EXPERIMENTAL WIRELESS

A Journal of Radio Research and Progress

Vol. 1. JUNE, 1924. No. 9.

Subjects dealt with in this issue include:

THE UTILITY OF VALVE CHARACTERISTICS.

VALVE MANUFACTURE.

THE HEARTSHAPE.

SERIES CONDENSERS IN TRANSMISSION AERIALS.

CUMULATIVE RECTIFICATION.

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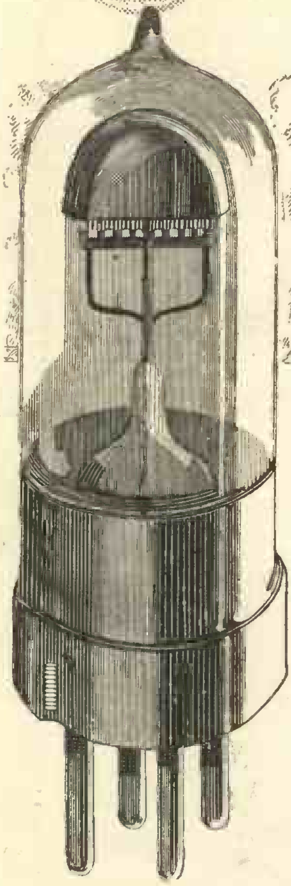

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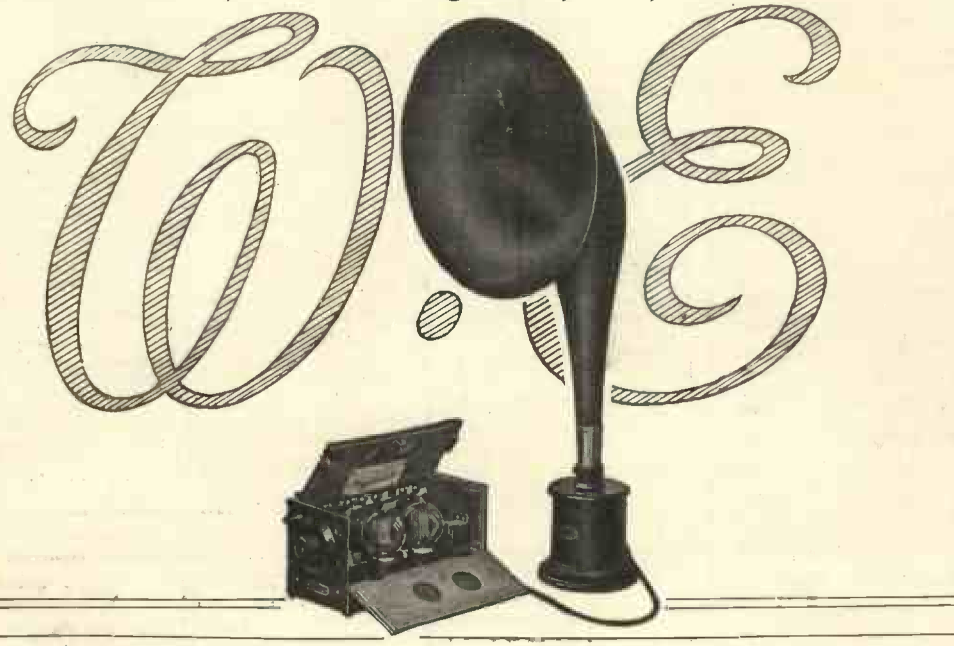

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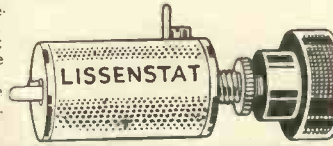

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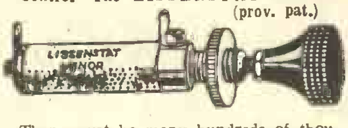

There must be many hundreds of thousands of inefficient rheostats in use. To provide something of the beautiful LISSENSTAT control at a popular price a new development of the LISSENSTAT has been introduced—the LISSENSTAT MINOR (prov. pat.). This will make it worth while discarding any existing device—it is a perfect little control and will be much appreciated in use. Can be used for dull emitter and all valves (the LISSENSTAT is a still better control). 3/6

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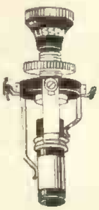

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Experimental Wireless

A JOURNAL OF RADIO RESEARCH AND PROGRESS

Vol. I, No. 9. JUNE, 1924. 1s. net.

Experimental Topics.

Developments in Radio Engineering.

Wireless telegraphy and telephony as we know it to-day is the outcome of experiment and research extending over a period of little more than a quarter of a century. Its history is crammed with ingenious inventions, those of the thermionic valve and the heterodyne method of reception, for example, standing out with particular prominence. It is upon such inventions as these that modern methods of radio telegraphy have been developed, and to these they owe their very existence. The progress of radio engineering, however, has recently undergone a considerable change, due entirely to the inauguration of a regular broadcast service. In the pre-broadcast era those interested in wireless telegraphy were comparatively few in number, and of these the majority were in some way or other intimately connected with the science in some professional capacity. To-day things are on a very different footing. In addition to the hundreds of thousands ot broadcast listeners, there are thousands who have rushed into "the wireless business" in the hope that it may prove a remunerative proposition. Those who are in any way scientifically inclined have naturally become interested in the technical aspect of the subject, and any inventive faculty which may lie dormant is accordingly aroused. This would appear, on the surface, to be a very happy state of affairs, but, unfortunately, such is not always the case. The progress of radio engineering has been so rapid that it is almost impossible in the space of some eighteen months to become fully acquainted with everything that has been done, and harder still to appreciate its significance without a thorough understanding of the fundamental principles of physics and electricity. The inevitable result is that many an ardent experimenter works for months and months upon absolutely wrong lines, or alternatively, spends considerable time over some subject which has previously been investigated. The latter is probably the more unfortunate, since, although his labours seem to be crowned with success, he ultimately discovers that he has been anticipated years ago by some radio engineer, and more often than not his invention is far less perfect and far more crude. Such discoveries are usually the outcome of a desire for publicity. Overjoyed at the success of his particular scheme he very frequently conveys the details of his invention to the popular or daily press, where it is described in extravagant terms, and is not infrequently exaggerated and distorted. It is then that some scientific body or some engineer examines it critically, explains the circumstances in scientific terms, and little else is usually heard of the inventor or his scheme. It would not be expedient to cite any particular examples within recent times, but, no doubt, the last few years afford many such cases. We would impress upon our readers the fact that any invention based upon sound scientific principles almost invariably becomes known through the channels of some scientific publication first, and subsequently finds its way into the popular and daily press. We assure our readers that we are fully alive to all that is taking place in almost every sphere of radio engineering, and any important development which, in our opinion, is both novel and worthy of consideration will be fully dealt with in the pages of this journal as soon as the circumstances warrant.

A Radio Research Fund.

We are pleased to hear from the Derby Wireless Club that they are proceeding with their scheme for the establishment of an Amateurs' Radio Research Fund as outlined in our issue of February last. We understand that approval of the movement has been expressed at the Conference of the Radio Society of Great Britain held in March, and also by members of nearly all the wireless clubs and societies with whom the Derby Club have corresponded. The stage of issuing collecting cards has now been reached, and donations have already commenced to come in. All this is so much to the good, but we are not at all sure that in their enthusiasm the Derby Club are not moving a little too rapidly. People who are asked to subscribe to any kind of fund are usually inquisitive, and among the things which collectors for this research fund are likely to be asked are: what is the Fund going to be used for, and who is going to control the expenditure? We have no doubt in our own mind that any funds collected in response to the Derby Club's appeal will be well and faithfully applied, but there are thousands of wireless amateurs in the country who might be asked to subscribe to whom the status of the Derby Club, and even its existence, may be quite unknown, and they may hesitate to give money for a fund about the administration of which they can have very little knowledge. With every desire to see this movement carried to a successful issue, we suggest that the Derby Club should, before going any further put the whole scheme on a broader and also a more definite business footing. The consent of well-known leaders in the wireless world to serve on a general committee should be obtained and their names announced. Trustees for the funds should be appointed, and the co-operation of eminent technical advisers as to the suitable employment of the funds should be secured. Some information should also be given as to the character of the earlier researches to be made. With a definite and responsible organisation of this kind behind them collectors would have a good case to state, and it is probable that a substantial fund would in due course accumulate. Without such guarantees of the soundness of the cause, we feel that only a very mediocre response can be hoped for, and that a well-intentioned and highly-commendable effort on the part of our friends of the Derby Club may mis-fire. The scheme is excellent in its conception; if it is to prove successful it must be equally good in its organisation and execution. There is no lack of enthusiasm in the wireless world, and we believe the public will respond if approached in the right way.

A New Feature.

Under the heading of "Experimental Problems," we commence in this issue a new feature, which should not only be of considerable interest, but of practical value to all experimenters. Readers' queries are both numerous and varied, and to find space to deal with each adequately would not be possible in EXPERIMENTAL WIRELESS without excluding considerable matter of general interest. Correspondence shows, however, that many readers experience similar difficulties, and it is these difficulties which will form the subject matter of "Experimental Problems" month by month. As our readers are aware, we do not undertake to answer queries either through the medium of this journal or through the post, but brief details of any matter which is presenting some difficulty will, if of sufficient general interest, be dealt with under the above-mentioned heading. Those who have already written to us, asking our advice on various problems, are reminded that they should look for our reply in the appropriate columns.

The Utility of Thermionic Valve Characteristics

By H. J. BARTON CHAPPLE, Wh.Sch., B.Sc. (Hons.) Lond., A.C.G.I., D.I.C.

Below are given simple methods for the determination of valve characteristics together with an explanation of the various constants and their use.

In view of the great importance of characteristic curves for all thermionic investigations and design of apparatus, the accompanying remarks on how to derive the maximum information from a given set will, no doubt, prove useful to serious experimenters.

The "static" characteristic curves of a triode (three-electrode thermionic valve) clearly indicate how the anode current changes as the grid potential is varied over a sufficient range to cause this current to rise from zero to its maximum value or *vice versa*, the anode potential being constant while the series of readings for points on one curve is being obtained. The same process is repeated for several convenient values of anode voltage, but as the details for carrying out this experiment are fairly well known, they will be omitted, but a reference to Fig. 1 will show the necessary apparatus required, and the diagram is practically self-explanatory.

It is immediately apparent that the anode current depends upon, or is a function of, the anode and grid potentials (assuming, of course, that the filament current is kept constant), and thus the connection between the three variables can be represented by a surface in three dimensions, and this is termed the characteristic surface, while sections of this surface are known as the "static" characteristic curves, Fig. 2 being a typical set for a "hard" valve.

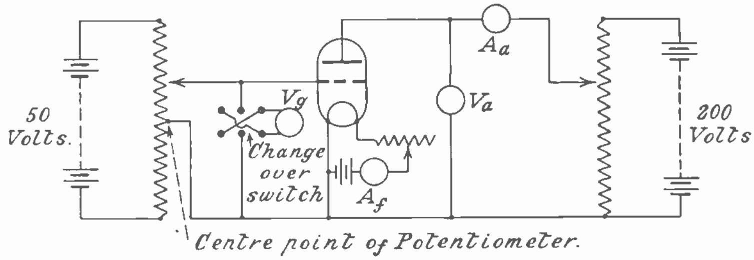


Fig. 1.—Circuit for the Determination of a Static Characteristic.

The most important quantities which can be derived from a given set of characteristic curves are the amplification ratio, resistance (or impedance), and the magnitude of the back E.M.F. produced by the electron current flowing from the hot cathode to the anode.

The thermionic current inside the triode consists of a stream of electrons flowing from the cathode to the anode. Since the electrons have a negative charge, they give rise to an electric field which tends to cause the electrons near the filament to return to it. This is really the "space charge effect," and can be conveniently portrayed as a back E.M.F. in opposition to the main anode battery (see "The Algebra of Ionic Valves," by Dr. Eccles, *The Electrician*, February 13, 1920). This effect can be represented in magnitude by the symbol V_s.

The amplification ratio is defined in the recent (December, 1923) publication of the British Engineering Standards Association, No. 166, as: "The numerical ratio of the slope of the anode current/grid voltage characteristic curve to the slope of the anode current/anode voltage characteristic curve of the three-electrode thermionic valve, the slope in each case being that at the point representing the particular adjustment under consideration."

When the control electrode, *i.e.*, the grid, is made positive or negative with reference

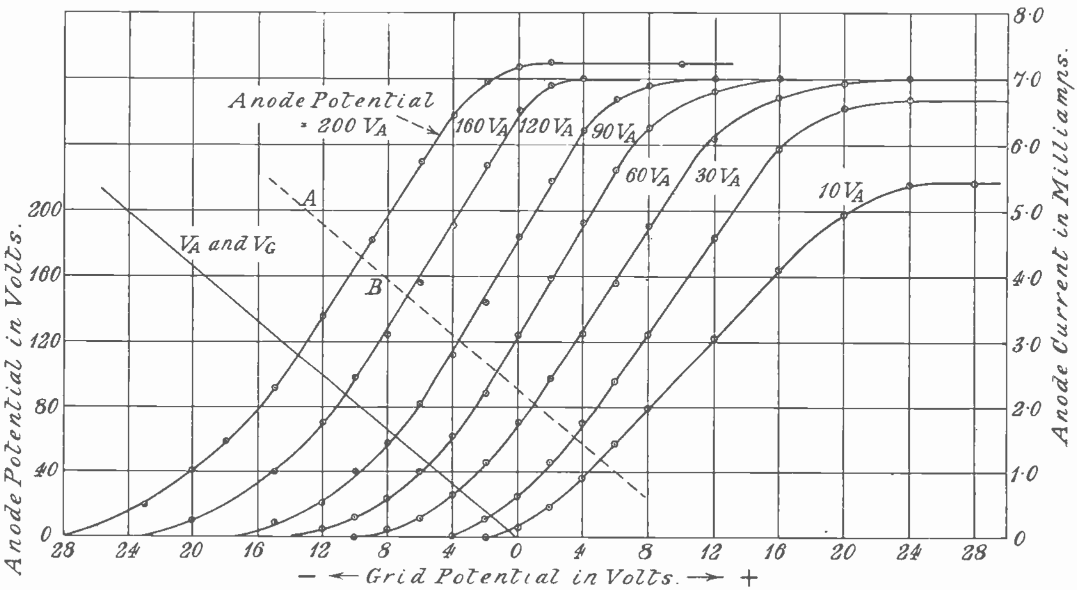


Fig. 2.—Marconi Osram Triode Anode Current-grid Potential Characteristic.

to the filament, it superimposes an electric field upon the one existing between anode and cathode, and thus alters the back E.M.F. due to the space charge. When the grid is positive, the reduction in V_s is proportional to the voltage of the control electrode, and this proportional constant is the quantity defined previously as the amplification ratio. Its symbol is μ, and for a constant filament temperature its magnitude depends mainly upon the closeness of the grid wires or mesh, and upon the relative distances of filament, grid, and anode from one another. An average value for the ordinary thermionic valve is a number between 6 and 10, and thus we see that the modification of anode voltage V_a is μV_g where V_g is the grid voltage. The importance of μ lies in the fact that it determines the value of the triode as an amplifier of feeble radio-oscillations of potential, and also for obtaining the magnitude of the reaction between the magnetically coupled grid and anode inductances when using the triode as a generator of oscillations.

The internal resistance or impedance of the thermionic valve from anode to cathode is more generally known as R_o. It is a pure resistance at low frequencies, but at high frequencies varies slightly owing to the effect of the inter-electrode capacities. This quantity also enters into all calculations connected with the design of amplifiers and "oscillators," as will be shown later in this article.

Having realised that a knowledge of these quantities is essential for the efficient use of a piece of apparatus embodying thermionic valves, it is necessary to see with what ease they can be determined from a given set of static characteristic curves.

Since the straight line portions of the curves must be used for amplification purposes, turn to Fig. 2, and choose a representative current cutting all the parallel straight portions, *i.e.*, 3.0 m.a. (milli-amperes), say. It now becomes necessary to obtain the ratio μ previously defined, and which in the appendix is shown to be the slope of the line connecting the two quantities V_a and V_g.

With a suitable anode potential (V_a) scale shown on the left of Fig. 2, we have:

When $I_a=3{\cdot}0$ m.a. $V_g=-13{\cdot}0$ volts, and $V_a=200$ volts.

This gives the point *A* when plotted to the chosen scales. Again:

When $I_a=3{\cdot}0$ m.a. $V_g=-8{\cdot}5$ volts, and $V_a=160$ volts.

This will give the point *B* when plotted, and so on, the ordinates of the points being erected vertically corresponding to the anode potentials of each curve where intersected by the 3 m.a. line. The line joining the points *A*, *B*, etc. (shown dotted in Fig. 2), thus expresses the relation between V_a and V_g, and its slope in terms of the scales of volts, conveniently settles the magnitude of μ. (According to the usual convention, this slope is negative in the figure.) Thus we have, by taking the extreme ordinates of this line:

$$V_a = 200 \text{ volts when } V_g = -13{\cdot}0 \text{ volts.}$$
$$\text{and } V_a = 0 \text{ volts when } V_g = \cdot\ 10{\cdot}8 \text{ volts.}$$
$$\therefore \mu = 200/(10{\cdot}8 + 13{\cdot}0) = 200/23{\cdot}8 = 8{\cdot}4.$$

Using the same symbols for current and potential as before, the effective E.M.F. for driving the electron current is:

$$(V_a + \mu V_g - V_s)$$

Thus along the straight part of the characteristic curve the value of the anode current can be found by dividing this voltage by the internal resistance R_o, *i.e.*:

$$I_a = (V_a + \mu V_g - V_s)/R_o$$

The quantity $(V_a + \mu V_g)$ occurs frequently in thermionic valve work, so it becomes convenient to call it the "lumped" voltage (*vide* Dr. Eccles), or "total" voltage, and thus we can express this equation graphically, and call it the "total characteristic." The method for delineating this curve from Fig. 2 will now be discussed.

A full line marked V_a, V_g parallel to the original dotted line is drawn through the

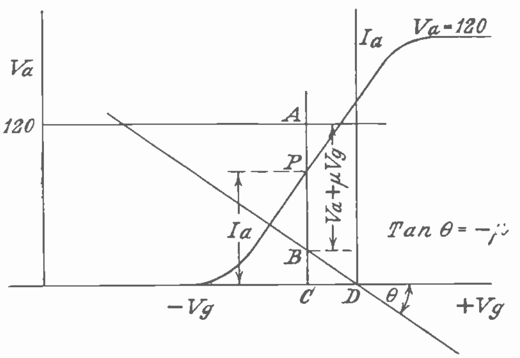


Fig. 3.—Determination of Lumped Characteristic.

origin so that its slope is obviously $-\mu$. To make the construction clear, reference must be made to Fig. 3, where the characteristic corresponding to a definite anode potential (120 volts) has been sketched with the I_a, V_a, and V_g axes shown. Drawing a horizontal line at 120 volts on the V_a scale, and choosing any point P representing I_a on the characteristic, erect a line perpendicular to the V_g axis.

Then:

$$PC = I_a. \quad AC = V_a. \quad CD = V_g \ (-ve \text{ in this case}).$$
$$\therefore BC = CD \tan \theta = -\mu V_g$$
$$\therefore AB = AC - BC = V_a - (-\mu V_g) + (V_a = \mu V_g)$$

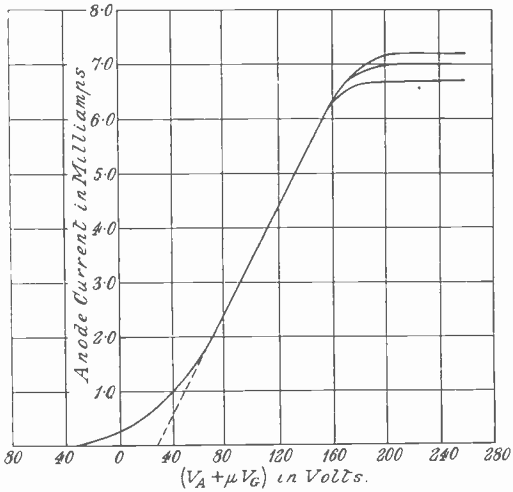


Fig. 4.—Lumped Characteristic for Triode.

Two co-ordinates for the new curve are thus easily found, and by choosing various points, P, *i.e.*, different values of I_a, a complete curve can be drawn for the definite value of V_a by transferring the lengths P,C and A,B to squared paper and plotting them so that I_a is the ordinate and $(V_a + \mu V_g)$ the abscissæ. This process should now be repeated for each individual value of V_a plotted in Fig. 2, but since it will be found that all the points for each anode potential lie approximately on the same curve, except near saturation, only one value of V_a need be taken to determine the constants V_s and R_o.

The curve shown in Fig. 4 is the new curve derived as indicated above from the set of characteristics in Fig. 2. It is now possible to determine the constants V_s and R_o for the straight portion indicated in the equation:

$$I_a = (V_a + \mu V_g - V_s)/R_o.$$

This is best done by taking two points as far apart as possible and substituting their co-ordinates I_a and $(V_a + \mu V_g)$. Expressing I_a in amperes and $(V_a + \mu V_g)$ in volts, we have from Fig. 4:

$I_a = 0{\cdot}002$ when $(V_a + \mu V_g) = 68$
$\therefore\ 0{\cdot}002 = (68 - V_s)/R_o$

Again—

$I_a = 0{\cdot}006$ when $(V_a + \mu V_g) = 153$
$\therefore\ 0{\cdot}006 = (153 - V_s)/R_o$

These two results can be used together and the equations solved simultaneously in the simple manner indicated:

$$0{\cdot}006 = (153 - V_s)/R_o \quad \ldots\ldots\ldots\ldots \quad (1)$$
$$0{\cdot}002 = (68 - V_s)/R_o \quad \ldots\ldots\ldots\ldots \quad (2)$$

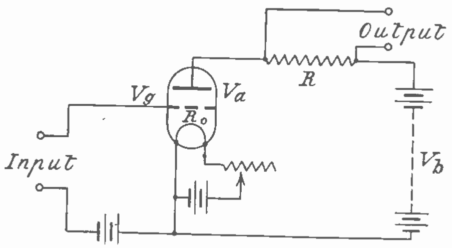


Fig. 5.—Triode Connected as an Amplifier.

Removing the brackets from equations (1) and (2) we have :—

$$0{\cdot}006 = 153/R_o - V_s/R_o \quad \ldots\ldots\ldots\ldots \quad (3)$$
$$0{\cdot}002 = 68/R_o - V_s/R_o \quad \ldots\ldots\ldots\ldots \quad (4)$$

Subtracting (4) from (3) we obtain:

$0{\cdot}004 = 85/R_o$
$\therefore\ R_o = 85/0{\cdot}004 = 21250$ ohms.

Substituting this value in equation (1), we can now find V_s, *viz.*:

$0{\cdot}006 = (153 - V_s)/21250$
$\therefore\ 127{\cdot}5 = 153 - V_s$
i.e., $V_s = 25{\cdot}5$ volts.
$\therefore\ I_a = (V_a + 8{\cdot}4\ V_g - 25{\cdot}5)/21250$

The quantities V_s and R_o can be obtained another way by producing the straight portion of the total characteristic (shown dotted) so that it cuts the $(V_a + \mu V_g)$ axis. We then have $I_a = O$ and $(V_a + \mu V_g) = 25{\cdot}5$, hence:

$O = (25{\cdot}5 - V_s)/R_o$
i.e., $V_s = 25{\cdot}5$

Again $1/R_o$ in this curve represents the slope of the line, so by finding the slope of the line and equating this to $1/R_o$ the quantity R_o becomes determinate. Thus:

$I_a = 0{\cdot}006$ when $(V_a + \mu V_g) = 153$
and $I_a = O$ when $(V_a + \mu V_g) = 25{\cdot}5$
$\therefore\ 1/R_o = 0{\cdot}006/(153 - 25{\cdot}5)$
$\therefore\ R_o = 127{\cdot}5/0{\cdot}006 = 21250.$

Both these values correspond to those previously determined, so that either method may be adopted in practice.

The value of I_a on the straight part of the curve can now be found for any given values of V_a and V_g, or *vice versa*. Thus:

If $V_a = 160$ volts, and $V_g = -4$ volts
$\therefore\ \mu V_g = -33{\cdot}6$,
and $I_a = (160 - 33{\cdot}6 - 25{\cdot}5)/21250 = 0{\cdot}00475$ amps.

Again, what value of V_a will make $I_a = 3{\cdot}5$ m.a. when V_g is zero?

$0{\cdot}0035 = (V_a - 25{\cdot}5)/21250$
$\therefore\ V_a - 25{\cdot}5 = 74{\cdot}3$
$\therefore\ V_a = 99{\cdot}8$ volts.

Several methods have been devised for measuring μ and R_o direct—see Appleton in *The Wireless World*, 1918, and Miller in "Proceedings of the Institute of Radio Engineers," Vol. 6, June, 1918.

It must be borne in mind that the quantities μ, V_s, and R_o have only been obtained for the straight portion of the characteristics, as this is the most important, but the fact must not be lost sight of that these three values will alter on both the top and bottom bends of the curves.

To consider two other illustrations of the importance of μ and R_o we have, for the amplifier circuit shown in Fig. 5, that the voltage amplification factor between input and output is:

$\mu R/(R + R_o)$ (For proof, see appendix.)

Thus, by assigning various values to R, it is possible to ascertain the resultant amplification factor, *viz.*:

If $R_o = 30000$ ohms, $\mu = 8$ and $R = 40000$ ohms.
Then $\mu R/(R + R_o) = 320000/70000 = 4{\cdot}6$.

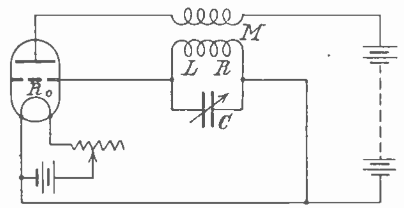


Fig. 6.—Arrangement of Triode as a Generator.

If an impedance Z had been used in place of the resistance R (*e.g.*, inter-valve transformer), then the amplification factor would have been:

$\mu Z/(Z + R_o)$

Again, with the triode generating circuit of Fig. 6, we have, for oscillations to be maintained, that the mutual inductance M must be negative in sign, and greater than the quantity

$(L + CRR_o)/\mu$ (See appendix for proof.)

By substituting the measured values for all these quantities, the critical value of the magnetic coupling between anode and grid coils can be easily determined.

The characteristic curve diagrams in this article were prepared from data derived experimentally in the High Frequency Laboratory at the Technical College, Bradford.

Appendix.

Using the symbols I_a, V_a and V_g, Langmuir gave the equation of the characteristic surface in the form :

$$I_a = A(V_a + k\,V_g)^{3/2} \quad \ldots\ldots\ldots\ldots \quad (1)$$

k being a constant depending upon the particular construction of the thermionic valve, grid, and anode.

It is observed that the central region of a characteristic surface is almost a plane, and the equation for that portion has been given by Vallauri as :

$$I_a = (aV_g + bV_a + c) \quad \ldots\ldots\ldots\ldots \quad (2)$$

From this we have :

$$\delta I_a/\delta V_g = a \text{ and } \delta I_a/\delta V_a = b.$$

The quantities a and b are of the dimensions of a conductance (inverse of resistance), and the ratio a/b is the same as k in (1). The internal resistance of the thermionic valve is $1/b$, and this is more generally known as R_o, as previously stated.

Van der Bijl has proposed another form of equation, *viz.* :

$$I_a = A(\gamma V_a + V_g + \varepsilon)^2 \quad \ldots\ldots\ldots\ldots \quad (3)$$

$1/\gamma$ is commonly known as μ, and we have a/b, k, $1/\gamma$ or μ all representing the amplification ratio.

Since $\delta I_a/\delta V_g = a$ and $\delta I_a/\delta V_a = b$, it follows that $a/b = \mu = \delta V_a/\delta V_g$, and thus the amplification ratio is the slope of the curve formed by plotting V_a in terms of V_g. Turning to Fig. 2, we can now see how to derive this curve from the original set of plotted characteristics, by assuming the very small changes of anode current δI_a used in equations above to be equal, which is strictly correct where the characteristic curves are parallel, and choosing a representative current cutting the straight portions, as pointed out early in the article.

Thermionic Valve as Amplifier.

Referring to Fig. 5, we have :

$$I_a = (V_a + \mu V_g - V_s)/R_o$$
$$\therefore (I_a + \delta I_a) = \{V_a + \delta V_a + \mu(V_g + \delta V_g) - V_s\}/R_o$$
$$\therefore \delta I_a = (\delta V_a + \mu\delta V_g)/R_o$$

An increase of anode current causes an increased fall of potential along R, hence V_a is reduced

$$\therefore \delta V_a = -R\delta I_a$$
$$\therefore \delta I_a = (-R\delta I_a + \mu\delta V_g)/R_o$$
$$i.e., \ \delta I_a = \mu\delta V_g\ (R + R_o)$$

If V = Output voltage from terminals of R, then

$$V = R\delta I_a = \mu R\delta V_g/(R + R_o)$$

and Amplification Factor $= V/\delta V_g = \mu R/(R + R_o)$

Thermionic Valve as Generator of Oscillations.

The decrement of the oscillating circuit of Fig. 6 is easily proved to be :

$$-[R + (L + \mu M)/CR_o]/2L.$$

Thus it is plain, if the oscillations are to be maintained in magnitude, this quantity must exceed zero. This can only be accomplished when M is negative in sign, and the limiting value of M is given by :

$$M = (L + CRR_o)\mu.$$

Thermionic Valve as Rectifier.

The curve for I_a and $(V_a + \mu V_g)$ deviates considerably from a straight line below 1·5 milliamps, and it is on this portion of the characteristic that the triode is worked for rectification. Many theories have been propounded to show that the curve is parabolic for this part, and in a paper before the Wireless Section of the Institution of Electrical Engineers (March, 1922), Messrs. Moullin and Turner dealt with the theory of rectification by assuming the curved characteristic was of the form $i = f(v)$. Expanding this function in an infinite series and neglecting the fourth and higher differentials, they demonstrated that the rectified current from a very weak signal was proportional to the rate of change of slope of the characteristic, and to the square of the signal potential difference, whether the latter contained harmonics or not—a point not always noticed. By using characteristics of an "R" triode similar to Fig. 2, they proved experimentally the conclusions arrived at theoretically.

Valve Manufacture.

By W. J. JONES, B.Sc., A.M.I.E.E.

In the February issue of "Experimental Wireless" an indication was given of the methods employed in the manufacture of German valves, which contrast to some extent with British methods described below.

THE thermionic valve is assuming more and more importance as the means of detecting and amplifying wireless signals, and the experimenter can scarcely estimate the debt that is owing to Prof. J. A. Fleming for his invention of the two-electrode valve, and to Lee de Forest for the subsequent introduction of the third electrode. Readers of this journal are already conversant with the use of the three-electrode valve as an amplifier and detector of electric currents at either radio or audio frequency, but there may be a number of points in connection with the manufacture of such valves on which information is not so readily available. It is a well-known fact that the thermionic valve depends for its operation upon the emission of electrons from a heated filament which may be considered as continually emanating or evaporating these particles of negatively charged electricity in a similar manner to the evaporation from the surface of a liquid. The greater the area and temperature the more the evaporation.

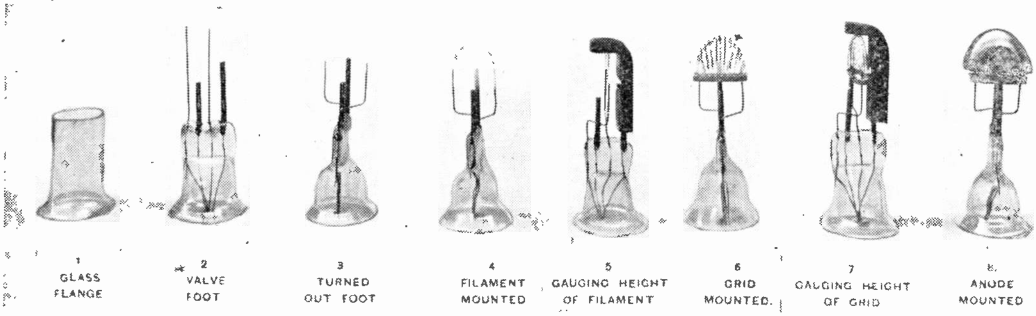


Fig. 1.—The Various Stages of Assembly of a Valve. [*Courtesy A. C. Cossor, Ltd.*

Under the influence of an electric force, produced by the plate or anode potential, electrons are drawn toward the anode, and constitute a current of negative electricity flowing from the filament to plate. The third electrode, the grid, by virtue of its potential, serves the purpose of modulating the plate current, for when it is negatively charged the grid causes a decrease in the plate current, and when positive the plate current is increased.

The filament of the ordinary valve with a tungsten filament is capable of an emission of 2×10^{-13} amps. per sq. cm. at a temperature of 800° C., while at 2,500° C. the emission is increased to as much as 1·23 amps. per sq. cm. It will be noted to what an enormous extent the current rises with the temperature, and it is in order to take advantage of this improved emitting power that the filament of the ordinary valve is operated at as high a temperature as possible consistent with good life. Saul Dushman* gives the following data relating to life and temperature of tungsten filaments.

Filament Diameter. Mils.	Safe Temperature to give Life of more than 2,000 hours.
5	2475° K.
7	2500
10	2550
15	2575

(*Note.*—°K. = °C + 273.)

* S. Dushman, *G.E. Review*, Vol. 18, p. 156, 1915.

Further, the amount of emission depends largely upon the material of which the filament is composed, and the table below is obtained from work by C. J. Davisson and I. Langmuir.

Substance.	Relative Emissivities.
Oxide Coat (Western)	$3{\cdot}0 \times 10^{10}$—$8{\cdot}1 \times 10^{11}$
Tungsten	1·0
Thorium	$6{\cdot}7 \times 10^{6}$
Tantalum	5·8
Molybdenum... ...	10·8

The oxides of some materials will be seen to have very large emissivities, and that of tungsten itself is greatly improved by the introduction of thoria. It is the use of such oxides which facilitate the manufacture of low-temperature valves of such low energy consumption that they may be operated from dry batteries. The oxides of barium and strontium are usually coated on a platinum base, while the thoria is introduced into the tungsten powder from which the slug is made prior to swaging and drawing into wire.

We are only considering in these notes the construction of the bright-filament valve with a tungsten filament as is used in the manufacture of incandescent electric lamps. Langmuir has shown that the presence of

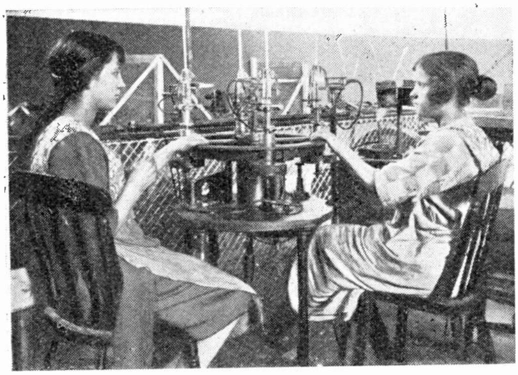


Fig. 2.—A Sealing-in Machine.

oxygen, whether free or in gas (such as water vapour), will cut down the emission of pure tungsten to a small fraction of that obtained in high vacuum. It is, therefore, of the utmost importance to ensure the attainment of really good exhaustion. To further this end, the materials of which the valve is constructed, must be carefully selected and treated, and subsequently kept as clean as possible during the manipulations necessary for the assembly of the component parts. The metal parts are heated for a prolonged

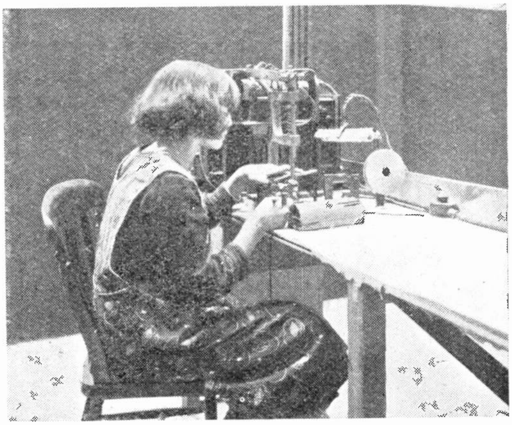


Fig. 3.—A Filament-mounting Machine.

period in vacuo at a temperature of approximately 1,200° C., after which treatment they present a bright and polished appearance. This operation extracts a large proportion of the gas which is latent within the pores of the metal, and its extraction in this way materially reduces the period of pumping. The store of gas which is found occluded by metals is so large that it will ruin the functioning of the valve altogether unless it is extracted before the valve is "sealed off."

The anodes are almost invariably made of nickel, partly because it can be obtained in great purity, and is readily worked into shape, and has a reasonably high melting point.

The grid must be rigid in order to avoid microphonic noises being produced when the valve is operating, and must not be readily melted during the process of exhaustion, when it is often rendered white hot by bombardment in order to still further drive off occluded gases. It is usually made of molybdenum wire.

The electrodes are mounted on a "foot," and it may be easier if the assembly of a particular valve is described. Fig. 1 shows the assembly of a valve in various states of completion; (*a*) shows a length of glass tube that is worked in a flame to form a flange. The flanged tubes (*b*) are placed in "foot-making machine" and the four electrode wires threaded into position; the whole then rotates in a gas flame until the glass is sufficiently hot to be worked, when metal jaws descend upon the glass tube, flattening it and forming a pinch. It will be noticed that each of the four electrode wires is made in three sections—first the wire or the tube to which the electrode is subsequently welded, then a piece of platinum about 3 mm. long, and finally a length of copper wire, which forms the connection to the split pin in the cap. The glass is pinched or flattened round the pieces of platinum, as it has been found that this metal is capable of making a permanent vacuum-tight joint in the glass. The four leads shown in (*b*) are required for the following purpose:—

1. Connection to filament; (2) Tube to take grid support; (3) Connection to filament; (4) Tube to take anode.

Fig. 4.—A Group of Sealing-in Machines.

After the wires are sealed into the glass flanges, the "feet" are kept for some hours in an annealing oven, in order to relieve the glass of any mechanical stress that may have been set up while the foot was in process of being made. Each wire in the foot is tested for electrical continuity, and passes through several operations in order to bend the

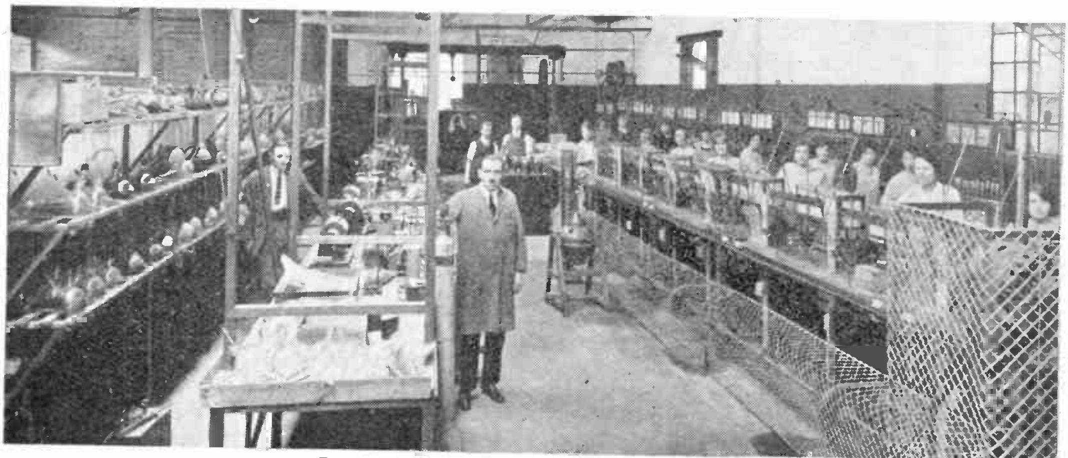


Fig. 5.—A Pumping Room in a Modern Factory.

filament wires to the proper position, and to cut them off to the desired length. See (*c*). The filament consists of specially annealed tungsten wire 60×10^{-3} mm. diameter, and supporting tube (*f*), and the grid set to its proper height by means of a gauge (*g*), being secured by welding in a high-tension electric arc in an atmosphere of hydrogen. The

Fig. 6.—A General View of an Assembly Room.

is automatically given its shape and measured for length. Up to this stage in the manufacture of the valve all the material and work receives careful inspection, but from now onwards still greater vigilance is kept, in particular with regard to dimensions, for it is on these that the impedance and amplification factor largely depend. In (*e*) the filament is shown being gauged for height before the grid is mounted in position. The stem attached to the grid is slipped into its atmosphere of hydrogen is used in order to avoid oxidation of the metals during the heating up involved in the operation of welding.

The finished "mounts" are now ready to be sealed in the glass bulb. The bulb, which has previously been cleaned and freed from traces of dirt and grease, together with the mount, are placed on a spindle of a machine (see Fig. 2) and rotated in a ring of high pressure gas flames until the flange of the

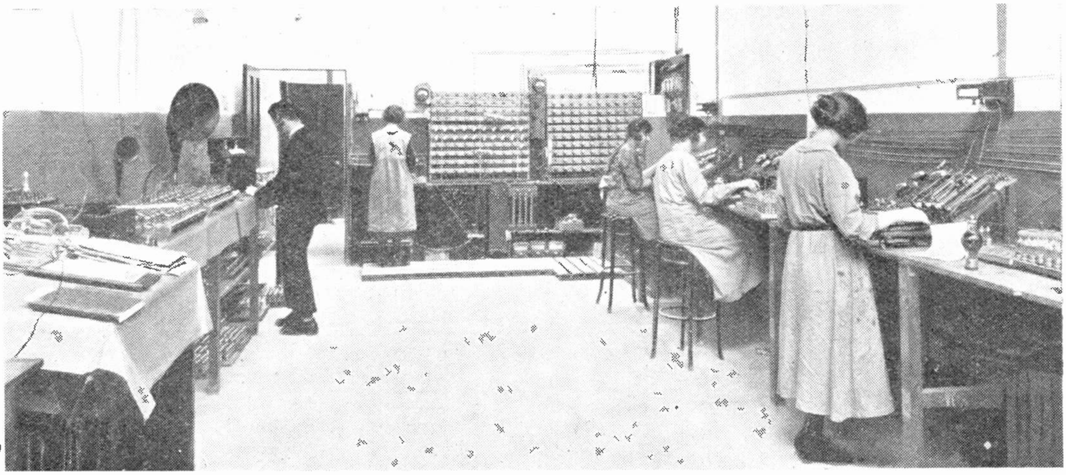


Fig. 7.—Testing Valves before Leaving the Factory.

"foot" makes a perfect joint with the wall of the bulb.

The valves are now ready to be exhausted, and are placed on glass sprays connected to vacuum pumps. During pumping the filament is lighted up and high tension of several hundred volts applied to the grid and anode. When first operated in this manner the interior of the bulb appears blue, due to the ionisation of the gas present. Pumping is continued until, when the anode is red hot, due to the electron bombardment, there is no visible trace of blueing. When sufficiently evacuated the valve is sealed off and sent to the capping room, where the copper shells and four pin plugs are fitted.

All valves now pass through a period of ageing, for in the process of heating the glass in sealing-off, a small amount of gas is evolved which is absorbed when the valve is run for a prescribed time. Testing for vacuum, current consumption and characteristics then ensues, and only valves giving values within definite limits are allowed to pass, and a certain percentage are tested on actual reception and for length of life; this last enabling the manufacturer to gain some reliable estimate of the probable life of valves in a given batch. The valves are then stamped with an etching acid, essentially composed of hydrofluoric acid, and, after further final inspection, are packed ready for dispatch.

Grid Rectification.

A CRITICAL EXAMINATION OF THE METHOD.

By J. H. REYNER, A.C.G.I., B.Sc., D.I.C.

Although grid rectification is universally employed probably very few experimenters have studied its action. This is explained below and practical information is given.

THE cumulative grid method of rectification is well known, and is almost universally employed in valve circuits. As is often the case, however, with an everyday phenomenon, the underlying principles are not always fully understood, and for this reason the best results are not always obtained with this system.

It is proposed in this article to describe the method and to investigate its action in some detail, after which reference can be made to the limitations of the system.

General Theory of Action.

The best mental conception of the process is obtained by deducing the action from that of a simple amplifier (Fig. 1). Here a high-frequency oscillating voltage is applied across the grid and filament, and produces corresponding variations of the anode current

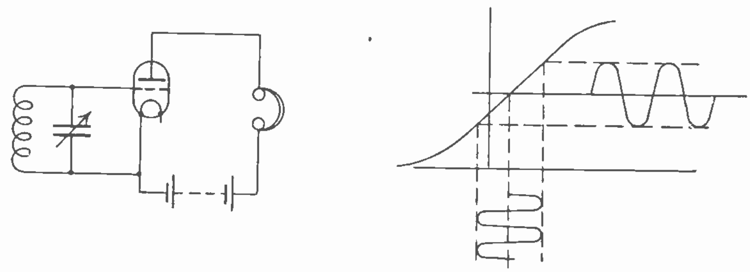


Fig. 1.—Illustrating the Action of a Valve as a Simple Amplifier.

above or below the steady mean value, as indicated in Fig. 1 (*a*). Such variations, however, would not affect a telephone receiver inserted in the anode circuit, because, apart from any effect due to asymmetry of the valve characteristic, the average value of the anode current remains unchanged. This, of course, only applies to high-frequency oscillations, the telephone diaphragm being unable to follow the variations themselves, and only responding to an alteration in the mean value of the anode current.

Now with this circuit when the grid is positive a small current flows from the filament to the grid and back through the external circuit. (Current is here used in the sense of an electron stream.) When the grid is negative no such current will flow. This current will have no effect on the operation of the amplifier beyond introducing damping into the oscillating circuit L—C, which may or may not be desirable according to circumstances. In passing it may be noted that this effect will cause slight dissymmetry in the applied voltage, which will permit the oscillations to be detected faintly in a telephone even though the anode current characteristic may be perfectly straight over the working portion.

Consider now, however, Fig. 2, which is identical with Fig. 1 except that a condenser C_1 has been inserted in the grid filament circuit. The oscillating voltage applied across the points A, B is transferred through this condenser to the grid, which is thus subjected to voltage variations as before, and the anode current will fluctuate about its mean value as in the previous instance.

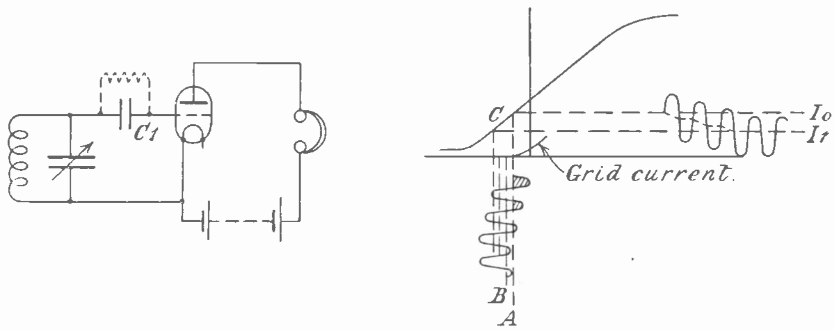
Now, due to the condenser in the grid circuit, the valve will adjust itself till it is working at a point A on the characteristic, at which point no grid current is flowing. This point occurs at different potentials with various types of valve, but the characteristic in Fig. 2 will serve for illustration purposes.

When the grid is positive a small current will flow from the filament to the grid. Due to the blocking condenser, however, this current cannot complete its circuit back to the filament, but remains as a charge on the condenser C_1. The grid, therefore, becomes slightly negative, relative to its original potential, and takes up a position as at B (Fig. 2). During the next half cycle the grid becomes more negative, but returns to the point B, since no further current has flowed into the grid condenser nor has any leaked away if the valve is hard.

The next positive half cycle will commence from the point B, and as soon as the grid voltage reaches the point A grid current will flow and will cause an increase in the negative charge on the condenser. The negative half cycle will have no effect, as before. Each succeeding oscillation, therefore, will cause the grid to acquire an increasingly negative potential, until a point C is reached where the voltage variation never makes the grid sufficiently positive to allow any grid current to flow. The action then ceases, and the grid is left charged to a steady negative potential.

Now the more negative the grid potential the less is the anode current, other things being equal. The effect of the oscillations on the anode current, therefore, is that the variations of anode current do not take place about a steady point, but about a mean value which is decreasing in a series of jerks and finishes appreciably less than the original value.

This change is, of course, detected in the



Figs. 2 (a) and (b).—Illustrating the Action of a Valve as a Cumulative Rectifier.

telephones, causing the diaphragm to emit a click. Considering a spark train as the simplest type of emission, each train of waves causes a click in the telephones, and the aggregate of these impulses, occurring at a musical frequency, gives rise to a musical note. It is, of course, necessary to reset the

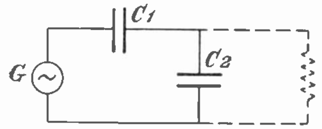


Fig. 3.—Equivalent Circuit to Fig. 2 (a).

device after each train of waves, and to effect this a high resistance is shunted across the condenser (or to the negative of the filament), which allows the charge to leak away during the comparatively long interval between successive trains of waves.

Size of Condenser.

The insertion of a grid-leak into the circuit introduces certain secondary effects, which will be considered later. The main action remains substantially as described, and it is now possible to investigate some of the points in greater detail. The first item of interest is the size of the blocking condenser. In considering this the circuit may be redrawn as shown in Fig. 3. Here G is the source of alternating voltage, C_1 is the grid condenser, and C_2 is the grid filament capacity of the valve. When the grid is positive C_2 is shunted by a high resistance (the valve having become conducting), but this effect may be neglected in the present instance, as also may the grid leak.

The voltage V will cause a current I to flow round the circuit, such that

$I = VC\omega$. C being the capacity of $C_1 + C_2$ in series.

$\omega = 2\pi f$

i.e., $I = V\omega\left(\frac{C_1C_2}{C_1+C_2}\right)$

The voltage applied to the grid is that across C_2—

$$V_g = I/C_2\omega = V\omega\left(\frac{C_1\,C_2}{C_1+C_2}\right)/C_2\omega = \frac{C_1}{C_1+C_2}\,V$$

Hence the voltage on the grid depends on the ratio of C_1 to C_2, *independent of frequency*, and to obtain best results C_1 should be large compared with C_2, so making $\frac{C_1}{C_1+C_2}$ approach unity. C_2 is of the order of 15–25 micro-microfarads, allowing for the valve-holder capacity, etc., and hence C_1 should not be lower than 200 or 300 micro-microfarads.

There is, however, a contrary effect to be considered. The value of the condenser must be such that it will build up to the full voltage required in the time available. Now the time taken to build up depends on both the capacity C and the leak resistance R where such is provided. As in all practical circuits a leak is essential these two factors must be considered together.

The full mathematical treatment is distinctly complex, because the building up depends on the grid-current characteristic of the valve, and the treatment involves both the first and the second differential co-efficients.

Fortunately, however, certain simplifications can be made in the treatment. There are two operations to be considered :—

(*a*) The building up of the condenser.
(*b*) The leak away, resetting the device for the next signal.

These operations are, of course, only distinct in the case of spark reception. For

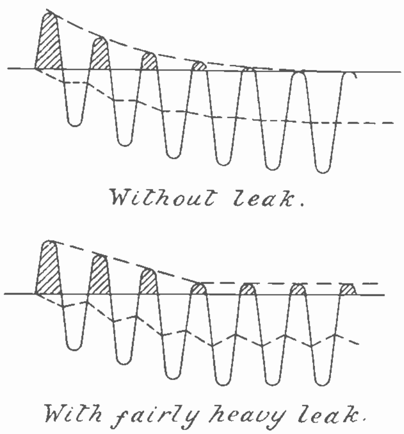


Fig. 4.—Illustrating Effect of Grid Leak.

C.W. and telephony the two operations take place together. This point, however, will be investigated later on, and for the present purpose the two operations will be considered in turn.

Time of Building Up.

During the positive half cycle the grid condenser collects a certain number of electrons which have been attracted from the filament to the grid. The exact number, or, in other words, the actual charge, depends upon the voltage applied and the grid-current characteristic of the valve.

The voltage to which the condenser will be raised by the acquisition of this charge is given by $\frac{q}{C}$, where q=total charge and C=capacity of condenser. Obviously, therefore, the smaller the capacity C the greater the voltage acquired for a given charge.

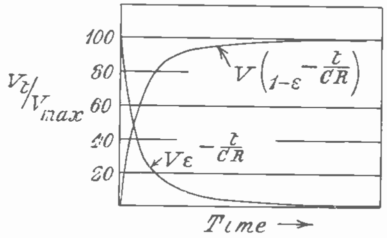


Fig. 5.—Grid Condenser Charge and Discharge Curves.

Now, as previously mentioned, the charging process continues till the steady condenser voltage is nearly equal to the maximum of the applied voltage. Hence, the greater the voltage per impulse the sooner will the condenser reach the limit. In other words, the more rapid will be the build-up. Suitable values of the capacity under different circumstances can thus be worked out. Before doing so, however, the influence of the grid leak must be considered.

Effect of Grid Leak.

During both the charging and the idle periods the voltage on the condenser is gradually leaking away. This is quite apart from the leak away after the signal has passed, in order to reset the device, and at first sight it would appear to have a serious effect on the charging of the grid condenser. Actually, however, within certain limits, the effect is very small. This somewhat remarkable point may be made clear by considering the effect in greater detail.

Fig. 4 shows the charging of the grid condenser both with and without a leak. As has been previously explained, it is only when the grid voltage rises above the point where grid current commences to flow that any charging of the condenser takes place. The effective portions of the voltage cycle are accordingly shown shaded in Fig. 4.

Without a leak, the voltage builds up rapidly at first and less quickly afterwards, gradually acquiring a steady value equal to the maximum amplitude of the applied voltage.

With a leak, on the other hand, the initial rate of building up is not so rapid, due to the leak, and the grid potential falls again during the idle half cycle from the same cause. This means, however, that in the next half-cycle the excess of the maximum applied voltage over the zero-current potential is greater; in other words, the shaded area is larger and more charge is acquired by the grid condenser. The net result is that the building up, although initially slower, continues at a more rapid rate than in the first case, and the total time required to build up is found to be very little different, whatever the value of the leak, within fairly wide limits. Mathematically it may be shown that for this condition to apply $\frac{1}{R}$ must be small compared with $\frac{1}{r}$, where r is the grid-filament resistance of the valve. r varies between 200,000 and 500,000 ohms, depending on the type of valve and position on the characteristic, which means that the grid leak cannot be reduced much below 2 megohms, which value would make $\frac{1}{R}=\frac{1}{10r}$.

It should, moreover, be noted that the final value of the grid potential is not steady, but is continually building up and leaking away, as indicated in Fig. 4. In other words, the grid voltage variations always exceed the final steady value by a small amount. This excess can be shown to be a definite proportion of the maximum voltage, and consequently increases as the applied

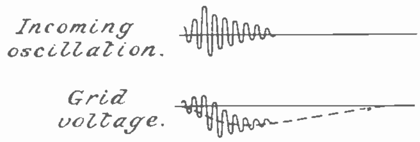


Fig. 6.—Building Up of Grid Condenser Voltage with Spark Signals.

voltage increases. This effect will be referred to later.

The building up of the condenser, therefore, is controlled almost entirely by the capacity thereof, the sole function of the grid leak being to arrange for the dissipation of the charge in good time for the next impulse.

Suitable Values of Condenser and Leak.

Now the time taken by a condenser to discharge through a resistance depends on both the capacity and the resistance. After a given time t, the voltage across the condenser is given by

$$V_t = V\varepsilon^{-\frac{t}{CR}}$$

where V = initial voltage
C and R are the capacity and resistance respectively
ε is the base of Napierian logarithms = 2·7183

Similarly, if a condenser is charged through a resistance R, then the voltage after a time t has elapsed, will be given by

$$V_t = V\left(1-\varepsilon^{-\frac{t}{CR}}\right)$$

V in this case being the applied voltage.

Fig. 5 indicates the nature of the phenomenon, and from these curves the proper sizes of C and R may be determined.

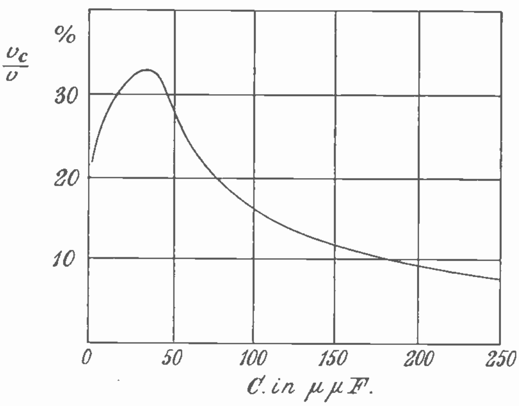


Fig. 7.—Efficiency of Rectification with Spark Signals.

The method which is adopted here is not strictly correct from a mathematical point of view, but gives a very fair approximation, which agrees with the results obtained by more complex methods.

It consists in estimating the time available for charging and then working out the value of the capacity from the formulæ given above.

The charging time is the time elapsing between the beginning of the oscillation and the point where the condenser has acquired its maximum voltage, and this is determined empirically. At first sight it would appear that the real time was only half this time, since only the positive half cycles are effective in charging the condenser. It will be seen later, however, that, due to the grid leak, there is really current flowing the whole time, but in an asymmetrical fashion, owing to curvature of the characteristic. This does not invalidate the conclusions already arrived at on the assumption that grid current only flows during the positive half cycle.

(1) Damped Waves.

Fig. 6 shows the building up of the grid voltage when receiving a spark train. It will be seen that the first three or four oscillations are sufficient to build up the voltage on the condenser, the succeeding oscillations having no effect owing to their rapidly diminishing amplitude. Consequently the time t available for building up is very small, and is dependent, moreover, on the frequency.

Assuming four effective oscillations and a wave-length of 600 metres ($f = 500{,}000$) the time available is—

$$t = \frac{1}{500{,}000} \times 4 = 8 \times 10^{-6} \text{ sec.}$$

Assuming the grid filament resistance of the valve to be 300,000 ohms, which is a reasonable average value, the capacity required can be worked out in order that the voltage may build up to a given fraction of the full value during the time available. For a trial calculation the condenser will be assumed to charge up to 90 per cent. of the applied voltage.

$$v = V\left(1-\varepsilon^{-\frac{t}{CR}}\right) = V(1-0{\cdot}1)$$

$$\therefore\ \varepsilon^{-\frac{t}{CR}} = 0{\cdot}1.$$

$$\therefore\ \log_\varepsilon \varepsilon^{-\frac{t}{CR}} = \log_\varepsilon 0{\cdot}1.$$

$$\therefore -\frac{t}{CR} = -2{\cdot}3026.$$

$$\therefore\ C = \frac{8 \times 10^{-6}}{2{\cdot}3 \times 300{,}000} \text{ approx.}$$

$$= 11{\cdot}6 \text{ micro-microfarads.}$$

This is, of course, ridiculously small, because the impedance of such a condenser would be so high that most of the voltage applied would be lost in voltage drop on the condenser. Moreover, such a capacity would be impracticable to work with.

In this instance, assuming the grid-filament capacity of the valve, including holder and leads, to be 25 μμF., the ratio of v_g the voltage actually applied across the grid, to the oscillating signal voltage v would be—

$$\frac{v_g}{v} = \frac{11\cdot6}{36\cdot6} = 0\cdot317.$$

The voltage acquired by the condenser is only 90 per cent. of this, which gives the ratio of v_c, which is the voltage to which the grid condenser builds up, to v as—

$$\frac{v_c}{v} = \cdot317 \times \cdot9 = 28\cdot5 \text{ per cent.}$$

As the value of C is increased, the build-up voltage will fall off, but the ratio of $\frac{v_g}{v}$ will increase, and the two effects tend to balance one another.

If the net ratio of $\frac{v_c}{v}$ is worked out for various values of C, the curve shown in Fig. 7 is obtained.

It will be seen that the maximum efficiency occurs around 35 μμF., but that even here the voltage acquired by the condenser is only 33 per cent. of the signal voltage, and with the values of C in common use to-day (200 to 350 μμF.) this ratio is of the order of 8 per cent. only. The method, therefore, is distinctly inefficient for spark reception, and, moreover, becomes increasingly poor the shorter the wave-length.

The size of the grid leak depends on the condenser. The time available for the leak-away to occur is very nearly 1-1,000th sec., assuming a note-frequency of 1,000 for convenience. If the condenser is assumed to lose 99 per cent. of its charge in this time, then—

$$\varepsilon^{-\frac{t}{CR}} = 0\cdot01$$

$$-\frac{t}{CR} = \log_\varepsilon 0\cdot01 = -4\cdot6 \text{ approx.}$$

$$R = \frac{10^{-3}}{4\cdot6\, C.}$$

If C = 35 μμF. R = 6·2 megohms.
C = 350 μμF. R = 0·62 megohm.

This last value, as has previously been shown, is too low for efficient working. It will be seen that the commonly accepted values of to-day are by no means the best as far as spark reception is concerned.

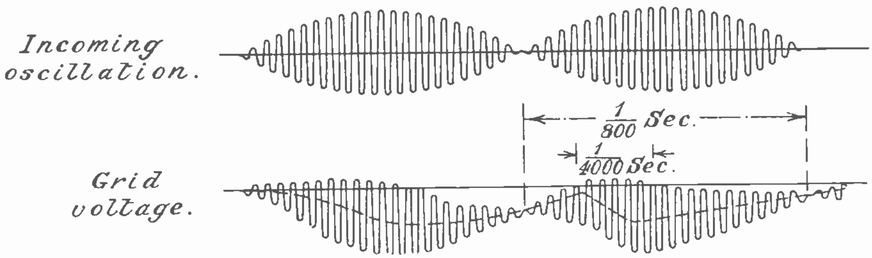


Fig. 8.—Building of Grid Condenser Voltage with Continuous Wave Signals.

(2) C.W. Reception.

The most common application of the method, however, lies in the reception of C.W. and telephony signals. The method of procedure is as before, except in one particular. With a C.W. signal the time available for charging depends on the grid leak, although in a somewhat indirect manner. Consider Fig. 8, which indicates the building-up process with a C.W. signal. It will be observed that, as the amplitude of the signal is steadily increasing for half the heterodyne modulation, the grid has a considerably longer time to build up than in the case of a spark train. Having built up, however, the charge must leak away during the remainder of the modulation, so leaving the condenser ready to build up again on the next modulation.

Now it will be found that, with the values in common use to-day, the leak away is not sufficiently rapid. Consequently, as indicated in Fig. 8, the grid does not start to build up until the oscillations have already grown to a fairly large proportion of their maximum amplitude, and this at once limits the time available for building up. The decrease in mean grid potential is obviously somewhat reduced by this action, but it will be found that a secondary effect occurs in compensation.

From Fig. 8 it will be seen that the time available for charging is only about one-fifth of the time of one heterodyne

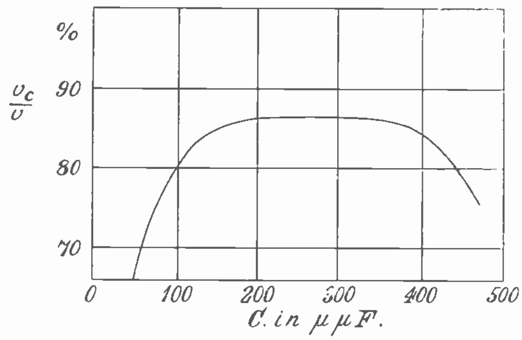


Fig. 9.—Efficiency of Rectification with C.W.

modulation. The average frequency of a heterodyne note may be taken as about 800, so that the time available is 1-4,000th second.

If, as before,

$$\varepsilon^{-\frac{t}{CR}} = 0{\cdot}1$$

$$C = \frac{1}{4{,}000} \cdot \frac{10^{12}}{2{\cdot}3 \times 300{,}000}\ \mu\mu F$$

$$= 362.$$

With this value—

$$\frac{v_c}{v} = \frac{362}{362 + 25} = {\cdot}96.$$

The ratio $\frac{v_c}{v}$, therefore,

$$= {\cdot}96 \times {\cdot}9 = 86\ \%$$

which indicates that the method is distinctly more efficient for C.W. reception. As before, a curve can be drawn showing the variations of $\frac{v_c}{v}$ as the capacity is altered, and Fig. 9 is the result.

It will be observed that this curve is really a very enlarged reproduction of the top of Fig. 7. The value of the capacity can be varied within wide limits without exercising much effect, and any value between 150 and 350 μμF. would be suitable.

The grid leak is usually made about 3 megohms. This means that in the time available, which is $\frac{4}{5} \times \frac{1}{800}$ sec. the voltage will have dropped to—

$$v = V\varepsilon^{-\frac{t}{CR}}$$

$$= V\varepsilon^{-\frac{10^{12}}{1{,}000 \times 3{,}000{,}000 \times 250}}$$

$$= V\varepsilon^{-1{\cdot}33}$$

$$= 0{\cdot}26\ V$$

assuming C to be 250 μμF., which is the maximum of Fig. 9.

This shows that the charge does not completely leak away in the time available, and hence some such action as was indicated in Fig. 8 will take place. The succeeding heterodyne modulations will thus not cause the grid to build up negative again until the amplitude has risen above the value of 0.26 volts quoted above. The maximum value to which the grid builds up is still the maximum value of the applied voltage, and consequently the effective reduction of grid voltage is only some 75 per cent. of the full voltage.

This further reduces the efficiency of the operation from 86 per cent. to 65 per cent

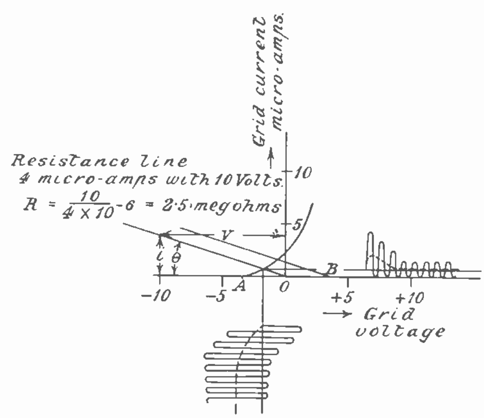


Fig. 10.—Control of Working Point by Grid Leak.

The only remedy is to reduce the leak, which, as has been seen, cannot be done, because for values below 2 or 3 megohms the leak begins to exercise an appreciable effect on the charging of the condenser. It will be seen, therefore, that the leak, though necessary, is a distinct evil.

Working Point on the Characteristic.

Owing to the presence of the grid leak, the valve does not work at the point of zero grid current, but at some other point which is determined by the value of the grid leak itself.

To elucidate this point reference may be made to Fig. 10, which shows a grid current-grid voltage characteristic. If the filament end of the leak is connected to the negative end of the filament, then a line may be drawn from O having a slope such that cot $\theta = R$ (to the same scale as the curve), where R is the resistance of the leak. At any point on this line the voltage and current will be connected by the relation $\frac{V}{I} = R = \cot\ \theta$.

Obviously, therefore, where this line intersects the grid-current characteristic will be the working point of the valve. For the grid current is determined by its characteristic and the current through the leak is determined by the straight line just referred to, and consequently if the two are connected together the only point fulfilling both conditions is the point of intersection.

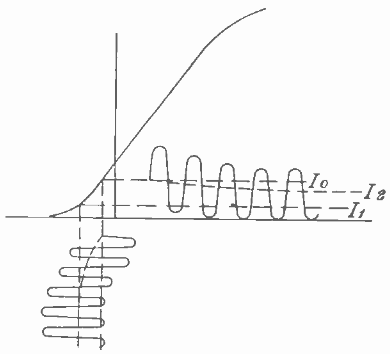


Fig. 11.—Loss of Rectification with Working Point too Low Down.

It will be seen that the smaller the leak the steeper is the line and the farther up the characteristic is the working point. In some cases the leak is connected to the positive filament lead, in which case the leak line originates at B, which for the same value of the leak gives a working point farther up the characteristic.

Fig. 10 also indicates the true nature of the building-up process. There is a permanent grid current flowing, and the incoming oscillation causes variations of this current. Owing to the curvature of the characteristic, however, these variations are not symmetrical and there is an increase in the average grid current, which causes the condenser to build up to a negative potential. In the steady state the increase of grid current is just a little more than the decrease to make up for the loss due to leakage.

For the purpose of the general explanation of the method, however, no harm is done by assuming that the valve is working at the point A, and that the condenser is only charged during the positive half cycles, provided the true action is considered where quantitative measurements are concerned.

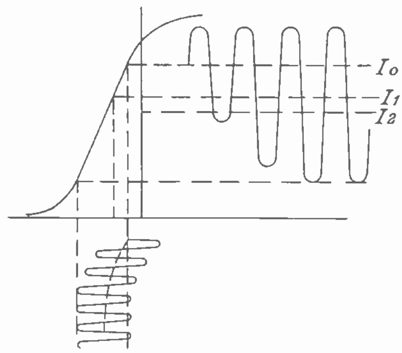


Fig. 12.—Increased Rectification at Top of Characteristic.

Telephony.

Telephony reception is similar to C.W. reception, except that for clarity of tone efficient rectification must take place with note frequencies as high as 2,000 cycles per second or more. For this purpose it is customary to use a smaller condenser (200 μμF. or less in place of the usual 350), which, of course, permits a more rapid build-up. It appears probable that still lower values could be employed with advantage.

The grid leak is often reduced at the same time, but since the grid leak controls the working point on the characteristic, its value depends to some extent on the type of valve with which it is employed.

Effect of Anode Voltage.

The working point on the grid characteristic is also important from its effect on the anode current.

Referring back to Fig. 2, it will be seen that the variations of anode current are perfectly symmetrical, but that owing to the grid condenser action the mean value steadily falls, finishing appreciably lower than the original value I_0.

Fig. 11, however, indicates the state of affairs when the working point on the characteristic is too low down. Here, due to the curvature of the characteristic, the variations of anode current become asymmetrical. The average value of the current is then no longer I_1, but I_2, which is not appreciably different from. I_0 In other words, the rectification effect is seriously impaired.

It will be observed that this effect is augmented by the fact that the maximum value of the grid voltage variations is always greater than the steady mean voltage to which the grid builds up. This is due to the leak, and, as has previously been mentioned, the excess voltage increases as the signal strength increases. Consequently there will be a critical value of the applied voltage at which there is no change whatever in the mean anode current, and no rectification will result.

The phenomenon occurs when the H.T. voltage is too low for the signal strength being received. A setting which is satisfactory for weak signals may be incorrect for a strong signal. This explains to some extent the limiting action on strong signals of some valve circuits, and also suggests a method of eliminating atmospherics. The remedy is to increase the H.T., while the connection of the grid leak to the positive side of the filament also obviates the trouble to some extent, because this shifts the working point well up the characteristic.

It may be remarked, in passing, that if the H.T. is increased so far that the working point occurs on the upper bend of the characteristic, as in Fig. 12, then the rectification is increased and not reduced. In this case the final value of the anode current I_2 is appreciably lower than I_1, so giving increased signal strength for the same applied voltage.

It will be obvious from the foregoing remarks that the very simplicity of the grid method of rectification is a pitfall, and a little care and consideration may result in very gratifying increase of signals. It should be observed, however, that the valve has been considered, throughout the article, as a rectifier pure and simple without any self-oscillation taking place. Such conditions introduce many secondary effects which necessitate a careful and separate study.

A Four-Electrode Valve Receiver.

By G. L. MORROW (*Development Engineer B.B.C.*)

At the presest time when many dual-amplification circuits and receivers are being disclosed the following description of a four-electrode valve receiver will, no doubt, be of great interest to the experimenter.

WITHIN the last two years much has been written, and many circuits have been disclosed with a view to obtaining what is commonly termed "dual amplification" in radio receivers. Stated briefly, the valve in a dual-amplification circuit is usually called upon to fulfil two, and in some cases three, functions. That is to say, one valve of the standard 3-electrode type may be used in a circuit in which the incoming signals are detected and then magnified at audible frequency, or the circuit may be so arranged that amplification at radio frequencies occurs as well as detection.

The object of such dual amplification is to obtain the range and signal strength of a two or even three-valve receiver with one valve, thus economising in the initial cost of the valves and in the filament watts consumed.

During the early parc of 1922 the writer spent several months experimenting with various dual-amplification circuits on short and long wave-le gth spark and continuous wave transmissions, and also on several telephony stations. The result of these experiments tended to show that, while in some cases various dual-amplifying circuits to a certain extent accomplished what was claimed for them, the majority did not give the results anticipated. Furthermore, the circuits being of considerable complication, adjustments were tedious and unstable, and unwanted capacity effects gave much trouble. With regard to economy in first cost and maintenance, it was soon apparent that what was saved on the valves was expended to an even greater amount on the cost of the various transformers and condensers used in a dual-amplification circuit.

The writer then turned his attention to another method of obtaining dual-amplification, namely, by the use of the 4-electrode valve, and it is his intention in this article to describe a receiver of this type which has given consistently good results.

Before, however, proceeding to consider the circuit in detail, it may not be out of place to deal, very shortly, with the functioning of the 4-electrode valve.

The valve used by the writer is the 4-electrode Marconi type, which, as will be seen from Fig. 1, is not unlike the "Q" valve, but rather larger in size. The electrode system consists of a cylindrical plate, an outer grid of mesh construction

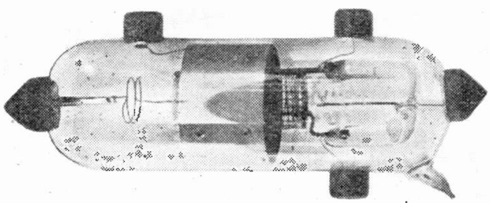


Fig. 1.—A Typical Four Electrode Valve.

and cylindrical shape, within which is an inner grid of the usual spiral form, the plate and the two grids being arranged in concentric assembly round a straight filament. The leads from these electrodes are brought to small metal caps, similar to those used in the "Q" and "V.24" types with an extra contact for the second grid. To describe clearly how this particular type of valve operates it is necessary to consider the simple application as a detector first, and then to show how it can be arranged to fulfil the functions of a high-frequency amplifier detector and note magnifier simultaneously. In passing, the writer would like to point out that where, as in the usual type of dual-amplification circuit employing the standard 3-electrode valve, it is the transformers and arrangement of the circuit

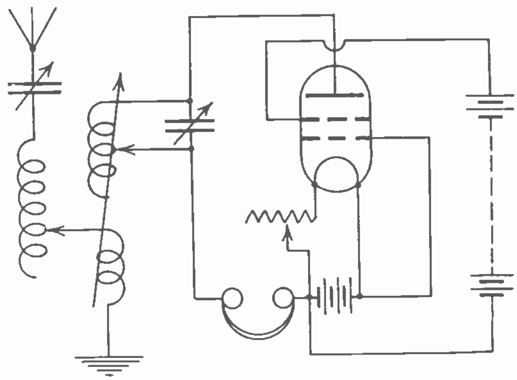


Fig. 2.—A Four-Electrode Valve used as a Detector.

which produce the desired results. In the 4-electrode valve receiver, however, the valve itself plays a much greater part in the simultaneous amplification at radio and note frequencies; in fact, the circuit which is about to be described can be built up easily by any experimenter who possesses the necessary components for a 3-valve receiver employing transformer coupled high-frequency amplification followed by a detector and one note magnifying stage.

Fig. 2 shows how the 4-electrode valve may be connected in order that it may operate as a detector, and it will be noticed that the connections of the outer grid are similar to the plate connections in a standard 3-electrode valve circuit, the high positive potential being applied to this outer grid in order that it may attract the negative electrons emitted from the filament. In point of fact this outer grid operates in a very similar manner to that of the plate in a 3-electrode valve of the usual construction, but since it has a mesh construction the electrons, emitted from the filament, will pass through this outer grid due to their velocity of emission. Now it will be seen from reference to Fig. 2 that the plate of the 4-electrode valve is connected to the negative limb of the filament, consequently the electrons which have passed through the outer grid are repelled from the plate due to its negative potential. The inner grid, being connected to the positive limb of the filament, is maintained at a slight positive potential, and there is thus a voltage rise between the filament and the inner and outer grids which, however, is nullified by the drop in volts between the outer grid and plate owing to the negative charge on the latter. If, now, the incoming oscillations are impressed between the plate and the negative end of the filament the incoming positive half cycles will cause electrons to be attracted to the plate where the negative half-cycles will cause the plate to become more negatively charged and will be entirely suppressed. A rectified current will therefore flow in the plate circuit and will become audible in the telephones which are inserted between the low potential end of the tuning inductance and the negative end of the filament. It must not be thought that, used in this manner, the 4-electrode valve offers any advantage over the usual 3-electrode valve ; it is, as a matter of fact, less efficient, but this rectifying action has been described in order that the reader may have a clearer idea of how radio frequency amplification may be obtained in addition.

Considering Fig. 3, which shows the circuit used for obtaining both radio-frequency amplification and detection, it will be seen that the primary winding of a high-frequency transformer of the usual type is inserted in the outer grid circuit, the secondary winding being placed in the plate circuit and the incoming oscillations impressed between the inner grid and negative end of the filament.

In a similar manner to a 3-electrode valve receiver, these incoming oscillations will be magnified in the outer grid circuit and, through the operation of the high-frequency transformer coupling the outer grid and plate circuits, an alternating current will be set up across the terminals of the secondary winding.

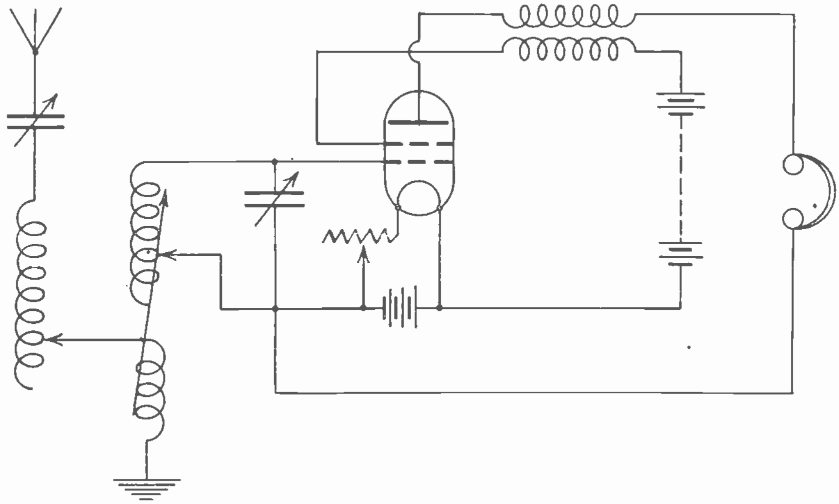


Fig. 3.—A Four-Electrode Valve used for Simultaneous H.F. Amplification and Detection.

Since the plate circuit is connected to the negative limb of the filament this alternating current will be rectified and a combined high-frequency amplifier and detector is thus obtained.

The final step is to magnify still further the low-frequency oscillations in the plate circuit by impressing these back on to the inner grid by means of a low-frequency transformer of, preferably, a one to one ratio, the note magnification being obtained in the inner grid circuit in which the telephones are placed. This circuit is shown in Fig. 4, to which has been added a power amplifying valve in order to operate a loud speaker. It would probably take the greater part of an issue of this journal to consider in

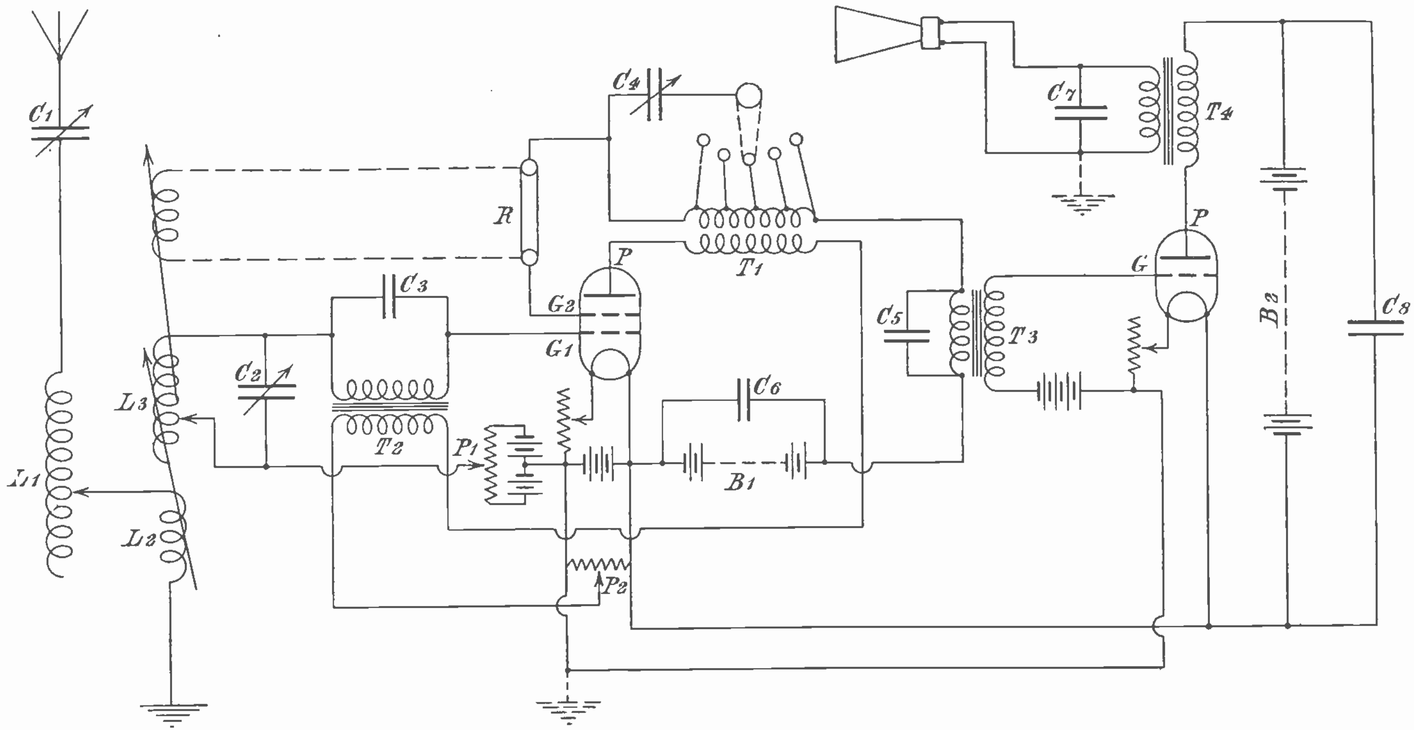


FIG. 4.—FOUR-ELECTRODE VALVE RECEIVER FOR SIMULTANEOUS HIGH-FREQUENCY AMPLIFICATION, DETECTION AND NOTE MAGNIFICATION.

L1. Aerial Tuning Inductance.
L2. Coupling Coil.
L3. Closed Circuit Inductance.
C1. Aerial Tuning Condenser, 0·001μF.
C2. Closed Circuit Condenser, 0·0005μF.
C3. By-pass Condenser, 0·003μF.
C4. H.F. Transformer Shunt Condenser, 0·0003μF.
C5. By-pass Condenser, 0·005μF.
C6. H.T. By-pass Condenser, 2μF.
C7. Telephone Condenser, 0·25μF.
C8. H.T. By-pass Condenser, 2μF.
T1. Radio-frequency Transformer.
T2. Low-frequency Transformer, 1/1.
T3. Note-magnifying Transformer, 4/1.
T4. Telephone Transformer.
B1. 30-50 Volts.
B2. 150-350 Volts.
R. Reaction Link.
P1. Inner Grid Potentiometer, 250 ohms.
P2. Plate Potentiometer, 250 ohms.

detail the action of the 4-electrode valve, but it is hoped that the foregoing rather brief description may be sufficient for the reader to grasp the outline of the main functions of this most interesting receiver. Before passing on to describe the values of the various components of the circuit shown in Fig. 4 the writer would mention that this receiver, on a standard Post Office aerial of a mean effective height of 25 ft., located 30 miles N.W. of London, gives good loud-speaker signals from the Birmingham, Cardiff and Manchester stations of the

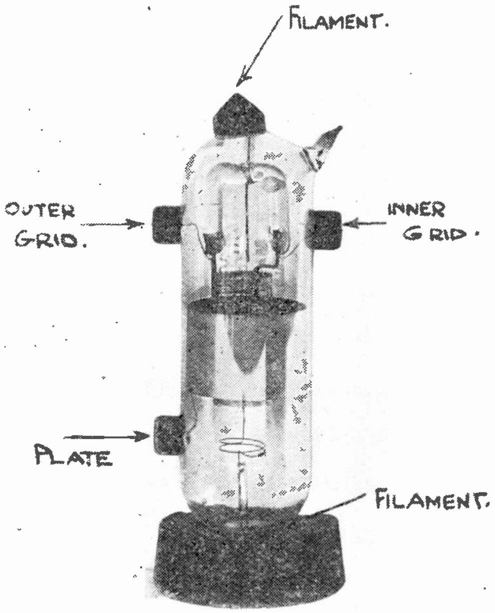


Fig. 5.—Showing the Relative Positions of the Electrode Connections.

British Broadcasting Company, 2LO works the loud speaker to the maximum of its capacity, and all the remaining stations of the B.B.C. give loud reception in the telephones.

Paris, Radiola, and the R.A.F. telephony station in Jersey give practically the same volume in the loud speaker as Birmingham. Considering the circuit (Fig. 4) in detail, the aerial tuning condenser, inductance and coupling coil, together with the secondary inductance and condenser may be of the usual type employing cylindrical inductances or duolateral coils may be used if desired. The note magnifying transformer (T2) should be, for preference, of a one to one ratio, and be shunted by a condenser of 0.003F capacity to by-pass the incoming oscillations, in their inital stage, on to the inner grid. The writer uses the 6,000 and 12,000 ohms windings of a Marconi "Universal" transformer (which may be obtained quite cheaply from most dealers in ex-Government apparatus) with the 12,000 ohms winding in the inner grid circuit. The potentiometer (P1) is of 250 ohms resistance, and, while not essential, gives a very useful control of the inner grid characteristic.

It will be seen that the plate circuit is connected through the secondary winding of the high-frequency transformer (T1) and one winding of the low-frequency transformer to another potentiometer (P2)—also of 250 ohms resistance. This potentiometer enables the plate potential to be varied, and will be found in practice to prove of the utmost help in eliminating jamming.

The high-frequency transformer (T1) mentioned above, may be of the usual type with tappings on the primary, a further refinement being the variable condenser (C4) of 0.0003F. capacity in shunt for fine tuning. If desired, a small reaction coil may be connected across the terminals (R) in the outer grid circuit, and when used will be found to bring up the signal strength at least 25 per cent., besides enabling the receiver to be used for the reception of C.W. signals.

The high-tension battery (B1) which should not exceed 50 volts is shunted by a Mansbridge condenser (C6) of 2μF capacity, and the note magnifying transformer (T3) has its primary winding shunted by a condenser (C5) having a capacity of 0.0005 μF. In conclusion, the writer does not lay claim to any originality in the circuit, as, with the exception of the addition of reaction and the use of a power amplifier in place of the telephones, it is essentially the same as that employed in marine 4-electrode receivers.

It is hoped, however, that the use of this receiver for amateur work may prove of interest and open out a very interesting field for experiments to those who wish an entirely satisfactory and efficient form of dual-amplification.

Supersonic Heterodyne Receiver Employing a Four-Electrode Valve.

By A. L. WILLIAMS, R.N. (ret.).

Below will be found details of a super heterodyne receiver employing a four-electrode valve which operates on the modulation principle.

ALTHOUGH for most practical purposes a well-designed and constructed two or three-valve receiver is all that the average experimenter requires, there is undoubtedly a demand for a receiver that will give real volume to a very distant signal, and, with this, a high degree of selectivity.

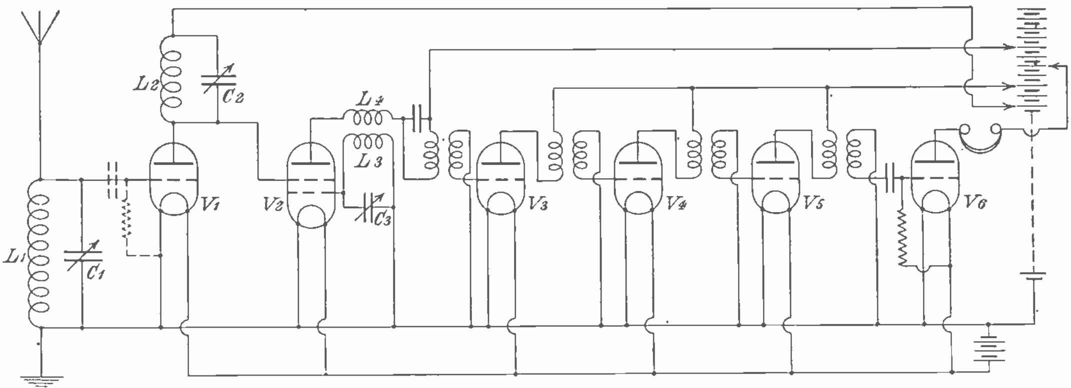


Fig. 1.—A Six-valve Super-heterodyne Receiver Employing a Four-Electrode Valve.

On the wave-lengths with which we are chiefly interested, say, between 80 and 500 metres, I do not think that more than one stage of high-frequency amplification is really practicable; firstly, because of the time taken to tune more than three critical circuits; secondly, that which always haunts us (or should) on the shorter wave-lengths, unwanted capacity effects. For these reasons I suggest the following circuit for giving both excellent results and wide scope for experimenting, and also, when constructed, being surprisingly easy to handle.

The receiver operates on the "modulation" principle, *i.e.*, the incoming signal is caused to modulate the output of an oscillating valve, so as to give a combined frequency equivalent to, say, 4,000 metres, which may then go through three or four stages of amplification at that wave-length, and is finally rectified. It will be seen, therefore, that it differs somewhat from the more usual form of supersonic heterodyne, and gives greater amplification for an equal number of valves. Another point of interest in this circuit is that it makes use of a "four-electrode" valve, that is, a valve with two grids.

In Fig. 1 V1 is an ordinary valve, preferably of small self-capacity, such as the V.24 Ora "B," coupled to the aerial in the manner and with its anode circuit "tuned." The anode is also connected direct to one grid of V2, a "four electrode" valve. The second grid of this valve is also "tuned," and is inductively coupled to its own anode circuit. H.T. is supplied to this valve through the primary of a high-frequency transformer, which with a by-pass condenser of about .0003 μF. tunes to say 4,000 metres. The secondary of this transformer supplies the grid of the first 4,000 metre high-frequency amplifier V3. I suggest that this is followed by at least two more high-frequency stages to the rectifying valve V6. In the sketch I have shown transformers, but choke or resistance-capacity coupling may be used for the latter stages.

As this circuit is inherently very selective I have not found it necessary to use a loose-coupled aerial circuit, but for work below, say, 200 metres an aperiodic aerial closely-coupled to the tuned secondary has been found very useful, without increasing the number of adjustments necessary to bring in a signal.

The *modus operandi* of this circuit is as follows :—

here that if V2 is oscillating at a frequency of 925,000 cycles the result will be the same (*i.e.*, there will still be a 4,000-metre component). There are, therefore, two positions of C_3 which will bring in the signal.

A potentiometer should be used to control the grids of valves V3, V4 and V5, one of which may be allowed to oscillate for the reception of C.W. signals. It is also very important that the correct potentials should be applied to the two grids of V2—these can only be found by trial. For the sake of simplicity and to allow for the various

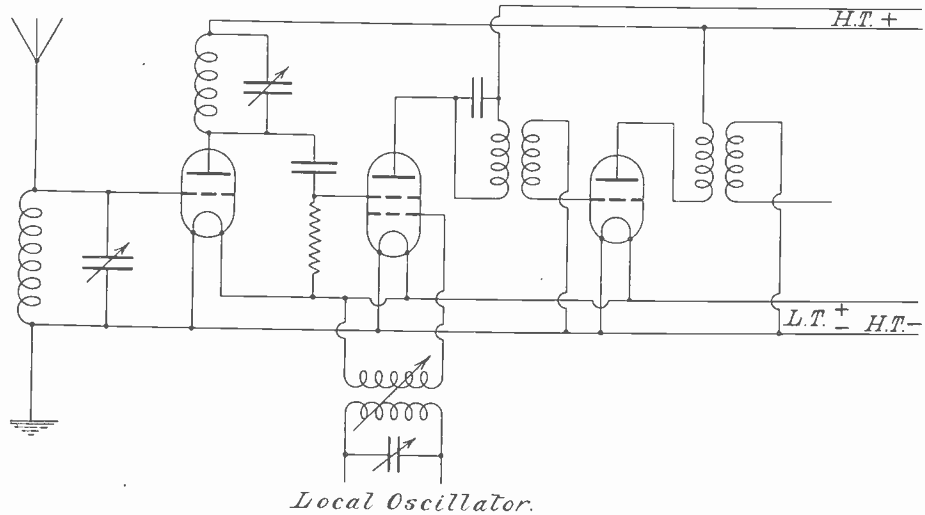


Fig. 2.—A Modification of the Circuit Employing a Local Oscillator.

Valve V2 is caused to generate oscillations at a frequency of say 1,075,000 by means of the coupling between its anode and second grid, the frequency of which is controlled by the grid circuit L_3C_3. An incoming signal on a wave-length of, say, 300 metres (or a frequency of 1,000,000 cycles) is amplified by V1, and impressed on the first grid of V2, thus "modulating" the output of V2. This valve will then be emitting, amongst others, oscillations at a frequency of 1,075,000 − 1,000,000 or 75,000, which alone are passed on *via* the first high-frequency transformer to V3. It may be mentioned

arrangements possible, rheostats and potentiometers are not shown in the sketches.

Fig. 2 shows a circuit on the more usual principle, making use of a separate oscillator; but still taking advantage of the "four-electrode" valve. This circuit may be preferred by those who already possess a heterodyne wavemeter, or, alternatively, the extra valve may be "built-into" the set.

The action of this circuit is similar to the usual supersonic-heterodyne, except that the incoming and local oscillations are "combined" in a "four-electrode" valve, with, I find, a considerable gain in efficiency.

The Heartshape.

By F. YOULE, B.Sc., A.C.G.I.

Experimenters who are anxious to receive some particular transmission with the minimum of interference will find that the heartshape method is one of the best solutions.

THE heartshape method of reception is used when it is necessary to obtain the sense as well as the direction of the transmitting station. It is also of great use in eliminating interference, as the receiving power is limited greatly in direction. Thus it is possible to separate stations on the same wave-length if they are on opposite sides of the receiving aerials. The frame aerial can determine direction, or separate stations whose bearings are 90 degrees apart, but it has two maximum points, while the heartshape has one only.

The simple vertical aerial has a circular diagram of reception, as its receiving or

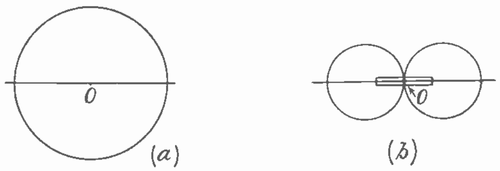


Fig. 1.—Reception Diagram for a Horizontal and Frame Aerial Respectively.

transmitting power is the same in all directions, in a horizontal plane. This is graphically represented by drawing a circle whose centre denotes the position of the aerial, and the radius is a measure of the radiating or receiving power.

The frame aerial has a figure 8 diagram, the maximum receiving power being in the plane of the frame, and the minimum in a plane at right angles to it. The point o (Fig. 1*b*), represents the position of the vertical axis of the frame, and the proportional receiving power in any given direction is obtained by drawing a chord from o in that direction, and measuring its length. The selectivity is obviously greater than that of the vertical aerial, but stations on approximately the same line cannot be separated owing to the double maximum. This often renders a frame useless on the coast. If one were trying to receive London at Brighton on a frame, any ship or station in the channel or in France on the Greenwich meridian or thereabouts will come in, so that the selectivity is to a certain extent useless.

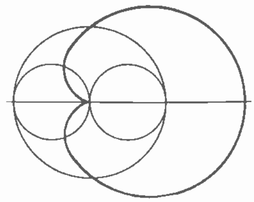


Fig. 2.—The Combination of Horizontal and Frame Aerial.

The heartshape will enable one to eliminate such interference almost completely. The diagram in Fig. 2 illustrates the receiving powers of the combination, and it will be seen that it is made up of the two diagrams already mentioned. In practice the two aerials are used, and the currents in both are combined by means of suitable couplings to the receiving amplifier circuit. The mechanism of this combination is extremely interesting, but before it can be understood

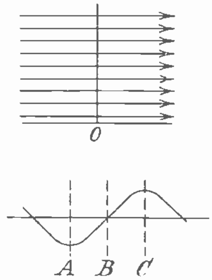


Fig. 3.—Reception on a Horizontal Aerial.

a knowledge is essential of how vertical and frame aerials receive.

Let us take firstly the vertical aerial. The magnetic field produced at the point o (Fig. 3) by a station which is in a direction vertical to the plane of the paper at that point may be represented at a given instant by the lines of force shown. As these cut the aerial they will produce an E.M.F. in it which will be proportional to the field

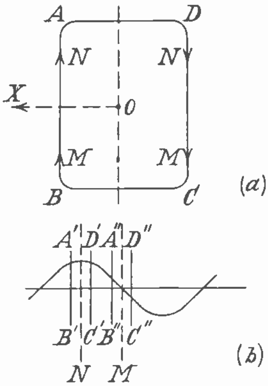


Fig. 4.—Reception with a Frame.

strength. If the latter varies sinusoidally the E.M.F. strength will be represented by a sine wave in phase with the field, assuming the aerial to be correctly tuned, and *the current will be in phase with the field.*

Turning to Fig. 4*a*, the transmitting station is in the direction OX. The magnetic field, which is perpendicular to the plane of the paper, on cutting AD and BC produces simultaneously equal and opposing E.M.F.'s in them, as indicated by the arrows. These therefore cancel out at every instant. In

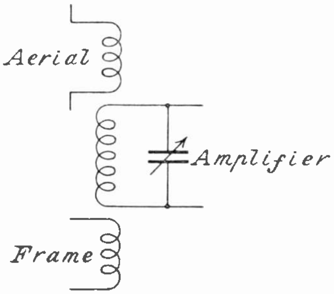


Fig. 5.—Reception with Combined Horizontal and Frame Aerials.

AB and DC there will be E.M.F.'s which do not cancel, except at one instant. A consideration of Fig. 4*b* will make this clear. The sine wave represents the field strength at any particular instant between two places a wave-length apart. Let the axis of the frame be at the point N, and its vertical sides be A′B′ and D′C′. The field strength is a maximum at N, and is slightly less at A′B′ and D′C′, producing equal E.M.F.'s NN (Fig. 4*a*) which cancel. Thus when the field at the axis of the frame is a maximum the E.M.F. round the frame is zero. Suppose now that the frame is at M. The field strength at the axis of the frame is zero. At A″B″ and D″C″ the two small field strengths are equal, but of opposite sign, and produce the E.M.F.'s MM (Fig. 4*a*). These add and give a resultant round the frame. It is easily seen that this resultant is a maximum at this point, increasing sinusoidally from the zero at N. The E.M.F. in a frame is thus 90 degrees out of phase with the field, and if it is tuned the resulting *current will also be in quadrature with the field.* It is also seen why the signals received on a frame are so much weaker than those received on a vertical aerial of average size. Not only do many less lines

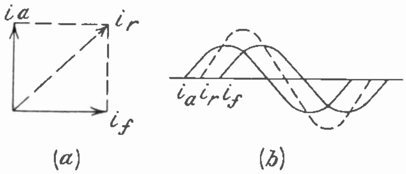


Fig. 6.—Illustrating the Conditions for Fig. 5.

of force cut the vertical sides, because they are so much shorter than the vertical aerial, but the two E.M.F.'s in these arms are nearly equal and the resultant depends on their difference, which is of necessity very small.

Suppose now that we are receiving a station on the two aerials, and we couple both to an amplifier circuit as indicated in Fig. 5, adjusting the couplings so that the two E.M.F.'s set up in this circuit are equal. The currents, if all three circuits are tuned correctly to the wave-length of the signals, will be 90 degrees out of phase (Fig. 6), and the resultant current will be of the form shown in dotted line. The vector diagram for this is given in Fig. 6*a*.

If the aerial is very slightly mistuned the current will no longer be in phase with the E.M.F. Let us mistune so that it leads or lags 45 degrees, and then mistune the frame so that its current will respectively lag or lead by the same amount on its E.M.F. Then the two currents may be either in phase or 180 degrees out of phase, and their effects in the amplifier circuit will then be to produce in the first case signals of double the strength of either alone, the coupling being as before; and in the second case the E.M.F.'s will cancel and no signals will be heard. (Figs. 7, *a* and *b*.)

Applying this to Fig. 8, the station A′ will produce at o the E.M.F.'s E_a and E_f, respectively in the aerial and frame. These being correctly mistuned and coupled in the right proportions to the amplifier circuit, as explained above, will produce the equal currents I_a and I_f, let us say, in that circuit. If station A″ is transmitting on the same wave-length, producing an E.M.F. E_a in the vertical aerial, it is easily seen that in the frame the result is not also E_f, but E'_f.

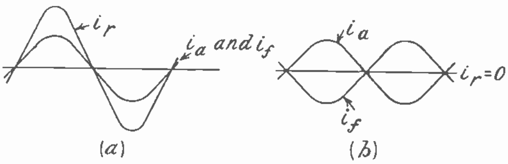


Fig. 7.—The Effect of Introducing a Lag of 45° in both Aerials.

Referring to Fig. 9, the field due to A′ is passing through the zero point and increasing. The E.M.F. in AB is negative and that in DC is positive, the resultant being a clockwise one. That due to A″ is also passing through the zero point and increasing. The E.M.F. in AB is positive and in DC negative, the resultant being anti-clockwise. In both cases the E.M.F. in the vertical aerial would be zero, and increasing, but in the frame we have two maxima of opposite sign.

Going back to Fig. 8, if the current produced by E_f is I_f, the current due to E'_f must be I'_f, which is 180 degrees out of phase with I_a. As the difference of signal strength in the aerial and the frame is compensated for by the coupling adjustment, I_a is equal to I_f and I'_f, hence the latter in effect wipes out I_a. Actually, of course, no current flows at all.

Thus, though both stations are on the same wave-length, and neither the aerial or the frame alone would separate them, the combination will do so. By reversing the coupling of the frame, or rotating it through

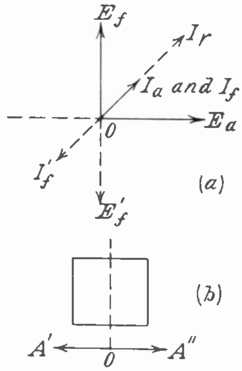


Fig. 8.—The Effect of the System on two Stations A′ and A″.

180 degrees, either station may be selected, to the exclusion of the other.

It may now be understood how the heart-shape diagram is obtained. If the large circle is taken as positive, representing the vertical aerial reception, the frame is rotated so as to make the small circle on the side of the station desired positive, the other being negative. On adding the two diagrams the heartshape results. When the frame is reversed the signs of the small circles are reversed and the heartshape swings round with the frame.

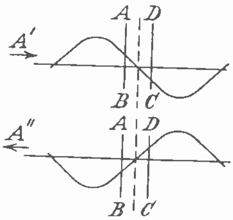


Fig. 9.—Illustrating the Conditions of Fig. 8.

Although it appears that stations in quadrature should be separated more completely by the frame alone, it does not always work out in practice, the combination seeming to be quite as good.

The Problem of High-Tension Supply.

INTRODUCTION.—1.

By R. MINES, B.Sc.

So many queries have been received relating to the supply of high tension that we have arranged for a short series of articles on the subject. The articles will summarise the various methods available, giving practical information, and should prove of considerable value to those interested in transmission.

IT may be stated that the large development in the radio world since pre-war days is in a great measure traceable to the advent of the triode valve. In commercial transmission of radio messages the Poulsen arc is playing a part comparable in importance to that of the valve, but for reception purposes the valve is almost without competitor. This almost universal use of the valve for reception and transmission, too, has brought the radio worker face to face with important secondary problems.

Any relay, or amplifier, or converter, whether embodying a valve or not, requires for its working at least one auxiliary source of electrical power, in addition to the controlling source. The three-electrode valve in its present form, with an electrically-heated filament, is no exception, for it requires at least two such auxiliary supplies. The most obvious of these is the supply of current for heating the filament. This presents no difficult problem from the technical point of view, though the development of the valve in the direction of economising on current requirements is a fascinating subject in itself. The recent article on "Dull Emitter Valves" in the November issue of EXPERIMENTAL WIRELESS was a valuable contribution to the subject.

The second supply required by the valve is the power supply to the anode or plate, and we intend to deal with this problem here, for it is at once the most important and the most difficult. It is the most important, because, whether a valve is functioning as amplifier or as oscillator, it is the anode supply which constitutes the local source that is controlled (modulated) or converted into oscillatory power, as the case may be. It is the most difficult, because, although the current supply to the anode is comparatively small, it must be maintained under an electric pressure which is at once of considerable magnitude and extremely constant in value. There have been developed recently some special receiving circuits which function correctly when only a low-tension source (up to 10 volts, say) is used as anode supply; in general, however, the lowest value used in this country is about 50 volts. (It may be noted here that 25 volts is a common figure for American practice, and for use with "soft" valves, but this need not affect our problem to any considerable extent). This minimum value is quickly exceeded in amplification work, where the pressure may be measured in hundreds of volts, and in transmission work, where the pressure may be measured in kilovolts.

We now have a concrete idea of what the requirements are in the matter of values of anode pressure used in radio work. The problem that arises for solution is, how are these requirements to be met. Naturally, the choice of a solution depends not only on the particular function the valves supplied are required to fulfil, it is affected also by the conditions of working, *i.e.*, what facilities are available in the way of electricity supply and what apparatus the radio worker is able to allocate to the purpose of high-tension supply. It may be assumed that a large number of the readers of this journal have to "start from the beginning," *i.e.*, have no suitable electricity supply, and, what is more important, will in any case have to purchase for the purpose any electrical apparatus required to deliver the desired high-tension power. The needs of readers will, therefore, best be met by a complete survey of the subject to cover all cases.

The various systems that may be employed for obtaining a high-tension supply may, in the first instance, therefore, be classified into three groups :

I.—Suitable for workers having an *A.C. supply*.

II.—Suitable for workers having a *D.C. supply*.

III.—Suitable for workers having *no electricity supply*.

It will be shown, however, as the various methods are detailed below, that the best method for any radio worker to utilise, bearing in mind his particular requirements, may fall outside the category indicated by the facilities available.

Following is a brief survey of the methods available at the present day, grouped under the categories given above. Each method is allocated to that group which means the most direct utilisation of any electric power available.

I.—(1) When an A.C. supply is available, and its pressure bears the correct ratio to that required, it may be converted direct into the required D.C. supply by means of some form of *Rectifier*, followed by a smoothing apparatus or *Filter*.

(2) When the A.C. supply pressure is different from that of case (1) it may be stepped either up or down, through very considerable ratios, by means of a *Transformer*. Subsequently the supply is sent through a rectifier and filter as in case (1).

II.—(1) When a D.C. supply is available whose pressure is in excess of that required for the radio work, a fraction of the pressure is most simply obtained by means of a *Potential Divider*.

(2) Obviously if the supply pressure be equal to that required, *direct connection* may be used.

(3) Should the supply pressure be insufficient, it may be stepped up by means of an *Electrostatic Transformer* (consisting of condensers in series charged successively from the supply of a high-speed commutator).

Both cases (1) and (3) admit of the use of a motor generator or a rotary transformer.

In each case it will be necessary to use a filter apparatus.

III.—When no electricity supply is available there is obviously no alternative but to generate the required electric power. Here will be considered the direct generation of the high-tension supply, though it is sometimes better to generate a lower tension D.C., or, more usually, an A.C. supply, and subject this to conversion, etc., as described above.

(1) The *Primary Battery* and the *Secondary Battery* take their place here, for they are really "chemical generators."

(2) The *Wimshurst Machine* should be mentioned as representing the electrostatic generators, though its sphere of usefulness does not cover ordinary radio work.

(3) The Electro-magnetic Machine, or *Dynamo*, is well represented in radio practice. These machines may be further classified according to the type of drive employed :

(i) With mechanical drive (by hand, treadle, or prime-mover) ;

(ii) with separate electric motor (giving a "motor generator") ;

(iii) with driving motor built as one with the generator (giving a "rotary transformer") ;

Note that in case (ii), and similarly in case (iii), the driving power may be obtained from electricity supply mains, either A.C. or D.C.

(4) There is also the Impulse Generator, represented by the *H.T. Magneto* and the *Induction Coil* (though this is really a converter or transformer rather than a generator.

These machines obviously must be used with a smoothing device (filter), and a rectifier or a minimum-potential device is also necessary.

Rectifiers.—There are a number of practicable method of rectification that may be used with alternating and impulsive supplies, as detailed below :

(1) *Mechanical* (commutator or distributor) ;
(2) *Electrolytic* or chemical.
(3) *Air-Blast* (assymmetric arc) ;
(4) *Ionic* ("gas discharge" vacuum devices) ;
(5) *Electronic* ("hard" vacuum tubes, with hot cathodes).

It is proposed to devote further articles to detailed descriptions of the above methods of High-Tension Supply and Rectification and a discussion of their relative advantages and disadvantages in relation to both the radio service required and the conditions and costs that have to be faced in installing the supply.

(To be continued.)

The Effect of the Series Condenser in a Transmitting Aerial.

By E. H. ROBINSON.

At first sight it would appear that, given an aerial system of fixed dimensions with a certain H.F. current flowing in it, the energy radiated into the ether would be quite a definite quantity whatever circuits were used to obtain this aerial current. It might be argued that compared with the electric field between aerial and counterpoise (or earth) the field due to the apparatus in the operating room is negligible

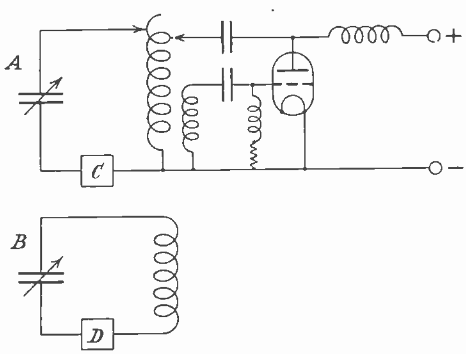


Fig. 1.—The closed circuit B is excited by the valve oscillator A. The oscillatory current in the circuit B may exceed that in A, even though similar condensers and inductances are used in both circuits.

and therefore why worry what happens in the operating room as long as the desired H.F. currents are going into the aerial and counterpoise leads on the right wave-length? This reasoning is right up to a certain point but there are some other effects which may play an important part—especially when a condenser is used in series with the aerial inductance for the purpose of operating the set at a low wave-length. As far as tuning the aerial to any desired wave-length is concerned it makes very little difference whether the condenser is inserted above or below the inductance, but where damping, losses and distribution of the aerial field are concerned the position of the series condenser may make a great deal of difference. It is the object of this article to consider in an elementary manner the effect of a series condenser on the aerial losses and on the distribution of the radiated field.

Losses due to Loading or Earthing Anti-nodal Points of an Oscillatory Circuit.

Loss-hunting in transmitting circuits is an interesting and instructive pastime. The following simple experiment made by the writer emphasised the importance of the correct arrangement of circuits to avoid loading any but the potential nodes of a circuit. A conventional type of valve oscillator was set up as shown at A in Fig. 1 and an entirely isolated resonant circuit B was fairly loosely coupled to it. The oscillatory currents in each circuit could be read on instruments inserted at C and D respectively. The filament end of the inductance in A is shown earthed as the filament battery and H.T. supply have a capacity to earth even if no intention of earth connection were provided. The circuit A was first adjusted to give the maximum reading on the thermo-ammeter C (circuit B being temporarily removed). This reading was very discouraging as the current registered was well under an ampere although the input to the valve was several watts. No matter what adjustments were made to the anode tap or grid coupling this current could not be materially improved for a given power input. Losses were therefore indicated of greater magnitude than could be accounted for by condenser and inductance losses. Circuit B was then loosely coupled to A and carefully tuned to it. Resonance was very sharp and much larger currents were registered in the circuit B than could be obtained in the original circuit A. This was very puzzling at first, especially as the actual condensers, inductances and meters in A and B respectively could be interchanged without affecting the result. Throughout the experiment the condensers in A and B were kept approximately equal in capacity.

The next step was to try the effect of

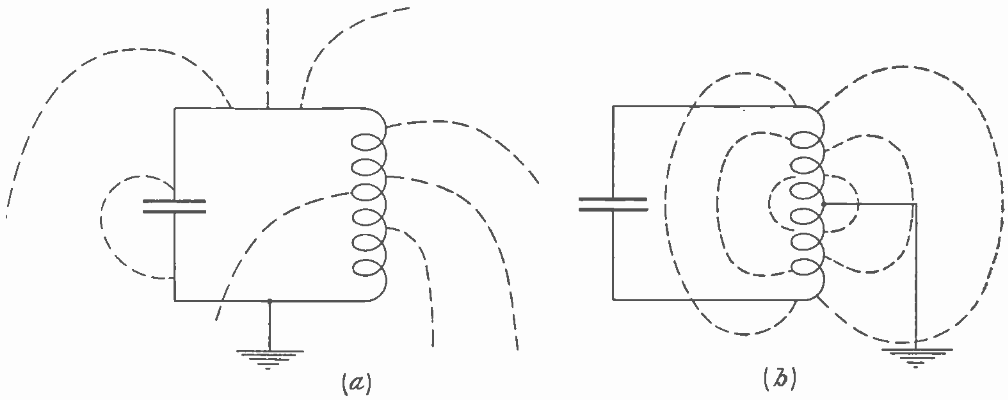


Fig. 2.—Showing how the location of the nodal point in an oscillatory circuit may affect the distribution of the electrostatic field of the circuit.

earthing different points in the circuit B. An earth wire was connected to one extremity of the inductance in B and the reading on D immediately dropped a full 50 per cent., and no amount of retuning would restore the current to its initial value. The earth wire was then touched on various turns of the inductance, a point being found somewhere in the middle of the inductance which could be earthed without reducing the current registered on D. This point is obviously a node of potential.

This all goes to show the importance of having both extremities of an inductance unearthed. The reason is not hard to appreciate. If we have oscillating currents in one inductance the extremities will be at high opposite oscillatory potential with respect to each other. If one end is earthed as in Fig. 2 (*a*) the circuit as a whole must have a mean H.F. potential to earth, its field straying as indicated and inducing all sorts of dielectric and resistance losses in surrounding bodies. In Fig. 2 (*b*) however the nodal point is earthed and the potentials at the extremities of the inductance are symmetrical about this point, being always equal and opposite; for this reason the electrostatic field of the various parts of the circuit will close on itself and very little will go to produce losses in neighbouring bodies. Quite a good analogy is found in the case of the tuning fork. If we hold it in the proper way by the tang and strike it, the fork will vibrate freely with low decrement. The tang is of course situated at a node and we may compare this case with Fig. 2 (*b*). If, on the other hand, we hold the fork by the extremity of one of its prongs it will not vibrate at all freely; here we have the case of Fig. 2 (*a*).

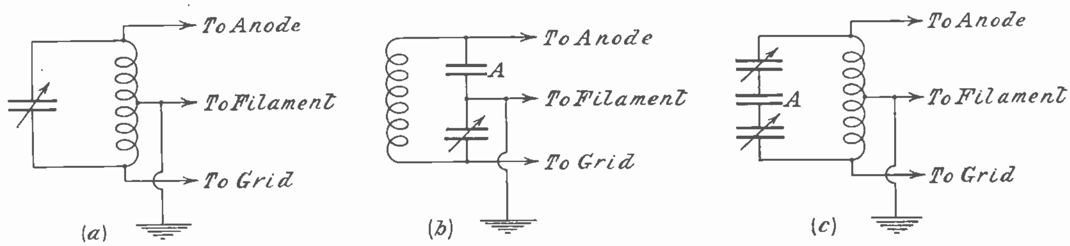


Fig. 3.—Three types of circuit in which node is naturally located at filament and earth tap. (a) Closed Hartley Circuit; (b) Colpitt's Circuit; (c) Reinartz modification of Hartley Circuit.

The foregoing consideration undoubtedly explains to a large extent why the Hartley circuit makes such a good closed circuit and why the Colpitts and Reinartz circuits make such good "straight" circuits as far as input-to-aerial efficiency is concerned. Figs. 3 (*a*), (*b*) and (*c*) show the basic circuits of these three systems with respect to earth. In (*b*) and (*c*) A represents the aerial-to-counterpoise capacity, which we must remember is always the condenser in the aerial oscillatory circuit. The Colpitts circuit, it will be noticed, has two natural potential nodes—one in the middle of the inductance and one at the junction of the two condensers if they are of approximately the same capacity. It will be found that with a closed Colpitts circuit that the best results are obtained with these two condensers of equal capacity, but when it is used in the more familiar manner as a straight aerial circuit the aerial-counterpoise capacity comprises one of these condensers, the other condenser, theless the same general rules hold to a certain extent and it is still highly advisable to make the filament and earthed bodies natural nodes if it is desired to bring aerial losses to a minimum.

But to get back to some practical results. The same components that were used to build the circuit in Fig. 1 were rearranged first in the form of a closed Colpitts oscillator and then a closed Hartley oscillator. It was shown most decidedly that much larger H.F. currents were obtained in the Colpitts and Hartley circuit for a given input than in the case of the ordinary magnetic reaction circuit with the lower extremity of the plate circuit earthed.

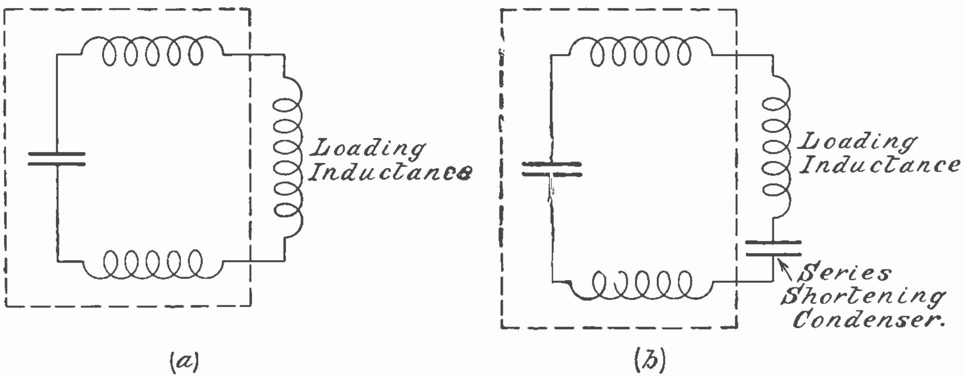


Fig. 4.—An aerial has appreciable inductance as well as capacity. The portions of diagrams (a) and (b) enclosed by the dotted lines are intended to represent that part of the total inductance and capacity of the aerial circuit which is contained in the aerial and counterpoise wires themselves.

i.e., the series tuning condenser below the A.T.I., usually requiring to be set at a rather larger value than the aerial capacity itself. It should be borne in mind that the usual aerial is not merely a capacity but has quite an appreciable inductance of its own, and this tends to complicate matters when we are working an aerial in the region of its fundamental wave-length, or below it, as the natural self-inductance of the aerial itself is quite comparable with any loading inductance we may have in the operating room. In this case it is necessary to picture our aerial system something as in Figs. 4 (*a*) and (*b*), the parts within the dotted lines representing the aerial itself. Even these figures do not exactly represent the actual electrical properties of an aerial as the inductance capacity and resistance are distributed together throughout the length of the aerial and counterpoise wires. Never-

An attempt was next made to substantiate our contention about the effect of the position of the nodal point on losses in an open aerial circuit. The aerial circuit was loose coupled to a closed Hartley circuit tuned to a wave-length well above the fundamental of the aerial, the aerial circuit being brought into resonance by a loading inductance and a series condenser. The series condenser was tried both above and below the A.T.I. as in Figs. 5 (*a*) and (*b*) with the thermo-ammeter always at the point A. With the series condenser below the inductance as in Fig. 5 (*b*) 10 to 20 per cent. more aerial current was obtained than with the condenser above the inductance. In both cases a hunt was made for nodes by touching various parts of the aerial circuit with an earthed wire; if any part at H.F. potential is touched, *i.e.*, any part that is not a node, the aerial current falls. In the circuit in Fig. 5 (*a*) no node was found in the inductance, the potential gradient being continuous throughout its length; there was a node in the aerial lead somewhere above the series condenser. In Fig. 5 (*b*), the better of the two circuits, a node was found somewhere near the middle of the inductance as expected. Thus there

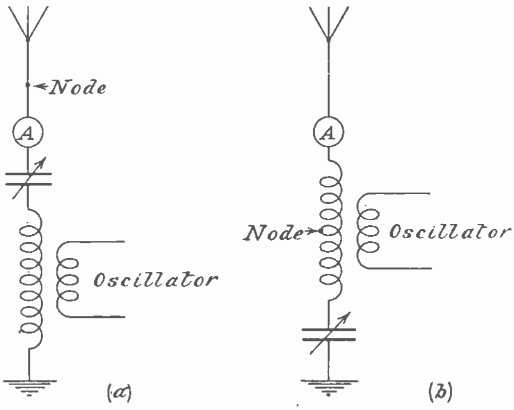


Fig. 5.—When a series condenser is used in an aerial circuit the position of the nodal point is dependent upon whether the condenser is placed above or below the loading inductance.

is a very fundamental difference between placing a series shortening condenser above the inductance and placing it below. The latter case is similar to the Colpitts in that the tuning capacity across the inductance is composed of two approximately equal capacities (aerial-counterpoise capacity and series condenser) the junction between which is naturally a node and to which the earth and filament leads are connected, leaving both ends of the inductance free to assume H.F. potentials. By actual test it will be found that both extremities of an inductance as in Fig. 5 (*b*) are at high H.F. potentials.

These tests on the position of the series condenser were repeated on a long aerial with high losses operating somewhat below its fundamental. Here the difference in aerial currents obtained with the condenser above and below the inductance was not nearly so marked—probably because the normal aerial losses were so bad as to mask any difference due to the two positions of the condenser.

The Colpitts circuit has a reputation for being better as a direct-coupled valve transmitting circuit than the magnetically-coupled reaction circuit, but the latter if used with a series condenser below the A.T.I. gives result nearly (but not quite) as good as those obtained with the Colpitts.

Loose-coupled circuits were also tried without any series condenser in the aerial circuit. This would appear to be the most straightforward thing to do where possible, and in some cases, particularly when only one or two turns of A.T.I. are needed, it is the best method. In other cases it has been found rather better to increase the aerial inductance and use a series condenser with reasonably low losses.

Effect of Series Condenser on Radiating Properties of an Aerial.

So far we have only considered the effect of the series condenser on the aerial circuit losses and the consequent damping effect. Another thing to be considered is what kind of electro-static field is being produced by the aerial—how it is distributed and to what extent it is effective in radiating waves in the desired direction. This is perhaps the most important consideration in the whole transmitting system as it is not much use radiating a large amount of energy into the ether with fairly high efficiency if most of the radiation goes in the wrong direction. It is true that most radio engineers do not attribute marked directional properties to small aerials such as most experimenters have to use; but the writer is at present chiefly concerned with the idea of short-wave working where the aerial is excited in

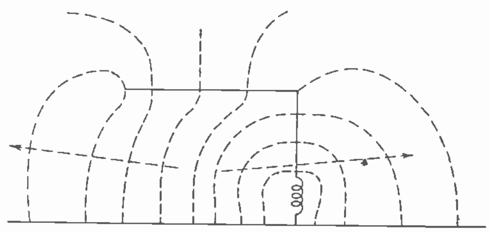


Fig. 6.—Field of inverted L aerial with loading inductance only.

the region of its fundamental frequency and cannot be considered as a capacity area pure and simple. In the case of an inverted L aerial, such as is so commonly used, there must be at any rate a certain amount of directional effect and all possibilities merit consideration when we are trying to unscramble the mysteries of short-wave transmission. An attempt has been made in Figs. 6, 7 and 8 to give an idea of the electrostatic field produced by a conventional inverted L aerial with a loading inductance only, with a series condenser above the inductance and with a series condenser below the inductance respectively. The counterpoise is assumed for simplicity to be an infinite plane—an assumption that must be modified if only a small counterpoise is used.

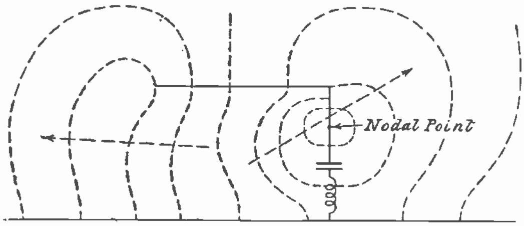


Fig. 7.—Field of inverted L aerial with series condenser above inductance. A node is produced in the aerial lead above the condenser.

Fig. 6 illustrates the simple case where there is no nodal point in the aerial above the earth connection. The waves will be propagated out into space chiefly in a horizontal direction or in a direction just slightly inclined to the horizontal as indicated by the dotted arrows.

In Fig. 7, for the reason previously given the series condenser causes a nodal point somewhere up the lead-in wire. It will be borne in mind that the H.F. potentials immediately either side of a nodal point are of opposite sign at any given instant; therefore the lines of electric force close on themselves about the nodal point distorting the field as shown. This will cause the field at the lead-in end to expand into space in a more vertical direction giving a direction of maximum propagation as shown by the inclined arrow on the right of the figure. The direction of propagation on the left would not appear to be much different from that in Fig. 6.

In Fig. 8 the condenser produces a node somewhere in the inductance which produces a distortion in field similar to that in Fig. 7 but which is less effective as it is lower down, more concentrated and well within the operating room. The direction of propagation from left to right will be similar to that in Fig. 7, though directed at a less steep angle to the horizontal, though more so than in Fig. 6.

The most generally assumed explanation for long-distance night effects on short wavelengths is that reflection takes place at the Heaviside layer, thus allowing the waves to negotiate the curvature of the earth. If this is so it is an obvious advantage to direct one's radiation upwards at the Heaviside layer in the vertical plane of transmission, and it has been suggested that the suitable location of one's nodal point by means of a series condenser contributes to this effect. It appears then that the aerial in Fig. 7 would be particularly well suited to communicate with a distant station situated to the right of the diagram, while the directional effect of the aerials in Figs. 6 and 8 would not be so marked.

No hard-and-fast rules can at present be laid down as to the best position for the series condenser, or indeed whether one should be used at all in many cases. It has been pointed out that a series condenser brings in two important effects quite apart from the actual tuning of the aerial and a compromise may have to be sought between two possible arrangements, one which gives the greater valve-to-aerial efficiency and the other which gives the greater aerial-to-ether efficiency. Many experimenters' aerials depart considerably from the types of aerial which are usually treated in theoretical treatises. For instance, the operating room may be at the top of the house, or the aerial and lead-in wires may be at all sorts of angles

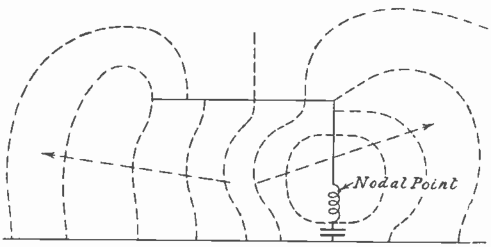


Fig. 8.—Field of inverted L aerial with series condenser below inductance. A node is produced somewhere in the inductance.

to each other and to the ground. Most amateur counterpoises are anything but infinite planes and often are not much bigger than the aerial itself. Then again, there is the effect of houses, trees, etc., in the neighbourhood of an aerial which may modify the distribution of the electrostatic field very considerably.

The only thing to do to get an idea of how an aerial is radiating is to draw a scale diagram of the particular aerial system under consideration and, having located by experiment the position of the nodal points (if any), in the aerial or counterpoise, draw in the lines of electrostatic force, bearing in mind the following important points :—

1. Each line must originate from a conductor bearing a charge and must start out at right angles to the surface of the conductor, no matter how it may be bent in passing through space.
2. Each line must terminate on a conductor at zero potential or opposite potential to the conductor from which it started.
3. The lines try to take the shortest path to the conductor of opposite sign, but
4. Lines going in the same direction repel each other so that the field tends to bulge out.
5. No two lines ever cross each other.
6. Lines swelling outwards tend to be retarded by earthed bodies—rather as if they stuck to them.
7. The direction of propagation at any point is at right angles to the lines of force, that is the electrostatic field bulges out into space very much like the ripples produced on the surface of water by throwing a stone in.

Fig. 9 is an illustration of how this might be applied in a practical case. The fictitious man in the hypothetical villa is using a series condenser which produces a nodal point somewhere in his down-lead and owing to the fact that he is not on sufficiently good terms with his neighbours his counterpoise is not of the optimum dimensions demanded by theory. A rough attempt has been made to show the state of affairs at an instant of the H.F. cycle when the aerial is at maximum potential. All lines within a quarter wavelength of the aerial must end on the counterpoise or some terrestrial body. Those which do not end on the counterpoise will entail resistance and dielectric losses in houses and trees, not to mention the energy wasted in heating up the neighbour's crystal set. Note how the operator's house may get in the way of his own radiation.

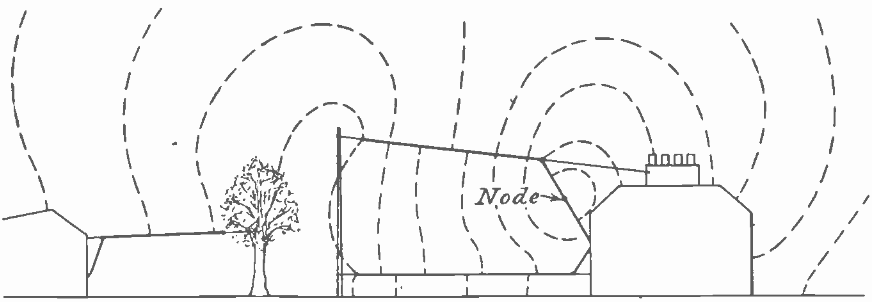


Fig. 9.—The field which may be expected in the case of a typical experimental aerial.

The object of these few remarks has not been so much to tell the experimenter anything new about operating his transmitter but to suggest reasons for things that are observed and to direct greater attention to the theory of short-wave transmission. A great many experimenters get the best results at their own station by the laborious process of trying everything at random and obtaining reports from other stations. They finally arrive at the most efficient arrangements for their own particular stations and then do not alter anything nor do many of them worry about the circuits they have scrapped. We shall never get any result of scientific use, however, unless we put forward some definite theories and test them practically until we arrive at the hard facts of the case. What has been said above regarding the effect of a series condenser on loss and radiation resistances has only been partly verified by the writer, but no doubt other experimenters have a great deal of information to contribute on the subject.

Radio Station 5DN.

By CAPT. L. A. K. HALCOMB.

BRITISH 5DN is situated on the outskirts of Sheffield. The district is in a valley and far from ideal for a wireless station.

The aerial system consists of a two-wire inverted L type, the flat top consisting of two wires (7/22 enamelled), each 66 ft. long separated by 6 ft. spreaders made of

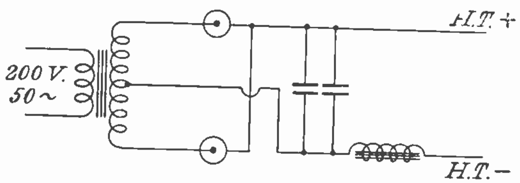


Fig. 1.—H.T. Supply System.

Simplex tubing. The lead-in consists of two wires, each 20 ft. long. Three earths are used, *viz.*, the water-pipe and two large copper plates buried under the aerial. The set, being on the first floor, entails the use of 35 ft. long earth leads.

A counterpoise 60 ft. long by 10 ft. wide made up of five wires solid 16 S.W.G. copper wire with a fan lead-in, is used in conjunction with the three earths. Incidentally, the addition of the counterpoise, when properly tuned, increases the radiation by 50 per cent.

The high-tension system consists of rectified and smoothed A.C.

Referring to Fig. 1, it will be seen that 220-volt 50-cycle A.C. from the mains supplies the high-tension transformer primary. Rectification is obtained by the use of two No. 3000 Amrad "S" tubes. These have given great satisfaction, and as there are no filaments in them they last, with care, almost indefinitely. Prior to the use of "S" tubes ordinary rectifying valves were used, but the filaments frequently burnt out, renewals becoming an expensive item. The makers of these "S" tubes state that 3,000 hours is the average minimum lite, and that the maximum rating for them is 50 milli-amps. at 750 volts. If more power is required they recommend larger tubes.

The filter-circuit consists of two oil-immersed 2 mfd. condensers connected across the high-tension leads and a motor car spark coil secondary in series with the negative lead. This filter-circuit gives a very pure C.W., and from reports received on the quality of the note appears to be quite efficient.

Coming now to the set itself, the aerial and other inductances can be followed out by reference to the diagram in Fig. 2 and

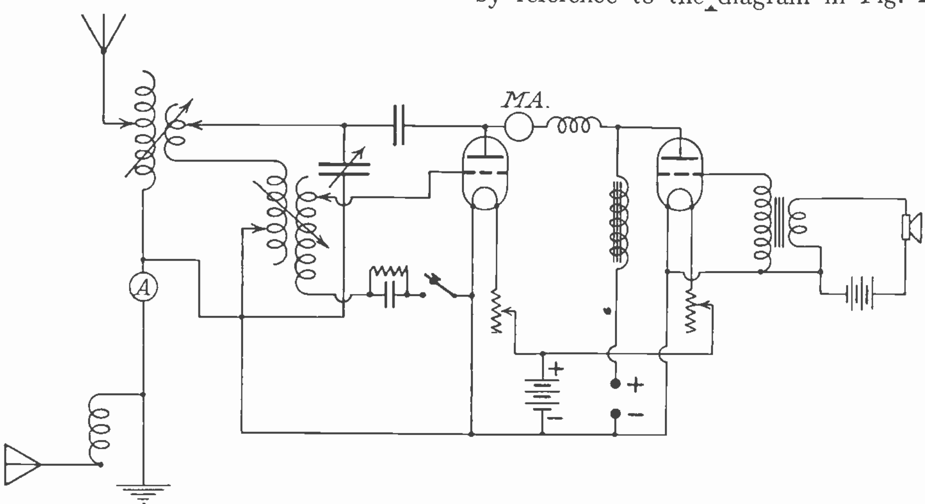


Fig. 2.—The Transmission Circuit used by 5DN.

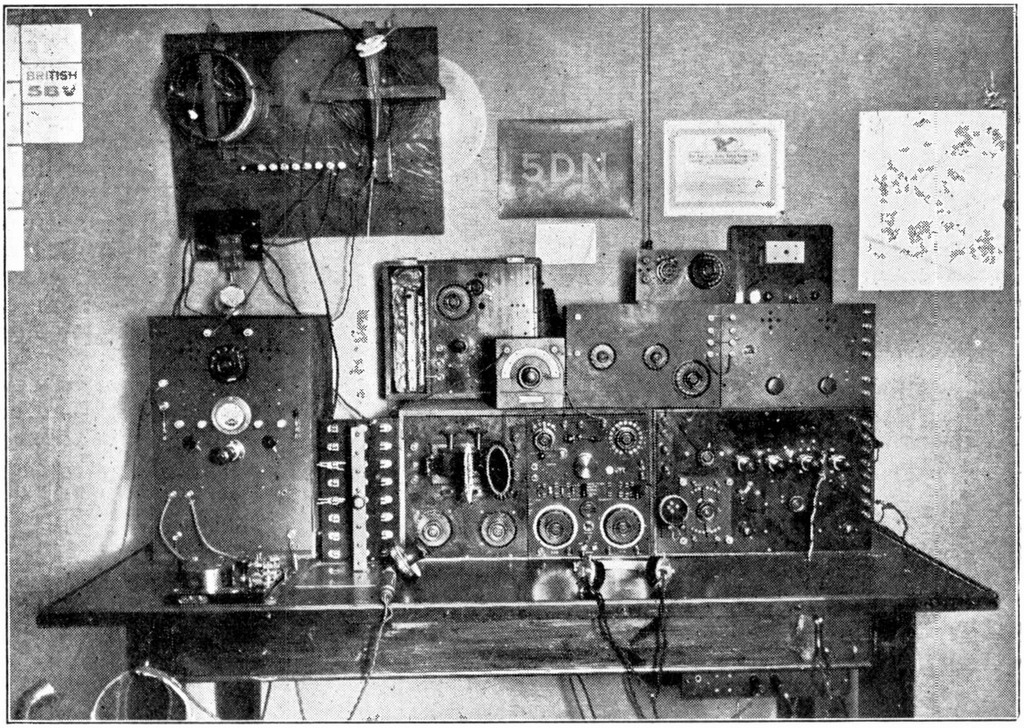


Fig. 3.—General View of Transmitter and Receiver.

the photograph. They are placed on a board on a wall. The secondary is wound in two parts, half being coupled to the grid coil and half to the aerial coil. The ammeter is in the earth lead and can be short-circuited when not required.

Looking at the transmitter panel on the left of the picture, the two terminals at the top lead to the closed circuit plate coil, which is tuned by means of a variable condenser just below the two terminals. Below this is the plate milli-ammeter, and below that is a bayonet socket into which a neon tube may be fitted. This latter is in series with the plate lead of the modulator valve. On each side of this socket are the filament rheostats for the power and modulator valves. Above each rheostat are two terminals to which a voltmeter may be connected to obtain the voltage on the filaments. A small knife-switch on the right breaks the modulator valve filament circuit when using C.W., and a similar switch on the left short-circuits the key when using telephony. The key is in series with the grid coil. Below the right-hand rheostat is a jack for the microphone. The H.T. terminals are placed at the bottom corners of the panel, and the remainder of the terminals are at the side behind the change-over switch. The valves used are Mullard o/20 for both oscillator and modulator. Two power valves may be used in parallel, if desired.

Using 10 watts (300 volts) on the plate of the power valve the radiation is ·6 amps. on C.W., and ·35 on telephony. Using this power the best "DX" on C.W. up to now has been two-way communication with Geneva and Venice. 8DY (Rouen) has been worked when he only used one valve and an indoor aerial for reception. Some months ago, before the ounterpoise was erected, telephony was received by 8BF (Orleans) on a 6-valve super heterodyne, but this has not since been repeated. These results seem to prove that large radiation figures are sometimes misleading.

Passing to the receivers, on the top is a short-wave tuner (range 85 to 220 metres) coupled to a two-valve amplifier (1 det. and 1 L.F.). This receiver is permanently inductively coupled, and cannot be used on the "stand-by" position. The aerial inductance is untuned, consisting only of six turns of 16 S.W.G. D.C.C. wire wound on a former 3 ins. diameter. This receiver and three valves (1 H.F., 1 det. and 1 L.F.) receives KDKA direct quite well on 100 metres.

Below is the long-wave receiver consisting of a Mark III tuner. The primary and secondary windings are broken and brought out to a three-coil holder on the left, so that they may be loaded up to any wave-length. Switches provide for working on the "stand-by" or "tune" positions. The reaction coil is brought to the three-coil holder and has a ·0005 mfd. condenser shunted across it. The amplifier employs 1 H.F., 1 det. and 2 L.F. valves. The second L.F. is hardly ever used. Tuned anode or transformer coupling may be used at will. The former is generally used below 300 metres, and the latter for the higher wave-lengths.

Above the Mark III tuner is a ·00075 mfd. variable condenser placed in series with the Mark III earth lead. This has been found better for short-wave work than the ·0015 mfd. in the tuner, and the latter is therefore short-circuited.

On the top of the three-coil holder is a heterodyne wave-meter (range 88 to 665 metres).

The transmitter is now working on 200 metres, but it is proposed to work down towards 150 metres very shortly, and any reports of reception on the lower wave-length will be much appreciated.

The Month's "DX."

GENERAL REPORT, BY HUGH N. RYAN (5BV).

SINCE writing last month's notes the inevitable has, of course, happened. The annual curiosity which passes in this country for spring has come upon us, to the usual accompaniment of loss of signal strength. Transatlantic work has become increasingly difficult, and for long periods American signals disappeared altogether, and those of us who had prophesied "Yank signals right through the summer" on the short waves began to feel a bit doubtful. But, bad as things have been at times, a somewhat spasmodic touch with the "other side" has been maintained. We have just passed through such a period of extraordinary advance in British "DX," consequent upon the "discovery" of the virtues of the waves around 100 metres, that we have all become somewhat blasé. But consider for a moment to-day's doings in the light of last year's experience. What should we have said last year to the idea of working two-way with America, on low power, half way through May? We never expected even to receive American signals later than February or March, and two-way working in May is really a great achievement. I firmly believe, as does our "Northern Manager," 5JX, that we can keep up some sort of touch across the "Pond" right through the summer, if we try.

Of course the summer provides many counter-attractions to Radio, but "please, gang," as the Yanks say, give a little time to it occasionally and try to keep the work going right through the summer. It will be a great achievement if we can do it, so it's worth working for.

No very startling work has been done during the past month by the higher-powered stations. All of them have added to their "bag" of Americans during their work, but their maximum range has not increased. The less powerful stations, on the other hand, have been doing some very good work, many of them "getting over" on very low powers. Just too late for last month's notes I heard that 2GO (London) had been logged by 3CJY (Washington), input power being under 10 watts. Though London had every other district "beat hollow" in the pioneer work with America and Canada, and in the subsequent high-power working, the later low-power work has been almost monopolised by the North. 5OT, 2PC, 2NO and 5JX have all been heard in America on powers below 20 watts.

Apart from Transatlantic work, very little of interest has happened. The Italians have been doing good work, 1MT having now bridged the Atlantic, and 1MT, 1ER and ACD having worked a number of very low-power British stations. 1ER is now heard regularly and very strongly in Britain.

Of the Danes, 7ZM is leaving Radio alone for a while owing to examinations. 7QF has packed up for the summer (though I doubt if he can keep off it that long ! !) and so the whole of the work falls on 7EC, whose signal strength seems to have risen to the occasion. His signals are very strong both on 200 and 120 metres, and he should soon reach America on the latter wave. By the way, I succeeded in relaying what was, I think, the first message from Denmark to America with the co-operation of 7EC. He suggested the attempt on May 9, and I told him that transatlantic conditions were very bad, but he gave me a test message and I was fortunately able to pass it on to American 1XAH within twenty-four hours. Danish experimental messages have been passed to America before, but they have come to England by post, and this was, I think, the first to go all the way by Amateur Radio.

At Easter the R.S.G.B. organised a four-day test to determine the range of members' transmitters. The tests were run like the transatlantic tests on a small scale, arrangements being made for listeners in France, Italy, Denmark and other European countries, as well as America and Canada. The tests were primarily for the lower-power stations, and at the end of each night's work a number of the higher-power stations (2KW, 5KO, 5BV, 2WJ, 5JX and others) who could be sure of reaching the various countries collected the reports. These, when published, should be interesting. Last month I suggested that a pure D.C. C.W. note was a very great help in long-distance work, and cited 2KF and 2NM as the only high-power D.C. stations in London. I forgot to mention 5LF, who, though not as powerful as the other two, is one of our higher-powered stations. I mention him now as his results bear out my last month's statement, 4th district American stations being able to receive him and 2KF through QRM and QRN, which blot out our A.C. stations.

We must use D.C. for Australia next winter. Speaking of Australia, in the March notes I spoke of the possibilities of our signals reaching that country, and, in view of the advances we had recently made, I prophesied that we should be working Australian amateurs within two years. I see that the American Radio Relay League Journal *Q.S.T.* has published my prophecy, and the reasons for it. This means that all the American amateurs, and, in fact, "hams" all over the world, since *Q.S.T.* and EXPERIMENTAL WIRELESS are read everywhere, will be expecting us to fulfil this prophecy. So it's up to us British amateurs. Let's do it next winter and make sure.

The MacMillan Arctic Expedition, with its amateur wave-length transmitter (WNP), provided an unusually fine opportunity for "DX," but our hopes have been sadly disappointed. I think many of us felt secretly sure that we should work him, but not only has nobody worked him from this country, but he has only been heard, and that very weakly, once by 5NN, once by 6XG and twice by 6LJ. There is still just a chance, but a very slender one, that someone may be lucky and connect with him, but even in America his signals have been almost inaudible since the beginning of February. I for one must confess to being very disappointed at not connecting with him. There used to be quite a rivalry between 5KO and me, as to which would work him first ! Well, 5KO has at any rate been heard by WNP around Christmas, so I suppose he wins on points !

The American Bureau of Standards, which is in close co-operation with the A.R.R.L, sends out very useful calibration signals for American amateurs, and these signals should be very useful to our men.

The call-sign of the "Bustans," as the Yanks call it, is WWV, and his signals have been heard by 2WJ and Italian ACD.

I cannot conclude without reference to a wonderful world's record, confirmed officially in America. 7ZU (Montana) has been received by 7ZU (Montana), the distance (round the world !) being 25,000 miles. Can any British station beat this ?

London District.

By 5BV.

REALLY, London, you haven't been showing up at all well during the last month. First, you have been letting the North beat you in low-power transatlantic work. Secondly, you have been filling the air with several new A.C. notes of perfectly awful QSB. Thirdly, you all forget to send me in your reports unless reminded every month. Come on, London, do brace up a bit and remember that "DX" records are not born, but have to be made.

We have been unfortunate in losing two of our best stations. 2NM is in America, and 2KF is now so busy that he has little time for Radio and none for "DX." Anyway, 2KF deserves a rest, since it was he who showed the rest of England "how to do it."

I think our outstanding performance this month has been on the receiving side. Although conditions have been very bad at times, 6LJ has been putting up perfectly wonderful logs of "Americans heard" right through the month.

On April 13 he logged 73 American amateurs and seven broadcasters in 2½ hours. He has logged over 500 Americans so far. Wish I could do that sort of thing! Our star receiving man, who could always be relied upon to hear anything that could possibly be heard, used to be 5NN, but he seems to be taking a protracted rest at present.

Of the high-power gang 2NM is absent and 2KF nearly so, but the rest (2OD, 2SH, 2WJ, 2SZ, 5LF and 5BV) have been keeping the ball rolling, without, however, any very interesting new records. All of them have worked a considerable number of Americans and Canadians, 2OD being far ahead of the others, and the number they work now depends only upon weather conditions and the energy of the operators.

One of 5BV's 150-watt valves has gone soft (inspired, doubtless, by the example of its relations at 2KW), and so 5BV's power is considerably reduced for the time being, but there are still enough available amperes for all European work and most American. By the time this appears full power should be again available.

The month's best all-round work has been done, I think, by 2WJ, who has worked eight Americans and Canadians. On one occasion he worked Canadian 1BQ, the latter using telephony most of the time. He has often heard 1BQ working other Canadians on 'phone. 2WJ also uses low power (3 to 10 watts) sometimes, and with this he has worked Danish 7EC and 7QF, and Italian ACD and 1ER. 2GO has reached America once on 8 watts. 5LF, in addition to excellent American work on about 50 watts, has worked all the possible European countries on 4 watts. Italy on 4 watts is, I should think, a record.

2ZT's last power valve has now given up the vacuum, so he is temporarily out of action.

5BT has worked most of the French and Dutch stations on a few watts.

2OD has sent the following summary of his transatlantic work, which is certainly a remarkable achievement:—

RADIO G2OD.

(Up to April 30th).

American Stations Worked.

1BBO	2AWF	3XAO	4BY	8AOL	9AZX
1XAK	2AWS	3OT	4XC	8ZAE	
1XJ	2BSC	3YO	4OA	8AVL	
1BDI	2AGB	3CKJ			
1BCF		3BVN			
1XAR		3BG			
1XW		3MB			
1CMP		3BJ			
1IV		3PZ			
1AJA		3ME			
1BSD		3ADB			
1JD					
1AUR					
1BLB					
1BCR					
1CAK					
1BVL					
1DZ					

Total American 40

Canadian Stations Worked.

1BQ	2BN	3BQ	9BL
1DQ	2BE		
1DD			
1AR			
1BV			
1DT			
1DJ			
1EB			
1EF			

Total Canadian 13

Grand Total of Transatlantic Stations Worked 53

Input.—1,200 volts and 75 milli-amperes = 90 watts.

Radiation on 115 *Metres.*—2 amps. (Weston thermo-couple).

Effective Resistance of Aerial at 115 λ.—15 ohms.

Radiation Resistance.—12 ohms.

Transmitter Efficiency.—60 watts in aerial = 66 per cent.

Total Efficiency from Input to Energy Radiated.—Useful power radiated=48 watts.

Therefore, total overall efficiency=53 per cent.

One hundred and seventy cards reporting reception of signals from 2OD have been received from America and Canada, including one from 6AJU of California.

That is all the London news to hand. Not a very good show this month, but I'm sure a lot more good work must have been done. Will all London stations please make a point of reporting any "DX" work to 5BV at once, before they forget, and will those regularly engaged in "DX" please send 5BV a report of their month's activities by about the 10th of each month. We must keep up touch with America and Canada through the summer, and London is the district to do it.

Scottish District.

By 5JX.

THE chief feature in this district during the past month has been a large degree of inactivity, or if there has been much "DX" I have not got to know about it. There is only a very small handful of transmitters here, and the most of them have not sent in reports, so the record this month must be rather brief.

It may be possible that people are slackening off now because it is getting into the summer, and, if so, it is due to the mistaken idea that "DX" is inseparable from darkness. Fortunately this is not the case. Owing to the way transmitters seem to fight shy of daylight, much information from other parts is not to hand on this subject, but as far as this station is concerned daylight tests have been a complete success, and signals from the South have often been at least as loud as at night. For instance, 9 watts at 220 miles consistently readable a fair distance from loud speaker with standard 0-v-1 receiver while the sun is shining is not at all bad. Why not carry on throughout the summer? We with aerials sloping downwards to the far end might get better results by leading in there to an outdoor sitting in the garden, and at the same time show the neighbourhood how it's done! We would need a reliable weather forecast or we might have damped waves!

But, really, a lot of good men seem to be wasting their time by creating records as a sheer amusement. Apart from being illegal, there might be worse things than this, and, of course, quite a lot of good is effected in the search after general efficiency, but it is felt that a number could be doing still better work by making it more definite. As a suggestion, groups of two or more stations well separated might arrange a definite schedule of times for calling, covering all times of day and night, and send dummy messages in routine fashion, the idea being to discover the minimum power and apparatus to effect *reliable* communication over given distances *at all times*, and not at the most favourable ones. This divides up into distinct problems, such as atmospheric elimination, steadiness of wave, optimum wave-length, topographical conditions, etc., which could be definitely investigated by those concerned. Definite objects would lead to definite results.

Mention has been made from time to time of C.W. *versus* I.C.W. It certainly seems worth while using the former. Apart from questions of interference as regards effectiveness, one report, among others, gives 5 watts C.W. as better than 25 watts I.C.W. That is another point that might be further gone into. All that is required is organisation.

As regards results here lately, our district is at last QSO America. As was stated last month, for various reasons the "DX" stations had been all more or less out of action during the best of the American season, and only started in April. 2MG had the honour, and led off, getting across to American 2CPD on that very good day, April 6, using 30 watts. He has also communicated since. This was on 180 metres. 5JX, apparently the only other one to go in for this business, favoured 130, and later 112 metres, and on April 26 got over to Canadian 1DD, very QRZ owing to tremendous QRN and QRM. This was with I.C.W., but for reasons given it is hoped to do better soon on pure C.W., notwithstanding the lateness of the season.

Considering the scarcity of transmitters and the low power of those in existence, this result does not compare so unfavourably with those in the Southern districts as might be supposed. American signals are still very good here on the shorter waves, and in Europe nothing very important is reported. Most of those with mysterious calls may be fairly safely put down as Belgian. 1CF is not yet located, and is reported very QSA over a wide area. 5JX is reported very good in Milan, but the latter (I1ER) has not been heard quite so much lately. Mr. Thompson, mentioned in our last, has taken to using an 8″×10″ frame instead of a 2 ft. He gets Yanks roaring loud on his single valve.

By the way, is it not time that a "DX" vocabulary were compiled? The meanings of all abbreviations, with historical notes! All attempts on the part of several to trace the exact origin of "73's" have failed. One sometimes shows "DX" cards to non-technical friends, forgetting they don't know the language. It at least has the merits of being international, and combines the advantages of Esperanto and shorthand.

I hope, at any rate, to have a few more reports from this area next time, and to hear something more interesting than QRK OM? when I std bi during the coming month.

East Anglian District.

By 2TO.

THE brightest spot in East Anglia just at present seems to be 5QV, situated at Clacton. On "fone" his record stands at being heard at Ancona, Italy, with a radiation of one amp. only. It is understood that a new generator delivering 2,000 volts is now coming into commission at this station, so may we ask you over in the States to QSL this station if heard at 3 a.m. G.M.T. on Sunday morning! At the first trial of the new generator the smoothing condensers emitted enough boiling pitch to asphalt the garden path! But that's a detail! The next station claiming attention is 6BT. Some good distances have been covered with a T.V.T. unit including "DX" to 5JJ Aberdeenshire. Reports of QSA have also been received from 7EC, W2, 8DP and many others.

2OF Lowestoft has at last installed a generator, and was heard chirping away the second week of May on 170. A great deal of trouble is experienced at Lowestoft owing to jamming from H.M.S. *Godetia* using call-sign ECP. Thank goodness he uses damped waves! At 40 miles the interefence is only just audible.

At Bury St. Edmunds also trouble is reported by "Constructors" going down to 200 metres and below whilst using "re-radiators." Now then, you chaps, play the game!

5TG Dovercourt is a very enthusiastic member of the family of East Anglians and it is to be regretted that the P.M.G. has not seen fit to grant him a radiating permit yet. 5JR, 6HA, and 5MA, all at Dovercourt, are very slow at making a start; 6HA is the only one heard to date. The great difficulty is that there is no power supply at Dovercourt, but a scheme is on foot to overcome this difficulty.

5ZW Tattingstone operates at week-ends occasionally, but again power supply is the difficulty. 2TO, the solitary transmitter at Ipswich, continues to cover good distances, cards having been received from 7EC, 7BJ 8EN, W2, and others. 'Phone "DX" is at present Northampton. The great difficulty at this station being the satisfactory rectification and smoothing of A.C. H.T. supply.

North-Western District.

By 2KW.

IT is gratifying to me to have received several good reports, and I hope that all those who have not yet let me have a *resumé* of their work will do so next month. Letters should reach me by the 6th of each month.

The news came to hand that 5OT (Colwyn Bay) has succeeded in establishing two-way communication with C1AR. At the time the aerial current at 5OT was 0·4 amp. Communication was maintained for about half an hour, and great credit is undoubtedly due to both stations for this very fine piece of work.

At last, at long last, G2PC has been heard on the other side of the Pond. Whether the Bug key did it or not we shall never know, but the fact remains that his signals were copied by U1BIG. The imput power at 2PC was at the time 15 watts, and the aerial current 0·7 amp. Although one of his masts has been damaged, he has stolidly "clung to his key," and has at last pushed it over. 5IK has had a fright. A response to a "Test" call was apparently made by C1AR on the night of April 6. It appears, however, that it was all a hoax. 5IK was using 200 volts D.C. for H.T. with an aerial current of

0·25 amp. at the time. Now that 5IK's hopes have been dashed to the ground, 2PC looks even more cheerful than when he first got across. 5IK has worked eight Frenchmen, six Dutchmen, two Belgians and two Rhenish stations, 8SSU and 1CF on the low power. 2PC has worked F8ML, 8EB, 8BV, NoNF, NoBA, LOAA, P2, while they have both worked Danish EC.

5AW (Southport) is our star low-power station. He has worked I1ER with an input power of 4 watts, and an aerial current of 0·17 amp. According to 1ER, reception was steady, with very little QSS. 5AW has also worked 7EC, while 8SSU, LOAA has been worked on 190 metres in broad daylight. Lately 3FF has reported him, and gives his position (3FF) as 500 kilometres S.E. of London. QSO, W2 and P2, oBA has been worked using an input of 2 watts, ·12 aerial current, but signals reported QRZ. The aerial at 5AW is a single wire 50 ft. long by 50 ft. high. The counterpoise is a four-wire fan. 6NY Preston, who has transmitted over a distance of 20 miles, is using a loop. Several stations are QSO a new station, or rather an old station with a comparatively new call sign. It signs "YL." Anybody tuning to the wave-length of a heartbeat can get QSO this station quite easily, even if the valves are out!

5DN (Sheffield) is working on 10 watts at present, with about 0·4 amp. in the aerial. He has worked 1ER, and counting the Channel Isles, is QSO 13 countries.

5NH (Birmingham) is obtaining ranges of around 300 to 400 miles, and has worked 8BM on several occasions. 2TR and 2UF have both worked French and Dutch stations, whilst 2UF has been QSO 1ER and 7EC-2GW conducted some very interesting tests with ACD, the latter station reporting that he was transmitting on a power of 5 watts. This is believed to be the lowest power used by an Italian station when conducting a test with this country. 5BG reports things pretty slack in Huddersfield. He says that interference is terrible. We would like to hear from hams in that district. No news from Liverpool either. 2KW is on the air now and then and has worked 1ER and 1MT, also several other stations. His signals have been reported QSA by U8ZAV and by U9BEP.

The idea of many of our stations all over the country seems to work with as many different stations as possible. Whilst undoubtedly being of great interest, and possibly of some use, this policy will not lead us very far. I realise the great thrill that one experiences when a distant station is worked, and I can truly say that some of the most joyful moments of my life have been such ones as these. I am, however, convinced that without some specific object in view, it will not be possible for the amateur to say that he has made some definite scientific advance in the field of Radio Telegraphy. The astounding success achieved by many amateurs in covering great distances merely goes to show that they are expert manipulators of their gear—possibly expert designers—and wholly enthusiastic amateurs. Yet I am confident that unless we approach some of the baffling problems from a scientific standpoint we shall not be able to help in the solution of many problems which are admirably suited for amateur investigation.

Take, for instance, the problem of fading. Some preliminary observations were carried out by 2GW and myself some little time ago, with results that have already been made known to the readers of EXPERIMENTAL WIRELESS. It seems to me that the only way one may gain definite information on this and other points is that a number of stations devote themselves to the solution of one particular problem. I should like to see some definite move made in this direction.

If the more advanced amateur who has the necessary gear and the more necessary inclination would endeavour to co-operate with others on these points, highly interesting data would be available. Facts are needed before a satisfactory theory can be advanced. He would be doing a great public service were he to co-operate in the solution of some present mystery, instead of promiscuously flinging his signals about the surface of the earth. After reading the "Editorial," let us hope that everyone will be more alive to a sense of their responsibility not only to themselves, but to their fellows.

It is not my intention to try and belittle in any way the splendid work done by those who have so magnificently kept us in almost nightly touch with our American and Canadian cousins throughout the winter. They have shown us that the possibility of doing this can be regarded as almost a regular thing. It is of itself of high importance, for we now know that were we to arrange schedules for scientific observations we might reasonably expect that our endeavours would be attended by some measure of success. But once the stunt is done the novelty ends, and it will be felt that unless we strive for something more than mere "DX" our position as a recognised section of the Radio community will become, to put it mildly, somewhat insecure.

Just before going to press comes the news that 5OT has been heard in Mexico with only 0·4 amp. in the aerial, and also that 2KW succeeded in raising American 1XAW and Canadian 9BL.

Western District.

By 5KO.

IN the West this month four whole stations reported their activities, so the task of writing the report is again a difficult one.

Transatlantic work here appears to be fizzling out for the summer. Both 5FS and 6RY report no new stations worked, while 5KO has only added Canadian 1AR and U3PZ to his bag. Reports of reception on the other side have been increasing, all three of our stations having been heard in the U.S. 4th District—5KO by 4BX, 5FS by 4BY, and 6RY by 4BZ, a rather curious coincidence. QRN has set in in earnest here, and it does not appear likely that any more transatlantic work will be done. 5KO has gone off the air to "swot" for a final exam., and will not be heard much until June is nearly over.

European work has continued as usual, and several new stations have been discovered. 5RQ, 6RY and 5WI (Dorchester) all report connecting with 1CF, believed to be located at Crefeld, Germany; 5WI's work being done on 1 watt, with 0.18 ampere in the aerial. He is also doing good duplex telephony with 5TN. 5FS has worked a new Swiss station, 9AA, who gave his address as Geneva. Italian 1ER is heard well in this district, working on about 125 metres with an A.C. plate supply: he has exchanged signals with 5KO, but usually appears to be engaged with 5SI of Shrewsbury, who is doing excellent work with his little M.L. generator running on accumulators. 6RY reports working 8SSU in broad daylight, and says European daylight work is easy after transatlantic stuff. He has also worked Danish 7EC, as have 5FS and 5KO—apparently 7EC has at last succeeded in his struggle to get down to 125 metres, and his signals are certainly terrific now. 5FS and 5KO have also connected with several Belgian stations with weird and wonderful call signs, such as 4C2 and P2. Why do they choose them, I wonder?

This week-end the district had the pleasure of a visit from 5MO of Newcastle, who arrived *via* 2KW and 5SI, spent Saturday with 5FS and Sunday with 6RY and 5KO, leaving on the Monday morning to visit the London crowd. Many yarns were exchanged, and it is felt here that such pleasant interchanges will be of great value in getting British amateurs to pull together. 7EC, 7QF and 5BV all promise a visit in the summer, and all this should improve amateur solidarity and cement friendships made "on the air."

Those interested in the noble art of wangling fresh concessions from the G.P.O. should be glad to hear of the astonishing success of 5FS in this direction. He is now the proud possessor of a 50-watt licence for waves of 20-40, 115-130 and 150-200 metres, and a 10-watt licence for all waves between 50 and 200 metres! At present he is on 125 metres, but is thinking about a drop to 40, when he can find out how to do it. An article on how to obtain such licences should prove a real "best-seller." Perhaps he will give us one?

A few apologies are necessary before closing this budget, first to 2NS for suggesting last month that he was dead: he resurrected for the T. & R. tests at Easter, and handed in a good list of calls heard. The second apology from 6RY and 5KO for inflicting "bug" sending on their numerous friends. They hope to improve.

In conclusion, one more appeal to Western stations. There are not many of you in the district, so it is all the more essential for every man who is doing good work to report, and help this section to keep its end up. Let's hear from you!

The Trend of Invention.

Reducing the Effect of Space Charge in Oscillator Valves.

It has been common knowledge for some time that the space-charge in a valve due to electrons between the filament and plate of a thermionic valve limits to a great extent the anode current which can be obtained for a given anode potential, and materially adds to the impedance of the valve. This defect has been overcome to a great extent by the introduction of a second grid between the filament and the usual control grid, the extra grid being given a slight positive potential to neutralise the space-charge. Such four-electrode valves have been made and used for reception purposes with only a few volts of plate supply for some time past, but our Fig. 1 shows how the same idea has been modified for transmitting valves. (British Patent 195,964, British Thomson-Houston Co., Ltd., and D. C. Prince.) The valve A contains a filament B, an anode D, and the usual control grid C. The extra space-charge grid E derives the necessary potentials, not from a bias battery, but from the H.F. potentials set up across the main inductance F. The object of the invention is to increase the efficiency of the valve and to render possible the use of

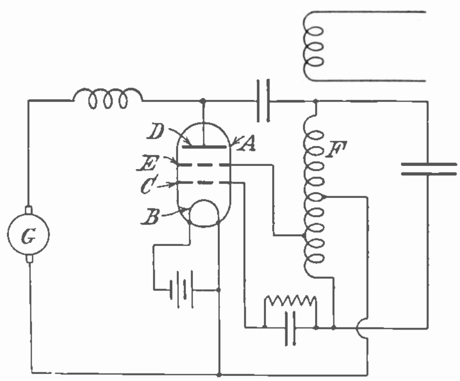


Fig. 1.—A device for reducing the effect of the space-charge.

lower plate potentials. It will be noticed that this invention differs from the usual four-electrode valve receiving circuit in that the space-charge grid is between the control grid and the plate, instead of between the filament and the control grid.

Elimination of Howling in Amplifiers.

It is very common for low-frequency amplifiers to howl at a very high-pitched frequency. Fig. 2 illustrates a method of suppressing regeneration at such frequencies (British Patent 193,010, C. Lorenz Aktiengesellschaft and W. Scheppmann). Across one

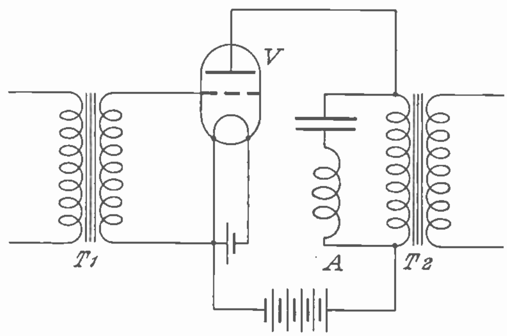


Fig. 2.—An arrangement for preventing howling.

or other of the intervalve windings is shunted a series resonant or acceptor circuit A, which is tuned to the offending frequency. Currents of this frequency are practically by-passed by circuit A, and, therefore, do not affect the intervalve transformer, T_2. This scheme for stabilising an amplifier looks as if it would be as effective as it is simple.

Anode Construction for Low-Impedance Power Valves.

In designing power valves capable of dissipating a large amount of power, it is necessary to use an anode of adequate area in order to dissipate the heat formed. With valves having anodes of the usual cylindrical type, it is necessary, in order to obtain the requisite surface area, to make the diameter greater than would otherwise be desirable. The result is that the distance of the anode from the grid and filament is rather large, and, owing to the space-charge effect, the impedance of the valve is high. Fig. 3 illustrates a recently patented method of overcoming this (British Patent 205,039, F. Peri). The figure is a cross-sectional plan, C being the filament, B the grid, and A the anode. The construction of the anode rather resembles that of a certain type of chimney cowl, con-

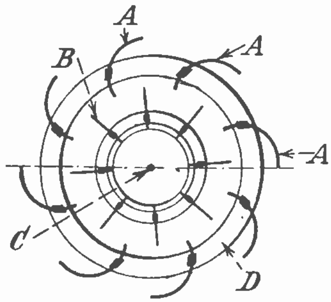


Fig. 3.—The construction of the electrodes.

sisting of a number of longitudinal vanes A which are given a curvature at right angles to their length and held between circular end-

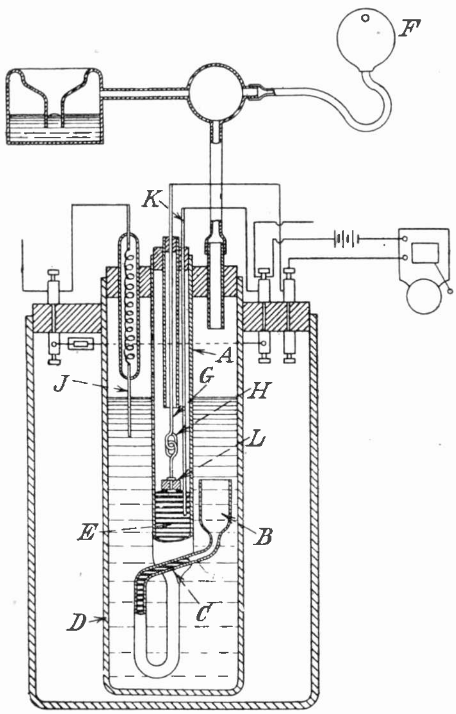


Fig. 4.—A capillary Micro-relay.

cheeks D. The grid may also be constructed of vane-like members B, which, however, are flat, and are arranged to occupy approximately the middle of the intervals between the inner edges of consecutive anode strips. This construction not only provides a large heat-dissipating surface at the anode, but also permits the effective distance between grid and anode to be greatly reduced, thus reducing the space-charge potential drop, and lowering the impedance of the valve.

Capillary Micro-Relay.

Fig. 4 shows how the principle of the capillary electrometer has been used in the construction of a relay capable of being used in wireless circuits, etc. (British Patent 213,386, I. Kajino). Two vessels A and B are connected by a fine glass capillary tube C. A and part of C contain mercury, shown by the thick shading E, while the rest of C and the vessel B are filled with a mixture of dilute sulphuric acid and glycerine. B is in connection with

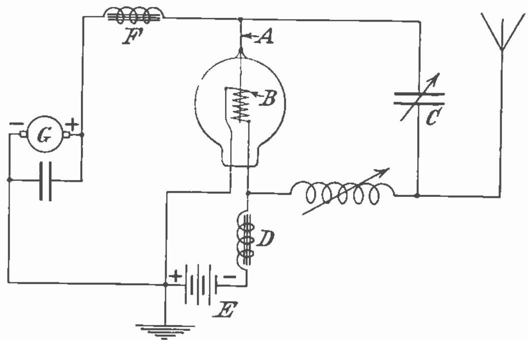


Fig. 5.—A magnetron without an external winding.

the outer vessel D, which is also filled with the sulphuric acid and glycerine mixture. The signal currents which are to operate the relay are applied by means of the electrodes J, K to the acid in D and the mercury in A respectively. If the currents are applied in the right direction the thread of mercury in the capillary tube C will creep up towards the vessel B ; the mercury level in A will sink slightly, and lower a float L, with the result that two hooks G and H come in contact and close a local indicator circuit. Most capillary electrometers are very slow in action, and this would appear to limit their application to relay work considerably, but possibly the inventor of the relay illustrated may have overcome this sluggishness to some extent.

Magnetron without External Windings.

The valve shown in Fig. 5 is of the magnetron type, that is, the electron stream is controlled by a magnetic field instead of by an electrostatic one. There are no external magnetising windings, however, the filamentary cathode B being of spiral formation, and carrying a normal heating current of such a value as to provide the necessary magnetic field. The anode A is linear and placed axially with respect to the spiral cathode. A choke D is inserted in series with the filament battery E in order that current fluctuations necessary for the production of the controlling magnetic field may flow through the spiral B, and not be short-circuited by the battery E. The anode is supplied with power through a choke F from a generator G. Although Fig. 5 illustrates a power oscillator, this type of magnetron may be used in receiving and amplifying systems. (British Patent 189,135, British Thomson-Houston Co., Ltd., and A. W. Hull.)

Improvements in Strip Aerials.

The use of strip aerials has found a certain amount of favour in certain quarters, and a recent patent claims to effect certain improvements in such aerials (British Patent 213,347, J. H. Cook). It is stated that ordinary plain strip twists about when in use,

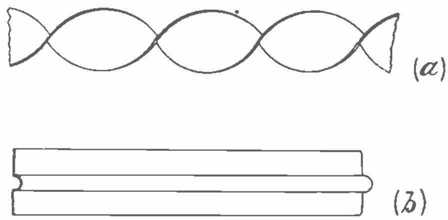


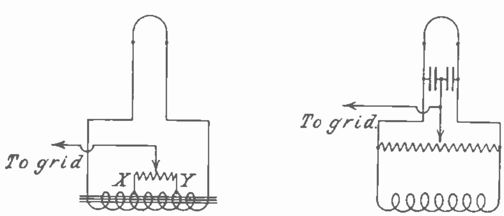
Fig. 6.—A new strip aerial.

and the surface area which it exposes in different directions is neither uniform throughout its length, and is not constant from one time to another. It is proposed in the specification to give a strip aerial a definite twist with a spiral pitch of, say, one complete twist per length equal to three times the width of the strip. Fig. 6 (a) shows a piece of such twisted strip. Before twisting, however, it is preferred to give the strip some form of longitudinal rib or corrugation, as in Fig. 6 (b), so that when twisted the strip will remain twisted. Various other means of obtaining such strengthening are described in the specification, as, for instance, using a number of strip vanes radiating from a common axis.

Experimental Problems.

Local Oscillators.

Several readers are apparently in need of a simple oscillator which is constant in operation and does not require coupling to its own oscillatory circuits; in other words, an oscillator consisting of a simple coil tuned by a variable condenser. This will mean the use of a dynatron circuit, which is difficult to manage, or else a valve which oscillates by virtue of some negative resistance effect such as the negatron, the patent rights of which are the property of Messrs. Radio Communication Co., Ltd. This valve, suitably connected with a single inductance, will oscillate between 100 and 25,000 metres. Personally, we see no objection why a tapping should not be made at the centre point of the coil and simply taken to the filament and an ordinary auto-coupled oscillator employed.



Figs. 1 and 2.—Connections to filament transformer.

A.C. for Transmission.

The use of alternating current for heating transmission valve filaments seems to be causing a little difficulty. The centre tap method is, of course, well known, but is not quite satisfactory. One reader submits an arrangement (Fig. 1), but this presents the unnecessary difficulty of two extra tappings on the filament winding at X and Y; also, of course, there will be a resistance in the potentiometer to the H.F. grid currents. The arrangement of Fig. 2 is to be preferred as the same result is obtained, but in this case by connecting a 300-ohm potentiometer across all the filament winding, the sliding contact of which is connected to the mid point of two small condensers (about ·04 microfarads), the outsides of which are connected to either side of the filament, thus providing a free path for the oscillatory currents, and at the same time allowing the exact centre point of the filament winding to be obtained. The negative

H.T. is also connected to the slider, which is, in fact, the base line for all the connections usually going to the negative filament. One reader who is employing A.C. to light filaments and also work the primary of a T.V.T. unit will find it necessary to provide a separate low-tension winding for this.

Weston Relay.

Several inquiries have been received relating to the connections of a Weston relay, which we give in Fig. 3. A and B are the marking and spacing contacts, which are insulated from each other, while C is the connection to the tongue T *via* the hair spring. The input side to the relay is opposite the end carrying the tongue, and the current is led

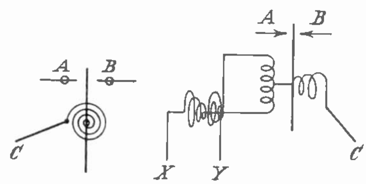


Fig. 3.—Connections of Weston relay.

through two other hair springs, which terminate in two stiff wires similar to C at X and Y.

A.C. Interference with Dual Circuits.

Alternating current seems to upset the proper functioning of many dual circuits. One of the best preventatives is that of screening the low-frequency transformers and placing all the grid leads to them in copper tube, insulated, of course, inside with "Sistoflex" sleeving. These tubes may then be connected together and earthed, or connected to a H.T. positive, whichever gives the better results.

Capacities of Condensers.

Several readers ask if it is necessary to adhere strictly to the capacities of various condensers which are shown in a given circuit. So far as variable condensers are concerned they may be made slightly larger if desired, which results in rather more critical tuning unless a vernier is employed, and will also increase the fundamental wave-length of the circuit. So far as grid condenser and also leaks in H.F. circuits are concerned, it is not usually essential that they should be accurately matched, although, of course, much depends upon the actual circuit. However, we would advise our readers to adhere to the values given, providing, of course, that the particular circuit has been properly designed.

Charging Accumulators from A.C.

Several queries have been received relating to charging 6-volt accumulators from A.C. mains by means of chemical rectifiers, and it is proposed to describe the method used at the writer's station. All accumulator charging is done by this method, and the transformer is used, which gives a secondary voltage of 25 volts. The rectifier cells consist of glass boxes 6 ins. by 8 ins. by 8 ins., and each contains aluminium and lead electrode measuring 7 ins. by 5 ins. The electrolyte consists of 75 per cent. saturated solution of sodium phosphate. Each cell of these dimensions will pass 4 ohms without overheating. If a larger output is required a sufficient number of cells in parallel are used to give the required number of amperes; thus for 12 amperes three cells in parallel are employed. In order that both a 2-volt battery and a 14-volt battery may be charged a 6-ohm resistance is used, made up from 16 gauge bare eureka wire divided into ten spirals fitted with selector switch. Each spiral is air cooled, and the whole suspended by two pieces of asbestos tubing having a core 3-16ths in. in diameter, and an overall diameter of ¾ in. For general information a circuit diagram is given in Fig. 4, and it will be noticed that an ammeter is included in the circuit. This should be of the moving coil type, as a moving iron instrument introduces error. Though not shown, the rectifier cells should stand in a stone water bath, which, as a matter of fact, is an old stone sink, the water, of course, keeping down the temperature of the electrolyte, which is necessary for proper rectification. This method is found to be perfectly satisfactory, and has been used for 2½ years. The solution requires renewing after about 750 ampere-hours of charging, and provided pure aluminium and lead sheets are used a longer life than this can reasonably be expected, especially if care be taken that the electrolyte be not allowed to overheat.

H.F. Switches.

High-frequency coupling switches seem to present a host of difficulties to many experimenters, and it must be confessed that it is an extremely difficult matter to design really efficient switch gear for this purpose for anything lower than about 500 metres. The chief difficulty is that the electrode capacity and coupling device of the valve have a total value of more than enough to pass quite a reasonable amount of H.F. energy at the higher frequencies. Many people do not seem happy

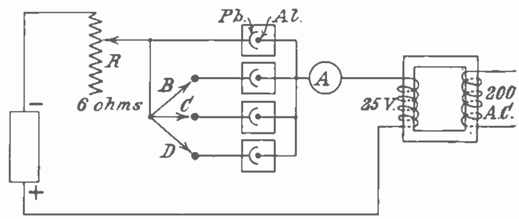


Fig. 4.—Accumulator charging circuit.

unless they can switch from one, two or three H.F. valves at will, and do not seem to realise the important fact that one stage of efficient high-frequency amplification on short waves (for example, the amateur band and the special 100-metre transmission) is of infinitely greater use than two or three stages inefficiently switched. The writer, therefore, does not care to recommend any switch gear with a clear conscience, as it has been found that, after extreme care in setting up three stage H.F. and detector circuit for KDKA, little, if any benefit was secured over one H.F. and detector even without switching, as it was not possible to keep the inter-valve coupling losses down sufficiently to be comparable with the extra amplification obtained. If switching must be indulged in, the writer would recommend a plug lead from the top of the secondary circuit and plugged with a length of flex to the grid of the valve it is desired to use, at the same time disconnecting the lead from the anode of the receiving valve completely and intentionally mistuning all preceding anode circuits to avoid losses by actual absorption. The circuit used by the writer for the reception of KDKA is shown in Fig. 5. It will be noticed that the aerial is aperiodic and consists of four turns only. It is wound side by side with the secondary coil of an old Mark III tuner former, the two coils being separated by ¼ in., both being wound with the turns touching, *i.e.*, no spacing between consecutive turns. The tuned anode is wound on a section cut from the same former and mounted in a fixed position, the reaction coil being mounted so as to enable the coupling to be varied as wished. The condensers are ·0003 of the square law variety, the total wave-length range being 90—100 metres. All inductances except reaction coil consists of 20 turns wound with 16 double silk covered on

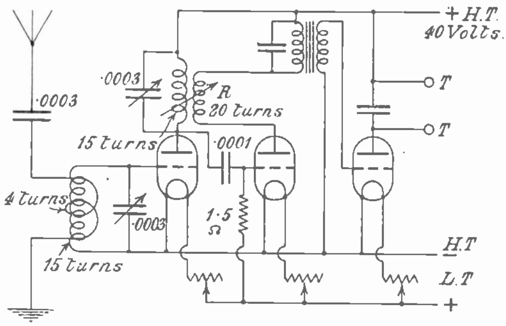


Fig. 5.—Circuit of reception of KDKA.

3½-in. diameter formers. The reaction coil is of the same diameter, but is wound with 24 double silk wire, and DER valves are used throughout.

L. E. Owen.

Direction Finding.

(Concluded from page 490, May issue).

By far the best construction for loops, working within the limits of wave-length mentioned in this paper, is to support them on five light spars, so that the dimensions of the loop are about 8 ft. high by 30-40 ft. wide, the apex being about 6 ft. above the upper outer corners. Spars about 25 ft. long with 6-in. heel tapering to 4-in. heads will generally meet the case, or a bridge can take the place of one of the

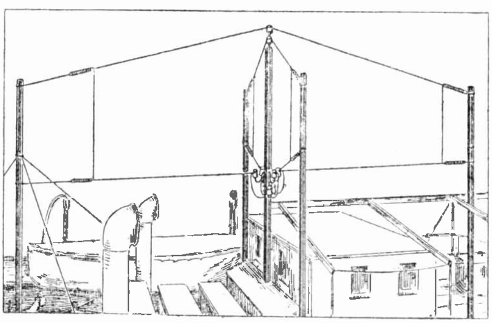


Fig. 1.—Direction-finder aerials supported on posts; s.s. "Motagua."

spars, or even of two of them. These spars must be placed with accuracy, the error of alignment of the sheeves not being allowed to exceed 1 in. Such an outfit can, as a rule be made absolutely permanent, and is independent of changes of temperature and the working of the ship in a seaway. Figs. 1 and 3 show various methods of attaching aerials.

The insulation of the apex of the loops is not of very great importance, but at all other points at least a 10-in. surface should be provided.

Very considerable trouble has been experienced in the past due to injury to the lead-covered cable between the loops and the direction-finder instrument. These are now generally run in steel conduits. Armoured lead-covered cable has been tried, and is satisfactory if either the lead sheathing or the armouring can be earthed at intervals of not more than 20 ft.; but, on the whole, plain lead-covered wire in steel conduits is the most satisfactory.

The ends of the paper cable are protected by cast-iron bifurcating boxes of the usual commercial pattern. When close to a compass wooden boxes are used. One of the minor difficulties of installing a direction-finder set in a ship is the protection of the ends of the paper-insulated cable from damp during the work of fitting.

After the loops are erected and have been proved to be geometrically correct and good for continuity and high insulation, they should be excited singly by a shunted buzzer as loops (not as plain aerials) and their wave-length checked. This should be below 400 m., preferably below 350.

The symmetry test should then be applied and, if the loops prove correct, the work of calibration can be commenced. But it is absolutely useless to attempt to calibrate until loop-tuning and lack-of-symmetry errors have been stamped out.

(4) Testing for Symmetry.

The principles on which a symmetry tester is arranged are as follows :—

Consider a single loop with its field coil. Let this be excited as a "plain" aerial—say by means of a shunted buzzer connected to a straight lead between the mid-point of its field coil and earth. If the loop under test is symmetrical current will be exactly divided between the two halves of the field coil and, consequently, there will be zero resultant magnetic coupling between the field coil and the search coil. There will be a certain electrostatic coupling between the field and search coils, which will be greatest when the search-coil windings are nearest to the field coil under consideration. If the search coil is turned round clear signals will be heard in the

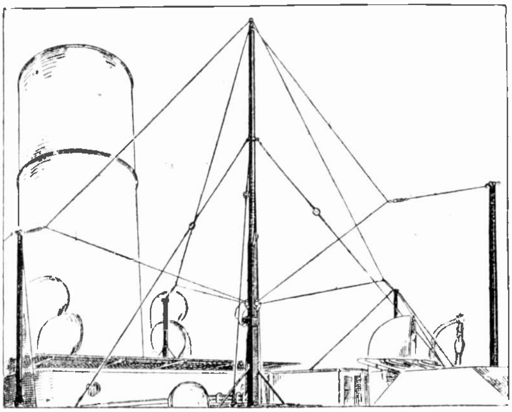


Fig. 2.—Direction-finder aerials fitted on posts; s.s. "Mooltan."

telephones, and the strength of signals should be adjusted by means of the coupling to the shunted buzzer until they are just comfortably audible at the maximum positions. If, now, one side of the loop be disconnected—giving the maximum lack of symmetry—signals will become very much louder and will be audible nearly all round the scale. A very slight lack of symmetry will cause a magnetic coupling between the field and the search coils, which will have its maximum effect in the same position as the electrostatic coupling. As the magnetic coupling is dependent on the sense of the windings, and the electrostatic coupling is not, these two will be in conjunction in one position of the search coil and in opposition in the opposite position, a slight lack of symmetry being betrayed by the fact that the signals are not of equal strength when the pointer is at these two opposite positions on the scale.

When both loops are joined to their field coils and the whole system is excited through its common mid-point as above, it might be expected that signals would (under suitable conditions of buzzer coupling) be just audible when the search coil was exactly inside each field coil, so giving four positions of audibility at 0°, 90°, 180°, and 270° (scale marked with 0° right ahead), but this is not the case, as the two combined electrostatic couplings have their maximum intensity at 45°, 135°, 225°, and 315°. This is possibly a peculiarity of construction of the instruments with which all available experience has been gained.

Hence the result of exciting a pair of properly symmetrical loops is to produce zones of clearly audible signals when the pointer is near to 45°, 135°, 225°, 315°, with well-marked silent zones around 0°, 90°, 180°, 270°. If one of the loops is but very little out of symmetry the silent zone about one of these points is obscured and signals at one pair of 45° are louder than at the other, with the result that signals become audible over a wide band about 0° and 180° (or 90° and 270°) with ill-defined minima between.

It has been found in practice that if the lack of symmetry is such that the zero is lost at 0°, 90°, 270° or 360° without destroying the perceptible maxima at the 45° positions, bearings will still be quite accurate when the mid-point is used unearthed, except for its static leak.

To sum up:—

(*a*) Perfect symmetry is indicated by signals of equal strength at the four 45° positions, with clear zeros between.

(*b*) Very slight lack of symmetry is indicated by signals at one pair of 45° positions being stronger than at the other pair, clear zeros still existing.

(*c*) Slight lack of symmetry is indicated by signals as at (*a*), but with the zero between the loudest positions obscured.

Bearings are still practicable under any of the above, provided that the mid-point is not earthed.

As the lack of symmetry becomes greater the maxima at the 45° positions disappear, loudest signals appearing with the pointer at one of the 90° positions. In all cases signals are loudest when the search coil is under the field coil of the defective loop.

These symmetry tests are very critical and easy to apply. They disclose any doubtful contact or poor insulation, as well as uneven distribution of inductance or capacity. Unhappily, they do nothing towards the detection of inductive lack

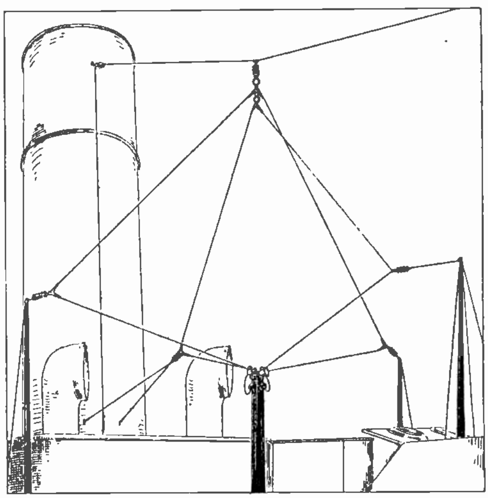


Fig. 3.—Direction-finder aerial hung from jumper stay.

of symmetry of the magnitude likely to be met with at sea, which can only be tested for the observation of external bearings with very strong signals.

(5) Calibration.

Calibration is perfectly simple provided that the ship is well clear of cranes, sheds, etc. A station having a bow or quarter bearing should be selected, and if the observed bearing is too near the fore-and-

Record of Working of Ships' Direction-Finders.

Name of Vessel.	Date Fitted.	1 September to 31 December, 1921 Total	Correct	1 January to 30 April, 1922. Total	Correct	1 May to 31 August, 1922. Total	Correct	1 September to 31 December, 1922 Total	Correct	1 January to 30 April, 1923. Total	Correct	1 May to 31 August, 1923. Total*	Correct*	1 September to 31 December, 1923 Total*	Correct*
"Ballygally Head"	25/12/19	—	—	66	66	3	3	7	7	18	18	17	17	†	†
"Cassandra"	17/6/20	17	13	†	†	20*	7	15	8	†	†	77§	60	24	21
"Empress of Britain" ...	1/9/22	—	—	—	—	—	—	86	73	†	†	46	39	18	15
"Fort Hamilton"	27/7/21	5	5	21	21	†	†	3	3	14	14	8	6	19	17
"Kenilworth"	21/7/21	9	8	15	14	15	15	5	5	9	9	Unfitted			
"Metagama"	6/10/22	—	—	—	—	—	—	22	21	32	24	49	48	92	90
"Montrose"	24/3/23	—	—	—	—	52	45	15	13	42	39	66	52	75	71
"Olympic"	15/12/20	—	—	14	14	3	3	†	†	†	†	†	†	3	3
"Rosalind"	14/5/21	32	31	13	13	44	44	31	31	41	41	30	30	58	54
"Saturnia"	2/7/20	‡	‡	†	†	33	32	10	10	7	7	13	13	23	23
"Tortuguero"	14/12/22	—	—	—	—	—	—	—	—	103	79	76	73	98§	73
"Vauban"	2/6/21	25	15	42	27	26	24	9	5	14	8	11	11	12	11
Total for 99 ships		455	406	389	355	528	433	855	699	910	800	2,180	1,972	2,884	2,625
Percentage correct		89 per cent.		91 per cent.		82 per cent.		82 per cent.		88 per cent.		90½ per cent.		91 per cent.	

* With reference to the last two columns, *i.e.*, 1 May, 1923, to 31 December, 1923, the charts of bad bearing-arcs in St. Lawrence and English Channel districts were available, and bearings taken in these bad arcs are not included in the results given above.

† No reports received. ‡ Working satisfactorily. No details available. § Fault developed and removed.

aft line the fore-and-aft loop must be reduced—or the impedance increased—until the bearing is correct. If all other errors have been eliminated the correction of a single bow or quarter bearing implies accuracy all round, but it is as well to take some check observations.

Under practical conditions the fore-and-aft loop is usually about four-fifths the area of the thwartship loop, and a reduction of 1 ft. on each side of the bottom of the fore-and-aft loop will produce a correction of about 1° in a bow or quarter bearing. Such figures are empirical and very rough but they give some idea of the state of affairs.

Calibration can be carried out only on or very near the bow and quarter bearings.

The final external test is for inductive lack of symmetry, which should be carried out with very strong signals very nearly right ahead and on the beam. In the absence of errors due to this cause the direction-finder can be trusted, but it must be remembered that the loops, and especially the lower parts, are almost as sensitive as a magnetic compass to the influence of external objects. A pile of Carless rafts placed temporarily under one limb of a loop, and a wet signal-halyard passing near one limb, have been recorded as producing errors of 5°, and a wire whistle-lanyard passing near one side of the fore-and-aft loop has been identified as the cause of an error of 14°.

It is well established that under conditions in which all the above can be eliminated, the errors of a Bellini-Tosi direction finder need never exceed 1°.

When using a direction-finder in a ship at sea it is imperative that the main aerial shall be completely disconnected from earth. Otherwise, large errors of a quadrantal nature will be introduced. If the main aerial passes close to either of the loops it is not sufficient to disconnect between the transmitting apparatus and the earth connections, the main aerial must be disconnected immediately it enters the wireless room. The reason for this is that there is sufficient stray capacity in the transmitter to allow so much current to flow in the main aerial that the resultant "loop" current is affected.

Calibration cannot be completed if the ship is lying near to cranes or dock sheds, although an approximate result can be obtained. The work must be completed with the ship at sea.

The symmetry tester will reveal the impossibility of calibration. A pair of loops which give excellent results and which testify perfectly for symmetry when the ship is at sea will appear to be hopelessly at fault if the ship is near to cranes, etc. The symptoms are different from those of slightly unsymmetrical loops—the usual effect being that the positions of all zero signals are slewed round bodily about 20°.

(6) Application.

Having established a direction-finder in correct adjustment, the problems of making full use of it as an aid to navigation can be tackled. The outstanding point is that a direction-finder takes relative great-circle bearings, that is to say, great-circle bearings relative to the keel line of the ship. These must be converted into true mercatorial bearings before they are of any use for navigation. If the ship is yawing, the observation of the direction of the ship's head at the moment when the bearing was taken may be rather vague. The usual practice is for the operator to ring a bell when the direction-finder bearing is taken and for the direction of the ship's head by compass to be noted when the bell rings; and considerable combined practice between bridge and wireless room is necessary before the gap between a good direction-finder bearing and a serviceable true bearing can be filled up.

Taking all the above into account, for the purpose of making up the attached tables bearings are reckoned as being "correct" if they do not err by more than 2° from that worked back from a recent position by observation, 1° being allowed for residual direction-finder errors and operator's observation, and 1° for errors developing in the operation of translating the direction-finder bearing into a true bearing.

Direction-finder bearings at distances of over 50 miles are not as a rule of any great service, and at distances over 100 miles they are only a rough guide. This is not because of the liability to error being increased, but because the fix so obtained is so very rough in comparison with older established methods of navigation.

The position is considerably improved in ships where a gyro-compass repeater is installed in the wireless room. In such cases a "true bearing indicator" is fitted whereby the bearing is read off on the face of the repeater instead of on the direction-finder scale, and the true bearing can be arrived at in one operation.

It is obvious that the measurement of "direction" is in fact a measurement of the direction in which the plane of the advancing wave-front lies, and if this is not at right angles to the line of advance of the wave the direction as observed will be subject to error. Any such distortion of wave-front must introduce errors which cannot be detected at the receiver, and the well-known "land effect" and "night effect" are the common manifestation of this wave distortion. Night effect is generally accompanied by an unusual "woolliness" of zeros, but there is nothing to warn the observer of land effect except the general track of the wave when laid off on the chart. This is clearly the business of the navigating staff and not of the telegraphist, and more definite knowledge of the subject is required. Certain stations have a reputation for bad bearings, but there is not sufficient first-class evidence available to allow of a comprehensive statement being drawn up. It appears, in fact, as though land effect does not always occur, and certainly it varies considerably in extent. The general idea emerging from the records is that it occurs in two sets of circumstances :—

(*a*) When the line of bearing cuts a coast line—high or low—at an acute angle, say less than 20°; and

(*b*) When high land intervenes close to the receiver or transmitter.

It may be remarked that, so far, no effects have been associated with ice or fog banks.

An attempt has been made to overcome the difficulty of translating great-circle bearings into rhumb-line bearings by three methods: (1) Gnomonic charts are issued on which the great circles appear as straight lines; (2) a "half-convergency" table is issued from which the correction can be ascertained; (3) a "half-convergency" diagram is supplied from which the correction can be extracted. As a matter of navigation this correction is not of much value, as bearings at over 70 miles are seldom really used, and under 70 miles the correction is too small to be of any account.

It is worth noting that if two true bearings are laid off with station pointers on a gnomonic chart, the result amounts to a three-point fix, because the true north point forms the third bearing.

When all is said and done, however, deep-sea navigation is not the proper zone of usefulness of a direction-finder.

The typical direction-finder as described gives an ambiguous result, there being no distinction between a bearing and its complement. In order to distinguish this point direction-finder instruments are now fitted with a sense-finder, which is a form of the ordinary "heart-shape" receiver. As fitted in most ships the heart-shape diagram is by no means true, and the zero not as a rule good, and it is only used as an indication.

It is doubtful whether this sense-finding is of much real use for fixing the position of a ship, but it is very useful when working through cross-traffic in fog, and has sometimes been of great value in helping to pick up a vessel in distress which has been badly out of her reckoning and has announced a very bad position.

All remarks on direction-finding have so far been made with sole reference to spark telegraphy. Bearings taken of continuous-wave stations are very crisp and clear, but the wandering due to "night effect" takes place at times to so great an extent as to make bearings of continuous-wave stations quite useless for navigational purposes. This is usually the case after dark.

If a sense-finder is used, and if the plain component is balanced so as to give an accurate zero, then the position of that zero is not subject to wandering. The chief trouble lies in the fact that the rate of reduction in signal strength is not the same on both sides of zero, and therefore the position of zero is not midway between the vanishing points. Hence it is practically impossible to fix the position of zero of a continuous-wave signal with sufficient accuracy for navigational purposes.

The table on page 553 is a precis of the record progress made during the last two years in the adaptation of the direction-finder to the purposes of navigation in the mercantile marine. It consists of the details of the working of 12 ships taken at random from among 99, the totals for the whole 99 being shown at the foot of the columns. Some difficulty has been experienced in compiling this table, as reports are not perfectly regular and are not always fully detailed.

Bearings recorded as inaccurate include all causes of error, unless the direction-finder is definitely known to be out of action. "Night effect" is also included, but, since the approximate positions of "bad" areas have been promulgated, bearings which have been taken in known "bad" areas have been excluded from the list.

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,—With reference to Mr. Andrewes' article on "Receivers" in the April issue, I should like to make a few remarks. In these days we have to build receivers which are fully selective—far more than was necessary some time back—because of the interference, and I confess I was astonished when I saw the author booming variometers. When we first used tuned anode sets some used variometers and some used condensers, because variometers were then very scarce. We all believed that the lower our capacities for tuning the better. Then interference began to grow and we found this was not altogether true. Take the Hague, for instance. Gradually we found we had to use quite respectable tuning condensers on a plain circuit up to ·0005 mfd. We found that whereas all inductance was fine when there was not any jamming, it was impossible to do anything through the slightest interference. Of course, I am not talking about loose-coupled circuits at all. Anyhow, we found some capacity desirable; our signal strength undoubtedly dropped a bit, but the signal interference ratio increased. It does not matter if the signals rattle the 'phones, if the interference is louder still you are as badly off. This fact has been brought out all along as we have been progressing in the past few years that while theoretically inductance alone is best, actually we must have capacity to get the selectivity and get a good signal stray ratio. I do not propose to enter into theoretical whys and wherefores, but it is an experimental fact. If you don't believe it, try a test on a weak B.C. station on a bad night and see how much you can actually read one way or the other. However, to pass on. The modern variometer has a perfectly colossal self-capacity, and this is in the wrong place. While its large inductance ratio is good, a variometer has absolutely no place in a decent amateur receiver aerial or tuned anode circuit. The secret of decent reception is to use heavy gauge wire coils, spaced—and have everything most carefully spaced, far more so than is ordinarily done. Everything nowadays seems to be sacrificed to professional (?) looks. My ideal S.W. receiver is a ·0005 series or parallel (above 300 m.) series condenser and a large coil, say 4 ins. or 5 ins. diameter, with good thick wire tapped at a few points (as a compromise), with a similar though less spaced coil for the anode, and a ·0003 condenser reaction from detector to aerial. If decent plug-in coils (not of the usual kind) can be used, so much the better. If Mr. Andrewes would try this he need no longer complain that his H.F. amplifier does not. A properly made H.F. tuned anode really amplifies even with ordinary valves down well below 100 m. As an instance, my present set has two very rough anode coils. One for 400 metres is double the other in turns, and the smaller has a centre tap for 100 metres. These coils are not spaced but are of 20 D.S.C. close wound. They are far from ideal and should have been scrapped ages ago, but the results obtained are as follows:—On 400 metres amplification in volume by H.F. not great but quite fair, noticeable most on faintest signals; on 200 metres amplification is increased quite 50 per cent., while on 100 metres, using the coil with a big dead end, at least twice the amplification is obtained as is got on 400 metres. I know that results can be further improved to a large extent. Incidentally an amusing point is that hand capacity effects are less on 100 metres than on 200 metres! This is by the way.

The correct set to build is, in popular opinion at present, the three-valve H.F., det. and L.F. arrangement. I'd be willing to bet if a serious "DX" man, living in any sort of a congested area, cut off his L.F. valve and used only H.F. and det. for a month, he would not go back for normal work to his note mag. It is all a question of what one is used to. At first the signals appear too faint to read, but after a time it will be found just as easy as before and far more accurate for interference will cause far less trouble. It is a question of operation. On only two valves the set had to be operated really carefully (that does not necessarily mean slowly) and the result is that the operator's standard rises and he gets better "DX." L.F. decreases the selectivity and this cannot be allowed.

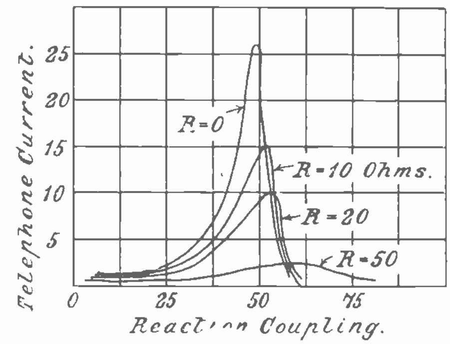


Fig. 1.

As a little demonstration take the Americans. A year ago they used variometers invariably and lots of L.F. valves. This year their receivers are 100 per cent. better and they are using little or no L.F. and heavy wire coils, condenser tuned.

Finally, as regards resistance control. It is all very well in its way, but is from the root of things inefficient. Have a look at Stuart Ballantine's "Radiotelephony for Amateurs," page 209, Fig. 117, and see the effect of a resistance in the grid circuit of a valve with reaction. Anyhow, the circuit confines the oscillations to the first valve and is obviously going to be tricky. The author drew a veil over the oscillation nuisance. It is just as well. I was fated to be 200 yards away from a certain person who was using this circuit. Suffice it to say that for six weeks we had to listen through the most appalling oscillation I have ever heard. The radiated wave was considerably louder than most transmitters heard on amateur waves. It was simply a case of go to bed ! It was not as if the offender was a novice—by no means so. His heterodyne would literally wipe out any station, and of course his receiving strength was rotten. Reaction coils may have disadvantages but a little patient work helps a lot, and anything is better than what it would be if everyone tried resistances.

I have endeavoured to fulfil the author's hopes of a discussion and am anxiously waiting for my brickbats to be returned. To quote his words, " how dull our lives would be if everyone agreed ! " —Yours faithfully,

FREDERIC L. HOGG.

INSIDE AERIALS.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—I read with interest the letter of Mr. Arnold Jowett on the above in your May number. Perhaps he and other readers may be interested in my own arrangement under conditions apparently approximating to his. I also have a large underdrawing running the entire length of my house (about 45 feet) and in it I also have erected an inside aerial as a substitute for a full length outside one previously employed. But whereas he arranges his turns horizontally I have adopted a vertical plan. My receiver is situated on the ground floor in a room at one end of the house. The lead-in goes through a window frame in the conventional manner and up the outside wall (in contact with it) and under a tile at the end of the roof. In the illustration a coil of 100 yards of ordinary double insulated (rubber and cotton) bell wire is connected to this insulated lead-in. The bell wire is secured to alternate rafters, to the ridge piece and the floor of the underdrawing by ordinary staples, forming a large diamond section coil of about 6 ft. 6 in. diagonals, the turns being approximately 30 inches apart (rafters spaced 15 in. centres). This coil extends practically from end to end of the house. An ordinary earth connection to a buried plate outside the window of the wireless den is employed.

The house is situated in a hollow, the South Downs rising some 650 feet above us within two miles to the southward while to the northward there is a rise which overtops the house within a few hundred yards. The axial direction of the aerial coil is exactly E. and W., the receiver being at the W. end. The mean height from ground level to centre of coil is about 25 feet, the house being a rather long low type of farmhouse. Roof tiled, fitted with iron gutters. A large cistern stands at the E. end within 6 feet of extremity of aerial.

On this aerial I can receive with absolute regularity and in daylight London, Bournemouth and Newcastle B.B.C. stations, and Brussels (410 metres), on one valve, using a modification of the Ultra-audion circuit which was evolved by myself, but I have since heard closely approximates to what is called the " Allbright " circuit, though without a choke coil. (A diagram of the circuit is given in Fig. 2.) After dark, and sometimes, under favourable conditions, in daylight, all B.B.C. stations, Brussels and the Ecole Superieure and the new 340-metre transmission of the Petit Parisien (the latter I believe only working on 500 watts) can be received on this circuit. Birmingham and Cardiff are the most difficult to get, Cardiff owing to its wavelength being so near that of London and Birmingham for some unexplained reason is always poor in this district.

The addition of a two-stage note magnifier brings London and Bournemouth up to loud speaker strength, indeed I have obtained readable signals from the former on the loud speaker from only the single valve. In this connection I should like to call attention to this circuit which I have found a most excellent one for single-valve work. The control to find the correct relative adjustment of variometer and variable condenser for best signal strength without howling is only a matter of a very little practice and once learnt the results are certainly superior to those I have been able to obtain

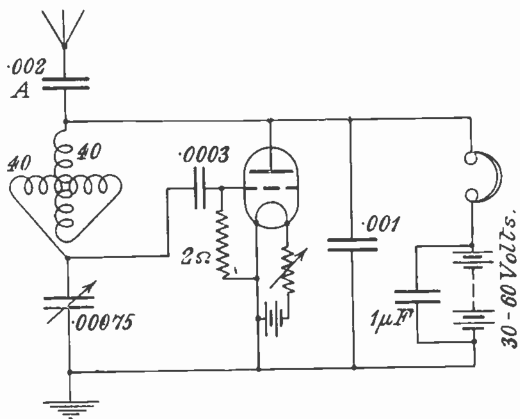


Fig. 2.

with any other single valver. The values of components given in the diagram are those arrived at by experiment on my own receiver. They might not be the best in all cases. My set is an " experimenter's " type of instrument mounted on an open oak panel without any attempt at compactness.—Yours faithfully,

HERBERT SHOVE.
Lieutenant-Commander, R.N. (retired).

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—In connection with Mr. Jowett's letter in last month's number of EXPERIMENTAL WIRELESS I should like to say that during the trouble we experienced here last Autumn my outdoor aerial came down in double quick time, and after sitting on my thumbs for a fortnight I decided to instal one indoors. Having an air space under the roof (which are flat here) extending over the whole building, a single wire aerial forming three sides of a square was suspended from the beams. As much care was taken of insulation as with an outdoor aerial and consists of two porcelain shell insulators at each point of suspension. The total length of the horizontal part is 90 feet with a down lead of 15 feet coming vertically through the ceiling, insulated by a glass tube. Using a single reacting valve signal strength is just right for headphones when receiving London, Bournemouth and Cardiff. Other B.B.C. stations are also received when the three mentioned are shut down (probably due to the home-made coils). Adding two L.F. valves an Ethovox loud-speaker comfortably fills a large room.

Although I have now installed a two-wire outdoor aerial preference is given to the indoor aerial, signal strength being slightly lower but with a very marked reduction in atmospherics and interference.

This is a very bad locality for wireless reception, being screened by a semi-circular range of hills to West, North and East, and all power and lighting distribution is carried out with aerial cables.

It is interesting to note that from the beginning of April to the end of October B.B.C. stations cannot be heard until about 15 minutes after sundown, when they come in at almost full signal strength ; incidentally, they are the telephone stations received at greatest strength, all other European stations being very poor.—I am, Sir, Yours faithfully,

BASIL HASTINGS.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—I have read with great interest and no little surprise your Editorial on "Amateur Transmissions" in the May issue. Taking the paragraph as it stands you state that the number of stations in the air has increased so enormously that the P.O. authorities must have relaxed their examination or the amateur had increased in his technical qualification. The answer to that is obvious. The figure prefacing the accompanying letters will practically answer it on its own. Nine-tenths of the jamming is due to people who persistently use fone for the mere pleasure of talking to one another, and a number of these have no right to be there at all ; they are not aware of the first principles of radio operating, namely, the reduction of interference, and if you are working a very faint station, say about 200 miles away, on a special test one has to put up with two people talking to each other on about 50 watts at a distance of two or three miles on a subject that generally has nothing whatever to do with the test they originally commenced. It's not good enough, especially as some of their licences are very questionable and Morse qualifications in some cases *nil.* There are numbers of amateurs who are very keen operators and experimenters, and undoubtedly the refusal of the powers that be to grant them licences is due to the people that I have mentioned. The part of your paragraph I object to, however, is that dealing with the relay scheme. Surely an efficient relay scheme would not be evidence of inefficiency on the part of the amateur ? Rather the reverse. In comparing the American scheme with our own, you must remember the difference in inputs. We have few 100-watt stations over here, and I venture to suggest that "*daylight*" work on 10 watts from Lands End to John o' Groats is not so easily accomplished as it sounds, and I cannot see why the authorities should not be interested in the undertaking. Such an undertaking in England, or, rather, the British Isles, would not be for the purpose of passing private messages, but rather experimental messages, and would certainly lead to the reduction of jamming, and much interesting data can be collected from intercommunication between stations in blind spots, etc. I venture to think that the new T. & R. section scheme will help towards this end. The unorganised chaos that is going on now is hopeless, and organisation must lead to a better condition in the Radio world. Where, then, is your argument ? An easy method of placing a Scotch member in communication *during daylight* with a Kentish member will give us something to work on regarding the effect of night and day transmissions between those stations and the same with the scattered stations of the relay league. The use of "Test" seems to me to be the only way in which an isolated transmitter can get a report. If he is silent, awaiting a call, the other fellow may be doing the same thing. He cannot use CQ, he cannot use QST, so what on earth is he to use, and what harm is there in the use of the letters ? In my opinion a relay league is the only solution to the terrible state of affairs now in being, and as such I earnestly hope that all transmitters will bear the fact in mind that wilful interference is doing the cause they love more harm than anything else can possibly do.—Yours,

W. W. CORSHAM (2UV),
Traffic Manager,
R.S.G.B. T. & R.

To the Editor of EXPERIMENTAL WIRELESS.

SIR,—I am much interested in the communications from Mr. Scroggie and Captain Finlay, in the April and May issues of your Journal, particularly with reference to the position of the aerial ammeter.

Captain Findlay says that "Mr. Scroggie's statement that the 'same amount of power is absorbed by the aerial ammeter in giving a reading, however it is connected,' is erroneous in this application," and he goes on to state that it is advisable to place the meter in a loose coupled circuit, as the decrement varies inversely with the resistance of the instrument under these circumstances, while the transformer loss operates against the loop circuit and not against the main circuit.

May I state that I consider Mr. Scroggie's statement to be correct, my reasons being as follows :—

Any meter requires a definite power input to cause it to register a certain deflection.

It may be connected in any direct manner but the power required remains the same.

If, however, we connect the meter in a coupled circuit the decrement of the complete circuit referred to the primary side increases with the resistance of the instrument. This may be proved by measurement on an impedance bridge.

May I suggest that Captain Finlay's contention that the power absorbed (coupled instrument case) is less, may be due to the fact that when calibrating his instrument he may have increased its range, *i.e.*, reduced the deflection and consequently the power per ampere input.

I find it difficult to understand the remark that the transformer loss operates only against the loop current, since any loss or work done in the loop circuit must be made good by a corresponding amount in the primary.

The only advantage, in my opinion, in using a loose coupler is that, in the case of high resistance instruments, the decrement referred to the primary side may be reduced *by arranging a suitable ratio of transformation*, but given a particular transformer or loose coupler (fixed coupling) an increase of instrument resistance results in an increased decrement in the aerial circuit.

The principle is to a limited extent analagous to the induction coil in a telephone line, where the resistance of the line without the coil would cut down the transmitter currents to a very serious extent, but the insertion of the coil with a suitable transformation ratio enables the decrement referred to the primary to be reduced. It is only prevented from being a complete analogy by the fact that a H.F. current is used in one case and varying D.C. in the other.

With apologies for taking up so much of your space.—I am, yours faithfully,

O. S. PUCKLE.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—I note with interest "Kilo-Watt's" letter in your issue of May 2. I have succeeded in obtaining ½" sparks from an aerial 60 ft. long (double) and average height 35 ft. The occasions have always been during the summer months and during an exceptionally heavy rain or sleet fall. I quite agree that hail appears to charge the aerial to a higher P.D. than anything else.

It is also curious that I have never yet succeeded in obtaining the smallest spark in thundery weather although I have tried during quite severe thunderstorms.

Trusting that some of your readers will let us have a record of their experiences with, perhaps, some definite measurements.—Yours truly,

H. A. CLARK.

Business Brevities.

THE "RADIANT" H.T. BATTERY.

The accompanying illustration shows a high-tension battery recently placed on the market by C. A. Finchett, of Old Armoury, 1, Welsh Walls, Oswestry, Shropshire. The battery, to our mind, fills a want in the serious experimenter's equipment. The 60-volt unit shown in the photograph is contained in an oak cabinet fitted with terminals mounted on an ebonite plate at the side of the box. The battery consists of 40 cells each, contained within a wooden partition so arranged that any individual cell may be removed merely by loosening a terminal. This in itself is a good point, as, should a cell fail, it may be instantly replaced, and, moreover, unit cells are procurable at the price of 4s. per dozen. Insulation between the cells is obtained by covering then thickly with paraffin wax. The actual cells measure about 2 ins. by 1¼ ins., and accordingly are capable of withstanding a fairly heavy output such as is necessary for power amplifiers and sub-control amplifiers on telephony transmitters. We were favourably impressed with its performance on several heavy loads and short-circuit tests, and it seems to be capable of standing up to heavy work. The price of the 60-volt unit in an oak case is 19s. 6d.

Fig. 1—The Finchett H.T. Battery.

* * *

A NEW LOUD SPEAKER.

The "Concert Grand" model of the Graham gramophone attachment is, no doubt, too well known to need description. A new model, however, has just been produced, and is best described, perhaps, as being comparable with the well-known Amplion Junior. Considering the very reasonable price, it should make a special appeal to the reader, as it enables him to experiment with various types of horns and sound conduits. The new gramophone attachment, made by Alfred Graham & Co., is supplied with a rubber gasket, and is sold in a very neat box at the price of £2 2s.

* * *

IGRANIC COILS CHARTS.

Messrs. Igranic Electric Co., Ltd., have recently issued a very useful leaflet showing the wave-length range covered by their various coils when used either in a standard aerial or closed circuit. A copy of this publication should prove of value where experimental work on varying wave-lengths is involved.

"WIRELESS TELEPHONY AND BROADCASTING."

"Wireless Telephony and Broadcasting" is the title of a very comprehensive work by H. M. Dowsett, who, of course, is too well known to need introduction to our readers. Mr. Dowsett's long association with radio engineering has enabled him to give almost an unique history of the development of wireless telephony, and this, in conjunction with a vast amount of practical information regarding both transmission and reception, makes the work of more than usual interest. To many amateurs it should prove invaluable. An extensive review will appear in a subsequent issue of EXPERIMENTAL WIRELESS.

* * *

EDISON BELL WIRELESS.

Messrs. J. E. Hough, Ltd., have sent us a copy of their new catalogue describing their well-known Edison Bell Products. A special feature is a large selection of moulded ebonite formers, which seem so extensive as to be capable of meeting the demands of the most exacting experimenter.

* * *

THE ETHOPHONE V.

Messrs. Burndept, Ltd., have sent us a copy of a new booklet dealing with their well-known Ethophone V, which is of considerable interest as it explains a scientific instrument in a non-technical manner. Such publication is undoubtedly a wise undertaking, and should prove of great value in educating the general public in wireless matters.

* * *

TERMINAL TAGS.

Messrs. S. H. Collett, of 52, Hampstead Road, N.W.1, have sent us some samples of their various terminal tags. There is a very extensive range of sizes, shapes, and finishes, including bright brass, tinned brass, tinned copper, and nickel. Readers who do not make use of terminal tags would be well advised to do so.

ACCUMULATOR CLIPS.

Messrs. The Runbaken Magneto Co., Ltd., have recently produced a pair of "Radio Clips" for use with accumulators. These should prove

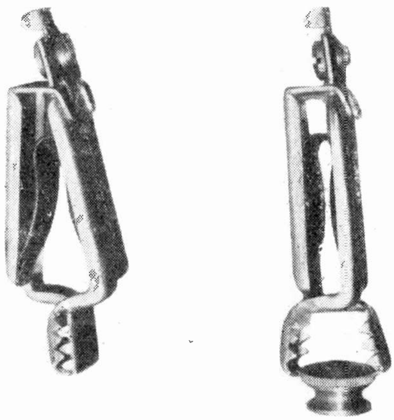


Fig. 2—Runbaken Accumulator Clips.

particularly useful to the experimenter, who is constantly changing filament batteries from one circuit to another. Those who charge their cells at home should find the clips invaluable on the two D.C. leads. One advantage of using a spring clip is that a positive connection is made with the accumulator terminals, which should tend to obviate any hissing noises sometimes heard in a receiver due to inefficient contacts. The clips are sold at 2s. 6d. per pair.

Recent Wireless Publications.

I.—TRANSMISSION.

LA NOUVELLE STATION DE CLICHY.—R. Belmère. (*R. Elec.*, 5, 58).

A NEW CAPACITY MICROPHONE.—D. F. Stedman, B.A.Sc. (*Exp. W.*, 1, 8).

THE MEISSNER TRANSMITTING CIRCUIT.—I. V. Iverson (*Q.S.T.*, 7, 10).

SMALL TRANSFORMERS FOR THE AMATEUR.—H. F. Mason (*Q.S.T.*, 7, 10).

RADIO BEACONS, NON-DIRECTIVE AND DIRECTIVE.—F. W. Dunmore (*R. News*, 5, 11).

THE PRODUCTION AND USE OF ULTRA SHORT WAVE-LENGTHS.—Prof. René Mesny (*R. News*, 5, 11).

II.—RECEPTION.

SOME NOTES ON REGENERATIVE RECEIVERS.—E. V. Appleton (*W. World*, 247).

AMPLIFICATION WITHOUT DISTORTION.—Louis Frank (*W. Age*, 11, 8).

LE RÉCEPTEUR COCKADAY.—P. Girardin (*R. Elec.*, 5, 58).

LOUD-SPEAKERS AND THEIR ENVIRONMENT.—G. P. Kendall, B.Sc. (*Mod. W.*, 2, 8).

FAITHFUL REPRODUCTION IN RADIO-TELEPHONY.—L. C. Pocock, B.Sc. (*El. Rev.*, 2424).

RECEIVING MEASUREMENTS AND ATMOSPHERIC DISTURBANCES AT THE BUREAU OF STANDARDS, WASHINGTON, SEPTEMBER AND OCTOBER, 1923.—L. W. Austin (*Proc. I.R.E.*, 12, 2).

SHORT PERIOD VARIATIONS IN RADIO RECEPTION.—G. W. Pickard (*Proc. I.R.E.*, 12, 2).

NEW APPLICATIONS OF THE SODION DETECTOR.—H. P. Donle (*Proc. I.R.E.*, 12, 2).

THE CONDITIONS FOR DISTORTIONLESS LOW-FREQUENCY AMPLIFICATION.—F. M. Colebrook, B.Sc. (*Exp. W.*, 1, 8).

THE DAMPING OF DIAPHRAGMS IN TELEPHONE APPARATUS.—C. M. R. Balbi, A.C.G.I. (*Exp. W.*, 1, 8).

A SOURCE OF LOSS IN HIGH FREQUENCY VALVE CIRCUITS.—Capt. St. Clair-Finlay, B.Sc. (*Exp. W.*, 1, 8).

Experimental Notes and News.

In connection with the Olympic Games to be held in Paris from May 3 to July 27 the Marconi Company, in conjunction with La Compagnie Radio-France, has arranged for special facilities for the rapid transmission of telegrams between Paris and London.

* * *

Messrs. Burndept have recently installed an Ethophone V at the Vatican, and in recognition of their service His Holiness the Pope Pius XI presented them with a medallion of his likeness.

* * *

The wave-length of the Brussels broadcasting station is to be between 220 and 280 metres, depending upon the result of experiments.

* * *

It is understood to be the intention of the Burnley Corporation to levy a toll of 2s. 6d. per year on all who have erected an aerial wire over a public roadway.

* * *

Derby Day traffic will be controlled by wireless again this year. This year two wireless cars will be employed—one of a new type just built to the design of the electrical engineering staff of the Metropolitan Police, capable of operating at a speed of forty miles per hour.

* * *

It is probably that Leeds and Bradford will each have a broadcast station, controlled by one studio situated somewhere in Leeds.

* * *

The aerials of the new Rugby station are to be fixed on sixteen masts each 820 ft. high, which will dwarf the 300 ft. high masts of Leafield, Oxfordshire, the station which is to be the British end of the proposed British Empire chain of wireless communications. Already eight of the masts are approaching completion. Each one is nearly six times that of the Nelson Column (145 ft.).

* * *

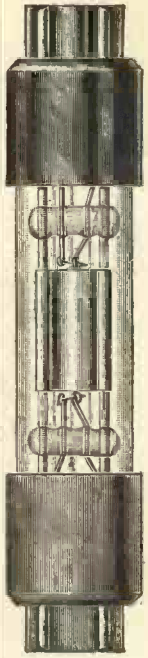
Wireless enthusiasts in Greenock are not to be allowed to have their aerials crossing streets. The police have reported to the Corporation Street Committee that in about a dozen cases wires have been erected over public thoroughfares, but that in several cases when the householders had their attention directed to the fact that they were in the wrong the aerials were altered.

* * *

The preliminary conference for the drawing up of an international wireless telephony agreement has concluded its labours, and it has formulated, amongst others, the following conclusions : That certain wave-length fields should be exclusively reserved to wireless telephonic emissions, and that those allotted to wireless telegraphy should be clearly differentiated ; That in view of the considerable contribution made by amateurs to the development and progress of wireless telephony, their rights should be taken into consideration, and certain fields reserved to their experiments.

* * *

It is understood that the Postmaster-General has informed the Imperial Merchant Service Guild that facilities for wireless direction finding are at present provided by the stations at the Lizard, Berwick, and Flamborough Head, and the question of the provision of additional stations at other points on the coast has recently been considered by an Inter-Departmental Committee.



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MANCHESTER—*R. Davies and Sons, Victoria Bolt and Nut Works, Bilberry Street, Manchester.*
NEWCASTLE — *Gordon Bailey and Co., Consett Chambers, Pilgrim Street, Newcastle.*
LIVERPOOL — *Apex Electrical Supply Co., 59, Oldhall Street, Liverpool.*
GLASGOW—*Milligan's Wireless Co., 23-25, Renfrew Street, Glasgow.*
YORKSHIRE — *H. Wadsworth Sellers, Standard Buildings, Leeds.*
SOUTHERN COUNTIES—*D.E.D.A., 4, Tennis Rd., Hove.*

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CONTENTS OF MAY ISSUE.—Vol. 1, No. 8.

SOME USES OF THE THREAD RECORDER IN THE MEASUREMENT OF PHYSICAL PROPERTIES.—By J. L. HAUGHTON, and W. T. GRIFFITHS.
A PORTABLE MAGNETOMETER.—By J. H. SHAXBY.
MODERN METHODS OF MICROSCOPE ILLUMINATION.—II. HIGH POWER OPAQUE ILLUMINATION.—By CONRAD BECK.
A CAPILLARY MERCURY LAMP.—By J. H. VINCENT, AND G. D. BIGGS.
ELECTRICAL REGISTRATION OF HEIGHT OF WATER AT ANY TIME IN TIDAL PREDICTION.—By J. DE GRAAFF HUNTER.
NOTE OF TUNING-FORKS.—By C. C. MASON.
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THE

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A Unique FREE Service.

As announced in our first number, we are placing the facilities offered by our laboratory and experimental station in the hands of our readers. In order that experimenters may be better able to conduct their investigations, we have formulated a system whereby we enable the reader to be the possessor of accurately calibrated instruments and electrical standards. To this end we have arranged to calibrate without charge any instrument, or determine various constants of any material or piece of apparatus. We set forth below the conditions upon which the determinations are made.

CONDITIONS OF SERVICE.

Each instrument or piece of apparatus must be accompanied by a Calibration Form cut from the current issue of EXPERIMENTAL WIRELESS, duly filled in as indicated. To each instrument must be attached a label bearing the sender's name and address. The instruments or apparatus, which must be adequately packed, should be addressed to the Editor, EXPERIMENTAL WIRELESS, 66, Farringdon Street, London, E.C.4, and marked "Calibration." Delicate instruments should be forwarded in wooden boxes, with screw-down lids. A remittance to cover the return postage must be enclosed. All instruments will be dealt with in strict rotation. Although every precaution will be taken to ensure their safety, the safe transit of the apparatus cannot be guaranteed, but full responsibility will be taken during the period between acknowledgment of receipt and advice of despatch.

SPECIAL NOTICE.

Readers are reminded that it is impossible to calibrate an instrument unless it is mechanically and electrically in order. It is essential, for example, that zero marks should be rigidly fixed and clearly visible. Amateur-constructed apparatus embodying switching devices must be accompanied by a diagram of connections.

To be sent, with apparatus, to The Editor, "Experimental Wireless," 66, Farringdon Street, E.C.4.

CALIBRATION FORM. [*June*, 1924.]

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Maker ....

Calibration Required ....

Leave this Blank.		

Return Postage Enclosed ....

Name..

Address ....

....

Date of Despatch ....

Wireless Sales & Wants

Advertisements are inserted in this section at the rate of **One Penny** *per word; minimum charge per advertisement,* **One Shilling.** *All advertisements, without exception, must be prepaid to ensure insertion. Single letters or figures are charged as words, and a compound word as two words. The advertiser's name and address are charged for.*

"Box" replies, *care of these offices, are charged 6d. extra to cover postages. The following words must appear at end of advertisement: "Box —— 'Experimental Wireless' Offices," for which usual rate will be charged. (Advertisers need not include our full address).* **When replying to a "Box No." advt.** *address your envelope: Advertiser, Box ——, "Experimental Wireless," 66, Farringdon Street, London, E.C.4.*

Advertisers who wish to separate *their announcements into distinct paragraphs must have not less than 12 words in any one paragraph, followed by the word "Below"—which is charged for.*

Remittances should be made by Postal Orders or Stamps, and sent to the Advertisement Manager, "Experimental Wireless," 66, Farringdon Street, London, E.C.4.

Advertisers are requested to send in their announcements as early in the month as possible; **Latest date for July issue, June 21, 1924.**

Telephone: Central 9071.

OUR DEPOSIT SYSTEM.

We will receive from intending purchasers the purchase money of any article advertised or sold by our advertisers, and will acknowledge its receipt to both the Depositor and the Vendor, whose full names and addresses must be given. Unless otherwise arranged beforehand between the parties, it is understood that all goods are sent on approval, and that each person pays carriage one way if the goods are returned. The deposit is retained by us until we are advised of the completion of the purchase, or of the articles having been returned and accepted. In addition to the amount of the deposit, a fee of **1/-** *for the sum of* **£1** *and under, and* **1/6** *for amounts in excess of* **£1** *to cover postage, etc., must be remitted at the same time, and sent to the Advertisement Manager, "Experimental Wireless," 66, Farringdon Street, London, E.C.4. In cases of persons not resident within the United Kingdom, double fees are charged.*

The fee should be sent in Stamps or by Postal Order as a separate amount.

The amount of the deposit must be sent either by Postal Order or Registered Letter. **(Cheques cannot be accepted.)**

In cases of exchanges, money to the value of the article should be deposited by each party. **We cannot receive the articles themselves.**

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"Wireless Circuits and Diagrams." Containing 90 diagrams of wireless circuits and connections with explanatory notes. A splendid guide to the most effective arrangement of the apparatus. Price 6d.; post free 7d.—PERCIVAL MARSHALL AND Co., Book Dept., 66, Farringdon Street, London, E.C.4.

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Creed High-speed Syphon Morse Recorder, absolutely new, motor driven, operates direct off 'phone terminals without relay, cost £40; no reasonable offer refused.—SECRETAN, 149, Lowther Parade, Barnes. 'Phone: Hammersmith 1264.

Valve Set, complete with all accessories, 65s. bargain.—R. FALLOWS, Dungiven, Londonderry.

Wanted.—Gambrell Wavemeter, send and receive; guaranteed accurate.—CONSTABLE, 6, Leysfield Road, Shepherd's Bush, London, W.12.

Wireless Components at lowest prices. Lists free. Prompt attention.—WEBB & GOWARD, Dept. E., Caxton Street, Market Harborough.

Armstrong Supersonic 5-valve, switch 2, 3 or 5 valves, in lock-up cabinet; Claritone loud speaker; three valve panels (one Marconi); one pair Brown "A" type 'phones. Offers wanted.—Apply GROOM, 5, Meigle Street, Galashiels, S.W.1.

Accumulators, Plates, Sets of Plates, Boxes, Separators; repairs any make.—See below.

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For Sale, First Volume "Modern Wireless"; also first three volumes "Wireless Weekly"; all unbound. What offers?—HARRISON, Little Billinge Scar Farm, Blackburn, Lancs.

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June, 1924.

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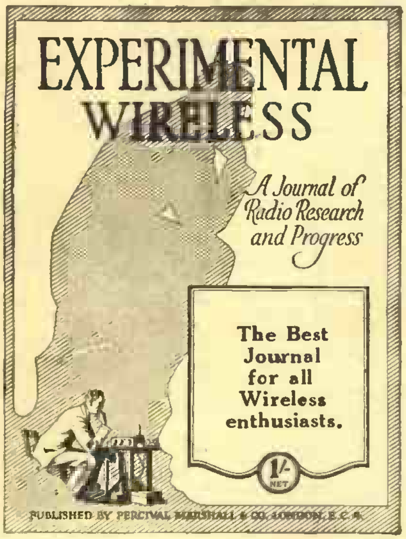

CONTENTS
of the
EARLIER NUMBERS.

New readers will be glad to know the principal contents of the back numbers of this journal—a limited stock of which is still held, and obtainable at the published price of one shilling per copy—post free 1/3 anywhere.

"EXPERIMENTAL WIRELESS" has jumped into the front rank of wireless publications by reason of its first-class presentation of the latest technical and experimental information. It is read by the best workers throughout the world.

Look through this list; there is certain to be an article—perhaps many — of considerable interest to you, and which will help you in your study of the science of radio work.

The following are the Principal Contents:

OCTOBER (No. 1).

Maintenance of High-frequency Oscillations.
The Fading of Signals.
Neon Lamps and their Uses for Wireless Purposes.
Antenna Constants.
Design and Operation of Tuned Anode Receivers.
Efficient Transmission.
An Armstrong Super-Heterodyne Receiver.
Crystals and Crystal Testing.
Distortionless Amplification.
An Ultra-Selective Circuit.

JANUARY (No. 4).

Microphone Amplifier and Control Circuits.
Directive Radio Telegraphy and Telephony, II.
Frequency Transformers.
Both-Way Amplification.
Alternating Currents and Wireless.
The "Old Vic." Wireless Relay.
Energy Loss in Condensers—II.
The Design and Construction of a Tuned Reed Rectifier for 200-volt 50-cycle Supply.
A Radio-Frequency Amplifier for a Wave-length Range of 300 to 1,000 Metres.
Aerial Design for 200-metre Transmission.

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Suitable Valves for Grid Absorption Modulation.
Neon Tubes for Electrical Measurements.
A Valve Generator for Audible Frequencies.
Electrostatic Transmitter Amplifier Circuits.
A Two-Valve Radio Frequency Amplifier.
The Electromagnetic Screening of Radio Apparatus.
Selectivity.
In Search of a Real Receiver.
Spade Tuning.
Filter Circuits in Radio Telegraphy.

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"Side-Band" Telephony.
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