 1921 the tests opened with transmissions from 27 American amateurs on wavelengths between 200 and 375 metres, some using spark and some c.w.

Of the large number of British amateurs who entered for the test, eight were successful in logging signals from the U.S.—all c.w. The American representative, who established his receiving station at Ardrossan, Scotland, was the most successful, however, logging all the stations. When commenting on this we wrote that it was "perhaps by reason of the fact that the authorities did not restrict him in the matter of aerials and location" that Paul Godley achieved such success. Godley's "Beverage" antenna exceeded the length then allowed to British amateurs.

To commemorate the station 1BCG which sent "the first message ever to span the Atlantic on short waves" a granite memorial has been erected at Greenwich, Conn., near the site of the original station which was built and operated by members of the Radio Club of America. At the dedicatory ceremony the operators of the station on that historic occasion were presented with medallions. Among the recipients were Major Edwin Armstrong—who, incidentally, contributed a letter on the a.m./f.m. controversy in the February issue—and Paul Godley, who operated the receiving station in Scotland.

To mark the thirtieth anniversary of these tests the Radio Club of America has issued a commemorative copy of its *Proceedings* with the title "The Story of the First Trans-Atlantic Short Wave Message" which is obtainable from the headquarters of the Club, 11, West 42nd Street, New York, 18, N.Y., price one dollar. It includes a description of the transmitting and receiving stations and reprints of the articles in *QST* of February 1922, giving Paul Godley's report.

WORLD OF WIRELESS

Festival Radio Convention ♦ T. L. Eckersley Honoured ♦ G3FB, Festival Station ♦ R.E.C.M.F. Show ♦ Television Servicing

Brit. I.R.E. Convention

DURING the Festival of Britain the British Institution of Radio Engineers plans to hold a Convention, the various sessions of which will be held in different centres.

The first session, covering electronic instrumentation in nucleonics, will be held on July 3rd and 4th at University College, London. Eight papers, including that of the chairman, Dr. Denis Taylor (Atomic Energy Research Establishment, Harwell), dealing with the applications of radioactivity in industry and the techniques employed in the associated electronic apparatus will be given.

"Valve Technology and Manufacture" is the title of the second session to be held on July 5th and 6th and of which J. W. Ridgeway (Ediswan) will be chairman. This session will also be held at University College, London.

University College, Southampton, is the venue for the third and fourth sessions, "Radiocommunication and Broadcasting" and "Radio Aids to Navigation," respectively. Paul Adorian (Brit. I.R.E. President) is chairman of the third which will be held on July 24th and 25th and F. S. Barton (Telecommunications Research and Development Establishment, M.o.S.) chairman of the fourth, to be held on July 26th and 27th.

The fifth session, on "Television Engineering," of which L. H. Bedford (Marconi's) is chairman, is to be held at King's College, Cambridge, from August 21st to 24th.

H. J. Leak will be in the chair at the last session which will deal with "Audio-frequency Engineering" and will be held from September 11th to 13th. The venue has not been decided, but it is hoped to be near Earls Court, London, where the National Radio Exhibition will be in progress.

The first day of each session is planned to open at 3.0, and subsequent days at 11.30. Each day's proceedings are scheduled to terminate at 7.0.

Dutch Television

DETAILS of the standards to be employed for the Dutch television service, which supplement those published recently in "Random Radiations," have been sent by a correspondent and are given below.

The first transmitter is to be erected at Lopik-Ijsselstein, near Utrecht, and the frequencies to be employed are 62.25 Mc/s vision, and 67.75 Mc/s sound. At present experimental transmissions are radiated from the Philips (Eindhoven) station on 48.25 Mc/s vision, and 53.75 Mc/s sound.

The Dutch standards are: 625 lines, picture frequency 25 per second (interlaced), picture ratio 3:4, negative picture modulation, single sideband, 5-Mc/s picture channel, f.m. sound (frequency deviation 50 kc/s), horizontal aerial polarization and total bandwidth 7 Mc/s.

Our correspondent adds that the sound transmitter at Lopik will probably be used outside programme hours for f.m. test transmissions.

Faraday Medallist

THE twenty-ninth award of the Faraday Medal has been made by the Institution of Electrical Engineers to T. L. Eckersley, B.A., B.Sc., Ph.D., F.R.S., for "his achievements in the field of radio research and, in particular, for his outstanding contributions to the theory and practice of radio-wave propagation."

Dr. Eckersley, who is senior research engineer of Marconi's W.T. Co., joined the National Physical Laboratory in 1910 at the age of 24, and after war service in the Royal Engineers joined Marconi's in 1919 where his work has been chiefly concerned with the study of radio-wave propagation. When in 1946 he was awarded a Fellowship of the American Institute of Radio Engineers it was stated that both his approach to the problem of propagation from the standpoint of practical communications and his invention of mathematical tools for the computation of radiated fields are "achievements of lasting value . . . and form a monument of which he may be justly proud."

T. L. ECKERSLEY, F.R.S.

The Faraday medal is awarded by the I.E.E., not more than once a year, for notable scientific service or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science.

R.I.C. Change

UNDER the new constitution of the Radio Industry Council an executive committee, consisting of two members from each of the four constituent associations (B.R.E.M.A., R.C.E.E.A., R.E.C.M.F. and B.R.V.M.A.), is appointed. This year's committee, which will meet monthly to conduct all the ordinary business of the R.I.C., consists of:—P. D. Canning (Plessey), G. Darnley Smith (Bush), M. M. MacQueen (G.E.C.), G. A. Marriott (G.E.C.), F. S. Mockford (Marconi's), L. H. J. Phillips (Metrovick), W. F. Randall (Telcon), and J. W. Ridgeway (Ediswan).

The new Council of the R.I.C. consists of sixteen members—four from each constituent association—and nominations are for one year only. At the first meeting of the Council J. W. Ridgeway, O.B.E., was elected chairman, and G. Darnley Smith, vice-chairman.

Festival Amateur Station

AS already announced (December 1950, issue) an amateur transmitting station is to form part of the Land Travel Exhibition which is being organized in conjunction with the Festival of Britain. This station, whioh will be set up for about three weeks in each of the following cities, Manchester, Leeds, Birmingham and Nottingham, and operated by local amateurs, has been allocated the call sign G3FB.

An amateur in each of the centres to be visited will be responsible for maintaining a rota of operators, and Class B licence holders who are interested to help are invited to get in touch with the responsible amateur. The dates of operation and the responsible amateurs are: Manchester, May 4th-26th, I. D. Auchterlonie (G6OM), 4, Stand Close, Ringley Road, Whitefield, Manchester; Leeds, June 23rd-July 14th, C. A. Sharp (G6KU), 56, Moore

Avenue, Wibsey, Bradford; Birmingham, August 4th-25th, organizer not yet announced; Nottingham, September 15th-October 6th, J. J. Curnow (G6CW), "The Yews," Mapperley Plains, Nottingham.

Components Show

THE eighth annual exhibition of components, valves, materials and test gear to be organized by the Radio and Electronic Component Manufacturers' Federation will be held at Grosvenor House, Park Lane, W.1, from April 10th-12th. It will open each day at 10.0 and close at 6.0 on the first two days and 5.0 on the last.

The space available for the exhibition is more than in previous years, so that there will be greater ease of access to the 101 stands.

This is not a public exhibition and admission is limited to ticket holders. Readers who have a professional, industrial or trade interest in components should apply for tickets to the R.E.C.M.F., 22, Surrey Street, London, W.C.2.

Television Servicing

CANDIDATES living outside the service area of a television station may now sit for the theoretical section of the R.T.E.B. examination for the Television Servicing Certificate providing they undertake to sit for the practical examination within twelve months of the opening of a station in their area.

The next examination will be held in May. Particulars are obtainable from the Radio Trades Examination Board, 9, Bedford Square, London, W.C.1.

Candidates will not receive the certificate until the practical examination has been passed.

Airmet

A CORRESPONDENT in *The Aeroplane* (January 19th) suggests that even if the present wavelength *impasse* was solved, say by the use of a frequency of the order of 7 Mc/s, for the re-introduction of the Airmet weather service, the authority responsible—whoever that may be—may consider that the cost of the service for 21,400 (the number of petitioners) is not justified.

He estimates that as the information is already available at the Central Forecasting Office, Dunstable, the cost of transmission could be kept down to £7,000-£8,000 a year. He suggests that every wireless licence holder should be made to contribute consciously to the return of a first-class weather broadcasting service by charging an additional penny for each future wireless licence (a penny stamp to be fixed and cancelled by the P.O. date stamp at issue). "Twelve million pence is £50,000, which would give us the world's finest possible weather service continuously, all round the clock on short wavelengths suited to the incidence of light and darkness," he adds.

Wenvoe Television Station

THE negotiations for the site on St. Lythan's Downs, near Wenvoe, Glamorgan, about five miles from Cardiff, for the fifth B.B.C. high-power television station have now been completed. The station, to be known as the Wenvoe transmitter, will be on a site 400ft above sea level and will have a 750-ft mast—to be supplied by B.I. Callender's Construction Co.—similar to that at Sutton Coldfield. A feature of the 50-kW E.M.I. vision transmitter is that the carrier wave will be modulated by the vision signal in a low-power stage instead of in the output stage as has been customary in previous installations.

The 12-kW sound transmitter is to be supplied by Standard Telephones and Cables.

The anticipated service area—calculated from tests using a 1-kW transmitter with the aerial suspended from a balloon flown at 600ft above ground—was given on the map published in our last issue.

PERSONALITIES

J. W. Ridgeway, O.B.E., who, as already mentioned, has been elected chairman of the reconstituted Radio Industry Council, is director and manager of the Radio Division of the Edison Swan Electric Co. He was also recently elected for the seventh term of office as chairman of the British Radio Valve Manufacturers' Association.

J. W. RIDGEWAY, O.B.E.

D. W. Heightman, who recently resigned from the Board of Denco (Clacton), Ltd., of which he was the founder in 1938, has joined the English Electric Co. as chief television engineer at the Liverpool Works.

L. H. J. Phillips, who, as stated elsewhere, is the new chairman of R.C.E.E.A., is manager of the radio sales department of Metropolitan-Vickers. During the 1939-45 war he left the Metrovick research section to become head of the radio department of the Royal Aircraft Establishment, Farnborough. He became Deputy Director of Communications Development in the Ministry of Aircraft Production and returned to Metrovick in 1945.

L. H. J. PHILLIPS

A. H. Ginman has relinquished the presidency of the Canadian Marconi Company and is succeeded by S. M. Finlayson. After serving with Marconi's in this country, Mr. Ginman went to America as an operator and in 1911 became manager of Marconi's W.T. Co. of America. He held various administrative posts in overseas telecommunication organizations and for some time prior to going to Canada in 1935 was general manager of the parent company.

IN BRIEF

Licences.—The number of television licences more than doubled during 1950. The increase during the year was 346,400 bringing the total to 586,100. The total number of sound and vision licences current at the end of December was 12,295,000, an increase of 113,700 during the year but a decrease of 36,900 on the November figure.

Rugby Jubilee.—To celebrate the twenty-fifth anniversary of the opening of the G.P.O. Rugby station, which was brought into service on January 1st, 1926, a dinner was held in the town on January 11th. Among the 100 or more present was H. Faulkner, the first Rugby engineer-in-charge, who is now deputy engineer-in-chief G.P.O.

Amateur Television.—It is learned from the European Broadcasting Union that the Netherlands Government has allocated the 146-148-Mc/s and 420-460-Mc/s bands to amateurs for the transmission of television.

Ultrasonics.—A course of four lectures on ultrasonics is to be given by L. I. Farren, M.B.E., Whit. Schol., M.I.E.E., of the G.E.C. Research Laboratories, at the Polytechnic, Regent Street, London, W.1, at 6.30 p.m. on Fridays, March 2nd, 9th, 16th and 30th. The lectures, each of which will last about one and a half hours and will be followed by a discussion, will cover, respectively, fundamentals, generation of ultrasonic waves, reception of ultrasonic waves and the applications of ultrasonics. Enrolment forms for the course, for which the fee is ten shillings, are obtainable from the Head of the Electrical Engineering Department at the Polytechnic.

Reunion Dinner of the Royal Engineers, Wireless Signals (1914-1919) Association, which is being resumed after a lapse of some years, will be held at the White Horse Hotel, Congreve Street, Birmingham, on April 7th. Further particulars are obtainable from C. R. Johnson, 88, Fox Hollies Road, Acocks Green, Birmingham, 27.

Valve Manufacture.—The Minister of Supply, in reply to a question in the House, stated that he was unable to give an assurance that adequate supplies of non-ferrous metals will be available to meet all the commitments of the radio valve manufacturers.

Radar Reunion.—The fifth annual reunion of the Radar Association will take place at the Royal Empire Society Hall, Northumberland Avenue, London, W.C.2, on March 10th. Tickets, price 8s 6d, and further particulars are obtainable from the Radar Association, 83, Portland Place, London, W.1.

Television Cameras with a full-range test pattern engraved on the face of the pick-up tube are now being produced by Marconi's and eight are to be supplied to the B.B.C. These monoscope cameras will facilitate the checking of transmissions from mobile stations without taking an ordinary camera out of service. It will also ensure constancy of test transmissions. The output of the cameras is of standard form with blanking but without sync signals.

"Explaining Television."—To assist prospective purchasers of television receivers by answering such questions as "Do I need an aerial?", "What size tube?", "What is television going to cost?" etc., the Radio & Television Retailers' Association has prepared a booklet for distribution by R.T.R.A. dealers. "Explaining Television," as it is called, includes field-strength maps of both the Alexandra Palace and Sutton Coldfield transmitters.

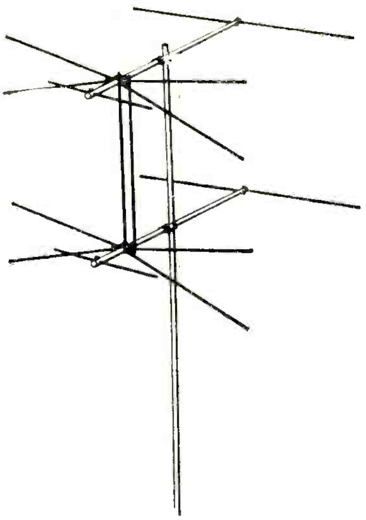
B.S.R.A. Diary.—Data on disc, film and tape recording and reproducing, standard and microgroove records and on the majority of pick-ups are given in the sixteen pages of information included in the 1951 edition of the B.S.R.A. Diary which is obtainable from H. M. Blaber, 9, Stanton Road, West Wimbledon, S.W.20, price 4s 3d, including postage.

Appointments Bureau. — J. Muil, A.M.I.E.E., who has been for the last five years with the Technical and Scientific Register of the Ministry of Labour, has been appointed Registrar and Secretary of the Professional Engineers' Appointments Bureau, 9, Victoria Street, Westminster, S.W.1.

Gratis.—A.A. Electrical Co., Ltd., inform us that they are supplying and fitting interference suppressors free of charge to customers' cars and vans at their Chiswick Works, 67, Rothschild Road, London, W.4.

"Radio World Digest" is the title of a new quarterly magazine published by the Eurap Publishing Co. which also issues the weekly *European Radio* giving details of foreign programmes. *Radio World Digest* gives general information on world broadcasting and schedules of regular transmissions in English from overseas stations. It costs one shilling.

S.R.E.—It is claimed that the installation of sound reinforcing equipment in the Banqueting Hall of the Glasgow Municipal Buildings by Philips Electrical has made it possible for the first time in 62 years for a full audience of 800 to hear clearly all that is said from the platform. The installation includes twenty-one 8-in reproducers, each of which is fitted with a deflector panel to prevent the sound rising to the roof of the building.



AMERICAN television aerial. This broad-band array with director and reflector covers all frequencies at present used by U.S. television stations (54-216 Mc/s). It is produced by the Walter L. Schott Co., Beverley Hills, Calif.

Malaya.—The Director of the Department of Broadcasting in the Federation of Malaya has urged importers to maintain a good supply of sets in 1951 so that the Government's efforts to keep the Malayan public properly informed may be effective.

"Square-Wave Generators."—In this article (p. 35, our January issue) the last part of the inscription to Fig. 2 should read "at (b) is the waveform at 8 kc/s"—not 80 kc/s.

INDUSTRIAL NEWS

R.C.E.E.A. Council.—At the annual general meeting of the Radio Communication & Electronic Engineering Association—one of the constituent bodies of the Radio Industry Council—the following member firms (with, in parentheses, the representative) were re-elected:—B.T.H. (V. M. Roberts), E.M.I. (J. S. Carr), G.E.C. (M. M. MacQueen), Kelvin & Hughes (C. G. White), Marconi's (F. S. Mockford), Metrovick (L. H. J. Phillips), Mullard (T. E. Goldup), Murphy (K. S. Davies), Plessey (P. D. Canning), Pye (C. O. Stanley), Rediffon (B. St. J. Sadler) and S.T.C. (L. T. Hinton). The new chairman is L. H. J. Phillips and K. S. Davies is vice-chairman.

Denco advise us that the manufacturing and sales rights of the DCR19 communications receiver and the associated equipment (all-wave coil turret (CT4), i.f. transformer (IFT9) and 1.6-Mc/s crystal filter unit) have been transferred to the recently formed Heightman Company of 25, Coppins Road, Clacton-on-Sea. Denco will continue the production of their other radio and television components.

A Decimal Point was omitted from the percentage of regulation given for the Furzehill stabilized power supply units on p. 24 of the advertisements in our January issue. The figure should have been 0.5%.

Murphy announce that they have received an unsolicited order for a substantial quantity of broadcast receivers from a New Orleans importer.

Radio Buoys & Beacons, Ltd., is the name given to the recently formed electronics division of Venner Time Switches, Ltd., New Malden, Surrey.

T.C.C. reports that although 1949 was a good year for export sales, the 1950 figure exceeded it by 61%.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"London-Birmingham Television Radio-Relay Link," by R. J. Clayton, M.A., D. C. Espley, O.B.E., D.Eng., G. W. S. Griffiths and J. M. C. Pinkham, M.A., on March 1st.

"Design Considerations for a Radiotelegraph Receiving System," by J. D. Holland, on March 7th.

"The Testing of Fine Wires for Telecommunication Apparatus," by R. C. Woods and J. K. Martin, and "The Use of an Electrostatic Wattmeter for Magnetic-Loss Measurements," by J. Choudbury, M.Sc.Tech., and Arvon Glynne, M.A., on March 13th.

Informal Lecture on "Radio Astronomy," by A. C. B. Lovell, Ph.D., on March 19th.

Education Circle.—Discussion on "The Best Means of Explaining the Internal Operation of Electronic Valves," opener A. F. H. Thompson, M.A., at 6.0 on March 5th.

The above meetings will be held at 5.30 (unless otherwise stated) at the I.E.E., Savoy Place, W.C.2.

Cambridge Radio Group.—Discussion on "Is there an Optimum Speed for a Gramophone Record?" opener G. F. Dutton, Ph.D., B.Sc.(Eng.), at 8.15, on March 6th, at the Cavendish Laboratory, Cambridge.

North-Eastern Radio Group.—Informal Lecture on "The Nervous System as a Communication Network," by J. A. V. Bates, M.A., M.B., B.Chir., on March 5th.

Informal Lecture on "The Acoustics of Studios and Auditoria," by W. Allen, on March 19th.

Both meetings of the North Eastern Radio Group will be held at 6.15, at King's College, Newcastle-on-Tyne.

South Midland Radio Group.—Informal lecture on "The Magnetic Tape Recorder," by G. F. Dutton, Ph.D., B.Sc.(Eng.), at 6.0, on March 19th, at the Imperial Hotel, Birmingham.

Southern Centre.—"The Radar-Sonde System for the Measurement of Upper Wind and Air Data," by F. E. Jones, M.B.E., B.Sc., Ph.D., J. E. N. Hooper, B.Sc., and N. L. Alder, B.Sc., at 7.30, on March 21st, at the R.A.E. Technical College, Farnborough.

Oxford District.—"The Use of the Synchrotron and other Particle

Accelerators in Atomic Research," by C. H. Collie, M.A., B.Sc., at 7.0, on March 14th, at the Electricity Showrooms, Southern Electricity Board, 37, George Street, Oxford.

London Students' Section.—Visit to E.M.I. Studios, Abbey Road, London, N.W.8, at 10.30 a.m., on March 10th.

British Institution of Radio Engineers

London Section.—"Nuclear Scintillation Counters" by J. B. Birks, B.A., Ph.D., at 6.30 on March 29th at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

North Western Section.—"A Survey of Television Development and its Problems" by H. J. Barton-Chapple, B.Sc., at 7.15 on March 1st at the College of Technology, Manchester.

Merseyside Section.—"The Use of Foster's Theorem in Circuit Design" by E. Williams, Ph.D., at 7.0 on March 1st at the Electricity Service Centre, Whitechapel, Liverpool.

Scottish Section.—"High-Fidelity Sound Reproduction" by D. T. N. Williamson at 7.0 on March 6th at the Natural Philosophy Department, The University, Glasgow, and at 7.0 on March 7th at the Natural Philosophy Department, The University, Drummond Street, Edinburgh. Both are joint meetings with the Institute of Physics, Scottish Branch.

"Magnetic Amplifiers" by H. M. Gale, B.Sc., at 7.0 on March 22nd at the Institution of Engineers and Shipbuilders, Glasgow.

South Midlands Section.—"A Transmitter for an Experimental Eight-Channel Carrier Wire-Broadcasting System" by R. G. Kitchenn, B.Sc., at 7.15 on March 14th at the Exhibition Gallery, Public Library, Rugby.

North-Eastern Section.—"Acoustics" by E. G. Richardson, B.A., Ph.D., B.Sc., at 6.0 on March 14th at Neville Hall, Westgate Road, Newcastle.

West Midlands Section.—"Engineering Aspects of Industrial Electronic Equipment" by R. J. F. Howard at 7.0 on March 28th at the Wolverhampton and Staffordshire Technical College, Wolverhampton.

British Sound Recording Association

Discussion on the measurement and use of standard frequency discs for the calibration of gramophone pickups; opener H. Davies, M.Eng., M.I.E.E., at 7.0 on March 16th at the Royal Society of Arts, John Adam Street, London, W.C.2. The paper by R. W. Lowden on "The Design of a Long-Duration Recording and Reproducing Equipment" has been postponed.

Television Society

Leicester Centre.—"Design of a Combined Radio and Television Receiver," by Alan Bamford, B.Sc. (Ultra, Ltd.), at 7.0, on March 14th, at the Leicester College of Technology, The Newarkes, Leicester.

Junior Institution of Engineers

North-Western Section. — "Marine Radar," by T. R. Goode, B.Eng., at 7.0, on March 5th, at the Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester.

Midland Section.—Lecture on the latest developments in television by J. C. Gilbert at 7.0 on March 14th at the Central Technical College, Suffolk Street, Birmingham.

Institution of Electronics

Midlands Branch. — "Radioactive Tracers: Their Uses in Research and Industry, with particular reference to their potentialities for Industrial Control," by I. S. Hallow, B.A. (Tracer Processes, Ltd.), at 7.0, on March 6th, at the Warwick Room, Imperial Hotel, Temple Street, Birmingham, 2.

Southern Branch. — "A Physicist Looks at Biology" by Dr. W. Summer, A.Inst.P., at 6.30 on March 16th at Southampton University College.

B.B.C. STATIONS

Location, Programmes and Present Power

In view of the difficulties experienced at present in many areas in receiving satisfactorily the B.B.C. medium- and long-wave transmissions, it has been considered desirable to publish an up-to-date list of British stations to assist readers in making the most advantageous choice of station for the reception of a given programme. The appended list, which gives the actual power used and the maximum power permitted under the Copenhagen Plan, was supplied by the B.B.C.

It is pointed out that there are various reasons why stations are not using the maximum permitted power; for instance where several stations are synchronized on the same frequency the best coverage for the whole group may be obtained with some of them working at a lower power than that permitted.

The power given for Daventry (Third Programme) is that to be used by the new transmitter now under construction.

Frequency (kc/s)	Station	Programme	Power (kW)	Permitted Power
200	Droitwich	Light	400	400
647	Daventry	Third	150	150*
	Edinburgh	,,	2	—
	Glasgow	,,	2	—
	Newcastle	,,	2	—
	Redmoss	,,	2	—
692	Moorside Edge	Home (North)	150	150
809	Burghead	Home (Scot.)	100	100
	Redmoss	,,	5	20
	Westerglen	,,	100	100
881	Penmon	Home (Welsh)	8	20
	Washford	,,	100	150
	Wrexham	,,	0.25	5
908	Brookmans Park	Home (London	140	150
1052	Start Point	Home (West)	120	150
1088	Droitwich	Home (Midland)	150	150
	Norwich	,,	7.5	20
1151	Lisnagarvey	Home (N.Ireland)	100	100
	Londonderry	,,	0.25	5
	Stagshaw	,,	100	100
1214	Brookmans Park	Light	60	60
	Burghead	,,	20	20

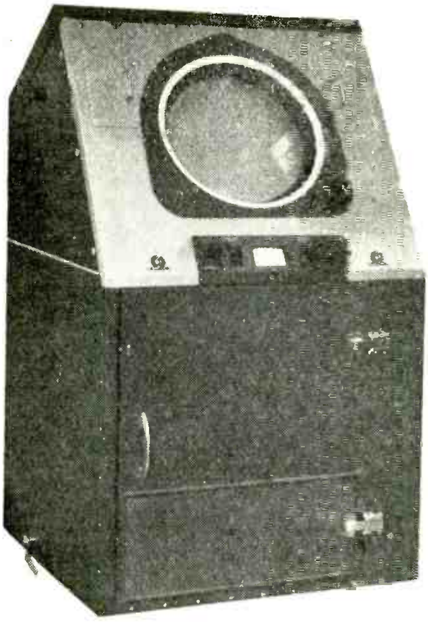
* Daventry is allowed 150 kW if the three 15-kW stations provided for in the Plan, also on 647 kc/s, are not used. Total power permitted on this frequency is 165 kW.

Frequency (kc/s)	Station	Programme	Power (kW)	Permitted Power
1214	Lisnagarvey	Light	10	10
	Londonderry	,,	0.25	1
	Moorside Edge	,,	58	58
	Newcastle	,,	2	10†
	Plymouth	,,	0.3	2
	Redmoss	,,	2	2
	Redruth	,,	2	2
	Westerglen	,,	50	50
1295	Ottringham	European	150	150
1340	Crowborough	European	150	150
1457	Bartley	Home (West)	10	60
	Clevedon	,,	20	60
1546	Belfast	Third	0.25	5
	Bournemouth	,,	0.25	2
	Brighton	,,	1	5
	Cardiff	,,	1	2
	Dundee	,,	0.25	2
	Exeter	,,	0.1	5
	Fareham	,,	1	2
	Hull	,,	0.25	5
	Leeds	,,	1	5
	Liverpool	,,	1	5
	Manchester	,,	1	2
	Plymouth	,,	1	5
	Preston	,,	1	2
	Redruth	,,	1	2
	Sheffield	,,	1	2
	Stockton	,,	0.25	2

† Allocated to Stagshaw

Harbour-Control Radar

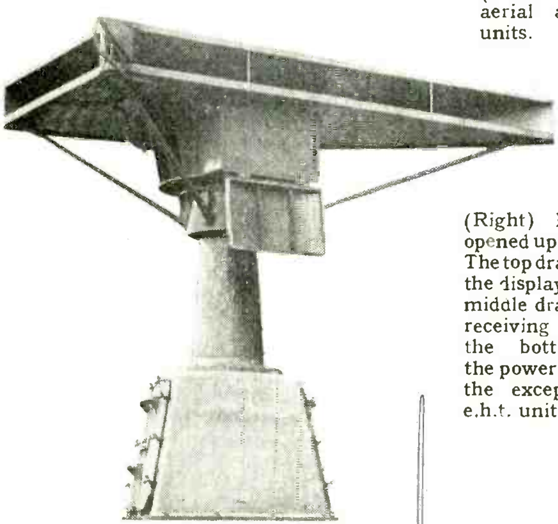
New Equipment Designed Specifically for the Purpose



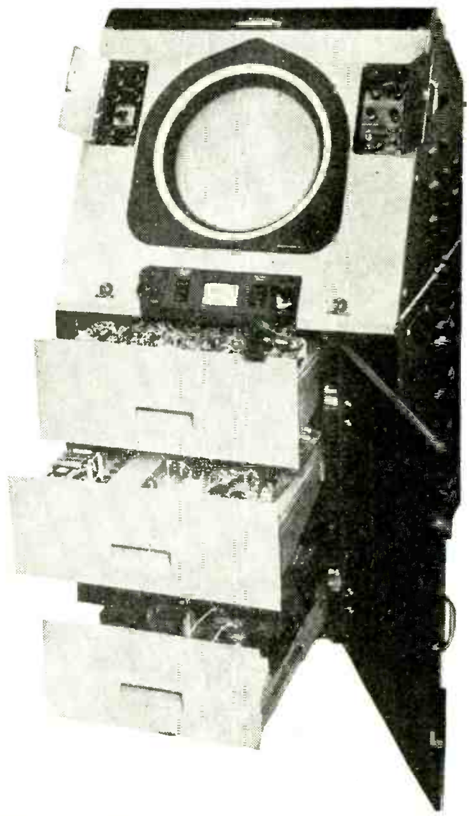
Decca harbour radar display console.

IN many respects the requirements of harbour radar are more stringent than those of shipborne radar. Provided that the clarity and accuracy of the display are good at short ranges near the centre of the picture, the mariner will not be unduly critical of lack of definition or some obscurity of distant features by false returns from side lobes in the aerial characteristic. A harbour authority, on the other hand, must have a clear picture over a very wide area in order that a watch may be kept simultaneously on a large number of vessels, and the range discrimination must be of an exceptionally high order if accurate navigational instructions are to be given in narrow and congested waterways.

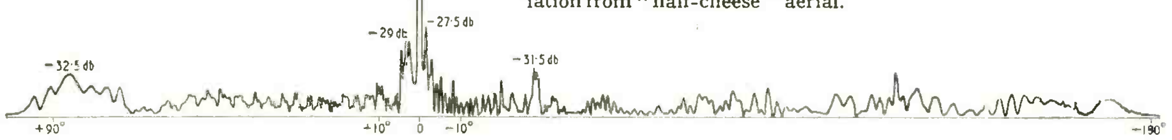
The new Decca radar, Type I, has been developed specifically for this purpose, and was demonstrated recently on a site overlooking Southampton Water. The results obtained indicate that a notable advance has been achieved. Range discrimination is of the order of 10 yards, as was clearly demonstrated when a motor yacht circled a navigation buoy at this distance. The critical factor determining range discrimination is pulse length and in the new Decca



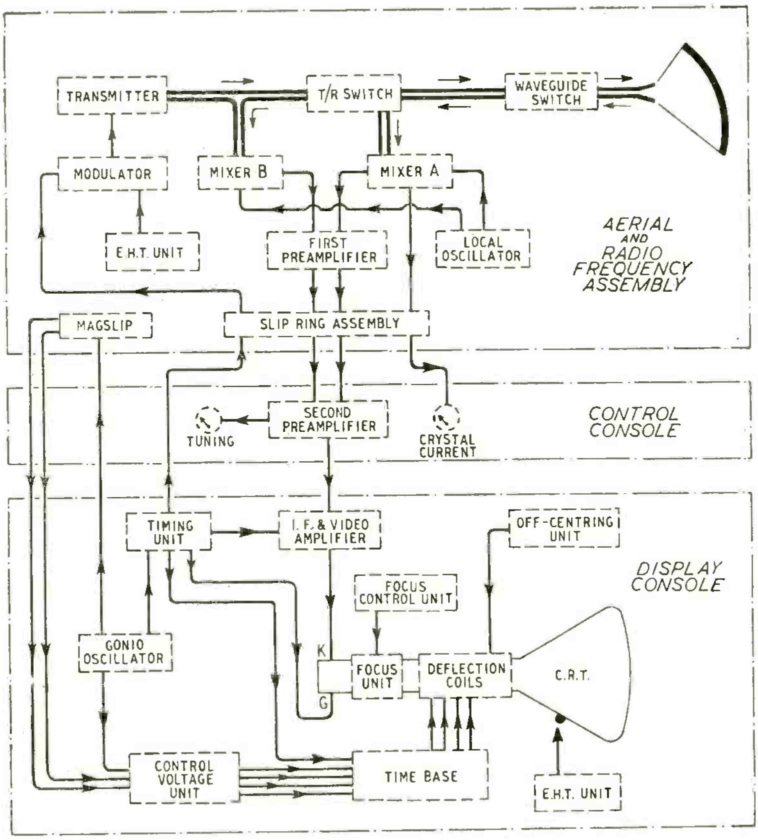
(Left) "Half-cheese" aerial and dual r.f. units.



(Right) Display unit opened up for servicing. The top drawer contains the display circuits, the middle drawer the final receiving stages, and the bottom drawer, the power supplies with the exception of the e.h.t. unit.

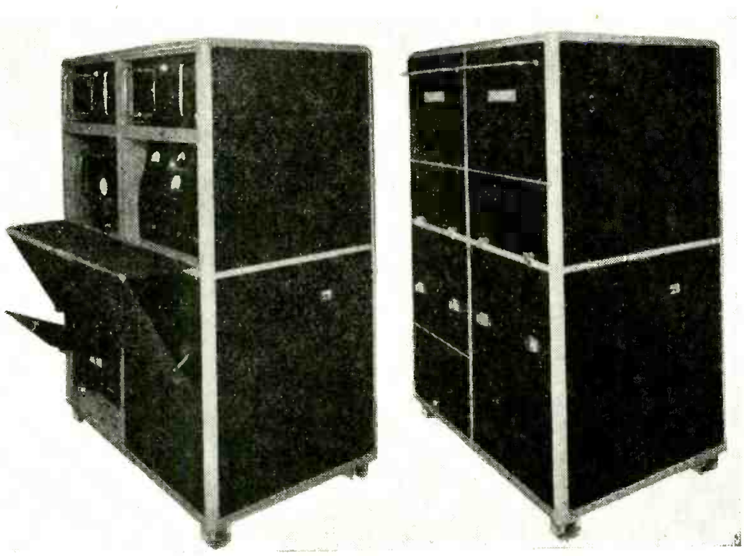


(Below) Polar diagram of radiation from "half-cheese" aerial.



Block schematic diagram of the Decca Type I harbour radar equipment.

(Below) Control cabinet showing, in the top compartments, the twin power packs, and below, from left to right, the second pre-amplifiers on one vertical chassis, the monitor oscilloscope and the master control panel. The front cover panels hinge down to form tables for intruments and tools when chassis are drawn forward for servicing.



design this has been reduced to the exceptionally low duration time of 0.06 microsecond. This is half the pulse length used in the Decca shipborne radar, in which separate aerials are used for transmission and reception and the range discrimination and minimum range are both 20 yards. In a harbour radar, minimum range is of less importance than on board ship, and the designers have reverted to the normal practice of using a single aerial with a transmit-receive switch. The extinction time of the gas discharge in the switch governs the minimum range, which is about 26 yards in the Type I equipment.

Definition in the p.p.i. picture is a function of beam width, as well as pulse length, and a width of 0.7 degrees (at points 3db down in power) is achieved in the 9ft "half-cheese" reflector which has been adopted for the new design. As the name implies, this scanner is a half-segment of the conventional parabolic cheese reflector, fed from one corner instead of the centre of the aperture. Shadow effects caused by the feeder are reduced, and there is less interference with the main beam from the aerial. As a result, side lobes are reduced in amplitude by as much as 6db, and the picture brightness can be considerably increased without revealing spurious side-lobe returns.

A cathode-ray tube of 15in diameter is used in the display console, and on the lowest range (maximum of the order of $2\frac{1}{2}$ miles) it is possible to distinguish between the point returns from navigation buoys and longer images from vessels; indeed, it is possible with this equipment to obtain a very good idea of the size of the vessel. A screen coating of moderate persistence is employed and the trail left by moving ships gives useful information on the course being steered. Bearings may be taken with the usual graticule and circumferential scale, while range is obtained with a continuously variable marker in association with an external calibrated dial. Three of these display consoles can be used up to a distance of 1,000 yards from the scanner.

Reliability of service is vital in a radar carrying the responsibility of shipping control in a large harbour, and to this end units are duplicated, including the main r.f. unit on the scanner, so that an immediate change-over to the standby units is possible in the event of failure. In most cases the switch-over is instantaneous, and the maximum delay is under half a minute.

In cases where the area under the harbour authority cannot be covered adequately by one scanner, several may be installed at strategic points and the radar information relayed to a central office by means of a centimetre-wave radio link. The bandwidth used will be the same as that of the video amplifiers in the main equipment and definition in the relayed displays will be in no way inferior to the original. It is claimed that coverage of a large area by a number of distributed scanners is capable of giving better local definition at points remote from the central control than the use of a single high-powered scanner. With standardization of the basic unit and a consequent lowering of production costs, it should be possible to meet widely divergent harbour requirements at an economical figure.

Hearing Aid Problems

IN a symposium on hearing aids on 10th January, arranged by the British Institution of Radio Engineers, E. R. Garnett Passe, F.R.C.S., gave an introductory paper on the clinical aspects of deafness and the possibilities of alleviation surgically, medically and by the use of hearing aids. After outlining the elementary physiology of the ear he explained the essential differences between conduction and nerve deafness, and indicated that although little could be done by medical treatment with drugs, promising results had been achieved by surgery.

Mr. Garnett Passe thought that the provision of tone control in hearing aids was important, but there was a limit to the useful compensation which could be employed for high-frequency loss in Corti nerve deafness. In cases where a transition from deafness to more or less normal hearing took place over a narrow volume range, some form of automatic volume control or peak limitation was essential and, if unavoidable, some sacrifice of quality must be tolerated to this end.

A master hearing aid designed at the Post Office Research Station for investigations into the relative merits of automatic level control and peak limitation, as well as the determination of optimum frequency response curves, was described in the second paper by E. Aspinall, B.Sc. This equipment is designed for articulation tests and normally makes use of standard test records. It is being modified for experiments with bone-conduction, as well as normal air-conduction receivers. The automatic level control can be set to start at different levels and the upper limit is maintained constant within $\pm 1\frac{1}{2}$ db over a range of inputs of 30 db. Operating (attack) and release (decay) time constants are variable over ranges of 10-100 msec and 0.25 to 3 seconds respectively. The peak limiter has a range of 40 db in 2 db steps.

Finally, the construction of a typical commercial hearing aid was described in detail by J. P. Ashton, B.Sc. (Eng.), who paid tribute to the qualities of British sub-miniature valves and indicated the trend of future developments. Some slides were shown of recent American aids employing printed circuits with silkscreen printed carbon ink resistors and miniature bypass and coupling capacitors of high value making use of deposited electrodes on ceramic plates of dielectric constant 3,000 and thickness 0.005 in.

U.S. Colour Television

A Correspondent's Observations

BOTH the General Electric frequency-interlace system, described by A. Dinsdale in the December issue, and the R.C.A. dot-sequential system are very ingenious, but they, and the line-sequential system (developed by Color Television Inc.), suffer from a serious disability, in that three electron guns are essential in the receivers. A single-envelope tube with three guns presents (as R.C.A. admits) a very difficult production problem, and both this and the three-tube system involve grave optical registration difficulties, if colour fringing is to be avoided. Very small changes in the characteristics of the deflection system (such as during warm-up and because of ageing) might cause inaccurate registration or unequal size of the three primary-colour images, producing even more unpleasant psychological effects than those of bad colour printing. Surmounting this hurdle alone would make for a very costly receiver; in the three-tube system, the optical arrangements introduce further difficulties.

The main objection to the C.B.S. system, approved by the F.C.C., has been on the grounds of "compatibility" — a C.B.S. transmission cannot be received on an unmodified black-and-white receiver. On the other hand, this system is "convertible"—a black-and-white receiver with a converter can reproduce, in black-and-white, a C.B.S. colour transmission. Further, a colour disc may be added to the receiver with the converter, which will then present coloured pictures with the original c.r.t. The G.E., R.C.A. and to some extent the C.T.I. systems are compatible, but convertible only with great difficulty and expense—for example, the c.r.t. and associated circuits must be scrapped in favour of very expensive substitutes if colour pictures are to be received.

It therefore seems that the C.B.S. system is the most practical, and that the F.C.C.'s decision was wise. The colour disc may be clumsy, but it is cheap, simple and foolproof. The limitation on picture size could be resolved with projection technique (a small colour disc permits the conversion of those receivers with tubes larger than $12\frac{1}{2}$in dia.). The lack of high-speed electronic switches and filters, and the greater circuit simplicity generally are advantages that surely cannot be ignored. (Is receiver cost no object whatever?) Added to all this is the fact that of all the systems demonstrated, that of the C.B.S. has by far the best colour fidelity—"better in some ways than Technicolor," to quote *Time*.

It is true that the C.B.S. system (frame-sequential, 405 lines, 144 frames, 48 complete colour pictures per second) entails degradation from the American standard of 525 lines interlaced, 60 frames, to something a little poorer than the British, in order to keep within the bandwidth. It is also true that a system which gives equal values to red, blue and green images is not making the best possible use of the bandwidth (for instance, the eye requires very little red detail and good green detail). On the other hand, it seems pointless to use high colour-switching rate systems, which require the satisfaction of a number of very critical conditions and involve very costly receivers, when a relatively cheap and simple alternative is available.

C. F. K. G.

Testing Steep-slope Valves

Problem of Parasitic Oscillation

By J. C. FINLAY, A.M.I.E.E.

RECENT experiences with some of the new miniature valves suggest that special precautions are necessary when checking high-mutual-conductance triodes in the usual multi-valveholder type of tester.

For instance, a new ECC91 miniature double triode was checked for balance, having been plugged into a B7G base which had been fitted in a spare panel position on the valve tester. The two anode readings differed in a ratio of about three, which was clearly excessive for a new valve. However, two further valves gave a very similar result. Subsequent tests, confirmed by a c.r.o., showed that the "low" section was oscillating.

The effect would seem to be due to the multiple electrode leads in the usual valve-tester panels, which can give rise to considerable external anode-grid capacitance when testing triodes and thus encourage parasitic oscillation, particularly with modern high-mutual-conductance types. The tendency is probably accentuated by the transient effect of the a.c. energizing voltages normally used in valve testers.

The high-mutual-conductance requirement was confirmed by testing for hand-capacitance effect with several valve types. Oscillations were found with some 6SN7 double-triodes and the PX4 power triode but not with the 6N7. Moreover, a "negative" reading of mutual conductance was obtained with the 6SN7. Among pentodes strapped as triodes the EF50, KT61 and KT66 all oscillated but not the KT63; when tested as pentodes there was, of course, no oscillation. Trouble is likely whenever the measured mutual conductance exceeds 3-4 mA/V.

A certain cure which does not interfere with the operation of the tester is to connect a damping capacitor from grid to cathode on the valveholder. For universal suppression it has been found satisfactory to use 100 pF between every tag likely to be used as a grid and the panel frame, which is connected to the low ("cathode") end of the supply transformer and the transformer core, and earthed through the usual third core on the mains lead. In the original case the balances then became reasonable.

If every valveholder is to be individually by-passed in this way the cost of ceramic capacitors is formidable and they will occupy considerable space, but they *must* be fitted as near as possible to the valve pins in order effectively to short-circuit the parasitic tuned circuits formed by lead inductance and capacitance.

A more fundamental cure might be to screen all leads to frame and thus considerably reduce the stray capacitance between any pair of electrodes and increase that between each electrode and frame. Alternatively, one completely suppressed holder might be used with different short adaptors for each valve-base type, but this would be inconvenient and probably more expensive.

Mr. Finlay's note has been passed to the Automatic Coil Winder and Electrical Equipment Company, makers of Avo instruments, who contribute the following comments, written by S. R. WILKINS, *chief electronic engineer.*

WE have noted difficulties that sometimes arise when testing modern high-slope valves in our original valve tester, which was, of course, designed many years ago when the extremely high slopes which are the present-day tendency were not met with.

As Mr. Finlay surmises, difficulty arises when a number of valveholders are wired in parallel. The inductance of this wiring, together with distributed capacity, results in a capacity loaded line being applied to the valve, with the result that the high slope of the latter, together with distributed feedback capacity causes oscillations to take place at a very high frequency determined by the random line constants.

The incidence of this effect will, of course, vary within limits from valve panel to valve panel, depending upon minor variations in the wiring, and, of course, will vary with the effective slope of the valve.

Whilst a certain measure of cure can be obtained by the application of by-pass capacitances connected directly to the valve pins, this necessitates, as your correspondent suggests, the connecting of a suitable capacitance to every pin of every valveholder, the capacitance having to stand up to the maximum peak applied voltage that can be applied for either screen or anode. Even then, since any pin can represent any electrode, depending on the base set-up of the valve in question, the presence of a by-pass capacitance on one electrode may be offset by a similar feedback capacitance of another electrode. This form of cure, therefore, besides being unwieldy and extremely expensive, is not really satisfactory. Further, the effect of loading capacitances can be to transform a line which would normally present too high a resonant frequency for oscillation into one of lower frequency at which oscillations will take place.

A form of cure which we have previously adopted consists in the inclusion in circuit immediately at the valve pin of a resistance stopper, overwound with an inductance so that, when the pin concerned becomes a heater or cathode, negligible d.c. resistance is presented. Here again, since it is impossible to do this for every pin, such stoppers have only been included at carefully chosen pins of specific valveholders, thus minimizing the possibility of oscillation in specific cases where it is liable to occur. This, of course, represents only a partial cure.

Considerable experimental work on this problem has resulted in our introducing on recent models of our valve characteristic meter an entirely new form of wiring design to overcome this trouble in all normal cases. It will be evident that the problem is many times worse on our valve characteristic meter, where the possibility of testing a valve on any portion of its characteristic can mean that a valve may be tested at many times its normal emission and at a point of extremely high anode slope. The method introduced (patent applied for) consists in so wiring the multiple valveholders in that any valve of sufficiently high slope will tend to oscillate at a predetermined frequency depending upon a controlled loop length in the wiring. The loop in question is then suitably resistively damped so that oscillation cannot take place at the frequency in question. Since the resonant frequency of possible oscillation is held within reasonably close limits by the nature of the wiring, this means in fact that oscillation does not occur at any frequency. The number of stoppers to promote this condition is thus reduced to the total number of wiring loops; i.e., one for each pin of the valveholder, and all other more difficult manufacturing methods including the use of screened wiring are thus eliminated.

Results with this system have shown, both on our valve characteristic meter and our valve tester, that valves such as the KT33C can be tested at twice their normal working emission, and with a slope of some 12 mA/V, with complete stability, and, as far as can be at present determined, this very difficult problem which has exercised our minds for many years has now to all intents and purposes been overcome.

Ionosphere Review: 1950

Rapid Fall in Sunspot Activity with M.U.Fs Lower than Anticipated—Forecast for 1951

By T. W. BENNINGTON (Engineering Division B.B.C.)

DURING 1950 the sunspot cycle continued in its "declining" phase, and the rate of decrease in sunspot activity was, in fact, greater than in any year since the maximum in 1947.

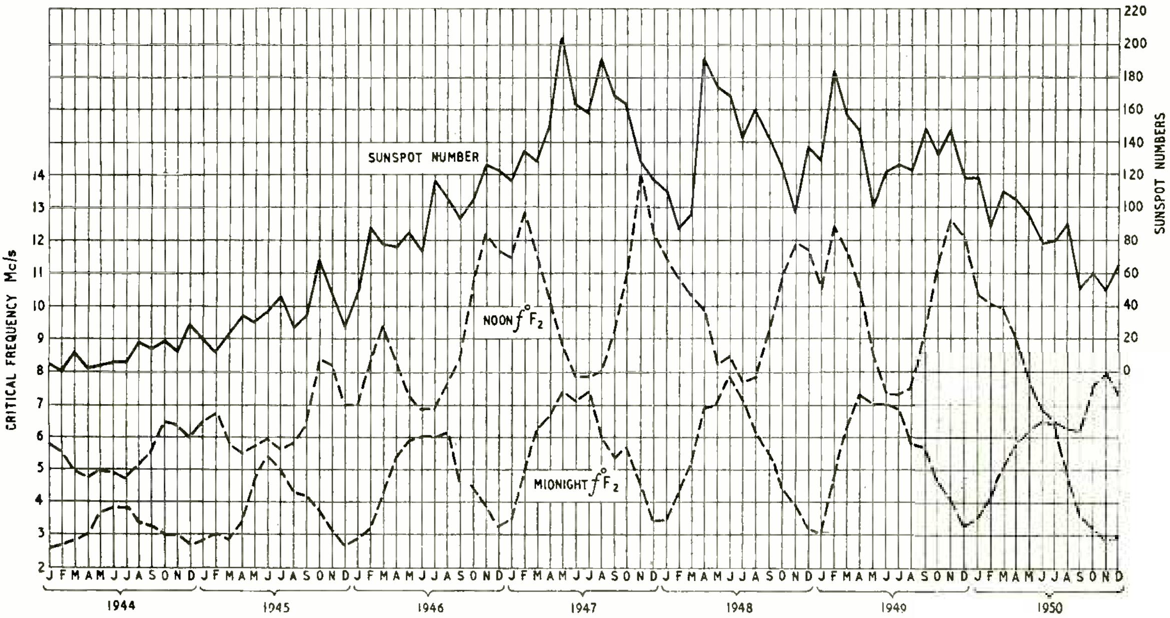
The corresponding ionospheric variations—which result from the variation in the amount of solar ultra-violet radiation falling upon the ionosphere, in accordance with the variations in the sun's activity—were also in a generally decreasing direction. The measured ionospheric critical frequencies at the beginning of the year were high, but, so far as day-time values in the northern hemisphere are concerned, after their summer fall they never recovered to anything like their springtime values, but remained low throughout the northern hemisphere autumn and winter. As a result of this the maximum usable frequencies for long-distance short-wave communication—which are directly related to the measured critical frequencies—were, from September onwards, very much lower than had been anticipated earlier in the year. But, of course, since it is not yet possible to forecast in detail the sunspot variations for very long ahead, the detailed behaviour of the ionosphere is also unpredictable far into the future, and occasional sharp disagreement between prediction and actuality are rather to be expected.

Sunspot and Critical Frequency Variations.—In Fig. 1 the top (full line) curve gives the monthly mean value of the sunspot relative number for each month of the present cycle, whilst the two bottom (dashed line) curves give the monthly mean of the F_2 layer critical frequencies for noon and midnight respectively. The latter data were obtained at the Slough station of the D.S.I.R.

Large and erratic variations occur in the monthly values of sunspot number, especially around the maximum, but the general increase towards the maximum (in May, 1947) and the decrease since then, is also apparent. During 1950, it is seen, the decrease became quite rapid and the value of sunspot number for November, 1950, was of the same order as those for late 1945 and early 1946, *i.e.*, about a year after the last minimum.

The curves for the noon and midnight critical frequencies show the large seasonal variations which have occurred, and which, at Slough and other northern hemisphere locations, tend to produce low noon and high midnight values of critical frequency at mid-summer, and *vice versa* towards mid-winter. It is interesting to note that at noon there is usually a small decrease in critical frequency at extreme mid-winter, this giving rise to a double-peaked curve, with its peaks at the early and late winter periods. During 1948 the increase after the mid-winter dip did not

Fig. 1. Monthly mean sunspot numbers and the noon and midnight F_2 layer critical frequencies during the present sunspot cycle.



occur, and a similar phenomenon took place during 1950, there being no increase in critical frequency after the January fall. The curves for the winters 1947/48 and 1949/50 were therefore single peaked, and it is interesting to note that, at the time when the secondary increase would have been expected, *i.e.*, about February, there was in both cases a fall in sunspot activity. It seems fairly certain that the failure of the ionosphere to show an increase in its ionization density at these times was thus due to a rather abrupt decrease in the amount of ultra-violet radiation reaching it from the sun.

Turning now to the long period variations in critical frequency it is seen that the fall during 1950 was quite remarkable. In September, 1950, the noon value was as low as that which prevailed in September, 1945, only about a year after the minimum, and it seems that in one year the critical frequencies have changed from "quasi-maximum" to "quasi-minimum" values. The m.u.fs. for short-wave communication have fallen proportionately also, for during the autumn and winter the higher short-wave frequencies, which had been giving good service at this time of the year for some years past, failed to become regularly workable. The night-time m.u.fs., as is indicated in Fig. 1, were also very low.

The question now arises as to how long this depression in the critical frequencies and m.u.fs. will last, or, indeed, whether very low values will not become a permanent feature for several years to come. Well, no one can give a confident answer to such a question because no one can be certain about future sunspot activity. A study of the curves of Fig. 2 may, however, help us a little on this point.

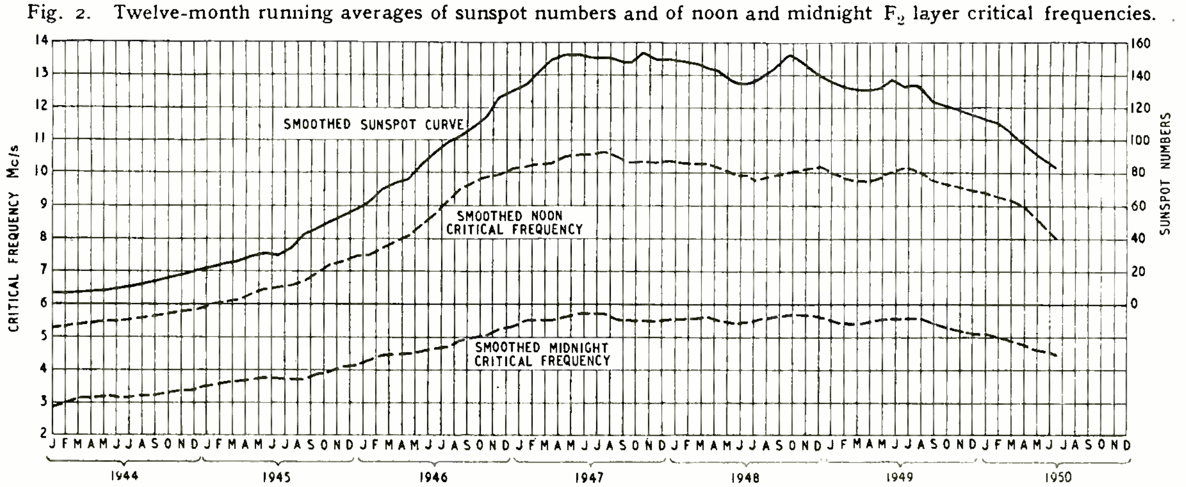
In Fig. 2 are plotted the twelve-month running means of the sunspot number and of the Slough noon and midnight critical frequencies. In this way the erratic month by month variations in sunspot activity and the seasonal variations in noon and midnight critical frequencies are smoothed out, enabling the long-period variations in all these quantities to be more clearly visualized. It is seen that after the sunspot maximum at the epoch May/June, 1947, there were some large up and down variations in the general sunspot activity, but, up to the epoch July/August, 1949, no very pronounced downward trend. Since that time, however, the downward trend has become increasingly pronounced, and this is the result of the decreased activity which took place during 1950. Similarly, in the running mean critical frequency curves there is no very pronounced downward trend until the epoch July/August, 1949, but since then it has become more apparent, due to the fall in critical frequencies during 1950. For the epoch June/July, 1950—the value in whose calculation the last monthly mean for 1950 is included—the running mean value of sunspot number had decreased by somewhat less than one half of the value reached at the maximum. The critical frequency graphs of Fig. 2 show that the running mean critical frequencies, both for day and night, have also fallen by about one half since the sunspot maximum. From this one might conclude that both sunspot activity and critical frequencies are still at a relatively high level.

But these graphs of running means, though they do show very well the general course of the sunspot cycle and the general variation in critical frequencies with it, are apt to be deceptive when used to indicate the situation at any one epoch. In fact, one should note, not only the actual value, but also the way in which it is changing and, so far as the epoch June/July, 1950, is concerned, all quantities are seen to be decreasing rapidly.

Forecast for 1951.—If sunspot activity continues to decrease at its present rate it will not be long before the truly "minimum" conditions are upon us. But considering the present sunspot cycle in relation to its predecessors it seems unlikely that the present rate of decrease will last for very long. Indeed it would be not surprising if the activity were to cease to fall and to remain relatively constant for a year or so, or even to show a general rise for a similar period, at this stage of the sunspot cycle. However, without anticipating such a possibility, we should note that in nearly all the recorded cycles there is a marked tendency for the rate of decrease to diminish when relatively low values of sunspot number are reached.

So far as 1951 is concerned, we might be justified in anticipating that the general level of sunspot activity will continue to decrease, but that the rate of decrease will soon begin to diminish. If this were so we should estimate that the running average of sunspot number for the epoch at the middle of 1951 might be about

Fig. 2. Twelve-month running averages of sunspot numbers and of noon and midnight F_2 layer critical frequencies.



50, and that the running average noon critical frequency might fall to about 7 Mc/s, and that for midnight to about 4 Mc/s. Critical frequencies during 1951 are, therefore, likely to be low.

The result would be that the m.u.f. for longest distance working in these latitudes should, by November, 1951, have fallen to about 24 Mc/s. This is not a great deal lower than it was in November, 1950, but then it is thought that the abnormally low m.u.fs. during the autumn of 1950 may have been a rather exceptional occurrence and contributed to partly by the large amount of ionospheric storminess which occurred at that time.

However all this may be—and it admittedly is no better than informed guesswork—there are one or two practical points about propagation during 1951 which it may be helpful to mention. It is unlikely that the 28-Mc/s amateur band will become regularly usable again at any time during the year. It may become occasionally usable for long-distance communication over north/south paths in the early spring, and during the summer medium-distance 28-Mc/s communication by Sporadic E may take place, but as a regularly workable band its utility throughout the year is likely to be small. The 26-Mc/s broadcasting band is likely to fail for long-distance communication over north/south paths during the summer, and the 21-Mc/s band to become generally less useful. In short, the highest daytime frequencies will be considerably lower this year than last. At night only the lowest short-wave frequencies are likely to be of use during the winter periods, either at the beginning or end of the year. During the summer, frequencies up to 11 Mc/s may be usable through the night; during the winter period those of the order of 7 or 6 Mc/s only will be usable, the tendency being more towards the lower frequencies at the end of the year than at the beginning. Unfortunately, the congestion which already exists on the short-wave bands is likely to be made worse by this limitation of the workable frequency bands. So altogether it cannot be said that 1951 is likely to be a very good year for short-wave communication, for conditions will render certain higher frequencies unworkable and, favouring the use of the lower short-wave frequencies, will so limit the workable bands that increased interference will result.

Interesting Phenomenon of 1950.—Before dismissing 1950 altogether to the past it may be of interest to call attention to an interesting phenomenon which occurred during the latter half of the year. It is generally assumed that the ionospheric storms which cause havoc to short-wave reception are produced by streams of corpuscles which are shot out from the sun —sometimes from a sunspot and sometimes from a particular active region on the sun which cannot be distinguished by any observable phenomena—called by Bartels an "M" region. These "M" regions seem to be a feature of the declining rather than of the rising phase of the sunspot cycle, and sometimes occur even at sunspot minimum. If the activity of such a region persisted for a relatively long period of time the corpuscular stream would encounter the earth at intervals corresponding to the rotative period of the sun, *i.e.*, each time the sun had rotated so that the active region was pointing towards the earth. Thus the ionospheric storm would recur at intervals corresponding to the rotative period of the sun as observed from the earth—the period of synodic rotation, which is about 27 days.

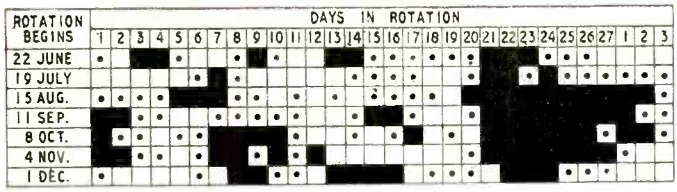


Fig. 3. Day-by-day record of "reception disturbance rating" compiled by the B.B.C. receiving station at Tatsfield for westerly circuits.

In Fig. 3 are plotted—along the lines of a Bartels diagram—the "reception disturbance ratings" compiled by the B.B.C. receiving station at Tatsfield from the receiving conditions experienced between June 22nd and December 27th, 1950. The daily period of worst conditions for westerly circuits only has been taken and the disturbance rating plotted for each day according to the following symbols: plain, "much better than normal to normal"; black spot, "slightly disturbed to moderately disturbed"; black, "considerably disturbed to blackout." The black squares may therefore be taken as representing days on which ionospheric storms were definitely in progress. Starting with June 22nd the days are laid off horizontally for the period of the synodic rotation, *i.e.*, for 27 days, and then the days of the next rotation are laid off horizontally underneath those of the first. The first three days of each rotation are repeated at the end of the preceding one for the sake of ease of observation. It will be seen that if an ionospheric storm recurs at intervals of 27 days the black squares will, in a diagram of this sort, fall under each other during successive rotations.

The quite remarkable recurrence propensities of the ionospheric storm which started on July 12th (day 21) are thus made evident, for this storm is seen to have recurred during no fewer than six of the following solar rotations, starting successively on August 8th, September 3rd, October 1st, October 28th, November 24th, and December 22nd respectively, all of which days were either day 20, 21 or 22 in the rotation. It should be mentioned that, because the mean period of the synodic rotation is slightly more than 27 days it might have been expected that the black patch would drift slowly to the right during successive rotations, but the fact remains that, for its first six occurrences, as shown by the Tatsfield data, it always started on the 20th or 21st day. If a similar diagram is drawn for the earth's magnetic field, by allotting similar symbols to the daily magnetic character figures, then the recurrence tendency is again evident for the magnetic storms which accompanied the ionospheric disturbances. Though the starting days for the two phenomena do not always quite coincide, and the black patch indicating the magnetic storms does drift to the right, the two phenomena—magnetic and ionospheric storms—are quite clearly interconnected and are more or less coincident in time. For how long this storm will continue to recur it is, of course, impossible to say, but its future behaviour will be watched with interest. For it is by the study of such phenomena as this that the knowledge of ionospheric disturbances may be advanced and the difficult problem of forecasting them be, in some part, solved.

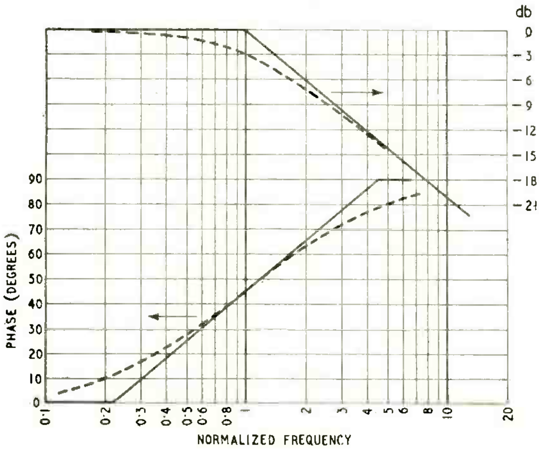
Stabilizing Feedback Amplifiers

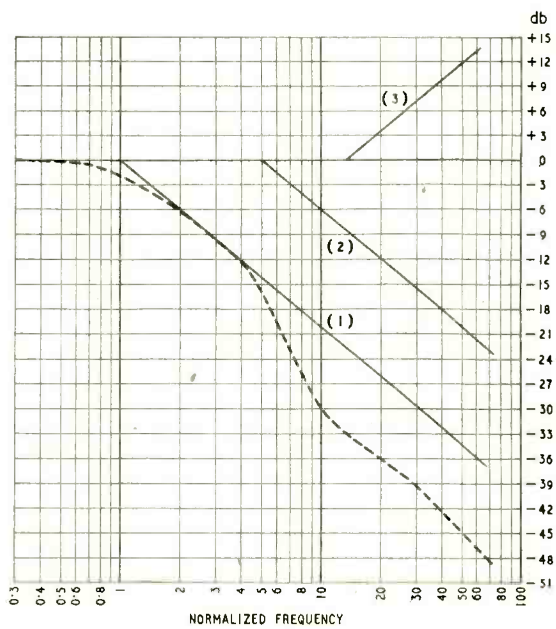
Simple R-C Networks and the Calculations Involved

By THOMAS RODDAM

A PROBLEM which must be fairly common is that of the unhappy man who wants to add feedback to an existing amplifier, or to a slightly modified version of an existing amplifier. What is he to do, if he can't afford a new transformer? This problem does arise in other feedback problems, too, and in this article I want to describe some simple circuits which can be used to help the amplifier characteristics. These circuits are often useful in keeping the size of components down.

First of all, let us assume that our impoverished reader can measure the overall frequency response of his amplifier. He can then determine the phase characteristic by making use of the very approximate results shown as Fig. 1. The phase error is at most 10 degrees and the amplitude error at the corner is exactly 3 db. It is easy to correct this. Our reader having measured his frequency response can now draw the straight-line approximations, using slopes of 20 db/decade, and construct the phase characteristic. This is shown in Figs. 2 and 3. It took about 5 minutes to plot out that phase characteristic. This is not going to be a discussion of the method in detail, but merely a background to what follows, a discussion of how to modify the response in the required way. But I must point out one thing. The reduction in slope above $f/f_0 = 10$ in Fig. 2, keeps the phase below 120 degrees, although the slope at $f/f_0 = 8$ is 40 db/decade, a figure often assumed to imply a phase

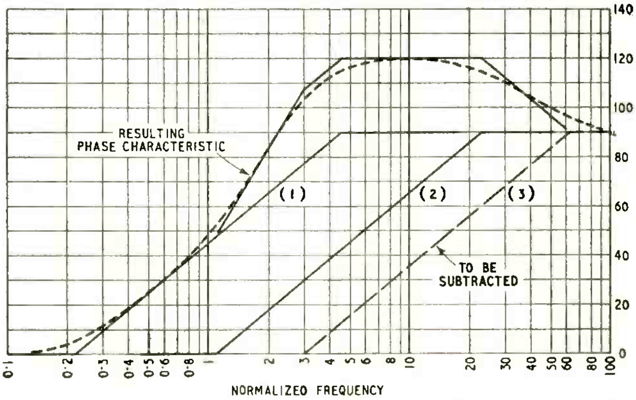




Above : Fig. 1—Simplified amplitude and phase characteristics (dotted lines are exact forms). Frequencies are normalized to f/f_0 or f_0/f where f_0 is the frequency at which the response is 3 db down.

Above right : Fig. 2—Typical amplitude response curve with component "semi-infinite" slopes (1, 2 and 3), from which Fig. 3 is constructed.

Right : Fig. 3—Phase characteristic constructed from amplitude characteristic of Fig. 2 using curves in Fig. 1.



shift of 180 degrees. One more thing: these are normalized curves, and if you twist them round they also work. The same curves are good for the low-frequency end, remembering that now the scale is proportional to 1/(frequency). And if I go into more detail I shall have no room for the meat: like the Yorkshire farmer, who always told the children: "Them as eats most pudden gets most meat."

The response with which we have normally to deal is fairly flat up to some high frequency (I shall consider the top end first) and then darts sharply down. The result of this sharp descent is that the phase shift runs rapidly up to 180 degrees *before* the amplitude response has dropped appreciably. One amplifier with which I had to deal recently actually had a measured phase shift of 180 degrees at a point at which the amplitude response had *risen* 1 db. As it was necessary to put in 20 db of feedback the whole thing had to be started again. But this was exceptional. Usually it is a matter of raking up another 6 to 10 decibels. How can we do this?

The first and simplest circuit is that shown in Fig. 4: just an extra capacitance connected across one stage of the amplifier. This has the characteristic shown in Fig. 1, in which the reference frequency is obtained from the equation $\omega_0 CR = 1$, where ω_0 is $2\pi f_0$. In the practical circuit R is the resistance produced by the parallel connection of the anode load resistance, the grid resistance and the valve impedance. Usually the first of these takes control, if pentodes are used, or the valve impedance if triodes are used. The first step, then, is to choose ω_0, 2π times the maximum frequency you hope to take out of the amplifier, and then calculate $C = 1/\omega_0 R$. Suppose that with 10 db of feedback your amplifier just oscillates at a frequency of 100 kc/s. Suppose also that your version of Fig. 3 indicates that you have 90 degrees phase shift at 50 kc/s. Then introducing the circuit of Fig. 4, cutting at 10 kc/s will give a drop of 14 db at 50 kc/s, and will bring the phase shift here up to 180 degrees. Any attenuation elsewhere in the circuit, say 3 db, can be added to this 14 db, so that the circuit will now just be unstable with 17 db feedback. There is a definite gain, even though it is not much.

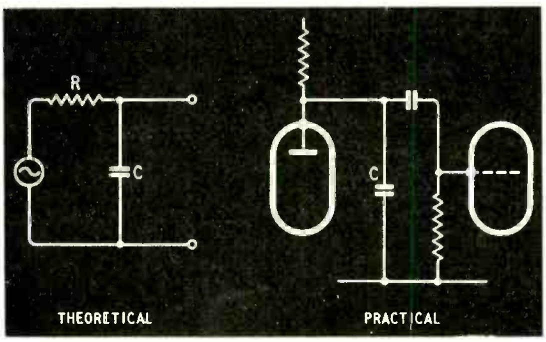


Fig. 4—Simplest form of stabilizing circuit.

The chief use for this simple circuit is across the output transformer. An output transformer works ideally as a low-pass filter, made up of the leakage inductance and the shunt capacitance. This is usually the worst possible form for a feedback amplifier and it is profitable to round off the response by using the circuit of Fig. 4.

What we really need for the inter-stage stabilizing networks is something which provides attenuation without phase shift. Outside a limited frequency range this is provided by the circuit shown in Fig. 5, which can be used across the anode load of a valve. The valve is most conveniently a pentode for calculation purposes. At low frequencies the gain of the stage is gR_1, because C is assumed to be small, but this changes over at high frequencies, where C can be neglected, to $g.[RR_1/(R + R_1)]$. Suppose, for example, $R_1 = 100{,}000\ \Omega$ and $R = 11{,}000\ \Omega$: $g = 2$ mA/V. At low frequencies we have a gain of 200, and at high frequencies a gain of 20. This is a drop of 20 db. The frequency response and phase characteristic are shown, both exactly and using the straight-line approximation, in Fig. 6. The cut-off frequency of this circuit is again determined by the equation $\omega_0 CR_1 = 1$, while the "flattening-out" frequency, which is 10 on this curve, is given by

$$\omega_0 C \left(\frac{R_1 R_2}{R_1 + R_2}\right) = 1$$

The advantage is clear. Instead of a phase shift of 90 degrees at a frequency of 10 on the scale we have only 45 degrees and it is getting less as the frequency increases. The maximum phase shift is obtained half-way down the attenuation char-

Below: Fig. 5—The most useful stabilizing circuit is one connected across the pentode load resistance R_1.

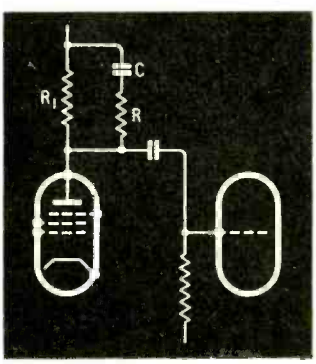
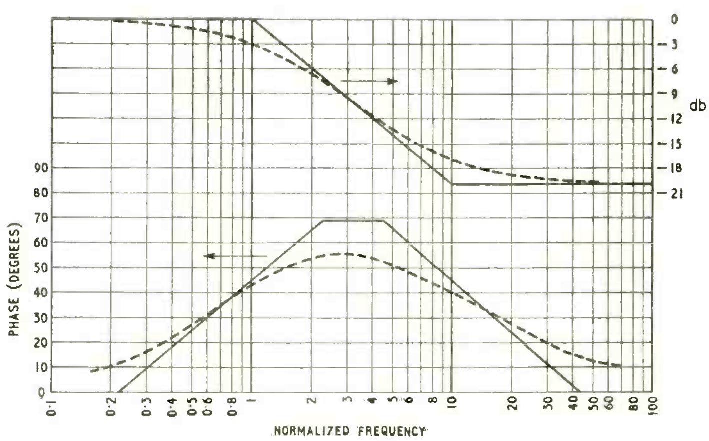
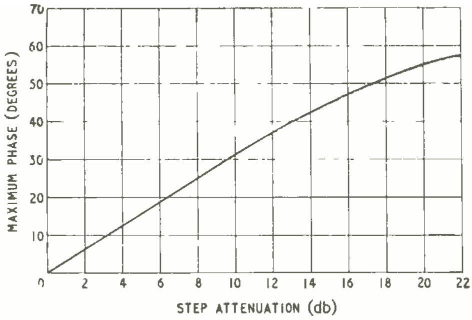
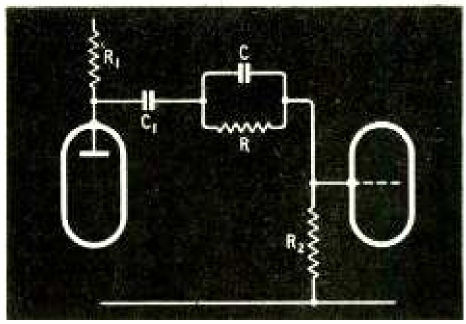


Fig. 6—Typical amplitude and phase characteristics of the circuit of Fig. 5.





Left: Fig. 7—Maximum phase shift as a function of attenuation in the circuit of Fig. 5.



Right: Fig. 8 Low-frequency stabilizing circuit.

acteristic, and I have plotted Fig. 7, which shows the maximum phase shift as a function of the size of the attenuation step.

This circuit really is astonishingly useful, because once the phase shift peak is passed it provides a very wide band response. Let us look at some typical figures. If the valve is a pentode we may have $R_1 = 50{,}000\ \Omega$, and the total capacitance at the anode 40pF. This would normally give a response which fell off by 3 db at $\omega = 1/CR = 500{,}000$, or $f = 80$ kc/s. By taking C in Fig. 5 = 400 pF and $R = 5{,}000\ \Omega$, the response will start to drop at 8,000 c/s, although it is only 6 db down at 16,000 c/s, and this loss of feedback can be tolerated. At 80 kc/s the phase shift will be 45 degrees, and the response will be 17 db down, but the response will then flatten out, at 20 db down, and will extend up to 800 kc/s, the phase remaining below 45 degrees the whole way. Thus in the region which is often most critical, above 100 kc/s, the phase shift is small. A glance at Fig. 6 will show that three circuits of this kind in cascade will have a phase shift of only 165 degrees and 60 db of feedback could be used without instability: without using networks of this type, but using three similar stages, the feedback would be limited to 12 db.

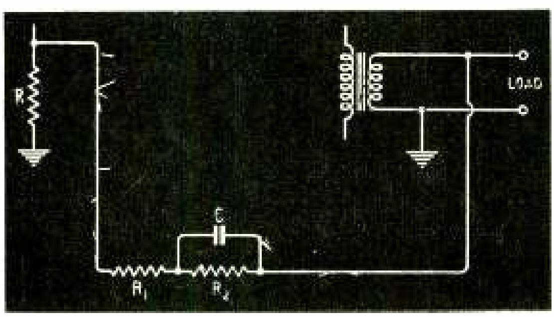
There is a similar circuit available for low-frequency stabilization. This is shown in Fig. 8. If we assume that C_1 is very large indeed, the low-frequency response will, at first, depend on the quantity CR_2. The response will, in fact, be 3 db down when $\omega_0 = 1/CR_2$, and the shape of the amplitude and phase curves is given by Fig. 1, remembering that the "normalized frequency" is now f_0/f, so that if the cut-off (the corner) is at, say 100 c/s, the response is 20 db down at $f_0/f = 10$, or $f = 100/10 = 10$, where the phase is within a few degrees of 90 degrees. But suppose that $R = 9R_2$: the response must flatten out before the 20 db down region is reached, and, in fact, it will be exactly that given in Fig. 6. Again the frequency *decreases* from left to right. Now, at 10 c/s, the phase shift is only 40 degrees. The curve of Fig. 7 applies here too, the step attenuation being simply $20 \log (R + R_2)/R_2$.

What about C_1? This capacitor, at very low frequencies, will also make the response drop, but it is working into an impedance of $(R + R_2)$, so that the new downward trend does not begin until we reach $\omega_0 = 1/C_1 (R + R_2)$. Let us look at some numbers again. R_2 can be 500,000 Ω, the most that the average valve will stand, and $R = 4.7$ MΩ. Taking $C = 0.01\ \mu F$, the response will start to drop at $\omega_0 = \frac{1}{0.01 \times 0.5} = 200$, or $f \simeq 30$ c/s. At 3 c/s the response will be 17 db down ($f_0/f = 10$) and will be flattening out. The phase will not have exceeded 55 degrees and will be approaching zero again. If now we take $C_1 = 0.1\ \mu F$, we shall start to get a new drop at 0.3 c/s, where the phase will be about 50 degrees, and the attenuation 23 db.

These two simple devices can be regarded as patches to a defective design, or they can be used as the keystones of a sound and stable amplifier. The low-frequency circuit, in particular, can often save both money and weight by allowing relatively small capacitances to be used. In this article I am regarding these circuits as patches. How can they best be applied? The obvious first step is to measure the overall response of the amplifier you are trying to add feedback to. Then the phase characteristic can be sketched by the method discussed very briefly at the beginning of the article. A study of the circuit, plus a little arithmetic, should show which part of the circuit does what: all the RC circuits start a 6 db/octave dive at a frequency given by $f = 1/2\pi CR$. The rest is due to the transformer—I assume that we are worrying only about an output transformer. This whole operation should not take more than about 20 minutes. At this point it is necessary to decide where the circuits of Fig. 5 and 8 should be introduced, and how much the step attenuation should be. It is always better to put in more circuits with smaller steps than to try to make one do all the work. I find that the most critical designs, involving very careful adjustment of the critical frequencies, take up to 3 hours, and need about half-a-dozen trial shots to get the required result. But that is only when I want about 40 db of feedback.

It is always the high-frequency end of the response which causes the most trouble. Low-frequency instability can, at the worst, be prevented by brute force methods, a handful of microfarads. One

Fig. 9—Stabilizing circuit in feedback path for use at high frequencies.



more network, related to those we have discussed, is very useful in controlling the top end. Fig. 9 shows how the normal feedback resistor has been split into R_1 and R_2, with a capacitor C connected in parallel with R_2. Here R is the resistor across which the feedback is applied, and is usually the cathode resistor of the first valve. At low frequencies the feedback depends on the ratio $(R + R_1 + R_2)/R$ in the usual way: at very high frequencies the feedback is increased, and depends on $(R + R_1)/R$. This means that the product $\mu\beta$, so familiar in feedback work, is arranged to remain more nearly constant, since as μ decreases due to the shunt capacitances in the forward path β increases. In the simplest use of this circuit R_1 is made zero, and the capacitor is connected across the whole feedback resistor. We can calculate the sort of size we need quite easily: suppose that R_2 is 10,000 ohms, and that we do not mind the response being about 3 db down at 15,000 c/s. Provided that we have a fair amount of feedback, say 20 db or more, we shall want $CR_2 = \frac{1}{2\pi \times 15{,}000}$, or C = 100 pF.

This shunt capacitor is of very great value indeed. I have used it for stabilizing awkward amplifiers, for providing a smooth roll-off to avoid overshoot on square waves, and for obtaining a particularly high stability margin in an amplifier which had to meet a wide range of load conditions.

In this article I have tried to describe a technique which can be used for patching. Of necessity such a discussion must itself be patchy. I can assure the reader that the method of sketching phase curves from amplitude characteristics is a very useful one, and that I have found it a very powerful way of determining quickly what should be done to bring an amplifier into a stable condition. Certainly there seems to be no alternative if you haven't a very well equipped laboratory to work in, and unlimited time and material.

Grouped Component References

Aids to Reading Circuit Diagrams

By L. BAINBRIDGE-BELL

IN the December, 1950, *Wireless World* M. Bamford drew attention to the difficulty of finding a particular component (though identified by a reference number) in a complicated circuit diagram. He suggested dividing the diagram arbitrarily into numbered vertical strips, a resistor in the 4th strip being numbered, for example, R4.3.

The problem of helping the reader quickly to find a component has exercised many brains. Perhaps the obvious solution would be the strict numbering of components from left to right. This counsel of perfection is nearly always defeated, either because the designer has some last-minute thought and adds a component with the next available reference number (say C33) near the left-hand side of the diagram, or because the diagram is drastically re-arranged after the component references have been allotted.

It has been suggested that a diagram should be divided into functional groups, each group being numbered consecutively from left to right, and that a component (R3) in Group 7 should be called 7R3. This solution breaks down because it is often impossible to decide to which group a component belongs. Mr. Bamford avoids this by the more sensible suggestion of *arbitrary* divisions.

An Inter-Services Committee which has been responsible for the production of the Inter-Services Standard Graphical Symbols for Telecommunication Engineering (known to Service readers as Tels. A301, AP2897 or BR1079 according to the colour of the uniform they wear) has given some thought to this problem. The result of their deliberations appears in paragraphs 85 to 87 and 90 of that publication.

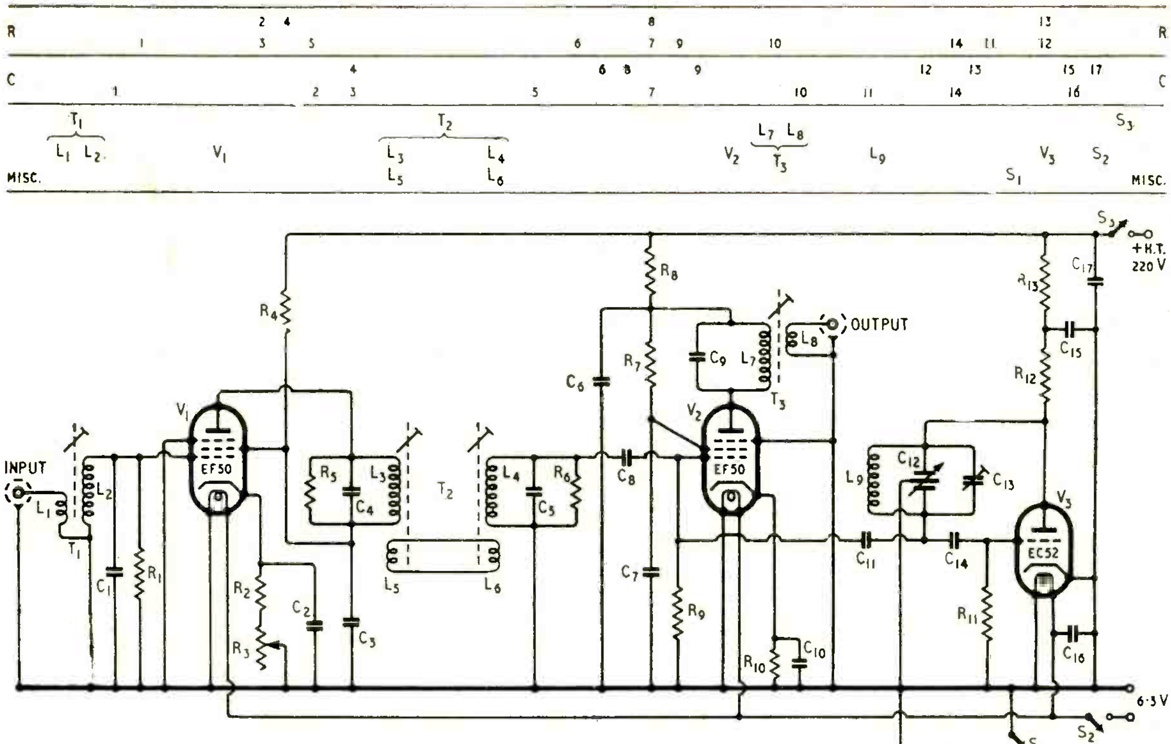
The Location-Strip.—So that any given component can be found quickly in a diagram or line illustration, the coded reference (e.g., R2, C5) should be written beside the components. For each common class of component, a horizontal strip should be drawn across the top of the diagram. At each end of this strip should be shown the reference letter, and in the strip the reference number of each component of that class, vertically above the component, thus:—

R	1		2		3 4 5		6	7 8	R
C		1		2 3		4		5 6	C

Components of which only a few of a kind appear should be shown all on one line marked MISC., and in this case (only) the full coded reference of each component should be shown, including symbols with no standard reference (referred to as XI, etc.) thus: MISC. LPI XI X2 SWA X3 MISC. In very long diagrams, the reference letters may be inserted at intervals in the horizontal strips, as well as at the ends.

The Map-Grid.—In the case of a diagram which is very complicated, or contains a large number of components, a map-grid system of location using letter-number references may be necessary. The grid lines need not be drawn across the diagram.

The location-strip (which is the only system recommended (on page 15) in BS530: 1943) appears to the writer to offer great advantages. When using this aid, the reader scans one row (say R) horizontally until he finds the required component reference (say R15). He then scans vertically up or down until he comes to R15. His eye, instead of roving at random over the diagram, is constrained to follow a unique



path made up of two straight lines. Examples of its use appears on pages 88 and 89 of BS530 and an example, using a circuit diagram which has already appeared in *Wireless World*, is given in the accompanying figure.

If the diagram is complicated, it is often helpful to put two sets of location strips, above and below. The diagram may naturally divide horizontally in two more or less equal paths; the two sets of strips can then refer to the respective halves nearer to them.

Pros and Cons.—Possible disadvantages are that the strip takes up valuable space, or else it may be difficult to use in a complicated diagram. In this case, the map-grid is the only solution.

The map-grid has one great disadvantage. It necessitates a separate table giving a list of components and their corresponding "map squares." Reference to this table—often on another page—is inconvenient, and often makes the reader "lose his place" in tracing out a circuit. In the writer's opinion, it should be adopted only as a last resort.

The location-strip (which was introduced to the Committee mentioned above by a representative from the Royal Air Force) is a very successful solution to Mr. Bamford's problem and is being increasingly used in electronic circuit diagrams. The writer thinks that it might be adopted with advantage in other fields and in telephone switching and power-control diagrams which often contain many relays and "detached" contacts.

CLUB NEWS

Birmingham.—At the meeting of the Slade Radio Society on March 2nd, C. H. Banks of C.J.R. Electrical and Electronic Development, Ltd., will talk on "High-Quality Tape Recording." At the following meeting (16th) the second of the Mullard filmstrip lectures on television will be given. Meetings are held on alternate Fridays at 7.45 in the Parochial Hall, Broomfield Road, Erdington.

Coventry.—The subject for consideration at the meeting of the Coventry Amateur Radio Society on March 12th is the radio control of models. Meetings are held on alternate Mondays at 7.30 at the B.T.H. Social Centre, Holyhead Road, Coventry.

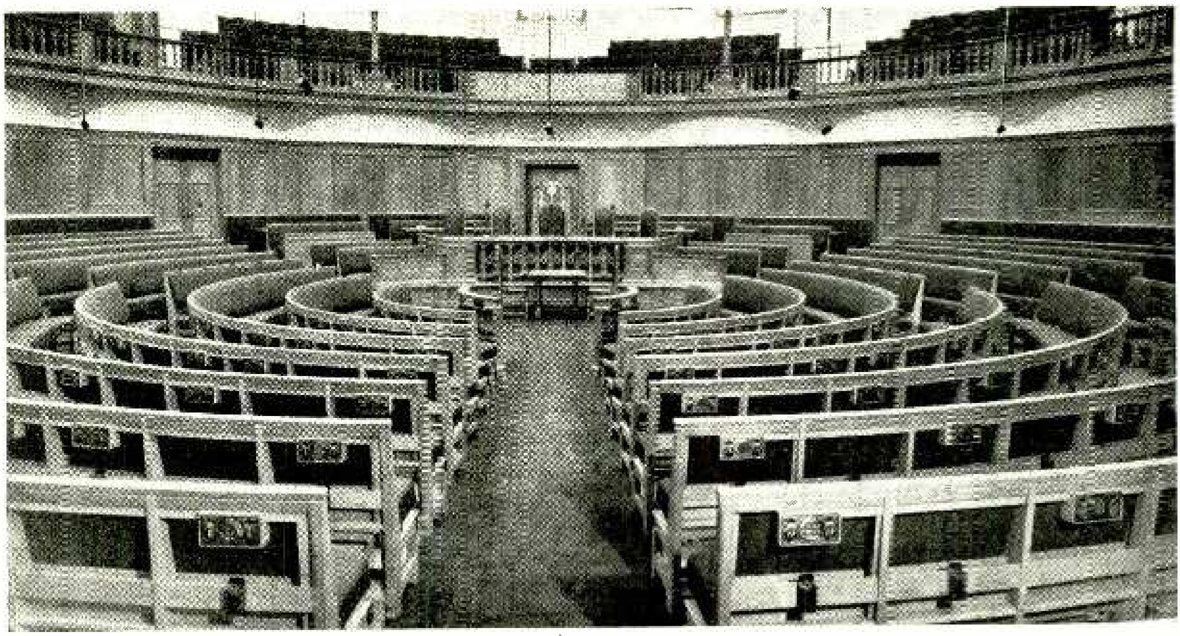
Edinburgh.—The programme of the forthcoming meetings of the Edinburgh Amateur Radio Club includes lectures and demonstrations on radar navigation aids, audio amplifiers, aerials and radio control of models. Classes are held regularly for the Radio Amateurs' Examination. Meetings are held on Wednesdays at 7.30 at 4, Hillside Crescent, Edinburgh.

Exeter.—Members of the Exeter and District Radio Society will discuss "Servicing Snags" at the meeting at 7.30 on March 1st at the Exeter Hobbies Association Hut, Haldon Road, Exeter. At the meeting on March 22nd the subject to be dealt with is "Oscilloscope Time-base Synchronization."

South Kensington.—The lecture on "Electronic Organs" by L. E. A. Bourn, of the John Compton Organ Company, to members of the City & Guilds College Radio Society at 5.10 on March 5th will be followed by a demonstration of an instrument and a short recital. Members will be inspecting the radio installation at London Airport on March 14th.

Radio Control.—The International Radio-Controlled Models Society, which was formed to further the development of the radio control of models throughout the world, has a number of groups active in this country, including London, Manchester—the British H.Q.—Birmingham and Tyneside. Details of the organization and information on the radio control of models, for which purpose the G.P.O. has allocated 26.96-27.28 and 464-465 Mc/s, are obtainable from the headquarters secretary, T. F. Sutton, The Lodge, Manchester Grammar School, Manchester, 13.

The names and addresses of the club secretaries were given in the directory published in the January issue.



The Assembly Hall, Church House, Westminster, showing the reproducers on the seating and the suspended microphones

Sound Reinforcing

Low-intensity Installation Incorporating Simultaneous Interpretation System

By D. W. PIPE*

IN the past, it has, unfortunately, been common for the electro-acoustic requirements of halls, conference rooms, etc., to be overlooked, and often the technicians have not been consulted until after the building has been completed and in use, with the result that restrictions have been imposed. Designers had to resort to compromise, which has, naturally, affected the overall efficiency of the system as well as offending the beauty of the building.

During the past decade, however, architects and consulting engineers have realized the necessity for incorporating electro-acoustic aids when such halls are designed, or when old buildings are to be reconstructed. It is possible for loudspeakers, microphones and ancillary units to be designed in harmony with the aesthetic requirements, so that, upon completion, the performance of the sound distribution will be both technically efficient and aesthetically harmonious.

The opportunity for the correct approach to the many problems connected with modern speech reinforcement systems was presented when decisions were made to install a comprehensive sound distribution system whilst undertaking the restoration work at Church House, Westminster. In the early stages of that programme, decisions were made to incorporate in the circular Assembly Hall a low-level reinforcement system, combined with a four-channel simultaneous interpretation system, with independent facilities for the three adjacent halls and the provision for the inter-change of speeches between the halls.

The requirements of the functions to be held in the Assembly Hall dictated that for general debates and conferences, any member participating should be able to speak without leaving his seat and yet be clearly heard by all other members, whilst all speeches and debates should be heard clearly by those present in the Press and Public Galleries.

The second main requirement was to provide means of enabling all present to have the choice of selecting any one of four languages to enable multi-lingual conferences to be held with simultaneous interpretation facilities. To incorporate this facility with the main speech reinforcement system it was decided to provide a large number of small loudspeakers accommodated within the seating, and adjacent to those loudspeakers, rotary selector switches connected

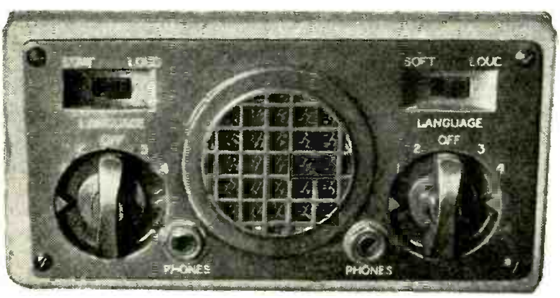
* Tannoy Products (Sound Rentals, Ltd.)

to headphone jacks, to enable headphones to be connected to one of four channels, the selection being at the discretion of the user.

Dealing first with the loudspeaker distribution, the units were arranged so that one would feed two seats. The loudspeakers are connected and operated in zones closely associated with the unidirectional microphones suspended above the main seating of the Assembly Hall, with other microphones on the dais.

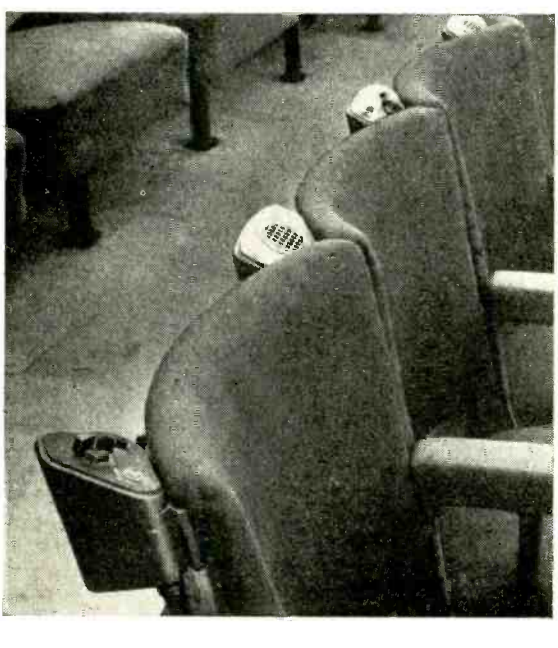
Positioning of the microphones is such that any member on the main floor of the hall is in the zone of one particular microphone and for this purpose the hall was divided into eleven operational zones. Each microphone is connected to a pre-amplifier, the output of which is connected through a selector switch on the operator's control panel. This is situated in the balcony where the operator has an unobstructed view of the assembly and, thus, is able to select the appropriate microphone circuit whenever a member rises to speak.

The loudspeaker units are connected to operate in zones associated with the microphones, since it is necessary to mute the loudspeakers in the area when the microphone is in circuit, thus enabling the remainder of the loudspeakers to operate at a higher sound level. These muting facilities are achieved by relays which are interlocked with the microphone selector switches. Contacts on these relays select the required attenuation through the use of tapped auto-transformer units. In order to obtain the required level of speech reinforcement with complete freedom from microphone howl, or feedback, adjacent loudspeaker zones are partially muted.



Control panel incorporating loudspeaker, language selectors and phone jacks as used on some seating.

The disposition of the reproducers and interpretation selector units on the seating in the gallery.



As all loudspeaker circuits are connected to the main power amplifier output via relays and multi-tapped auto-transformers, it is possible to adjust the power level to each individual zone, or group, irrespective of the main gain controls of the system, thus the degree of speech reinforcement in the galleries can be adjusted to a higher level.

The originating speech from the Assembly Hall is so arranged that it can be not only connected to the low-level distribution system but also to the interpretation system, to enable it to be heard in any one of four languages via headphones on a predetermined channel. To enable any conference to be interpreted simultaneously into a maximum of four languages, four dual interpreter's booths are placed on the balcony overlooking the dais. Each interpreter is provided with a pair of headphones, which are energized from the amplifier used for the speech reinforcement system for the Assembly Hall; each interprets simultaneously into one of four pre-determined languages by means of a microphone in each booth, this being connected to one of four high-gain amplifiers associated with the main amplifying system. The main gain controls for the interpretation amplifiers are situated on the operator's control panel to enable a single operator to have means of controlling the interpretation as well as the speech reinforcement system. To compensate for differences in hearing ability of the audience, each headphone outlet socket is provided with a loud/soft switch.

It has already been mentioned that for the seating on the main floor of the Assembly Hall a loudspeaker has been arranged for each pair of seats, and these loudspeakers are mounted on bronze plates on the rear of the seat in front. As there is only one loudspeaker for each pair of seats, the bronze plates are fitted with two separate language selector switches and two loud/soft switches. To maintain freedom of access to each of the seats, the headphone jacks are fitted on the side of each seat.

Owing to the high stepping of the theatre-type seating in the public gallery it was found impracticable to accommodate the sound reinforcement loudspeakers and interpretation control points in a common unit at the rear of the preceeding row of seats. Accordingly, the loudspeakers have been provided in unobtrusive castings fixed on the rear of the seats, one such unit being provided for each two seats, whilst the alternative positions between the seats are provided with similar castings accommodating dual headphone outlet sockets and selector switches for the interpretation system.

For the other but no less important halls, similar facilities to those outlined for the main hall have been provided, but as the seating in them is movable it was not possible to consider fixing, permanently, loudspeaker units or simultaneous interpretation units. Therefore, each of these subsidiary halls has been provided with loudspeakers permanently fixed on the walls, or ceilings, with microphone circuits terminated in sockets at convenient positions. These microphone and loudspeaker circuits are connected to a recessed control panel in each of the halls to enable a local amplifier and control equipment to be employed. These amplifiers and the main amplifying equipment are inter-connected.

In these halls, transportable interpretation equipment is available and this functions in a similar manner to that described for the main Assembly Hall but, owing to the design of the removable seating each chair is provided with a clip-on metal case accommodating four headphone jack sockets, each being fitted with a coloured disc, and each connected to one of the four language amplifiers.

Each of the microphones in the Assembly Hall has a separate single-valve pre-amplifier from which the signals are selected either at the operator's control panel or from an input selector panel on the main rack apparatus before being connected to the input of a buffer amplifier. This latter amplifier is provided in duplicate—as are the D.C. power units. A third buffer amplifier is provided for connecting tape, wire or disc recorders and can, naturally, be employed for play-back of recordings.

The output of the buffer amplifiers is taken to another control panel on the rack apparatus to enable G.P.O.-type tie lines to be used for receiving programmes from, or transmitting to, places beyond the confines of Church House. After selection of the required buffer amplifier, in which the required tone correction is applied, the signals are amplified by four identical power amplifiers; two of these are associated with the low-level distribution loudspeakers in the body of the Assembly Hall, the third is used for feeding the loudspeakers in the gallery, and the fourth for energizing the subsidiary loudspeaker circuits.

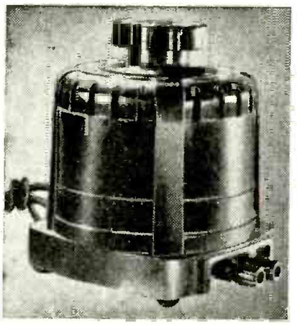
The system of speech reinforcement available in these halls is based on the principles evolved and incorporated by Tannoy Products (Sound Rentals, Ltd.), for the new House of Commons, the House of Lords and the new Legislative Assembly, New Delhi.

Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Variable Mains Transformers

A NEW range of ten variable transformers, built on the auto-transformer principle and fitted with graduated scales and knobs, has been announced by Philips Electrical, Ltd., of Century House, Shaftesbury Avenue, London, W.C.2. Each model is designed for a particular output in the range 130VA to 2,080VA, and can be supplied either as a bench type or as a type for building into an existing installation. In all models the secondary, or output, voltage can be varied from zero to 20 per cent above the nominal primary voltage.



Philips variable transformer.

Unspillable Accumulator

IN the new Exide 2-V cell, type LPM4, designed principally for use in "walkie-talkie" apparatus, special precautions have been taken to prevent spillage of acid. The separators between the plates are constructed of a highly absorbent wood-fibre material that reduces the quantity of freely mobile acid in the cell, whilst the lid has been designed to prevent the free acid from escaping even when the cell is inverted. Another feature is the polystyrene container, which remains unaffected by wide variations of temperature and ensures a long life for the cell even under tropical conditions. The capacity of the LPM4 is 30 ampere-hours, and its charge rate is 2 amperes; it is made by Chloride Batteries, Ltd., Exide Works, Clifton Junction, near Manchester.

Exide unspillable accumulator.

Magnetic Sound Heads

POLE pieces cylindrically ground flush with the end caps are a feature of the tape recording heads produced by Bradmatic, Ltd., Station Road, Aston, Birmingham, 6, and it is claimed that this method of construction produces less wear in the edges of the tape.

Two types are available, 5RP for combined recording and playback, and 5E for erasure; the price is £3 5s each. The heads are reversible so that both gaps can be used to extend the life of the head. Bias and erase frequencies of 30 to 45 kc/s are recommended and the windings are of the high-impedance type. Adjustment is provided in both horizontal and vertical planes and the heads are quickly detachable without unsoldering connections.

In the range of tape recording heads recently introduced by Phi-delity Magnetic Products, Ltd., 65-66, Chancery Lane, London, W.C.2, the windings are of low impedance and the mounting is designed for single-screw fixing. The following types are available: Type SA (£3 6s 6d) dual-purpose record and playback, gap 0.001in; Type SE (£3 4s 6d) supersonic erase head, gap 0.005in; Type SR (£3 10s) recording head with separate audio and bias windings, gap 0.001in; Type SP (£3 13s 6d) special recording head, gap 0.00025in.

Half track (⅛in wide) heads can be supplied at 10s extra in each case.

Correction

In a note on the Belclere miniature transformer (January issue) the impedance ratio was wrongly given as 250:1. As can be seen from the turns ratio, this should have been 2,500:1.

UNBIASED

By FREE GRID

Television Pirates

I SEE that there is quite a to-do in the columns of some newspapers about the number of television viewers whom the G.P.O. alleges have not taken out licences. All the hoary and futile old remedies which were trotted out years ago to checkmate "sound" pirates are being brought forward once more. Nigh on eighteen years ago, on April 21st, 1933, I pointed out in these columns how futile they were. It is the peremptory demand for forty shillings in a lump sum that makes criminals of otherwise honest citizens, most of whom get their television sets on "easy terms." If the P.M.G. had the courage to declare an amnesty for all offenders and to issue to every viewer a card on which a tenpenny, or even a shilling, stamp could be stuck every week the response would be immediate. Would the football pools enjoy the success they do if their promoters peremptorily demanded that their patrons put down a year's "investments" in a lump sum?

Speed of an Electric Current

MANY people imagine that an electric current moves with almost incredible speed in an ordinary circuit. There is, in fact, much confusion in the average mind about the difference between the speed of an electron when it crawls along an ordinary circuit and when, like the man on the flying trapeze, it flies through the air—or at any rate the inside of one of the "tron" family—with the greatest of ease, urged on by accelerating electrodes and all that. The whole matter is, in its way, as interesting as the difference between an e.m.f. and a p.d. which "Cathode Ray" was discussing recently.

Incredulous astonishment.

Many years ago (December, 1943) I stated to you on very good authority (Morecroft) that the speed of an ordinary electric current, whether it be propelled by a power station or a humble torch battery, worked out at about walking pace or, in other words, 3 m.p.h. or so. No technical pundit contradicted me; in fact, my statement subsequently received favourable comment from "Diallist" (February, 1944).

This slow speed means that in the case of the ordinary 50-cycle mains supply the electrons in a lamp filament would never leave it, but merely shuffle backwards and forwards a distance of about half an inch, and as for the electrons in a television aerial, why, they hardly have time to move at all, so slow is their speed in comparison with the tremendous sequential rapidity of the directionally alternating shoves which they receive.

My whole interest in this matter was aroused again when I read in *W.W.* (page 6, January issue) that electrical impulses travel along the nerves of our bodies at about 80-100 metres per sec, or 200 m.p.h. When I first read this my eyebrows went up in incredulous astonishment to such an extent that they pushed my bowler hat off, as for the moment I imagined this to be the actual electron speed.

A Red Letter Day

HAGIOLOGY is a subject usually ignored by this august journal, not because it is improper or has anything to do with mothers-in-law, as the less learned of you might think, for it isn't and it doesn't. The reason for its neglect might, to superficial thinkers, seem to be that it has little to do with "Radio, Television and Electronics," to quote the words on the cover of *W.W.*

Hagiology, which literally means the study of holiness, in practice deals with the saints and their works, and so is often referred to by the more particularized word hagiography. Now cynics might say that its connection with wireless seems almost as tenuous as the ether, but I hope to rout them as the Israelites routed the hosts of Midian.

September 29th.

The reason for my discussing this subject in *W.W.* is that I am seeking a patron saint of wireless, for it is high time that we had one like other professions and industries such as the medical profession (St. Luke) and the motor industry (St. Christopher). I feel all the more strongly about this now that the craze is growing among garages and car-accessory dealers for selling plaques of St. Christopher, the patron saint of travellers, for bolting on to the radiator of a car.

The question is, of course, who can we choose to be the patron saint of wireless, and that is where you hagiologists and hagiographers may be able to help, for I have several ecclesiastical—and at least one episcopal—readers of this page. First we must decide whether we are going to emphasize the entertainment or the communications side of wireless. I feel it should be the latter. The obvious choice is, therefore, St. Michael, the archangel, for does not the word angel mean a messenger, and are not *all* other angels—including Gabriel, whom the Pope has proclaimed protector of radio communication — invariably coupled with his name?

With regard to an emblem for use on our sets, let us adopt something simple, striking and easily recognized, namely, a michaelmas daisy, and let us set aside September 29th each year for the opening of the National Radio Exhibition at Earls Court which, under the name of Michael-Mecca, might become as well-known as the old Radiolympia. But there is need for haste in the matter if we do not wish to see our profession and industry lapse into paganism, as it well may if the recent suggestion is carried out of adopting "Hermes, the messenger of the gods," as the symbol of the radio industry.

LETTERS TO THE EDITOR

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

Beveridge Report

THE B.B.C. monopoly of originating programmes is fundamental. Relay service licences forbid the organization of programmes and the Beveridge report recommends that this condition should continue (38).

Is it not, therefore, somewhat inconsistent to propose (33) that licences might be issued to approved public authorities or voluntary organizations to establish their own local stations? It is true that this proposal is only put forward for extra-high-frequency channels, but that does not alter the fact that it would be driving a tank through the B.B.C. monopoly.

HUGH TILLY.

London, N.W.2.

WHY all this fuss in the "Report of the Broadcasting Committee, 1949," about television in the cinema? Can anyone tell me why a Committee whose terms of reference are confined to broadcasting should concern themselves with matters that relate to point-to-point radio communications? As I see it, the Postmaster-General alone is empowered to say whether a cinema firm shall be granted a licence to transmit pictures by radio for public showing in its theatres. That has nothing to do with broadcasting; no more, in fact, than has the transmission of radio pictures for publication in newspapers.

"RADIOPHARE."

Thorn Needles

ACCEPTING the statement that the six illustrations in Mr. Pollock's article in the December, 1950, issue are to the same magnification and that the sapphire in Fig. 1 has in fact a point radius of 0.0025in, then it is surely futile to consider high-fidelity reproduction with a point that can only trace a standard modulated groove about as well as a pea in a roulette wheel.

I would not contradict the fact that "miniature thorns" cause less wear than harder points, or that they produce quite a nice noise from a record, but I have yet to experience accurate reproduction of the recorded sound using such a point.

C. E. WATTS.

Sunbury-on-Thames.

I HAVE read with interest A. M. Pollock's article, "Thorn Gramophone Needles," in the December, 1950, issue. There are various statements in the article which I cannot reconcile with experiments which I have performed using thorn styli.

It is assumed that the photographs illustrating the article are all reproduced to the same scale of magnification, and that the sapphire stylus is, in fact, 0.0025in tip radius. Use of this reproduction as the standard indicates that the photomicrographs are of the order of x50 diameters magnification.

From this it is deduced that the point of Fig. 2 is 0.0006in radius, with a probable error of 0.0001in. The average included angle of the styli shown is 20 degrees, and this will give a length of approximately 0.2in for the "cone" of the stylus, assuming the rondel is 1/16in diameter (or ¼in long in the case of miniature thorns of 0.036in to 0.040in diameter).

Referring to Fig. 3, the dimensions (as far as I can measure) of the tip are 0.0012in radius; the bottom appears to be slightly rounded and would probably be a snug fit in the bottom of a modern recording.

Fig. 4 shows an apparent dimension of 0.0016in radius, which is not very much bigger than Fig. 3.

It has been my experience that a thorn stylus wears itself to the full dimensions of the groove in a very short period of time—considerably less than the playing time of a 12in record. The top groove width of a standard 78-r.p.m. record is 0.006in, and I would therefore have expected the photomicrographs to have shown results similar to this.

I must mention, in passing, that I have been unable consistently to obtain a tip of less than 0.002in radius, even using the finest grade of sandpaper, and attempting to use a diamond-loaded lap only resulted in the lap becoming choked. I would be interested to know how Mr. Pollock manages to grind such a fine point, and how many attempts are necessary before the thorn is judged to be satisfactory.

It is a well-known fact that if the stylus point is smaller than the bottom radius of the groove, the point will skate along the bottom of the groove and give rise to quite a lot of distortion and increased surface noise. Mr. Pollock's statement that "the principal difference is a slight change in the pitch or quality of surface noise, but little in the amount" when speaking of response of thorn against sapphire, bears out the statement, because if the pitch

of surface noise can be detected it means that there is some resonance in the system, and if the pitch of this resonance changes on replacing the stylus it must be connected with the mechanical system of the pickup. I have found that trying to play a 78 r.p.m. record with a 0.001in tip radius stylus often results in a high-pitched whistle, due to (a) the stylus skating along the bottom of the groove, and (b) the increased compliance between the stylus tip and the record groove lowering the resonant frequency.

It is common knowledge that the bottom radius of the groove is much "rougher" than the side walls, and for that reason the dimensions of styli are such that contact is not made with the bottom but only with the sides of the groove. A test was made, using the unmodulated grooves of the H.M.V. test records; an increase in noise level of between 6 to 8 db was observed when a 0.0025in tip radius stylus was replaced by one of 0.001in.

A resonance at 5 to 8 kc/s, with a sharp cut-off above it, gives brilliance often mistaken for extended top response, and whilst I am the first to subscribe to the opinion that the final criteria of performance of any reproducing device must be the aural results, a very good guide as to what results may be expected can be obtained from performance curves of the equipment, particularly frequency response and distortion curves. It would be very interesting to have these performance figures of the pickup using both a sapphire and thorn stylus. If Mr. Pollock is unable to make these measurements himself, I shall be very pleased to put the facilities of my laboratory at his disposal.

STANLEY KELLY.

Enfield, Middx.

Beginnings of Radar

SO long as your contributor "Free Grid" confines himself to the realms of fantasy in his well known and inimitable manner your readers can be trusted to look after themselves: they know when their legs are being pulled. But we have come to trust his accuracy (and memory) when he is dealing with facts. Surely he slipped up badly in your December, 1950, issue where he said, in dealing with the origin of radar, that the N.P.L. used radio waves to find the position of meteorological balloons in 1928. In *Wireless World* for March, 1945, Dr. R. L. Smith-Rose (who should know something about that) said "there was still lacking at the beginning of the 1930 decade a satisfactory practical demonstration that the reflection or scattering of radio waves from an object such as a ship or aircraft was of a sufficiently high order to be detected."

"Free Grid" can hardly plead he was using "radiolocation" in the modern sense to describe both echo and non-echo systems.

Nottingham. J. A. WALKER.

Television Visor

E. G. HARRISON (your December issue) may be interested to know that the pinhole disc (which is of course what he constructed) is often used by practitioners who examine eyes to investigate the possibility of improving the sight.

In principle the pinhole disc in front of the eye may be likened to a pinhole camera, the pinhole reducing the size of the blur circles and thus giving better definition. There is a critical size of hole where the reduction in illumination causes a loss of definition rather than a gain. Possibly it is this lack of illumination in home pictures that limits the use of the pinhole.

In Mr. Harrison's case it sounds as if he has a slight optical error and consequently the pinhole helps to cut down the size of blur circle produced. From his comment that he prefers to view blue to red, I would say that basically he is long-sighted. Blue is refracted more than red by an optical system and consequently blues are seen better by an eye that is long-sighted, and red better by an eye that is short-sighted. This fact is used in a sight-testing instrument known as the Duochrome test.

The size of pupil (or iris mechanism) is controlled by reflex action. The light reflex causes the pupil to become smaller in high illumination and larger in low illumination. It is never, however, a fixed size since as the eye adapts itself to the prevailing condition of illumination, so the pupil size varies, normally becoming slightly larger with time.

One other thing that may govern the definition of the picture is that the eye is not a perfect optical system. Consequently it suffers from aberrations. These are greater when the aperture is large.

If Mr. Harrison is interested in the subject he will find an excellent description of the pinhole in Fincham's "Optics" and of aberrations of the eye in Emsley's "Visual Optics."

F.S.M.C. (Hons.).

E.H.F. Broadcasting

YOUR correspondent R. C. Burnell asks in the January issue for "lots of a.m. broadcasting on e.h.f." This may be satisfactory if one is situated, as he is, some 18 miles from the transmitter. At 57 miles a.m. is very inferior, especially in signal-to-noise ratio.

I note that Mr. Burnell finds the a.m. signal to be the stronger. This is strange, as the relative powers of the transmitters are similar. As a deviation of 75 kc/s is used there should be some five times the audio voltage available from his demodulator.

If an unlimited number of low-power transmitters are used the "land line considerations" which limit the quality of transmission at present will be so multiplied as to be an insuperable barrier to real fidelity. Surely the answer in e.h.f. broadcasting is to have a few f.m. stations, which, by virtue of their superior system of modulation, will give complete coverage of the country.

There are no additional complications to f.m. receivers worth mentioning, and with the development of "know how" in this branch of the art I have no doubt they will become as docile as any a.m. receiver.

F. A. RUDDLE.

Reading, Berks.

E.H.F. Communications

WITH reference to J. R. Brinkley's letter in the October, 1950, *Wireless World*:—

It is obvious that Major Armstrong was writing for home consumption and was considering American practice when he stated that "the use of f.m. for police communication is universal." Universal is perhaps an unfortunate choice of adjective.

The amount of a.m. mobile radio telephone equipment manufactured in this country may be greater than the production of equivalent apparatus for f.m. but, if considered together with American production, it is very small, and therefore Major Armstrong's contention is substantially correct.

In the British market, the a.m. system was the first in the mobile radio telephone field and, as a result, succesful systems were available for demonstration to potential customers before f.m. systems were ready. The performance of the a.m. systems was satisfactory and was, in some cases, enhanced by the technique of using comparatively high-power base station transmitters and low sensitivity mobile receivers. Under these conditions, the advantages of f.m. are not so readily discernible, since the received field strength at the mobile station is so high that the ambient noise level is unimportant and the improved performance of an f.m. system is less noticeable than it is under poor received signal-to-noise ratio conditions. Also, the comparatively low receiver sensitivity tends to set the ultimate limit to the smallness of the usable signal, whereas receivers of the highest sensitivity used for mobile applications generally have this limit set by the ambient noise level, the effect of which must be more marked with a.m. than with f.m.

In any case, an a.m. system is more expensive and gives less satisfactory performance for the following reasons:—

F.M. Transmitter.—No high power modulator is required but a further stage of high frequency multiplication is used.

Less power is required for a given r.f. output with a consequent reduction in size and weight.

F.M. Receiver.—For a given noise factor, the minimum useable signal is smaller.

The effect of local interference disappears at much smaller distances with f.m. than with a.m.

Screening of the electrical system of the vehicle is unnecessary with f.m. H. N. GANT.

Southall, Middx.

Power-cut Radio

IN the January issue of *Wireless World* "Free Grid" says he would like to see a mains/battery receiver with automatic change-over to deal with power cuts. I am at the moment listening to a 1939 Pilot "Twin Miracle" receiver which uses a relay circuit in the feed system so that the set starts up on the battery and switches to the mains when the rectifier has warmed up. Should the a.c. (or d.c.) mains supply fail the relay releases and the battery is brought into circuit again. I believe there are other sets arranged to do the same thing but do not know if any one has been put into production since the war.

I. G. BENBOUGH.

Reading, Berks.

Air Traffic Control Records

AT a demonstration of the new sound recording equipment adopted by the Ministry of Civil Aviation, and described by you in the September, 1950, issue, the impression may have been given that the International Civil Aviation Organization were responsible for recommendations concerning the possibilities of erasure and the type of recording medium to be employed.

I think it should be made clear that the I.C.A.O. recommendations on the subject refer only to the provision of recorders, and do not stipulate whether or not the recording medium shall be incapable of being erased or altered without visual evidence of interference.

E. L. BADDELEY,
Senior Press Officer,
Ministry of Civil Aviation.
London, W.C.1.

RANDOM RADIATIONS

By "DIALLIST"

"M" Regions

IT SEEMS THAT I was not quite right when in a recent note in these columns I attributed the November radio blackout to ordinary sunspots. No less an authority on ionospheric conditions than T. W. Bennington sent me some very interesting information about the real cause. This is news to me; and as I expect it will be news to many readers as well I gladly avail myself of his permission to pass it on. Some of the disturbances which give rise to interference with long-distance radio occur when there are no visible spots, or at any rate none of important size, on the sun's disc. That they are due to solar activity is beyond doubt; nor can it be doubted that particular regions of the sun's surface are responsible, for such disturbances take place when one of these "M" regions, as they are called, is near the central meridian of the sun. There is peace and quiet when the "M" region responsible has been carried by the sun's axial rotation to the side away from the earth; but the trouble often breaks out again when this "invisible spot" arrives once more on the side facing us. The November disturbance was actually due to the fifth return of an "M" region which first made its presence felt in the middle of July, 1950.

Times and Seasons

Blackouts attributable to the familiar visible sunspots are usually most frequent and most severe near the "maximum" of one of the eleven-year cycles. These "M" regions, however, generally cause disturbances after the maximum has been passed and when the decline towards the minimum is under way. They may even continue right on to the minimum period. Exactly what "M" regions are and at what kind of levels in the sun they are developed both seem still to be matters of conjecture. Visible sunspots are believed to be great vortices in the mass of incandescent gases that forms the photosphere. Since they are not visible it seems likely that "M" regions are indications of disturbances taking place far below the surface. I would like to know more about them—and so, I expect, would readers. Do they, for instance, go (as sunspots so often do) in pairs of opposite magnetic polarity? If so, do they show the same queer behaviour as visible sun-spots? In these the relative positions of the poles are always the same all through an eleven-year cycle, but a reversal takes place in the following cycle.

Second Thoughts

NOW THAT I HAVE had time to digest the revised edition of "Letter Symbols for Electronic Valves" (B.S.1409:1950), published by the British Standards Institution, I do not feel anything like so happy about it as I did about the original edition of 1947. The 1947 symbols were simple, logical, straightforward and easily memorized. They were a boon to writers (and readers) of books and articles concerning valves, for they meant that the same thing or property or quality was always denoted by the same unmistakable symbol. They appeared to offer a real hope of a standardization so complete and so satisfactory that it would embrace all technical writing from the "without-tears" popular book to the most learned and most excruciatingly mathematical treatise. Clearly, too, they would be of very great value to valve manufacturers for the presentation in concise form of the nature and performance of their products. To be really useful, symbols must provide a genuine short cut to the point which the writer wishes to make, and his reader wants to grasp in the shortest time and with the least unnecessary mental effort. The whole purpose of symbols is defeated if they become so numerous that considerable effort is needed to commit them to one's memory.

Going Too Far

Most languages are reasonably easy to read or write because their alphabets consist of only some 25-30 letters. The new edition of "Letter Symbols for Electronic Valves" lists over 100 signs and symbols—and that seems to be going too far. It would take quite a bit of practice to use them easily and correctly. It is stated on the cover that they are intended mainly for use in valve catalogues and similar technical literature. The words "similar technical literature" mean, presumably, other technical matter drawn up and issued by radio manufacturers. Even so, I very much doubt if they will make the reader's task easy. The golden rule of making each symbol stand for one thing and one thing only has gone by the board. Thus *m* can signify inner metallic coating or internal mutual inductance; *h*, heater, hexode or heptode; *r*, rectifier or internal resistance; *s* is an internal shield, but S (which should logically represent an external shield) is the sensitivity of a photo-electric cell or c.r. tube.

Marine Radar Again

LETTERS FROM SEAFARING readers of *W.W.*, who comment on the note I wrote some months ago on the use and abuse of ships' radar, continue to come in from ports in distant parts of the world. Some take me to task for having (as they say) stressed the accidents due to the mis-use or non-use of radar equipment, rather than the cases, infinitely larger in number, in which accidents were avoided by the correct use of the radar set. They accuse me of undermining confidence in radar. If I gave any such impression, that must be due to sheer bad writing on my part; for there can be no firmer believer than I in the efficacy of radar as a preventer of disasters at sea and in the air—if full use is made of it. In marine radar that depends very largely on the appreciation by navigational officers of its possibilities and of the accuracy of the information that it supplies. I contended that too few navigators bothered to familiarize themselves with the radar presentation by making it a rule to have the set working *and to study the screen closely* either when entering harbour or when passing near another ship on the open sea in clear weather.

Practice Makes Perfect

My correspondents include both navigating and radio officers. Many of them, I am glad to say, tell me that in their ships clear-weather practice with radar regularly takes place. Some give thrilling accounts of the regular and successful use of radar in narrow waters where foul weather conditions are frequent. Some bear out my contention, telling of senior officers who look on radar as just another of those new-fangled gadgets, installed to make the poor sailor's life more difficult.