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Editorial Views.

A Wireless Institution.

IN our correspondence columns this month are letters from Mr. James Nelson, M.I.E.E., and Mr. Y. W. P. Evans, on the subject of a proposed "Institution of Radio Engineers."

That it is eminently desirable that those technically interested in Wireless—in fact the readers of E.W. & W.E.—should have some such institution nobody will deny. But the question instantly arises as to whether a new body is necessary for the purpose, or whether, on the other hand, they are catered for already, or could be catered for, by existing bodies.

One's thoughts turn naturally to the R.S.G.B. At present, undoubtedly, this is rather a social, semi-technical, and administrative body for the general amateur. We gather that it proposes to retain this position, and has no objection to the foundation of another institution being established for the exchange of technical knowledge.

There are also various other associations of a general wireless interest, but none of these are technical or official bodies.

Lastly, what of the Institution of Electrical Engineers? Here, according to the claims of some of its members who have written published comment on the new suggestion, may be found all that the wireless engineer requires in the way of technical brotherhood.

Unfortunately, as things are at present, this view is hardly justified by facts. True, the I.E.E. has a Wireless Section; but it is open to any member of the Institution, and therefore may contain many members with no qualifications whatever as *wireless* engineers; while at the same time a real highly-skilled wireless engineer, unless he has considerable professional experience of heavy electrical engineering, cannot get in!

The I.E.E. has not yet learned that a wireless engineer needs at once more and less experience than an electrical engineer pure and simple: more knowledge of high frequency technique, and less of some branches of electrical engineering with which he is not directly concerned.

Obviously, the ideal solution would be to have a Wireless Institute under the patronage of the I.E.E., covered (if possible) by its charter and affiliated to it, while having its own qualifications for entry, its own proceedings, and its own distinguishing initials as a mark of membership.

But unfortunately the I.E.E. cannot move quickly—we believe that its next Council meeting is some months ahead. So that it would appear sound to support the proposed new institution provisionally, on the understanding that if the I.E.E. are prepared to recognise the distinct qualifications of the wireless engineer, and cater for him properly, the new body and the Wireless Section of the I.E.E. should be fused.

The greatest difficulty that we foresee (except possibly opposition from competing bodies) is that of membership qualification, as regards the proposed grades of Member and Associate Member. Obviously, examination must be the basis. But there are some men, in established positions, for whom an examination would be an indignity. Yet, among these well-known men there are some who are "whited sepulchres"—who have a reputation unearned and unjustified. Such must always be the case. The only obvious way out of the difficulty is to insist on examination for *all* entrants except those who, after the most searching deliberation, are esteemed worthy of being invited as Fellows.

Lastly, a minor criticism: if this is to be a *British* rather than an international institution, why use the international "Radio" instead of the British "Wireless"? We would sooner see it called the "Institution of Wireless Engineers," or the "Wireless Institution." This will also limit the amount of confusion with the I.R.E. of America.

Poor Henry!

People do some curious things in the matter of names. One need only quote the French popular name for a tuning coil, which began by borrowing "self-inductance" from English and went on to drop the last part, so that a coil is now not only a *bobine d'accord* (which is quite sound) but is often called a "*self*." How this must enrage those Frenchmen who love their language!

Just recently we have come across another curiosity, though this time not a matter of language.

We have been testing a considerable quantity of commercial receiving coils, and find them hardly ever to have the nominal number of turns. Coils marked "25," for example, ranged from 22 to 31. The object is fairly obvious.

The first plug-in coils marketed were quoted by their actual number of turns, and new types are being given enough turns to bring them up to the same inductance value. Thus, in addition to the several existing units of inductance, we have a new one. The *turn*, which is "the inductance possessed by one turn of a typical plug-in receiving coil of 1922."

Was there ever anything more ridiculous? Remember, moreover, that the actual inductance is proportional to something between the turns and the square of the turns, depending on the shape of the coil, so that the new unit tells us very little as to the actual inductance.

No; let us stick to microhenries, and exert all influence on the manufacturers to sell coils by microhenries, with perhaps (for the present) some note as to the equivalent number of turns on a typical coil. What is more important, let us *think* in microhenries. As a start, we give below a table showing approximate average microhenries for typical plug-in coils of the best known sizes.

Turns.	μH.	Turns.	μH.
25	30	300	5 000
35	60	400	9 000
50	130	500	15 000
75	300	600	20 000
100	500	750	32 000
150	1 200	1 000	60 000
200	2 200	1 250	90 000
250	3 500	1 500	135 000

Filters.

By *P. K. Turner.*

[R386

To the best of our knowledge there is no simple and fairly accurate account of filter design available at present, so we have provided what we believe to be one. Practice is given first, theory after.

THERE seems to have been written in this country very little about filters that is at the same time correct and reasonably easy to understand. The following notes may therefore be of interest—the analysis on which they are based is given at the end of the article for the benefit of those serious workers who wish to carry the investigation further.

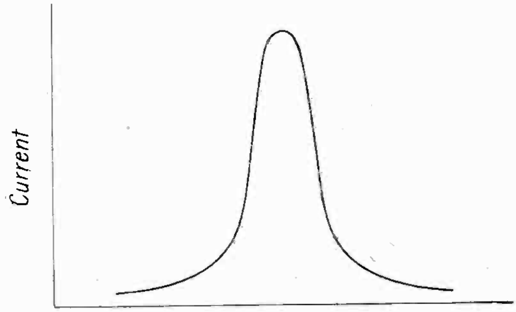


Fig. 1. *A rough idea of the resonance curve of an ordinary tuned circuit.*

First, to clear our ideas, what is a "filter"? Strictly speaking, any circuit which has a selective effect on the currents entering it. A "frequency filter" is one which exercises its effect according to the frequency of the current, and is the only type we are considering.

According to the above definition, any circuit whatever containing inductance and capacity is a filter; but the term has come to be restricted to a particular type. For example, a tuned circuit having a resonance curve of the type in Fig. 1 is not usually called a filter. The word, in modern practice, is used only to denote a circuit in which the object striven for is to give a resonance curve of the type in Fig. 2: a high, even current over some part of the frequency range, and a low, equally even, current over any other part, the dividing line being as abrupt as possible. Such filters are sometimes called "Campbell" filters, and we shall deal only with them. Their uses are very numerous.

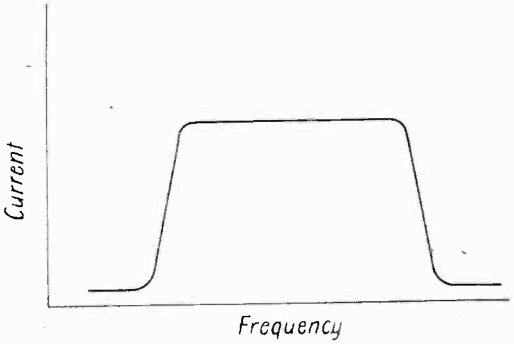


Fig. 2. *By contrast with Fig. 1, this is one sort of curve from a filter such as that in Fig. 3.*

General Ideas.

Now the most general arrangement of such filters is that of Fig. 3, and is seen to be a network of impedances—nature at present unspecified—partly in series with the output circuit and partly across it. It is found to make the calculation much simpler if the two end series impedances are made one-half the value of the rest. The particular filter shown has three stages according to the convention to be adopted in this article, in which the input, but not the output, circuit is regarded as a "stage." In fact, the number of stages equals the number of "Z_2's."

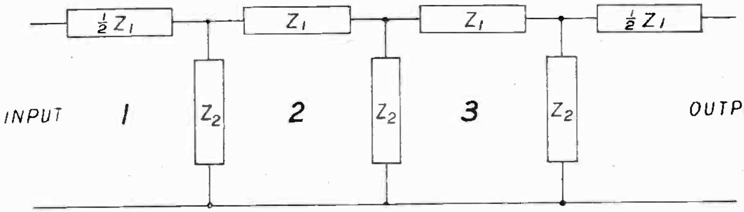


Fig. 3. *The most general type of filter: Z_1 and Z_2 represent impedances of some kind.*

Such a filter may be made to behave very diversely, by a suitable selection of the values for Z_1 and Z_2. Unless otherwise indicated, we are only considering filters in which all the Z_1's are equal, and also all the Z_2's. Four examples are shown in Fig. 4, together with their ideal frequency-current curves. We say "ideal," because (as we shall show) such curves are actually only got with an infinite number of stages.

The form of the filter usually gives the clue by which we can remember its function. Fig. 4*a*, for example, is a "High Pass" filter. Obviously D.C. (*i.e.*, zero frequency) could not get through it at all. Similarly, for Fig. 4*b*, D.C. wou'd pass easily through the inductances, so we can easily recollect that 4*b* is a "Low Pass" filter; 4*c* and 4*d*, in turn, can be remembered as Band Pass and Band Stop filters by recollecting that the series impedances of 4*c* are "acceptors," which easily pass currents to which they are tuned, whereas the series impedances of 4*d* themselves consist of inductance and capacity in parallel, and therefore form rejectors which stop resonant currents.

We have explained that the frequency curves in Fig. 4 are ideal ones, and could only be given by filters with an infinite number of stages. When the number of stages is finite—say *n*—the filter is in resonance for $n+1$ distinct frequencies: if *n* is large enough, these are so close together that they simply give the "flat" top or bottom of the curve a gentle waviness. Note that there is no question of tuning each stage to a different frequency. Each stage *as a unit* is tuned to the same frequency: it is the combination of the stages which gives the different ones. Examples of this will be shown later.

Practical Design.

We can now get down to a consideration of the design of a filter. The questions to be solved are three, being given the frequencies to be passed and those to be stopped: (1) How many stages must be used? (2) What must be the values of Z_1 and Z_2? (3) How are we to design coils and condensers of these values?

The last question will not be considered here, as there is quite a lot of literature on the subject.

Before however going on to give instructions we will, to prevent any chance of confusion, define our terms:—

"Inductance" and "capacity" need no definition. "Reactance" is the opposition to an alternating current offered by an inductance coil or a condenser. It varies with frequency and is measured in ohms.

If the frequency is *f*, and we define ω as $f\times 2\pi$, and if we call reactance *X*, then for an inductance

$$X = \omega L \quad \ldots \quad \ldots \quad (1)$$

where *L* is the inductance in henries.

For a condenser,

$$X = -\frac{1}{\omega C} \quad \ldots \quad \ldots \quad (2)$$

where *C* is the capacity in farads. (Note that capacity reactance is negative.)

Impedance is the combined effect of reactance and resistance. It is measured in ohms and called *Z*, and is got by

$$Z = \sqrt{R^2 + X^2} \quad \ldots \quad (3)$$

Next, there are two frequent errors in considering filters that might be cleared up.

First, it is common to find the impedance of the filter itself at various frequencies, and consider it as a constant thing in itself. Certainly, it is a "thing-in-itself," but it is not constant; it varies with the impedance of the output load. It is not accurate simply to add the impedance of the unloaded filter to that of the load and expect the sum to be the impedance of the whole circuit.

Second, it seems to be thought that on adding stages to a filter they all behave alike: *e.g.*, that if one stage cuts down a current to 1/10, two stages will cut it to 1/100, three stages to 1/1 000, etc. This again is not accurate; for each stage has a different output load, and, as shown above, this means that each stage behaves differently.

I have, however, found a way of expressing the impedance effects of the load and the filter itself, by the aid of some graphs. These have been worked out for 1-, 2-, and 3-stage filters; and are reproduced herewith.

Let us call Z' the "filter impedance" of the filter, *i.e.*, the *input* volts divided by the *output* current. Z_1 and Z_2 have already been defined; Z_1 is the impedance of the series part of one stage and Z_2 that of the parallel part (see Fig. 3); Z_e is the external or load impedance.

Now it is possible to find certain quantities, which we are calling A and B, such that, at any frequency,

$$Z' = B\,Z_e + A\,Z_2 \quad \ldots \quad (4)$$

Obviously the last part gives the impedance on short-circuit, *i.e.*, when $Z_e = 0$.

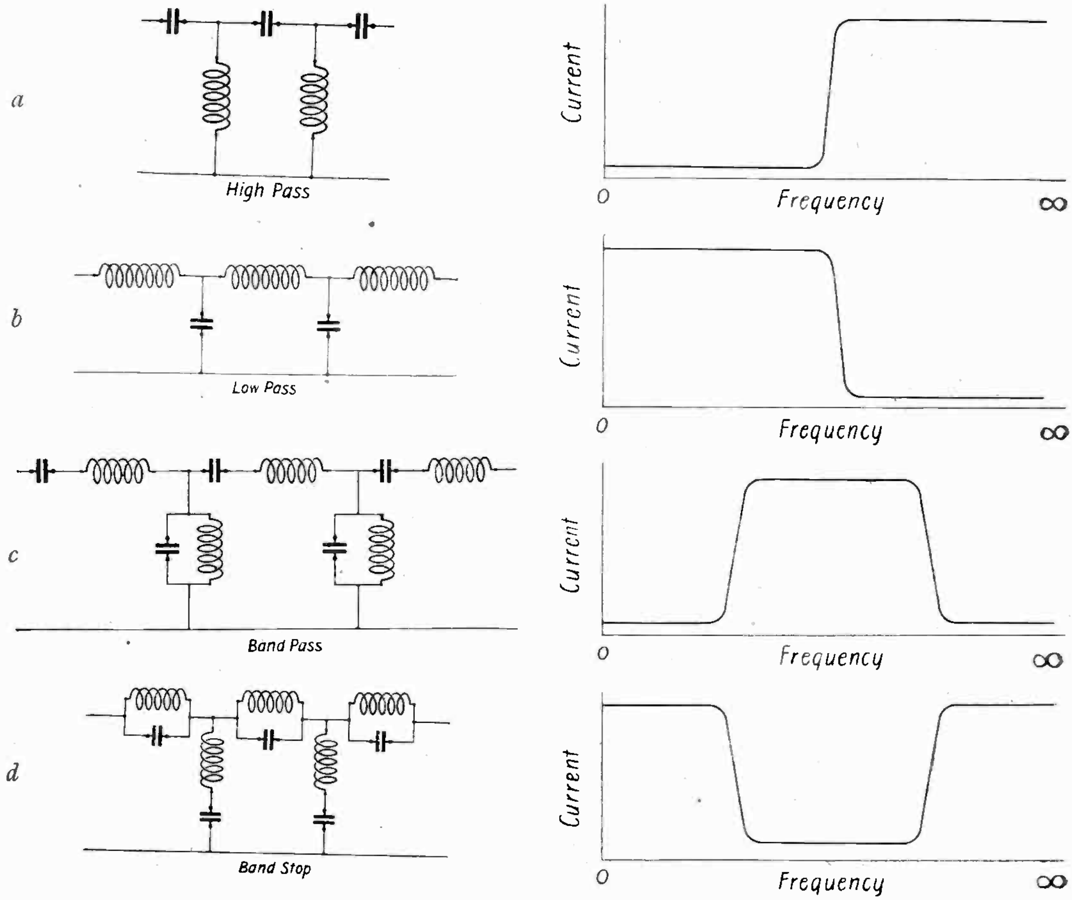


Fig. 4. *The four main types of filter, with their ideal resonance curves.*

We give curves for these two quantities, A and B, but in order to make them available for various types of filter we have had to express them, not directly in terms of frequency, but in terms of a quantity s, which depends on frequency, and which we will now define :—

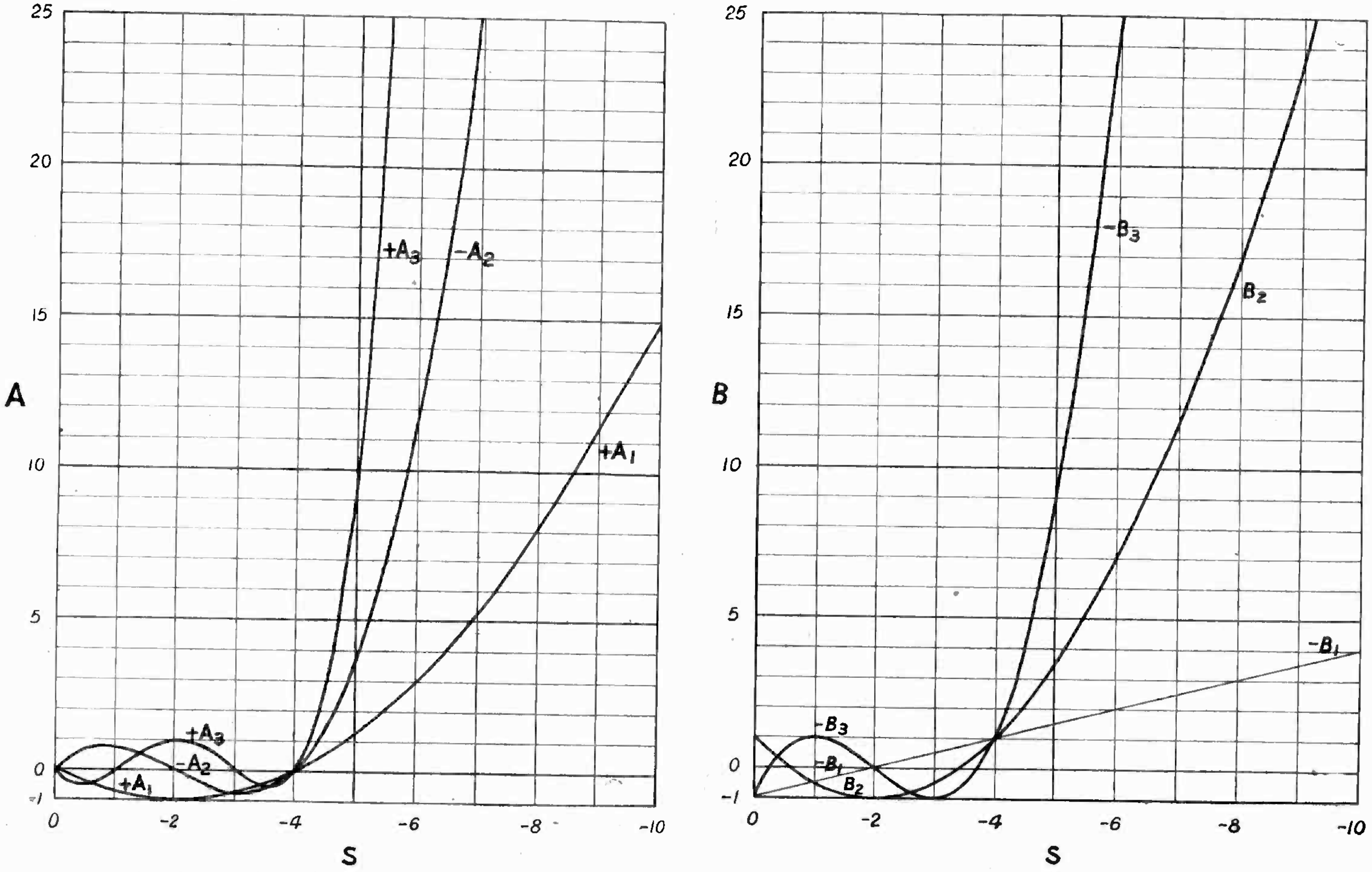
$$s = \frac{Z_1}{Z_2} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

It is to be noted that in every type of filter that we are dealing with here, s is always negative. (Those inclined for mathematics should also note that if account is taken of the *resistance* of the filter components, s will be a complex quantity.) Throughout these notes we are assuming that the resistances in the filter itself are negligible, as is the case in practice except where specially noted otherwise. Thus, since R is zero, Z_1 and Z_2 reduce to X_1 and X_2 respectively (see equation (3)), and we have

$$s = \frac{X_1}{X_2} \quad \ldots \quad \ldots \quad (6)$$

In the case of a *Low Pass filter*, X_1 is due to a coil of inductance L, say, and X_2 due to a condenser C, so

$$s = \frac{\omega L}{-1/\omega C} = -\omega^2 LC \quad \ldots \quad (7)$$



Figs. 5 and 6. *Curves for A and B, the two quantities which enable one to design filters with ease. For explanation see matter.*

For a *High Pass filter*, X_1 is due to a condenser and X_2 to an inductance, and

$$s = -\frac{1}{\omega^2 LC} \quad \ldots \quad \ldots \quad (8)$$

Working out the other two cases, we have:—

Band Pass filter

$$s = -\frac{(1-\omega^2 LC)^2}{\omega^2 LC} \quad \ldots \quad \ldots \quad (9)$$

Band Stop filter—

$$s = -\frac{\omega^2 LC}{(1-\omega^2 LC)^2} \quad \ldots \quad (10)$$

Remembering that, if the natural frequency of a simple circuit containing L and C is f_0, and $\omega_0 = 2\pi f_0$, then

$$\omega_0^2 LC = 1,$$

it will be seen that alternative expressions for s are (putting λ_0 for the wave-length corresponding to f_0),

Low Pass—

$$s = -\left(\frac{\omega}{\omega_0}\right)^2 = -\left(\frac{f}{f_0}\right)^2 = -\left(\frac{\lambda_0}{\lambda}\right)^2$$

High Pass—

$$s = -\left(\frac{\omega_0}{\omega}\right)^2 = -\left(\frac{f_0}{f}\right)^2 = -\left(\frac{\lambda}{\lambda_0}\right)^2$$

Band Pass—

$$s = -\left(\frac{\omega}{\omega_0}\right)^2 = -\left(\frac{f_0}{f} - \frac{f}{f_0}\right)^2 = -\left(\frac{\lambda}{\lambda_0} - \frac{\lambda_0}{\lambda}\right)^2$$

Band Stop—

$$s = \frac{-1}{\left(\frac{\omega_0}{\omega} - \frac{\omega}{\omega_0}\right)^2} = \frac{-1}{\left(\frac{f_0}{f} - \frac{f}{f_0}\right)^2} = \frac{-1}{\left(\frac{\lambda}{\lambda_0} - \frac{\lambda_0}{\lambda}\right)^2}$$

Where, in each case, L and C are the inductance and/or capacity of a single unit, and in the case of band filters it is assumed that the inductances and the capacities in the series units are equal individually to those in the parallel units. The value of s, where this is not the case, is a little more complicated, but can be easily worked out by those interested.

By means of formulæ (7) to (10), or (5) or (6) in more complicated cases, s can be found for a series of values of ω, and hence, by the curve sheets reproduced as Figs. 5 and 6, A and B can be found for all frequencies.

This enables us to find Z', but as a general rule we are not so much interested in Z' as in the ratio Z'/Z_e, for it can easily be shown that this latter is what may be called the "filtering ratio"; the proportion of applied voltage which actually reaches the load. It is easily seen from equation (4) that

$$\frac{Z'}{Z_e} = B + \frac{Z_2}{Z_e} A \quad \ldots \quad (11)$$

In the case of complicated filters, Z_2/Z_e is a quantity which varies with frequency, and must be worked out in each individual case. But in the case of High Pass and Low Pass filters one can express it quite simply, in cases where Z_e is either a pure inductance or a capacity. We then have the following four values for Z_2/Z_e:—

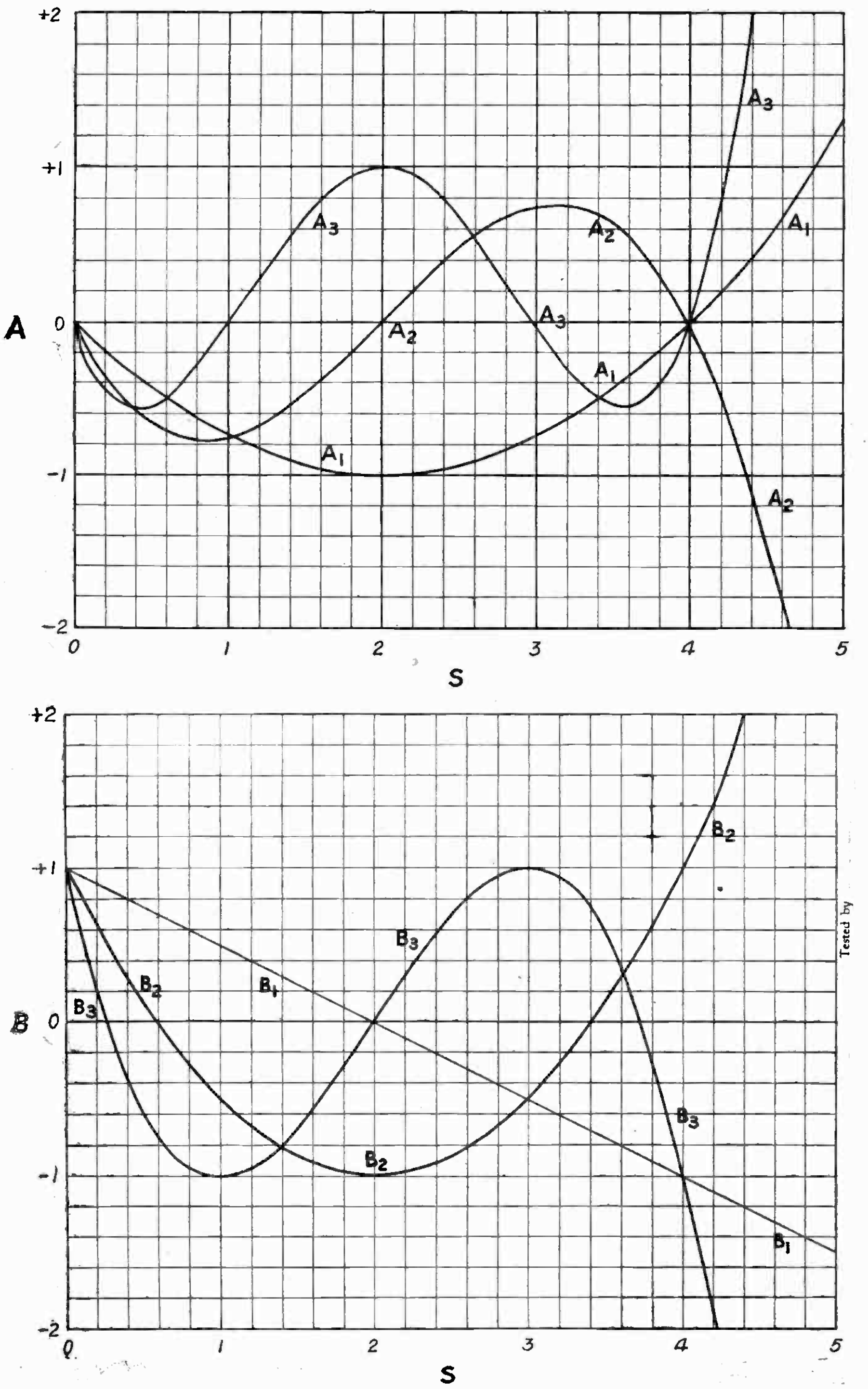
$$\begin{array}{lcc} & \textit{Low Pass.} & \textit{High Pass.} \\ Z_e = \omega L_e & \frac{L}{L_e} \cdot \frac{1}{s} & \frac{L}{L_e} \\ Z_e = -\frac{1}{\omega C_e} & \frac{C_e}{C} & \frac{C_e}{C} \cdot \frac{1}{s} \end{array} \quad (12)$$

We therefore see that Z'/Z_e can for these cases be expressed in terms of B and either A or A/s, and to deal with this latter case, which often arises, we give curves for A/s as well as for A.

Coming now to the curves themselves, Fig. 5 gives values of A for 1-stage, 2-stage, and 3-stage filters. Note that the value for a 2-stage filter is given as negative, in order to avoid doubling the size of the diagram: *e.g.*, A_2 for $s = -6$ has the the value -11.5. Note also that at various values of s between 0 and 4, A falls to zero, which appears to mean that the filter has no impedance. Actually, as we have stated above, we have neglected resistance throughout, so that what this actually means is that there is no *reactance*; the impedance depends only on the ohmic resistance, and in any well-designed filter it will be, not actually zero, but at any rate a minimum. By the same token, a negative value of A means that the *reactance* is negative, *i.e.*, that at that frequency the filter behaves as a condenser. Fig. 6 shows values of B, and the remarks made in connection with Fig. 5 also apply.

In these two figures, however, the necessity of showing what happens when s is greater than -4, *i.e.*, when the filter is "cutting off," has made us show on rather a small scale the effect when the filter is "passing." We therefore show to an enlarged scale in Figs. 7 and 8 values of A and B when s is less than -4. Also, in Figs. 9 and 10, we give two corresponding curves for A/s.

How, then, do we set out to design a



Figs. 7 and 8. *Enlargements of that part of Figs. 5 and 6 dealing with small values of s.*

filter? We must first know two, or rather three, things: First, the pass frequency range; second, how sharp a "cut off" is required; third, what is the load impedance. Perhaps we can best show by an example. A recent case we had to consider was a special filter for a long-wave amplifier. It had to pass all audio-frequencies, but cut off everything from 30 000 upwards; and the working load was an L.F. transformer. It was, therefore, a Low Pass filter, for which (see equation (7))

$$s = -\omega^2 LC$$

Fig. 5 showed that the critical value of s is -4, and we therefore, as a preliminary, said: "s shall be -4 for f about 20 000, or $\omega = 125\,000$, or, say, $\omega = 120\,000$.

What, then, is Z_e at frequencies of this order? Well, an intervalve transformer consists, really, of a high inductance shunted by a condenser (its own self-capacity). Most transformers resonate at 2 000—3 000 cycles. Above this they act as condensers. At 20 000 cycles practically all the current will flow through the capacity, and so we will neglect everything else and say that Z_e is due to a condenser of .0001 μF.

This leads us to (12), from which

$$\frac{Z_2}{Z_e} = \frac{C_e}{C},$$

and we want to find out what value of C_e/C, used in equation (11), will give us a good high value of Z'/Z_e for frequencies of 30 000 and over, while at the same time keeping this value low for audio-frequencies up to, say, 15 000.

For this purpose we got out, using Figs. 5 and 7 and equation (11), the curves of Figs. 11 to 13, showing Z'/Z_e against s for various values of C_e/C. Remember that we wish to pass 20 000 and stop 30 000. The value of s for the latter is approximately twice that for the former. Also, we naturally want to use as few stages as possible, and we will assume that Z'/Z_e must be *at least* 50 for 30 000 frequency: *i.e.*, only 1/50 of the applied voltage is to get through, as an absolute maximum.

Looking at Fig. 11, we find that with one stage we can just fulfil the requirements by putting $s = -4\frac{3}{4}$ for 20 000 cycles, when we shall have $s = -10$ (about) for 30 000, using $C_e/C = 3$. This, however, means a value of Z'/Z_e of -3 for $s = -2$ (about 12 000 cycles)—the filter will cut off quite a lot of the audio-input for high notes. Further, $C_e/C = 3$ means that the filter condensers must be one-third the load capacity, or .000 03, which will mean very large inductances.

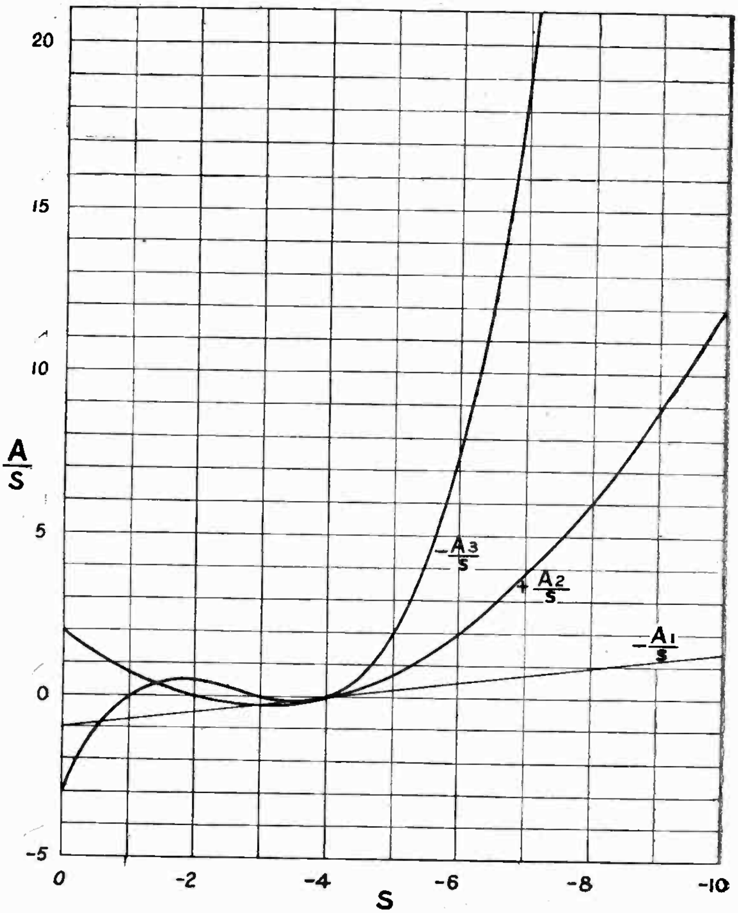


Fig. 9. *A curve for A/s, which is needed in some cases.*

Comparing Fig. 12, for two stages, we find that for $C_e/C = 1$, with $s = -5$ for 20000 cycles, we shall get a much higher filtering ratio at 30 000 cycles (over 100) while the largest values of Z'/Z_e for low frequencies are 1.5 at $s = -1\frac{1}{2}$ and 1 at $s = -4$. The former means a 33 per cent. decrease in input at 10 000 cycles. Examination of Fig. 13 shows still higher efficiency, but at the cost of an extra stage. Assume then two stages, $C_e/C = 1$.

This means that the filter condensers must be .0001, as was the load. Also, $s = -\omega^2 LC = -5$ for a frequency of 20 000 (or $\omega = 120\,000$ approximately). Knowing ω and C, we can find L, which comes out at 3.5 henries. Our filter will therefore be as shown in Fig. 14, remembering that the end coils are one-half the centre one.

(N.B.—This condition—that the end units are $\frac{1}{2}Z$—may seem to offer difficulties in band filters, when each unit has both inductance and capacity. The solution is to use half the inductance and double the capacity.)

This completes the design of the filter *as a filter*. True, we have to work out the turns, etc., of the coils; but that is the design of coils, not filters, and (as already stated) will not be treated here.

Recapitulating the design procedure :—

(1) Find out what Z_e is, and decide what sort of filtering ratio (Z'/Z_e) is wanted for the "cut-off" part of the range, and between what frequencies the cut-off is to occur.

(2) This will give the clue to the type of filter. By the use of (11) and (12) draw rough curves of Z'/Z_e against either s or frequency, for various values of Z_2/Z_e.

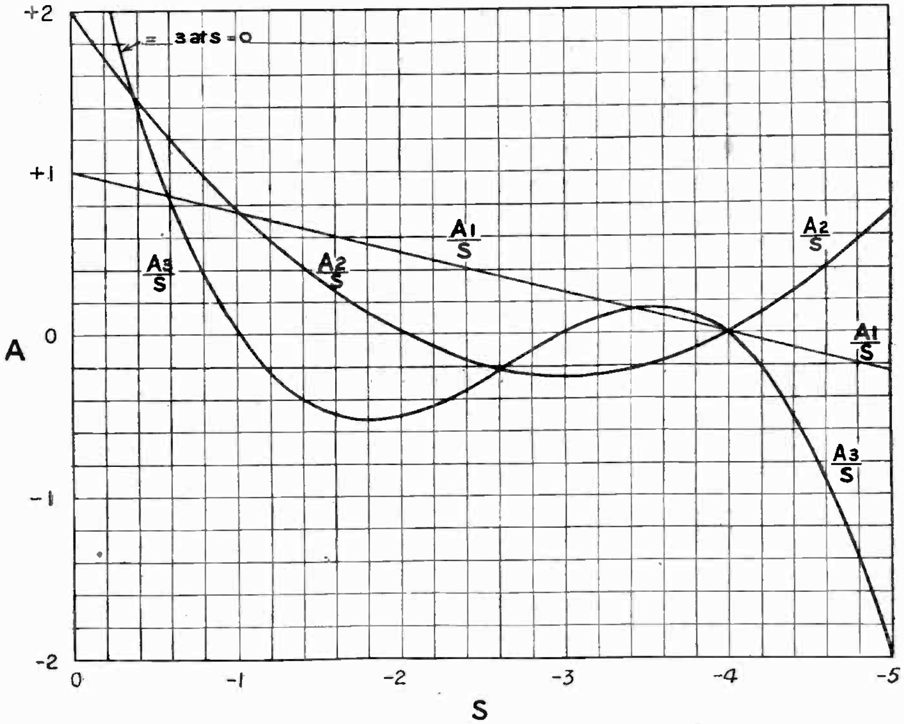


Fig. 10. *The lower part of Fig. 9 enlarged.*

(3) Decide from these the most hopeful curve. High values of Z_2/Z_e give high ratios in the "pass" region, but give a good "cut-off" with few stages. Don't forget that high or low values of Z_2/Z_e may affect the ease of construction of the filter. Individual judgment and "horse sense" must come in here.

(4) Having decided on Z_2/Z_e you can specify the coil or condenser value for Z_2, and from s, ω (or frequency) and Z_2 you can find the coil or condenser value for Z_1.

Theory.

The analysis is based on a treatment by Cohen, which appeared in the *Journal of the Franklin Institute*, May, 1923, and which had the great advantage of dealing with filters having a finite number of stages.

This treatment, however, did not include any provision for an output load, and was mainly directed towards finding the resonant frequencies. From the present point of view the expression for current (or, alternatively, impedance) at various frequencies is the real desideratum.

As the effect of a finite load shows itself quite early in the analysis, it is considered best to give here the complete calculation, and not merely a supplement. This also enables us to avoid one or two errors in the Cohen analysis as presented.

Regarding now Fig. 15, it is obvious that the E.M.F.s acting in any circuit, say the m^{th} (not an end circuit), fulfil the equation:—

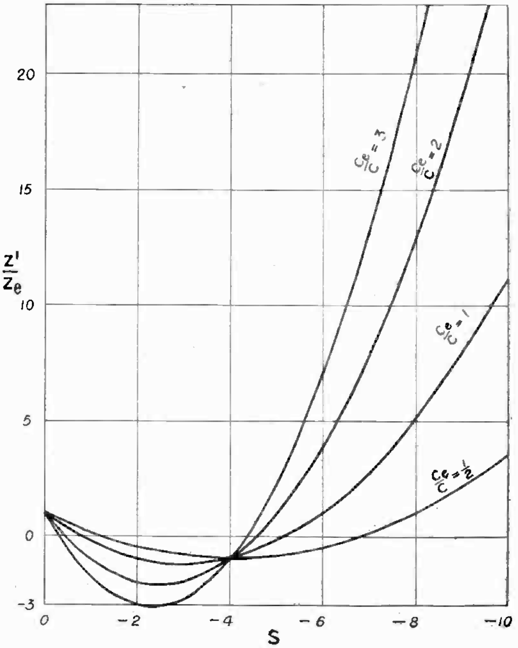
$$(Z_1 + 2Z_2)I_m - Z_2(I_{m+1} + I_{m-1}) = 0 \qquad (13)$$

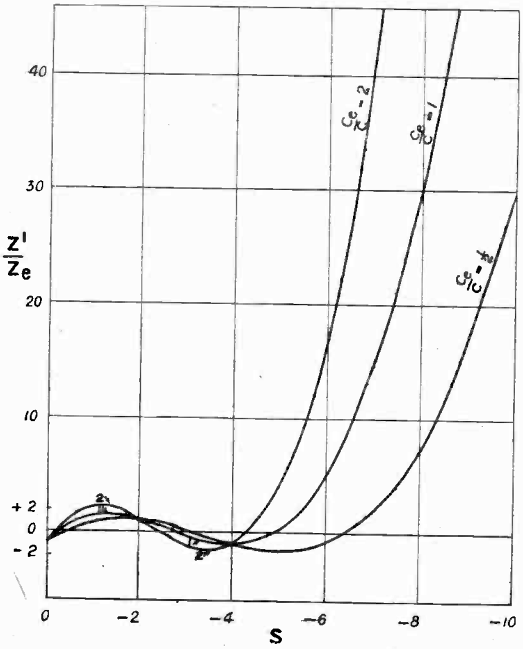
I_m being supposed the current set up by a sinusoidal E.M.F. applied at the input, and Z_1 and Z_2 being impedances of the form $R + jX$.

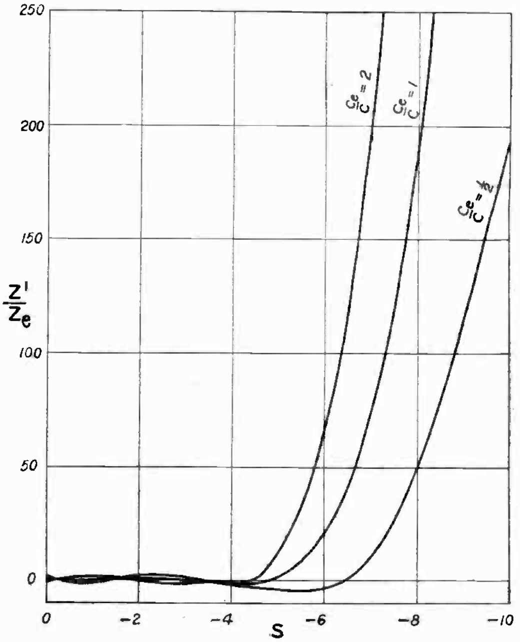
It is easily proved that the solution of (13) is

$$I_m = (-1)^m (A\epsilon^{m\gamma} + B\epsilon^{-m\gamma}) \quad \ldots \quad \ldots \quad (14)$$

subject to a condition as to the value of γ.







Figs. 11 to 13. *Three curves showing the performance of the particular filter chosen as an example, and shown in Fig. 14.*

Substituting from (14) in (13) we have

$$(-1)^m Z_1(A\epsilon^{m\gamma}+B\epsilon^{-m\gamma})+Z_2[2(-1)^m(A\epsilon^{m\gamma}+B\epsilon^{-m\gamma})$$
$$-(-1)^{m+1}(A\epsilon^{\overline{m+1}\gamma}+B\epsilon^{-\overline{m+1}\gamma})$$
$$-(-1)^{m-1}(A\epsilon^{\overline{m-1}\gamma}+B\epsilon^{-\overline{m-1}\gamma})]=0 \quad (15)$$

Collecting terms in the second expression,

$$(-1)^m Z_1(A\epsilon^{m\gamma}+B\epsilon^{-m\gamma})=$$
$$-(-1)^m Z_2(A\epsilon^{m\gamma}+B\epsilon^{-m\gamma})\ (\epsilon^{\gamma}+\epsilon^{-\gamma}+2) \quad (16)$$

whence $-Z_1/Z_2=\epsilon^{\gamma}+\epsilon^{-\gamma}+2$,

or $$\epsilon^{\gamma}+\epsilon^{-\gamma}=-(2+Z_1/Z_2) \quad .. \quad (17)$$

or, as an alternative expression,

$$ch\,\gamma=-(1+\tfrac{1}{2}\,Z_1/Z_2) \quad .. \quad (18)$$

which is the condition for γ.

To find A and B (these are not, of course, the quantities defined as A and B in the earlier part of this article), we use the conditions in the first and last circuits.

E being the input voltage, we have :—

$$(\tfrac{1}{2}\,Z_1+Z_2)\,I_1-Z_2 I_2=E \quad .. \quad (19)$$

Substituting from equations (17) and (14), we find

$$Z_2(\epsilon^{\gamma}+\epsilon^{-\gamma})\,(A\epsilon^{\gamma}+B\epsilon^{-\gamma})-2Z_2(A\epsilon^{2\gamma}+B\epsilon^{-2\gamma})=2E$$

or, on simplifying,

$$A\epsilon^{\gamma}-B\epsilon^{-\gamma}=-\frac{2E}{Z_2(\epsilon^{\gamma}-\epsilon^{-\gamma})} \quad .. \quad (20)$$

For the $(n+1)^{th}$ or last circuit,

$$(\tfrac{1}{2}Z_1+Z_2+Z_e)I_{n+1}-Z_2 I_n=0 \quad .. \quad (21)$$

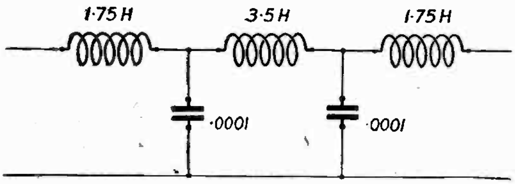


Fig. 14. *The example : a filter to pass freely up to* 20 000 *cycles, and practically stop everything above* 30 000.

or

$$(Z_1+2Z_2)\,I_{n+1}-2Z_2\,I_n=-2Z_e I_{n+1}$$

again substituting from (17) and (14),

$$-(-1)^{n+1}Z_2(\epsilon^{\gamma}+\epsilon^{-\gamma})\,(A\epsilon^{\overline{n+1}\gamma}+B\epsilon^{-\overline{n+1}\gamma})$$
$$-2Z_2(-1)^n(A\epsilon^{n\gamma}+B\epsilon^{-n\gamma})$$
$$=-2Z_e(-1)^{n+1}(A\epsilon^{\overline{n+1}\gamma}+B\epsilon^{-\overline{n+1}\gamma})$$

dividing by $(-1)^n Z_2$, and simplifying,

$$A\epsilon^{\overline{n+1}\gamma}(\epsilon^{\gamma}-\epsilon^{-\gamma}-2\,Z_e/Z_2)-$$
$$B\epsilon^{-\overline{n+1}\gamma}(\epsilon^{\gamma}-\epsilon^{-\gamma}+2\,Z_e/Z_2)=0$$

or $$B=A\epsilon^{\overline{2n+2}\gamma}\frac{\epsilon^{\gamma}-\epsilon^{-\gamma}-2r}{\epsilon^{\gamma}-\epsilon^{-\gamma}+2r} \quad .. \quad (22)$$

where $r=Z_e/Z_2$.

Now substituting from (22) in (20),

$$-\frac{2E}{Z_2(\epsilon^{\gamma}-\epsilon^{-\gamma})}=A\epsilon^{\gamma}-B\epsilon^{-\gamma}$$
$$=A\epsilon^{\overline{n+1}\gamma}\left(\epsilon^{-n\gamma}-\epsilon^{n\gamma}\frac{\epsilon^{\gamma}-\epsilon^{-\gamma}-2r}{\epsilon^{\gamma}-\epsilon^{-\gamma}+2r}\right)$$
$$=A\epsilon^{\overline{n+1}\gamma}\cdot\frac{-(\epsilon^{\gamma}-\epsilon^{-\gamma})\,(\epsilon^{n\gamma}-\epsilon^{-n\gamma})+2r(\epsilon^{n\gamma}+\epsilon^{-n\gamma})}{\epsilon^{\gamma}-\epsilon^{-\gamma}+2r}$$

or

$$A=\frac{-2E\epsilon^{-\overline{n+1}\gamma}\,(\epsilon^{\gamma}-\epsilon^{-\gamma}+2r)}{Z_2(\epsilon^{\gamma}-\epsilon^{-\gamma})[2r(\epsilon^{n\gamma}+\epsilon^{-n\gamma})-(\epsilon^{\gamma}-\epsilon^{-\gamma})(\epsilon^{n\gamma}-\epsilon^{-n\gamma})]} \quad (23)$$

In terms of hyperbolic functions, this becomes

$$A=\frac{E\,\epsilon^{-\overline{n+1}\gamma}}{2\,Z_2\,sh\,\gamma}\cdot\frac{sh\,\gamma+r}{sh\,\gamma\,sh\,n\gamma-r\,ch\,n\gamma} \quad (24)$$

and by a simple transformation, using (24) in (22)

$$B=\frac{E\,\epsilon^{\overline{n+1}\gamma}}{2Z_2\,sh\,\gamma}\cdot\frac{sh\gamma-r}{sh\,\gamma\,sh\,n\gamma-r\,ch\,n\gamma} \quad (25)$$

Finally, substituting these values of A and B in the expression derived from (14) for the current in the load, one sees at a glance from (24) and (25) that the expression simplifies considerably. We have, in fact,

$$I_{n+1}=(-1)^{n+1}\frac{E}{Z_2(sh\,\gamma\,sh\,n\gamma-r\,ch\,n\gamma)} \quad (26)$$

If now we define Z' as E/I_{n+1} (input E.M.F. over output current), we have

$$Z'=(-1)^{n+1}(Z_2\,sh\,\gamma\,sh\,n\gamma-Z_e\,ch\,n\gamma) \quad (27)$$

or if we define Z'/Z_e as the "filtering ratio" (ratio of input E.M.F. to the E.M.F. across the load)

$$\frac{Z'}{Z_e}=(-1)^{n+1}\left(\frac{Z_2}{Z_e}sh\,\gamma\,sh\,n\gamma-ch\,n\gamma\right) \quad (28)$$

As shown in (18) above, γ is defined by

$$ch\,\gamma=-(1+\tfrac{1}{2}\,Z_1/Z_2),$$

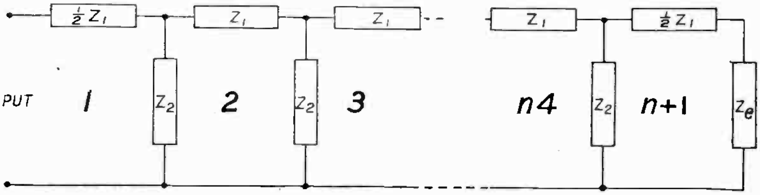
and it will be found that in all useful reactive filters, Z_1/Z_2 is essentially negative, so that where $Z_1/Z_2 > 4$ in absolute value, $ch\gamma$ is positive and > 1 as is necessary.

For $Z_1/Z_2 < 4$, $ch\gamma < 1$. To deal with these cases, we have only to postulate $\gamma = j\theta$, whereupon (18) converts to

$$\cos\theta = -\left(1 + \tfrac{1}{2}\frac{Z_1}{Z_2}\right)$$

and (28) becomes

$$\frac{Z'}{Z_e} = -(-1)^{n+1}\left(\frac{Z_2}{Z_e}\sin\theta\sin n\theta + \cos n\theta\right) \quad (29)$$



(28) and (29) can be expressed a little more neatly by changing the exponent of -1 thus :—

$$\frac{Z'}{Z_e} = (-1)^n\left(ch\, n\gamma - \frac{Z_2}{Z_e} sh\gamma\, sh\, n\gamma\right)$$

$$= (-1)^n\left(\cos n\theta + \frac{Z_2}{Z_e}\sin\theta\sin n\theta\right) \quad (30)$$

The curves for "A" and "B" in the earlier part of the article are derived from (30) ;

$$\text{"A"} = (-1)^n \sin\theta\sin n\theta$$
$$= -(-1)^n\, sh\,\gamma\, sh\, n\gamma$$

while

$$\text{"B"} = (-1)^n \cos n\theta$$
$$= (-1)^n\, ch\, n\gamma$$

Resonances.

If it is desired to get, without actually drawing curves, information as to resonant frequencies, one has only to put $Z' = 0$, when we have

$$Z_e\, ch\, n\gamma = Z_2\, sh\,\gamma\, sh\, n\gamma,$$

or $$-Z_e\cos n\theta = Z_2\sin\theta\sin n\theta \quad .. \quad (31)$$

or $$sh\,\gamma\, th\, n\gamma = Z_e/Z_2$$

$$-\sin\theta\tan n\theta = Z_e/Z_2 \quad .. \quad (32)$$

These equations are easily solved graphically, and will be found as a rule to have $n+1$ solutions.

In the case of a shorted filter ($Z_e = 0$) both equations (32) lead to

$$n\theta = s\pi \quad (s = 0,\ 1,\ 2, \ldots . n) \quad .. \quad (33)$$

Under these conditions, equation (18) becomes

$$\cos\frac{s\pi}{n} = -\left(1 + \tfrac{1}{2}\frac{Z_1}{Z_2}\right) \quad .. \quad (34)$$

Where there is any possibility of resonance, Z_1/Z_2 will not be independent of ω : putting $Z_1/Z_2 = f(\omega)$, we have

$$f(\omega) = -2\left(\cos\frac{s\pi}{n} + 1\right) \quad .. \quad (35)$$

and putting $s = 0, 1 \ldots . n$, we have $n+1$ values for $f(\omega)$ from which we can find $n+1$ resonant frequencies.

A Variable Resistance for Radio Frequencies.

[R248

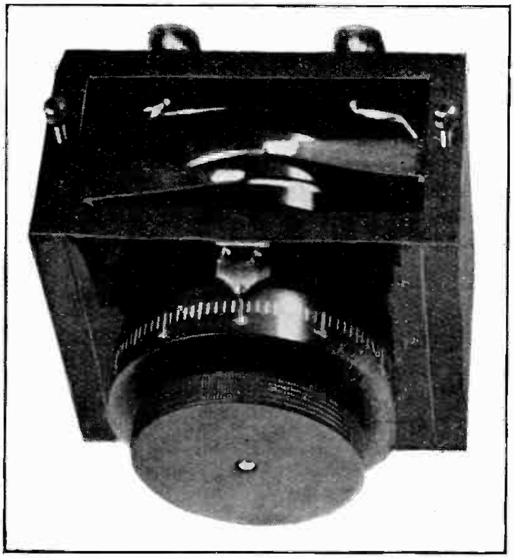
By R. M. Wilmotte, B.A. (of the National Physical Laboratory).

Describing the design and construction of an instrument enabling continuous resistance variations to be made without affecting the shape and reactance of the circuit.

IT is often necessary in measurements at radio frequencies to be able to vary the resistance of a circuit. This is usually done in discontinuous steps by adding short lengths of resistance wire.

The need of being able to vary the resistance continuously to simplify certain measurements became apparent to the writer, and it was with this end in view that a number of designs were tried and tested. In order to fit with resistance boxes available for radio frequencies, which read units up to 10 ohms, it was decided to design a variable resistance reading to just over 1 ohm with a scale divided into hundredths of an ohm using about 25 cms. of wire.

A variable resistance for radio frequencies is required to have the following properties: It must be possible to vary the resistance without altering the shape of the circuit in any way, so that in the usual case, when an E.M.F. is being induced into the circuit in which the measurements are made, the coupling, whether magnetic or capacitative, will remain unaltered. The value of the resistance should be very little affected by frequency, and the reactance of the circuit should not change as the resistance is altered.



A photograph of the actual instrument.

It is not possible to make a resistance absolutely inductionless or without capacity: the terminals alone will always have a capacity of 2 or $3\mu\mu F$. This will alter the effective resistance and self-inductance of the resistance.

Supposing R is the effective resistance, L its self-inductance, and C its effective capacity, then the resistance can be represented to a high degree of approximation by an equivalent circuit having a capacity C shunting the resistance R and the inductance L in series. This circuit can easily be shown to be equivalent to a resistance R_0 in series with a self-inductance L_0 where

$$R_0 = \frac{R}{(1-LC\omega^2)^2+R^2C^2\omega^2}$$

and

$$L_0 = \frac{L(1-LC\omega^2)-R^2C}{(1-LC\omega^2)^2+R^2C^2\omega^2}$$

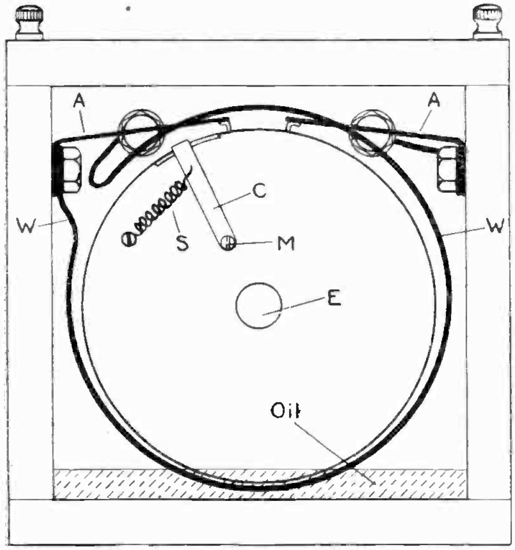
When L and C are both small these approximate to

$$R_0 = R \text{ and } L_0 = L - R^2C.$$

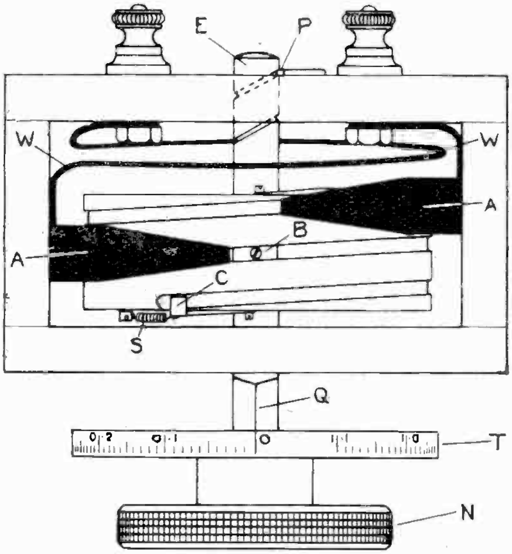
From this it is seen that in order to keep L_0 small, it is necessary to make L and C as small as possible, while the effective resistance is unaffected so long as L and C are sufficiently small.

The variation of resistance in the design finally adopted is obtained by making part of the wire of copper and the other part of some high resistance wire. The brushes are kept fixed and the wire moved, so that when the pointer is at zero, the wire between the brushes is nearly all copper and when the pointer is at 1 ohm the wire between the brushes is nearly all resistance wire. In this way the shape of the circuit remains absolutely unaltered.

On account of its good surface qualities, nickel wire, which was tested and shown to be non-magnetic, was chosen. No. 20 S.W.G., having 0.8 ohm resistance per metre, was rolled out to a thickness of 0.045 mm. and a width of 2 mm. so as to have a resistance of about 5 ohms per metre. This was necessary on account of the "skin" effect, which would have been very appreciable in the circular wire at high frequencies.



ELEVATION WITH SIDE REMOVED.



PLAN WITH TOP REMOVED.

The wire thus rolled out showed no appreciable "skin" effect at a frequency of 1 500 kilocycles per second. Some No. 20 S.W.G. copper wire was similarly rolled to a thickness of 0.042 mm. and a width of 2 mm.

Diagrams of the variable resistance are given in the accompanying figures, which show the instrument in plan, with the top removed and in elevation, with one side removed. The wire is wound round an ebonite drum 7.7 cms. in diameter in which a small rectangular groove 3 mm. in width and 1 mm in depth is cut — making two complete turns of 1 cm. pitch. One turn is of copper and the other of nikelin, soldered at the centre of the groove to a fixed copper strip *B*. The other ends of the wires are soldered on to copper strips *C*, pivoted at *M* and held by springs *S*.

This was found necessary, for in ordinary resistances which are wound on ebonite, trouble often occurs through the expansion of the ebonite with a rise in temperature, which causes the wire to come out of the groove when the ebonite cools. By means of the springs *S* this difficulty is overcome.

The reason for the big pitch of the groove is to diminish the effective capacity and the proximity effect: that is, the loss due to the eddy currents in the wire produced by the magnetic field of the rest of the wire. This would be produced mainly by the radial component of the magnetic field, owing to the large width of the wire compared to its thickness, and it is the radial component which is most affected by the proximity of the turns.

The brushes *A* are made of phosphor bronze with a small silver contact fitting into the groove. As the handle *N* is turned the ebonite drum advances while the brushes remain in the grooves. This motion is obtained by a pin *P*, which fits in a screw thread cut on the spindle *E* of the drum. On this spindle is fixed another ebonite drum *T*, on which the scale is engraved. This is read by means of a fixed pointer *Q*. The scale moves backwards and forwards with the motion of the drum, so that it is necessary either to have a long pointer or engrave the scale on a helical line.

In the instrument as described the current makes one complete turn of the drum and resistance has, therefore, quite an appreciable self-inductance. This is counter-balanced by the thick copper wire W, which is fixed, going from one brush, round the drum to the terminal. This wire is always in the circuit, so that the current flows in one direction round the drum and in the other direction along the wire W. The area enclosed by the current is thus very small.

A small layer of transformer oil was put at the bottom to keep the surface of the metal clean. By rotating the handle once the groove becomes filled with oil and good contact is ensured between the brushes and the wire. The whole instrument fits a cubical box of 12 cms. side.

There is, of course, always a resistance in circuit, even when the pointer is at zero. The calibration refers to the difference in resistance and not the actual resistance, this method being the most convenient for the majority of purposes.

The instrument was compared with some No. 37 S.W.G. manganin and showed an error of ½ per cent. at 1 500 kilocycles. The D.C. calibration therefore can be assumed to hold up to that frequency.

After a lapse of two months, the calibration had not altered to within 2×10^{-3} ohms. The instrument has been in constant use and has proved to be reliable, no trouble of any kind having been encountered with the contacts.

A simple application of a variable resistance is in the measurement of effective resistances by the resistance variation method. In this method the current I_1 in a tuned circuit is measured and a resistance r added, reducing the current to I_2. If the current in the circuit does not react on the source and the coupling remains unaltered, the resistance R of the circuit is given by

$$R = \frac{I}{I_1 - I_2} \cdot r \quad .$$

When a large number of these measurements have to be taken, they become very tedious. The work is much shortened and the reliability slightly increased if r can be adjusted to make I_1 a simple fraction of I_2.

Thus, if

$$\frac{I_2}{I_1} = \tfrac{1}{2},\ \tfrac{3}{5},\ \tfrac{5}{8},\ \tfrac{2}{3},$$

$$\frac{R}{r} = 1,\ \tfrac{3}{2},\ \tfrac{5}{3},\ 2.$$

This represents the usual range, for the accuracy decreases rapidly for small and large ratios of I_1 to I_2. Curves by which I_2 can be read quickly from I_1 for any of the above ratios are convenient, for it is necessary to take more than one reading to obtain reliable results. By this means the author has been able to reduce the time of taking readings in conjunction with high frequency resistances research by nearly one-half.

The apparatus described herein has been designed and used in connection with work carried out for the Radio Research Board established under the D.S.I.R., and I am indebted to the Committee of the Board on Propagation of Waves and Standards for their helpful criticism.

A Correction.

We regret that two unfortunate typographical errors crept into a formula appearing on page 614, E.W. & W.E., July. This was in Mr. S. Butterworth's article on "High Frequency Copper Losses in Inductance Coils."

The formula for the resistance of single-layer, short solenoids was given as

$$R' = R\left\{1 + F + \left(3{\cdot}29 + \frac{b}{2}\right) - \frac{d^2}{D^2}\,G\right\}$$

instead of

$$R' = R\left\{1 + F + \left(3{\cdot}29 + \frac{b}{a}\right)\frac{d^2}{D^2}G\right\}$$

Rectifiers for High-Tension Supply.

Part I: Mechanical Rectifiers. [R555·5

By R. Mines, B.Sc.

The first part of a short series treating this interesting subject in detail.

BROADLY speaking, a rectifier (or sometimes "detector") is no more than an "assymmetric conductor," that is, a conductor whose electrical behaviour is different for positive and negative applied voltages. It will be realised, however, that when such apparatus is to be used for obtaining high-tension power from an alternating source, the ratio between the powers passed by it in the two directions must be taken into account, as it is an important factor in the efficiency of the combination. It is desirable, in fact, to use only those types of apparatus that offer a complete block to the passage of current in one direction (called "perfect rectifiers"); hence the definition given in our previous article (E.W. & W.E., p. 580, July, 1924)—"an apparatus that will allow current to flow through it in one direction only when an alternating P.D. is applied to it."

The knowledge that the direction of flow of current in a circuit may be controlled by a mechanical device, called a "switch," leads to the suggestion that such a switch may be used for rectifying an alternating supply. It must be realised at the outset, however, that to make full use of the supply the switch must perform a complete cycle of operations for each cycle of the alternating supply, whatever the frequency of this may be. To comply with this condition, for supplies at the usual power frequencies, two main types of rectifier have been evolved, viz., the vibratory or "reed" type, and the rotary or "commutator" type.

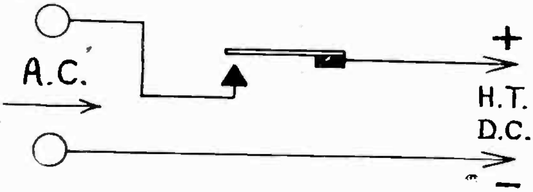


Fig. 1. *Half-wave rectification—single-pole switch synchronously operated.*

One of the main advantages of the mechanical rectifier is the direct control that may be exerted on the cycle of operations—the instants of making and breaking the connection in either direction, *i.e.*, the "duration" and the "phase" of the contact may be chosen within wide limits to suit the work in hand, and if desired may be made variable during the running of the apparatus.

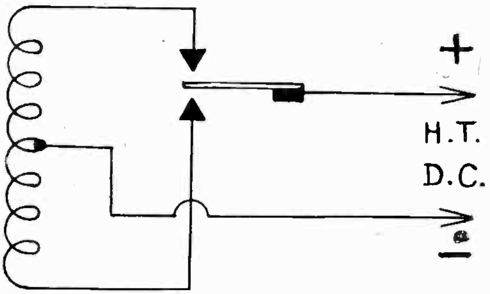


Fig. 2. *Full-wave rectification, with two-way switch and mid-point tap.*

Vibratory Type.

As suggested in the article referred to above, let us consider the high-tension circuit as having a constant P.D. maintained at its input terminals, so that supplying power to the circuit must consist in pumping current against this steady P.D. The problem then becomes analogous to the low-tension one of charging accumulators from an alternating supply.

(*a*) The simplest method that presents itself is to use a "single-pole one-way" switch, as shown in Fig. 1. The operating mechanism of the switch (to be described later) must be arranged to close the circuit for as long as the supply P.D. is sufficiently high and in the correct direction to drive current into the high-tension circuit, and to keep the circuit open for the remainder of the cycle of the alternating supply. The

P.D. relations, the current pulses flowing, and the "back E.M.F." which the switch must withstand, are similar to those in the general case, described on p. 581 of E.W. & W.E., July, 1924, and illustrated in Figs. 1 (*b*) and (*c*) thereof.

(*b*) "Full-wave" rectification may be obtained from two transformers or one with a mid-point tapping on its secondary by using a "single-pole two-way" switch as shown in Fig. 2. This corresponds in a similar manner to the second method described (see Figs. 2 (*b*) and (*c*) of July article).

(*c*) The same result may be obtained without the necessity of a second transformer or a mid-point tapping by using a "double-pole" switching device instead of a "single-pole" one. The arrangement is shown in Fig. 3; the two switch-arms shown have to work in step with one another, which may be accomplished by mechanical coupling or similar means, so that no addition to the operating mechanism is involved. A modification is shown in Fig. 4 which requires only one vibrating armature; but this must carry two contact plates as shown, insulated to withstand the full D.C. P.D., between them.

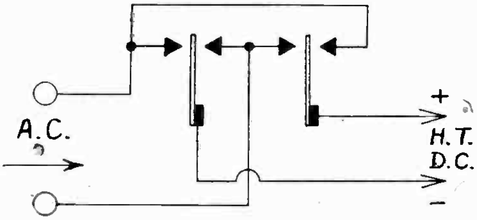


Fig. 3. *Full-wave rectification without mid-point tap, using double-pole switch.*

(*d*) In Fig. 5 is shown the vibratory rectifier applied to the Coolidge and Hull method of rectification; the rectifier is of the "single-pole two-way" type, as used in method (*b*) above.

Operating Mechanism.

Since the moving contacts of the switch have to operate in synchronism with the alternating supply, a solenoid excited with A.C. from this supply and acting on a magnetic armature which carries the moving contacts, affords a solution that is at once simple and effective. It should be noted in passing that the magnetic armature must be "polarised," else it will give a double frequency of motion. More simply, a soft iron armature changes its polarity with that of the solenoid, by induction, and hence is attracted for each maximum value of the A.C. (in either direction) and released for each time the A.C. passes through zero. On the other hand, "polarising" the armature (*i.e.*, giving it a fixed magnetic polarity) makes it sensitive to the direction of the magnetic flux; it is attracted at the maximum values of the A.C. in one direction, but is repelled at those in the opposite direction.

It is necessary now to consider what means can be adopted for "timing" the making and the breaking of the contact. In general, with this type of rectifier, the "contact time" or duration of contact may be controlled directly by either or both of two factors: (1) The position of the fixed contacts relative to the vibrating contact; (2) the amplitude of vibration of the moving contact. In practice it will be found most convenient first to obtain an approximate value of (2) by choosing a suitable size of driving solenoid; then final setting to the working conditions is obtained on (1), which is usually a screw adjustment. Next, the correct phase relation must be established between the switch movement and the supply alternations, and to do this, use may be made of the inductive property of the driving solenoid—that the current flowing through it lags behind the supply P.D. by some angle less than 90°. By connecting external resistance in series with the solenoid, this angle may be reduced to a few degrees; and if a condenser is used it may be taken past zero and the current caused to lead the supply P.D. By reversing the connections to the solenoid, the considerable range of adjustment thus made available may be doubled. Perhaps it is hardly necessary to point out that controlling the phase of the solenoid current affects the phase of the motion of the vibrating contact through the intermediary of the flux produced by the solenoid.

In such a tuned reed rectifier, Simmonds[1] finds that sufficient control is obtained on a 50-cycle supply by using only a series resistance (maximum value, 300 ohms). He also states that he relies on adjustment

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[1] Simmonds, "The Construction of a Tuned Reed Rectifier," E.W. & W.E., January, 1924, p. 221.

of this resistance to obtain sparkless operation under varying working conditions, without alteration of the screw adjustment of the fixed contact.

The Moving Contact.

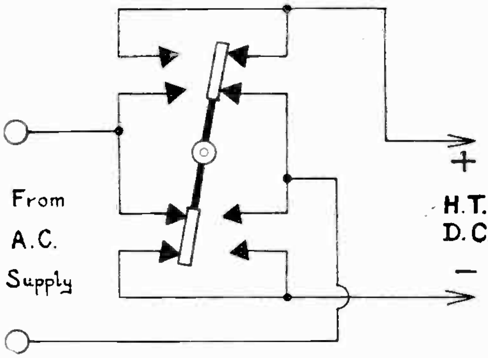

Fig. 4. *Same as Fig. 3, but with an alternative form of switch.*

There are two kinds of moving armature in use; they may be denoted by the terms "tuned," and "free" (or so-called "aperiodic"). As may be gathered from the name, the tuned armature consists of a mechanical oscillatory system, having a natural frequency which is made equal to that of the alternating supply. Thus, in operation the system is vibrating in resonance, and as is well known the maximum amplitude of vibration is obtainable under this condition; herein lies one of the advantages of using a tuned armature. Simmonds (*loc. cit.*) uses as armature a flat strip or "reed" of spring steel, the dimensions being chosen so that it resonates with the supply frequency of 50 cycles per second.

Generally speaking, however, the difficulties of making a tuned armature operate satisfactorily increase with rise in frequency, for even though the condition of resonance is still used the amplitude obtainable in the mechanical vibration falls off rapidly. This effect may be noted in the case of the "Microphone Hummer" used to generate alternating current at 800 cycles per second for telephony testing work. In this apparatus the steel reed and its mounting block are cut from the solid; the amplitude of vibration is very small (measured in thousandths of an inch) so that operation is rendered possible only by use of a sensitive microphone worked by the reed in place of a make-and-break contact.

The free type is in general an armature whose natural frequency of vibration is very low, this being secured by weakening the elastic controlling force rather than by increasing the moment of inertia (dependent on the mass). Thus, in normal operation the armature executes "forced vibrations" at a frequency considerably above its natural frequency. An example of this type is the Army "D Mark III." Telegraph Vibrator, which is essentially a high-pitched buzzer normally operating at a frequency between 150 and 500 cycles per second. Dyer[2] describes the adaptation of this instrument as a full-wave rectifier, working at the frequency of a public supply. In view of its performance as a buzzer, working from dry cells, there should be no difficulty in securing satisfactory rectification from a power supply at higher frequencies, *e.g.*, 500 cycles per second as is obtained from the small wind-driven alternators.

"Voltage" Limitations.

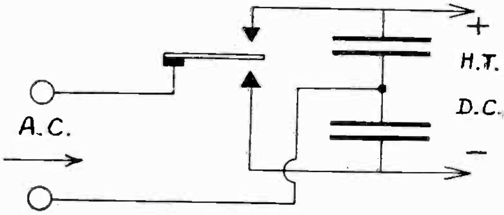

Fig. 5. *Full-wave rectification—"Pulses" delivered to the two halves of the D.C. circuit in series.*

The rectifiers developed by Simmonds and Dyer were both designed for low-tension operation, *i.e.*, the charging of accumulators. The latter states, however, that his apparatus operates satisfactorily direct on the 200-volt supply. It is recognised as desirable that the time of breaking circuit should be adjusted as closely as possible to the instant when current ceases to flow, if only to secure maximum life of the contacts. If in addition to this, the time of making contact can be sufficiently closely adjusted to the instant when the P.D. between the contacts reaches zero, then the following condition is obtained: That the P.D. between the separated contacts (whose maximum value is the "back E.M.F." on the rectifier) is approximately proportional to the distance

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[2] Dyer, A Full Wave Rectifier, E.W. & W.E., September, 1924, p. 728.

between the contact surfaces. Thus, having eliminated all tendency to sparking, the next limit that imposes itself is the breakdown strength of the air-gap between the separated contacts. Needless to say a fairly large factor of safety must be allowed in this respect, but if a reasonable amplitude of vibration is obtainable the P.D. rectified may be raised to cover most of the requirements of the radio worker.

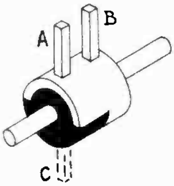

Fig. 6.

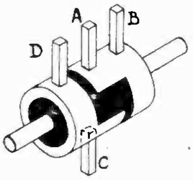

Fig. 7.

Fig. 6. *"Single-pole" commutator—one-way (brushes A and B only), or two-way (all three brushes in use).* Fig. 7. *"Reversing" commutator.*

Rotary Type.

It must be confessed at the outset that the operating mechanism required for a vibratory type of rectifier is inherently simpler and cheaper for the radio experimenter to install than a motor with shaft and bearings, such as is necessary for driving rotary apparatus (sometimes, however, there is available the shaft of the alternator generating the supply to be rectified, to which the rotary rectifier may be coupled). But in any case we shall see that rectifiers of the rotary type possess many advantages over those of the vibratory type, in respect of frequency, P.D., and current for which they may be designed.

The most elementary form is a drum, part of whose surface is conducting and part insulating, with a brush A bearing upon it (Fig. 6), the conducting part being connected to the external circuit through the shaft and bearing or preferably through a "slip-ring" to a second brush *B*. In practice it is convenient to make the slip-ring and conducting part in one piece; the arrangement constitutes a "single-pole one-way" switch.

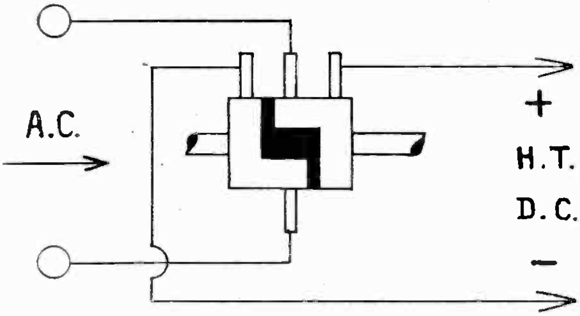

Fig. 8. *Connections for the commutator of* Fig. 7, *in use as rectifier.*

To convert this into a "two-way" switch (to obtain "full-wave" rectification) it is necessary only to add a third brush "*C*" diametrically opposite the first, so that on rotating the drum the conducting part establishes connection from brush *B* alternately to the brushes *A* and *C*.

By mounting two conducting parts with their slip-rings on the same drum, and using six brushes, a standard "double-pole two-way" switch is produced (corresponding to Fig. 3). Actually, however, method (*c*) above requires not a complete "six-point" switch such as this, but a "reversing switch" ("four-point," or having four terminals); the paralleled connections indicate that certain parts may be coalesced, as shown in Fig. 7 (here only four brushes are needed). The connections may be represented as in Fig. 8, which it will be seen corresponds to Fig. 4.

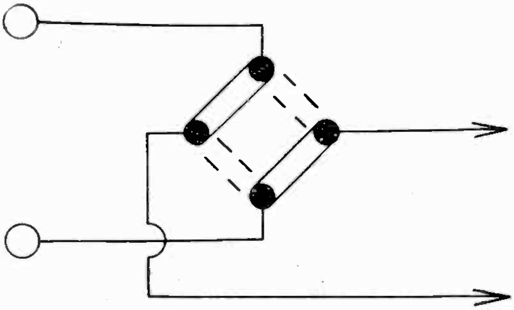

Fig. 9. *Four-point reversing switch.*

Alternative Arrangement.

For purposes of distinction the arrangement evolved above may be denoted as the "slip-ring" type of rectifier. For there is an alternative way of producing the same result as Fig. 7, which possesses certain distinguishing characteristics as described in a later section.

This type may be described as the "interrupter" type, since in method of working it resembles the rotary interrupter switches that are used for induction coils, for "contact" methods of wave-form delineation, and for capacity measurement. It is a direct application of the "four-point reversing switch" (Fig. 9), and is shown complete with connections in Fig. 10.

One of the advantages of this type is its slower speed of rotation for the same supply frequency; for it performs two complete cycles of operation for each revolution, instead of one.

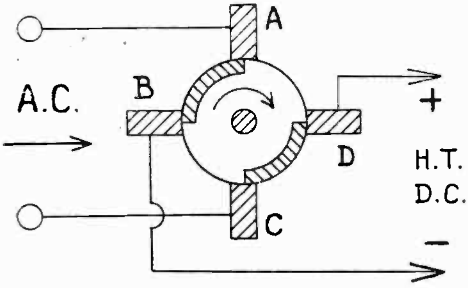

Fig. 10. *"Interrupter" type of commutator.*

Timing.

With the rotary rectifier it is possible to exert independent positive control over the two factors, the "phase" and the "duration" of the contact. The phase of contact depends on the relative angular positions of the brushes *A* and *C* (Fig. 7), and the stator of the motor (or alternator) by which the commutator is driven. The brushes can be mounted on some form of rocker arm, just as is done in D.C. electric motors, so that rotation of this arm gives the required phase variation. Alternatively, the rotation may be made at the driving machine, as is done by Butement.[3]

The duration of contact is dependent on the design of the commutator and the brushes. Fig. 11 is a cross-section of the commutator of Fig. 7 taken in the plane of the brushes A and C; (*a*) shows the position of making contact, and (*b*) that of breaking. By superposing the figures it is seen that the angle through which the commutator rotates while contact is established is $\theta+b$, where θ is the angle subtended at the centre by each conducting part, and b that subtended by each brush. Now this rectifier makes a complete revolution for each cycle of the alternating supply; therefore the duration of contact is $(\theta+b)/360$ of a period (if the angles are measured in degrees).

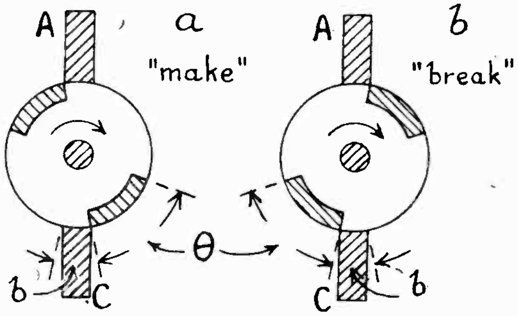

Fig. 11. *Illustrating the timing relations of the slip-ring type of commutator.*

To simplify the handling of the formulæ, this interval of time is called "$\theta+b$ electrical degrees."

This quantity becomes variable only if θ or b can be varied. By using two sets of brushes, connected together electrically, the arc covered by the brushes may be varied between certain limits. If the two sets of brushes are mounted in different planes so that they may be set opposite each other (showing as in Fig. 11), the lower limit is the width of each individual brush (which we shall continue to call "b"). Then the minimum contact time is $\theta+b$. Alternatively the two sets may be moved apart (this must be done symmetrically so that the phase adjustment shall not be disturbed), as far as the point where the gap between the brushes of the two sets equals the width θ of the conducting part on the commutator, as shown in Fig. 12. This is the limiting position, because with a larger gap contact would be broken and discontinuity established. The arc commanded

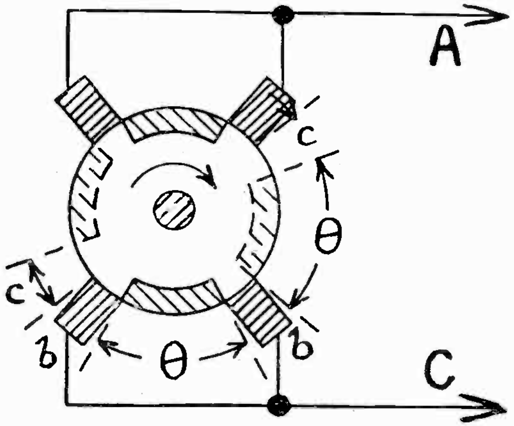

Fig. 12. *Illustrating the limiting conditions in the design.*

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[3] A. Butement. A Simple Rotary Rectifier. E.W. & W.E., August, 1924, page 658.

by the brushes is now $2b+\theta$, and the maximum contact time has become $2\theta+2b$, *i.e.*, twice the minimum value.

A further limit must at this point be investigated. Imagine the conducting parts to be in the position shown "dotted" in Fig. 12. If the width θ were made so large as to bridge the gap between the brushes connected to opposite poles, a short-circuit would occur. From Fig. 12, the width of this gap is found to be $180°-(2b+\theta)$. Further, in practice it is necessary to allow a definite clearance "c" to prevent flash-over with medium and high P.D.s. The maximum permissible value that θ may be given is therefore fixed by the following relation :—

$$\theta+c=180°-2b-\theta,$$

which gives,

$$\theta_{(max.)}=90°-b-c/2.$$

Substituting the maximum contact time obtainable with this apparatus is

$$2(\theta+b)=180°-c.$$

The method involving variation of θ for control of the contact time carries with it the disadvantage of requiring a special type of commutator, although the two symmetrically-adjustable sets of brushes are no longer necessary. The conducting parts are tapered, so that they have their maximum width ("$\theta_{(max.)}$" above) at one end, and their minimum width (which may be made practically zero) at the other end of the commutator. This design is depicted in Fig. 13. The brushes A and C are mounted on a frame so that they can be traversed axially along the commutator from one end of the triangular-shaped conducting parts to the other.

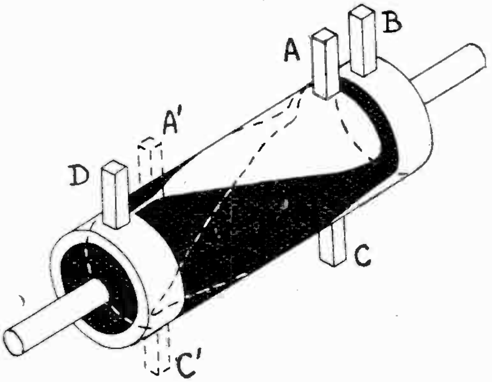


Fig. 13. *Commutator with varying segment angle —brushes A and C have axial traverse.*

Here the minimum permissible gap between adjacent parts of opposite polarity is $b+c$; so that $\theta_{(max.)}=180°-(b+c)$. By substitution, the maximum contact time is $180°-c$, the same value as with the preceding arrangement. The minimum value of θ may be called zero, so that the minimum contact time becomes b. This may be considerably less than half the maximum value, showing an advantage over the preceding method.

Timing of the Interrupter Type.

The time relations of the interrupter type of rectifier may be analysed on similar lines. As before, control of the duration of contact may be obtained by two methods —by using two sets of brushes with equal and opposite rotation, or by using tapered conducting parts on the commutator and brushes with an axial traverse.

Figs. 14 (a) and (b) show the positions at "make" and "break" respectively; the brushes A and C are "doubled" and command an arc ϕ; those at B and D remain single and have a width a. By superposing the figures the contact time may be evaluated; thus the angle of revolution during which contact is established is $(a+\phi)+\theta-90°$. Since there are two cycles per revolution, the contact time in electrical degrees is twice this, *i.e.*, $a+\phi+2\theta-180°$. Notice here that by sufficient reduction of ϕ or θ or both, the contact time may be made zero or negative (mathematically speaking), whereas with the slip-ring type the minimum contact time is b electrical degrees. (This property is of most use in selecting extreme peaks of a P.D. wave, such as for running an X-Ray tube from an induction coil.)

As with the slip-ring type, short-circuit occurs when a conducting part bridges the smallest gap between brushes of opposite polarity; the width of this gap is $180°-\phi$, and allowing the clearance, c, we have the relation

$$\theta+c=180°-\phi$$

giving

$$\theta_{(max.)}=180°-c-\phi,$$

and

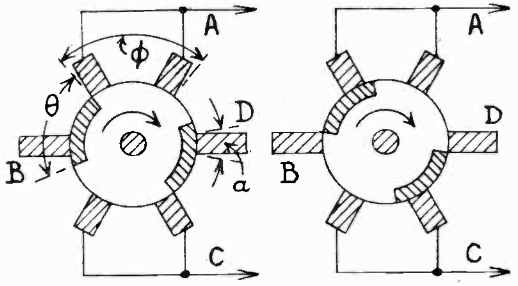
$$\phi_{(max.)}=180°-c-\theta.$$

By substitution the maximum contact time obtainable is $180^\circ + a - 2c - \phi$ in terms of ϕ as variable, or $a - c + \theta$ in terms of θ as variable.

In working out concrete examples from these formulæ, such as by choosing the minimum and maximum contact times and working backwards, it must be remembered that θ cannot become less than zero, ϕ cannot become less than a, and c must be assigned a value appropriate to the P.D. to be used. In general it will be found that the maximum contact time obtainable with this apparatus is much smaller than with the "slip-ring" type; but it is sufficient for most high-tension work.

"Multipolar" Commutators.

The "slip-ring" commutator may be made in the "four-pole" form, giving two cycles per revolution, like the "interrupter" type; it is shown thus in Fig. 15. The commutator has four conducting parts instead of two; but no additional brushes are required. Note, however, that the brush C must retain its 180 electrical degrees of phase displacement with respect to brush A, and this becomes a space angle of *half* the amount, *i.e.*, 90°.



a – "make" b – "break"

Fig. 14. *Illustrating the timing relations of the Interrupter type of commutator.*

Similarly either type of commutator may be designed for any number of cycles per revolution, giving control over the speed of revolution independently of the frequency of the supply. In rotating machinery the limit experienced at high speeds is that imposed by centrifugal force, and this is proportional to N^2D, where N measures the speed of rotation and D the diameter of the commutator. Having fixed the P.D. at which the commutator is to operate, the contact time required, and the size of brush to carry the current, the design of the commutator may be completed at least as far as concerns fixing the peripheral width that shall be occupied by 360 electrical degrees. The diameter D then will be proportional to the number of cycles per revolution. Further, for a given frequency, the speed N is inversely proportional to this same number; as a result the product ND becomes a constant. Substitute this constant in the factor for the centrifugal force, and it is found that this force becomes proportional to N, the speed.

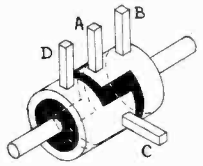


Fig. 15. *A "four-pole" slip-ring commutator, corresponding to the interrupter commutator of Fig. 10.*

Thus, with high P.D.s, which necessitate liberal clearances in the commutator design, or high frequencies, or both, the centrifugal force may be brought within the limits of safety by increasing the diameter (and number of cycles per revolution) of the commutator, and thus decreasing its speed. The only limit is the cost of construction, and in some cases the space occupied. Note that the driving machine must operate with the same number of cycles per revolution as the commutator which it is to drive.

The Perfect Set. [R342·4

Part XI: More about the Reflex; and Conclusion.

This month we conclude our series, since the only possible extension—a consideration of the superheterodyne principles—at the moment is impossible owing to the fact that there is still a large amount of experimental work to be done.

In Parts IX. and X. of this series we have described some general properties of Reflex or Dual Amplification and have applied ourselves to the detailed consideration of a typical circuit. It is now proposed to consider some of the most important variations from this type. By way of reminder, we reproduce herewith our illustration of the typical circuit.

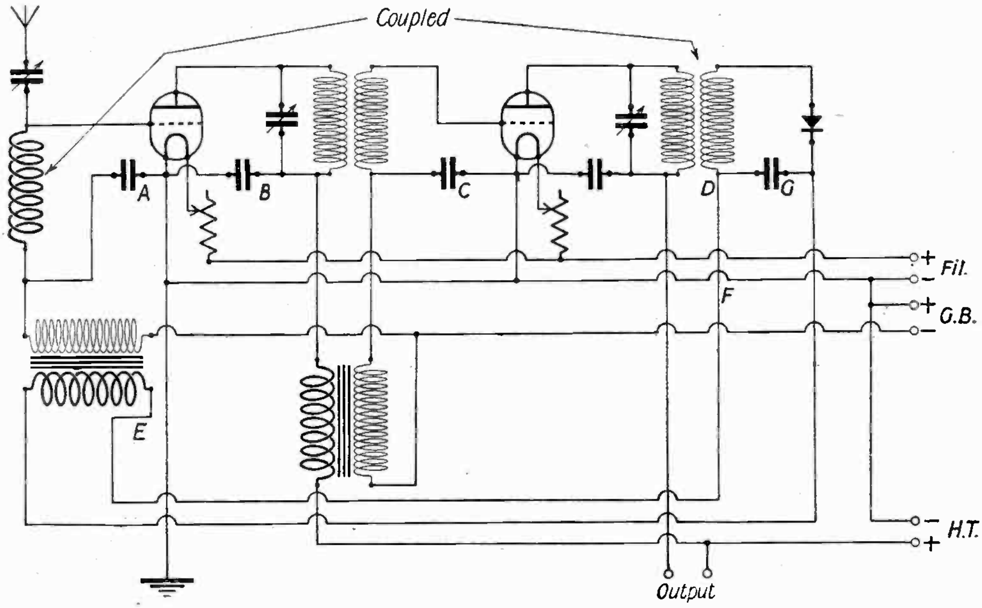


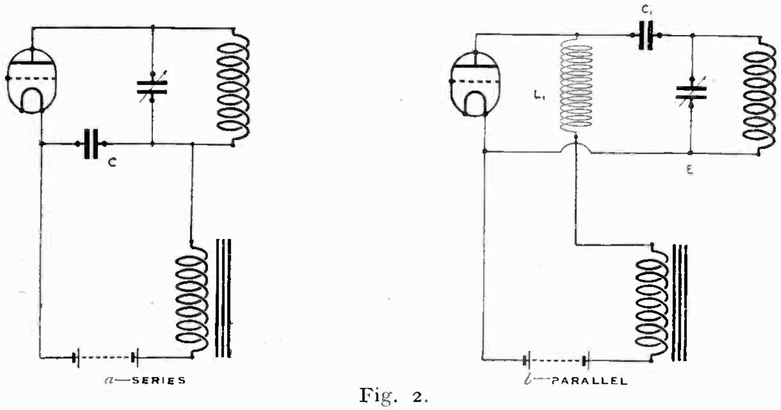
Fig. 1.

Series and Parallel Couplings.

Perhaps the most important variation is that in which the H.F. and L.F. couplings between any given points, instead of being in series as in Fig. 1, are in parallel. Thus, in Fig. 2,*a* shows the typical anode circuit, with the primaries of an H.F. and an L.F. transformer in series, the H.F. currents being led round the latter by the by-pass condenser *C*. In Fig. 2*b*, these two instruments are in parallel. To separate the two components of the combined H.L. and L.F. current, we provide the stop condenser C_1 and the H.F. choke L_1.

Theoretically, these two circuits should behave identically as regards their real function, leaving one free to choose between them on the grounds of secondary effects. In practice, owing to the unavoidable self-capacity of L_1 and other minor difficulties, the parallel connection is not quite so good as the other. One point is that if one wishes to cover a wide range of wave-lengths one should change both L_1 and C_1, while in circuit 2*a* there is only *C* to change.

It is sometimes claimed that *b* is the better owing to the absence of the by-pass condenser *C* across the L.F. transformer. But careful examination of *b* shows that C_1 is across the transformer for L.F. currents, so nothing is gained. A real difference is that in *b* the point *E*, at the lower end of the H.F. coupling, is directly connected to the filament, and this gives us the clue to the one point in the set at which this connection has real advantages. Looking at Fig. 1 we see that the aerial circuit has two series condensers. The range of wave-length obtainable by varying the tuning condenser is rather small, because, however large we make it, the total capacity in series cannot be greater than that of the rather small by-pass condenser. We can get a larger range of wave-length by using a condenser across the A.T.I., but at the cost of efficiency.



a—SERIES *b*—PARALLEL

Fig. 2.

Fig. 3 shows how the difficulty is avoided by using the parallel connection. For broadcast wave-length C_1 should be of the same value as the original by-pass condenser in Fig. 1, say .000 1μF, while L_1 may be a coil of anything from, say, 1 500μH upwards—a 200- or 600-turn coil of the usual size will do—but it must be of a make having really low self-capacity. One point to be noticed is that the introduction of C_1 may lead to a tendency for the first valve to rectify, and this must be avoided carefully by proper attention to grid bias and H.T. voltage. For the other coupling circuits the author's personal preference is for the series connection, as in Fig. 2*a*.

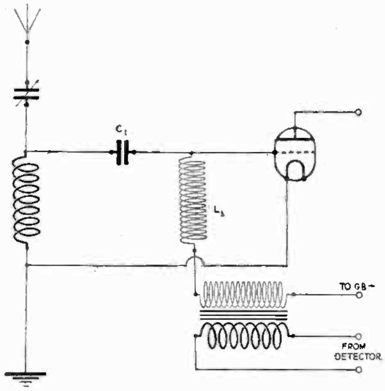
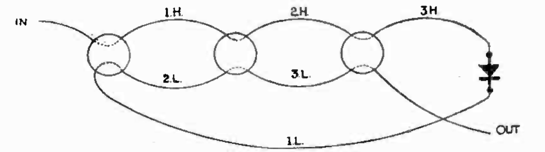


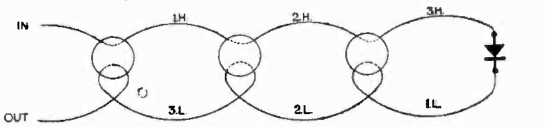
Fig. 3.

Inverse Dual Amplification.

The next great field for variation lies in the choice between "direct" and "inverse" arrangements, credit for the invention of the latter being due to Grimes of America. The essential difference is shown in Fig. 4, which



a. DIRECT



b. INVERSE.

Fig. 4.

gives the simplest possible graphic explanation, the line simply representing the course of signals.

Fig. 5 shows the typical wiring diagram of such a circuit, and should be compared with Fig. 1.

This arrangement has one definite advantage, which we will deal with shortly. There is also claimed for it an advantage which is quite fallacious. This is that, since the last H.F. valve is the first L.F., and *vice versa*, the total load on the valves is equalised.

As we have stated already, this is quite a mistake. A few minutes' work based on the known amplification of the valves at high and low frequencies shows that the L.F. input voltages are so large compared with the H.F. that the "equalisation" is quite illusory, the change in the total load on the heaviest-loaded valve being of the order of 1 per cent. on changing from one type of circuit to the other.

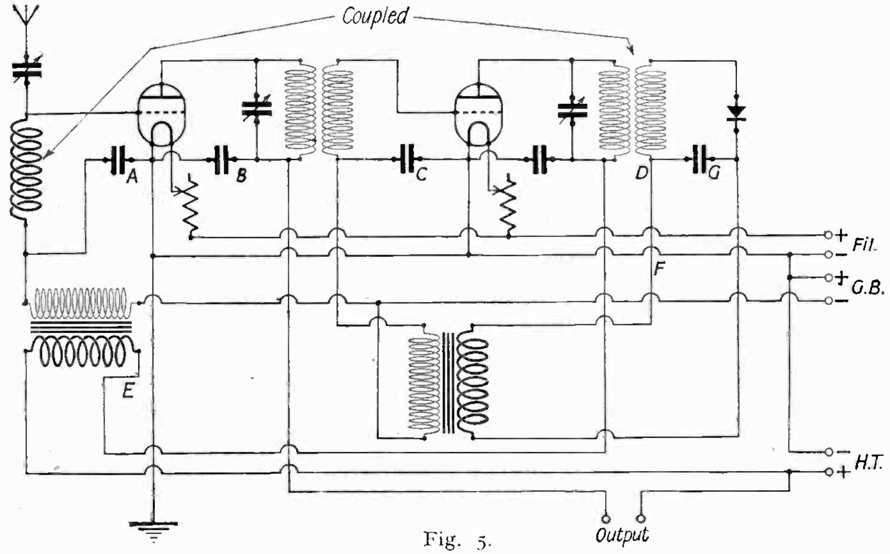


Fig. 5.

The real advantage is this: suppose that some audio-frequency interference, such as hum from electric mains, etc., is induced into the aerial. With the "direct" connections, Fig. 4*a*, it will be amplified by several stages before reaching the output: in the case of the Grimes inverse, it will be amplified by one stage only.

But there is a very serious disadvantage. It is absolutely essential in the inverse circuit that there shall be a complete separation of the two current components in the intervalve couplings; in other words the H.F. transformer must on no account pass *any* L.F. output from its primary to its secondary, nor must the L.F. transformer pass any H.F. For consider the first valve in Fig. 5. It is amplifying L.F. from transformer *E*, and the L.F. output is supposed to go to the output terminals. But if any L.F. gets through the H.F. transformer to the grid of the second valve, then this second valve is having part of its own output returned (*via E* and the first valve) to its own grid—in fact there is L.F. reaction. Similarly there will be H.F. reaction if any H.F. gets through an L.F. transformer.

Now in practice one can, with care, avoid any noticeable effects of this kind on short-wave sets not using many stages. But outside these limits we ourselves have found so much trouble that we have given up the inverse.

In fairness, we must note that there is a possibility of a similar trouble in the "direct" circuit of Fig. 1. Here, it does not matter at all as regards the general intervalve coupling—in fact for long-wave telegraphy one can get quite good results with a single transformer for each stage. But it must not be forgotten that there is an H.F. component in the rectified output from the crystal, and that if any of this gets through to the grid there is H.F. reaction over the whole set. In this case, however, the trouble is localised in one spot, and can be dealt with easily.

As mentioned in Part X., a large value (say .001μF) for *G* is a solution for short waves, and in practice we have had little difficulty up to 15 000 metres with values of *G* up to .005μF. In rare cases, as perhaps in that where the "H.F." is really the "intermediate amplifier" of a multi-stage supersonic set, it may be advisable to substitute a filter for the simple condenser *G*. Such a filter is mentioned in a special article on filters in this issue (see p. 673).

Other Intervalve Couplings.

Hitherto we have confined our remarks to circuits using transformer coupling; and this is for the reason that, as will be remembered from the earlier instalments on H.F. and L.F. amplification separately, our personal view is that transformer coupling is the best for such work as reflex sets are best fitted to do. It is not, however, by any means an essential that this coupling should be used. Fig. 6 shows a coupling using choke coupling for the L.F. and either choke or "tuned anode" for the H.F. according as the dotted condenser is omitted or included. The separate choke for H.F. is necessary, since it is practically impossible to build the L.F. choke of low enough self-capacity to stop H.F. currents. The main difficulty is with regard to the coupling condenser. This must be large enough to handle L.F. currents (say .05μF), and therefore particular care must be taken to use enough grid bias, as otherwise the second valve may be out of action as an amplifier for periods of 1/100 sec. or so—a long time when one considers H.F. currents.

If resistance coupling is desired it may be used in the same way, substituting a single resistance of low capacity for both chokes. Hitherto, however, we have not found the perfect resistance for this purpose: wire-wound resistances usually have too great a self-capacity. It is possible that an H.F. choke or tuned anode, as in Fig. 6, followed by a wire-wound resistance instead of the L.F. choke there shown, might meet the case. But there is still the difficulty with regard to the coupling condenser.

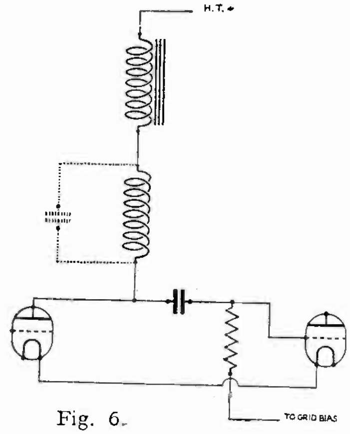


Fig. 6.

Extra-simple Reflex Sets.

In many cases sets can be designed using the dual amplification idea, but without the necessity of any double intervalve coupling. This occurs, for example, in the single valve reflex, which, followed by one stage of power amplification, makes a most admirable loud-speaker receiver for "suburban" broadcast work, giving ample strength up to 30 miles or so from a typical B.B.C. station. Such a set can be made to give very fine musical quality. At some sacrifice of signal strength a single-valve set may be built without any L.F. transformer at all, the arrangement being as in Fig. 7—the main idea due to Voigt. Obviously the output may go *via* a transformer to a stage of L.F. amplification.

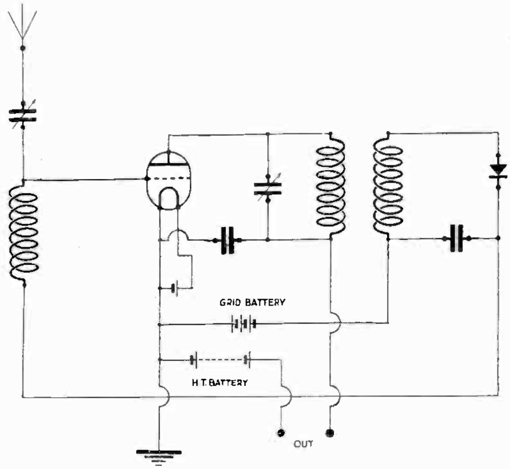


Fig. 7.

This, however, loses the effect of the step up in the crystal-to-valve transformer, and as this may be of high ratio a considerable gain can be got. Probably the best local loud-speaker set is that shown in Fig. 8. This, with the addition of an on-off switch, a combined H.T. milliammeter and filament voltmeter, and a few definite instructions, can be put in the hands of a maiden aunt with complete confidence. The values of components necessary can be gathered from earlier parts of this series.

Conclusion.

This series has now covered the essentials of crystal and valve rectification, and amplification either H.F., L.F., or both; and we believe that this is an appropriate point at which to conclude it. Not that we are congratulating ourselves on having completely settled all wireless problems, but that our particular object—to deal with some of the neglected essentials of well-known types of set—is more or less accomplished.

Originally it had been our intention to extend the series to cover the supersonic set; but after mature consideration we have decided not to do so. These articles embody the results of several years' experience on each point dealt with, and, although we have had some experience on supersonics, we do not feel justified yet in writing articles of this type about them. Perhaps we may describe in another article some ideas that we have gained from our work on them, but that is very different from "laying down the law," as we have presumed to do in this series.

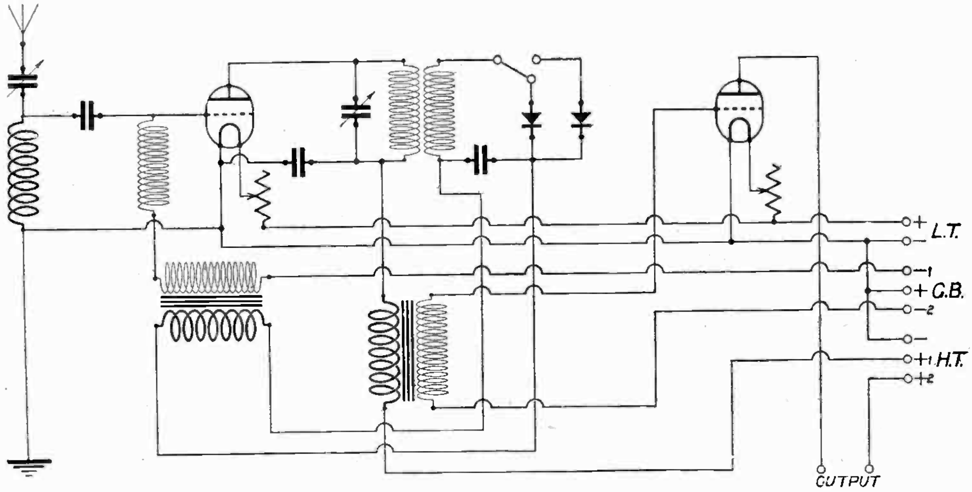


Fig. 8.

One last word. In the course of our discussions of various types of set we have shown, now and again, circuit diagrams. Various readers have written saying that they want to build a set accordingly, and rebuking us because the diagrams contained insufficient particulars. We should like to state quite plainly that these diagrams are only the *groundwork* of set design. These are all the matters of switchgear, tuning devices, battery voltages, and so forth, to be decided. It is not the idea of E.W. & W.E. to give particulars by which all readers can build identical sets. What we try to do is to give the *basis* on which the readers can design his own set.

This series has been a labour of love: we hope that it has been of use to some readers.

P. K. T.

A Standard Report-Card

By M. T. Coode. **[R623·23**

IT seems that in America there exists a form of report-card which has become standardised through general, unspoken consent; but in England one has to go to the trouble and expense of writing one's own card or of having it printed privately. For these reasons there are several advantages in having a standard report-card which could be printed conveniently. Were this the case the transmitting amateur would find his reports many times more valuable and far easier to classify, while the receiving amateur would be saved time, trouble and expense. If a publisher were to print a card of this kind, it would cost little more than a plain postcard, and should go through the post for a halfpenny (a big consideration for an amateur who logs, and would like to report, more than a hundred amateurs on some days).

That reproduced herewith seems the most suitable form of report-card. Of course, a letter is nearly always preferable to a card for exchange of opinions after two-way working, but the card is designed for the amateur who is not in communication with another amateur, but is picking up whom he can.

The author would like to maintain the advantage of using a card index at a receiving station in preference to a log-book. The former can be rapidly compiled from the message forms used while receiving, or might well consist of duplicate report-cards. Since the cards could be arranged in (alphabetical) order of the call signs received—which appear at the top left-hand corner of the card—reference could be made easily. In addition a small log-book of dates and call signs heard, which must necessarily be entered in chronological order, could be made without trouble, and would be quite useful.

In the report-card the author has indicated the "R" method of measuring signal strength chiefly for want of a better one. All simple and inexpensive methods put forward to date, such as shunted phones, depend more on the listener's ear than does the "R" method. Besides this any measuring instrument having a control needs another hand as well as those for tuning and writing! Nor would anyone like the experience of finding the station whose signal strength he was trying to measure to several places of decimals close down when he was half-way through the delicate operations which accurate and rather unnecessary measurements must entail. In any case, the "R" method has become standard and has been proved to be consistently sure in the Army and elsewhere.

The method of describing the receiving set is one which has now become standard, and which has the advantage of being short. A dash over the V seems the easiest way of denoting reaction, but is not in any way original. The space left for the type of receiver is obviously necessary: some description of the receiver must be given, as no report can be completely accurate when the signal strength is given without any indication of the efficiency of the set, although the "R" method eliminates errors due to this fairly well. It will be much better to give these details until some method of measuring the strength of signals before reaching the aerial is discovered.

Fading, atmospherics and jamming are obviously of importance to the transmitting amateur, while it is a good thing to give the distance between the two stations if it is known, as he may not be able to find out so easily for himself.

Some long distance amateurs use a code word besides their call sign and this is usually sufficient for the identification of the message. If a code word is not used, some outstanding part of the message should be given, for mistaken call signs are more frequent than would seem possible.

The form given below has been typed quite easily on a fair-sized postcard, and when printed there would be sufficient room for remarks which cannot be classified under a separate heading. To make this report-card really useful it should be in agreement with the ideas of every amateur, and to get as near this as possible criticism of the form given below is essential and will therefore be welcomed, so that a final card can be drawn up.

(Receiver's
Call Sign)
Address ....

....

Date ....

7 ABC was heard calling *9.*
on *10.12.25* at *13.20* hours G.M.T.
Signal Strength R *5* λ *440*
no fading, QRM *jamming, no* X's.
QRB *98* miles. Receiver *O-V-O,*
Reinartz. Aerial system 100′ × 40′
cpsc. Code word and/or
identification *ZADO, "Am receiving you well."*
Remarks *"Modulation good."*

6TM. An Amateur Station.

By W. A. S. Butement.

[R612

LIKE many others this station had to be constructed under considerable financial difficulties: the total cost of the entire station, including the aerial and the receiver, was less than £15.

The station is situated on the edge of a small ridge, running north and south, in West Hampstead, London. (The exact QRA for purposes of reference is 127, West End Lane.) The location is far from ideal, and it is surprising that such long ranges have been obtained, using so little power and with an aerial system of the type installed.

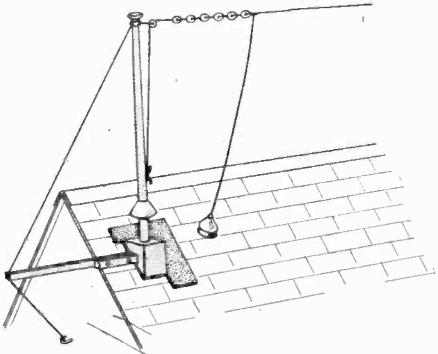


Fig. 1.

The problem of the aerial was the first real difficulty when transmission was seriously contemplated in August, 1924. The house is about 50 feet high with a very steep roof of slate. It was eventually decided to cut two holes in the roof, one at each end and about 45 feet apart, and to erect masts on the roof from these holes. With much difficulty the holes were cut and fitted with lids, and the erection of the masts was the next problem.

Two poles about 15 feet in length were obtained, and these had to be hauled up the side of the house, with the head and shoulders only of the "hauler" protruding through the hole. The final method of fixture is shown in Fig 1.

These two masts, being accessible from inside, form a very convenient support for almost any type of aerial, and various systems have been compared. Apart from its accessability, the aerial is held very rigidly between the masts, and can be pulled quite tight, so that it cannot swing in the wind. This is not the case with an aerial attached to a tree, where, to obtain an absolutely steady note in windy weather, it is necessary to employ a master oscillator set.

Many different aerials were tried between these masts, but the system which gave the best all-round results, was a single strand of 16-gauge enamelled copper wire, forming an inverted L. This was 42 feet long, 10 feet above the roof and well insulated at both ends (see Fig. 2).

The counterpoise consisted of four similar gauge wires, four feet apart and 45 feet long. This is situated *inside* the roof and about three feet from the top. Thus almost the whole roof is between the aerial and counterpoise.

Strangely enough, the results obtained with the counterpoise just outside the roof were in no case as good as those obtained with the system described above, even though 50 per cent. more aerial current was obtained. With either system, however, the results in wet and dry weather were very different: in wet weather no really reliable results could be obtained at all.

Every "earthed" body within reach is connected to the transmitting inductance, each one being brought into resonance with the rest by tapping it on to an appropriate turn of the inductance. To find these positions accurately for a number of "earth" leads took quite a long time, the positions of the various leads being continually changed until the aerial current as shown by the meter was at a maximum.

This assumes, of course, that the position of the nodal point does not shift during these changes; this can be verified, either with a neon lamp, or, more simply, on moderate power, by merely touching the A.T.I. If you touch the wire at the voltage node, you will *not* see a small jet of smoke!

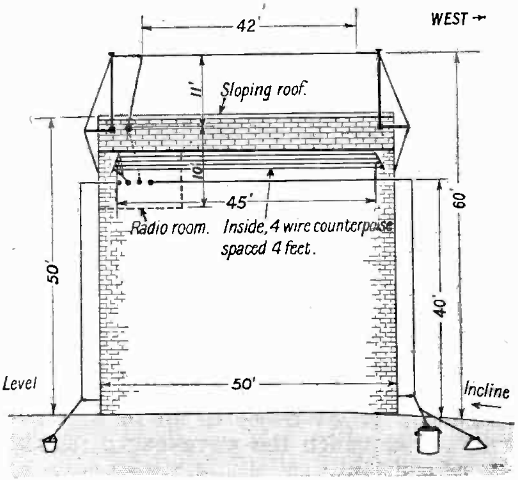


Fig. 2.

At 6TM seven "earthed" bodies are employed as well as the counterpoise. These are a buried bucket (minus bottom) in the front garden; a buried dust bin in the back garden; the main water pipe; the gas pipe; the casing of the electric mains in the house; the casing of the land line; and finally the so-called earthed main lead itself.

The power is derived from A.C. mains, at 105 volts, 50 cycles, single phase current.

The transformer used for H.T. supply is one that was picked up second-hand for seven-and-sixpence. This was found to give results without any adaptation, although the voltage regulation was appalling. The core measured 2 ins. by $1\frac{1}{8}$ ins. in cross section. The transformer would work at .5kW for a time when required, and delivered 10 000 volts across the whole of the secondary.

The rectifiers used up to date have always been some kind of chemical rectifiers. Those now used consist of 48 cells (1 in. by 6 ins. boiling tubes), the electrodes of which are aluminium and lead clamped together as shown in Fig. 3. The aluminium ones are 6 ins. by $\frac{1}{2}$ in.; the leads 6 ins. by 1 in. and are bent round the insides of the tubes. The solution used is chemically pure ammonium phosphate—$(NH4)_3PO_4$—dissolved in distilled water. The cells are all immersed in cold water in a sink for cooling purposes.

It is found necessary to switch on the rectifiers once every evening for about one minute, in order to keep them in working condition. If this is not done, a film of some black substance forms on the surface of the aluminium, which seems to allow current to pass equally in either direction. If the cells are left idle for a few days it is very difficult to get them back into working condition.

Rectifiers, consisting of tantalum and, say, lead, in a solution of sulphuric acid in water, would be used in preference, if the tantalum could be obtained at a reasonable price, but up to the present none has been procurable.

The smoothing is effected by means of four $1\mu F$ oil-filled condensers, and two chokes (by Ford). These condensers have stood at least 3 000 volts of pulsating D.C. —measured, not guessed; they are ex-W.D. goods. The four condensers provide absolute smoothing, and pure C.W. can be obtained, even with A.C. on the filament.

The transformer used for lighting the filaments was made as follows: a bobbin of thin wood, about 6 ins. in diameter, and with a hole of 2 ins. diameter in the centre was made (the width inside may also be 2 ins.), and then filled with soft iron wire (22 gauge) wound tightly. The whole was then immersed in paraffin wax and, after removal, allowed to cool. The wood was then stripped off, and the slab of iron wire wound with tape. The windings were then put on, using the thickest wire possible consistent with space considerations. (The winding is a little tedious but is well worth while.)

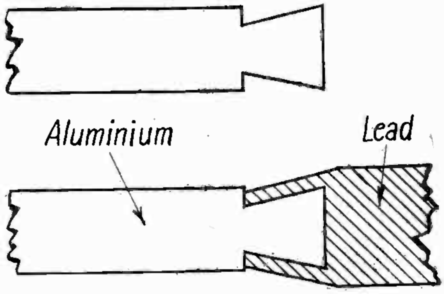


Fig. 3.

The transformer output is shunted with a potentiometer, the centre of which is connected to the appropriate position on the A.T.I., etc. The two halves of the potentiometer must, of course, be shunted by condensers to pass the R.F. These condensers should be of good quality, and should be well spaced from surrounding objects. Of course, a centre tap on the secondary of the filament transformer would serve the same purpose as the potentiometer.

The transmitting valve used was a Mullard 0-250-C. This was obtained second-hand (vy) from a well-known London amateur, and was as a matter of fact the actual valve used when amateur communication between England and Canada first took place in 1923.

The transmitting inductance was made as shown in Fig. 4. Four strips of ebonite 1 in. by $\frac{1}{4}$ in. were clamped together, and holes drilled right through every $\frac{1}{4}$ or $\frac{1}{3}$ of an inch. These strips were then cut down the centre to admit the wire previously formed into a spring of cylindrical shape.

Lastly the strips were screwed together.

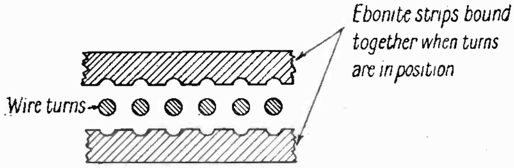


Fig. 4.

This inductance is held suspended in the air by thick string, and is thus securely fixed 18 ins. from all surrounding objects. Although the appearance is not all that could be desired, the dielectric losses must be very low.

The photo reproduced on page 721 shows a general view of the station, but was taken after several changes not described above had been made. The power valve (the 0-250-C) is shown on the right, just below the A.T.I.

In the centre is the H.T. transformer, below it, on the floor, are the rectifiers, not shown in the sink, to the right of the transformer are the smoothing condensers, and in front of these a choke.

Below the valve is the filament voltmeter, the rheostat being on the table just below the aerial ammeter. The keying relay and the grid tuning condenser are on the extreme right. The grid coil cannot easily be seen, but is slipped into the right hand of the A.T.I., immediately above the "bottle" grid leak.

Just below the inductance is the anode stopping condenser, in a jam jar, oil-filled. The aerial ammeter is seen on another jar just below to the left.

On the left is the high wave receiver, 15 metres upwards, and on the right, under the table, is the low wave set. (This is the same as that described recently by G2VW in E.W. & W.E.)

The circuit which has given the best results has been the reverse feed back shown in Fig. 5. If the grid coil is coupled to the A.T.I. in the opposite direction from the orthodox, some remarkable results are obtained: the aerial current is the same as usual, after careful adjustment, and the range seems to be the same as with the standard arrangement; but whereas, in the usual way, increasing the number of turns in the aerial coil results in increase of wavelength, here this increase of A.T.I. produces a decrease of wave-length, up to a certain point, after which the wave-length remains almost constant.

A definite point is found where the aerial current is a maximum: usually 10 turns 8 ins. diameter are used between aerial and earth system when working without a series condenser, on 95 meters, while under similar conditions, using the standard arrangement, only $1\frac{3}{4}$ turns are required.

The grid coil is tuned by a .000 2 condenser, and a vernier condenser is shunted across the plate coil for final adjustment.

The grid-leak consists of two lead wires, one in a bottle of water and the other in a capillary tube in the bottle. This leak gives good results except when a bubble of hydrogen leaves the electrode accompanied by a slight change of power.

As shunt H.T. supply is used, an anode stopping condenser is required. At first this condenser was always giving trouble by breaking down, with consequent shorting of the H.T. The present one, however, is a "double spaced" variable condenser, the fixed plates being $\frac{1}{4}$ in. apart. This is immersed in condenser oil in a jam jar.

Keying is effected by breaking the connection between the grid coil and filament.

It is noteworthy that direct connection to the aerial is used, as this gives the best range, and the note has always been reported as dead steady. No series A.T.C. is used.

Although an aerial current of several amps is obtained, this is due to the unusual aerial system, rather than to any abnormal efficiency.

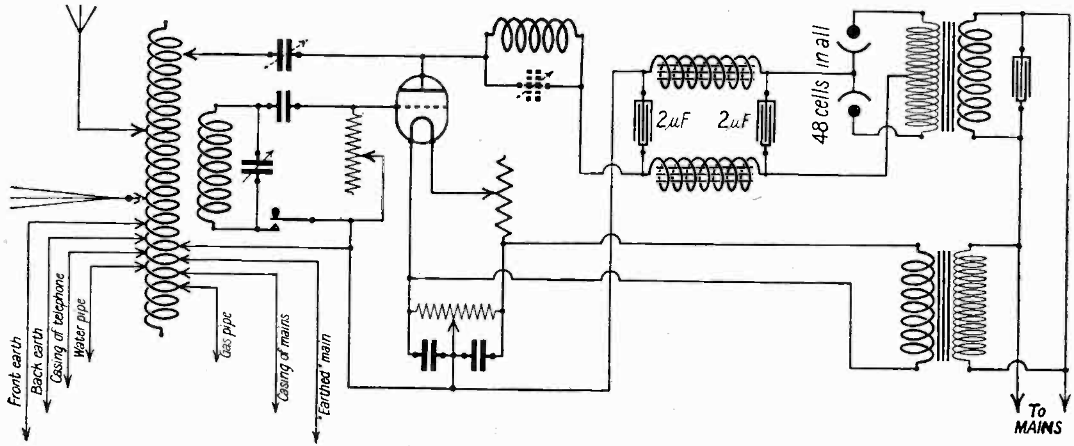


Fig. 5.

Almost all work has been done on, or around, 100 metres; little has been done recently on 200 metres, but some successful tests have been made on about 3 metres.

Concerning the results obtained on 100 metres, no station *had* been worked at over 1 500 miles until 26th October, 1924, when Z4AG was called and a reply was received—Z4AG calling U6TQ or U6TMA, which was probably a misreading of G6TM. However, on 29th October, 1924, an N.Z. call at 6.15 was answered by Z4AA, who was worked till QSS set in—about 1¼ hours. Every message each way was received perfectly, and he was worked again the next morning. As we were "signing off" 4AA said: "You are the best station in G.B.," but, of course after that, the rectifiers at 6TM immediately began to give trouble, and the A.T.I. collapsed, and ever since some cause or other has prevented reliable N.Z. working.

Several local receivers report that two Australians have been heard calling G6TM, but nothing definite has yet been done. Several Americans have been worked, but only one serious attempt has been made to work U.S.A. stations. This was on 28th November, 1924, when eight were worked; also 31 cards relating to the occasion have been received.

The receiver at 6TM is merely a detector and 1 L.F. This set goes down to about 15 metres, and another from about 6 down to about 2.5. The front of the panel of the high-wave set is lined with lead to prevent capacity effects.

The rectifiers previously used for accumulator charging were of the rotary type, but more recently a chemical one, designed as shown in Fig 6, has been employed. This gives excellent results if reasonably used.

A number of Yank 6's have been logged, including one remarkable freak (since confirmed), namely, the reception in January, 1924, of U6XAD, on 200 metres, using one valve, a Telefunken of prehistoric and idiotic design, with anode and grid in the form of flat plates.

Apart from freaks, however, 4Z's and 4A's have been logged, and a large number of other Yanks. For instance, on the last occasion, 150 different Yanks were logged.

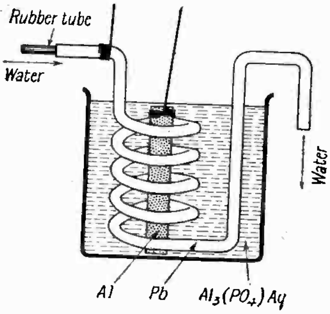


Fig. 6.

In conclusion it may be stated that the station is being entirely rebuilt, and hopes to be on the air again by the time this article appears.

Measurements with the Numans Oscillator.

By K. C. van Ryn. **[R201·22**

This article describes methods of making accurate measurements of capacity, inductance and wave-length without the use of expensive apparatus.

As this oscillator, described in E.W. & W.E. for December, 1924, has the property of bringing into oscillation any closed circuit connected to it, it is obvious that an ordinary buzzer-wavemeter can be converted into an oscillating wavemeter by connecting it to this oscillator. If one possesses a commercial wavemeter it can thus be used for the longer wave-lengths while extra coils can be inserted into the oscillator for the shortest waves, down to ten metres. The curves of the ordinary wavemeter, however, will have to be corrected.

Capacity Measurements.

The first thing to do is to calibrate the variable condenser of the oscillator. A small accurately calibrated fixed condenser of about 0.1 of the capacity of the condenser on the oscillator should be obtained: it can be got, usually, by paying a few pence extra. To calibrate the variable condenser proceed as follows: Set up the oscillator, and near it a simple single valve reaction receiver. Insert a coil in the oscillator, set the variable condenser at zero, and tune the receiver to zero beat. Shunt the variable with the known fixed condenser, and tune the receiver condenser till the beat-note reappears. By alternately enlarging the receiver and oscillator capacity some ten points can be found which will be almost on a straight line, though the zero and maximum capacities will probably deviate slightly from it. (For convenience in capacity measurements it is advisable to use an ordinary condenser in the oscillator, with semi-circular plates, and not one of the "square law" type.) The absolute error of the fixed condenser is of course multiplied by ten, but the relative error will not alter greatly.

To measure with the oscillator a capacity smaller than that of its variable condenser, set this near its maximum position, listen for the beat-note, shunt it with the unknown capacity, and turn the knob back till the note reappears. The unknown capacity can now be read off from the graph. Larger capacities can be measured by first calibrating a larger variable condenser or by shunting the oscillator condenser with a number of fixed condensers of known capacity.

The zero capacity of the oscillator can be found by the two following methods:—

(A) The first method makes use of two absolutely identical coils, for example, two 200 turn honeycomb coils. Two coils can be matched with the Numans oscillator by listening to the beat-note in a receiver while the coils are plugged into the oscillator. Remove windings from one of them till the wave-lengths produced by each are equal. An amazing degree of accuracy can thus be obtained, though it is not essential for this purpose. (The value of the inductance plays no part in this measurement, only the self-capacity.) Now insert one of the coils in the oscillator and listen for the beat-note. Then

$$\lambda = 1\,885\sqrt{(C_1 + C_c + C_g)L} \quad .. \quad (1)$$

where C_1 is the capacity of the oscillator condenser, C_c is the self-capacity of the coil and C_g is the self-capacity of the oscillator. If we have set the oscillator condenser near the upper end of its scale (say 160°) we shall find the second harmonic in the neighbourhood of 30° (the second harmonic gives the strongest beat-note after the actual wave-length itself). We can now write

$$\lambda/2 = 1\,885\sqrt{(C_2 + C_c + C_g)L} \quad .. \quad (2)$$

whence

$$C_c + C_g = \frac{C_1 - 4C_2}{3} \quad .. \quad (3)$$

C_1 and C_2 can be read from the graph.

We now make use of the second similar coil which we shunt in parallel with the first one and repeat. Then

$$\lambda' = 1\,885\sqrt{(C_3 + 2C_c + C_g)L'} \quad .. \quad (4)$$

$$\lambda'/2 = 1\,885\sqrt{(C_4 + 2C_c + C_g)L'} \quad .. \quad (5)$$

(3), (4) and (5) give us

$$C_g = \frac{2C_1 - 8C_2 - C_3 + 4C_4}{3} \quad .. \quad (6)$$

Once the zero capacity of the oscillator has been measured in this way, we can easily find the self-capacity of any coil from the equation (3).

(B) If the wave-length calibration of the oscillator is available (see below) we can dispense with the second coil. Place the coil to be measured near the oscillating wavemeter. When the oscillator (oscillating strongly) passes the wave-length of the open circuited coil, a click will be heard in the oscillator, and another one on turning the condenser back again. By carefully loosening the coupling, the two clicks may be brought together and the point where they occur indicates the wave-length to which the open coil is tuned. We can then write

$$\lambda = 1\,885\sqrt{(C_cL)} \quad .. \quad .. \ (1)$$

Now shunt the open coil with a condenser of known capacity and repeat. Then

$$\lambda' = 1\,885\sqrt{(C+C_c)L} \quad .. \ (2)$$

(1) and (2) gives us C_c and L in $\mu\mu$F and μH, if we express λ, C and L respectively in metres, micro-microfarads and microhenries. The C_g is then found by plugging the coil into the oscillator with its condenser at zero. If we measure the resulting wave-length, we have

$$\lambda'' = 1\,885\sqrt{(C_g+C_c)L} \quad .. \ (3)$$

The equations (1), (2) and (3) then give us the capacity C_g. (Some doubt may arise as to whether the capacity C_c thus measured is the real self-capacity. In any case it is the value we may substitute for it.)

Inductance Measurements.

Shunt the inductance to be measured with a known capacity C and measure the wave-length of this combination by the "click" method as shown above. Then

$$\lambda = 1\,885\sqrt{(C+C_c)L} \quad .. \ (1)$$

If C_c is small in comparison with C, which is mostly the case, it can be neglected and L can be found from (1) directly. For very accurate measurement we must first determine C_c.

An idea of the comparative inductances and capacities of telephone and transformer windings can easily be obtained by plugging them into the oscillator and comparing the resulting audio frequency notes. By increasing the parallel capacity until the frequency is halved (distinguished with the ear or a tuning fork), the value of the self-capacity can be determined.

The Numans oscillator can easily produce frequencies as low as 25 per second. The telephone in this case should not be plugged into the anode circuit, but connected by one lead only to the winding under measurement. (Otherwise a "mush" will be heard instead of a clear note.)

Aerial Measurements.

To find the fundamental wave-length of an aerial system proceed in the usual way, *i.e.*, connect a buzzer or an induction coil in the aerial circuit and listen on the oscillator for the emitted wave. To obtain a sharp note the wavemeter should not oscillate.

The actual capacity of an aerial system can be determined simply by measuring its capacity with the oscillator as mentioned above. Plug a coil in the oscillator, set its condenser near the maximum, shunt the coil across the aerial circuit (earth to the filament side of the coil), and turn the condenser back until the apparatus is again tuned to the original wave-length. The aerial capacity varies with the wave-length but a fair idea of its value (above the fundamental) can be obtained in this way. The inductance of the aerial is in parallel with the coil but can safely be neglected if a large inductance, say a honeycomb coil of not less than 200 turns, is used.

Wave-length Calibration of the Oscillator.

The wave-length calibration of the oscillator is an important matter, as the oscillator is probably used most frequently for wave-length measurements. A very high degree of accuracy is obtainable once the calibration has been accurately performed. To do this we may proceed in two ways:—

(A) By the use of a calibration signal. It is possible by the use of harmonics to make a complete series of curves (say from 10 to 30 000 metres), providing that one wave-length is accurately known.

(B) By the use of a standard wavemeter.

The following practical hints may be of use. If a regenerative receiver or a Numans oscillator oscillates, there will be produced, besides the fundamental wave-length, harmonics on 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, . . . etc., of the wave-length. The strength of these gradually decrease in the above order. It will be assumed here that the first harmonic is the wave itself and the second one-half of the wave-length. On this assumption the sixth harmonic has 1/6 of the wave-length and not 1/5. It is to be remembered that when listening, for example, to the fundamental with the tuning condenser at the maximum (100 divisions), the second harmonic will not be found at 25 divisions but somewhat lower (¼ of the total capacity) owing to the zero capacity of the condenser. With a very small condenser it may therefore be necessary to plug in a new coil in order to find the second harmonic.

As mentioned above one can force the oscillator *or* the regenerative receiver to produce the harmonics. The valve of the former should therefore be given ample high-tension and the filament should be as bright as possible; the latter in addition requires a strong feed-back coupling. *One* of the two should be made to produce the harmonics, not both, otherwise all the harmonics of the one will interfere with all those of the other. Near the fundamental, especially on short wave-lengths, the coupling between the receiver and the oscillator should be made very loose, otherwise the note will be wiped out and passed without notice. With a single valve, the harmonics of an oscillator or an oscillating receiver can be distinguished until about the tenth; with a two valve note magnifier added, up to the thirtieth harmonic can easily be heard.

Dealing now with the actual calibration, we will assume that an oscillator produces a wave of 1 000 metres wave-length. The harmonics produced will be: 500, 333, 250, 200, 167, 143, 125, 111, 100, 91, 83, 77, 71·5, 66·5, 62·5, 59, 55·5, 52·5, 50, 47·5, 45·5, 43·5, 42, 40, 38·5, 37·1, 35·7, 34·5, 33·3, . . . metres. It will be noted that at the higher frequencies the harmonics are more crowded and therefore a curve can more easily be drawn. Therefore, to draw a curve ranging from 100 to 240 metres, we set the oscillator which is producing harmonics at 2 400 metres, for a curve from 60 to 140 metres we use the harmonics of a 1 600 metre wave and for a curve from 42 to 100 metres we use a wave-length of 800 metres.

As mentioned above, we can make either the receiver or the oscillator produce the harmonics. Assume that we have an accurate calibration at 600 metres on the oscillator. To proceed *upwards* we can make the oscillator produce the harmonics, and listen in the receiver for the beat-notes. We then obtain calibrated points on the oscillator at 1 200, 1 800, 2 400, 3 000, 3 600, 4 200 metres. To calibrate *downwards* we make the *receiver* produce the harmonics, the fundamental of the oscillator beating with these. We then obtain calibrations at 300, 200, 150, 120, 100, 86, . . . metres.

We will now give an example of the procedure for obtaining a calibrated curve from 100 to 240 metres. For this purpose we may use a coil of 7 cm. diameter wound with 39 turns of No. 19 D.C.C. wire.

Assume that we have obtained, by the use of an accurate wavemeter, a curve for the oscillator, *e.g.*, from 300 to 550 metres. With the aid of this we set our receiver at 400 metres, then plug the above coil in the oscillator and take the reading of the oscillator condenser for a wave-length of 200 metres, *i.e.*, the first harmonic of the receiver. As mentioned before, for a 100 to 240 metre curve we will make use of the harmonics of the receiver when it oscillates at 2 400 metres. We therefore set the receiver at what we think will be 2 400 metres (*i.e.*, a weak beat-note) and leave it there. To make sure that we are really on a wave-length of 2 400 metres and not on 1 600, 2 000, or 2 800 metres, we again plug the calibrated coil into the oscillator and note the harmonics that are produced with the receiver set at what we suppose is 2 400 metres. We can then make a table such as that following.

Reading of oscillator condenser.	Wave-length of oscillator.	Degree of harmonic.	Wave-length of receiver.
7·7	299.0	8	2 392
18.2	343.0	7	2 401
34.6	400.0	6	2 400
62.0	480.0	5	2 400
		Average	2 398 m.

The third column gives the degree of the harmonic; at 7.7 divisions we strike the eighth harmonic of the receiver and so on. We can now safely assume that the receiver is tuned to 2 400 metres. (The accuracy here is better than 1/3 per cent.) We now once more plug the coil to be calibrated in the oscillator and note the condenser reading every time we hear a beat-note due to the fundamental of the oscillator interfering with a harmonic of the receiver.

For *one* condenser setting we already know the degree of the harmonic, and from this, going up and down the scale, we may make a table such as that shown in the next column.

Care must be taken not to miss any beat-note, because then the degree of the harmonic will become incorrect. The points should lie on a smooth curve and the distance between the points should increase proportionally, which serves as a check. If desired more points can be found at the top of the curve by repeating the measurement with, for example, a 1 600 metres wave.

In conclusion, I would like to urge the reader not to be discouraged by the somewhat lengthy description of the method of getting the calibration and of making the measurements. Once the oscillator has been calibrated and the self-capacity and capacity curve known, the instrument will soon become, to the real experimenter, a most valuable piece of apparatus.

Reading of oscillator condenser.	Degree of harmonic.	Wave-length of the oscillator.
98.8	10	240.0
79.2	11	218.0
64.5	12	200.0
53.0	13	184.5
43.5	14	171.5
36.0	15	160.0
30.0	16	150.0
25.3	17	141.2
21.0	18	133.3
17.5	19	126.3
14.5	20	120.0
11.8	21	114.2
10.0	22	109.2

Further Valve Tests. [R333·009

Below we describe four more valves which have recently been tested in our laboratory—the D.F.A.4 by the Mullard Radio Valve Co., the R and B.6 by the British Thomson-Houston Co., and the "C & S" by Messrs. Craik & Smith.

The D.F.A.4.

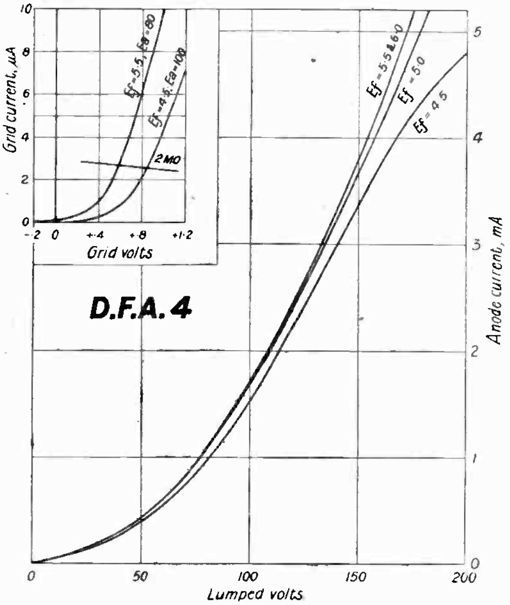
THIS valve, as our readers may remember, was first reported upon on p. 367 of our March, 1925, issue. In this case we found the voltage amplification to vary from 10.5 to 15.0, the anode impedance rising from 13 000 to 27 000 ohms. The power amplification was in the neighbourhood of 9.0. Both the voltage amplification and the power amplification were thus rather low for this type of valve.

The Mullard Radio Valve Co., Ltd., the makers of the valve, on seeing the report, suggested that we had received a specimen of unusually low μ and accordingly they sent us another of these valves for a further examination. This we have now tested, and find that the second sample is distinctly different. The filament voltage and current are exactly as before, namely, 4.5V, .17A; 5.0V, .18A; 5.5V, .19A; and 6.0V, .20A. The saturation plate current is somewhat greater, rising to 35mA at 6.0V on the filament. The anode impedance is approximately the same as that of the previous specimen, but the μ is much higher, rising to 21.8. The power amplification is also much higher, and so is the filament efficiency.

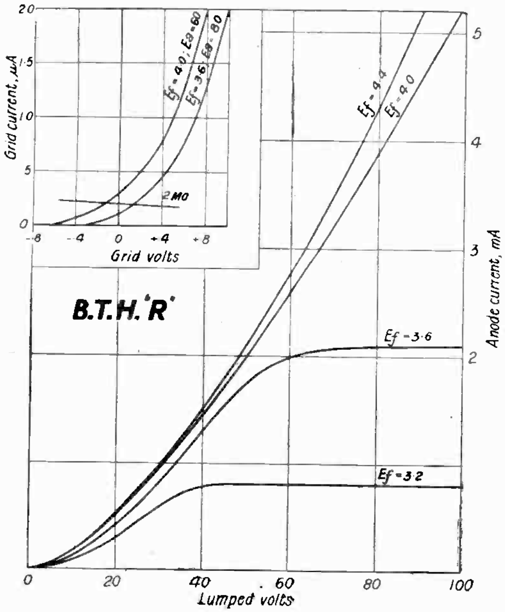
D.F.A.4.

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
4.5	.17	7	27 000	19	13	9.2
5.0	.18	13	20 600	20.6	20	14.5
5.5	.19	22	18 000*	21.6*	26	21.0
6.0	.20	35	17 500*	21.8*	27	29.0

* At 200V.



In fact, the second valve tested falls into line with the other members of its class (625b) though it is quite an open matter whether it is a *better* valve, even for use in a resistance-coupled amplifier.



The curves obtained with the second valve are reproduced herewith. It is to be noticed that no great advantage is secured by increasing the filament voltage above 5.5. In fact, the lower portions of the curves for 5.5 and 6.0V are practically identical.

The price of the valve is now 22s. 6d.

The B.T.-H. "R."

This valve is a bright emitter of the R type, which still finds favour with many users, in spite of the growing popularity of the dull-emitter. It is rated by the makers, the British Thomson-Houston Co., Ltd., at 4.0V, 0.7A for the filament; plate voltage (maximum) 100. It thus really belongs to our "460" (or, rather, "470") class. The electrodes, which are of the usual form, are mounted vertically, and the bulb of the valve is of the tapering, "pipless" type.

With filament voltages of 3.2, 3.6, 4.0 and 4.4, the filament current of the valve varied from 0.59 to 0.7 amp. Thus the current consumption is somewhat less than that mentioned by the makers.

B.T.-H. "R."

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
3.2	.59	.8	33 000	3.3	.33	.42
3.6	.62	2.1	20 000	2.7	.35	1.0
4.0	.66	6.5	14 000	2.24	.36	2.4
4.4	.70	17.0	9.500	3.5	1.28	5.5

The saturation anode current rises from .8 to 17.0mA. The current value at 4.0 volts on the filament, 6.5mA, is a trifle low for a valve of its class. The impedance is roughly normal, but the magnification μ is very low, being in the region of 3. An average value for valves of this type is 7. As a consequence, the power amplification, which is proportional to $\mu^2 R_a$, is also rather low. The filament efficiency is normal.

From the curves obtained, it can be seen that the valve requires the full 4.0V on the filament for use as an amplifier. At about 60 lumped volts, the curves for 4.0 and 4.4 filament volts begin to straighten out nicely. The valve will probably function best as a first stage L.F. amplifier (transformer coupled), since for H.F. amplification and resistance-coupled L.F. amplification a valve of fairly high μ is desirable.

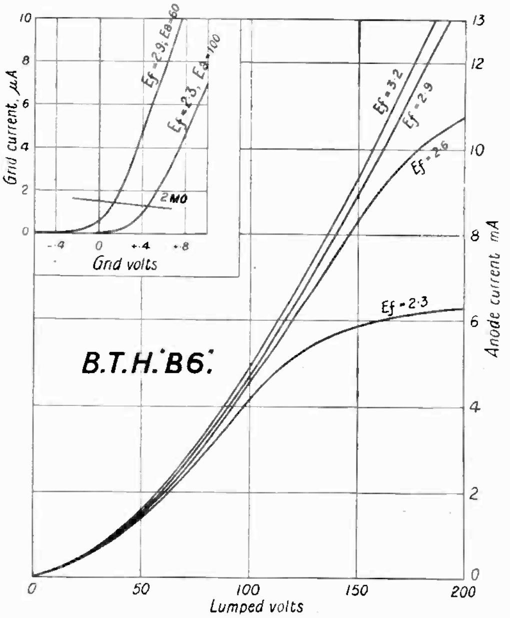
From the grid-current curves it will be seen that the valve will serve as a reasonably good detector using the usual 2MO grid-leak.

We think that the valve we tested may have been a rather abnormal one as regards the low amplification factor, since in other respects it was, comparatively speaking, normal.

The price of the valve is 8s.

The B.T.-H. B6.

This is a 3-volt dull-emitter power valve, with a filament rating of 3.0V, 0.12A. It therefore belongs to our "312" class, and is intended for use in sets employing for the other stages valves of the popular "306" type.



Actually at filament voltages of 2.3, 2.6, 2.9 and 3.2, the currents varied from .10 to .13 amp, while the saturation plate current rose to 28mA at 3.2V;

hence the valve is capable of dealing with plenty of power. The impedance was in the region of 12 000O, the amplification factor (μ) remaining approximately constant at 6.7, which is quite a normal value. The filament efficiency is one of the highest yet found.

B.T.-H. B6.

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
2.3	.10	7	16 000	6.4	2.6	30
2.6	.11	13	13 500	6.7	3.4	45
2.9	.12	20	11 000	6.7	3.9	57
3.2	.13	28	10 000	6.7	4.4	70

From the anode current curves it will be seen that both those for 2.9V and 3.2V on the filament are excellent for amplification purposes. As, however, no great gain in μ or power amplification is obtained at the higher voltage, it is probably best to use only 2.9V on the filament, resulting in an increase in the length of life of the valve.

For small loud-speaker work, the amplitude on the grid may be 5V. From the curves, the lumped voltage should not be less than about 125 volts for distortionless results. If the grid is biased to — 5 volts, the anode voltage will thus have to be $125+(5\times7)=160$ (assuming $\mu=7$).

An inspection of the grid-current curves shows that the valve has good possibilities as a detector, as the bend in the curves is quite sharp. For best results a leak of rather higher resistance than 2MO—say 4MO—will probably prove advantageous.

The "C and S" Dull Emitter.

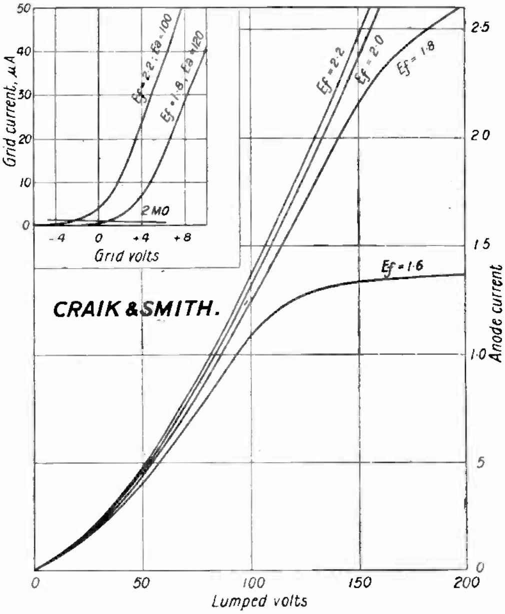
A rather unusual valve is that supplied by Messrs. Craik and Smith, of Allen Street, London, E.C.1.

This has a rather squat, tubular bulb and the electrodes are small in size and arranged horizontally. The grid is peculiar in that it consists of thin and narrow strips of metal arranged in cylindrical formation, instead of the more familiar wire spiral.

Tested at filament voltages of 1.6, 1.8, 2.0 and 2.2 the filament currents ranged from .20 to .23. It must thus be placed in the "235" class, though actually a "220" classification fits it better. The saturation current, which is 10mA at 2.2V on the filament, is lower than that of the average "235" class valve, while the impedance is much greater, varying from 70 000 to 37 000O. The voltage amplification is also abnormally high, being about 15. The power amplification and the filament efficiency are roughly normal for this class.

The valve might almost be said to be a "220b," or high magnification, valve, though, owing to the high impedance, the power amplification is not as great as would be expected in this type of valve.

Owing to its high magnification and to the fact that it cannot deal with a very large amount of power, the valve, if used as an amplifier, should be placed preferably in the H.F. stage. Here it should work very well, with a fairly high plate voltage.



"C & S."

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
1.6	.20	1.5	70 000	14	2.8	4.7
1.8	.21	3.5	54 000	15	4.2	9.0
2.0	.22	7.5	39 000	14	5.2	16.5
2.2	.23	10.0	37 000	16	6.9	20.0

As a detector, the valve should work extremely well, as will be seen from the gird current curves. Here again the plate voltage must be high (at least 100 volts), owing to the high impedance of the valve. A 1MO or 2MO leak should prove quite satisfactory.

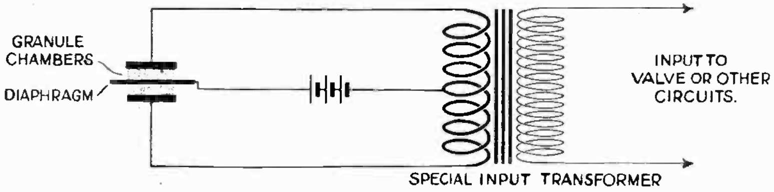
The price of the valve (12s.) is quite low, and this coupled with the fact that the current consumption is also below the average of its class, should make the valve worth trying.

Apparatus Tested.

The Brown Differential Microphone. [R009

EXPERIMENTERS who are interested in telephony are familiar with the difficulty of obtaining a good microphone at a reasonable price. Messrs. S. G. Brown have submitted to us a specimen of their differential hand microphone. Before commenting upon this particular microphone it may be best briefly to summarise the connections and advantages of such differencial or "push-pull" arrangements.

The response of a carbon microphone is not a linear function of the pressure applied to the diaphragm, that is to say, the variation of resistance with pressure is not quite the same at different absolute pressures. This gives rise to a form of distortion similar to that produced by an L.F. amplifying valve operating over a curved portion of its characteristic. The object of the push-pull arrangements of valves or microphones is to eliminate this form of distortion. The circuit used in the case of microphones is given herewith. The microphone has two distinct granule chambers and when the diaphragm moves one is under compression while the other undergoes expansion, and *vice versa*. The resistance variations in the two granule chambers are in opposite phases, so that a differential input transformer is necessary to superimpose their undistorted components in the same phase. This transformer has simply a mid-tapped primary and an ordinary secondary winding. Without entering further into the theory here we can state that this arrangement eliminates such current variations as are proportional to the square and other even powers of the amplitude of the displacement of the diaphragm. If the full advantage of the system is to be realised it is essential that the two microphone chambers should have exactly the same electrical characteristics.

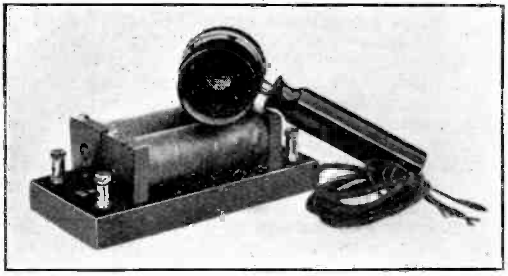


The microphone circuit.

The Brown double-button microphone which we have tested is of the hand type and is exceptionally light and convenient, the case being of aluminium and similar in size and shape to the Brown telephone earpiece. The combined mouthpiece and screw-cap is of ebonite as is also the handle. There are three leads from the microphone; one is distinguished by green binding at the end and is the connection common to both halves while the other two leads are the "outers." The diaphragm which actuates the microphone is a light aluminium cone such as is used in the "A"-type receivers.

The microphone is meant to work off a 4 or 6-volt battery. Its mean resistance is rather variable and the currents passed are not high. Using 6 volts we found that the total current taken by both halves varied between 50 and 200 milliamperes. Although the makers carefully adjusted the two halves to have equal resistances before submitting the microphone to us, we find that the two halves do not stay properly balanced, so that the advantages of the push-pull connections are hardly fully realised. The quality of speech given by the microphone is, however, very good, and mechanical resonance in the body of the instrument is practically absent. It is undoubtedly better than the generality of microphones, such as the solid-back type, which are available to amateur experimenters and others. We have tried it on our choke-control transmitter, and, to be quite candid, have received estimates of the quality of speech tending to show that the quality obtainable by using one-half alone as an ordinary microphone is as good as that obtained by using both halves in the push-pull manner. The double microphone doubtless has the advantage, however, over the ordinary type that it is less likely to pack or become inactive when held in certain positions. The microphone is singularly free from hissing and crackling sounds.

As already indicated, the microphone does not handle a large current, but it should be remembered that good speech quality in microphones cannot usually be expected to be accompanied by high current carrying capacity. The serious worker will not object to using a stage or so of L.F. amplification if this will permit the use of a good microphone. With regard to the differential microphone transformer supplied, we do not consider that this is of the best possible design for controlling the grid of a valve. The step-up ratio from primary to secondary



The microphone and its special transformer.

is much too low. The grid input of a properly biased valve amplifier takes practically no load from the secondary, which may therefore have a large number of turns. We obtained much better results by using the secondary from an ignition coil. It also seems rather a makeshift plan to use two ordinary telephone transformers simply screwed down side by side on a common baseboard instead of winding a special differential transformer over one core.

We understand that the microphone was not originally put on the market for amateur use, which may account for the rather high price of £11 for the outfit.

E. H. R.

Some "Grelco" Products.

The Grafton Electric Co., of 54, Grafton Street, W.1, have recently produced a range of excellent L.F. transformers together with an L.F. choke, bearing the name "Grelco." Samples of these were sent to us for test, and the results obtained will be of unusual interest to our readers. The transformers are made in three ratios, 6 to 1, 4 to 1 and 2 to 1.

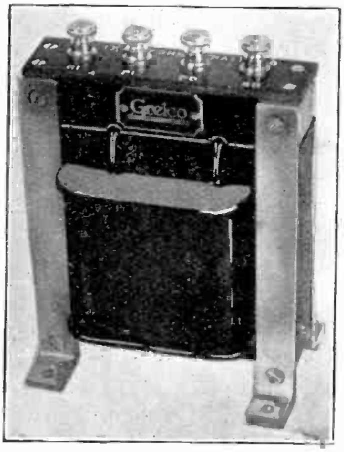
With regard to the first two, excellent results were obtained, and they can be highly recommended. So good were they that instead of comparing them with our usual standard (a first-class commercial instrument) we used the one particular transformer which has hitherto been the best which we have handled. Against this, the "Grelco" 6 to 1 and 4 to 1 instruments showed up very well.

Comparing transformers of the same ratio, there was no appreciable difference in the strength. In tone a slight difference could be detected, though it would be unfair to say that one was better than the other in this respect.

The low ratio transformer (2 to 1) did not give such good results. The volume fell off, as might be expected, owing to the low ratio; but, in addition, the tone was noticeably higher. The makers have possibly reduced the number of turns on the secondary in this case.

The choke, though not actually tested, should be quite efficient, since the number of turns is 30 000 and the iron core is similar to those of the transformers.

As will be seen from the illustration, the transformers have very generous windings and large cores. At the top is an ebonite strip on which are mounted the terminals. The size of the instrument is necessarily large, the measurements being 3½ ins. wide by 2½ ins. thick by 5 ins high, but this disadvantage always has to be faced where extreme efficiency is desired.



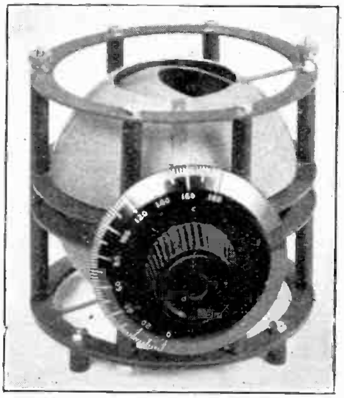
The "Grelco" transformer.

The prices are £1 10s. each for the transformers and £1 5s. for the choke.

Some New Variometers.

Messrs. Varic, Limited, of Castle Hill, Bedford, are making some neat and efficient air-spaced variometers bearing the name "Varic." These are of the ball type, and are made in two patterns—for panel mounting and for table mounting. The latter can also be used for panel mounting if desired. The coils, which are wound with a heavy gauge wire (about 20 S.W.G.), are self-supporting, so that dielectric losses due to the usual former are avoided. The clearance between the coils is quite small, and hence a good range of inductance is to be expected.

The spindle of the rotor, which is in two parts, is ¼ in. in diameter, and efficient contact to it is made by two spring bearings. The dial and knob, which are moulded together, are attached to the spindle by a set screw. Terminals are provided for making contact to the variometer.



The "S.T." type of "Varie" variometer.

The table mounting type (which we illustrate) is made in two sizes—for wave-lengths of 250-650 metres and 580-2 320 metres. We tested one of the former. The results obtained were very good. The minimum inductance was 35μH (microhenries), and the maximum was 338μH. The self-capacity ranged from $10\mu\mu$H to $25\mu\mu$F, and the resistance at about the middle of the range was 8.4 ohms, giving a power factor of approximately .016, which is quite good for this type of tuner. There is no doubt that these variometers are some of the most efficient we have yet tested.

One small defect was noticed, namely, that it was possible to push the spindle in and out for about 1/16 in., thus varying the position of the rotor relatively to that of the stator, which might cause trouble when accurate tuning was required. This is, however, not a very serious fault, and, in any case, it can be easily rectified.

We are of the opinion that the wave-length range claimed by the makers is rather conservative—we should imagine that the variometer tested would tune down to well below 250 metres with an average P.M.G. aerial.

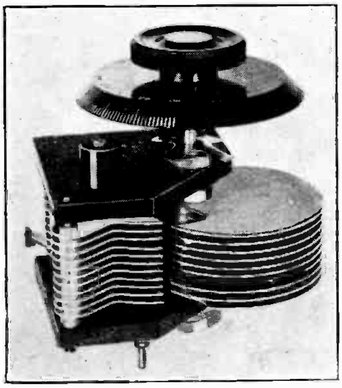
Although we did not test the larger model, it is similarly made, and should prove equally efficient.

The prices are :—

	s.	d.
Type S.P. (250-650 metres, panel mounting)	10	0
,, S.T. (ditto, table or panel mounting)	12	6
,, L.T. (580-2 320 metres, table or panel mounting)	15	0

The "A.J.S." Variable Condenser.

Messrs. A. J. Stevens & Co., Ltd., of Wolverhampton, have recently sent us one of their special variable condensers for test and report. This, as can be seen from our illustration, is provided with stout ebonite end-plates, and the spindle of the moving plates has substantial adjustable metal bearings. The condenser is not intended for one-hole fixing, two screws with ebonite distance-pieces being supplied for mounting. There is also a neat friction washer which is placed between the dial and the panel. The dial and knob are well finished, the former being engraved from 0 degs. to 180 degs.



The A.J.S. condenser. Note the curiously shaped plates.

Positive connection to the moving plates is made by means of a spiral of brass strip. On handling the condenser, one realises that it is a sound job from the mechanical point of view. The plates, which are of aluminium, are curiously shaped in order to give a "square law" effect, as will be gathered from the illustration.

On test the condenser gave very good results. The particular one we have is rated as .000 5μF maximum, and we found it to be .000 532μF. The minimum capacity was exceptionally low, being only .000 007μF. The high frequency resistance was also very low. These facts, coupled with the mechanical efficiency, make the condenser a very satisfactory instrument.

The condenser is made with maximum capacities of .000 2μF, .000 3μF, .000 5μF and .001μF, the prices being 10s. 6d., 11s. 6d., 12s. 6d., and 17s. 6d. respectively.

Two Crystal Detectors.

The Harlie Detector.

This is a most interesting little component, out of the usual run of galena detectors. As will be seen from our sketch, the crystal is a special one moulded into a cylindrical shape, and the contact point can be adjusted entirely without skill.

When we started to test it, we were quite puzzled at first by an unusual phenomenon: most of the points tried rectified very well, but some passed the current one way and some the other, whereas in the usual galena the current almost always goes from crystal to point.

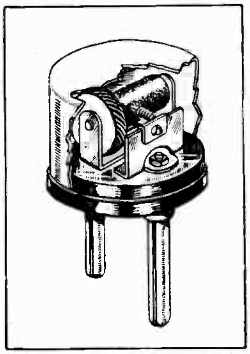
On trying five points taken entirely at random, we got an average output power of 32 per cent. of the input, and an average H.F. resistance of about 20 000 ohms—rather on the high side; all these figures were obtained with an input voltage of .5, at a frequency corresponding to 377 metres.

Next we found a good point and applied various voltages from 1 to .1, getting an efficiency of 69 per cent. at the high voltage and 16 at the low. Taken together, these figures show an excellent performance, and another point in its favour is the ease of handling. It is sold by Harlie Bros., 183, Dalston Lane, Hackney, E.8, at 5s. 6d.

The Ledion Crystal.

This is a very interesting crystal, although it is offered as an ordinary galena. The outstanding point is the exceptional output current given. The efficiency (*i.e.*, ratio of input power to output power) is first-class, though not extraordinary—it was about 50 per cent. on most of the points tested—but the H.F. resistance was only about 4 000 ohms.

A good point about the crystal is the fact that it is almost equally sensitive all over; of five points tested at .5 volt, the worst gave 44 per cent. and the best 52 per cent. efficiency. Also, the efficiency is maintained better at low input than is usual with this type of crystal.



A line drawing showing the construction of the "Harlie" detector.

Altogether it is a very good crystal, but it should be put across part, and not all, of the aerial coil, as otherwise it will take too much power and give flat tuning.

It is sold by Messrs. Ledion, Ltd.

A Method of Testing the Insulation Resistance of a Condenser without a Galvanometer.

By Forbes W. Sharpley, A.M.I.E.E. **[R240**

IT occasionally happens that on endeavouring to locate a fault in the working of his receiving set a wireless experimenter will suspect one or other of his fixed, sealed condensers as being the probable cause of the trouble. However, there are comparatively few amateurs who possess a galvanometer sufficiently sensitive to show a leak even as large as 1 megohm through the dielectric of a condenser, and a smaller leak than this (*i.e.*, one of greater resistance) may make a considerable difference in the strength of received signals. On the other hand all experimenters will possess either a high or low resistance pair of telephones, and if properly used these may take the place of a galvanometer for detecting the presence of a leak and, if required, for estimating its value to some degree of accuracy.

Connect up as in Fig. 1, where *C* represents the condenser under test, *T* the telephones, *K* an ordinary morse key, and *V* a steady applied voltage (about 2 volts to commence). On closing *K* there will be a click in the telephones of a strength depending, for a given pair of telephones and a given voltage *V*, on the size of the condenser under test and on the value of the leak, if any, through it. This click will be caused by the current, which is the sum of that flowing in to charge the condenser and that which may flow through any leak in it.

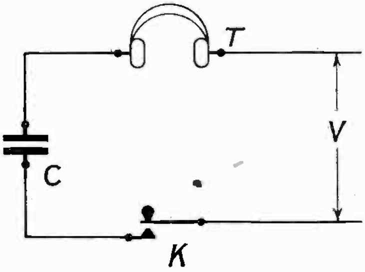


Fig. 1.

Now if the condenser be perfect, as soon as it is charged all current will cease to flow, since it will exert a back E.M.F. equal in value to *V*. On the other hand, if the condenser leaks, the current which flows on closing *K* may diminish immediately, but will never reach zero value.

This gives us the method of discovering the leak, for on opening *K* after a moment, there should be absolutely no sound in the telephones if the condenser is good, while if it is faulty, there will be a second click due to the sudden cessation of the leakage current. The strength of this second click depends on the value of the leak, and will be approximately as loud as the first only if there is a complete short-circuit in the condenser; while if there is a partial leak, this click will be small compared with the first. In either case its strength depends on the value of the leak (for any given voltage) and on the size of the condenser.

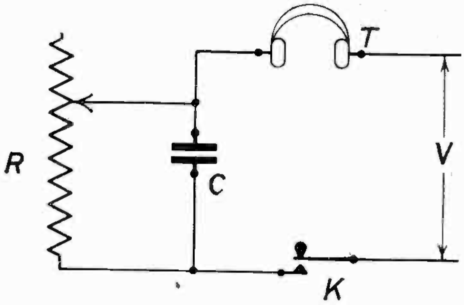


Fig. 2.

The following figures will give an idea of the results which may be obtained so far as merely detecting a leak is concerned. It was impracticable to obtain condensers for testing purposes having various degrees of leakage resistances, but one or two perfectly good condensers of very high insulation resistance were tested, using an external leak connected across or in parallel with the condenser as in Fig. 2. Electrically, of course, this leak acted in exactly the same manner as an internal one would have done, with the advantage that it was easily adjusted to any desired value.

In Fig. 2, C is the condenser and R the external leak, consisting of an accurately calibrated wire-wound tapped resistance of maximum value 1 megohm. The other reference letters are the same as for Fig. 1. With $V = 2$ volts and a condenser of 2μF, using a first-class pair of telephones of total resistance 120 ohms, and adjusting R to its maximum value, a very faint click was just audible on opening K. Adjusting R to $\frac{1}{2}$ megohm the click was more decided, and with $R = 1/10$ megohm ($= 100\,000$ ohms) the click on breaking was unmistakable. With R disconnected no sound whatever was heard on opening K.

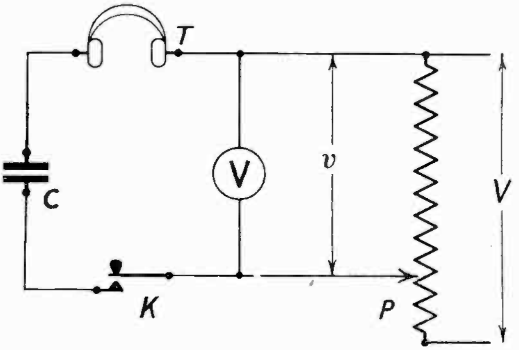


Fig. 3.

Using a condenser of $.05\mu$F capacity, the results were exactly similar to the above. The click on closing K was not, however, quite so loud: but as stated above this is of no significance so far as these tests are concerned.

The tests were repeated with a pair of telephones of 2 000 ohms total resistance. Again no sound was heard while R was disconnected, but with a 1 megohm leak a click was considerably more easily distinguishable than with the 120 ohm telephones; in fact, a leak of between 2 and 3 megohms was detected using extra resistances to increase the value of R. Similarly, using 4 000 ohm telephones, a leak of 5 megohms resistance was quite easily detected.

In this manner by using higher voltages smaller leaks up to many megohms resistance might be detected, but these very high resistance leaks should not have any serious effect on the performance of a receiving set.

While the presence of a leak which would be detrimental to the efficient working of a set may be detected in this way, the author does not mean to assert that the magnitude of the leak can be measured with any degree of accuracy unless the current just necessary to produce a click in any given pair of telephones is known. If it is, the most accurate way to proceed (the apparatus being connected as in Fig. 1) is to shunt the telephones with a variable resistance adjusted to such a value that the (second) click becomes so faint as to be just audible, but no more.

Then, from the value of this shunting resistance and the voltage used, it is quite easy to deduce the value of the leak. As, however, this method necessitates the use of a suitably calibrated resistance box, it is hardly possible to the average amateur. On the other hand, if he possesses an accurate voltmeter reading down to fractions of a volt, he may, with the use of an ordinary potentiometer, such as is used for regulating the grid voltage of a valve, make a tolerably accurate measurement of the leak.

Connect up the apparatus as in Fig. 3, where P represents the potentiometer of (say) 300 ohms maximum resistance, and Vm the voltmeter. V, as in Fig. 1, represents the total voltage of the battery used, while v represents the voltage on the other side of the potentiometer. C, T and K are as in Fig. 1. The voltage v is now adjusted until, as before, on opening K only the faintest possible click is audible.

Example: Suppose for a pair of 4 000 ohm telephones the necessary current to produce this click is 0.3 mA (a pair the author recently tested were sensitive to 0.21mA), and suppose vM reads 0.9 volt. Let R be the internal value of a leak through the condenser C, then, by Ohm's law

$$R = \frac{0.9}{0.3 \times 10^{-6}} = 3 \times 10^{-6} \text{ ohms} = 3 \text{ megohms}.$$

Note: Neither the voltage V nor the resistance of the potentiometer need be considered, while the resistance of the telephones is negligible. Also it is necessary to keep the voltmeter Vm in circuit during the whole time of testing.

The following points should be noted in making any of the above tests:—

(1) The condenser to be tested should be completely disconnected from the set, as well as the telephones and battery; otherwise misleading results may be obtained.

(2) Assume that the condenser is completely short-circuited until you prove otherwise. Therefore, use a low voltage to commence and if necessary insert a resistance of a few hundred ohms value when using low resistance telephones, so that the latter may be protected from excess current.

(3) Always connect the telephones so that the current will enter at the terminal marked positive. A good pair are usually more sensitive when so connected.

(4) Though it is not essential, it is advisable before making a second test to discharge the condenser under test by momentarily short-circuiting its terminals.

(5) A good key or means of making and breaking the circuit is essential if false clicks are not to result.

(6) It is very important that the room be perfectly quiet during the test. Any extraneous noise prevents very faint clicks from being heard.

It is worth remembering that low resistance telephones may be used in conjunction with their telephone transformer when the two together will be equivalent to a pair of high resistance telephones. The primary or high resistance side of the transformer should be connected in the testing circuit exactly where the low resistance telephones previously were, and the latter now connected across the low resistance side of the transformer as when used for reception in the ordinary way. Of course, the transformer must be completely disconnected from the receiving set.

It might be worth while testing one's grid condenser by one of these methods even though no fault is suspected, for it is quite possible that the external grid-leak on the detecting valve may really pass less current than an unsuspected internal leak through the dielectric of a condenser. What is more, it is by no means certain that, if a condenser is faulty, its resistance will remain constant.

Finally it may be remarked that while the smallness of a leak capable of being detected by the telephone is dependent on the sensitiveness of both the observer's hearing and the telephones he is using, yet neither of these factors (over a certain range) will interfere with the accuracy of the measurement of the leak (as distinct from the mere detection of it) provided the observer measures the apparent sensitiveness of his own telephones.

It is not intended that the methods here outlined should be confined to testing condensers: they may equally well be used for measuring any high resistance, and, indeed, with some modifications, low resistances, too.

Addendum.

Note on a method of determining the minimum current to which a telephone receiver is sensitive. The simplest way for an amateur to do this, while still preserving tolerable accuracy in the result, is to connect up as in Fig. 3 above with the exception that some high resistance of *known* value is inserted in the circuit in place of the condenser, which is completely removed. It is suggested that such a resistance might be supplied by a 2 megohm grid-leak of reputable manufacture. Then, as before, the voltage v is adjusted until on either *opening* or *closing* K, only the faintest possible click is heard. Example: Suppose when this condition is obtained, that Vm reads 0.5 volt, then by Ohm's law

$$I = \frac{0.5}{2 \times 10^6} = 0.25 \times 10^{-6} \text{ amps} = 0.25\text{mA.}$$

where I represents the required current.

Apart from the need of this value of minimum current being known for the purpose of testing a condenser, it is of great interest in itself to be able to compare the sensitiveness of two or more telephones.

The Self-Capacity of Inductance Coils.

By H. J. Barton Chapple, Wh.Sch., B.Sc. (Lond.), A.C.G.I., D.I.C., A.M.I.E.E.

[R382·1

This article describes the results of exhaustive tests made both with commercial and experimental coils

THESE tests were carried out to determine the magnitude of the self-capacity of various inductance coils. The term "self-capacity" is applied to that capacity which, if placed across the terminals of an ideal coil, possessing inductance only and no capacity, would give rise to the same electrical effects as are found in the actual coil. Since this quantity forms one of the main sources of error in the calculation of radio circuits, a knowledge of average values to be expected in practice and a method of deriving them is important.

A condenser in parallel with an inductance coil produces a circuit which at one particular frequency offers a very high impedance to the flow of current through the combination, but the effect of raising the normal effective resistance of the coil is not entirely confined to that frequency to which the coil is tuned by the capacity. In the appendix the magnitude of the increase in resistance, due to self-capacity alone, has been mathematically determined, the approximate result being :—

$$R=R_0/(1-\omega^2 L_0 C_s)^2$$

where R_0 is the H.F. resistance of the coil, and R the apparent resistance of coil and self-capacity combined.

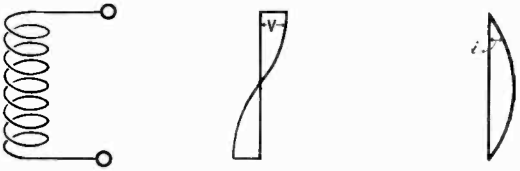


Fig. 2.

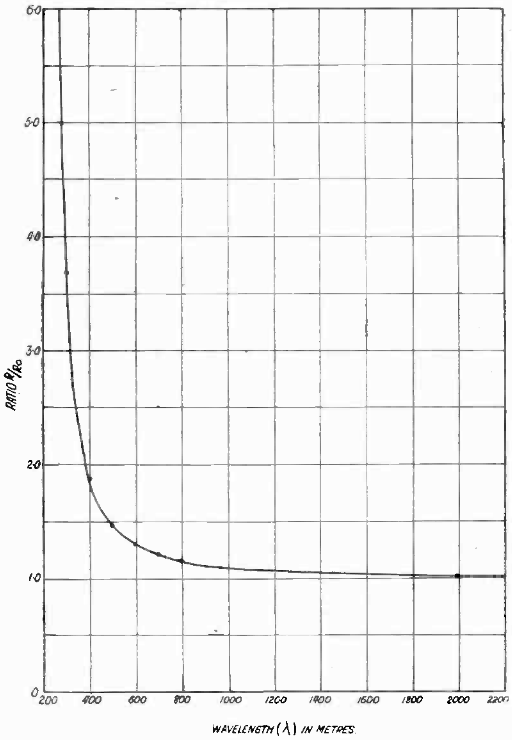


Fig. 1.

In terms of wave-lengths, which are perhaps more familiar, the expression can be easily modified to

$$R=R_0/(1-\lambda_s^2/\lambda^2)^2$$

A curve indicating the ratio R/R_0 against wave-length λ has been plotted for a coil the natural wave-length of which, due to self-inductance and self-capacity, is 200 metres, and is shown in Fig. 1, and even at 2 000 metres a 2 per cent. increase in high frequency resistance is experienced. From this standpoint along, then, the self-capacity of a coil is important.

Of course it should be borne in mind that this increased resistance only takes effect when the coil is untuned, and is in a circuit being supplied from some other source of E.M.F. When an E.M.F. is introduced into the coil itself by coupling, the effect of the self-capacity is to add to the other capacities in the circuit which comes across the coil. Again, if the coil is tuned by an external added capacity, the whole becomes a rejector circuit, and the increased resistance calculation must now take account of the complete capacity.

In a paper before the Physical Society (Vol. 25, 1912), Prof. Howe indicated that the main source of error in the calculation of the frequency of an inductance coil shunted by a condenser was the capacity between neighbouring portions of the coil. Even when the variable condenser is removed, the coil itself has a definite natural frequency, the ends acting as the plates of a condenser and the central portion as an inductance, the two functions, however, being distributed over the whole coil and gradually merging into one another. The potential and current distributions were given as Fig. 2 for the coil alone. Fig. 3 gives the modification introduced by an added capacity.

Further detailed information was given by Prof. Howe in the *I.E.E. Journal*, Vol. 60, page 67, where "The Effective Self-Capacity, Inductance, and Resistance of Coils" was discussed. It was shown that although it is necessary, for practical purposes, to represent the self-capacity by a condenser connected across the extremities of the coil, it would appear more reasonable from physical considerations to represent it by a condenser connected across two intermediate points along the coil; between the centres of gravity, as it were, of the positive and negative charges on the coil. Regarding the coil as an auto-transformer, however, this condenser across these imaginary tappings could be replaced by an equivalent condenser of smaller capacity across the extremities of the coil.

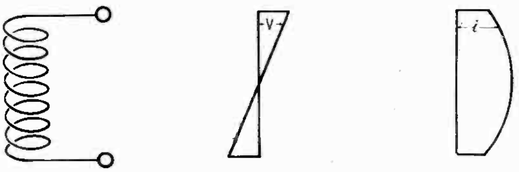


Fig. 3.

In order to test the magnitude of the self-capacity a series of experiments were conducted on the following lines :—

Let C_s = Self Capacity of Coil in μF.
Let L = Inductance of coil in μH.
Let C = Added variable capacity.

Then from the familiar wave-length equation we have

$$\lambda = 1\,885\sqrt{L(C+C_s)}$$
$$\therefore\ \lambda^2 = 1\,885^2 LC + 1\,885^2 LC_s$$
$$i.e.,\ \lambda^2 = k_1 C + k_2,$$

where k_1 and k_2 are constants.

Thus, if the true wave-length of a coil set oscillating in conjunction with a shunted variable condenser is determined, and a graph plotted with λ^2 as ordinates and capacity C as abscissa, a straight line AB will pass through the points as indicated in Fig. 4. When λ^2 is zero,

$$0 = 1\,885^2 LC + 1\,885^2 LC_s$$
$$i.e.,\ C = -C_s,$$

or the intercept AO gives the value of the coils' self-capacity C_s.

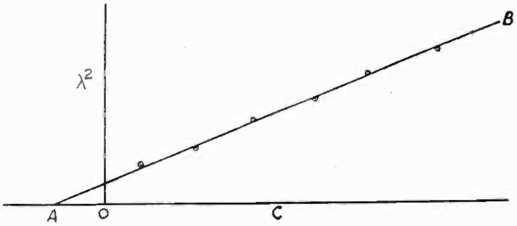


Fig. 4.

This method is strictly only an approximate one, since it depends for accuracy on obtaining the best straight line among the plotted points. For accurate purposes recourse has to be made to the method of "least squares" as pointed out in the excellent article by P. K. Turner in the March issue of **E.W. & W.E.**, but provided the necessary care and precaution is taken in determining the wave-lengths, and well calibrated apparatus is used, it will be found that the plotted points lie very well on a straight line.

The apparatus employed was a Sullivan Standard Heterodyne Wavemeter (150-20 000 metres range) as a source of high frequency oscillations, and the coil of which the self-capacity was to be determined was shunted by a variable air condenser of high grade. With the coupling coil of the wavemeter loosely coupled to this circuit resonance was indicated by varying the wave-length and observing maximum deflection in a unipivot micro-ammeter shunted with a crystal across the given coil, as shown in Fig. 5.*

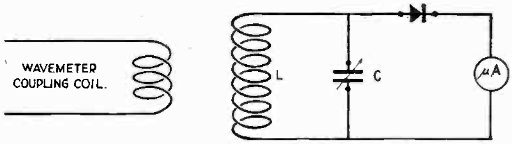


Fig. 5.

At resonance the above conditions hold, so a series of values of λ and C was tabulated,

---

* Strictly, a correction should be made for the self-capacity of this.

and a graph drawn between λ^2 and C. The ultimate results for a series of coils is shown in the table, due allowance being made for stray capacities.

Description of Coil.	Self Ind. in μH.	Self Cap. in $\mu\mu$F.
B Gambrell	223·5	6
75 Airmax	280·2	25
S5 Burndept	360·1	6
75 Igranic	323·5	35
H.D.B. slab coil (1½″ dia.)	981·0	7
H.D.B. slab coil (1½″ dia.)	295·1	22
25 turns of "Mars" wire on red fibre basket former	31·2	17
25 turns of 22's D.C.C. wire on red fibre basket former	33·5	20
Wax impregnated basket coils, 3 cm. inner dia. :—		
(1) 2.4 cm. winding depth	326·3	18
(2) 2.15 cm. winding depth	227·8	16
(3) 1.5 cm. winding depth	105·5	10
(4) 1.25 cm. winding depth	63·0	4
Single layer coils wound with 20's D.C.C. wire :—		
266 turns 20.0 cm. dia.	73 90·0	0
254 turns 18.8 cm. dia.	61 50·0	0
126 turns 15.2 cm. dia.	16 20·0	0
123 turns 13.8 cm. dia.	14 35·0	0
Multilayer coils wound with 24's S.C. wire :—		
2300 turns 3.3″ dia. × 1.2″	575 000·0	220
850 turns 1.3″ dia. × 0.9″	66 000·0	170
Multilayer coil wound with 36's S.C. wire :—		
3810 turns 6.8″ dia. × 1.2″	3 080 000·0	725

The selection embraces a number of popular loading coils used for broadcast reception, where efforts have been made to reduce the self-capacity to a minimum by recourse to patent winding methods, which will also permit the necessary conditions of compactness and rigidity. These include the familiar banking, sectionalising, interspacing, basket or pancake, honeycomb, duolateral, etc.

From an observation of the results it is clear that the coils with least self-capacity are large, single-layer ones, which, of course, would have been expected. To test the effect of multi-layers a wooden former with winding diameter 1½ inches and winding length 3 inches was wound with 20 gauge D.C.C. wire, so that successive measurements could be made for each layer of 58 turns up to eight layers. The results are appended.

No. of layers	1	2	3	4	5	6	7	8
Self capacity in $\mu\mu$F's	40	350	178	140	130	125	115	106

The addition of a second layer to the first increases the self-capacity considerably—a result always found in practice; but the other layers tend to counteract this effect somewhat. If the self-capacity is regarded as being entirely due to inter-turn condensers in series and parallel, the reason for this may be simply explained.

For a single layer the capacities between turns are added in series and hence the result is to reduce the resultant capacity. With two layers, however, since the winding is brought back on itself, the total capacity between the terminals T_1 and T_2 must at least exceed the capacity between first and last turn, see Fig. 6, which shows a few turns. Adding another layer, however, brings T_r across to the other side again and the series effect reduces the capacity once more. Fig. 7.

For the few turns illustrated it can easily be proved mathematically that :—

First Layer Capacity $= C/2$,
Second ,, ,, $= 15C/11$, and
Third ,, ,, $= 2C/3$,

where C is capacity between individual turns.

This can be continued, but, of course, in actual practice the problem becomes far more complicated, due to terminal capacities, capacity to earth, irregular winding, etc. However, the improvement resulting from an addition of further layers beyond the second is worth bearing in mind.

J. H. Morecroft, in his book on the *Principles of Radio Communication*, deals with the problem of the internal capacity of coils, and gives methods for calculating it. He indicates that a multilayer coil constructed with an air space between each layer may have a comparatively small self-capacity, and in a short analysis shows that this capacity decreases with increase of layers to the extent that, if C is capacity between two adjacent layers, the internal capacity of a coil with N layers is C/N.

Repeating the same experiment with a larger coil—winding diameter $4\frac{3}{4}$ inches and winding length 6 inches—the same considerable increase of self-capacity for two layers was noted. The prime object in this case, however, was to prove that wire of inferior insulation gives serious self-capacities; 20 gauge D.C.C. was employed, but the insulation was badly charred in places although the wire was never bare. The values for four successive layers are :—

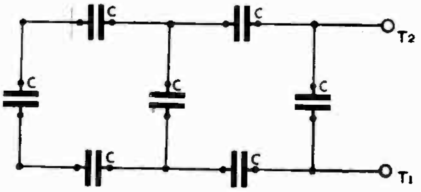


Fig. 6.

No. of layers	1	2	3	4
Self capacity in $\mu\mu$Fs. ..	40	710	625	784

The number of turns per layer was 112, and the benefit of added layers above the second was negatived after the third owing to the insulation being very poor. The large self-capacities would make coils of this nature (*i.e.*, solenoidal multi-layer, closely wound) practically useless for short wave work, and the importance of taking extreme care to produce coils of low self-capacity cannot be over-emphasised, in addition to employing wire of best quality insulation.

The above experiments were carried out in the High Frequency Laboratory, Bradford Technical College, and the author wishes to thank Mr. G. N. Oddy for assistance in obtaining a number of the results.

APPENDIX.

Treating the self-capacity as a condenser shunted across the whole inductance, as mentioned previously, we have from the formula for parallel circuits

$$\frac{1}{(R + j\omega L)} = \frac{j\omega C_s + 1}{(R_0 + j\omega L_0)}$$

where

C_s = Coil's self-capacity in farads ;
L_0 = Inductance of coil (in henries) with no self-capacity ;
R_0 = High frequency resistance of coil with no self-capacity ;
R = Effective resistance presented by coil ;
L = Effective inductance presented by coil.

$$\therefore\ R + j\omega L = \frac{(R_0 + j\omega L_0)}{(1 - \omega^2 L_0 C_s + j\omega C_s R_0)}$$

Rationalising the expression on the right and simplifying we now have

$$R + j\omega L = \frac{\{R_0 + j\omega(L_0 - C_s R_0^2 - \omega^2 L_0^2 C_s)\}}{\{(1 - \omega^2 L_0 C_s)^2 + \omega^2 C_s^2 R_0^2\}}$$

Equating real quantities

$$R = \frac{R_0}{\{(1 - \omega^2 L_0 C_s)^2 + \omega^2 C_s^2 R_0^2\}}$$

$$= \frac{R_0}{(1 - \omega^2 L_0 C_s)^2}$$

if the quantity $\omega^2 C_s^2 R_0^2$ is neglected in comparison with $(1 - \omega^2 L_0 C_s)^2$.

From the above it is seen that the effect of the self-capacity is to increase the resistance of the coil, the magnitude of the increase depending upon the frequency at which the coil is used.

Now equating imaginary quantities

$$L = \frac{(L_0 - \omega^2 L_0^2 C_s - C_s R_0^2)}{\{(1 - \omega^2 L_0 C_s)^2 + \omega^2 C_s^2 R_0^2\}}$$

$$= \frac{L_0(1 - \omega^2 L_0 C_s)}{(1 - \omega^2 L_0 C_s)^2}$$

If, in addition to neglecting the same expression as before in the denominator, the quantity $C_s R_0^2$ is omitted when compared to $\omega^2 L_0 C_s$, then

$$L = \frac{L_0}{(1 - \omega^2 L_0 C_s)}$$

Thus the inductance of the coil is also increased, but not to the same extent as the resistance ; and since the inductance of a coil at high frequencies is less than that measured at low frequencies, it is possible by careful design to balance this decrease against the afore-mentioned increase so that the coil's inductance will not seriously alter at different wave-lengths and affect design calculations.

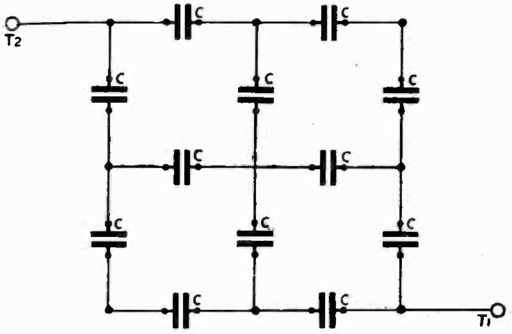


Fig. 7.

Long-Distance Work.

By Hugh N. Ryan (5BV). [R545·009·2

As was to be expected, work on the waves around 90 metres has now entirely ceased, except for a small amount of local work and work between stations in various European countries. Contact with America on this wave apparently lasted about as long this year as it did last year on 115 metres.

Work on 45 metres, however, is going extremely well. There is apparently little or no diminution in signal strength on this wave as the summer proceeds. Even though only a few stations are in regular operation, compared with those working in the winter months, steady and almost nightly contact with America is being maintained.

Australians and New Zealanders can be heard well on a good night, though what constitutes a good night is yet somewhat doubtful. They are, at any rate, quite frequent. In the early months of our original American work, on 115 metres, many amateurs became quite expert in predicting, early in the winter evenings, whether the coming night would be a good one. 2KF, I remember, was a very prolific (and occasionally accurate) prophet in this connection. Though conditions do vary in modern 45-metre work, it is not possible, I think, to foretell a good or a bad night. The only method is to try it and see. One stands a very good chance of picking a good one. In any case, goodness or badness only means the presence or absence of signals from the Antipodes. The Americans are always there.

Last month I said that, in my opinion, the ideal DX wave-length would turn out to be somewhere around 40 metres. Looking through some back numbers of E.W. & W.E. I find that I made a similar prophecy in December, 1923—putting the ideal wave at 150 metres—"as soon as sufficient amateur receivers could receive such short waves." It is interesting to note that on each occasion I received a number of letters agreeing with me, and a few disagreeing. In the first case those who disagreed said 150 metres was much too low for useful work. This time the critics say 40 metres is too high. I hope they are right, as there is much more room for all of us the lower we go ; but I hold to my prophecy.

Stations in the London district have been particularly active during the past month, considering the time of the year. 5LF, I think, has done the best all-round work. Every morning that he comes on he works Americans in large numbers, on his normal power, but the more interesting part of his work has been conducted on a low-power set. This set has a maximum power of two watts and uses a small vertical aerial (on 45 metres). Though he has not worked America with it (yet !), he has obtained some very fine results within Europe, the best report being from Danish 7EC, who reports the signals R7.

2DX has worked Brazil 1AB using only 66 watts (on 45 metres). He has also been heard in India when working on an indoor aerial, signals being reported R7. A report just received from Australia shows 2DX to have been heard in New South Wales, when working on low power to G6TD (Old North Wales !).

The most interesting reception report comes from 6HY, who heard New Zealand 1AR in April, transmitting a concert. He has just received confirmation of this, and sends me an interesting cutting from a New Zealand newspaper, dealing with this feat. 1AR was only using 35 watts input, and 6HY only using two valves.

I was mistaken last month in saying that 5TZ was the only British station who had yet worked Iceland BG1, as I hear that 6DO also worked him in May.

5CV, who was often heard two years ago working from Walton-on-Thames, is now soon starting again, this time in London. 2LZ has been extremely active recently, having worked Brazil 1AB, Argentine CB8, three New Zealanders and two Australians.

Mr. W. K. Islip (a member of the Cambridge Society's experimental section) recently heard Z2XA, who, I think, has not previously been reported in this country. Italian 1NO heard 2XA at the same time and called him, but without success.

Now that a number of British stations have been heard in South Africa, one is glad to note that a South African station has been heard in England. 2KK heard South African A4Z on 7th July. A4Z is now working on 48 metres, and it is to be hoped that other British stations will hear him, and soon communicate with him. The South African intermediate letter is "o."

6JV (Norwich) has spent the month comparing experimentally the results of fundamental and harmonic working of the aerial, on 45 metres, and finds that in his case harmonic working gives better results on the same power. The work of this station is noteworthy for the way in which the owner settles down to the investigation of a definite question, and keeps steadily to it. He thus collects a great deal of useful data, though perhaps does not put up any startling DX records. It is, I think, a pity that so many amateurs, undoubtedly competent men and possessing good apparatus, spend so much time in record-hunting, instead of performing more systematic experiments.

2CC has blown the valve on his 45-metre transmitter, and for the time being is working only on a low-power 23-metre set. With this he worked 26 Americans during June alone.

5KO, once of Bristol, who was so well-known to all of us in the old days, is at last coming back "on the air," this time at Newcastle. This is very good news. 2MG is not working at present, but 2TF is keeping the 23-metre wave alive in Scotland, while 2VX does the same for the 96-metre wave.

2VX has worked a number of European countries in daylight with nine watts, and, in the nearly-darkness which passes for night in summer in Aberdeen, has worked 8ALG (North Africa) and BSM (Palestine).

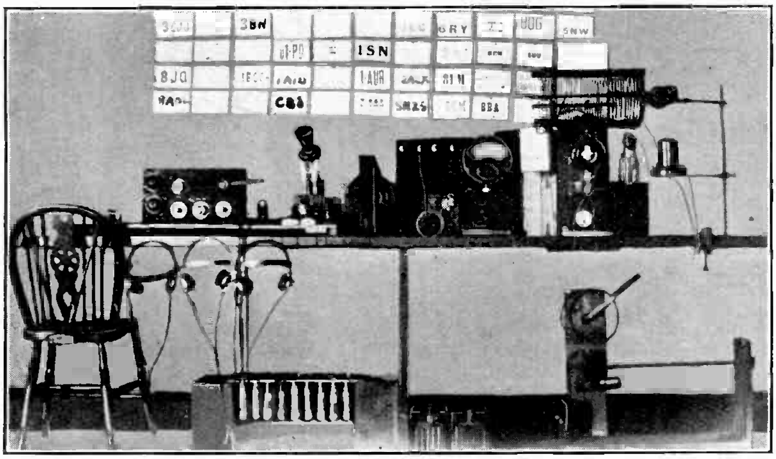
Mr. Neill, of Belfast, is now working again, and has at last a transmitting licence, his call being 5NJ. He now uses a superhet for all receiving work and has received 2NM and 2KF on 45-metre telephony in the early afternoon.

Last month I mentioned that 6YM's voyage had been somewhat disappointing from our end. I perhaps did not make it clear that this only applied from our end. The voyage was not made for the purpose of working a lot of stations, but for making observations, and in this it accomplished its object most successfully, though certainly more British stations would have liked to work the ship-station as a matter of interest.

One of the northern amateurs, 2JO, has gone to Borneo, and will be there by the time this appears. He has taken some of his station with him, and hopes to get in touch with us, probably on 45 metres. I do not yet know what call-sign he will use there.

By the way, when I mention a fairly new station in these columns, it often happens that other stations, having reports for them, and not knowing their addresses, send the cards to me, under cover, for forwarding. While I am glad enough to do this, I think one might expect the cards to be stamped—which they seldom are!

Next month's reports by 10th August, please.



A photograph of Amateur Station 6TM This is described in detail on page 701, et seq.

For the Esperantists.

A GLIMPSE AT ESPERANTO.

The Alphabet.

A B C Ĉ D E F G Ĝ H Ĥ I J Ĵ K L M N O P R S Ŝ T U Ŭ V Z.

No Q, W, X, or Y.

Pronunciation.

The Vowels :	**A**	**E**	**I**	**O**	**U**
	bah	there	pier	pore	poor

The **Consonants** sound as in English, except **C** like **ts** in **bits,** *e.g.*, **caro** like *tsaro* ; **acido** like ah-tsee'-doh. **Ĉ** like **ch** in **church. G** like **g** in **go. Ĝ** like **g** in **gem. J** like **y** in **yes,** *e.g.*, **jaro** like *yaro* ; **bojo** like *boyo*. **Ĵ** like **z** in **azure. S** like **s** in **so. Ŝ** like **sh** in **show. Ĥ** (guttural, very seldom used) like **ch** in **loch.**

AJ, OJ, as in **my boy. EJ,** as in **obey. UJ,** as in **hallelujah. Ŭ** is the Esperanto **W,** as in **well, how** ; **AŬ** as **ow** in **cow. EŬ,** as in **they—were.**

Accent always on the second last syllable. Phonetic spelling. **-O** is the ending of the **NOUN. ADJECTIVES** end in **-A.**

Nouns and adjectives form the **PLURAL** by adding **-J.**

The simple **VERB** endings :—

Infinitive.	Present.	Past.	Future.	Conditional.	Imperative.
I	**AS**	**IS**	**OS**	**US**	**U**

N marks the **ACCUSATIVE** (direct object). **ADVERBS** end in **E. NO IRREGULARITIES. NO EXCEPTIONS.**

Distordado. [R800

Serio de artikoloj verkitaj de teknika spertulo por montri la kaŭzon de la nebona tonkvalito de nuntempaj aparatoj, kaj kiumaniere oni povas ĝin eviti.

PARTO I.

LA ĈEFAJ PRINCIPOJ.

La unua celo estas korekti tre ĝeneralan kredon. Verŝajne estas la kutimo ekskuzi malbonan kvaliton, kulpigante la laŭtparolilon. La verkanto opinias, ke ĉe granda plimulto da okazoj, la kulpo estas tute ne de la laŭta parolilo. Jen, liaopinie, la ordo de la ĉefaj kaŭzoj de distordo :—

1. Netaŭgaj valvoj kaj malbona valvalĝustigo ;
2. Malbona intervalva kupleco ;
3. Malbona laŭtparolilo ;
4. Netaŭga aranĝo por detektado.

Konforme al tiu vidpunkto, ni unue pritraktu la valvon. Tiu ĉi artikolo faros simplan studon pri funkciigo de valvo por malaltfrekvenca amplifado, kaj finiĝos per resumo de praktikaj instrukcioj.

Ni unue akcentu, pri laŭtparolila funkciado, kiun ni nun konsideras, ke oni devas ne forgesi, ke ni nun pritraktas la amplifadon de potenco. Se ni sugestus, ke 2LO (Londona Stacio) anstataŭigu la 1-kilovatajn valvojn per "R" (malgrandaj ricevaj) valvoj por la ĉefa senda amplifikatoro, ĉiu kompreneble ridus. Oni prave dirus, ke ili ne povus produkti la bezonitan elmeton. Sed oni verŝajne ne ekkomprenas, ke ĝuste la sama rilatas al funkciigo de laŭta parolilo.

Kiam oni uzas telefonilon, la demando ne okazas, ĉar ĉia komerca valvo havas sufiĉan potencon. Sed laŭta parolilo bezonas kelkmiloble da potenco ol telefonilo, kaj ekzistas multe de ricevaj valvoj (inkluzive la "R"), kiuj *ne* kreas sufiĉe da elmeta potenco por la laŭtparolilo.

Oni devus kompreni, ke ĉiu valvo, je sia taksita filamenta varmeco, havas difinitan limon de elmeta potenco. Sed multe sub ĉi tiu limo ekzistas alia : la limo de elmeto sen distordo ; kaj estas ĝuste tio, kio gravas rilate al nia nuna celo.

LA GUSTA UZO DE VALVO.

Evidente, ĉi tiu konsiderado kondukos nin al rekomendo por la utiligo de altpotencaj valvoj kiam bezonataj, kaj ni devas rimarkigi pri alia ĝenerala eraro. Oni *ne* uzas altpotencan valvon por ricevi pli laŭtajn signalojn ol per ordinara valvo. Efektive, ĝi ofte amplifas malplimulte. Oni uzas ĝin por ricevi *laŭtajn signalojn sen distordo.*

La kialo por tio estas videbla post rigardo al Fig. 1, kiu montras la karakterizan kurvon de tre konata kaj tre bona riceva valvo. Oni rimarkas, ke la anoda kurento varias de 0 ĝis preskaŭ 5 miliamperoj laŭ la variado de la krada tensio ; la anoda tensio estas 160 voltoj—sed tio estas negrava nunmomente. Nu, kiel oni vidas, la " kurvo " estas "rekta," aŭ preskaŭ rekta inter 1 miliampero kaj 4, interrespondante al kradtensioj de —4 kaj —12. Do, se ni aldonos 8 voltojn al la krado, la malaltfrekvenca enmeta tensio povus havi amplitudon de 4 voltoj, dum ĝi ankoraŭ funkcias je la rekta parto de l'kurvo.

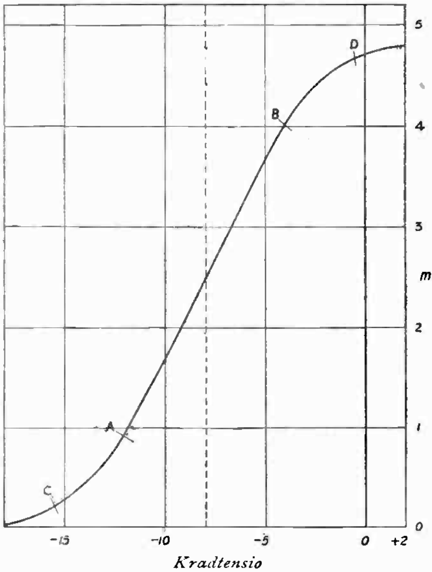


Fig. 1.

La unua regulo pri bona kvalito ĉe amplifikatoro estas, " neniam forlasu la rektan parton " ! Oni kutimas paroli pri la tuta voltŝanĝo kaŭzita de la alterna enmeto—la amplifita muziko de la valvo antaŭa—kiel la " svingiĝo." Je la nuna okazo, la valvo povus porti svingiĝon de 8 voltoj.

Sed tio ne estas sufiĉa.

Oni multe eksperimentis lastatempe pri mezuro de la svingiĝo ĉe efektivaj amplifikatoroj, kaj la rezulto estas ke, kiam ordinara laŭtparolilo bonforte funkcias en mezgranda ĉambro, la meza svingiĝo ĉe la krado de la lasta valvo estas ĉirkaŭ 15 voltoj. Koncerne la aluditan valvon, se ni fiksus la kradtension je 8 voltoj (la plej taŭga pozicio), la signalo variigus la kradtension de $-\frac{1}{2}$ ĝis $-15\frac{1}{2}$, aŭ de C ĝis D sur la kurvo.

Tio signifas, ke ĉiu muzika tono ricevus aldonitan tonon proksimume unu oktavo-kaj-duono pli altan, kaj emisius la bone konatan " gramofoneman " tonon. Tute ne helpus al ni " ludado " je kradaj kaj anodaj voltoj, ĉar la kurvo ne permesus svingiĝon de 15 voltoj. La sola efiko de plia alta tensio estus kvazaŭ la kurvo moviĝis maldekstren ; ĝi ne plilongigus la rektan parton.

LA UNUA PUNKTO.

Estas nur unu metodo tion fari—plivarmigi la filamenton. Sed la valvo pri kio ni traktas estas taksita je " 3.6 ĝis 4 voltoj," kaj la kurvo estis farita je 4.2, do ni jam iomete troŝarĝas ĝin, kaj la vivo de la valvo estus serioze mallongigita se ni plue ŝarĝus ĝin.

La vera kuraco estus uzi valvon desegnitan por produkti la bezonitan potencon. Kiel tio efektivigas nian celon estas videbla per Fig. 2, kiu montras tri kurvojn por malsamaj filamentaj varmecoj de bone konata altpotenca valvo de la tipo 435 (4 voltoj, 0.35 amperoj). Ĉiuokaze la kurvo reprezentas valoron de altatensiaj voltoj, kiu portas la supran finon de la kurvo. Ni vidas ke, kun 3.2 voltoj ĉe l'filamento, la "svingiĝo" povus atingi 10 voltojn (A ĝis B) ; je 3.6 voltoj, la svingiĝo estas 22 (C ĝis D) ; kaj je 4 voltoj, 36-volta svingiĝo estas permesebla—sufiĉa por malgranda halo.

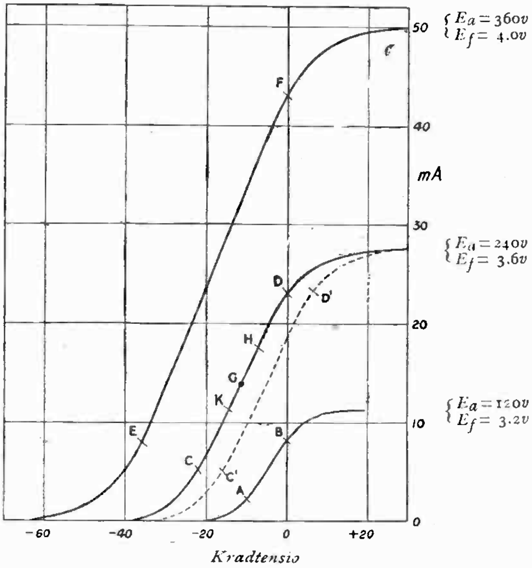


Fig. 2.

Jen, do, nia unua punkto : *Por la lasta valvo uzu specon, kiu permesas 15-voltan svingĝon sen troŝarĝo.*

Jen kelkaj britaj valvoj gradigitaj laŭpotence :—

L.S.5. Tiu ĉi estas altoptenca valvo Marconi'a, iom altpreza. Bonega por eksterdoma aŭ koncerta funkcio. Efektive pli potence ol necese por ĉambro. 4v, .8a.

P.V.5.D.E. Jen Ediswan'a valvo de tipo 625 (6v, .25a), aparte citita pro tio, ke ĝi verŝajne havas pligrandan elmeton ol multaj samtipaj.

Tipo 625. Preskaŭ ĉiu granda firmo fabrikas tiun specon. Bonege taŭgas por endoma funkcio.

Tipo 435. (4v, .35a). Simila valvo kiel la tipo 625, sed ĝi portos pli altan filamentan kurenton je plimalalta tensio ; ĉu uzi ĉitian aŭ la 625-specan dependas nur, ĉu oni preferas 4- aŭ 6-voltan baterion.

Tipoj 606 kaj 312. (6v, .06a kaj 3v, .12a.) De potenco malplialta, sed sufiĉa por endoma funkcio, kvankam oni devas uzi ilin ĝis preskaŭ maksimuma taksita tensio. La unua portas treege malaltan filamentan kurenton, dum la dua estas oportuna, ĉar ĝi utiligas la saman filamentan baterion kiel la " .06 "—aj valvoj.

Tipo 240. (2v, .40a.) Tre simila al la tipo 235 (2v, .35a), de valvo por ĝenerala uzado ("duone malhela"). Efektive nesufiĉe forta por granda ĉambro, sed bonega por malgranda ĉambro.

Ĉiun supre aluditan valvon (escepte la unuaj du) fabrikas, sub diversaj nomoj, bonekonataj valvfirmoj.

Tiom pri elekto de la lasta valvo.

LA ANTAŬAJ ŜTUPOJ.

Koncerne valvojn por la antaŭaj ŝtupoj de amplifado, ni povas facile kalkuli la svingiĝon traktotan de ili. Se, ekzemple, ni uzas transformatoran kuplon por la lasta ŝtupo, kaj la transformatora proporcio estas 1—4, kaj ni intencas uzi por la antaŭa ŝtupo valvon kun pligrandiga povo de 8, tial la " pligrandiĝo " de krado al krado trans la ŝtupo estas 8 (por la valvo) × 4 (por la transformatoro), aŭ 32 ; kaj ĉar la lasta valvo havas 15, tiu antaŭ ĝi havos svingiĝon duonvoltan ĉe sia krado.

Ekrigardo al kelkaj karakterizaj kurvoj montras, ke ia ordinara valvo kapablas sufiĉan elmeton ; do ni trovas ke, por " hejma " funkcio, sole ĉe la lasta ŝtupo estas bezonata altpotenca valvo. Eĉ se ŝoka aŭ rezistanca kuplo estas uzata, la svingiĝo ĉe l'valvo antaŭa ne superos 4 ĝis 6 voltojn, ankoraŭ portebla de ia ordinara valvo.

Kontraŭe, por celoj pligravaj ol hejma funkciado, estas necesaj valvoj de multe pli alta potenco ol tio, kion oni ĝenerale kredas. Ekzemple, dum la demonstracioj ĉe la du britaj ekspozicioj pasintan aŭtunon, la lasta ŝtupo havis 8 valvojn (Tipo L.S.5A), paralele aranĝitaj (la L.S.5A estas simila al la L.S.5, sed speciale por la malalta pligrandigapovo de 2) kun 300-volta kradtensio, 700-volta altatensio, kaj konstanta anoda kurento de preskaŭ triono da ampero. Tamen ĉi tiu aspekto estas afero de specialistoj, kaj ni ne intencas trakti ĝin.

Good Work on Standardisation

IT will be remembered that some months ago, at the joint request of the Ebonite Manufacturers' Association and of the Radio Society of Great Britain, a committee was set up by the British Engineering Standards Association to determine a British Standard for Ebonite for wireless purposes. The work of this Committee is well in hand, but a further move in the matter of standardisation of wireless parts has now been made.

A few weeks ago the R.S.G.B. sent a request to the British Engineering Standards Association to call a meeting of all concerned to consider the advisability of forming a Committee for the standardisation of wireless apparatus and components. On the 25th May there was held at the B.E.S.A. a conference at which were represented the R.S.G.B., the National Association of Radio Manufacturers and Traders (N.A.R.M.A.T.), other manufacturers, the Valve Manufacturers' Association, the Institution of Electrical Engineers (Wireless Section), the B.B.C., the Wireless Retailers' Association, the Wireless Board, the G.P.O., and the Technical Press.

This Conference passed unanimously a resolution to the effect that the setting up of such a Committee is highly desirable.

Among the matters to be considered the following were mentioned :

1. Physical dimensions ;
2. Maximum error from rated electrical values ;
3. Suitability of the electrical and mechanical qualities of the materials to be used ;
4. Uniformity of nomenclature, particularly as regards valves and inductance coils.

The purchasing amateur is warned not to expect to see definite standards within a few weeks, or even months, but the first step has been made.

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.

A New Organisation.

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

SIR,—If one reviews the wireless societies which exist at the moment, and at the same time peruses the Wireless and Technical Press, one is forced to the conclusion that a really technical society is wanted in Britain—a society which would correspond to the Institute of Radio Engineers of America.

This subject has been talked over between a number of professional men and advanced amateurs, and it has been decided to go ahead with the forming and registering of such a body. A sufficient number of keen wireless men have agreed to find the necessary capital for registering, and to see the matter through; but to ensure lasting success there must be a large membership so that offices can be secured and good proceedings issued at not infrequent intervals.

It is intended that the Society shall be called the British Institute of Radio Engineers. The rules and regulations would, as far as possible, be taken from the constitution of the Institution of Electrical Engineers, or a similar body.

The classes of membership proposed are: Fellows, Members, Associate Members, Graduates and Students. Entrance would be by examination after proposal and seconding by not less than four corporate Members or Associate Members.

The body would be a non-political one and would deal only with the technical side of wireless. It would not attempt to deal with the non-technical side of broadcasting. An effort would be made to issue proceedings of value at monthly intervals.

It should be clearly understood that a professional standing would be adopted in all matters, and that the headquarters would eventually be situated in London.

The Society is actually in the process of being registered, so will all those interested or willing to co-operate please send in their names either to Mr. Y. W. P. Evans, M.I.R.E., 66, Oxford Road, Manchester, or to the writer, at an early date, and at the same time indicate the class of membership for which they would apply.

JAMES NELSON, M.I.E.E.

7, High Street,
Prescot.

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

SIR,—I understand that Mr. James Nelson has sent you a letter outlining the proposed Institute for Radio Engineers, and I shall be glad if you will publish in your next issue this short report of the result of the discussion which has taken place within the last fortnight regarding this matter in the *Electrician* and *Electrical Review*.

We have had over 60 applications for membership, several of which are made by persons holding positions exclusively wireless, and who are not really in a position to enter the Institute of Electrical Engineers, owing to the fact that the rules of this Institute place electrical knowledge far above wireless knowledge, and we have received letters from members of this Institute stating that the Wireless Section is very well catered for in London, but that very little has been done in this respect in the provinces.

We have also received letters which are definitely against the formation of another Institution and stating that the radio engineer is fully provided for by the Wireless Section of the I.E.E. The curious part about these communications is that they are from electrical engineers, and it seems that there will be some difficulty in endeavouring to impress upon the Electrical Engineering Branch that radio engineering is an entirely separate profession, in which electrical science forms only a part of the knowledge required by a fully qualified radio engineer.

It is earnestly hoped that your readers will send their views on this subject in order that we may gauge the feeling of the radio engineer in regard to a separate Institute in this country.

Yours faithfully,
Y. W. P. EVANS,
Hon. Secretary Temp.,
Proposed British I.R.E.

66, Oxford Road,
Manchester.

Short Wave Oscillations Generated by Incandescent Lamps.

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

SIR,—In experimenting at night time with the 5-metre receiver described in the issue of this journal for December, 1924, I have been troubled with a peculiar form of 50 cycle interference due in some way to the house lighting supply which is A.C. of this periodicity. The peculiar thing, which I noticed from the first, was that this 50 cycle hum tuned in to fairly well-defined maxima at certain settings of the 5-metre tuner and was particularly loud when the set was just oscillating. The sound was rather like that produced by a valve transmitter using raw A.C. supply on the plate except that its tuning spread over a rather broader band. For some time I was under the impression that the effect was only observable when the receiver was actually oscillating and that it was due to some obscure form of modulation by the house wiring carrying A.C. A few days ago, however, I went into the matter more carefully and found it possible to tune in the hum on a completely non-oscillating receiver. Moreover, on switching off the incandescent lamp in my room the interference ceased. The next step was to light the lamp and couple it closely to the receiver; on doing this the interference could be tuned in as a loud roar without the use of reaction. This demonstrated almost conclusively that the lamp was generating oscillations. These oscillations can be stopped completely by holding a small steel magnet near the lamp. A piece of brass or other non-magnetic metal similarly held has no effect. The oscillations are therefore very susceptible to feeble magnetic fields. The type of lamp in which I noticed these oscillations was the ordinary metal filament, hard vacuum lamp taking 60 watts at 105 volts. Gas-filled lamps produce no oscillations. Two similar ordinary lamps produced oscillations of about the same frequency although there was a slight difference. The insertion of chokes in the leads to the lamp or the shunting of the lamp by a large condenser seems to have little effect on the oscillations produced. The effect seems, therefore, to be localised within the lamp itself. The oscillations are stopped if the hand is placed round the lamp. Sometimes a lamp requires an impulse to start it oscillating. If the voltage applied to the lamp is increased the frequency of the oscillations is also considerably increased. This, of course, brightens the lamp a good deal and the intensity of the oscillations is increased. Since the frequency is a function of the voltage it will vary over the A.C. cycle with a consequent broadening of the waveband, which explains the absence of any heterodyne note. The next obvious thing to do was to try a lamp working on D.C. mains. Some brief tests with a D.C. lamp showed that it was also capable of producing oscillations, but this line of investigation has not been properly followed up yet.

How these oscillations are produced in the lamp is not at all clear. I have taken care to make sure that they are not due to sparking at any loose contact in the lamp-holder. Their intensity is quite feeble but is sufficient to cause serious interference with a 5-metre valve receiver in the same house. The hum due to the oscillations can be received on a crystal detector and phones without amplification if the lamp is brought within a few inches of the tuner. The production of ultra-short wave-length oscillations under peculiar conditions in thermionic valves has been noticed by Barkhausen and Kurz in Germany and by Gill in this country and perhaps the lamp effect is an allied phenomenon. If the 105-volt lamp with its 18 inches or so of filament gives out waves of the order of 5 metres, is it not possible that a smaller lamp, say the 12-volt size, might form a source of much shorter waves?

E. H. ROBINSON (2VW).

London, N.W.3.

Experimental Work in Russia.

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

SIR,—In the May, 1925, issue of your valuable journal on page 511 is published a short article on wireless in Russia, and the work of the wireless laboratory at Nijni-Novgorod.

It is very regrettable to find that so many difficulties are placed in the way of obtaining a knowledge of the state of affairs in this country.

All our work (from 1918) has been recorded in our wireless journal (*TiTbp*), which is published by the laboratory, and is sent to many foreign wireless engineers and editors. Unfortunately, this journal is, of course, printed in the Russian language.

One of the most famous discoveries made in our laboratory is that of the oscillating crystal, by M. Lossew (Jun.), which has been fully described in many wireless journals in Europe during 1924 and 1925. This rectifying-oscillating circuit is very useful to amateurs as a source of amplification without the use of valves.

M. A. Bontsch-Brujewitsch is now Director of the laboratory, and not myself. His 100kW valve is in course of construction, while the 25kW one has been in use since 1923. With the aid of this, Mr. W. W. Tatarinov, also of our laboratory, has developed his scheme for short wave (85-100 metres) transmission with a power of 10kW. With this transmitter a description of the celebrated work of S. A. Popoff was broadcast to the world on 6/7th and 7/8th May, 1925. The message was received by the Geltov Transradio station very loudly and steadily. The transmission was also heard in India (near Calcutta), Chili, Java, Porto Rico, Brazil, Argentina, Africa, and the Belgian Congo.

I also wish to state that the "oil and filings" method of producing very short waves (0.082 mm. to 40 mm.) due to Mme. Glagolewa-Arkadjewa, described in E.W. & W.E., March, 1925, page 343, was first published in our journal *TiTbp* in March, 1924.

Prof. W. K. LEBEDINSKY.

Nichnij-Novgorod.

Stability in H.F. Amplifiers.

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

SIR,—I am particularly interested in the series of articles on "The Perfect Set," as my hobby, since broadcasting started, has been the attempted elimination of distortion in telephony reception. For some years I have been using a variable stabilising resistance in the oscillatory circuit, and for convenience and effectiveness I know of nothing better. Personally I prefer to connect the resistance in series with the inductance in the oscillatory circuit. If the amplifier is carefully designed it does not need a high resistance here to obtain stability. Even considering the 400 ohms mentioned, the D.C. voltage at the anode would only be reduced by about half a volt. When working on the broadcast wave-lengths and using the condenser near the bottom of the scale a considerably larger damping resistance has to be connected in series with the condenser. The explanation is, I think, that the capacity of the wiring then forms a not inconsiderable part of that in the oscillatory circuit.

When speaking of "potentiometers of the usual 400 ohm type," I believe you mean those wound on a thin flat former. To many of us the "usual type" is the straight cylindrical form, which is, of course, unsuitable for the purpose.

An easy way of obtaining stability without any special device is by the use of a smaller inductance and more capacity, thus increasing the oscillatory current and so the losses. However, this is an arrangement which I do not like.

H. H. Dyer.

22, Leopold Street,
Derby.

DX Records.

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

Sir,—With reference to a letter from Mr. J H. Ridley (5NN), published in your issue for July, in which the writer claims to be first station to communicate over long distances on wave-lengths of the order of 18-23 metres in any part of the world, I am giving a few details of experiments carried out by stations in Great Britain, Australia and America long before the date given by Mr. Ridley.

February and March, 1925.—Signals received at various times from American Stations 1XAM, 1CMP, 1CCX, IXU, 3APV and 6TS in England on 20 metres.

8th March, 1925.—Successful two-way communication between G5LF and UNKF, Washington, D.C., U.S.A., on 18.3 metres. These experiments were continued for one month with great success each day at 5 p.m. G.M.T.

28th March, 1925.—Successful two-way working between G2KF and U1CMP on 21 metres at 5 p.m. G.M.T.

14th April, 1925.—Successful two-way communication between G2KF and U1CMX on 23 metres at 5.30 p.m. G.M.T.

15th to 18th April, 1925.—Signals from A2CM, Sydney, Australia, copied solid for two hours each morning by G2KF, wave-length 21.5 metres.

19th April, 1925.—Signals from G2KF on 23 metres, logged by A2CM through heavy static.

Whilst *not* wishing to have the fullest possible publicity given to these achievements, nor claiming to be the first experimenter to communicate over long distances on short waves, I shall be glad if you can find an odd space in your correspondence page to publish this letter, which I am sure will be of interest to amateur transmitters and other experimenters.

In conclusion, I would mention that American amateur stations on the Atlantic and Pacific coasts had exchanged signals on 20 metres some time before the dates given above, when they were logged in this country.

J. A. Partridge (G2KF).

22, Park Road,
Colliers Wood, S.W.19.

Amateur Transmission in Northern Ireland.

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

Sir,—It is with very great pleasure that I write to inform you that the Government of Northern Ireland has now permitted me to carry out experiments in wireless transmission, and a licence has accordingly been issued to me by the Post Office.

It is proposed to commence transmission experiments from my station about the middle of August, on wave-lengths of 23 and 45 metres, and the help of British experimenters in these tests would be much welcomed. The station's call sign is 5NJ, and the address is "Chesterfield," Whitehead, Co. Antrim, Ireland.

As this station has been appointed Official Observation Station to the T. & R. Section of the R.S.G.B., I should like to state that, as far as possible, I am at all times very pleased to listen for and report to members of this section on wave-lengths of from 18 metres upwards.

I also wish to tender my best thanks to my many friends in England for the valuable help they have given me at various times, and particularly to Mr. E. J. Simmonds (2OD), Mr. G. Marcuse (2NM) and Mr. A. J. Cooper (5TR).

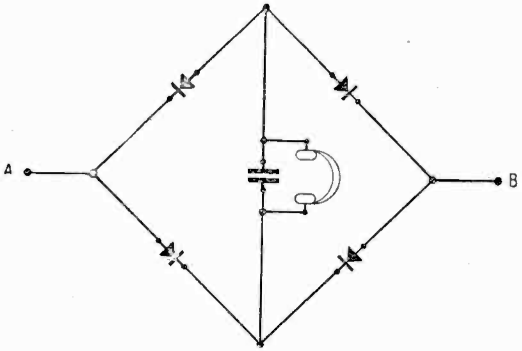
F. R. Neill.

"Chesterfield,"
Whitehead, Co. Antrim, Ireland.

Full Wave Rectification.

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

Sir,—With reference to the discussion following the R.S.G.B. lecture on Rectification in which full wave rectification was suggested, the following experimental results may be of interest.



A comparison was made, somewhat roughly, of the signal strength of 5XX at a distance of about 130 miles, first with the ordinary crystal rectifier, and then with the arrangement of four similar detectors shown in the diagram, the input being across A B. The adjustment of the detectors was tested both before and after the combination was used, by means of a suitable switching arrangement, as a check on the results.

Two types of detector were tried, one of high, and one of low, resistance. The former was silicon-copper, and the latter Hertzite-copper.

As far as could be judged, the combination gave results almost identical with those of the single detector. There was certainly no improvement.

W. R. Harper.

St. John's College,
Cambridge.

Station News.

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

SIR,—I beg to inform you that the call sign 5QT has been allotted to me. I expect to commence transmission shortly on wave-lengths of 23 and 45 metres. Detailed reports will be greatly appreciated and all QSL cards will be acknowledged.

A. DAVIDSON.

21, Queen Street,
Worksop, Notts.

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

SIR.—Please note the following amendment *re* my transmitting station, 5DV; 10 watts C.W. and telephony. I now sign myself,

D. WHITTAKER, B.Sc. (Hons.).

56, Park Road,
St. Annes-on-Sea.

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

SIR,—The call sign 6SU has been allotted to me, and all reports on my transmissions are welcomed.

ERIC A. PARSONS.

111, Chester Terrace,
Brighton.

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

SIR,—I should be pleased if you would publish the fact that my call sign 2ABR has been changed to 6VP. Reports of C.W. transmissions on 90 metres will be appreciated and acknowledged.

ALAN SMITH.

48, High Street,
Yiewsley, Middx.

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

SIR,—The call sign 2OK has been allotted to the C.A.V. firm, Acton, and 2VL to C. A. Vandervell, 87, Holland Park, W.11.

We shall be glad if you will insert these in your next issue.

(For C. A. Vandervell & Co., Ltd.),
C. A. VANDERVELL.

London, W.3.

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

SIR,—Will you please insert a short notice in your next issue to the effect that the QRA of G2NJ is as given below.

Power 10 watts, C.W. and I.C.W.

N. JOHNSON-FERGUSON.

Luckington Court,
Chippenham, Wilts.

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

SIR,—I should be favoured if you would make it known through your correspondence columns that in place of my old call-sign, 2AMG, the call-signal 2VR has been allocated to my station.

Transmissions are conducted, generally during week-ends, on wave-lengths of 115-130 metres.

Reports are welcomed and all QSLs answered.

F. W. WILSON.

115, Richmond Road,
Montpelier, Bristol.

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

SIR,—I should be very grateful if you would publish the following facts: I am now transmitting from two addresses, and would welcome any reports. The wave-lengths in use are 45 metres and 90 metres. Call sign—6BD. Addresses: "Tullagee," Wellington Road, Eastbourne (permanent address); and Wellington College, Berks.

F. M. G. HUTTON.

The Orange,
Wellington College.

Misuse of Call Sign.

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

SIR,—I have received at various times three reports of telephony transmissions from a station calling 5JX, on broadcast wave-lengths, and in each case from Yorkshire.

As my station (5JX) only works on short wave morse now, any such transmissions as the above are unauthorised, and it is hoped that the offender will cease to use this call.

MARCUS G. SCROGGIE.

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

Addresses Wanted.

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

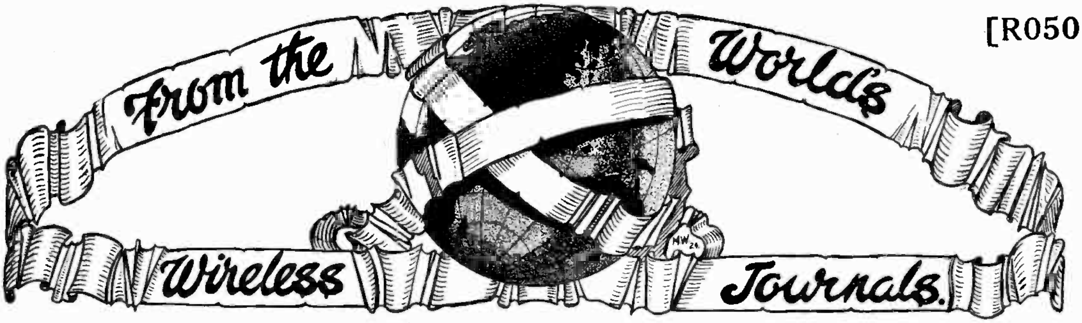
SIR,—As the present addresses of the following members of this Society are unknown, I shall be grateful if you will be good enough to make an announcement in your columns asking them, or anyone who knows their present whereabouts, to communicate with me. I have certain literature and copies of the Society's Journal which I wish to forward to them. I give their last known address in each case:—

F. G. Aylott, Esq., 8, Sumatra Road, Kilburn, N.W.6; L. Birch, Esq., 30, Limesford Road, Waverley Park, S.E.; F. H. Dupre, Esq., 2, Edinburgh Mansions, Howick Place, S.W.; P. V. Dupre, Esq., 101, Dartmouth Road, Brondesbury, N.W.2; J. G. Evans, Esq., "Highbury," Harrop Road, Hale, Cheshire; H. A. S. Gothard, Esq., 8, Longford Terrace, Folkestone; E. Hare, Esq., "Penelve," Leiston, Suffolk; Captain Sir J. K. Mackensie, Bart., F.R.C.S., 19, Upper Richmond Road, S.W.15; G. Mahon, Esq., 11, Haymarket, S.W.1; F. Marshall, Esq., Junr., 2, Park Lane W.1; J. C. Mason, Esq., 16, Cressingham Road, New Brighton, Cheshire; Captain Simon Orde, 16, Pelham Crescent, S.W.7; J. B. Purefoy, Esq., c/o Royal Automobile Club, S.W.1; Rev. Phillip S. Sidney, 4, River Terrace, Sunbury-on-Thames; W. M. Smith, Esq., 3, South Tay Street, Dundee; H. J. Talbot, Esq., 1 South Hill Mansions, South Hill Park, N.W.3.

H. A. ROCK
(for Hon. Secretary),
Radio Society of Great Britain.

53, Victoria Street,
London, S.W.1.

[R050



R100.—GENERAL PRINCIPLES AND THEORY.

R112.—RE-RADIATION FROM TUNED ANTENNA SYSTEMS.—Henry C. Forbes. (*Proc. I.R.E.*, June, 1925.)

The paper considers Dellinger's treatment of the radiation from aerial systems, and applies correction factors thereto for the field-strength near to the aerial. The term " equivalent height " is suggested and is differentiated from effective height. The expressions are then applied to the case of a tuned receiving aerial to determine the distortion produced in the field of a distant transmitter by re-radiation from the receiving aerial. The calculated results are then compared with the field distortion found by the Bureau of Standards near the Washington Monument, and also with measurements made near a typical aerial. The distorted field is found to have practical application as a means of eliminating interference in short distance transmission without a local source of power and in providing a means of measuring the equivalent height of an aerial system.

R113.1.—FADING MEASUREMENTS.—E. A. Anson. (*Exp. W.*, July, 1925).

Results are given of some quantitative observations on instant broadcasting stations. Observations are also made upon distortion effects.

R113.1.—SOME RECENT OBSERVATIONS ON PERIODIC FADING AND THE NIGHT EFFECT.—Paul D. Tyers (*Exp. W.*, July, 1925).

Results are given of some quantitative observations on distant broadcasting stations. Observations are also made upon distortion effects.

R140.—COMPUTATION CHARTS.—R. S. MacArthur, *Q.S.T.*, June, 1925).

A short explanation of the use of graphical methods of facilitating the calculations commonly involved in radio circuits.

R141.—AERIAL TUNER DESIGN.—W. B. Medlam, B.Sc., and U. A. Oschwald, B.A. (*Exp. W.*, July, 1925).

Concluding part of a paper dealing analytically and practically with relation between the electrical constants of an aerial, the input impedance of the receiver to be operated and the design of the aerial tuning arrangements.

R144.—IRON LOSSES AT HIGH FREQUENCIES.—Prof. G. W. O. Howe (*Electn.*, 12th June, 1925).

An expression is developed for the energy loss per unit volume in a lamination of given thickness, permeability and resistivity. The formula shows that the eddy current loss is directly proportional to t and inversely proportional to $\sqrt{\mu\rho}$, where t is the thickness of the lamination, μ the permeability and ρ the resistivity.

R149.—THE RECTIFICATION OF SMALL RADIO FREQUENCY POTENTIAL DIFFERENCES.—F. M. Colebrook, B.Sc. (*Exp. W.*, July, 1925).

A paper read recently before the Radio Society of Great Britain. The work summarised has special reference to crystal detectors.

R300.—APPARATUS AND EQUIPMENT.

R329.—A SPECIAL SHORT-WAVE ANTENNA.—G. W. Pickard (*Q.S.T.*, June, 1925).

An ingenious aerial system devised by H. Beggerow is described. A pair of Lecher parallel wires act as a closed feeder from the oscillator; at the far end one of the wires projects half a wavelength beyond the end of the other and therefore acts as an isolated half-wave radiator.

R342.5.—POWER AMPLIFIERS IN TRANSATLANTIC RADIO TELEPHONY.—A. A. Oswald and J. C. Schelleng (*Proc. I.R.E.*, June, 1925).

A paper describing the development of a 150-kilowatt (output) radio frequency amplifier installation built for transatlantic telephone tests. The single side-band system of telephony is described with particular reference to its bearing on the design of the apparatus used.

R343·4.—ETUDE OSCILLOGRAPHIQUE DE LA SUPER-REACTION.—M. M. David, Dufour and Mesny. (*Onde Elec.*, May, 1925).

A study of the Armstrong super-regenerative receiver. The writers have worked with this type of receiver on wave-lengths from 450 metres, down to 2 metres. They find no support for the conclusion arrived at by other investigators that the amplification increases as the square of the frequency of the received signal. If the supposition were correct, the amplification on 2 metres would be something incredible. As it is, the writers find that below about 50 metres the amplification is more or less constant. Super-regeneration ceases to be effective on wave-lengths somewhat higher than 450 metres owing to insufficient difference between the quenching frequency and the frequency of the incoming signal. Around this transition point one would naturally expect a rapid variation of amplification with wave-length, but, as stated, this variation falls off below a certain wave-length. Some most interesting oscillograms are reproduced which show how the oscillations start and stop when a signal is present and when no signal is arriving. The spasmodic bursts into oscillation in the latter case are very well shown, these being due to parasitic effects and giving rise to the " mush " so familiar in receivers of this type. For their experiments the writers have favoured the type of super-regenerative receiver in which the quenching oscillations of about 10 000 per sec. modulate the anode supply to the regenerative detector. As a source of signals for the experiments a transmitter capable of being modulated by a microphone was placed in another room. One set of oscillograms was obtained on a rotating drum by means of a cathode-ray oscillograph, the horizontal base-line being provided by an auxiliary controlling frequency of about 500 cycles, while the ordinates are controlled by the H.F. grid potential acting on the cathode beam to produce vertical displacements. This set of oscillograms only shows the envelopes of the H.F. oscillations, the individual oscillations being too close to be registered separately. In order to obtain traces of the individual H.F. oscillations another set of oscillograms was taken in which the horizontal auxiliary frequency was 273 000 per second. It is found that different adjustments may be necessary for receiving C.W. and telephony. Some adjustments give a response almost independent of the amplitude of the incoming signal ; such adjustments would be very good for C.W. reception but would be useless for receiving a modulated transmission. The conditions for receiving the latter are discussed in the paper. It would appear that the amplification obtainable is only limited by the parasitic noises.

R376.3.—THE MOTIONAL IMPEDANCES OF AN ELECTRO-DYNAMIC LOUD SPEAKER.—A. E. Kenelly (*Q.S.T.*, June, 1925).

An abstract of a paper by Prof. K. Kurokawa of Waseda University dealing with the type of loud speaker in which a moving coil carrying the signal currents is suspended in a strong radial magnetic field. By a bridge method the impedance of the moving coil was measured at various audio frequencies and under various conditions of acoustical loading. Some resulting motional resistance-reactance diagrams are given.

R382.1.—THE HIGH-FREQUENCY COPPER LOSSES IN INDUCTANCE COILS.—S. Butterworth, M.Sc. (*Exp. W.*, July, 1925).

An article dealing with losses due to skin effect and eddy-currents.

R382.—WHAT SIZE OF WIRE ?—F. J. Marco (*Q.S.T.*, June, 1925).

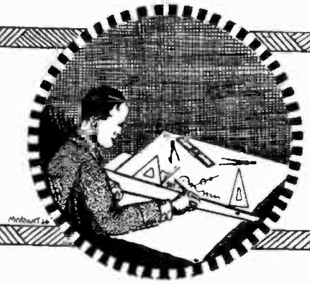
A number of coils all having the same inductance (suitable for the broadcasting band) were constructed in different dimensions and of different gauges of wire with a view to finding which would have the lowest average resistance over the broadcasting band of wave-lengths. For longer wave-lengths gauges 20 to 24 (American) has a slight advantage over thinner gauges but this advantage is relatively smaller on lower wave-lengths. The space occupied by a coil is an important practical consideration in the design of commercial receivers. For a given volume occupied by the coil, spaced winding of finer wire gives better results than close winding with thick wire. Generally speaking, there is not much to be gained by using wire thicker than 26 or 28 gauge. A heavy coating of dope consisting of collodion dissolved in amyl acetate is stated to have absolutely no measurable effect on either the resistance or distributed capacity of even the best inductances. Double silk covered wire was used in making up all the coils measured.

R400.—SYSTEMS OF WORKING.

R412.—PRODUCTION OF SINGLE SIDEBAND FOR TRANSATLANTIC RADIO TELEPHONY.—R. A. Heising (*Proc. I.R.E.*, June, 1925).

This paper describes in detail the equipment and circuit used in the production of the single side-band for transatlantic radio telephony in the experiments at Rocky Point. The set consists of two oscillators, two sets of modulators, two filters and a three-stage amplifier. The oscillators and modulators operate at power levels similar to those used in high-frequency communication on land lines. The three-stage amplifier amplifies the side-band produced by these modulators to about a 500-watt level for delivery to the water-cooled valve amplifiers.

The first oscillator operates at about 33 700 cycles. The modulator is balanced to eliminate the carrier, and the first filter selects the lower side-band. In these transatlantic experiments the second oscillator operated at 89 200 cycles, but might operate anywhere between 74 000 and 102 000 cycles. The second modulator, which is also balanced, is supplied with a carrier by the second oscillator and with modulating currents by the first modulator and first filter. The second filter is built to transmit between 41 000 and 71 000 cycles, so that by varying the second oscillator, the resulting side-band, which is the lower side-band produced by the second modulating process, may be placed anywhere between these two figures. Transmission curves for the filters are given as well as some amplitude-frequency performance curves of the set.



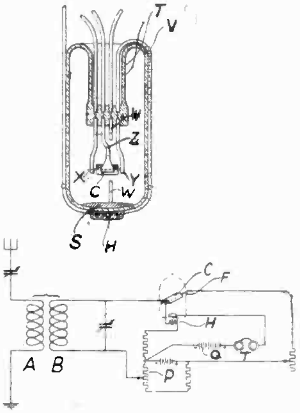
Some Recent Patents

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

THE ORIGINAL SODION.

(Convention date, U.S.A., 1st December, 1922. No. 207,818.)

The construction and connections of the early sodion detector are described in the above British Patent by the Connecticut Telephone and Electric Company Incorporated, and H. P. Donle. Referring to the illustration of the valve it will be seen that it consists of a glass vessel *V* provided with a re-entrant tube *T*. The end of this re-entrant tube carries four supports, which are sealed through in the ordinary manner. A filament is held between *X* and *Y* while the support *Z* carries a U-shaped collector *C*, which surrounds the filament. The support *W*, which is shown discontinuous for the sake of clearness, communicates with a quantity of sodium *S*, which rests on the bottom of the valve. It will be noticed that the filament lead *Y* is continued round the side of the valve to a heater *H*, consisting of a quantity of resistance wire. Thus it will be seen that on connecting the filament battery the current passes through the filament and through the heater coil, the object of which is to maintain the liquid sodium at a desired temperature. Referring now to the circuit diagram, it will be seen that a loose coupled aerial circuit *AB* is employed. The coupling is much looser than is usual with a valve receiver. The secondary circuit *B* is connected between the filament, or, rather, the potentiometer, and the U-shaped collector. The potentiometer *P* provides the collector *C* with a negative potential, while the H.T. battery *Q* is connected through telephone receivers to the liquid anode in the normal manner.

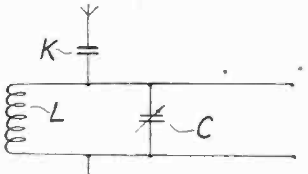


The operation of the device is exceedingly complicated. Briefly, there are two streams of current, one between the filament and the anode, and the other between the filament and the collector. Part of this latter current is neutralised by the negative potential supplied by the potentiometer *P*. Thus the device may be considered as operating by virtue of a pulsating current between the filament and the collector. This has a very small amplitude and is of a frequency of the order of 100 000 per second.

When radio frequency potentials are applied to the collector, there is a substantial fall in the average value of the collector current. The average value in the anode circuit follows the audio frequency variations in the collector current, and hence the telephones, or communication means included in that circuit are proportionally affected. The operation involves several electronic and ionisation phenomena. The sensitivity of the device is exceedingly good, increasing both with weak signals and with signal frequency.

AN OBVIOUS CIRCUIT.

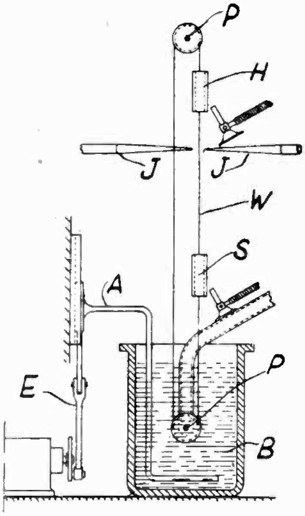
(Application date, 1st November, 1923. No. 232,659.)



J. Scott-Taggart describes an aerial circuit arrangement in British Patent No. 232,659, one arrangement of which is shown in the accompanying illustration. The object of the invention is to provide a broadcast receiver which is practically independent of aerial capacity. For example, it will be seen that a broadcast receiver can be roughly calibrated and suitably adjusted, and can then be used on aerials of various capacities without any trouble arising when in the hands of an inexperienced operator. Referring to the diagram it will be seen that an ordinary aerial tuning circuit LC is provided, and the invention consists merely in inserting another condenser *K* in the serial lead. The capacity of this condenser is preferably less than that of the aerial, and for a broadcast receiver it is stated that it may be of the order of 0.0001 μF. We were under the impression that arrangements of this description had frequently been employed ever since tuning was introduced into wireless transmissions. In fact, we thought it was a common practice to employ a fixed series condenser in the manner indicated. This arrangement has been actually used in certain broadcast receivers for a considerable time. It would appear therefore that the patent would be exceedingly limited in its nature.

COATING FILAMENTS.

(*Application date, 12th November*, 1923. *No.* 233,374.)



An interesting method of coating filaments is described by W. R. Bullimore in British Patent No. 233,374. The invention consists in coating a metallic core with an agglutinant, and subsequently dissolving the agglutinant by a solution containing in suspension the desired coating material.

One method of carrying this into effect is indicated in the accompanying illustration. Two pulleys *P* drive a wire *W* in band formation, which comprises the filament core. Two jets *J* coat the wire as it passes with a solution, for example, of celluloid. The wire passes through a heating tube *H*, which serves to dry the celluloid solution. The wire then passes through a bath *B* containing a solution of some substance such as amyl acetate, which contains in suspension salts or oxides of barium, strontium, or similar materials. An agitator *A* driven by an eccentric device *E* serves to maintain the coating material evenly in suspension in the amyl acetate.

The wire then passes through a tube *S* of silica or similar material which is heated sufficiently to dry off the solvent and burn off the celluloid, but not so strongly as to injure the oxide coating. The cycle of operation is then repeated until a sufficiently thick coating has been applied to the wire.

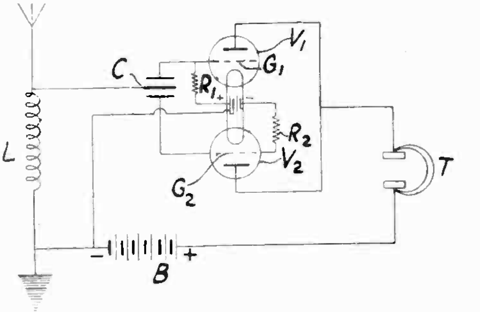
A FULL-WAVE RECTIFICATION IDEA.

(*Application date, 22nd January*, 1924. *No.* 232,672.)

British Patent No. 232,672, granted to D. S. B. Shannon, gives details of a rectification scheme. It is stated that the object of the invention is to rectify both the positive and negative half-cycles of a wave.

The suggested scheme is shown in the accompanying illustration. An aerial circuit containing, for some reason, merely an inductance *L*, is shown coupled between the filaments of two valves V_1 and V_2, and the middle plate of a double condenser *C*. One half of the condenser is connected to G_1, while the other half is connected to G_2. G_1 is connected by a low resistance R_1, to the positive side of the filament battery, while G_2 is connected by another low resistance R_2 to the negative side of the filament battery. Both anodes are connected together, and are supplied by a high tension battery *B* through a pair of telephones *T*.

It is stated that by making one grid positive and the other grid negative with respect to the filament, full wave rectification will be obtained, but we do not quite follow, in the inventor's explanation, how this is brought about. It is certainly new to us that a positive potential on the grid will rectify positive half-waves, while a negative potential will rectify negative half-waves. When a radio frequency potential is applied between the filament and the common point of the double condenser, both grids will be of substantially the same R.F. potential with respect to the filament.



The specification does not say how the valves are intended to rectify. In any case, if the grids become positive with respect to the filament—and this must occur simultaneously with both the valves—there will be either an increase or a decrease of anode current through the telephones; whereas, if the grids become simultaneously negative, the opposite effect, or nothing at all, will result, according to the manner in which the valves rectify: *i.e.*, as bottom bend rectifiers, or by virtue of accumulative grid rectification. We are of the opinion that the scheme as stated is fallacious.

FILAMENT CONSTRUCTION.

(*Application dates*, 12*th November*, 1923, *and* 12*th November*, 1923. *No.* 233,375.)

A form of filament is described by W. R. Bullimore in the above British Patent. This form, it is stated, has a comparatively large diameter in relation to its resistance, whereby greater mechanical strength and emissive surface are obtained without increase of temperature or current consumption. A further feature of the invention is the provision of an active emissive coating which will remain united to the filament.

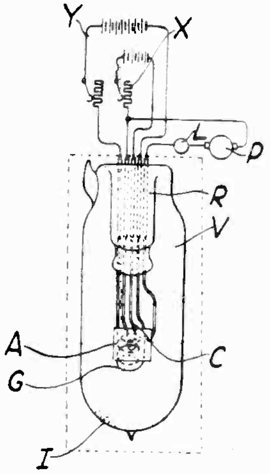
The invention really consists in coating a core of refractory metal or alloy, of relatively high specific resistance and melting point, with a "noble metal," *i.e.*, one which does not tarnish under ordinary conditions. The filament may be produced, for example, by nickel chrome alloy with platinum; or alternatively a molyndenum or tungsten wire may be coated with platinum or palladium. For example, platinum may be deposited by passing the core through a bath of ammonium platino-chloride salt.

A further feature of the invention is to coat a wire of this description by passing it through a bath containing nitrates of alkalis and alkaline earth metals. Fairly explicit details are contained in the specification.

A "GENODE" DEVICE.

(*Convention date, U.S.A., 21st December,* 1922. *No.* 231,188.)

A very interesting device, in connection with which the term "genode" is introduced, is described by the British Thomson-Houston Company, Limited, K. H. Kingdon and I. Langmuir. The accompanying illustration shows one form of the device, which consists essentially of an anode and two incandescent filament cathodes.



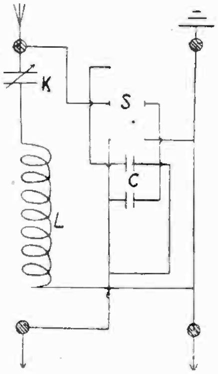
A glass or other tube *V* contains a re-entrant tube *R*, which has sealed into it four supports. Two leads go to an ordinary cathode *C* consisting of a coiled filament of tungsten. This is heated by the circuit *X* consisting of a battery and a resistance. Surrounding the cathode is a cylindrical anode *A*, and between the cathode and the anode is a source of power *P* and a load *L*. Another coiled tungsten or nickel filament *G*, constituting the genode, is placed between the cathode *C* and the anode *A*. The genode is also provided with a heating circuit (*Y*) consisting of a battery and resistance. Means are provided for the generation of positive ions, and before any suitable substance is introduced the electrodes are freed from occluded gases. After evacuation a material having in the gaseous state a low ionising potential is placed in the valve. A member of the alkali group such as cæsium or rubidium is shown at *I*. The vapour pressure of the ion-generating material may be controlled by an external heater, as indicated by the dotted outline round the valve.

This somewhat resembles the sodion, which is described in these columns, and the device functions by a somewhat similar process. When the cathode is heated to incandescence, electrons are emitted, and when a potential is applied between the anode and the cathode from the source *P*, as is indicated, pure electronic current will be set up, the value of which is determined and limited by the space-charge. When the genode is heated to obtain a generation of positive ions, the opposition to the flow of electron current by the space-charge is reduced, and with sufficient generation of ions the space-charge effect is substantially eliminated. It will be noticed that the genode circuit has no definite potential difference with respect to the other electrodes, which is an interesting feature.

A WAVE TRAP.

(*Application date, 5th December,* 1924. *No.* 232,877.)

A wave trap is described in the above British Patent by M. A. Hutchins. It is stated that the invention incorporates a trap comprising a tuned rejector circuit consisting of a plug-in coil and a variable condenser connected in series, in conjunction with a small-value fixed condenser in parallel. A circuit is placed across the tuned circuit of the receiver, and adjusted to the wave-length of the interfering station. It is stated that the difference in wave-length occasioned by the use of the trap is neutralised by one or more fixed condensers.

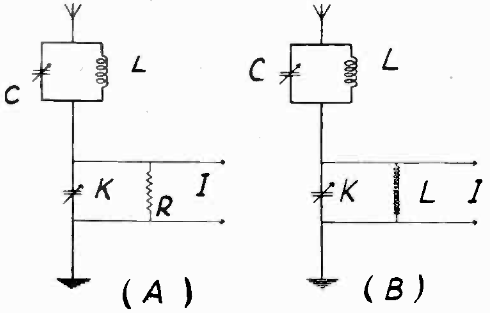


Referring to the accompanying illustration these are shown at *C*, and are adapted to be connected by a switch *S*. The traps appear to consist of a condenser *K* and an inductance *L*. We fail to see exactly what the novel point of the invention is, and the circuit diagram is not at all clear. A circuit consisting of an inductance and a capacity in series is more usually known as a series-acceptor circuit, and not a rejector circuit.

FILTER CIRCUITS.

(*Application date, 19th February,* 1924. *No.* 233,802.)

A form of filter circuit is claimed in the above British Patent by D. H. McDonald. Two arrangements are shown in the accompanying illustration. In the aerial lead to receiver is included a tuned circuit *LC*, while the input *I* to the receiver is connected across another variable condenser *K*.



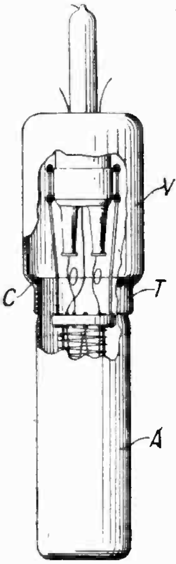
It is stated that by suitably adjusting the two condensers *C* and *K* any undesired signal can be eliminated, and the desired signal tuned in. It will be noticed that in one arrangement (A) a resistance *R* is connected across the input and across the condenser *K*, while in another form (B) a choke *L* is employed.

So far as the arrangement *B* is concerned there appears to be very little novelty about it. The use of a series-tuned circuit *LC* for the purpose of eliminating undesired wave-lengths has been known for years, and the input arrangement as shown at (A) or (B) has also been known for many years. It would appear that the substance of the patent is limited to the combination of the two schemes.

A COPPER-GLASS SEAL.

(*Convention date, U.S.A., 21st April*, 1923. *No.* 214,584.)

An interesting copper-glass seal is described by the Western Electric Company, Limited, and W. G. Housekeeper in the above British Patent. In previous copper-glass or similar seals it was customary to give the metal a very thin edge at the sealing point. A totally different method is illustrated by the accompanying diagram, which shows a valve employing a seal of the type we describe.

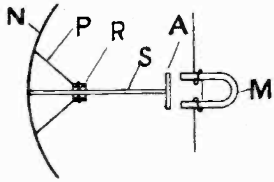


The vitreous portion *V* of glass or silica is provided with a tubular-shaped end *T* having cylindrical walls. A metal anode *A* is also provided with a thin cylindrical end *C*, and is arranged so that it slides into the cup-shaped end of the vitreous portion *T*, the end of the copper projecting beyond that portion. The seal is made by heating the vitreous portion in the neighbourhood of *T*, which compresses it round the thin end of the copper tube *C*. It is stated that a seal of this description remains vacuum-tight up to the fusion point of the glass or silica. We should imagine that it would be infinitely more rigid and is mechanically stronger than the previous types.

A "ROUND" LOUD-SPEAKER.

(*Application date*, 19*th November*, 1923. *No.* 229,382.)

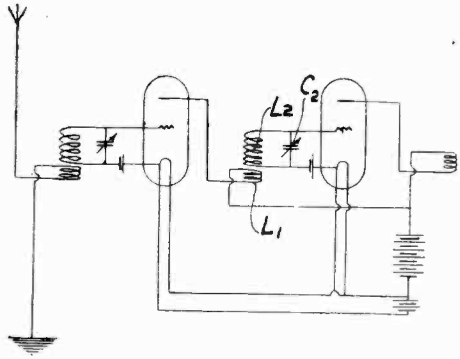
Captain H. J. Round describes in British Patent No. 229,382 the construction of a loud-speaker movement which is illustrated by the accompanying diagram. The loud-speaker is of the hornless type, and is built up in a similar manner to an umbrella or parasol. Thus, referring to the illustration, it will be seen that a main stick *S* is provided, which passes through a runner *R*. The runner *R* has attached to it a number of stretchers *P*, which are joined to a concave area *N*, built up of a number of radial supports covered with material such as paper or varnished silk. The end of the stick *S* is provided with an armature *A* which is operated by an electro-magnet *M*. The electro-magnet, of course, is fed with audio-frequency currents in the usual manner. The invention also provides for energising the stick mechanically, electrostatically, or by a magneto-striction device.



A RADIO FREQUENCY COUPLING.

(*Application date, 4th February*, 1924. *No.* 233,053.)

Some fairly extensive details of a radio frequency coupling device are described in the above British Patent by W. Rawsthorne. The accompanying diagram illustrates the arrangement of the circuit, which, it will be seen, is more or less normal. The object of the invention is to provide a radio frequency coupling device which can be used with a multi-stage amplifier without any tendency to produce oscillations. The novelty of the invention lies essentially in the coupling device, or radio frequency transformer. This is wound so that both the primary and the secondary have a small self-capacity; and also the windings are arranged so that the capacity between them is reduced to a minimum. For a wave-length of the order of 350 metres it is suggested that a transformer may be wound on a former having a diameter of 7 centimetres and a primary winding (L_1) of 25 turns of 30 s.w.g. wire with a secondary (L_2) of 90 turns of the same gauge. The secondary winding L_2 is tuned by a condenser C_2. The ratio of the inductance of the primary and secondary windings is roughly 1 : 10.



An explanation is put forward in the specification which accounts for the operation of the circuit, but we are not altogether in agreement with the statements. In another form the primary and secondary are wound as ring coils, one being within the other. An important feature of the arrangement is that the primary winding is placed nearest the earthed end of the secondary winding.