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Future of Broadcasting

Preparing for Post-war Reconstruction

In our May issue we stressed the interdependence between the broadcasting section of the wireless industry and the B.B.C., pleading for a closer liaison between the two. Both will have to face vastly changed conditions after the war; the industry has at least made a preliminary move towards planning its future by appointing a Committee to study post-war problems, and it seems at least equally important that the B.B.C. should begin to prepare for the peace.

Before the war, broadcasting could still thrive, or at least survive, on its novelty value, and during the war its function in satisfying our hunger for news is by itself more than sufficient justification for its continued existence. But when peace returns it will have to offer new attractions if it is still to flourish. In a world where a member of almost every family has been in close contact with wireless communication during the war, the appeal of novelty will no longer operate. There will be other strong attractions; indeed, it has been said that the ordinary citizen will prefer the novelty of a stroll through lighted streets to listening to a broadcast programme. There is certainly some truth in that statement, although it will doubtless apply only to a passing phase of our post-war life. But the habit of listening is interrupted, broadcasting as a feature of our national life will decline, and it will never be fully re-established unless the very best efforts that can be summoned up are put into the organisation of our post-war system.

Criticisms Cancel Out

Criticism of the B.C.C., and planning for its reform, is surely one of the most vain and fruitless of our national activities. With unfailing regularity the subject comes up in Parliament, and with hardly any deviation the usual gambit is followed. Politicians of the Right accuse the Corporation of being too Leftish, those of the Left say it is too Rightish. The highbrows say it is too lowbrow, while the lowbrows are certain it is too highbrow. Those who plead for sweeping reforms of the whole system generally end by describing a "new" system with an extraordinary resemblance to the B.B.C. we all know—but better, of course! Can one blame the average fair-minded citizen if, after listening to the arguments, he decides that there cannot be much wrong with the B.B.C.—but it might be a bit better, of course!

Most criticism of the B.B.C. is fruitless because it is generally confined to superficialities, and the fundamental issues involved in making the best use of what is still a new medium are ignored. Again, those whose suggestions for sweeping reforms in the organisation of broadcasting might otherwise be worthy of serious attention often come to grief through ignorance of the technical problems involved.

Spur of Competition

There is a general feeling that some intangible factor is lacking in the B.B.C.; some fresh incentive or stimulus is needed. In our October issue last year we suggested that the stimulus of competition, at present entirely lacking, might best be introduced by setting up two separate B.B.C. Programme Boards, completely independent and each under a Director responsible only to Parliament. Each network would be responsible for providing a nationally distributed programme. Since then Sir Allan Powell, chairman of the B.B.C., has referred publicly to the possibility of internal post-war competition, and is reported as foreshadowing "friendly competition between Regions," but nothing approaching autonomy. That seems to be a rather useless form of competition, except to those listeners living in an overlapping transmitter service area. It would be small consolation to an Aberdonian to know that the London Regional programmes were exactly to his taste.

From some points of view it is a pity that the recent suggestion for setting up a Government Commission to examine the future of broadcasting has been negatived. Sooner or later, this question will have to be examined, and it is desirable that decisions may be reached in time for putting into effect as soon as the war ends. If broadcasting retains its prestige and influence, it is capable of playing a great part in post-war reconstruction.
TRACING THUNDERSTORMS
A Use for Atmospherics

By J. S. FORREST,
M.A., B.Sc., F.Inst.P.

READERS of Wireless World who were actively interested in wireless about twenty years ago will remember the “experimenter’s licence.” In those days if one desired to construct a wireless receiving set it was necessary to convince the Postmaster-General that one was a bona-fide experimenter, and particulars had to be submitted of the investigations which it was proposed to make. Many of us chose as a subject of research “the elimination of atmospherics.” This was a safe choice—no one was likely to have solved this problem over-night! As in many other problems, the solution came from an unexpected direction—short waves were found to be practically immune from atmospheric interference. Now, atmospherics have not only been conquered but are even being made to serve a useful purpose by providing evidence of the presence of thunderstorms.

It is well known that every visible lightning flash produces a strong atmospheric, and it is probable that every atmospheric originates in a lightning flash, although the latter statement is not so easy to prove. It has been found in practice, however, that atmospherics do give a reliable indication of thunderstorm activity particularly in the case of the relatively high field strength disturbances which are produced by storms within a few hundred miles of the receiver. A thunderstorm can therefore be located and its path traced by any radio method which will determine the source of the atmospherics.

Thunderstorms are uncontrollable and it may be asked why one should wish to trace their movements. Quite apart from the interest of such problems from a purely meteorological standpoint, there are certain other applications in which a knowledge of the outbreak and whereabouts of thunderstorms is of value. For example, thunderstorms are one of the hazards encountered by aviators, as not only are the electrical discharges dangerous in themselves, but the violent air currents in the storm are also a menace to aircraft. It should therefore be of considerable assistance to a pilot if he were given details of the position and direction of travel of a thunderstorm so that he could, if necessary, deviate from his course in such a way as to circumvent the storm. A further application is found in the operation of electric power supply systems. Lightning strokes to overhead power lines are responsible for a large number of breakdowns which may interrupt electricity supplies and cause extensive damage to electrical plant. If the operating engineers can receive a few hours’ warning of the outbreak of a thunderstorm in the area under their control, then it is often possible to take certain steps to safeguard the supply and minimise the damage; alternative lines may be put into service, while transformers which are not essential for the immediate load requirements may be switched out. Arrangements may also be made for repair gangs to stand by.

In order to find the position of the source of the atmospherics from a single receiving site, it is necessary to determine both the distance the atmospherics have travelled and their direction of arrival. Alternatively, if receiving instruments can be operated at two or three different sites it is sufficient to determine either the distance or the direction, as the position of the source can then be found by triangulation.

Direction-finding Methods

(a) The usual methods which have been employed for finding distance and direction may be very briefly summarised as follows:

The atmospherics are received on an aperiodic receiver and are recorded by a cathode-ray tube. The distance the atmospherics have travelled can then be deduced approximately from their amplitudes and wave-shapes.

(b) A “cathode-ray direction finder” tuned to a long wave-length is used to determine the direction of arrival of the atmospherics. This instrument consists in principle of two frame aerials at right angles, each connected through its own amplifier to the deflecting plates of a cathode-ray tube. The bearing of each atmospheric received is then shown directly on the screen of the tube.

(c) The direction of arrival may also be found by means of a “narrow-sector recorder” tuned to a long wave-length. This apparatus takes the form of two slowly-rotating frame aerials at right angles, the outputs of which are combined with that of a vertical aerial in such a way that
signals are accepted only in a narrow sector. The atmospherics, after amplification, are recorded by a pen-type recorder on a drum, rotating synchronously with the frame aerials.

These methods all require complicated and specialised apparatus, but a much simpler method may be found to be adequate when it is not required to record thunderstorms at distances of more than a few hundred miles. This method has been used successfully in Britain in order to provide thunderstorm warnings for electric power system operators, and it may therefore be of interest to describe the apparatus in some detail.

The instrument consists essentially of a mains-driven radio receiver, a calibrated oscillator, and an output recorder. The receiver, a slightly modified standard chassis made by the Armstrong Manufacturing Company, is tuned to a frequency in the band 145–200 kc/s. The lower frequency end of the long-wave band is used, as the intensity of atmospheric disturbances increases as the frequency decreases. A straight circuit is employed with two radio-frequency stages, a diode detector, and two audio-frequency stages. The receiver has manual RF and AF gain controls; automatic gain control is not used. The output meter is an Evershed and Vignoles rectifier-type moving-coil pen-recorder giving full-scale deflection with 10 mA. The

interference from the electrical plant, and if such interference is present a mains filter and screened aerial system must be used to suppress the interference below the level which will affect the recorder. If necessary, interference can be eliminated by using a battery-driven receiver installed at a site some distance from any source of interference. The modulated oscillator, made by the Automatic Coil Winder and Electrical Equipment Company, was designed to maintain constancy of output and modulation depth, but provision is made to check its characteristics occasionally by means of a valve volt-meter and oscillograph. The components of the receiver are liberally rated, and the receiver operates twenty-four hours a day for at least three months without trouble; one equipment has been in operation for over a year without breakdown or valve replacement.

A typical thunderstorm record is reproduced in Fig. 2; this shows the severe summer thunderstorm of August 29th, 1942. The lines drawn on the chart by the recording pen when each atmospheric is received can be clearly seen; the length of the line is very approximately proportional to the signal strength of the atmospheric. It will be noted that between 7 p.m. and 10 p.m. full scale deflections were recorded; the storm was only a few miles distant at this time, and lightning

chart is driven by a synchronous motor and has a speed of one inch per hour. The modulated oscillator is built into the equipment so

for monitoring purposes. An ordinary outdoor aerial, having a length of about 60 feet, is used. The instrument is affected by

was visible at the recording site. By correlating many records similar to the one shown in Fig. 2 with the known locations of the
RADIO DATA CHARTS—9

The Dynamic Resistance of a Parallel Tuned Circuit

By J. McG. Sowerby, B.A., Grad.I.E.E.

(By Permission of the Ministry of Supply)

It is well known that a parallel tuned circuit behaves as a resistance at its resonant point. At other frequencies it behaves as an impedance with capacitive or inductive reactance predominating, depending on whether the incoming frequency is higher or lower than the resonant frequency. The maximum impedance is presented to the incoming signal at the resonant frequency, and it is at this point that the gain of a valve stage (say) is normally calculated. Hence it becomes important to know the dynamic resistance \( R_d \), and it is the purpose of this chart to calculate it in terms of known quantities—the inductance, the tuning capacity, and the resistance of the coil. However, before coming to the chart it may be helpful to go over the mathematics on which it is based.

Consider the circuit of Fig. 1, which represents a parallel tuned circuit with resistance in the coil arm only—this being the commonest practical case.

Using the symbols shown in the figure, let us calculate the impedance of the circuit. The inductance may be represented by \( (r + jX_L) \) and the capacity by \( (-jX_C) \), where \( X_L \) and \( X_C \) are the inductive and capacitive reactances respectively. Since the two are in parallel the circuit impedance, \( Z \), is given by

\[
Z = \frac{r + jX_L}{r} - jX_C = X \quad \text{(say)}.
\]

Hence

\[
Z = \frac{x^2}{r}.
\]

The absolute value of the circuit impedance may be written

\[
|Z| = \frac{x^4}{r^2} + X^2
\]

In any practical tuned circuit it is clear that the reactance \( X \) will always be large compared with the resistance \( r \). For this reason we can safely ignore the \( X^2 \) term in comparison with the other; and so we are left with

\[
|Z| = \sqrt{X^4/r^2} = X^2/r = R_d.
\]

\( R_d \) is, of course, almost purely resistive, and is usually called the dynamic resistance.

Now since \( X_L = X_C = X \), then obviously we may write any of the following with equal truth:

\[
\begin{align*}
R_d &= \frac{X_L^2}{r} \quad \text{(a)} \\
R_d &= \frac{X_C^2}{r} \quad \text{(b)} \\
R_d &= \frac{X_L X_C}{r} \quad \text{(c)}
\end{align*}
\]

It is versions (a) and (c) which are of most use in practice, but both may be put into a more immediately useful form still. What is known more often than the resistance \( r \) is the \( Q \) of the coil and this is \( X_L/r \). Hence (a) becomes

\[
R_d = QX_L.
\]

But since \( X_L = 2\pi L \) and \( X_C = 1/2\pi C \), (c) may be written

\[
R_d = \frac{2\pi L}{2\pi C} \quad \text{and so}
\]

\[
R_d = \frac{L}{C} \quad \text{and so}
\]

Broadly speaking (1) would be used when the \( Q \) of the coil is known, and (2) when \( r \) has been found either by measurement or calculation, say, from the abacae designed for the purpose in "Radio, Data Charts." The present chart is therefore designed to cover both formulae and is used as shown in the two keys.

Normally it will be found that \( R_d \) will change over a band of frequencies and so usually it is calculated at three points in the waveband—at either end and in the middle. Note too that the

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Example 1. (Key I).
A coil whose Q is 90 at 1 Mc/s has an inductance of 159.2 μH. Calculation shows the dynamic resistance to be 90,000 ohms, and this is the value given by the chart.

Example 2. (Key II).
In the medium-wave band a coil of 160 μH (RF resistance 8 ohms) is tuned by a condenser of 400 μF. What is the dynamic resistance? The chart gives the answer as 50,000 ohms, and this is the calculated value.

U.S. ARMY SETS
Portable Transmitter - Receivers

The United States Signal Corps, like our own Royal Signals, is responsible for the Army's communication system and, in addition, for ground communications of the U.S. Army Air Force. To maintain the lines of communication many different types of transmitters and receivers are required.

Few facts having been published in this country about the sets used by the Corps, it is proposed to give some details about some of the pack sets—or "walkie-talkies" as they have been aptly styled—at present in use.

One of the most interesting of the transmitter-receivers used by the U.S. Army is type 511. Although originally designed for cavalry, this set is now being extensively used by the infantry for communication between company and battalion. Circuit details of this set, which is fixed tuned on six frequencies, are not available, but some of the salient features in design may be given.

"Miniature" technique is employed in the design of this nine-valve set, which is housed in a metal case measuring approximately 6 x 6 x 8 in., mounted on a heavy 30 lb. 6 in. spike. Although intended for insertion in the cavalryman's stirrup bucket, the spike is useful for inserting in the ground.

Access to the valves, etc., is gained by sliding the base plate down the spike. This reveals a second plate, which, when withdrawn, comes away with the screening cans of all the valves.

Incidentally, rubber cushioning is provided in each valve screen. The joints of the case are rubber-faced to render them waterproof except under most unfair treatment: the set can be passed through water without suffering damage, but would be damaged if left submerged.

When extended, the 6 ft. telescopic aerial, fitted to the top of the case, switches on the set. The send-receive switch is fitted at the base of the aerial where it is accessible and easily depressed. A multiple cable from the set is connected by means of a 9-way plug to a case measuring approximately 10 x 9 x 2 in., carried on the operator's chest. This case contains the combined HT/LT battery, spare oscillator coil and the combined microphone-loudspeaker.

This interesting set, weighing 16 lb. complete, has an appreciable range and has been used with considerable success in North Africa and Guadalcanal.

Photographs have recently appeared in the lay press of another U.S. Army set, which has been styled the "handie-talkie." This transmitter-receiver, used by our Allies for communication between platoon and company, is about 14 in. long. As can be seen from the photograph on this page.
it is used like the hand-piece of a modern desk telephone.

Miniature technique is also employed in the construction of this 7-valve set, which weighs approximately 5 lb. Very few details are available however, regarding the circuit. Like the set already described it is switched on by extending the short telescopic aerial.

The original “walkie-talkie” pack set is a two-valve combined transmitter-receiver of considerably larger size and weight. The whole outfit complete with two telephone hand sets, telescopic rod aerial, spare valves and batteries is carried in a canvas haversack on the back of the operator, and weighs approximately 27 lb.

This set, although now obsolescent, is still used in considerable quantities in the U.S. Army.

When used as a transmitter one valve functions as the oscillator in a modified type of crystal-controlled Hartley circuit; the anode being maintained at RF earth potential. The second valve functions as the amplifier of the Heising (constant current) modulation system. For reception these valves operate, respectively, as super-regenerative detector and AF amplifier.

Reproductions from the U.S. Army instructional manual of the basic circuit diagram of the original “walkie-talkie,” when functioning (a) as a transmitter and (b) as a receiver. The set, with separate microphone and headphones, is seen worn by a sergeant of the U.S. Signal Corps in the upper illustration.

The set has a frequency range of from 52.80 to 65.80 Mc/s using one oscillator coil. There is a separation of 400 kc/s between the 33 available frequencies.

Power for the set is provided by a block battery, which, when continuously operated, has a life of approximately 20 hours. When used intermittently the effective life of the battery is, of course, two or three times as long.

Transmitter anode
(unmodulated) ... 35 mA
Microphone ... 35-60 mA
Relay ... 18 mA

The controls and components mounted on the front panel of the set, comprise tuning calibration switch, calibration adjuster, filament resistance and switch filament voltmeter, and microphone and headphone socket.

Receiver anode ... 21 mA
Transmitter anode (modulated) ... 45 mA
NEGATIVE FEEDBACK

Some Pitfalls in Applying It to Quality Amplifiers

By J. T. TERRY

The behaviour of a valve circuit is radically affected by feeding back part of the output voltage into the input circuit. This has been done for some considerable time past, with and without intention. De Forest was not long in applying positive feedback to his three electrode "audion" valve to obtain a detector of high sensitivity, or an oscillator. Negative feedback was also used even in the infancy of radio (multi-stage amplifiers of the First World War embodied this feature), but it was Nyquist's work which ten years ago paved the way to a deeper understanding and hence more widespread application of all forms of feedback.

Since then it is usually held that the performance (especially the frequency/gain characteristic) of an audio amplifier is enhanced by the provision of negative feedback. This belief is based on the usual analysis of negative feedback which assumes that in the absence of feedback the output voltage contains a distortion term D which is independent of the gain m. It is then easily shown that with a fraction β of the output voltage V_o fed back in any phase whatever, both gain and distortion are modified in the ratio 1/1 - mβ. In general, of course, mβ is a complex term and a function of frequency. The feedback is said to be purely negative if mβ = -|mβ|, where |mβ| is the magnitude (positive) stages of the amplifier containing negative feedback. In other words, the comparison must be on the basis of a given output for a given input, i.e., on the basis of a given amplification factor. Doubt may then arise as to whether negative feedback is of any use; for the necessary addition of extra loading or stages tends to add equally to both the amplification and the distortion. The argument is admittedly somewhat academic, as any telephone engineer may proudly point to his amplifier racks containing dozens of valves, an achievement unthinkable without the bounties of negative feedback. Nevertheless, this does not solve the problem and it still awaits a general solution.

The difficulty lies in the varied sources of the distortion term D which it is rather rash, if expedient, to assume independent of the output voltage proper. This could at best be maintained about one of its parts, e.g., mains hum, possibly about valve noise, certainly not about distortions arising in the grid circuit (grid current), in the mutual characteristic (bottom bend curvature) or in the anode circuit (non-linear behaviour of anode resistance RA and load impedance Zl), the latter also varying in general with frequency. Only one factor has been cleared up so far, i.e., irregularities arising from changes in the amplification factor of individual valves, due to arbitrary reasons. J. Peters has shown that the greatest improvement obtains when the stage or stages over which feedback is applied has a gain equal to e (= 2.718 approx.).
While this is only a partial answer to the general problem, it is not proposed to attack it in a formal manner here. Nevertheless, it may be of interest to investigate the physical background and to warn the negative feedback enthusiast against some of the more frequently encountered pitfalls.

For a start, it is necessary that the feedback should be truly negative. This does not mean pure negative feedback necessarily; but that the feedback voltage \( \beta V_o \) should contain a component 180 degrees out of phase with the applied input voltage \( V_i \). This postulate is not quite as trivial as it may first appear, as the following example will demonstrate.

Consider a stage of voltage amplification with transformer coupling (Fig. 1). The switch \( S \) is arranged to apply feedback from the secondary of the transformer when in position \( 2 \). If both \( b \) and \( d \) are feedback is applied, and providing the resistance \( R_1 \) of the potential divider is adequately high, a frequency/gain characteristic as sketched in the top curve of Fig. 2 is likely to result. It reveals a poor low-frequency response below \( b \), a resonant peak at \( d \) then a falling off rapidly towards \( e \).

Obviously this characteristic is associated with serious frequency distortion and the cure would seem to lie in applying negative feedback rather than redesigning the transformer. Suppose then that the switch (Fig. 1) is thrown into position \( 2 \). Assuming that the feedback potentiometer has been suitably connected (otherwise set oscillation is probable) the result will be disappointing, as is shown in the lower curve of Fig. 2. The gain is generally lower than before, but instead of a flatter characteristic it will be adorned by an additional “bump” at \( b \), the obnoxious one at \( d \) still being present.

The simple truth is that neither below \( b \) nor at \( d \) does negative feedback obtain. This is explained by the vector diagrams of Fig. 3; they are based on the fact that the coupling transformer is in effect a complicated network of mutual inductance, leakage reaction \( L \), shunting capacitances on primary and secondary (\( C \)), etc. This is more fully treated elsewhere, and roughly indicated here by Fig. 4. Hence, while the secondary voltage \( V_o \) is always very nearly 90 degrees out of phase with the primary current \( I_o \), the phase angle between the anode circuit EMF \( -\mu V_e \) and \( I_e \) varies from a slight to a large lagging angle as the frequency increases from \( a \) to and beyond \( b \), since the effective load in this region is mainly the primary inductive reactance which increases with frequency. But at some point between \( b \) and \( d \) the transformer primary becomes effectively bypassed by the series combination consisting of \( L \) and \( C \). The angle \( \phi \) thus decreases again, becoming shown would not provide negative feedback. Hence the hump at \( d \) is, if anything, increased relatively. Beyond \( d \) the load is likely to be capacitive on account

![Fig. 4. Simplified equivalent circuit of valve and transformer at frequencies above (c) in Fig. 2.](image)

![Fig. 6. Waveforms of “instantaneous” voltages in the amplifier of Fig. 5 (a) with, for the sake of clarity, \( m = 3 \) and \( \beta = 1/3 \). (a) Sine wave input voltage. (b) Output voltage without negative feedback. (c) Effective input voltage (full line) made up of the original sine wave input and a fraction \( \beta \frac{1}{1 + \text{Im} \beta} \) of the distorted waveform (b). (d) Output voltage with negative feedback (where \( m = 3 \) for the positive half cycles falling to 2.5 for the negative). It should be noted that curves (c) and (d) are approximations only, and an “infinite series” method would be necessary to arrive at the true waveform.](image)

![Fig. 5. (a) Circuit of resistance capacity coupled pentode amplifier with provision for negative voltage feedback. (b) Dynamic characteristic of pentode with resistance load.](image)
The basic cure for the resonant rise in the frequency characteristic is not to use feedback, but to eliminate it by some known stratagem, such as a resistance shunt on the secondary. This would also modify the phase-frequency characteristic suitably and allow of negative feedback at any frequency above the.

Thus, it seems axiomatic that feedback can correct frequency distortion in voltage amplifiers if, and only if, the distortion is not due to series-resonance.

Now, the conventional analysis referred to is formally correct; hence the reason for possible failures in practice must be sought in the underlying physical assumptions. What tends to be overlooked is the question of how the distortion term \( D \) arises in the first place, and by what mechanism, if any, negative feedback may reduce it. As a simple example, consider the circuit of a resistance-capacity coupled amplifier with pentode valve, as shown in Fig. 5 (a) switch \( S \) being in position 1. As is well known, the mutual or \( V_g/I_a \) characteristic of a pentode with load approximates less to a straight line than that of a corresponding triode circuit; in fact, as \( V_g \) gets less negative, the characteristic tends to flatten out. Thus, what happens when an operating point such as \( M \) in Fig. 5 (b) is chosen and a pure sine voltage \( V_s \) is applied to the input terminals of the circuit of Fig. 5 (a) is roughly as shown in Fig. 6 (b): the output voltage suffers amplitude distortion, its negative half cycles being flatter than the positive. This state of affairs is termed "second harmonic distortion" as the output voltage is here practically equivalent to the sum of two sine voltages, one having the frequency of the input voltage, and a smaller one of twice that frequency.

Suppose now that we apply negative feedback in the circuit of Fig. 5 (a) by moving the switch \( S \) from position 1 to position 2. Assuming the blocking condenser \( C \) to have negligible reactance compared with the resistance of the feedback potentiometer \( R_f \), the feedback will be purely negative, i.e., the actual grid-cathode voltage (alternating component) will be the sum of the input voltage Fig. 6 (a) and a fraction \( \beta \) of the voltage drawn in Fig. 6 (b); this resultant is drawn in Fig. 6 (c) and differs from the original input of Fig. 6 (a) both in amplitude and form. In particular, the positive half cycles are larger than the negative. On working it out you will see that this is exactly what is required to make the output voltage such as in Fig. 7 (a). It is conceivable that the loudspeaker impedance is non-linear, i.e., that it draws a distorted current in spite of sinusoidal voltages both on the primary and secondary sides of the output transformer. For simplicity, let us assume the latter to be perfect and the valve of zero internal resistance. It then requires no further argument to show that in Fig. 7 (a) the feedback (or, more precisely, its negative component) cannot combat this type of distortion.

Let us revert to Fig. 5 (a) for an illustration of the third postulate for successful negative feedback. Suppose the grid bias be chosen too large, shifting the operating point to cut-off, say, at \( N \) of Fig. 5 (b). The output voltage will then have the rectified appearance of Fig. 8 (a) and on applying negative feedback, this is changed to Fig. 8 (b) with its smaller magnitude but practically identical waveform. This is due to the inability of the amplification path to amplify the negative half cycles of the input voltage, even though the
Wireless World

The analysis of the above is as follows and may help in understanding the problem better; for a Class A operated valve and its equivalent circuit (Figs. 7 (a) and (b)) we may write down, neglecting loudspeaker reactance,

\[
P = \frac{(\mu V_0)^2}{n^2 RL} \cdot \frac{(RA + n^2 RL)^2}{(I + RA/n^2 RL)^2}
\]

where \( \mu \) = valve amplification factor,
\( RA \) = valve slope resistance,
\( RL \) = AC resistance of voice coil,
\( n \) = output transformer ratio,
\( P \) = electrical power supplied to speaker.

At the resonant frequency, the speaker resistance rises to 10 \( RL \), say, hence the electrical power in it, \( P \) (res.), rises to

\[
\frac{(\mu V_0)^2}{10 n^2 RL} \cdot \frac{I}{(1 + RA/10 n^2 RL)^2}
\]

For the desired damping effect to occur, i.e., \( P \) to fall as \( RL \) rises, examination of the last equation indicates that \( RA \) must be small compared with \( n^2 RL \). Indeed, if \( RA \) were zero, \( P \) (res.) would be equal to \( P/10 \), or \( P \) would vary inversely with \( RL \), i.e., damping would be ideal. Conversely, if \( RA \) is very large compared with the effective load resistance,

\[
P = \frac{\mu V_0^2}{RA^2} \cdot n^2 RL \text{ and } P \text{ (res.)} = 10 P \text{ i.e., } P \text{ would vary directly with } RL \text{ and resonant ‘boom’ would be increased still further!}
\]

This is roughly illustrated by the graphs of Fig. 12.

Negative feedback is thus called for. There are two basic ways of applying it, either as current or as voltage feedback. The former is readily achieved by leaving off the by-pass condenser across the self-bias resistor in the cathode lead (Fig. 10); while this reduces amplitude distortion, it will actually increase the frequency distortion, for this step has the effect of increasing the anode resistance by the factor \((1 + [m/\beta])\).

On the other hand, voltage feedback decreases \( RA \) by the factor \( 1/(1 + [m/\beta]) \) and will thus look after both forms of distortion in pentode power stages. The outline of a suitable circuit is shown in Fig. 11; it forms the basis of handling pentodes in push-pull circuits. Note that the feedback potentiometer should have a high value compared with the reflected speaker resistance \( n^2 RL \).

Thus you will see that in applying negative feedback to a circuit, it is necessary not only to make sure that the feedback is truly negative, and does not affect the operating point, but also that it can achieve your requirements in principle.

REFERENCES

BIRTHDAY HONOURS

In the long list of recipients of honours on the occasion of the King’s Birthday appear those of L.H. Bedford, chief research engineer at Cossor’s, and P. I. Dee, F.R.S., principal scientific officer of the M.A.P. Telecommunications Research Establishment, who become Officers of the Order of the British Empire.

R. N. Holmes, radio officer, R.A.F. Ferry Command, and H. Oliver, first radio officer, Merchant Navy, become M.B.E.s.

Among the recipients of the British Empire Medal are C. E. Miles, foreman of the electric assembly and wiring shop at Cinema-Television works, and A. B. Stockwell, chief of Cossor’s test section.
THE accurate measurement of voltages across different sections of high-resistance circuits or networks involves the use of an instrument that does not take current from the circuit, as this would alter the value of the quantity it is intended to measure. The measurement of the anode voltage or grid voltage of a valve is a case in point. When, as is usually the case, high resistances are incorporated in the valve circuit, voltage measurements are often made by indirect means. For instance, if the anode current is measured and then multiplied by the ohmic value of the resistance in the anode circuit, the result subtracted from the applied voltage will give the anode voltage. This is, however, a cumbersome and lengthy process when a number of tests have to be made.

An electrostatic voltmeter is the most speedy and direct means of making such a test, but such an instrument is expensive and delicate and not suitable for very low voltages. A suitable type of valve voltmeter* can, of course, be used, but one of the most suitable devices would seem to be the potentiometer voltage balance, and this is the device that has been used in the apparatus to be described.

The design adopted was based on the following requirements:

1. Adequate accuracy for the purpose in view.
2. Convenience and speed in testing.
3. Reasonable cost.
4. Simplicity of construction and adjustment.
5. Immunity to damage by accidental overloads.

The effective input resistance on balance is equal to the insulation resistance of the apparatus. It is necessary for the construction of the instrument that means should be available for accurately measuring resistance values and that a reasonably accurate voltmeter should be available for the initial calibration. The cost of material and components is quite reasonable. The main features that enable simplicity to be attained are the use of a neon tube as a voltage stabiliser and a cathode ray (magic eye) tuning indicator for indication of balance. There is no delicate instrument to be damaged by accidental overload. The accuracy is at least as high as would normally be obtained by more indirect methods and is certainly sufficient for ordinary requirements.

Fig. 1 shows the schematic arrangement of the potentiometer assembly. It will be seen that three potentiometers, of 1,250 Ω, 11,250 Ω, and 25,000 Ω respectively, are connected in series across a 150-volt supply. Each potentiometer provides a voltage range in proportion to its resistance, so that the values stated will give voltage ranges of 0–5, 5–50 and 50–150. It is not easy to obtain potentiometers having these exact values of resistance and the best procedure is to obtain three potentiometers of approximately 25,000 Ω each and to connect across two of them fixed shunt resistances, which can be adjusted to give the values required between the potentiometer end terminals. For instance, for the 11,250 Ω 5–50 volt range, a potentiometer having a resistance of 25,000 Ω can be shunted with


The complete voltage tester; power supply equipment is embodied in the assembly.
a fixed resistance of 20,454 Ω.
In the instrument described, three potentiometers of 25,000 Ω each have been used, appropriate shunts being provided as shown in the complete circuit diagram of Fig. 2, which also shows details of the power supply. If the unshunted potentiometer has a value differing from 25,000 Ω, the other two must have shunts adjusted to give appropriate ratios.

The 5-watt neon lamp N and 15,000 Ω fixed resistance R1 provide stabilisation for the potentiometer voltage, which is adjusted to exactly 150 V by means of the 10,000 Ω variable resistance Rp. If the neon lamp is changed, Rp may need re-adjustment. The resistance in the cap of the neon lamp should be removed.

**Avoiding Grid Current**

The cathode-ray tuning indicator M, used here as a balance indicator, has a 4 MΩ resistance connected across grid and cathode, and the slightest trace of grid current or leakage through this resistance would upset the accuracy of the balance indication. It is therefore necessary to provide grid bias to neutralise such an effect. This is done by means of the 400 Ω variable resistance Rg. The key K1 is used to check the correct adjustment of Rg. On tapping K1, no disturbance of the image should be visible on the indicator M. The 100,000 Ω resistance R2 allows sufficient current to flow through Rg to provide the necessary bias voltage.

**Wireless World**

Resistances R3 and R4 are not critical in value and may be ordinary carbon resistances. R6 and R7 may also be carbon. These two latter resistances are not essential to the operation, but are advisable as protective resistances under certain conditions of test. All other resistances, including the potentiometers A, B and C, should be wire-wound. The capacitance values of condensers C1 and C2 are not critical, but the insulation resistance values must be high, as any leakage will impair the accuracy of tests. These two condensers and the screen provided on the power transformer primary are necessary for eliminating traces of superimposed AC which, under certain conditions of testing, would otherwise cause the outline of the cathode-ray image to appear blurred so that the DC balance would not be so distinct. For the same reason and also to prevent DC leakage to earth, both the test gear (including the chassis) and the apparatus under test should be insulated from earth. The transformer screen is connected as shown to the switch arm. Insulation between transformer windings and between windings and screen should be of high quality. These details are very important if the appropriate range is selected by means of the three-way switch S. Initial adjustments are made as follows:—

1. Adjust Rg until on tapping K1 no deflection is observed on M.
2. Apply exactly 150 volts across the test terminals, set switch S to 150 V range and turn dial C to full scale reading.
3. Adjust Rp until on tapping K2 no deflection is observed on M.
4. Various known values of voltage may then be applied to the test terminals and A, B and C scales calibrated in turn. These scales will be approximately evenly divided. Rp should not, of course, be altered once it has been set as previously stated.

**Measurement Procedure**

The apparatus is now ready for use and requires no further adjustments unless the neon lamp or cathode-ray indicator is changed. If the neon lamp is changed Rp may require readjustment. If the indicator tube is changed Rg may require readjustment.

To measure a voltage, apply the unknown voltage to the test terminals, taking care that polarity is correct, and set switch S to the appropriate voltage range. Then adjust dial A, B or C as required until on tapping K2 no deflection is observed on M. Read volts directly on A, B or C, whichever range is in use. If the polarity is wrong, no harm will be done to the instrument, but it will be impossible to obtain a

![Complete circuit diagram, with values of components.](image-url)
Wireless World

DC Voltage Tester—

Balance. Similarly, the instrument will not be harmed if an attempt be made to test a high voltage with the switch on the 5-volt range. It should be remembered, however, that a voltage equal to the instrument setting, exists across the test terminals. Owing to the high internal resistance, this voltage falls rapidly on the application of any load, and the terminals may be safely short-circuited, but care should be taken when testing grid voltages that a high voltage of reverse polarity is not applied to the grids, as valves may be damaged by such treatment.

Incidentally, in testing grid voltages it is sometimes an advantage to insert a resistance of, say, 1 megohm at the end of the test lead nearest the grid, where the mere touching of the grid with a long test lead might perhaps start oscillation, or otherwise affect the working conditions. The insertion of this resistance will not affect the accuracy of the reading.

![Diagram of DC Voltage Tester](image)

Fig. 3. Input potentiometer for doubling the 150-volt range.

Measurements up to 5 volts can be made to within 0.1 volt or even less; up to 50 volts to within 0.25 volt, and up to 160 volts to within 0.5 volt. Higher voltages than 150 may be measured by the addition of a high-resistance potential divider, but the effective input resistance will then, of course, be considerably reduced. A useful potential divider to give a range of 300 volts can be made by connecting two 2-megohm resistances in series across the voltage to be measured and measuring the voltage across one of them. The dial reading should then be multiplied by 2. (See Fig. 3.) The effective resistance of the test apparatus under these conditions will, of course, be 4 megohms. The resistances need not be exactly 2 megohms, but they must be of equal value. Any resistance inserted in the test lead must, of course, be removed if the potential divider is in use.

A practical layout for the panel is shown in Fig. 4. The volt dials are discs of aluminium covered characteristics, and some specimens may not be quite so good as the above.

If the neon lamp is removed from its socket after the apparatus

![Diagram of Panel Layout](image)

Fig. 4. Layout of the panel; component references correspond to Fig. 2.

has been calibrated, it should always be replaced the same way round. That is to say, it is sensitive to polarity and the operating voltage may be slightly higher or lower if it is reversed.

Another point is that for the greatest accuracy the apparatus should be switched on a few minutes before preliminary adjustments and calibration and also before using it on subsequent occasions.

"DESIGNING SUPERHETS"

Errata

In equation (1), page 164 of the last issue the terms $E_p$, $C_a$ and $D_p$ should read $B_k$, $C_k$ and $D_k$ and a few lines lower, the line beginning $x = 4$, should end

$$ D = \frac{x}{12} (f_t - \Delta f) $$

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Wire or Wireless? International Valve Standardisation

Question No. 12.—Though I have followed with an open mind the arguments of those who advocate wired broadcasting in place of radio, it seems to me they have failed to make out a case for such a revolutionary change.

The main argument against radio broadcasting is that it is subject to serious interference. That, so far as our pre-war service was concerned, is an exaggeration. A large majority of the population could receive two transmissions sensibly free from interference during peace-time (much of the interference being avoidable) hardly seems a good argument against a system, by the use of which all the population could receive any number of transmissions completely free from interference at any time.

The questioner goes on to state that if we want more channels (which wire broadcasting supplies) we could use, instead, FM or AM ultra-short wave radio and avoid all interference.

But the questioner doubts if we want more channels and states that the interference with the existing system is negligible. So what? I feel "Radiophare" should make up his (open) mind as to what he does want. So far as I can gather he just does not want wire broadcasting; anything else, but not that. I wonder why?

I have been thinking about this problem for about twenty years. First, I have certain ideas about an ideal service of broadcasting, secondly, a conception of the means to put this ideal service into practice. Argument can develop on the issues:

(a) As to whether these ideas are sound. (b) As to whether the means to implement them, assuming they are sound, are the best available.

To my mind an ideal service would be based on the following facilities:

(1) That the listener should have a wide choice of programme material.

Just as I can read any number of different books with different themes, hear contrasting views on politics, religion, sociology, choose my newspaper, select my friends and my food, so, in a so-called "democratic" broadcasting service, I should be allowed to indulge a like freedom of selection. If the B.B.C. is "hard put to it" to give the public a wider choice of programmes, I suggest they give me the job of showing them how to do it. It would be much easier than mixing up the indigestible hotch-potch served up to us at present.

(2) That the listener should hear the programme he selects clearly and without distracting noises.

If the gramophone companies sold records with the same crackles and bangs and noises printed on them as we get to-day when we listen to anything other than a very local station, I doubt if they would long continue in the business. The quality of reproduction on a gramophone record is much better than we get on the average radio receiver.

(3) That the receiver should be simple and cheap and judged mostly on its merits as a means to reproduce the programmes clearly and nothing else.

As a means to implement my ideals, set out above, I have chosen wire broadcasting. If a better means exists I would be its champion.

The sole difference between wire and wireless broadcasting is that in the former you "bury your ether" and connect your receiver to a source of supply which contains no energy other than that representing the intelligence broadcast; in the latter your aerial is coupled with extraneous sources of energy which can produce interference. True, with ultra-short wave radio this interference is minimised, but there is still a limited amount.

The chief objection I have to an open, contrasted with a closed, ether, is that based on the logical use of technical facility. It is essential to use radio for mobile services (aeroplanes, ships, trains, etc., etc.). The number of channels that will be required for these important services, particularly aircraft, is enormous. Why use them for broadcasting when another solution is available?
Wireless World

There is no other fundamental difference between wire and wireless broadcasting than that, in one, the system is "contained" within definable boundaries; the other scatters the waves anywhere and everywhere, producing mutual interference and being transmitted in an interference-ridden medium.

Of course, if my ideas about an ideal service are not accepted, then there is no need to make any changes. I am not devoted to wire broadcasting because of any passion for a particular technique; I just think it is the proper method to bring about a more exciting, amusing and stimulating broadcasting service. If some people do not want more programmes they could be perfectly satisfied with a wire broadcasting system; they need not listen to more than two out of the six or more programmes provided. We could arrange, if necessary, to supply a little interference with two of the less exciting programmes just to indulge the nostalgia of those who feel like "Radiophone"!

Question No. 13.—What can be done to bring about a practical scheme of valve standardisation, both in Great Britain and overseas?

F. LANGFORD-SMITH.

The writer of this question, F. LANGFORD-SMITH, of the Amalgamated Wireless Valve Company, of Australia, has had experience of the valve problem not only in that country, but also in England and U.S.A. He adds, "May I be allowed to open the discussion by attempting to answer my own question? The excuse for this somewhat irregular procedure is the present delay in the mails between Australia and England." His proposals are printed below.

As a first step, the obviously desirable course is to form some representative body in England under the chairmanship of the most able engineer who can be found (he should also have detailed knowledge of the commercial aspect) to enquire into all the circumstances, to consult with an equivalent body in U.S.A., and make recommendations to be put into effect, either voluntarily by the industry as a whole, or, alternatively, under Government control.

In general, valves can be grouped into two categories, which we may conveniently call Equipment and Replacement types.

Replacement Types. Small-quantity replacement types may then be allocated for manufacture, each type by a single factory selected for the most economical production, until the demand ceases. This will eliminate wasteful competition or the splitting up of production between several factories on a type which is no longer being used in new sets.

In many cases it should be possible to use one valve to meet the replacement demand for several "types" marketed by different manufacturers but having substantially similar characteristics and basing, thus reducing the number of different types to be manufactured. The Committee could also draw up a plan for the discontinuance of production of old types which have reached their limit of usefulness.

Equipment Types. The major task facing the Committee would be the selection of a list of types to which receiving set manufacturers would be restricted for ordinary models. It is in the final selection of these types that consultation with a similar American body would be so important. In the past it has happened that English manufacturers have tried to assure their replacement market by using types which were not available from foreign competitors, but this policy has been most unsuccessful in practice, and in many areas has restricted the sale of the sets owing to uncertainty or difficulties (real or imaginary) associated with the purchase of replacement valves. A number of English manufacturers have, therefore, taken up the manufacture of standard American ("International") octal types so that it might be said that the ice has been broken as a first step towards the adoption of a standard international range of types. Perhaps all readers are not aware of the fact that standard American types were also manufactured before the war in many European countries, in Canada, Australia, and even Japan, so that a considerable measure of international standardisation has already been achieved in this way.

Unfortunately, however, the American range is far too large, so that the problem of selecting a standard international range for equipment purposes has still to be determined. My remarks concerning the American series should not be taken as meaning that the range to be used in England should necessarily be a selection from the American range at present manufactured, since it should be possible to obtain American co-operation with give and take on both sides.

In reality, the position is not so difficult as some may imagine, since American and English manufacturers in many respects have been approaching one another for some years past. For example, the very low slope of many of the older American valves was in distinct contrast to the very high slope of some earlier English valves, and the medium slope of most types in current use to-day. American design has so much changed that valves having slopes quite comparable with those of English valves are widely used to-day, so that this question of slope or stage gain is no longer one of conflict between the two countries. The basic point for early decision is the type of socket to be used, whether the "International" octal or the "Lock-in" type or some other. If agreement can be reached, as it should be reached, there should be no doubt regarding the final attainment of an agreement on the valve types to be included in the Equipment range.

Having decided upon the Equipment range, it would be necessary to ensure that receiver manufacturers restricted their models, or at least all models other than those for very special purposes, to this new range.

If such a standardisation scheme is put into operation, the writer is convinced that it will enable the English valve manufacturers to compete both in their home country and in the export market with valves of American origin, the reduction in unit cost of production being used to bring about a general reduction in selling price. Moreover, the eventual reduction of types required to be stocked by retailers will undoubtedly assist those engaged in their distribution and sale.
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WIRE BROADCASTING
Sir Robert Watson-Watt's "Pipe Dreams"

WHEN Sir Robert Watson-Watt, the pioneer of radio-location, addressed the Radio Industries Club last month on "The Distribution of Broadcasting after the War," he stressed the fact that he spoke "as a member of the radio family" and not in his official capacity. His talk followed an address delivered by him before the British Association in March, in which he demanded for the broadcast listener "four freedoms": freedom from interference, freedom from distortion, freedom of choice, and freedom from distraction. Sir Robert, who had previously criticised our present technical methods of broadcast distribution and advocates a wire system as opposed to radiation for some at least of the programmes, contends that the "four freedoms" should guide the policy of distribution.

In the Radio Industries Club talk he developed this theme of "piped" broadcasting; in his own words he indulged in "pipe dreams," and urged that after the war there would be a heaven-sent opportunity of making a fresh start. Broadcasting is, in his view, a medium that should "be used seriously, but never heavily," and, to realise its full potentialities as a source of public enlightenment, some six channels should be available to every listener. He suggested that two of these should provide two kinds of good music, one news and topical talks, and another educational matter.

Advantages of "Canalisation"

Sir Robert, in advocating "canalisation" as opposed to "haphazard broadcasting" enumerated the various forms of interference to which radiated transmissions are liable; they included side-band splash, atmospherics, man-made electrical interference, and such incidents of propagation as the Luxembourg effect. As a listener the speaker demanded freedom from measurable interference from all these sources, which in his opinion, are controllable.

When dealing with the question of freedom from distortion, Sir Robert stated that "the man at the transmitting end was less responsible for distortion than some would have us believe." The set designer was, in his opinion, not entirely blameless, moreover, the allocation of frequencies played a big part in the realisation of this freedom. "Ought we," he said, "to stay in the medium-wave band, or in any open broadcast band?"

He urged that the system he advocates would not bring about standardisation or an end of technical advances in receiver design; there would still be plenty of scope for developing different types.

He stressed that the arguments concerning the merits and demerits of "space" and wire broadcasting had got to be settled, and in favour of the latter he claimed a higher degree of freedom in each case.

Although the speaker did not enlarge on the technical details of the system he favours, it is assumed that he has in mind a "wired wireless" or "carrier" technique, distribution being carried out over the electric mains and telephone lines—or possibly both. He said that most communities of over 1,500 could be served by wire, but that radiated transmissions would be needed in isolated or mainly agricultural districts, and, of course, for foreign broadcasting. This question of broadcasting to other countries he regarded as a strong supporting argument for retaining radiated transmission as an auxiliary or parallel service.

Opposition Views

In the discussion which followed, Sir Louis Sterling suggested that Sir Robert exaggerated the seriousness of interference and other handicaps from which radiated broadcasting allegedly suffers. As to the question of freedom, before the war millions of people in this country preferred the commercially sponsored programmes from Continental stations; Sir Louis himself wanted real freedom to hear what he liked and implied that such freedom would be denied him under a system where broadcasting is predominantly by wire. Still on the subject of listeners' freedom, he suggested that a good example of the possible evils of "canalised" broadcasting is to be found in the enemy-dominated countries of Europe. If those countries had had a wired system before their occupation, the vast majority of their population would now hear nothing but Nazi propaganda.

Sir Louis thought that, if the whole country were "piped up," technical development would be slowed down, as there would be a relatively small demand for receivers for radiated broadcasts. More important still, as there can be no export market without a big domestic market, our foreign trade in sets would disappear.

Sir Robert replied that the whole of the available programmes of the world were, in fact, chosen by a handful of men, so that the only real guarantee for freedom of choice was an increase in the total programme material. He was convinced that the technical problems of the "piped" system offered a very wide field for technical and industrial enterprise. So long as he was assured a system satisfying his four freedoms he had no desire "to deny to others bad reception of radiated programmes."
Electromagnetic Fields in Radio—VI.

WAVES IN METALS AND THE IONOSPHERE

By

MARTIN JOHNSON
D.S.C.

We have discussed the bending of radio waves when they enter dielectric materials and their polarisation when they are reflected at the surface separating two dielectrics; we have still to consider what happens when they enter conducting material. Two instances of the latter are of practical importance for radio technicians, first, the wires and aerials and wave-guides representing the metallic termination of lines of force for the electric field, and, second, the ionosphere or regions of the earth's upper atmosphere which contain free electrons liberated by solar agencies, and which therefore control radio transmission over long distances.

We found that the behaviour of radio waves towards any material could be decided by inserting into Maxwell's equations of the electromagnetic field the variables $k$ (dielectric constant), $\mu$ (magnetic permeability), and $\sigma$ (electrical conductivity). For empty space, in the simplest units, $k = 1$, $\mu = 1$, and $\sigma = 0$, and for air these are still good approximations. $\omega$ does not increase much except for iron and other magnetic materials, but in the previous article we considered the effect upon speed and bending of waves when $k$ rose to 30 to 50 or even 80 in an insulator. $\sigma$ was considered to be not far from zero for such substances, but the effect of a growing $\sigma$ must now be taken into account if metals and the ionosphere are to be compared with non-conductors and their behaviour explained.

Electrical Grading of Materials for Waves of Different Frequencies.—We mentioned that a dielectric could show "dispersion," the refractive index and dielectric constant varying for different frequencies, and the mechanism of orientation of molecules gave reason for this becoming important for very short waves. It is useful therefore to classify materials not solely according to their $k$ and $\sigma$ as measured with DC, but to include the frequency for which their properties will hold or fail. Engineers specialising in constructional materials for RF have tried various ways of specifying the useful ranges between insulating and metallic extremes; the ratio of "conduction current" over "displacement current" is commonly used and corresponds to the principle of interpreting Maxwell's equations which we outlined previously. The following useful quantitative criterion may now be found in one of the most recent and thorough treatises on electromagnetic theory*:

(i) \[ \sigma^2 \ll k^2 \omega^2 \]

For such material, displacement current is large compared with any conduction. The inclusion of $\omega$, the angular frequency, shows that this relationship may occur either (a) if the material has highly insulating properties, or (b) even in moderate conductors when the electromagnetic field has sufficiently high frequency, for example, in sea water through which U.H.F. is passing.

(ii) \[ \sigma^2 \gg k^2 \omega^2 \]

The conduction current in this case greatly predominates. Metals where $\sigma$ is of the order of $10^6$ mhos/metre, will obviously belong here. Not much is known about the dielectric constants of metals, but it is clear that the displacement current would only equal the conduction current at frequencies greater than $10^{17}$ c/s, a region well known in the general electromagnetic spectrum but which concerns atomic behaviour and is far removed from the wave bands of radio.

Manipulation of these and related expressions in the treatment of "attenuation" shows that wave amplitudes are damped out more readily as frequency, permeability, or conductivity increase. They also indicate that whereas in an ideal dielectric the electric and magnetic vectors oscillate in phase as in a vacuum, in a conductor the magnetic vector lags behind the electric. We utilise this later.

(iii) Many materials of practical importance cannot be regarded as exclusively dielectrics or conductors, and cannot be treated as conforming to either of the above two extreme conditions. Alloys and semi-conductors we have discussed elsewhere, and there are also electrolytes. Many cases can be treated by retaining in the principle the $k$ of the dielectric but adding to it in practice a term involving both conductivity and frequency. The compound expression enables us to pick out the conditions under which, conducting or insulating properties predominate.

Analysis of the speed of radio waves and their attenuation in these wider circumstances becomes complicated in comparison with our simple discussion of dielectrics, and we propose here to deal with one or two practical consequences only.

"Skin Effect" in Metals—We needed on a previous occasion to take account of the fact that some fraction of the wave energy becomes transformed into heat when absorbed in a dielectric; when the quantity $\sigma$ allows metallic conduction currents to be fairly large, this also results in a loss of radiant energy into heat, which would cease if $\sigma$ were either zero or infinite. Similarity of the electromagnetic mechanism throughout the whole spectrum is recalled by the fact that the radiation from a fire or the sun, of shorter wavelength than radio, can heat a metal in which it is absorbed. The heating accompanying propagation of radio waves in metal is, of course, decided by $iR$, the watts dissipated, as if $i$ were DC instead of RF current; but the location of $R$ is not so simple as in DC. Radio experimenters are familiar with the bundle of thin strands often used to carry RF in the metallic parts of a circuit, and will appreciate that since the

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Wireless World

magnetic permeability $\mu$ has the same effect as increased conductivity $\sigma$; materials of high $\mu$ like iron tend, however, to possess lower $\sigma$, and copper shows extreme examples of “skin effect” by reason of its $\sigma$ rather than its $\mu$. The amplitude of waves is not just an inverse function of depth penetration, the simplest expression involving $e^{-ms}$ where $m = \sqrt{2\pi\omega\mu}$ for an attenuation at any depth $x$ below the surface, and in general Bessel functions are needed for the calculation. All of these expressions show the dependence upon frequency $\omega$.

This $N_e$ increases from almost zero near the ground to its maximum in some region of the “E” or “F” layers which has been most strongly ionised, but in which recombination between electrons and positive ions is not too rapid. The presence of these free electrons enables this atmosphere to reflect and refract radio waves, and for some purposes it acts as if it had a refractive index given by $\sqrt{1 - \frac{AN_e}{\omega^2 \pm B}}$. The constants A and B involve properties of the medium and of the electron, but B involves also the earth’s magnetic field. The expression shows that in addition to depending on $N_e$ the material is “dispersive” in the sense used in our articles, its behaviour to the waves depending on the angular frequency $\omega$. The ambiguity of sign $+$ or $-$ for constant $B$ suggests at once that there are two possible refractive indices and a split into two modes of propagation. The form of expression also shows that “refractive index” is a wider term than the simple one which we described for optical phenomena; in fact zero and infinite and imaginary indices have significance in the case of radio waves in the ionosphere.

We saw, in the simpler case of light waves passing from one transparent dielectric to another, that refractive index controls the bending of the track because it represents a change in velocity; but we insisted that “wave velocity” not “group velocity” is there implied and is not limited to “c”. Actually the wave velocity of radio entering the ionosphere may greatly exceed “c” but this velocity is not in the direction in which a Poynting vector carries energy; so there is no contravention of the principle that “c” is the maximum rate at which energy can be transmitted.

The phenomenon of “critical
angle," discussed earlier, becomes important: at a given frequency vertical or nearly vertical incidence transmits a beam right through a layer whose \( N_g \) is sufficient to produce sharper bending as incidence becomes more oblique, until at some layer the increasing \( N_g \) returns the beam down to earth again. The gradual alteration of refractive index and gradual increase of obliquity of incidence turns our simple diagram of the previous article into the curved trajectory illustrated in T. W. Bennington’s article on the ionosphere.

**Polarisation in the Ionosphere.**—We have seen that as a conductor the rarefied gas of the ionosphere possesses far fewer free electrons than a metal, and that their distribution is not constant: in consequence a metal totally absorbs in a very short distance any fraction not reflected from its sharp boundary, whereas the ionosphere returns radio to the earth or transmits it outward according to frequency and in most cases by a gradual bending in material of continuously varying refractive index.

But there is another peculiarity of propagation in the ionosphere: it takes place in the presence of the earth’s magnetic field. The

![Fig. 2. Model of plane and elliptic polarisation.](image)
The resultant vector in each case is compounded out of the vertical and horizontal vibrations, but its shape depends on the phase lag between the components. If the amplitudes of the components are equal, the resultant for phase lag 90 deg. and 270 deg. becomes a circle; but the intermediate cases remain elliptic, with straight lines for phase lags of 0 deg., 180 deg., 360 deg., etc., which reverse the sequence from anticlockwise to clockwise.

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The complexity of the effects, as it had long been known that certain crystals can split a light ray into two components, polarised in planes perpendicular to each other and travelling with different speeds: the material is "birefringent," possessing two refractive indices, one for the "ordinary" and one for the "extraordinary" ray which therefore bend differently and are differently absorbed. The analogy with radio seems at first sight more complete than it actually is, for recombination of the two plane-polarised rays of light from the crystal can produce "circularly or elliptically polarised light," and "elliptically polarised radio" does certainly return to us after refraction in the ionosphere. The literature of radio fading and direction-finding and ionospheric propagation can become very confusing unless this optical analogy is utilised for what it is worth but not pressed too far. The clue to the difference between the light and radio lies in the term involving the earth’s magnetic field in the expression which we quoted for refractive index of the ionosphere, and which is absent from crystal optics.

The first crucial observation was due to Appleton and his collaborators, to whom this remarkable clarification of radio transmission is due. They found that radio signals reflected down from the ionosphere showed "left-handed elliptic polarisation" in the northern hemisphere, but under similar conditions in Australia showed "right-handed elliptic polarisation." So the ionosphere, in conjunction with the earth’s magnetic field, acts somewhat as the birefringent crystal, but the expression for the refraction shows that each of the two waves into which a plane-polarised system must split can itself be represented by an equation of elliptic polarisation.

"Intensity fading," as well as "directional errors," are due to interference between the various portions of single- and multiple-reflected components. Accounts of this process are generally known as the "magneto-ionic" theory, but are difficult to follow unless the reader has some conception of "circular" and "elliptic" polarisation. We add here, therefore, a treatment to bring this into line with the simplified ideas of vibrations and waves on which the earlier portions of the subject were shown to depend.

**Circular and Elliptic Polarisation.**—Early in these articles we related any mechanical or electrical wave motion to vibrations taking place to and fro and up and down along the diameters of a circle. The properties of these simple harmonic vibrations were derivable from a uniform motion round the circle itself. For understanding the various polarisations of light or of radio, vibrations in straight consequence is a splitting of the entering radiation into two polarised components, bending differently and absorbed to very different extents: in fact the downward returning waves may consist solely of one or the other or a mixture. The final state of polarisation can be found by analysing reception with a CR tube.

Here again the optical analogy was very useful for disentangling lines can be compounded into movement in circular or elliptic paths, and clockwise and anti-clockwise circular motions can combine into linear oscillation. For the simplest case imagine a pendulum swinging in its arc in a fixed plane, and give to it periodic impulses in a plane perpendicular to that of the original arc. If the period of the disturbing impulses agrees accur-
Wireless World

ately with the period of the original swing, the shape of the resulting compound motion may be linear, circular, or elliptic, entirely according to the phase difference between the swings and the applied impulses. Apply the latter at the instants when the original vibration is passing through its dead centre; the resultant is a diagonal linear motion either "North East—South West" or "North West—South East" according as the phase difference is 0 deg. or 180 deg. But if the crosswise impulse is applied when the original vibration is at its maximum extent and turning point, the result is a rotatory path, anticlockwise or clockwise according as the phase difference is 90 deg. or 270 degrees. The path is circular or elliptic according as the amplitudes of the two vibrations are equal or unequal; but in either case, for intermediate phase differences, the path is an ellipse which opens out and then collapses on to the two diagonal lines. These facts may be verified in a few minutes by swinging a weight on a string and applying the crosswise impulses by hand.

Translated into optics these simple mechanical models afford a picture of the orientation of electromagnetic vectors which is imposed upon ordinary light when a crystal splits a ray into plane polarised components; subsequent recombination of the latter produces elliptic or circular or plane polarisation, according to the thickness of the crystal and therefore the distance of path controlling the amount of phase difference between the components. The optics of transparent insulators and crystals and metals becomes thus intelligible, with useful practical consequences. The notions can also be applied to radio; for the experiments of Appleton and his collaborators of the Radio Research Board have shown that long distance transmission, direction finding, radio navigation, and the ionospheric effects upon "fading" can also become intelligible if we recognise that an ionised atmosphere in a magnetic field can resolve a plane-polarised beam into two elliptic motions. Even the very different absorption of the two shows the strongly "dispersive" properties to which we have repeatedly drawn attention, since resonance may occur between the frequency in the radio wave and the frequency with which electrons can gyrate in the earth's magnetic field, and such resonance absorbs energy. Terms expressive of this are included in the constants which for simplicity we merely labelled by letters in the "refractive index" of the ionosphere.

It is fitting that we end this last of a series of articles concerning the electromagnetic field by so striking an instance of the way mechanical and optical models contribute to understanding radio, for the first clue to the existence of radio was the identification of wave motion with the solution of Maxwell's equations which summarise the connections between magnetism and electricity. Electromagnetic radiation, whether known as light or heat or X-rays or radio or cosmic rays, will continue to present us with puzzles as to its real status in nature when correlated with atomic phenomena, and in some aspects nowadays it seems to have properties not all explainable in terms of waves: but there is no doubt that some of the behaviour of radiation appears as wave properties, and it is through understanding these that the utilisation of radio has become possible.

BOOKS RECEIVED

Accumulator Charging.—Eighth Edition. By W. S. Tidbenton, B.Sc., A.M.I.E.E. After introductory chapters dealing with the elements of electricity and measurement of power, the book goes on to describe accumulator construction, operation and maintenance in considerable detail. The latter half of the book deals with the charging from various sources of different types of cells. Accumulators of the alkaline type, as well as the more common lead-acid cells, are treated. Pp. 168+XIII; 42 diagrams and illustrations. Sir Isaac Pitman and Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 6s. net.

Airwomen's Work.—By Leonard Taylor. A description of the various kinds of work undertaken by the Women's Auxiliary Air Force, written for those who expect to join that service. There are sections on morse, electricity and wireless. Pp. 54, with many illustrations. Sir Isaac Pitman and Sons, Ltd. Price 1s. 6d.

REDUCING POWER-LINE INTERFERENCE.—As pointed out in an article in our May issue, interference from power-lines during damp weather may be reduced by ensuring a uniform potential distribution over the insulators. This photograph, taken in the American Westinghouse laboratory where interference problems of this kind are investigated, shows the testing of an insulator that has been treated with a semi-conducting glaze in order to stabilise its insulation resistance at a relatively low value.
PICK-UP COUPLING TRANSFORMER

Practical Design for Use with Moving Coil Pick-ups

By JOHN BRIERLEY

SINCE the description in the July 1942 issue of this journal of a moving coil pick-up, there have been many inquiries by readers regarding a coupling transformer—particularly from those requiring data for the construction of a suitable component.

Before giving the constructional details it would be better perhaps to examine the considerations on which the design is based. The turns ratio is the first matter to be settled and this is determined by the values of the input and output impedances. The input impedance is that of the pick-up coil which can be taken as about 1.7 ohms, but the output impedance, in cases where the secondary is connected direct to the valve grid, is not quite so definite. Experience indicates that a safe maximum is about 50,000 ohms; with careful design this value can be considerably exceeded, but as the output impedance increases as the square of the turns ratio and hence of the voltage output for a given input, such a course should be adopted only in exceptional cases and it must not be forgotten that to accommodate the increased number of secondary turns in the available space an even finer gauge of wire must be used which increases the difficulty of construction when only improvised winding gear is available. Taking then the value of 43,000 ohms, the ratio becomes

\[ \sqrt{43000/1.7} = 160 : 1 \text{ (approx.)} \]

The considerations which determine the winding particulars are equally definite: for a good bass response it is essential that the inductance of the primary should be such that its reactance is at least twice that of the coil at the lowest frequency which it is required to reproduce. Taking this frequency as 25 c/s, then an inductance of not less than 20 mH is required. At the same time it is essential that the DC resistance of the windings should be as low as possible. It will be realised that these two requirements are directly opposed and that for a given core and winding area, one can be gained only at the expense of the other. It will suffice for our present requirements if the primary resistance is not more than 0.1 ohm and the secondary 2,000 ohms, though by using a nickel-iron alloy core of only moderate dimensions it will be possible to effect considerable reductions in these values primary and secondary and this can be made to suit our requirements by sectionalising the windings; as for a given response the need for this is less the smaller the transformer, here again a nickel-iron alloy core by enabling us to reduce the size of the transformer, simplifies the construction to a very acceptable extent.

Fig. 1. (a) Section of transformer showing arrangement of windings and dimensions of core. (b) Method of joining up inside and outside wires of the six winding sections.

Turning now to the practical design, employing nickel-iron alloy lamination such as No. 70—T “Mumetal” laminations of the Telegraph Construction and Maintenance Co., Ltd., built up to a core thickness of half an inch, the requisite primary inductance is obtained with 50 turns; the secondary will therefore need 8,000 turns. For the primary No. 20 SWG enameled wire is used and No. 40 SWG enameled for the secondary.

Two bobbins are used with two secondary sections and one primary section on each—Fig. 1(a) shows the arrangement. The dimensions of the bobbins and the position of the wire holes which are drilled before winding are shown in Fig. 2. Both bobbins are exactly similar and the holes are on one end only but on two opposite sides of the square centre hole. The two holes on one side take the inner and outer ends of the primary section and the four holes on the opposite side take the ends of the two secondary sections.

Before commencing the winding the bobbins should be checked to
ensure that the core can be inserted properly and a block of wood cut to fit exactly the centre hole; end pieces should also be cut to prevent the end-checks being forced out by the windings and slots to expose the wire holes should be cut in one of these. The winding is started by soldering on to the beginning of the No. 40 SWG wire about 8 inches of No. 32 SWG DSC as a lead out wire, leaving about 2 inches exposed. Another length of about 12 inches of the No. 30 gauge DSC is soldered on after winding on the 2,000 turns leaving about 6 inches exposed. One layer of thin varnished paper is then put on and the primary section of 25 turns of No. 20 SWG enamelled wound on in two layers followed by another layer of varnished paper. The 6 in. lead out wire of the end of the first secondary section is then threaded through the hole for the start of the second secondary section, the No. 40 SWG soldered to it and the bobbin complete by winding on the second secondary section of 2,000 turns complete with lead out wire. The second bobbin is wound in an exactly similar manner and it is essential that both bobbins and all of the windings on both bobbins should be wound in the same direction.

The bobbins can now be mounted back to back on the core—that is, with the leads coming from the exposed end-checks—the 33 pairs of laminations being inserted from alternate ends. The two outer ends of the second secondary sections on each bobbin are joined together and also the outer ends of the two primary sections, as the winding direction of the bobbins when assembled in this manner is opposite. Fig. 1(b) shows the wiring arrangement. The resistance of the primary is 0.08 ohm, and that of the secondary 950 ohms; 1 oz. of No. 20 SWG enamelled and 2½ oz. of No. 40 SWG enamelled are required for the windings.

When a transformer is used at low signal levels and followed by several stages of amplification including bass boost as in a gramophone pre-amplifier, there is almost always difficulty in placing it that it does not pick up hum due to stray fluctuating magnetic fields. It is therefore desirable in most cases to screen the transformer in a thick copper or iron case, though a high-permeability alloy case is better than either. The following figures show the reduction in hum pick-up at 50 c/s when the transformer, which was connected to a 4-stage battery amplifier, was housed in cases of various materials, and placed at a distance of 30 inches from a 100-watt mains transformer.

<table>
<thead>
<tr>
<th>Material</th>
<th>Copper</th>
<th>Cast Iron</th>
<th>Mummel</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 dB</td>
<td>22 dB</td>
<td>42 dB</td>
<td></td>
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</tbody>
</table>

It is interesting to note though that in practice a thin copper case is often sufficient when the signal voltage across the secondary is not much less than 0.1 volt, though care must then be exercised in placing it as far as possible from possible sources of hum and in orienting it by a process of trial and error to the position of minimum hum.

**Fig. 3. Frequency response curve of transformer with artificial loads of 1.5 and 50,000 ohms across primary and secondary respectively.**
Mahomet to the Mountain

DURING the palmy days of peace I never bothered myself overmuch about the nature of the B.B.C.'s programmes, but made it my business to see that adequate and efficient technical arrangements existed for conveying those programmes to our homes, and that I criticised receiver manufacturers and the B.B.C. engineering department alike.

Nowadays my concern is not so much to get programmes into your homes as to get propaganda into the homes of the enemy, and here again I do not regard it as my duty to join the controversy as to what form our propaganda should take, but I do consider it my business to see that adequate technical means are provided to get the propaganda into enemy loudspeakers. According to information which reaches me from the continent far too few people are listening to propaganda, and I have long thought that we should adopt a bolder technical policy in order to remedy this defect.

Apparently I am not alone in my views, for this subject has been well "plugged" in the House of Commons by the honourable and gallant member for Rochester, but, whereas he wants propaganda transmitters built all round the perimeter of Europe, my own ideas on the subject are far different. To start with, the building of these proposed transmitters would take time, and I doubt very much if they would be very effective when built; for it must be remembered that the wily Adolf saw to it years ago that the "el volkk" of the Fatherland were for the most part provided only with primitive medium-wave Volksempfängers, and the proposed perimeter transmitters would be largely defeated by distance unless they were of prodigious power.

My proposal is simply to take of vision been taken years ago and all coal burned at the pithead, the latent energy dug out of the earth being swiftly distributed electrically instead of at the shambles gait of the average coal train.

Instead of hanging his head in shame on behalf of himself and of the whole electrical industry as I had expected, he rounded on me and ordered me soundly for supporting what he called a popular superstition regarding the supposed economy of burning all coal at the pithead. He then went into a mass of statistics to prove that I was wrong, which is, of course, impossible. He stated that apart from the high initial outlay, the operating costs of the pithead idea would, owing to transmission losses and other factors, exceed that of the present archaic system.

Frankly speaking, I was appalled at his ignorance of elementary economics. A little knowledge is a dangerous thing, and, as I pointed out to him, there is no subject of which this is more true than economics. As I told him, in the statistics which he had given me he had not mentioned one word about the costliest item of all which must be debited to the account of the present system, namely, the public health services.

Any good medical work will tell you of the health havoc wrought each year by the soot and smoke belched forth from our countless domestic chimneys. Apart from specific diseases, the screening of the sun's ultra-violet rays by this veil of the products of combustion is responsible for a large amount of "off-colour" health, resulting, of course, in much swallowing of noxious medicines which cost money and man-hours to produce.

Ignorance in High Places

IT is astounding what a tremendous amount of muddled thinking exists even among those who have had the advantage of being life-long readers of Wireless World. This fact was strikingly brought home to me the other day when talking to an electrical engineer of some eminence who is associated with the Central Electricity Board and is therefore in a position to speak with some authority.

Our talk had turned on the war, and I had remarked on what a tremendous saving in money and effort there would have been had the advice of myself and other men...
WORLD OF WIRELESS

U.S. SETS FOR US

WHEN once again asked whether he was in a position to announce the date utility receivers would be available, Mr. Dalton, President of the Board of Trade, stated he had decided that "after the sets in process of manufacture have been completed, any new domestic sets made here shall be of simple standard designs." Discussions on this are understood to be proceeding with the trade. No sets of this type could, however, be available until next year.

He also announced that arrangements have been made to import receivers from the United States for early delivery.

It would appear from this and other statements that the much-talked-of utility set is still in the embryonic stage.

RADIO OFFICERS' GALLANTRY

WHEN presiding at the General Meeting of the Marconi International Marine Communication Company, Admiral H. W. Grant, C.B., referred to the devotion to duty of the company's radio officers. He read a letter from the beginning of the war and up to March 31st of this year, the following 21 decorations for gallantry have been awarded: O.B.E.s, 2; D.S.C.s, 2; M.B.E.s, 15; Silver Medal of the Royal Humane Society, 2. Three of the 21 have been awarded also Lloyd's War Medal. In addition, 45 radio officers have been officially commended for gallant conduct, 16 of them posthumously.

VOICE OF BELGIUM

WE thank readers who have informed us of the reception of the experimental transmissions from the new 50-kW station at Leopoldville, which is now working on a regular eight-hour daily schedule.

The transmissions, broadcast in the two national languages of Belgium, are radiated on 25.70 metres from 0545 to 0730 and 2115 to 2330, and on 16.88 metres from 1215 to 1400 and 1830 to 2115 (BDST).

In addition to the programmes emanating from the capital of the Belgian Congo, transmissions from London and New York are rebroadcast daily.

SIGNAL STRENGTH CODES

IN a recent issue of Radio Times reference was made to the code B.B.C. engineers encourage overseas listeners to use when reporting short-wave transmissions. It is a three-figure code, the first figure referring to the strength of signal, the second to the degree of fading, and the third to the over-all merit of usefulness of the signal to the listener.

Col. Sir A. Stanley Angwin, D.S.O., M.C., T.D., B.Sc. (Eng.), nominee for the I.E.E. presidency. He succeeded to the post of G.P.O. Engineer-in-Chief in June, 1939, and has been a member of the Government Television Committee since its inception. Sir Stanley was created a Knight Bachelor in June, 1941.

For each figure a reading of from 0 to 5 is used, those limits respectively representing minimum and maximum. The perfect signal, therefore, would be reported "505." This code has not been internationally adopted and should not, therefore, be confused with the QSA and QRK codes. These employ the numerals 1 to 5 for strength and readability of signals, the highest figure being used for the best signal.

AUTOMATIC SOS SETS

PORTABLE automatic SOS transmitters are now being dropped in buoyant bags from patrolling aircraft of Coastal Command to shipwrecked seamen.

Few details of the apparatus are disclosed except that it is about the size of a domestic coffee mill and transmits a continuous SOS signal so long as the handle is turned. It was recently instrumental in locating, after five days, a lifeboat with 19 survivors which, owing to bad visibility, had been lost by the patrolling aircraft.

B.B.C. SHORT WAVES

FIVE new frequencies have recently been introduced by the B.B.C. in its short-wave overseas services. They are:

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.75</td>
<td>25.47</td>
</tr>
<tr>
<td>15.42</td>
<td>19.45</td>
</tr>
<tr>
<td>11.93</td>
<td>25.15</td>
</tr>
<tr>
<td>17.87</td>
<td>16.79</td>
</tr>
<tr>
<td>11.73</td>
<td>25.58</td>
</tr>
</tbody>
</table>

The frequency of GRN has been
changed from 6.19 Mc/s, as given in our list of short-wave stations in the May issue, to 6.20 Mc/s.

Some of these frequencies are used for the General Oversea Service introduced by the B.B.C. some time ago. It is intended for the Forces and "Britons in exile" in the Far East, Near East and North and West Africa. This service now occupies 12½ hours a day and is designed to provide an alternative service from 1200 to 0045 (BDST) in the areas served.

We give below the current schedule of short-wave transmissions of news in English in various B.B.C. services (times are BDST):

0000 31.35, 42.46
0045 35.53, 35.68, 30.53, 31.32
0100 25.58, 30.53, 30.96, 31.32, 41.96, 42.13
0200 42.46, 48.35, 49.16
0215 10.82, 25.53, 25.68, 30.53, 31.55, 42.13
0300 16.64, 16.79, 16.84, 19.82
1500 16.64, 16.79, 16.84, 19.42, 19.82, 25.53, 30.53, 30.96, 31.32, 35.55, 31.75, 31.55, 31.68, 41.96, 41.96, 42.45, 45.54, 49.10, 49.59
1700 16.54, 16.79, 16.84, 19.42, 19.82, 23.25, 23.29, 31.52
1800 16.59, 16.64, 16.84, 19.56, 25.53
1900 10.66, 16.82, 25.15, 25.39, 25.47, 35.53, 31.75, 32.70
2245 10.66, 25.59, 25.53, 31.55, 31.55, 41.75, 41.96, 42.46, 48.35, 49.42, 49.92
2345 25.58, 25.68, 30.53, 31.32
* Sundays excepted.

AUSTRIAN LICENCES

It is learned from Australia that during the first five months of the operation of the new Broadcasting Act, which came into force last July, over 23,000 supplementary receiving licences for sets in excess of one in a house have been issued. It will be recalled that in our February issue we referred to the new Act which necessitates the purchase of a licence for each set in use. The standard licence fee is 5s or 1 florin a year, according to the area in which the set is situated; the fee for additional sets being half this standard rate.

The total number of licences in force at the end of November was 1,335,336, of which 1,367 were issued for car radio receivers.

MUSIC WHILE YOU WORK

It was announced in the House of Commons at the end of May that agreement had been reached between the Government and the Performing Right Society and Phonographic Performance, Ltd., whereby, for the duration of war, the diffusion of broadcast and other programmes of music and gramophone reproducing machines engaged on essential work—and in the associated canteens and hostels—will be free of charge to the individual managements. The necessary fee will be covered by composite annual payments by the Government of

£25,000 and £7,500, respectively, to the two concerns.

A navigation prize

THE Royal Society of Arts has again offered a prize of £50, under the Thomas Gray Memorial Trust, for an invention which, in the opinion of the judges, is considered to be "an advancement in the science or practice of navigation," proposed or invented by a person of British or Allied nationality in the period January 1st, 1938, to December 31st, 1943. Competitors must forward their proofs of claim between October 1st and December 31st, 1943, to the Acting Secretary, Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. The prize of £50 will be awarded to any member of the British Merchant Navy for any deed brought to their notice, which, in the opinion of the judges to be appointed by the Council, is outstanding professional merit. The period to be covered by the offer will be the year ending September 30th, 1943.

ANTI-INTERFERENCE

The question "who should pay for the installation of anti-interference apparatus?" has been discussed at some length in Switzerland. The result has been an agreement between the Swiss Postal Administration and the Association Suisse des Electriciens providing that the expense of rendering new high-voltage equipment interference-free should be divided between the owner of the apparatus and the listeners in the immediate vicinity who will benefit by the suppression. In exceptional cases (for factories, etc.) the Postal Administration undertakes to meet one-third of the expense.

It is now compulsory for all new high-voltage equipment to be rendered interference-free "unless the expense of so doing would be excessive. Manufacturers are now required to deliver only such products as are marked with the A.S.E. anti-interference mark. According to the U.I.R. Bulletin, the obligation to make existing high-voltage apparatus interference-free to be enforced only when "receivers in the neighbourhood are disturbed to an intolerable degree."

IN BRIEF

Australian Transmissions.—Short-wave listeners will have noticed the use of several new call signs and wavelengths for the transmissions from Australia. They are:—

VLF Sydney 9,500 Mc/s 31.58 metres
VLF 11,870 25.27
VL17 11,800 25.55
VL18 16,315 10.59
VLG4 Melbourne 11,835 25.35

The station VL1z is used for transmissions to the British Isles from 0845 to 0925 BDST.

Reports of the reception of these transmissions will be welcomed by the Australian Broadcasting Commission, which, if addressed care of Wireless World, will be forwarded.

New Pacific Station.—A new 50-kw international short-wave broadcasting station is being erected near San Francisco. It will operate on the following frequencies, which will be shared with stations WBOS and WKID: 6.06, 7.25, 9.57, 11.87, 13.29, 17.75 and 21.61 Mc/s.

L.E.F. Councillors.—Col. Sir A. Stanley Angwin, D.S.O., Engineer-in-Chief, G.P.O., has been nominated president of the L.E.F. for the 1943-44 session. Among the names proposed to fill the vacancies occurring on the Council at the end of September are Dr. E. B. Moulin, M.A., Oxford University, who stands as a vice-president, and Brig. F. T. Chapman, C.B.E., D.Sc., Deputy Director of Military Training, J. S. Forrest, M.A., B.Sc., of the Research Staff of the Central Electricity
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Hearing-aid Batteries.—Customs and Excise inform us that the following goods are now exempted from Purchase Tax:—Batteries of not less than 2½ volts and not more than 90 volts specially designed for high-tension supply for hearing-aid appliances and using cells not larger than 40 mm. overall in length and 13.5 mm. in diameter.

I.E.E. Premiums.—The Council of the Institution of Electrical Engineers has made the following award of premiums for papers read before the Wireless Section during the 1943-44 Session:—Duddell Premium (£20) to Dr. R. L. Smith-Rose and Miss A. C. Stickland, "A Study of Propagation over the Ultra-Short-Wave Radio Link between Guernsey and England on Wavelengths of 5 and 8 Metres"; Ambrose Fleming Premium (£10) to G. Farr and W. Gray-Walter, "Amplifying and Recording Technique in Electro-Biology, with special reference to the Electrical Activity of the Human Brain"; Extra Premium (£5) to Prof. Willis Jackson for "The University Education and Industrial Training of Telecommunication Engineers."

British Wireless Dinner Club.—About 150 members attended the 21st anniversary dinner of the British Wireless Dinner Club in London on June 4th, which was presided over by Air Commodore, Blandy, C.B., D.S.O., founder of the club. Vice-Admiral Lord Louis Mountbatten, G.C.V.O., D.S.O., was the guest of honour. His presentation was made to Capt. Chas. F. Tripe, who has acted as honorary secretary since the formation of the club.

Brit. I.R.E.—The following awards to the most successful candidates in the two Graduateship examinations held during 1943 have been approved by the General Council of the British Institution of Radio Engineers:—President’s Prize (Bronze Medal and cash total value £15) to L. W. Black, London, N.11, who also receives the Mountbatten Medal, awarded annually to the best candidate from the Services; the I.R.E. Prize (text-books to the value of £15), entry to the candidate taking second place, goes to J. Pollard, B.S.C., Liskeard, Cornwall.

Radio Industries Club.—Capt. H. de A. Donisthorpe has been re-elected chairman of the club for the 1943-44 Session.

Institution of Electronics.—A joint meeting of the N.W. England Section of the Institution of Electronics and the Manchester and District Branch of the Institute of Physics, will be held at the Reynolds Hall, College of Technology, Manchester, on July 9th at 7 p.m. Dr. A. Sommer will be the speaker and his subject is "Photo-electric Cells" (with special reference to the Vacuum and Gas-filled Types). Tickets are obtainable from Leslie F. Berry, 14, Heywood Avenue, Austerlins, Oldham.

Japanese Stations.—A recent article in a German journal reviewing the expansion of broadcasting in the Far East claimed that Japan now operates more than fifty stations with a total power of over 300 K.W. Many of these are, of course, in the occupied countries.

T. E. Goldup, director of Mullard Radio Valve Co., and also of Radio Transmission Equipment, who has been nominated chairman of the I.E.E. Wireless Section for the 1943-44 Session.

See that FLUXITE is always by you—in the house—garage—workshop—wherever speedy soldering is needed. Used for over 30 years in Government works and by leading engineers and manufacturers. Of all Ironmongers—in tins, 8d., 1/4 and 2/8.

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www.americanradiohistory.com
Why 121 Kilovolts?

Talking the other evening to an engineer who has been responsible for carrying out some biggish electrical installations in various parts of the country, I put a question that I have put to others without obtaining a satisfactory answer. "Why," I asked, "was 121 kv chosen for the grid scheme instead of, say, 125 or 150 or some other rounder figure?" He smiled. "I've asked heaps of people the same thing," he said, and no one that I have approached yet has been able to tell me. There must, I suppose, be some excellent reason for the choice, though for the life of me I can't fathom it. One suggestion was that 121 is eleven times twelve, and we Britons have a liking for thinking in dozens. Were there anything in that (as I am sure there is not), 144—the gross—would surely have been a likelier figure. Were many rival figures offered by experts for the grid line voltage when the scheme was in its infancy, and was 121 the average that would suit our national spirit of compromise so well? Or is there some deep mathematical reason for maintaining 121 kv in long power lines, the voltage of which will eventually be transformed down to 400 and 230? Perhaps some reader will answer a question that has long puzzled me, and no doubt many others as well. While he is about it, can he tell me why the household voltage from the Scottish section of the grid (or a considerable part of it, at any rate) should be 250, instead of the 230, which one fondly believed was eventually to be the standard for the whole of the United Kingdom?

Implosions

In the days before the war that now seem so far away I had often heard and read of the unpleasant results of implosions (to implode is to burst inwards instead of outwards) of cathode-ray tubes. Since then my job has been concerned to a large extent with CRTs of all sorts and sizes. I have known a good few broken, but, so far—and here I touch wood firmly—I have never heard an implosion. Possibly that is because most of the breakages that have come my way have been caused by the splitting off of one of the "horns" that contain the leads to the X and Y plates. When one of these is broken off, the entrance of air is to a large extent controlled by the comparatively small hole in the glass that is opened to it. This is not the same wild rush that there would be if the screen or the body of the tube were splintered. That would probably cause the father and mother of a bang. I am told that in that case the "electron gun" assembly has a way of shooting out en bloc like a shell from the breech of a gun. The biggest implosion that I have come across during the war was that of a transmitting valve, of which the glass envelope, more than an eighth-inch thick, was cut through by an arc-over. There was not much noise, and there cannot have been any high voltage present, for the damage done was nil save to the valve itself. Even its push-pull partner was uninjured. Curiously enough, the glass of the bulb was cut off near the base in an absolutely straight line, just as if someone had taken a diamond to it. Has anybody had first-hand experience of an implosion of a big CRT?

Off the Map

It may seem hard to believe that in this country of ours there are places more than forty miles from the nearest "inhabited locality," to borrow a phrase from the Russian commissaries, that has any pretensions to being called even a townlet. But there are right enough, and in the past few months I have visited a good few of them. Here is a typical instance. The camp is connected by six miles of the worst road you ever saw with a tiny village which boasts but a single general shop. The village is unpeopled from the middle of the week to the weekend, the connecting link being a once-a-day bus service, liable to suspension if the weather is bad enough (as often it is) to cause the road to be blocked or washed away. Normally, the morning papers arrive at about 7 p.m. on week-days; the Sunday papers do not get there at all. If it was not for the broadcast receiver, the soldiers would get scanty news of the war. As it is, they are able—provided that their batteries are not down—to tune in all the news bulletins and to keep au fait with events. I must say that a place where a three-valve battery set would not give respectable loudspeaker reproduction of the news—and that, you will admit, says a great deal for the efficiency of our wartime broadcasting service. In some places HTBs have been a bit of a problem. I shall write only a week before this was written, where the only radio set was out of action because its HTB had given out and the post had not yet brought a replacement. But, on the whole, the HTB problem is less of a headache than it was, and these out-of-the-way spots do not now so often find themselves cut off from the rest of the world for want of one. You have to visit such places to realise what a lot of non-broadcasting can be. These notes are being written at one of them, and I am sure that if I put the question to those around me in the mess there would be no two opinions, I have even developed a lurking sympathy with those who indulge in non-stop wireless reception and do not much care what is coming in so long as some kind of cheerful noise is issuing from the loud speaker.

Post-war Planning

Have you ever thought of the vast demand that there will be for wireless receivers as soon as the war is over? Those expert in the subject used, I believe, to calculate the average life of a wireless set as four years. With ten million receiving licences in force the annual needs of the people of these islands would thus have been 2,500,000 sets a year in the ordinary way. But of the sets now in service probably a great many more than nine million are over four years old, and before we are back to normal supplies the figure is certain to be over ten million. The potential demand is thus colossal, and I do hope that the industry is making plans to meet it. What we must not do is to find ourselves able to supply only a small proportion of the sets required. The plans must be ready in advance; it will be too late if we do not start thinking about them until Adolf Hitler signs on the dotted line.

Television: An Opportunity

What a chance we shall have when the war is well and truly won to scarp all the messes and muddles of the past and to see that television development here gets a flying start. I say "start" because I don't honestly think that it ever did get a proper start before the war. There was so much badgering by the lay press of the authorities to get a television service going that we probably led off before we were really ready to do so from either the technical or the programming point of view. The lay papers kept up their loud-voiced demands for an immediate service on
the ground that the public would fall over itself to buy television receivers as soon as regular programmes were transmitted. But events proved that the public’s view of the situation was quite different. There was no rush to buy; the public had an idea that any apparatus produced would be out of date before it could say knife. They were not even reassured by the Government’s undertaking to make no change in the system for some considerable time — three years, wasn’t it? That undertaking, though it probably had to be given, was a mistake, for it committed us to a limited degree of definition, which was out of date almost as soon as it was adopted. The United States and the Continent plunged for a greater number of lines as soon as they got any kind of service going. Is there any reason why, when the war is over, we should remain wedged to a system that is behind the times?

A Fresh Start

Why shouldn’t we make an entirely fresh start in television? The number of television sets in private ownership is comparatively small, and the Government cannot be accused of a breach of faith if it brings the standards up to date, for the guaranteed no-change period has long since run its course. I maintain that there should be international definition standards, adopted by every civilised nation as the result of a conference held as soon as possible after peace is signed. Wartime research and experience are bound to have profound effects on the development of television and the standards adopted after the suggested conference may be surprisingly in advance of those of pre-war days. Do not let us handicap television by binding ourselves to hangovers from the past.

Wartime Soldering

Before the war you could obtain solders as "soft" as you liked, that is, containing a large proportion of tin. But now that the Japanese occupy some of the world’s greatest centres of tin production, tin has become a very precious munition of war and no very soft solder is allowed to be made. This makes wireless soldering in wartime rather difficult, especially if you use an electric iron; many of these are not designed to work at the higher temperatures needed by the harder kinds of solder now available.

With a non-electric iron you can tackle most jobs, so long as you heat it until the surrounding flame shows a distinct green-blue tinge. But most of us prefer the electric iron on account of its cleanliness and its simplicity. One way out of the difficulty is to obtain a fresh heater element (if you can get it!) designed for a higher temperature.

---

LETTERS TO THE EDITOR

Gramophone Record Wear

Referring to comments in your June issue by G. E. Horn and R. H. Thrussell on needle armature pick-ups, I note they state that “drag across the turntable causes wear on the outer side of the groove...”

Surely the wear takes place on the inner side of the groove as it would appear from the accompanying diagram of forces acting.

\[ F = \frac{d}{T} \]

The frictional force \( F \) due to the rotating record and needle pressure has a turning moment about the centre of rotation of the pick-up carrying arm. In order that the needle shall stay in the groove, therefore, there must be a side thrust (T) acting away from the record centre, and this is obviously supplied by the inner face of the record groove.

That the natural tendency is to move “centre-wards” unless restrained by the groove is evidenced by the action of a pick-up placed on the smooth initial portion of one of the older type records having no lead in towards the first groove.

If the pick-up arm hinges freely it will automatically start to move centre-wards without assistance from the operator.

R. BOORIAN.
Gillingham, Kent.

Simpler Valves

All that “Diallist” says about multiple valves in your June issue is true, but he seems to have missed the main reason

---

The Improved VORTEXION 50 WATT AMPLIFIER CHASSIS

The new Vortexion 50 watt amplifier is the result of over seven years' development with valves of the 6L6 type. Every part of the circuit has been carefully developed, with the result that 50 watts is obtained after the output transformer at approximately 4% total distortion. Some idea of the efficiency of the output valves can be obtained from the fact that they draw only 60 ma per pair no load, and 160 ma full load anode current. Separate rectifiers are employed for anode and screen and a Westinghouse for bias.

The response curve is straight from 200 to 15,000 cycles. In the standard model the low frequency response has been purposely reduced to save damage to the speakers with which it may be used, due to excessive movement of the speech coil. Non-standard models should not be obtained unless used with special speakers loaded to three or four watts each.

A tone control is fitted, and the large eight section output transformer is available in three types: 2-5-15-30 ohms; 4-15-30-40 ohms or 15-60-125-250 ohms. These output lines can be matched using all sections of windings and will deliver the full response to the loud speakers with extremely low overall harmonic distortion.

PRICE (with 807 etc. type valves) £18.10.0
Plus 35% War Increase

MANY HUNDREDS ALREADY IN USE
Supplied only against Government Contracts

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Letters to the Editor—
for the adoption of the "toad" valve (as a service-man I knew called it, with venom). It was first and foremost a matter of production cost.

At one time the British manufacturer, under a ridiculous and stultifying royalty system, was paying royalties on a valve-holder basis at a rate exceeding the cost of the valve he placed in the holder.

It was therefore to his benefit to reduce the number of valve-holders to a minimum, making up for sensitivity and volume by using complex valves, the unfortunate purchaser being left to carry the expense of replacements.

Wireless World

Fortunately, I see every prospect of "Diallist's" hopes being realised. Wartime experience is teaching us the real advantages of simplicity.

A. A. TURNLEY.

Devonport.

" Stereoscopic and Colour Television "

REFERRING to D. A. Bell's letter in your March issue, I think it should be stressed that the anaglyphic method of television has been publicly demonstrated by Mr. Baird, who also described the use of Polaroid in Electronic Engineering for February, 1942.

The principles of stereoscopic

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

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MEDIUM-WAVE TRANSMISSIONS

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It should be noted that the times are BDST—two hours ahead of GMT. † Sundays excepted.
is on its axis and projects it in a parallel beam, so that two parallel beams enter the converging lens and are brought to a single point at its focus; a similar action takes place for every point in the picture. The apparatus when demonstrated to the writer gave what appeared to be practically perfect register of the superimposed images. N. W. M.

WASTE PAPER SALVAGE
The Industry’s Part

To ensure more effective collection and disposal of waste paper, the radio industry is co-operating with the electrical industry in organizing schemes for furthering this vital aim. The Electrical Industry Waste Paper Recovery Committee, in whose hands this matter has been placed, has already received support from many important wireless firms. An appeal for a further effort to increase both economy in the use of paper and the collection of waste is now made by the Committee. It is pointed out that the appointment of a paper "warden" in individual establishments has been proved to bring about good results.

Information on the work of the Committee can be obtained from the Secretary, 2. Savoy Hill, W.C.2.

WIRELESS HOWLERS

The correspondent who sends us the following collection of "howlers" vouches for their authenticity and ascribes their authorship to "some of the less nimble-witted soldiery." They are in the form of answers to examination questions.

"A right angled triangle is the opposite of a left angled triangle."

"The side opposite the right side is called the hipopotamus."

"An Ampere is the current per square second."

"Electrolyte is waves with a speed of 186,000 miles an hour."

"Centi means hundredth of; it is used in the centimetal system."

"Resistance is measured in O.H.M.S."

"The electron gun is fired by pressing a button. It is used in the Navy."

"A dull emitter valve emits dulley."

"The way to charge accumulators is to pay 6d., but this depends on the garage."

GOODS FOR EXPORT

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

COMMUNICATIONS DEPEND...

ON SMALL PARTS...

In countless instances quite intricate pieces of apparatus are wholly dependent on the proved reputation and reliability of their component parts.

All products from the House of Bulgin are pre- eminent for superior design and workmanship and every article bearing our Trade Mark has to pass exacting and exhaustive tests during the course of its production.

We ask the kind indulgence of the Trade on delivery until peaceful conditions return.

The Choice of Critics

BULGIN FOR SWITCHES

The best Radio and small Electrical Switches in the world. Every one is the finest of its class, and the best for any job. Snap-action, low and constant contact resistance, reliable performance for tens of thousands of operations: all these are permanent characteristics.

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ESSEX
RECENT INVENTIONS

RADIO GUIDEWAYS

The directional characteristic of a vertical dipole is a figure of eight curve in the plane of the two limbs. If an earthed horizontal screen is interposed between the two parts of the dipole, the response curve takes the form of four lobes extending symmetrically above and below the plane of the screen. The angle at which the periphery of each lobe cuts across the earth's surface varies from a minimum where the screen is infinitely large to a maximum when the screen is infinitely small (in the latter case the curve again becomes a figure of eight, which cuts across the horizontal plane at 90 deg.). This fact is utilized to produce a radio guide wave of sharp discrimination by inserting a suitable size of screen between the two halves of a dipole aerial, and connecting first one and then the other to the screen, preferably in the same direction A-N leading sequence. The result is an overlapping beam course in which the centre zone is marked by a steady sustained note, with distinctive A or N signals on each flank.

Aga Baltic Radio Akt. Convention date (Sweden) April 10th, 1940. No. 549/98.

SUPPRESSING STRAY CURRENTS

Trouble may arise from the presence of the so-called "standing" current in the cathode-ray tube, that is, the current which persists even when the modulating voltage on the grid is at cut-off, the electron beam proper is wholly suppressed. This undesired current is due to electrons from the heater filament which pass down or away from the cathode and so find their way to the anode.

The leakage is stopped, according to the invention, by mounting a guard-ring below the heating-filament and surrounding the wires which pass from the stub to support the modulating electrode of the tube. The guard-ring is preferably gapped to prevent damage by smoke during the "gettering" process, and carries a permanent negative bias.


AIRCRAFT WIRELESS

The rotating propellers of an aircraft tend to modulate or distort the field pattern of radiant energy passing through them, and thus may interfere with the transmission or reception of directions or other signals by the craft. The disturbance is most noticeable on short waves and when the propeller blades are of metal and of the same or a similar radiating dipole.

In order to minimize this undesirable effect, a tunable circuit is interposed, preferably between the propeller and aerial system, and is coupled either magnetically or electrostatically to the propeller in order to alter the resonance of the blades relatively to the radiation.


A SELECTION OF THE MORE INTERESTING RADIO DEVELOPMENTS

WIRELESS RECEIVERS

The circuit shown is designed to give constant gain as well as uniform regeneration over a wide band of frequencies. The first result is secured by the use of permeability tuning, and the second by employing one valve as an amplifier and a separate valve to provide feedback, instead of making the same valve serve both purposes.

The anode circuit of the first valve V1 includes an inductance L which is shunted by a condenser C1 in parallel with two series condensers C2, C3, and the cathode of the second valve V2 being connected through a resistance R to a point between the two last-numbered condensers. The main circuit is tuned by sliding a powdered iron core S relatively to the coil L, these two elements being designed to preserve a constant ratio of inductance to resistance over the frequency range. The grid-cathode circuit of the valve order to give the pentode a favourable working characteristic. It is, however, desirable to wind the suppressor grid with an open-pitched spiral. But this clearly reduces its efficiency as a suppressor.

The inventors propose to overcome the difficulty by coating both the anode and the screen grid with a highly emissive material such as caesium oxide. This rather surpising solution is based on the discovery that although the total emission is heavier than from the ordinary metal, say nickel or molybdenum, of which the anode and screen grids are usually made, the content of fast-moving secondary electrons is smaller. The braking action of an open-pitched grid is sufficient to prevent the passage of the comparatively slow electrons, even though it will fail to stop those travelling at high speed.


VARIABLE CONDENSERS

Two hollow tapered parts of ceramic material fit snugly one inside the other. The outer one, whilst the inner can rotate in contact with it about a coaxial shaft which prevents relative axial movement. The inner surface of one and the outer surface of the other are coated with a metallic layer, which extends only over a part of the available surface so that relative rotation alters the effective capacity of the system. The shape and relative extent of the metallic coating can be chosen to give any desired law of variation with angular setting. The two hollow shells may also be made of materials with different dielectric constants. Preferably, the metallic layers consist of a silver deposit cemented in place by a firing-on process.


VACUUM CONDENSERS

The plate-like tubes of a radio-frequency condenser of the vacuum type are usually made of nickel. When subjected to high voltages pure nickel produces secondary electrons by cold emission, and this eventually gives rise to a point-contact anode, in effect, destroys the condenser.

According to the invention the plates are made of a material having a high "work function" such as nickel, which is found to be remarkably free from spurious emission of the kind mentioned.