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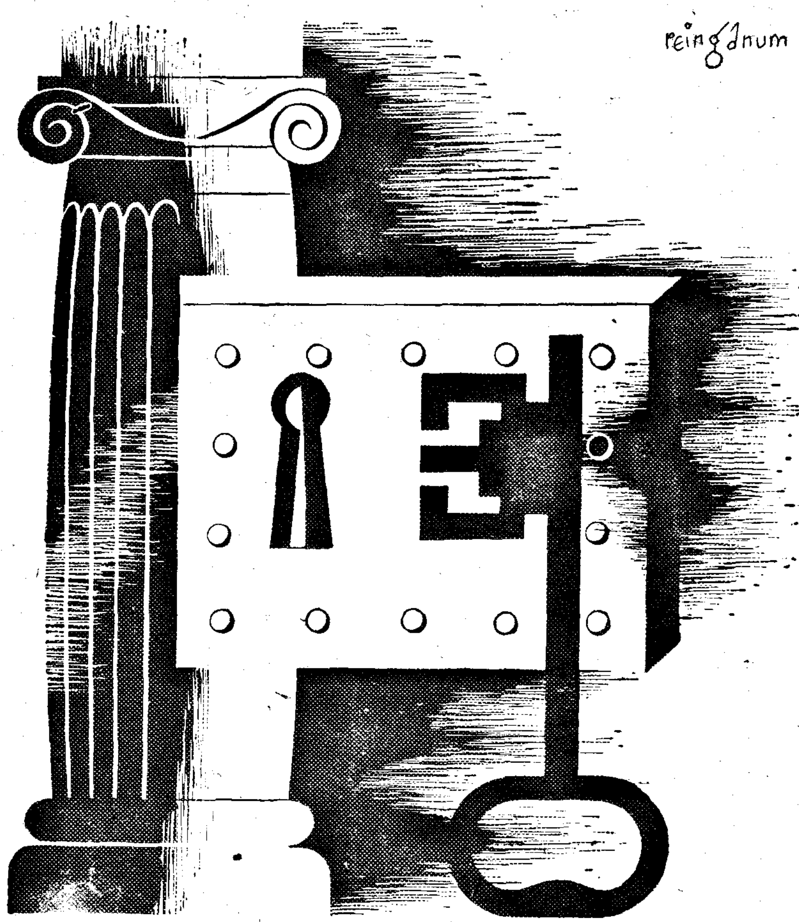

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Our Brains Trust

Stimulating Constructive Thought

WHEN we started the *Wireless World* " Brains Trust " (acknowledgments for the title to the B.B.C., and, going back farther, to President Roosevelt's " New Dealers ") it was hoped that the feature might eventually grow into a forum where all controversial matters within our scope might be usefully discussed by acknowledged experts, each working in his own particular field. Fallacies that have gained wide credence might be corrected, and constructive thinking might be stimulated in many directions. This journal is fortunate in being able to call upon the services of specialists in many fields, and there were no misgivings as to whether answers well worth while recording would be forthcoming to any reasonable question.

It was decided that the ideal type of question should deal with matters that are within the knowledge, or at any rate, have come under the observation of practically all readers, but preferably with subjects on which few have given deep thought or have much precise and specialised knowledge. Technical subjects of a kind that are best described as text-book material were ruled out, as were all highly specialised questions that would interest only a strictly limited circle of readers. Another subject with which few readers would wish us to deal is the make-up of broadcast programmes, although a possible exception to this rule might exist with regard to fundamental questions touching the basic principles of utilising the medium of broadcasting.

So far, the tendency has been for questions published to be confined to severely technical topics, but there are indications that many readers consider that " Brains Trust " is a section of the journal that might well deal on occasion with such political, commercial, economic or even sociological problems that especially affect the lives and work of those concerned with wireless. With this view we are in agreement, and questions of this nature will certainly be considered.

Perhaps the best of all " Brains Trust " questions will prove to be on those subjects relating to his work on which a wireless man might devote thought during his spare time—on subjects sufficiently divorced from his daily tasks to afford real relaxation. One of the most desirable attributes of a question is that it should stimulate thought, and occasions will arise when each reader will himself have to find the answer that satisfies him best. Under present conditions, shortage of space will sometimes make it impossible to present all possible shades of opinion on highly controversial subjects, and, indeed, attempts to do so might in the end become wearisome.

Invitation to Readers

The time has now come when questions from readers may be definitely invited. Already a large number have been submitted. but, if a criticism may be allowed, the great majority are of so specialised a nature to be of interest only to the questioner —or at best, to comparatively few readers. Those who propose to submit questions are asked to frame them in conformity with the general principles set out in the preceding paragraphs. In the interests of national economy—which includes the ever-present need for saving paper—readers are asked to forgo the usual acknowledgment of their questions, and not to expect us to enter into correspondence concerning them.

Finally it may be pointed out that the success of our " Brains Trust " will ultimately depend on the quality of the questions asked by readers themselves. The question is more than half the battle : a good one can hardly fail to evoke a good answer. Given the co-operation of readers, the new section of the journal will, we hope, do something more than contribute to their entertainment ; it should make at least some contribution to the progress of the wireless art.

Overhauling MOVING-COIL METERS

Procedure for Carrying Out a Delicate Operation

By "TIFFEY"

THE moving-coil milli- or micro-ammeter is used as the basic indicating instrument in the large majority of multi-range meters. It is a comparatively simple piece of mechanism and well worth a little careful attention to keep it working in these times when meters of all kinds are at a premium. To reassure those who have not before attempted the repair or cleaning of a MC meter, it may be said at once that the chief difficulties arise in the process of calibration or construction of shunts, multipliers, current transformers, and such accessories; the meter itself demands only patience, good eyesight, and steady fingers for its renovation.

Fig. 1 shows the construction of a fairly typical moving-coil milliameter. The majority are of this screwed-together type, with pole pieces carrying the movement structure. A few may be met with, however, in which the bearing structures—pillars, bridging pieces, etc.—are mounted directly on the magnet, the pole faces of which are made concave. Occasionally, too, it is found that a movement is merely "stuck together" with shellac, instead of being built up with bolted parts; this type is difficult to repair because the proximity of the hot iron needed to melt the shellac in one part softens the rest of the structure. The tools needed for overhauling and minor repairs to meters are as follow:—

A really small plain soldering iron. This can be easily made from an inch or so of 10 SWG copper wire fixed to a stiff iron wire handle, and can be heated over a small gas Bunsen flame or spirit lamp. The "pencil" bit, or added small extension bit of an ordinary electric iron is not satisfactory, as it does not get hot enough.

Finely pointed tweezers; small, long-nosed pliers; a set of small watch-makers' screwdrivers; very small box spanners to deal with 8 and 10 BA nuts. These, save for the pliers, are fairly easily constructed out of odds and ends of steel by the handyman of average skill if they cannot be bought nowadays.

A watchmaker's eye-glass; a small camel-hair artist's brush; a few sticks of pith or very soft wood; a lump of Plasticine; a simple mask for the nose and mouth to keep the breath diverted when dealing with delicate moving parts; a strong pencil-beam spotlight—sunlight reflected from a mirror is best of all.

These are all the tools required. All work on meters should be done on a *clean,* firm table with plenty of elbow room, and the work in hand should be done over a clean sheet of white paper. The ordinary work-bench is not really suitable. It is bound to be covered with very minute iron dust particles, and these have a knack of positively floating through the air to the magnetic pole faces, where they may ruin a movement that has taken a long time to set up nicely.

Common Defects

The things that normally require either minor repair or adjustment in an old or misused meter are more or less as follow—of course, such tricky major repairs as rewinding open-circuited coils, fitting new pivots or spring ligaments, are really only suitable for handling by skilled professionals. The cleanliness of the jewel or steel pivot cups, and the pivot points; their accurate adjustment for tightness; the alignment of the bearing structure so that the coil moves centrally round the gap between the iron core and the wall of the pole faces; the levelling of a damaged or warped spring ligament; the adjustment of zero controls; the replacement or straightening of a bent or damaged pointer; the balancing of the pointer—these can be attended to by a patient, unhurried and steady fingered amateur with a little common sense.

The first thing to do is to free the meter itself from all its attachments to the accessories and lift it out on to the clean sheet of white paper. It is probable that the magnet can now be separated from the soft iron pole pieces carrying the bearing structures; either there will be some simple bolt arrangement holding the magnet, or it may be so constructed as to grip the pole pieces by pressure and can be cautiously eased off them. When the magnet is removed *it is very important that a keeper should at once be placed across the poles,* and that it should not be subjected to a violent jar or blow; rough treatment can bring about disastrous results to the sensitivity of the meter. A keeper is simply any piece of iron that will complete the magnetic circuit.

What is done next depends on the nature of the defect in the meter. It is assumed that previous tests have determined that the coil is not open-circuited, and that the fault does not lie in the accessories, such as the shunts, multipliers, current transformers rectifiers, switches, etc. It is probable, in that case, that the defect in the movement shows itself by "stickiness" of movement of the pointer over the scale—it seems to stick at certain points, especially at the ends of the scale. It may be difficult to set at zero, or it may not hold its zero adjustment for

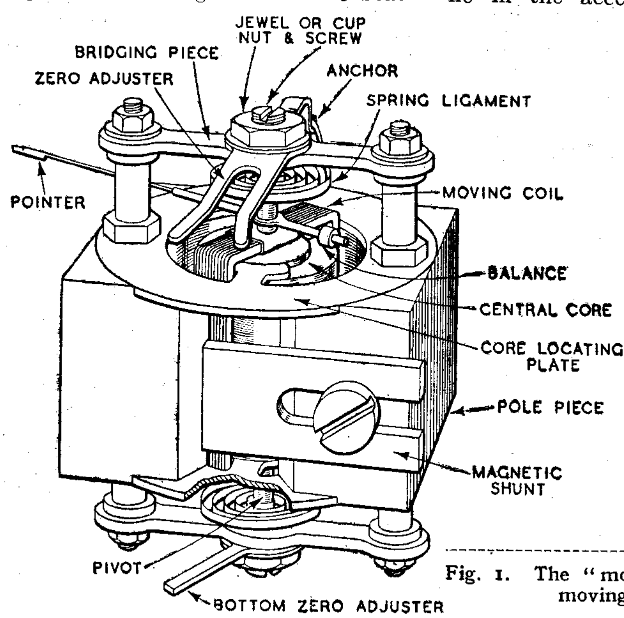


Fig. 1. The "movement" of a typical moving-coil meter.

long. The indications, too, may be erratic—it does not give the same reading twice running for the same voltage or current it is measuring.

Whatever it is, a defect of this nature demands the dismantling of the movement structure, its cleaning, and its reassembly. The first step in this is to unsolder the spring ligaments from the anchor points, which are on the zero adjusters at the top and bottom. For this, the little soldering-iron must be well heated and tinned and just touched to the points for long enough for the spring ligaments to fall away. This must be done *quickly* and steadily. The iron must be hotter than is usual in order to minimise the time it is held to the anchoring point. The spring ligaments are made of phosphor bronze or some such non-magnetic metal, and their temper is obtained by the rolling process, and is quickly destroyed by heat.

Next, the small box-spanners can be used to loosen the nuts holding down the bridging pieces. It is advisable to have ready a few rectangular wood blocks on which to rest the pole pieces, to avoid the weight coming on to the lower pivots when the structure is loosened. When the nuts have been removed, the tweezers can be used to separate the various bits and pieces, and the eye-glass will give a better vision to avoid damage. The ligaments should not be removed from the pivots, or the pivots detached from the coil and former; they are difficult to replace. Usually, it will be found that, once the bridging pieces have been removed, the whole structure separates quite easily, and the coil and iron core can be taken out of the gap. The current is conveyed to the coil through the spring ligaments, which are in contact with the anchor points, which are held to the bridging pieces by the jewel or cup nuts, and the bridging pieces are, therefore, insulated from the pillars by tiny insulating washers which should not be lost.

Methods of Cleaning

The parts can now be cleaned by brushing with the camel-hair brush. No spirit or liquid must be used for the cleaning. To remove any traces of iron dust, Plasticine can be pressed on to the concave pole faces and over the iron core. The jewel or cup is cleaned by twirling a point of pith into it, and the pivot point by being stuck into pith a few times.

Now comes the touchiest part, the reassembling of the structure. The first thing is to loosen the jewel nuts and unscrew the jewel or cup screws one or two turns in order to make quite sure that, when the bridging pieces are put back, undue pressure is not put on the pivot points. Reassembly is a matter of common sense, but the utmost care must be taken to avoid excessive pressure on the pivot points. Adjusting them is quite a tricky and delicate piece of work, since both the nut and the screw holding the cup or jewel must be exactly right. A useful tool is a hollow box spanner down the inside of which may be passed a screwdriver, so that both the nut and the screw are under control. The idea is to have the pivot point fitting into the cup so that, while there is not a trace of friction, there is also no lateral play. It is also very important that the coil should move parallel with the inner concave faces of the pole pieces and be exactly midway at all times between the iron core and these inner pole piece faces. Never move the pointer with the fingers; to test the movement, it should be either gently blown round or pushed round with the camel-hair brush. It must be remembered that an apparently trivial strain on the pivot points may do serious damage.

Refitting the Ligaments

When soldering the ligaments back to the anchor points, the process should be done in stages as follows: First, the top zero adjuster is set at right angles to the bridging piece; then the top ligament is soldered to the anchor point on this zero adjuster, regardless of the resulting position taken up by the pointer; next, the bottom zero adjuster is moved so that its anchor point is exactly in position to make contact with the free end of the bottom ligament—it does not matter whether this zero adjuster is at right angles to the bridging piece or not; then the bottom ligament is fixed by a touch of the soldering-iron to the anchor point. If this is done, it will be found that the pointer can be brought *approximately* to the zero mark on the meter scale by moving the *bottom* zero adjuster. The top zero adjuster should not be moved; it remains at right angles to the bridging piece until the meter is put back into its case, when the external zero adjuster screw engages with the slot in the top zero adjuster.

The pointer of a meter is normally made of aluminium, either as a channelled strip or as a slender tube. If bent, it can be straightened, using care not to put much strain on the pivots. It will usually be found to be stuck on with shellac or, if a tube, slipped over a stub. It is possible to construct these thin aluminium tubes out of the foil from old electrolytic condensers—if one has a draw-plate. The difficulty is to make the draw-plate without suitable drills. The author, however, has discovered—the thing was probably old in Faraday's time!—that excellent pointers can be made from naturally dead and dried grass stalks. Gathered in the autumn, nothing is left of them but a thin, tubular shell of cellulose fibre, very light and strong and easily dyed black with Indian ink. These "natural" pointers, being tubes, can be slipped over the stub at the coil, or stuck with shellac. They do not appear to be affected by humidity, and although it is difficult to obtain them absolutely dead straight in lengths of more than a few inches, in the short lengths needed for pointers their curvature is negligible.

When the movement has been thus reassembled and the magnet replaced, the movement can be finally checked for perfection of motion. This is done electrically. Either the existing scale, or a temporary blank one, is fixed so that the position of the pointer can be accurately marked. Then the meter is connected in a circuit as given in Fig. 2. The pointer is brought accurately to the zero mark on the scale, with no current flowing, by the top zero adjuster. Then the circuit is closed and the current *slowly* increased until the first unity mark on the scale of the *standard* meter is reached. This must be done slowly and with the pointer *always moving in the same direction*—if the mark is passed, it is no good decreasing the current to come back to it; this vitiates the test

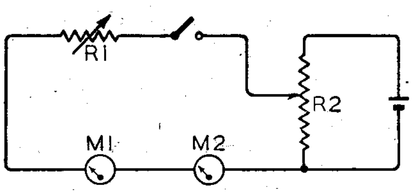


Fig. 2. Circuit for testing the movement of a milliammeter. M1 is a standard meter; M2 the meter under test. R1 provides fine control of current and R2 is the coarse control.

When the pointer of the standard meter, then, stands at the first unity mark, the position of the pointer on the scale of the *test* meter is marked accurately with a pencil dot. It does not matter whether it reads exactly the same as the standard or not. Then the current is increased until the next unity mark is reached on the standard meter, and again the corresponding position of the test meter pointer marked with a dot on the scale. This is continued until full-scale deflection

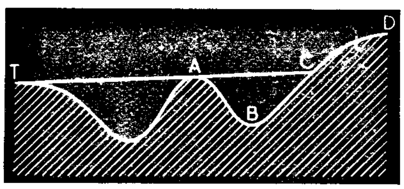
Moving-coil Meters—
of the test meter is reached. There will now be a line of dots on the test meter scale. Next, the current is slowly *decreased*, again stopping as each unity point on the standard meter is reached. If the test meter movement is good its pointer should stop, with that of the standard meter, exactly at the dots that mark its stopping places on the "way up" the scale. If, however, it does not stop at the same places on the way down, its movement is untrustworthy and must be re-examined mechanically. This test is purely of the movement alone, although it may be combined with calibration in some cases.

While the movement is still exposed and a scale is fitted, it is possible to balance the pointer. Since the pointer has some weight, its position both at zero and on the rest of the scale, while giving indications, will be affected by the position of the whole meter; i.e., it may give one reading while the meter is lying on its back and another when the meter is vertical. This is avoided by a counterweight on the stub on the coil in the opposite direction to the stub carrying the pointer. This small counterweight may consist of a metal tube that can be slid along the stub, or of a small knurled nut that can be adjusted by screwing along the stub. Balance—i.e., a condition in which the pointer always returns to zero, no matter what the position of the meter as a whole—is secured by trial adjustments of the counterweight along its stub. This balancing should be done, of course, before calibration.

Ultra-Short-Wave Diffraction—

—*and the Earth's Curvature*

RADIO waves produced by simple dipole aerials are linearly polarised, that is to say, the "strain" or "force" in the electric and magnetic fields of which they are composed is in a constant direction, the strain in the electric field being at right angles to that in the magnetic field. In order to define the direction of polarisation the direction of the *electric* strain is always referred to. Thus a horizontally polarised wave, such as would be produced by a horizontal dipole, is a linearly polarised wave in which the direction of strain in the electric field is horizontal. Similarly, a vertically polarised wave, such as a vertical dipole would produce, is one in which the direction of strain in the electric field is vertical.



[Courtesy *Nature*

Fig. 1. Section of the terrain over which the experiments were conducted.

It has for some time been known, and has been pointed out by McPetrie and Saxton([1]) that ultra-short waves which are vertically polarised provide much stronger fields in the shadow of hills than do horizontally polarised waves. These investigators have recently observed some further effects in this connection, which they describe in a recent letter to *Nature*([2]).

Fig. 1, which is taken from this letter, represents the terrain over which they obtained the results described. T represents the transmitter situated at the top of a ridge from which horizontally and vertically polarised waves were sent out on a wavelength of 3 metres. Over the region ABC, which is within the shadow of the hill A, the vertical field was greater than the horizontal field, the ratio of vertical to horizontal fields being least at A and C and greatest at B. A table showing the field strengths in μV/m for both vertically and horizontally polarised waves for position A, B and C—as well as for a number of intervening points—is given, and this is continued for a number of points over the region CD. Over this region, which is outside the shadow cast by hill A, horizontal polarisation gave the strongest field.

Similar results would be expected in transmitting over a relatively great distance with a flat terrain, where the obstruction caused by hill A was replaced by that due to the earth's curvature. At all receiver positions within the shadow cast by the earth's curvature, vertically polarised wayes would provide the greatest field, but an elevated receiver located above them so as to be within the optical path would be better served by horizontally polarised waves. It is also stated that in practice horizontal polarisation may be better even at ground level and within the optical path where there is tree-clad country, because at ultra-short wavelengths greater attenuation is caused by trees to vertically than to horizontally polarised waves.

These results will probably be of significance in connection with various ultra-short-wave developments which we may expect to see in the post-war world. Among these may be mentioned the establishment of a television service on a nation-wide basis, and the use of radio guidance for aircraft.

T. W. B.

(1) J. S. McPetrie, J. A. Saxton, *Nature*, Oct. 7th, 1939
(2) J. S. McPetrie, J. A. Saxton, *Nature*, Sept. 5th, 1942

Wireless World Brains Trust—No. 5

More Views on Interplanetary Communication

"CATHODE RAY," in a postscript to his letter which is printed on page 271, writes:—

IN my capacity of Member of the *Wireless World* Brains Trust, and referring to the question of whether there are any inexplicable radiations reaching us from outer space, I recall that in 1933 Karl Jansky reported in *Proc. I.R.E.*, as a result of at least a year's experiments, that he obtained continuous reception of radio waves from a certain stellar region. So far as I know, this matter has never been cleared up.

ARTHUR C. CLARKE, Hon. Treasurer of the British Interplanetary Society, adds a note:—

THE fantastic figure of six million kW, quoted as necessary to produce a 5 microvolt/metre field on the nearest planet, presumably relates to spherical radiation, which no one for a moment considers. The use of beam technique would reduce power requirements to a minute fraction of this. Moreover, there seems very good evidence that radio waves from comparatively low-powered transmitters *have* travelled distances which are almost interplanetary. The existence of echoes of several seconds' duration (equivalent to the distance of the moon) is well established, and delays of up to ten *minutes* or so have been reported—corresponding to distances of several times those of Mars or Venus at perigee.

Secondly, the evidence that radiation reaches the earth from space is quite strong, and I am surprised that your contributor did not mention it. I refer to Jansky's reports on the subject (*Proc. I.R.E.*, Oct., 1935). Jansky reports this "star-static" as lying between 9-21 Mc/s and being 10-30 db. above the level of thermal agitation. (See also Jansky, *Proc. I.R.E.*, Dec., 1937, and Friis and Feldman, *Proc. I.R.E.*, July, 1937, for a further discussion of this matter.)

Finally, if radio is incapable of really long-range communication (which I doubt) the solution to the problem lies in the modulated light beam. Light can be focussed with extreme accuracy and the sensitivity of a photo-cell collecting light at the focus of a giant reflector, and backed by an electron multiplier and the usual amplifying stages, is so enormous as to be almost meaningless. It is certainly capable of maintaining communication between all the planets in so small a space as the Solar System! As to the objection that most planets have opaque atmospheres, I would answer that all except Venus have airless satellites very close to them to which they could be linked by UHF.

"T.W.B.," the Member who wrote the original reply as published last month, now sums up in the light of these comments:—

TO the first part of the question, "Is it theoretically possible to hold communication with other planets?" the answer given was "Yes—in the case of some planets." Surely this did not imply that radio is incapable of really long-range communication—on the contrary, the whole of the first part of the answer was intended to show that it is. But, in discussing the present day *practicability* of holding communication with a planet, the use of an *existing* transmitting station was assumed. The rough estimate of 6,000,000 kW. was for spherical radiation, but was given merely as a starting point, and in order to give some idea of the effect of spatial attenuation at such a distance with ordinary technique. Using a highly directive but perfectly practicable type of short-wave transmitting array, and assuming the required field intensity at the planet to be only 1 microvolt per metre, it would appear that the radiated power might be reduced to somewhat less than 1,000 kW, which still is greater than that used by most existing stations. However, if the frequency used were such as to permit the employment of some type of parabolic reflector, and special equipment were built for the job, then there would not appear to be anything highly impracticable about it, since the spatial attenuation would be reduced to negligible proportions. It is important, in connection with the choice of frequency, to remember the possible effect of a planetary ionosphere, which might impose severe limitations.

As Mr. Clarke says, echoes of several seconds' delay have been well established, but the time delays in these cases are too short for planetary distances to be involved, though they do fit in with the distance between earth and moon. As to the echoes of long delay—running into several minutes—these were discovered about 1929 by the Norwegian, Jorgen Hals, and were afterwards confirmed by Professor Störmer, of Norway, and by Dr. van der Pol, of Holland. But I think it is true to say—and in doing so would mention that I have the greatest respect for the opinions of these very eminent scientists—that they have never been repeated, and there is now some considerable doubt as to whether they were, in fact, echoes from space at all. A long period of mass listening about 1937—in which hundreds of listeners took part—failed to yield any conclusive results as to these long delay echoes, and it is very difficult to account for the strength of the echoes if they had indeed been returned from points in space so far distant as the time delays would imply.

Coming to the matter of the Jansky "star-static" mentioned both by Mr. Clarke and by "Cathode Ray," this ought perhaps to have been mentioned, but it was omitted from the Brains Trust answer for two reasons. Firstly, Jansky proved early in his investigations that its source was far outside the solar system and so it could not have its origin in a planet—and planets appeared to be the main concern of the questioner—and, secondly, recent work by Reber (see *Proc. I.R.E.*, August, 1942) has shown that these radiations are not entirely inexplicable. They were first noticed by Jansky in 1932, who then thought that their source was associated with the sun. Later he proved that it was outside the solar system altogether, and subsequently found the radiations to come from the direction of the Galaxy. He found that this interstellar noise set the lower limit for the noise-level in his receiver, i.e., that it was always above that due to the thermal agitation in the receiver. In 1940 Reber reported that he had made some experiments with a view to locating the source of the noise and of explaining its origin, and it is of interest to us here that his repeated attempts to measure radiation from Mars—the only planet with which he seems to have concerned himself—yielded no results. Recently—and it must be mentioned that the paper has only just arrived in this country and so may not have been seen by these two correspondents—Reber has done further work with a highly directive system, and now suggests that the Jansky noise is really thermal agitation noise caused by electrons which have been erupted from stars and float in interstellar space, all space being the conductor in which the thermal agitation is set up.

RADIO DATA CHARTS

By

J. McG. SOWERBY,

B.A., Grad. I.E.E.

(*By Permission of the Ministry of Supply*)

No. 2. (3rd Series)—Effect of a Screening Can on the Inductance and Resistance of a Coil

IT is well known that if a screening can is placed round a radio coil there is a fall of inductance and of Q, the magnification of the coil. It is not impossible to calculate these changes *exactly*, but there is no doubt that the final formulae would be unwieldy in the extreme, and the great labour of computation would mean, in practice, that the formulae would never be used. However, it is fortunate that the effects of a screening can on a coil may be expressed by more reasonable formulae to an accuracy of about 2 per cent., which is sufficiently accurate for the great majority of purposes.

It has been shown by A. G. Bogle (*Journ. I.E.E.*, Vol. 87, p. 299, Sept. 1940) that, making certain assumptions, the inductance of a screened coil is

$$Lo = L\left\{1 - \frac{l/g}{l/g + 1.55} \cdot \frac{b^2}{a^2}\right\} \quad .. \quad \text{(I)}$$

where Lo = screened inductance, L = unscreened inductance and the other symbols are as shown in Fig. 1. The assumptions are (i) that the coil is cylindrical, (ii) that the screen is cylindrical, (iii) that the coil and screen are coaxial, (iv) that the gap between the ends of the winding and the ends of the screen is equal to or greater than the gap "g" and (v) that the screen is not unreasonably thin.

Since coils are generally wound on fairly rigid formers for stability, there will normally be no marked deviation from (i). The screen—especially if made of thin sheet—may easily be slightly deformed and become elliptical instead of cylindrical. If the diameter of the screen is reduced by 10 per cent. (e.g. from 2in. to 1.8in.) in one direction by compression, the resultant inaccuracy of equation (I) is about 1 per cent. Assumption (ii) is therefore not serious. The coil may not be placed exactly coaxially in the screen due to accidental circumstances. If the coil is displaced by 10 per cent. of the screen diameter the inaccuracy of equation (I) will be about 1.4 per cent. Hence assumption (iii) is not serious. For equation (I) to apply, assumption (iv) must be complied with, but this condition presents no practical difficulty and is hardly even a limitation. If the screen consists of an insulator with an exceedingly thin conducting film (of graphite for instance) on its inside surface, equation (I) may not apply; but for all normal sheet metal screens a change of thickness will have a negligible effect at the frequencies at which radio coils are used. For further information on these and other points reference should be made to Bogle's paper.

The chart for the change of inductance due to a screening can is based on equation (I), and Bogle claims this to be accurate within 2 per cent. Fig. 1 shows the various dimensions involved and the relations between them, and the key indicates the procedure to be adopted on the chart. One example will be given by way of illustration.

Example 1. A solenoid coil of 20.6 μH unscreened is placed coaxially in a cylindrical screening can, and the dimensions are l = 1.75in., g = 0.75in., b = 1.25in., a = 2.75in. What is the inductance when screened?

Starting at $l = 1.75$ and joining this to $g = 0.75$, a point of intersection is found on the reference line. From this point draw a tangent to the curve, and the ruler cuts the winding length scale at a point. Join this point to 1.25 on the "b" scale, and a second point of intersection is found on the reference line. Join this point to $a = 2.75$ on the screen diameter scale and the ruler cuts the inductance ratio scale at 0.876. Thus the screen inductance is $20.6 \times 0.876 = 18.05$ μH. Opposite 0.876 on the inductance ratio scale is 0.124 on the $\Delta L/L$ scale. A note should be made of this figure as it will be used in the second chart for finding the increase in resistance of the coil due to the screening can.

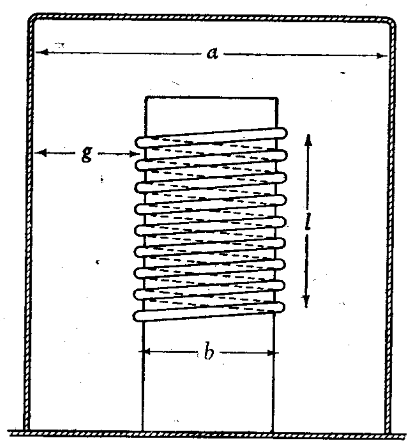


Fig. 1. Section of screened coil showing essential dimensions required in calculations.

Part of Bogle's paper is devoted to the analysis of the effect of the screening can on the resistance, and this is a matter of considerable importance, as will be shown later. Making the same assumptions as before, Bogle has shown that the additional resistance R¹ due to the screening can is given by the formula

$$R^1 = \frac{\Delta L}{L} \frac{N^2 b^2 l}{a} \sqrt{\rho f} \cdot \frac{2\pi^2}{10^4\sqrt{10}} \quad .. \quad \text{(II)}$$

Where the symbols are as before, N = turns per inch, ρ = specific resistivity of screening can material in microhm-cms., and f = frequency in megacycles. Practically all the remarks about the accuracy of equation (I) apply to equation (II). The chart for computing this added resistance is based on (II), using copper as the screening material. For any other material the R¹ given by the chart must be multiplied by a factor depending on that material. The factors for the common screening materials are given in Table I.

TABLE I

Material	*Factor*
Copper	1
Aluminium	1.28
Brass	2.16
Zinc	1.85
Nickel	2.05
Phosphor Bronze	2.16
Silver	0.97

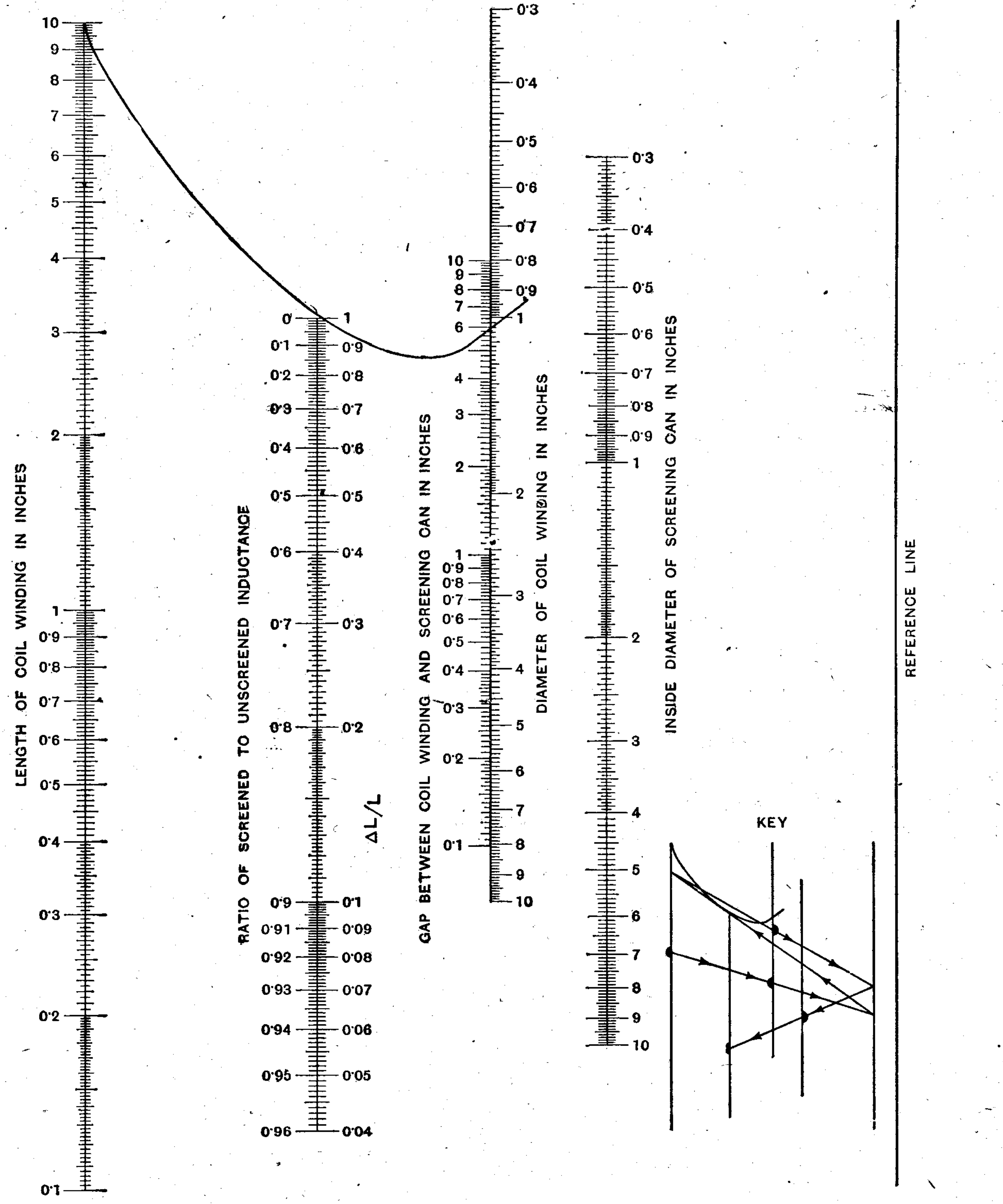
The chart is quite straightforward to use, and the procedure is indicated in the key. Let us do an example:

Example 1*A*. The screening can of Example 1 is made of aluminium, the winding pitch is 20 turns per inch, and the working frequency is 1 Mc/s. What is the added resistance R¹?

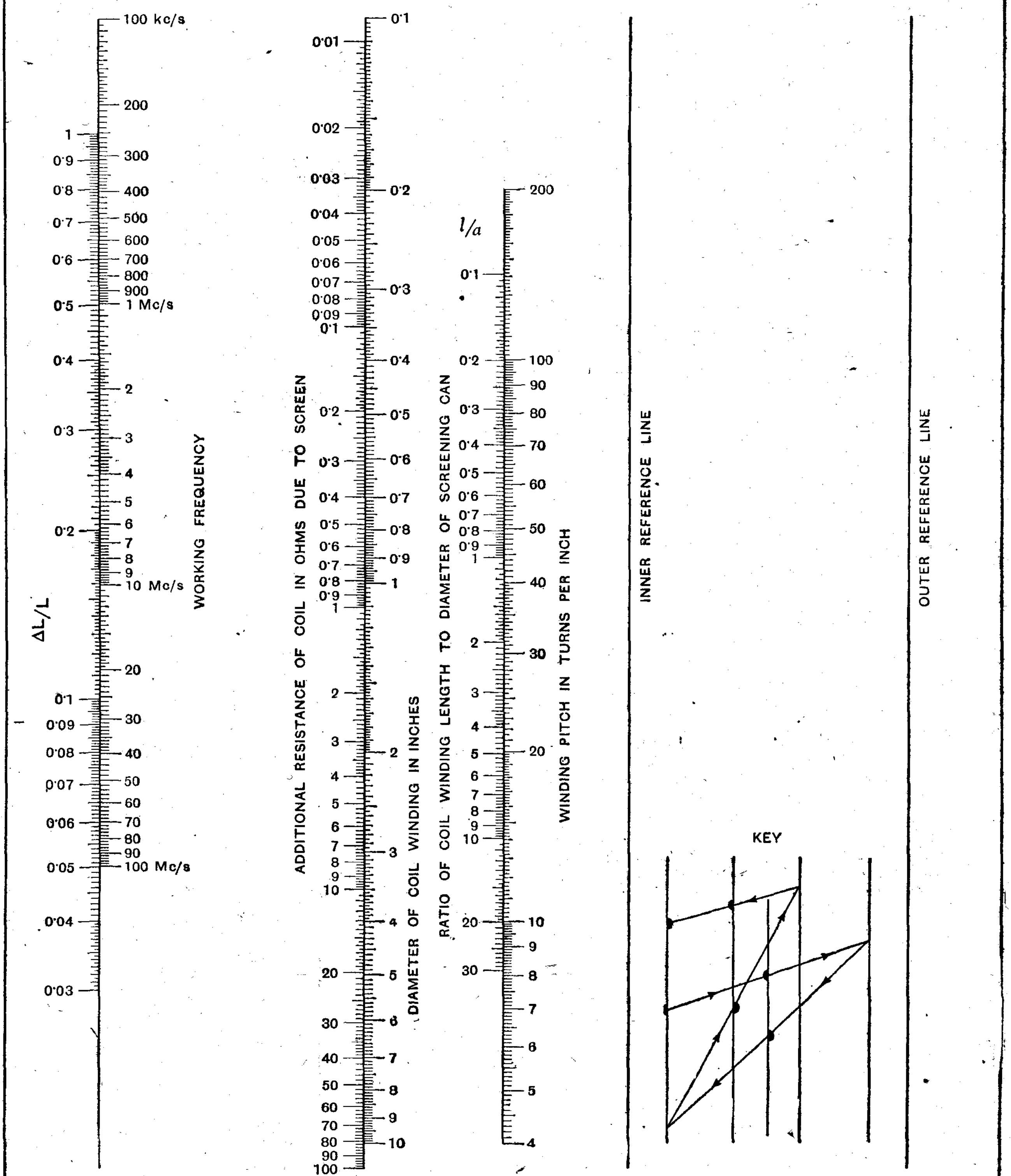
Join

$$\frac{\Delta L}{L} = 0.124 \text{ to } l/a = \frac{1.75}{2.75} = 0.636$$

(*Continued on page* 257)



CHANGE OF INDUCTANCE OF A COIL
DUE TO A CO-AXIAL CYLINDRICAL COPPER SCREENING CAN



INCREASE OF H F RESISTANCE OF A COIL
DUE TO A CO-AXIAL CYLINDRICAL COPPER SCREENING CAN

and produce to a point on the outer reference line. Join this point to 20 on the turns per inch scale and produce to a point on the $\frac{\Delta L}{L}$ scale. Join this point to $b = 1.25$in. and produce to a point on the inner reference line. Join this point to 1 Mc/s and the ruler cuts the R^1 scale at 0.0402 ohms. This is the added resistance due to screening if the screen were of copper. It is actually aluminium, and reference to Table I gives 1.28 as the factor for this material. Hence the required added resistance is $0.0402 \times 1.28 = 0.0515$ ohms. This looks negligibly small, but let us find the total effect on the Q of the coil at 1 Mc/s. We may take the RF resistance (including skin effect) as 0.75 ohms, and the Q of the unscreened coil is

$$\frac{2\pi f L}{r} = Q = \frac{2\pi \times 10^6 \times 20.6 \times 10^{-6}}{0.75} = 173.$$

Taking the screened value of the inductance, and adding the value for R^1, the Q of the screened coil is

$$Q^1 = \frac{2\pi \times 10^6 \times 18.05 \times 10^{-6}}{0.75 + 0.0515} = 142.$$

This represents a change of Q due to screening in the specified manner of nearly 18 per cent. If R^1 had been ignored as being negligible, Q^1 would have been 151, representing a change of Q due to screening of 12.7 per cent. In many cases R^1 will be found to have a considerably greater effect on Q. The example shows that even when the coil-can clearances are quite large, screening produces a marked deterioration in the goodness of the coil.

The R.E.M.E. and Telecommunications

It should, perhaps, be pointed out that the formation of the new Corps of Royal Electrical and Mechanical Engineers referred to in our last issue will have very little effect, other than in change of badge and button, on the personnel who are responsible for the engineering aspect of army telecommunication equipment—the collective term adopted in the R.E.M.E. for radiolocation, wireless and line gear. Of course, the R.E.M.E. has many tasks other than those associated with telecommunication apparatus, but such matters are outside the scope of this journal.

The whole of the R.A.O.C. Engineering Branch is being incorporated in the new corps, while a much smaller number of personnel from the R.E.s and R.A.S.C. is being transferred. The R.A.O.C., and not the R.E.M.E. as previously stated, will continue to supply telecommunications equipment, while the new corps will keep it working to maximum efficiency.

S.A.A.F. Signals Section

During the Abyssinian campaigns, the official history of which has recently been published, the Signals Section of the South African Air Force played a very important part. It was the vital link in the chain of communications between the Air Force squadrons, which were continuously penetrating deeper over enemy-occupied country, and headquarters.

The Signals Section, which includes air crew operators and ground staff—comprising operators and maintenance personnel—is responsible for wireless and line communication in the field.

A Section under the command of a Signals Officer is attached to each Squadron and Headquarters, but the personnel varies in number according to the type of work on which the unit is engaged.

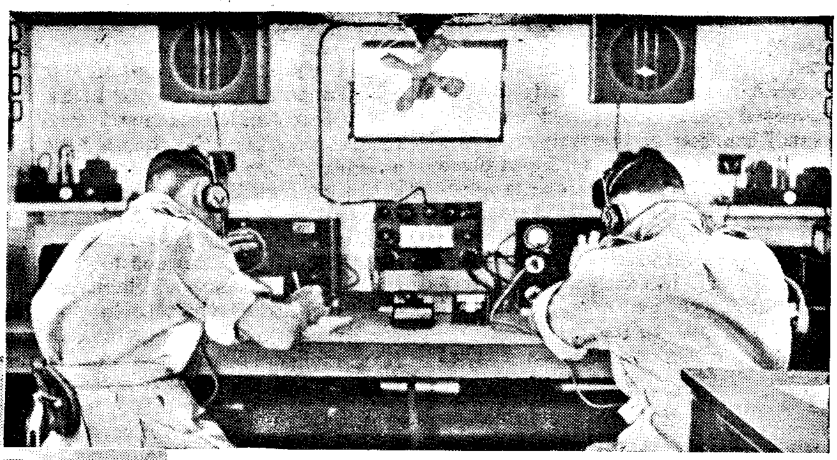
The larger of the mobile ground stations in general use comprises three 3-ton trucks. In one is installed two medium-power transmitters, each of which work in the high-frequency band. The 7-kW power supply for the transmitters, which can also be worked off 220-volt AC mains when available, is contained in a separate truck. A receiving station, comprising two communication-type receivers, is installed in the third vehicle.

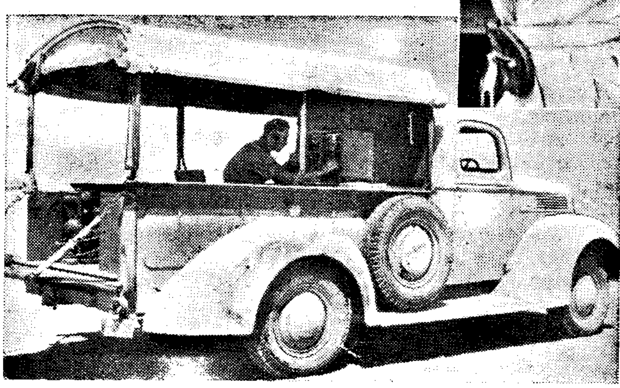
During the Abyssinian campaigns these transmitters frequently provided the only means of communication with bases, which were not infrequently well over a thousand miles away.

The smaller type of station is fitted in a small truck and comprises a low-power transmitter and receiver working in the high-frequency band. The apparatus is battery operated, and a portable charging set is, therefore, part of the equipment.

Owing to the extremely fluid type of warfare experienced in Abyssinia and also in the Middle East, the amount of traffic handled by these mobile stations, which deal with 'phone, CW and MCW, was considerable. Many of the operators are ex-amateurs and high praise has been accorded to their efficiency.

Because of their frequently isolated position the personnel have to be capable of undertaking major repairs, and their training, therefore, takes this into consideration.





Operators of the S.A.A.F. Signals Section in the receiving van of the larger of the two mobile stations. (Left) The self-contained low-power station.

HOME-MADE PICK-UP

Further Notes : Author's Replies to Queries

By
JOHN BRIERLEY

IT is gratifying that the description of my moving-coil pick-up in the July *Wireless World* has aroused interest, and I am grateful for the comments made by correspondents.

My remarks regarding the desirability of a light head and arm were based on the fact that records stored in a certain popular album are consistently warped in a manner which makes it necessary for the head to be able to move with an acceleration of 30 cm. per sec. per sec. without affecting the downward pressure appreciably. Owing to the fact that this peak figure exists for only a small fraction of a second, it happens in practice that a variation to only 25 per cent. of the average downward pressure can pass unnoticed; indeed, unless by some coincidence the note at this part of the record is such as to require the full downward pressure for good needle tracking, no harmful effect can result. There are, however, some records (usually containing long-sustained notes) in which such an effect does become noticeable, so I think all possible precautions should be taken to avoid this defect on any record.

Dr. Mole is, I think, a little optimistic in calculating that it is possible to reduce the downward pressure of his pick-up head (105 grams), plus the arm, to 15 grams, with a counterbalance of only 25 grams effective at the head. The fact is that, as the downward pressure required becomes a small fraction of the weight of the head, etc., the use of a spring in place of a counterbalance reduces the effective mass by nearly half. As on the type of warped record I have mentioned, the downward pressure of Dr. Mole's pick-up will vary by ½ oz. (approximately 50 per cent.), I would recommend him to try in further experiments either an Eclipse Pocket Magnet or Type M.5535 of Messrs. Darwin's, which is an Alnico U magnet weighing slightly over 1 oz.

With regard to the trailing angle, in its absence, the needle and armature of the usual commercial pick-up would vibrate in a way that would cause considerable distortion, but with an adequate trailing edge this would necessitate the point bouncing on the record. If the point is given adequate support, a trailing angle becomes unnecessary.

I can't agree with Mr. Hay that there is any practicable arrangement of the tone arm that will reduce the moment of any torsional forces to *zero*—the arrangement he describes will not. While generally they can be reduced (not to zero) by keeping the tone arm axis low, the cross-sectional area of the arm (and hence its rigidity) will probably have to be reduced, too, which might in certain circumstances aggravate rather than mitigate this trouble.

Needle Changing

The references to the choice of and suitability of celluloid prompt me to explain the reason for its use. While I was examining the various causes which contributed to the buzz output in pick-ups, I noticed that an undamped top resonance had a considerable effect. As in pick-ups using miniature moving parts, advantage is generally taken of the natural period being high, to reduce the damping, it is desirable to make them as self-damping as possible. A Silent Stylus needle, even cut down as I suggested in my article, is springy enough to make this impossible, whilst if the needle holder is made of springy material, too, such as would be good for gripping the needle well, the top resonance becomes too pronounced. The only satisfactory solution is to use much smaller points. As I did not think this would commend itself to readers to whom this was a new and possibly rather fiddling type of constructional work, I accepted the faults inherent in a steel needle and recommended the toothbrush handle grade of celluloid which seemed to be about the best compromise available. I think it will be found that, so long as the needle is inserted with reasonable care (the smaller the tool used for this purpose the better), and the former is not cut too finely round the needle, the hole will not become enlarged, and the former will last indefinitely. The needle is gripped just above the tapered part and pushed in until the tool touches the former. It cannot, therefore, be inserted too far except deliberately. It is the length of the tapered portion, and the fact that a little above this has to be left for gripping the needle for inserting and extracting, that limit the length to which it can be cut.

The query regarding the practicable needle life obtained is difficult to answer, as it depends to a very great extent on the type of associated apparatus employed—particularly the loud speaker; also new records wear the point very much less than old ones, and dust in the grooves (and how few people keep their records really clean!) halves the life of a point. With first-class apparatus I think 30 sides is the absolute limit with ½ oz. downward pressure, and 15 to 20 is probably the normal average number. There appears to be excessive wear quite often owing to the rather poor contact the point makes with the groove, and this makes the needle peculiarly susceptible to variations in groove shape. I find that a less acutely shaped point gives better results on the whole. Getting a point of good average fit is one of the prime difficulties of gramophone reproduction. Another difficulty which has assumed greater importance lately is the variation in groove shape, as the groove direction departs from the tangent. It would be interesting to know if the recording engineers can see their way to making improvements in this respect.

Finally, I would like to point out that pick-ups using an elongated coil, such as I have described, come, I think, under a patent taken out by P. G. A. H. Voigt.

Broadcasting Statistics

COMPARATIVE figures giving the number of broadcasting stations throughout the world at the end of 1939 and 1941 are published in the *U.I.R. Bulletin*. It is noticeable that in countries where the broadcasting service is monopolised the number of stations is small, but they are high powered, whilst in countries where there are commercial stations there is a preponderance of low-powered transmitters.

The number of transmitters in the world is given as 2,768, compared with 2,509 in 1939, although the average power remains at 7.8 kW. In Europe there is stated to be 470 transmitters with an average power of 25.86 kW, whilst in North America there are 1,122 stations, the average power of which is 5.09 kW. Although in Central America the number of stations has increased during the two years from 195 to 279, the average power has dropped from 1.24 kW to below one kilowatt.

PHYSICAL FOUNDATIONS OF RADIO

III.—Hot Cathode Emission (Metallic)

By

MARTIN JOHNSON,

D.Sc.

In the two preceding articles the meaning of "free" electrons was discussed for idealised metals and for practical alloys, and some grounds were given for the differing resistivity of various chemical structures. The familiar phenomenon of cathode emission next raised the question as to what physical factors control the escape of these electrons from surfaces which are either heated, bombarded by other electrons or ions, or exposed to radiation. We begin with thermionic emission, and will follow as before the policy of developing simplified mechanisms and diagrams to suggest reasons underlying the facts met by any radio experimenter.

Potential Diagrams at a Cathode Surface—We previously considered the status of the electron in the metal from two closely related points of view, the work required to remove it from one equipotential to another, and the potential barriers obstructing its free movement. The "wave-like" aspect of certain electronic properties allowed barriers to be penetrated if they are not more than a few atoms in thickness, even when the electron has not acquired sufficient kinetic energy to reach the summit of the barrier on the potential diagram.

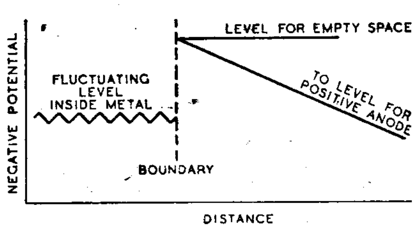


Fig. 1. Potential for electron passing from region of periodic pattern among lattice atoms to vacuum outside the cathode and then to anode.

In problems of conduction within the metal, these barriers and energy increments were merely those concerned in the passage from atom to atom or from one crystal grain across an impurity to another microstructure in the same substance. But in problems of emission, the barrier to be similarly discussed is the high wall of potential separating the whole metal interior from the vacuous space outside it; the step on the potential distance diagram is from the level of averaged influence of all the positive lattice points in the cathode material to the level of complete absence of any material between the electrodes of the valve, and finally to the level of a strongly positive anode. (Fig. 1) Ordinates on such potential diagrams are conveniently in electron-volts, the familiar work unit eV representing energy acquired by a single electronic charge e falling through so many volts V. In these units radio experimenters know that they will find "work-functions" controlling emission with their magnitudes ranging from about 1½ for coated filaments containing barium to about six for platinum: because of the high work function, platinum, although the material used for many of the early fundamental experiments, is quite unsuitable for even "bright emitter" valves.

Interpretation of Work Functions.—In terms of the diagrams which we have used for illustrating the theory of metals, the work function measures the extra energy needed to enable the free electron to negotiate its barrier and escape from the metal lattice. This will therefore be the difference between the "inner potential," which characterises the interior relative to exterior of the metal, and the maximum energy of the electrons in the cold lattice. On the older theories these quantities were not easy to interpret, but they have been among the successes of the Fermi and Dirac method of calculating the distribution of energy in the "free electron gas" to which reference has previously been made.

Calculated on this basis, for example, the energy of the "cold" electrons in a nickel filament would be either 11.7 or 7.4 electron-volts, according to whether an average of two electrons or one is liberated from each parent atom. The "inner potential" is about 16.5, estimated from experiments on the diffraction of an electron beam from a nickel surface. The work-function for nickel ought therefore to be about 5 or about 9 for these two alternatives respectively. The fact that it is found by measurement to be 5.03 volts makes it clear that the theory is on correct lines if two, not one, electrons per atom become "free" in nickel. Much progress in the understanding of the mechanism of emission has been due, in this country, to R. H. Fowler and his pupils, beginning with Nordheim who calculated the probability of electron waves from the interior being reflected or transmitted at various kinds of surface barrier.

Image Force and Schottky Effect.—When we have defined and measured a work-function, it is reasonable to ask what makes up this work which has to be done in getting the electron away from the metal. One important part is certainly contributed by the so-called "image force": an electrostatic charge when just outside a conducting surface may be considered as inducing its opposite or "image" in the reflecting mirror of the metal. (Fig. 2). Attraction between the negative and positive pair must occur according to the usual electrostatic law of inverse square of distance and product of charges; this holds back the escaping electron and requires work to be done against such a force

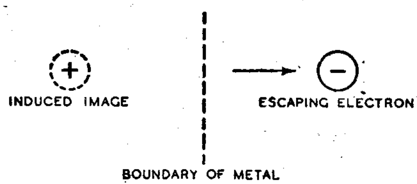


Fig. 2. Image attraction at metal surface.

for the electron to get clear away. This simple electrostatic attraction is only part of the story, which must also include the lesser-known chemical and polarisation attractions between the electron and the last atomic layer of the metallic structure, constituting forces of shorter range than the image force.

The image force betrays its presence, since it must round-off the shape of any potential barrier which we have hitherto supposed to be merely a vertical step on the diagram; this rounding of the potential step is

Physical Foundations of Radio—
probably what causes the "Schottky effect," or incomplete saturation of the current/potential line on the diode characteristic for even the purest metal filaments. In Fig. 3 different anode potentials provide differently sloping lines away from the surface on the potential diagram; it is seen that the more gradual the potential step the more the growth of anode potential succeeds in "shaving off the summit" of the hill. Maximum height of a rectangular barrier is scarcely affected by anode potential, so that for such a case at fixed cathode temperature a potential on the anode sufficient to collect electrons from the space-charge will give the maximum possible current. But the more rounded hill of the image force will be cut into more and more by increasing anode potentials, lowering the summit, reducing slightly the effective work function and allowing the current to rise above the first apparent saturation. Schottky's calculations of this effect fit experiment excellently, and it is interesting to note orders of magnitude; in a field

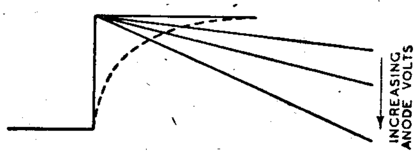


Fig. 3. Schottky effect (exaggerated): increasing anode potentials slightly diminish the summit of the potential barrier to electron emission if it is rounded (dotted curve) by image attraction. (Compare Fig. 1.)

of 10^6 volts per cm. the summit of the hill, between image attraction and anode slope, occurs at $17\frac{1}{2} \times 10^{-8}$ cm. from the idealised "boundary" and the effective work function is reduced from 4.54 to 4.16 volts for pure tungsten. This gives considerable rise in current as the summit of the potential curve is considerably "shaved." The effect upon the diode characteristic appears in Fig. 4.

This Schottky effect of anode potential must be distinguished from two others, the infra-saturation region of Fig. 4 to which we next devote some detail, and also the phenomenon of "field emission" from cold electrodes at enormous fields which will be dealt with in a later article on non-thermal emissions.

Infra-Saturation Currents and Space Charge.—The lower portion of the diode characteristic (x) in Fig. 4 shows a dependence upon anode voltage which is also calculable upon a basis of Coulomb's law of electrostatic attraction and repulsion. The mathematics is that of integrating Poisson's differential equation for a space charge accumulating in a region bounded according to the geometry of the various shaped electrodes.

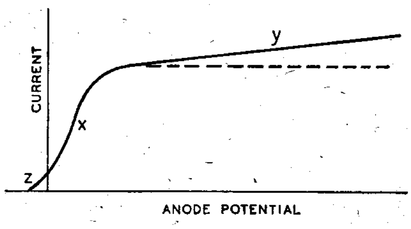


Fig. 4. Diode characteristic showing region (y) with imperfect saturation due to Schottky effect, and region (x) of the 3/2 power law. The region (z) of finite emission velocity is here exaggerated to show its existence.

Fig. 5 shows a plot of potential (ordinates) against the distance between two idealised parallel plane electrodes. AA′ gives the potential from cathode to anode across a valve. For an isolated electron in this space, nothing disturbs the linearity of ABA′. But when emission is copious and the crowding of electrons become dense enough to constitute a finite space-charge outside the cathode, this will progressively disturb the anode attraction and cause the line to sag to ACA′, ADA′, etc. Where the graph sags so distinctly as to show a horizontal tangent, the slope has become zero and there is no longer a pull from the anode collecting electrons from the vicinity of the cathode, since the slope of potential against distance was the force of attraction. If space charge becomes excessive enough for the graph to dip below the horizontal, AEA′, there is even a reversed force between cathode and bottom of this dip.

The point E, the minimum in the curve, contains the germ of the notion of "virtual cathodes," as it replaces the cathode surface as a new starting point for any electron. Radio experimenters will be familiar with this term, as much care in design of multi-electrode valves has been expended in arranging virtual cathodes to be situated at various points in the inter-electrode space to provide very uniform flow to subsequent electrodes.

It was the analysis of these curves that led Langmuir and other pioneers to the well-known "three-halves power law," that the anode current for moderate voltages rises proportionally to $V^{3/2}$. The various proportionality factors cover varied shape and size of electrodes, and the mathematics becomes awkward for any case except plane or cylindrical. It should also be remembered that the law is somewhat vitiated by "local" fields at the surface of composite or impure metallic cathodes, and that in any case it ignores initial velocity of emission and so is unable to fit the bottom of the characteristic curve of the actual valve.

Temperature Law and Richardson Plots.—Consider the nearly flat portion of a diode characteristic: the valve is presumably "hard" so that there are no gaseous ions, and the anode potential is not enormous, so that there is no "field emission," but approximate saturation has been reached and the extra current can be eliminated by calculating the excess due to Schottky effect. (Fig. 4, region y). The thermionic current can under these circumstances be regarded as a purely thermal phenomenon, i.e. an evaporation of electrons from their free state in the metal similar to the evaporation of the molecules of a liquid when they attain their vapour stage of escape from an exposed surface. In fact the electron emission can be calculated by analogous means to that employed by physical chemists in their calculation of vapour pressure. Various alternative derivations on slightly differing thermodynamic arguments all agree to give the law associated with the pioneer discoveries of Sir Owen Richardson

Current per unit area = $AT^2e^{-\phi/kT}$

In the early days $T^{1/2}$ was preferred to T^2, which would require ϕ adjusting to different temperatures, but this variation of work function with temperature is "taken care of" in the

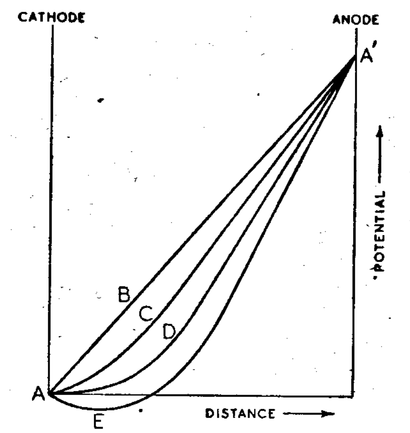


Fig. 5. Potential/distance graph between idealised plane electrodes with successive stages of growth in space-charge. E has "virtual cathode" properties.

T^2 form of the law. Thus ϕ is pictured as a fixed work function analogous to a latent heat of evaporation; k is the Boltzmann constant, in this case $\frac{2}{3}$rds the value of the constant referred to in our previous discussion of metals, T is temperature on the "absolute" scale which describes the freezing point of water as 273 deg. The two constants characterising any metal emitter can therefore be obtained from experiments recorded in a "Richardson plot" (Fig. 6) of $\log_{10} i - 2 \log_{10} T$ against $1/T$, in which the slope multiplied by 2.3 (the conversion factor between common and Naperian logs) gives ϕ/k while the maximum vertical intercept gives log A. When later

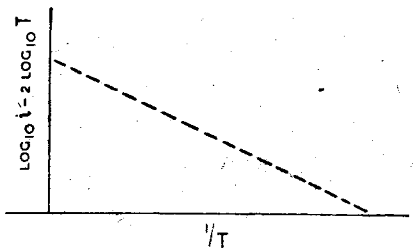


Fig. 6. "Richardson plot." The slope multiplied by the logarithmic constant 2.3 gives ϕ/k. The maximum vertical intercept gives log A.

discussing composite surfaces it will be important to know what to do with the curved Richardson plots which have puzzled many workers; they obviously imply non-constant conditions of emission.

Emission Constants.—It is clear that A, as inferred from the logarithmic plot, will not be very accurately determined. In fact the magnitude of this quantity, known as the emission constant, has been disputed over a wide range even for the same material, and for composite filaments may have fantastic values. Much ingenuity has been expended in distributing the responsibility for "queer" emitters between their ϕ and their A. It is worth noting that $e^{-\phi/kT}$ is the dominant term in temperature, in fact distinction between the alternatives $T^{1/2}$ and T^2 in the other factor has not always been easy. $e^{-\phi/kT}$ will however always be a very small quantity: for k is 1.37×10^{-16} ergs per degree or 8.6×10^{-5} electron-volts per degree, so that if the work function is in electron-volts it must be multiplied by the reciprocal of k or 11,600 to obtain ϕ/kT for any given emitting temperature. For example, the work function for pure tungsten used in bright emitters is 4.54 so that $e^{-\phi/kT}$ at 2,000 degrees is e^{-x} where x is $4.54 \times 11{,}600/2{,}000$. This is about e^{-26} or 10^{-11}. For actual emission to be at all considerable for such a work function the constant A must be very large. On the modern Fermi-Dirac theory of electrons to which we have before referred, A has a maximum possible value A_0, given by

$$A_0' = \frac{4\pi mek^2}{h^3} \text{ where}$$

m is the electron mass 8.9×10^{-28} gm., k is as before, e is in this case the electronic charge 4.8×10^{-10} electrostatic units, and h is Planck's constant 6.55×10^{-27} erg seconds. This makes A_0 to be 3.6×10^{11} electrostatic units per cm.^{2} per deg.^{2} or 120 amps. per cm.^{2} per deg.^{2} For instance, tungsten at 2,000 degrees would have an emission per cm.^{2} area of filament $120 \times 2{,}000^2 \times 10^{-11}$ or about 5 milliamps. In practice this is not attained as A never reaches the maximum A_0, there being more internal reflection of the electrons than accounted for in the theory. The merit of a tungsten emitter is that it can stand very high temperature, and a filament of 0.1 millimetre diameter can be run at a temperature giving 22 milliamps. per cm. length. But this means only 8 milliamps. per watt of cathode heating. The Richardson equation shows that reduction of work function from $4\frac{1}{2}$ to 2 volts alters e^{-26} to e^{-11} at the same 2,000 degrees. This increases emission a millionfold. But metals refractory enough to stand high temperatures all have high work functions. We reach in our treatment of emission, therefore, the urgent need for the "dull emitter" or filament of composite material instead of the pure metal. The laws of such are not so simple as those of the pure metal emitter, but are understandable when compared with the "pure" properties which we have here outlined. The search for composite filament material of low work function will be discussed in the next article.

I.E.E. Wireless Section

Inaugural Address of the New Chairman

AT the first meeting of the 1942-43 session of the Wireless Section of the I.E.E. on October 7th, appreciation was expressed of the work of the retiring Chairman, Mr. H. Bishop, C.B.E., and the new Chairman, Dr. R. L. Smith-Rose, delivered his inaugural address. This was divided into three parts, dealing successively with the growth of the Wireless Section of the Institution, a review of the work of the Radio Research Board, and a technical paper on recent advances in the measurement of the speed of travel of electromagnetic waves.

In a brief survey of the origin and growth of the Wireless Section, which has now been in existence for 23 years and has a membership of 1,100, he mentioned the occasions when movements have been set on foot to detach the section and to establish a separate Institution and the steps which were regarded as rendering such a course unnecessary—for instance, the decision as early as 1926 to welcome physicists whose qualifications, although not those of the electrical engineer, specially fitted them for many branches of wireless development work.

His remarks on the past and present work of the Radio Research Board were in support of the wisdom of fundamental research without regard to immediate applications. Many of the researches initiated years ago were now providing valuable material for the rapid extension of wartime radio technique.

The final section dealt with refinements in the measurement of the velocity of light and wireless waves. The work of Michelson, Pease and Pearson, in America, using a rotating mirror and a vacuum tube a mile long, was described, and also the recent work of W. C. Anderson with more compact apparatus, using a Kerr cell with frequencies up to 56 Mc/s as an interrupter. Both methods gave a value of 2.9977×10^{10} cm/sec. in vacuo. The direct measurement of the velocity of wireless waves was more difficult, and comparable accuracy was not yet in sight, but the work of Ross and Slow at the N.P.L. in 1937 on the phase velocity of waves in separate aerial systems had given 2.95×10^{10} cm/sec. $\pm$ 5 per cent. In the U.S.S.R. Mandelstam and Papalexi had recently completed an outstanding research involving the transmission of waves to a distant receiver, frequency conversion and re-transmission back to the starting point. Modification of the phase throughout all parts of the apparatus was traced with an accuracy of one part in 1,000, and the number of whole wavelengths and fractions of a wavelength between the two stations deduced. The results gave a velocity lying between 2.990 and 2.995×10^{10} cm/sec. in clear air over the sea.

This work was by no means academic as an accurate knowledge of the velocity of waves in free space was necessary before the more complex problem of transit time between stations could be investigated.

INSTRUMENTS: *Test and Measuring Gear and Its Uses*

By W. H. CAZALY

VII.—Valve Testers

A VALVE tester is a device that gives sufficient indication of the all-round goodness of a valve for an observer to ascertain whether the valve is going to perform satisfactorily in a wireless set or ampifier. For such purposes the goodness of a valve is dependent upon several factors, of which the chief are (a) the emissivity of the cathode; (b) the degree of vacuum inside the glass envelope; (c) in the case of indirectly heated cathode valves used in mains sets, the insulation between heater and cathode, particularly when hot, as in working conditions; and (d) the mechanical condition of the electrodes inside the glass envelope, including their insulation from each other.

It is perhaps best to consider each of these factors separately at first, in order to perceive how, in commercial valve testers, ingenious arrangements enable their effects to be observed by the movement of a pointer across a meter dial. Taking the last-mentioned factor first—the mechanical condition and insulation of the electrodes—the testing of this factor is very simple. A valve with mechanically defective electrodes will, save in rare cases, be "microphonic"—that is, it will set up anything from crackles when tapped to continuous howling as soon as the set is switched on. Modern manufacturing processes have gone a long way towards making electrode structures strong and rigid, and towards attaching the various parts of the structure to each other very firmly—usually by spot welding—but perfection is impossible; a turn of the control grid may become detached, or a strut of the anode, and hang loose or ready to vibrate with the slightest jar; overheating, even of short duration, of the filament of a battery valve may cause it to sag without breaking and become vibrant when jarred. There is no quantitative test possible, or needed, for valve microphony—the ear is a sufficiently competent tester, if the valve is lightly tapped.

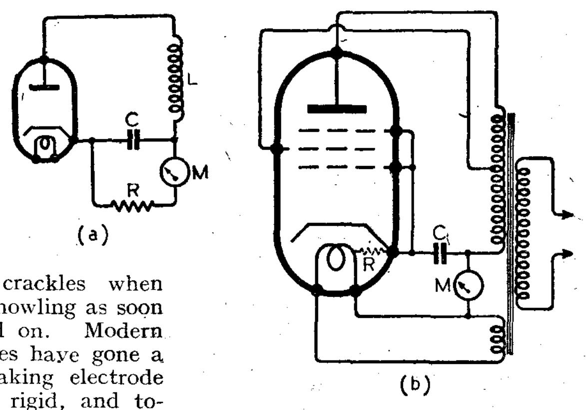


Fig. 1. (a) Indirectly heated diode "leak and condenser" rectifier. (b) Circuit showing how the same principles are used to indicate faulty cathode-heater insulation in a valve when the cathode is hot, as in normal operation.

Inter-electrode Insulation

The insulation between the electrodes of a valve is best tested by some sort of megger of neon circuit, since it must be extremely high to be satisfactory. Several commercial valve testers have something of the sort incorporated, for the preliminary test of a valve in this respect before its insertion in the tester, since a short-circuit between electrodes might damage the tester.

Taking the matter of cathode-heater insulation next, this is a factor that can be measured quite accurately. It is essential, however, that it should be measured "hot" as well as "cold"; and, if possible, with working voltages applied to the other electrodes. This is because leakage paths between heater and cathode quite often do not appear until the normal working heat has expanded the parts involved. Tested when cold, the insulation between cathode and heater may appear quite satisfactory—i.e., some $1\ M\Omega$ at least, and usually very much higher; as soon as the valve is put back into the receiver and used, it may give rise to intolerable hum. It would, of course, be possible to test hot cathode-heater insulation directly with a fairly obvious arrangement insulating the heating source very carefully from the cathode. But a rather simpler arrangement from a practical viewpoint, especially when mains supplies are used for power, as is usual in valve testers, is given in Fig. 1.

How it works may be understood by reference to Fig. 1 (a), which is that of a simple diode with a leak and condenser. When an alternating voltage is developed across the coil L, the condenser C becomes charged on account of the rectifying action of the diode and discharges through the leak resistance R, which normally is included deliberately in such a circuit as this. A sensitive microammeter in series with R, as shown by M in Fig. 1 (a) would measure the value of the discharge current. A similar principle is involved in the circuit of Fig. 1 (b). Here, the required alternating voltage is supplied by the secondary of a mains input transformer (of which another secondary provides the heater supply in addition) and the leak resistance R is provided by the leakage path, if any, between cathode and heater, as shown in dotted line. If insulation is good, i.e., R is very high, little, if any, movement will be observed of the pointer of the meter M, the dial of which may even be calibrated, if desired, in terms of megohms leakage. The valve under test—in the circuit shown it is a pentode—is being made to act as a rectifier.

Softness

The vacuum inside the envelopes of modern valves is extremely high, except in the case of special types such as certain power rectifiers, neon types, etc. The slightest crack in the envelope, even if invisible, or defect in the sealing between the glass and the leads-out of the electrodes, lets in sufficient air to ruin this vacuum. Moreover, the heating of the electrodes when the valve is in use may cause them to release a residuum of occluded gas. Elaborate precautions are taken against it, of course, in manufacture, but valves are still liable to "go soft" in this way.

The easiest way to test a valve for softness is to measure the anode current with and without a high-resistance between the control grid and the cathode. If the vacuum is satisfactory, the presence or absence of high resistance (say 2 MΩ) between grid

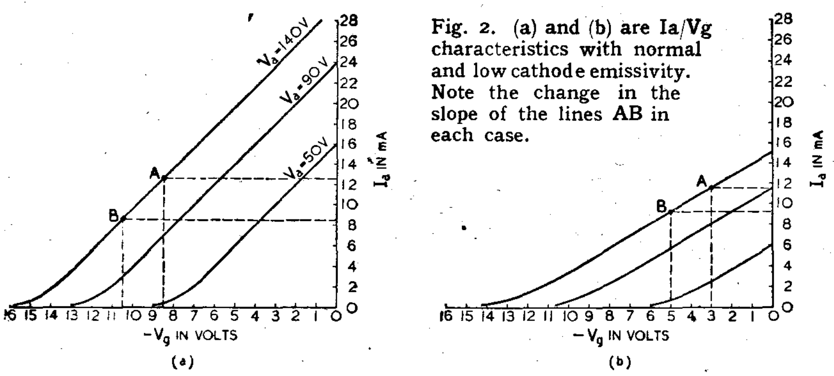


Fig. 2. (a) and (b) are Ia/Vg characteristics with normal and low cathode emissivity. Note the change in the slope of the lines AB in each case.

and cathode should make no appreciable difference to the anode current. If the valve is soft, however, the anode current will not be the same in both cases: with high resistance in the grid circuit, the anode current will be greater than when the grid is returned directly to cathode.

Finally, there is the factor of emissivity of the cathode which, apart from anything else, determines inevitably the life of a valve. Most modern receiving valves are expected, if used normally, to have a satisfactory operational life of about 1,500 hours, although a lot depends on how much distortion or other falling off in performance a user is willing to tolerate. The important effect of loss of emissivity lies in the change it makes in the slopes of the families of characteristic curves. Two main families of curves are outlined in Figs. 2 (a) and (b), and the thing to note about them is that a change in cathode emissivity makes a change in the slope of the lines to a greater extent than does a change of any of the other parameters.

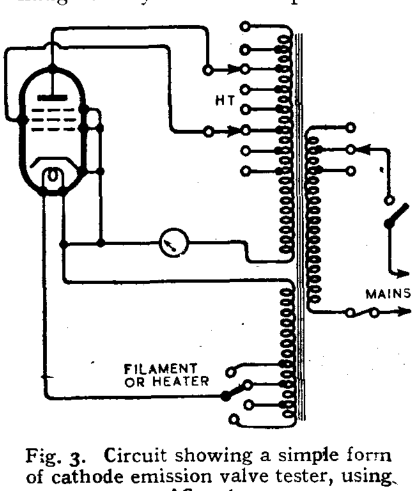


Fig. 3. Circuit showing a simple form of cathode emission valve tester, using AC only.

Now, the constants of valves μ, Ra, and Gm, are derived from the slopes of the characteristics; hence change in the emissivity of the cathode affects the valve constants considerably.

A few commercial valve testers merely test the emissivity of the cathode, without attempting to give any idea of the slope of any characteristic. It is assumed that if a valve does not pass the normal anode current when the filament or heater current, and the voltages applied to the other electrodes, are normal, the slopes of the characteristics will be altered. As a rough check on the condition of a valve, this is often good enough.

Instruments of this class are comparatively simple in construction, require only meters of a very moderate order of sensitivity, and are easy to use. When mains driven, they consist of little more than a transformer with multi-tapped secondaries for filament or heater supplier and for HT voltages to the other electrodes, a table being given for switching to the correct taps for the various types of valves to be tested. The valve being a unidirectional current device, the registering meter is merely a DC moving-coil instrument. A skeleton circuit showing the principles is given in Fig. 3. The scale of the meter is usually marked arbitrarily and is used with a table of the deflections to be expected with various types of valve.

Another form of valve tester does reveal approximately the slope of the Ia/Vg characteristic, by showing the amount of alternating current component developed in the anode circuit of a valve when a standard alternating voltage is applied to the grid. The principle is shown by the circuit given in Fig. 4. It will be evident from a consideration of the Ia/Vg characteristic shown in Fig. 2 (a) that the application of an alternating voltage, to the grid of a valve having this characteristic, of a valve of about 0.75 volt RMS will produce an AC component superimposed on the steady DC flowing in the anode circuit (with 140V as Va of about 2 mA RMS. If, however, the slope is less steep, as in Fig. 2 (b), the same Vg will produce only about 1.5 mA.

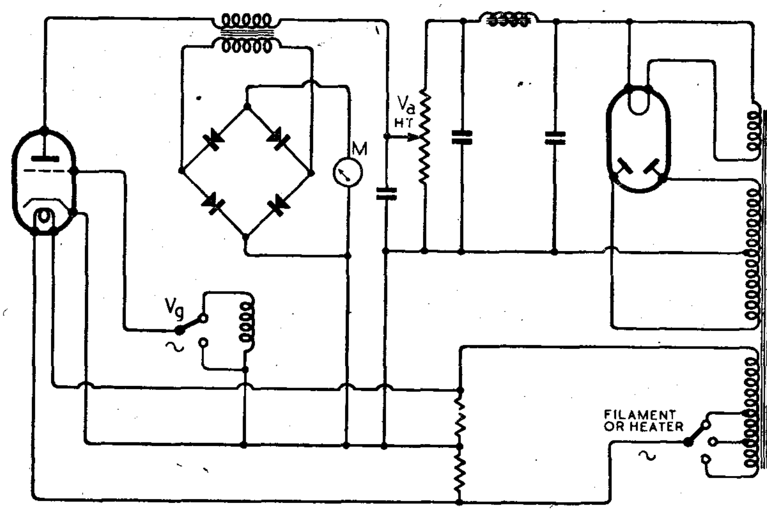


Fig. 4. Simplified circuit of a form of valve tester that registers the effect, in a rectifier type AC meter, of the AC produced in the anode circuit of a valve by the application of a suitable alternating voltage to the grid.

To make the point clearer, it will be assumed first, referring to Fig. 4 in conjunction with Fig. 2 (a), that the grid of the valve is not excited from the voltage developed across the coil L1, but is kept steady at −9.5 volts, while Va is 140 volts. A *steady* current will flow through the primary of the meter transformer, at 10.5 mA. Since this current is perfectly constant, no voltage is induced across the secondary of the transformer and the

Instruments—
meter will, therefore, register zero. Now if the grid is conected to a tap on coil L1 such that the potential on the grid rises to −8.5 volts, returns to −9.5 volts, falls to −10.5 volts, and returns again to −9.5 volts—as would happen if the voltage developed by this tap on L1 developed a sine-wave alternating voltage of 1 volt peak to peak (0.707V. RMS)—the current through the transformer primary would no longer be steady; it would start at 10.5 mA, rise with the grid voltage to 12.5 mA, return to 10.5 mA, fall to 8.5 mA, and return again

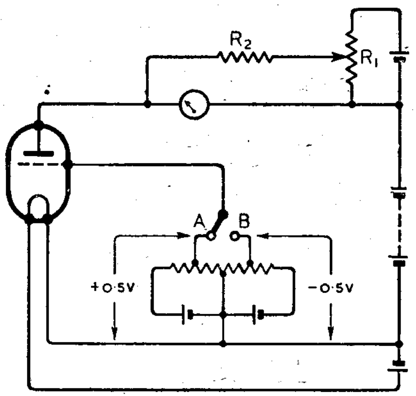


Fig. 5. Circuit showing principle employed in measuring the mutual conductance of a valve with DC power supplies.

to 10.5 mA. That is, an alternating component of a peak to peak value of 4 mA would appear in the current through the transformer primary, and this component would induce a voltage across the secondary that would operate the meter M. Applying the same alternating voltage to the grid of a valve of which the Ia/Vg characteristic had a less steep slope, as in Fig. 2 (b), would produce an alternating component of less than 3 mA with corresponding smaller effect on the meter.

In practice, of course, a valve tester of this type is mains driven, and L1 consists conveniently of a winding on the mains power transformer, developing 0.5 volt RMS—i.e., a peak to peak grid voltage swing of 1.4 volts—and the resulting alternating current component occurring in the anode circuit, varying in amount according to the slopes of the valves being tested, is registered on the rectifier-type meter M. Since manufacturers' valve data regarding mutual conductance (which is the slope of the Ia/Vg characteristic) is normally given with mean Vg=0, no standing bias need be provided. Tables are provided to enable the testing conditions for each type of valve to be set up by use of control knobs and switches, and the meter dial may be marked in terms of mutual conductance.

Another type of valve tester measures the slope of the Ia/Vg characteristic directly—i.e., the actual change in anode current brought about by a change of grid potential of 1 volt is measured. Ingenious use is made of alternating voltage alone, without the complications of providing DC for both anode and grid voltages. Before considering the simplified circuit of this type, given in Fig. 6, the main principle can be grasped by a study of the circuit given in Fig. 5, in which DC is supposed to be employed. The grid of the triode valve that is supposed to be under test is taken to a bias source that can provide a grid potential relative to the filament of either + or −0.5 volt. When the switch connects the grid to 0.5 volt negative, the anode current is a certain I1 as registered on the meter. If the grid is then switched to 0.5 volt positive—a total change of 1 volt—the anode current will change to I2. Then the mutual conductance in terms of mA/V is (I2−I1) mA per volt.

Backing-off Circuit

This simple arrangement, apart from anything else, has one serious snag: if the valve under test is, say, a power output type passing a standing Ia of the order of 20 or 30 mA, the small *change* of Ia—which is the important factor—will not be easily or accurately observed on a meter that is capable of passing such a heavy current. To enable a sensitive meter to be used, therefore, which will be capable of giving a large readable deflection with or change of Ia of less than 1 mA, a backing-off circuit is provided, formed by a cell, in series with the positive end of the HT battery, with a potential divider, R1, across it. The sides of this potential divider is adjusted, with the valve passing anode current when the grid is switched to 0.5 volt negative, so that the voltage developed across the meter (through R2) from this backing-off circuit is exactly equal and opposite to the p.d. set up across the meter itself by the passage of anode current through it. The meter then gives no deflection. As soon, however, as the grid is switched to 0.5 volt positive, the *increase* of anode current is registered on the meter, since the p.d. across the meter due to this increase of current becomes greater, whereas the voltage due to the backing-off potential divider remains the same as before. Thus, even a change of a fraction of a milliamp. of Ia is readily observed on a sensitive meter without it being affected by the passage of heavy current. The resistance R2 should be many times greater than the resistance of the meter in order to avoid an excessive shunting effect.

From the foregoing, the operation of the circuit of Fig. 6 can be derived. Referring to this figure the anode voltage is obtained from a HT secondary winding suitably tapped on the mains input transformer, as is the heater or filament supply from another tapped winding. The valve, therefore, only passes anode current during the positive half-cycles of voltage at the anode end of the secondary winding. How much anode current it passes depends on whether the grid is connected by the switch to the "in-phase" or the "out-of-phase" side of the centre-tapped winding (additional to the two previously mentioned), that supplies grid potential. "In-phase" and "out-of-phase" refer to the polarity of the grid potential in relation to the anode potential; i.e., if the grid is positive when the anode end of the HT winding is positive, it is "in-phase" and vice versa.

Assuming, then, that the valve is in position and that suitable anode and filament voltages have been selected by the switches, the procedure is on the following lines: first, the grid is switched to the "out-of-phase" end of the grid voltage winding, say at B;

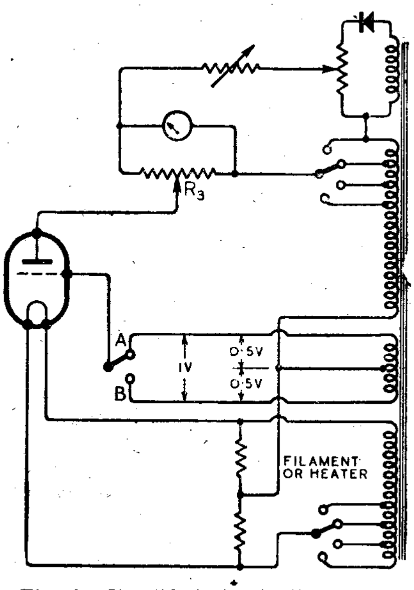


Fig. 6. Simplified circuit of a valve tester using alternating supplies to provide the working voltages for measurement of mutual conductance.

the resulting standing anode current (actually, of course, unidirectional pulses of current each positive half-cycle at the anode end of the HT secondary) is backed off by the adjustment of the slider of a potential divider across a continuation of the HT winding until the meter registers zero. Then the grid is switched to the "in-phase" end of the grid voltage winding at A; this changes the effective grid potential by 1 volt in the positive direction, and the resulting increase of anode current is registered on the meter. The function of the half-wave rectifier in the backing-off circuit is to prevent a reverse current flowing through the meter during the negative half-cycles in the HT and backing-off windings.

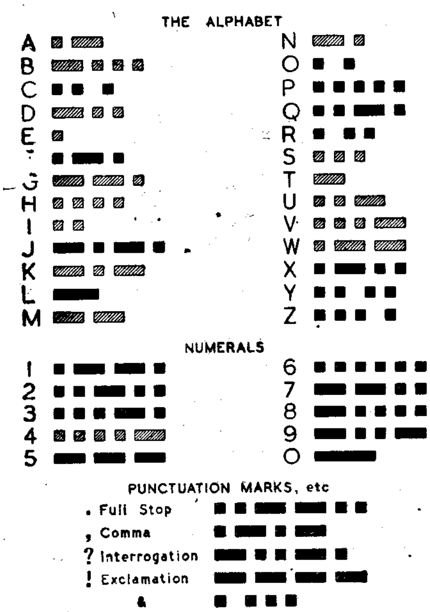
The shunt potential divider R3 across the meter may serve two purposes. One is to adjust the sensitivity of the meter circuit to suit various mutual conductance constants. The other may be to provide means of showing the state of a valve in a rough but attractive way by colourings or similar devices on the meter scale. The slider of this shunt potential divider is adjusted, by reference to a table or dial markings, to such a position that, if the increase of current brought about by the switching of the grid from the "out-of-phase" to the "in-phase" connection is normal, the meter is sensitive enough to give nearly a full scale deflection—or, for instance, for the pointer to swing over to a part of the meter scale marked "Good" or coloured brightly. If, however, the increase of current is below normal—indicating a less steep Ia/Vg characteristic, probably due to loss of cathode emissivity—the pointer only swings as far as the "Indifferent" or "Bad" part of the meter scale, or an appropriate colour which much impresses the lay customer, in whose view "meters do not lie"! Plainly, much depends on the accuracy with which the slider on the meter shunt is adjusted.

For the rest, rapidity and ease of preparation for test of many valve testers are facilitated by various forms of semi-automatic switching by means of perforated cards, numbered switches, etc., that also tend to make such instruments almost fool-proof. When a number of valves, of many different types, have to be quickly tested, such devices are of considerable and quite satisfactory service.

American Morse Symbols

MANY readers of the *Wireless World* booklet "Learning Morse" have enquired about the original code devised by Samuel Morse which was mentioned briefly in the booklet. Although of purely academic interest to the modern wireless operator, it is worth while putting it on record. The American code was used even for wireless communication up to the time that the United States joined the International Radiotelegraphic Convention and adopted the International Code. Some of the symbols survived much longer in unofficial abbreviations, notably OK (shorter than International) and the "&" sign.

American morse differs mainly from the International code in the fact that spacing between the elements of individual letters plays a more important part. The ordinary dash is equal in duration to three dots; the space between the elements of most letters is equal to one dot. So far this corresponds to the International Code, but in American morse there are five letters (C, O, R, Y, Z) with double spaces equivalent to two dots. There are also two long dashes; the L symbol is 1½ times the length of T and 0 (zero) is twice the length. All the symbols are shown with their correct relative length and spacing in the accompanying table. Characters that are the same in both the American and International codes are shown in the table by shaded symbols. The code as given here is in the form finally standardised for American internal communications, and has a number of differences from the original version, of which a copy was attached to Morse's application for patent protection in 1837.



In American morse the symbols for certain letters, and also for the "&" sign, contain double-length spaces.

MULTIVIBRATOR ACTION

Principles of Operation

By

EDWARD HUGHES,

D.Sc., M.I.E.E.

THE multivibrator has latterly attained great importance, and much discussion has taken place as to how its principle of action should be presented to students and even as to how it operates, especially as the oscillograms given in several of the most reputable textbooks are misleading and some are incorrect.

It is suggested that the principle of action of the multivibrator should be dealt with after the students have seen the cathode-ray oscillograms referred to below and that the explanation and the derivation of the waveforms should be based upon the waveforms of *anode* currents in the *asymmetrical* multivibrator. These waveforms are easily obtained by inserting additional resistances R5 and R6, as shown in Fig. 1. That these resistances have little effect upon the waveforms can be checked by making R5 and R6 small and using an amplifier stage on the oscillograph. In practice, it is simpler to use values such as those suggested in Fig. 1, thereby avoiding having to switch over from amplifier to "direct" or vice versa when shifting the oscillograph tappings to the circuit.

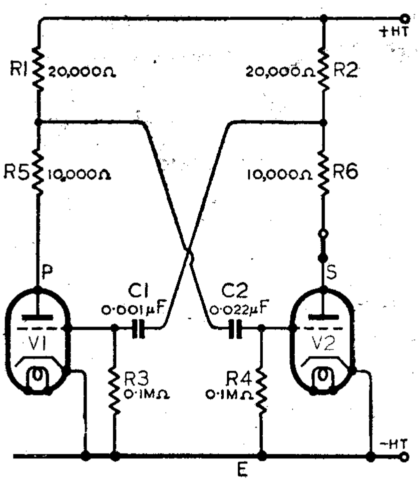


Fig. 1. Circuit of a multivibrator, with additional resistances R5 and R6 inserted.

The oscillograms in Fig. 2 are typical waveforms of the PD's across R5, etc. It is extremely important that the zero axis should be inserted for each oscillogram. This axis can be obtained by merely disconnecting the HT supply.

Let us first assume that the switch S in the anode circuit of V2 is open. Anode current flows through V1; C2 is charged to the PD existing across R5 and V1, and the PD across C1 becomes equal to the voltage of the HT supply. The various PD's are as represented at instant *a* in Fig. 2.

Suppose the switch to be closed at instant *b*. The PD across R2 due to the anode current of V2 reduces the PD across R6 and V2 so that C1 discharges through V2 and R3, making the grid end of R3 negative relatively to the cathode end. Consequently, the anode current of V1 and the PD across R1 are reduced. The increased PD across R5 and V1 sends a charging current to C2, making the grid of V2 positive relatively to its cathode, thereby accentuating the growth of anode current in V2 responsible for starting the cycle of reactions. The latter, though taking long to describe, occur at such a rate that the anode current of V2 increases to its maximum and that of V1 falls to zero simultaneously and practically instantaneously.

The anode current of V1 remains zero as long as the grid of V1 remains sufficiently negative. Owing, however, to C1 being small, it discharges quickly, as indicated by curve L. Also, the PD across PE increases instantly at *b*, and would be equal to the HT voltage had it not been for the voltage drop in R1 due to the charging current of C2.

At instant *c*, the combination of anode and grid voltages on V1 is such as to allow anode current to flow, and the reactions, described earlier, follow one another but in the reverse direction. Hence, the anode current of V1 rises instantly to its maximum while that of V2 falls to zero equally suddenly. Condenser C2 now discharges through V1 and R4; but owing to the time constant of circuit C2—R4 being far greater than that of C1—R3, C2 discharges comparatively slowly. Consequently, the grid of V2 is maintained negative for a correspondingly long time, as shown by curve M in Fig. 2. The shape of M is not quite exponential owing to the variation of the PD across R5 and V1.

At instant *c*, the PD across SE increases almost instantly to that of the HT supply, any delay being due to the charging current of C1 flowing through R2. But since C1 is relatively small, this delay is also small. That the PD across SE during interval *cd* is equal to the HT voltage can easily be demonstrated by opening switch S.

Let us next consider what is happening at V1 during the interval *cd*. From the oscillogram for the PD across R5, we find that at *c*, the anode current suddenly grows to its maximum, as explained above, and then falls to a steady value corresponding to X. This transient effect is due to

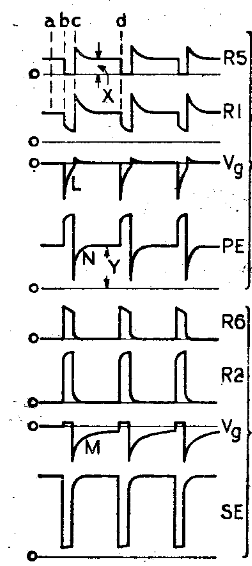


Fig. 2. Typical waveforms as developed by the circuit of Fig. 1.

the corresponding positive potential on the grid of V1 caused by the charging current of C1. As the anode current of V1 falls to a steady value, the PD across PE increases, as shown by curve N, to a steady value Y. That X and Y represent the corresponding values under static conditions can be checked by opening switch S and noting the deflections when the oscillograph is connected across R5 and PE respectively.

At *c*, the positive potential on the grid of V1 is accompanied by grid current of such a value that most of the charging current of C1 flows *via* the grid. Consequently, the corresponding PD across R3 is very small; and owing to the smallness of C1 the latter is quickly charged and the grid-cathode voltage falls to zero accordingly.

At instant *d*, the negative grid voltage on V2 has decreased to such an

Multivibrator Action—
extent that anode current begins to flow in V2, thereby producing reactions similar to those which occurred when switch S was closed.

During interval *bc*, most of the charging current of C2 flows as grid current in V2, so that the grid potential of the latter becomes only slightly positive. Also, during this interval, the PD across SE is comparatively small owing to the large voltage drop in R2 and R6.

It will now be evident that the duration of intervals *bc* and *cd* depends upon the rate of discharge of C1 and C2 respectively. Hence, the frequency of the oscillations is determined mainly by the time constants of circuits C1—R3 and C2—R4; while the asymmetry of the oscillations depends upon the relative values of these time constants. Also, it is seen from Fig. 2 that during the latter part of interval *cd*, valve V1 is operating under static conditions and is just waiting for C2 to discharge until the grid potential of V2 has fallen sufficiently for anode current to commence.

We may summarise the above treatment thus: (1) The anode currents of an asymmetric multivibrator can be drawn roughly as complementary rectangles of unequal widths. (2) When the anode current is zero, the grid potential is negative but decreasing at a rate depending upon the time constant of the grid condenser and leak, and the anode-cathode voltage tends to rise to the HT value. (3) When anode current is flowing, the grid voltage may be slightly positive and decreasing, and the anode-cathode voltage tends to rise to its static value.

European Listeners

Comparative Figures of Radio Density

THE U.I.R. recently issued a synoptic table drawn up by its Geneva office showing the increase in the number of listeners in Europe and the European zone from 1939 to 1941. One part of the graph shows the number of listeners and the other the radio density in the different countries.

Owing to the exigencies of war it is not practicable to draw comparisons between the totals at the end of 1940 and 1941; an examination, however, of the figures for those countries for which they are available showed, with a few exceptions, that the number of listeners continues to grow.

Germany claims the first place with 15,843,144 listeners, the increase for 1941 being 878,096.

Owing to the fact that details of the listeners in the U.S.S.R. were not available, Great Britain, with its 8,625,579 listeners, which is a reduction of 506,621 on the previous year, is second. The U.S.S.R. had 10,551,361 listeners in 1940 and was second in that year.

France, with its 5,262,642 listeners—an increase of 129,607 on the preceding year—takes third place, with Italy fourth, although having only 1,674,546.

Among the less densely populated countries Sweden, with its 1,550,691 listeners, is first. Its increase of 80,316 is remarkable, since it has the highest figure for radio density in Europe. Then comes Holland, one of the few cases in which there is a decrease, its 1,531,791 listeners being fewer by 8.835 than the year before.

Perhaps the most instructive comparisons can be drawn from the radio density figures for some of the countries.

Sweden comes first with 243.4 per thousand, followed closely by Denmark with 233.91 per thousand. They compete with each other for the laurels and it is only two years ago that Sweden succeeded in surpassing Denmark. Commenting on these figures in the *U.I.R. Bulletin*, the secretary of the Union points out that the two countries offer an example of the satisfactory results that may be attained by broadcasting under very different geographical conditions. In Denmark, which is comparatively flat, with no great forests, and where the population is dense, one single long-wave station is sufficient to assure good reception everywhere. In Sweden, on the other hand, with its great distances, its many mountains and forests, and its sparsely populated country districts, a different system had to be adopted; its wide-spreading network contains 33 stations, mostly for local reception only. Both countries show an increase in radio density: 11.50 per thousand for Sweden and 8.48 for Denmark.

Next come Great Britain, with a density of 187.51 per thousand, and Germany, with 177.48 per thousand. This is a decrease of 10.19 per thousand for Great Britain and an increase of 11.21 for Germany.

The total number of receivers in Europe at the end of 1941 is given as 51,794,499, an increase of 2,458,447 over the previous year. With an average of four listeners to each receiver the total number of listeners in the European zone was 207,177,996.

THE WORLD OF WIRELESS

BATTERY SUPPLIES

THE President of the Board of Trade was recently asked in the House of Commons if he was aware of the difficulties experienced by people in country districts in obtaining renewals of batteries for wireless sets and what steps he was taking in the matter.

In his reply, Mr. Dalton said that increased Service requirements had led to a temporary decrease in the number of HT batteries for wireless sets available for the public ; but steps had been taken to secure a substantial increase in production and an improvement in distribution.

Replying to supplementary questions he announced that two new factories would come into production shortly and that he hoped that the output from these would be available early in the new year.

In an endeavour to improve the present method of distribution the Radio and Television Retailers' Association and the Scottish Radio Retailers' Association have, with the approval of the Board of Trade, devised a scheme of voluntary registration for HT batteries.

A window bill displayed by retailers asks battery set users to register before October 30th with their dealer for future supplies of HT batteries. The notice adds: "Whilst we cannot guarantee supplies we will do our best to see that a battery is available when you require one."

It is pointed out by the R.T.R.A. that whilst a retailer "must not make it a condition of sale to a prospective customer that he must be registered with him" he can, "refuse sale from stocks to any customer if such sale would interfere with arrangements made by him for an orderly disposal of stocks among regular customers."

PASSING OF POULSEN

NEWS has been received through devious channels that Dr. Valdemar Poulsen, the Danish wireless pioneer, died recently at the age of 63.

In 1903 Poulsen patented the continuous-wave system of telephony transmission based on Duddell's arc which he improved by placing the electrodes in a chamber containing hydrogen, coal gas, alcohol vapour or other gas of high thermal conductive power. Poulsen arc transmitters were installed at two British Post Office stations.

A VITAL LINK. Men from headquarters with pack transceiver move-up with a battalion of the Queen's Own Royal West Kent Regiment during a recent combined operations exercise when a successful landing on "enemy occupied" beaches was made

AMERICAN VALVE RELEASE

A CONSIDERABLE quantity of American valves, of the types which have for some time been difficult to obtain, are being released through normal trade channels by the Board of Trade solely for replacements in domestic receivers.

After consultation with the Central Price Regulation Committee, the Board of Trade has made an Order (S.R. & O. 1942 No. 1934) which came into force on September 28th, controlling the prices to be charged for these valves, which are imported under the Lease-Lend Agreement with the United States.

Approximately 120 types are listed covering the requirements of midget AC/DC receivers, "all-dry" battery portables, as well as the larger domestic receivers and radiogramophones. Most are of the international octal type, but there is a representative selection of UX valves, including the 43 output-pentode and the type 80 rectifier. Retail prices (including purchase tax) range from 9s. 2d. for simple triodes to 18s. 3d. for power output valves such as the 6L6. Frequency changers average 14s., RF pentodes 12s. 10d., and power rectifiers 11s.

NEW I.E.E. PRESIDENT

IN his inaugural address, delivered on October 1st, Prof. C. L. Fortescue, O.B.E., M.A., the new President of the Institution of Electrical Engineers, pleaded that all engineers should study social, political and economic questions. By doing so, they would be able to play their part in bringing about better social organisation and a better industrial system in the post-war world.

Prof. Fortescue, who is professor of electrical engineering at the City and Guilds College, South Kensington, was, from 1911 to 1922, professor of physics at the Royal Naval College, Greenwich. He has undertaken valuable research in the development of wireless telegraphy and has published his findings in a number of papers read before the Institution.

The retiring president, Sir Noel Ashbridge, Director of Engineering of the B.B.C., announced that Lord Hirst of Witton (Chairman of the G.E.C.) had given £20,000 for the use of the I.E.E. Benevolent Fund.

RECEIVER MAINTENANCE

TWO questions have been raised in the House of Commons during the past month on the difficulties of receiver maintenance.

The Minister of Labour was asked in view of the essential nature of wireless sets in wartime whether he would exempt skilled radio service-men from further call-up in order that they might cope with the large number of sets requiring repairs.

Mr. Bevin, in reply, said: "I appreciate the importance of making provision for the maintenance of wireless receiving sets. Applications for deferment in respect of wireless repairers or mechanics are granted to the extent necessary to ensure adequate servicing facilities in the locality. Men not granted deferment are either called up for the Services in their trade capacity or are transferred to other work in their own occupation."

Subsequently the President of the Board of Trade was asked "whether, in the national interest and by arrangement with the appropriate trades, he would set up official wireless repair shops in each district to which all sections could have access, and where spares, irrespective of make or origin, could be obtainable at reasonable prices or repairs carried out with more expedition than was at present possible." Capt. Waterhouse, the Parliamentary Secretary to the Board of Trade, said that the President had no evidence to show that the existing arrangements did not give as good service to the public as the limited resources of labour and components permitted. He was, therefore, unable to accept the suggestion.

ASPECTS OF MODULATION

AT the first meeting of the 1942-43 session of the British Institution of Radio Engineers, Dr. James Robinson, vice-president of the Institution, delivered a paper on "Aspects of Modulation." He reviewed and compared methods employed to increase the efficiency of our use of the ether, from the point of view of accommodating the greatest number of communication channels in the available spectrum.

Dr. Robinson discussed beam transmission, which effected an economy in a geographical sense; single-sideband transmission, which effected a 50 per cent. saving in the spectrum with a considerable economy in transmission power; and suppressed carrier transmission, which was not suitable for general broadcasting work. He added that he did not think the answer lay in wired broadcasting.

The relative merits of amplitude modulation and frequency modulation occupied the major part of the paper, with special reference to the author's "Stenode" system as applied to transmission and reception; the demodulation of a weak signal by a strong one at the detector was explained in detail.

CANADA'S S-W STATION

FOR many months frequent requests have been made in the Canadian House of Commons for the establishment of a powerful short-wave broadcasting station in the Dominion.

It is now announced that the Government has authorised the Canadian Broadcasting Corporation to erect as soon as possible a high-power station at Sackville, New Brunswick, at the estimated cost of $800,000. The purpose of the station, the proposed power of which is 50 kilowatts, is to provide a means of counter-attacking Axis propaganda.

When the Government Radio Committee were investigating the proposal it was pointed out that the nine short-wave channels allocated to Canada at the 1939 Cairo Conference are now in use by other countries.

N.B.C. LONDON REPRESENTATIVE

THE U.S. National Broadcasting Company recently announced the appointment of Stanley Richardson as director of its London office. Eighteen months ago Mr. Richardson was appointed co-ordinator of international broadcasting, and in that position he represented the six American international short-wave broadcasting companies, acting in a liaison capacity between them and the United States Government. He was granted six months' leave of absence from that post to act as adviser to the U.S. director of censorship on the censoring of material transmitted by short waves.

It is not without significance that Mr. Richardson has had a very wide diplomatic experience, for prior to his appointment as co-ordinator of international broadcasting he had served with the U.S. Embassies in a number of countries.

IN BRIEF

Post-war Television and FM

THE recently re-elected chairman of the U.S. Federal Communications Commission, James Fey, stated that he had the greatest hopes that both television and FM would be important factors in staving off any possible depression in the industry in the post-war years. He further stated "Both the FM and television fields are now set for unlimited commercial expansion immediately after the war. There is already one FM network and the linking of television stations into one or more networks is clearly foreshadowed."

Official News in Morse

ALTHOUGH no changes have been made in the schedule of the transmissions of official news bulletins radiated in morse from the Post Office stations since the last published details, the schedule is repeated for the convenience of those concerned with the reception of the bulletins. The call signs and the wavelengths employed for these transmissions, which are intended for oversea, are:—

GIA:	15.27 m.	GIH:	28.17 m.
GAD:	15.40 m.	GAY:	33.67 m.
GBL:	20.47 m.	GBR:	18,750 m.
GID:	22.13 m.		

The times (GMT) of the transmissions and the transmitters used are:—

0930: GBR, GIA, GID, GIH.
1200: GBR, GAD, GIA, GID.
1600: GBR, GAD, GIA, GID.
1930: GBR, GAY, GBL, GID.
2330: GBR, GAY, GIH.

Servicing Certificates

AN agreement has been concluded between the Brit.I.R.E., the R.T.R.A. and the Scottish R.R.A. for the formation of a Radio Trade Examination Board for the purpose of holding half-yearly radio servicing examinations and awarding certificates.

I.E.E. Meetings

THE chairman of the I.E.E. Wireless Section, Dr. R. L. Smith-Rose, will de-

World of Wireless—

liver a paper jointly with Miss A. C. Stickland, M.Sc., at the meeting of the Section on Wednesday, November 4th, at 5.30 p.m. The subject will be "A Study of Propagation over the Ultra-Short-Wave Radio Link between Guernsey and England on wavelengths of 5 and 8 metres." At the Informal Meeting on Tuesday, November 17th, at 5.30 p.m., a discussion on "Plastics in Radio Production" will be opened by C. C. Last.

Radio-Mindedness

ACCORDING to statistics issued by the National Broadcasting Company, 13,800,000 sets were purchased by Americans during 1941. It is further estimated that there are more than 56,000,000 receivers in use in the country, where 90 per cent. of the houses have receivers. This is stated to be more than twice the percentage of houses fitted with baths!

U.S. Soldiers' Portable

AMERICAN soldiers have been equipped by the Special Service Branch of the U.S. Army with a portable "radio-phonograph-library kit." Each of these kits contains a medium- and short-wave receiver, a gramophone turntable with electric and acoustic pick-ups, 50 gramophone records, 25 half-hour transcriptions of sponsored broadcast programmes and a collection of books. A set of spare batteries and valves is included in the kit which, contained in a wooden case, weighs 25olb. The gramophone is spring-driven and runs for 15 minutes with one winding.

A Hardy Annual

THE *Wireless World Dairy and Reference Book* for 1943, which includes much useful data, is now on sale. Our publishers inform us that supplies are limited and readers are, therefore, advised to obtain their copies without delay from stationers, booksellers, or bookstalls. The price, including purchase tax, is 3s. 1d.

Empire News Bulletin

NEWS in English is transmitted in the B.B.C. short-wave Empire Service at the following times (BST) and in the wavebands listed:—

0200: 31, 25.	1600: 31, 25, 19, 16.
0345: 49, 31, 25.	1800: 31, 25, 19, 16.
0530: 49, 41, 31.	2045: 31, 25, 19.
0715: 41, 31.	2145: 49, 41, 31.
0900: 49, 41, 31, 25.	2245: 31, 25.
1200: 25, 19, 16.	2345: 31, 25.

I.E.E. Premiums

CERTIFICATES for the three Wireless Section Premiums for papers during the 1941-42 I.E.E. session were presented at the last meeting. The Duddell premium (£20) was awarded to O. S. Puckle for his paper "Time Bases." Dr. D. C. Espley and D. O. Walter received the £10 Ambrose Fleming premium for their paper "Television Film Transmitters Using Apertured Scanning Discs." Another £10 premium was awarded to J. E. Thwaites and F. J. M. Laver for their paper "The Technique of Frequency Measurement and its Applications to Telecommunications."

Brit. I.R.E.

L. H. BEDFORD will deliver a paper on "Theory of Units" at the meeting of the Brit. I.R.E. on October 23rd at 6.30 p.m.

Appointments

THE name of Sir Lawrence Bragg, Cavendish Professor of Experimental Physics at Cambridge, and chairman of the Institute of Physics, appears among those of four scientists who have been appointed by the Lord President of the Council to the Department of Scientific and Industrial Research.

Sir Robert Renwick has been appointed to take charge of all questions of telecommunications equipment at the Ministry of Aircraft Production with the title of Controller of Communication Equipment. Sir Robert Watson Watt will assist him and has been appointed vice-controller. They both hold similar appointments at the Air Ministry.

H. J. Allcock has been appointed Director General of Communication Equipment at the Ministry of Aircraft Production. He was formerly process manager in Callender's Cable and Construction Co.

Sir Edward Wilshaw, K.C.M.G., chairman and managing director of Cable and Wireless, has been appointed to the board of Marconi's Wireless Telegraph Company of Egypt, S.A.

Resignation

SIR FRANK SMITH has resigned his position as Controller of Telecommunications Equipment at the Ministry of Aircraft Production, which he has held for the past two years.

Record Salvage

THE closing date of the Record Salvage Campaign organised by the British Legion is advanced to October 31st.

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
America			
WNBI (Bound Brook)	17.780	16.87	2.0†, 2.45‡, 4.0§‡, 6.0.
WRCA (Bound Brook)	9.670	31.02	7 0 a.m., 9.45 a.m.
WRCA	15.150	19.80	2.0†, 2.45‡, 4.0§‡, 6.0.
WGEO (Schenectady).	9.530	31.48	9.45 a.m., 9.0†, 10.55§‡.
WGEA (Schenectady).	15.330	19.57	2.0, 3.0, 7.45§‡, 11.0.
WBOS (Hull)	11.870	25.27	12.45 a.m.†, 12.0 mdt.
WBOS	15.210	19.72	2.0†, 2.45‡, 4.0§‡, 6.0.
WCAB (Philadelphia).	6.060	49.50	6.0 a.m.
WCBX (Wayne) ..	15.270	19.65	11.30 a.m., 3.30, 7.30‡, 9.30.
WCRC (Wayne) ..	11.860	25.30	11.30 a.m., 3.30, 7.30‡, 9.30.
WCW (New York) ..	15.870	18.90	3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0.
WRUL (Boston) ..	11.790	25.45	9.30‡, 11.45§‡.
WRUL	17.750	16.90	3.0‡, 3.45‡.
WLWO (Cincinnati) ..	6.080	49.34	6.0 a.m., 7.0 a.m.
WLWO	11.710	25.62	7.0, 8.0, 9.0, 10.0.
WLWO	15.250	19.67	3.0, 4.0, 5.0.
Australia			
VLQ6 (Sydney) ..	9.580	31.32	8.0 a.m.
VLG6 (Melbourne) ..	15.230	19.69	8.0 a.m.
China			
Chungking	11.900	25.21	2.0, 4.0, 5.15, 10.30.
French Equatorial Africa			
FZI (Brazzaville) ..	11.970	25.06	8.45.*
India			
VUD4 (Delhi) ..	9.590	31.28	9.0 a.m., 1.30, 4.50.
VUD3	11.830	25.36	1.30.
VUD3	15.290	19.62	9.0 a.m.

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
Sweden			
SBU (Motala) ..	9.535	31.46	10.20.
SBT	15.150	19.80	4.0.
Turkey			
TAP (Ankara) ..	9.465	31.70	8.15.
U.S.S.R.			
Moscow	5.890	50.93	11.0.
	6.970	43.04	11.45.
	7.300	41.10	8.0. 9.0, 10.0, 11.0.
	7.360	40.76	11.0.
	7.560	39.68	11.0.
	9.390	31.95	4.0.
	11.830	25.36	4.0, 6.0.
	15.110	19.85	2.15 a.m., 12.40, 11.45.
	15.180	19.76	12.40, 11.45.
	15.230	19.70	2.15 a.m., 11.45.
	15.270	19.65	12.40.
	15.750	19.05	1.0 a.m., 2.0 a.m., 11.45
Kuibyshev	8.050	37.27	8.30.
	13.010	23.06	6.0 a.m., 2.0, 2.45.
	14.410	20.82	2.0, 2.45.
Vatican City			
HVJ	5.970	50.25	8.15.

MEDIUM-WAVE TRANSMISSIONS

Ireland	kc/s	Metres	
Radio Eireann ..	565	531	1.40‡, 6.45, 10.0.

It should be noted that the times are BST—**one hour** ahead of GMT—and are p.m. unless otherwise stated. The times of the transmission of news in English in the B.B.C. Short-wave Service are given at the top of this page.

* Saturdays only. § Saturdays excepted. † Sundays only. ‡ Sundays excepted.

LETTERS to the EDITOR

Player-Piano v. Gramophone

WHILE gratefully acknowledging the tribute to my versatility paid by "Free Grid" in the October issue, I must correct his references to my "too-long-disused pen" and the length of memory necessary to recall my contributions to your esteemed journal. Leading psychologists are well aware of the egoism to which prominent authors are prone, manifesting itself in such ways as reluctance to read any other writings than their own. This may, indeed, be the "psychic factor" to which "Free Grid" himself alludes, and which under the subconscious influence of a sex inversion complex he attributes to a undoubtedly imaginary lady. There may, of course, be other influences, induced by war conditions, which cause "Free Grid" to be unaware that as recently as the previous month I appeared in your pages as a member of the *Wireless World* Brains Trust; while a little earlier I participated in a heated dog-fight on the "Valve Equivalent Circuit."

The theory that "Free Grid" is the victim of grave mental perturbations is strengthened by the nature of the problem which he invites me to consider, namely, the reason for the reproduction of a player-piano being better than that of an exceptionally well-designed gramophone. If "Free Grid" has been less zealous than myself in contributions to paper salvage collections he may be able to check the precise wording of a statement due, I believe, to no less an authority than Sir James Jeans, that "pianist's touch," such an important part of the stock-in-trade of concert promoters, is all bunk, and that exactly the same result is produced whether the sounding of a note on the pianoforte is due to the finger of Moiseiwitsch or the tail of an ape, or even the dropping of an inanimate body on the key from the correct height.

Assuming that the player-piano has been properly designed, therefore, and the record properly made, the result should be indistinguishable from that produced by the same instrument played by the live pianist; and stereophony, scale distortion, and whatnot, do not enter into the subject at all.

On the other hand, a whole chain of processes is interposed between the original performance and reproduction from a gramophone, which as a source of sound normally differs in shape and size from a piano.

"CATHODE RAY."

Classification of Frequencies

UNCERTAINTY often arises over the use of expressions such as "low-frequency waves," "HF waves," "ultra-short waves," since the significance of such terms must always depend to some extent on the context and on the instantaneous state of development of the art. I suggest that greater clarity might be attained by the adoption of a numerical reference system on the lines of, though not necessarily identical with, that given below:—

Frequencies from 1 cycle per sec. (inclusive) to 10 cycles per sec. (non-inclusive): Range 0.

Frequencies from 10 (inclusive) to 100 (non-inclusive): Range 1.

. . . .

Frequencies from 10^6 (inclusive) to 10^7 (non-inclusive): Range 6.

This reference system can be extended whenever technical developments demand it, without a hectic search for "hypers," "supers," etc.

Southall, Mddx. D. LOMAN.

Electrolytic Condensers

YOUR contributor W. H. Cazaly, in his article on "Instruments" in the October issue, implies that the relatively high power factor of electrolytic condensers is due to their leakage current. This is not entirely true, as a simple calculation will show.

Imagine a good quality mica condenser of capacity 10 μF and power factor 0.0003 (a normal value for mica). Now suppose it be shunted by a 5 megohm resistance to give a leak of 0.1 mA at 500 V, as might reasonably be obtained with a 10 μF electrolytic condenser. The effect on the power factor at 50 c/s will be merely to increase it to 0.000364. Even if the condenser be shunted by 50,000 ohms to give a leak of 10 mA at 500 V, i.e. 100 times greater than might reasonably be expected of a good electrolytic condenser, the power factor would only be 0.00667, still only about one-tenth of the normal figure.

Actually, the power factor of an electrolytic condenser is largely due to the series resistance of the electrolyte, which explains why the power factor increases rapidly with frequency.

J. H. COZENS.

Research Department,
Telegraph Condenser Company.

Hearing Aids

THE article in your October issue on "Types of Deafness" gives a broad classification of the physical aspects of

Letters to the Editor—

deafness. While it advocates co-operation with the medical profession it says nothing of the dangers of non-co-operation mentioned in Mr. Jowitt's letter (August) and by "Diallist" (October).

What is the degree of these dangers?

Those who claim that deaf aids should not be distributed through the wireless dealer have still to show that their views are justified by a material number of deaf people being liable to use dangerously unsuitable aids.

The automatic volume control of the ear itself is a safeguard against unexpected and transient noise. I believe that continual exposure to noise of excessive volume will destroy the power of hearing the frequencies used. Can the hearing ever be endangered in this way without the threshold of pain being reached? Does the threshold of pain not warn the patient in the dangerous cases in question?

If it does, the case for restriction of trading rights to "oticians" is gravely weakened, although some such qualification would still be desirable on its merits.

JOHN A. HAMILTON.
Peterculter, Aberdeenshire.

B.S.R.A. Activities

MAY I beg a little space to deny a rumour which has reached me from various sources to the effect that the British Sound Recording Association is now entirely defunct?

Since 1940 it has not been possible to hold any meetings or arrange visits, etc., but the Association still acts as a clearing-house for information on aspects of sound recording by all known systems, and its members maintain contact through correspondence. Reports of any activities and publications have appeared in the technical Press, e.g., *The Electrician* and, through your courtesy, in *Wireless World*. Present research in the field of plastics holds some promising developments for sound-recording media when it is permissible for the details to be released.

All communications should be addressed to me at "Strathdee," Studley Road, Torquay, and, if from a non-member requiring a reply, please enclose postage. If this letter should catch the attention of Member C. L. Appleby (believed R.A.F., number 1258460), please do not fail to get in touch. DONALD W. ALDOUS.
Technical Secretary, B.S.R.A.

RANDOM RADIATIONS By "DIALLIST"

The Wonderful CRT

WHAT a marvellous thing the cathode-ray tube is! And yet, like not a few other wonder-working appliances, it's a perfectly simple affair. Just a combination of heater, cathode, coated grid, anode assembly, a couple of pairs of plates and a fluorescent screen; it's not so complicated in its make-up as some valves. But think of its uses. It is, of course, the heart and soul of the television set, and in the laboratory, besides providing the fastest and most accurate of stop-watches, it has probably done more to further the study of the behaviour of condensers, inductances, rectifiers, detectors, oscillators and amplifiers than any other single instrument. It is one of the good radio service-man's chief standbys, and in the lecture room there's nothing to equal it as a demonstrator of the truth of formulæ and theories. The other day I saw a most elaborate and useful CRT set-up for training purposes. A medium-sized soft tube, giving a trace of considerable brilliancy, was connected to an ingenious and pretty complicated switchboard, which had been built up gradually in five or six years as more and more new uses for the CRT as demonstrator were found.

So Simple!

With this instrument in use there is never any need to draw valve curves on the blackboard—in fact, its originator told me that he had first installed it in self-defence to meet the needs of the moment when the establishment found itself short of blackboard chalk! Tetrode curves? In goes a screen-grid to the valve holder. Flick! And as the heater warms up the anode-volts/anode-current curve spreads over the screen. Flick! The screen-volts/screen current curve takes its place. Put in a pentode, and flicks demonstrate the constant-current properties of this valve. Rectification? In goes a single diode, and first we see the 50-cycle AC input. Then comes unsmoothed output, and, as condensers, resistances and chokes are switched in, the ironing out of the rectified current is convincingly demonstrated. And so it goes on, with almost unlimited possibilities.

Split Beam

Do you, I wonder, know the double-beam CRT? That is an even better instrument for certain demonstration purposes. By means of a splitter plate the horizontal beam is divided into two, so that a pair of horizontal time-bases appear on the screen. The degree of split can be regulated by a knob, and, if you wish, you can use one part of the beam to show a voltage wave-form, and the other to form a horizontal reference or zero line. I used the CRT a good deal before the war, both for valve work and for adjusting my short-wave and broadcast receivers. But I'm determined to use it a great deal more when peace returns, and one of the first jobs I've promised myself when I can get my workshop going again is the making of a top-notch cathode-ray oscilloscope.

Exact Results

To take one example: You remember how in making up circuits we used (possibly after working out impedances and time-constants, possibly not!) to try combination after combination of resistances and condensers until the best result appeared to have been achieved. It was a matter of trial and error, with too much guesswork about it. With the CRO there's no guesswork. You can *see* what you're getting both in and from the circuit. Not only that, but you have a ready and accurate means of determining the quality and the condition of most of the radio components in your stock. If, by the way, you're not *au fait* with the CRT and CRO, and would like to know more about them, there's an excellent and simply written little book, "The Cathode Ray Oscilloscope," by W. E. Miller,* that I can thoroughly recommend.

The Call-up

MR. BEVIN has admitted the importance of maintaining broadcast receivers to the extent of undertaking that deferment of call-up will be granted to service-men when necessary to ensure "adequate servicing facilities in the locality." But he has not promised that no more service-men will be called up, which is, to my mind, somewhat disquieting. Surely there are few enough left already. The needs of the Services must, of course, come first, and there's no doubt that men with a knowledge of radio equipment are required in large numbers. But all three Services have their own training arrangements, which have been working since the early days of the war, and by means of which a steady stream of men (and women) with the necessary specialised training in Navy, Army and Air Force equipment is always flowing in. My own experience, for what it is worth, is that, so long as care is exercised in

*Published by Iliffe & Sons; 2s. 6d.; by post 2s. 8d.

the choice of trainees (and I can assure you that it *is* exercised), it doesn't matter enormously whether or not they had wireless experience in civil life or not. I've mentioned before that some of the best radio men I've come across in the Army had never done more in that way in civil life than the twiddling of the knobs of a broadcast receiver. Now, in wartime it's a matter of extreme difficulty to train men to keep civilian wireless receivers in order, for neither the men to conduct the training nor the facilities for doing it are readily found. It's also of vast importance that the authorities should be able to keep in touch ' with the civil population through the medium of the broadcasting stations. Therefore, I maintain that they should think twice before they thin further the already depleted ranks of those who repair and adjust the receivers of John Citizen.

American Valves Again

'TIS good to learn that the importation of a certain number of American valves of various widely used types is to be allowed again. When the war broke out there were thousands of American sets in use in the country, and as time went on two things happened: their valves wore out and the importation of new ones from the States to replace them was prohibited. The result was that large numbers of these sets either went out of commission or could be re-valved only at very high cost. At one time certain types of U.S.A. valves were selling at several times their cost price. The number of imported valves won't be large, but it will be sufficient to ease the position; and, as prices will be strictly controlled, the cost of replacements should not be too stiff. It may be some little time before supplies find their way on the market, but they'll come along all right, and many a set now silent will find its voice again. Let's hope that one outcome of the war will be not only a thorough purge of our own superabundant valve types, but also a getting together with the United States valve industry for the adoption of similar types in both countries.

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

UNBIASED

By

FREE GRID

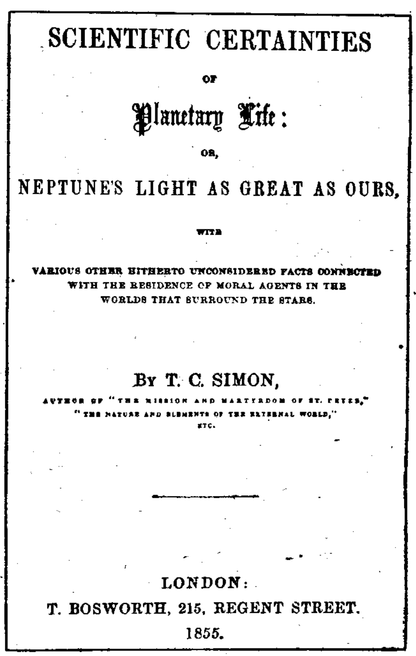
Relativity and Radio

MY recent note in which I endeavoured to bring home the great truth that time and space are infinite has resulted in my being deluged with acrimonious correspondence. Certain so-called scientists who have written —some holding the degree of D.Sc.— do not even seem to have heard of Einstein or Relativity. They question my views that each atom with its extraordinary resemblance to the solar system is in actual fact a solar system with intelligent beings dwelling on its satellite planets or electrons, the conglomeration of atoms which go to make up matter being galactic systems like our own "milky way."

The stumbling block to their apparently finite minds is that each time we smash up such sub-atomic stellar systems as, for instance, when we drop a brick, we suddenly, in the twinkling of an eye, smash up whole worlds and their inhabitants and we are doing this every day. It is quite evident that they neither understand nor appreciate the grandeur of the whole idea of relativity. To the inhabitants of one of these worlds which we destroy, one of our minutes represents countless ages of time. The travel of one of their worlds around its orbit, although taking but a split microsecond to us, represents a full year on the sub-atomic scale.

Similarly, of course, our old earth and the solar system to which it belongs, represents merely an atom of the chalk or cheese of a vast world utterly beyond our comprehension, and the æons during which our world and its inhabitants have slowly and painfully evolved from the primitive nebula which gave us birth represent but the tick of a clock in this mightier world of which we form part, and so *ad infinitum*.

Lest it be thought that we on this earth are a sort of half-way house between these universes consisting of the inconceivably small and the unimaginably large, I would point out that this is impossible since if a thing has neither beginning nor ending, it obviously cannot have a middle or half-way house. Swift undoubtedly had a glimmering of the truth when he wrote "Gulliver's Travels." As will be seen from my illustration, another writer seems to have had somewhat similar ideas to mine nigh on ninety years ago.


SCIENTIFIC CERTAINTIES

OF

Planetary Life:

OR,

NEPTUNE'S LIGHT AS GREAT AS OURS,

WITH

VARIOUS OTHER HITHERTO UNCONSIDERED FACTS CONNECTED WITH THE RESIDENCE OF MORAL AGENTS IN THE WORLDS THAT SURROUND THE STARS.

BY T. C. SIMON,

AUTHOR OF "THE MISSION AND MARTYRDOM OF ST. PETER," "THE NATURE AND ELEMENTS OF THE EXTERNAL WORLD," ETC.

LONDON:

T. BOSWORTH, 215, REGENT STREET.

1855.

Evidence from the past.

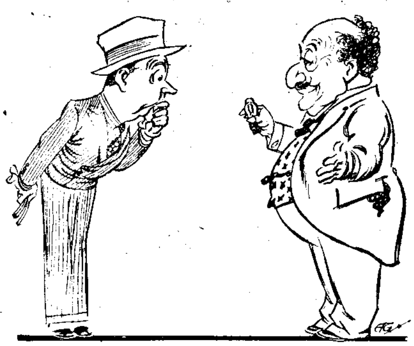
Rampant Radio Ramp

THE radio industry has been singularly free from the racketeering ramps which beset other great industries. It is true, of course, that it has not been entirely free; indeed, at one time "Radio Ramp" was quite a familiar title of a news item in the daily Press. But this, of course, only goes to show how comparatively rare they were. Ramps in other industries have always been so commonplace that they have been on a par with "dog bites man," and did not constitute news. It is only when a man bites a dog, or, in other words, when there is a ramp in the radio industry that it constitutes news worthy of an honourable mention in our great dailies.

Unfortunately, the great valve famine has resulted in one of these rare radio ramps rearing its ugly head. But the racketeers are at least carrying out their project with a degree of finesse well worthy of wireless men, knowing full well that such a blatantly vulgar and unscientific thing as a black market in valves would be entirely out of keeping with the traditions of radio. Their *modus operandi* is delightfully simple.

Supposing, as some of you must have done, you have trudged wearily round to all the radio dealers in search of a valve replacement. You are for the most part met with a sorrowful shake of the head, with here and there an offer to put your name on the waiting list which, like a woman's minute, is practically endless. Suddenly, however, your whole world changes from the drab and dirty grey of Manchester in a November fog to the glory of a "rosy-fingered dawn arising from the wine-coloured sea," as one of "Diallist's" friends so succinctly puts it, and like the same gentleman you cry "Eureka!"

The dealer actually has a valve and, what is more, the price he is asking is no ramping overcharge but the official figure. But the dealer is adamant in his refusal to let you have it unless he has your set in for "test"


"Eureka!"

for, as he very reasonably explains, in these days of valve shortage it would be very unfair to other valve users to risk the precious valve being wasted as would be the case if your set had developed some defect like a broken down smoothing condenser, which spells speedy death to the mains rectifier, that scarcest of valves, rarer than rubies and more precious than pearls.

Now all this may, and often does, happen in the case of a perfectly honest dealer, and it is only when you get the bill for the "test" and "necessary repairs" that you can distinguish between the two, for the racketeers' charge can only be compared in breath-taking nerve with that of the Light Brigade at Balaclava. But don't be misled into condemning an honest dealer for the modest charge he makes for his services. After all, you know, dealers do eat, although I will admit that, judging by the amount of stuff they get to sell nowadays, it is a marvel how they manage to do it.

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

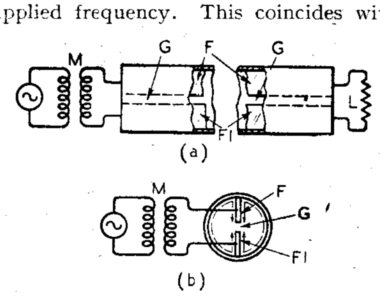
BEAM AERIALS

AN aerial array for producing a highly concentrated beam consists of a number of elements or rods, each several wavelengths long, and each fitted with means for suppressing alternate half-waves, so that the remaining energy is all radiated in phase. The suppressors take the form of quarter-wave sleeves or cylinders which are strung over the main rod at quarter-wave intervals, and are electrically connected to it by a flange, only at their top ends, standing away from the rod for the remainder of their length. Carrier-current flows in the space between the outer surface of the centre rod and the inner surface of the overlapping sleeve, arriving at the bottom of each sleeve in phase-opposition, so that it cancels out. The current then continues along the outer surface of the sleeve and the succeeding "open" quarter-wavelength of the rod, to form a succession of half-wave "loops" of current which slightly overlap along the effective length of each aerial element. This method of suppression is stated to produce comparatively low attenuation losses.

Standard Telephones and Cables, Ltd. (Assignees of A. B. Bailey). Convention date (U.S.A.), January 26th, 1940. No. 543,337.

"MAGNETIC" GUIDE-LINE

THE sketch (a) shows a side-view, with a part broken away, and (b) an end view of a transmission line in which ultra-high-frequency energy is conveyed by a maximum of magnetic flux. In the simple form illustrated the "line" consists of a tubular conductor with two internal fins F, F1, which extend continuously along the length of the line and towards the centre, leaving a uniform gap G between their inner ends. The UHF input M is applied across the two fins, so that oscillations are set up in a plane at right-angles to the axis of the line, as shown by the arrows in Fig. (b). The line carries maximum energy when the capacitive reactance of the gap and the inductive reactance of the metal cross section of the tube are resonant to the applied frequency. This coincides with



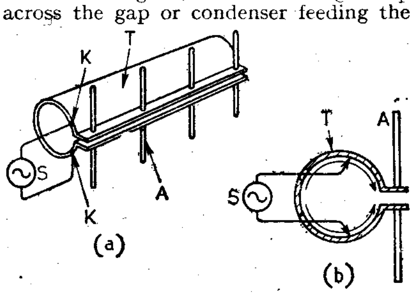
Arrangement for UHF transmission line.

the production of maximum magnetic flux inside the hollow tube. As in the case of a dielectric guide, the physical dimensions of the line determine its efficiency in transmitting currents of a given frequency. The output is taken by a load L connected across the two fins.

Marconi's Wireless Telegraph Co., Ltd. (Assignee of G. L. Usselman). Convention date (U.S.A.), 16th August, 1939. No. 543,334.

FEEDING AERIAL-ARRAYS

A PERSPECTIVE view (Fig. a) and a cross-section (Fig. b) is given of a flanged or gapped tube T acting as a transmission line for an array of dipole aerials A. Power is applied across the gap from a source S. The dimensions of the tube and gap are such that each cross-sectional slice resonates to the applied frequency, as indicated by the arrows in Fig. b, with a voltage loop across the gap or condenser feeding the



USW transmission-line coupling system.

aerials, and a current loop at the section of the line immediately opposite. The characteristic frequency of the line is altered by varying the size of the gap or of the flanges, whilst its impedance is matched with that of the feeder (or generator) by adjusting the position of the tapping points K relatively to the gap. When setting up the installation, the spacing of the aerials may be varied for optimum results.

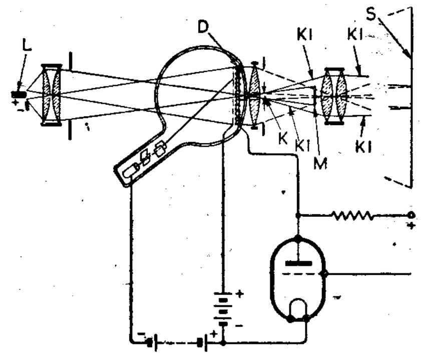
Marconi's Wireless Telegraph Co., Ltd. (Assignees of G. L. Usselman). Convention date (U.S.A.), 19th September, 1939. No. 543,471.

INTENSIFYING TELEVISION PICTURES

THE limitations of the fluorescent screen, both as regards size and brilliance, are avoided by a method of reproducing the picture, on an external screen, by direct projection through a sensitive diaphragm inside a cathode-ray tube from a source of light outside the tube.

The sensitive diaphragm D consists of a thin layer of oil and gum which, under the electrostatic changes produced by the scanning action of a modulated electron stream, is deformed into a series of small lenses.

Normally the layer is homogeneous, and light from an arc lamp L is focused on to a small mirror M which reflects it back again, so that none reaches t[illegible]



Externally projected television pictures.

viewing screen S. The effect of the small lens as formed by the scan[illegible] alters the focusing of the [illegible] system, and allows an i[illegible] formed at the point K, an[illegible] jected by the marginal ra[illegible] the viewing screen S. Af[illegible] jection, the composition [illegible] phragm D is restored to [illegible] by some method of obtu[illegible] second electron stream [illegible] the prevailing static char[illegible]

Ges. zür Forderung [illegible] Hochschule, Zurich. (Switzerland), 8th Nov[illegible] 543,485.

TELEPHONE INTERFERENCE

DIALLING an automatic telephone makes and breaks contacts across a line which includes a source of voltage, and so creates surges of current which, though small, are sufficient to cause interference in a nearby receiver.

The invention provides an eliminator unit which consists of two pieces of metal foil separated by several sheets of pap[illegible] the whole being wound around a sm[illegible] core of permalloy. The assembly is sufficiently compact to fit inside the cover of the telephone dial, where it is connected in shunt across the line. The piece of foil next to the permalloy core acts as the inductance of the filter, and also as one plate of a condenser. The outer piece of foil is the second plate of the condenser, and also serves as an electrostatic shield.

Standard Telephones and Cables, Ltd. (Assignees of A. J. Christopher and F. W. Webb). Convention date (U.S.A.), 29th September, 1939. No. 544,144.

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