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Editorial Views.

Valve Rectification.

WE commence in this issue the publication of a second most important paper by Mr. F. M. Colebrook, B.Sc., A.C.G.I., D.I.C. This paper deals with valve rectification in the same complete manner as this author's paper on "Crystal Rectification," published in E.W. & W.E. for March, April and May last, and in our opinion the two papers will form by far the most important contribution to the subject that has yet appeared.

Although the mathematical part of Mr. Colebrook's work is not really exceptionally difficult, there may be readers who are content to accept his very important conclusions without actually checking his arguments; and for these we are preparing a short summary of the paper, as non-technical as possible.

We only mention one point here. Mr. Colebrook confirms, both theoretically and practically, our personal view that grid rectification is not to be recommended for telephony.

Valves and their Names.

We do not, as a general rule, like to repeat ourselves, but for once we propose to do so, in the effort to call attention again to the question of valve nomenclature. At the moment of writing, we have no access to our records, but even speaking from memory, we can give sufficient examples to show the absurdity of the present position. For example, Marconi-Osram valves in common use comprise "L.S." Nos. 1 to 5, and "D.E." 2 to 8—perhaps now that Marconi and Osram are separating one of them will rename them! Among Mullard valves are a ".3" and a ".06" series, an "S" series, a "DFA" series, and a new valve called the "PM4." Many of these are practically identical with the M-O types, but neither the letters nor the figures have any correspondence with one another nor with the purpose of the valves. B.T.-H. have a "B" series, and Ediswan "ARDE" "AR06," and "PVDE" series, and the same remarks apply. Cossor valves have their own keys, and so have all the other makers. This in spite of the fact that most of these firms work together, and that a definite nomenclature has already been suggested.

We are glad to see that the new Burndept valves are actually marked according to our suggested scheme, a considerable improvement in it having been made by them. What we now suggest is that, since the other valve-makers are apparently too indifferent to users' convenience to make any step, our readers should consistently use the new nomenclature, order valves accordingly, and so gradually force a reasonable scheme on the makers.

As a reminder, the scheme suggested is as follows: every type of valve has a 3-figure number, of which the first figure as rated filament volts, and the last two rated filament current. Thus the popular "60-milliamp" type is a 306, and the old "R" a 465.

In our original scheme, we used final small letters *a* and *b* to indicate valves of exceptionally low or high μ. But we now suggest a slight elaboration of the Burndept scheme, *for use when desired*. According to this, letters before the number denote magnification, as follows:—

- HH: extra high; for μ of 20 or thereabouts.
- H: high; for μ of 9—14.
- HL: medium; for μ of 6—9.
- L: low; for μ of 4—6.
- LL: extra low; for μ of 2 or thereabouts.

These letters also correspond to the present popular habit of recommending high μ valves for H.F. and low μ for L.F. amplification.

Thus the valve sold by M-O as D.E.5b, and by Mullard as DFA4, should be called in either case HH625 if we wish to note its μ; otherwise simply as 625 type.

Perhaps if readers will help, we can in time put an end to the ridiculous situation under which the *same* valve, according to the firm who sells it, is called a D.E.5, a DFA1, a B4, or a PV5D.E.

Supersonic or Stabilised?

Judging by the exhibits at the recent shows, and also by the components being much advertised at the present moment, it is expected that the supersonic set is to be the popular high-power set of the season. At the same time, one of our greatest wireless engineers has taken the opposite view, and specialised in a "straight" neutralised set. There is a good opportunity here for some of our readers to produce a critical review of the respective merits of the two types, assuming that equal skill and care is put into each.

It is, of course, obvious that an amplifier to work at a fixed wave-length of 3 000 or 6 000 metres is by far a more reasonable proposition than one to give equally good results of over a range of short waves from, say, 200 to 600. The question then is, whether the troubles and difficulties which may be introduced by the "frequency changer" necessary, do or do not outweigh the advantage.

Frankly, our own opinion is that these troubles are much overrated, and that the supersonic is undoubtedly superior for most purposes; but we should very much like to see a detailed discussion of the point from different individual points of view.

Amateur Research.

Mr. Ryan, in his notes on "Long Distance Work" in E.W. & W.E. for September last, made what we consider to be a very good point. He said, readers will remember, that now that amateurs have "DX'ed" half round the world, he proposed to devote less attention to simple distance records, but to note in particular any *use* made of such work in increasing our wireless knowledge.

The point is brought home by the account in our last issue of the Radio Research Board's tests on fading. Reading between the lines of the report, it is obvious that many of the amateurs who gaily undertook to make reports could not—or at any rate *did* not—send in regular full reports such as would have been of real scientific value when collated; and we feel that this is a serious reproach.

Wireless is beyond doubt a fine hobby, and has immense value in encouraging technical study; but we fear that much of the amateur work being done at the present day is just "hobby" work—like fretwork or stamp-collecting—and that some of those who claim to be scientific workers engaged on research have not yet learned the fundamental truth that *real* research demands previous knowledge, self-discipline, and above all incessant work, much of it most laborious and uninteresting; and is not quite the same thing as playing with a scientific novelty.

Readers must not imagine that we ignore the real work that is being done by some amateurs scattered all over the country. Fine work is being done; but one cannot deny the existence of the "fretworkers" as well; and some of them are vociferous on the ether.

The problems of transmission are extraordinarily difficult, and the expense of a real attempt to solve them is considerable. Might we suggest that there are still a few problems in reception, and that apparatus for serious work in this direction is by on means hard to acquire?

The Rectification of Small Radio Frequency Potential Differences by means of Triode Valves.—Part I. [R134

By F. M. Colebrook, B.Sc., A.C.G.I., D.I.C.

IN a previous paper[1] the author has outlined a general theory of rectification and illustrated the theory by reference to typical crystal detectors. The present paper is the extension of the theory to valve rectification.

1. *General.*

There are three principal methods of rectification by means of triode valves. The first and most generally used is that commonly known as "cumulative grid rectification." This depends on the curvature of the grid-current—grid-voltage characteristic. For shortness, it will be referred to in this paper as "grid rectification." The second method depends on the curvature of the foot of the anode-current—grid-voltage characteristic, and will be referred to as "anode rectification." The third method is generally known as "autodyne" in relation to the reception of continuous waves, and is more suitably termed "homodyne" in relation to the reception of modulated continuous waves. These three types of rectification will now be considered separately, in sections A, B and C respectively. A fourth section, D, will be devoted to a general comparison of methods of rectification.

A.—Grid Rectification.

2. *Nomenclature.*

It will be shown in the course of the following discussion that the terms "cumulative grid rectification" and "grid-leak" are not accurately descriptive in relation to the great majority of practical applications of the above process at the present time. They are, in fact, a survival from the time when wireless telegraphy consisted exclusively of the transmission and reception of trains of damped waves, as applied to which process they were not inappropriate. In connection with the reception of unmodulated continuous waves the terms are definitely misleading, in that they bestow undue emphasis on a transient condition of secondary importance. Unfortunately this not very accurate nomenclature is probably too well established to permit of general acceptance of more suitable alternatives, but, as far as the present paper is concerned, the term "grid rectification"

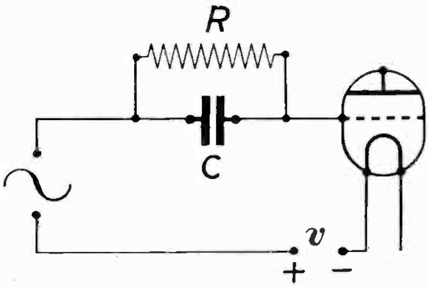


Fig. 1*a*.

will be used for the process as a whole, and "grid circuit resistance" for that element which is generally called the "grid-leak." The grid-circuit resistance must be distinguished from the internal resistance of the valve from grid to filament, which will be referred to as the "grid-filament resistance." This must be further distinguished from the resistance of the grid-filament path to current changes, which will be referred to as the "grid-filament slope resistance," since it is derived from the reciprocal of the slope of the grid-current—grid-voltage characteristic.

3. *The grid rectification circuit.*

The practical details of grid rectification are too well known to need description. Alternative arrangements are shown in

[1] "The Rectifying Detector." E.W. & W.E., March, April, May, 1925.

Figs. 1*a* and 1*b*. Of these only the first will be considered in detail. The modifications of the analysis required for the second arrangement will not present any difficulty.

4. *The mechanism of grid rectification.*

It was shown in the paper referred to above that in a simple rectification circuit such as that illustrated in Fig. 2 the continuous current produced by the rectification of the alternating E.M.F. could be expressed in the form

$$i_c = \frac{E_c}{R + R_c} \quad \cdots \quad (4.1)$$

where E_c is an effective continuous E.M.F. associated with an internal resistance R_c,

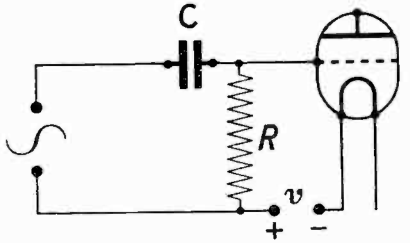


Fig. 1*b*.

acting in a circuit of external resistance R. In general E_c depends chiefly on the amplitude of the alternating E.M.F., but also to a less extent on R. The effective internal resistance R_c also depends to some extent on both the alternating E.M.F. and on R. The change of continuous potential difference across the resistance R is given by

$$v_c = \frac{R}{R_c + R} E_c \quad \cdots \quad (4.2)$$

If the terminal F of the detector be considered fixed in potential as regards direct currents, then v_c will be the change of potential of the terminal G. Thus the change of potential of G is a fraction $R/(R+R_c)$ of the total internal rectified E.M.F. E_c. Apparently this fraction can be made indefinitely near to unity by increasing R.

Now F can be considered to be the filament terminal of a grid rectifying valve, G being the grid terminal, and the rectifying grid-filament path taking the place of the detector shown in Fig. 2. The circuit then becomes identical with that shown in Fig. 1*a*. This simple derivation should make clear the functions of the different components of a grid rectifying circuit. That of the condenser is to provide a path of low impedance for the high-frequency currents flowing in the rectifying circuit. It was shown in the paper on the general theory of rectification that such a condenser materially increases the efficiency of the rectification process. The function of the grid circuit resistance is seen to be the externalisation, so to speak, of the internal rectified E.M.F., which, in the absence of this resistance, would remain internal, giving no change of mean grid potential. The function of the grid-filament path is the production of the rectified E.M.F. E_c.

The effect of the application of an alternating E.M.F. to the terminals of a grid rectifying circuit is thus seen to be a change of grid potential v_c. This will in turn produce a change of anode current given by

$$i = \frac{\mu v_c}{R_a + R_e} \quad \cdots \quad (4.3)$$

where μ is the voltage factor of the valve, R_a the internal slope resistance of the valve from anode to filament, and R_e the external or load resistance in the anode circuit. This change of anode current is, of course, the real objective in the applications of grid rectification.

It has here been assumed that the changes concerned take place instantaneously. In practice this will not be strictly true, since a combination of a capacity and a high

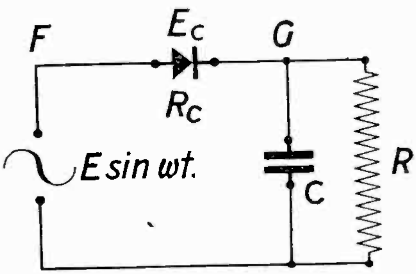


Fig. 2.

resistance is unable to respond instantaneously to a change of potential. At the instant of the application of the alternating E.M.F. there will therefore commence a building up process leading to the final potential change v_c. Also, when the signal ceases to act, there will be a gradual leaking away of the charge on the condenser, which will finally return to its initial equilibrium condition. Hence the terms "cumulative grid rectification" and "grid-leak." It will be shown, however, in the course of the detailed discussion, that the initial and final equilibria are the essential features of the process, the transient conditions being of very slight importance in the majority of practical applications.

Two points should be noted in connection with the above simple explanation. The first is that the actually utilised change of continuous current does not flow in the rectification circuit itself, but in an associated circuit. This is a point of difference from the cases considered in the paper on the general theory of rectification. The second is that as far as the rectification process itself is concerned, nothing is to be gained by short-circuiting the anode circuit load R_c with a condenser. It must be remembered, however, that if reaction effects are being utilised, then it will be desirable that there shall be appreciable high-frequency components of current in the anode circuit. In all such cases the use of a by-pass condenser across the anode circuit load will be advantageous.

In the detailed analysis of the process which follows the simplest possible case will first be considered, *i.e.*, the rectification of a pure sine wave high-frequency E.M.F. The other and more practically important applications of grid rectification will then be derived from this.

5. *Grid rectification in terms of a general form of characteristic.*

For any given conditions of anode voltage and filament current the relation between the grid current i and the grid voltage, *i.e.*, the difference of potential between the grid and the negative end of the filament, can be expressed in the form

$$i_g = f(v_g) \quad .. \quad .. \quad (5.1)$$

where f is some finite and continuous function. In general the characteristic does not pass through the origin, *i.e.*, i_g is not zero when v_g is zero. If the grid circuit is as shown in Fig. 1*a*, *i.e.*, it consists of a source of continuous potential v in series with a resistance R, then the initial value of the grid current will be given by

$$i_0 = f(v_g) = f(v - i_0 R) \quad .. \quad (5.2)$$

If now an alternative E.M.F.

$$e = E \sin \omega t \quad .. \quad .. \quad (5.3)$$

acts in series with v and R, there will be produced a change of grid current i of instantaneous magnitude given by

$$i_0 + i = f(v - i_0 R - i_c R + E \sin \omega t) \quad .. \quad (5.4)$$

where i_c is the mean value of i over a complete period T (*i.e.*, $T = 2\pi/\omega$). It is here assumed that the condenser connected across R is of sufficient magnitude to prevent any appreciable fall of high-frequency potential across R. Taking the mean value, over a period, of equation (5.4),

$$i_0 + i_c = \frac{1}{T}\int_0^T f(v - i_0 R - i_c R + E \sin \omega t)dt \quad (5.5)$$

or, putting $i_0 R = v_0$ and $i_c R = v_c$

$$v_0 + v_c = R\frac{1}{T}\int_0^T f(v - v_0 - v_c + E \sin \omega t)dt \quad (5.6)$$

In the general case, therefore, v_c is the solution of this equation.

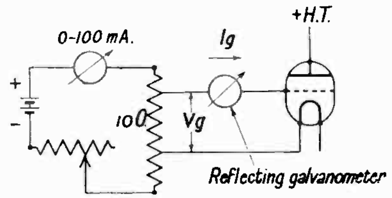


Fig. 3.

6. *The form of the characteristic for small receiving valves.*

The next step is clearly the determination of the at present unspecified characteristic

$$i_g = f(v_g) \quad .. \quad .. \quad (6.1)$$

and its expression in as simple a mathematical form as possible. A convenient circuit for the experimental measurement of the static characteristic is that shown in Fig. 3. The necessary grid voltages are obtained as the fall of potential due to a measured current in a known resistance, preferably of the four-terminal type. The grid currents are measured by means of a sensitive reflecting galvanometer. It will be found that the magnitude of the grid current is very sensitive to changes of filament voltage and anode voltage, which must accordingly be maintained constant at known suitable values.

A typical characteristic curve is that illustrated in Fig. 4, which refers to an Ediswan dull-emitter valve with an anode voltage of 50 and a filament voltage of 1.8.

It is now required to express the characteristic in mathematical form. A large number of forms of representation were tried without success, until it was discovered that the differential of the curve was very similar to the curve itself. As an example of the ease with which the obvious is overlooked the author confesses that he

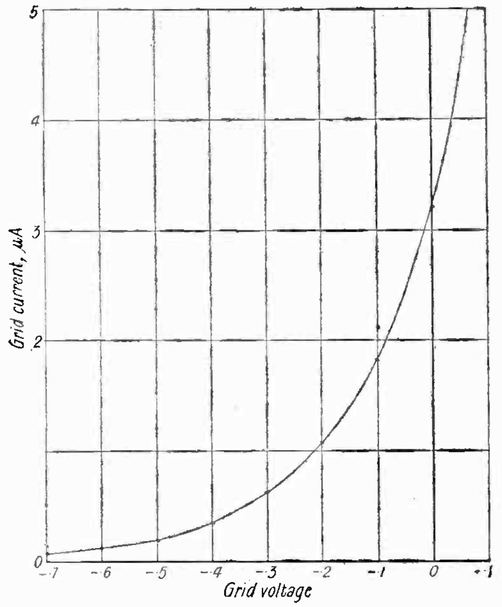


Fig. 4.

did not realise the significance of this fact until it was pointed out to him by a colleague (Mr. J. Hollingworth, of the National Physical Laboratory). It suggested, of course, an exponential form. This was tested by plotting the logarithm of the grid current against the grid voltage. The result for the curve of Fig. 4 is shown in Fig. 5. It is, to a close approximation, a straight line which can be expressed in the form

$$\log i_g = a' + b'v_g \quad \ldots \quad (6.2)$$

This is equivalent to

$$i_g = a\varepsilon^{bv_g} \quad \ldots \quad \ldots \quad (6.3)$$

where $\log a = a' \quad \ldots \quad \ldots \quad (6.4)$

and $b = 2{\cdot}303\ b'$

Both a and b can therefore be determined from the curve of Fig. 5.

A large number of small receiving valves were examined, and it was found that in every case a curve of the type $a\varepsilon^{bv_g}$ would represent to a fair degree of accuracy the variation of the grid current with the grid voltage. A number of the logarithmic lines are shown in Fig. 6, and the corresponding values of a and b are given in the following table.

Valve.	Anode Voltage.	Filament Voltage.	a	b
Ediswan R.	50	4	44.1×10^{-6}	4.01
Marconi R5V	50	5	10.35×10^{-6}	3.23
Ediswan A.R.	50	2	7.5×10^{-6}	5.12
Ediswan A.R.	25	1.8	5.83×10^{-6}	5.45
Marconi R.	50	4.5	2.06×10^{-6}	4.48
Marconi R.	50	4.0	$.29 \times 10^{-6}$	4.80
Marconi V24	50	5.2	2.43×10^{-6}	7.48

It will be noted that the constants differ very considerably in magnitude. It must be clearly understood that the exponential law is only followed over the ranges of grid voltage shown in the diagram. Generally

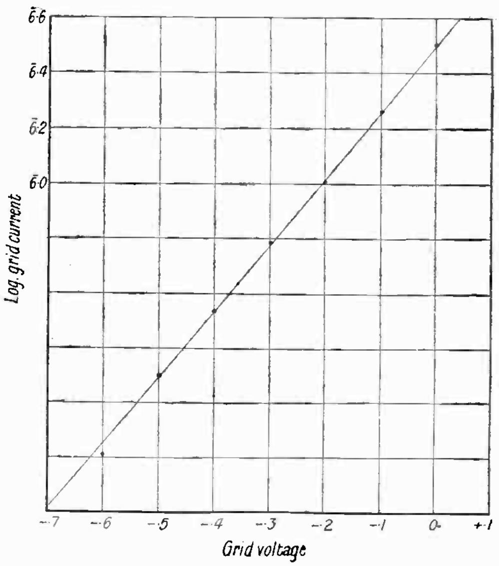


Fig. 5.

speaking it applies to all negative values, the characteristic becoming more nearly parabolic for positive values. In the great majority of practical cases, however, the valve will function inside the range of the exponential law.

In Fig. 7 is given a series of logarithmic lines for an Ediswan dull-emitter valve for a constant filament voltage and various anode voltages. In Fig. 8 are shown the logarithmic lines for the same valve with a constant anode voltage of 50 and filament voltages of 1.8 and 2 volts.

The data so far obtained scarcely warrant a generalisation, but it appears that b, which is by far the more important factor, is principally a function of the geometry of the valve, while, for a given valve, a is chiefly a function of the conditions of operation, $\partial a/\partial v_f$ being positive and $\partial a/\partial v_a$ being negative.

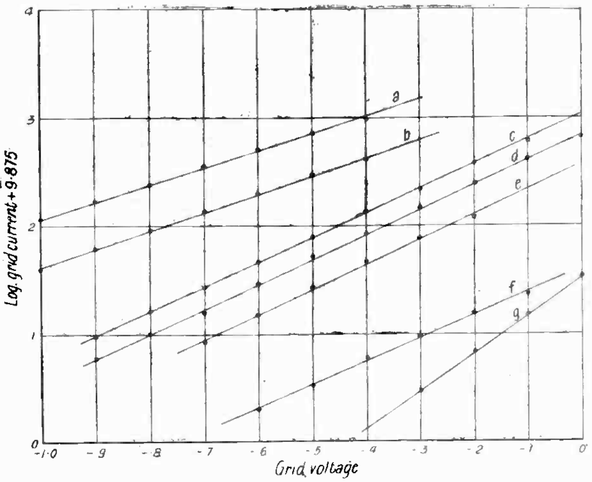


Fig. 6.

The matter is an important one from the point of view of design, and is worthy of a fuller investigation, which it is hoped will be possible at some future date.

7. *The solution of the rectification equation for an exponential characteristic.*

The discovery that the characteristic could be represented in the above simple form proved to be the key to the whole problem. Various other workers have investigated the matter with varying degrees of completeness (see, for instance, the excellent paper by E. B. Moullin, M.A., and L. B. Turner, M.A., published in the *Journal of the I.E.E.*, Vol. 60, pp. 706-719); but hitherto no general quantitative analysis has been presented, as the form of the characteristic was left unspecified. It is interesting to note, however, that the exponential form was distinctly foreshadowed in the above-mentioned paper.

In terms of the exponential characteristic, equation (5.2) becomes

$$i_0 = a\varepsilon^{b(v-i_0R)} \quad (7.1)$$

$$= a\varepsilon^{bv}\varepsilon^{-bRi_0} \quad (7.2)$$

This equation cannot be solved directly, but the solution can be obtained in this way: multiplying each side by bR,

$$bRi_0 = abR\varepsilon^{bv}\varepsilon^{-bRi_0}$$

i.e.,

$$bv_0 = abR\varepsilon^{bv}\varepsilon^{-bv_0} \quad (7.3)$$

$$(7.4)$$

or

$$x\varepsilon^x = y \quad .. \quad .. \quad (7.5)$$

where $bv_0 = x$ and $abR\varepsilon^{bv} = y$.

Now equation (7.5) is a perfectly general one, containing no specific constants. The relation between x and y can be shown in the form of a curve, as in Fig. 9. For known values of a, b, R, and v, y is known and the corresponding value of x can be read off the curve. This gives bv_0, *i.e.*, v_0, and the initial equilibrium is determined.

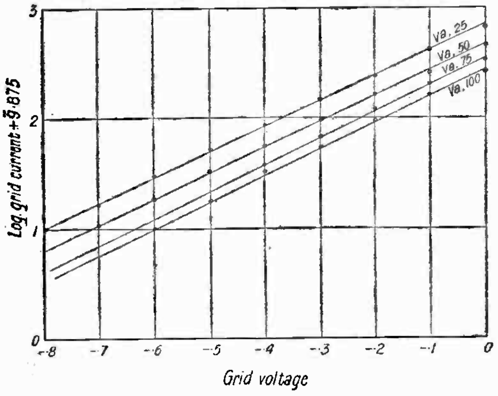


Fig. 7.

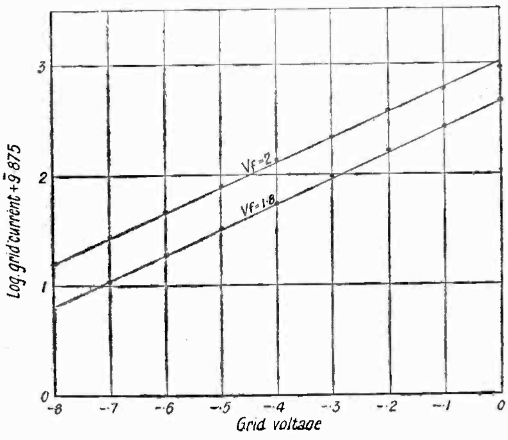


Fig. 8.

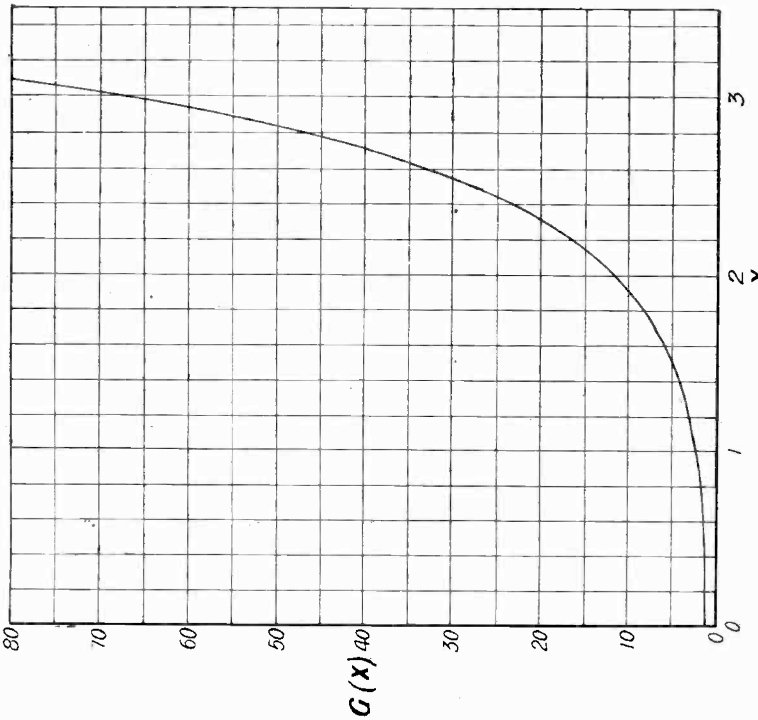


Fig. 10.

X	G(X)
.0	1
.25	1.0634
.50	1.2660
.75	1.6466
1.00	2.2795
1.25	3.2882
1.50	4.8790
1.75	7.3690
2.00	11.2990
2.25	17.4800
2.50	27.2700
2.75	42.7600
3.00	67.5000

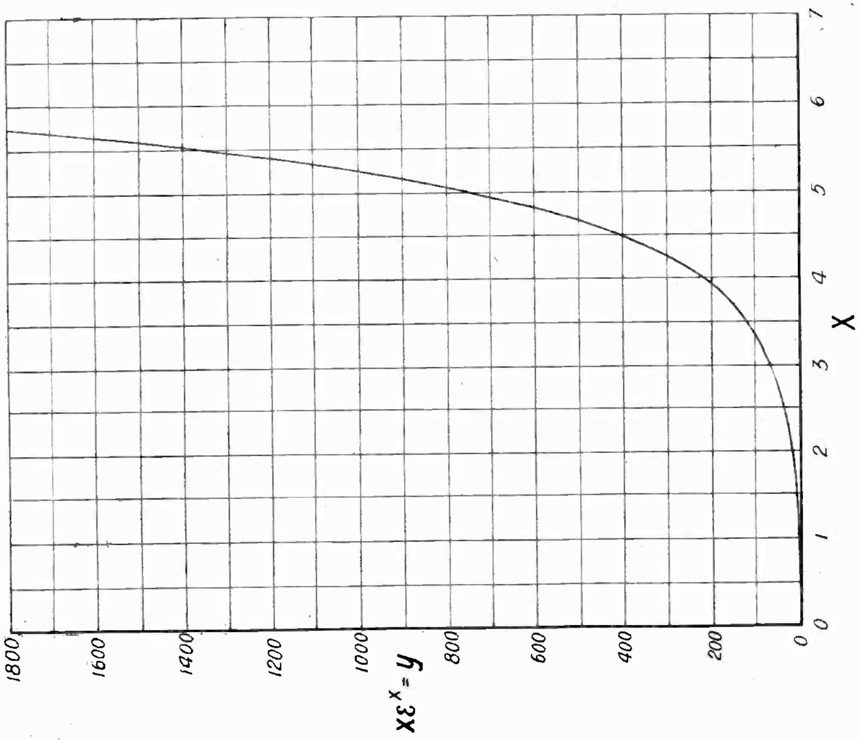


Fig. 9.

Taking as an example

$$a = 3.16 \times 10^{-6}$$
$$b = 5.55$$
$$R = 1.89 \times 10^{6}$$
$$v = 0$$

then

$$abR\epsilon^{bv} = y = 33.1$$

From the curve

$$x = bv_0 = 2.56$$

Therefore

$$v_0 = .461$$
$$i_0 = .244 \times 10^{-6}$$

So much for the initial equilibrium. Considering now the effect of an applied signal voltage $e = E \sin\omega t$, equation (5.6) becomes

$$(v_0 + v_c)\epsilon^{b(v_0+v_c)} = aR\epsilon^{bv}\frac{1}{T}\int_0^T \epsilon^{bE\sin\omega t}\,dt \quad (7.6)$$

i.e.,

$$b(v_0+v_c)\epsilon^{b(v_0+v_c)} = abR\epsilon^{bv}\frac{1}{T}\int_0^T \epsilon^{bE\sin\omega t}\,dt \quad (7.7)$$

If now the right hand side of the equation can be determined this becomes another equation of the form $y = x\epsilon^x$ which can be solved in exactly the same manner as for the first equilibrium.

The evaluation of the right hand side is actually a simple and straightforward matter. It is given in detail in Appendix I. The result can be stated in the form

$$\frac{1}{T}\int_0^T \epsilon^{bE\sin\omega t}\,dt = G\left(\frac{bE}{2}\right) \quad \cdot\cdot \quad (7.8)$$

where

$$G(x) = 1 + x^2 + \frac{x^4}{2!^2} + \frac{x^6}{3!^2} + \frac{x^8}{4!^2}, \text{etc., } ad\ inf. \quad (7.9)$$

The integral can therefore be represented by a general curve, applicable to all cases of exponential rectification, by taking $bE/2$ as the argument. The curve is shown in Fig. 10 for values of x from 0 to 3, a range which will be sufficient for most practical purposes.

By means of the above two curves the change of mean grid potential corresponding to any given continuous wave signal amplitude can be calculated in a comparatively simple manner. For example, taking the values given above, and assuming a signal amplitude of .707 volt (*i.e.*, an R.M.S. value of .5)

$$G\left(\frac{bE}{2}\right) = G(1.964)$$
$$= 10.5$$

Therefore

$$b(v_0+v_c)\,\epsilon^{b(v_0+v_c)} = 10.5 \times 33.1$$
$$= 348$$

and from the curve of Fig. 9

$$b(v_0 + v_c) = 4.38$$

and since, as already shown,

$$bv_0 = 2.56$$
$$bv_c = 1.82$$

and

$$v_c = .329 \text{ volts.}$$

From v_c the magnitude of the change of anode current can be calculated in the ordinary manner, which need not be described here.

If the change of anode current, or the change of mean grid potential, calculated in the above manner for a number of different signal amplitudes, is confirmed by actual measurement, then

(*a*) The above theory of the rectification process is correct ; and

(*b*) The dynamic characteristics of the valve are the same as the static characteristics ; or

(*c*) The deviations of (*a*) and (*b*) from the truth cancel each other.

Neglecting the remote possibility of (*c*), experimental confirmation of the analysis will establish the two very useful results (*a*) and (*b*).

8. *Experimental confirmation.*

The circuit shown in Fig. 11 was used for the experimental confirmation of the theory. The chief difficulty in measurements of this

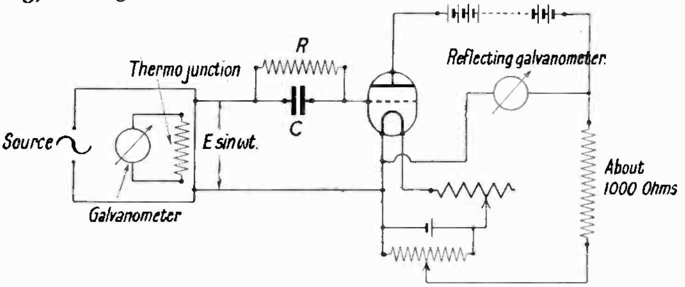


Fig. 11.

kind is to obtain accurately known small voltages of the frequencies required. (The range covered in these experiments was from 75 to 750 kilocycles, *i.e.*, 4 000 to 400 metres in wave-length.) At very high frequencies the use of a contact thermo-junction is liable to introduce errors unless special precautions are taken. In the present case the necessary voltages were obtained as the fall of potential due to a measured current in a known resistance. To ensure that the current measured was actually flowing through the resistance the latter was used as the heater of a non-contact multi-junction arrangement. The changes of mean grid potential were determined from the consequent changes of anode current, the initial anode current being balanced out of the galvanometer circuit by means of the potentiometer arrangement shown in the figure. In order to relate the observed changes of anode current to the corresponding changes of mean grid-potential, the relevant portion of the anode current—grid

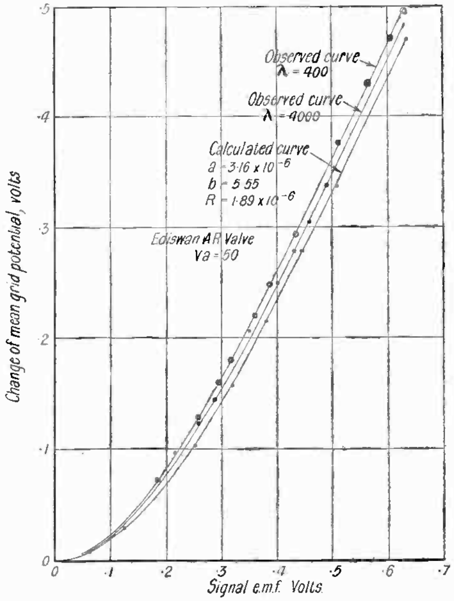


Fig. 12.

voltage characteristic of the valve was measured separately under the same experimental conditions of filament and anode voltage.

The valve used in these measurements was an Ediswan dull-emitter, its grid constants being

$$a = 3.16 \times 10^{-6}$$
$$b = 5{\cdot}55$$

The anode voltage was kept constant at 50 volts, the filament voltage at 2 volts, and no additional grid potential was used (*i.e.*, $v = 0$). Two different grid circuit resistances were used, (*a*) 1.89×10^6 and (*b*) $.0\,878 \times 10^6$. Measurements were made at three frequencies, corresponding to wave-

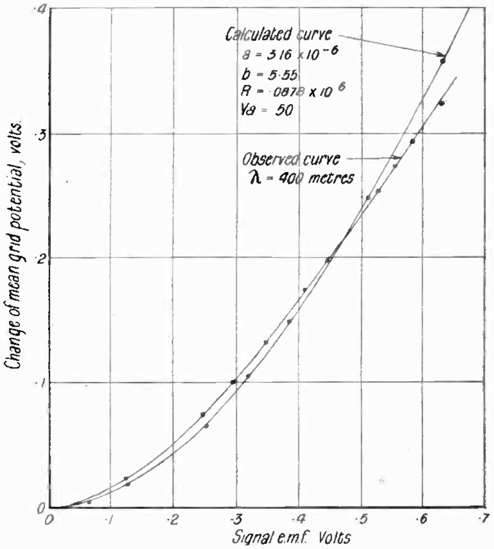


Fig. 13.

lengths of 400, 1 000 and 4 000 metres. In every case the variation with frequency was small, probably less than the limit of accuracy of the measurements.

In Fig. 12 the results are shown for the higher grid resistance, compared with the calculated curve determined from the measured grid constants in the manner described above. The comparison affords a very satisfactory confirmation of the theory, and shows that the characteristics of the valve determined at zero frequency appear to be identical with those corresponding to a frequency of nearly a million. There appears to be no appreciable time lag over this wide range of frequency.

In the curves of Fig. 13 are shown the results for the lower value of grid-circuit resistance. Here again the agreement is very good, though not quite so satisfactory from a theoretical point of view as in the former case, since the curves are not quite of the same shape. This is probably due to the fact that for this very low resistance the initial grid potential is only $-.133$ volt, which means that the operation of the valve will take the characteristic point into a region where the exponential law is not followed very closely. This is, in fact, an extreme case, so that the agreement is closer than might have been anticipated.

A further series of measurements was made with the anode voltage reduced to 25 volts, for which value the grid constants were found to be

$$a = 5{\cdot}37 \times 10^{-6}$$
$$b = 5{\cdot}6$$

It was found that there was apparently a considerable deviation of the measured from the theoretical curve. This is shown in Fig. 14. The reason for this deviation was soon discovered.

The method of determination of the change of mean grid potential involves the assumption that the anode current—grid voltage characteristic is a straight line over the range of the changes concerned. If it is not a straight line the high-frequency components of the anode current will themselves be partially rectified, giving a slight increase of anode current. The curvature of the anode current—grid voltage characteristic will thus give rise to a change of mean anode current opposed in direction to that given by pure grid rectification. Now with a low anode voltage the region of operation of the anode current-grid voltage characteristic will be rather near its lower bend and will therefore have a slight curvature.

This reasoning was confirmed by experiment in the above case. The grid circuit resistance was short-circuited and the galvanometer brought back to balance by applying an equivalent negative grid potential. The high-frequency potentials were then applied to the grid as before, and it was found that there was a small change of mean anode current in the reverse direction, as indicated above. The magnitudes of the changes corresponding to various applied voltages were measured and were added as corrections to the corresponding readings in the grid rectification measurements. The dotted line in Fig. 14 is the corrected curve obtained in this way. It gives a very satisfactory confirmation of the theory.

9. *The physical interpretation of the part played by the grid circuit resistance.*

It was stated in Section 4 that in all cases of rectification the fall of potential v across the load R in the rectifying circuit could be expressed in the simple form

$$v_c = \frac{R}{R_c + R} E_c \quad \ldots \quad \ldots \quad (9{\cdot}1)$$

E_c being an effective rectified E.M.F. and R_c an effective internal resistance. It will be of interest to relate this to the case under consideration.

In the general case no simple expressions can be found for E_c and R_c in terms of the constants of the grid circuit, but certain approximations can be made if the signal amplitude is small, say, less than 100 millivolts, which enable the process to be interpreted very simply.

From equations (7.7) and (7.8),

$$b(v_0 + v_c)\varepsilon^{b(v_0+v_c)} = abR\,\varepsilon^{bv}G\left(\frac{bE}{2}\right) \quad \ldots \quad (9{\cdot}2)$$

and since

$$bv_0\varepsilon^{bv_0} = abR\varepsilon^{bv} \quad \ldots \quad \ldots \quad (9{\cdot}3)$$

$$(v_0 + v_c)\varepsilon^{bv_c} = v_0 G\left(\frac{bE}{2}\right) \quad \ldots \quad (9{\cdot}4)$$

Now for small values of E, bv_c will also be small, and it will be permissible to simplify the above equation to

$$(1 + bv_c)\,(v_0 + v_c) = v_0 G\left(\frac{bE}{2}\right) \quad \ldots \quad (9{\cdot}5)$$

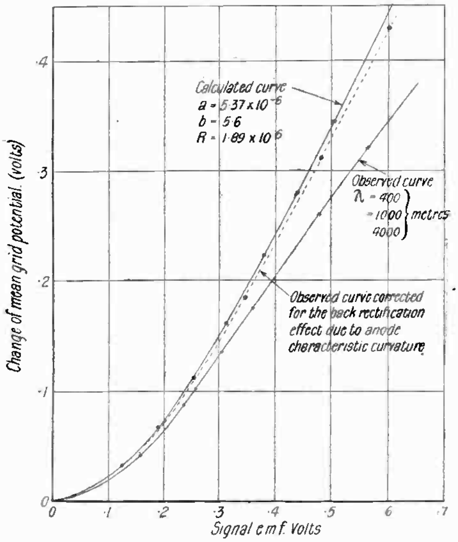


Fig. 14.

and, neglecting bv_c^2,

$$v_0 + v_c + bv_0 v_c = v_0 G\left(\frac{bE}{2}\right) \quad .. \quad (9.6)$$

whence

$$v_c = \frac{bv_0}{1 + bv_0} \cdot \frac{G(bE/2) - 1}{b} \quad .. \quad (9.7)$$

$$= \frac{R}{R + 1/bi_0} \cdot \frac{G(bE/2) - 1}{b} \quad .. \quad (9.8)$$

Comparing this with equation (9.1) above, it is clear that the rectified E.M.F. E_c is given by

$$E_c = \frac{G(bE/2) - 1}{b} \quad .. \quad .. \quad (9.9)$$

$$= \frac{bE^2}{4} \text{ approx.} \quad .. \quad (9.10)$$

and the internal resistance R_c by

$$R_c = 1/bi_0 \quad .. \quad .. \quad (9.11)$$

It should be noted that R_c is actually the slope resistance of the grid-filament path at the initial point of operation, for, putting

$$i_g = a\epsilon^{bv_g} \quad .. \quad .. \quad .. \quad (9.12)$$

$$di_g/dv_g = ab\epsilon^{bv_g} \quad .. \quad .. \quad (9.13)$$

$$= bi_g \quad .. \quad .. \quad .. \quad (9.14)$$

Therefore

$$\text{slope resistance} = (dv_g/di_g)_0 \quad .. \quad (9.15)$$

$$= 1/bi_0 \quad .. \quad (9.16)$$

It was pointed out in Section 4 that the ratio of R to $R_c + R$ could apparently be made indefinitely near to unity by increasing R. This, however, is not the case in practice, since an increase in R will be accompanied by a decrease in i_0, *i.e.*, by increase in R_c. There is thus an upper limit beyond which an increase in R will not produce any appreciable increase in v_c. This point will be considered in fuller detail in a later paragraph.

10. *The high-frequency input resistance of the grid rectifying circuit.*

A full discussion of the input impedance of a rectifying valve would be a very lengthy business, since it should take account of the effect of inter-electrode capacity and inherent or externally induced reaction effects. This will not be attempted in the present section, the scope of which is limited to the discussion of the part of the input impedance which is due to grid-filament conductivity.

Equation (5.4) gave the instantaneous magnitude of the component i of grid current due to a given signal amplitude $e = E \sin \omega t$. The equation referred to the general characteristic. In relation to an exponential characteristic it becomes

$$i_0 + i = a\epsilon^{b(v - v_c + E \sin\omega t)} \quad .. \quad (10.1)$$

$$= a\epsilon^{b(v - v_c)} \epsilon^{bE \sin\omega t} \quad .. \quad (10.2)$$

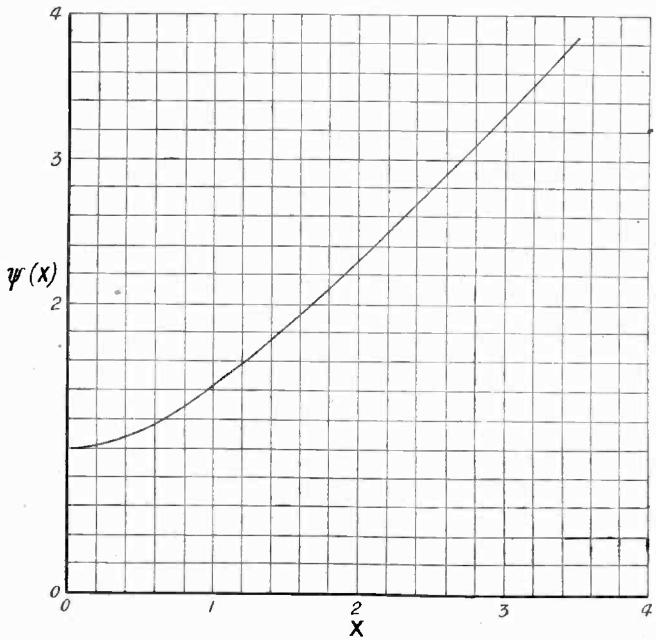


Fig. 15.

X	$\psi(X)$
0.0	1.000
0.5	1.120
1.0	1.430
1.5	1.853
2.0	1.315
2.5	1.835
3.0	3.300

This component i will obviously consist of a continuous component i_c and a complete Fourier series of fundamental frequency $\omega/2\pi$. It can be shown[1] that the amplitude of the fundamental component is given by

$$I_1 = a\varepsilon^{bv}\varepsilon^{-b(v_0+v_c)}\, 2\phi\left(\frac{bE}{2}\right) \quad .. \quad (10.3)$$

where

$$\phi(x) = x + \frac{2x^3}{2!^2} + \frac{3x^5}{3!^2} + \frac{4x^7}{4!^2} \ . \ . \ . \ \text{etc., } ad\,inf. \quad (10.4)$$

Further, since

$$a\varepsilon^{-b(v_0+v_c)} = \frac{i_0 + i_c}{G(bE/2)} \quad .. \quad (10.5)$$

(from equation (7.7)), equation (10.3) can be written

$$I_1 = 2(i_0 + i_c)\frac{\phi(bE/2)}{G(bE/2)} \quad .. \quad (10.6)$$

Putting

Input high-frequency resistance $= R_1 = \dfrac{E}{I_1}$

then

$$R_1 = \frac{1}{i_0 + i_c} \cdot \frac{E}{2} \cdot \frac{G(bE/2)}{\phi(bE/2)} \quad (10.7) \quad (10.8)$$

i.e.,

$$R_1 = \frac{1}{bi_0 + bi_c} \cdot \frac{(bE/2)\,G(bE/2)}{\phi(bE/2)} \quad (10.9)$$

The function

$$\psi(x) = \frac{xG(x)}{\phi(x)}$$

is shown plotted in Fig. 15. By means of this curve the variation of R_1 with E or with R can be very easily calculated. The curves of Fig. 16 illustrate the results for a valve having the grid constants

$$a = 3 \times 10^{-6}$$
$$b = 5$$

The chief points to be noted are:—

1. The effective high-frequency input resistance increases with the magnitude of the grid-circuit resistance (although the high-frequency currents do not flow through this resistance).

2. For a given grid-circuit resistance the effective high-frequency input resistance will decrease if i_0 is increased (*e.g.*, by applying an additional positive voltage v in the grid circuit). This point will be considered more fully later.

3. For small values of x, $\psi(x)$ does not differ very greatly from unity, which value it approaches as a limit when $x = 0$. The limiting value of the input resistance is therefore $1/bi_0$, which is otherwise obvious, since this is the slope of the grid voltage—grid current characteristic at the initial point of operation.

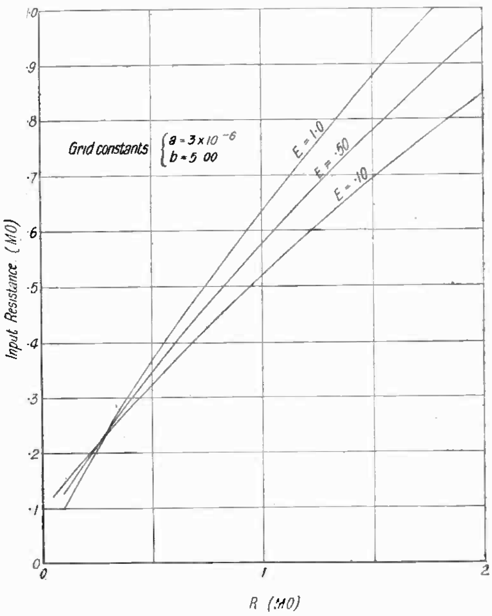


Fig. 16.

4. For a given grid-circuit resistance the input resistance increases with the signal amplitude, but the increase is relatively small.

11. *Independent control of the initial equilibrium, i.e., the effect of a grid potentiometer.*

From equation (7.2), the initial equilibrium is given by

$$i_0 = a\varepsilon^{bv}\varepsilon^{-bv_0} \quad .. \quad (11.1)$$

The initial grid potential v_g is

$$v_g = v - i_0 R = v - v_0 \quad .. \quad (11.2)$$

[1] See Appendix II.

By a simple transformation equation (11.1) can be put in the form

$$v = v_g + aR\varepsilon^{bv_g} \quad .. \quad (11.3)$$

from which the values of v corresponding to known values of a, b, R, and v can easily be calculated. As an example the following table gives the results for a valve having the grid constants.

$$a = 3 \times 10^{-6}$$
$$b = 5$$
$$R = 10^6$$

v_g	v	R' Megohms.	$1/bi$ Megohms.
−.75	−.80	14.6	3.70
−.50	−.62	5.2	1.48
0	−.40	1.0	.495
.5	−.28	.36	.271
1.0	−.19	.20	.173
1.5	−.13	.10	.128
2.0	.08	.08	.100
2.5	.03	.02	.078
3.0	.00	.00	.066

The table also gives the values R', which is written for the magnitude of the grid-circuit resistance which would give the same initial grid potential in the absence of any additional applied continuous potential.

The above typical example will show the nature of the control of the initial equilibrium given by a grid potentiometer. It will be seen that a variation of the applied grid potential from .75 volt negative to plus 3 volts produces the same effect on the initial equilibrium as a variation of the grid-circuit resistance from 0 to 15 megohms. This does not mean that a grid potentiometer is in every way equivalent to what is generally known as a variable grid-leak, for it is only in respect of the initial equilibrium that they are similar in effect.

The effect of an additional applied continuous grid potential on the rectification performance of a valve is most easily seen in the equation for small signal amplitudes given in section 9, *i.e.*,

$$v_c = \frac{R}{R + 1/bi_0} \frac{G(bE/2) - 1}{b} \quad .. \quad (11.4)$$

The important thing to notice is that the second term on the right hand side, *i.e.*, the rectified E.M.F., depends only on b and the signal amplitude. The applied continuous grid voltage will therefore not affect this term at all. The remaining term, however, which determines what fraction of the rectified E.M.F. shall be available as a change of mean grid potential, will increase as i increases, *i.e.*, it will increase with an applied positive grid potential. It appears therefore that an applied positive grid potential does not increase the rectified E.M.F. but does increase that fraction of the rectified E.M.F. which is available as a change of mean grid potential.

Whether or no this will result in any increase in effective sensitivity in any given practical case will depend on the conditions of operation. It must be remembered that the above analysis has been based on the assumption of a constant input voltage. In practice the input voltage will depend to a greater or less extent on the damping imposed on the receiving circuit by the detector, and the increase of intrinsic sensitivity associated with an applied positive grid voltage will be accompanied by an increase of the damping effect of the detector. This is shown in the above table, which gives the values of $1/bi_0$, *i.e.*, the effective input resistance for small amplitudes, corresponding to various applied continuous grid voltages.

Further, it will be shown in a later section that the magnitude of the grid condenser must be such that its impedance at the frequency of operation is small compared with $1/bi_0$. A decrease in the latter will, therefore, call for an increase in the magnitude of the grid condenser, and this, for reasons to be given later, may be very disadvantageous.

In view of the above considerations, it is clearly impossible to generalise, but it seems likely that in most cases a small applied positive voltage will be advantageous, particularly if the increased damping so produced can be compensated for by reaction.

APPENDIX I.

The evaluation of $\frac{1}{T}\int_0^T \varepsilon^{bE \sin \omega t} . dt$.

$$\frac{1}{T}\int_0^T \sin^{2p}\omega t\, dt = \frac{1.3.5\ldots(2p-1)}{2.4.6\ldots 2p}$$

$$\varepsilon^{bE\sin\omega t} = 1 + \sum_{n=1}^{n=\infty}\frac{(bE\sin\omega t)^n}{n!}$$

$$= 1 + \sum_{p=1}^{p=\infty}\left\{\frac{(bE\sin\omega t)^{2p}}{(2p)!} + \frac{(bE\sin\omega t)^{2p-1}}{(2p-1)!}\right\}$$

Therefore

$$\frac{1}{T}\int_0^T \varepsilon^{bE\sin\omega t}\, dt = 1 + \sum_{p=1}^{p=\infty}\frac{(bE)^{2p}}{(2p)!}\,\frac{1.3.5\ldots(2p-1)}{2.4.6\ldots 2p}$$

$$= 1+\sum_{p=1}^{p=\infty}\frac{(bE)^{2p}}{(2)^{2p}}\,\frac{1}{p!^2}$$

$$= 1 + x^2 + \frac{x^4}{2!^2}+\frac{x^6}{3!^2}\ldots \text{etc., } \textit{ad inf.}$$

where

$$x = \frac{bE}{2}$$

APPENDIX II.

The amplitude of the fundamental component of the high-frequency current in the grid-circuit is given by

$$I_1 = \frac{2a}{T}\int_0^T \varepsilon^{b(v-v_0-v_c)}\varepsilon^{bE\sin\omega t}.\sin\omega t\, dt$$

$$\varepsilon^{bE\sin\omega t}.\sin\omega t = \sin\omega t + \sum_{n=1}^{n=\infty}\frac{(bE)^n}{n!}\sin^{n+1}\omega t$$

$$=\sin wt + \sum_{p=1}^{p=\infty}\left\{\frac{(bE)^{2p}}{(2p)!}\sin^{2p+1}\omega t + \frac{(be)^{2p-1}}{(2p-1)!}\sin^{2p}\omega t\right\}$$

Therefore

$$\frac{1}{T}\int_0^T \varepsilon^{bE\sin\omega t}\sin\omega t\, dt = \sum_{p=1}^{p=\infty}\frac{(bE)^{2p-1}}{(2p-1)!}\,\frac{1.3.5\ldots(2p-1)}{2.4.6\ldots 2p}$$

$$=\sum_{p=1}^{p=\infty}\frac{(bE)^{2p-1}\,2p}{(2.4.6\ldots 2p)^2}$$

$$=\sum_{p=1}^{p=\infty}\left(\frac{bE}{2}\right)^{2p-1}\frac{p}{p!^2}$$

Therefore

$$I_1 = a\varepsilon^{b(v-v_0v_c-)}.2\left\{x+\frac{2x^3}{2!^2}+\frac{3x^5}{3!^2}+\frac{4x^7}{5!^2}\ldots \text{etc., } \textit{ad inf.}\right\}$$

where

$$x = \left(\frac{bE}{2}\right)$$

(To be continued.)

A Loud-Speaker Receiver on A.C. Mains.

By P. Johnson (G5IS). **[R343·7.**

Describing the principles and method employed to obtain both filament and anode current from the house mains.

LAST winter the writer carried out some experiments with a view to obtaining good loud-speaker signals from the local broadcasting station. Having 220V 50~ mains laid on at the house, these were used for the supply of L.T. and H.T. It was necessary that the apparatus should be cheap and reliable, and after many tests with thermionic rectifying valves, these were dropped, figuratively speaking. Firstly, valves suitable for the job are expensive; and secondly, filaments do not last for ever. A measure of success was attained by their use, but the greatest difficulty experienced was in getting perfect smoothing of the H.T. supply.

The Nodon cell was then pressed into service. Many experimenters regard the chemical rectifier as a messy arrangement which only rectifies on occasions and then only for short periods. Now the chemical cell, if made up with pure materials and a little care, is extremely cheap and reliable. In the case of the receiver to be described, the rectifier has been in use for five months and is still running without the slightest defect or cause for dissatisfaction. During this time it has had no attention whatever. The cells were constructed at a cost of about 9d. each, and four cells at a cost of 3s., or even eight at 6s. are cheaper than thermionic valves at 30s. each. Further, comparing performances, the writer prefers the chemical cells on account of the ease of smoothing the output.

Before giving a description of the receiver, the rectifying cells will be described. The containers are glass jars of a type generally used as receptacles for chemicals, and, like the rest of the material used in the cells, were purchased from Messrs. Griffin of Kingsway, London. The jars are $5\frac{3}{4}$ inches high, $2\frac{1}{2}$ inches square, and are fitted with flat corks $1\frac{1}{2}$ inches in diameter and $\frac{1}{2}$ inch deep. The aluminium electrode is of 2 mm. wire, the length of the submerged portion being $3\frac{1}{4}$ inches. The other electrode is a carbon rod 6 inches long and $\frac{1}{4}$ inch in diameter, such as is often used for optical lantern arcs. Connection is made to the carbon by taking three turns of tinned copper wire round the end of the rod, running a spot of solder between the turns, and while hot twisting the ends of the wire with pliers. On cooling and consequent contraction, the wire binds tightly on the carbon and good electrical contact is

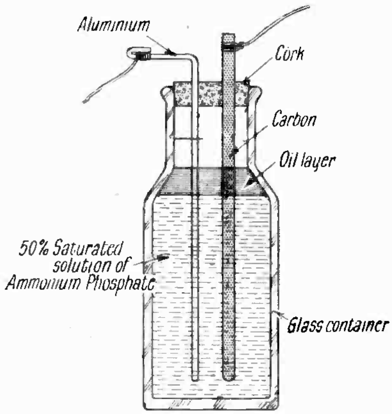


Fig. 1.

assured. In the case of the aluminium, the connection is made by wrapping several turns of the connecting wire about half an inch from the end of the aluminium and then nipping them by bending back the end of the aluminium with pliers. The electrodes are held in position by punching holes in the corks (see Fig. 1).

The electrolyte used is a solution of ammonium phosphate, and only chemically pure material should be used. The writer does not recommend the use of a saturated solution. Fifty per cent. saturation is sufficient, and the aluminium will keep quite clean and uncorroded for long periods.

Before putting the cells into use, it is most important that the aluminium electrodes be formed. Two rods should be placed in a jar of solution, and plugged across the mains with a lamp of the same voltage as that of the mains in series. The lamp will

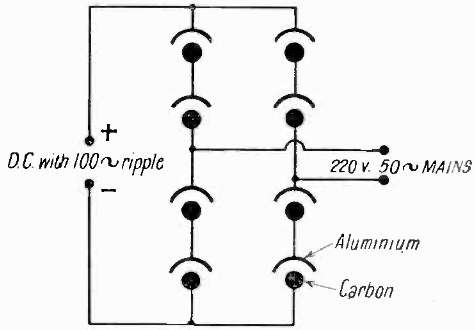


Fig. 2a.

light up fully for a moment and then slowly die out. When the lamp is extinguished, forming is complete, and if the operation is performed in a dark room, the electrodes will appear to be covered with a luminous sheen.

The glass jars should be filled up to the shoulder with fresh electrolyte and the carbons and aluminiums fitted into the corks. To complete the cells, a layer of light oil about half inch deep is floated on the electrolyte. Medicinal paraffin is excellent for this purpose, as it is without smell and of the right viscosity. The oil prevents creeping and evaporation of the electrolyte. To experimenters who have used electrolytic cells of this description, the cells may appear large when taking into consideration the small load. It must be remembered, however, that rectifiers must be kept cool, and with ample electrolyte, they are kept cool by convection.

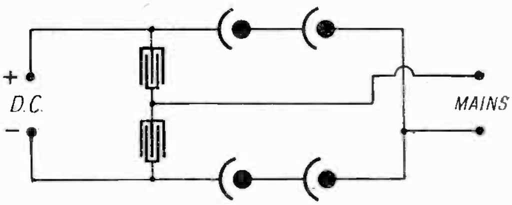


Fig. 2b.

Two systems of full-wave rectification may be used, and are shown diagrammatically in Figs. 2*a* and 2*b*. In Fig. 2*b* the condensers should be of large size, four μF or more, as they must be of low reactance at the supply frequency. It will be noticed that only four cells are necessary in this circuit, and as much as twice the voltage of the mains is available at the output terminals. On load, the voltage drops by an amount depending on the resistance of the cells and the size of the condensers used.

without the use of a normal earth, as the H.T. is earthed through the mains.

The H.T. smoothing circuit consists of a choke (which is the secondary of a burnt-out L.F. transformer in the writer's case) and a $2\mu F$ condenser. This will be found to eliminate all H.T. ripple.

The complete circuit, receiver, H.T. smoother, rectifier and L.T. supply is shown in Fig. 3.

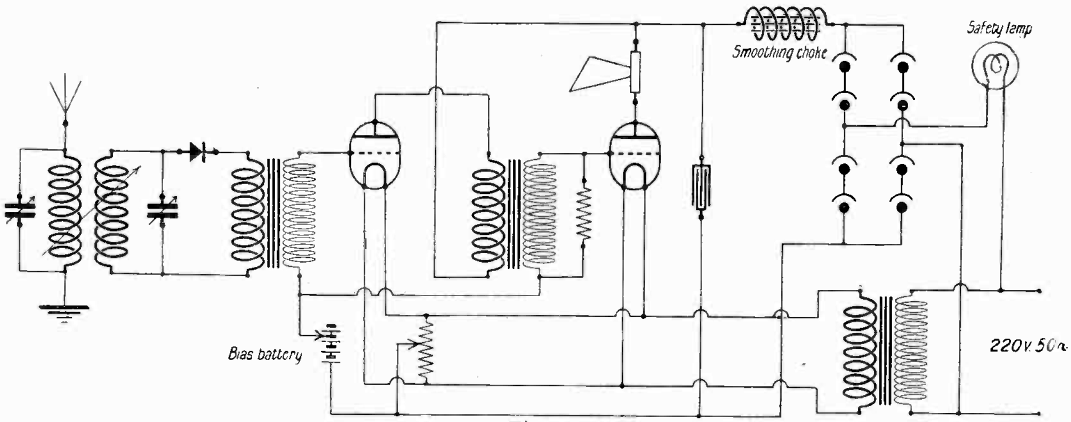


Fig. 3.

Using this circuit on the 220V, 50~ mains, two L.S.5 valves are comfortably supplied with 300V. For safety's sake, however, a lamp is included in the main's side of the rectifier, and so the voltage is reduced to about 200 on load. This is ample voltage for any British valve used in loud-speaker work.

With reference to the use of a carbon rod in place of the more usual lead electrode, it will be found that after several hours' use the carbon appears to dissolve to a slight extent. The electrolyte becomes discoloured, and after about 250 hours' working it appears quite inky. Whether the carbon does dissolve or whether the discolouration is caused by finely divided particles in suspension, the writer admits he does not know. Perhaps a chemist will explain. At any rate, there is no apparent loss of efficiency.

A tip for users of A.C. mains of 220V 50~ is the use of old Ford spark coils as transformers. The secondary winding is put across the mains, and about 3 volts A.C. is available from the other winding.

As one side of the mains is usually earthed, a loose-coupled circuit should be used; alternatively, a well insulated counterpoise earth. If the local station is within a few miles, good signal strength may be obtained

Should it be desirable to use a valve detector in place of the crystal, it is most important that anode rectification should be used, and not cumulative grid rectification. Hum and distortion are certain to be present if the latter method is used, and for fairly strong signals, anode rectification gives far superior quality. The connections for valve detection are given in Fig. 4.

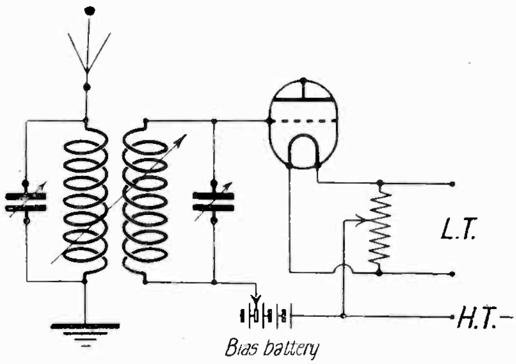


Fig. 4.

In conclusion, the writer would be pleased to hear from anyone who finds this article of use, and would be glad to help in any cases of difficulty.

Some Recent Research on Crystals.

By John P. McHutchison, M.A., B.Sc., and George T. MacLeod, B.Sc. (Hons.).

[R374.1

IT is a remarkable fact that the action of the crystal in a wireless receiver is still unexplained, and that no adequate theory of the changes occurring at a crystal rectifying-point has yet been advanced. On the basis of different physical or chemical ideas many suggestions have been made, but no satisfactory solution has so far been obtained, and the probability is that the final complete theory awaits the discovery of new facts.

The problem has been approached from many angles, and in the pages of the *Wireless World* has appeared the record of much pioneer work by Strachan. In the present article a new viewpoint is suggested, and a brief account is given of recent research on these lines.

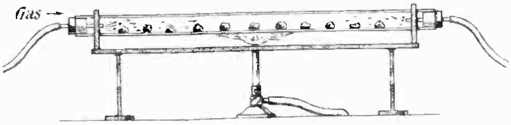


Fig. 1.

The starting point of the experiments to be described was that crystal action appears to be essentially a surface action, and that the interior of the crystal is not involved except as an ordinary metallic conductor. Rectification seems to depend upon a light contact between two conducting surfaces, and the action is believed to occur only in a very thin film, perhaps but a few molecules thick. Experimental facts are not lacking in support of this view, and perhaps the two most conclusive are amongst those that emerged in the course of some work conducted by one of us some time ago, and described elsewhere. These illuminating facts are :—

1. Rectification is obtained when the surface of *pure clean* mercury is *just* broken by a clean metallic point.
2. Two similar pieces of pure copper wire in light contact produced rectification.

Our object was, therefore, to investigate the nature of the surface of a rectifying crystal, and in particular to produce a good rectifying surface on galena, which generally does not rectify well in the natural state. Most of the proprietory brands of crystals appearing with pseudo-mineralogical names are of the galena type, and the majority of these are, no doubt, treated galena (lead sulphide).

Our first experiments were concerned with producing sensitive crystals from ordinary insensitive lumps of galena ore.

The Effect of Heat on the Surface of Galena Crystals.

Heating lead sulphide (PbS) in air, simply results in partial oxidation to lead sulphate ($PbSO_4$), which, since it is a non-conductor, cannot rectify. The heating had therefore to be done in a non-oxidising gas. The apparatus used is shown in Fig. 1.

Coal gas, which was the first to be tried, was passed slowly over pieces of crude galena contained in a combustion tube, heated by a spread flame, so that the different crystals were subjected to different temperatures, varying from 300°C to 800°C.

The heating was continued for four to five hours, and the crystals were cooled in a current of coal gas. The result of the treatment was very marked, in that crystals heated in the 800°C area were dull and tarnished, and on being tested were found to rectify splendidly (see below for methods of testing). When viewed through a microscope, the tarnished areas were seen to be covered with tiny cubic crystals of galena, whereas before treatment the surfaces were perfectly plane and clear. Several photomicrographs were taken with a Bausch and Lomb microscope and camera, using a 100 c.p. tungsten arc "Pointolite" for illumination.

Fig. 2 shows the surface of an ordinary insensitive piece of galena ; Fig. 3 shows the same piece after treatment as described above, the small squares being really the faces of very tiny galena crystals, which had been formed by the heating.

It appears therefore that the microscopic growth of cubic lead sulphide crystals had been formed on previously flat planes, and that the presence of these minute crystals was in some way responsible for rectification. It must be noted that the tiny crystals formed by this treatment were far too small to be apparent, as such, to the unaided eye, and were only detected by microscopic examination.

The results obtained suggested further heating of crude crystals of galena in other gases, all necessarily non-oxidising. The gases tried and the results obtained are shown in the following table.

this growth occurs is not exactly certain. It may be that the microscopic cubes are formed by sublimation and subsequent condensation, and indeed one treated specimen showed square markings on an otherwise plane surface.

The growth was most plentiful along cleavage lines, and was practically unobtainable on a polished surface, as is indicated by the photomicrographs (Figs. 4 and 5).

The action is certainly not a case of etching, for however produced, the cubes appear to be deposited on the crystal surfaces and stand out from it.

	Chemical Formula.	Gas.	Remarks on Appearance of Treated Crystals.	Degree of Rectification.
I.	—	Coal gas.	Surface tarnished.	*First class.*
	H_2	Hydrogen.	Surface clear and sparkling.	
II.	H_2S*	Sulphuretted hydrogen.	Very similar in appearance to hydrogen.	Fairly good, but definitely poorer than Group I.
	SO_2	Sulphur dioxide.	The others in this group also similar, but less well-marked crystal growth.	
	NH_3	Ammonia.		
	CO_2	Carbon dioxide.		
	N_2	Nitrogen.		
III.	N_2O_4	Nitrogen peroxide.	Surface blackened with deposit of carbon owing to decomposition of gas.	Poor.
	CH_4	Methane.		
	C_2H_2	Acetylene.		
IV.	Cl_2	Chlorine.	Surface attacked.	No rectification whatsoever.

* Heating in this gas was first suggested by Mr. W. Jamieson, B.Sc.Lond.

Interpretation of Results.

Galena rectification in its best degree would appear to be associated with the formation of *microscopic* crystals. How

Methods of Estimating the Degree of Rectification.

A simple receiver was employed with three crystal detectors, two containing

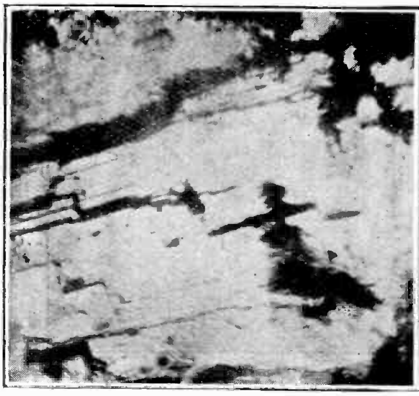


Fig. 2. *Natural galena.*

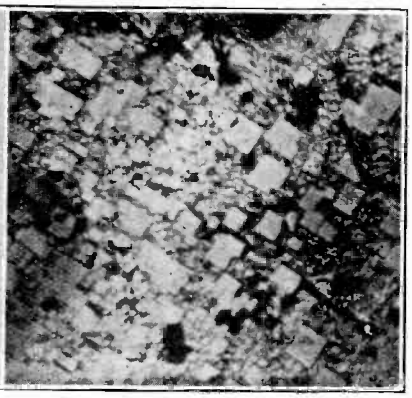


Fig. 3. *The same piece of galena after treatment in coal gas as described.*

standard brands of crystals, the other being the treated specimen. It was thus possible to have immediate comparison of the laboratory crystals with market crystals. The methods employed for testing were :—

1. Personal estimate on 5SC's transmission.

2. Tuning out oscillations from a buzzer.

3. A directional method due to Fleming.

4. Comparative values obtained by shunting phones with a P.O. box, and putting in resistances till the phone signals were inaudible. The formula used was :—

$$S = \frac{R + r}{R} \text{ where}$$

S = degree of rectification (comparative).

R = resistance in P.O. box.

r = resistance of phones (generally 4 000Ω).

5. Deflection of galvanometer (D'Arsonval type).

Characteristic Curves for Treated Crystals.

These were determined in the usual way, and were noticeably different for the three grades of crystals produced as in Table above (see Fig. 6).

It will be noticed that the curve obtained for the poor crystal is very close to the straight line demanded by Ohm's Law for a non-rectifying point.

One or two other experiments, mostly negative in results, may perhaps be noted.

1. Treatment in Liquids.

A few tests were made to discover if boiling in hot liquids would cause the forma-

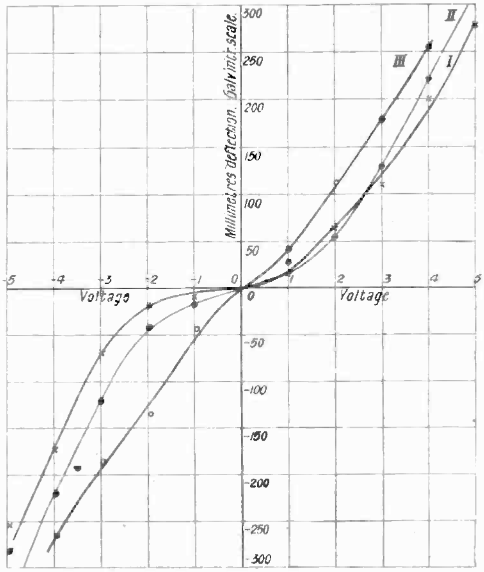


Fig. 6.

Characteristic Curves for the Crystals treated.
Curve I : Good rectifying crystal.
,, II : Second grade crystal.
,, III : Poor crystal.

NOTE.—*Each ordinate is the average of a number of readings for various test points taken on the surface of each crystal. The curves so obtained were indicative of the quality of the particular crystal, but were not sufficiently accurate to give precise degree of rectification.*

tion of a sensitive layer. For the most part no improvement in detecting qualities was noted, although boiling for five hours in

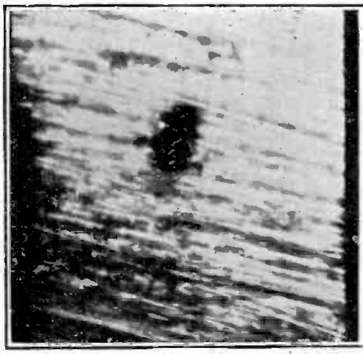


Fig. 4. *A piece of natural galena polished to a high degree of brilliance on a polishing lap.*

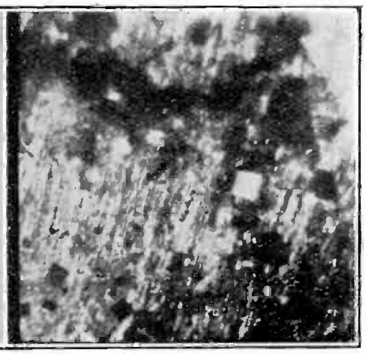


Fig. 5. *The same piece. Note that few cubes have been formed.*

ammonium sulphide solution produced slightly sensitive crystals. No real results were perhaps to be expected from this method, since the temperature at which the deposition of the minute cubes occurred in the previous experiments was several hundred degrees higher.

2. Effect of Medium.

If, as appears most likely, rectification is solely a surface phenomenon, it would be quite feasible that a change in the medium surrounding the detecting point might make some alteration in the action. It was considered that if some gas other than air were employed, a poor crystal might be improved, and a good crystal made better. A Burndept detector was used, and two side tubes sealed on the glass cylinder for the admission of the gas, and numerous tests were made, but no change of any kind was noted.

When the detecting point was immersed in a *liquid*, no alteration took place unless the liquid was an electrolyte, when rectification was completely destroyed. Non-electrolytes, such as chloroform, alcohol, or carbon tetrachloride produced no effect at all.

Still relying on the surface nature of detection, two other series of tests were made:—

1. Various kinds of crystals were sealed into a tube with radon (*i.e.* radium emanation) and an active deposit of great electronic emitting power was thus formed on the surface of the crystals. The result was that the rectifying power was removed, since as in the case of the electrolytic medium ordinary electric conduction formed an easier path than the high resistance of the crystal point.

2. A very good galena rectifier was made most simply by precipitating lead sulphide from a solution of a lead salt with sulphuretted hydrogen gas. The precipitate was thoroughly washed, dried in a water oven, and then compressed tightly in a tabloid press. The sides of the galena sticks thus produced, polished in the process of compression by rubbing on the walls of the tabloid press, were found to have excellent rectifying surfaces.

A Short Wave Tuner.

THE "Bruno" 99 Tuner, which is being marketed by the Wholesale Wireless Co., of 103, Farringdon Road, London, E.C.1, has just been tested by us, with very good results.

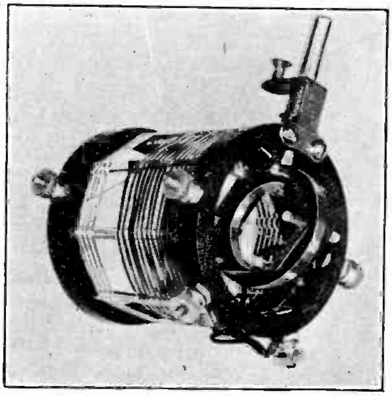
The tuner is designed for short wave work, from about 20 to 100 metres, and comprises three specially wound coils, an aerial coil, with fixed coupling to a secondary coil, and a reaction coil, which is rotatable within the secondary.

The former on which the aerial and secondary coils are wound is made of a number of quartzite rods supported by two rings of ebonite, on which the various terminals are fixed.

The aerial and secondary coils themselves are wound with strip metal about 1/16 in. wide, the metal being copper or phosphor-bronze in the case of the secondary coil and what appears to be aluminium in the case of the aerial coil. The numbers of turns in these coils are respectively 12 and 4, the reaction coil having 15 turns. This coil is fitted with a ¼ in. spindle, to which a knob can be attached. The aerial coil is untuned, and is spaced about ½ in. from the secondary.

We confined our tests to the secondary coil alone, and found that the inductance was $10.9\mu H$ the H.F. resistance was 0.9 ohm, the self-capacity $2.5\mu\mu F$ and the power factor .004 8. As would be expected from the design of the tuner, these results are very good, the power factor being particularly low.

To get an idea of the tuning range, we calculated the minimum and maximum wave-lengths which would be obtainable with a .000 $25\mu F$ variable condenser. The minimum wave-length is, of course, largely dependent upon the minimum capacity of the condenser and the capacity between connecting leads. Taking this total minimum capacity to be $20\mu\mu F$, the minimum wave-length of the tuner will be about 27 metres and the maximum about 102 metres.



The short-wave tuner described herewith. It should be useful for DX reception work.

Owing to the constructional difficulties of a component such as this, the price is necessarily higher than usual, being 36s. Those, however who are interested in short wave work (and there will be many during the coming winter), will not object to this, providing the tuner is really good, as is this one.

Autumn Presidential Address to the Radio Society

23rd September, 1925, on

The Mechanism of Radiation.

By Sir Oliver Lodge. **[R110·6**

WHATEVER radiation may be it is certainly an affair of the ether: it is the way in which the ether transmits energy. Thus and thus only is energy transmitted across empty space, that is across space empty of matter. There are reasons for asserting that no piece of matter is in contact with any other piece, and that between every atom, or the constituents of every atom, empty space exists, that is to say every part of space is filled with ether. And the connection between one piece of matter and another—the connection between world and world, and the connection between atom and atom—is maintained by radiation.

Radiation travels at one definite velocity, which must depend on the medium through which it moves, that is on the properties of the ether. Hence to understand the mechanism of radiation we ought to understand the constitution of the ether.

But we don't.

There have been attempts to regard the ether as an elastic solid; or alternatively as an extremely viscous liquid like pitch, rigid to rapid forces, permeable to slow ones. The only justification was that such a solid would transmit transverse waves, whereas no simple fluid can transmit any but longitudinal waves. Lord Kelvin expended much ingenuity on elastic solid theories of the ether, but in the end had to confess failure. No mechanical theory of radiation works.

Clerk Maxwell's electro-magnetic theory does work. Certainly the radiation is due to a combination of the ether's electric and magnetic properties, the lines of force being at right angles to each other and in the same phase, with the direction of propagation at right angles to both.

But an electro-magnetic explanation is not ultimate. We want to know more about what electricity is and what magnetism is. There have been attempts to explain the magnetic field in terms of spin; and indeed many of the magnetic properties of atoms suggest gyrostats. So that there have been attempts to explain the transmission of transverse waves of a fluid in terms of vortex motion. The elasticity necessary can be imitated by an arrangement of gyroscopes. Lord Kelvin initiated a theory of kinetic elasticity, in which springs could be imitated by rigid bodies in spinning motion. And FitzGerald tried to work out a theory of the ether in terms of what he called a "vortex sponge."

These elaborate and difficult mathematical attempts are imperfect at present: there are difficulties about stability. But the last word has not been said about them: they may turn out to be steps in the right direction. The effort should not be abandoned until all the possibilities associated with the hydrodynamics of a perfect fluid are exhausted. Vortex theory is a complicated branch of mathematics; indeed it is not so very long since it was begun, by Helmholtz.

If this hydrodynamic could be developed and fully worked out, it is probable that the whole of Physics would be covered; moreover a complete treatment of Physics would include Chemistry, and in fact would constitute an explanation of the material universe, except in so far as Life and Mind may modify it. But notice that even a complete theory of the purely material universe would not allow for free will or planning for the future; everything would be controlled and dependent on the present and the past; and inasmuch as this is contrary to experience, we perceive that the material universe is not the complete universe, that the universe as a whole contains a great deal else. Nevertheless from the point of view of the physicist he may reasonably strive to reduce his aspect of it to ether in various states of vortex motion.

For what we know primarily through our senses is matter. It is that of which our bodies, and therefore our sense organs, are composed; and it may be said that they tell us of nothing else. (Even matter is an inference from our senses of force and motion. But let that pass. Most things are really inferences; for without intelligent appreciation and interpretation our information would be very small.)

Meanwhile it is interesting to see what position the intuition of Faraday led him to take about the nature of radiation, nearly a century ago.

He (Faraday) begins one of his papers with the following passage :—

Extract taken from Supplement to NATURE, *27th June*, 1925.

"That wonderful production of the human mind, the undulatory theory of light, with the phenomena for which it strives to account, seems to me, who am only an experimentalist, to stand midway between what we may conceive to be the coarser mechanical actions of matter, with their explanatory philosophy, and that other branch which includes or should include, the physical idea of forces acting at a distance.

"And admitting for the time the existence of the ether, I have often struggled to perceive how far that medium might account for or mingle with such actions generally, and to what extent experimental trials might be devised, which, with their results and consequences, might contradict, confirm, enlarge, or modify the ideas we form of it, always with the hope that the corrected on instructed idea would approach more and more to the truth of nature, and in the fullness of time coincide with it."

We have now in this century analysed matter into electrons and protons, that is into electric charges. Electricity and magnetism are affairs of the ether, hence matter is resolved into modifications of ether, just as much as radiation is. What kind of etherial motion constitutes an electron we do not yet know, but that is not our present business. We want to know what kind of motion constitutes radiation, and even that we cannot answer fully. We have to explain radiation in terms of the known and comparatively familiar phenomena of electricity and magnetism. This was begun by Clark Maxwell and continued by Hertz.

In the 'seventies and 'eighties of last century there were many of us contemplating Maxwell's waves and trying to produce them. I partially succeeded, but Hertz went one better, displaying them in a wonderful manner and also giving their theory in some detail, based upon Maxwell's more general theory, but worked out by Hertz with consummate skill. The mechanism of Hertz radiation, that is of the ether waves we use in wireless telegraphy, can be represented diagrammatically in a well-known way in terms of lines of force.

Referring to Hertz's diagram of the lines of force caused by electric charges surging up and down an aerial or dumb-bell radiator, it is well known that the lines cross or intersect at one point (about a quarter wave-length distant from the origin), and that beyond that point a loop is thrown off. The energy nearer the crossing-point returns to the conductor; the energy beyond that crossing-point advances out into space as independent wave motion. A certain amount of energy is shocked off at every oscillation, in accordance with diagrams illustrating the lines of force in different phases.

The question arises whether these lines of force are physical realities or only geometrical abstractions. Most of us thought they were abstractions. Faraday seems sometimes to have had an instinct that they might be real: and that great master in Physics, Sir J. J. Thomson, has always had a suspicion that they were real, and has treated them accordingly; and now the discovery by Max Planck of the quantum seems to me to justify that suspicion, and in a sense to confirm or corroborate some of the speculations of Sir J. J. Thomson, which hitherto perhaps have been looked at rather askance.

To understand what I mean by this, let us return to the Hertz diagram for the emission of radio waves. If the lines of force are realities, the loops which are thrown off by a transmitting aerial are not mere pictorial representations or diagrammatical illustrations but are a bundle of physical realities, each loop with an independent existence, *each loop constituting a quantum.*

Hitherto it has been thought that the idea of the quantum only applies to ultra-microscopic Physics, that it is not met with until we come to atomic dimensions, that it has to do with the discontinuities of atomic matter, and that for large-scale phenomena the quantum need not be considered. Certainly in engineering practice the quantum need not be considered, for it has no practical bearing on large-scale phenomena. Nevertheless I think it exists, though of so feeble an intensity that myriads are required to achieve any result, and that accordingly the individual quantum can be ignored. I conceive therefore that what we detect in radiation emitted by atoms is also occurring in radiation emitted by antennæ. But here I think I am in conflict with the views of Sir J. J. Thomson as so far expressed: at any rate he is not responsible for what I say on this part of the subject, and he may disagree with it; in which case it is likely to be wrong. But I put it out for what it is worth, in order that it may be criticised. What I suggest is that *the quantum arises from the reality of lines of force.*

I have said that a Hertz radiator emits quanta. And it is quite easy to calculate their energy for radiation of any given wave-length. Their energy is simply inversely as the wave-length.

The expression is hc/λ; that is, if the energy is measured in ergs, and the wave-length in centimetres.

The energy in ergs is $\frac{18 \times 10^{-17}}{\lambda}$

For instance, if $\lambda = 180$ centimetres an energy quantum is the trillionth of an erg. So you see it is fearfully small for radio waves; but it is a good deal bigger for short waves than for long ones. The number of quanta emitted in a single swing of an aerial must be enormous; it will depend on the number of its lines of force, and that must at least be as numerous as the electrons in the terminal charge. Knowing the terminal charges, we can reckon the number of electrons. We can thus see how many lines of force go to a single electron. We can also reckon it in terms of energy; but I am not going to trouble you with arithmetic. Suffice it to say that the kind of quanta emitted by an aerial are individually very large and very feeble: so that to absorb them something nearly as large as that which emitted them, that is some kind of aerial, is required. They are not likely to have any effect on atoms and their attached electrons.

Have they then no effect on loose electrons? Can they not make an electron jump at all? Yes, they can, and we can reckon how much they will make an electron jump, that is what speed they can impart to it. Being big, they will encounter a great many, but, being weak, they won't make them jump much.

Absorption of radiation only occurs when an atomic electron is made to jump out of one orbit into another, or it may be out of its orbit into free space. To do that requires quite a lot of energy. A quantum has to be energetic to do that. But there would be no absorption if it was not done, and accordingly these long waves are not absorbed by any crowd of electrons they may encounter. Short waves are absorbed in a curious metrical and definite manner, in accordance with the theories of Bohr, thereby giving a definite absorption spectrum. But that again is not our present business.

That the long waves actually do disturb free electrons a little, is required by the theories of long-distance transmission, and the Heaviside layer, and all those ideas so well elaborated of late by Eccles and Larmor. And it is easy enough to reckon how much the quantum of radiation of any wave-length will make an electron jump. For the equation is:—

$$\frac{hc}{\lambda} = \frac{1}{2} mv^2$$

And since h and m are of the same numerical order of magnitude in the c.g.s. system, we may say that on that system of units the order of magnitude of the velocity imparted to an electron is $\sqrt{\frac{c}{\lambda}}$.

Or more closely $\sqrt{\frac{13c}{\lambda}}$ centims per sec.

For a wave 40 metres long this amounts to 100 metres a second (which for an electron is exceedingly slow), about 200 miles an hour, that is of the order of magnitude of some motor cars and aeroplanes.

The voltage required to give such a speed as that to an electron is next to nothing. ($V = 3 \times 10^{-16} u^2$) about the thirty millionth of a volt.

Nevertheless though the waves have but little effect on the electrons, loose electrons, ionised by other means, have some effect on the waves; and it appears to be owing to that effect that some of these long waves are able to curl round the earth without absorption and reach the Antipodes.

Atomic Radiation.

Now let us contemplate atomic radiation, which, as many of us know, is on Bohr's theory due to the drop of an atomic electron from one orbit to another; or a drop from space into one of the atomic orbits. Many have been the attempts to explain how such a drop can emit radiation. I have tried to think of the nucleus of the atom as surrounded by a series of elastic films, due to some ether vortex motion, which catch and retain the electron, and quiver with the impact. But it does not seem to work, and I don't think I have ever published the attempt. It seemed to have promising features, but they tended to evaporate on further scrutiny; and whenever that happens one may suspect that one is off the track of truth.

A much better attempt has been made, quite recently, by Sir J. J. Thomson, in the *Phil. Mag.* for October last year, and has been used by him as a theme for popular exposition in his Fison Memorial Lecture at Guy's Hospital on the 7th May this year, with Lord Balfour in the Chair, a Lecture which has just been issued by the Cambridge University Press under the title *The Structure of Light.*

For, mark you, the structure of light has been under debate through about half the years of the present century, that is for about a decade. Some of you have heard Professor Lorentz lecture brilliantly on the subject at the Royal Institution. The theory of quanta and the undulatory theory of light were in the field against each other. They each explained one set of phenomena and declined to explain the other. When the action of light on atoms and electrons was under consideration, the quantum theory was supreme, and the wave theory hopelessly out of it. When the long-known phenomena of Optics were being treated, the quantum failed utterly, and the wave theory was entirely satisfactory, enabling new results to be predicted, as well as accounting for the old. Each was supreme in its own domain, and hopeless in the other. The conflict was likened to a fight between a tiger and a shark: they never really came to grips. But everyone had a sort of feeling as if somehow they must both be true, and Sir J. J. Thomson has made a valiant attempt to reconcile them.

Present extended knowledge seems to revive the old theory between the corpuscular and the wave theory; and it has been found that Sir Isaac Newton, though the founder of the corpuscular theory of light, perceived that a wave theory was necessary too, that is, his corpuscles had to be affected with a periodicity in space and time, which might be likened to a frequency or a wave-length. And unless this semi wave-idea was introduced, certain optical phenomena (diffraction, interference, and the like) refused to be explained.

Sir J. J. Thomson's is an attempt to reconcile the corpuscular and wave theories; or at least it may be so expressed, but we must be cautious in our terms. A corpuscle is a thing travelling through the ether at its own speed, depending on the velocity of projection. There is no such phenomenon as that in light. The thing that travels can only be an affection of the ether, for it travels at the one etherial velocity. Sir J. J. Thomson's corpuscles are not real corpuscles, though he seems rather to call them corpuscles and to say that they excite waves which travel at the same speed. I would rather say that they were themselves of the nature of waves in some respects, though apparently vortex rings, but vortex rings with a wave-length equal to their circumference.

My attempt or suggestion is after all only a modification of his, and depends like his on treating the lines of force as realities; but it would seek to explain light in terms of radio or Hertzian waves, that is to say to explain it on the same lines. The effect of a sudden drop of an electron from orbit to orbit is to bend the lines of force and form and liberate a loop, which shall travel out into space as a quantum of energy, a free ether disturbance which can only exist by travelling with the speed of light; but, as far as I can see, travelling edgeways, not broadside on. It is itself a purely etherial disturbance with all the requisite periodicity. It is in fact just like the disturbances we receive on our aerials; it has a definite wave-length, and it requires no supplementary generation of waves for its motion. It is itself a wave, and yet it is itself a projectile.

As emitted by an atom it is exceedingly minute, it may penetrate a great number of electrons without hitting any, but if it does hit any it will give up its energy and make that electron jump. It will make it jump not a little; it may jump enough to get clear out of an atom if the wave-length is sufficiently short, as it is in the case of X-rays. The velocity imparted to an electron by an X-ray wave of length 10^{-8} cm. will be 10^{8} cm. per sec.—1 000 kilometres—which corresponds to 3 volts. Even if the wave-length is rather longer, like that of visible light, it can still make it jump from one orbit to another, and can thereby deliver up its energy to the atom, and thus be absorbed. If it cannot do that, if when it jerks an electron up the speed is not sufficient to carry it to the next stable orbit, the electrons will drop back again and emit a precisely corresponding pulse; so that the radiation will not be absorbed, but will go on just as if nothing had happened, except indeed that it has been retarded a little by the absorption and re-emission. This delay might be supposed to account for the lessening of velocity as waves of light go through a transparent substance. I am afraid it won't work like that however, at any rate I haven't thought about it enough. If the electron is jerked up through several orbits and then drops back to an intermediate one we shall have fluorescence; if the drop back is delayed for some little time (it may be only the fraction of a second or it might be some minutes) we shall have phosphorescence.

But all these things are off our immediate beat. What I want to call your attention to is Sir J. J. Thomson's theory, whether in its original or in a modified form, and especially to call attention to the probable fact, which at present I think has been overlooked, that the same sort of phenomenon which emits Hertz waves on a large scale may emit light and X-rays on an atomic scale, and that the quantum is as real in one as in the other; except that the *atomic* loops are extremely energetic and have a great effect on the atoms over which they pass, giving us the phenomena of photo-electricity, and incidentally (as I think) giving us vision, photographic action, and the photo-synthesis of chemical compounds, especially of starch and sugar in the leaves of trees.

Furthermore we are beginning to learn what radiation can accomplish in the interior of stars. One of the most amazing and interesting discoveries of recent times is the discovery by Eddington of the dissociated gaseous nature of all stars, even those of great density, and the discovery that it is possible to have ionised gas in a condition 50 000 times as dense as water, at the lowest estimate—it may be more than that—proving how absolutely it is true that the ultimate particles of which matter is composed do not come into contact, but can be squeezed nearer and nearer together by forces unknown.

Thus it happens that the companion of Sirius, barely visible even in a large telescope, and yet extremely massive and therefore very bright, is visible so dimly only because it is so small; almost as if something like the sun were compressed until it was no bigger than something like the earth or one of the other planets, say the planet Uranus.

Thus the sciences of Astronomy, Chemistry, and ultimately all other non-mental sciences, will be linked up together, mainly by the phenomena of radiation—that is, by the remarkably comprehensive properties of the Ether of Space.

* * *

At the conclusion of the meeting a vote of thanks was proposed by Admiral Sir Henry Jackson, G.C.B., K.C.V.O., and was seconded by Mr. A. A. Campbell Swinton, F.R.S.

The next meeting will be held on Wednesday, 25th November, 1925, at the Institute of Electrical Engineers, commencing at 6.30 p.m.

Proposed Institute of Radio Engineers.

A general meeting was held in London, on 31st October, to discuss the advisability of continuing with the proposed Institute of Radio Engineers. The Chair was taken by Mr. James Nelson, M.I.E.E.

It is hoped to give a detailed report of the meeting in our next issue.

Volume II. E.W. & W.E.

The present volume (II.) of E.W. & W.E. will be completed with the next issue, which will be followed by both a numerical (Dewey system extension) index and the title index covering the fifteen issues from October, 1924, to December, 1925.

In the next issue there will be given details of binding cases for the complete volume.

The Tantalum Rectifier.

By E. H. Robinson (2VW). [R355·54

Describing a series of experiments and the actual rectifier in use.

THAT a tantalum electrode immersed in a conducting solution shows a rectifying effect has been known for several years. The effect has been studied by a number of investigators, including Dr. Gunther Schulze, who made a prolonged study of the valve action not only of aluminium and tantalum, but a number of other metals in all sorts of electrolytes and under various conditions. Those who are interested in the details of this work are referred to *Science Abstracts* for the last twenty years.

For some reason the tantalum rectifier has not attracted much attention until quite recently; no doubt this is largely due to the expense incurred and difficulty experienced in obtaining tantalum metal. Further remarks on the latter subject will be found at the end of this article. The tantalum rectifier is very reliable, and the efficiency is quite good. The following remarks will help to give the reader an idea of its general properties.

The tantalum rectifier resembles the aluminium rectifier in its general principles, tantalum being used instead of aluminium and dilute sulphuric acid in place of ammonium phosphate; lead may be used as the other electrode. Current will pass from the acid to the tantalum freely, but only to a very small extent in the reverse direction unless the E.M.F. applied to the cell exceeds a certain maximum value, which may be anything from 40 to 200 volts according to conditions.

Before proceeding further, it may not be out of place to say a few words about tantalum itself. Chemically, tantalum falls into the same group as antimony, bismuth and niobium, but in many of its physical properties it resembles the platinum metals. It is one of the most resistant and refractory metals known. It is unattacked by any acid or mixture of acids, excepting, perhaps, hydrofluoric acid, and cold dilute alkalis are said to have no effect upon it. The writer found, to his cost, however, that a tantalum electrode acting as a rectifier in a strong solution of caustic soda became brittle and badly corroded after several hours' use. No such corrosion takes place with acid.

The melting point of tantalum is extremely high (about 2 300° C.), and it was used for filaments in electric lamps before the advent of the tungsten lamp. Commercial metallic tantalum has a dull, silvery appearance, rather like aluminium or platinum. Sheets of the metal a few mils thick are flexible and springy and may readily be cut to the required size with a pair of scissors.

Current Density.

In designing a rectifier for a given purpose, two of the most important things we need to know are the current-density allowable at the rectifying electrode and the voltage to which one cell will stand up. A current density of one ampere per square inch has been found to be quite suitable—that is to say, for every amp of rectified current to be delivered there should be a total area of one square inch of tantalum immersed in the solution (back and front surfaces of electrode being included).

Owing to the cost of tantalum, however, it might be politic to work with a still higher current-density, particularly in the case of high tension rectifiers, where a little extra resistance in the rectifier is not a very great objection.

It will be noted that the rating of one amp per square inch is considerably in excess of the working current-density usual in aluminium rectifiers. The question of the resistance of the rectifier cell and the consequent volt-drop is of particular importance in the case of low-tension rectifiers for charging accumulators. In charging a 6-volt accumulator through a rectifier it may be necessary to use an applied A.C. voltage of anything from 15 to 30 R.M.S. in order to push through sufficient amps, and considering that the resistance of most accumulators is a fraction of an ohm, this implies a poor efficiency. Hence it hardly pays to stint one's dimensions in a charging rectifier.

Electrolyte Experiments.

The voltage allowable per cell depends to a large extent upon the electrolyte. For ordinary dilute sulphuric acid, which seems to be the best all-round electrolyte, there is not much reverse current when 120 volts (R.M.S.) of A.C. is applied to the cell; and for D.C. potentials applied in the reverse direction the voltage across the cell may be made much higher before an appreciable reverse current flows.

In spite of this it was found desirable to limit the voltage to between 60 and 80 volts per cell in the case of a high-tension rectifier. A higher voltage per cell gave rise to unsteady working and a fluctuating D.C. output. The exact strength of the acid is not critical, ordinary accumulator acid being perfectly satisfactory.

A few other electrolytes were tried in place of sulphuric acid, with varying results. Pure or slightly diluted nitric acid used in place of sulphuric acid allows higher voltages to be used, but at the same time gives the rectifier a higher resistance. A tantalum rectifier cell made up with nitric acid worked fairly well on an A.C. voltage of 150. On the whole, this advantage of nitric acid is outweighed by its practical disadvantages; the acid gives off fumes, and carbon must be used instead of the lead electrodes, as nitric acid corrodes all the commoner metals. A strong solution of caustic soda was tried in a rectifier cell built for charging purposes, and for a short time this appeared to be the ideal electrolyte for the job. The cell would only stand a maximum voltage of 40, but would deliver an ample D.C. output for a considerably smaller excess of transformer voltage than in the case of sulphuric acid. After a test run overnight, however, it was found that the tantalum electrodes were corroded and had become extremely brittle. This at once rules caustic alkalis right out.

Other solutions, such as common salt and potassium dichromate, were given a trial, but were found to offer no advantages. One sometimes sees statements to the effect that tantalum rectifies up to 500 volts or more in certain solutions. Such statements are apt to be misleading as they usually refer to D.C. tests made with very dilute solutions or with very small electrodes. As far as the writer has been able to ascertain at present, there is not much hope of making a practically useful tantalum rectifier to work at more than about 100 volts per cell. In the matter of maximum voltage the aluminium rectifier is superior, since a good cell of this type will work well at 150 volts and even as high as 200 volts under the best conditions.

Advantages of Tantalum.

The tantalum rectifier has some very important advantages over the familiar aluminium electrolytic rectifier. Firstly, the tantalum rectifier, once it is made up, requires practically no attention. The electrodes need no cleaning and the acid does not deteriorate; it is only necessary to add a little water at rare intervals to make up for electrolysis and evaporation. Since dilute sulphuric acid is one of the best conducting electrolytes known, the resistance of the rectifier is much lower than in the aluminium cell using ammonium phosphate. This implies a smaller voltage drop in the rectifier itself and offsets to a great extent the fact that the aluminium rectifier will work at higher voltages.

Another beneficial result of the lower resistance of the tantalum rectifier is a considerable reduction of heating up; this permits the use of smaller and more compact cells for a given power. As a matter of fact, the tantalum cell does not mind a reasonable amount of warming up—it somewhat increases the D.C. output if anything.

The tantalum rectifier "forms" almost at once. Only those who have spent hours trying to form a refractory aluminium rectifier can fully appreciate this advantage. It is sometimes stated that the forming of the tantalum electrode is instantaneous, but the writer has not found this to be invariably the case. The rectifier may pass quite a large reverse current for a few seconds, especially if the tantalum electrode has not been used before. This period rarely lasts more than a second or two, but it is just as well to provide a safety resistance in series when starting up for the first time.

When working at pressures over 40 volts the surface of the tantalum electrode scintillates in a similar manner to the aluminium in an aluminium rectifier. This scintillation unaccompanied by any sound is quite in order, but any excessively bright arcing, localised at one point and accompanied by a spluttering sound, indicates a too high voltage and results in an unsteady output. Seen in the dark, an aluminium rectifier electrode appears to be covered with a more or less uniform glow, while the tantalum rectifier electrode is mainly dark with isolated specks of light.

All the writer's tests on the tantalum rectifier have been made with a 50-cycle supply; the possibility of its use for higher periodicities still requires investigation. It was found recently* that the aluminium rectifier functioned to a considerable extent at 500 cycles provided that small electrodes were used. It is only reasonable to expect the same of tantalum. One of the limiting factors to the use of these high frequencies is the capacity effect of the rectifier. It will be recalled that a polarised aluminium electrode has an enormous capacity; tantalum is stated to show a similar effect. Incidentally, the writer is rather surprised that the experimental fraternity does not make more use of the electrolytic condenser. In this field aluminium easily holds its own against tantalum.

The Effect of Ferrous Sulphate.

It has been stated elsewhere that the addition of a small quantity of ferrous sulphate to the acid in a tantalum rectifier improves the efficiency. The following experiment made by the writer fully confirms this point. A full-cycle rectifier was made up by placing two tantalum electrodes and one lead electrode in a 3 lb. jam jar filled with dilute sulphuric acid, the tantalum electrodes being connected to the outer ends of the centre-tapped secondary of a step down transformer. The rectifier was used for charging a 6-volt accumulator which was connected in series with a D.C. ammeter between the lead electrode and the centre-tap of the transformer. The dimensions of each tantalum strip were 5 in. × ½ in. and the strength of the acid was about 20 per cent. as usual. The rectified current output was measured for different input voltages before and after the addition of ferrous sulphate. The results are tabulated below.

Without Ferrous Sulphate.

Volts across each half of centre-tapped Transformer.	Output D.C. Current.	Output load condition.
15 volts	2.6 amps.	No accumulator in output
25 ,,	6.0 ,,	
15 ,,	0.75 ,,	6-volt accumulator on charge
25 ,,	2.0 ,,	

After Addition of Ferrous Sulphate.

Volts across each half of centre-tapped Transformer.	Output D.C. Current.	Output load condition.
15 volts	8.2 amps.	No accumulator in output
25 ,,	12.3 ,,	
15 ,,	3.5 ,,	6-volt accumulator on charge
25 ,,	7.5 ,,	

The quantity of ferrous sulphate added was 3 fluid ounces of freshly-made and nearly saturated ferrous sulphate solution. The addition of 1 oz. made most of the difference; the second and third ounces produced very little extra effect.

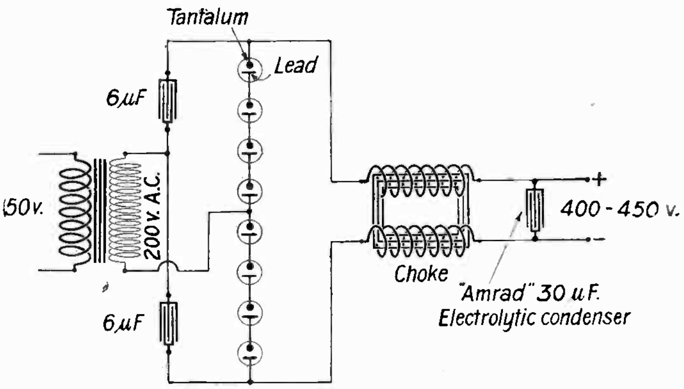


Fig. 1.

These figures show, then, that the addition of ferrous sulphate brings about an enormous improvement in the working of the tantalum rectifier. It reduces the internal resistance and also the heating effects in the rectifier. The ferrous sulphate therefore should never be omitted when a tantalum rectifier is being

* See E.W. & W.E., Vol. 1, No. 11, August, 1924.

made up. It is better to add slightly too much ferrous sulphate than too little. The amount indicated by the above test is about one fluid ounce of saturated ferrous sulphate solution to every pint of acid.

The above experiment was made with a battery-charging rectifier but the same results apply to high-tension rectifiers as well.

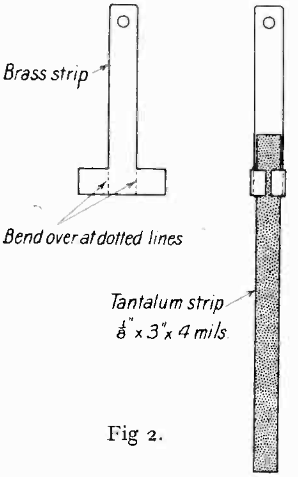


Fig 2.

A Description.

A brief description of the writer's own H.T. tantalum rectifier may be of interest. It is intended to deliver 50 milliamps of D.C. to a load at a voltage of 400. The connections are shown in Fig. 1. This is the voltage-doubling circuit and is preferred because it works well and allows a great saving in the number of rectifier cells necessary. The cells are made up in the familiar way with "boiling tubes," *i.e.*, test tubes six inches long and one inch diameter. The lead electrodes are strips half an inch wide reaching nearly to the bottom of the test tubes. The tantalum electrodes are strips three inches long and an eighth of an inch wide cut from 4-mil. sheet. Thinner sheet could easily be used and a considerably smaller electrode area would suffice for many purposes. In order to economise tantalum the strips are clamped to brass strips as shown in Fig. 2, the brass strips themselves being bolted to the tops of the adjoining lead electrodes.

About two inches of each tantalum strip is immersed in the acid. It is important to see that the brass holding strips are well out of contact with the acid. Three-quarters of an inch depth of paraffin oil is floated on top of the acid in each cell to arrest acid spray and protect the brass strips. The two 6μF condensers, shown in Fig. 1, are made up of a number of Mansbridge condensers in series-parallel.

Excellent final smoothing is obtained with a double choke and an "Amrad" electrolytic smoothing condenser. Running light, the rectifier does not absorb more than a few watts from the mains; the output when short-circuited readily delivers over 120 milliamps. The rectifier is always ready for use, and when switched on, does its work at once without fuss or bother. It has proved most useful and reliable for working power amplifiers, master oscillators and general experimental work.

In Praise of Atmospherics.

By J. F. Herd, A.M.I.E.E., M.I.R.E. **[R589**

The author quotes a lecture in which it was shown that atmospherics are of value in observations on meteorological phenomena.

MUCH has been written, and said, in condemnation of atmospherics, and it is novel to find anyone dealing with their more useful aspect. Yet this aspect has been admirably set forth in a recent lecture before the Royal Aeronautical Society, by Mr. R. A. Watson Watt, B.Sc., F.Inst.P., A.M.I.E.E., Superintendent of the Radio Research Board's Atmospherics Station at Slough. The text of the lecture has now been published in the Society's Journal (No. 170, Vol. XXIX, February, 1925), and reveals an interesting and highly-important correlation between directional observations on atmospherics and the meteorological conditions reported from the regions whence they appeared to originate.

For delivery before the Aeronautical Society, the paper naturally dealt with the subject particularly from the point of view of the application of such a system to the needs of aircraft, and devoted, to quote the author, "special attention to the aspect of the atmospheric in which it is to be regarded simply as a meteorological phenomenon, and to investigate the possibility of basing on its indications a thunderstorm warning service for the guidance of the aerial navigator who desires to steer clear of thunderstorms."

The paper then deals in considerable detail with observations on atmospherics made aurally as time and circumstances allowed at a group of direction-finding wireless stations arranged round the British Coast. In the two-year period under review there were a thousand cases when three or more of the stations were able to make observations within the same hour of the direction from which atmospherics were arriving. In about half of these cases the approximately simultaneous bearings gave intersections meeting more or less in a point, or in a small area, which would appear to be the region from which the atmospherics were then originating. The meteorological conditions then prevailing in or near these regions were subsequently examined, and the results set out in a table showing the percentage number of cases when some of the meteorological phenomena shown below were reported :—

(*a*) Thunderstorms within 250 kilometres.

(*b*) Thunderstorms within 1 000 kilometres.

(*c*) Hail showers within 200 kilometres.

(*d*) "Passing showers" within a similar distance.

(*e*) Squalls.

(*f*) Rainfall.

(*g*) Barometric minima.

(*h*) No correlation found.

The table can be briefly summarised into the following regions :—

A. British Isles.

B. South-west Europe.

C. Total for all Europe, Iceland, Atlantic, Mediterranean and North Africa, this division being made by the author on the strength of the decreasing adequacy of the meteorological data available. The results are then as follows :—

	No. of locations	a %	b %	c %	d %	e %	f %	g %	h %
A.	120	22	18	6	28	13	7	3	3
B.	373	30	9	3	13	6	20	9	10
C.	490	25	11	2	10	5	21	13	13

Twenty-five per cent. of the locations are thus definitely associated with comparatively-near thunder; an overall total of almost 40 per cent. are connected with either definite thunder or thundery conditions; and a total of 87 per cent. of all the locations are correlated with some of those meteorological conditions which form the basis of the frequent announcement "further outlook unsettled."

It must not be imagined that the above numbers represent the author's views or findings as regards the proportion of our received atmospherics which originate in thunderstorms. It merely states the proportion which have been correlated with *definitely reported thunderstorms.*

Considering these results, the paper points out that, had the above table as given for the British Isles been used as a means of thunderstorm warning, 50 per cent. would have provided valid warnings of considerable danger, and that in almost all the remaining 50 per cent., cautious aerial navigation would still have been necessary.

In addition to general discussion of these results, the paper quotes some special cases when almost spectacular agreement existed, both as regards space and time, between intersections from the directional stations and thunderstorms in various places, at distances ranging from 165 miles from the nearest to 1 200 miles from the farthest of the reporting stations.

The work on the directional observation of atmospherics was inaugurated by the Meteorological Office, from whom it was subsequently transferred to the Radio Research Board. A continuous directional recorder developed at the Board's Station at Aldershot (now transferred to Ditton Park) was then described and illustrated by slides at the lecture. Such a recorder had already been running at Aldershot for some $2\frac{1}{2}$ years, when a second was installed at Lerwick, in the Shetland Islands.

On the first day of the conjoint running the charts from both recorders gave intersection off the Hebrides. From hour to hour the locations given by the intersections were followed across Scotland, Scandinavia, Mid- and East-Germany, all in close agreement with thunderstorms reported by the meteorological services. Finally, some 37 hours after its first appearance, the source as given by the intersections appeared to be on the Roumanian coast of the Black Sea.

On six other occasions during their first month of mutual running, intersections from both recorders located thunderstorms, subsequently confirmed from local observation.

U2BRB. An Amateur Station.

By B. H. J. Kynaston. [R625

THIS description of one of the best American amateur stations will no doubt be of interest to the great number of wireless experimenters who have worked with U2BRB. The information, diagrams and photographs were kindly supplied by Mr. E. M. Glaser, the owner of the station, during my recent visit to New York. As I happened to be present just when he had decided to come down from 75 metres to 40 metres, information of both circuits can be given.

The station itself is situated in an upstairs room at Mr. Glaser's home, 845, East 13th Street, Brooklyn, N.Y., and consists of two transmitters, two receivers and two

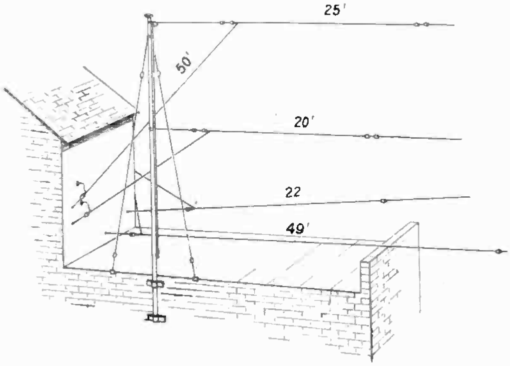


Fig. 1.

aerial systems. This allows for transmission and reception on short waves and the simultaneous reception of broadcast programmes in another part of the house. The transmitter does not interfere with the broadcast programme being received although situated so near to the receiver.

The aerial system used is shown in Fig. 1. The small aerial is used for 40-metre transmission and the other for 75-metre work. Whichever aerial is not being used, is switched on to the broadcast receiver. A single wire counterpoise as shown is used with both aerials. All the great distances reached by this station have been attained with the same single wire aerial. The lengths of aerial and counterpoise are shown in the diagram; the aerial is of No. 16 copper wire and the counterpoise of insulated wire of the same size.

Fig. 2 shows the circuits of the transmitter. It will be noticed that the well-known Hartley parallel feed circuit is used for both transmitters. A 250-watt German valve is at present being used, but a fifty-watter and an American 200-watt are also available.

There are two sources of high tension supply at this station, one being A.C. from the house lighting mains stepped up by means of a transformer to 1 200 volts and properly rectified by a chemical rectifier of fifty cells. The other source consists of a motor generator set which runs off the lighting mains and supplies H.T. at 2 000 volts. This motor generator set is installed in the cellar and is controlled from the wireless-room by means of a switch and relay. The high tension supply to the valve is controlled by means of a telegraph key and relay. Three keys are installed, two of the ordinary type, and one "side swiper" or "cootie key." Normally the station operates on about 200 watts, but when greater power is desired the two high tension supplies are connected together.

For the benefit of those desiring information as to the construction, Mr. Glaser has supplied the following details. The left-hand side of Fig. 2 shows the 40-metre transmitter. The dimensions of aerial and counterpoise have already been given. The two condensers in the aerial circuit are ordinary moving vane receiving condensers of .000 5μF maximum capacity. The coil L_1 is a spiral or pancake wound with ½-in.

brass ribbon with a spacing of ½ in. There are 5 turns, the diameter of the inside turn being 7 ins. The coil is wound in slots cut

The short wave receiver (which covers 30-95 metres), like the transmitter, makes use of a Hartley parallel feed circuit and can

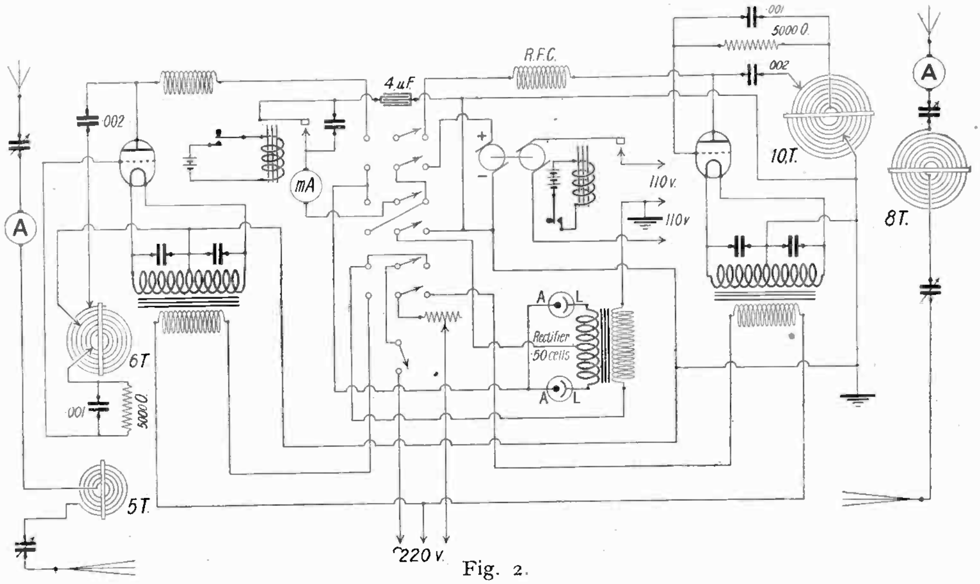


Fig. 2.

in an ebonite strip as shown. The values of the other components of the 40-metre set are shown in the diagram. The primary coil, like the aerial coil, is wound with ½-in. brass ribbon and the inside turn has a 7-in. diameter.

The H.F. choke coils, both for 40 and 75 metres, consist of 20 turns of 24 D.C.C. wire wound on a 4-in. former. The grid condensers are of the usual mica type, .001μF capacity, and the leaks are G.E.C. 5 000 ohm resistances. The coils of the 75-metre transmitter are also spirals like those of the 40-metre set, but consist of a primary of 10 turns and an aerial coil of 8 turns. Each of these coils were originally mounted on 6 ebonite strips until it was discovered that a much greater aerial current could be obtained when only one supporting strip was used. For this reason the slots holding the ribbon are only cut to a depth of ⅛ in.

These coils and the valve are mounted at the back of a large ebonite panel. On the front of this panel the controls for the motor and the various meters are mounted.

The edge of the transmitting panel can be seen in the one photograph but there was not sufficient space to obtain a photograph of the transmitter without dismantling a good deal of the gear.

be seen in Figs. 3 and 5, while Fig. 4 gives the diagram of the circuit. The values are as follows: The aerial coil (this is not shown in Fig. 3 but can be seen in Fig. 5) consists of 5 turns of No. 19 D.C.C. wire, space wound, and coupled very loosely to the secondary. These two coils were actually about six inches apart. The secondary coil consists of 17 turns of No. 20 D.C.C. wire space wound, and having a tapping, as shown in Fig. 4, between the eighth and ninth turn,

The H.F. choke coil consists of 60 turns of No. 22 D.C.C. wire on a cardboard former 2 in. in diameter. A tapping from the high tension battery is connected to this choke as shown, the full high tension supply being connected to the L.F. valves.

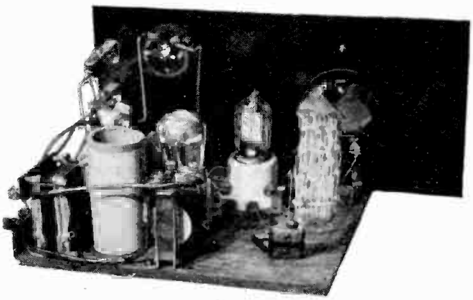


Fig. 3.

Fig. 5 shows both the short wave receiver and the broadcast receiver. The latter embodies the usual regenerative circuit, with three L.F. valves.

Before concluding it would be as well to give a few details as to the normal range obtained by this station. The editor of the

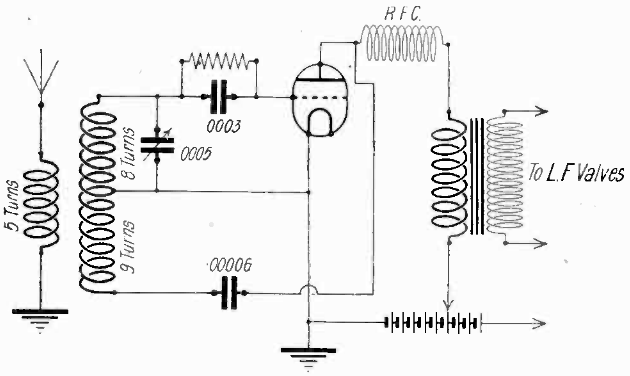


Fig. 4.

New York Telegram and *Evening Mail* asked a similar question to U2BRB a short while ago, and as he seemed to regard wireless amateurs' ranges as we often regard the size of anglers' fishes, Mr. Glaser let the representative of the paper work the station for eight hours.

He was shown the various controls and then left to it alone. A copy of his log for the eight hours is shown below.

Extract from Log 2BRB. *Sunday, 25th January,* 1925.

Weather clear. Wireless conditions fairly good, except QRM. W. A. Schudt operating station.

12.02 a.m. Heard British 5LF very loudly.
12.03 a.m. British 2KF calling A.R.R.L. We answered him and he reported us very loud.
12.25 a.m. British 5NN called us and we gave him two messages.
12.45 a.m. CQ from G2NM. English.
1.12 a.m. Cuban 2MK called us and gave us two messages.
1.32 a.m. CQ de Bermuda BER. We called him and immediately received a reply.
2.00 a.m. Worked French 8GO for fifty minutes and sent on message.
2.55 a.m. We connected with 7WM over Seattle way.
3.30 a.m. Talked with British 2JF.
4.10 a.m. Heard CQ from 4IO down South.
4.11 a.m. Heard 7DD very QSA Another W. Coast station.
4.12 a.m. We worked 6ADT of California. Reception bad.
4.40 a.m. We called New Zealand 2AC and received reply immediately. He told us to listen for 4AA.
5.20 a.m. Connected up with N.Z. 4AA. "Chewed fat" with him.
6.00 a.m. Hear New Zealand 4AG.
6.45 a.m. 9CLG calling Australian 3BQ.
6.50 a.m. We hear Australian 3BQ and called him.
6.52 a.m. Australian 3BQ answers us. Talked with him for awhile.
7.10 a.m. As soon as we finished with 3BQ Australian, 2DS called us. Sun was coming up and fading was bad. Worked for twenty minutes after sunrise.

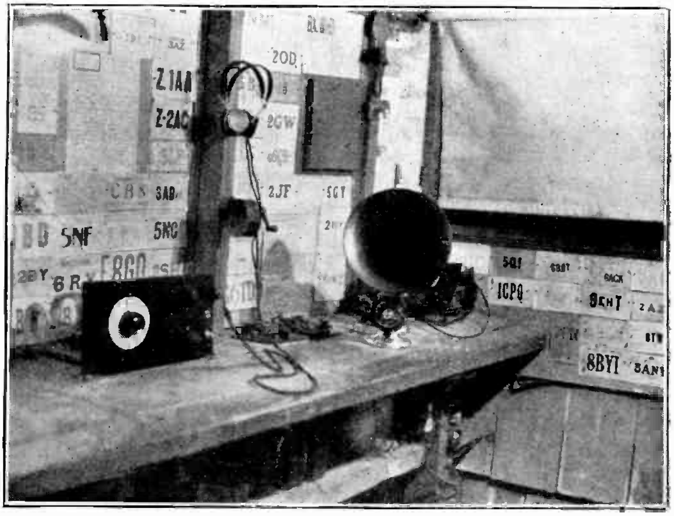


Fig. 5.

Rectifiers for High-Tension Supply.

Part IV: Arc Rectification at Atmospheric Pressure.

By R. Mines, B.Sc.

[R355·5

I.—Ionisation Produced by Combustion.

THE gases entering a flame are undergoing a reaction which is exothemic, that is, heat energy is being liberated as an accompaniment of the reaction; this heat raises the temperature of the gases, and is carried away (at a rate equal to that at which it is generated, with a steady flame) partly by the products of combustion, and partly by radiation. This elevated temperature is the chief characteristic of a flame; and in general it is an essential condition for the chemical reaction to take place, thus a "vicious circle" is pursued.

A chemical reaction consists in a re-arrangement of the constituent atoms (or groups of atoms, *i.e.*, "radicles") of the different kinds of molecules taking part in it. It is thus necessarily preceded by a "dissociation" of the molecules (followed eventually by a "recombination"). The action is analogous to that taking place when a salt is dissolved in water (as described in our previous article on "Electrolytic Rectifiers"[1]) and affords an explanation of the fact that considerable numbers of ions are generated in flames.*

In a Flewelling receiver that has recently been described, two flames with wire electrodes at their bases and tips were used as a grid-leak and anode resistance respectively; control of the resistance value was obtained by varying the height of the flame and so the extent to which the space between the two electrodes is rendered conducting by ions from the flame.

[1] E.W. & W.E., Vol. 2, p. 780. Sept., 1925.

*It is found that if a salt is introduced into the flame its conductance is very greatly enhanced, because the vaporised salt molecules do split up in the manner described at the high temperature. This statement is supported by the fact that the current that may be passed through the flame reaches a "saturation value" which is found to be the amount of current necessary to electrolyse all the salt supplied to the flame.

II.—The Vibrating Flame Rectifier.

On this principle, a flame may be used as a kind of switch, and with suitable modifications it may be made to rectify on the lines described in our previous article on "Mechanical Rectifiers."[2]

It has been found practicable to perform the "switching operation" by a vibrating flame playing between two electrodes (*e.g.*, two horizontal carbon rods). A gas flame is used, controlled by a "manometric capsule" (see Fig. 1), the diaphragm of which is fitted with a soft iron armature situated near the air-gap of an electromagnet. This magnet is fed with current taken from the supply to be rectified, with the result that the armature vibrates in the alternating flux; the pulsations are applied to the gas supply by the diaphragm and therefore the flame oscillates in synchronism.

To eliminate the square law response and the double frequency of vibration that would otherwise obtain, the electromagnet is polarised, either by passing a continuous current through a part of its winding, or by using a permanent magnet as core.

[2] E.W. & W.E., Vol. 2, p. 687. Aug., 1925.

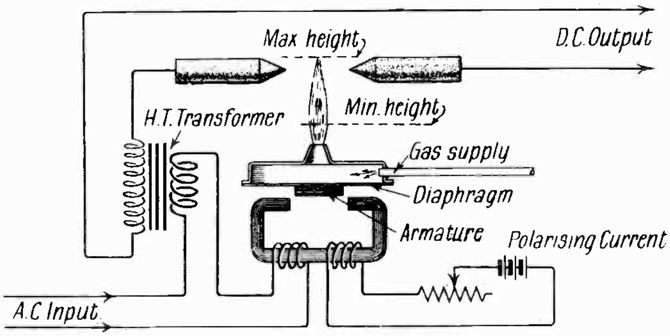


Fig. 1.

In order to pass a reasonable current, a spark discharge is used (instead of a silent one, as suffices for a "grid-leak"). The separation of the electrodes is adjusted so that a spark will just not pass when the flame is smallest (say, 1 cm. high); during the other half cycle of the supply, the flame shoots up to, say, 10 cm. in height, and its tip reaches between the electrodes, ionising the gap and causing current to pass in the form of a spark.

Due to the use of a spark, the apparatus is suitable only for high P.D.s (for example, 6 000 volts), and the rectification is not complete.

III.—Thermionic Emissions.

It has been known since the 18th century that many solid substances emit ionised particles when their temperature is raised; the phenomenon may be described as normal evaporation (or sublimation) accompanied by ionisation of the resulting vapour. However, this ionisation, though it is facilitated by the higher temperature (involving greater "thermal agitation"), is not the result of chemical reaction among the molecules as in the case of fuming gases.

Thus metals emit positive ions in the first stages of increasing temperature, that is, a proportion of the vaporised molecules have lost an electron or so. This is not surprising when it is remembered that in metals at normal temperatures this is a condition that exists spontaneously (or is very easily brought about), and explains the ease with which these substances conduct electricity.

Further rise in temperature causes an emission of negative ions in addition, which at about 400°C. equals, and at higher temperatures by far exceeds, the rate of emission of positive ions. These negative ions are usually electrons unattached to any material particles—it is to these that the name *thermions* meaning "thermal ions," has been applied. It must be borne in mind that this "thermionic emission" is a phenomenon quite distinct from, and independent of, the evaporisation of material particles; whether these are positively charged or neutral.

These phenomena are also exhibited strongly by many "semi-conducting" substances, of the kind that show increased conductivity with rise of temperature (*i.e.*, having a negative temperature coefficient of resistance). Examples of these are the "oxides of the alkaline earths," as used on "oxide-coated" dull-emitting filaments.

IV.—The Arc Discharge.

Suppose that two electrodes, arranged for applying an electric stress to the gas between them, are raised in temperature sufficiently for them to emit copious supplies of electrons. It will be evident that under these circumstances the bombardment of an electrode surface or of gas molecules by positive ions are superseded as sources of supply of the negative ions. The amount of ionisation occurring in the gas when a P.D. is applied to it will become greater in proportion to the increased supply of electrons until, in the limit, the gas may become "saturated," that is, all the molecules of gas in the region of the discharge become carriers. Beyond this point any further increment of current can be carried only by the "thermions"; it is, in fact, found that in arc discharges as a rule the bulk of the current is carried by electrons.

V.—Vapour Conduction.

It is evident that with electrodes at this hypothetical high temperature there will be present in the path of the discharge some vaporised electrode material; this material is necessarily a conductor, which means, as we have stated above (Section III.), that its atoms easily lose planetary electrons. In other words, this vapour has a low ionisation potential, and as a result the discharge will pass with a much lower P.D. applied to the electrodes.

VI.—Maintaining the Electrode Temperature.

We have also noted that with this type of discharge the gas or vapour (whichever may be present) is saturated, that is, practically all of the molecules present are ionised, and are therefore disposed of by being driven along the potential gradient. Thus, in the absence of any other factors, the current is carried entirely by ions moving in one direction only, and only one electrode, the positive one or anode, is subjected to bombardment capable of maintaining it at a high temperature.

It must be borne in mind, however, that evaporation from the (supposedly) hot electrodes is a continuous process—there is a continuous supply of vaporised molecules, which are ionised by the electron stream from the cathode as soon as they appear. These positive ions bombard the cathode and maintain its temperature. If this were not so, there would be no source of electrons, hence no bombardment of the anode, and so forth. Thus in the normal *arc discharge*, which is self-maintaining in the above-described manner, the actions follow a circle.

As is usual when cause follows from effect in a circle, the action will not commence spontaneously; in the case we are considering, it is necessary to heat the electrodes (or at least one of them, the cathode) initially before the arc can become established. This may in practice be very simply accomplished by touching the electrodes together at some point while connected to a suitable circuit for maintaining the necessary P.D. across them; heating takes place at the contact, and on separating the electrodes this is sufficient to cause a "hot spot" that will give rise to evaporation and thermionic emission. It was in this manner that the arc was first discovered.

VII.—Asymmetry of the Arc Discharge.

In the *carbon arc*, for example, the electrons so far outnumber the positive ions that the anode, which they bombard, is kept at a temperature considerably higher than that of the cathode; in addition the hot area (or "crater") of the anode is much the larger. It is found in fact that about 85 per cent. of the light emitted is due to the positive crater; 10 per cent. only comes from the negative crater, the arc itself accounting for the remainder.

We have seen, however, that it is the negative crater whose high temperature is the essential condition: it is in fact possible to maintain a proper arc with the anode quite cold; the only possible difference is that there may be little or no electrode vapour in the arc, but this will always be compensated by diffusion into the arc of neutral gas molecules from the surrounding atmosphere, resulting in a higher potential drop in the arc. Actually, quite a sufficient supply of vapour may come from the cathode itself, the neutral molecules on evaporation being ejected into the arc space (*i.e.*, in the direction of the anode) prior to being ionised and drawn back to the cathode as positive ions. (This condition is exhibited to a maximum extent by the Mercury Vapour Arc operating under reduced pressure.)

VIII.—Rectification in the Arc.

If then by any means one electrode is cooled, an asymmetry is introduced, which may be put to practical use for rectification. Thus if an alternating P.D. is applied to the electrodes in place of a steady P.D., all will go well so long as the cooler electrode is positive; but when the P.D. reverses for the next half cycle the arc tends to "go out," because the cooler electrode will not emit electrons in sufficient quantity—in fact, the current flowing in the second half cycle is only a fraction of that in the first.

This condition is evidently one of "imperfect" rectification. In practice it is not possible (without the introduction of additional factors hitherto unconsidered) to reduce the "inverse current" to zero, for if complete extinction of the arc were permitted the cathode proper would cool down from its necessarily high temperature during the interim and the arc would not be able to re-establish itself at the commencement of the next cycle.

IX.—Effect of Electrode Material.

The character of the arc is considerably effected by the physical properties of the materials used for the electrodes. The equilibrium temperature attained by the cathode at its hot spot, the seat of the arc (and by the anode, too, in the absence of undue cooling) is dependent on the boiling point of the material—in general, the actual temperature of the vapour in the arc is not far removed from the boiling point. The higher the temperature attained by the electrodes, the faster is their rate of cooling if the arc is allowed to go out during the second half cycle. This rate of cooling is also dependent on the specific heat and on the thermal conductivity of the material, and to a smaller extent on its emissive properties as a heat radiator.

The properties of the electrode material will determine the minimum current with which an arc can be kept in existence—and this is the minimum inverse current attainable in the absence of independent means for maintaining the electrode temperature.

An easy way of introducing the asymmetry required for rectification is to use different materials for the two electrodes ; the anode, for example, can be chosen with a high heat conductivity and a high specific heat—it will then tend to keep itself cool without artificial means.

X.—Conditions for Perfect Rectification.

Perfect rectification means zero inverse current, and this can be attained only by extinction of the arc. The achievement

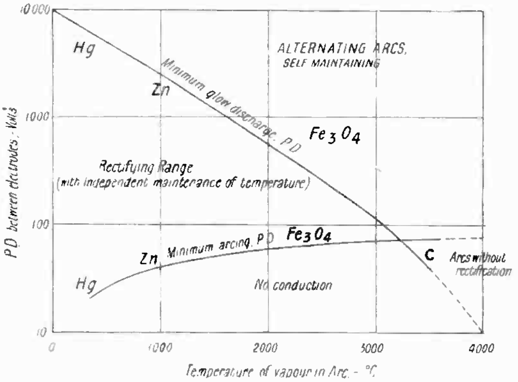


Fig. 2.

of this result can be assured most simply, whilst at the same time making the apparatus as a whole self-maintaining, by using multiple anodes with a single common cathode—on the lines described in our previous article.[3]

With this arrangement the arc is in continuous operation, playing always upon the one cathode, but on one anode only at a time (so that with respect to the remaining anodes it is " extinguished " in so far as no conduction takes place). Under these circumstances the anodes may be quite " cold," or, rather, they must be incapable of supplying electrons in any quantity by thermionic emission or otherwise.

The accompanying Fig. 2 gives an idea of the rectification conditions obtainable with different materials ; in this case, the materials used for the two electrodes do not differ greatly in their properties. The lower curve gives the P.D. below which it is not possible to maintain an arc discharge.

The upper curve gives the minimum P.D. required for a discharge (other than an arc) to pass between the electrodes of sufficient intensity to heat the electrodes to the point where an arc discharge can set in.

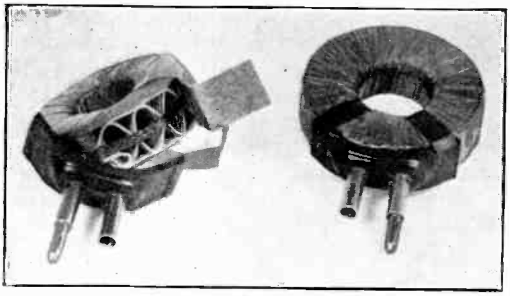
If the P.D. rises above that indicated by the upper curve, an alternating arc will be set up, but no rectification will ensue ; if it lies at a value between the two curves, then rectification is obtainable, but some auxiliary means must be available for maintaining the cathode temperature (*e.g.*, an electrically heated filament, as in the "Tungar" Rectifier).

[3] E.W. & W.E., Vol. 2, pp. 783, 784, Sept., 1925.

The O'Keeffe Plug-in Coils.

THESE coils, of which we have received a set for test, are manufactured by the Dickinson Electrical Manufacturing Co., Ltd., of Graham Road Works, Bexley Heath, Kent, who are the patentees.

A feature of the construction is that there is no great difference in size between any of them, as will be seen from our illustration which shows the smallest (No. 25) partially dissected, and the largest (No. 500) by its side.



The smallest and largest of the O'Keeffe coils. The construction can be plainly seen from the former.

This uniformity is a good point, and it seems to have been attained without appreciable loss of efficiency. Other good points which make themselves apparent on casual observation are that the coil mounting has a minimum amount of solid dielectric between the sockets ; the fitting is made reversible by the use of a loose plug fitting into the sockets, and the coil itself is completely enclosed by windings of red empire silk.

We noticed in one or two cases that the plugs and sockets were rather roughly finished—a little attention to this point would be advisable.

We confined our tests to two coils, the No. 50 and No. 500. The former had an inductance of 178.5μH, a H.F. resistance of 10.1 ohms, a self-capacity of 10$\mu\mu$F, and a power factor of .013. For the latter coil the corresponding results were 12 480μH, 149 ohms, 20$\mu\mu$F and .023.

Interpreting these results in the light of those obtained from other coils tested, we can say without doubt that they are quite good. In fact, in only one or two cases of plug-in coils tested have these results been surpassed The prices of the coils range from 3s. 6d. for the No. 25 to 9s. for the No. 500.

Wireless, the Moon and the Barometer.

By W. J. Turberville-Crewe. **[R113·8**

EVERY experimenter knows at least something of the action of the sun's rays, ionisation of the ether, the Heaviside layer, etc., etc.; but I wonder how many have logged results against the phases of the moon and the barometric readings?

Some months ago G6LJ showed me a very interesting chart that he had prepared, in which he had carefully plotted the number of DX stations he had received each night for over twelve months. We had a lengthy argument, in consultation with the calendar, finally coming to the conclusion that the phases of the moon had a very definite effect upon wireless waves.

Again, Canadian 3GG has been carefully plotting barometric readings in the same way and has derived some pretty conclusive evidence of conditions being largely dependent on a steady pressure.

With regard to the moon, other things being equal, it would appear that the waning period seems to favour DX: but, as really good work has frequently been done on a bright moonlight night, it will be as well to study the barometric effect more closely. If the weather really does affect DX reception, what we want to know is what sort of weather will give us the best results and what is the brand that spirits away our signals and makes our sets inoperative.

Now, to get fair comparisons of this description and to eliminate as far as possible the chances of error in the reckonings, one must make tests with the receiver constant. It is of little use chopping and changing values—circuit, wave-length, etc.—and the H.T. and L.T. supply should be as free from fluctuations as it is possible to make it. Tests should be arranged for a definite time at definite intervals in conjunction with definite stations. Two-way communication will be helpful as results may vary east or west.

Three logs should be kept in graph form for ease of reference :—

(1) Strength of signal on audibility meter plotted against date and phase of moon;

(2) Barometric reading against date and time;

(3) Number of DX stations logged in a fixed time against date.

If the readings of a barometer are taken every few hours and plotted on squared paper, it will be found that the pressure of the atmosphere is constantly changing in an irregular manner from day to day and hour to hour. One must bear in mind that the "glass" does not tell the present so much as the future—say the coming 24 to 48 hours.

Many enthusiasts clamour for clear, bright nights, whilst others prefer dark and cloudy spells. The majority, however, seem to favour a night with low-lying rain or snow clouds following a dull day in which the sun has not had the chance to suck most of the life out of the air.

Since distant reception is often excellent during a deluge there are no statistics to show whether rain helps or hinders the penetration of wireless waves. On the other hand a few occasions have been recorded when reception has not been at all good during a rain storm. Blizzards usually affect reception pretty badly; but one can scarcely blame the blizzard if it is recalled that it is the result of a falling barometer.

Fading is often reported during wind, and a deal of it can be attributed to a swinging aerial. There is, however, another possible explanation: to investigate this phenomenon intelligently a careful study must be made of the Heaviside layer theory. It is well known that in distant reception the ray reflected by the Heavyside layer is far stronger than the direct ray, even if the latter is received at all. If the position of the layer is shifting at all rapidly, it naturally follows that the angle of refraction will change in sympathy; and thus the intensity of the signal will also vary.

Another channel of investigation that will suggest itself is that of the Northern Lights. About these practically nothing is known from the wireless standpoint save that static is prone to rise in intensity on occasions during their continuance.

To sum up the position in a nutshell it would appear that (1) a waning moon is helpful to good DX reception; that (2) depressions of the barometer are bad; that (3) a steady rise after a fall is good.

Who will come to the rescue and tell us for certain what are the ideal atmospheric conditions for best work?

The Radio Relative Subject Index.

Compiled by

R. Borlase Matthews, Wh.Ex., A.M.Inst.C.E., M.I.E.E., F.R.Ae.S.

[025·4

It should be borne in mind that the letter R really represents the figure 621·384. This must be remembered when filing wireless data with other data so as to get everything into correct numerical order.

Editorial Note.

IT will be remembered that in our issues of October, 1924, to April, 1925, we published the sections of a complete classification of wireless subjects, so that those who take the trouble to collect and file away information on the subject could do so in a systematic manner. In introducing this classification, we promised to provide in due course an alphabetical index to it, so that any definite subject could be put in the right place and found again.

Readers not experienced in filing work may naturally ask: "If an alphabetical index is needed, why not file away matter in alphabetical order and be done with it?" The answer is that the *logical* arrangement of the decimal classification is of enormous assistance by bringing allied subjects together. For example, "Amplifier, H.F." and "Transformers H.F." are a long way apart in the alphabet, but can be kept together in a logical classification.

In fact, the consistent user of the Decimal Classification soon gets to know the main divisions, and can turn up, off-hand, any desired subject. But for those just beginning to use it an alphabetical key to subjects is very valuable.

In our particular case, there is a further point. We propose, when preparing the index to Vol. II. of E.W. & W.E. (which will be complete at the end of the year) to provide, in addition to an alphabetical index, also a decimal index to the contents. By doing this we shall facilitate research. Thus, suppose a reader wishes to find what has been said about Amplification throughout the volume. On looking up "amplification" in the subject-index *to the classification*, which we print now, we find several numbers, grouped about R132 and R342. Then, referring to these numbers in the Decimal Index to E.W. & W.E., Vol. II., when it appears, there will be found references to all articles, *whatever their titles may have been*, bearing on the subject.

This is obviously simpler than finding in an alphabetical index articles on, say, "Distortion in Amplifiers," "The Perfect Set," "Stability in Amplifiers," and other titles.

With these remarks we will pass on to the Index, just remarking that its compilation from the classification itself as published in E.W. & W.E., has been both a laborious and a difficult task, admirably carried out by Mr. Matthews, who is an expert in both Classification and Wireless matters, as well as other things such as making two blades of grass grow where one grew before!

ERRATA.

Our attention has been drawn to a printer's error which occurred in Appendix I. to the first part of the article on "Distortion in Wireless Telephony," by Messrs. E. K. Sandeman and N. Kipping (E.W. & W.E., September, page 764).

In the second line of equation (5)

$-\frac{KE}{2}\cos^2(c+v)t$ should read $+\frac{K^2E^2}{4}\cos^2(c+v)t.$

In addition, on page 758, in the last line of paragraph 2, column 2, the word "not" should be "now."

Lastly, we have been asked to point out that our statement with regard to the Marconi D.E.R. valve in the review of the Albert Hall Show (in the last issue) was incorrect. This valve, we are informed, is still marketed by the Marconiphone Company as a "general purpose" valve, the other models mentioned being additional.

The Horticultural Hall Exhibition.

A general review, showing the present trend in the design of apparatus.

[R064

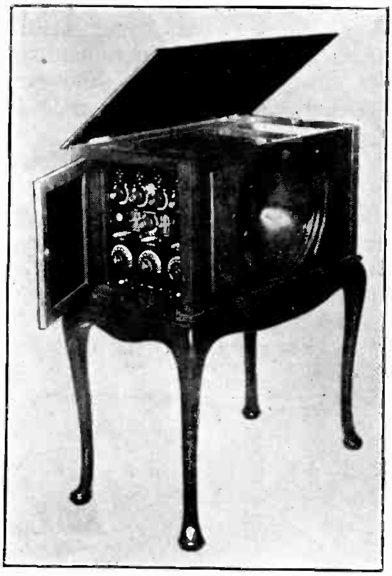
THE second London wireless exhibition this year, staged at the Horticultural Hall, Westminster, was a smaller one than that held some time previously at the Albert Hall, which was described last month.

Despite this, however, the exhibits were very interesting and in the following pages it is proposed to describe the general trend in the design of sets and components which was revealed by an inspection of the apparatus in the exhibition.

Broadcast receiver design was on much the same lines as was indicated at the previous show. In the present one the firms exhibiting were, on the whole, smaller concerns, and for this reason the handsome and costly "luxury appeal" sets were not so prominent. Several of the larger firms, however, were showing some handsome receivers, notably Messrs. Peter Curtis, Messrs. Rotax, Messrs. Read & Morris, and Messrs. R. F. Graham. Most of the circuits employed by these makers followed conventional lines, though in some cases there was incorporated some novelty in design.

Messrs. Rotax have made some attempt at increased selectivity in their "Rotola" III. receiver by incorporating a simple wavetrap, which may be used, or not, at will. Messrs. Read & Morris make a range of receivers for which the filament and H.T. supplies are obtained from the lighting mains simply by plugging into a socket. The unit which renders this possible is contained in the set, though it is also obtainable separately. Unfortunately, details as to the construction of this were not obtainable. Two types were made, for D.C. or A.C. supplies. Messrs. R. F. Graham make a set which is fitted in a Broadwood cabinet. The novelty is that the loudspeaker, which is contained in the set, is carved from a solid block of wood by Messrs. Broadwood. Messrs. C. F. Elwell were also well to the fore with a range of the well-known "Aristophone" receivers.

Most of the other firms were showing ordinary broadcast receivers of some description, and it was noticed that in many cases some attempts had been made to secure purity of reception. Messrs. Seagull, Ltd., were showing some sets in which the L.F. valves were coupled by the choke-capacity method, which with well-designed chokes of high inductance and low self-capacity is quite successful, though not so powerful, stage for stage, as good transformer coupling. The chokes as used in these sets are also sold separately, and an N.P.L. amplification curve which is exhibited shows an amplification factor of 8 (with the valve used) which is practically constant for all frequencies between 250 and 4 000 cycles.



The Broadwood-Graham cabinet receiver. The loud-speaker horn is carved from a solid block of wood.

Generally, it was found that it was the exception rather than the rule, to find receivers employing L.F. amplification which had no provision for grid bias and extra H.T. voltage on the L.F. valves. In most cases, too, it was found that power valves for the L.F. stages were either supplied or specified. There is no doubt that manufacturers are at last realising the fact that the ability to receive a station is not everything—quality counts.

This being the case, it was remarkable that in only one case did we see a set in which crystal rectification was employed, other than in crystal sets themselves. We have consistently stated, and still maintain, that a crystal detector, preceded by an H.F. valve where necessary, and followed by well designed L.F. stages, will give the best possible tone in the reception of telephony. The days of the insensitive and unstable crystal are over—witness the large numbers of really good crystals at the Show, and the many permanent and semi-permanent detectors. The "Harmo" detector, shown by the Sclerine Crystal Co., is permanent and sensitive. The former property may be verified by throwing the detector about, or dropping it on the floor !

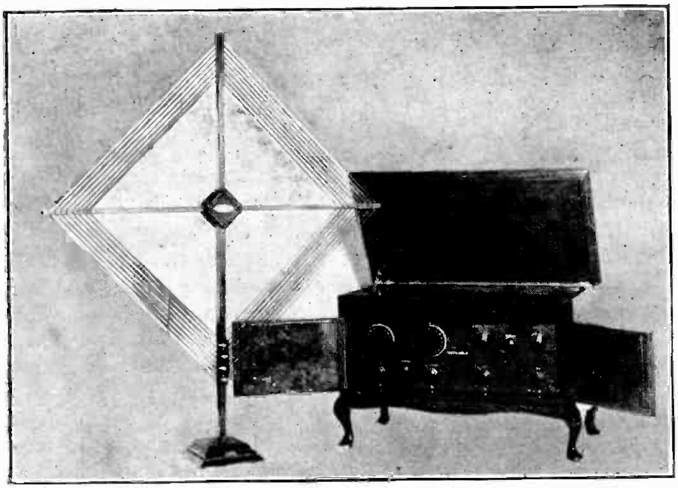
As was expected, supersonic receivers and sets of parts for constructing the same were largely in evidence. Most of these followed the usual lines, namely, a detector and oscillator, followed by three or four intermediate frequency stages (one of these often being tuned), the second detector, and one or two L.F. stages.

The "Super-Het. 8," manufactured by Messrs. Peter Curtis, Ltd., is novel in that it represents an attempt on the part of the makers to design a set which will be particularly suitable for use in this country. It has been realised that many wireless amateurs spend a large part of their time in listening to the local station, and for this purpose a supersonic receiver is not only unnecessary, but costly in valves and batteries. For this reason the makers have incorporated two switches, by means of which the oscillator, one detector and the I.F. valves are cut out, leaving a straight 2 or 3-valve

A luxury portable set. That of the M.P.A. (Wireless), Ltd. The loud-speaker standing on it is manufactured under the Celestion patents.

receiver for local station work. The complete receiver employs 8 valves: detector, oscillator, 3 I.F., 2nd detector and 2 L.F. Tuning controls are two in number. A 2-valve oscillator unit is also available which, with a receiver employing two or more H.F. valves, constitutes a supersonic set. The supersonic components are also sold separately.

The Igranic Company are also selling boxed sets of parts for the construction of a supersonic receiver. This employs 6 valves, and a special reactance-capacity coupling unit which is said to be very stable in action, constitutes the coupling for the I.F. valves. A wide wave-length range (215—4 500 metres) is made possible by the use of three interchangeable oscillator units. The Western-Electric Company are also showing a supersonic receiver, using 7 Wecovalves, with a wave-length range of 300 to 3 000 metres, controlled by switches. One of these sets



The Peter Curtis 8-valve supersonic receiver and frame. It has several novel features.

has recently been taken on a tour round Europe in a car, and the original valves are still intact.

Before leaving the subject of receivers, it should be mentioned that portable sets were in strong evidence at the Show, most of the firms showing one or more.

Turning now to the subject of loud-speakers, novelties in design were not so noticeable as at the previous Show. The general tendency seemed to be towards the improvement, both as regards tone and appearance of existing models, coupled with reduction in prices. One novelty was outstanding, namely, the "Kone" loud-speaker by the Western Electric Company. This was a feature of the firm's exhibit. The instrument is of the hornless type with a double-conical diaphragm, about 18 in. in diameter the back cone being truncated to permit the placing of the specially designed electro-magnetic system within. The absence of a horn renders it practically non-directional. In preliminary tests of this instrument we were impressed by its performance, speech being particularly well reproduced. The resistance of the windings is 750 ohms and the impedance at speech frequencies approximately 5 000 ohms. Special power amplifiers are being produced for use with the "Kone," and are available in panel or cabinet form. During the exhibition, some of the "Kone" loud-speakers, together with a larger model of the same, were reproducing orchestral music played elsewhere in the building.

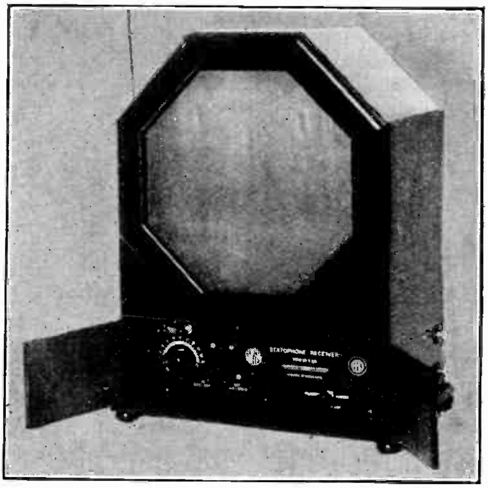
The Western Electric "Kone" loud-speaker and amplifier.

Another novel loud-speaker is the "Statophone" produced by Messrs. C. F. Elwell, and sold with a built-in set. Details of its construction were not available, but it is understood that the action is entirely electrostatic. The conventional electro-magnetic system with a diaphragm or reed has been replaced by a light metallic membrane, which presumably moves under the force of electrostatic attraction, the principle being similar to that employed in electrostatic voltmeters.

Several cabinet and hornless loud-speakers were also noticed, notably those by S. G. Brown, C.A.C. Radio (the "Violina") and W. Bullen.

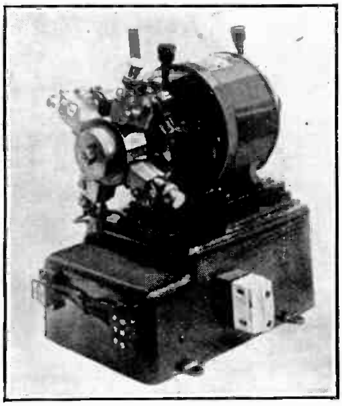
Batteries and other sources of L.T. and H.T. supply now claim our attention, and here the most striking point was the tendency shown by makers to introduce accumulator high-tension batteries, of which many were on view. There is no doubt that the increasing use of high-powered sets and power valves will in time render the use of these (or H.T. supply from the mains) necessary. Dry batteries of large capacity only partly solve the problem.

Several H.T. and L.T. supply units were to be seen—most of these were for D.C. mains only, and did not appear to embody any new principles. Rectifiers, of the rotary type, for accumulator charging from A.C. mains were present on at least two stands.



The Elwell Statophone. The loud-speaker operates electrostatically.

Valves were to be seen on several stands, though, with one or two exceptions, no new types were to be seen. Power valves are now made by almost all the makers, a 525 or 5-volt power, being a great favourite. The 525*b*, or high magnification ditto, is also frequently met. The Nelson Electric Company. have produced a series of three-filament valves, with double flat plates and



One of the "M.W." rotary rectifiers for accumulator charging. Many types are made.

grids. A neat scissor switch at the base enables different filaments to be used, or two filaments at once. In the latter case, the valve can be used as a power valve, since the total emission is increased, and the plate impedance is lowered.

Manufacturers are beginning to realise that an efficient tuner is an essential where long-distance reception is concerned.

Coils of many types were to be seen, and most of them appeared to be well-designed from the point of view of low self-capacity. Quite a number, however, were very flimsy in character. For serious work, coils must be robust and capable of remaining substantially constant in inductance and self-capacity. For this reason, enclosed types are preferable providing the covering does not introduce dielectric losses.

A survey of the condensers at the Show indicated clearly that the square-law type is very popular—in fact, it is now almost impossible to buy one of the ordinary type, apart from laboratory instruments.

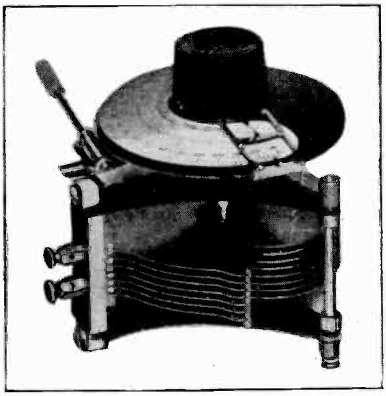
The single-plate " vernier " is disappearing —in its place is the slow-motion device, either built into the condenser, or applied by means of a special geared dial. This is a great improvement—the difficulty of accurately logging a station, when using a separate " vernier," is well-known.

At the same time it should be pointed out that for supersonic work, particularly for the oscillator condenser, control is exceedingly critical, and a reduction of at least 80 to 1 is almost essential. Some of the slow-motion devices only give an 8 to 1 or 16 to 1 reduction, which for this purpose is not sufficient. Many of the devices shown were spoilt by backlash.

With regard to the design of the condensers themselves, we noticed several really well-designed instruments, notably those by the Igranic Company and the Formo Company. In the latter case, the two sets of vanes are complete units, the separate vanes being bonded together by metal strips. The vanes are thus quite rigid. The only insulating material in the whole instrument is a small strip of pure (not moulded) bakelite, so losses should be small.

Another novel condenser is the Newey four-point shown by Pettigrew and Merriman. It contains two sets of square vanes, mounted on toothed sectors, which are both operated by a gear wheel attached to the knob and spindle. A square-law effect is produced.

L.F. transformers as a general rule followed conventional lines, totally enclosed types being common. A novelty was seen in the shape of the Microhm Toroidal Transformer. The coils are wound in an ebonite



The new Formodenser, by the Formo Company. It has several novel features.

ring, and are of small cross-section. The core is in four distinct sections, arranged at intervals of 90° round the ring, which they embrace. It is said that the self-capacity of the windings is extremely low, coupling between the coils is very tight, and no external field is produced. It will be interesting to test this transformer, for which distortionless amplification is claimed.

On the Application of the Neon Lamp to the Measurements of Leaky Condensers and very High Resistances.

By J. Taylor, B.Sc. [R220, R240, R337

Introduction.

A METHOD for the comparison of capacities and high resistances was described in a previous issue of this journal.[1] In the method referred to the capacity was shunted across the neon lamp, which was placed in series with a high resistance, and a battery of sufficiently high voltage to drive the lamp. With this arrangement "flashing" occurs at regular intervals of time, and this regularity of "flashing" is utilised for the comparison of capacities and high resistances.

There is, however, an alternative position of the condenser—across the circuit resistance, as shown in Fig. 1—which has several advantages over the previous position for the comparison of capacities and resistances. It will be well, perhaps, to give the theory of this method. (The theory of the other capacity position is very similar.)

Theory of the Method.

The theory of the position where the capacity is across the lamp has been put forward previously.[2] It is shown in the paper referred to that the current through a neon lamp connected to a supply of voltage, may be represented by the linear relation,

$$i=k(V-V_a) \quad \ldots \quad \ldots \quad (1)$$

where i is the current through the lamp, V is the potential across its terminals at any instant, V_a is the cathode fall of potential approximately, and k is a constant which may be termed the conductance of the lamp.

The production of "flashes" in the neon lamp has been the subject of previous articles in this journal, so that it is not necessary to enter into the causes of the phenomenon again. Further, the nomenclature is the same as in the previous papers.[3]

Referring to Fig. 1 it is obvious that, if E is the voltage of the charging battery, and C the magnitude of the capacity, the potential across C at any instant is,

$$V_1=E-V.$$

Now the quantity of electricity dq_1 flowing

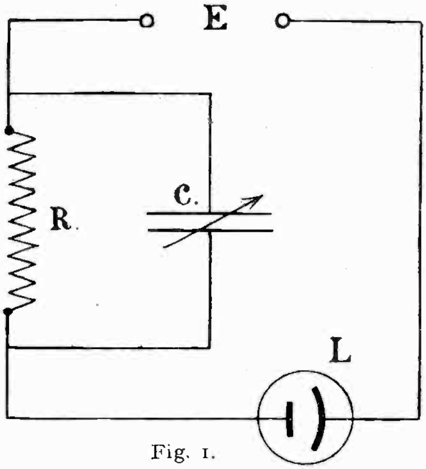


Fig. 1.

into the condenser in dt. secs. *via* the lamp is evidently

$$dq_1=K(V-V_a).dt. \quad \text{(From equation (1))}$$

and the quantity dq_2 flowing out of C *via* the resistance in the same time is evidently,

$$dq_2=\frac{V_1}{R}.dt=\frac{E-V}{R}.\ dt.$$

Therefore the net gain of condenser charge dq, is given by,

$$dq=dq_1-dq_2=C.d.\ R=k\,(V-V_a).\,dt-\frac{E-V}{R}dt. \quad (2)$$

Or we may write,

$$\frac{dV}{(kR+1)V-(E+kRV_a)}=-\frac{1}{CR}dt. \quad \ldots (3)$$

[1] Vol. 2, No. 14, p. 97. Clarkson & Taylor. Also see *Journ. Scien. Instrs.* Vol. 1. p. 173, Taylor & Clarkson.

[2] *Journ. Scien. Instrs., loc. cit.*

[3] E.W. & W.E., Vol. 2, No. 13, p. 41. Taylor.

Integrating equation (3) and writing

$$D=\frac{(E+kRV_a)}{(1+kR)},$$

we obtain

$$-\frac{t}{CR}=\frac{1}{(1+kR)}.\log_e(V-D). \quad .. \quad (4)$$

The condenser charges up till the voltage V across the lamp is equal to the lower critical voltage V_b, and then discharges till V is equal to V_c, the upper critical voltage; so that if t is the duration in secs. of the luminous period, we have from equation (4)

$$t_1=\frac{CR}{(1+kR)}\cdot\log_e\frac{V_c-D}{V_b-D}. \quad .. \quad (5)$$

Now during discharge of C through R in the "dark" period we have

$$-C.dV=\frac{E-V}{R}dt.,$$

and integrating from $V=V_c$, to $V=V_b$, we obtain

$$-\frac{t_2}{CR}=\log_e\frac{E-V_c}{E-V_b} \quad .. \quad .. \quad (6)$$

it being the duration in secs. of the "dark" period.

We have, therefore, from equations (5) and (6) that the total time period T $(T=t_1+t_2)$ is given by

$$T=CR.\log_e\frac{E-V_b}{E-V_c}+\frac{CR.}{(1+kR)}.\log_e\frac{V_c-D}{V_b-D}. \quad (7)$$

This is an exactly similar relation to that obtained for the other condenser position, and it may, on certain assumptions, be reduced to the form

$$T=CR.\log_e\frac{E-V_b}{E-V_c}+C\Delta. \quad .. \quad (8)$$

where Δ is a constant for a fixed value of the charging voltage E.

It will be readily seen from equation (8) that T is a linear function of R (for fixed values of E and C), and of C (for fixed values of E and R). The graphs of these functions are thus straight lines. Now the second term of equation (7) is negligibly small compared with the first (when the "flashes" are of easily countable order), and so we may write the equation fairly accurately in the form,

$$T=CR.\log_e\frac{E-V_b}{E-V_c}. \quad .. \quad .. \quad (9)$$

The above position of the capacity has the additional advantage that there is no variation of V_b with the capacity,[4] since the latter is not across the lamp terminals.

Overcoming the Disabilities of the Neon Lamp Methods.

The writer pointed out in a letter[5] that erraticity in the time of the "flashes" produced in the lamps is largely attributable to a "lag" in the actual occurrence of the "flash" or discharge behind the voltage producing it, due to the lack of sufficient ionisation within the lamp to allow the discharge to pass when the upper critical voltage value across the lamp has been attained. This "lag" may be overcome by having a bright light, neon lamp, or radio-active substance, in the near vicinity of the experimental lamp. These agents produce sufficient ionisation within the lamp to ensure that the discharge takes place without a "lag." If the above precautions be adopted, "flashes" of very long time period (a minute or so) and of regular and repeatable duration may be obtained.

In order to obtain consistent and repeatable results, the lamps are stabilised by "over-running" them before use on a high voltage (480 volts is suitable), so that the electrodes become red hot, and the impurities are driven off from them. After being treated in this manner and rested for a day or two, the lamps exhibit much greater steadiness of their constants, and are less prone to progressive variations.

Experimental Results.

It is found experimentally that both the T, C graphs (E and R constant), and the T, R graphs (E and C constant) for the position of the capacity across the resistance pass through the origin—within the limits of experimental error—and are very exactly straight lines. These results are seen to be in accordance with the relation of equation (9).

Application to the Measurement of Leaky Capacities.

We may assume that a leaky capacity is equivalent to a non-leaky capacity shunted by a high resistance of value R_x megohms. Let C_x be the magnitude of the capacity.

[4] For the determination of the variation of V_b with the capacity, see Taylor and Stephenson's *Journ. Scien. of Instrs.*

[5] E.W. & W.E. Correspondence, vol. 2, No. 14, p. 121.

If we place the capacity in the position given in Fig. 1, and further place a resistance R, of magnitude suitably high to give " flashes " conveniently countable, across the capacity terminals, we have from equation (9),

$$T_x = C_x \left[\frac{RR_x}{R+R_x}\right] \log_e \frac{E-V_b}{E-V_c} \quad \ldots (10)$$

where T_x is the time of " flash."

If we put an additional capacity (non-leaky) of magnitude C_1, in parallel with C_x, we have, with obvious notation,

$$T_1 = (C_x+C_1) \left[\frac{RR_x}{R+R_x}\right] \log_e \frac{E-V_b}{E-V} \quad (11)$$

Dividing equation (11) by (10) we obtain,

$$\frac{T_1}{T_x} = \frac{C_x+C_1}{C_x}, \text{ whence } C_x = C_1 \frac{T_x}{T_1-T_x} \quad (12)$$

Cx is thus determined without any reference to its leakage resistance R_x.

Further, if the capacity is maintained, constant and R is varied, R_x may be determined under the conditions of experiment, and its variation with the charging voltage E may be easily investigated.

Examination of very High Resistances.

Fig. 2 shows diagrammatically the arrangement used for measuring a high resistance, such as the leakage resistance of a small condenser (resistances of 100 megohms or so can be easily measured by this method). A condenser C, of capacity usually of the order of one microfarad, is placed across the terminals of the lamp L, which is connected in series with the high resistance R and a battery of voltage sufficient to drive the lamp.

The condenser C charges up to V_c, and then discharges through the lamp: the presence of the external ionising agent ensures that discharge shall take place as soon as the voltage across the lamp has attained the critical value V_c. If E is the voltage of the battery, it is evident that the time required for the capacity C to charge up from zero potential to V_c volts, when a " flash " takes place, is given by,

$$T = CR.\log_e \frac{E}{E-V_c} = 2{\cdot}302\,6.CR.\log_{10} \frac{E}{E-V_c}$$

or, if the " flashes " occur at a rate suitable for counting, the condenser charges up and

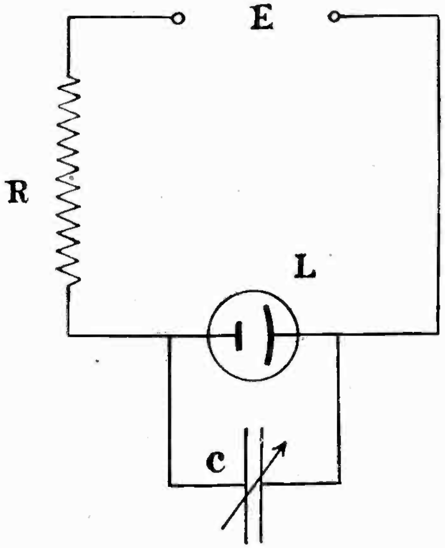


Fig. 2.

discharges between the voltages V_c and V_b, and we have for the time of " flash," the relation of equation (9).

Alternatively, if a standard high resistance of magnitude R_o, giving a time of " flash " T_o, is substituted for the unknown resistance, we have

$$\frac{T}{T_o} = \frac{R}{R_o}, \text{ whence } R = R_o \left(\frac{T}{T_o}\right) \quad (14)$$

By this method R may be determined for different values of the charging voltage E, and its variations determined.

A RE-UNION DINNER.

The Annual Re-Union Dinner for past and present Officers of No. 1 (T) Wireless School and Squadron, Royal Air Force, will be held at the Criterion Restaurant, Piccadilly Circus, W. (Jermyn Street entrance), at 7 for 7.30 p.m., on Friday, 4th December, 1925.

All Officers interested should communicate with the Hon. Secretary, Mr. J. F. Herd, Ditton Corner, Datchet, Windsor, who will send full particulars as soon as they are available.

Bedside Radio.

By A. G. Wood. [R440

AN experimenter's life is not a happy one these days. He has to carry out all his experiments between the hours of midnight and dawn, and as he usually has his daily duty to attend to as well, he seldom obtains much sleep or rest. The writer happens to fall under this heading, and has found through bitter experience that sitting up until about 3 o'clock every morning hardly gives one that "Kruschen feeling" necessary to carry out the day's work. He therefore set to work to minimise the strain as much as possible.

It is well known that to test out a circuit it is advisable to try it over long distances and under varying weather conditions in order to arrive at some conclusion. Also for testing various adjustments a few hours' work is not sufficient. The same remarks apply to the work upon which the writer is engaged—investigations relating to weather conditions and wireless. For this work it is necessary to be "on the air" every night from about midnight until 2 o'clock and the strain becomes acute after a week or two.

The writer conceived the idea of running the set from his bed, but immediately several difficulties presented themselves. Of course, it is practically essential to transfer the receiver to the bedside, but in the writer's case the bedroom adjoins the wireless room, so that it was not out of the question to knock a small hole through the connecting wall.

This was done and the aerial lead was taken through and attached to the set. Similarly low tension leads were run through and an earth attached to the gas main. It was found that the receiver worked quite as well under these conditions in spite of the longer aerial lead-in. The next question to be considered was how to change the aerial over from "receive" to "send," and to switch on the transmitter. Accordingly relays were installed, one at the aerial switch and one on the power board, the control leads being run into the bedroom and attached to a control board mounted up adjacent to the receiver.

Fig. 1 shows the original power switch installed on the switchboard. Under these conditions all worked well for a time until the power relay developed a habit of sticking down, with the result that the operator had to keep leaping out of bed after every transmission to switch off the power! This would never do, and accordingly steps were taken to improve matters. At the same time it was felt that losses were occurring at the aerial change-over switch, due to leakage, capacity, etc., and further improvements were looked for. Finally it was decided to erect a small receiving aerial in front of the house and to do away with the aerial change-over switch altogether. This was done with no loss in the efficiency of the receiver and a slight increase in that of the transmitter.

A special relay switch was constructed for the power board and resolved itself into a

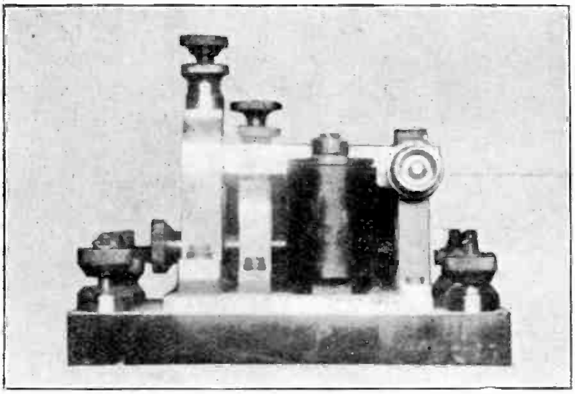


Fig. 1.

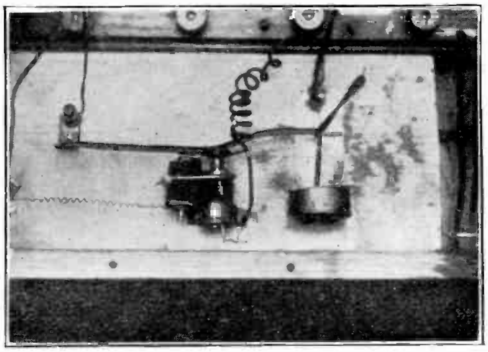


Fig. 2.

mercury switch, breaking under oil (Fig. 2). This was much more satisfactory, except for the fact that the mercury and oil has to be renewed from time to time, as the two seem to form a sludge of some carbon compound. An attachment was made (not shown in the photo) for inserting a starting resistance before the full power was applied. This eliminated surges when the switch was thrown over. Fig. 3 explains this in detail. The blade of the switch is V-shaped and just before making contact with the mercury it engages with a small spring contact which has the effect of putting in a resistance of about 40 ohms for a fraction of a second before main contact is established. It might be mentioned here that this particular switch controls about 8 amps at 220 volts A.C. and seems to perform its duties in a very satisfactory manner. A small elastic band (or preferably a steel spring) returns the switch to the "off" position as soon as the control supply is taken off. Thus the arc produced at "break" is quite small.

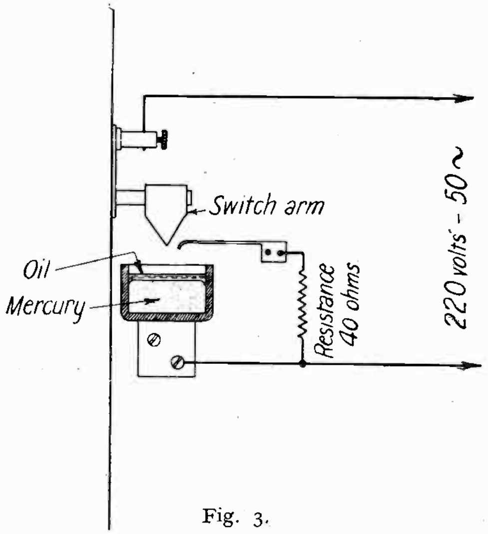


Fig. 3.

The control panel consists of a small cigar box, with a transmitting key and a Dewar switch. Fig. 4 shows the panel in question beside a portion of the receiver.

It might be thought that the receiving serial would appreciably affect the efficiency of the transmitter by absorption, but this is not the case. It is true that with 0.6 amp in the transmitting aerial it is possible to dim the filament of the receiving valve when the receiver is in tune and to obtain 0.1 amp in the receiving aerial but it must be remembered that the transmitter is working on a wave-

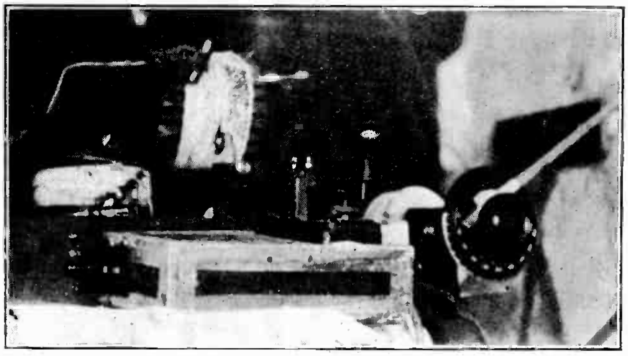


Fig. 4.

length above 90 metres, whereas all, or nearly all, the receiving is carried out on wavelengths below this, and under these conditions no absorption is noticeable.

The receiver is a modified Reinartz with an optional note magnifier and is all that can be desired. Using low loss coils, etc., very strong signals are obtainable from American and Canadian stations.

A word about the transmitter. It must be understood, of course, that in order to carry out this scheme, the transmitter must be reasonably safe to be left to its own devices, although any alteration which occurs when the set is running can generally be detected in the receiver. Apropos this remark, the writer had the exciting experience of having a small fire raging in the wireless room whilst he was sleeping the sleep of the just. A bad connection on the centre tap of the H.T. transformers caused a small arc to form, and set light to the waxed paper which was used for insulating layers of the secondary from one another. The transmitter was functioning (apparently) in a perfectly satisfactory manner and was duly switched off. The next morning when the writer entered the wireless room he found himself looking at the remains of what was once a perfectly sound H.T. transformer! However, if due precautions are taken, this should not occur more than once or twice during the course of the year!

Fig. 5 shows the entire system and the method of keying. This method gives a spacing wave, the divergence of this from the marking wave being controlled by the

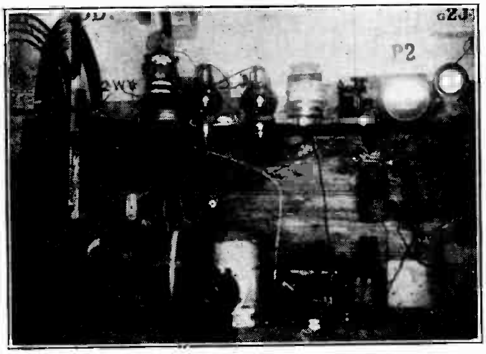


Fig. 6.

variable .001μF condenser across the resistance (200 ohms). The resistance is shorted out for the spacing wave which should be a little above the marking wave. This method has the effect of producing a perfectly steady wave which is essential for long distance work. There is no variation in H.T. voltage, etc., and the smoothing condensers remain charged to the same value the whole time.

The grid coil is not coupled to the plate coil and the set appears to give a purer wave when using this method. The valves employed are two Marconi T 50's in parallel and they work very well together. A coupled aerial circuit is used with a counterpoise of three wires 8 ft. high and 100 ft. long. The aerial is a four-wire cage 4 in. in diameter with a 40 ft. flat top and a 30 ft. lead-in, the height above ground being 70 ft. The wireless room is situated 40 ft. above the ground and immediately underneath the aerial.

Fig. 6 gives a general view of the transmitter.

In conclusion it may be stated that this station has worked over two dozen American and Canadian stations "from the bed." It is run jointly by the same operators as was last year's transatlantic station—G5RZ (which apparently earned a reputation for being unsuccessful in its object), but the location is now different. As an experiment a line was laid between the two locations and it was found possible to control the apparatus from the distant position as well as from the bedside.

In the words of a well-known electrical firm, "Rely on the Relay." The writer takes off his hat to the instrument which has most assuredly lengthened his life by a large number of years!

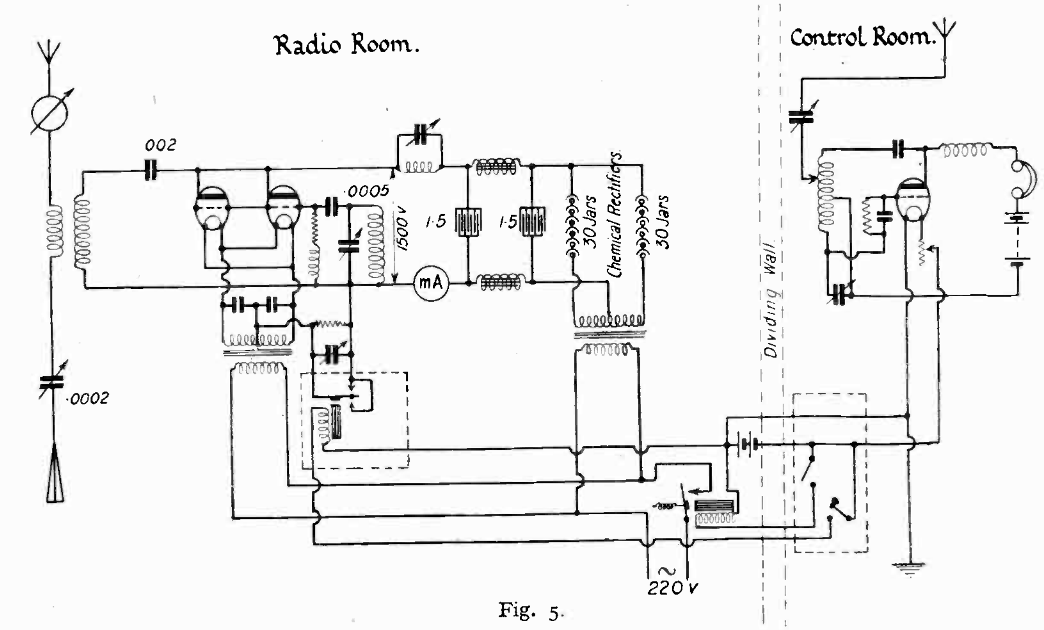


Fig. 5.

Long-Distance Work.

By Hugh N. Ryan (5BV). **[R545·009·2**

THE most notable thing in this month's report is the way in which the great bulk of those interested have returned to the work after the summer "slack period." The change is not very apparent "on the air," as, anyway, we seldom hear our own stations on the 40-metre band where most of the work is now conducted; but it has been made apparent to me by the very great increase in the reports I have received for these columns. Most of my correspondents, I may add, have expressed satisfaction at the inclusion of foreign work in these reports, and a desire for more of it. This desire I am unable to satisfy to any extent this month; but I hope to do so soon. More countries are now sending me reports, but there are still some important exceptions, notably Spain, Italy and Finland, in each of which there are many stations working; perhaps a reader in each country will send me reports in future.

The general trend of work has changed little since last month, except that the Antipodes are occasionally worked in the evenings as well as in the mornings. The amount of this evening work would be very much greater but for the fact that broadcasting hours limit it to Sundays, and curtail it even on that day. (May I correct a prevalent idea among broadcast listeners, in case any of them read this, by stating that this is *not* due to our inability to receive 40-metre DX signals while broadcasting is on!)

At the time of writing, work with South Africa has not become general, but it has been accomplished at last, by G2LZ and O4Z. For some time before this event signals from O4Z had been coming in very well—almost nightly in fact—but again broadcasting usually prevented us from replying. Perhaps we shall be able to find some time outside broadcast hours when we can hear each other, but this has not yet been done. O4F of Johannesburg has not yet been heard here, but has heard G2LZ, G2SZ and G5BV.

Brazil, Argentina and Mexico are worked fairly regularly, but little work has yet been done with Chile, though ChIEG and Ch2LD are quite often heard here, the former being especially strong. Both have worked Britain, as has also Ch9TC.

We have yet to work the American 6th district, but several of us have recently had a sudden great increase in reports from that district, while their signals are more often heard here, so two-way work should soon be accomplished.

The higher-powered stations in London have been working much as usual, though I don't seem to hear a great deal of 5LF these days. All their signals are very weak in London and their phone, when they use it, usually unreadable, though OK at a distance.

2SZ has spent some time on 5 metres, his best DX being 5 miles (to 2VW). On 45 metres he has been heard in Russian Turkestan, and has worked two Chilians and a Mexican.

5BV has "heard and been heard by" both Chile and South Africa, without having worked either. 6QB is only on the upper waves at present, and has worked Spain and Germany on 4 and 3 watts respectively.

5YM has recently started working on 90 metres, and works most of Europe regularly with 10 watts.

6YK is working with a maximum power of 1.5 watts, with which he has reached as far as Italy. Experiments with T.V.T. generators and D.C. voltage raisers having both ended disastrously, this low power is likely to endure for a while.

Mr. Guy of Pinner and Messrs. Studley of Harrow send me very fine lists of stations logged, each including thirteen New Zealanders. 2QJ, of Gerrards Cross, is using 1.2 watts, with which he gets good ranges inall directions except through London.

6VP finds that his signals on 90 metres are always reported as stronger at 1 000 miles than at 50 miles, so that shorter waves have not a monopoly of this effect, though they exhibit it in a more marked degree.

A Mr. Drew (QRA pse, OM?) recently received fourteen Antipodes and South

American stations in an hour in the early evening, a performance distinctly above the average.

5QV is making a determined attempt, by means of weekly schedules, to work the Canadian 4th district, but has had no luck so far. He has worked C3BQ's phone on one occasion. 2TO has not been working recently, but may soon be expected back on distinctly high power. 5SI, probably our best low-power station, has been trying to fulfil in truth the remark I recently made in jest, about his QRO to 5 watts for New Zealand. He has not yet quite succeeded, but he has done it with just under 12 watts, which is not a bad start.

2NB is working Z's on quite low power, and 5QT, in the same country, has worked Palestine at mid-day, also on low power.

6IZ is, I believe, the only station in Northern Scotland now working on 90 metres. He has been working for two months, during which time he has worked most of Europe. He hopes soon to be on 45 metres. 6MU (Belfast) has now worked both Australia and New Zealand, being the first Irish station to do so.

A number of amateurs have been keeping careful records with the object of trying to establish a connection between meteorological conditions and signal strength. Mr. Erith, of Sutton (Surrey) sends me an interesting graphical record covering September and part of October. 5YM is also keeping a very complete record of a similar nature. I know of a number of others doing the same, and they naturally want to get together with a view to pooling results. If any others in this position, who actually have some observations taken, will let me know, I shall be glad to put them in touch with each other.

Danish 7EC is still working as usual, and has been received in South Africa. 7ZM is just starting to work again. During the summer he made two trips from Copenhagen to Hull and back, keeping in touch with 7EC all the time.

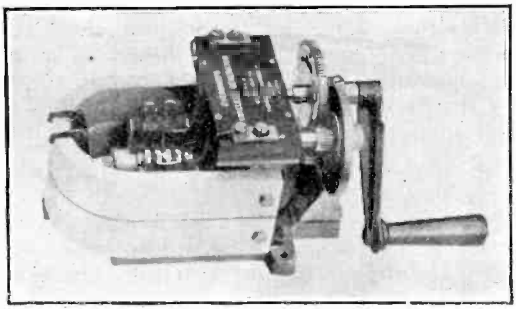
The Swedish ship *San Francisco* (SGC) left some time ago for South America, and several Swedish stations have been keeping him in touch with home. SMYY has worked Brazil almost nightly since May, and has also worked Argentine and New Zealand. SMZS has worked all over the world, but the owner is now away from home, and a second operator is in charge. The owner himself hopes to work on low power from his temporary QRA at Stockholm.

Chilian 9TC asks me to state that he is now using the call-sign CLAA for his work with RMA1. I hope that stations in all countries will send me reports of their work in future, and please remember that the post takes a few days to reach here. Reports should reach me by the 10th of each month, if possible.

Apparatus Tested. [R·009

The Evershed H.T. Generator.

Messrs. Evershed and Vignoles have submitted to us for test one of the hand-driven H.T. generators which they have now placed on the market for wireless purposes. The generator is of the type used in megger testing sets and has powerful permanent field magnets. We have given the generator trials under both station and field conditions, and, in general, have found it to be a useful and reliable piece of apparatus, particularly for portable work and under circumstances where other forms of H.T. supply are not available. It is suitable for 10-watt valve transmitters.



The Evershed hand generator.

The makers have wisely fitted a substantial handle with a four-inch stroke, allowing a powerful force to be applied to the gears provided that the generator is firmly bolted down to a solid bench. The handle operates the gears through a ratchet and pawl arrangement which prevents the armature from being rotated in the wrong direction. When no load is connected across the output terminals of the generator it turns easily and smoothly, showing that very little power is wasted as friction in the gears and bearings; a load taking, say, 15mA entails very much harder work in turning. The total gear ratio of 25 to 1 seems rather high and renders it somewhat difficult to maintain a steady speed of turning at full load. The trouble may, however, be attributable in part to the winding of the armature; the machine is rated to give 600 to 1 000 volts, and although it is easy enough to obtain these voltages on open circuit it is very hard work to maintain 500 volts across the terminals when a current is being supplied to the anode circuit of a transmitting valve. It should be mentioned here that our tests were carried out chiefly using valves of the L.S.5 type having a comparatively low impedance and taking a correspondingly large anode current; the low-impedance valve is rather coming into favour with amateur transmitters. Our tentative suggestion is that even for working in conjunction with valves of normal impedance the armature of the generator might be wound with rather fewer turns of wire so that a larger current could be obtained at lower voltages. We believe that this would not only permit turning at a slightly faster and steadier speed, but would actually allow more power to be delivered to the valve. It should be remembered that a nominal 10-watt transmitting set often has a choke control valve for telephony purposes, so that a total H.T. power of at least 20 watts may be required.

The commutator of the Evershed generator is worthy of note. It comprises four two-part commutators and four pairs of carbon brushes connected in some peculiar way which we could not investigate without dissecting the machine. The system of commutation is most effective in reducing ripple; without any smoothing device at all we have done some quite good telephony work, the commutator ripple being quite small and not interfering with the speech to any appreciable extent. With a condenser of 0.5μF across the generator the ripple became negligible and with the addition of a smoothing choke and a second condenser of 1.0μF absolutely no ripple was detectable at all. At full load there is slight sparking at the commutator brushes, but this does not appear to have any harmful effect.

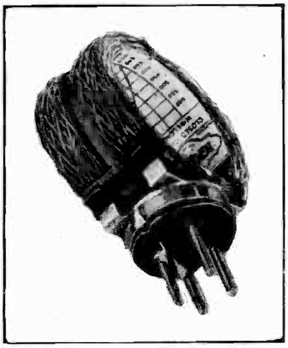
The generator is solidly constructed and there is very little that can go wrong. The armature windings are completely encased. For a cog-geared mechanism we consider it very silent-running. It is important to mention that the makers will also supply the generator with a driving pulley instead of the hand gear should it be desired to use a power drive.

The price of the hand-driven model is £13, and that of the power-driven model is £11.

Honeycomb High-Frequency Transformers.

The Igranic Electric Co., Ltd., of 149, Queen Victoria Street, E.C., are now making a series of high frequency transformers wound on the well-known honeycomb system as used for their inductance coils.

In each case the windings (primary and secondary) appear to be exactly similar in size and form, and are spaced by about ¼ in. They are fixed side by side and mounted similarly to an ordinary plug-in inductance, except that the base is circular and is fitted with a standard 4-pin plug, thus enabling the component to be plugged into an ordinary valve-holder.



The "Igranic" honeycomb H.F. transformer.

Incidentally, the plugs are mounted so that the transformers are inclined at an angle when the holders have the sockets corresponding to the grid and anode of a valve arranged in a line. This has the effect of reducing the mutual coupling between two or more transformers if mounted close together, which is a good point.

The transformers are made in four sizes, and we confined our tests to the smallest, which is stated to have a wave-length range of 288 to 538 metres when the secondary winding is tuned by a .000 5μF variable condenser in parallel. Further, since both windings appeared to be similar, we measured the inductance of one only, and found it to be 150μH, which corresponds roughly to an ordinary 50-turn coil. The self-capacity of this winding was 33$\mu\mu$F.

The coupling coefficient between primary and secondary was found to be on the low side, namely, 38 per cent. This is due to the rather large spacing between the two coils. We are of the opinion that in the case of the larger sizes the coupling coefficient would improve, because while the spacing between the coils remains the same, the coils themselves are much deeper. In fact, it is fairly safe to say that the coefficient would become about 60 per cent.

In conclusion, though these transformers are no doubt quite efficient components, we see no reason why a step-up ratio between primary and secondary should not have been introduced with a considerable increase in efficiency and without any adverse effects coming into play.

The prices range from 8s. to 12s. 6d. each.

For the Esperantists.

Distordado. [R800

Oni nun diskutas la necesaĵojn por perfekta ricevado pere de transformatore-kuplitaj aparatoj, kune kun kelke da utilaj praktikaj konsiletoj.

Parto IV.

Mallongigoj: A.F., Alta Frekvenco; M.F., Malalta Frekvenco; A.T., Alta Tensio; M.T., Malalta Tensio; K.K., Kontinua Kurento; A.K., Alterna Kurento.

LA ELEKTO DE TRANSFORMATOROJ.

EN la lasta parto ni esprimis nian opinion, ke nunmomente la ŝok aŭ rezistanc-kuplita amplifikatoro ne havas veran avantaĝon por kompensi sian malefikecon. Ni nun pritraktos detale la transformatoran kuplecon, kaj unue konsideros la necesaĵojn, laŭ nia nuna vidpunkto (koncerne la kuplo mem) pri la desegno de transformatore kuplitaj aparatoj.

La tri punktoj, kiuj tuj sin montras, estas: (1) la proporcio de la transformatoro; (2) ĝia desegno; (3) iaj akcesoraĵoj ekster la transformatoro uzataj por helpi eviti la distordon. Ni antaŭsupozas ke, per ĝusta elekto de valvoj kaj zorga aranĝo de voltkvantoj, ni jam forigis valvdistordon.

Nun, pri la proporcio. Estas strange ke, se oni povus fabriki transformatoron teorie perfektan, la proporcio ne estus grava rilate al distordo. Sed unu el la ĉefaj efikoj de neperfekteco naskiĝas pro la mem-kapacito de la sekundaria vindaĵo, kiu donas al la transformatoro naturan frekvencon propran, kun rezulto, ke frekvencoj apud ĉi tiu troe grandiĝas. La uzo de alta proporcio plifortigas tiun ĉi efikon, kaj samtempe ŝanĝas la naturan frekvencon. Generale, per bonaj transformatoroj, oni malmulte eraros, uzante proporciojn laŭjene:—

Post valvo, tipo A.F., de anoda impedanco 25 000 omoj, 1 : 3; post valvo "ĝenerala," aŭ tipo 625b, de anoda impedanco, ĉirkaŭ 20 000 omoj, 1 : $3\frac{1}{2}$ aŭ 1 : 4; post valvo, tipo M.F., de anoda impedanco, ekzemple, 15 000 omoj, 1 : 4 aŭ 1 : 5; post altpotenca valvo, de 5 000 ĝis 10 000 omoj, 1 : 5 aŭ 1 : 6.

Se ial estas necese uzi transformatoron netrebonan, oni elektu proporcion iom malpi altan. Kontraŭe, se oni elektos transformatoron bonegan, oni povos uzi proporcion iom pli altan.

Rilate al la ĝenerala desegnado. Ni unue konstatu, ke ni celas doni konsilon pri *elekto* de transformatoroj. Notoj pri desegno de transformatoro por fabrikado estus multe pli komplikitaj, ĉar la desegno de M.F. intervalva transformatoro estas unu el la plej malfacilaj problemoj de la radio-industrio. Parolante ĝenerale, transformatoroj nuntempe vendataj suferas pro malsufiĉo de fero. Do, se oni bezonas bonan transformatoron, oni elektu tiun kun plej granda koro; la plej bonaj havas koron proksimume 2.5 c/m. × 2.5 c/m. en la meza membro. Ankaŭ, la koraj lamenaĵoj devus esti maldikaj.

Estas avantaĝo aranĝi vindaĵon sekcie, kvankam tio en si ne estas sufiĉa por bona transformatoro. Se eble, oni informiĝu pri la ĝusta nombro da vindaĵoj. Sekundario de 20 000 vindaĵoj (ĉirkaŭ granda koro) estas taŭga, la primario estante ŝanĝita por doni la ĝustan proporcion.

DIFEKTOJ EVITENDAJ.

Provante transformatorojn, certiĝu ke ne estas valva distordo, kaj tiam serĉu difektojn. La plej oftaj estas:—

(*a*) *Akreco*.—Raŭka sonado, kune kun troa emfazo je la altaj tonoj—ordinare pro tro malgranda koro. Kelkfoje transformatoro estos akra je la lasta ŝtupo, kvankam bonega je la antaŭaj. Tion kaŭzas pligranda K.K. tra la primario de la lasta ŝtupo, kiu troŝarĝas la koron.

(*b*) *Resonanco*.—Ekstra grandiĝo de frekvencoj en unu aparta regiono; tre rilatas al sekvanta difekto.

(*c*) *Malbona ekvilibro*.—Konstanta pliiĝo de emfazo, dum la tono plialtiĝas, aŭ eble dum ĝi malplialtiĝas. Efektive resonanco ĉe unu fino de la gamo. Ambaŭ ĉi tiuj ofte estas parte forigeblaj laŭ ĉi-malsupre, sed oni zorgu ke, kiam oni faras tion, la sekvanta difekto ne enkondukiĝos.

(*d*) *Fortranĉo.*—La forteco falas rapide ĉe unu fino de la gamo. Vere bona transformatoro funkcios bone de ekzemple 200 ĝis 5 000 cikloj, sed kelkokaze ĉio sub 1 000 parte perdiĝas. Aŭskultu atente al la fortepiana baso, trombono, kaj la basa vjolo, por la malalta fino, kaj al la altaj tonoj de la violono kaj pikolo, por la alta fino, kaj notu, ĉu ili envenas je plena forteco.

Oni devas, kompreneble, memori, ke ofte kelke da difektoj kunestas, sed akra orelo baldaŭ povos apartigi ilin.

PLIBONIGOJ.

Trie, venas la demando, kiel plibonigi la funkcion de neperfekta transformatoro. La plej konataj metodoj estas la uzo de alta rezistanco aŭ fiksa kondensatoro trans la vindaĵoj, kaj ili estas ofte uzataj. Oni devus kompreni, ke la efiko atingita per ŝunto trans la primario havas definitivan rilaton kun tiu atingita per ŝunto trans la sekundario. Se s estas la volvaĵa proporcio, tial la meto de ŝunta rezistanco aŭ kondensatoro trans la sekundario havos efikon laŭ grado s^2 de la sama kondensatoro trans la primario. Ankaŭ, la efiko pligrandiĝas laŭ la pligrandiĝo de la kondensatoro, sed pligrandiĝas dum la rezistanco fariĝas *malpligranda*. Tial, kun transformatoro, kies proporcio estas 4 : 1, kondensatoro .0001 trans la sekundario havas saman efikon (por malaltaj frekvencoj) kiel .0016 trans la primario, kaj 100 000-oma rezistanco trans la primario estas sama kiel $1\frac{1}{2}$-megoma rezistanco trans la sekundario.

Nu, kiaj la efikoj ? Ĝenerale ŝunta rezistanco iom malfortigas ĉiujn signalojn, sed aparte emas ebenigi ian neegalecon ekzistantan pro resonanco kaj malbona ekvilibro. Tia rezistanco nemulte helpos forigi akrecon aŭ " fortranĉon."

Ŝunta rezistanco, kontraŭe, emas al resonanco, sed ordinare je malplialta tono, ol alie okazus. Ĝi tial estas utila por malpliigi la akrecon aŭ tiun specon de malbona ekvilibro, kiu troemfazas altajn tonojn, aŭ por malpliigi la fortranĉon je malaltaj frekvencoj. Sed, uzante ĝin, oni devas zorgi ne kaŭzi apartan resonancon malaltan aŭ fortranĉon de altaj tonoj.

Ĉe transformatoro ne ŝirmita en metalujo oni kelkafoje ricevas utilajn rezultojn, vindante fadenon proksimume dekfoje ĉirkaŭ la transformatoraj vidnaĵoj mem, ĉiu el la dek vindaĵoj tuŝante al alian. Tio ordinare helpas al la ebenigo de la resonanco.

Sed tiaj rimedoj estas vere artifikoj, kiuj ne povas kompensi kontraŭ malbonaj transformatoroj ; oni preskaŭ ĉiam malsukcesas, per ili, havigi vere kontentigajn rezultojn, por kio oni devas dependi je vere bonaj transformatoroj. Tiaj transformatoroj apenaŭ bezonas tiajn rimedojn, kaj oni devas eĉ observi, ke la ŝunta kondensatoro uzata en la detektora anoda cirkvito ne estas tro granda (.0001 estas sufiĉe granda), aŭ ĝi eble havos efikon.

STABILECO INTERNE DE LA APARATO.

Kelkaj punktoj estas prikonsiderindaj ĉe aparatoj kun kelke da ŝtupoj de M.F.'a amplifado. La plej evidenta estas la demando pri stabileco. Ne malofte okazas, ke eksperimenta aparato komencas persistajn oscilojn. Ili konsistas el du specoj. Unu speco havas nenian rilaton kun la amplifikatoro mem. Ĝi naskiĝas kiam kelkaj el la valvoj estas mikrofonemaj. Tiuokaze, se la laŭtparolilo estas sur loko, de kie ĝi povas ĵeti al la valvoj laŭtan bruon, ili eble amplifos la bruon mikrofone, kaj la tuta aparato baldaŭ bruegos. Tio estas kuracebla, se oni uzos malpli sentemajn valvojn, kaj formovos la laŭtparolilon.

Pli malfacila afero estas la kuraco de persista mem-oscilo, kaŭze de vera M.F'a reakcio interne de l'aparato. Oni ofte diras, ke ĝin kaŭzas la valv-kapacito, sed estas tre dube, ĉu tio vere okazas je malaltaj frekvencoj. Ĝi preskaŭ ĉiam estas kaŭze de hazarda kuplo *ekster* la valvoj.

Oni eble ne unue komprenos, ke la A.T'a baterio estas fonto de kuplo se (kiel ofte okazas) ĝi posedas iom altan rezistecon. Granda kondensatoro—ekzemple, 1 μF—devus esti metita trans ĉiu pozitiva ŝtopilo (se estas pli ol unu) kaj la negativa fino. Oni ofte nuntempe uzas savan rezistancon ĉe unu el la kondukiloj, aŭ interne de ŝtopilo aŭ aparte. Ankaŭ, kompreneble, estas la demando pri senpera magneta kuplo de unu transformatoro al alia. Sirmitaj aŭ aliaj bonaj transformatoroj estas kelkfoje meteblaj tutapude sen ĝeno ; sed kelkaj tipoj ne funkcias bone se la distanco inter ili estas pli ol 30 cm.

En nia sekvanta parto ni pritraktos la du restantajn punktojn, la laŭtparolilon kaj la detektoron.

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.

"Wipe Out."

The Editor, E.W. & W.E.

SIR,—I noticed on p. 853 of the October issue of E.W. & W.E. an article entitled "Wipe Out." Whilst not criticising the subject matter of the article, I should like to state that, in my mind, the term "wipe out" has never been associated with the automatic synchronisation of valve oscillators.

The latter phenomenon is well known, but as far as I am aware, has no "slang" title, although in its application to telephony it has been christened the homodyne or "zero beat" method of reception.

I think the term "wipe out" has always been associated with the literal wiping out of signals on a receiver, when the amplitude of the local oscillations is increased to such an extent that the mean grid potential of the rectifying valve is sufficiently large in the negative direction to cut off the anode current of that valve. It is evident that this condition will give rise to a complete disappearance of all signals, whether these synchronise with the oscillator or not.

There are important differences between the two phenomena in question. First, to produce automatic synchronisation on "pulling-into-step" by the incoming signals, the local oscillator must be moderately weak, although tightly coupled to the receiving system. To produce "wipe-out," a powerful local oscillator is necessary, its actual magnitude depending upon the circuit and adjustments of the rectifier.

Secondly, in the synchronised condition, although no beat note will be heard, any modulation on the incoming carrier wave will be received perfectly; it is, indeed, the ordinary homodyne method of reception, and further, it can be carried out without the usual rectifying arrangements, as shown by Mr. Colebrook.

In the "wipe out" condition, neither beat note nor modulation can be received: the receiver is, in fact, "polarised," to quote another slang term in use among wireless engineers some years ago. The same effect can be produced by a powerful continuous wave transmitting station working in close proximity to the receiver.

R. L. SMITH ROSE.

National Physical Laboratory,
Teddington, Middlesex.

The Editor, E. W. & W.E.

SIR,—I am interested in the matter discussed on page 853 of the October issue, in which two trains of oscillation are present in a receiver. There is a phenomenon which takes place in this case which I have not seen mentioned anywhere, but which was a little surprising when noticed.

The receiver consisted of a Moullin voltmeter of the grid rectification type, with the normal anode current balanced out by the filament battery. The input was connected across an ordinary tuned aerial circuit, and when tuned to 2LO a current drop of 70 microamps was shown at resonance. A separate oscillator was arranged to give a reading of equal strength, and this was slowly tuned across 2LO's wave. An increase in the reading was noticed even before a note was heard in the phones, and this increased until, when near resonance and a low, audible note was being produced, the deflection was approximately double that with either oscillation alone.

When the oscillator was brought into step it was expected that the two trains of oscillations would add up to produce one of double strength, but instead the reading went back to zero, the two oscillations completely neutralising one another. The only indication was produced by 2LO's modulation, which, consisting of side bands of a different frequency, were not neutralised.

If the oscillations were of different strengths, the decrease in reading on falling into step was double the difference between the two.

The reason for the gradual increase in deflection as the two sets of oscillations are brought near resonance is obvious from a consideration of the expression for the sum of two sine waves of different frequency, but it is not clear why, when they fall into step, they should do so in opposite phases. Perhaps somebody would explain this matter.

MARCUS G. SCROGGIE, B.Sc.

19, St. Mildred's Road,
Lee, S.E.12.

An Esperanto Society.

The Editor, E.W. & W.E.

SIR,—For some time past your progressive paper has been in the habit of publishing articles in our language, and, in consequence, quite a number of your readers joined our circle last Friday.

As it is not generally known that we exist, and especially as we serve a very large area, I would be extremely obliged if you would publish this letter, feeling sure that a large number of your subscribers will welcome the information.

The New Cross & District Esperanto Circle.
W. H. MATTHEWS (*Hon. Sec.*).

Clyde Street, Deptford.

The Supersonic Patent.

The Editor, E.W. & W.E.

SIR,—Our attention has been called to your article on "Supersonics" on page 800 of your issue for October.

From this we notice that it is your intention to give detailed designs of a supersonic set. In doing so, we would ask you to be good enough to make due acknowledgment of the fact that the basic patent covering the construction of wireless receiving sets employing the supersonic principle, namely British Patent No. 143,583, is the property of this company.

Any amateur wishing to construct a supersonic set should apply to us for a licence, accompanying his application with the royalty of 30s., on receipt of which a licence will be issued immediately.

We would like to mention that the royalty of 30s. is irrespective of the number of valves employed.

Western Electric Co., Ltd.
H. A. P. DISNEY (*Asst. Sec.*),

Connaught House,
63, Aldwych, London, W.C.2.

The "R.I." Transformer Curve.

The Editor, E.W. & W.E.

SIR,—I have read with interest the letter of your correspondent, E. A. Anson, and first of all, wish to state that it was anticipated before the publishing of the advertisement referred to that criticism similar to this would be forthcoming.

I agree with your correspondent that the perfect transformer would be the one which amplified, not only all frequencies equally, but amplified to the same degree, greatly varying input values of energy, at each frequency. Herein lies the difficulty and the factor which is not generally realised.

In the plotting of an amplification curve, some arbitrary and constant value of input current must be taken as the basis, and the curve obtained is only correct for the particular value of input energy used. In practice, however, the amplitude of the incoming energy may be hundreds of times greater at once frequency than another, and unless a series of curves is obtained for each value of input energy, it is a decidedly incomplete characteristic of the apparatus under test. Obviously, it is not possible to obtain a reliable series of amplification curves, covering the wide variations of input current. The N.P.L. calibration curves shown are only correct as far as they go, and are not necessarily indicative of the results which may be obtained in actual reproduction. When the input energy applied to a transformer is below a certain value, the amplification factor practically disappears, and as the smaller values are usually at comparatively high frequencies, forming the overtones and harmonics of cound, some means of compensation must be employed to maintain a more complete reproduction of all the different frequencies.

Your correspondent will, therefore, see that in general the "R.I." theory does not differ from his own, except that the "R.I." theory goes further, inasmuch as it takes into account the minute values of input energy for which it is not possible to obtain a reliable characteristic curve.

It should be appreciated that in order to obtain a high amplification factor of the lower frequencies, that is, in the vicinity of 200 per second, it is only a question of increasing the number of turns and consequent impedance of the windings. On the other hand, by using the larger number of turns, the effect of self capacity is unavoidably increased, and the amplification of very weak high frequencies decreases enormously.

A large number of experimental transformers are made and tested every year, and while some of them give what seem at first beautiful mellow tones at low musical frequencies, the overall reproduction leaves much to be desired.

I do not agree that the advertisement is misleading, and the "R.I." transformer stands on its merits according to the satisfaction to the user.

Radio Instruments, Ltd.,
WM. A. APPLETON (*Director*).

12, Hyde Street,
New Oxford Street, W.1.

A Standard Report Card.

The Editor, E.W. & W.E.

SIR,—I have read with interest the letters which have appeared in E.W. & W.E. *re* the standard report card, and would like to state that as a non-transmitter I agree fully with Mr. King, whose letter appeared in your September issue.

I have settled on a type of card, of which I enclose a specimen, as a result of a considerable number of changes, and feel that, for non-transmitters, it is quite a reasonably satisfactory article.

A. STEWART CLACY.

10, Melrose Avenue,
Reading.

A. S. Clacy 10, Melrose Avenue,
To Radio Reading,
Berkshire,
ENGLAND.

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QSD. G.M.T. *QRH.* METRES.
QRK. R *QRB.* KILOMETRES
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Aerial. *Cpse.* *Earth.* *Remarks.*
Wires Wires
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Length Length

PSE QSL BY CARD. 73s.

Aerials and Lightning.

The Editor, E.W. & W.E.

SIR,—A few instances have been reported during the past summer of wireless apparatus being destroyed by lightning, but considering the number of aerials now in use, the damage has been unexpectedly small. The extent to which aerials are affected by lightning discharge and the results likely to arise therefrom are questions of practical importance to all users of wireless apparatus, and an attempt is being made to collect information relative to actual cases in which aerials and apparatus have suffered in this way. I should be glad if I may use the publicity of your columns to ask anyone, and everyone, whose apparatus has been damaged, to forward full information to me at the address given below. The data particularly required are :—

(A) The date and time of the occurrence.

(B) The position and approximate dimensions of the aerial.

(C) The nature and position of the earth connection.

(D) A brief description of surroundings, *i.e.*, position of adjacent houses, trees, telephone wires, etc.

(E) Whether the aerial was directly earthed or whether either receiving or transmitting apparatus were in circuit.

(F) The fullest possible description of the incident and the nature of the damage done.

CECIL L. FORTESCUE.

City & Guilds Engineering College,
Exhibition Road, S.W.7.

Station News.

The Editor, E.W. & W.E.

SIR,—It may be of interest to you to note that the P.M.G. has granted me an artificial aerial transmitting licence, the call sign allotted to me being 2BLO.

J. A. A. NOTTAGE.

26, Manbey Street,
Water Lane, Stratford, E.15.

The Editor, E.W. & W.E.

SIR,—Will you please advise your readers that any QSL cards for South African transmitters may be addressed to c/o S.A. Radio Relay League, "Myrtle Grove," Irwell Street, Observatory, Cape Town.

J. S. STREETER.

The Editor, E.W. & W.E.

SIR,—Kindly note that from this date my call sign is G6TB. 10 watts maximum, 150/200 metres, 45 metres, 23 metres, C.W. and phone QRA as above.

No fixed schedule for general tests, but reports from amateurs logging occasional general test calls will be welcomed, and will be acknowledged in every case.

Am QSO with G5NJ on low power at fixed times.

The original call sign 5RL expired a long time ago, but has not yet been deleted from all the call books. Congratulations on the continued excellence of "E.W.," and best 73's.

JOHN A. SANG.

22, Stranmillis Gardens,
Belfast (Northern Ireland).

The Editor, E.W. & W.E.

SIR,—I believe that my QRA is unknown to a number of amateurs. I should be pleased if you could make this known in the next issue of your journal, also that I am making tests on 23. 45 and 90 metres, with a power of from 2 to 4 watts. All QSL cards acknowledged by return.

Wishing your journal every success.

F. COLSTON HARDWELL,
(British 2GY.)

91A, Temple Street,
Bristol, England.

The Editor, E.W. & W.E.

SIR,—I beg to inform you that the call sign 5JO has been allotted to me in place of my old one, 2ARY.

Transmissions will take place in a few weeks on 150-200 and also 440 metres. Reports will be very welcome, and will all be answered. Power, 10 watts.

LAWRENCE W. JONES.

50, King Street, Cambridge.

Proposed Institute of Radio Engineers.

The Editor, E.W. & W.E.

SIR,—I have read with astonishment the arguments advanced by Mr. H. Gambrell in his letter published in your October issue. I do not know what Mr. Gambrell means when he says "wireless has become a large family." If he refers to the family of broadcast listeners, I can well understand why they cannot be housed "under the roof of the I.E.E."

Wireless engineering embraces not only most phases of electrical engineering, but many branches of civil engineering as well. This is well known to any wireless engineer who has been entrusted with the erection of even a small powered wireless station. Why, therefore, should the labelling of a wireless engineer as a "chartered electrical engineer" falsify the status of the latter? It may "bring blushes to the cheeks of the purely wireless *man*," as Mr. Gambrell suggests, but not to the wireless engineer.

The second paragraph of Mr. Gambrell's letter seems to me inconsistent with the first. He outlines the training of a wireless engineer, which I find it difficult to differentiate from the training of an electrical engineer. In any case the proposed syllabus contains nothing which could "falsify the status of electrical engineering."

I have had 18 years' experience of wireless engineers and have been responsible for the selection of a number of men, and, so far as my experience goes, all the most successful men have developed from those having a sound University training in electrical engineering. True, as Mr. Gambrell states, may of these men commenced their wireless activities as amateurs, often while engaged in other branches of electrical work, but without their initial training they would never have reached the positions they hold to-day. As in many other vocations in life, it is often a mistake to specialise in a professional capacity too early.

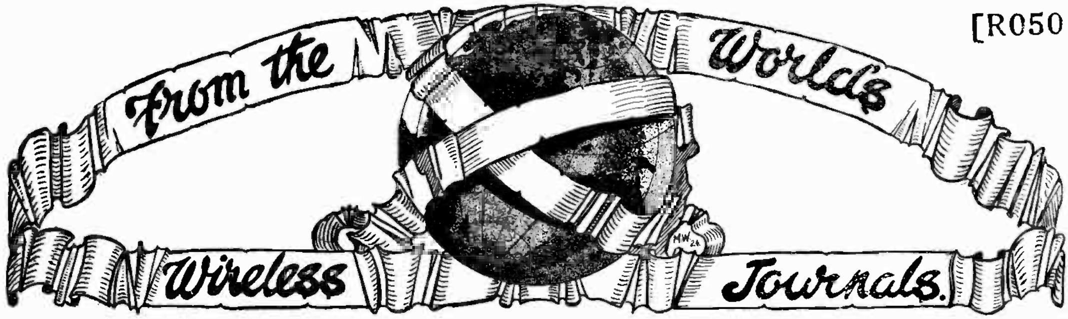
I believe that the link between wireless and electrical engineering, which the I.E.E. has forged by the formation of the Wireless Section, is too valuable to be broken and will be productive of many new workers to the radio field, while catering for all the needs of the professional wireless engineer of to-day.

B. BINYON, O.B.E., M.A., M.I.E.E.

34, Norfolk Street,
Strand, W.C.2.

[While Major Binyon's statements are all perfectly correct, it would appear that he has not quite grasped the point of the controversy, which is the allegation that the I.E.E. does not properly serve the Wireless Engineer: the last two lines of his letter beg the whole question at issue.—ED., E.W. & W.E.]

[R050



R.200.—MEASUREMENTS AND STANDARDS.

R240.—METHODE ZUR BESTIMMUNG DES ANTENNENWIDERSTANDES.—M. Osnos (*Zeitschr. f. Hochfrequenztechnik*, Vol. 26, No. 1).

Some methods of discussing aerial resistance are discussed. It is pointed out that the well-known method of coupling the aerial circuit to a source of oscillations and noting the aerial currents for various values of added resistance is not strictly accurate unless the mutual inductance between the source and the aerial circuit is taken into account. A method is described in which this mutual inductance is taken into account. Let R_a be the aerial resistance, i_c the current in the drive circuit, i_a the aerial current, M the mutual inductance and ω be 2π the frequency. Adjustments are made until the ratio $\frac{i_c}{i_a}$ is a minimum. Under this condition the aerial resistance is given by the relation : $R_a = \omega M \left(\frac{i_c}{i_a}\right)_{min.}$

Another method of measuring aerial resistance is described in which a loading inductance and a series condenser are included in the aerial circuit. Between some point on the loading inductance and another point somewhere in the aerial circuit on the other side of the series condenser the H.F. potential difference is a minimum. These two points are found by trial and the potential difference $E_{min.}$ between them is measured. Then, if the aerial current is i_a, the aerial resistance is given by :

$$R_a = \frac{E_{min.}}{i_a}$$

A modification is also described by means of which the aerial resistance may be determined by measurements made in an intermediate coupling circuit.

R269.—ELECTROSTATISCHE VOLTMETER UND GLIMMRÖHREN ZUR SPANNUNGSMESSUNG IN HOCHFREQUENZ.—A. Palm (*Zeitschr. f. Hochfrequenztechnik*, Vol. 26, No. 1).

There is not much choice in the matter of instruments for measuring high-frequency potentials, the electrostatic type being about the only available type. This article gives some constructional details of electrostatic voltmeters developed by the firm of Hartmann and Braun. These are virtually quadrant electrometers fitted with pointer and scale. For low voltages (5-150) the multi-cellular construction is used to increase the sensitivity. A most ingenious method of measuring H.F. voltages, and one which should commend itself to the amateur on account of its simplicity, is described. A neon discharge lamp of special construction is employed which starts to glow at a definite voltage (113 volts A.C. or 160 volts D.C.) independently of the frequency. This flashing voltage must first be determined by using a source of known E.M.F. at any convenient frequency. Two condensers, one fixed and the other variable, are shunted in series across the source whose E.M.F. is to be measured. The neon tube is connected across one of the condensers and the one which is variable is adjusted until the tube just glows. We the known the voltage across one of the condensers and by calculation from their relative capacities we can easily arrive at the E.M.F. of the source.

R271.—NOUVELLE CONTRIBUTION À L'ETUDE DE LA PROPAGATION DES ONDES.—M. Lardry (*Onde Elec.*, Sept., 1925.)

An article giving results of some signal strength measurements on wave-lengths of 450 metres, 200 metres, and 115 metres. Shunted telephones were used, this method allowing rapid readings to be made and giving curves consistent with those obtained by means of an oscillograph. The transmitting stations upon which the measurements were made were situated 180 kilometres from the receiver.

A number of fading curves are shown which were taken in various months of the year. The writer points out that statements to the effect that fading is absent on short wave-lengths (115 metres and below) are quite false. Variations in wave-length as well as intensity of signals were observed but it was found that these two types of variation were independent of each other.

R300.—APPARATUS AND EQUIPMENT.

R344.4.—SUR LES HARMONIQUES DES OSCILLATEURS À ONDÈS TRÈS COURTES.—C. Gutton and E. Pierret (*Onde Elec.*, Sept., 1925).

Some observations are described which were made upon the harmonics of the oscillations produced by valves generating on wave-lengths of the order of 2 metres with object of obtaining much shorter wave-length oscillations. With a one-valve oscillator it was found that the strongest harmonics were produced when anything was done which increased the stability of the oscillations, such, for instance, as increasing the coupling between grid and anode by bringing their respective leads closer together. With the two-valve symmetrical oscillator of Mesny strong harmonics to the seventh (47 cms.) were obtained when the symmetry was upset by displacing the anode connection somewhat. Another two-valve oscillator with reversed coupling was tried. This had a fundamental of 176 cms. and gave a number of detectable harmonics. The second was the strongest, but the fifth on 35 cms. could be measured with the aid of a very sensitive thermo-electric couple.

R387.1.—The Shielding of Electric and Magnetic Fields.—J. H. Morecroft and A. Turner (*Proc. I.R.E.*, Aug., 1925).

An experimental investigation of the shielding of electric and magnetic fields is reported for both constant and changing fields. The effect of using iron shells, or sheets, for shielding against the fields of permanent magnets, as well as those set up by electric currents, is considered; the best form for the iron sheets is deduced and an expression for the measure of the shielding action is suggested.

The reason for the leakage of electric and magnetic fields is shown to be due to the differences of magnetic or electric potentials in the circuit in which the fluxes are being set up; several cases are cited in which no external fields are set up, as the circuits exhibit no differences in potential. An expression for the shielding effect of a short-circuited coil is deduced and experimental verification is offered for frequencies between 10^2 and 10^6 cycles per second.

Finally the shielding effect of metal sheets against changing magnetic fields is analysed and experimental results are given to show how the action depends upon the characteristics of the material of which the shielding plate is made, its thickness, and upon the frequency used. The effect of slits in the metal sheet is indicated.

Amateur DX in South America.

By Ch9TC (Los Andes, Chile). **[R545·009·2**

I BELIEVE a note on the present position in South America will be of interest to British readers; of course, there are relatively few stations working at present, but results have been excellent.

Argentine.—CB8 has now worked four continents and been heard in five (unless he has found any more lately). His nightly "family press" to his son in Birmingham is, of course, familiar to British stations. Other Argentine stations have worked New Zealand and U.S.A., but CB8 rather eclipses everyone else.

Chile.—New Zealand has been worked by two of our stations and U.S.A. by one (the writer's); calls were exchanged by the writer and G2NM.

Over 250 U.S. stations have been logged at Ch9TC, but only two in Britain, and no others in Europe. It seems as though the tablelands of Brazil and the Andean range kill signals from the north-east, although, in the reverse direction, Ch9TC has been reported from Finland, Great Britain, Sweden and France, using 200 watts nominal. Australia and South Africa are QSA here.

Brazil.—Two-way communication was recently established between Bz1AB (Rio) and SMYY, and between 1AT (also at Rio) and U.S.A. These are the only DX achievements of which I have definite knowledge, but I believe signals were exchanged between Rio and Great Britain on at least one occasion.

Uruguay.—This is only just opening up on telegraphy, and as yet no DX has been recorded.

Bolivia.—A station at Oruro worked the writer months ago, but has not been heard since; I believe no DX is likely.

Local.—Chile, the Argentine, Brazil and Uruguay are steadily QSO, both in morse and telephony; this makes the route *via* Brazil to Europe worth trying whenever any traffic is held for other South American republics. Santiago de Chile has worked Montevideo and São Paulo with five watts nominal, and there are many higher power stations available, so that this route can be regarded as reasonably reliable.

The telegraphy amateur in these parts is a reasonable person, and little interference is caused with the broadcasts. There are exceptions, but at least 90 per cent. of such interference is due to amateur telephony stations, and it is in this direction that more stringent measures are likely.

Most apparatus is home-made. The standard receiver is the old Armstrong inductive-regenerative, with untuned primary—called locally the "Perry O. Briggs" from the U.S. amateur who recently re-popularised it in *Q.S.T.* Reinartz (original and latest), Reinartz-Weigant, and Paragon (plate-variometer) also have their adherents.

Transmitters are frequently Meissner; many stations are getting excellent results with inductively-coupled sets with untuned antenna, transmitting on a harmonic, *e.g.*, the five-watt Santiago station mentioned, Ch2LD, with 2 000 mile DX to its credit.

Wave-lengths range from 35 to 250 metres (in telegraphy: telephones go on up to 400 metres), but the majority are below 100 metres. Unfortunately we are just suffering from an attack of "40-metre" fever, and the QRM around that wave is bad—and increasing.

Ch9TC on 89 to 91 metres está à sus ordenes, senores!

Some Recent Patents

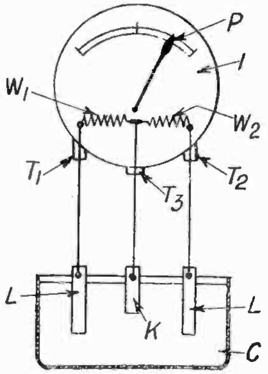
(The following notes are based on information supplied by Mr. Eric Potter, Patent Agent, Lonsdale Chambers, 27, Chancery Lane, W.C.2.)

[R008

THE CADMIUM BATTERY TESTER.

(*Application date, 3rd April,* 1924. *No.* 236,284.)

An interesting cell tester is described in the above British Patent specification by A. W. Rayworth. The method of operation is shown diagrammatically by the accompanying illustration, and it will be seen that the device consists essentially of a differentially wound voltmeter provided with two ordinary terminals and a third terminal connected to an auxiliary electrode designed to be introduced into the electrolyte of the cell to be tested.



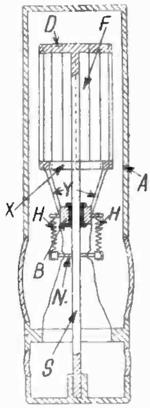
Thus the voltmeter comprises a centre zero instrument *I* provided with two windings W_1 and W_2 arranged differentially. The ends of the windings are connected to two terminals T_1 and T_2, while the centre tapping is taken to a third terminal T_3. The cell to be tested is shown at *C*, and two elements *L*, to which the outer terminals T_1 and T_2 are connected, are also shown. The third terminal T_3 is connected to an electrode *k*, preferably made of cadmium, which is introduced into the cell.

In operation the pointer *P* will indicate the true potential difference between the elements, and also the amount of charge remaining in the cell, *i.e.*, the pointer will indicate the net result of the potential difference between positive to cadmium and negative to cadmium. It is interesting to note that if the positive terminal of the voltmeter be connected to the positive element of the cell, during the time the cell is either on charge or discharge, the pointer will indicate the probable condition of the element. A similar method can be employed in the case of the negative element. We should imagine that the device would be very useful in practice, and we understand that it is already on the market.

FILAMENT CONSTRUCTION.

(*Application date, 10th March,* 1924. *No.* 235,295.)

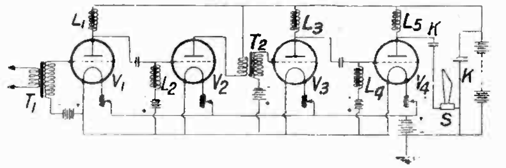
A method of filament construction suitable for high power rectifying valves is described by H. J. Round in the above British Patent. The specification points out that when it is desired to obtain a large current and low internal resistance it is necessary to use a large filament close to the anode or grid. When this is done, difficulty has previously been experienced owing to the filament sagging due to the attraction from the anode, and when a number of filaments have been used in parallel similar difficulty has been experienced owing to magnetic effects. According to this invention these difficulties are overcome by constructing the filament in the form of a cage consisting of a meshwork or number of parallel wires, arranged in the following manner. Referring to the accompanying illustration it will be seen that the filament structure is supported from a disc *D* fitted to an upright stem *S*. The disc *D* carries the filament wires *F*, which are supported at the lower end by a spider *X*, providing supports *Y* fixed to a ring terminating in an insulated bush *B*. Springs *H* are placed between the ring and a support *N*, fixed to the stem *S*. Thus it will be seen that the spider supporting the filament is free to slide up and down the stem. The action of the springs can compensate for any expansion due to heating. The filament is shown inserted in a valve of the high power type containing an external anode *A*.



AN EXTRAORDINARY AMPLIFIER PATENT.

(*Application date, 12th April,* 1924. *No.* 236,993.)

British Patent No. 236,993, granted to S. W. Bligh and E. Ll. Crowe, has for its object the prevention of distortion by the use of iron core choke coils in the anode and grid circuits of the valve amplifier, and also to prevent the magnets becoming demagnetised or the windings burnt out, either, or all of which, it is stated, may happen when the high tension current is fed to the valves from the windings. So far as distortion is concerned, with the use of iron-cored chokes in the anode and grid circuits, this depends entirely upon the actual electrical constants, the use of which has been known for years. So far as the elimination of the steady anode current from the loud-speaker is concerned, this has also been known and it is interesting to note that it can be shown mathematically that the distortion is inversely proportional to the steady magnetic flux, which is obviously increased by allowing the anode current to pass through the windings. Neither do we see how the magnets are likely to become demagnetised when a steady magnetising current normally flows through them, unless, of course, they are connected

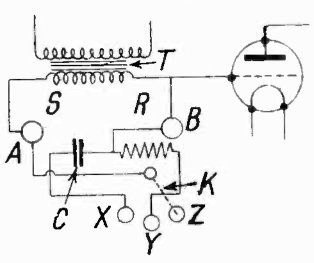


in the wrong direction, but this is not usual. Referring to the accompanying illustration, which shows one arrangement of the idea, it will be seen that the input to the valve $V1$ is an ordinary intervalve transformer $T1$, this valve being coupled to the valve $V2$ by means of a choke $L1$ and a grid choke $L2$. $V2$ is coupled to $V3$ by a transformer $T2$, while the valve $V3$ is coupled to the valve $V4$ by a choke $L3$ and a grid choke $L4$. The loudspeaker S is connected through two condensers K across a choke $L5$ in the anode circuit. We confess that we do not see the novelty of the scheme, as we are of the opinion that all these devices have been known and used for some considerable time. Incidentally, the absence or presence of distortion depends entirely on the electrical constants of the coupling device, and this arrangement may easily produce far more distortion than a series of transformers. It is obviously dependent upon the design, and no details of this nature are given in the specification.

A TONE IMPROVER.

(*Application date*, 19*th March*, 1924. *No.* 235,932.)

C. H. Gardner, of the Midland Radiotelephone Manufacturers, Limited, claims a system of controlling or improving the tone of broadcast reproduction in the above British Patent. He claims in the invention the use of a number of impedances, such as condensers or resistances shunted across the secondary of a transformer, which is connected to the input of a low frequency amplifier valve. The specification contains actual constructional details of a device of this nature consisting of condensers and resistances arranged to be connected in circuits by means of a switch. One arrangement of the idea is shown in the illustration. It will be seen that the secondary S of a transformer T is connected between two terminals A and B. The terminal B is connected to the grid, while the terminal A should be shown connected to the filament and also the contact arm K of a radial

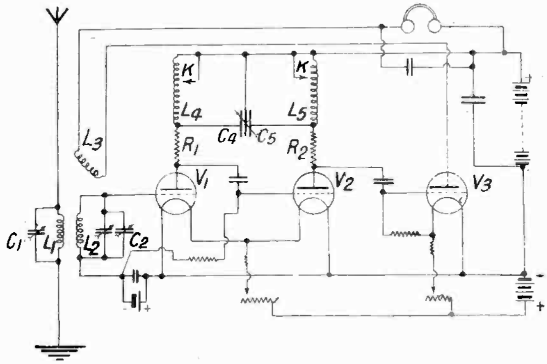


switch, which is provided with contacts X Y and Z. When the arm is on the contact Z, the secondary is merely connected between the grid and the filament; when it is on the contact Y, a resistance R is shunted across it, while when it is on the contact X, a condenser C is shunted across it. Frankly, we do not see very much novelty in the idea as it has been customary to shunt a transformer with a resistance for many years, while the introduction of the condenser between the grid and filament of an amplifier valve is also well known. For example, readers will find the idea described in E.W. & W.E., Vol. 1, No. 1, October, 1923, page 26.

MULTI-STAGE HIGH-FREQUENCY AMPLIFICATION.

(*Application date*, 12*th March*, 1924. *No.* 235,307.)

A system of multi-stage radio-frequency amplification is claimed in British Patent No. 235,307 by Burndept, Limited, and C. F. Phillips. The invention relates essentially to a practical system of stabilising a number of similarly tuned circuits by the introduction of ohmic resistance. Referring to the accompanying illustration it will be seen that

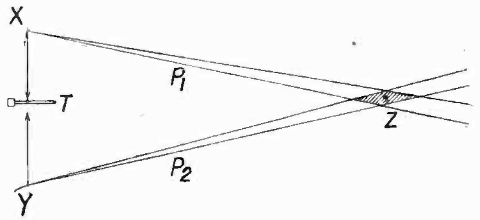


a three-valve arrangement is shown, the valves $V1$ and $V2$ acting as radio-frequency amplifiers, while the valve $V3$ functions as a detector. The tuned aerial circuit $L1$ $C1$ is shown coupled to an input circuit $L2$ $C2$. A third coil $L3$ provides regeneration between the anode circuit of the detector valve and the input circuit of the first amplifier. The tuned circuits of the amplifier consist of $L4$ $C4$, $L5$ $C5$, a double condenser $C4$ $C5$ being shown. Greater wave-length change is obtained by variable contacts K. The system of radio-frequency coupling is therefore an ordinary tuned anode. However, between the tuned circuits and the anodes of each valve resistances $R1$ and $R2$ are included. It is pointed out in the specification that when a number of tuned circuits of this nature are arranged oscillation will occur owing to a regenerative effect being obtained by virtue of the inter-electrode capacities of the valve. In order to overcome this difficulty the resistances $R1$ and $R2$ are therefore inserted, this idea, of course, being well known for several years. The actual novelty of the invention lies in the construction of these resistances. They are wound with insulated wire over a brass or copper cylindrical former, which renders them noninductive, and at the same time act as a by-pass condenser to radio-frequency currents. It is stated that the resistance and capacity may be suitably proportioned by varying the size of the wire. We would point out, of course, that this system does not eliminate the transference of energy by inter-electrode capacities, owing to the by-passing effect of this condenser, which really exists across the resistance. The stabilisation, of course, is simply due to the introduction of resistances into the anode circuits of the valves.

INTENDED SECRET COMMUNICATION.

(*Application date*, 9*th April*, 1924. *No.* 236,647.)

A rather interesting system of secret communication is described by R. D. Bangay in British Patent No. 236,647, and is illustrated by the accompanying diagram. Referring to the illustration, it will be seen that the idea relates to a short wave beam transmission system, in which one transmitter is provided at *T*, alternative beam paths being shown at *P*1 and *P*2. The alternative paths are obtained by reflecting a beam at *X* and *Y* respectively, and



focusing the two beams on to the desired receiving point *Z*.

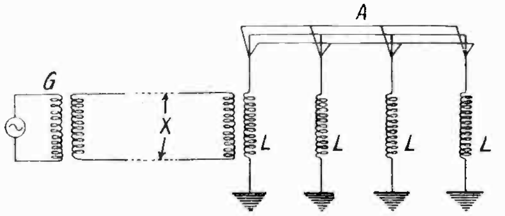
Secrecy can be obtained in a variety of ways. One method consists essentially in splitting up the dots and dashes, and sending the dots down one beam, and the dashes down the other. In the case of telephony one simple method is by the use of a double filter system, one filter rejecting all frequencies above, say, 1 000 cycles, and another rejecting all frequencies below, so that the resulting speech is split into two sections, each of which is sent down one of the beams.

Even this system, of course, would not give perfect secrecy. In the case of anyone being particularly desirous of obtaining the message, it would only be necessary to use two recording receivers, one arranged in each beam, the two records being arranged so that they blend together properly, in which case it would be possible to obtain the whole message.

A TRANSMISSION SYSTEM.

(*Convention date, U.S.A.*, 25*th June*, 1923. *No.* 218,299.)

A system of transmission is described in the above British Patent by Marconi's Wireless Telegraph Company, Limited, and P. S. Carter. One object of the invention is to enable the radiating system to be placed at some distance from the generating system, the two being connected by a radio-frequency transmission line. Previously difficulty has been experienced owing to reflection taking place along the line, particularly on short waves, and this is overcome by the arrangement illustrated by the accompanying diagram. A multiple tuned aerial *A* is earthed through a series of inductances *L* and constitutes the radiating system. A source of oscillations is shown at *G*, and is situated at some distance from the aerial. The source of

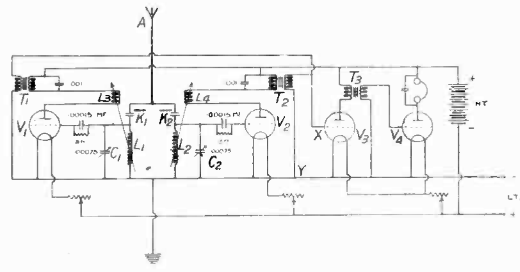


oscillations and the multiple tuned aerial are connected by a line *X*, and the losses in this line are a minimum when the transmission is at unity power factor, *i.e.*, when the current and voltage are in phase. In this condition no waves can be reflected back from the ends to interfere with the natural flow of energy into and out of the transmission line. This result is obtained by closing the end of the line with an impedance in such a manner that the effective impedance at the end of the line is equal to the surge impedance of the transmission line. It has been found in the case of a multiple tuned aerial that this condition is satisfied when the ratio of the total current flowing through the tuning inductance to the current flowing in the input inductance is equal to the square root of the ratio of the surge impedance of the line to the resistance of the aerial system. Another object and modification of the invention is to provide a system which gives directional transmission by utilising separate aerials fed from a single source from a number of transmission lines. The specification contains details and circuits of systems satisfying these conditions.

SECRET COMMUNICATION.

(*Application date*, 6*th March*, 1924. *No.* 235,275.)

A system of reception for use with secret methods of transmission is claimed by W. H. Fulford in the above British Patent, the accompanying illustration showing one form of receiver. It is stated in the specification that secret transmission is frequently obtained by periodically altering the frequency of the transmitter, or, alternatively, by transmitting

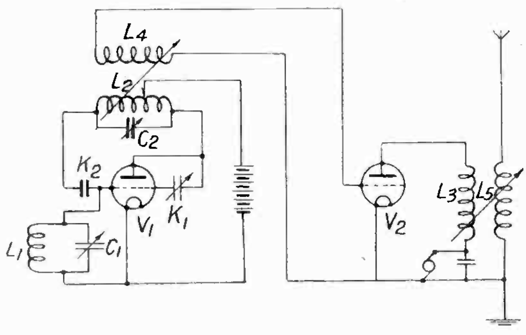


some speech frequencies at one radio frequency, while the others are transmitted at another radio frequency. The present invention consists in providing a receiver which will respond simultaneously to the two different frequencies which are chosen. In the accompanying illustration it will be seen that two valve detectors $V1$ and $V2$ are employed. These are provided with tuned circuits $L1$ $C1$ and $L2$ $C2$, reaction coils $L3$ $L4$ being connected in the anode circuits and coupled to the respective grid coils. The anode circuits further contain the primary windings of transformers $T1$ and $T2$, the secondaries of which are connected at X and Y, between the grid and filament of the amplifying valve $V3$, which is further connected to another amplifying valve $V2$ by a transformer $T3$. A single aerial A is employed, and is coupled to the high potential end of the two tuned circuits, associated with the valves $V1$ and $V2$, through two condenser $K1$ and $K2$, each having a capacity of 0.000 01μF. This feature is the essential novelty of the invention, and in another modification these condensers can be included between the lower ends of the tuned circuits and the earth connection. It is claimed that a condenser of this capacity is sufficiently small to render the effect of the one tuned circuit upon the other comparatively negligible, and it is stated that approximately an equal amount of energy will be transferred from the aerial to the two tuned circuits on the two wave-lengths that are being employed by the transmitter. We should imagine that the scheme would work quite well.

ELECTROSTATIC MODULATION.

(*Application date, 25th April,* 1924. *No.* 237,025.)

A system of electrostatic modulation is described in the above British Patent by G. W. Hale, and the Radio Engineering Company, Limited. The general idea of the arrangement can be gathered by reference to the accompanying illustration. A valve $V1$ is provided with two tuned circuits, $L1$, $C1$ and $L2$, $C2$. The connection of the circuits $L2$, $C2$, to the anode, grid and filament of the valve is quite familiar, and constitutes the normal centre feed arrangement. Both $L2$, $C2$ and $L1$ $C1$, are tuned to the same frequency, this frequency being that of the transmission. The circuit $L1$, $C1$, replaces the ordinary grid leak. $L2$, $C2$ is coupled to a coil $L4$, which is connected between the grid and filament of a power amplifier valve $V2$, containing an anode coil $L3$, which is coupled to the

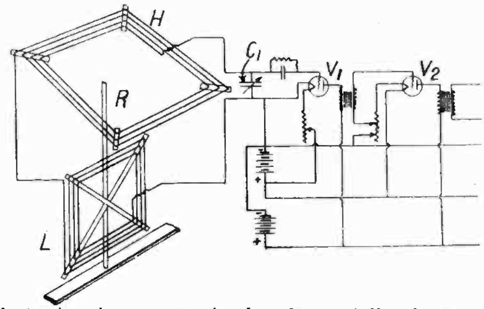


aerial coil $L5$. Between the anode and the grid of the valve $V1$ is connected a variable condenser $K1$ of similar capacity to the coupled condenser $K2$. It is stated that the regenerative coupling effect of the condenser $K1$ is equal and opposite to that of the condenser $K2$, and this condenser can be so arranged that normally no oscillations will be produced by the valve $V1$, whereas an unbalancing of the circuit will cause oscillations to be produced. This fact is utilised as a system of modulation, the sound waves either causing the condenser vanes to move directly, or through the medium of some electro-mechanical device. It is stated that the arrangement may be used as a quiescent system or that the condenser may be adjusted so that the valve is just oscillating. The specification is fairly detailed, and shows several modifications and arrangements of the idea.

UNI-DIRECTIONAL RECEPTION.

(*Application date, 7th July,* 1924. *No.* 235,407.)

A system of uni-directional reception is claimed by J. H. Herzog in British Patent No. 235,407. The invention consists in combining the effect of two frame aerials in such a manner, it is claimed,



that signals are received substantially from one direction only. The idea of the invention is illustrated by the accompanying diagram. Two valves $V1$ and $V2$ are shown, the valve $V1$ acting as an ordinary detector, and the valve $V2$ as an amplifier. The input of the valve $V1$ consists of the directional aerial system, which forms a closed circuit with the variable condenser $C1$. The aerial system comprises two loops or frames at right angles. The frame H is supported in a horizontal plane on a rod R while the frame L is supported in a vertical plane, and is capable of rotation. The two loops are connected in series, and form the input of the receiver. It is stated that the horizontal loop acts chiefly in the form of a capacity, and receives signals equally well in all directions, while the vertical loop L acts as an ordinary frame in a known manner : *i.e.*, maximum signal strength is obtained when the plane of the loop lies in the plane containing the transmitting and receiving station. The specification states that there is a peculiar relation or connection between the stationary coil and the vertical loop, whereby signals from one direction in which the loop lies will be blocked out, and only those from the opposite direction received. In other words, the device is similar to the ordinary cardoid system, which consists of a combination of a plain open aerial, and a frame, the superimposition of the two receiving diagrams giving the well-known cardoid. No receiving diagrams are actually shown, but we imagine that the scheme functions in this manner, although no definite suggestions are put forward.