Experimental Wireless

A JOURNAL OF RADIO RESEARCH AND PROGRESS

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Experimental Topics.

Transmission Regulations.

Since our last issue went to press we have received a number of communications from many of our readers who possess transmission permits to the effect that the Postmaster-General is considerably revising the conditions upon which they were originally granted. Moreover, the readers in question seem to be very perturbed at the impending changes, and it would be well for us to consider how the new regulations are likely to affect amateur work throughout the country. We would mention first of all the fact that we ourselves have received no official communication from the Post Office, but perhaps, of course, it may not be their intention to inform the technical Press. It appears, however, that the following is the substance of some of the more important clauses :

(1) Spark transmission to be forbidden.

(2) Wave-lengths of 150-200 and 440 (C.W. and telephony only).

(3) The wave-length of 440 metres not to be employed between 5 p.m. and 11 p.m., or on Sundays during the British Broadcasting Company's programmes.

(4) Messages shall be transmitted only to stations in Great Britain or Northern Ireland, who are actually co-operating in definite experiments.

(5) A record of all transmissions must be kept, giving complete details.

As a result of a very careful scrutiny of one of the "new permits," we feel that the Postmaster-General has framed his regulations upon the assumption that the average transmitting amateur wishes to transmit "for the fun of the thing," and is rather prone to regard amateur transmission as a hobby and amusement upon the same footing, perhaps, as golf, tennis, or even philately. We are obviously not in a position to determine exactly the technical ability of the average amateur, but we can definitely say that there are many men throughout the country of undoubted technical ability. On the other hand, there is also very definitely a large body of amateurs who (to use an Americanism) are nothing more than "hams." They transmit with the idea of sending messages. Their very language is an incomprehensible jargon of codewords, letters, figures, abbreviations, and cruelly murdered King's English, which is supposed to represent the result of their "scientific experiments." It is surely obvious that so long as this type of amateur continues to thrive, he does so as a menace to the freedom of the serious experimenter. The Postmaster-General is naturally liable to be influenced by a majority, and it is plainly the duty of the serious experimenter to raise a very strong objection to the continuation of these perfectly futile transmissions. There is no doubt that the present regulations are certainly more severe than the preceding ones, and may be taken as an omen of what is likely to follow unless every serious experimenter puts his case before the authorities concerned. We have every reason to believe that the Postmaster-General is perfectly willing to give the serious experimenter as much freedom as possible; but, at the same time, it must be remembered that it is very difficult to make one rule for one and another rule for another. We ourselves feel that perhaps the Postmaster-General has been a little too lenient in granting permits. While we hold the view that the amateur should be given every facility for the study of transmission problems, we think that a higher technical standard should be demanded before authority is given for the use of a radiating system. The really scientifically inclined beginner would not raise the slightest objection to the use of an artificial aerial until he had learnt sufficient of the subject to warrant the use of a radiating system. Such a scheme as this would obviously raise the general technical standard amongst the transmitting amateurs, and, no doubt, the Postmaster-General would then have every confidence in granting greater facilities. The regulations as they now stand certainly impose a number of restrictions which are liable to hamper experimental work. Why, for example, is an experimenter, having devised a new form of quenched gap, to be prevented from trying it out. Presumably he has to suffer because many amateurs now possessing permits would not have the vaguest notion of how to tune a spark transmitter, and *might* cause interference. Why, also, is transmission to be confined to the British Isles? Possibly to remove the temptation to exceed the licensed ten watts on the part of an ignorant amateur whose apparatus is so appallingly inefficient that it cannot send to the Continent on even twice that power. And, again, why is the serious experimenter to waste half his spare time by recording in a log book such entries as: "11.42 p.m. Increased anti-regenerative coupling 5 per cent," or "Cut down drive feed by 10 milliamps." Once more, we suppose, to enable the authorities to locate easily some badly-adjusted station which is, perhaps, 20 per cent. off the correct wave-length.

We earnestly hope that the experimenter will fully realise the seriousness of his present position, and we strongly advise him, in his own interests, to show the authorities that he is strongly opposed to the promiscuous use of the æther merely for purposes of amusement. We have no doubt whatever that he will receive a welcome hearing.

The Month's DX.

It will be noticed that this month we have discontinued the regular transmission reports which have appeared under the heading of "The Month's DX." This does not mean in any way that we are going to eliminate the subject of amateur transmission, but merely that we propose to deal with it in a slightly different manner. Formerly, the reports have simply comprised a log of amateur work throughout the country, and while being of interest, have been of little help to other transmitters. In future we shall give, under the heading of "Amateur Transmission," details of definite experiments which have been carried out. We trust that not only those whose names have appeared regularly, but also many others, will assist us by sending in reports of their transmissions. The report should give details of the object of the experiment, the results obtained, and the conclusions which are drawn, together with full technical data. In this way it is hoped that the columns may be made of greater value to all interested in the subject.

The Experimental Laboratory.

As our readers are aware, for the past nine months a certain section of our experimental laboratory has been devoted exclusively to the free calibration of instruments and apparatus. Commencing with this issue, we propose to make some slight alterations in this direction with a view to making the laboratory of even greater value. From time to time articles have appeared in EXPERIMENTAL WIRELESS which have been the direct outcome of experimental work conducted in the laboratory. The appreciation extended to these articles has decided us to devote more time and space to similar experimental work, and in order to do this, we are obliged to restrict our calibration service to a certain degree. What we have arranged to do, therefore, is to limit the free calibration to our annual subscribers, and we draw their attention to the revised calibration coupon and conditions of service which will be found elsewhere in these pages.

The Prevention of Interference Between "Wired-Wireless" Circuits and Wireless Stations.

By E. M. D. (*International Western Electric Co. Inc.*)

No doubt many readers are familiar with ordinary "wired-wireless" systems. but it is thought that some details of the methods which have been devised to eliminate interference from wireless stations should be of interest.

It is now a well-known fact that an aerial telephone line is not used to the fullest possible extent when carrying the voice-frequency currents corresponding to one telephone conversation, or even when it is used at the same time to carry telegraph currents. The telegraph uses frequencies from 0 to about 100 cycles, the ordinary telephone from 200 to about 2,000 cycles. It is possible to use the frequencies from 5,000 to, say, 30,000 cycles to carry additional messages. For each channel there is one "carrier" frequency which is modulated by the voice currents or by the telegraph relay. The modulated currents are sent over the line, selected according to their frequency at the receiving end, demodulated, and thus used to reproduce the original currents.

The telephone and telegraph channels using "wired-wireless" are designed to be practically free from mutual interference and from interference due to other "wired-wireless" circuits and ordinary telephone and telegraph circuits. Furthermore, the wired-wireless circuits are relatively free from ordinary interference from power circuits because of the high transmission frequency employed.

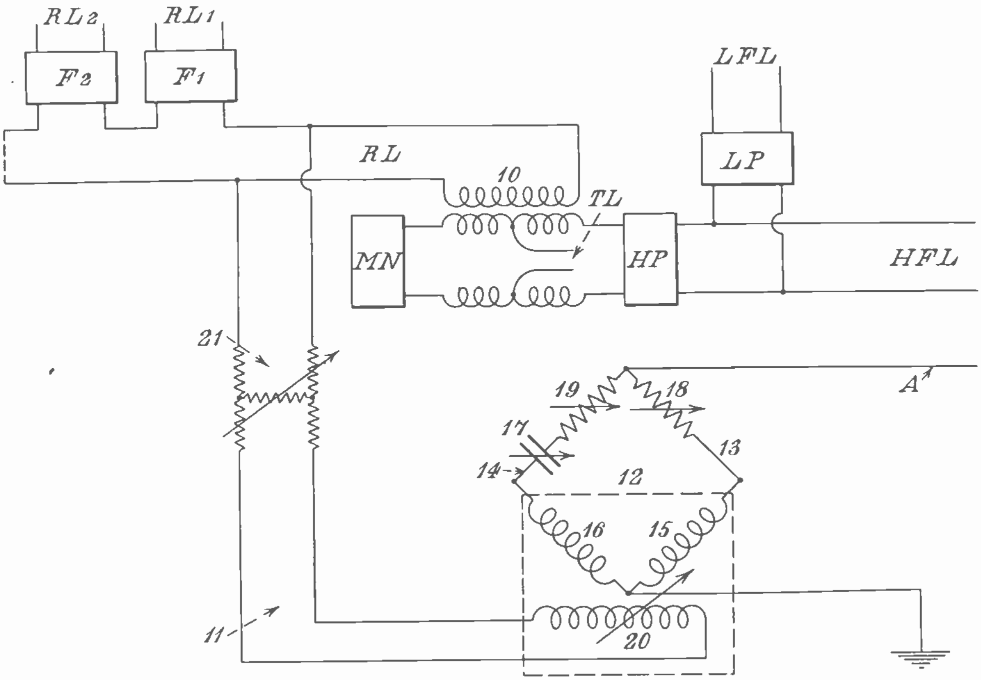


Fig. 1.—A System in which the Phase and Amplitude of the Balancing Potential may be Controlled Independently.

On the other hand, a certain amount of

interference is experienced from "statics" or atmospheric electrical effects, as observed in radio reception. This interference varies in amount from time to time, and is usually greatest in the summer months. There is, finally, a possibility of interference from high-power radio stations which use frequencies in the upper end of the carrier range. This may be serious where the wired-wireless line comes within 50 miles or so of the radio station.

It is, however, possible to balance out the radio interference in a wired-wireless circuit, and we propose to show a few methods of attaining such results.

It is necessary, when attempting to balance out the radio signals, to impress upon the wired-wireless line a signal of equal amplitude and opposite phase to the interfering signal. Some difficulty has been experienced in obtaining the proper balance, due to the fact that the adjustment of the balancing potential must be made in phase and amplitude. The circuit shown in Fig. 1 provides a system in which the phase and amplitude of the balancing potential may be controlled independently of each other. The circuit used for wired-wireless divides into a low-frequency line and a high-frequency line, the selection being obtained by means of a low pass filter LP and a high pass filter HP. The high-frequency equipment comprises a transmitting circuit TL and a receiving circuit RL. The separation between incoming currents and outgoing currents is obtained by means of a specially balanced high-frequency transformer TL, the balance being obtained by proper adjustment of the balancing network MN.

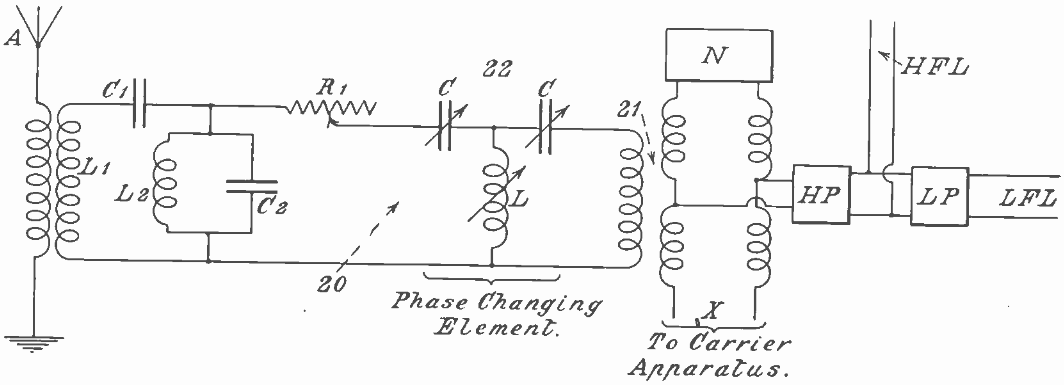


Fig. 2.—A System for the separate Adjustment of Phase and Amplitude.

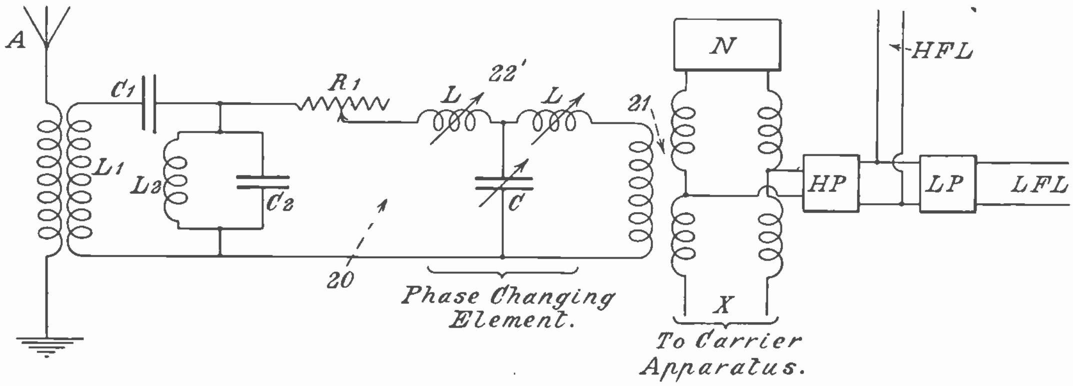


Fig. 3.—The Use of a Low Pass Filter as a Phase-charging Device.

The various high-frequency receiving channels, such as RL_1, RL_2, etc., are associated with the receiving circuit RL through suitable filters adapted to select the range of frequencies assigned to each receiving channel.

Let us assume that the main high-frequency line is subject to interference from a radio station employing a frequency within the range of one of the receiving channels—for instance, the channel RL_2. It is apparent that the interfering radio-frequency will be transmitted to the receiving channel RL_2 in the same manner as the modulated high frequency corresponding to this channel.

In order to balance out the interfering frequency a radio antenna A is provided which absorbs from the distant radio station the same radio signals as are impressed upon the line HFL, and this frequency may be impressed upon the channel RL_2 through the circuit 11 in opposite phase relation, but with the same amplitude as the interfering potential.

In order to adjust the phase angle, a rotary field phase adjustment is provided. This arrangement comprises two branch circuits 13 and 14, including suitable field windings 15 and 16 for producing the rotary field. In circuit with one of the windings, such as, for example, the winding 16, is a capacity 17, and in each of the branches resistances 18 and 19 are provided. Since the capacity 17 is included in one of the branches and not in the other one, the component of the frequency received from the antenna flowing through the winding 16 will be out of phase with the component flowing through the winding 15. The resistances 18 and 19 may be set so that both components have the same amplitude. Consequently, the two components energizing the two field windings 15 and 16 will produce a rotary field, which rotates at the frequency of the electromotive force impressed upon the antenna A.

A third winding 20 is placed within the field of influence of the windings 15 and 16, and by merely shifting the angle of the coil 20 with respect to the field of the coils 15 and 16 any desired phase angle may be obtained for the induced electromotive force in the circuit 11.

The amplitude of the induced electromotive force may be adjusted by means of series and shunt resistances 21, as indicated, the series and shunt resistances being adjustable together, so that, as the series resistance is increased, the shunt resistance is decreased, and *vice versa*. Under these conditions the impedance of the circuit 11 viewed from coil 20 will be constant.

The circuit described will, in consequence, provide a means of separately adjusting the phase and amplitude of the current. The phase adjustment may be made first by listening in the receiving circuit RL_2 and adjusting the position of the coil 20 until the interference is reduced to a minimum. The amplitude is then adjusted until the interfering disturbance can no longer be heard in the channel RL_2. The latter adjustment will not disturb the phase angle, and accurate balance may be obtained without difficulty.

The separate adjustment of phase and amplitude may be obtained in a somewhat different manner, which will be described now.

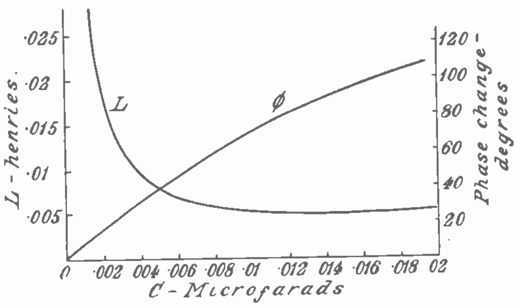


Fig. 4.—The Curve corresponding to Fig. 2.

The transmission line terminates in a manner similar to that described previously. Referring to Fig. 2, it will be seen that the circuit 20 associates the antenna A with the carrier branch X through a balanced transformer 21, so arranged that potentials from the antenna A will be impressed upon the carrier branch X, but will not be transmitted back through the high-pass filter HP to the high-frequency line HFL. The circuit 20 is tuned by means of an inductance L_1 and a capacity C_1 to the radio frequency producing the interference, and a shunt and a resonant combination comprising an inductance L_2 and capacity C_2 is bridged across the circuit 20 to shunt out other frequencies than the particular frequency which it is desired to use for neutralising purposes.

A single section of a high-pass filter 22 is included in the circuit 20 for producing phase changes in the balancing electromotive force, and an adjustable resistance R_1 is also included in the circuit 20 for adjusting the amplitude independently of the phase-changing arrangement 22. The high-pass filter section 22 comprises series capacities C with a shunt inductance L bridged across the circuit at the junction point of the two capacities C. By adjusting the values of the capacities alone, or making suitable adjustments of both the capacities and the inductance, phase adjustments may be made

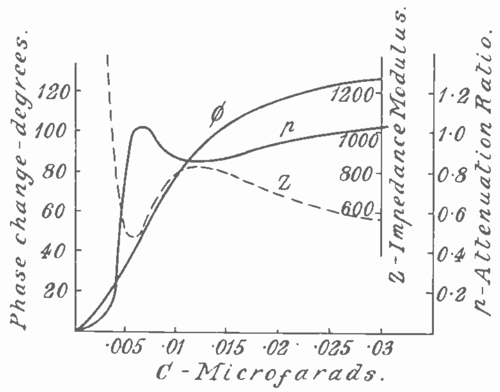


Fig. 5.—Characteristics of the Filter Section as Phase Changer.

without producing any change in amplitude. While this result may appear to be somewhat unusual, when it is remembered that a high-pass filter is substantially non-attenuating with respect to frequencies lying within its range, the reason for the result becomes more apparent.

In making phase adjustments by means of the high-pass filter 22 the inductance and capacity elements will be varied in steps, but the two condensers should be kept equal to each other. The relation between the inductance and capacity is given by the formula :—

$$L = \frac{1 + R^2 C^2 w^2}{2 Cw^2} \quad \dots\dots\dots\dots\dots\dots \quad (1)$$

in which w represents 2π times the frequency. The relation of this formula is derived on the assumption that, when one side of the network is terminated in a resistance of R ohms, the impedance, looking into the other side of the network, will also be R ohms non-inductive. The phase change due to the network is given by the formula :—

$$\varphi = \tan^{-1} \left[\frac{R}{Lw - \frac{1}{Cw}} \right] \quad \dots\dots\dots\dots \quad (2)$$

Curves computed in accordance with formulæ 1 and 2 are illustrated in Fig. 4, for the case in which the frequency whose phase angle is to be changed is 19,000 cycles, and the impedance of the circuit looking into the transformer 21 from the filter is 600 ohms. In Fig. 3 the curve designated L is the value of the inductance corresponding to each capacity setting of the capacity C of the filter 22. The curve marked ϕ shows the phase change for each adjustment of the capacity C, the inductance L, of course, being correspondingly adjusted. It will be seen that by varying the capacity from ·002 microfarads to ·02 microfarads the inductance L will be adjusted from about ·018 henries to about ·005 henries, and a phase change of about 90° will be obtained. The amount of this phase change may be increased as indicated by the curves by further increasing and further reducing the capacity. This may not be practical, however, as further increase in the capacity does not tend to produce a corresponding change in phase, while the smaller values of the capacity involve very sudden increases in the amount of inductance. Consequently, where phase changes materially greater than 90° are desired it may be necessary to use two filter sections in series to obtain the desired phase change.

It will also be noticed in the curve L of Fig. 3 the value of the inductance does not change materially over a very considerable variation in the values of the capacity of the filter, the curve L being almost flat through a large part of its range. This at once suggests that the network may be simplified by maintaining the inductance constant and only adjusting the two capacities. The curves of Fig. 5 illustrate the characteristics of the filter section as a phase-adjusting system for a frequency of 18,750 cycles with a terminal impedance of 600 ohms and a non-adjustable shunt inductance of ·006 henries. The curve marked ϕ indicates the phase change corresponding to different values of capacity. The curve marked p represents the variation in ratio of the current flowing into the 600-ohm impedance with the filter in circuit to the current which would flow into the impedance with the filter removed. Obviously, if the filter introduced no attenuation at the frequency under consideration, this ratio would be unity. An examination of the curve p' shows that for a capacity range from about ·0055 microfarads to somewhere over ·03 microfarads this ratio does not depart excessively from unity, and consequently the phase adjustment over this range may be obtained without material change in amplitude of the current. The phase change corresponding to this change in capacity runs from approximately 35° to approximately 125°, a total phase change of about 90°. It is not practical to make adjustments outside of the range indicated, for an increase in the capacity does not produce any substantial phase change, while a decrease in the capacity below the value ·0055 produces a very marked increase in attenuation and also results in a very sharp increase in the impedance of the filter, as indicated by the dotted line curve Z. Where phase changes greater than 90° are desired it is best that two filter sections in series should be used, so that the first section will shift the phase 90° and the second section by a corresponding adjustment will shift it 90° further.

Fig. 3 illustrates a modified circuit in which a low-pass filter section 22′ is used as a phase-changing element. The other features of the circuit for balancing out interference are the same as those of Fig. 2 and need not be described. The filter section comprises a shunt capacity C connected to the mid-points of two half-section inductances L. The inductances should be kept equal to each other, and the relation between inductance and capacity for different adjustments of the filter is given by the formula :—

$$C = \frac{2L}{R^2 + w^2 L^2} \quad \text{.................. (3)}$$

The phase change due to the network is given by the formula :—

$$\varphi = \tan^{-1}\left[\frac{2RwL}{R^2 - W^2 L^2}\right] \quad \text{............... (4)}$$

The characteristics of this type of filter as a phase-changing system are shown by the curves of Fig. 6 for the case of a frequency of 18,750 cycles and terminal impedance of 600 ohms. In Fig. 6 the curve L gives the values of inductance corresponding to different values of the capacity, while the curve marked ϕ indicates the phase change corresponding to each capacity value. The type of filter employed in Fig. 2 involves only one variable condenser instead of the two necessary for the high-pass type of Fig. 1, but in this case a fixed inductance cannot be used as the inductance varies materially for each material change in capacity, as indicated by the curve L. There is no part of the curve in which the inductance stays reasonably constant over a range of capacity changes. This type of filter, however, has the advantage that a greater phase change is obtained with a single section of the filter, so that in most cases it would not be necessary to use two sections. For example, if the inductance be varied from zero to ·014 henries, a phase change from zero to 140° will be obtained. The capacity will be varied from zero to a maximum of slightly over ·014 microfarads, and from this maximum point the capacity values fall off with further increase in inductance to a value of about ·009 microfarads.

If desired the inductances L in the filter section 22′ of Fig. 2 may be so wound as to have a certain amount of mutual inductance. In general, no advantage will be gained by this, however, as a greater phase change per section is possible when the mutual inductance is zero.

In the arrangements of both of Figs. 2 and 3 the filter sections may be adjusted

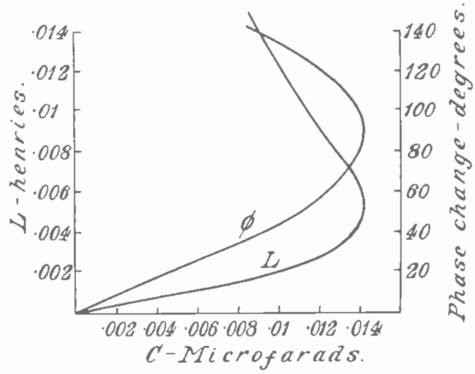


Fig. 6.—Characteristics of the Low Pass Filter.

to produce the desired phase angle for the balancing component without producing any material change in the amplitude of the current, as the filter section is approximately non-attenuating. Adjustments in amplitude may be made by a simple series adjustable resistance R_1 included in circuit 20. Variations in the resistance R_1 will produce little or no effect upon the action of the filter section as a phase changer. Consequently, the phase and amplitude of the current may be independently adjusted.

A second method of preventing the interference due to a radio station on high-frequency wire circuits originates from the following considerations :—

The interfering frequencies on the wire circuits are due to potentials induced in the two sides of the transmission circuit in parallel. Ordinarily it would not be expected that such potentials would affect the receiving apparatus which is in bridged relation with respect to the line. However, in practice the two sides of the line are not exactly alike, so that some unbalanced results and a current is permitted to flow through the bridged receiving apparatus owing to a difference in the two interfering potentials on the two sides of the line.

In the present method it is proposed to balance out the interference by obtaining a current derived from the interfering potentials impressed upon the two sides of the circuit in parallel and impressing the derived current serially upon the circuit in opposite phase relation, but with the same amplitude as the serial disturbance flowing through the bridge.

The circuit used is shown in Fig. 7, where HFL and HFL′ designate two carrier transmission lines, which have similar characteristics and are subject to similar interference from a radio-transmitting station. The lines HFL and HFL′ terminate in the same manner as that described in connection with the previous method of interference elimination.

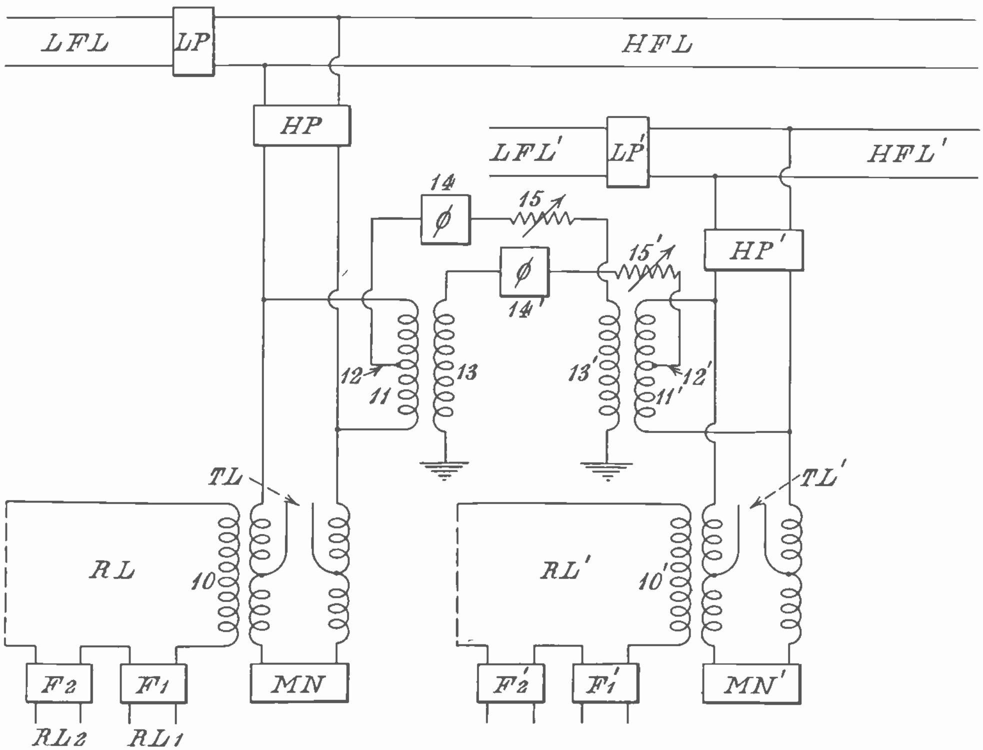


Fig. 7.—A Practical Circuit Used to Balance Out the Interference.

The interfering radio frequencies from a distant radio station may be impressed upon both the high-frequency lines HFL and HFL′ and will be transmitted to the individual receiving channels of each line which have assigned to them a range of frequencies corresponding to the interfering frequencies.

These interfering frequencies are impressed in parallel on the two sides of both high-frequency circuits, as for example the high-frequency line HFL, but due to unbalance of the two sides of the circuit a series component results which will be transmitted through the transformer 10 to the corresponding receiving channel to produce the interference above referred to. In order to balance out this component an inductance comprising a winding 11 is bridged across the carrier terminal circuit of the high-frequency line HFL, this winding having a very high impedance so as to produce but very little shunting effect with respect to the series carrier frequencies transmitted over the line HFL when used for ordinary wired-wireless transmission purposes. A tap 12 is taken from the midpoint of the inductance 11, and as the two halves of the inductance oppose each other with respect to the tap 12, it will be apparent that the disturbing potentials flowing in parallel from the two sides of the circuit HFL will pass into the tap 12 without being materially impeded by the inductance 11. The tap 12 includes a winding 13 inductively related to an inductance 11′ bridged across the carrier circuit associated with the line HFL′ in a manner similar to that of the inductance 11 already described.

The phase angle and amplitude of the currents flowing in the tap 12 may be controlled by the phase-shifting device 14 and the adjustable resistance 15 respectively, so that the currents flowing in the tap 12 may be adjusted as regards phase and amplitude so as to impress upon the carrier terminal of the circuit HFL′ through the inductance 11′ a potential equal in amplitude but opposite in phase to the disturbing component from the distant radio station. Similarly, by means of a tap 12′ from the midpoint of the inductance 11′ and leading to ground through a coil 13 inductively related to the inductance 11, the disturbing components flowing over the sides of the line HFL′ in parallel may be impressed upon the carrier circuit of the line HFL in series to neutralise the series disturbing component impressed upon the latter line. A phase shifter 14′ and an adjustable resistance 15′ will, of course, be used to obtain the desired phase and amplitude for the balancing potentials.

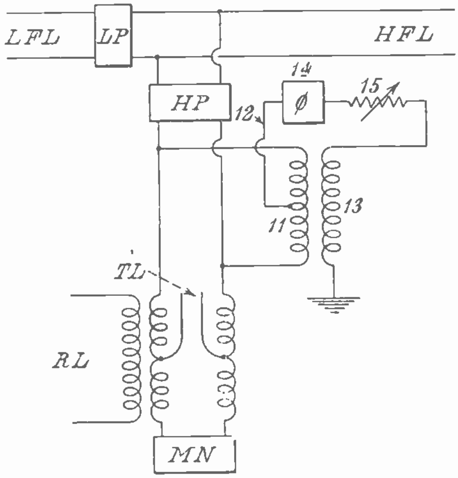


Fig. 8.—An Alternative Balancing System.

Instead of using potentials obtained from one line to balance out disturbing potentials upon another line, the balancing potential may be obtained from the disturbed line itself in the manner indicated in Fig. 8. In this case the ground tap 12 is taken from the midpoint of the inductance 11 as before, but it is connected to the coil 13 inductively associated with the inductance 11 of the same line, instead of a coil, associated with an inductance of another line. The disturbing components flowing in parallel over the sides of the line HFL will pass into the

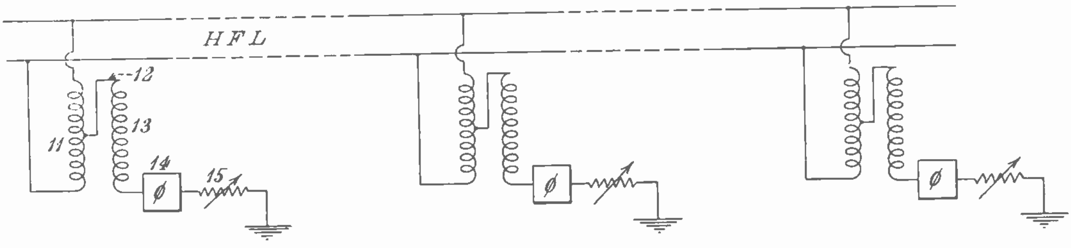


Fig. 9.—The Use of Compensating Devices at different Points along a Line.

ground tap 12 without producing any effect upon the inductance 11 which is balanced with respect to the parallel components. These components, in passing through the ground tap, will be adjusted as to phase and amplitude by the devices 14 and 15, and will then be impressed through the primary 13 upon the inductance 11 in such a manner as to cause a series component in the carrier branch of the line HFL. This series component will, of course, be adjusted to balance out the disturbing series component due to unbalance between the two sides of the line HFL.

Instead of arranging compensating devices at the terminal station, such devices may be located at different points along the line as indicated in Fig. 9 for the purpose of balancing the disturbing potentials before transmission to the terminal station. Each of the compensating circuits in Fig. 9 may be similar to those shown in Fig. 8 comprising a bridged inductance 11 with a tap 12 taken from its midpoint and leading through a primary 13 inductively related to the inductance 11 and also through a phase shifter 14 and through amplitude changing devices 15.

The Screening of Radio Receiving Apparatus.

By R. H. BARFIELD, M.Sc., A.C.G.I.

WIRELESS experimenters cannot advance very far at the present time without encountering the necessity for screening in some form or other. Possibly they will first meet with the problem in connection with multi-stage amplifiers for which judicious screening offers a means of obtaining increased stability by avoiding unwanted retro-action. Later, if they take to more serious work they will wish to make measurements in connection with the various phenomena which they observe. They will then find that it is often necessary to ensure that all parts of their circuits, save the aerial or receiving loop, are screened from the

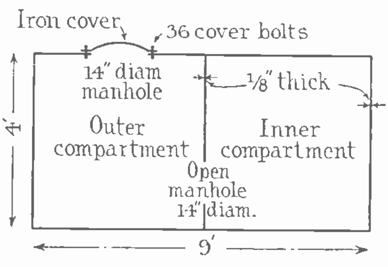


Fig. 1.—Iron Tank used in the First Experiment.

direct action of the waves. Finally, should it be necessary for them to instal their apparatus in the neighbourhood of conducting objects, such as metal buildings, electric cables or wires, etc., they will wish to know to what extent such things will affect their instruments and will therefore be interested in screening from yet another point of view.

The object of this article is to describe some experiments on screening* which bear on these problems and to discuss the results from a simple theoretical point of view and thus to draw conclusions which it is hoped will be of use to those engaged in wireless experimental work.

Principles Underlying Screening Action of Conductors.

The simplest way of screening a piece of apparatus from electric waves is to place it inside a metal box so that it is totally enclosed. For owing to the well-established fact that good conductors are practically opaque to wireless waves, it is clear that by making the sides of the box thick enough and entirely free from cracks or other openings, the protection of the interior can be brought to any desired degree of perfection.

Though perfect screening can only be attained in the manner described above, it may be said in general that any conductor

* The experiments here described constitute a selection of those of most general interest from a detailed investigation of screening phenomena. See *Journal Institute of Electrical Engineers*, Vol. 62, No. 327, pp. 249-264, March, 1924.

or system of conductors has a screening action in its immediate neighbourhood. For, when a conductor is acted upon by the alternating fields which constitute a wave, currents are set up in it which create by induction secondary fields in its neighbourhood. Thus at such points we have two fields existing at any instant: (1) the main field as it would be in the absence of any screen, and (2) the secondary field due to the currents set up in the screen by the main field. A little consideration will show that in general, with waves much longer than the dimensions of the conductors employed, these two fields are in opposition, so that the resultant of the two fields is less than the main field. It is this fact which constitutes the screening action of the conductor.

This is indeed the simplest way of regarding all kinds of screening, including that of the closed box already referred to in which particular case the secondary field inside the box is almost exactly equal in magnitude to the main field so that the resultant field is almost zero. Although, as will now be seen, the principles underlying the screening action of a conductor are extremely simple, it is generally a comparatively difficult matter to calculate the exact effect of a screen of given construction. The experiments about to be briefly described were therefore carried out for the purpose of finding out the effects of screens of various simple kinds obtaining as far as possible actual measurements. It is thought that the results have brought to light some interesting facts and moreover are very suggestive of possible new commercial uses for some of the screens experimented with and, further, that a field has been opened up for some further experimenting on the same subject.

Wireless Receiver in Tank.

In this experiment a wireless receiver consisting of a frame coil and multi-stage amplifier was set up inside an empty oil tank, as shown in Fig. 1. The tank was provided with a single opening just large enough to admit the operator and the frame coil which, however, had to be collapsible for the purpose. The interior of the tank was divided into two compartments by means of an inner partition also provided with a small opening.

In the outer compartment and with the man-hole open, the operator, with his set, was able to pick up signals from Paris (spark) and also from a small tuned buzzer situated close to the tank and outside it. The manhole cover was then put in place and screwed on by means of 36 bolts round its circumference. Signals from Paris could be picked up until the last of the bolts was in place when this station was no longer audible but

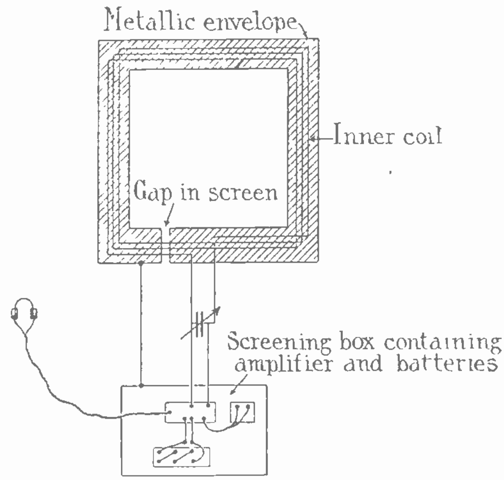


Fig. 2.—Screened Loop showing Gap.

signals from the buzzer could still be heard at good strength. When, however, the operator with the complete set retired into the inner compartment, neither buzzer nor signal of any kind could be picked up even though both manholes were left open.

Although perhaps this experiment may be considered rather crude it emphasises at least two important points with regard to screening in general, the first being that it is extremely difficult to close up an opening in a screen so as to prevent the entrance of energy, for there is no doubt that all the energy detected inside the tank must have passed through the imperfect joint between the cover and the tank, while the second is that the most effective way of attaining a high degree of screening is to employ a screen within a screen, as in the latter part of the experiment, when the screening was apparently perfect.

Receiving Loop with Screened Sides.

The next experiment attempted was one of considerable interest; the sides of a frame coil 2′ 6″ square were completely encased in a metallic envelope made of tinned iron and in the form of a pipe of rectangular section (about 6″×3″). The leads from the coil were brought through two small holes in the envelope and connected to a sensitive amplifier contained in a metallic box. With the coil so screened, as was indeed expected, no signals whatever could be picked up. The envelope was next sawn completely through at the centre of one of the sides as shown in Fig. 2, a piece of wood being inserted in the gap to prevent the two ends from springing together and thus making contact. When the coil was again tested it was found to be quite an efficient receiver and stations many hundreds of miles distant could be picked up. A rough measurement showed that its efficiency was at least 50 per cent. of its normal amount. The size of the gap could be varied from the smallest obtainable crack to a width of several inches without any alteration in the strength of signals. Since only an entirely inappreciable amount of energy could penetrate the envelope itself, it is clear that practically all must have

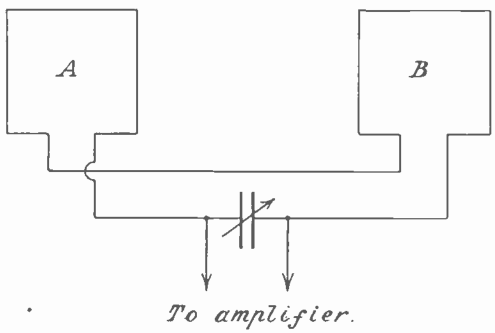


Fig. 3.—Method of Measuring Effect of Screen.

passed through the gap in order to get to the coil within—a further instance of the extreme importance of avoiding cracks in screens.

Unexpected as this result appears at first sight, a logical application of the simple principles of screening will be found to predict it. For, considering the case of any unscreened loop receiver we know that the signal strength obtained is proportional to the amount of magnetic flux due to the wave which links with the coil. To screen such a coil then it will be necessary to arrange a conductor so that the currents set up in it by the wave produce a secondary magnetic field in opposition to the main field and as nearly as possible equal to it in strength. Now a simple calculation shows that the envelope, forming a continuous circuit round the coil as in the first arrangement, will produce just such a field, but if we interrupt the continuity of the screen by a gap as in the second case the currents in the envelope and therefore the secondary field will drop to a negligible amount and there will therefore be no screening. The theory, then, is in entire agreement with the experiments. Nevertheless it must be admitted that it does not in this simple form give a satisfactorily physical explanation of the phenomenon as it is still not clear how the energy gets through the gap.

Method of Measuring the Effect of Screens.

In order to measure the effect of various screens a very simple apparatus was devised. This consisted of two frame coils A and B, connected so as to oppose one another as shown in Fig. 3, but so separated as to avoid any mutual interference; one of these coils (A) could be fixed either outside or inside the screen under investigation, while the other (B), which was made to rotate on a vertical axis and provided with a scale and pointer, remained outside.

In investigating a given screen the system was first tuned to some suitable transmitting station, then by rotating the coil B in the manner of a direction-finding coil, a position was found between its maximum and minimum setting for which, owing to the mutual opposition of the two coils, the signals were reduced to zero. This operation was performed twice with the coil A first unscreened and then screened and the angle (β) made by the coil B with the direction of the transmitter was noted in each case. Then remembering that the amount of magnetic flux linking the coil B is proportional to cos β, the amount by which the screen reduces the magnetic field within it can be easily obtained for it can be shown that :—

$$\frac{H_2}{H_1} = \frac{\cos \beta_2}{\cos \beta_1}$$

where H_1 and H_2 are the field intensity outside and inside the screen respectively and β_1 and β_2 are the corresponding angular positions of the coil B at the balance positions. This method proved very accurate and reliable and by means of it the effect of several kinds of screen were investigated.

Effect of Screen of Straight Wires and Open and Closed Loops.

To facilitate the experiments a light wooden frame work in the form of a cube of 6′ side was constructed to serve as a support for the various screens to be investigated. In the first place the four sides of the cube were covered with parallel vertical wires spaced 1″ apart and with their ends left free as shown in Fig. 4. By applying the method of measurement described above this arrangement was found to have no effect whatever on the magnetic field within it.

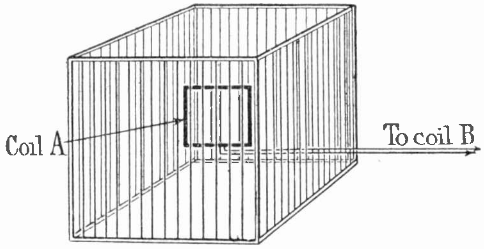


Fig. 4.—Screen of Short, Straight Wires.

Horizontal wires were now stretched across the bottom face of the frame and connected at each end to one of the vertical wires, thus joining two of the opposite faces, the remaining two being left as before. The screen therefore now consisted of a series of conductors of the type shown in Fig. 5 (*a*). This again was found to have no screening effect. Wires were now added on the top face but in the first place were only joined at one end to the vertical wires so that the cage was now composed of conductors as in Fig. 5 (*b*) (*i.e.*, of "open" loops), but still no screening effect was detectable.

The gap in each loop was next closed so that a screen of closed loops (as in Fig. 5 (*c*)) was obtained. A marked screening effect was now noticeable which was a maximum when the plane of the loops was aligned on the transmitter but zero when at right angles to this direction. In the position of maximum screening the field within the cage was found to be about 1-10th of its value outside. That is to say, 90 per cent. of the intensity of the magnetic field had been cut off by the screen. This percentage has been named the screening ratio of the screen as it is thought that this value most clearly expresses its screening properties.

On reducing the number of loops forming the screen the screening ratio was found to fall off rapidly at first and then more slowly as the intervals between the wires became very large. This is shown in the curve in Fig. 6, in which the spacing of the loops is plotted against the screening ratio. It appears from this curve that if the spacing were made still closer than its original value (about 1½″) the screening ratio could be made to approach very closely to 100 per cent.

These experiments demonstrate very clearly that to screen the magnetic field of wireless waves it is essential to employ a screen containing closed circuits, that is to say, the screen must be so constructed that currents can flow uninterruptedly round its exterior in all directions. If the screen is to be non-directional the current must be able to circulate in all directions.

Suggested Use for Screen of Closed Loops.

The directional properties of the screen of closed loops arranged in parallel planes which were demonstrated in the preceding experiment suggest that such a screen might have a practical use at a wireless station which wished to receive and transmit simultaneously on one wave-length. For, if, as shown in Fig. 7, the receiving frame coil were installed inside a multi-loop screen of which the loop planes were directed accurately towards the home transmitter while the site of the screen was so chosen that the direction of the distant transmitter was nearly perpendicular to the loop planes, by careful orientation of the loops and by employing close enough spacing the receiver so installed could be protected to any desired extent from the home transmitter while

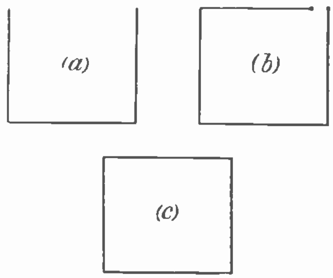


Fig. 5.—Conductor "Elements" of some Screens Experimented with.

signals from the distant transmitter would not be affected at all. Such an arrangement, in fact, should certainly prove a valuable addition to existing interference-preventing devices as employed in such cases even if not sufficient in itself.

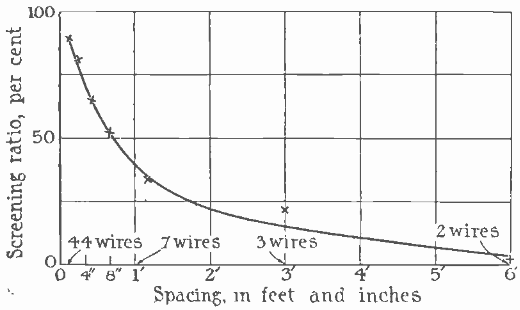


Fig. 6.—Variation of Screening Ratio with Spacing of Closed Loops.

Screening Effect of Wire Netting.

In the next series of experiments the framework was covered with wire-netting, first of two-inch mesh and then of one-inch mesh, so as to form a closed box or cage. No gaps were left and all the seams were bound together with copper wire so as to make joints of good conductivity. The measurement of the screening effect was made in the same way as before—a temporary opening being made in the side of the cage in order to admit the coil A when necessary. The screening ratio was found to be 89 per cent. for the two-inch mesh and 96 per cent. for the one-inch for a wave-length of 4·5 km. The experiments were repeated on different wave-lengths ranging from about 0·5 to 7·0 km., and a definite decrease in the screening ratio with increase in wave-length was observed but so small as to be unimportant over the range of commercial wave-lengths. Since a screen of this kind is symmetrical its screening properties should not vary with the direction of arrival of the waves and this point was verified by experiment. The effect of the cage at points outside it was also investigated, and it was found that when the distance away exceeded the dimensions of the cage its effect was negligible.

In order that the screening properties of the various screens described may conveniently be compared a table is given above in which the screening ratio of each of them is recorded.

Comparison of Screening Properties of Various Screens.
(Magnetic Field.)

Type of Screen.	Screening Ratio.
Screen of straight wires (Fig. 4)	0%
Screen of open loops (Fig. 5*b*)	0%
Screen of closed loops (perpendicular to direction of transmitter)	0%
Screen of closed loops (parallel to direction of transmitter)	90%
Screen of wire-netting 2" mesh	89%
Screen of wire-netting 1" mesh	96%

Practical Use for Wire-Netting Screen.

The preceding experiment shows that wire-netting is capable of making a screen quite effective enough for many purposes. For this reason it has since been employed to screen a Bellini-Tosi direction-finding set from "direct pick-up." That is, to prevent the amplifier and its associated circuits from picking up energy from the waves independently from the aerial loops. Since it was essential for the operator to be within the screen, the walls, floor and ceiling of the hut containing the apparatus were lined with wire-netting of 1" mesh, great care being taken to ensure that good contact was made at the seams. The result was very satisfactory, for after the installation of the screen it was found that no direct pick-up whatever could be detected whereas before its erection it was possible to obtain signals of considerable strength from low power stations hundreds of miles away with the aerials entirely disconnected. The use of wire-netting for a purpose of this kind entails the advantage that it is inexpensive, and unlike solid metal sheet, does not interfere with ventilation or lighting.

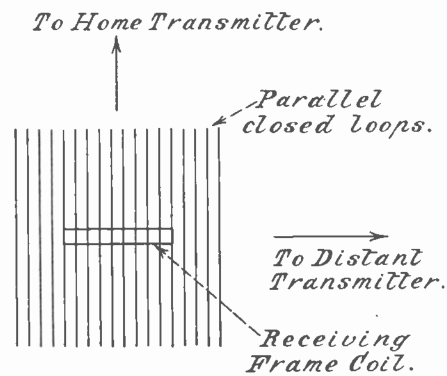


Fig. 7.—Directional Screen arranged to Protect Receiver from Local Interference.

Screening of Electric Field.

It has already been pointed out that the method of measurement employed in the preceding experiments deals only with the magnetic field. The investigation was therefore not complete without some examination of the effect of screens on the electric field and this was accordingly carried out, though not in such a detailed manner as the first part of the investigation. Summarising the results briefly it was found that the screens of straight wires (Fig. 4) and of open loops (Fig. 5 (*b*)) which had already been found to be without influence on the magnetic field (see Table) had a considerable screening effect on the electric field, the screening ratios being 80 per cent. and 94 per cent. respectively. The effect of the closed loop and wire-netting screens was not measured.

The fact thus demonstrated that a given screen may cause a large reduction in the electric field of a wave without affecting the magnetic field is of some considerable interest

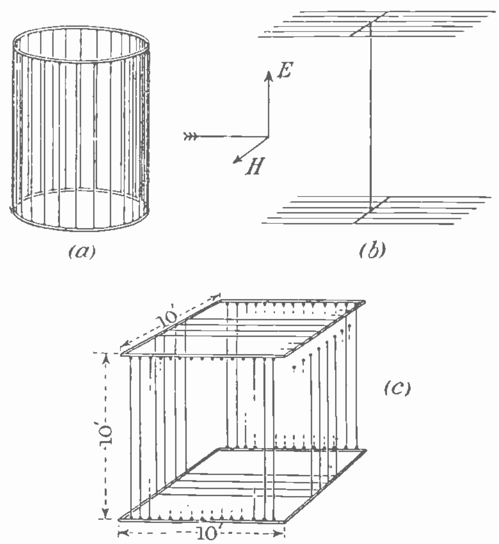


Fig. 8.—Screens which Reduce Electric Field of Waves without Reducing Magnetic Field.

since we know that outside the screen the two fields are always exactly equal. It will be found, however, that it is quite in accordance with the simple theory as outlined at the beginning of this article, for in screens which have this property the electric induction field is of the same order as and in opposition to the main "wave" field while the magnetic induction field is negligible owing to the absence of closed circuits which alone can produce such a field. Three types of screen having this property of screening the electric field without affecting the magnetic field are illustrated in Fig. 8;

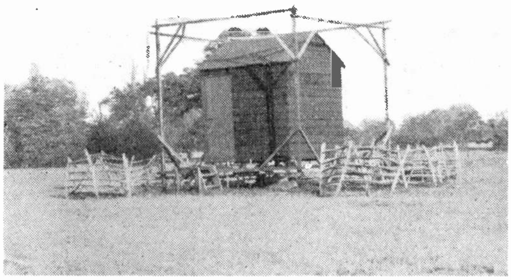


Fig. 9.—Open Loop Screen Erected Round Hut containing D.F. Apparatus.

two of them (*a*) and (*c*) have already been described. Such screens have since been applied very successfully to solving one of the problems of direction finding, namely, that of eliminating the source of trouble known as "antenna" effect. This effect, which causes errors and flat minima in direction finding sets, is due to the action of the electric field of the waves on the directional coil and its associated circuits. Consequently, if the apparatus be placed entirely within a screen which protects it from the electric field "antenna" effect must necessarily vanish; while at the same time if the screen has no effect on the magnetic field of the waves the receiving properties of the directional loop will be unimpaired.

This device has now been put into successful operation as an anti-"antenna" effect screen for a direction finder of the single-coil type which is being used for making accurate observations. The coil has been erected inside a screen of the open loop type (Fig. 8 (*c*)). The exterior of the installation is shown in the photograph (Fig. 9) in which the screen can be seen surrounding the hut containing the apparatus. It will be noticed that the hut is insulated from the earth by means of four large insulators placed under each of its four corners.

A Universal Meter.

By H. E. DYSON.

Very little useful experimental work can be accomplished without the aid of measuring instruments. Below will be found details of a universal instrument which can be made quite cheaply from the simplest of materials.

THE amateur is often, and wisely, urged to forsake rule-of-thumb methods, to measure all his quantities, and thereby become a useful member of society. Undoubtedly the value of experimental work is enormously increased by the taking of accurate measurements. The most convenient way to ascertain current and voltage values is to purchase a good range of high-grade meters. A cheaper way is to purchase one instrument having a number of ranges, though this sometimes necessitates changing the meter from one part of a circuit to another during an experiment.

It may be taken that the ordinary small pocket voltmeter or ammeter of the soft iron type is not usually very accurate, and also the energy required to operate them often entirely alters the conditions in the circuits to which the experimenter applies them.

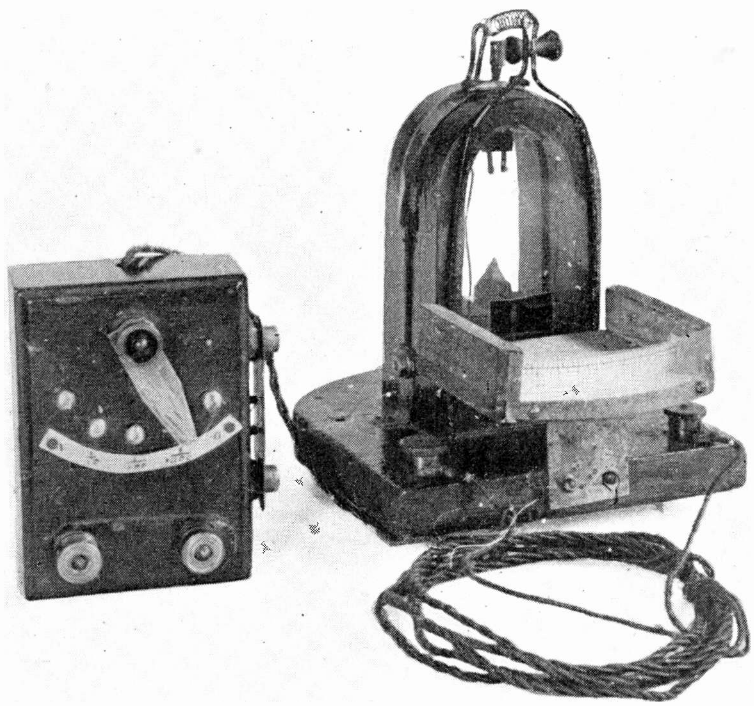


Fig. 1.—A General View of the Instrument and Shunt Box.

The amateur who cannot afford high-grade instruments need not, however, despair. A moving coil instrument of the suspended type is not at all difficult to make and requires no lathe or special tools. It can be used with a home-made shunt, which will enable measurements to be taken with sufficient accuracy for all ordinary purposes, down to a milli-volt, and small fractions of a milli-ampere, and up to any current or voltage that may be required. Owing to the even scale of this type of instrument, and to the fact that a " universal " shunt is employed, it is only necessary to obtain one point in order to calibrate the instrument. A standard cell and a 1,000-ohm resistance may be purchased from any large electrical firm. An ordinary Leclanché cell may be used as a sufficiently good standard for ordinary use, of less than a thousand ohms, nor for more than thirty seconds. The zinc must be kept quite smooth and clean. The voltage will then be 1·47. With the known voltage and known resistance it simply requires the use of Ohm's law to obtain the voltage or current for a given deflection of your meter. The scale being perfectly even, it is again a matter of simple proportion to fill it in. The shunt box being arranged in steps of 10 to 1, the same instrument serves for

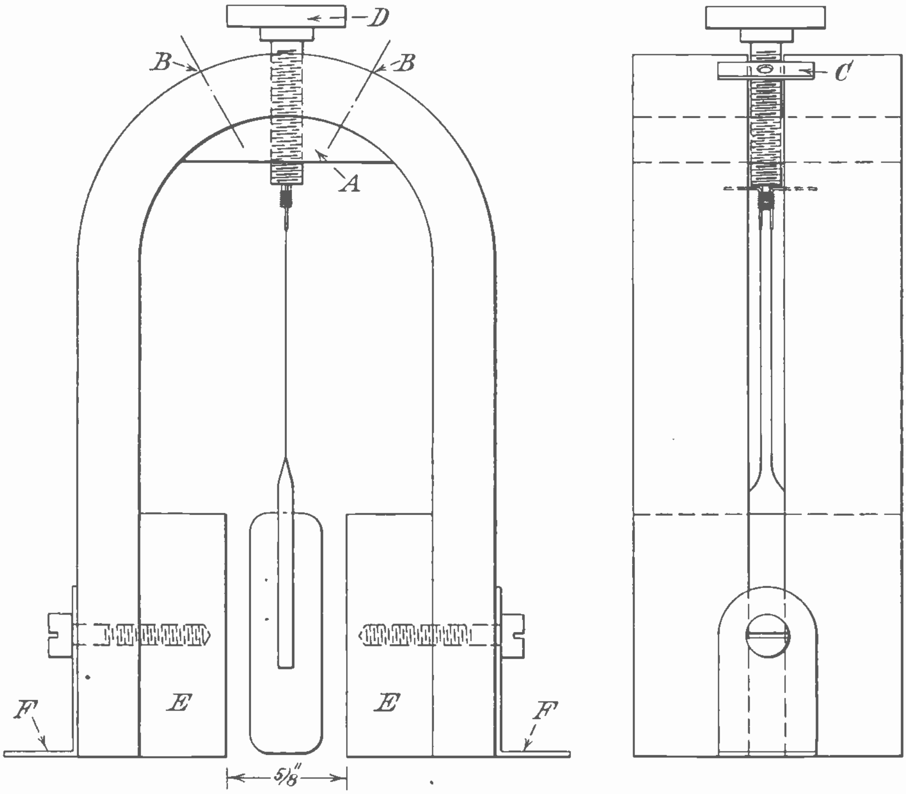


Fig. 2.—General Assembly of the Instrument.

providing certain conditions are rigidly adhered to.

The cell must be new when taken for use as a standard. The solution must be 1½ ozs. of ammonium chloride (sal ammoniac) to the pint of water, and water must be added from time to time to keep the solution level and, therefore, its density constant in spite of evaporation. The cell must not be used for any other purpose than the calibration of your meter, and never closed by a circuit currents much larger or smaller than that used to calibrate the instrument.

The essential parts of the meter are shown in Fig. 2. A coil is suspended between the poles of a powerful magnet by two fine parallel wires (No. 47), or two strips of the thin phosphor bronze sold for this purpose. Current is led down one strip to the coil, and back again along the other. The coil bobbin is made of wood, as this is lighter than most insulating materials. If a good hard wood is chosen the groove for the wire 3-16th" wide and ⅛" deep can be easily filed in it (Fig. 3). The most useful gauge for general work is about No. 44 enamelled wire.

A strip of copper foil is cemented on each side of the bobbin with hot shellac (not shellac varnish). To these are soldered the two ends of the coil, and also the two suspension wires or strips. A pointer of copper wire or other non-magnetic material is inserted in a hole in the bobbin and fixed with hot shellac.

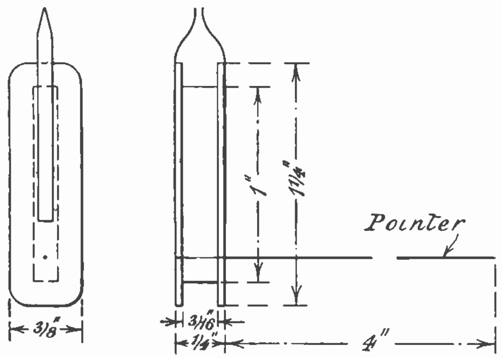


Fig. 3.—Details of the Moving Coil.

To carry the top screw D of the suspension system a fixed piece of ebonite A, having its upper surface filed to fit the magnet, is fixed in position by two screws at B, B. These pass between the two magnets and through the strips of brass C. The end of the suspension screw D is shown enlarged in Fig. 4. The end of the screw is reduced by turning or filing to enable the suspension wires to be brought closer together. Two No. 36 double silk covered wires are fastened to this reduced end by hot shellac. The end can then be bound with silk and varnished. The top end of the suspension wires are soldered to these. The No. 36 wires on the screw and the copper plates on the bobbin should be bent to hold the suspension wires parallel and about 1-32nd" apart. The No. 36 wires are also connected by fine wires to the terminals of the instrument. An alternative method is shown in the photographs, an ebonite block being fitted to the end of the screw and two small screws inserted. The suspension wires are then soldered to these. The purpose of the screw D is to enable the user to adjust the pointer to zero. It will be convenient to use No. 2 B.A. rod, and then an ordinary condenser knob on top, instead of the lever adjustment seen in the photograph.

The magnets from ordinary telephone magnetos are very suitable for providing the magnetic field, and at the present moment a large number of ex-Government magnets are being sold very cheaply.

The use of two enables screws to be passed through the narrow gap between them, and thus avoids the necessity for softening, drilling, re-hardening, and re-magnetising them.

The two like poles must, of course, be placed on the same side. Two iron blocks E, E are used to reduce the air gap. Dimensions of these parts are not given, as they must be made to suit the particular magnets which may be obtained. The same screws which hold the blocks and magnets together also hold the two angle pieces F, F which are used for fixing the instrument to its wood base.

An ivorine condenser scale forms quite a good scale if screwed on the base under the pointer. Only about two-thirds of the scale will be required.

The instrument must be protected from draughts either by placing it in a glass case or by covering the ends of the magnets and the space for the pointer with thin celluloid, as in the instrument photographed.

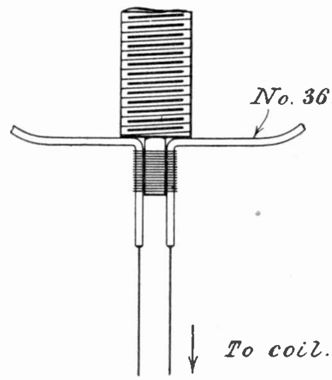


Fig. 4.—Details of the Suspension.

The coil as well as the scale must be clearly visible in order that it can be seen when it is swinging properly clear of the magnet poles.

The wire frames at the ends of the magnets hold the celluloid ends on. These go into holes in the base and at the top are held together by a spring from one to the other.

This instrument has also been fitted with an edge scale, this being the most convenient form of scale when the instrument is on a bracket on the wall. It is absolutely essential that the meter should be fixed where it will

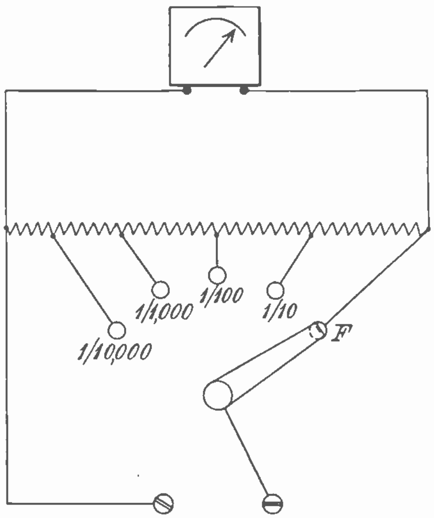


Fig. 5.—Arrangement of the Shunts.

not be subject to vibration, and fixing on the wall is generally the best method of obtaining this result.

The scale is made with Indian ink on white card, and afterwards bent to the required arc and glued in the small box made for it. The pointer comes over the top edge of the scale, and is bent down in front of it. The tip of the pointer is also fitted with a piece of card soaked in red ink so that an approximate reading may be obtained from the opposite side of the room. In using a scale of this kind two methods of dividing it are available—one to mark it in degrees, the other to mark it when the instrument is ready for calibration in milli-amps or some other suitable division of an ampere or volt. The first method requires more calculation in taking a reading, but involves no difficulty if at any time the instrument alters its "constant" or sensitivity.

The insulation to earth should be very high, but that across the coil is unimportant, as the voltage across it will always be extremely low. The desired result can be obtained by mounting the wood base on three ebonite feet.

The instrument will be ballistic when used with a shunt box. All ordinary measurements will be made with the shunt box in use, and the instrument will then be dead beat. Its great sensitivity enables very low resistance shunts to be used when measuring current, and for measuring volts the full shunt resistance for damping purposes in conjunction with very high series resistances. Thus they consume very little energy, and rarely affect the circuit conditions. Large currents such as the filament current of a valve, or the charging current of the accumulator, can often be measured by considering the instrument as a voltmeter, and connecting it across several inches of the leads. If these are a known gauge of copper wire, an ordinary

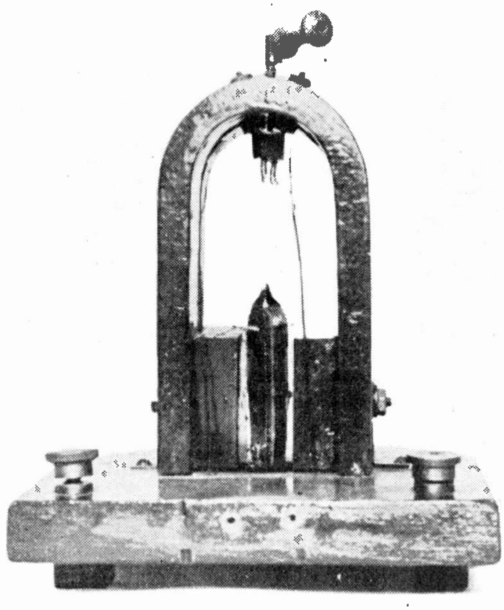


Fig. 6.—Rear View showing Pole Pieces and Coil.

rule and a table of resistances will give the resistance of the length used as a shunt, and Ohm's law gives the current.

The shunts in general use can be placed in a box about six inches square by two inches deep with the switch mounted on top and connected as shown in the diagram. The usual wireless switch parts should be used for this (the instrument illustrated was made before these were so readily obtainable), and ebonite used for the top. Care must again be taken that the insulation to earth is extremely high.

If the shunt ratios are to be 1 : 10, 1 : 100, etc., the switch must reduce the resistance between the terminals to 1 : 9, 1 : 99 and so on of the total shunt resistance. About No. 30 of any good brand of high-resistance wire will be suitable for the shunt resistances, and if one gauge is used throughout the correct quantities can be measured off. The total resistance can be obtained approximately from resistance tables for the resistance wire used. Its value does not affect the accuracy of the shunt box. It is the ratios which must be kept as correct as possible. The total should preferably lie between 20 and 200 ohms. The lowest values should have several strands in parallel. The instrument will give its own resistance either used alone or with any value of shunt if a known standard resistance is available.

The writer's instrument gives one division on the scale for 1-50th of a milli-amp, and gives four divisions per amp. when shunted by 1·32″ of 18 gauge copper.

The meter works, of course, on direct current only, but is eminently suitable for operating with a thermo-couple for alternating currents of any frequency.

The Problem of High-Tension Supply.—II.

By R. MINES, B.Sc.

(*Continued from June issue, page* 531.)

Use of an A.C. Supply.

(1) *Transformers.*

As has been stated in our introduction, an alternating supply may be changed into a supply at a different pressure by means of a transformer. This is a very simple and reliable method, for a transformer is essentially nothing more than two inductive windings coupled with an iron core. There is also every facility nowadays for obtaining trustworthy apparatus, for quite a few firms of repute in the electrical industry manufacture small power transformers specially for supplying wireless apparatus. An output of 2,000 volts on the secondary is a standard rating, and these same transformers can be supplied with a low-tension secondary to supply filaments when valve rectifiers are to be used; this winding is, of course, brought to separate terminals, and is highly insulated.

One may say that this part of the "problem" of using an alternating supply for deriving the high-tension power is easy to solve.

(2) *Rectifiers.*

An electrical rectifier may be sufficiently defined as an apparatus that will allow current to flow through it in one direction only when an alternating P.D. is applied to it. There are many different kinds of apparatus that can be used as rectifiers, each with its particular advantages and its special mode of operation; a detailed discussion of these different types will be given in a later section of this article. However, the definition given permits us to consider how we may use our rectifier.

(*a*) We have an alternating supply, either alone or through a transformer, chosen to give the correct pressure; the problem is to derive a unidirectional supply from this. The simplest plan, using a single rectifying apparatus (denoted by R) is shown in Fig. 1 (*a*). Here the alternating supply is connected up to the high-tension terminals with the rectifier in series. Let us suppose that by using a "reservoir condenser," or other means, the potential difference (P.D.) between the high-tension terminals X, Y is maintained constant; then our supply of power to the circuit connected behind these terminals must consist in pumping current into the circuit against the steady P.D.

Now in Fig. 1 (*b*) curve (i) shows the

alternating P.D. which is to be utilised, and curve (ii) represents the steady P.D. on terminals X, Y. Curve (iii) shown in Fig. 1 (*c*) is the difference between these two, and represents, therefore, the P.D. available for pumping current into our high-tension circuit. The portions N H M', etc., of this curve (iii) represent the P.D. across the rectifier in such a direction that no current is allowed to flow; the portions K M N, K' M' N', etc., of the curve represent the P.D. across the rectifier in such a direction as to allow current to flow, and current will, therefore, flow through the rectifier and into the high-tension circuit, according to some curve such as (iv).

It will be noted that this current flow takes place in "pulses," a heavy current flowing for a small fraction of each cycle of the alternating supply and nothing happening in the interim. We shall see under the heading of "Filters" that this is an undesirable condition and involves considerable additional apparatus if the power supply to the high-tension circuit is to be maintained constant with respect to time.

(*b*) It is possible, however, to improve this state of affairs, and provide two pulses per cycle. It is necessary now to use two rectifiers (R_1 and R_2), and either two transformers or a mid-point tapping must be available, in order that the two rectifiers may be subjected to P.D.'s in opposite sense, and their contribution of current so made to alternate with each other, instead of to coincide. Fig. 2 (*a*) gives the connections and shows also the methods of using two separate transformers, or an auto-transformer, to supply the mid-point tap when the supply is being used direct. In Fig. 2 (*b*) curves (i) and (ii) represent the alternating P.D.'s of the two sides of the alternating supply, while curve (iii) is the steady P.D. as before. Fig. 2 (*c*) curves (iv) and (v) are the P.D.'s on the rectifiers 1 and 2 respectively, and curve (vi) shows the resultant current flowing into the high-tension circuit.

This method is described as "full-wave rectification" (the first being known as "half-wave rectification") because it utilises both the positive and the negative pulses of the alternating supply.

The obvious disadvantage of this arrangement is the necessity for the use of a mid-point tapping, which involves insulation difficulties on a high-tension secondary winding, or the use of two separate transformers instead of one. Again, supposing the same transformer apparatus to be used in each case, this method of connection enables the D.C. supply to be maintained against a P.D. which is only half of that possible if the connections of Fig. 1 (*a*) were used. The

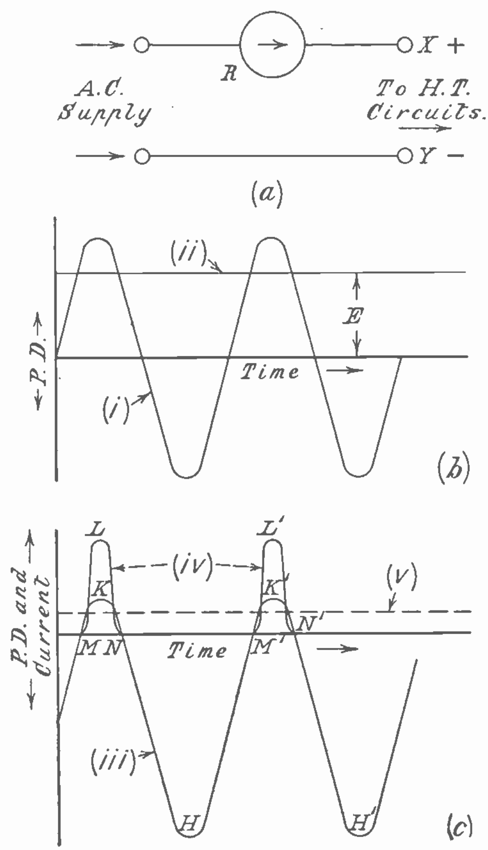


Fig. 1.—Illustrating the Effect of Rectification.

current pulses have been doubled at the expense of halving the pressure.

(*c*) An improvement on this method is shown in Fig. 3, which eliminates the need for a second transformer or a mid-point tapping. As will be seen, however, it requires four rectifying units instead of two (but this may be no disadvantage if it is found necessary to use banks of rectifiers, instead of single units).

The potentials acting in this circuit may be represented by Figs. 2 (*b*) and (*c*), as in the previous case ; the only difference being that the positive potential pulses M K N, M′ K′ N′ come across the two rectifier units R_2 and R_3 in series, and similarly the

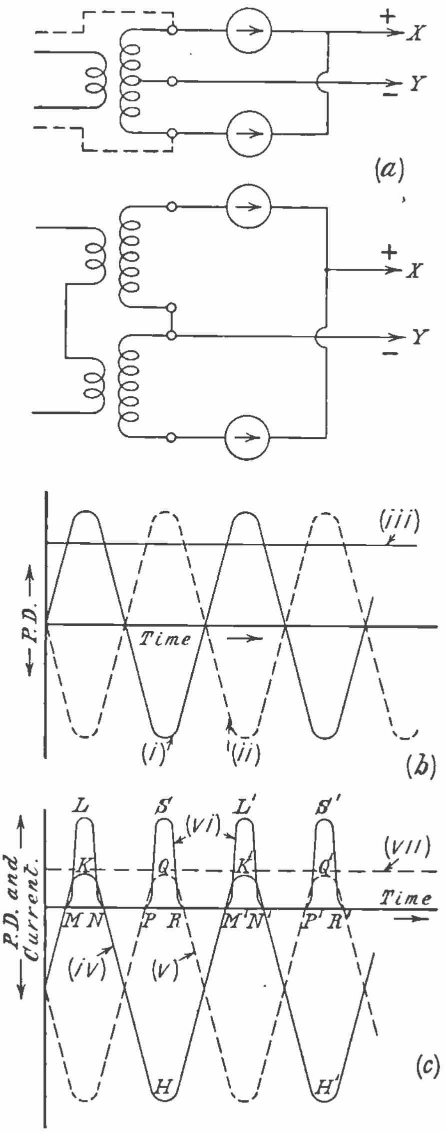


Fig. 2.—Two Pulses per Cycle are now Rectified.

pulses P Q R, P′ Q′ R′ come across R_1 and R_4 in series. Likewise, the current pulses in M L N, M′ L′ N′ pass through R_2 and R_3 in series, and the pulses P S R, P′ S′ R′ pass through R_1 and R_4 in series ; therefore, if the rectifier units are of the same type and rating, the potentials will divide equally across the two in series ; note, therefore, that each unit is called upon to deal with only half of the total potential drop.

It will be noticed also that with this method of connection (Fig. 3) the full D.C. pressure is obtainable, as with the first method (Fig. 1*a*), together with the double pulse of current.

(*d*) We will now describe a simple but ingenious method of connection used by Coolidge and Hull ; this is shown in Fig. 4. The means employed for maintainance of the D.C. pressure are here shown as reservoir condensers. It will be noted that there are two condensers, C_1 and C_2, joined in series ; the mid-point between them (which may be earthed if desired) may be regarded as a " mid-wire," so that the D.C. output is in the form of a " three-wire system," with one reservoir condenser across each half. This is the essential feature of the system. One lead from the alternating supply is connected to this mid-point, and the rectifiers (only two are required) are connected with the other alternating supply lead in such a manner that current pulses are pumped alternately into each side of the D.C. supply. The potential distributions and current pulses in this circuit are similar in nature to the previous cases.

Note that this method shows two improvements over the previous one—only two rectifiers are necessary, and the D.C. pressure available is doubled ; while considering the D.C. circuit as a whole, the current pulses are injected still at double the frequency of the alternating supply.

(*e*) It will have been noticed as a characteristic of the above methods of generating high-tension supply that the delivery of current is not constant, but has a periodic variation (" pulses "). Reference to Figs. 1 (*c*) and 2 (*c*) shows that the maximum value of the current flow is represented by the ordinate at L or S. Now, the area of a pulse, M L N, for example, represents the quantity of electricity delivered at each pulse of current. The average rate of flow of electricity, which gives the value of the current supplied to the wireless apparatus if this current is held constant (as by a filter), is the product of this quantity per pulse and the frequency of the pulses. The pulses of current occur during the periods of time M N, M' N', etc., which are less than half the time-period of the alternating supply; and, again, the current attains its maximum value for only a portion of each period M N, etc. It will be seen, therefore, that the average value of the current delivered by the converting system (shown approximately by curves (v) and (vii) of Figs. 1 (*b*) and 2 (*b*) respectively) is only a small fraction of the maximum value that flows. This point is of importance in choosing the size of rectifier that must be installed, for with some types (*e.g.*, the diode valve), the current rating is determined by this maximum value.

(*f*) We have noted also in our first article that the pressure delivered to our wireless circuit must be extremely "constant in value." It is obvious that the supply delivered in pulses as described above is of no use—but it can be "smoothed" to the required degree by means of suitable filter apparatus, details of which will be given in a later section.

(3) *Efficiency.*

There are two principal sources of loss of power in this method of producing high-tension D.C. supply. First is the loss usually occurring in a transformer, and needs no detailed description here; it will amount to

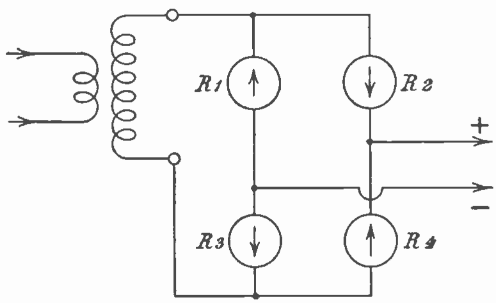


Fig. 3.—Full Wave Rectification.

only a small proportion of the power passing through even for this class of work.

The second seat of loss is the rectifier itself. We have seen, in the simple case shown in Fig. 1, for example, that the portions M K N, M' K' N', etc., of the P.D. across the rectifier are accompanied by the pulses of current M L N, M' L' N', etc., flowing through the rectifier, and the instantaneous product of these two quantities, P.D. and current, gives the power wasted in the rectifier at each instant. The average value of this loss is naturally the product of the average value of the P.D. and the average current, taken over a whole number of cycles. The amount of power wasted in this manner may be a considerable proportion of the amount of power passing through the system; but it can be reduced to a minimum by proper care in the choice of type as well as size of rectifier, to suit the P.D., current, and frequency that are to be used.

Use of a D.C. Supply.

(1) *Direct Connection.*

Provided the supply pressure is not less than the pressure required by the wireless apparatus, the problem is relatively easy of solution. In fact, if the pressure is suitable for the purpose in hand, all that it is necessary to do is to connect one's apparatus direct to the mains; except that in most cases it will be necessary to take the supply through a filter circuit, because the electricity supply, being generated by machines with commutators and armature teeth, will contain objectionable ripples that must be eliminated.

Needless to say, there are certain precautions that require attention:

(*a*) The correct polarity of the supply must be determined, and the connection made accordingly;

(*b*) There must be no independent earth connection (such as would be occasioned by a single-circuit tuner without an earth condenser) on the wireless apparatus that is to be supplied with high-tension power, because either the positive or the negative main may be at earth potential;

(*c*) Especial care should be taken to guard against accidents with the high-tension circuits, and in particular these should be connected to one point only of the valve filament circuit to eliminate the possibility of a short-circuit current using a valve filament as a fuse!

(*d*) In all probability sufficient protection to the high-tension circuits will be afforded by the fuses in the distribution box of the electricity supply, but if blowing this fuse puts out the light one is working by, separate fuses must be installed designed to blow out at a much smaller current.

(2) *Potential Divider.*

When the pressure of the supply is too high for direct use a portion of it may be tapped off by means of a potential divider. This consists essentially of a high-value resistance, connected across the mains, the output being taken usually from one of the mains (one end of the resistance), and a tapping point on the resistance (whose position is frequently made variable). The arrangement is shown in Fig. 5. Here A C is the high resistance, of value R ohms, and B is the tapping point; the portion of resistance B C will then be variable, and its value may be called x ohms.

Let E be the supply pressure, and e the pressure required by the wireless apparatus, both in volts. Then when no current, or a negligible current, is being drawn by the circuit connected to B C, the following relation holds:

$$E : e = R : x.$$

Therefore we can determine where the tapping point must be to give the required pressure e, for:

$$x = e \times \frac{R}{E}.$$

The effect of drawing a current from the points B C is to increase the potential drop in the portion of the resistance A B, and,

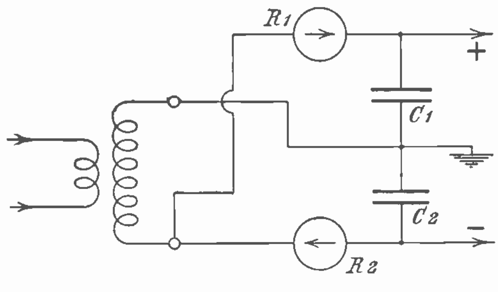


Fig. 4.—Full Wave Rectification by means of four Rectifiers.

therefore to decrease the pressure available across B C, *i.e.*, the value of e. This effect may, of course, be compensated by moving the tapping point B nearer to A, *i.e.*, by increasing x.

This method is rather wasteful of power, due to the fact that current is flowing through the resistance R independently of how much current is being drawn off for use by the circuit on B C. However, if one can determine exactly how much current (call it i amperes) is to be used, the arrangement may be modified. The portion of resistance B C may be omitted (*i.e.*, made infinite); then the current drawn from the mains becomes equal to i. The arrangement is now a simple series resistance. Care must be taken to proportion the value (say y ohms) of this resistance A B correctly, for it must drop all the surplus pressure with only the small current i flowing through it. In other words,

$$y = \frac{E - e}{i}.$$

The same remarks apply in this case as in the first, as regards the necessity of using a filter and the precautions to be taken.

Gayes' article in the November issue of EXPERIMENTAL WIRELESS may well be read at this point, for he gives useful tips concerning precautions mentioned in section (1); shows a convenient way of making connection to the supply mains without any disturbance of or addition to the wiring, and show a useful method of building up a potential divider, using low-power lamps as the resistances.

(3) *Electrostatic Transformer.*

There will be many cases, mostly where transmission or similar work is carried on, where the supply pressure is insufficient for use by itself. A favourite method of overcoming this difficulty is to use the supply pressure combined with some auxiliary supply connected in series. A small battery may be used when the deficiency in pressure is small; if larger, a generator ("booster") may be used, and this is a convenient method, for the generator may be driven by a motor running on the D.C. supply. Needless to say, there are a number of the methods to be described in these pages which may be used in series with the electricity supply. A case in point is the one described in the article "Transatlantic Radio-Telephony," which appeared in the March issue of this journal; in this case a generator of the "impulse type" (to be described later) is used in series with a 500-volt D.C. supply (which happens to be a secondary battery).

On the other hand, it may be better to convert the supply straightway to the desired pressure. The use of a motor-generator or a rotary transformer, or a battery system with units charged in parallel and discharged in series, are well-known methods for accomplishing this result, but their description comes under other headings. The method to be described here involves a direct electrical conversion of the energy, without its appearance intermediately in a mechanical or a chemical form.

This electrical D.C. converter may be described as an "electrostatic transformer," since it performs the same function for a D.C. supply as the inductive transformer does for an A.C. supply. In its practical form the apparatus is the "D.C. Voltage Raiser" developed by Scroggie, and described by him in EXPERIMENTAL WIRELESS for February last. The method is to use a number of condensers, each charged successively from the supply mains by a motor-driven commutator and discharged continuously in series into the high-tension circuit (through a filter circuit of course). Owing to the finite capacity of the condensers there is a fluctuation of the output P.D. for each charge, and the capacity value required for each condenser to keep this fluctuation within specified limits may be determined from the formula:

$$C = \frac{I}{f.Ex}.$$

where C = Capacity of condenser in μF (microfarads);
I = Output current ma. in (milli-amperes);
E = Output P.D. in kv. (kilo-volts);
x = Fractional variation of output P.D.;
f = Frequency of charging of the condensers in cycles per second.

This is quoted to show that the condensers function similarly to "reservoir condensers."

The apparatus should prove to be a very efficient converter—perhaps some keen ex-

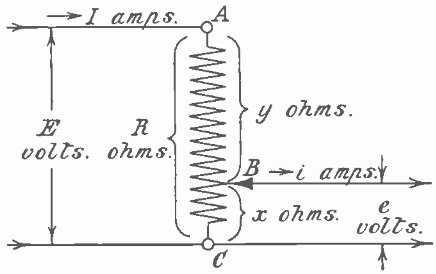


Fig. 5.—A Potential Divider.

perimenter who is using the apparatus will carry out tests and publish some figures for actual overall efficiency. There are three principal sources of loss:

(i) The power required to drive the commutator, including motor losses; this is probably the largest item in small power apparatus;

(ii) Electrical losses at the commutator, due to P.D. drop at the contact and to sparking;

(iii) Dielectric losses, etc., in the condensers (these will be dealt with under "Reservoir Condensers" in the section on Filters).

(To be continued.)

The Design of Transmitting Valves.

BY G. L. MORROW.

Below will be found the fundamental principles underlying the design of transmission valves, which should be of great value to all engaged in transmission.

THE object of these notes is to describe as simply as possible the theoretical design of transmitting valves, knowing the power which it is proposed to use for its excitation and also the general type of characteristics which it is desired to obtain.

Whilst it is obvious that certain discrepancies are bound to exist between theoretical predicted values and those obtained in practice, it will be found that the methods of calculation employed for the various essential quantities will show a sufficiently close agreement with practical results for the purpose of this article.

Three important factors relating to the

probable behaviour of the valve as designed will be dealt with in detail as they arise. These are :—

(1) The anticipated life of the valve, *i.e.*, life of the filament.

(2) Whether the electrodes are liable to become distorted or even melted, or

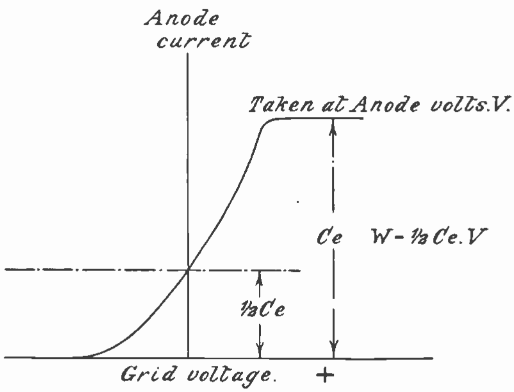


Fig. 1.—An Anode Current Grid Voltage Curve.

the vacuum destroyed by sudden overloading when working on the rated power.

(3) Stability of operation.

The three factors given above are very closely bound up with the design of the valve itself, but the question of the probable transformation efficiency, namely, the proportion between the power expended in the oscillating system and the power drawn from the supply, is also dependent to a very large extent on the type of circuit employed, and will not be discussed in the present article except incidentally.

The order in which the various factors are dealt with is as follows :—

(*a*) The general consideration of the proposed form of power supply to the anode and filament in relation to the probable life of the latter. That is to say, the operating temperature of the filament.

(*b*) Arising from (*a*) the design of the filament.

(*c*) The choice of the general form of the anode current—grid volts characteristic of the valve.

(*d*) The design of the anode in order that it may be capable of dissipating the necessary power without overheating.

(*e*) Arising out of (*c*) the arrangement of the filament system and the closeness of the grid to give the required characteristics.

(*f*) The detail design of the grid.

Certain other important factors in the design of a transmitting valve will be dealt with later, because, in the actual manufacture of power valves, experience has shown that certain difficulties arise directly consequent on determining arbitrarily certain quantities at too early a stage in the design.

Even so, in particular cases, modifications are often necessary and the design may have to be slightly altered several times before the final form is arrived at. We shall now attempt to discuss in some detail the various factors of design as tabulated above.

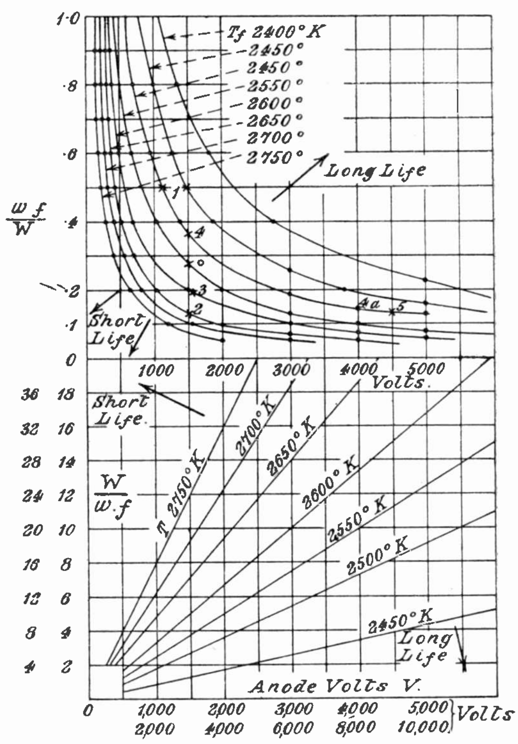


Fig. 2.—Relationship between Anode Voltage, Anode Power, Filament Power and Temperature.

(*a*) The general consideration of the proposed form of power supply to the anode and filament, and the temperature of the latter.

Usually the general form of the anode current grid voltage characteristic taken at voltage V of the high-tension supply will be as shown in Fig. 1.

When oscillation takes place in the associated circuit the fluctuation of grid voltage will cause the anode current to vary from zero to the saturation value Ce with a mean value of approximately $\frac{1}{2}$ Ce. Thus, the mean power taken from the H.T. supply is $\frac{1}{2}$ CeV, which we may denote by W. Now, to be capable of emitting an electron current of the full value Ce the filament must have sufficiently large an area maintained at a sufficient temperature T_f.

The watts required to maintain such an area at the temperature T_f increase rapidly with the temperature, but the electron current obtainable from that given area increases more rapidly still; hence the ratio filament watts/saturation current, "watts per ampere of electrons" denoted by $\frac{wf}{Ce}$ decreases rapidly with increase of temperature for tungsten surfaces, and we may therefore write

$$\frac{wf}{Ce} = f(T_f) = \left(\frac{w^1 f}{0{\cdot}3\, l^1}\right)$$

where $w^1 f$ is the watts required by and l^1 the electron current given by a tungsten cylinder 1 cm. long and 1 cm. in diameter. The factor 0·3 is a correction factor based on practical experience, and will be explained later.

For a given anode supply W a low value of the anode voltage V will mean a high value of Ce, and therefore either a large wf or a high T_f.

The actual relationship between these factors being

$$V = 2\left(\frac{W}{wf}\right)\left(\frac{w^1 f}{0{\cdot}3\, l^1}\right)$$

and is shown diagramatically in Fig. 2.

The desirability of making V as large as is conveniently possible is at once obvious, but, unless extremely long life is desired, it need not in most cases exceed 3,000 volts. In order to take advantage of the longer life given by a low filament temperature, either a high proportion of filament watts must be allowed or else the anode voltage must be high.

In Fig. 2 the numbers marked correspond to certain valves in use under normal operating conditions.

(1) A valve of 100 watts rating gives a long life of several hundreds of hours, but has a somewhat high filament power.

(2), (3) and (4) are 250-watt valves having similar characteristics and designed for the same voltage, but the life of (2) is comparatively short.

(4*a*) is the same type of valve as (4) but the power has been increased by increasing the anode volts, leaving the filament adjustments unaltered.

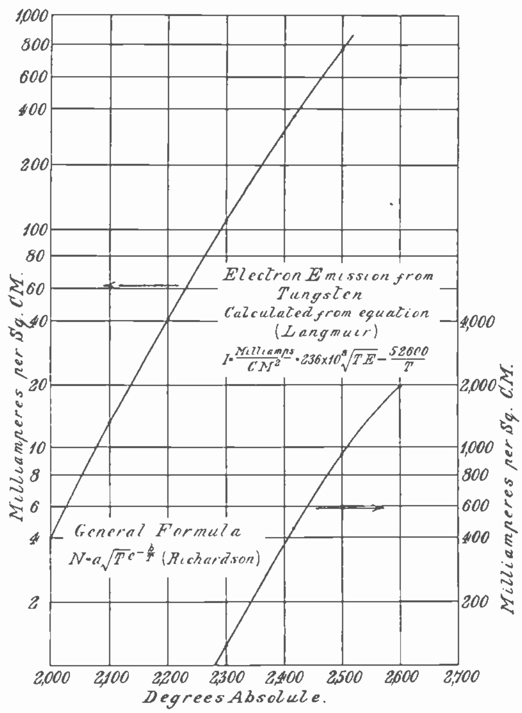


Fig. 3.—Emission from Tungsten plotted against Temperature.

(5) is a high-power valve of 1,500 watts rating.

Note.—The ratings given above are the safe dissipation at the anode of the valve.

Basis of Filament Design.

The numerical data on which the design of tungsten filaments is based are taken from two papers by Irving Langmuir, *Phys. Rev.* (Amer.) N.S. II, page 450, 1913, and *Phys. Rev.* (Amer.), N.S. VII, March, 1916, and the graphical results are those shown in Fig. 3.

The observed electron current differs slightly in similar types of valves and corresponds to a temperature about 150° C. below the calculated value.

Causes which may be contributing to this discrepancy are, in order of their probable importance :—

(1) A reduction of electronic emission caused as described by Langmuir by traces of residual gas.

(2) A difference in the specific resistance of the tungsten wire used and its temperature coefficient.

(3) Insufficient allowance for the cooling of the ends of the filament.

(4) The diversion of a certain proportion of *wf* (about 5 watts per ampere of electrons emitted) to supplying the "latent heat of evaporation" of these electrons.

It is found that the simplest method of correcting for this disagreement is to take

$$Ce = 0{\cdot}3\ I,$$

which is nearly the same as moving the I curves 150° C. to the right relatively to the others. If, in accordance with the second supposed cause corresponding corrections were made of C_f, V_f, etc., they would be smaller but more confusing in use.

It is clear that the correction (2) implies that what is in this article termed the "temperature" of the filament is probably higher than the true temperature. To correct for this would necessitate shifting all the curves to the left.

Measurements available tend to confirm this view, hence the tendency is to underestimate rather than over-estimate the life of the filament.

Dushman, in the *General Electric Review*, XVIII (page 156, March, 1915) states that the life of a filament at a given temperature increases with its diameter, but without a measure of true temperature it is difficult to make fair comparisons.

(To be continued).

The Design and Construction of a 50-cycle Transformer for Production of High-tension Voltages.

By L. E. OWEN.

Below are given the constructional details of a transformer suitable for lighting the filaments and providing the anode voltage for a small power transmitter, which has been employed by the writer at his station, 2VS.

FOR the past year the author's station (2VS) has been worked at intervals on a supply of D.C. obtained from rectifying high-voltage A.C. from the lighting company's mains. Quite a number of transformers have been employed, each being more or less successful. For some time past experiments have been carried out on the most economical form of transformer by altering the various constants, such as the amount of iron, flux density, turns per volt, and the like. Various difficulties have come up from time to time, and the overcoming of them has given great satisfaction and interest.

For instance, it was found that the drop in voltage occasioned by reactance in the core-type transformer was great, it being remembered that the load is practically non-inductive ; consequently a given design of turns and core sizes gave very different potentials on load of the oscillator than on open circuit. For example, the volts off load of a certain design were found to be 800, while when on load of the oscillator the potential dropped to 500, this figure often allowing for reasonable losses in the rectifying system. The same transformer on an induction load four times as great gave a potential of 750. On transferring similar windings to a shell-type transformer the available potential on the oscillator load was 740 volts.

It will, therefore, be evident that, owing to the nature of the load, it will be no easy matter to predict the actual output of any one design of transformer.

After some months of experimenting the design hereinafter described was completed, and has given great satisfaction. It is thought that a description of the machine will be of some assistance to amateurs who have experienced similar troubles.

The supply voltage was 220 at 50 cycles, and it was finally decided that the transformer should be of the shell type and that stalloy iron should be used for the core. Accordingly the core was designed to be capable of dealing with a constant load output of 230 actual watts, made up thus: For power (main secondary), 2,500 volts at 60 milliamps.; for oscillator filament (one low-voltage winding), 8 volts at 4 amps.; for rectifier filaments (two low-voltage windings), 8 volts at 3 amps.

After due allowance had been made for losses, of iron, copper and those due to reactance, it was decided that a core suitable for 250 watts would be a convenient size to adopt.

A cross-sectional area of 2·25 sq. ins. was chosen as being a liberal allowance, having a length between cheeks of 5 ins., with a window clearance of 2 ins. The dimensioned sketch (Fig. 1) will show the sizes of the core.

It will be noticed that, as in standard practice, each half of the shell has half the main cross-sectional area of the main limb. The core was constructed of stalloy ·002 in. thick, having a patent insulation on one side of each lamina, the laminæ being of the following size: Main core, $1\frac{1}{2}'' \times 5\frac{3}{4}''$; tops of shell, $\frac{3}{4}'' \times 5\frac{3}{4}''$; sides, $5\frac{1}{4}'' \times \frac{3}{4}''$; butts, $\frac{3}{4}'' \times 2\frac{3}{4}''$.

We will at this point calculate the weight of the iron core, and on measuring up the size we find that we can consider it as a bar of iron of $2\frac{1}{4}$-sq. in. section and ($6\frac{1}{2}+6\frac{1}{2}+4$) 17 ins. long.

∴ Volume of iron $=17 \times 2\frac{1}{4}=38$ cub. ins. (about).

As the iron is covered on one side by insulation deduct 10 per cent.

∴ Total volume of iron in cub. ins. $=38-3{\cdot}8=34{\cdot}2$

Now, 1 cub. ft. of stalloy (uninsulated) weighs 420 lbs.

∴ Weight of core $=\dfrac{34{\cdot}2 \times 420}{1{,}728}=8\frac{1}{4}$ lbs. (about).

This calculation being required for losses computation in the iron.

The fundamental equation for all transformers is one in which there are several unknowns, and is as follows:—

$$E=4{\cdot}44\ T\ \varphi f\ 10^{-6}$$
$$\text{or}\quad \frac{4{\cdot}44\ T\varphi f}{100{,}000{,}000}$$

when E = applied voltage.
4·44 is a constant.
T = number of turns.
φ = flux density per unit area × area.
f = frequency of supply.

Now, we know the cross-sectional area of the core—2·25 sq. ins.—and also E as 220;

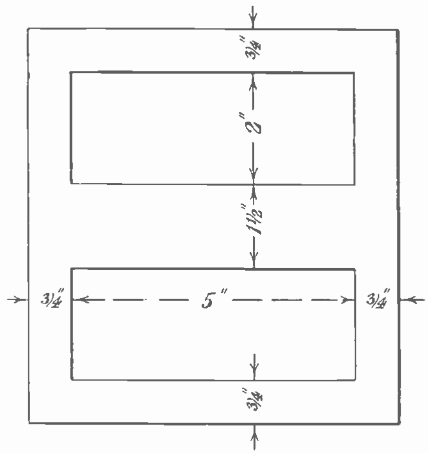


Fig. 1.—Dimensions of the Core.

also the frequency—50 cycles. What we require is the number of turns on the primary. However, we do not at present know the flux density per unit area. We shall, therefore, consider a reasonable figure for working on.

First, let us assume that the number of turns per volt shall be 3. In order to produce ·33 volts per turn of wire the flux must charge at the rate of 33,333,333 lines per second.

Now, the sectional area of the core is 2·25 sq. ins. Therefore, in order to produce this charge each square inch of core section must carry—

$$\frac{\left(\frac{33,333,333}{2}\right)}{2\cdot 2} = 7,500,000 \text{ lines per second.}$$

Now, owing to our frequency being 50 cycles, it follows that the flux density per half.cycle is—

$$\frac{7,500,000}{100} = 75,000.$$

For stalloy iron this is a reasonable figure, and we may now proceed to solve the equation for the number of turns—

$$E = \frac{4\cdot 44\ T\varphi f}{100,000,000}$$

$$220 = \frac{4\cdot 44\ T\ 75\times 10^3\times 2\cdot 25\times 50}{10^8}$$

$$= \frac{4\cdot 44\ T\times 75\times 2\cdot 25\times 5}{10^4}$$

$$= 3\cdot 75\ T$$

$$T = 825.$$

Having now arrived at the number of turns for the primary, we must now consider the three secondaries.

(*a*) Main secondary—

Volts required 2,500.

$\therefore$ Turns $=2,500\times 3\cdot 75=9,375$.

(*b*) Three secondaries to give 8 volts.

$\therefore$ Turns $=8\times 3\cdot 75=30\cdot 00$.

The figures for the secondary turns do not at present take into account the copper and iron losses, which we shall next consider.

From the curve accompanying the iron it was seen that the total iron losses at 50 cycles for stalloy working at a flux density of 75×10^3 lines per square inch is 2 watts per pound. Now, the weight of our iron core is 8·25 lbs.

$\therefore$ Total iron losses $=8\cdot 25\times 2=16\cdot 5$ watts.

Now copper losses—

Primary total length of wire = length of average turn × No.

$$= \frac{7\cdot 5'' \times 825}{12} = 517 \text{ ft.}$$

Now, maximum current primary has to carry—

$$= \frac{\text{total rating in watts}}{220}$$

$$= \frac{250}{220} = 1\cdot 137 \text{ amps.}$$

Say 2 amps. for safety.

In order to get low losses we will take 22 S.W.G. double cotton covered. The resistance of this gauge per 1,000 yards is 39·7, say, 40 ohms.

$\therefore$ Resistance of one primary $=\frac{517}{3}\times\cdot 04=6\cdot 88$

$\therefore$ C^2R loss $=6\cdot 88\times(1\cdot 137)^2$
$=8\cdot 9$ ohms.

Similarly with low-tension secondaries for filament lighting—

Length $=30\times 3\times$ length of mean turn

$$= \frac{30\times 3\times 30 \text{ ft.}}{12}$$

$$= 225 \text{ ft.}$$

Now, gauge of wire to carry 4 amps. safely is, say, 16 gauge. Resistance of 225 ft. of 16 S.W.G. at 7·6 ohms per 1,000 yards

$$= \frac{\cdot 0076\times 225}{3}$$

$$= \cdot 57 \text{ watts.}$$

$\therefore$ C^2R losses $=\cdot 57\times$ average current of three secondaries

$=\cdot 57\times(3\cdot 3)^2$

$=6\cdot 3$ watts.

Lastly, C^2R losses in secondary for high voltage is found similarly.

Length of secondary $=9,400\times$ aver. length of turn

$=9,400\times 13\cdot 25''$

$$= \frac{9,400\times 13\cdot 25}{12\times 3} \text{ yards}$$

$=3,466$ yards.

Now, gauge of wire suitable for the secondary will be about 34 S.W.G. single cotton covered, which has a resistance of 368 ohms per 1,000 yards.

$\therefore$ R of secondary $=3\cdot 466\times 368$

$=1,277$

$\therefore$ Losses $=1,277\times(\cdot 06)^2$ watts

$=1,277\times\cdot 0036$ watts

$=4\cdot 5$ watts.

Now our total losses are as follows :—

	Watts.
Main secondary	4·5
Three low-tension secondaries ...	6·3
Primary	8·9
Iron	16·5
	36·2

This computation of losses is an exceedingly liberal one, as the lengths of the windings have big positive allowances.

The efficiency of the transformer should next be considered. On full load our transformer is rated to deliver 250 watts, but of this number we find that 36·2 are accounted for by iron and C^2R losses.

$$\therefore \text{ Efficiency} = \frac{\text{watts delivered}}{\text{watts supplied}}$$

$$= \frac{213\cdot 8}{250}$$

$$= 85\cdot 5 \text{ per cent.}$$

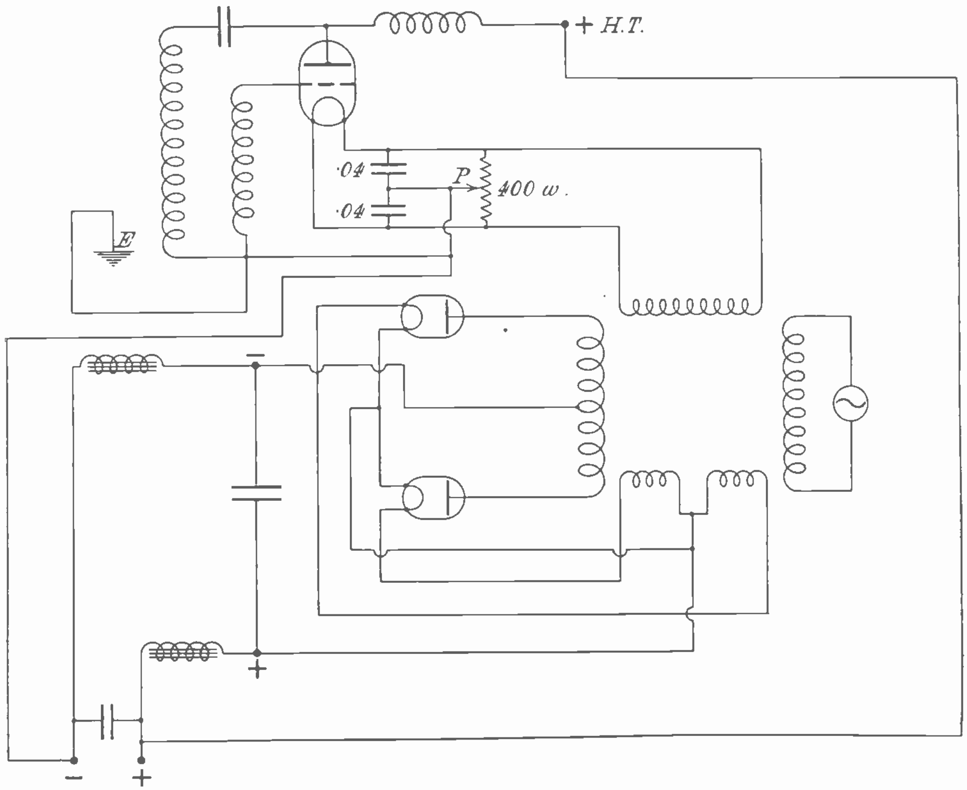


Fig. 2.—Showing the Connections of the Transformer to the Set.

It is interesting to note that the ratio of iron to copper losses is 16·5 : 19·7, or as 1 : 1·19, which ratio is satisfactory for a transformer of this class.

We must next consider the insulation. Probably the most convenient to use and work will be micanite. This substance may be readily cut with shears and made to take the shape of the former by the application of heat. For the primary a piece of this material should be formed round a wooden block, the same as the cross-section centre limb of the transformer, and 2 ins. longer, *i.e.*, $1\frac{1}{2} \times 1\frac{1}{2} \times 7$ ins., and fitted with an end-piece nailed on one end 5 ins. × 5 ins. The other end should have a similar end-piece on it, with a square hole cut in the centre, and provided with some means of clamping it so that it gives a clearance of 5 ins. for the main winding, and also so that it may be advanced for winding the secondary sections.

Next, two end checks should be cut from micanite $\frac{1}{8}$ in. thick, and one firmly secured to the square micanite tube insulation referred to above and held to the face of the wooden end-piece by adhesive tape. The other end should be similarly fixed to the movable wooden end-piece, but not to the tube, in order that the secondary section may be slipped into place. The primary is then wound on in eight layers of 103 turns each. It will be found that there is room for slightly more turns per layer, and packing of worsted soaked in wax must be carefully put into position to make up this deficit. Next a second layer of micanite, $\frac{1}{8}$ in. thick, must be placed over the primary and the low-tension winding placed into position, insulating them the one from the other by 3-32nd-inch micanite and bringing out the ends of each winding to the sides of the bobbin; and, finally, a further tube of $\frac{1}{8}$-in. micanite is placed over the whole of the low-tension windings. If the winding has been carefully carried out this series of windings will present a cross-sectional area of not more than 3·6 ins., leaving a window space depth of nearly 1 in. on each winding for the secondary.

This will be found plenty for the high-tension winding, which should be wound in eight sections. This is a convenient number, as the R.M.S. volts per section will not be more than 315. The peak value of this should not be greater than 475, so if we insulate for a potential of 800 volts (1-16th-in. micanite) between sections we shall be on the safe side.

The low-tension windings are next removed from the former, and a dummy of wood of the same overall cross-sectional area, *i.e.*, 3 ft. 6 in. by 3 ft. 6 in., and of ½ in. in length, is placed in its stead and the movable check brought up in its place. The former, by the way, should be made of oak or some good hard, well-seasoned wood, as the former and each secondary section has to be boiled in wax; 1,200 turns of wire are put on each section, and are then boiled in wax, care being taken to remove them from the former just before they are cold. When all the sections are finished they are slipped on over the primary and connected up to form one continuous winding all in the same sense, and having a tap brought out from the connecting point between No. 4 and No. 5 sections for the centre earth point of the transformer.

It will be noticed in the accompanying diagram that an extra micanite washer of ⅛ in. thickness is placed between the main check of the winding bobbin and the outside of the first section at each end of the secondary, and its purpose is to prevent creeping leakage which might occur.

The low-tension windings should be given a coat of shellac varnish or bakelite solution on each layer, which should be allowed to dry, final exclusion of all moisture being obtained by passing a current of sufficient magnitude through all the windings in series to obtain a hand-warm rise in temperature. This current should be allowed to pass for about one hour, taking care it is not sufficient to damage the insulation of the windings.

The resulting transformer will be found to give good results, and may be relied on not to overheat on quite long runs. It is not claimed that it is the last word in efficiency, but it is claimed that it will deliver its rated output if properly constructed.

Special attention must be paid during winding as regards insulation, and especially that care be taken to wind the turns as closely as possible, the secondary sections being wound as evenly as possible so as to get the turns in as small a space as they will go.

Lastly, it should be noted that the potential delivered by the secondaries are calculated for R.M.S. values. We, therefore, have peak voltages of considerably higher values in the case of the low-tension winding. We can control this by series resistances to the filaments of the values to be lighted. Now, regarding the secondaries H.T. winding, we must remember that the peak voltage is the value that the rectified D.C. would be were it not for losses in the smoothing chokes and losses due to the impedance of the rectifying value or values, and the author has found in practice that the total drop due to these circumstances does not greatly, if at all, exceed the difference between the R.M.S. value of the secondary potential and the peak value; therefore, the final rectified potential on load should be approximately the same as the rated R.M.S. potential of the voltage delivered by the secondary.

In conclusion, it is thought that a diagram of connections (Fig. 2) of an oscillator supplied by A.C. to the filaments would be of interest, together with the direct supply of A.C. to the rectifier tubes.

The potentiometer slider P is moved until no A.C. is heard in side tone, and such an arrangement is perfectly suitable for use with radio-telephony.

A Few Observations on the Recent American Re-Radiation Tests.

By ERNEST W. BRAENDLE.

We give below details of some interesting experiments which have been carried out by a contributor and should prove of interest to our readers.

IT was the writer's privilege during the recent re-radiation of KDKA to listen simultaneously to both KDKA direct and to KDKA as re-radiated by the British Broadcasting Company. A description of the method employed, together with a few observations, will no doubt be of interest to readers.

Two entirely separate sets were used, one being a two-valve receiver capable of receiving KDKA on 100 metres, and the other a normal broadcast receiver, each, of course, having its own aerial and earthing system. The output of these sets was brought through a switching arrangement which permitted of both ear-pieces of a pair of 'phones being connected to each set in turn, or else one ear-piece to each receiver. Quite early on it was decided to keep to the latter arrangement, as by suitably adjusting the receivers, strength of signals in the 'phones was kept balanced and simultaneous comparisons obtained.

It may be as well, perhaps, to give briefly the main effects noticed, which, although not numerous, were sufficient to suggest possible applications to which re-radiation might be applied, in the hope of obtaining reliable information on at any rate, one or two of the important problems which the present-day engineer has to face.

Static and atmospheric conditions were in every way identical.

Fading, which at the time was occasionally very bad, was exactly similar, except when the B.B.C. varied their receiver.

There was quite an appreciable time lag between direct reception and that re-radiated by the Manchester station of the British Broadcasting Company. This was in the nature of one-hundred-and-fiftieth of a second, and took the form of a slur from one ear-piece to the other, which reversed itself when the ear-pieces were changed over.

It was quite evident that the B.B.C. were using a highly selective receiver, as there was some distortion due to selectivity. Also spark interference, noticeable on the comparatively flatly-tuned 100-metre receiver, was not present in the B.B.C.'s transmission.

The quality of the re-transmission was from 3 per cent. to 5 per cent. worse than direct reception.

Perhaps of these observations the ones referring to static conditions and fading are those having the most importance. It must here be remembered that the signals were received in London by the B.B.C., re-radiated and checked in Manchester. So much has been done in recent years with regard to studying these conditions in different parts of the country and making comparisons in the hope of coming to some definite conclusion regarding them, that the possibility, and, indeed, the advisability, of some simultaneous checking on the lines mentioned is obvious. Let us suppose that the B.B.C. or the Government of this country could be persuaded to re-radiate from each of their stations in turn for a short period, say five minutes every evening, either before or after broadcasting hours, nothing but the existing atmospheric conditions pertaining in their district on whatever wave-length should be considered suitable. This could be simultaneously checked, not only in every part of this country, but also on the Continent both officially and by interested amateurs. By this means a great deal of data, not so greatly affected by the human factor, which has been a great source of error so far, would be forthcoming.

As regards time lag, although interesting, one can see nothing in it other than as a factor which must be taken into consideration whenever a high degree of accuracy is required, such as the possible re-radiation of time signals, etc.

The observation on the comparative quality of the re-transmission need not be taken too seriously as a factor, as a large proportion of the observed distortion was due, as has been previously mentioned, to the use by the B.B.C. of a super-selective receiver.

To the uninitiated these tests have probably been quite interesting as a novelty, but the results, so far as the public are concerned, have not seemed to warrant the very great expense entailed. This has not been the fault of those concerned, but due rather to the perversity of nature. These tests have had, unfortunately, to be advertised some days previously, in order to meet the public demand, with the inevitable result that at the advertised times conditions have been anything but at their best. The writer has not once but several times listened to KDKA when reception has been quite as good as listening to distant B.B.C. stations in this country, and that for periods of an hour or even more. It may be of interest here to add that, having listened almost continuously to transmissions by KDKA for the past few months, a very considerable improvement has been noticeable both in strength and quality since the end of January. So much so indeed that it is now possible to receive this almost regularly on a two-valve (detector and low-frequency) receiver.

At the present time re-radiation of American stations, or any other stations for that matter, has been little more than an interesting experiment, but it surely does not require a very great stretch of imagination to foresee the time when semi-automatic wireless repeater stations, on the lines of the existing long distance telephone systems, will be set up.

Cementing Metal to Glass.

By J. F. CORRIGAN, M.Sc.

Writers on the experimental aspects of wireless construction have often dealt with the possibility of employing glass panels in receiving sets in place of the more usual ebonite. Whilst there are many disadvantages to be encountered in the use of glass panels, such as their extreme brittleness and the great difficulty which is ordinarily experienced in drilling holes into them, the employment of glasswork in radio apparatus is not without several good features. It is not opportune, however, to dilate here upon the relative advantages and disadvantages which attend the use of glass as a material for wireless construction, but the following note on the preparation of a metallic cement which is very efficient for the purpose of joining together glass and metal-work may be of interest to those amateurs whose experimental work lies in this direction.

An alloy of the composition given below should be carefully prepared by fusing in a graphite or metal crucible the constituent metals and stirring them well together. The alloy melts at 212° F.:—Lead, 3 parts; tin, 2 parts; bismuth, 2–3 parts.

Metallic bismuth can be obtained in the form of small cast sticks at any good firm of manufacturing chemists. The metal is not very expensive, its present price being in the neighbourhood of 1s. 6d. an ounce.

The prepared alloy presents a dull greyish appearance. In order to join glass and metal together, the parts should be well cleaned beforehand, and the surfaces roughened by rubbing with a fine file or a piece of coarse sandpaper. The two surfaces which are to be joined together are first warmed to a temperature of about 80° C., and the cement is applied to them in a manner similar to the ordinary operation of soldering. If possible, it is advisable not to use any flux during the operation, but if the use of the latter material is found to be absolutely necessary in order to make the alloy "grip," only a very small amount of pure rosin should be applied.

As will be readily understood, the

successful performance of the cementing process requires a little practice for its achievement. It should be observed that the glass-work must be thoroughly warmed before the alloy is applied, otherwise it may crack owing to the effect of uneven heating. At the same time the metal part of the joint must not be heated to that temperature at which it will become covered with a coating of oxide.

If a cement such as the above is carefully prepared, it will be found to possess many uses for wireless and general electrical instrument construction. Among one of its many uses may be mentioned the joining of the bulbs of electric lamps to their metal holders, and for the radio amateur who is sufficiently enthusiastic and daring to attempt the repairing of his valves the cement is worth making for this purpose alone.

The Heaviside Layer and How it may be Produced.

By O. F. BROWN, M.A.

IN the first number of EXPERIMENTAL WIRELESS the writer described some of the effects which the existence of the Heaviside layer might be expected to have upon the propagation of wireless waves. As explained in that article, the Heaviside layer is the name given to those layers of gas in the upper regions of the earth's atmosphere which are believed to be rendered conductors of electricity by the presence of ions or other electrically-charged particles. In the present article it is proposed to consider shortly certain astrophysical hypotheses which may account for the production of such layers.

In the first place it is hardly possible to suppose that the existence of such charged particles can be accounted for by the ionisation caused by the direct action of the sun's light upon the gases in the upper atmosphere. There is very little evidence that ultra-violet light, unless it is exceedingly intense, has any considerable ionising effect upon a gas, and even if it were possible for ions to be produced by such action they would disappear rapidly by recombination during the dark hours, or just at the time when the effect of the Heaviside layer is assumed to be most marked.

About two years ago, however, Prof. Fleming suggested in a lecture before the Royal Society of Arts that the production of the Heaviside layer might be due to the collection in the upper atmosphere of charged *dust* particles projected from the sun. This theory is based on a modification of a hypothesis advanced by S. Arrhenius, a Swedish professor, to account for certain cosmic phenomena—in particular the repulsion of the tails of comets as they approach the sun. To explain such repulsion the presence of a repulsive force, which under certain circumstances must be more powerful than the pull of gravity, is essential. Ordinary electrostatic attraction fails to account satisfactorily for the facts, and, extraordinary as it may seem at first sight, scientists were led to seek this repulsive force in the pressure exerted by the sun's light on the particles forming the comet's tail, since it can be shown that the pressure due to this cause when acting on particles of a certain size and density can be stronger than the attraction of gravity on the same particles.

That light exerts a pressure upon a body on which it falls can easily be shown from the principles of the conservation of energy. For suppose that a plane wave of light or some other form of radiation is falling upon a body of area q which completely absorbs all wave-lengths. Then the amount of energy absorbed in time t is

$$EqVt,$$

where E is the radiant energy in unit volume of the medium due to the wave, and V is the velocity of light. If now the body on which the wave falls is displaced a small distance d in the direction from which the light comes, then the energy which falls on the body in time t is reduced by

$$Eqd$$

The amount of heat developed in the body is reduced by the same amount measured in mechanical units. But by the principle of the conservation of energy the loss must be represented by the work gained through the displacement of the body. Since work is measured by force multiplied by distance, the radiation must therefore exert a pressure on the body. If then p represents this pressure, the work gained is represented by

$$pqd$$

$$\text{Hence } pqd = qEd$$

$$\therefore p = E.$$

or the pressure of light or other radiation which is exerted by a train of plane waves falling perpendicularly on a perfectly absorbing body is equal to the amount of energy of the incident waves contained in unit volume of the medium.

In the case of bodies which reflect some of the radiation $p = E\ (1+\epsilon)$ where ϵ is the reflecting power of the body. This theoretical result has been confirmed in a remarkable manner by the careful laboratory experiments of Lebedew, Poynting and others.

It has been calculated that the total pressure on the earth's surface due to the radiation of the sun is about 75,000 tons, while the attraction of gravity is 40 billion times this pressure. The pressure of radiation, however, depends on the area of the surface of the body on which it falls, *i.e.*, in the case of a sphere on the radius squared; while the attraction of gravity depends on the mass of a body, *i.e.*, the density multiplied by the volume, or, in the case of a sphere, on the radius cubed. Both the forces decrease as the square of the distance, but it can easily be seen that as the radius decreases the two forces become more nearly equal. Thus, for a body of the same density as the earth, whose diameter was 1/40 billionth that of the earth, the two forces would balance. The radius of such a body would, however, be less than the wave-length of violet light and scattering and diffraction phenomena would have an important effect, and as a result a particle of that size in the neighbourhood of the sun would be attracted and not repelled. For the same reason the force of repulsion of radiation pressure on the molecules of a gas cannot be as great as the attraction of gravity upon them.

It can be shown, however, that in the neighbourhood of the sun with particles of unit density equilibrium can be established between gravity and radiation pressure on particles whose diameters are ·0015 mm., and similar particles whose diameters are between this value and about 0·3 times the wave-length of violet light will be repelled by radiation pressure rather than attracted by gravity. For particles of the right size and density the repulsive force may be several times the attractive force.

The question then arises as to how such particles of the right size and density can be supplied by the sun. The sun spots observed on the sun's surface are now known to be in reality the craters of vast volcanoes through which clouds of gases are expelled into the sun's outer atmosphere, and it is probable that smaller expulsions of gases are continually taking place. It is also highly probable that these masses of gas are in an ionised state either through the action of the heat of the sun or through the presence of radioactive substances produced under great heat and pressure in the sun's interioı.

The gases driven out from the sunspots expand rapidly and in doing so may be expected to cool. Applying now to such gases the well-known results of certain experiments of C. T. R. Wilson, in which he showed that if ions are present in water vapour which expands suddenly, then these ions act as nuclei upon which the molecules of the vapour collect to form drops, we should expect the ions contained in the gases projected from the sunspots to act as nuclei for the collection around themselves of molecules of the gases and metallic vapours which condense, as it were, into dust particles in the cooler outer regions of the sun's atmosphere. In his experiments Wilson observed that condensation took place more readily round the negatively charged ions than round those positively charged, and that condensation was made more rapid by the action of ultra-violet light. The general effect then would be the creation in the outer region of the sun's atmosphere of clouds of small particles charged electrically, which are collections of groups of molecules of gases and metallic vapours making up the sun's atmosphere. Among these collections we may expect to find particles of all sizes. Some will be drawn back by the action of gravity, some repelled by the action of the pressure of radiation with various velocities, while in the case of others these two forces may be equal and such particles may remain in equilibrium so forming perhaps the phenomenon known as the sun's corona.

On the above hypothesis a stream of electrically-charged particles would be continuously driven out by the sun into space. The particles would have various velocities varying between perhaps 300 kilometres and 2,000 kilometres per second according to their size and density. Certain of these particles would be caught in the atmosphere of the earth, where they would come under the effect of the earth's magnetic field which would tend to separate out the positive and negative particles ; for in accordance with other well-known laboratory experiments such charged particles will arrange themselves in helixes round the lines of the earth's magnetic force. The greater the velocity of the particles the farther they will penetrate in the earth's atmosphere. Round the magnetic poles the particles will be more closely collected and the production of auroras with their well-known streamers and rays may be explained in this way.

Professor Fleming, however, points out that there is another cause operating to sort out the particles and bring the particles to rest as they approach the earth. This is the viscosity of the atmosphere. By viscosity is meant the frictional resistance which the atmosphere exerts on bodies moving through it. Stokes proved many years ago that a small sphere of diameter d and density σ falling through a gas of density ϕ and viscosity μ under the action of gravity attains a final velocity

$$v = \frac{1}{18}\frac{d^2g}{\mu}(\sigma - \phi).$$

where g is the acceleration due to gravity. At the earth's surface this relation explains the slow rate of fall of the water drops constituting clouds.

It has long been known that the viscosity of a gas was independent of the pressure over a wide range of pressures. Thus the viscosities of nitrogen and oxygen are of the same order of magnitude and are constant for pressures between about one atmosphere and one-thousandth of an atmosphere, but below this pressure their values fall rapidly to zero. Hence the effect of the viscosity of the atmosphere in checking the approach of the dust particles to the earth will only begin to be effective at a height of about 100 kilometres and the particles will be sorted out and practically brought to rest at a height of some 80 kilometres. At this height the sorting process may result in the formation of a conducting layer such as we believe the Heaviside layer to be.

These theories are chiefly supported by the explanations they afford of many cosmic and terrestrial phenomena, as in the correlations between sunspot activity and auroras and magnetic storms.

It is interesting to note on this hypothesis of the origin of the Heaviside layer the dust particles making up the layer would probably be of the right size to affect those shorter waves of lengths between 100 and 300 metres which are believed to be reflected by the Heaviside layer in long-distance night transmissions of short waves. Also observations made on the variations of intensity and the direction of arrival of atmospherics appear to point very clearly to a solar control of these phenomena either direct or indirect. Watson Watt in his paper read before the Royal Society on "Observations of Atmospheric Disturbances," 1920-1921, points out that the mean direction of arrival of atmospherics at Aldershot was not widely different from the direction of the magnetic meridian, and states : "The periodic variation of the direction of arrival of atmospherics although vastly greater in amplitude, is in the same direction as that of the magnetic declination and the fact must not be lost sight of in considering the possible common relation of both phenomena to electrical phenomena at very high levels in the atmosphere." If atmospherics were due partly to electric fields radiated by electric discharges between clouds of charged particles forming the Heaviside layer and if, on the hypothesis suggested above, such particles were following the earth's lines of magnetic force, then such a correlation between magnetic phenomena and atmospheric disturbances as Watson Watt suggests might be expected.

On the Influence of Input Connections upon the Operation of Triodes.

By WILLIAM D. OWEN, A.M.I.E.E.

Many experimenters fail to realise the importance of the position of the connection to the filament circuit, and the subject is dealt with below.

THE ease with which amateur constructors can get results with their maiden efforts, despite the number of variables involved, is undoubtedly one of the explanations of the strange spell that wireless casts over its adherents. Encouraged by the fact that the first loosely-conceived and hastily-built receiver actually emits music or speech comparable in quality with that from expensive sets by experienced makers, the novice gives himself up whole-heartedly to the lure of this new cult and immediately starts upon something more ambitious.

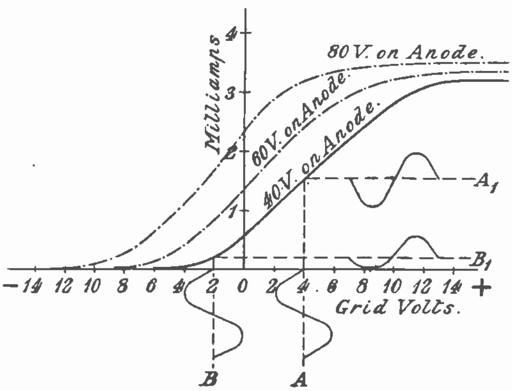


Fig. 1.—Characteristic of B.T.H. R4V. Valve.

In cases where funds permit, the next step is, all too frequently, to pile on valves and to amplify signals up to loud-speaker value, long before the idiosyncrasies of the valve are mastered or the variables in any way understood.

To appreciate the extraordinary possibilities of the valve one has only to be reminded of the fact that American broadcast stations have been heard in this country with a single valve. Results such as this can be achieved only when the several variables are adjusted to certain critical values which, incidentally, differ to some extent with each individual valve. It is seldom, if ever, that two valves of the same nominal type behave quite the same in similar circumstances, hence it is that characteristic curves supplied by makers should not be regarded as strictly true for all such valves.

It is not generally realised that in operating a thermionic valve there are three factors that can be varied apart from variations in the associated circuits, as to which there is no limit. These three factors are filament temperature, plate potential and grid potential.

The designers of commercial apparatus have, of necessity, to keep down the number of adjustable factors in order to simplify the operation of their instruments. It is customary, therefore, to fix the potential of the plate and grid, and to provide a simple rheostatic control for the filament heating current. This explains why amateurs are sometimes surprised and flattered to find that they can get, with two valves, results similar to those obtainable with four or five valves on a commercial set. It is due to the deliberate sacrifice of sensitiveness for simplicity and reliability because of the relatively greater importance of these characteristics in apparatus intended for general use.

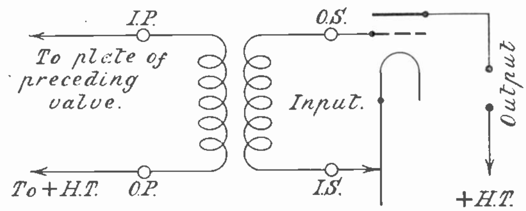


Fig. 2.—The Input and Output Connections.

Experimenters labouring under no such obligation may multiply the number of controls until nobody but themselves can operate the set. It is then possible to "ring the changes" until the right combination is arrived at, either by accident or by application of first principles. What is generally lost sight of, however, is the fact that the combination suitable for one valve is probably quite unsuitable for another. Yet we are frequently treated to expressions of opinion—apparently from experienced observers—which opinions, when analysed, prove to be based on a comparatively superficial observation of the behaviour of different valves *in identical conditions* regardless of the fact that these conditions may be favourable to one type and unfavourable to another. An observer whose valve panel is rigidly wired and permits of no modification of grid and plate potential, is not in a position to say that such and such a valve is the best detector or amplifier, as the case may be. All he can say is that it suits his circuital arrangements better than the others he has tried.

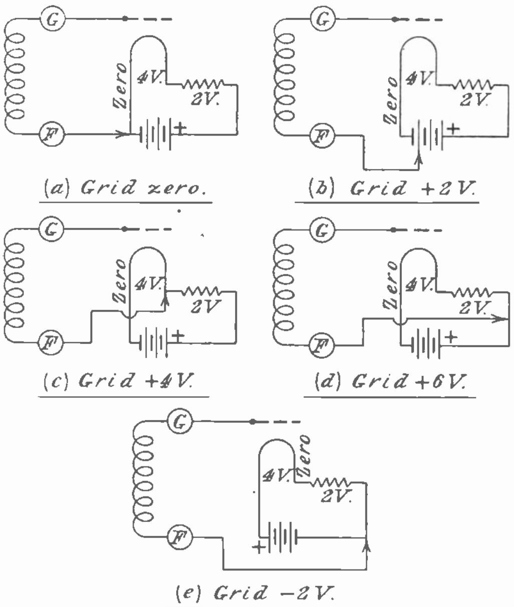


Fig. 3.—The Series of Various Points of Connection.

The operating characteristic of any triode valve is the relation between the current in the plate circuit and the potential of the grid *relative to the negative end of the filament.* In other words, the "output" current depends upon the magnitude of the grid-potential variations around a certain fixed point which may be called the operating point. If the relation between grid-potential and plate-current were lineal the precise position of this point would be immaterial

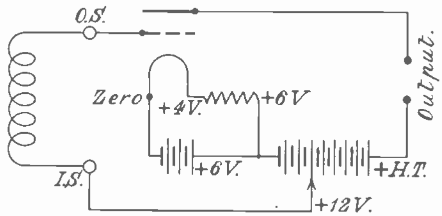


Fig. 4.—Connection to Produce a Large Positive Potential.

(within certain limits). Unfortunately the characteristic curve that graphically depicts this relation is not linear throughout its whole length. It is only approximately straight throughout a portion of its length. The consequence of this is that, unless the operating point falls on or near the straight portion of the curve, distortion is bound to occur.

This is clearly seen by referring to Fig. 1, which shows the characteristic curve of a B.T.H. R4V valve. The normal potential of the grid is the same as that portion of the filament circuit to which the secondary side of the input transformer is connected. If the connections are such as to give to the grid a normal potential 4 volts positive to the negative end of the filament, the operating point is at A, and a grid-potential

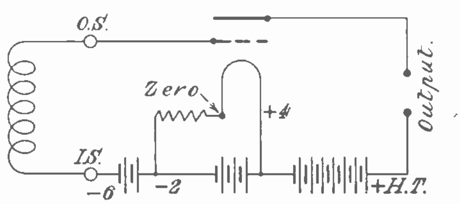


Fig. 5.—Connection to Produce a Large Negative Potential.

variation of $\pm$ 2 volts gives rise to a plate current variation of exactly the same form, as shown at A_1. But if the operating point be at B a similar grid-potential variation (drawn sinusoidal for simplicity) gives rise to the distorted plate-current variation illustrated at B_1. Obviously, therefore, the operating point is of considerable importance and the factors governing it should be carefully considered.

It is not generally appreciated that the input lead from OS, Fig. 2, has five alternative connections and that the normal grid-potential varies from +6 to −2 volts, according to which of these is chosen. The whole series of connections is illustrated in Fig. 3 which is almost self-explanatory. It should be noted, however, that in condition *e* the polarity of the filament battery is reversed, and that condition *b*—which is not so well known as it deserves to be—involves the use of one of the intermediate connections on the accumulator.

Positive potentials beyond the limits specified above may be obtained by connecting to the low voltage end of the plate battery at a suitable distance from the negative terminal Fig. 4. If, however, greater *negative* potentials are required it will be necessary to introduce grid cells connected as shown in Fig. 5.

Danish 7QF.

By THE OPERATOR.

The Danish station 7QF is well known to many transmitters, and we give below some details which have been prepared by the operator.

THE Copenhagen experimental station 7QF is one of the newer arrivals in the fascinating pastime of brass-pounding, as the power has only lately been increased sufficiently to reach outside Denmark. The first A.C.C.W. transmitter was made in June, 1923, a small Philips' power valve being used with the 220-volt 50-cycle A.C. mains as H.T. supply. With this transmitter 7ZM, 20 miles away, was often worked on 330 metres, the aerial current being ·1 amp. with a water-pipe earth. The first improvement effected was the raising of the twin-wire T aerial from an average height of 20 ft. to a flat top height of 35 ft., an aerial series condenser being put in at the same time. This brought the wavelength down to 220 metres and the radiation up to ·15 amp. Several attempts to reach England at this time were made, but without success. In the beginning of December a twin-wire counterpoise was erected, which increased my radiation to ·2 on 195 metres and at once resulted in my being reported by Mr. Geo. Rogers, of Ashford, Middlesex. I next tried rectification of my H.T. A "Ferrix" transformer having two secondaries giving 4 volts each and one secondary giving 200 volts was purchased, the 200 volts being put in series with the mains to give 420 volts A.C. A 20-watt Philips' power valve was then bought, as was also a German 50-watt neon rectifier tube, the latter in conjunction with two paper-insulated 2-mfd. condensers and a Ford coil being used for rectifying the 420 volts. With this I really did get C.W., though only on low power (·1 radiation). Then, at long last, I worked with a foreign station (G5US) on December 30 at 1550 G.M.T. (before sundown in England, Hi!). I have often since wondered how I did it, since my radiation was only ·2. After this I called CQ for many weary hours without avail, until I one day thought of trying to go down to 125 metres. I moved the aerial clip from turn No. 18 to turn No. 3 on the A.T.I, and removed 32 of the 40 turns on my grid coil (I have always used the standard direct-coupled reaction set with tuned grid coil). My radiation was still ·2, but my wave was now 120 metres, and the very next morning, early, I worked 2KF. From then till the beginning of March I worked about a dozen stations of various nationalities. Then my bottle went west. I put in a hard receiving valve instead and got exactly the same radiation! (True, this with 5 volts instead of 3·8 on the filament.) With this valve I worked until it burst, and then closed down for a thorough overhauling of the station. Towards the end of April I started work again, but could not reach England any more. Instead, I had a daylight test with Sald (Lund, Sweden, 30 miles from here). He was using four R valves in parallel with 300 volts on the plates, his radiation being ·3 on 170 metres, using the electric bell-wires as a counterpoise system (Hi !). He also tried 'phone, which I received O.K. on one valve, every word being readable. Transmission has been permitted in Sweden for some time, but they are only just beginning to allot call signs, so by the time this appears in print SALD will probably be SALD no longer*. The call signs being allotted are horrid—thus there is one in Stockholm called SMZZ. I have now closed down my transmitter, at any rate for the summer, as I believe the authorities are beginning to wake up and start searching for us ; I consider it the best policy to stop before being caught. However, my interest in "DX" is undiminished, and I still listen on short waves and send reports to the stations heard—I have 400 reporting cards in stock ! My present receiver is an ordinary one-valve set with loose-coupled tuner ; the valve is of Danish manufacture and contains a slight amount of residual neon gas. It uses 3·5 volts ·4 amps. filament current, and about 30 volts H.T. (critical). This valve is very sensitive, I have heard 2IJ several times when his radiation was only ·1. WGY's carrier on 107 metres comes in R8, but speech is so distorted as to be quite illegible. The B.B.C. stations come through O.K., though I seldom listen for them because of trams, ships and arc-hash (OXE, 8 miles away, 40 kw. input). Most of the listening is done on 600 metres ; on this wave SUH, FFA, GMH, etc., and hosts of ships can be heard any evening. I wonder why so few people listen on 600 metres ; surely it is the most fascinating wave of all. On 200 metres and under I have heard 225 stations since April last year ; on 125 metres, 15 Yanks.

In conclusion, let me state that I am always delighted to undertake special distance tests with low-power stations, and anybody wishing to test has only to drop me a line *via* this paper.

*The call is now SMZV, and the address is : Fil. Dr. G. Alb. Nilsson, Skolgatan 5, Lund, Sweden. He would be pleased to hear from English amateurs desiring to test with him. He generally works on Saturday evenings ; pure C.W. on 200 metres.

The Mechanics of Components.

BY GEORGE GENTRY.

Home-made experimental equipment frequently suffers from faulty mechanical details. In the following notes an expert deals with the principles of good design and sound constructional methods as applied to wireless components.

No. 2.—Variable Condenser Construction.

IN the absence of any useful standard components of variable condensers, it is proposed to centre these notes around a design, which the writer offers as embodying about the best arrangement of simple standard fittings to make up a condenser, which is designed to meet the following mechanical and electrical requirements :—

Avoidance of dielectric losses in the end plates, and yet to use a metal foundation. Good electrical connection between consecutive plates and consecutive vanes. Rigid construction of such a nature that the relationship between the vanes and plates is not likely to alter with time. Minimum capacity to be as small as possible as compared with maximum capacity. And the condenser moving parts to have a simple adjustment that will allow of movement to be made stiff enough to retain its setting under ordinary conditions of usage ; although it is not suggested that the design is suitable, in this respect, to be used with its spindle in a horizontal position. The whole of the metal parts to be brass, but if a condenser of this construction were

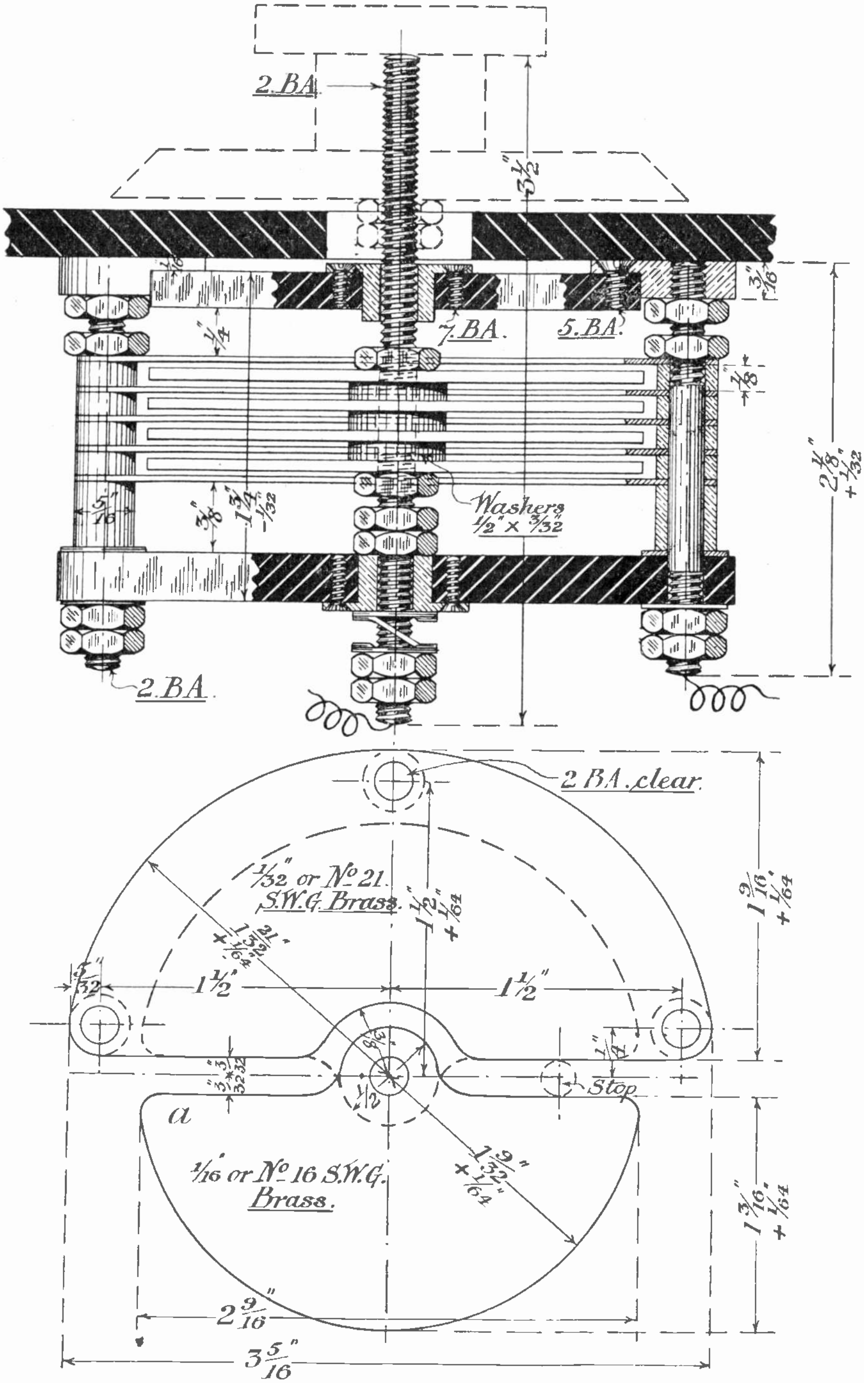


Fig. 1.—Sectional Elevation of Condenser and Plan of Plates.

made in quantities it would be quite permissible to have the foundation half-circular ring made in a die-cast metal, which, however should be as hard a material as could be made by that process, or, at any rate, a somewhat more stable material than the soft metal of which die-castings are usually made.

It is proposed to refer to the stationary plates as the stator plates and the moving plates as the vanes. Fig. 1 shows a front sectional elevation of the condenser as made up of four vanes and five stator plates, and as mounted upon a ¼″ ebonite panel. At the moment the writer is not prepared to give this size any particular maximum capacity, but the drawings have been produced and dimensioned in such manner that it would be a simple matter to modify them to agree with any reasonable number of plates and vanes in excess of those drawn. The same figure also shows on plan the relative positioning of the stator plates and vanes at maximum and minimum position, and their respective dimensions. Fig. 2 shows at the top an underside plan of the top plate and foundation ring, and Fig. 3 a topside plan of the bottom plate. All the drawings are to scale and to the scale given on Fig. 2. In Fig. 3, just above the bottom plate, is shown a modified form of vane (at *a*) to which reference will be made.

In order that the best results can be maintained in the matter of conductivity between the plates and vanes and their distance pieces both are to be of brass sheet in preference to any aluminium alloy. The latter on account of its chemical instability is liable to form films of oxide, which must modify conductivity, especially in the case of a large number of plates and vanes. The stator plates are to be of hard brass sheet, especially flat and free from bruises or dents, 1-32nd″ thick, or its equivalent standard wire gauge No. 21. The vanes, on the other hand, are to be double this thickness, or No. 16 S.W.G., as being then less liable to deformation by accident. The spacing of the plates being ⅛″ gives an air space of 1-32nd″ each side of vane, which is a dimension rather under that of the generality of condensers and therefore on the side of extra capacity.

The bottom view of Fig. 1 shows the key dimension of the condenser arrangement, *viz.*, the straddle centre to centre of the framing bars 3″, or 1½″ on each side of the centre line through the centre of rotation. The holes in the stator plate corresponding to these dimensions are to clear No. 2 B.A. and should be drilled by means of a 3-16th″ drill and opened out if necessary by a broach. The plate as arranged to be spaced by a 5-16th″ diameter brass distance washer is therefore 3 5-16th″ across out to out, and as a whole conforms to many plates of standard size sold. In order to reduce edge capacity to a minimum the vanes and plates face edge-on in the minimum position 3-16th″ apart, and this therefore brings the centre of rotation 3-32nd″ in front of the front line of plate or vane. That the clearance and capacity space be kept constant between the edges of the vanes and the distance washers of the stator plates, the edges of the plates must be struck in curvature from the centre of rotation. This gives rise to the method of referring to these radial distances both in the drawing of the stator plate, vane, and in the end plates, and also where reference is made to the depth front to back of these various fittings. It will be noticed that for convenience a radial distance or depth is given plus 1-64th″ in every case. Looking on the stator plate drawing it will be noticed that the distance 1½″ of the frame hole from the centre line is not on the diameter of the rotary circle, but on a line ¼″ higher than this diameter. Therefore if we wish to refer to the radial distance of this hole from the centre of rotation it is equal to $\sqrt{\frac{1}{4}^2 + 1\frac{1}{2}^2}$ (*i.e.*, the square on the line subtending the right angle, in a triangle, is equal to the sum of the squares on the sides containing it). This distance comes out just a shade over 1-64th″ over 1½″, and in the view mentioned it will be noticed that the radius of the back of the plate must then be 1½″ + 5-32nd″ = 1 21-32nd″, and this has to have added the 1-64th″. To actually set out this plate, however, the best thing to do is to draw the vertical centre line and cross it with a horizontal centre line corresponding to the centres of the holes. Upon the latter measure a distance of 1½″ each side of the former and make centre dots accurately at these two points. Scribe circles from these centres each 5-16th″ diameter. Below the horizontal centre line draw another line 5-32nd″ below it, and parallel, to form the straight front edge of the plate, and below this again another parallel horizontal line $\frac{1}{4}$" below the first one. The last drawn line is the cross centre of rotation, and where it crosses the vertical centre line a dot should be punched exactly at the intersection. From this centre the centre of either of the edge holes will be found to be very closely $1\frac{1}{2}$" plus 1-64th", and that, if the dividers be set to 1 23-64th" a little full

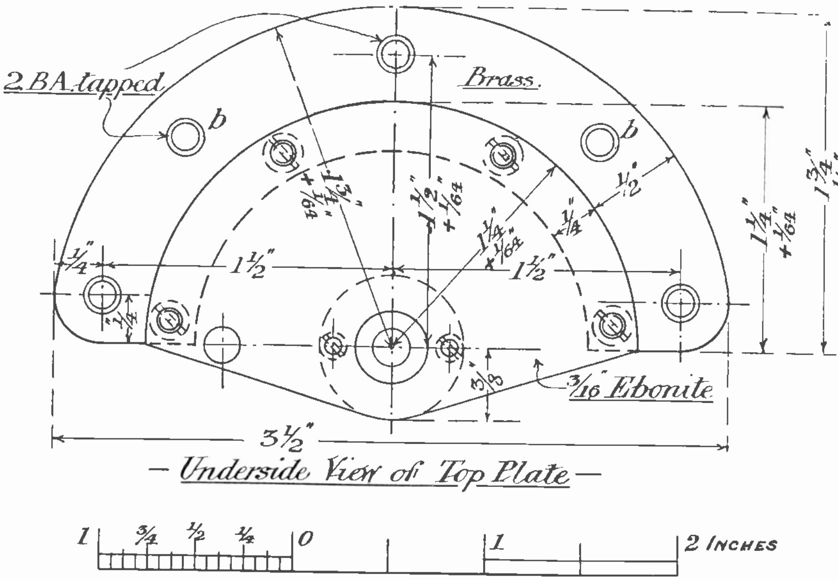


Fig. 2.—Underside Plan of Top Plate.

it will scribe the back curve of the plate tangent to the two 5-16th" circles.

The setting out of the vanes follows that of the stator plates very closely, but it is a more simple operation, as no holes have to be drilled beyond the centre spindle hole. If any number of vanes are required it would be good practice to mount them, having roughed them out and drilled the centre holes, two one way and two the other, close together, and bolt up tightly on a true-running mandrel, and turn the outsides to a diameter of 2 9-16th" plus 1-32nd"; but it would be necessary to run a line of solder along the edges of the boss portion to keep any one vane from moving. If any number of stator plates are required it would also be good practice to make a template of, say, $\frac{1}{8}$" brass plate, and use this clamped to the other plates packed together to drill the stay holes through all at once, the holes being carefully drilled in their correct positions in the template. The template should also be made with the centre pivot hole so that it could be used to drill the top and bottom frame plates and thus ensure that their holes are in correct position relatively to the centre pivot hole. It should be remembered that in this connection in dealing with the top semi-circular ring of the top plate the holes would only just be started with a full-size drill (3-16th"), and followed through with a No. 26 drill which is the tapping size for No. 2 B.A.

The top plate, as seen in Fig. 2, which is reversed to show the underside, consists of a metal semi-circle $\frac{3}{4}$" wide, divided to two thicknesses, *viz.*, outside $\frac{1}{2}" \times$ 3-16th" thick and inside $\frac{1}{4}" \times$ 1-16th" thick. The inner flange forms a semi-circular rebate to take a 3-16th" thick ebonite plate, and is, of course, $\frac{1}{8}$" deep. The ebonite plate which is rounded concentrically to the rotary centre fits snugly in the rebate, and is attached thereto by four No. 5 B.A. countersunk headed brass set-screws screwed downward through a countersunk clearance hole in the brass and into tapped holes in the ebonite. The ebonite is lined at the centre of rotation with a flanged brass bush, flanged upward, of a standard size sold by all dealers, and holed for No. 2 B.A. clear. This top bearing is only a steady bearing, but as it confines the spindle to the upright it must be of brass to resist wear. The bottom frame plate, Fig. 3, is for cheapness and ease of production all in $\frac{1}{4}''$ ebonite with a similar brass bush. The bush in this case takes the spindle weight and sets it to height by means of a pair of lock nuts on the upper side. The underside of the spindle also carries locknuts, between which and the flange is placed, sandwiched between brass washers, a copper spring washer. The compression given to this spring by the lower nuts determines the required tension on the lower journal of the spindle to retain the vanes at any setting.

The spindle and three frame stays may be screwed throughout to No. 2 B.A., but would preferably be made of 3-16th″ round brass, left plain where not required to be screwed, which is within the region of the stator plates and vanes. The bearings must of necessity have screwed journals in them. The frame stays are screwed down $\frac{5}{8}''$ length from the top, and $\frac{1}{2}''$ length up from bottom. The spindle is screwed down $1\frac{3}{4}''$ length from the top, and up $1\frac{3}{8}''$ length from bottom. The total lengths given refer to a four-vane condenser, and for every extra vane added add 5-32nd″ to the lengths given. The bottom plate may be a replica of the top instead of all ebonite, but it should have 3-16th″ clear holes through the brass edging and be put on the other way up, in which case no washer would be required under the bottom spacing tubes, and these tubes instead of being $\frac{3}{8}''$ long about, would have to be $\frac{1}{2}''$ long.

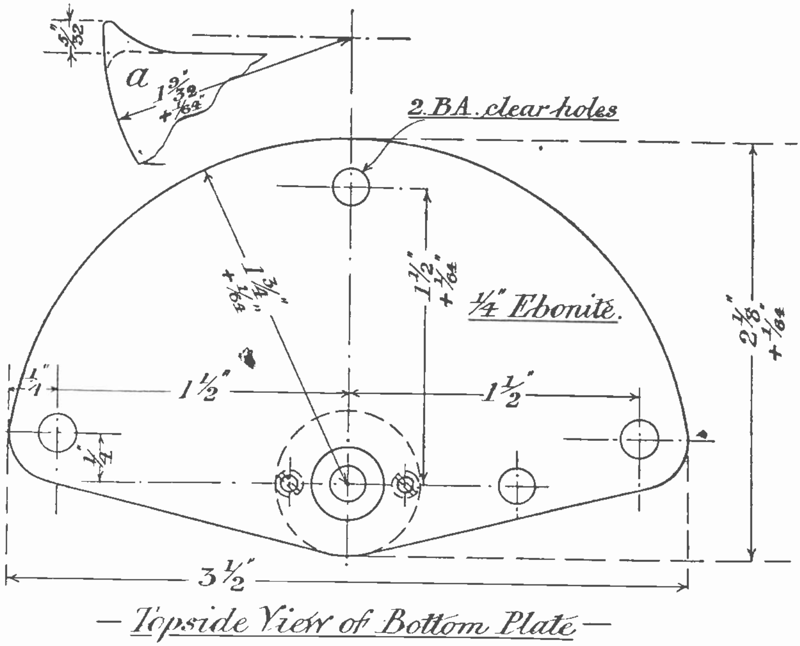


Fig. 3.—Topside Plan of Bottom Plate.

To assemble the condenser, having tapped the three holes in the brass edging of the top plate dead upright, screw in the three stays tightly and flush with the top, checking them by means of the lock-nut, two of which will be put on each. The second lock-nut on each is then arranged to space the top stator plate $\frac{1}{4}''$ from the top ebonite plate, and parallel with it. Held upside down all the stator plates and their $\frac{1}{8}''$ thick distance washers are put on, finishing with the final long distance tube and washer. The vanes are now put on the spindle and locked as closely to position as possible by their top and bottom nuts, and two extra locknuts are put on bottom of spindle. With the vanes in the out position the spindle is put up through the top bearing, and the bottom plate put on and secured. After this the positioning of the vanes is effected either by shifting the locknuts immediately above the bottom bearing, or, if necessary, the nuts top and bottom of the vanes.

The locknuts, shown dotted on the spindle beneath the dial, can be put on after, and are suggested as being perhaps a check on some unwary person screwing on the knob and dial too far and thus drawing up the spindle and perhaps deforming the vanes. If the condenser be used self-contained these nuts would not be required, and the dial would be screwed down to read against an index on the brass ring.

The leads, as shown, may be sweated respectively to the end of a fixed stay, and to the end of the spindle, or to the face of the flange of lower bearing. In the spindle connection, however, the best practice would be to sweat a piece of copper flex to the end as shown, and carry it to a screw terminal on the bottom ebonite plate, which terminal should stand as close to the bush and as far from the fixed stays as possible.

The attachment is shown as to a $\frac{1}{4}''$ ebonite panel, and this is effected by screwing to the tapped holes *bb* in Fig. 2 by a pair of No. 2 B.A. countersunk-headed set-screws, passing through the panel and holding up the condenser by the ring.

It remains to point out that with the vanes in the off position, as in Fig. 1, there will be several degrees of movement comparatively inactive as to change of capacity. This may be obviated by making the vanes horned at *a* on the entering side. If the vanes be shaped, as shown in the small detail of Fig. 3, the edge capacity will not be materially increased, whereas these horns entering the stator space will tend to affect the building up of capacity somewhat sooner than otherwise. These horns will, of course, be put only on the one side.

The stop consists of a 3-16th" bar of round red fibre put through holes in the ebonite of top and bottom plates which are shown holed for the purpose on the horizontal centre of rotation and about $\frac{7}{8}''$ centres from this centre. It may be less, however, but cannot be greater. The bar passes down through the vane and plate gap, and should be flattened slightly over the fronts of the stator plates so as not to touch their edges. Fibre is not a good insulator, and therefore should not connect conductively any two contacts, but it is stronger as a stop than ebonite, and, if dry, must have a lower specific inductive capacity. The bar will act as a stop in both directions, but care must be taken to ensure that it cannot readily be pressed back against the edges of the fixed plates by the vanes when in the off position.

If this condenser be made with a view to rearrangement to add to or deduct from its total capacity by adding or deducting from the plates and vanes, it would be better to mount the plates and vanes loose for the most part or not sweated. In any case, the three points on the stator plates should be tinned, as also each side of every spacing washer, both for the plates and vanes, and also both sides of the centre boss of vanes. All these tinned surfaces may be wiped with an oil rag when hot to wipe off superfluous tinning. Then, if the condenser is to remain intact, build it up with all the tinned surfaces fluxed, and then, when together, by the aid of gentle heating by the blowpipe, carefully applied, all plates and vanes can be sweated to their distance pieces and thus ensure good contact. If left unsweated, however, no flux should be applied, and just before assembling the tinned surfaces should be well cleaned to ensure their making at any rate a clean contact.

To get good results the very best sheet ebonite must be employed in condenser construction, and certainly no moulded material claiming to be ebonite.

"Hands Across the Sea."

By MAJOR WM. COATES BORRETT

(*Manager, Maritime Division, A.R.R.L.*).

Much has been published on the subject of transatlantic amateur telegraphy from the point of view of the English experimenter. Below we give a brief resume of what has been done in Canada.

THE A.R.R.L. transatlantic tests of 1923-24 will long be remembered by the amateur radio operators of the Canadian Maritime Provinces as the beginning of the real international work for amateur radio. As Canadians it was of especial interest to us to link up with our Mother Country, and the success which has met our efforts has been beyond our fondest hopes.

The Maritime Division, A.R.R.L., being Canada's most eastern division, felt it their special duty to make every effort to connect. Having only about twenty amateur stations in the Division that had worked any distance worth while, it meant that we had to put on all effort possible to compete with our American cousins all along the East Coast of the U.S.A. Of our twenty stations, not more than five or six had ever worked over five hundred miles, and only two had ever been reported from Europe.

We found that in reception the Europeans who came in with regularity were all on short waves, so taking a lesson from this, we went down from the usual 200 metres to around 125. The first station to work England from this part of the globe was C1BQ of Halifax, who linked up with G2OD. The news spread fast, and before long C1DQ had hooked G2SZ. Next C9BL connected with G2OD, then C1DD connected with G2NM, and then C1AR worked G2SH, and the latest two Canadian 1's to get two-way working have been C1DT and C1DJ, both with G2OD. In addition to these, C1BV has been reported in England. All of the above Canadians have connected with inputs of less than 100 watts. The first five have worked Europe so often, especially 1BQ, that it is a rare occasion when at least one or two of them cannot be heard sending messages and exchanging remarks with their brother hams of England.

The Maritime Division, A.R.R.L., feel proud of their work, but it is due to the splendid co-operation which we have received from the English end that has made it possible, and the writer feels it would interest English hams to know how we get their signals. The greatest credit for this continuous nightly communication, in my humble opinion, goes to G2OD and G2NM. These two English stations have been logged and worked, I am sure, on more occasions than any others of Europe. There has scarcely been a night for the last five months but what these two stations have been pounding in here. Other stations have been logged on many occasions, but never with such regularity as these two, who have done more to cement the feeling of Empire unity by radio than any other English stations. They are by far the best known among the rank and file of the amateur gang out here. G2OD has as good a signal as any we hear from Europe, and has been worked more than any other. G2NM is equal, perhaps, in strength, but has not been quite so steady as 2OD in breaking through. 2SH follows them very closely, and has worked most of the Maritime gang. Other English stations logged or worked here are 2KF, 2SZ, 5BV, 5KO, 5NN, 5FS, 6XX, 2WJ, 5OT, and 6RY. The last-named station has only been coming through for the last week, and is evidently a new one. However, he is on a par with the best of them, and, no doubt, will be known as well as 2OD and 2NM and 2SH before long. It might interest our English brother hams to know that the following stations of Europe have been logged in Halifax during the past winter season :

BRITISH : (2KF), (2NM), (2OD), (2SH), (2SZ), (5BV), (5KO), 5NN, (5FS), 6XX, (6RY).

FRENCH: (8AB), (8ARA), (8BF), (8BM), (8CT), 8JL, FL.

DUTCH: PA9, (PAODV), NAB2, (PCII), PCTT, PAR14.

ITALIAN: ACD.

Note.—Those in brackets worked.

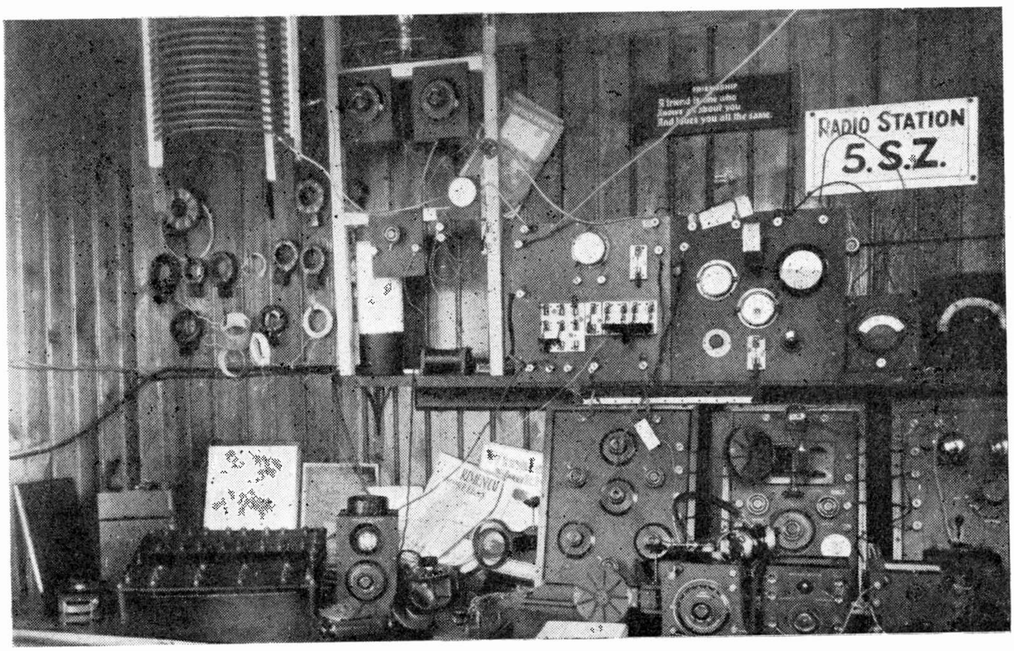
It might also interest our English brother hams to know that the seven Maritime stations that have been successful in two-way work with England have all been able to reach the goal of their ambitions with *inputs* of less than 100 watts. In fact, 1BQ on one occasion worked 2OD with an input of 20 watts, which shows the English amateurs are on the job at reception. One British station, G5US, although he has not worked us, has logged every local station that has worked England. We would particularly be glad to hear of any British stations, and are ready at all times to make tests of any kind.

All Maritime stations to have had two-way work with England to date are located in Halifax or Dartmouth, which is across the other side of Halifax Harbour from the city. It is, therefore, an easy matter to notify them of any tests which the English stations may wish to make.

Let us continue and make "The Royal Order of Transatlantic Brass Pounders" grow.

In conclusion, I trust that all amateur readers of your paper will endeavour to communicate with any Maritime Provinces hams that they hear in future, as in the past.

Radio Station 5SZ.



A general view of 5SZ, which uses two Mullard 0/10A valves in parallel fed from an M.L. converter.

Constructional Notes on Loud-speaking Telephones.

By E. SIMEON.

We give below the results of some experimental work which has recently been conducted on loud speakers.

THE following notes deal with various points in connection with two types of loud speaker: that using an iron diaphragm similar to an ordinary telephone, and the type often called the "electro-dynamic," and perhaps better described as a "moving coil" instrument.

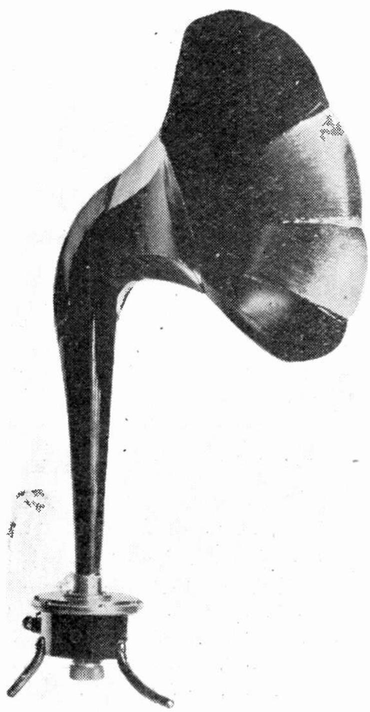


Fig. 1—A loud speaker with a built-up zinc horn.

There are, of course, several other types, such as that using an iron reed; but even on the commercial instrument the results obtained, while exceedingly loud, are somewhat weak as regards quality; and an amateur's attempt is scarcely likely to be an improvement on it.

Effect of Horn.

It is necessary to use a horn if any degree of efficiency is to be obtained. In that type of loud speaker using a large diaphragm and no horn probably only the few square inches in the centre move at all, except at very low frequencies. At all events, much the same results are given with a $2\frac{1}{2}$-in. diaphragm, supported so as to have the same natural frequency, as a 12-in. one. In either case the efficiency is low, nor is the quality appreciably better than can be obtained from a properly-made loud speaker with a horn.

A horn (such as is generally used) about 2 ft. long, measured along the curved axis, will probably be resonant at about 50 p.p.s., roughly indicated by blowing across the small end. If a telephone is caused to emit a pure note it will be found that the increase in volume obtained by placing a horn on it is very much greater on low notes (say up to 400 p.p.s.) than on higher ones. On frequencies above about 1,500 hardly any change can be observed. Therefore when music consisting of a great number of frequencies is reproduced, not only will the volume increase on applying the horn, but also the tone will be altered considerably, and, if the loud speaker is properly made, considerably improved. The effect of the transformer, together with the high natural frequency of the diaphragm, will result in exaggerating the higher notes. The horn will bring out the lower notes more than the others, so tending to restore the balance.

If the diaphragm has a low natural frequency the addition of the horn will make matters worse.

Construction of Horn.

A simple conical horn will increase the

volume to a certain extent, but one of the familiar curved shape will give much better results, and can be made without much difficulty.

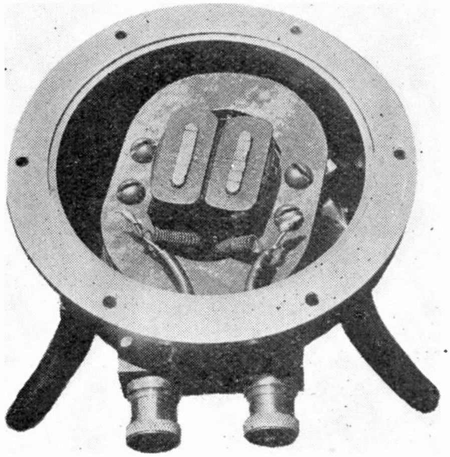


Fig. 2—Magnet and coils of iron diaphragm loud speaker.

Fig. 1 shows a horn made up of pieces of zinc soldered together, as described below. The bell-mouth consists of eight similar

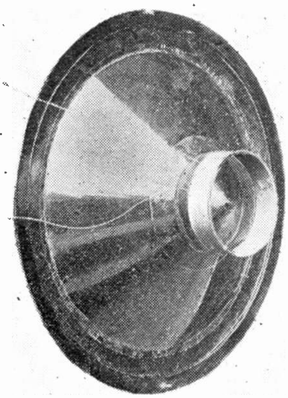


Fig. 3—Diaphragm and moving coil.

pieces, while the upright part is in one piece. These two parts present no difficulty. The pieces which go to make the right-angle bend are set out as follows :—

A wire frame is made to fit the octagonal smaller end of the bell, and another the shape of the larger end of the straight part, which is circular in section. The parts are then placed and held at the right position and angle relative to each other, while a wire is shaped so as to continue one of the corners of the bell-mouth down to the other part, as shown in Fig. 8. The other seven wires are also bent and soldered in place, giving a sort of outline of the bend. From this a paper pattern can be made of each piece by folding a flat sheet round each space and marking round with a pencil. Having made these patterns the horn may be completed. It should be quite strong and rigid, and in fact the writer's suffered no damage when the whole thing accidentally fell on the floor.

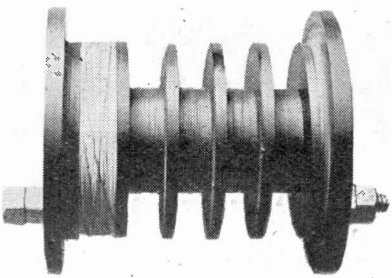


Fig. 4—Details of transformer.

This method of producing awkward parts can, of course, be applied to other shapes.

Suitable horns may also be purchased or made of paper pulp on a wax former, afterwards melted out. This type of horn is, however, somewhat messy to make, takes a long time to dry, and does not give a very good-looking horn, nor does it produce the same increase in volume as a smooth metal one does.

Construction of Moving Coil Instrument.

The field magnet consists of a bobbin $2\frac{1}{4}$ ins. diameter by $2\frac{1}{2}$ ins. long, wound full of No. 22 D.S.C. on a core $\frac{3}{4}$ in. diameter of soft wrought iron. A narrow air gap ·035 in. wide is left all round the top as shown, the top and bottom plates being

¼ in. thick (see Fig. 5). The magnetic circuit is closed through the tubular case.

The reluctance of the iron circuit (which determines the flux produced, and hence the force on the coil) will be proportional to the length of the gap, the reluctance of the rest of the magnetic circuit being negligible. Thus the flux would be halved were a gap of ·07 in. left. To produce the same flux in this gap would need twice the current, which again would mean doubling the voltage—or four times the energy. A current of about ¾ amp. at 4 volts is used to energise the field.

Diaphragm and Coil Former.

These are both made from celluloid, cemented together with a solution of celluloid in amyl-acetate (see Fig. 3). Celluloid is ideal for the purpose, its S.G. being only about two-thirds that of aluminium. It is also possible to dispense with nuts and screws, resulting in absence of rattle. The dimensions are given in Fig. 6. The coil must be exactly to size and perfectly round, and should be rolled on an ebonite rod turned exactly to size, and bound on with wire (without

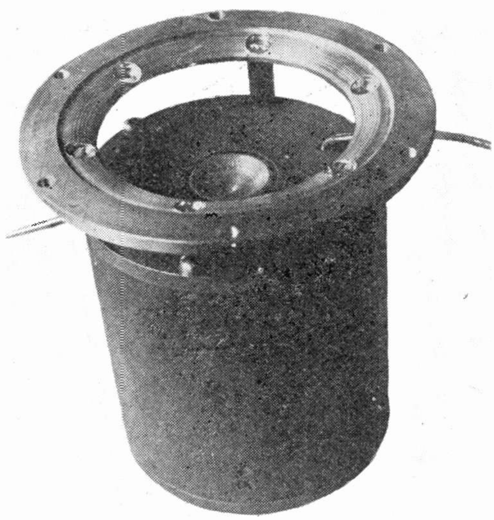


Fig. 5—Showing air gap in the core.

removing the rod from the lathe) until the cement sets—this will take some hours—and then turned to size, after which it can easily be slipped off. It is wound with two layers of 44 s.s.c., about 80 turns, with a resistance of 16 ohms being got on. The wire should be embedded in celluloid cement.

Fig. 5 also shows the method of holding the diaphragm. A top plate with six 4 B.A.

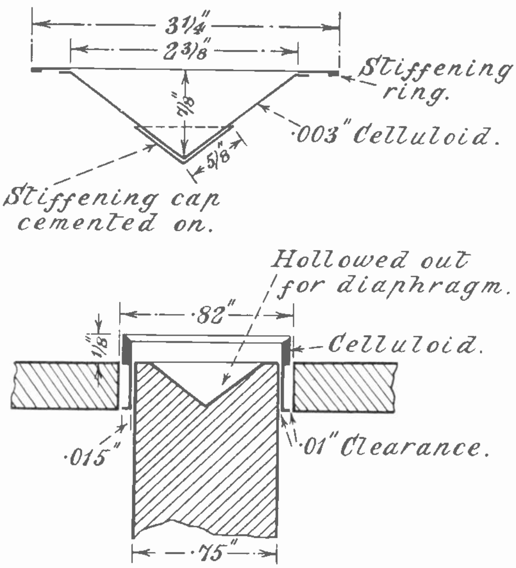


Fig. 6—Dimensions of coil and diaphragm.

screws holds it in place, and also carries the horn. The arrangement shown leaves room for adjusting the diaphragm into position, through the side, after the top has been put on.

A tubular brass case with three feet encloses the whole of the iron part up to the lower diaphragm ring.

Three terminals are provided, one to one end of the small coil, and one to one end of the field-coil, the other ends of both coils going to the middle terminal.

Transformer.

This loud speaker cannot be used without a transformer. If much power is to be used very considerable voltages may be set up across the primary when the plate current suddenly varies, probably more than that of the H.T. battery itself. For this reason, and to reduce the self-capacity, the primary is wound in five sections as shown in Fig. 4, the beginning of each section being taken down a small hole in the thickness of the ebonite wall. This will mean a joint at the bottom of each section.

A total of 11,000 turns of 40 s.s.c. are used for the primary, after which a few layers of paper and shellac varnish are put on. The secondary, wound without sections, consists of 300 turns of 22 D.S.C.

The high insulation of the primary may be shown by joining the ends of the thick wire coil across a pocket lamp battery, when a

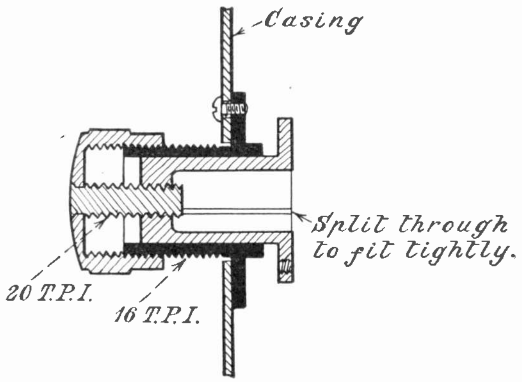


Fig. 7—Illustrating method of adjusting air gap.

spark up to ⅛ in. will jump the ends of the other winding. An open core of iron wires, ⅝ in. diameter, is employed.

This transformer can be replaced by an ordinary ignition coil, using the high resistance winding for primary; in this case, the diaphragm coil should be wound with two layers of No. 40 S.S.C.

Iron Diaphragm Loud Speaker—Adjustment of Air Gap.

The magnets and coils (see Fig. 2) are mounted on a round sliding piece, which is prevented from turning by its tight fit, but can be raised or lowered by a knurled head. The arrangement shown in Fig. 7, while somewhat elaborate, is rigid and capable of fine adjustment, the distance moved forward per revolution being the difference between the two pitches employed (1-16th in. and 1-20th in.) or 1-80th in.

When putting the instrument away for a time always close the air gap.

Windings.

No. 44 S.S.C. should be used, wound to a resistance of 1,500 ohms. Nothing is gained by winding to a higher resistance than this; in fact, if a low impedance valve (as the B.4) is used, practically equal results are obtained with the two coils in parallel—giving 375 ohms.

The cores of the bobbins are of welding iron, a very pure form of the metal. The wire is filed up square, and bent into L shape, using six pieces for each pole piece. The poles are ⅛ in. wide, 11-16th in. long across the top and ½ in. apart.

The diaphragm is of tinplate, with the tin wiped away while hot. It is 3¼ ins. diameter by ·012 in. thick.

Comparison between the Two Types.

These two loud speakers were both constructed by the writer, and gave the best results of many variations on both types The following notes as to their performance (on a resistance coupled amplifier without reaction) may be of interest as indicating what may be expected of similar apparatus.

The iron diaphragm loud speaker reproduces remarkably well in some directions, particularly a man's voice, or, say, a violin or flute solo. On orchestra music and the piano a certain flavour is introduced which ought not to be there, which renders it impossible to imagine that one is listening to the real thing. On rustling noises (such

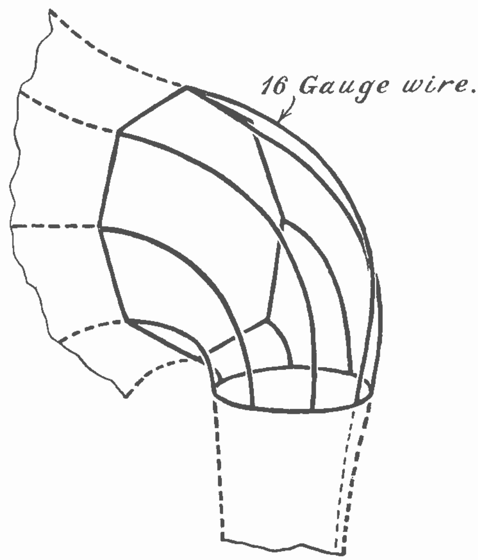


Fig. 8—Wire former for horn.

as "sea waves" recently broadcast) it shows up at its worst, being quite unrecognisable.

For all this, it is quite as good as the average commercial instrument of the same type.

The above defects are not so much due

to the horn as to distortion produced by the iron, and by the low natural frequency of the diaphragm. A fairly large diaphragm *must* be used if any volume is required.

The moving-coil type is capable of extremely good rendering of practically any music or speech. Comparative tests on the same horn show that in some circumstances the improvement is very marked.

The diaphragm with its coil of this loud speaker only weighs about $1\frac{1}{2}$ grams, whereas an iron diaphragm of the same diameter weighs about six times as much. Due to the small mass the natural frequency is not nearly so well marked, and owing to the special shape employed, considerably over 1,000 p.p.s.

Except what occurs in its transformer, no iron distortion is present, since, although plenty of iron is used, the intensity of the field in the iron is maintained perfectly constant.

An instrument of this type can be worked so as to be audible at $\frac{1}{4}$ mile distant.

In spite of its superiority, the moving-coil type does not seem very popular. It is, of course, more expensive to buy, and requires a certain amount of power for its field. A certain residual magnetism remains on switching off the field current, and the instrument will work on this; on applying the field current the volume increases five to ten times. It is then giving much the same volume as would an iron diaphragm loud speaker, under the same conditions.

If it were thought worth while to fit the instrument with permanent magnets, six or eight bar magnets would replace the outer iron case, with their axes parallel to the central rod, which should remain of soft iron.

Use as a Microphone.

It is interesting to note that either of these loud speakers can be used as a microphone. They are, however, very inefficient in this respect. Speaking close to the horn only a very moderate strength of speech was obtained with a stage of L.F.

Using an ordinary 2,000-ohm earpiece without horn similar results are obtained with three stages of L.F. It is, therefore, rather surprising that the inventor of the telephone (who used it as both transmitter and receiver) could hear anything whatever with it. His instrument could only be a fraction as efficient as a present-day telephone, as would also be the telephone used with it, and no amplification was possible.

The Trend of Invention.

We summarise below the more important inventions which have been disclosed during the month; special reference being made to those of particular interest to the experimenter.

The Anson Relay.

The arrangement illustrated in Fig. 1 is now fairly familiar, its object being to improve the working of Morse relays by three-electrode valves (British Patent 214,754, H. St. G. Anson). The audio-frequency Morse signals are sufficiently amplified and impressed by means of a transformer on the grid of valve D. In the grid circuit of this valve is included a grid condenser C, with leak E, so that the signal currents depress the mean potential of the grid and cause a decrease in plate current. The interesting feature is the inclusion in the plate circuit of a neon lamp A in series with the relay B. The neon lamp acts as a suitable series resistance for reducing the time-constant of the relay circuit, at the same time steepening the response characteristic or sensitivity of the system. An ordinary ohmic resistance used in place of the neon lamp would reduce the time constant, but would flatten the characteristic.

Uranium as Cathode for Thermionic Tubes.

British Patent 207,514 (Western Electric Co., Ltd., and J. E. Harris) covers the use of the metal uranium for the electron emitting cathode in thermionic discharge tubes. It is stated that uranium has about the same emissivity as the alkaline earth oxide coated filament, but has a relatively high melting temperature, and a relatively low rate of volatilisation, and retains its activity when subjected to high voltages. The form of tube illustrated in the specification is shown in Fig. 2. The cathode C consists of a molybdenum boat containing finely powdered uranium, the leads E and D being taken

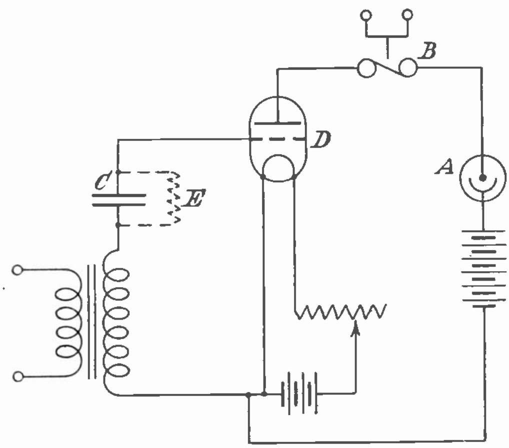


Fig. 1—The Ansu relay circuit.

through sub-divided seals to deal with the cathode heating current. The patent, however, covers the use of metallic uranium by itself or an alloy of uranium with another highly refractory element.

Improved Loud-Speaking Reproduction.

H. J. Round has evidently realised the extravagance of expecting one diaphragm and one circuit to do everything over the entire range of audibility, and has accordingly patented the use of two or more diaphragms having natural periods of vibration of different values, and actuated by separate magnet windings (British Patent 215,104, H. J. Round). The effects from the various diaphragms combine in one common horn of large dimensions. It is preferred to use a series of magnetophones of the type illustrated diagrammatically in Fig. 3, the case and central core of which form the magnetic circuit ; the large winding is used to produce the necessary magnetic field, while the small one is a light movable coil carrying the speech currents, and which actuates the diaphragm. The inventor states that good results for speech are obtained by the use of two magnetophones whose diaphragms have natural frequencies of 600 and 6,000 respectively. For music he recommends three of natural frequencies—200, 900 and 6,000—while better still is a combination of five diaphragms having frequencies of 200, 500, 900, 2,000 and 8,000 respectively. Systems of multiple amplifiers and filter circuits are described in the specification for the purpose of suppressing unduly prominent frequencies, and for ensuring the reproduction of the various frequencies in their right proportions.

Method of Repairing Valve Filaments.

Fig. 4 illustrates a process of renewing the filament in valves such as the R type, where the filament is horizontal (British Patent 215,437, J. M. Longe and P. V. Castell-Evans). The pip is first removed to release the vacuum, and through the hole thus made at F air is forced in from the tube E, while

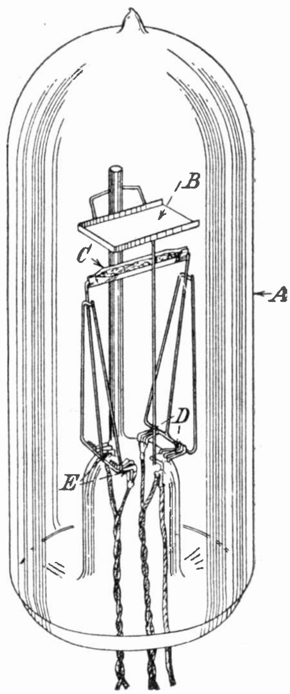


Fig. 2—A uranium cathode valve.

the points C are heated with a pointed blowpipe flame G. Two holes are thus burst in the glass at points C sufficient to allow the introduction of suitable manipulating tools. The tops of the vertical portions of the filament supports D are cut off, and removed along with the remains of the old filament. New tops to these supports are made and fixed, as shown at H in the second figure, by forming their lower ends into spirals that will just fit over the remains of the old supports. When in position, the spiral portions are

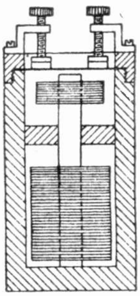


Fig. 3—Construction of the Round loud speaker.

pinched to secure them firmly in position. The new filament may be attached to the tops of these new supports before their insertion in the valve. The holes at C are sealed up again, and the bulb is evacuated through a tube sealed on at F.

Overcoming Mechanical Resonance in Telephone Receivers.

Most telephone diaphragms have a pronounced resonant frequency which results in

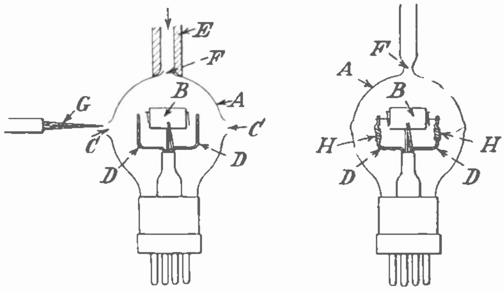


Fig. 4—Method of re-filamenting valves.

undue prominence in reproduced sounds of this frequency; this, in fact, is one of the commonest forms of distortion. J. Bethnod has patented the use of a rejector circuit in series with a telephone receiver, the rejector being tuned to the mechanical resonance frequency of the telephone diaphragm (British Patent 206,139, J. Bethnod).

Business Brevities.

A Legless Valve Holder.

The accompanying photograph illustrates a legless valve holder which has been produced by Messrs. Goswell Engineering Co., Ltd., of 12a, Pentonville Road, London, N.1. It will be seen that the holder is arranged so as to allow either panel or surface wiring to be employed. The connecting wires may be gripped by passing through the panel, allowing the ends to enter the sockets where they are gripped by the setscrews, or they may be fixed externally under the screw heads. We notice that the base of the sockets are level with the ebonite moulding which necessitates the holder being mounted on an ebonite panel. Perhaps it would have been advantageous to have countersunk the base of the sockets so that the holder could be mounted on a woolen or other panel, thereby increasing its use materially.

* * *

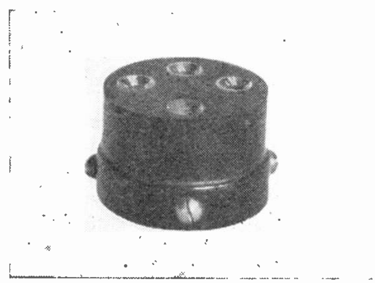
A New Mullard Resistance.

The Mullard Radio Valve Co., Ltd., have recently produced a very interesting type of filament rheostat. It consists essentially of a drum carrying the resistance wire arranged in a spiral form. The drum is caused to rotate by turning a knob which is fixed to a pointer arranged to operate over a spiral scale. The total resistance of the wire is about 8·8 ohms, and gives an exceedingly fine gradation of filament current. The price of the rheostat is only 4s. 3d.

* * *

Fallon Condenser Co., Ltd.

We are advised that Messrs. Fallon Condenser Co., Ltd., have just opened a city depôt at 143

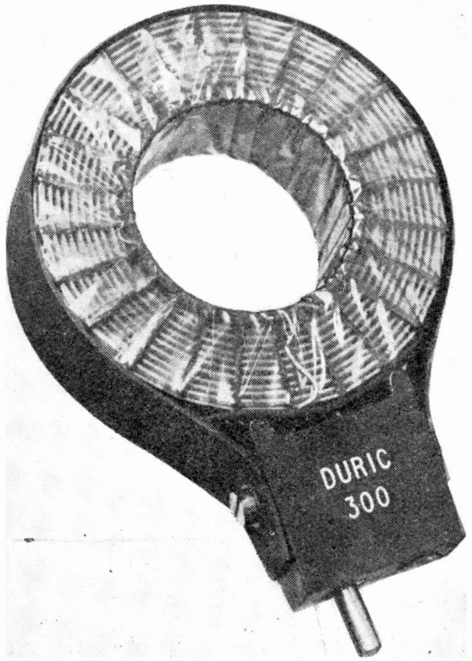


A legless valve holder.

Farringdon Road, London, E.C.4, where all their goods may be obtained, both wholesale and retail.

"Duric" Inductance Coils.

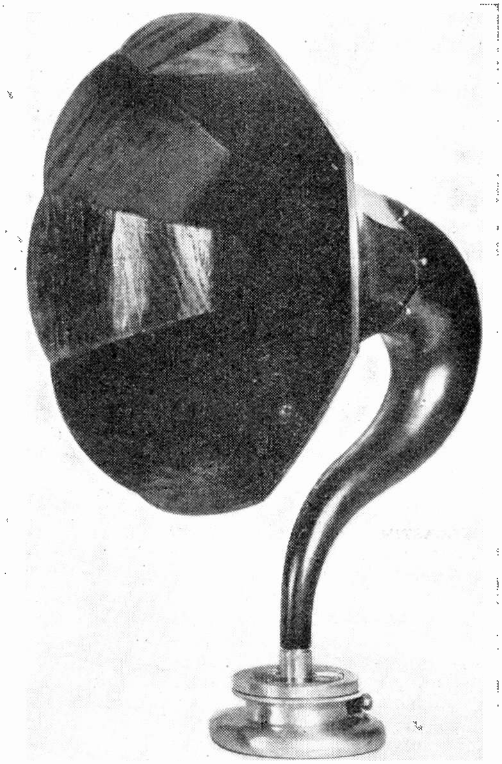
Messrs. Radio Acoustics, Ltd., have submitted to us a set of their new "Duric" plug-in coils, one of which is shown in the accompanying photograph. We find these coils electrically satisfactory, and the method of construction gives them a mechanical rigidity and durability which many other makes lack. Multi-layer winding is employed, the layers being air-spaced by means of separate spacing elements and not by means of the wire itself. The windings are bound with oiled-silk tape to protect them from the atmosphere. For general tuning purposes we find these coils at least as good as most other makes of plug-in coil. We have made special tests in our laboratory with the largest and smallest sizes (coils Nos. 500 and 30). With no external loading capacity the No. 500 coil tunes to 960 metres, and with a shunt capacity of ·001μF. it tunes to 7,800 metres, indicating a self-capacity of about ·000014μF., which is creditably low for a long-wave coil. The No. 30 coil has only two layers, tuning to 90 metres by itself and 540 metres with a ·001μF. condenser, indicating a self-capacity of about ·000028μF. Although this latter value is twice that for the large No. 500 coil, it compares favourably with other short-wave multi-layer coils that we have tested. Our tests indicate that the advantages of multi-layer winding are less for short-wave coils of few layers than for long-wave ones having a large number of layers.



The Duric Inductance.

The Allison Loud Speaker.

We have recently received from the Cromwell Engineering Co. one of their "Allison" loud speakers for purposes of test. It will be noticed that in appearance it is very similar to the well-known Amplion loud speaker but the construction is entirely different. The smaller photograph illustrates the construction and arrangement of the diaphragm and magnetic system. The strong permanent magnets and coils are rigidly fixed in the base chamber and are hermetically sealed by a good quality wax filling. The mounting of the diaphragm is of special interest. The diaphragm, which is of Stalloy, is rigidly fixed round the entire circumference to the top cover plate, which also serves to carry the horn. In operation the cover plate carrying the diaphragm and horn is screwed down until the diaphragm is at the correct distance from the magnet poles. It is claimed that this method of construction results in extreme rigidity and tends materially to improve the tone. On test we found the loud speaker both sensitive and mellow in tone, there being not the slightest trace of either harshness or shrillness. Several models are made, fitted with aluminium, mahogany or oak horns and the prices range round £4 or £5 according to the size of horn and resistance of the winding. The address of the Cromwell Engineering Co. is 81, Oxford Avenue, Merton Park, S.W.20.



The Allison Loud speaker.

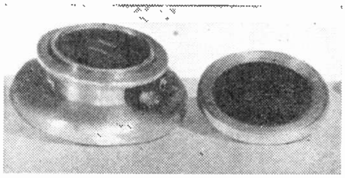
WATMEL WIRELESS CO.

Messrs. Watmel Wireless Co. advise that owing to increased business they have been compelled to move into much larger premises which are now situated at 332A, Goswell Road, London, E.C.1.

* * *

"CLIX."

Readers will be pleased to learn that Messrs. Autoveyers, Ltd. have now been able to revise the retail price of their ever popular and useful Clix as follows:—Clix, with locknuts, 3d. each; Clix insulators (six colours), 1d. each; Clix bushes (six colours), 1d. pair.



The Allison Diaphragm.

Recent Wireless Publications.

Figures after the title of each publication indicate Volume and Number of Publication containing the article. Where only one number is given, this indicates the serial number of the publication. The abbreviations used in this bibliography will be found in the early issues of "Experimental Wireless."

I.—TRANSMISSION.

DIRECTED RADIO RAYS.—Prof. René Mesny (*R. News*, 5, 12).

ZIEHVORGÄNGE IN INDUKTIV GEKOPPELTEN ZWISCHENKREISRÖHRENSENDERN. — Wilhelm Runge (*Jahrb. d. drahtl. Tel.*, 23, 1).

TYPISIERUNG VON DREIELEKTRODENRÖHRENSENDERN.—H. Wigge (*Jahrb. d. drahtl. Tel.*, 23, 1).

VERSUCHE ÜBER TELEPHONIE MIT DOPPELGITTERRÖHREN.—A. Hamm (*Jahrb. d. drahtl. Tel.*, 23, 2).

DIE MASCHINELLE FREQUENZ - MULTIPLIKATIONSANORDNUNG VON W. DORNIG.—Eugen Nesper (*Jahrb. d. drahtl. Tel.*, 23, 2).

THE DEVELOPMENT OF SIMULTANEOUS BROADCASTING.—E. K. Sandeman, B.Sc. (*W. World*, 250 and 251).

BROADCASTING DISTRIBUTION.—R. Brown and G. Gillett (*Electn.*, 2,403).

PRACTICAL MASTER OSCILLATOR SETS.—E. A. Laport (*Q.S.T.*, 7, 11).

A GOOD BREAK-IN SYSTEM.—P. Laskowitz (*Q.S.T.*, 7, 11).

SMALL TRANSFORMERS FOR THE AMATEUR.—H. F. Mason (*Q.S.T.*, 7, 11).

THE EFFECT OF THE SERIES CONDENSER IN A TRANSMITTING AERIAL.—E. H. Robinson (*Exp. W.*, 1, 9).

II.—RECEPTION.

POUR RECEVOIR LES ONDES TRÉS COURTES.—M. Malgouzou (*L'Onde Elec.*, 27).

L'INFLUENCE DU BROUILLAGE SUR LES RÉCEPTEURS A RÉACTION.—L. Brillouin and E. Fromy (*L'Onde Elec.*, 28).

L'AMPLIFICATEUR H.F. À RÉSISTANCES ET LES ONDES COURTES.—M. P. Lafond (*L'Onde Elec.*, 28).

QU'EST-CE QU'UN COLLECTEUR D'ONDES ?—Michel Adam (*R. Elec.*, 5, 60).

GÉNÉRATEUR - AMPLIFICATEUR SANS LAMPE. — I. Podliasky (*R. Elec.*, 5, 60).

SUR LA THÉORIE DU RÉCEPTEUR TÉLÉPHONIQUE.—J. Bethnod (*R. Elec.*, 5, 61).

EINE NEUARTIGE RUCKKOPPLUNG BEIM VIERRÖHREN-HOCHFREQUENZ-VERSTÄRKER.—W. Hey (*Jahrb. d. drahtl. Tel.*, 23, 3).

ÜBER STÖRUNGEN BEIM RADIO-EMPFANG.—E. Lübcke (*Jahrb. d. drahtl. Tel.*, 23, 3).

A NEW THEORY OF CONTACT DETECTORS.—James Strachan, F.Inst.P. (*W. World*, 250).

PUSH-PULL SPEECH AMPLIFIER.—W. James (*W. World*, 251).

OSCILLATING AND AMPLIFYING CRYSTALS.—Hugh S. Pocock (*W. World*, 252).

SHORT-WAVE RECEIVER.—(*W. World*, 252.)

THE TUNED CATHODE CIRCUIT.—J. F. Johnston (*W. World*, 253).

THE SENSITIVITY AND PHYSICAL PROPERTIES OF CRYSTALS. — James Strachan, F.Inst.P. (*W. World*).

BUILDING SUPERHETERODYNES THAT WORK.—Part I (*Q.S.T.*, 7, 11).

A FOUR-ELECTRODE VALVE RECEIVER.—G. L. Morrow (*Exp. W.*, 7, 11).

SUPERSONIC RECEIVER EMPLOYING A FOUR-ELECTRODE VALVE.—A. L. Williams, R.N. (*Exp. W.*, 1, 9).

DIRECTION FINDING.—Commdr. J. A. Slee (*Exp. W.*, 1, 9).

III.—MEASUREMENT AND CALIBRATION.

DIE MESSUNG DER SCHEITELSPANNUNG MIT DER GLIMMRÖHRE.—A. Palm (*Jahrb. d. drahtl. Tel.*, 23, 1).

CHECKING UP ANTENNA FORMULAS.—Ralph R. Batcher (*Q.S.T.*, 7, 11).

IV.—THEORY AND CALCULATION.

SUR PLUSIEURS EXTENSIONS DE LA NOTION DE RÉSISTANCE.—Lieut. Blanchard (*L'Onde Elec.*, 28).

ZUR BERECHNUNG KOMBINIERTER SCHWINGUNGSKREISE.—G. Kuprijano and P. Schmakow (*Jahrb. d. drahtl. Tel.*, 23, 1).

DIE RESONANZKURVEN BEI VERSCHIEDENEN DÄMPFUNGSTYPEN.—D. Roschansky (*Jahrb. d. drahtl. Tel.*, 23, 2).

BERECHNUNG DER KOPPLUNGSKOEFFIZIENTEN FÜR EINIGE BENSÖNDERE FÄLLE DER GEGENSEITIGEN INDUKTION.—D. Wicker (*Jahrb. d. drahtl. Tel.*, 23, 2).

NAGAOKA'S CORRECTION FACTOR K.—E. J. Hobbs, M.C. (*W. World*, 250).

GRID RECTIFICATION.—J. H. Reyner, B.Sc. (*Exp. W.*, 1, 9).

V.—GENERAL.

OBSERVATIONS RADIOÉLECTRIQUES.—(*L'Onde Elec.*, 27.)

L'ANTENNE ONDULATOIRE OU ANTENNE BEVERAGE.—M. F. Bedeau (*L'Onde Elec.*, 27).

LA STATION RADIOTÉLÉGRAPHIC DE MOSCOU-HODINSK.—(*L'Onde Elec.*, 28).

THE VACUUM TUBE AND HOW IT WORKS.—Prof. J. H. Morecroft (*R. News*, 5, 12).

LOOSE-COUPLED TRANSFORMERS.—(*W. Trader*, 2, 16.)

CORRECTION DE LA DISTORTION DUE À LA CAPACITÉ DE CABLES TÉLÉPHONIQUES, DES AMPLIFICATEURS ETC.—I. Pödliasky (*R. Elec.*, 5, 61).

DIE QUECKSILBERLAMPE ALS FUNKENSTRECKE UND UNTERBRECHER.—W. Burstyn (*Jahrb. d. drahtl. Tel.*, 23, 1).

ZUR BESTIMMUNG DER KURVENFORM VON WECHSELSTRÖMEN MIT HILFE DER BRAUNSCHEN RÖHRE.—L. Casper, K. Hubmann and J. Zenneck (*Jahrb. d. drahtl. Tel.*, 23, 2).

ÜBER ERZWUNGENE SCHWINGUNGEN IN GEKOPPELTEN ELEKTRONENRÖHREN KREISEN.—F. Rossmann and J. Zenneck (*Jahrb. d. drahtl. Tel.*, 23, 3).

DER EINFLUSS EINER LEITENDEN VERBINDUNG VON ZWEI GEKOPPETEN KREISEN.—F. Rossman and J. Zenneck (*Jahrb. d. drahtl. Tel.*, 23, 3).

DAS VERHÄLTNIS VON INDUKTIVER UND DIREKTER KOPPLUNG.—F. Rossman and J. Zenneck (*Jahrb. d. drahtl. Tel.*, 23, 3).

FAITHFUL REPRODUCTION BY BROADCAST.—Capt. P. P. Eckersley, M.I.E.E. (*W. World*, 250 and 251).

THE CHEMISTRY AND MINERALOGY OF CRYSTALS.—J. Strachan, F.Inst.P. (*W. World*, 251).

THE EARLY HISTORY OF TELEVISION.—J. Strachan, F.Inst.P. (*W. World*, 252).

AN ALTERNATIVE TO THE HEAVISIDE LAYER THEORY.—Prof. G. W. O. Howe (*Electn.*, 2,404).

ÜBER DIE BESEITIGUNG DER WECHSELSTROMPARASITEN BEI GLEICHSTROM - VERSTÄRKER - RÖHREN.—H. Greinacher (*Zeitschr. f. Physik.*, 23, 6).

ÜBER DIE REFLEXION UND BRECHUNG ELEKTRISCHER WELLEN AM GESCHICHTETEN MEDIUM.—K. Försterling (*Ann. d. Physik.*, 74, 2).

DAS VERHALTEN HERTZSCHER.—Clemens Schæfer (*Ann. d. Physik.*, 74, 3).

ON THE EMISSION OF POSITIVE IONS FROM HOT TUNGSTEN.—Prof. W. A. Jenkins (*Phil. Mag.*, 281).

TELEPHONE DIAPHRAGM RESONANCES.—Prof. E. Mallett, M.Sc. (*W. World*, 253).

A NEW RADIO SIGNALLING SYSTEM.—Paul B. Findlay (*Q.S.T.*, 7, 11).

THE UTILITY OF THERMIONIC VALVE CHARACTERISTICS.—H. J. Barton Chapple, B.Sc. (Hons.) (*Exp. W.*, 1, 9).

VALVE MANUFACTURE.—W. J. Jones, B.Sc. (*Exp. W.*, 1, 9).

THE HEARTSHAPE.—F. Youle, B.Sc. (*Exp. W.*, 1, 9.)

THE PROBLEMS OF HIGH-TENSION SUPPLY.—R. Mines, B.Sc. (*Exp. W.*, 1, 9).

Correspondence.

Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—In the letter from "Kilo Watt" in the present issue of EXPERIMENTAL WIRELESS mention is made of sparks being drawn from an aerial during rain or hail. In this connection I should like to mention that one of my aerials runs towards a railway line at the end of the garden, and while it was connected to the receiver (it is usually used only for transmission) I heard a very loud noise when a train passed. Later, when the receiver was switched off, I heard clicks coming from it, which proved to be due to sparks passing across the series condenser; any number up to about a dozen or more were caused by the passing of a train. On disconnecting the aerial altogether and bringing my finger near it a brush discharge started at about ⅛ in., and about ⅛ in. spark could be obtained. The most favourable occasions are dry days when the steam from the engine is evaporated very rapidly. It is not necessary for the smoke, etc., actually to pass against the aerial.

The action of this effect seems to be similar to that of the hydro-electric machine, consisting of an insulated boiler, which becomes charged to a very high potential when steam is blown off, and presumably any insulated wire near-by would receive a charge of opposite sign.

Perhaps some other readers have noticed an effect of this sort, and would be interested to compare results.—I am, faithfully yours,

MARCUS G. SCROGGIE.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—With regard to the correspondence in the last two issues of this journal concerning spark discharge from aerials, I concur with the opinion that hailstorms apparently charge an aerial to a higher P.D. than anything else. To quote my experiences :—

Two cases came to my notice of sparks being obtained from an aerial during a heavy rainfall, but they were quite small.

However, on April 12, 1924, I distinctly obtained sparks from an aerial 100 ft. long by 40 ft. high (single wire).

I discovered the presence of an unusual charge through the medium of a gentleman (who was using the aerial at the time) receiving a very appreciable shock.

On holding the end of the "lead-in" near the earth terminal a spark about an inch in length occurred, accompanied by the characteristic crack associated with spark discharge. This was loud enough to be heard plainly in a large room, in which a number of persons were talking.

After this one large spark others were obtained, of decreasing length, for the space of two minutes or thereabouts.

A heavy hailstorm had occurred previously, and at the time of obtaining the sparks a low-lying cloud was passing overhead.

I also have tried to obtain sparks during many thunderstorms, but without success, although loud crackles are heard in the 'phones as the lightning stroke occurs.

This subject seems to be raising an interesting point, and I hope somebody will come along with some actual measurements.—Yours faithfully,

D. C. W. JOWERS.

To the Editor EXPERIMENTAL WIRELESS.

DEAR SIR,—I should be glad if you would allow me to reply to Mr. Hogg's letter. I fear that Mr. Hogg has never, or at any rate does not usually, employ loose coupling. That, I think, is his chief trouble. His chief grouse against variometers seems to be their unselectivity.

Surely it is better to get our selectivity in the aerial, or at any rate the secondary, circuit. He admits that a greater amplification is obtained. If, then, the grid circuit of the H.F. valve is made selective (of course, this cannot be done efficiently with a direct-coupled set) then no trouble will be found with the variometer and better amplification obtained than by sacrificing amplification to selectivity in the tuned anode coil. Another advantage incidentally of loose coupling is that hand capacity, of course, disappears, as a parallel condenser may be used in the aerial and secondary circuits.

Having described his own set, Mr. Hogg then makes the amazing statement that L.F. amplification decreases the selectivity of a set. What the L.F. amplifier has to do with the aerial or tuned anode circuits beats me, unless, of course, Mr. Hogg used a reflex with a L.F. transformer in the aerial circuit, as I saw in a magazine the other day. As regards Mr. Hogg's statement that a circuit using resistance-controlled regeneration causes oscillation trouble, I suppose he must have his little joke. Surely a resistance cannot make the set radiate more than if the regeneration was controlled in the conventional manner. I suggest that his neighbour has excessive H.T. on his H.F. valve.—Yours faithfully,

H. ANDREWES.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—An Erla Transformer has been sent to me by the Electrical Research Laboratories of Chicago for testing. A preliminary examination of the transformer showed that it was of neat appearance and well made. On testing it the tone was found to be extraordinarily good even when used in the third stage of amplification and the volume compared well with the majority of British transformers. The core although very simply and easily made is perfectly satisfactory. The ohmic resistance of the primary winding is 1050 ohms and of the secondary winding 6300 ohms. The transformer ratio is one to three and a half. The insulation resistance of primary to secondary is infinite, or windings to case 300 megohms and of windings to core infinite. The reason for the low resistance between windings and case is probably due to the fact that the terminals are set in the top of the casing and the methods of insulation are perhaps a trifle insufficient. The impedance of the transformer was not tested for various frequencies. The price of the transformer (5 dollars) is a little high compared with the majority of British transformers but there is no doubt that it gives excellent results. Perhaps the above results of my tests may be of interest to some of your readers.—Yours truly,

BRIAN H. COLQUHOUN (2QZ).

MISUSE OF CALL SIGNS.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIRS,—I noted Mr. Hay's letter in your issue of April 30 last but think he must have made a slight mistake.

The call sign Radio 2KG (two kg) was allotted to my station in December of last year so I presume that Mr. Hay has for some reason or other failed to comply with G.P.O. regulations.

Before people rush into Press regarding such matters I should have thought it more diplomatic to approach H.M. Postmaster-General to ascertain whether he might have erred in issuing duplicate call signs and incidentally give him the opportunity of correcting same or dealing with the delinquent.

I would remind Mr. Hay that the call sign is the property of the Post Office, and I fail to see what legal redress he has in the matter, beyond protection from the issuing authorities.

I would compliment him, however, on his direction finder which appears to be of the 99½ per cent. efficiency type.—Yours faithfully,

GEO. K. FIELD (Major),
Chartered Electrical Engineer.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—Recently I have received reports from the North of England stating times of receiving my station during the majority of which I have been able to prove that I was not working. It appears therefore that some experimenter unknown has taken to himself the authority to make use of my call sign. May I, through the medium of your columns, draw attention to this fact in the hope that the individual or individuals concerned may note that I am aware of this use of my call sign and consequently discreetly forego taking such liberties? May I also point out that should I receive any further intimation of the unauthorised use of my call sign I do not intend to allow the matter to remain unattended?—Yours faithfully,

BRIAN H. COLQUHOUN (2QZ).

Experimental Notes and News.

The French Government has not been slow in making use of wireless to open up communication with its African colonies. A station at Saigon has been working for several months, and on June 10 one was opened at Bammako, on the Niger, which puts French West Africa in direct communication with France. Two other stations are planned, one at Brazzaville, on Stanley Pool, and one at Antananarivo (Madagascar).

* * *

The first ship to carry the new type of Marconi installation for ships' lifeboats, including a directional receiver and sense finder, is the P. & O. steamer *Majola*. This apparatus has been specially designed for use under the most adverse weather conditions, and in very confined space. The transmitter is capable of attracting the attention of a ship using a crystal detector at a distance of fifty miles, and at greatly increased distances if the ship is fitted with valve receivers. The directional properties of the receiver enable the lifeboat crew to ascertain the bearing of other ships.

* * *

Reception from the transmitting station at Teviot Place, Edinburgh, has considerably improved as a result of the visit of Mr. H. L. Kirke, the B.B.C. development engineer. It was found that the transmitting aerial was partially screened by surrounding buildings. The unscreened portion was accordingly extended, and reports show a great increase in the strength of reception.

* * *

Complaints have been made that naval wireless signalling interferes with broadcasting near naval stations, with the result that the Admiralty may reduce the destroyer wave-length, which, in home port areas, is now 310 metres. Orders have already been given at Portsmouth that signalling between 7 o'clock and 10.30 each evening is, as far as possible, to be avoided.

* * *

On Friday, June 13, the first message was transmitted by Signor Marconi's wireless beam system to the Argentine, a communication being sent by Senor Le Breton, Minister of Agriculture to the Republic, to General Justo, Minister of War. This opens up the possibility in the near future of a direct telegraphic service to the South American Republics, ensuring the delivery of messages within a few minutes of their transmission.

Mr. J. W. Riddiough asks us to announce that the address of his experimental station 5SZ is now White Croft, Bare Lane, Morecambe, Lancs.

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Mr. John McLaren, of Dalriada, Worthing, has been allotted the call sign 5AO. This call sign was previously held by Mr. H. H. Elsom, of Birmingham.

* * *

An interesting experimental wireless trip has recently been carried out from Australia. Mr. C. D. Maclurcan sailed from that country for America, with the object of carrying out wireless tests in connection with long-distance transmission on low waves and comparatively low power. A complete low-power wireless installation was fitted up on board R.M.S. *Tahiti*, with special aerials and counterpoise systems. Before the voyage considerable uncertainty had prevailed in Australia regarding the reception in America of signals transmitted by Australian amateurs. Sydney amateurs and experimenters in other States reported regularly the reception of American messages, but no reports came from America acknowledging the receipt of Australian signals. A strict checking method was employed to confirm all claims of reception, and messages were picked up all the way to San Francisco. The trip proved conclusively that the fault lay with the American amateurs, who have a great deal of interference to contend with. Moreover, the American is not so used to receiving weak signals as the Australian, and there is little incentive for him to "reach out." The Australian Government does not allow the use of much power, and accordingly amateurs in that country must rely upon increased efficiency. In America transmitters use far greater power. Mr. Maclurcan mentioned one station which was rated at 250 watts, but which actually used over 6,000 watts!

* * *

At the Annual General Meeting of the British Broadcasting Company, held on Wednesday, June 18, a resolution was adopted to the effect that from July 1, 1924, there should be one uniform licence fee of 10s., so that whether a listener was buying a complete set, or making up a set from parts, he should pay the same fee. The meeting also approved the proposal to abolish all tariffs and the passing of sets by the Post Office. This left only one restriction—that against the use of foreign parts—and at the end of the year that also would be removed.