Experimental Wireless

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Experimental Topics.

Amateur Transmission.

Reception in the neighbourhood of both 200 and 440 metres shows that during the last six months the number of amateur experimenters now in possession of transmission licences has increased enormously, much more, in fact, than we should have expected. Is it, we wonder, a sign of less stringent examination on the part of the General Post Office or is it the result of a higher standard of qualifications amongst amateurs? We have no means of answering the questions other than by listening to the various transmissions which are always so prolific. Frankly we frequently cannot see the value of many of the so-called tests which are conducted and it is hard not to believe that far more knowledge would be gained by the use of an artificial aerial circuit instead of the usual radiating system. Many experimenters seem to forget that transmission permits are granted exclusively for experimental work and not primarily for the purposes of communication. We refer here to much of the unnecessary interference which is caused by futile "DX" work. Amateur transmission in America, for example, is essentially organised for the relaying of messages. In England with suitable transmission and reception gear it is possible to get from Land's End to John o' Groats on ten watts and any British relaying scheme would be almost *prima facie* evidence of inefficiency. Moreover, we understand that the authorities are not particularly interested in such an undertaking. It must not be imagined, however, that we look with any disdain upon the so-called "DX" work, for admittedly it can be of extreme value. Take for example the case of an experimenter who is testing the radiating properties of various aerial systems. Nothing is more helpful than to receive a series of accurate reports on signal strength from a number of scattered stations at great distances, but when one hears night after night "Test," "Test," "Test," and even "CQ," which, of course is strictly forbidden for amateur use, we feel that the persons responsible are not really helping the amateur in his relationship with the Post Office.

Wireless Terminology.

Because wireless is comparatively a new science it is not surprising to find that there is a considerable difference of opinion concerning many of the more common terms used in radio engineering. The British Electrical Standards have recently issued a suggested list of terms and definitions, and once again we refer our readers to this pamphlet, No. 166. At the present time we find that in many cases several names are given to one particular object and this can only lead to confusion. There is, of course, no real international nomenclature, nor even any recognised standard conventional representations of wireless apparatus, but there is absolutely no need to mix with our own terminology words culled from other countries. We do not refer particularly to scientific treatises, but rather to contributions to the wireless press in general. Such terms as "feed back," for example, are quite unnecessarily finding their way into our literature, but we have our own equivalent expression, and surely when we are writing in English there can be no objection to using English terminology.

The Location of the London Broadcasting Station.

One of our esteemed contemporaries in an editorial comment draws the attention of their readers to the location of the London Broadcasting Station, a subject which has been under consideration by the British Broadcasting Co. for some time. As everyone knows the main part of the 2LO gear is situated at the present time on the top floor of the Marconi Company's building in the Strand and the fact that it should be so intimately connected with one particular member of the British Broadcasting Company is no doubt responsible for the decision to move the station at the earliest possible moment. Rumour has it that a proposal has been put forward to move the station to a very well-known building in the West End and our contemporary suggests that it would be equally undesirable for the new London station to be associated with any building "controlled by another interest where rivalry in commercial enterprise is even stronger than in the wireless industry." As a satisfactory solution to the problem they suggest that it would be advisable from all points of view if the British Broadcasting Company were to find a suitable site and become the sole owners. This is certainly very wise counsel, but we are afraid that it is easier said than done. The conditions determining a suitable site are both numerous and hard to fulfil. In the first place the studios must be readily accessible and accordingly must occupy some central position. If the station is to be in the same building as the studio it may be extremely difficult to arrange for an efficient radiating system. To build the station at any considerable distance from the studios leads to certain difficulties, particularly in a crowded district such as the Metropolis as line troubles are sure to be increased. Also of course the fact that a large amount of simultaneous broadcasting is carried out from 2LO at once complicates matters as the relay lines must follow suitable routes to the main station. Obviously then, the problem is not an easy one and we are surely not justified in criticising too severely any suggestions that are put forward. It is not likely that the British Broadcasting Company will make any rapid decisions without giving due consideration to every point which is involved.

Distribution of Components.

As a result of a considerable number of statements made by many of our regular readers we have come to the conclusion that there must be some little hitch in the methods employed either in the distribution or manufacutre of certain components which have been placed upon the market during the last few months. It appears to be no exaggeration to say that some of them are almost unprocurable, which is indeed strange, in view of the fact that the components are repeatedly and universally advertised, and accordingly the prospective purchaser is justly led to believe that immediate supplies are available. We have not sufficient knowledge of the facts to suggest the possible cause of delay, but feel that it is a subject of considerable importance to the manufacturer and experimenter alike. At the present time wireless sales are still in the ascendant. The demand is abnormal, and consequently the individual requirements of a customer are liable to be lost sight of, while the manufacturer is all concerned with increased production. At the same time, however, the experimenter looks for service, and it is only natural for him to use those components which can be obtained with the minimum of trouble and delay. Surely this is a point which the manufacturer would do well to remember, for although several dissatisfied customers are relatively of no importance at the present time, conditions will be very different when the demand for wireless goods is stabilised. On the whole, we may say that the majority of manufacturers give their clients excellent service, but just now there seems to be some little trouble. Perhaps this is only a passing phase and is capable of reasonable explanation.

Antenna Constants—Capacity.

By GORDON WILLIAM INGRAM, B.Sc., *Maintenance Engineer, B.B.C.*

THE simplest method of calculating the capacity of a radio-telegraphic antenna system is first to evaluate the average potential of the system, due to the charge of electric energy applied to that antenna.

Experimental data shows that if a single straight aerial wire, either horizontal or vertical, be charged to a potential above that of earth, then the electric charge will not be uniformly distributed over the surface of the wire. The greatest density of charge is found

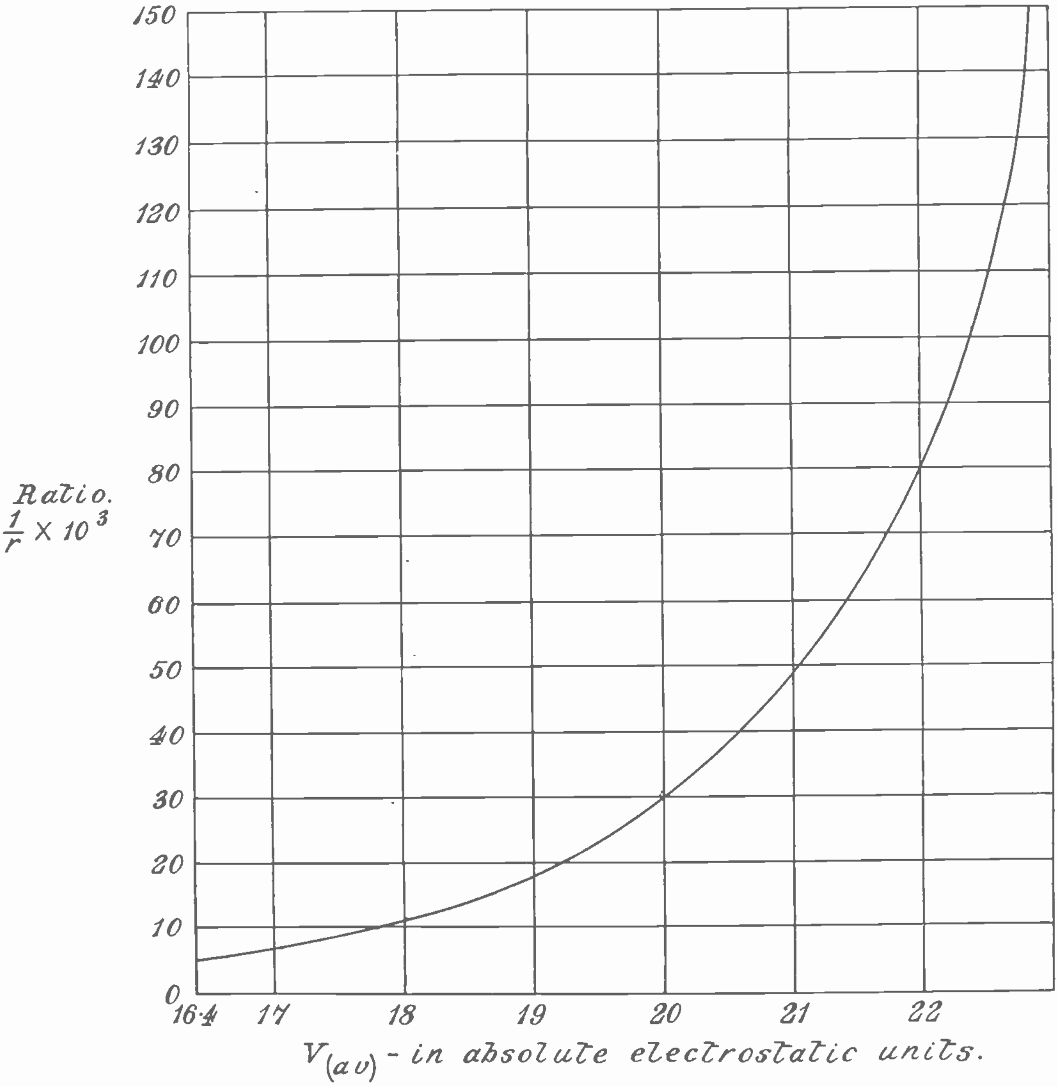


Fig. 1.—Single wire antennae $V_{(av)}$ where o=1 unit per sq. cm.

$V_{(av)} = 4\,r\,(\log_e \frac{l}{r} - 0{\cdot}307)$ in absolute electrostatic units.

at the two ends of the wire or aerial system, but for the purposes of calculation it is simpler to find a case where uniform distri-

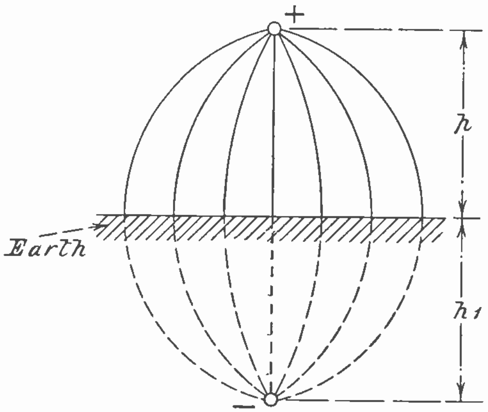


Fig. 2.—Illustrating the image of the aerial.

bution obtains, in which case the potential variation from point to point can be readily calculated.

Since, in practice, uniform distribution does not obtain in a continuous wire, assume that the antenna system is composed of a fairly large number of short pieces of wire, say 1 cm. long, placed end to end, and insulated one from another ; then uniform distribution is possible along the whole length of the antenna. When the value of the charge in each of these insulated sections is known the insulation between them is removed, thus a continuous conductor is formed, and the current will flow from the centre sections towards the ends of the wire, until we can say that the average potential of the system is equal to the potential of any one of the insulated sections which was found previously—that is to say, that the total charge in the antenna composed of the insulated sections is exactly equal to the total charge in the continuous wire system.

From the value of the average potential of the system we may calculate the capacity of the antenna by using the formula :

$C=\frac{Q}{V}$ where C is the capacity due to total charge Q, at potential V.

It is true to say that the capacity of any antenna depends not only on the charging potential, and its dimensions, but also on its distance from earth, which latter quantity can be considered analogous to the dielectric thickness in an ordinary plate condenser.

In Professor G. W. O. Howe's calculations, the average potential is obtained first taking the distance of earth as infinity, extra potential being added to allow for the proximity of earth.

Straight-Wire Antenna.

In a straight-wire antenna having a single strand the average potential is approximately given by :

$$V_{(av)}=4\pi r\sigma\left(\log_{\varepsilon}\frac{l}{r}-0{\cdot}307\right)$$

where r = radius of the wire in cms.
l = length of the wire in cms.
and σ = surface density of the charge in absolute electrostatic units per sq. cm.

The accurate expression is :

$$V_{(av)}=4\pi r\sigma\left(\sin h^{-1}\frac{l}{r}-\sqrt{1+\frac{r^2}{l^2}}+\frac{r}{l}\right)$$

but the difference between the two expressions is, for all practical purposes, negligible. The curve, Fig. 1, provides a ready means of evaluation of $V_{(av)}$ for a single-wire antenna charged with one unit per sq. cm. at distance infinity from earth.

Multiple-Wire Antenna.

The average potential of a flat-topped

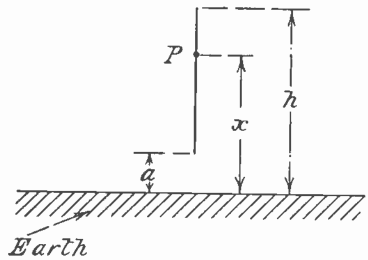


Fig. 3.—The conditions for a vertical wire.

multiple-wire antenna system is approximately given by the formula :

$$V_{(av)}=4\pi r\sigma\left[n\left(\log_{\varepsilon}\frac{l}{d}\right)+\log_{\varepsilon}\frac{d}{r}-B\right]$$

where n = total number of wires in the system
and d = distance between them in centimetres.
B is a factor variant with the number of wires in the antenna.

n	B	n	B
2	0	7	4·85
3	0·46	8	6·40
4	1·24	9	8·06
5	2·26	10	9·80
6	3·48	11	11·65
		12	13·58

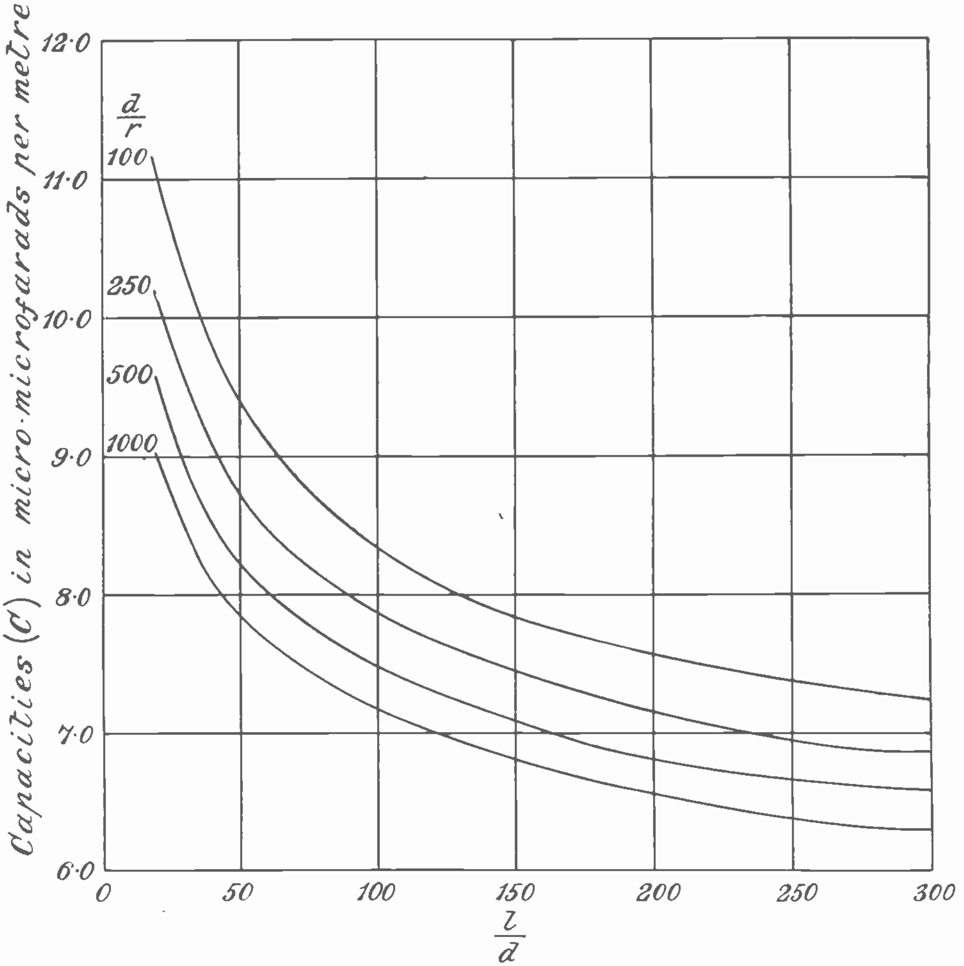


Fig. 4.—Capacities of two-wire (parallel) antennae—neglecting the influence of earth.

Ratio $\frac{d}{r}$ where d=distance between the wires in cms.

and r=radius of wire in cms.

Now, $C=\frac{Q}{V}$ where Q=the total charge

and V=the charging potential.

By application of the formulæ we already investigated the above curves have been drawn.

Four-Wire Cage Antenna.

Where the wires occupy the four sides of a square of side d, then for assumed uniformly distributed charge the average potential of any wire due to its own charge :

$$V_{(av)}=4\pi r\sigma\left(\log_\varepsilon\frac{l}{r}-0{\cdot}307\right)$$

the potential due to the two nearest wires :

$$=2\times 4r\left(\sin h^{-1}\frac{l}{d}-\sqrt{\frac{d^2}{l^2}+\frac{d}{l}}\right)$$

and that due to the wire diagonally opposite :

$$=4\pi r\sigma\left(\sin h^{-1}\frac{l}{\sqrt{2d}}-\sqrt{1+\frac{2d^2}{l^2}+\frac{2d}{l}}\right)$$

therefore, the average potential of the whole system will be :

$$V_{(av)}=4\pi r\sigma$$
$$\left[\log_\varepsilon\frac{l}{r}-0{\cdot}307+2\left(\sin h^{-1}\frac{l}{d}-\sqrt{1+\frac{d^2}{l^2}+\frac{d}{l}}\right)\right.$$
$$\left.+\left(\sin h^{-1}\frac{l}{\sqrt{2d}}-\sqrt{1+\frac{2d^2}{l^2}+\frac{2d}{l}}\right)\right]$$

or, where Y is a factor,

$$V_{(av)}=4\pi r\sigma\left(\log_\varepsilon\frac{l}{r}+Y\right)$$

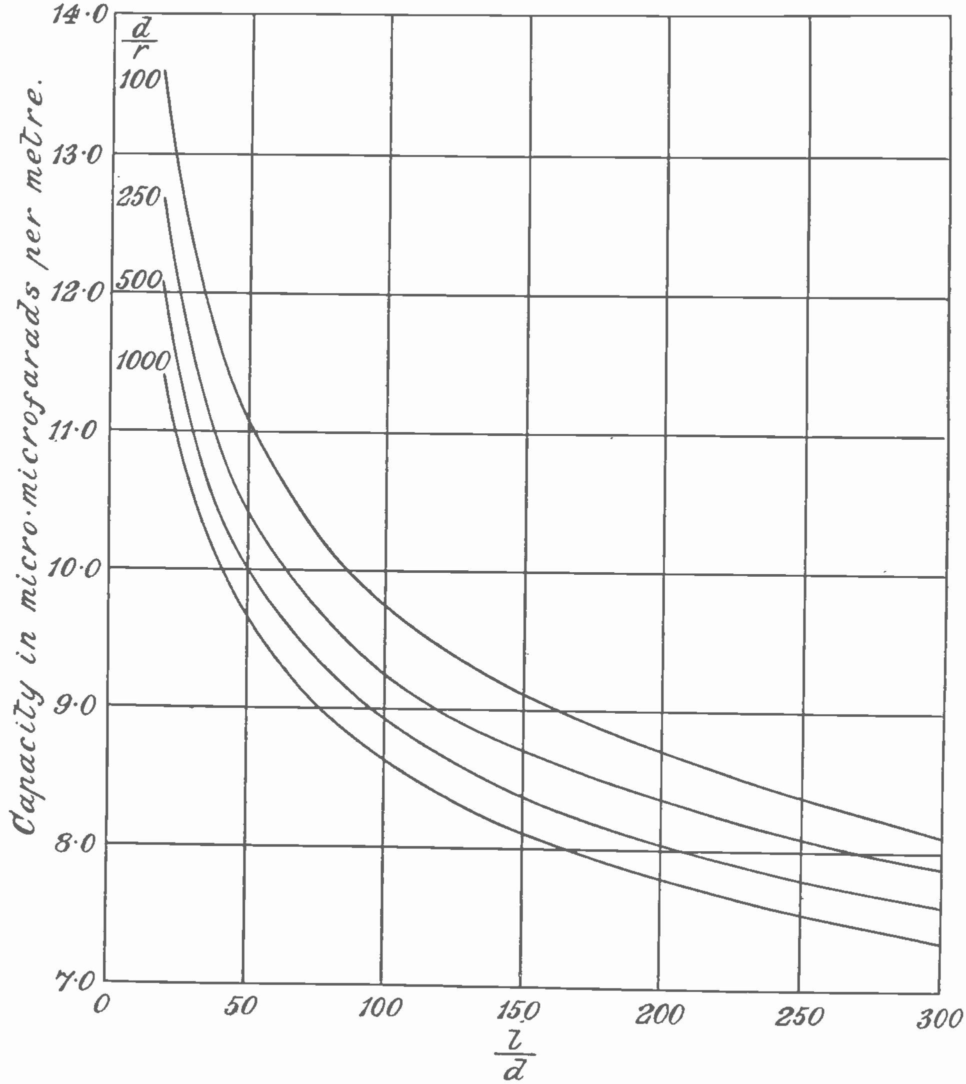


Fig. 5.—Capacity of three-wire (parallel) antennae. In micro-microfarads per metre.

Note.—The expression $\sqrt{1+\frac{d^2}{l^2}}=1$ practically with negligible error.

$\frac{l}{d}$	Y.
20	7·58
50	10·22
100	12·26
150	13·48
200	14·33

The Increase of Capacity, Due to Nearness to Earth, in a Horizontal Antenna.

When the antenna is not far from the earth, as is usually the case, its average potential will be lowered since negative charges are induced in the earth, hence the capacity is increased. Practically, the ratio of the height to the length of the system is large enough to enable us to take it that this induced negative charge is concentrated at a point in the centre of the electrical image of the antenna, where the earth is taken as the reflector, and $h=h_1$ (Fig. 2). Then :

$V_i=\frac{Q}{2h}$ where V_I is the potential due to the induced charge,

$$Q=2\pi r l\sigma.$$

Reducing $V_i=4\pi r\times\frac{1}{4h}=E$, a negative value.

Therefore, the formula for the average potential of a four-wire cage antenna becomes by correction for V_i:

$$V(av)=4\pi r\sigma\left(\log_\varepsilon\frac{l}{r}+Y-2Vi\right)$$

Note.—

$$\frac{Q}{2h}=\frac{2\pi r l\sigma\times 4}{2h}=4\pi r\sigma\times\frac{l}{h}=4\pi r\sigma\times 2Vi$$

$$=4\pi r\sigma\left(\log_\varepsilon\frac{l}{r}+Y-\frac{l}{h}\right)\text{OR } 4\pi r\sigma\left(\log_\varepsilon\frac{l}{r}+Y+2E\right)$$

In a vertical wire the potential at point P, due to induced charge on the earth is given by

$$V_p=\log_\varepsilon\frac{2\ (x+h)}{r}-\log_\varepsilon\frac{2\ (x+a)}{r}$$

For the whole wire the average potential is given by:

$$V_{av}=\frac{1}{h}\log_\varepsilon 2^{2\ (a+h)}\cdot\left(\frac{a}{h}\right)^{2a.}$$

$$\text{or } \frac{1}{h}\left\{2\ (a+h)\ \log_\varepsilon 2+2a\ \log_\varepsilon\left(\frac{a}{h}\right)\right\}.$$

Neglecting the second term since a is small $V_{av}=2\log_\varepsilon 2=1{\cdot}386\times\sigma=1{\cdot}386\times$ charge per unit length.

Practically V_{av}=Charge per unit length expressed in absolute electrostatic units.

Now, since $C=\frac{Q}{V}$, where C is the capacity, Q is the total energy in the antenna, and V the average potential of the whole antenna, the capacity can be readily calculated.

Potential of a Wire due to a Parallel Charged Wire of Equal Length and the Potential of a Horizontal Wire due to Proximity to Earth-Unit Charge per Centimetre Length.

ABSOLUTE ELECTROSTATIC UNITS.

$\frac{l}{d}$	E.	$\frac{l}{d}$	E.	$\frac{l}{d}$	E.
0·5	0·48	8·0	3·78	30	6·27
1·0	0·94	8·5	3·88	40	6·81
1·5	1·32	9·0	4·00	50	7·26
2·0	1·64	10·0	4·20	75	8·05
2·5	1·94	11·	4·36	100	8·62
3·0	2·20	12·	4·52	200	9·98
3·5	2·42	13·	4·64	350	11·10
4·0	2·62	14·	4·80	500	11·81
4·5	2·82	15·	4·94	750	12·62
5·0	2·98	16·	5·06	1000	13·20
5·5	3·18	17·	5·18	1300	13·72
6·0	3·28	18·	5·28	2000	14·58
6·5	3·42	19·	5·38	4000	15·91
7·0	3·54	20·	5·46	8000	17·18
7·5	3·66				

Note.—C will be in electrostatic units when Q and V are given in those units. Electrostatic unit =0·906 micro-microfarads.

It is found that the potential of an antenna is reduced by proximity to masts, buildings, and is calculated by assuming the electrical image of the wire to be on the side of the wall or mast, or most remote from the antenna system—as an average potential is decreased it follows that the capacity is increased.

The tables following are taken from the paper by Prof. G. W. O. Howe, reference to whose works have already been made. Fig. IV gives these results in the form of curves from which the capacity in micro-microfarads per metre can be found for two, three, and four wire aerials.

TABLE 1.

TABLE OF CAPACITIES OF PARALLEL WIRE ANTENNAE (NEGLECTING INFLUENCE OF EARTH).

In micro-microfarads per metre.

No. of Wires.	$\frac{d}{r}$	$\frac{l}{d}$—20.	50.	100.	150.	300.
FIG. IV.	100	11·14	9·41	8·35	7·84	7·24
	250	10·20	8·73	7·88	7·46	6·82
2	500	9·60	8·29	7·51	7·12	6·55
	1000	9·05	7·88	7·19	6·82	6·26
FIG. V.	100	13·60	11·15	9·78	9·15	8·20
	250	12·69	10·49	9·29	8·71	7·84
3.	500	12·07	10·06	8·94	8·40	7·61
	1000	11·48	9·66	8·63	8·14	7·39
	100	15·58	12·50	10·82	10·03	8·92
4.	250	14·60	11·88	10·35	9·64	8·60
	500	13·94	11·45	10·03	9·36	8·40

A New Capacity Microphone.

By D. F. STEDMAN, B.A.Sc.

We give below details of construction of a new type of capacity microphone which is easily made and is capable of giving excellent results. The sensivity is so great that little amplification is needed.

IN view of the recent interest in any type of microphone claiming to be a "high quality" instrument, the writer passes on his endeavours in this direction.

A perfect microphone must conform to quite a number of conditions, but slight deviation from any one of which produces serious defects, and the design of such a microphone must be considered in relation to the required characteristics. The most essential of these are :

1. No diaphragm resonance ;
2. No internal "chamber" resonance ;
3. Uniform sensitiveness for all frequencies—possibly allowing a slight increase at the extreme ends of the scale, partially compensating for the insensitiveness of the ear ;
4. No audio lag ;
5. Must have a linear characteristic.

Either of the first three produces a somewhat similar effect, the accentuation of a few notes in a bad case or a broader band of frequencies in a more usual case. Much of the "tin" which was audible at 11.30 arises here.

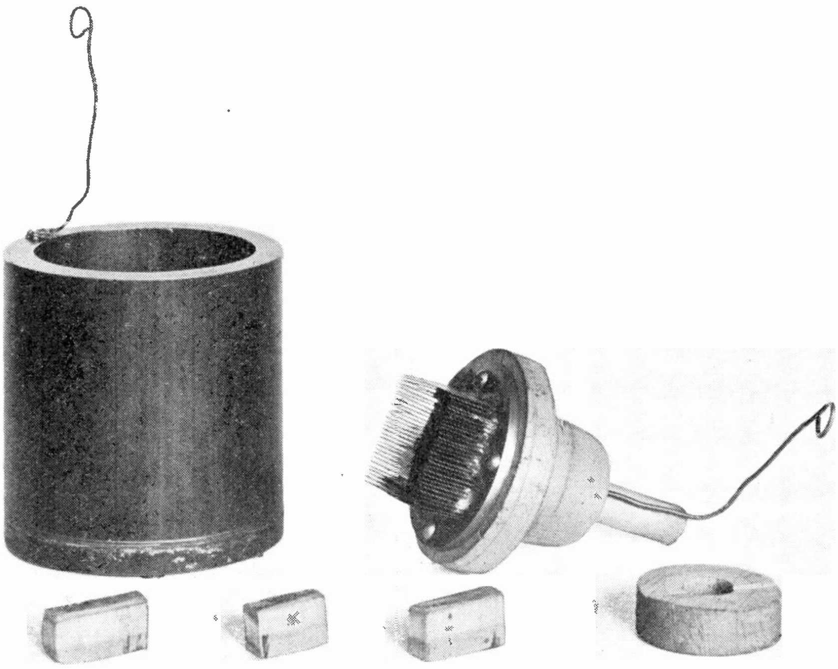


Fig. 1.—A near view of the various parts of an experimental microphone. Note the laminated back electrode.

If a microphone possesses an audio lag it cannot tell the difference between P and B, T and D, etc., that is, an explosive or sometimes an unsymmetrical wave shape is lost or badly distorted. The modified Post Office type, described in the January issue, would probably suffer rather badly here.

The diaphragm and moving system being sufficiently heavy to respond equally to all frequencies, requirements 1, 2, and 3 will now have a much larger inertia and would distort the explosive characters, *i.e.*, such a microphone would be reasonably close to the ideal for music, a complex of more or less related and sustained sine-waves, but for speech, a mass of unrelated transients, it is probably not so good, it was, in fact, sugested for the transmission of music.

A microphone may also have uniform sensitiveness and still not have a linear characteristic. That is, it will respond perfectly to all frequencies if applied alone, but if the diaphragm is temporarily disturbed from its position of rest by a relatively large low-frequency oscillation (and low-frequency oscillations are in general large, or they will not be heard) its sensitiveness will then be different. If a microphone has this defect it will produce a most curious effect. Consider that notes of frequencies of 100 and 800 pps. are applied simultaneous to a "non-linear" microphone. The diaphragm, while vibrating at 800 pps., passes through points of greater and less sensitiveness at 100 pps., *i.e.*, the 800 pps. will vary in intensity at 100 pps., introducing two other undesired notes—900 and 700 pps. While this case would probably not sound objectionable, it "isn't in the music," and it is easy to see how if all the notes present at an instant in an orchestral item are treated similarly a harshness would be produced with very slight curvature of the microphone characteristic, each note being interfered with by the resultants of the others. If n sine waves are present at any instant the number of resultants is $n\ (n-1)$, obviously a very large number, even if each one is hardly detectable the total result may be considerable.

The above requirements are common to all types of microphones, including capacity microphones, although being so simple they would seem to possess less inherent distortion, the production of an ideal microphone being a matter of design, principally of the diaphragm and the method of using it.

Items in the Design of such a Microphone.

Taking requirements 1 and 4 together, that it shall have no diaphragm resonance or audio lag (also largely a characteristic of the diaphragm). There are several ways of attacking this:

(*a*) Give an "ordinary" metal diaphragm a definite resonance frequency above the required band, by stretching it; or

(*b*) A resonance frequency below the required band, by weighting it, or

(*c*) Use a diaphragm material that has no "will of its own," which will then move as part of the air.

Although method (*a*) may produce excellent results it is hardly suitable for amateur use, and it shares with (*b*) the serious defect of producing excessive insensitiveness. Method (*b*) also has the defect of needing such a large mass that considerable audio lag is introduced. This is noticeable even with a material as light as a silk diaphragm, the explosive characters being somewhat softened. It must be remembered that at 6,000 pps. the air column in immediate contact with the diaphragm, and actually effective in moving it, is only about half an inch long, and weighs but a few milligrams

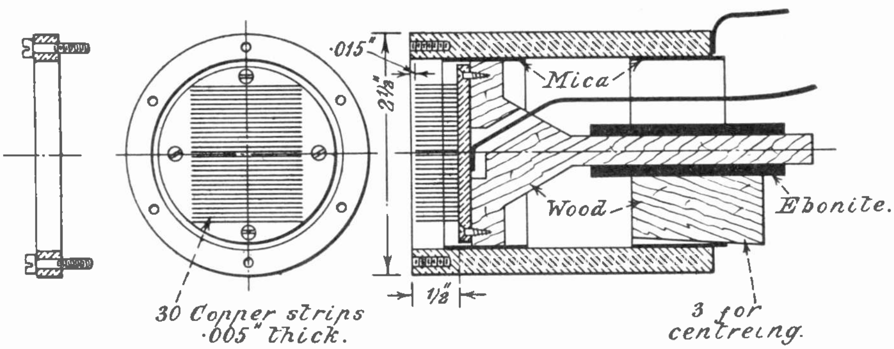


Fig. 2.—Constructional details of the microphone.

where the diaphragm usually weighs fractions of ounces. Method (*c*) seems far the simplest to the writer, and should produce equally good results.

The diaphragm materials tried were thin Jap silk with a gold leaf carefully stuck on one side (gold leaf, although so thin, is an excellent conductor, the resistance between two touch contacts about an inch apart is only about 2 ohms); a thin rubber film (toy balloon material) similarly treated with a gold leaf; and a gold leaf alone.

The silk being so light is rather difficult to mount flat and at the same time unstretched, also being very hygroscopic its tension varies considerably from day to day. In mounting the gold leaf on the silk or rubber support the front surface must be kept clean or it will not make contact, and, of course, every tear increases its resistance. A gold leaf diaphragm may seem very flimsy, but once mounted it is quite the reverse, provided one does not lay it down on a drawing-pin or test its tension by touching it. We have in this case the other extreme, the air is now the heavy body, and the diaphragm, although a good conductor, only weighs about 2 mg., and can obviously have no resonance or audio lag—in fact, it moves as if it were part of the air, a sound wave being transmitted, but not reflected.

The results obtained with these diaphragms is exactly as one would expect. The gold leaf is best both for purity of reproduction and is about twice as sensitive; the silk shows decided resonance at a low frequency (as it should not be deliberately stretched) but which varies from day to day, also due to its relatively large weight its sensitiveness falls somewhat at the higher frequencies; while the rubber is decidedly inferior in every way, except that its resonance is constant. Possibly a very thin film of collodion might be better as a support for the gold leaf, but it is perfectly satisfactory alone, and is not sensitive to draughts, the back of the microphone being nearly airtight. Possibly Dutch metal might be a good substitute for the gold leaf.

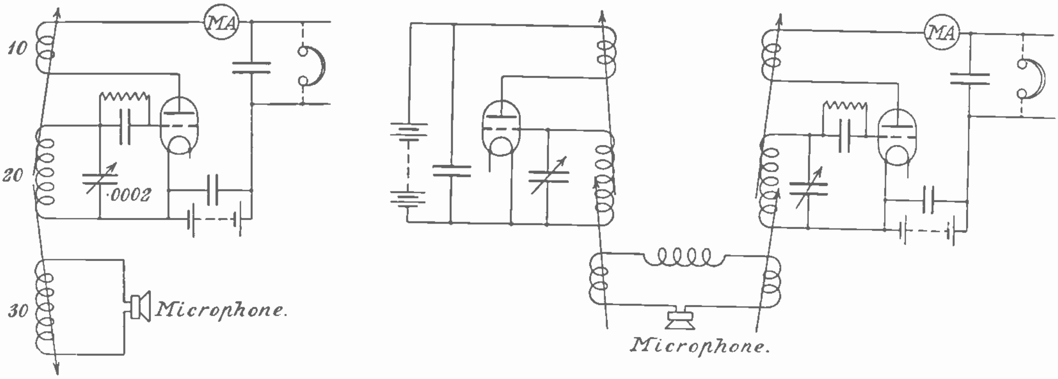


Fig. 3.—Two suitable absorption modulation arrangements for use with the microphone. The circuits are tuned approximately to 100 metres.

The other requirement in the design of the microphone is that it shall have no internal or chamber resonance. As the diameter is large compared with its depth it can only resonate as a "closed tube" with a wavelength of twice its depth, which, in this case, will not be a very strong resonance, as the

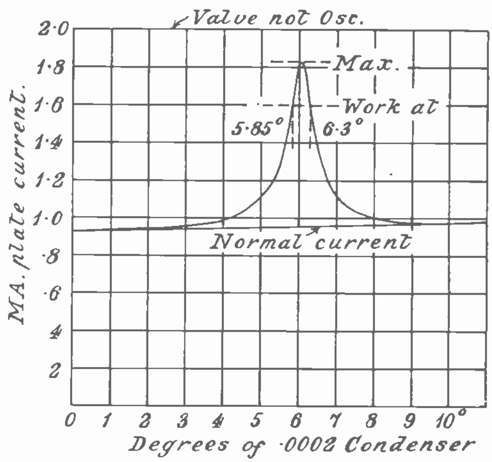


Fig. 4.—Curve showing correct position for operating microphone.

diaphragm is not capable of reflecting much of a sound wave. The air chamber can evidently have considerable depth without introducing audio resonance up to about ·75″ (resonance frequency of 8,800). As compression of the internal air volume limits the movement of the diaphragm a reasonable amount of air space is desirable. On the other hand, the ratio of the capacity variation to total capacity is wanted as high as possible, therefore the device illustrated was used—a series of copper strips ·005″ thick be as sensitive as possible (it will hardly be too sensitive).

A circuit is given in the January issue (p. 189), this is a frequency "modulation" the detection of which here depends on the selectivity of a crystal circuit (as is well known, an extremely unselective device and almost certainly non-linear), and detection of this frequency modulation with a valve is simply horrible at 100 metres in such close proximity to the oscillator. After considerable experiment on one or two valve circuits,

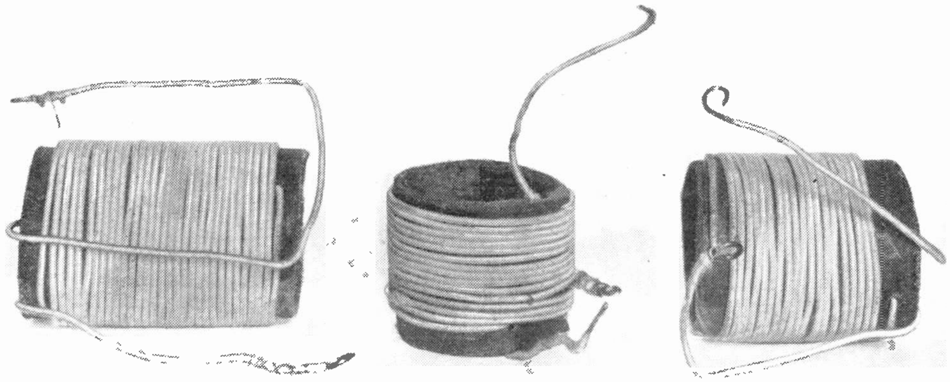


Fig. 5.—A near view of the modulator, reaction and oscillator coils, about half actual size.

soldered edgewise on a brass plate, *i.e.*, the electrical surface is only ·015″ behind the diaphragm (and could be closer still if desired), but the air depth is still ½″. This simple arrangement makes it at least twice as sensitive as the simple brass plate close to the diaphragm. No difficulty is experienced in soldering on the strips if machine-cut strip is used and is clamped between cardboard strips during the process. This completes the electrical design of the microphone, the actual mechanical shape being merely a matter of convenience. The construction of the writer's microphone will be obvious from Figs. 1 and 2.

The next matter is the method of using it, which must conform to requirements 3 and 5 above, *i.e.*, it must not distort the uniform sensitiveness of the microphone, must provide a linear characteristic, and, at the same time, using amplitude and frequency modulation the two circuits given in Diagram 3 were far superior to any others tried. The two-valve is but very little more sensitive than the single-valve, and the simplicity of the single-valve circuit has much to recommend it. This is the circuit recommended, and Fig. 4 refers only to this circuit.

The microphone is here used as a loosely coupled tune and detune absorption circuit. The valve is only gently oscillating in order that quite loose coupling may be sufficient to effect modulation, as tight coupling ruins the shape of the resonance curve. The plate current curve close to resonance is given in Fig. 4, and it can be seen that for the small fraction of a milliamp. required it is linear for quite a considerable distance. Either side of the resonance point can be used equally well, but not too near the peak (a silent spot), as the characteristic is curved, for this particular adjustment, 1·5 to 1·7 ma. is about the best part to work on. In order to obtain selectivity the circuit was wired throughout with No. 16 D.C.C., and small spaced cylindrical coils of the same wire used, no dead ends or unused turns being allowed, and adjustment must be very smooth throughout.

It might be objected that the grid condenser rectification will introduce a lag, but this is essentially a radio lag, and at 100 metres even a 6,000-pp. note represents 500 radio cycles per audio period; this also applies to the lag introduced by the highly selective circuits, but as no appreciable reaction is applied to the microphone circuit, it has a very definite although somewhat small damping factor, otherwise it would not affect the plate current to such a large degree. In the writer's experience the radio lags introduced here only seem to amount to but a small part of the shortest audio period considered, although, if considered advisable, potentiometer rectification and somewhat less selective circuits can be used, but with a drop in sensitiveness.

The sensitiveness of this microphone is such that with phones in the plate circuit, and using only one valve, as Diagram 3, speech is quite clear at 10 feet from the microphone, although, of course, not loud, and quite strong at two or three feet, without using any kind of microphone trumpet. It thus compares quite favourably with the ordinary carbon microphone, while the quality is infinitely better, sibilants and explosive characters being practically as sharp as in the original speech.

The Conditions for Distortionless Low-Frequency Amplification.

By F. M. COLEBROOK, B.Sc., D.I.C.

(Of the National Physical Laboratory.)

Although many readers are no doubt perfectly familiar with the general and more obvious factors determining true reproduction, there are several more obscure points. These will be found fully considered below, and the following paper should prove of considerable value.

THE whole subject of distortion has recently come in for a great deal of attention. This is probably one of the consequences of the growing popularity of "broadcast" reception. It is quite understandable that once the initial condition of wonder has subsided the critical faculty will make its voice heard demanding an ever-increasing purity of reproduction, and it is desirable from every point of view that those in any way concerned with the design or production of apparatus intended for use in connection with the reception of wireless telephony in general and broadcasting in particular should realise the necessity of meeting this demand.

At a recent joint meeting of the Institution of Electrical Engineers and the London Physical Society on the subject of loud-speakers Capt. Eckersley, of the British Broadcasting Company, maintained that at present the weakest link in the transmission-reception chain is the loud-speaker. Making due allowance for the fact that his association with the transmission end of the chain will naturally dispose him to an indulgent view of this part of the process, there will probably be a very general assent to his proposition.

The unfortunate loud-speaker must not, however, be made the scapegoat to be loaded with all the sins of omission and commission of which the ear gradually becomes conscious when "listening-in." In the demands it makes on the last valve of a receiving-set the loud-speaker may indeed be an indirect cause of distortion, for a reason considered at some length by the writer in a recent article in *The Electrician.** This, however, is the fault of the valve rather than the loud-speaker, and the trouble can be remedied by using a valve of suitably modified design for the operation of the loud-speaker. Such valves are, as a matter of fact, already on the market.

Quite apart from the loud-speaker, however, it is certain that low-frequency amplification is rich in possibilities of distortion. Without desiring to belittle in any way the very creditable performance of some of the low-frequency transformers at present on the market, the writer has good reason to state that many of them are very far from guiltless in this important matter.

The object of the present paper is not to specify any ideal design of transformer. That is a matter for experiment, and more experiment, and still more experiment! Its object is rather to consider the mechanism of low-frequency transformer amplification and to point out the essential requirements which must be fulfilled if it is to be free from distortion. The writer hopes that those actually engaged in experimental work on the subject may find herein some little assistance towards the practical solution of the problem.

It will be well to consider first exactly what is meant by distortionless amplification. Does this require that the wave forms of the input and output sound energy shall be identical? No; fortunately, it does not.

Given a certain fundamental and a set of associated harmonics the wave form can be varied very considerably by altering the phase relationships of the harmonics. It appears, however, that the ear is in no way disconcerted by such changes of phase relationship. It takes the total energy as it comes and receives from each harmonic the appropriate contribution to the total impression. The intelligent co-operation of the ear in this respect is very fortunate for low-frequency transformers since they are thereby freed from the necessity of maintaining unaltered the phase relationships of the constituent harmonics of the alternating currents passing through them.

An alteration of wave form, therefore, does not necessarily produce distortion. What must be kept unaltered, however, is the relative distribution of the total energy over the whole range of frequencies with which it is associated. Stated in electrical terms this means that the voltage amplification produced by a valve-transformer combination must be independent of frequency over the whole range of frequencies involved in the transmission of speech or music.

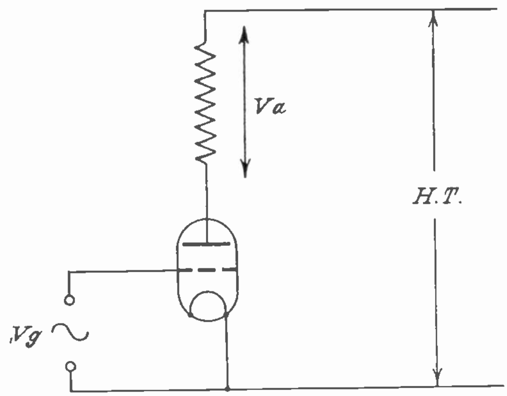


Fig. 1.—Potentials are produced across a resistance in the anode circuit.

To say that this distribution must be maintained unaltered is of course a counsel of perfection. Without doubt, a considerable deviation from this standard can be permitted in practice before a noticeable distortion is produced. The extent of this permissable deviation is not a matter in which it is possible to lay down any definite rule. It is probable, however, that a sound reproduction in which the distribution of intensity with frequency did not differ by more than 30 per cent. from the original for any given frequency would be accounted very good. Throughout this paper, therefore, this figure, corresponding to a 15 per cent. constancy of voltage amplification, will be taken as the standard to be aimed at.

In order to translate this into terms of amplifier design it will be necessary to consider briefly the mathematical representation of the amplification process. A

* "Grid-filament Conductivity: Its nature and effect on amplification." *The Electrician*, Nov. 23.

thorough treatment of the subject on mathematical lines would be out of place in a paper intended as much for the non-technical as for the technical reader. It is, moreover, unessential to the present purpose as the most important feature of the process can be made clear by a very much simplified analysis.

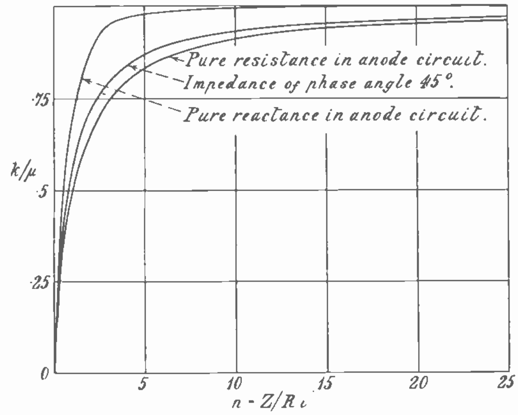


Fig. 2.—Showing relative amplification with a resistance, pure reactance and combined resistance and reactance.

Consider the arrangement shown in Fig. 1, which represents a valve, in the anode circuit of which is inserted a pure resistance R. If an alternating electromotive force of magnitude V_g be applied to the grid of the valve, then it can be shown that there will result across the terminals of the resistance R an alternating potential difference of magnitude V_a given by

$$V_a = \frac{\mu}{1 + \frac{R_i}{R}} V_g$$

where R and μ are constants dependent on the valve. These constants are usually referred to as the internal resistance of the valve and its voltage factor respectively, and their magnitudes are of the order 30-50,000 ohms for the first, and anything from 6 to 10 for the second.

Re-writing the expression in the form

$$\frac{V_a}{V_g} = k = \frac{R \; R_i}{1 + R, R_i} \mu$$

then k is the voltage amplification factor for the valve under the given conditions, since an applied grid voltage V_g produces a potential difference V_a, k times as large, across the terminals of the resistance R. It is clear that the important feature of the expression is not the absolute magnitude of R or of R_i, but the ratio of R to R_i. Calling this ratio n the expression for the voltage amplification factor takes the form

$$k = \frac{n}{n+1} \mu$$

In the more general case in which, in place of the resistance R there is an impedance of magnitude $Z = n$R and phase angle θ, it can be shown that the expression for k is

$$k = \frac{n}{\sqrt{(1 + n\cos\theta)^2 + n^2\sin^2\theta}} \mu$$

$$= \frac{n}{\sqrt{1 + 2n\cos\theta + n^2}} \mu.$$

The function $n/\sqrt{(1 + n\cos\theta)^2 + n^2\sin^2\theta}$ is illustrated in Fig. 2 for values of n from 0 to 20 and for $\theta = 0$, 45, and 90, *i.e.*, for the cases in which Z is a pure resistance, an impedance containing equal resistance and reactance, and a pure reactance. These curves demonstrate the great superiority of the reactance from the point of view of constancy of voltage amplification. For a variation of n from 3 to infinity the corresponding change of voltage amplification is only about 5 per cent., and for a variation from 2 to infinity only about 10 per cent. This is a fact of considerable practical value. It should further be noted that the larger the resistance component of the impedance the smaller is the permissible variation of n

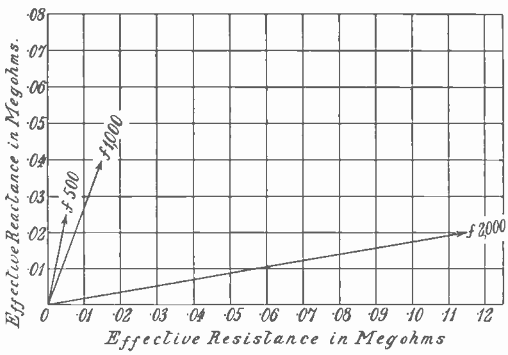


Fig. 3.—Primary impedances at various frequencies.

for a given maximum variation of voltage amplification.

We are now in a position to consider the application of the above results to the practical question of the design of low-frequency transformers for low-frequency amplification.

In the usual form of connection the primary winding can be regarded as an impedance inserted in the anode circuit. At a given frequency f this winding will have a certain effective impedance (its own impedance as modified by the presence of the secondary winding) and to this impedance there will correspond a certain voltage amplification factor defined as shown above. We will call this factor k_f. This means that an applied grid voltage V_g. of frequency f, will produce a potential difference $k_f V_g$ across the terminals of the primary winding. Across the terminals of the secondary winding the corresponding potential difference will be $k_f \rho_f V_g$, ρ_f being the value of the step-up ratio of transformation at the frequency f. As the suffix indicates, this is not constant with respect to frequency. The total voltage amplification produced by the valve-transformer combination is therefore $k_f \rho_f$ We may say, therefore, that if the transformer is to come up to the standard specified in this paper the quantity $k_f \rho_f$ must not vary by more than 15 per cent. over the whole range of the frequencies at which it is intended to operate. Strictly speaking, if the transformer is to be suitable for all kinds of speech and music this means the whole range of audible frequencies. Actually, if constancy to 15 per cent. is maintained down to about 300 cycles per second the result would probably be considered very satisfactory.

Before considering the possibility or otherwise of achieving this result it will be of interest to analyse the actual performance of a typical transformer, of average quality judged by present standards.

The measured effective impedances of the primary winding corresponding to three frequencies (500, 1,000, and 2,000) are shown in Fig. 3. The impedances are exhibited in vector form, with reactance as ordinate and resistance as abcissa. It should be noted that a frequency of 2,000 is in the neighbourhood of one of the resonance points of the system, for at this frequency the winding behaves almost as a high non-inductive resistance. (The possibility of such resonance points is of course attributable to the distributed self-capacities of the two windings and the capacity between the two windings. These self capacities play a large part in the performance of the transformer. It might be mentioned at this point that the measured effective impedance was found to depend to a very great extent on the way in which the terminals of the windings were arranged relative to each other and to points of fixed potential in the measurement circuit. The values given are for an arrangement corresponding as closely as possible to that of the usual valve circuit.)

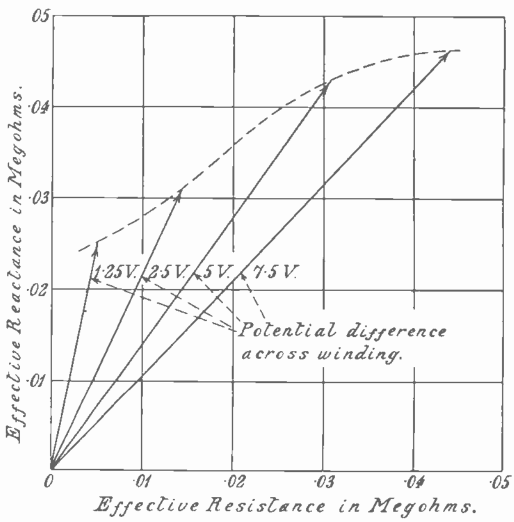


Fig. 4.—Showing variation of effective impedance with amplitude.

The diagram makes clear the very large variation of impedance which may be expected with frequency.

In general, variations of the magnitude of the effective impedance will occur not only with frequency but also with amplitude. This is illustrated in Fig. 4 for the primary winding of the same transformer for four different values of the potential difference across the terminals, at a constant frequency of 1,000. (The values of Fig. 3 are for a constant terminal potential difference of 2·5 volts.)

By reference to Fig. 2 we can see the significance of these variations of effective impedance. The curves indicate that, provided the effective anode impedance does not fall below a certain definite amount dependent upon the degree of constancy desired, variations in its value will only cause relatively small variations in the corresponding value of *kf*. It is clear, however, that the transformer winding which forms the subject of these measurements does not satisfy this requirement. The consequence of this is shown in curve 1 of Fig. 5 which represents the variation of the calculated value of *kf* with frequency

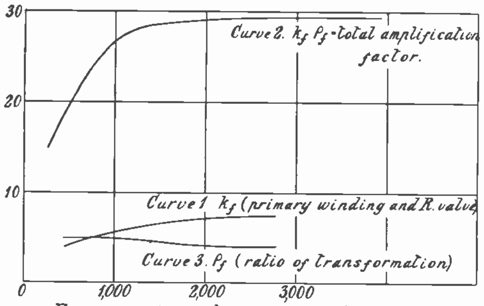


Fig. 5.—Variation of *kf* with frequency.

(assuming a value 10 for μ and 50,000 ohms for R*i*.) Between the frequencies 500 and 3,000 there is a variation of just over 100 per cent. in *kf*. This variation is again reflected in curve 2 of the same figure, which shows the measured voltage amplification produced by this transformer in conjunction with an ordinary R valve. There is a very rapid falling off below a frequency of 1,000, and between 300 and 1,000 cycles/sec. there is a change of over 90 per cent. in the voltage amplification. From 1,000 upwards the change of total amplification produced by the valve and transformer is less than would have been anticipated from the corresponding change in *kf*. This shows that the change in *kf* has been partly compensated by a change in the reverse direction on the part of ρf, the transformation ratio. Curve 3 of Fig. 5 shows this apparent change in ρf, obtained by dividing the ordinates of curve 2 by those of curve 1.

This raises the question of the general nature and extent of the variation of the transformation ratio with frequency. It is not one on which the writer has very extensive information. It appears, however, that there is generally a tendency for the ratio to decrease as the frequency increases, and it is probable that many transformers at present on the market, with comparatively low primary impedances, owe their relatively good characteristics to a fortunate combination of an increasing *kf* with a decreasing ρf.

Coming now to the practical conclusions derivable from the above analysis, it is clear that there are two alternatives for the designer in his endeavour to maintain the constancy of the product *kf* ρf. Either he can arrange for the constancy of each factor separately, or, allowing either of the factors to vary, he can endeavour to compensate for the variation as closely as possible by producing an opposite variation of the other factor.

From a commercial point of view the first alternative would appear to be of doubtful practicability. It would mean that the primary impedance even at a frequency of, say, 300 cycles, must not be less than about 100,000 ohms, which would involve an inductance of the order of 50 henries in the primary winding and, of course, four or five times this amount in the secondary. Such a transformer, however well designed, would be of formidable bulk and probably no less formidable expense.

The second alternative would certainly seem to be the more hopeful. Even in this case, however, it is desirable to work for as large a value of *kf* as is practicable, in order to minimise the extent of the variation to be compensated for. In general this variation will be most pronounced in the region 300-1,000 cycles. What will be required therefore is a correspondingly rapid increase in ρf as the frequency decreases from 1,000 to 300. A preliminary investigation of the important factors in the variation of ρf would be necessary. It is probable that the study of the effect of varying the thickness of the iron laminations of the core (and also the material) would be a fruitful line of research, since the screening effect of the eddy currents in the core undoubtedly play a part in the variation of the transformation ratio.

There are, of course, other possibilities in the way of low-frequency amplification and, in the opinion of the writer, they should not lightly be disregarded. From a theoretical point of view the resistance-capacity type of coupling has a very great deal to recommend it. The design of resistances whose value shall be independent of frequency is a very simple matter. (They should preferably be of wire, to avoid unsteadiness in operation.) As far as constancy of amplification is concerned such an arrangement is almost ideal. From a practical point of view, however, it has the serious disadvantages of requiring very high anode potentials and yielding relatively low amplification—not more than about 5 to 7 per valve (whereas a transformer coupling can be made to give as much as 30 per valve).

There is a further alternative which seems to the writer to present very great possibilities, namely, the reactance capacity coupling. This is of course identical in type of connection and principles of operation with the resistance capacity coupling and differs from it only in the use of a comparatively low resistance impedance in place of the usual anode resistance. It will be seen on reference to curve 3 of Fig. 2 that an impedance consisting of an inductance of not less than about 50 henries with a resistance of a few thousand ohms would give a minimum amplification factor of about $\cdot 9\mu$, with not more than a 10 per cent. variation with frequency from 300 cycles upwards. The amplification so produced is of course considerably less than the maximum obtainable with transformer coupling. In efficiency three such stages would be about equivalent to two transformer coupled stages, but it is more than likely that the small extra cost would be amply compensated by the greater uniformity and purity of reproduction.

Reverberation and Binaural Hearing in their Aspect to Studio Damping.

By E. K. SANDEMAN, B.Sc.

Reverberation.

WHEN a sound is produced in any enclosed space by means of any suitable source, such as a musical instrument or the human vocal organs, the wave front is propagated radially until it meets with some obstruction such as the walls of the enclosure.

On striking the walls it is reflected according to the ordinary laws of reflection, in greater or less degree, giving rise to a new series of wave fronts at each surface of reflection, which in their turn strike the walls of the enclosure and are again reflected. The sound is actually reflected backwards and forwards an infinite number of times, diminishing in intensity at each reflection until finally the volume of reflected energy is so small that the ear can no longer detect its presence. This process is correctly termed reverberation and is often incorrectly called resonance which has quite another meaning.

The amount of energy which is reflected at each impact depends entirely on the nature of the medium which is hindering the progress of the wave. Reflection of energy in any form occurs when the energy meets a surface of separation of two media of different characteristic impedance. The characteristic impedance of a medium may be defined as the relation between the maximum amplitude of stress and the maximum amplitude of strain, where the stress applied is of sinusoidal form.

In the practical case for sound energy we say for convenience that the sound reflected from a given substance depends on the absorption coefficient for the substance, reflection in air being understood. The absorption coefficient for a substance (designated by α) is the fraction of sound which is absorbed when a wave front strikes it. The reflection coefficient then $= 1 - \alpha$.

A large amount of work has been done in recent years on sound absorption in its aspect to reverberation, but since the subject is probably new to most people it will be simplest to take examples from the original work of Professor W. C. Sabine, of Harvard University, to whom practically all the credit is due for placing this branch of science on sound lines of development.

In Sabine's original experiments his basic method consisted essentially in measuring by ear the time required for the reverberation due to a standard source of sound to reach the threshold of audibility (*i.e.*, to die away) after the source had ceased emitting.*

Starting with a bare room he brought in gradually increasing numbers of ordinary padded cushions and plotted the time of reverberation against the number of cushions. As the number of cushions increased he found, as might be expected, that the " time of reverberation " decreased. He found that the most effective method of damping was to have large areas of window open. He assumed, as seems to be very reasonable, that an open window represented 100 per cent. absorption and so was able to express the absorbing power of any material in terms of open-window units—an open-window unit being the absorbing power of 1 square metre of open window. If we express the absorption coefficient α of a substance per square metre of the substance, then on the assumption above, as we have already stated, the absorption coefficient represents the fraction of incident sound which is absorbed.

Some of the absorption constants obtained by Sabine and published in his original papers are given under.

ABSORBING POWER OF WALL SURFACES.

Open Window	1·00
Wood sheathing (hard pine)	·061
Plaster on wood lath	·034
Plaster on wire lath	·033
Glass, single thickness	·027
Plaster on Tile	·025
Brick set in Portland Cement	·025

ABSORBING POWER OF AN AUDIENCE.

Audience per square meter	0·96
Audience per person	0·44
Isolated woman	0·54
Isolated man	0·48

ABSORBING POWER OF SETTEES, CHAIRS AND CUSHIONS.

Plain ash settees	0·039
,, ,, ,, per single seat	0·0077
,, ,, chairs " bent wood "	0·0082
Upholstered settees per single seat	0·28
Chairs similar in style	0·30
Hair cushions per seat	0·21
Elastic-felt cushions per seat	0·20

In Fig. 1 is shown one of the original curves obtained by Sabine in his experiments in the Fogg Art Museum, relating the number of cushions brought into the room and the time of reverberation as defined above; cushions being the damping material then most immediately to hand.

It is evident from Fig. 1 that, by suitable damping, the "time of reverberation" of a room or chamber may be adjusted to any required degree.

This would have no practical value if it were not possible to relate the degree of damping to the requirements of musicians and their audience. Sabine made experiments with a committee of observers of musical accomplishment listening to a piano played in turn in five different rooms whose period of reverberation was adjusted until the acoustics as judged by ear were decided to give the best results.

The values of reverberation obtained are startling in their nearness to one another, showing that the exact degree of reverberation permissible is a very critical adjustment. They are so striking that they are given under :—

Rooms.	Reverberation time in Seconds.
1	0·95
2	1·10
3	1·10
4	1·09
5	1·16
Mean	1·08

Sabine remarks, " The final result obtained, that the reverberation in a music room in order to secure the best effect with a piano should be 1·08, or in round numbers 1·1 is in itself of considerable practical value; but the five determinations, by their mutual agreement, give a numerical measure to the accuracy of musical taste which is of great interest. Thus the maximum departure from the mean is 0·13 seconds, and the average departure is 0·05 seconds. Five is rather a small number of observations on which to apply the theory of probabilities; but, assuming that it justifies such reasoning, the probable error is 0·02 seconds—surprisingly small."

* With the limited means at his disposal it was very difficult to measure absolute value of sound intensity, it was possible however to measure relative intensity. He therefore employed as his initial sound a source such that the initial energy reaching the observer was one million times that at the threshold of audibility. The "time of reverberation" therefore represents the time required for the sound energy to decrease in intensity one million times. The actual sound generator was an organ pipe blown by air at constant pressure.

Binaural Hearing.

By binaural hearing we refer to the fact that the possession of two ears gives to the normal individual two pictures of a sound source which are simultaneously impressed on his mind.

This simple fact has many consequent results, some of which are so complicated that they have not been fully explained, while the physiological mechanism by means of which the two sound pictures are combined is very little understood.

A certain number of things have, however, been definitely established.

Just as the possession of two eyes has the advantage over one eye that stereoscopic vision is attained, so the possession of two ears has the advantage over one in that directive hearing is possible.

It is a fact that people who are deaf in one ear are able to locate a source of complex sound once they are familiarised with its nature, but it is not possible to locate by hearing a source of sound which is emitting a pure sinusoidal note when only one ear is available for observation.

The physical reasons underlying the location of complex sounds have been very fully discussed in an extremely interesting article by R. V. L. Hartley and Thornton C. Fry, Ph.D., in "Electrical Communication," Vol. 1, No. 4.

The authors point out that since we are conversant with three dimensions in our space the location of a source of sound requires at least three independent co-ordinates and that if more are obtained it is an advantage.

Normally in the case of a pure note we have :—

(*a*) The absolute intensity of the sound.
(*b*) The relative phase displacement at each ear.
(*c*) The relative intensity at each ear.
(*d*) The change in relative phase displacement at each ear on moving the head.
(*e*) The relative change in intensity at each ear on moving the head.

Of these (*a*) is of value only if the observer is familiar with the sound source, while (*c*) is possibly the one which might at first sight be expected to be of most importance, though there is evidence to show that (*b*) is of greater value in sound location, while (*d*) and (*e*) we must probably regard as being merely of effect in helping us to balance (*b*) and (*c*).

We have thus in the case of a pure note barely three co-ordinates by which to locate it.

In the case of a complex sound made up of two distinct notes we have double this number of co-ordinates, the corresponding accuracy of location being very much increased since it is possible to form combinations of co-ordinates giving separate data for location which may be checked one with another.

As sounds become more and more complex it is of course true that owing to the ear failing to differentiate clearly between all the notes or frequencies resulting, the degree of discrimination does not bear a simple relation to the complexity of the sound. This, however, is a small point which may be noted in passing.

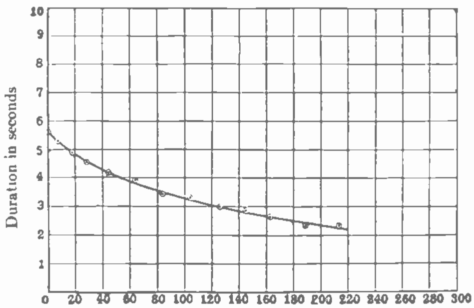


Fig. 1—Relation of reverberation to damping.

When a sound source and an observer are placed in an enclosed space, such as a room, the ears make use of their binaural advantage to discriminate between direct and reflected sound.* For this reason any person of normal hearing will find that by going into a room having a fairly large period of reverberation (an ordinary plaster wall room devoid of carpets and furniture will do very well) the echo effects are found to become very much more troublesome if one ear is stopped up, and the loss in intelligibility of speech is out of all proportion to the loss of loudness effect. It is rather

* This is possibly because the discriminating mechanism of the mind, having located a certain set of sounds as originating at a source, makes allowances for their difference in phase, which allowance is not made for the echoes, which cannot be located to a source.

difficult to describe the special effect of monaural hearing in words, but since it is so easy for anyone interested to make the experiment in an empty room it is not worth taking up space here.

We have already pointed out the futility of trying to understand how the mind assesses all the data and forms an estimate of location instantaneously, and it will probably be simplest to look at it from the generalised point of view of the psychologist. The location of sounds by hearing is undoubtedly an instinctive process which may be inherited and which is probably modified and developed subconsciously by the experiences in the life of the individual. In other words, by continually observing the nature of the sound sensation produced by a sound in a certain position the record of the subconscious mind eventually enables the individual to assign a definite position to each type of sound impression.

In the case of hearing it is surprising how easily it is possible to assign a direction to a sound without any other knowledge of the method of location than that the noise "sounds" to be in such and such a direction.

The Application of the above Principles.

The Western Electric Company have recently taken out a patent for an improved method of adjusting the acoustics of a studio in order to obtain the best results for the reproduction of music. At a risk of repetition the patent is outlined below almost in its original words.

The patent covers broadly a studio in which sounds may be recorded or broadcasted with substantially all the natural effects that an auditor listening directly to the sounds would receive.

In order to achieve this result damping material is provided on the walls to such a degree that the time of reverberation will be between 0·5 seconds and 1·0 seconds as determined by Sabine's method referred to above. This method is described in "Collected Papers on Acoustics," by W. C. Sabine, Harvard University Press, 1922, as are also the experiments referred to above.

To obtain the best results the damping material should be so disposed on the walls of the studio that there are no large parallel reflecting surfaces opposite each other, and arranged so that the sound waves may not travel around the room and back to the pick-up device (*i.e.*, transmitter) without striking a damping surface.

It will be noticed that the time of reverberation specified has as an average a time very considerably less than that determined by Sabine as being best for an audience hearing music directly. The reasons for this are then explained in the patent as follows :—

Experiments have shown that owing to the time of reverberation in a studio, there is produced on the listener a different acoustic effect, depending on whether he hears the sound with both ears or indirectly through a single pick-up device as in the case of reproducing sounds from records or from broadcasting. Under the usual conditions of hearing reverberation is always present to some extent and for this reason the effect produced on a person in a room damped so that there is no perceptible reverberation is not natural.

When a person listens to music or speech in a room he naturally uses both ears and is thereby enabled by his binaural sense to discriminate between the direct source and the reflections which constitute reverberation. He thereby subconsciously minimises the blurring effect of the reverberation.

On the other hand, when a person listens to the same sounds through a single pick-up device he no longer hears them binaurally and hence loses this ability to discriminate between the source and the reverberations and the sounds reproduced are displeasing. Since the usual recording and broadcasting apparatus is not binaural it is therefore necessary to decrease the time of reverberation, that is, to damp each sound so that it will not "hang over" so long. If this is not done the reproduced sounds become unnatural and if the reverberation is much too large the sounds will be blurred. The more sensitive the pick-up device to the weaker sounds the greater must be the damping.

It has been found that by damping the walls of a studio so that the time of reverberation will be between ·5 of a second and 1·0 second, as determined by Prof. Sabine's method, records made in a studio so damped will give an effect which is as near true binaural hearing as it is possible to obtain without actual binaural hearing. To most listeners this appears as natural as binaural hearing.

Low Consumption Dull Emitter Valves.

By W. E. MILTON AYRES, A.M.I.E.E., Mem.A.I.E.E.

In the November issue of "Experimental Wireless" some details were given of a number of dull emitter valves. Since then several new types have made their appearance, and we describe them below.

IN the November issue of this journal were given particulars of a number of dull emitter valves then available. Since that date a new series of valves has been placed on the market by various manufacturers which require a very small filament current and enable primary batteries to be used economically.

These new valves are all of the thoriated tungsten type of filament. According to the writer's experience, they are not unduly fragile, but, of course, must be handled with care. Apart from mechanical strength, they also have this feature in common that they may be easily spoiled by ill usage. In this respect, however, they have a decided advantage over the coated filament type of valve inasmuch as they can usually be recovered.

It is desirable that users of these valves should have a physical conception of their action, and this is best given by an analogy. The filament consists of a solution of thorium, or thorium compounds, in tungsten. Just as diffusion takes place in a gaseous or liquid solution (as, for instance, sugar will diffuse itself through water until the whole is evenly

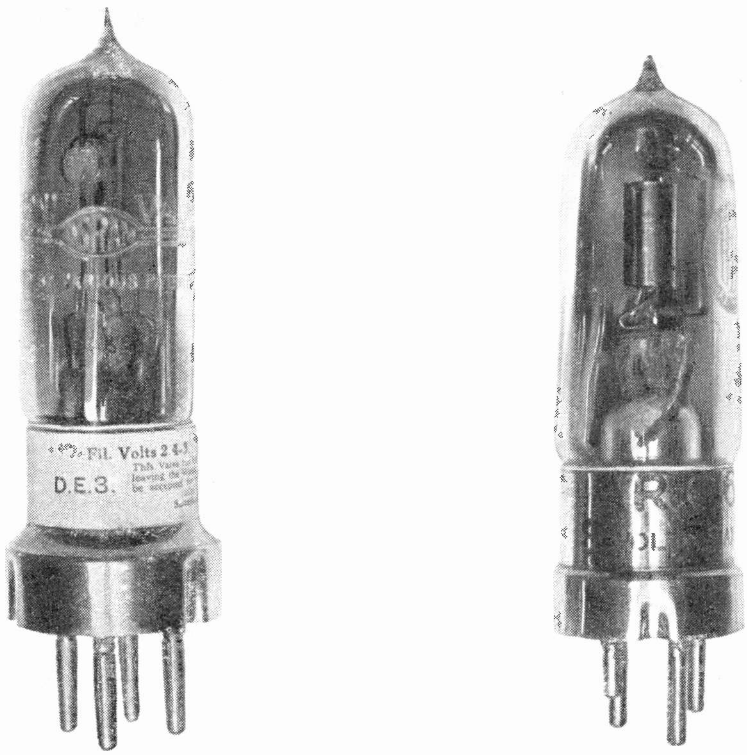


Fig. 1.—The "D.E.3" is a good general purpose valve, while the "AR.06" is an excellent H.F. amplifier and detector.

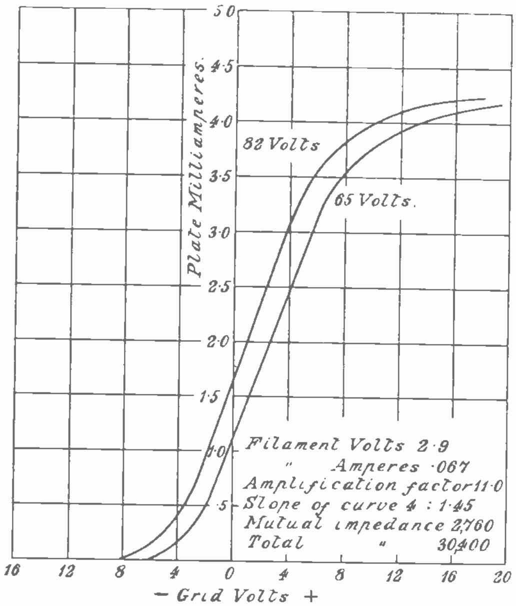


Fig. 3.—The Ediswan AR.06 has an amplification factor of 11 and a total impedance of over 30,000 ohms.

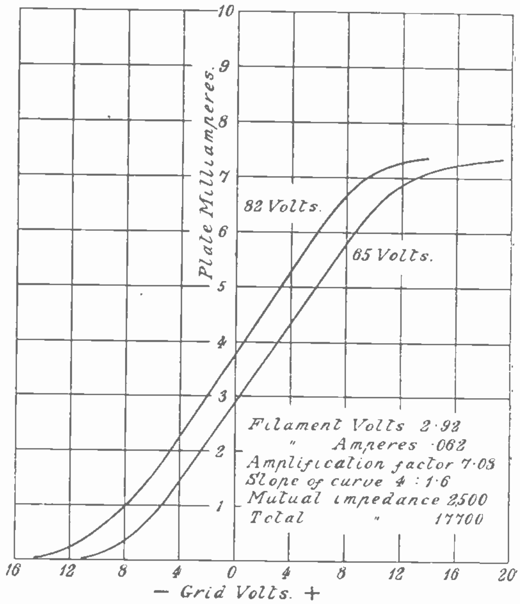


Fig. 3.—The General Electric Co. D.E.3 has a much lower impedance than the AR.06, but of course the amplification factor is only about 7.

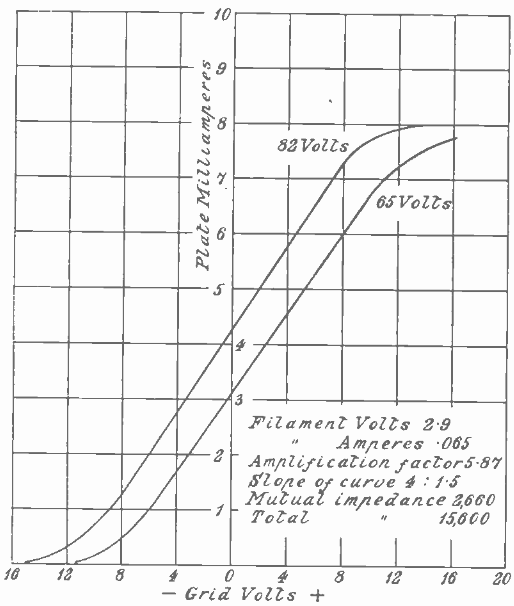


Fig. 4.—The French " Metal " is somewhat similar to the D.E.3 and AR. 06, the total impedance being a little lower while the mutual impedance is about 2,600 ohms.

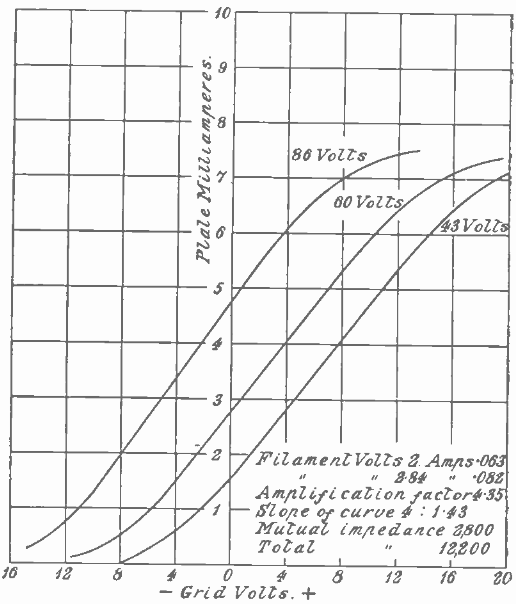


Fig. 5.—The Mullard D.F. ORA is slightly different from the three preceding valves in that it has a lower total impedance and a higher mutal impedance.

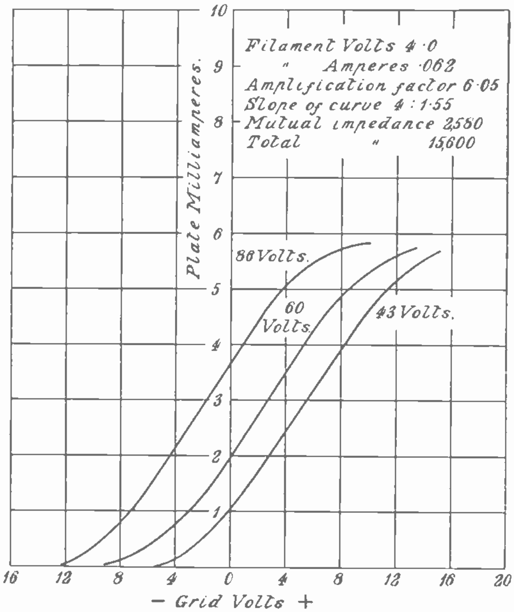


Fig. 6.—The B.T.H. B.5 is somewhat similar to the French Metal, but has a slightly greater amplification factor for a similar total impedance.

sweet), so one metal dissolved in another will diffuse itself throughout the mass, though usually only at an elevated temperature.

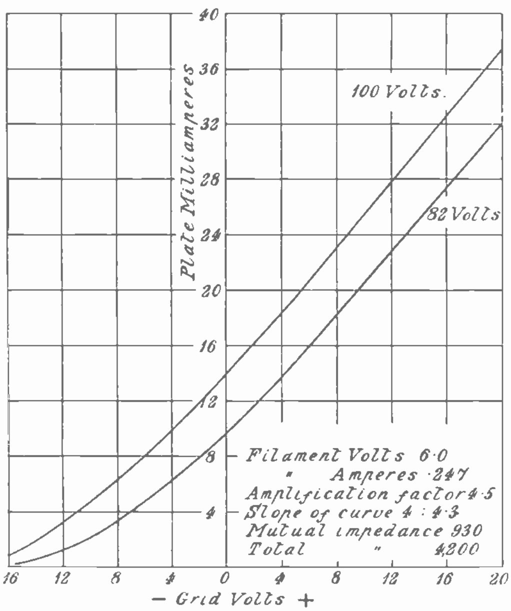


Fig. 7.—The B.T.H. B.4 with a μ of 4·5 and an impedance of 4,200 ohms is an excellent L.F. amplifier.

This process is used commercially in the case-hardening of steel, where carbon diffuses itself into the solid metal at a suitable temperature.

Thorium, as most readers will already know, is a radio-active substance, and breakes up into isotopes giving off " Beta " rays, or electrons, in the process. We have in the filament a solid mass permeated with this unstable radio-active substance, but

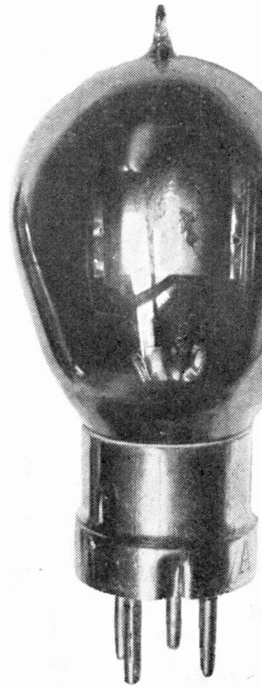


Fig. 8.—The B.4 consumes only 0·25 amp. Note the large flattened anode.

with a limited surface from which the electrons can be ejected. Suppose, for partial analogy, we imagine this as a long self-supporting column of water in which is dissolved an unstable salt, say, ammonium carbonate. The salt will diffuse through the liquid at a certain rate dependent upon the resistance offered to the migration of the free ions. This resistance decreases as temperature increases. There will be from the surface a certain evaporation of ammonia (NH_3) corresponding in our analogy to the emission

Fig. 9.—The construction of the B.5 is obscured by the magnesium getter.

of electrons. This rate of evaporation will depend upon the temperature, and can be considerably increased by warming, just as the electron emission is increased with increased brilliance (or temperature) of the filament. Now suppose this liquid column to be encased in a closed vessel and a vacuum pump applied. The evaporation of ammonia from the surface will be very much increased, and if suction is carried too far the evaporation might for a time be greater than the fresh supply by diffusion, and the "emission" of ammonia will fall in quantity. This is equivalent to applying a positive potential to the plate or grid of the valve, which has a suction effect on the negative electrons by electrical attraction. In this way the emission of a dull emitter valve may considerably fall in value by misuse.

The cure in either case is to keep up the accelerating influence in diffusion and stop the suction for a time ; in other words, keep the filament alight, but disconnect the H.T.

From the above analogy readers will see the reason for manufacturers instructions not to exceed a specified filament current (*i.e.*, temperature) and plate voltage (*i.e.*, electron attraction). They might also add a warning about positive grid bias.

We would not like to frighten any readers, however, into thinking that any excessive care must be taken with these valves. It is too early to state life tests on the new ·06 ampere filaments, but the writer knows of an ARDE valve taking ·25 ampere which has done 11,800 hours' service, and the emission is still up to standard. One of the valves of which curves are produced in this article was delivered from the manufacturer's showing a total emission of only 1·10 milliampere, but two hours' "cooking" without any plate voltage brought it up to standard. Following this another was deliberately "spoiled," and recovered to prove the adaptability of the method. The procedure sometimes advocated of flashing for a very brief period

Fig. 10.—The D.F. ORA has inclined electrodes which distinguish it from the ordinary ORA.

with 50 volts is much too risky a performance for the amateur, and has no advantage except in time-saving. Emission recovery should be considered as an extreme measure and its necessity avoided by proper use.

The six curves produced show that a remarkably high standard has been reached in this class of valve, in fact, they are much superior in performance to any high-temperature valves yet marketed. The average amplification factor is high and the emission is ample for ordinary loud-speaker operation.

AR.06.—The high amplification factor and plate impedance make this an ideal valve for H.F. amplification, and it is also a good detector not too critical of plate voltage.

B.5, *D.E*.3, *and D.F. Ora*.—These are good general-purpose valves and have sufficient emission for L.F. amplification when used for an ordinary loud-speaker. When used as detectors it is essential to keep the plate voltage down, and any using these valves in existing receiving sets which have only one + H.T. terminal should alter them to bring out a separate wander plug for the detector plate voltage. With this precaution these valves are excellent rectifiers. When used as L.F. amplifiers negative grid bias will usually be necessary.

B.4.—This is a power amplifier of very modest watt consumption. Those who have only heard a loud speaker operated from a general-purpose valve have a revelation in store when they try this excellent product, both from the standpoint of volume and quality. The price is also moderate.

Metal.—This is a French product of very good quality, and included here for comparison with our British manufactures.

In using any of the above valves as detectors it is very desirable to use a variable grid leak of reliable make. In general they require a low-resistance leak, but the value is fairly critical.

All dull emitters are, unfortunately, somewhat microphonic, and this cannot be avoided as the filament is not run at sufficient temperature to destroy its vibrant elasticity. By sturdier construction and eliminating spring from the filament supports this fault has been much reduced recently, so that the present valves are no worse than many of the high-temperature valves in use.

The Scientific Preparation of Fusible Alloys.

By J. FREDERICK CORRIGAN, M.Sc., A.I.C.

It is well known that some crystals if set in a fusible alloy are liable to be damaged if the fusion point is too high. Details of suitable alloys are given below, and should prove of value to those engaged on accurate crystal determinations.

THE radio experimentalist may often have observed that many of the specimens of so-called "fusible metals" which are at present upon the market by no means melt at the temperatures at which they are supposed to do. Several samples of "Wood's metal" which the writer has come across have exhibited melting points above 90 degrees Centigrade, and hardly one which he has tested has shown the correct melting point of the alloy. These facts, of course, may be due to carelessness or accidents which have occurred during the process of manufacture, but nevertheless they restrict the sphere of usefulness of the supposed low temperature melting alloy, and place it merely on a par with an ordinary soft solder.

The preparation of fusible alloys for experimental purposes is a procedure which is not altogether devoid of scientific interest, and often it is advisable for the radio experimenter to prepare for himself the particular low temperature melting alloy which he requires for his special purpose. The preparation of the alloys merely requires care and accuracy in working, and if these important factors are borne in mind very satisfactory products will be obtained.

Generally speaking, fusible metals may be divided into two main classes, *viz.*, those which contain a certain proportion of the metal cadmium, and those which contain bismuth in addition to cadmium and the rest of the necessary metallic ingredients of the mixture. The metal cadmium, when admixed with other metallic elements possesses the remarkable property of being able to lower the melting points of the other metals to an enormous extent, and for this reason alloys containing cadmium always possess very low melting points. Such alloys exhibit a considerable degree of ductility, and they can be rolled as well as worked with a hammer or other beating tools.

Bismuth alloys, on the other hand, whilst somewhat less expensive, are generally very brittle. Their melting points are not as low as those of the cadmium alloys, and they tarnish very rapidly when they are exposed to moist air. When they are immersed in hot water they become covered with a greyish-black film of oxide. These alloys are very useful for the purpose of taking castings of delicate objects. They expand to a slight extent on cooling, and thus a very clear and sharp-cut casting is obtained.

So much, then, for the general properties of the two classes of fusible alloys. Let us now proceed to a more detailed consideration of one or two of the more important and better-known examples of them.

Wood's Metal.

This substance is perhaps the best known of all the fusible alloys. As a reference to the table of cadmium alloys will show, Wood's metal consists of a mixture of 2 parts of cadmium, 2 of tin, 4 of lead, and 5 parts of bismuth. When carefully prepared it should possess a melting point of 158° F., and it should become very soft and plastic at several degrees below this temperature. The alloy is quite malleable and it has a metallic appearance not unlike platinum. The addition of 1-16th part by weight of mercury to Wood's metal lowers the melting point of the alloy to a considerable extent.

Lipowitz's Metal.

The above metal is another cadmium alloy whose composition is given in the above quoted table. The alloy becomes quite plastic at a temperature of 140° F., and at 158° F. it melts completely. It has a silvery lustre, and it can be polished and worked in almost any fashion. The alloy is very suitable for the purpose of soldering thin strips of lead and tin in those cases in which the use of ordinary solder would be inadmissable. On account of its silvery appearance Lipowitz's metal is very useful for soldering nickel.

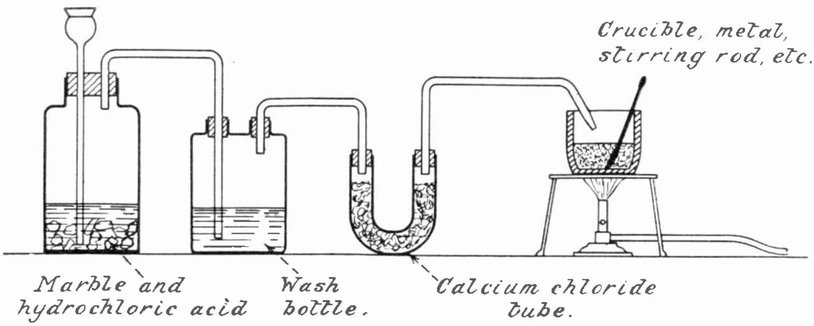


Fig. 1.—Suitable apparatus for the preparation of alloys.

Rose's and Newton's Alloys.

These alloys do not contain any cadmium, and consequently their melting points are higher than those possessed by metals which contain an admixture of the latter element. Their exact composition and melting points will be apparent from a glance at the table of bismuth alloys. These fusible metals find many uses in general scientific instrument making. Formerly, plugs of the alloys were inserted into the tops of steam boilers, it being supposed that they would melt at fixed temperatures. However, several disastrous explosions occurred with boilers in which the safety plugs had been fitted, and upon subsequent examination and enquiry it was discovered that under the prolonged influence of moist steam and high pressures, the composition of the alloys undergoes a complete change, and compounds possessing a much higher melting point are formed. Consequently the use of these alloys for the construction of safety devices in boilers and other mechanical structures has been discontinued.

Method of Preparation of Fusible Alloys.

When a metal such as tin, cadmium, or lead is exposed to the atmosphere in a molten condition its surface rapidly becomes covered with a dull film of oxide. The non-realisation of this fact is one of the underlying causes of the failure of many amateurs to prepare fusible metals which really melt at their appointed temperatures, for a certain proportion of the metal is used up in forming the oxide, and thus the exact proportions which are required for the particular alloy are not maintained in the mixture.

Again, a fusible alloy must be entirely homogeneous in composition. That is to say, it must possess the same composition at all parts of its mass. It is very easy to throw the various metallic constituents of a fusible alloy into a heated crucible, and then to trust to luck and the guidance of Providence to do the rest. However, the constituents of the alloy have all different specific gravities,

Metal.	Melting Point (Degrees Fahr.)
Tin ...	437
Bismuth ...	520
Lead ...	620
Cadmium ...	609

Table Showing the Melting Points of the Constituent Metals of Fusible Alloys.

and they will form separate layers of molten metal if the contents of the crucible are not thoroughly stirred during the whole of the melting operation. Therefore when preparing fusible alloys the molten metal ought to be continually stirred with a thin stick of hard wood.

The question of the change in composition of the alloy which may result owing to oxidation whilst it is in a molten condition is another point which requires attention if the best results are to be obtained. Personally, the writer has, to a great extent, overcome this difficulty by allowing a jet of carbon dioxide (carbonic acid gas) to flow into the crucible during the whole of the proceedings. By this means air is almost entirely kept out of contact with the surface of the molten metal, and thus oxidation is prevented. The diagram (Fig. 1) will make the arrangement of the necessary apparatus clear. Carbon dioxide is generated in a large bottle by the action of hydrochloric acid (spirits of salts) on marble, chalk, or limestone. Before being allowed to flow into the crucible the carbon dioxide should preferably be freed from any acid vapours which may accompany it by passing it through water, and with advantage it may also be dried by passage through a U-tube containing anhydrous calcium chloride.

In all cases the metals should be alloyed on their exact proportions by weight, the

COMPOSITION. (Parts by Weight.)

Melting Point.	Tin	Lead.	Cadmium.	Bismuth.	Name.
158° F.	2	4	2	5	Wood's Metal
158° F.	4	8	3	15	Lipowitz's Alloy.
167° F.	3	8	10	8	—
170° F.	3	11	2	16	—
204° F.	3	—	1	5	—
300° F.	4	2	2	—	Very Soft Solder.

Table Showing the Composition and Melting Points of Various Fusible Alloys Containing Cadmium.

COMPOSITION. (Parts by Weight.)

Melting Point.	Lead	Tin.	Bismuth.	Name.
197° F. ...	3	2	5	Lichtenberg's Metal.
200° F. ...	1	1	2	Rose's Metal.
202° F. ...	5	3	8	Newton's Metal.
205° F. ...	6	2	8	—
211° F. ...	9	7	16	—
212° F. ...	3	4	8	—

Table Showing the Composition and Melting Points of Bismuth Alloys.

metal which possesses the highest melting point being melted first. It is quite unnecessary to attain a very high temperature. Indeed, such a degree of heat is inadvisable, for it promotes the rapidity with which the metals will oxidise if the surrounding atmosphere is allowed to come into contact with them. The temperature of the crucible ought only to be slightly above that which is required to maintain in a thoroughly molten condition the metallic constituent which has the highest melting point.

Iron crucibles are quite suitable for the work described above, but unless the fusible alloys are made in considerable quantities at a time, a certain amount of waste is bound to occur. Crucibles made of graphite, such as are used by jewellers for the alloying of rare metals are cleaner and more efficient for the purpose in every way. Not only do they help to prevent the oxidation of the metal, but they possess the very great advantage of not allowing the alloy to cling and adhere to their sides when it is poured out. Thus, a good deal of wastage is obviated.

Of course, graphite crucibles are more expensive than those which are made of iron. They are also very brittle, and require much more care and attention than iron crucibles. Nevertheless, their employment for the purpose of preparing small quantities of metallic alloys is to be recommended.

From the foregoing description of the effective production of fusible alloys, it will be seen that the process is by no means a haphazard one. If fusible alloys which possess correct and accurate melting points are to be obtained their preparation must be very carefully carried out. The production of these alloys, however, is well worthy of attempting, for, besides the cementing of rectifying minerals and crystals in their cups, fusible metals find various other uses in radio and scientific experimental work, all of which, however, are rendered more or less inefficient if the alloy does not melt at its appointed temperature.

Ex-W.D. Oil-Immersed Smoothing Condensers.

MANY readers are, no doubt, familiar with the external appearance of Disposals Board 1 mfd. condensers contained in rectangular iron cans, with insulated terminals and a screw-plug for filling with oil. It often happens that these condensers may be picked up cheaply, but are found to be defective in some way. For instance, the condenser may not hold its charge, or the connections to the condenser elements may appear to have gone completely. This does not invariably mean that the condenser is useless, as the can actually contains four one-microfarad condensers, and the probability is that only one, or at the most two, of them are defective. These condensers are of the rolled type, but have a considerably higher dielectric strength than the ordinary " dry " " tinned " Mansbridge type, and will readily stand 600 volts if in good condition. It will be found that the condensers are arranged in two pairs of two in parallel, the two pairs being in series, thus giving a total effective capacity of 1 microfarad capable of standing 1,000 volts or so.

The interior of the condenser case is best got at by removing the top side (containing the screw-plug). This is soldered on, and may be removed by running a bunsen or blowlamp flame round the edge to melt the solder, the top being prised off at the same time by means of an old screwdriver or similar tool inserted in the joint. Before attempting this operation, however, it is necessary to empty out all oil as far as possible. On no account should the screw-plug be left in during the process, and it is advisable to confine the heating as far as possible to the edge to be unsoldered in order to reduce the vaporisation of any residual oil, and to avoid scorching the condensers inside. Once the top of the can is removed, the four condensers may be examined individually, and the defective ones isolated. Sometimes even the broken-down condensers are not altogether useless if the puncture is located in the outer layers, as in this case it is only necessary to unroll the condenser until the defective part is reached (usually indicated by a charred patch) and cut off the unrolled part.

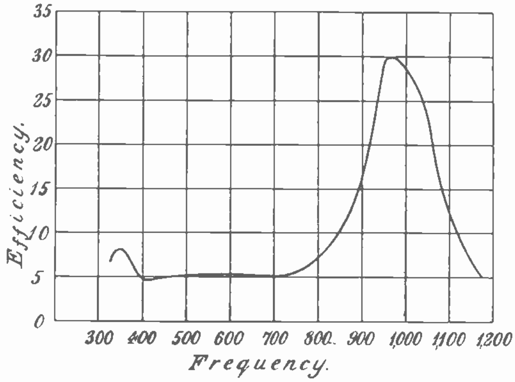
E. H. R.

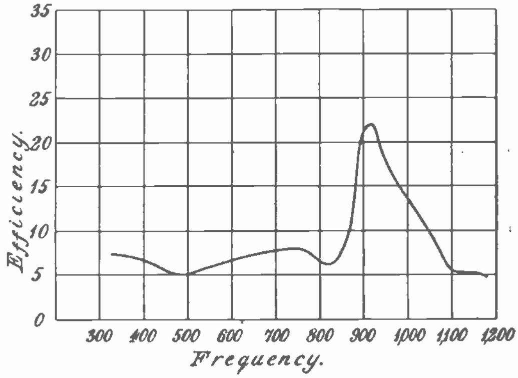
The Damping of Diaphragms in Telephone Apparatus.

By C. M. R. BALBI, A.C.G.I., A.M.I.E.E.

IT is interesting to note the recent change of attitude of the scientific world towards "resonance" in telephone apparatus.

In the early days it was the aim of manufacturers to design a "receiver" that had a greater degree of resonance than any of their competitors; after having done this they would erroneously claim that they had obtained the most efficient form of receiver on the market.





Figs. 1 and 2.—Two typical resonance curves of well-known makes of telephone receivers.

The reason for this can be readily understood when it is remembered the demand for a sensitive headphone was chiefly in connection with the reception of very weak signals in Morse telegraphy from wireless spark transmitting stations. In this case a chopped wave was arranged to give a musical note of about 1,000 cycles-sec. and sensitivity was only required at this frequency; but in present days when it is found messages can be sent so much more quickly and effectively by word of mouth a gain of efficiency obtained at the expense of resonance has become to be regarded with mistrust, as in this case it is essential that messages shall be as clear as possible.

Figures 1 and 2, which are representative of two well-known types of receiver, illustrate the degree that the mechanical resonance of a receiver diaphragm has on its efficiency.

The effect of resonance is threefold.

First.—The efficiency is raised at the resonant point.

Secondly.—The amplitude of a note at the resonant point is not proportional to the amplitude of other notes being reproduced.

Thirdly.—A note pitched at the resonant point is sustained.

The condition for perfect reproduction is that the efficiency of a receiver is constant at all frequencies as shown in Fig. 3.

The bad effect that resonance has on the quality of reception is obvious; it is sometimes difficult to understand how intelligibility is retained. Although it is known that after practice the ear becomes accustomed to the new conditions and treats the reception as if it were some new person speaking with a rather peculiar voice.

However, where the accurate reproduction of delicate sounds is required, like the notes of a violin solo on a loud speaker or in certain experiments where "Audiometric" measurements are being made, it is necessary to damp out resonance.

If such means as the placing of some soft substance, such as cotton wool, between the diaphragm and the ear-cap is adopted the resultant damping not only reduces the tendency for the diaphragm to resonate,

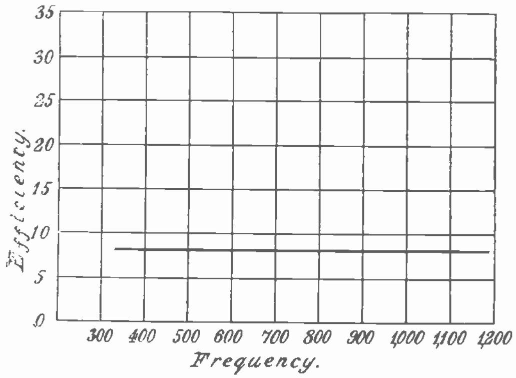


Fig. 3.—Form of desirable response curve.

but it also greatly reduces the effect of the forced vibrations, as can be seen from Fig. 4.

Other patent specifications covering different methods of applying mechanical friction to the diaphragm have this defect, but a system of electrical damping devised by Mr. J. T. Irwin has great advantages over the former methods.

Mr. Irwin has shown that by shunting the electrical system of an electro-magnetic receiver by means of a Capacity, Inductance and Resistance as shown in Fig. 5, the free vibrations of the mechanical system can be damped out.

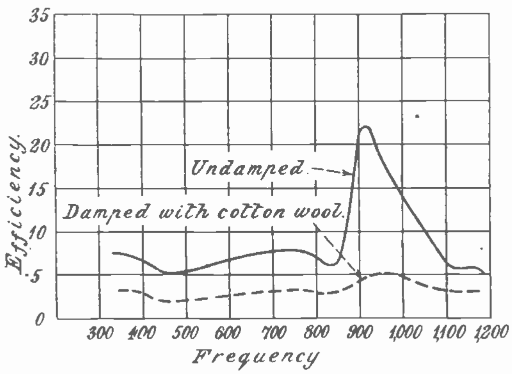


Fig. 4.—Showing effect of response by damping with cotton wool.

By suitably arranging the values of the apparatus in the shunt circuit, "Critical" or any required degree of damping may be obtained.

The first condition is that the capacity and the inductance when closed on themselves should be equal to the resonant period of the receiver diaphragm, this then fixes the product of the inductance and capacity.

Thus if L is the value of the inductance and C is the value of the capacity then $\frac{1}{LC} = w^2$, where w is 2π times the natural frequency of the diaphragm when undamped.

The second condition is that the relation $R_1 + R_2 = \frac{2}{Cw}$ has to be satisfied to make the electrical circuit dead beat, so that the deflection due to a current of a certain value when applied suddenly does not exceed that due to the same current when brought up to this value gradually, where R_1 is the

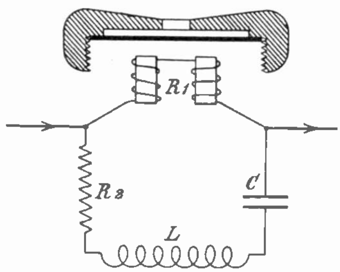


Fig. 5.—Arrangement of circuit to damp out free vibrations.

resistance of the receiver and R_2 is the total value of the resistance in the shunt circuit.

Lastly the ratio R_2 to $R_1 + R_2$ depends upon the ratio of the residual damping of the receiver itself including the damping set up by the action of the eddy currents in the diaphragm that would be required to make it dead beat without the resonant shunt, *i.e.*,

$$\frac{R_2}{R_1+R_2} = \frac{\text{Mechanical damping actual}}{\text{Mechanical damping to secure dead beat condition}}$$

These relations determine the values of the capacity, inductance and resistance to make the movements of the diaphragm dead beat for any applied current. The degree of damping required may be altered by varying the value of R_2.

The Neon Lamp as an Oscillation Generator.

By H. St. G. ANSON, F.P.S.L.

In the October, 1923, issue of "Experimental Wireless" considerable nformation was given on the use of Neon Lamps for wireless purposes. Below will be found an analysis of the conditions obtaining during the process of the production of oscillations and should be of considerable value to the advanced reader.

NUMEROUS articles have appeared in the technical press relating to the oscillations produced by neon lamps when connected in series with a resistance, and in parallel with a condenser. It is thought that it may be of interest to summarise a previous paper* which shows in what manner the frequency of the flashes may be calculated from the constants of the circuit.

Let us look at the fundamental circuit which is shown in Fig. 1. It will be understood that no current will flow until the voltage across the electrodes rises to a definite value—that is, the ignition voltage of the lamp—and therefore the resistance will be infinite for all values of voltage up to the value at which the discharge commences. When a condenser of capacity K farads is connected in series with a high resistance R, and a constant voltage V is applied to the ends of the circuit, the condenser will begin to acquire a charge, and the voltage v across its terminals will rise according to the law—

$$v = V\left(1 - e^{-\frac{t}{KR}}\right)$$

where t is the time in seconds after switching on the voltage. If the lamp is connected in parallel with a condenser, as in Fig. 1, it will flash on as soon as the voltage across the condenser reaches the ignition voltage. When this occurs the condenser becomes shunted with the low resistance of the glowing lamp, and consequently loses its charge. This continues until the voltage across it falls to the extinction voltage. If a and b represent the ignition and extinction voltages respectively, the glow will continue while the voltage falls from a to b. As soon as the glow ceases the condenser will charge up again from b to a, and so the process is carried on indefinitely. As we have already stated, the duration of the dark period is the time taken for the condenser to charge from b to a. Call this time T_1.

$$\text{Then } T_1 = K\,R\,\log\,(v-b)/(v-a)$$

In order to calculate the duration of the light period it is necessary to know the manner in which the resistance of the glowing lamp varies with the voltage across the electrodes. Fig. 2 shows a typical characteristic curve for a neon lamp, and from it

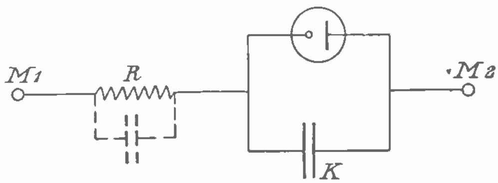


Fig. 1.—A circuit normally used for the production of oscillations.

we can deduce an expression for the resistance in terms of the voltage across the electrodes.

Put $\cot\theta = r^1 = (v - v_0)/c$

Now $c = v/r$

Where r = the effective resistance of the lamp,

$$\therefore\ r^1 = r\ (v - v_0)/v$$
$$r = vr^1/(v - v_0)\ \text{ohms}$$

We are now in a position to find the duration of one light period. Let v = the voltage across the condenser at any time seconds after the commencement of the flash.

When $t = o$ $v = a$

Charging current flowing through R from the supply will be—

$$i_1 = (V - v)/R$$
where V = the constant applied voltage.

The current flowing through the lamp will be—

$$i_2 = v/r = (v - v_0)/r^1$$

The resultant current flowing from the

* *Proceedings. Physical Society of London,* Vol. xxxiv. Part v, 1922.

condenser, or the rate of discharge, will be—

$$\begin{aligned} i &= i_2 - i_1 \\ &= (v - v_0)/r^1 - (V - v)/R \\ &= v\ \ (1/R + 1/r^1) - (V/R + V_0/r^1) \end{aligned}$$

Also rate of discharge

$$i = -\frac{dq}{dt} = -K\frac{dV}{dT}$$

Hence $\frac{dv}{dt} + \frac{1}{K}(1/R - 1/r^1)v - \frac{1}{K}(V/R + V_0/r^1) = O$

The solution of which is :

$$v = \frac{Vr^1 + v_0R}{R + r} + Ae^{-\frac{R+rI}{KRvI}}$$

Where K is a constant which can be determined from the original conditions, when $t = o,\ v = a$.

Hence $$A = \frac{Vr^1 + v_0R}{R + r^1}$$

Therefore the voltage across the lamp

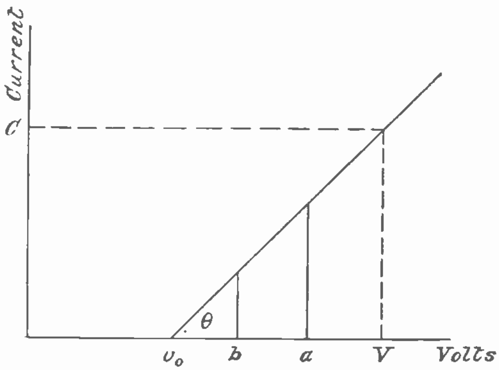


Fig. 2.—A typical characteristic curve for a Neon lamp.

at any time t after the commencement of the flash is given by—

Let $$v = \frac{Vr^1 + v_0R}{R + r^1}\left(1 - e^{-\frac{R+rI}{KRrI}t}\right)$$

$$+\ aE^{-\frac{R+rI}{KRrI}t}\ \frac{Vr^1 + V_0B}{R + r^1} = Q$$

Then $$v = Q + (a - Q)\ e^{-\frac{R+rI}{KRrI}t}$$

When v falls to b—

$$t = T_2 = \text{duration of flash.}$$

Therefore $$b = Q + (a - Q)\ e^{-\frac{R+rI}{KRrI}q}$$

Or $$T_2 = \frac{KRr^1}{R + r^1}\ \log\ \frac{a - Q}{b - Q}$$

Where $$Q = \frac{Vr^1 - V_0R}{R + r^1}$$

Hence the total time of a flash and a dark period is given by—

$$T = KR\left(\ (\log\ \frac{V - b}{a - v} + \frac{r^1}{R + r^1}\ \log\ \frac{a - Q}{b - Q}\right)$$

It will be noticed that the first term is independent of the lamp characteristic, while the second is modified by the design of the lamp. This theoretical formula agrees quite closely with observed values of frequency when we are dealing with low frequencies, but diverges slightly at the higher values, indicating that, perhaps, we have overlooked some effect.

It may be of interest to just state that there are several other methods of producing oscillations by means of Neon lamps. Among the better ones are the following :—

Some lamps of the beehive type have the pressure so adjusted that on slightly reducing the voltage below the normal a pencil of positive rays will jump out from the wires of the cathode. If the lamp is put into a magnetic field oscillations will be produced. The frequency of these oscillations will depend on the slope of the characteristic curve of the lamp, the strength of the magnetic field, the value of the series resistance used, and the voltage applied to the ends of the circuit. Alterations of supply voltage will have the reverse effect on the frequency as in the previous case. Often the two types of oscillations may be simultaneously generated in the same tube. If the voltage is altered, the frequency of one will rise while the other will fall.

In some neon lamps oscillations may be produced even when there are no special connections or arrangements. This may be due to convection currents in the gas, which might cause a reduction of molecules in the vicinity of the electrodes. If a Neon lamp is run for a short time on a very high voltage the electrodes will become white hot and an arc will be formed. If tungsten electrodes are used this arc can be maintained at a very low voltage. If an inductance in series with a condenser is connected across the lamp when it is in this condition strong oscillations will be produced, owing to the negative resistance of the arc. Finally, I wish to offer my thanks to Mr. S. O. Pearson, B.Sc., for his great help with the mathematical portion of this paper.

A Source of Loss in High-Frequency Valve Circuits.

By CAPTAIN ST. CLAIR FINLAY, B.A., B.Sc., D.S.E.

Every experimenter is familiar with valve interelectrode capacity but possibly some do not realise its effect. This is discussed below and practical suggestions are offered.

If we consider any arrangement of a valve wherein the grid is directly connected to the filament by a resistance or leak, it becomes evident that a certain leakage of alternating currents must occur when such currents are applied to the grid circuit of the valve across such resistance or partial conductor as is usually the case, the aggregate leakage being due to component leakages of two kinds, *viz.* (*a*) conductive, along the resistance, and (*b*) capacitive, across the resistance—the amount of such leakages, individually and collectively, being dependant, other things being equal, upon (*a*) the conductance of the resistance, (*b*) the value of the capacity, and (*c*) the frequency of the alternations.

Examining first the conductive leakage (*a*), we find, firstly, that in the usual case where this is used across a condenser for the purpose of applying a negative bias to the grid of the valve or to discharge a condenser conveying potential variations thereto in

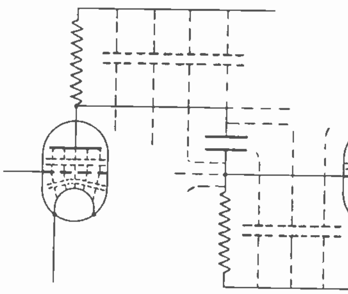


Fig. 1—Illustrating the capacatative losses in resistance coupling.

synchrony with such variations, such conductance will be very small and usually less than half the internal conductance of the valve itself, so that loss arising therefrom may in general be dismissed as negligible except in certain cases of transmitters where the conductance of the grid-leak may exceed half that of the valve.

A point also arises that the A.C. conductance of a leak varies inversely with the frequency, but as the order of conductance

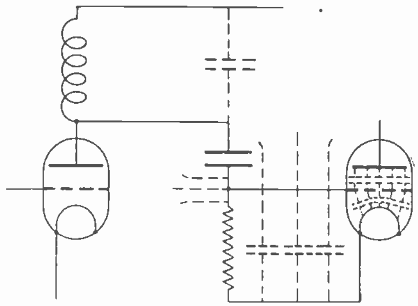


Fig. 2—A standard inter-valve coupling. Here the inherent capacity resonates the anode circuit, but still causes loss in the grid circuit.

is usually negligible, as stated above, it may in general be taken that such variation is also negligible in its influence upon loss.

Considering the second and third factors (*b*) and (*c*), however, we find from the formula

$R = \frac{1}{2\pi n C}$, where R=H.F. resistance or reactance of a capacity, C=capacity, and n=frequency, that the conductance or loss from this cause is directly proportional to both the capacity and the frequency, and from an examination of the representative valve and circuital characteristics in this connection we may deduce the order of loss arising from this cause in practice.

Taking an average example of a three-electrode valve suitable for high-frequency amplification, we find an internal inter-electrode capacity of the order of ·003-·005 milli-microfarads or ·000003-5 μF, and this at a frequency of 3,000,000 cycles, corresponding to λ 100, gives us a reactance or internal impedance of the order of 15,000 ohms.

The internal resistance of such a valve will be of the order of 250,000 ohms, and in a resistance amplifier optimum amplification might be expected with an anode resistance

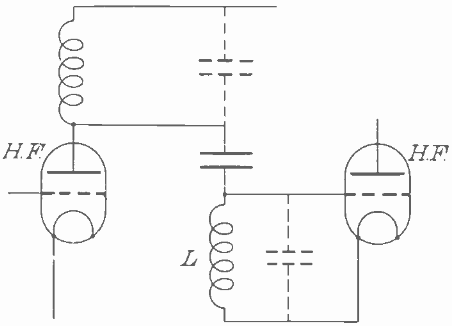


Fig. 3—A similar coupling to Fig. 2 but using inductance in the grid circuit. Both circuits are now resonant and capacatative losses are thus reduced.

of some ·5 meg-ohm, but across this resistance we have the internal valve capacity offering a H.F. path of R 15,000 ohms only, so that the effective resistance cannot exceed the latter figure.

Turning now to the circuital capacitance, we find that this, due to wiring, terminals, etc., will commonly be of the order of ·000005 to ·00002 μF in a well-designed receiver, and cannot in any circumstances be reduced much below the former figure, so that, assuming ·000006-8 μF in a reasonably favourable case, we find the shunt impedance at 3,000 kilo-cycles to be of the order of 7,000 ohms, which, considered conjunctively with that of the valve as determined above, gives a total shunt capacity across the anode resistance of some ·00001 μF with impedance of the order of 5,000 ohms only, and this will represent the *effective* resistance of the anode resistance at that frequency, no matter how much greater its actual ohmic resistance may be.

Now, since the voltage amplification obtainable will, other things being equal, depend in such an amplifier upon the ratio of external to internal effective resistance as shown by $A = \mu \times \frac{R}{Rp + R}$ where R = external effective resistance, Rp = internal effective resistance, and μ = amplification factor of the valve, and if we regard—as an analysis shows that we may in fact regard—the internal effective resistance as represented by the ohmic resistance and the capacitive reactance in parallel = 15,000 ohms nearly, taking a practical average for $\mu = 8$, then $A = 8 \times \frac{5{,}000}{15{,}000 + 5{,}000} = 2{\cdot}0$, so that the loss amounts actually to 75 per cent. in the one (anode) circuit alone.

This is a prohibitive figure, and demonstrates the inefficiency of resistance coupling for H.F. amplification on short waves, a fact which is, of course, generally recognised.

But let us now consider the grid circuit of a valve under similar conditions. Here, common practice connects the grid to the filament conductively by means of a non-inductive resistance of a value between 5,000 ohms and 5 meg-ohms, the actual value in general considerably exceeding the internal grid-filament resistance of the valve, so that the conditions remain substantially as discussed above.

In these circumstances such an arrangement constitutes, in fact, a resistance coupling applied to the grid of the valve instead of the anode and the effect of capacitance

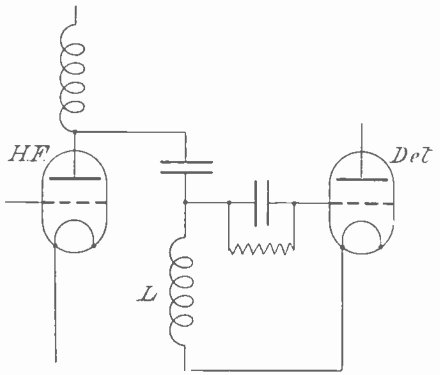


Fig. 4—A form of coupling combining the functions of resistance and inductance in Figs. 2 and 3, suitable for intervalve detector coupling.

across it will evidently be identical, *i.e.*, it will constitute a shunt path across the resistance causing losses which will be directly proportional to the frequency, so that at the high frequencies of the shorter waves such losses may, and actually will, reach such serious proportions as cannot reasonably be neglected.

Therefore, it is necessary in short-wave work to consider the grid circuit not less carefully than the anode circuit, and where a given form of coupling is unsuitable in the one case, it must logically be regarded as unsuitable in the other also.

In practice, inductance is used in the anode circuit in lieu of resistance for short waves for the reason that, if the values of inductance and capacity be suitably proportioned, the resultant *resonance* will produce a high value of impedance to a given oscillation frequency, and the inevitable capacity will thus become useful instead of merely a source of loss, tending to maintain voltage amplification by reasonance. Under

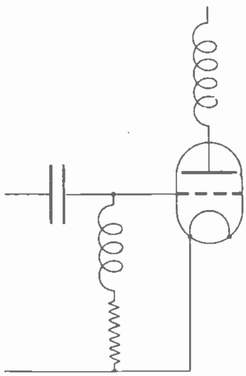


Fig. 5—Here the inductance and resistance are in series ; a common arrangement in transmitters.

these conditions the circuit becomes an infinite-impedance loop or rejector circuit, the effective resistance of which will be $\frac{L}{CR}$, where L=inductance, C=capacity, and R=ohmic resistance of the circuit, so that if as before C=·00001 μF, and L=300 μH to tune to 3,000 kilo-cycles=λ 100, so long as R is small compared with the internal effective resistance of the valve as will usually be the case, the effective resistance of the circuit will be practically infinite compared with that of the valve and the resultant amplification almost equal to the μ factor of the valve, the loss being consequently very small. Actually, we can show by analysis that it should not in the general cases exceed 20 per cent., since R will always be almost negligibly small compared with the internal resistance, and R=effective resistance of the circuit, therefore nearly always more than twice that of the valve, under which conditions A must exceed 90 per cent. of μ, or, deducting minor losses, say, 80 per cent.

This is a very different matter from the preceding case where A=25 per cent. only, and if this is true of the anode circuit it is true of the grid circuit also—wherefore it is evident that inductance should be used in the grid circuit of a valve handling H.F.

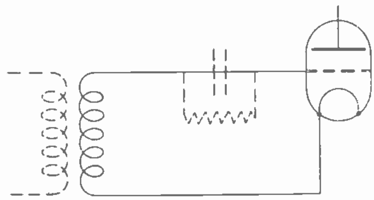


Fig. 6—In a single detector or transformer coupled stage the grid circuit normally forms an infinite impedance loop.

currents, and not resistance, in so far as the H.F. component is concerned.

Since, however, resistance may in practice be essential to a certain function of the grid connections, it becomes necessary to consider in what manner inductance may be arranged to supersede it in so far as the H.F. currents

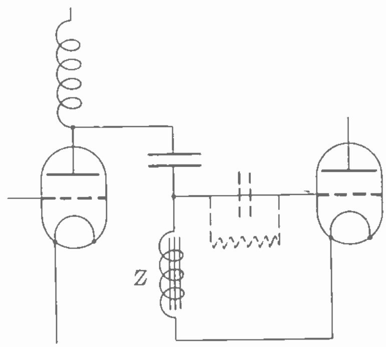


Fig. 7—An iron-cored choke is used here in place of L. A form of coupling particularly suitable for short waves.

are concerned without disturbance of such other functions.

In the case of a transmitter having a grid leak resistance of a few thousand ohms only the actual conductive loss along such leak may be considerable, and it is usual in such cases to place the inductance in *series* with the resistance to form a H.F. choke. Under such conditions we have inductance and resistance in parallel with a capacity, and the arrangement becomes a more or less highly damped rejector circuit according to the value of the resistance, R being now usually considerable compared with the internal effective resistance of the valve, so that the impedance no longer approaches infinity, and the loss will consequently be greater than that of the same circuit without the resistance ; but it will still be less than that across the resistance without the inductance, so that the latter may be said partially to serve its purpose—often to a highly important extent in practice.

But in the case (of a receiver) where the value of grid leak resistance will be comparatively high and usually more than twice that of the valve itself such an arrangement is not necessary, since the conductive loss may be regarded as negligible, and would in any case be ineffective since R would now be so large as to reduce the impedance of the circuit to little more than that due to its capacitance, which is the very effect we desire to avoid, so that here it is essential that the resistance be otherwise than in series with the inductance.

If we place it in parallel with the inductance the impedance of the circuit can be raised practically to that due to the inductance and capacity alone, since the conductance of the leak is in this case negligibly small, but this, on the other hand, may not suit the function of the resistance in the circuit.

A practical arrangement whereby the functions of both resistance and inductance may be fully preserved is shown in Fig. 4, and the impedance of the circuit can now be shown to be practically infinite and loss generally less than 20 per cent., as against the 75 per cent. of the standard arrangement of Fig. 2 at λ 100.

It will be observed that this condition actually exists in the usual arrangement of a single valve used as a detector and in transformer-coupled stages, in which the leak (if any) is connected directly across a condenser and the existence of a grid coil provides the inductance, the grid circuit in this case normally constituting an infinite-impedance loop ; and this fact may be responsible for an impression that H.F. amplification is in itself inefficient on short waves, or that transformer coupling is actually more efficient than, for example, reactance capacity coupling, whereas if logically applied no such discrepancy exists.

We have assumed, of course, a condition of resonance, *i.e.*, that the grid circuit is actually *tuned*, and as this would manifestly increase the complexity of the apparatus and render it less convenient to operate it may be thought that the ordinary arrangement of simple leak must remain the more practical and therefore preferably be retained, notwithstanding its imperfection ; but consideration of the matter will show that, whilst full efficiency certainly demands tuning of the grid circuit, an important measure of improvement will still be obtainable when that circuit is but roughly tuned or even semi-aperiodic, so that in a short-wave receiver, for example, a single coil—even untapped—can be designed to cover a band of say λ100-200 or 200-500 sufficiently well to offer considerably greater impedance than the usual non-inductive resistance, of whatever value, shunted by a natural capacity of the common order of ·00001-2 μF.

Further, the action of iron-cored chokes with high-frequency oscillating current may with advantage be considered in this connection.

It is evident from the formula $Z = \sqrt{(2\pi n)^2 L^2 + R^2}$ that the impedance of such a choke to oscillating currents is dependant not only upon the values of inductance and ohmic resistance of the winding, but increases particularly with the frequency, so that its effectiveness may be expected to approach a maximum on short waves, where it is particularly required, and, since the value of L can conveniently be made considerable, the impedance of the circuit can readily be made much greater than that of a circuit possessing only resistance and capacity ; and since moreover no tuning will be necessary such improvement will be obtainable without complication whatsoever of the apparatus.

Analysis thus discloses that the standard circuital arrangement wherein a grid leak is connected directly between the grid and filament of a valve is very inefficient when applied to short-wave work, and it is suggested in these circumstances that the grid circuit should invariably be rearranged to form an infinite-impedance loop.

It will be appreciated that the apparent efficiency of the standard arrangement on short waves is in fact a spurious quantity due

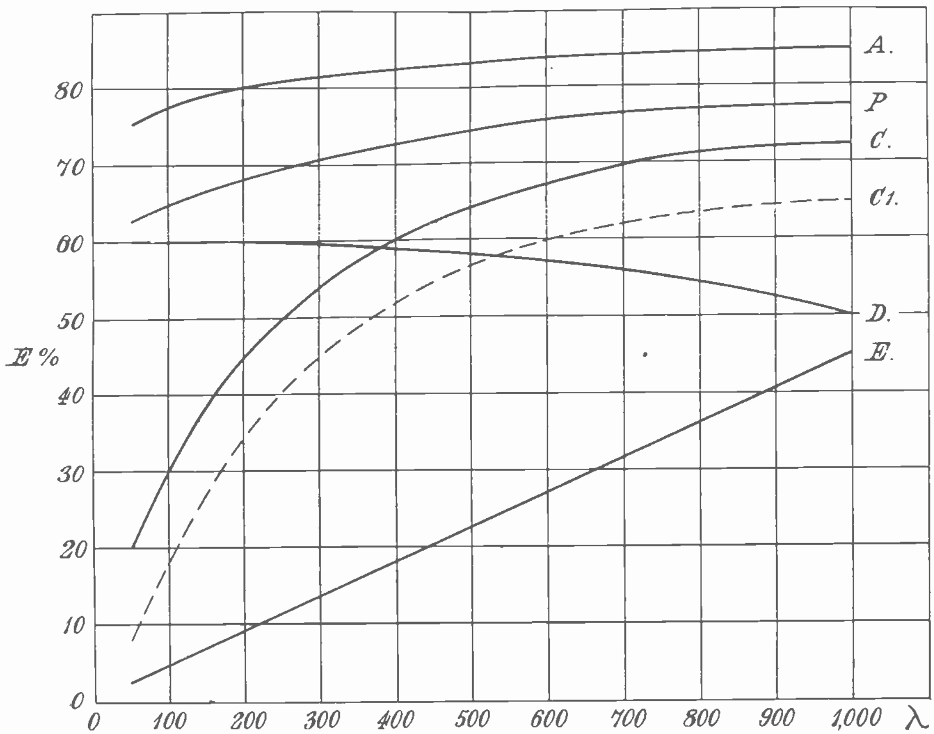


Fig. 8—Curve showing amplification at various frequencies for usual types of receiving valves.

A = Fully-tuned plate and grid.
B = Tuned plate, semi-tuned grid.
C = Tuned plate, grid resistance.
D = Tuned-plate grid choke.
E = Plate and grid resistance.

to the inherent reactive coupling between plate and grid of the valve and in the wiring, which at high frequencies becomes very considerable; and to this is due also the tendency to self-oscillation usually noticeable even when the circuital efficiency is as low as 20 per cent., a significant trait being the insensitivity of the arrangement *unless* operated close to the threshold of oscillation.

Increasing the circuital efficiency will, of course, have the effect of increasing the self-oscillation tendency and means require to be provided to control this; but since a single stage may now be more efficient than two stages coupled in the ordinary manner this should present no real difficulty in a well-designed apparatus, whilst the ease of operation may actually be improved, since one stage in every two may invariably be discarded so far as wave-lengths below λ200 are concerned.

A series of test curves showing the order of percentage efficiency obtained in practice with the various forms of coupling enumerated when used in conjunction with valves of a type suitable for high-frequency amplification is appended, and clearly illustrates the practical import of the theoretical deductions contained in the article.

The Month's "DX."

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

This month we commence "The Month's 'DX'" in its new form. As will be seen, there is a general report and discussion on the month's work, written by 5BV as before, and detailed district reports, each written by a well-known amateur in each district.

THE new form of our monthly notes will permit of them becoming rather more than a mere report. There is, each month, much to be discussed concerning "DX" work all over the world (and with our transmitters "reaching out" as they are now, world-wide "DX" is becoming a matter of interest to all of us). All the points of interest which arise will be discussed in the General Report, and the detailed local reports will deal with the work done in the areas which they respectively cover. It is hoped that there will be a keen rivalry between the various divisions to show the best report each month, as is the case in the States. Already two of the "Divisional Managers," 5KO for the West and 5JX for Scotland have seized upon this idea, and intend to keep their divisions "at the top."

5KO complains that there are so few active stations in the West that this Division will have more difficulty in doing good work than the others. I think that most of those who (like 5BV) have to work in a district crowded with transmitters would consider this an advantage! At any rate, if 5KO continues to do as well as he has in the past, his individual "scores" should keep his division well up.

This brings us to the question of the awful jamming which goes on in some places at present. When hearing it, one cannot but think that most of it is quite unnecessary. It is due to an extraordinary lack of co-operation between stations. So why not try to co-operate and avoid it? The telephony stations (and their name is legion) in London and other large towns could help immensely if they would curtail the interminable conversations about nothing in particular with which they at present occupy most of their time. They are the cause of most of the trouble.

Another group of offenders are the fairly powerful Morse stations who come on without any definite idea of what they intend to do, and call wildly every station they hear. We know that these calls spring from a genuine keeness for "DX," and the men concerned have the makings of really good "'DX' hams," but they must learn not to be selfish. Remember that every transmitter is a potential source of QRM, and before putting the key down one should consider "Is there any real object in calling this station?" If you have worked him often before and have no experiments to carry out with him, don't call him just for the fun of the working him again. Somebody else may want to work him, and even if this is not the case, your transmission may be jamming some other station who is doing good work.

Those stations which do not keep logs of all their transmissions should do so. You will find that, after keeping one for a few months, you become so interested in it that you do not like transmitting anything without entering it, and since this involves some trouble it has a wonderful effect in preventing you making those wild calls which, upon consideration, are not necessary, and certainly not worth the trouble of logging.

Altogether, the jamming should be considerably reduced if every station would realise that he and the man with whom he is working are not the only two who want to use the ether.

Having moralised at such length (and, I hope, to some effect) I will get on with the reporting side of the business.

My prophecy of last month about the transatlantic signals fading away was fortunately not fulfilled, and at present they seem stronger than ever. There was one rather bad week, but even then it was possible to "get across." It is certain that 2OD and 2KF will head the list of transatlantic successes this year, having worked over 40 Americans each. 5KO and 5BV have each decided to have the third place, if possible. 5KO should get it, having worked 14 at the time of writing.

In Europe many new stations are in action, and new countries taking part in "DX" work. 1JW and LoAA are working in Luxembourg, both QSO England, as are Belgian P2, W2 and 4C2 (what curious calls some stations use!). 4AA, 4ZZ and 4GG are also in Belgium, but have not yet, as far as I know, worked England. XY (Geneva) is going strong, as is a new Swiss station, XZ. Both are QSA in London. A third Italian station (1ER, Milan) is now working. A new Dutch station, PCRR, sends on 100 metres. Danish 7EC is very strong and has worked several English stations. Dutch PA9 has now closed down. Its operator, Mr. Van Rijn, tells me that at the end they were using 1,600 watts, and there was "no more fun in working Americans, as everyone reported signals so QSA." Lucky man!

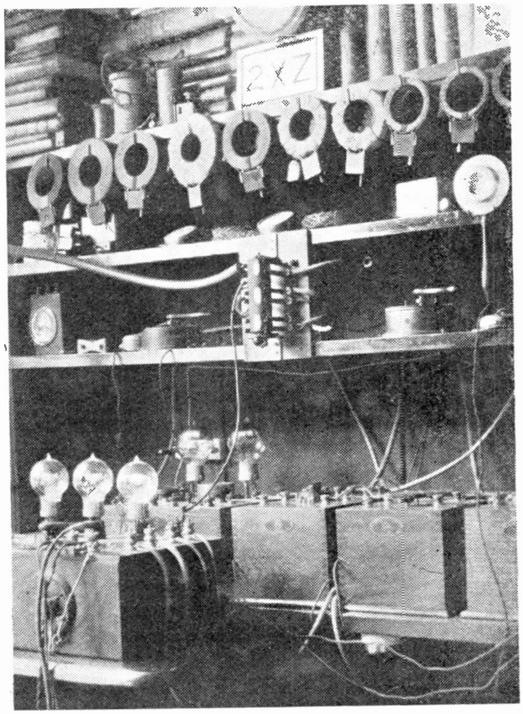
London District.

By 5BV.

NO new stations have "got over" the Atlantic since last month, but several of the stations who had been successful previously have done more good work.

Our star station, in London proper, is, of course, 2KF. He has been heard nearly all over the States and Canada, and has at present over 100 American cards on his wall. 2OD, some twenty miles out of London, has done equally well. 2NM, 2SH, 2SZ, and 5BV have all worked ten or more Americans and Canadians. 2KF has been heard by 7ZU (Montana) near the Pacific Coast of America, and I believe 2NM has also been heard near the Pacific. 5NN, 5LF and 2WJ have done good work across the "Pond," while 2UV, a keen "DX" man who is handicapped by having no power mains available has "got over" on a hand generator.

I think that completes the list of Londoners who have been successful in transatlantic work. We have a number of other very good stations who could "get over" if they tried, but they don't seem to the "midnight oil" component of the work. 2ZT continues to do excellent European work, as does 2YQ, but neither have tried for America. Another of our best-known "brass-pounders," 2DF, of whom we all expected wonders in the tests, has completely subsided. He occasionally works stations in Scotland, and there is a fine "punch" behind his signals. He is unique among powerful London transmitters in that, even on full power, he confines his signals closely to one wave-length, and does not spread over about 20 metres each way (those with guilty consciences please note!).



2XZ, owned by Mr. L. T. Dixon, who successfully transmitted a musical programme across the Atlantic on Dec. 28, 1923.

Apart from our "3 amp. in the aerial" stations, we have a number of very low-power stations who are doing splendidly. 5GF is one of these. During the last month he has worked XY (Geneva) with 0.18 amp. in the aerial and 0YR (Amsterdam) with 0.1. The latter test was carried out in bright sunlight, and signals were reported as R4 in Amsterdam. 2WY, 6LJ, and 6NF also do very good low-power work. These results remind me of the time when I could work Holland on a radiation of 0.01 amp. and make me wonder whether my 3 amps. is doing all it might!

I think the explanation lies in the fact that all this very low-power work is done on pure C.W., while most of the high-power work is done on A.C.C.W. The only high-power pure C.W. stations in London are 2KF and 2NM, and the results obtained by these two show the value of pure C.W. (apart from the awful QRM caused by unsmoothed A.C.). In America certain cities like to boast that they are "spark-less" cities (which usually means that everybody uses raw A.C.). Why not go a step further and make London a "pure C.W. town"?

Finally, there are many tests in the near future. See that London stations show a good record. We are losing 2NM for a time, as he is going to see "how it's done" in America, so the rest of our stations must work a bit harder.

North-West District.

By "2KW."

BEFORE giving any particulars of "DX" work in the North-West District I should like to make an appeal to all experimenters situated in this area. It is of great importance that I be kept informed of any work done, regular reports being submitted. It might be suggested that these reports from the individual be sent to me by the 6th of each month. I shall then be able to incorporate any interesting items in my monthly report. Let us show the other districts that we are as keen and as eager to be to the fore in matters affecting the amateur "DX" man as they are themselves.

I cannot help thinking, how all those of us who are really "amateurs" in the true sense —"admirers" or "lovers" of the game—should be brought more into touch with one another. And it is with the transmitter that the greatest responsibility rests. He is the most important class of amateur in the country and therefore he should endeavour so far as he is able to co-operate and help his fellows. There is only one way, in my opinion, that we may achieve this most desirable end, and it is this: that in every city and district where there are sufficient numbers of amateur transmitters a society be formed. It can be an individual body; it may govern itself absolutely; it can, in short, do anything the members have a mind to do—but it must support any move made to render the position of the amateur easier by the R.S.G.B. There need be no definite affiliation even, but a trust in the one by the other and an honest desire by both to play the game. We in this country have many hundreds of amateur transmitters and I feel that until we *all* get together other countries will not show the confidence in us that we all desire so much.

By far the most important thing that has happened up to now in my district is the formation of the Manchester and District Radio Transmitters' Society. With a membership of upwards of fifty, every member holding a transmitting licence, this venture promises exceedingly well. It is the intention of the Society to co-operate in every possible way with other organisations, generally helping to advance the status of the amateur transmitter in this country. After reading my opening remarks it is to be hoped that other districts will follow our example. I am glad to see that Wolverhampton has already done so. The Society arranged two series of week-end range tests, the transmissions taking place from 0000-0100 and 2300-0000 GMT. on March 30 and April 6, 1924. Each station called MRTS and sent a five-letter code word. About fourteen stations participated. Reports on the reception of any of these stations would be very welcome.

With regard to "DX" working, G2JF and G6NI have received shoals of cards from U.S. stations. In October last 2JF succeeded in getting across. 2IJ on a power of three or so watts has been reported by 7ZM, also having worked many good distances. 2GW has been studying the most efficient method of maintaining his masts which, on occasion, reached 90 ft. in a vertical position. He has done some good "DX" reception and his name will be remembered in connection with observations on fading. 2PC has been waiting for rectifier valves all the winter and I regret to say he has not had the audacity to try a Chemy. Rec. However, he has obtained ranges of 1,000 miles with very moderate power.

My own "station" 2KW has, as usual, been "up for repairs" pretty frequently. Two 150-watt valves softened and after patient lingering (on my part) they were returned with due absence of gas again. A day or so later the elements got their say in the matter and wrecked my 70-ft. mast. Weep!!! In spite of all this my signals have been reported from the 1st, 2nd, 4th, 5th, 8th and 9th districts whilst WNP has also heard 2KW. Several stations, including 1KC, 1CMP, 1XAH, and 1AJA, have been worked. The last station, 1AJA, was worked on a power of 12·7 watts with an antenna current of ·4. The valve used was a Mullard 0/20 (20D hi !). Confirmation has not yet been received though the signals of 1AJA have often been heard at 2KW.

5IK has been experimenting with a method of obtaining H.T. which involved the use of that singular anomaly a chemical rectifier. Both 5IK and myself are convinced that no death could be too "lingering" for the wretched beasts. 2WK has sold up and bought, so we are told, a John Henry.

2TR, 2QJ (the guy who measures the amount of E.M.F. across two terminals by the distance he is thrown), 2PC (the expounder of the "bug key"), 5IK, 2UF, 2RM, 2RP, 6XY, and 5LG are all going strong though on low power.

One last word this month. Please let me have those reports by the 6th of each month and then we can make these notes highly illuminating to say the least of it. Best 73's.

Western District.

By 5KO.

THE report for the Western District is a somewhat difficult proposition, for the fact is that there are not many stations in this area, or at any rate very few, who show any interest in short wave "DX." During the brief intervals when there is no broadcasting a few stations may be heard on 440 metres turning out gramophone and piano music, but such business is outside the scope of these columns. Turning to 200 metres and below, perhaps we had better start with the Transatlantic work, as that is of chief interest to all "Hams." There are three stations in the West who are QSO America, and considering the small number in this locality who work on short waves this may be regarded as a very creditable percentage for the district. Thanks, however, to poor conditions during the last week or so, very little progress has been made. 5FS (Bristol) has been busy and has been unable to be on the air much, so his "bag" of Americans worked remains at two. 6RY (Bath) has worked three more—1XAH, and Canadian 1AR and 1DD, thus bringing his score up to five. 5KO (Bristol) has been very QRW with exams, and has only worked two fresh stations across the pond, 1BCR and Canadian 9BL, so his total now stands at 13. Hope it won't be unlucky. We were all on the verge of despair on account of bad "DX" conditions, but a great improvement has taken place during the last few days, and Sunday, April 6, was apparently a morning for super-"DX"; on this date 5KO was reported "all over the shack on two tubes" at 1XAR, and further surprised himself by working Canadian 9BL half an hour after daybreak. By the way, QST for March reports 5KO as heard by WNP at North Greenland.

The station at Kansas City, owned by a Mr. White, which received the prearranged test from 2XZ.

European "DX" does not progress much here; we are all QSO Denmark, France and Holland as usual. A message received *via* 6QB, London, states that 6RY and 5KO have been heard in Warsaw on a single valve super, and a frame. Some leg-pulling is suspected here somewhere. 5CC (Bath) is beginning to reach out, and has been heard in Stockholm. 5RQ (Bristol) had has a nervous breakdown and the doctor has forbidden "brass-pounding" for a few weeks. Hard luck, O.M. 2GV of Bristol is kept busy with his parish and cannot find time for much wireless work. 2CW is reported in Algiers, and 5KO in Italy. 5KM of Bristol is expected back on the air shortly; he has been off for a year, but has now acquired some A.C. mains, and expects to create a big noise. No doubt the B.C.L.'s will welcome the appearance of yet another local station with a "hum." 2NS must be either dead or married, he seems to have dropped right out. Several Ford coil enthusiasts have appeared in the Bristol district, but it is hoped that they will soon see the error of their ways, as the local Radio Inspector has bought a receiver!

In conclusion, will stations in Devon and Cornwall (if there *are* any) please get in touch with 5KO if they want their activities chronicled. There must be some transmitters in this area outside the Bristol and Bath district. Let's hear them on the air, this section must not be beaten by London or the North. And where are all the transmitters in South Wales? Wake up, the West!

Scottish District.

By "5JX."

SCOTLAND does not boast many transmitters, there being only some half-dozen working "DX," but this in itself contributes to the excellent receiving conditions, distant signals not being jammed out by crowds of nearby QRM-ers.

Regarding general conditions, the most obvious is that signal strength varies directly with the distance! This anomalous fact is confirmed by everyone. Signals between stations in the North are never strikingly robust, unless huge power is used; for example, 2MG, reported all over the Continent, was weaker in Edinburgh during the R.S.G.B. tests than almost any other station heard. 2TF and 5JX QSA in Denmark, medium in Dollar, 24 miles away! Of the B.B.C. stations, not counting Glasgow, Bournemouth is easily the best received in Edinburgh; even Plymouth is not bad. Using the same receiver I get WGY several times stronger than 5NO, one-fortieth of the distance. This is of course quite satisfactory, as it prevents the nearer stations drowning out the distant ones.

One of the chief features of discussion here lately has been the relative merits of 100 metres and 200. The finding is roughly as follows:—100 metres—more QSA, less QRM, no harmonics from arcs, less QSS (though occasionally this is very bad, but is often nil), much worse QRN, when there is any about, bad night distortion of telephony, and much longer daylight range. The last-named is a good omen for summer work. The necessity for maintaining a steady wave is vital, a bad wave cuts down the range worse than low power.

Coming to actual results, the distinguishing feature this month has been tremendous Continental activity. Making an indiscriminate log here any evening French stations predominate every time, British being a bad second. Many new stations are reported by all listeners; Belgium's W2 seems the best of their contingent; P2 and 4ZZ also quite good. Danish 7EC seems the only representative heard much here lately. Italian ACD and 1MT seem to have largely retired in favour of a new man 1ER, who works nearly every night with G5SI and G5MO on all sorts of wave-lengths and a growling tonic train. Swiss XY was heard in daylight some time ago; he is quite a long way off. Of the innumerable Frenchmen now on 8DN, Lyon, can be heard QSA every night at 21.00, making calls in weird English to all sorts of people; 8AP is putting through some exceptionally strong telephony, and gives his call with a buzzer in front of the microphone. Other stations please copy! Luxembourg 1JW and Rhineland 8SSU are both reported here, and a great many new Dutchmen. A number of British telephony men are reported OK, 5QV and 2IM in daylight. Also 6VT, 2NM, 2KF, and 5DT.

Of the mystery stations that crop up from time to time 1CF heard on March 24, A42, in the early evening on 181 metres is rather a good one. G2XAA sounds a bit queer, too.

The local transmitters have been fairly quiet until just now; 2TF, 2MG, 6GY and 5JX have all been more or less out of operation for several months, and all have resumed, or are about to. 2MG is going strong with 1·8 amps. in his aerial, has worked Denmark, and is trying America. 5JX, after three months' silence, is now busy at all hours on 132 metres. He is also trying America, though with rather feeble hopes owing to modest equipment. A new arrival on the ether is Dingwall. Judging from his receptions this furthest-north British transmitter should do some good work. 5ST near Glasgow has been busy and has worked 2NM on speech with 0·5 amp.

Talking about America, the best time for working appears to be from an hour before to an hour after sunrise, on the shorter waves at any rate. After that there is a tendency to fade off. The last day or two of March QRN rendered all except the strongest signals useless, but on April 5 U's and C's came in too quickly to log; many of them A32, and 2OD was workig them with ease and precision well into the day. oAA has been trying to get across, but he did not appear to be QSL'd. A very notable result is that of Mr. J. G. W. Thompson, of Edinburgh, who besides a large array of European stations has logged six or more Americans on a single valve Armstrong with a 2-foot frame situated in a room in the worst screened part of the town.

In conclusion, there appears to be no doubt left that taken all round, the ± 100 metre wave does better work than the 200. Curiously enough the most pronounced advantage is its greater consistency. I fully believe that American "DX" will proceed throughout the summer. The only snag seems to be QRN, so it may be worth while now to produce the real atmospheric eliminator!

Radio Station 5CF.

BY F. G. S. WISE.

THIS station is situated on Crouch End Hill in the North of London. The antenna system consists of a four-wire 3-ft. diameter cage, 30 ft. in length, slung diagonally across the roof, directionally S.E.–N.W., and an earthed lead roofing, the shortness of the aerial being amply compensated by the fact that it is well above any local screening. A general view of the receiver and transmitter is shown in Fig. 1. Many experimenters who have visited this station have remarked upon its

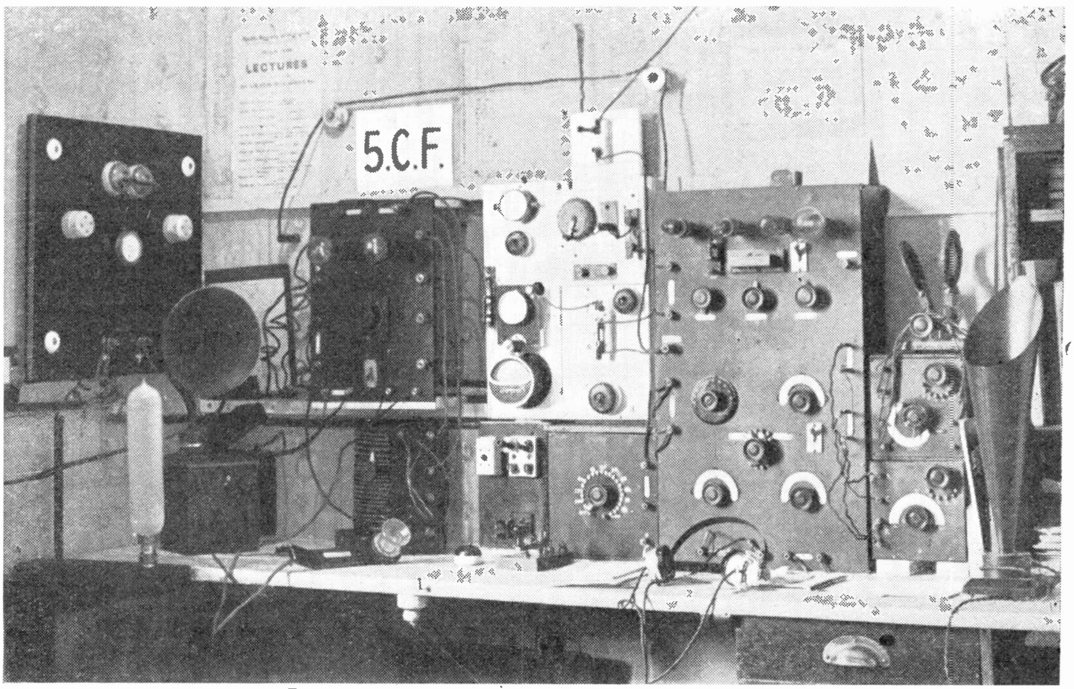


Fig. 1.—A general view of the standard transmitter and receiver.

neat appearance, but the author would state that the apparatus shown in the photographs forms only the permanent working units of the station, all experimental apparatus being assembled on a bench running at right angles to the one shown in the photograph. The author has found that by having apparatus in a consistent form it has proved of great value to stations giving reports

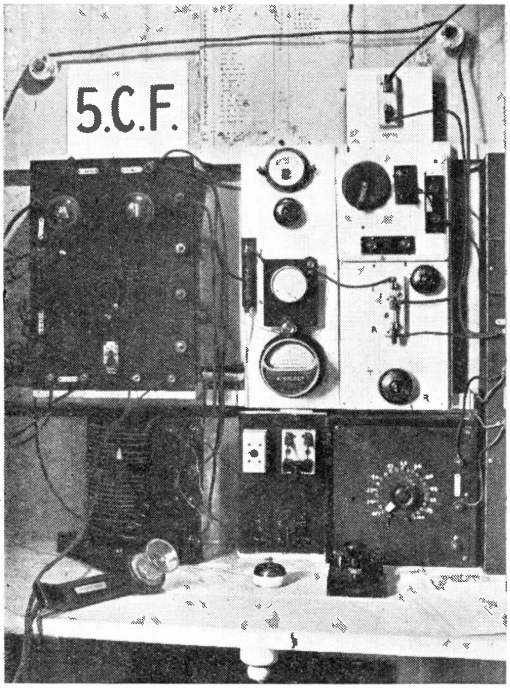


Fig. 2.—A close-up view of the transmitter.

on various experiments, as a standard transmission is always available for comparison. The same point applies when testing new receiving circuits, a receiver of a standard type being always at hand for comparison and calibration. Reception on new circuits can then be judged and their respective merits noted. A general description of the station may now be given. Looking from the left of Fig. 1 is seen the power supply board, which carried the arrival leads of the 240 D.C. mains, used for operating the transmitter. The resistance lamp is used in conjunction with a floating battery system for charging the filament accumulators. Fig. 2 gives a "close up" of the transmitter. The circuit is that of the standard reversed feed-back grid control, and using two valves in parallel. This circuit has been considerably stabilised by the use of a separate battery in the microphone circuit, and the author would suggest to the many experimenters who use this type of circuit, for low-power telephony, that their speech would be considerably improved if they paid more attention to controlling the voltage applied to their microphone. The helix is wound with heavy gauge wire, spaced, and is tapped to allow for fine wave-length adjustment (100–200 metres), the grid coil rotating inside. A switch is shown which throws the microphone or the key in circuit at will. The instrument board contains the filament voltmeter, the aerial ammeter (0–1 amps.), a $\frac{1}{2}$-amp. lamp, and the plate milliammeter. A master rheostat gives control of the filament current, for either transmitter or receiver, power being controlled by a double-pole switch shown below the aerial change-over switch. H.T. supply for the receiver is derived from dry batteries, it being found that the enormous hum from the mains, if used, prevents perfect reception of weak signals. The receiver itself is the standard four-valve circuit, employing one H.F. tuned anode, detector and two L.F. As a point of note it should be mentioned that the anode of H.F. valve is tuned by a variometer, it having been found by exhaustive experiments that variometer tuning in the H.F. circuit on short waves gave the best results, although the hoped-for degree of amplification has not yet been obtained. Switches are provided for controlling the various valves in or out of circuit. The tuning apparatus on the extreme right of Fig. 1 consists of a tapped short-wave coil, and an acceptor circuit, consisting of a condenser and a tapped inductance, which is plugged in shunt with the aerial and earth. Switches are provided for the loud speakers. A switch for the use of an indoor aerial is also shown. As regards the efficiency of the station, possibly a high degree has not yet been reached, but on 10 watts input an average of $\frac{1}{2}$ ampere aerial current is obtained. The greatest transmitting range on 'phone that has been reported was from Bolton, Lancs., about 200 miles. On the receiving side two to three valves are invariably used, and many distant stations have been logged, including American broadcast and amateur stations.

The Mechanics of Components.

By GEORGE GENTRY.

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

No. 1.—Switch Construction.

THE forms of switch referred to in these notes are those of the multiple-contact type, which have long been used in all varieties of electrical apparatus. In the old galvanic batteries they were fitted under the title of current collector switches, or voltage collectors. Each stud of the switch was in contact with a cell, the cells being connected in series, and the operation of the arm over the studs collected one or any number of cells in series. When two arms were fitted, they became double-pole selector switches, and would take any cell, or any series of cells, from the battery, led to the terminals in either direction. Applied to accumulator batteries, they are still used as "accumulator" switches. The same form of switch is used on rheostats or variable resistances to collect sections of a resistance into series, and is used also in electrical engineering in this manner principally on motor starters or controllers.

In radio work the form of switch is applied as mentioned in the first place as a collector switch for high and low tension batteries, and in the second, as an inductance coil collector in the familiar form of the tapped inductance coil.

As far as possible, it is proposed to describe the correct method of assembling these switches, made up from the regular stock parts as supplied by wireless dealers, and as such they can as readily be set up and used as single way on and off switches, one stud being blind. There are two methods of fitting them, one with rotary spindle control, and the other with fixed spindle and arm control.

Fig. 1 is a section drawn to scale showing a single-pole rotary spindle multiple stud switch made up of a 1¾″ length of 2B.A. screwed brass rod, running in a standard panel bush, also of brass. The whole of the fixing is done by No. 2B.A. brass lock-nuts with plain washers and a spring washer, the remainder of the switch comprising an arm, the requisite number of studs with washers and nuts, and a brass nut-bushed ebonite or compo knob. This is shown mounted on a ¼″ ebonite panel. The standard throw or radius of the arms is apparently 1½″ in all the specimens examined, and the usual diameter of the stud-heads 5-16″. To set out, mark the spindle centre on the ebonite by means of a centre punch pressed in at first; and from this describe an arc of 1½″ radius by sharp-pointed dividers, covering the number of studs required. The view to the left shows the end view of arm, which is 5-16″ wide, and radiussed at both bottom corners. Allowing for the radii, the straight bearing portion of the arm will not be much over 3-16″ wide, and, as the arm must rest with its flat on two adjacent studs at once to work smoothly, the studs must not have more than 5-32″ gap between them. This makes the stud centres on the arc 15-32″ apart, which may be less—say, down to 13-32″—but not much, because it will be seen that a 4B.A. nut and washer fills a greater space than the head, and the adjacent nuts will conflict on the underside of panel if the heads are put as closely as they might be. For smooth working, however, the closer the studs are together the better, so long as they do not touch, and in cases where a saving of room is necessary, it will be better to use studs of less shank diameter, say 5B.A.

When the panel is thus marked off, deepen the dots by means of the centre punch in conjunction with a light hammer. Put the panel on a flat surface over something solid, as a bench leg, and, holding the punch *upright* in the dot, one blow with a ¼ lb. hammer will suffice to give a good start for a drill, without splitting even ⅛″ ebonite. The drilling should be done in the first place with a drill—preferably straight-fluted—much smaller than actually required. A 1-16″ drill, for instance. Follow this on, so far as the stud holes are concerned, with the correct size clearing drill. A suitable drilling machine is best, but if only a hand brace is available, it is important that it be held quite upright relatively to the panel. The stud holes are clearing holes, and not tapped. Before starting to drill the spindle bush hole, mark, by means of dividers, a $\frac{3}{8}''$ diameter circle on the ebonite concentric with the dot, and use this as a guide in the subsequent drilling. Drill this hole also at first with the small drill, and follow on, opening out the hole gradually by steps ; or, after drilling the small hole, use first a 3-16″ drill, next a 5-16″, and finally a $\frac{3}{8}''$ clearing drill, which may be as much as $\frac{3}{8}'' + 1\text{-}64''$ to

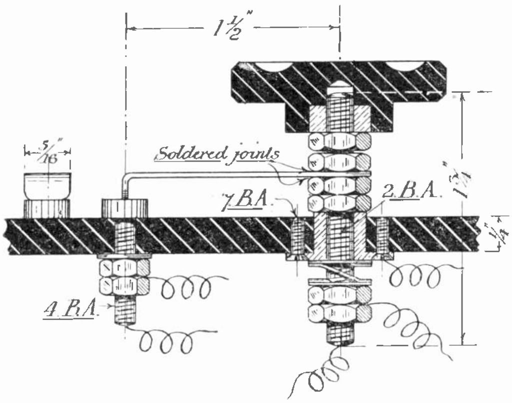


Fig. 1.—Illustrating the correct method of assembly of a switch, together with suitable dimensions.

clear the $\frac{3}{8}''$ outside diameter of bush. During the drilling, note whether there is any tendency to go out of centre of the circle, and if so, draw the eccentric hole over by filing the high side by means of a rat-tail file (*i.e.*, a small round file about $\frac{1}{8}''$ or 5-32″ diameter and pointed). The subsequent accuracy of assembly of the switch and its truth of running depends upon all the holes being drilled truly square to the panel.

The bush is shown fitted the correct way to admit of making a joint for a fixed lead on underside of panel. If this is not necessary it can as well be fitted with the flange on the top side, but in either case fit the two No. 7 B.A. countersunk head screws to tapped holes in the ebonite. The flanges are ready holed for two screws on opposite sides, but it will be found necessary to slightly deepen the countersinks so that the heads of the size screws given stand either flush or a little under the face of flange when screwed home. The flange must sit truly on the ebonite to ensure that the axis is square all ways with the panel.

To assemble the switch spindle, it will be necessary to provide oneself with a pair of spanners for locking the nuts. Don't use adjusting spanners, or try to do the locking with any kind of pliers. A pair of suitable spanners can be made from finger strips of mild steel plate 1-16″ thick, $\frac{5}{8}''$ wide, at one end, and tapering to about $\frac{3}{8}''$ wide at the other end, which may be rounded ; 4″ long, or a little less will be a handy length. Cut a slot midway of the broad end, $\frac{3}{8}''$ deep and $\frac{3}{8}''$ wide, and adjust the width by filing the sides carefully to just slip on, a fairly easy fit, to the flats of a No. 2 B.A. nut, which measures about $\frac{3}{8}''$ across the flats in the generality of nuts examined. When finished, round off the corners at the broad end.

First provide six lock nuts, and tin two of them on one face. It is not necessary and will be a hindrance to leave the solder blob on the nuts, and the tinning must be wiped while hot. Also see that no solder gets to the screw threads. To wipe the tinned surface use a piece of clean waste or rag moistened with clean thin oil. This, if wiped across the tinned face when hot, will remove all the superfluous solder, and leave the equivalent of a bright tinplate surface. Tin both sides of the arm at the swivel end in the same way, but do not let the heat travel along the arm to avoid softening it. Wipe all the tinned surfaces quite free of oil and assemble as follows : Position the switch arm on the spindle, and lock it tightly between the two tinned lock nuts (tin to tin in all cases), after having fluxed all the faces a little. If the joint be then held in a blow flame, and the spanners applied carefully, the whole will form one nut a tight fit on the screw. Check this with one other lock nut (not tinned) on the underside, as shown, locked to the combination, and add the knob as indicated at the top in section. The latter is not screwed right home, but is checked with a lock-nut brought up to it on the underside. If the knob is not true enough for appearances, it probably may be made better by unlocking and shifting its position on the screw a little up or down, and re-locking. As shown, the frictional compression is obtained by the spring washer on the underside. Put this between two plain washers, and adjust and lock the nuts at bottom to give just the right frictional resistance to the turning. There is only one other practical point to refer to, and that is that the underside of the lock-nut immediately above the bush should sit evenly on the bush. To make it do so is a simple lathe job, but, failing a lathe, it can be done in the following manner: Smear a little black paint (say a little gas black mixed with oil) evenly on the top rim of bush, and putting the spindle in position, without the underside nuts and washers, press home and turn it round backward and forward. If it is bearing hard at one point, it will show it by a black smear on the nut, but if bearing all round, the smear will take the form of a more or less bright ring on the nut. If a point shows, file it away carefully without touching the face elsewhere, and continue this till it shows up a ring when locked up in position. The lock-nut must be removed for filing, and put back in the same position.

The above constitutes all of a practical nature in making the switch, but there are one or two points to mention in the assembling. Put, say, the centre stud in first, and arrange the arm to normally spring down with its bearing face about 7-16" below the face of stud when the spindle is adjusted, with its nuts and washers on underside. Lift it on to the stud and see that it sits evenly just as drawn in the end view. If it tilts up at one end, twist the arm by means of a pair of flat-nose pliers till it bears evenly on the stud top all along its bottom edge.

The arm shown is about the simplest that can be fitted, made either of spring brass strip or similar German silver strip. Spring strip is harder and more springy than most sheet metal, and should not be made hot in the arm portion, or it will lose its springy nature. It should be No. 20 or 21 S.W.G. in thickness, 5-16" wide at point, and 7-16" wide at the swivel or rounded end, and plain clearance holed, not tapped.

The methods of lead attachment may be in the several ways shown. If the lead to studs is sweated on, sweat to the tinned point, and only one nut will be required, which must be tightened again after applying the heat, as this is sure to loosen it. The second nut is only applied as a binding nut when it is desired to make a screw joint. The latter can be effected by making a neat flat hook loop on the wire, which fits just round the screw. In the case of the spindle leads, such can only be fitted in the way just described if they are flexible. A rigid lead can only be sweated to the flange of bush as indicated, and sweat this to the flange surface and not to the screw head (as we are obliged to show it).

Fig. 2 is a similar scale part section of a swivel-spindle double-pole switch, made and fitted, so far as one arm is concerned, just as the foregoing. There is no lock-nut or tinned joint, however, on the upper side of the arm. The second pole is represented by a second

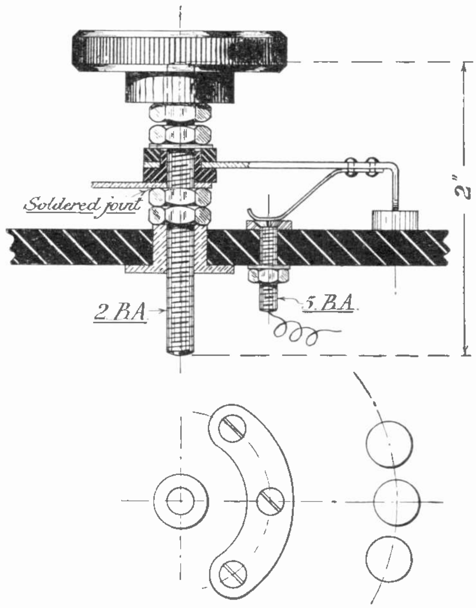


Fig. 2.—Design for a two-pole selector switch with a common shaft. Note the method of insulating the arms.

spring arm, which must be insulated from the spindle, and can be used at any angle to the first arm to suit the stud arrangement. If room will permit, it is much the best position to have it in opposition to the first arm, as then the switch is balanced, but it is possible to balance a single arm, as will be described later. The second arm is holed larger (not less than 9-32") and fits snugly on to an ebonite bush which is clearance holed to fit —a tight sliding fit—on the screw, and not tapped. It is tightened to the bush by a stout ebonite washer, also holed as the arm, and the whole joint is held down by the upper lock-nut, which must have a washer under it.

The method of leading off from the second arm is indicated also in the plan below in Fig. 2. Over the range of studs to be in contact with the second arm is fitted a segmental strip of copper plate placed concentric with the spindle, and at about half (or less) the radius of the arm upon the top side of panel. This strip must lie flat, and should have at least one countersunk headed screw

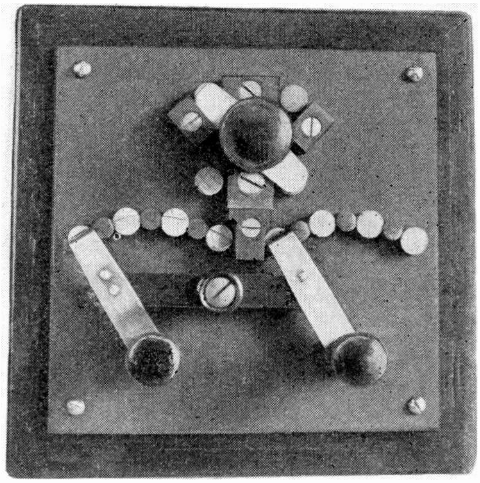


Fig. 3.—A double-pole battery collector switch with intermediate fibre riders.

at each end tapped to the ebonite, and one at or near the centre, passing through a clear hole, and nutted on the underside, as described before for the studs. It is important in this case that all the countersunk heads lie flush with the face of strip exactly. The lead off is a piece of spring German silver riveted to the arm as shown, bent down and formed with a flat-bottomed hook in the form of a shoe to ride nicely round the top face of segmental strip. The side bottom edges of this spring may be a little rounded at the shoe to aid in the sliding both ways, and the shoe must be fitted to bear nicely more or less all over the flat foot. Note that the spring must be of a much lighter gauge and more sensitive than the arm in order that its spring action will not prejudice the rubbing contact of the arm, and it is to avoid any trouble of this nature that the spring is attached to the point of the arm this way rather than the other way round. The lead is attached on the underside just as the studs, either by sweating or bound by a second nut.

There will be some more notes published dealing with points of construction in fixed spindle multiple-contact switches in a future issue, and in respect of these an example is given in Fig. 3, a photo of a fixed spindle double-pole battery collector switch, with a turn-button two-way series switch, with rotary spindle at the top. Details of construction will be forthcoming later, but a point to notice here is that the double-pole switch, having fixed spindles, is preferably made as a double switch with an ebonite bar link connecting the arms and keeping them at constant voltage. The link carries the controlling handle. Another point is that to prevent short circuiting adjacent cells by bridging over adjacent studs by the arm, the studs are spaced a little wide, and have between a fibre plug, which is raised slightly above the stud level, and thus acts as a rider for the arm, lifting it clear of the contacts. Other points to notice are that the riders of the turn button at top are also of fibre, and all the stops as well, the fibre in all cases being so fixed as not to connect any two contacts. The fixed spindles carry terminals top and bottom for both high and low tension battery connection, the terminals at the top are of insulating material, and are hooded to prevent accidental short circuiting. The whole switch is to be covered with a transparent insulator cover, which, however, is not celluloid for obvious reasons. This cover will have holes and slots, through which the knobs and insulated terminals project, and is designed to be foolproof.

The Trend of Invention.

Selective Receiving Apparatus.

British Patent Specification 212,177 (Marrec, Ltd.), describes a receiving apparatus intended to select and amplify Morse signals of constant wave-length to the exclusion of atmospherics and jamming signals. Audio-frequency beats are obtained by heterodyning, the beat-note being first amplified by an aperiodic transformer-coupled amplifier and then passed on to a cascade of three-electrode valves coupled by tuned transformers which are resonant to the beat frequency. The latter cascade contains a greater number of valves than would be necessary for normal amplification as the filaments are dimmed to obtain a limiting action on loud parasitic impulses. In order to prevent self-oscillation in a system containing so many stages of amplification the inventor earths the positive H.T. terminal and not the filament battery; the H.F. side of the receiver is, of course, operated off separate batteries. Where the transmitting station uses marking and spacing waves provision may be made for selecting and recording both independently in order to minimise errors or loss of Morse characters due to strong atmospheric impulses.

It will be seen that the invention depends essentially on audio-frequency tuning and on the limiting action of thermionic valves, neither of which is in any sense novel, and it is not clear from the specification wherein the novelty lies. The wording of the specification is lengthy and obscure—a defect which is by no means rare in wireless patents.

Another recently-patented selective device (British Patent 202,320, Marconi's W.T. Co., Ltd.), is illustrated in Fig. 1. O, P and Q are the usual H.F. amplifier, detector and L.F. amplifier respectively. By means of the centre-tapped coil E the valves H and J are differentially coupled to the output circuit D of the L.F. amplifier Q. One of the valves H is provided with a grid-condenser and leak MN, while the other valve J has none. The anodes of the two valves are supplied from a common battery through two resistances, the recording instrument being connected at T as shown. The device is intended to act as follows:—A strong momentary parasitic impulse will affect both grids equally and oppositely, therefore the effects in T will cancel out. Sustained oscillations due to C.W. signals will, however, cause a negative potential to accumulate on the grid F of H while there will be no such effect in the valve J. Therefore the instrument T in the output will be affected by sustained oscillations. Unfortunately the circuit as shown in the specification and reproduced in Fig. 1 would not work, as a push-pull input circuit does not cause a cancelling effect in a push-pull output circuit but the effects add (*cf.* the ordinary push-pull audio-frequency amplifier). T is shown in what is virtually a differential or push-pull output circuit. If the anodes were

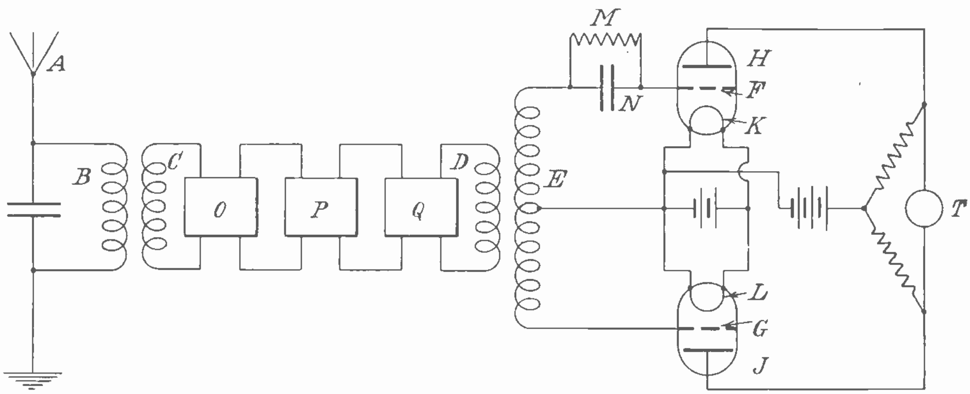


Fig. 1.—A selective system of reception.

connected together and made to affect T in the same sense the device might work quite well.

The two schemes mentioned above serve only for the reception of Morse signals. The system in Fig. 2 is the subject of a Telefunken patent (British Patent 206,838) and would answer equally well for the selective reception of Morse and telephony signals. The aerial circuit C is coupled to the receiver through the medium of two intermediate circuits A and B. A and B provide coupling in opposite senses so that they tend to neutralise each other's effect on the receiver; B, however, is highly damped by the series resistance D and is considerably detuned from the desired signal, while A is sharply resonant and only slightly detuned. Aperiodic impulses or received oscillations well off tune will tend to cancel, while oscillations of the desired frequency will affect A so strongly in comparison with B that their effect will be substantially passed on to the receiver. A very similar scheme was recently patented by Round (see Exp. W., Vol. I, No. 1).

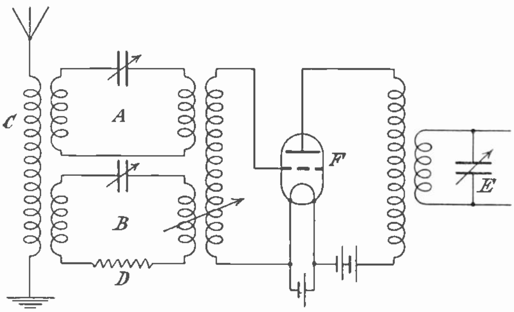


Fig. 2.—Another selective system.

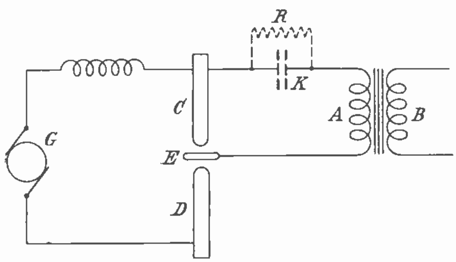


Fig. 3.—A controlled arc.

Talking Arc with Control Electrode.

The fact that an arc can be made to act as a telephone receiver was discovered by Simon some thirty or forty years ago, but it is very insensitive compared with other forms of receiver. The Telefunken Co. have recently patented the use of a control electrode between the carbons which they claim renders the device more sensitive (British Patent 203,293). Fig. 3 shows the connections. The arc electrodes C and D are supplied from the source G through a suitable choke. The control electrode E takes the form of a ring. When it is desired to control the bias on E a condenser may be inserted at K and shunted with a resistance R. It is desirable to provide means for cooling the ring E. It is stated that the device will act either as a receiver or conversely as a microphone transmitter, A B being the input or output transformer as the case may be.

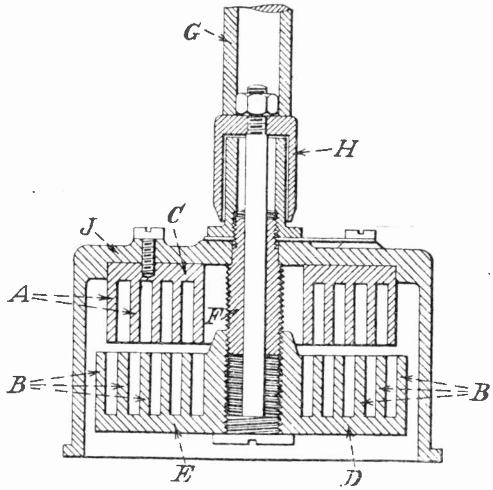


Fig. 4:—Rigid condenser construction.

Variable Condenser.

A large variety of variable condensers have been patented recently and the construction depicted in Fig. 4 is a distinct departure from the usual types (British Patent 212,199, A. Courtecuisse). The figure is practically self-explanatory. A and B are two sets of concentric annular cylindrical surfaces capable of interleaving to a variable extent without touching. The upper set A are connected together and fixed to the case J. The lower set are carried on a vertical rotatable threaded shaft F.

Direction Finding.

At the meeting of the Wireless Section of the Institution of Electrical Engineers on March 5, there was an interesting discussion, which showed that "direction finding" for navigational purposes is making progress. The paper set down for reading, entitled "Development of the Bellini-Tosi system of Direction Finding in the British Mercantile Marine" was not actually read, the author, Commander J. A. Slee, C.B.E., R.N. (retired) stating that since preparing it he had obtained additional new information, and with the permission of the meeting he would proceed with it, and asked that his paper, as set down, should be taken as read. But he remarked that the term "Capacity error," which he had used in section marked *f* was not a good term; the errors were not really due to capacity, they might be termed rather as errors due to working of the instruments, And with regard to the table, "Record Working of Ships' Direction-Finders," sixty-nine reports have now come to hand. They show results which come within the limits given in the body of the paper. A considerable number of speakers took part in the discussion, their remarks indicating some of the difficulties obtaining in "direction finding" for marine navigation. There was a difference of opinion as to whether the spark system or the continuous wave system was preferable for transmission of signals. Other remarks dealt with possible error due to variation in the loading of the ship and consequent difference in height of the instruments above water line, influence of waves deflected from the sky (that is the newly assumed envelope of frozen nitrogen); apparently fog does not introduce errors. The topic of sending continuously or at intervals by beacon stations was discussed. About 120 British ships are equipped with direction finders. A number of the speakers gave their remarks from actual experience. We give below a reprint of the paper :—

(1) Retrospect.

The following notes concern the development of direction-finding on the Bellini-Tosi system, in which two fixed loop aerials at right angles to one another are used in conjunction with a rotable search coil. The results mentioned have been obtained with spark (as opposed to continuous-wave or interrupted continuous-wave) telegraphy.

The first attempts were made with loop aerials, each tuned independently to the frequency of the signal the direction of which it was desired to obtain. the loop aerials being very loosely coupled to the search coil and its circuits. This system, which had given admirable results on land, was found when fitted in an iron ship to be too difficult to work and to possess too grave errors of a quadrantal nature to be of practical value for navigational purposes, the only justification for its existence in the mercantile marine.

The method of using untuned loops, usually, though incorrectly, called aperiodic loops, was then resorted to, and promising results were at once obtained.

(2) Errors Encountered.

(*a*) *Calibration error*.—In all that follows the word "loop" is used to convey the idea of the whole arrangement used to absorb energy from the ether, including the field coil, lead-covered cable and junction boxes, as well as the simple loop itself. The capacity present in this circuit is a complex quantity, of which the greater part is the capacity between the core and core of the lead-covered cable. Such a circuit has a well-marked natural frequency. The expression "simple loop" is used to denote that portion of the whole which is purposely opened out so as to enclose a considerable area.

An analysis of the nature of the errors obtained when identical loops were used brought forward the fundamental conception on which all subsequent work has been based; that is to say, the idea that the ship herself with all her rigging might be imagined to be replaced by a fictitious simple loop lying in the vertical plane and parallel to the keel line of the vessel. The action of this fictitious simple loop is taken into consideration when determining the area of the fore-and-aft loop of the complete direction-finder system.

Since this fictitious simple loop is fore-and-aft, and since its effects cannot be ignored or eliminated and must not be allowed to produce an effect equivalent to mutual induction between the two tangible simple loops of the aerial system, it is clear that one of the two tangible simple loops must be parallel to the fictitious simple loop, that is to say, fore-and-aft. Therefore the other tangible simple loop must be athwartships.

Since the tangible fore-and-aft simple loop is coplanar with the fictitious ship simple loop, there will be considerable coupling between these two, and therefore the current circulating round the tangible fore-and-aft loop will, under any given conditions, be greater in some geometrical proportion than would be expected from a consideration of the dimensions of the fore-and-aft loop alone.

If identical loops were used the result of the above would be that the directions as observed would tend to be crowded towards the fore-and-aft line, the error being a maximum when the correct relative bearing is on the bow or quarter, and vanishing when the correct relative bearing is abeam, or ahead, or astern.

This error, which is now in practice usually given the name of "calibration error," can be completely removed by reducing the area of the tangible fore-and-aft loop, or by adding to its impedance, or by a combination of these two methods. It is usual in practice to employ the largest convenient thwartship loop (up to an area of about 400 sq. ft.), and to adjust the size of the fore-and-aft loop until a slight calibration error remains, finally removing it by adding impedance equally to the two limbs of the fore-and-aft loop.

(*b*) *Loop-tuning error*.—The last paragraph shows that the two loops are essentially of different dimensions and therefore, in all probability, of different natural frequencies. If both the loops are very considerably different in frequency from that of the signal to be received, the current circulating in each will be almost in quadrature with the voltage applied by the incoming wave, and therefore the currents flowing round the two loops will be almost exactly in phase with one another. Further, the value of the current reached in each loop will be almost exactly proportional to the voltage applied to that loop by the incoming wave.

In the first of these two conditions (similarity of phase of circulating currents) is not made good, the familiar rotating-field effect will be produced on the search coil. Since the position of zero coupling between the search coil and the field coils which are connected to the loops is the index by which directions are measured, the effect of such a rotating field is to fog the observation by obscuring the position of zero signals.

Also, if one loop happened to be of the same, or very nearly the same, frequency as the incoming wave, the circulating current round it would be greater, in proportion to the voltage applied, than the current in the other loop (by hypothesis of different frequency) and therefore less nearly in resonance with the incoming wave. Therefore the proportionality between impressed voltage and circulating current will be different in the two loops, and a quadrantal error similar in effect to calibration error will result. Its extent will vary with alteration of wave-length of the received signal, and will vanish if the frequency of the incoming wave is midway between the frequencies of the two loops. As such an error varies with wave-length, it is quite inadmissible. These two effects of one cause are in practice lumped together under the name of " loop-tuning error." They can be completely avoided by fitting loops of suitable dimension in the first place, and are almost unheard-of in practice.

(*c*) *Lack-of-symmetry error*.—If we consider the current flowing in any part of a vertical loop under the influence of an incoming ether wave, it is clear that there are two distinct components. One is a circulating current round the loop. The cause of this current is as follows :—

If we imagine each half of the simple loop from apex to junction box to be replaced by its phantom vertical projection, the incoming wave will induce a voltage between the two ends of each phantom projection, the potential to which each of these four ends is raised at any instant, by effects of the incoming wave being different. If the plane of the simple loop is not parallel to the wave-front the voltages induced in the two phantom vertical projections will be unequal, and the difference between them is the useful voltage available for the production of a circulating current. For brevity this current is in practice called the " loop current," and clearly the instantaneous value of the voltage causing it depends upon the height and distance apart of the phantom projections (in practice, the area of the loop) and the rate of change of intensity of electric and magnetic stresses caused by the incoming wave at the instant under consideration.

The other component is a simple alternating current flowing in both sides of the complete loop from the apex to the mid-point of the field coils, the actual current distribution being to a great extent governed by the capacity to earth of the various parts of the loop. For the sake of brevity this current is in practice called the " plain current," and the instantaneous voltage to which it is due is caused by the instantaneous value of the electric and magnetic stresses set up by the incoming wave.

Hence we see that the " loop " voltage and the " plain " voltage are in quadrature, the loop current leading or lagging relatively to the loop voltage in accordance with the electrical constants of the loop circuit, while the plain current will lead or lag relatively to the plain voltage in accordance with the electrical constants of the plain circuit.

If the construction of the loop and its attendant field coil is perfectly symmetrical electrically, the plain current will be equally divided between the two halves of the loop, and the effects of each half of the field coil on the search coil will neutralise one another.

Absence of this condition of symmetry is the most troublesome, the most common, and the most dangerous source of error. It is generally called in practice " lack-of-symmetry " error, and the satisfactory operation of direction-finders on board ship is almost entirely a question of the success with which causes tending to produce or accentuate this error can be counteracted.

In order to protect the insulation of the connections between the loops and the direction-finder instrument, and also the windings of the field coils themselves, from the effects of accumulated static charges or the induction due to transmission, the centre of each field winding was at first connected direct to earth. This direct connection accentuated the effects of lack of symmetry, and has since been replaced by a suitable inductive choke.

The causes of lack of symmetry are twofold : " permanent " lack of symmetry due to unequal distribution of any electrical dimensions between the two sides of a loop, which would result in unequal impedance in the two halves, measured from apex to mid-point ; and " inductive " lack of symmetry due to re-radiation and or induction from individual conducting portions of the ship's structure, which may have unequal effects upon the two halves of a loop. The effects of the former are apparent, irrespective of the strength of signals, but the effects of the latter increase with the strength of signals and are often only noticeable with very strong signals. This state of affairs appears to be explained as follows :—

Consider an athwartship loop which is inductively unsymmetrical, the relative bearing being considered to be right ahead. There is zero loop current in this loop, but the effect of inductive lack of symmetry is to cause an unequal distribution of plain current between its two halves, and therefore there is a magnetic coupling between the field coil and the search coil. The effects of this current may be too slight to deflect the resultant magnetic field through the field coils to any appreciable extent, and no error is then observable, but when the effect of the inductive lack of symmetry becomes sufficient to deflect the resultant magnetic field through the field coils the error begins to appear. There is, in short, a marked threshold effect observable in cases of inductive lack of symmetry. In cases of permanent lack of symmetry, the disturbance due to unequal distribution of plain current increases in the same proportion as the loop current, being due directly to the plain voltage and not to the effects of an outside conductor itself under the influence of the wave, and no threshold effect is observed. Inductive lack of symmetry is the source of the most elusive and the most dangerous errors which have been experienced in the application of direction-finding to navigation.

Having decided on the position of the loops, the next point is to decide on their form. This is a matter of but very little importance provided that extremes are avoided, but it is very desirable that there should be a pronounced geometrical apex to each loop. For sea-going work it is essential that the thwartship loop should have a well-marked apex, and it is advisable that the fore-and-aft loop should have one also. The reason is simple. Consider a flat-topped thwartship loop. If the vessel is on an even keel the top of the loop is horizontal and the electrical apex is in the centre of the horizontal limb. If now the ship heels over, even to a very small angle, the apex becomes the weather corner and symmetry is destroyed. The same applies, but in a less degree, to the fore-and-aft loop.

Lack-of-symmetry error is the only error which can make a bearing appear to be in the wrong quadrant, and lack of symmetry in the thwartship loop may well be sufficient to make a bearing appear to be on the wrong bow.

If it can be assumed that the loops are symmetrically rigged truly fore-and-aft and athwartships, and with the geometric axis of each loop directly over the point where the ends of the loop join its cable, and that they can be kept taut, then the possibility of errors due to lack of symmetry is reduced to a minimum; and as permanent lack of symmetry can be detected by easily applied internal tests of sufficient delicacy, the actual danger due to lack of symmetry in all its forms is zero.

Lack-of-symmetry error takes many forms according to its extent, and whether one or both loops are at fault. The strange diversity of results is hardly worth recording now that symmetry testing has been established, but it is worth noting that a combination of a slight lack-of-symmetry error and a slight electrostatic error often has the effect of leaving one zero accurate and sharp and the other very "woolly." It is sometimes necessary to accept this as a temporary measure, and to let well alone.

(*d*) *Plain tuning error.*—The remaining inherent error is due to the effects caused by the frequency of one loop, viewed as a simple plain aerial, being very nearly in tune with the incoming wave when the frequency of the other loop is somewhat less nearly in tune. This error is comparable with loop-tuning error and is negligible if loops of proper dimensions are used. The adoption of the inductive choke mentioned in the preceding paragraph renders the loops viewed as "plain" aerials practically aperiodic (in the true sense of the word) and is now almost unheard of. The effects are zero if perfect symmetry exists; if not, it accentuates the lack-of-symmetry error on certain waves. It is generally called "plain tuning error."

(*e*) *Electrostatic error.*—There are also two inherent instrumental errors. Of these the more important is the result of superposing the stray capacity coupling between the field coils and the search coil upon the magnetic coupling. The effect of this stray capacity coupling is to distort both positions of zero resultant coupling, and, although the line bisecting the angle between the observed zeros is at right angles to the proper zero due to magnetic coupling only, the presence of this error is detrimental to rapid and accurate work. It can be practically annihilated by the interposition of an earthed shield between the windings of the transformer connecting the search coil with the tuning condenser. It is most noticeable when the stray capacity is large in proportion to the tuning capacity that is to say on the shorter waves, when the tuning capacity is very small. This is commonly called the electrostatic error.

(*f*) *Capacity error.*—The second instrumental error is due to the varying capacity coupling between the search coil and first one and then the other of the field coils. By spreading out the windings of the search coil on one side of its former in a V shape, this error, which is never as much as 1°, can be made to reach its maximum and fall to zero eight times in the 360°, and so long as "swing" readings are used it is truly negligible, and in practice no notice is taken of it. This is the cause of the important difference in practical working between systems employing "tuned" and "untuned" loops. In the former case the arc through which the search coil can be moved, while still preserving inaudibility of a naturally good signal, is very small—perhaps only 2° to 3°—and under these conditions what are familiarly known as "sitting" readings can be taken. In the latter case the arc of inaudibility is usually 20°-40° and "sitting" readings are impossible; only swing readings can be used, and these of necessity eliminate the second instrumental error.

The colloquial term "swing readings" means observing the position of the pointer which gives equal strength of signals on either side of the arc of inaudibility, and taking the mean of these two positions as the position of true zero. It is usual to observe the position in which the signal just becomes inaudible. Bearings are perfectly reliable with vanishing points up to 60° apart.

(3) Construction of Loops.

From the foregoing it is clear that, given a properly constructed direction-finder, everything depends upon the erection of electrically symmetrical loops of the correct relative areas, the planes of the loops being necessarily vertical and at right angles to one another. One must be exactly fore-and-aft and the other exactly athwartships, but there is no reason why their planes should intersect, and no practical disadvantage is found if they do not do so, so long as the distance between their axes is small in comparison with a quarter wave-length.

It should be noted that there is no obvious theoretical reason why the fore-and-aft loop should be on the centre line of the ship, though common sense indicates that it is desirable to place it there. No experiments have been tried with fore-and-aft loops out of the centre line, as every effort has been concentrated on producing a seamanlike and trustworthy aid to navigation, and no opportunity has offered for academic investigation. One fore-and-aft loop accidentally fitted a little off the centre line gave indifferent results.

Under ordinary sea-going conditions a subsidiary difficulty is experienced. If the loops cannot be made permanent, but have to be lowered and re-hoisted frequently, there is a great likelihood of the symmetry being destroyed in the process. This has been found to be a very real and serious cause of trouble.

Summarising the above, it is clear that the main practical difficulty lies in the selection of a suitable position for the loops and in the appropriate arrangements for rigging them. Before selecting the position of the loops it is first necessary to decide on the position of the direction-finding instrument. As far as the mercantile marine is concerned, it is highly desirable to have the instrument in the wireless room. It should be under the charge of the telegraphist and always available for practice, and when using it he should be in his own place and not an intruder among the navigating staff. The position of the directing-finding instrument must to some extent limit the choice of positions for the loops, on account of the capacity of the connecting leads.

For this purpose twin lead-covered paper-insulated cable is used, the cores each consisting of one strand of 20 L.S.G. copper, and with this cable a total length of 100 ft. is permissible from the direction-finder to the commencement of the loops. This figure is based on the assumption that the loops are to be large enough to allow good bearings to be obtained up to a distance of 100 miles on spark waves between 400 and 1,000 m , and small enough to avoid " loop-tuning " error in 400 m.

Experience shows that the larger the ship the larger should the loops be for a high degree of accuracy. Small loops, even down to an area of 70 sq. ft., have given accurate service at ranges up to 30 miles in small ships, though they are not accurate in large ships. The reason for this appears to be best explained if the state of the electric field among the rigging, funnel, boat gear, etc., of a large ship be regarded as a mass of eddies, in which loops large in proportion to their surroundings are affected by many such eddies tending to balance one another and thus give an accurate average result, whereas loops small in comparison with their surroundings are more likely to feel the effect of a single eddy and thus give inaccurate bearings.

Experience has shown that loops work well for all frequencies lower than their own natural frequency, but they are very unsatisfactory for frequencies higher than their own. Obviously, the capacity from core to core of the lead-covered cables is a very important factor in determining the " loop " frequency of each aerial, and the capacity from cores to lead covering is of similar importance in determining the " plain " frequency of each aerial. The core-to-core capacity also acts as a shunt to the field coils, and, briefly speaking, the shorter the cables the better are the results.

Having complied with the limits imposed by the permissible length of cable, a search must be made for some place where the loops can be erected and in which it will not be necessary to lower them. For work under mercantile marine conditions as outlined above (400 to 1,000 m. spark), the area of the loops should lie between 200 and 400 sq. ft.

No part of the loop should come within 6 ft. of earthed metal, and if the disposition of such earthed metal is not symmetrical about the axis of the loop, this distance must be increased to at least 12 ft. This figure is not yet definitely fixed, but there is clear evidence of evil effects at distances up to 10 ft., and it is quite possible that the safe distance may be as great as 20 ft.

If unsymmetrical objects, such as ventilators or hatches, are unavoidable, they must be screened by the interposition of an earthed plane—say wires 1 ft. apart—at least 6 ft. wide and symmetrically disposed on each side of the axis of the loop which it is intended to shield. Satisfactory results are obtained if the screen is mid-way between the nearest limb of the loop and the object from which it is to be shielded. If these precautions are neglected, evanescent errors may occur due to, for instance, the opening and shutting of large iron skylights, turning of ventilators, etc.

(*To be concluded*).

Correspondence.

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

To the Editor of EXPERIMENTAL WIRELESS.

SIR,—With reference to the interesting article on wireless telephone receivers by Mr. Gayes in your last number, one can but agree with the writer that the standard methods of applying these in valve circuits are technically unsatisfactory; but may I be permitted to point out that the actual polarising arrangement suggested by your contributor would, as applied to a pair of head-telephones, result in acoustic assynchronism ?

The receivers, whilst in series relative to the polarising current, are now in parallel, and of opposite polarity relative to the speech-currents, neither is it possible in this arrangement to introduce correction in one relation without introduction of error in the other; so that at time t in each cycle the speech currents will be co-polar in the one case, and counter-polar in the other, reversal without commutation occurring at time t^1; and whilst symmetrical displacement of the diaphragms may be obtained the movements will be opposite in phase, and the accoustic resultant theoretically zero if the amplitudes are equal, as shown in Fig. 1.

In practice, the human senses are to a considerable extent able to contend with assymmetry, and to a less extent with assynchrony, though they cannot commutate, and this will prevent the *aural* result being zero ; but the result will actually be such that one ear or receiver of a pair will assume command, and the other will be practically non-effective when applied simultaneously—the effect being in this respect comparable to that observed in a wrongly interconnected pair of receivers wherein the connections to one earpiece are reversed, with the difference that whereas in such case both assynchrony and assymetry may be present and the senses will in that case be assisted differentially, in the present case assynchrony only will be present, and, whilst the receivers will be equally effective individually, collectively one or other of them must

Mr. Gayes' arrangement is, moreover, applicable to a *pair* of receivers only, and could not be used in connection, for example, with a single loud speaker, as the polarising battery of negligible resistance would then be in shunt with the receiver, whereas the arrangement now suggested is applicable in either case, the receiver or receivers being in series relative to both speech and polarising currents.

A development of this arrangement which works well in practice and is actually used by the writer for both headphone and loud speaker work is shown in Fig. 3. Here the choke itself is used to minimise the losses occurring across the resistance, and a somewhat different action is set up. Since both anode and polarising currents now traverse the

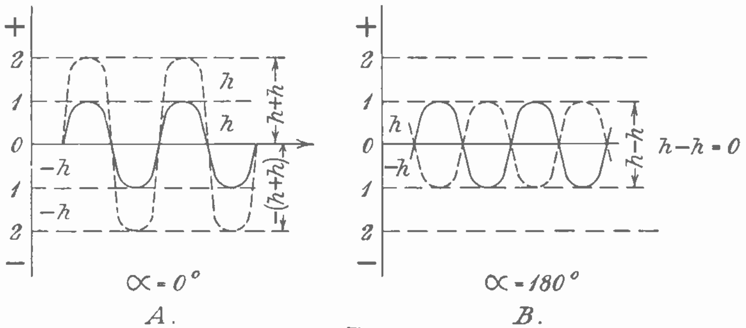


Fig. 1.

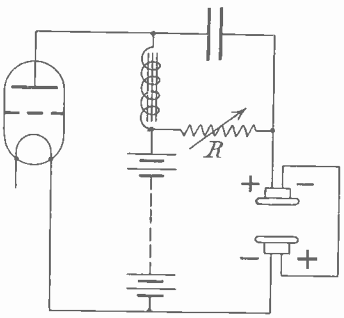


Fig. 2.

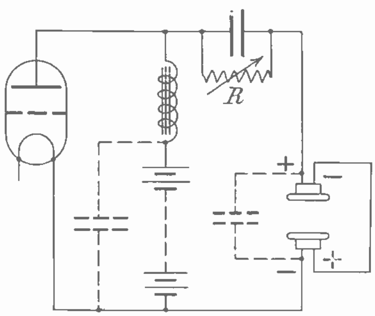


Fig. 3.

be aurally non-effective, in the sense that both cannot be heard simultaneously ; and the practical effect of this, in addition to an apparent loss in volume of at least 50 per cent., is extremely unpleasant and fatiguing.

May I venture to suggest that a better arrangement from this point of view would be such as is shown in Fig. 2 ? Here a resistance R is certainly in shunt with the telephones, and a certain loss of speech currents inevitable even when such resistance is made considerably greater than the impedance of the telephones thereto, but this is discounted by the fact that the action of the receivers is now synchronous ; and in practice, whilst the net result is not actually a gain in signal strength, considerable improvement in the quality of reproduction is obtainable without loss in volume as compared with the usual connections.

choke, we have in effect reproduced the conditions obtaining in a choke controlled transmitter, and audio-frequency variations in the anode current give rise to equal and opposite variations in the telephone current, the steady mean polarising current being, however, adjustable by means of R independently both of the steady mean anode current and of the speech currents in the telephone circuit, the ideal degree of polarisation being thus obtainable without loss of the speech currents themselves or other complications ensuing.

This arrangement was originally suggested by the writer a year ago to Mr. Gerald Marcuse in connection with loud speakers of the auto-excited type usual in this country, with which it was suggested that considerable improvement in reproduction and efficiency might be obtained by these means ; and the theories involved in this suggestion and in Mr. Gayes' article are borne out in practice with all forms of magnetic receiver.

A practical disadvantage of any such arrangement, however, is the extra drain imposed upon the anode battery, which in the generality of cases, where this consists of small dry cells, becomes a serious consideration, and it is regarded as questionable whether the actual advantage gained is such as to justify this in the majority of cases—exceptions being, of course, provided for special purposes and where (as happens in the writer's case) the H.T. supply is practically unlimited.

Since the arrangement proposed by Mr. Gayes, whilst unsuitable for general use, is eminently suitable in the case of two or more loud speakers so disposed that assynchrony becomes unimportant, it is thought possible that its conception may originally have been in view of such an application rather than in connection with actual headphone receivers—though it will be appreciated that the effect in the case of loud speakers disposed within *audible range* one of another would necessarily be similar, in less marked degree, to that obtaining in the latter case—and this letter is written by no means in a spirit of criticism, but solely in discussion of a subject interestingly opened by your contributor about which little has yet been heard in amateur circles.

ALAN ST. CLAIR FINLAY,
Captain.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR.—I have read with considerable interest Capt. Finlay's letter concerning my article on Telephone Receivers. I must thank Capt. Finlay for contributing additional information, particularly for Fig. 3. This, in my opinion, represents an excellent method of applying telephone receivers to wireless circuits and has an advantage over the method I selected in that there is no necessity to use two receivers in parallel, and thus a high impedance output circuit can be maintained if necessary.

Capt. Finlay's rather startling assertion that receivers connected in the manner I suggest would give an acoustic resultant approximating zero, is, I think, of theoretical interest only, as in practice such effects very seldom occur and then often when they are least expected. Were we interested in two similar sources of sound of equal periodicity, displaced 180° and so disposed as to eliminate sound reflections, then the zero effect referred to by Capt. Finlay would be noticeable, but experience with telephone receivers as sources of sound show the problem to be more involved, and, as I will show later, the conditions are not always what they appear to be at first glance.

I would refer for a moment to a form of loud speaker frequently seen on the market, which consists of a common air chamber energised by a pair of ordinary head receivers fitted on the ends of a " T "-shaped arm. Here is an ideal case for assynchrony, but those who have experimented have probably found any such effect very erratic in its appearance, and it was the writer's experience that a particular pair of head receivers had to be deliberately wrongly poled before the full volume of sound was obtainable from this apparatus.

A second set of experiments having bearing on the problem may be of interest. These tests were made recently by an expert experimenter when studying the binaural effect of sound. This latter effect is mentioned by Capt. Finlay, and for this reason the following notes may be of special interest. Two triode oscillators each of smoothly controllable frequency were set up. First, a pair of series head 'phones were joined to a coupling coil so placed as to receive equal induction from each oscillator. The oscillators were adjusted to beat, and, of course, the beats were readily detectable. Next, the two head 'phones on a common head band were joined to separate coupling coils each of which was coupled to an oscillator, the two systems being widely separated to avoid mutual induction. With this arrangement it was still possible to get beats although their presence was dependent upon the magnitude of the sound. In other words there appeared to be a saturation limit to the ear above which the beats were not apparent. Experiments were made at various frequencies with similar results. *No difference whatever* was apparent on reversing *one* of the receivers, either as regards intensity of sound or ability to set up beats.

Without taking further apparent anomalies it might be advisable to attempt to explain what takes place. Every telephone receiver has its own particular natural frequency of vibration, and it will be seen from the reports which have recently been made public before the I.E.E. by our research workers in their discussions on Loud Speakers, the phase relationship between the energising current and the movement of the diaphragm is considerably affected by this point of resonance. Thus we see that two receivers poled and energised to be in perfect phase at one frequency will be hopelessly out of phase at some other frequency. Therefore, for any complex sound, such as those in which we are interested, it must be a practical impossibility to secure two receivers functioning 180° out of phase.

As a matter of fact " phase " in telephony is of very little consequence, as the aural faculties are essentially integrating and responsive to sounds lasting over a certain period of time. This statement must, of course, not be confused with the mutual destruction of the sound waves in a common medium. Here the effect is not integrated, but is an instantaneous one.

Should any proof of these statements seem desirable reference should be made to a complete work on the subject, by M. G. Lloyd and P. G. Agnew, entitled the " Effect of Phase of Harmonics upon Acoustic Quality," a paper published under No. 127 by the American Bureaux of Standards. Here the authors studied the effects of phase by taking a supply from a Franke machine, so arranged that the phase of the harmonic was under perfect control. The general conclusion is that aurally the phase relationship of sounds is of no consequence whatever.

ALEXANDER J. GAYES.

To the Editor EXPERIMENTAL WIRELESS.

SIR,—In reply to the letter from Mr. J. A. Partridge in the last issue of this journal concerning transatlantic radiotelephony, the author regrets that he cannot at present undertake to provide fuller information than has already been published.

The experiments concerned were essentially of a private and confidential nature undertaken for the investigation of a radiotelephony system evolved by the writer, and divulgence of further details of any kind at the present juncture would not be in the best interests.

The writer is therefore able to assure Mr. Partridge that neither the American Radio Relay League nor any other body has fuller information at its disposal than has already been provided, and wishes to make it clear that establishment of individual "records" of any kind was not amongst the objects of the experiments, which were of a purely scientific nature.

The article in question, in so far as it was applicable to standard methods, was published in the hope that it might prove of some interest, and perhaps use, to other experimenters; but it will be appreciated than an investigator cannot always be prepared to disclose full details of his work until ready to do so—a prerogative which the author has no alternative but to exercise in the present case.

It is, however, far from the writer's wish to appear discourteous, and Mr. Partridge—whose interest in the matter is much appreciated—may rest assured that adequate information on the subject will be published in due course, when not only will it be fully available to him, but the writer will be happy to afford him a personal opportunity of witnessing a demonstration of the system, both as regards the results achieved and the means whereby they are obtained, which it is hoped Mr. Partridge may see his way open to accept.—I am, Sir, yours faithfully,

ALAN ST. CLAIR FINLAY.

To the Editor EXPERIMENTAL WIRELESS.

SIR,—With reference to Mr. Scroggie's comments concerning the article on transatlantic radiotelephony, recently published in this journal, the author is, unfortunately, not at present free to discuss these as fully as he would wish for reasons which are stated elsewhere in these columns; but to reply to the points raised by your correspondent as far as circumstances will permit :—

(1) The writer is unable to agree that the useful effect in the receiver of a modulated wave can be shown to be proportional to the product of aerial current and modulated amplitude, as such effect must in fact be regarded as proportional to the square of the product of the steady component and the determining amplitude, which will lie in the modulated component.

The relative effects of the two examples chosen are therefore not 0·8 and 1·4, but as ·25 and ·49, although this still appears favourable to your correspondent's contention; but when the power expenditure involved in the two cases is taken into consideration (that in the latter will, of course, be equal to four times that in the former) the relative efficiencies of the two from the transmission standpoint may be computed, and the author's statement in the matter be understood.

Lest the derivation of the figure ·25 given above be considered obscure, it should be pointed out that, where the modulated component is the major component, the determining amplitude must be equal to exactly ·25 of the total output, which proportion it cannot exceed, and that the effect of over-modulation such as 80 per cent. will therefore be disproportionate rendering of the major and minor amplitudes, resulting, not in loss of general signal-strength, but in distortion.

This under ordinary conditions is inevitable where more than 50 per cent. of the output is modulated, and is a matter quite apart from pre-control distortion discussed in the article, although, the ear being unable to detect disproportion of this nature up to an order of 300 per cent., modulation depths up to 70 per cent. are in practice permissible in the majority of applications, and result in a certain increase in efficiency.

(2) The meaning of the reference to modulation frequencies and antenna tuning is not clear, since the antenna is normally tuned not to the modulation frequencies but to the carrier frequency. It is, of course, common knowledge that side-frequencies are formed and a carrier "spread" by modulation, but reference to this elementary fact was not made in the article, the passage in question actually referring to tuning of the oscillatory circuits —aerial inclusive—to the carrier frequency, and being intended to emphasise that control should be exercised as far as possible upon amplitude and not upon frequency—*i.e.*, that the carrier should be maintained at a constant frequency to which the circuits should in the general case be resonant, and should not be caused by the operation of the control to occupy a band of frequencies, the reasons for which will surely be evident.

(3) Mr. Scroggie's statement that "the same amount of power is absorbed by the aerial ammeter in giving a reading however it is connected" is erroneous in this application. In the former case the decrement varies directly with the resistance of the instrument, whereas in the latter it varies inversely, where the instrument constitutes a resistance in series and in shunt respectively; and the advantage to be gained under these conditions by connection of an instrument of high resistance in an indictively-coupled loop rather than directly in series should be evident.

Moreover, the transformer-loss in such case does not operate against the main-circuit current, but against the loop current, and can be allowed for.

The coupling and instrument concerned naturally require appropriate setting and calibration, and that this is actually done is stated in the article—variation in the coupling being in fact utilised to provide a double-reading scale suitable for wide power variations and a correction applicable to the use of different frequencies. The writer is unable to agree that this method need be in the least degree more uncertain than the series if correctly applied, and would assure Mr. Scroggie that it is, in fact, standard practice and in no way novel.

(4) With regard to leakage of H.F. currents, *via* the LT+ lead, the writer would point out that the object of the choke L7 in the LT− lead is primarily to relieve the source of filament current supply of small H.F. PD's set up across the filaments and associated resistances, which are undesirable, and is purely a refinement. Since the low-potential side of the entire system is earthed, the question of leakage to earth scarcely arises, and neither the meaning of the reference thereto nor the object of a choke in the LT+ leads are clear. The writer would, moreover, point out that the common pole of the H.F. E.M.F. in a valve oscillatory system

is the filament, and the common portion of the oscillatory circuits include, *ipso facto*, the negative lead thereto or part thereof, but not the positive.

(5) The misconception concerning the function of the variable resistance shown shunting the voltmeter in Fig. 3 is not the fault of your correspondent, as a millimeter should have appeared in HT+ lead immediately above this, as stated below that diagram. Actually, the arrangement is designed for the determination of the anode supply voltage under load, and takes the place of an electrostatic voltmeter, varying loads down to that imposed by the instrument itself, representative of valve loads, being reproducible by variation of the resistance when the switch is closed, and the supply voltage at any load may thus be checked. But it is surely not conceivable that such an arrangement could reasonably be intended to have the function attributed to it by your correspondent ?

(6) The writer much regrets that the inductance of a speech-choke of 17,500 turns should accidentally have been given as 12 *micro*-henries instead of henries, but it is felt that this should scarcely affect the sense of an article intelligently read, since one cannot but agree with your correspondent that the intention is somewhat obvious.

The writer is indebted to Mr. Scroggie for the opportunity of clearing up certain points which, owing to considerations of space, may not have been adequately dealt with in the article itself, and wishes that certain of these could be discussed more fully than is at present expedient.—I am, Sir, yours faithfully,

ALAN ST. CLAIR FINLAY.

To the Editor EXPERIMENTAL WIRELESS.

DEAR SIR,—Your correspondent, " Short Wave," is guilty of two defects of logic. Firstly, he argues by analogy, and, secondly, he assumes as data various facts which, to make his analogy sound, it would be necessary to prove.

He also confuses " force," which has the dimensions MLT^{-2}, with " power," which has the dimensions ML^2T^{-3}.

Analysing his analogy : For the comparison of the displacement of coarse and fine thread screws it must be postulated : (1) That the volume of the screws per unit length is the same, and at first, that (2) no friction or other irreversible phenomena exist. This will give a theoretical answer. Then, by admitting friction, the practical answer can be deduced.

If no friction occurs the power given to the screw must be stored in strain energy in the wood, and if the same volume displacement takes place in the same time the strain energy will be the same and the power taken will be the same. In other words, for equal power the screws will travel in at the same rate. Now admit friction.

It is easily proved that the fine thread screw has for the same volume a greater surface area than the coarse thread and will therefore generate greater friction per unit length. It will therefore consume more energy in overcoming the force of friction than the coarse thread screw and will therefore take more power when progressing into the wood at a certain velocity than will the coarse screw when progressing at the same velocity. This is, as a matter of fact, fully borne out by practical experiment, and your correspondent's analogy is in exact opposition to the true facts.

He then goes on to suggest that long waves and short waves may travel at a different speed. He has engaged heavier metal than I am here, as the whole foundation of the electro-magnetic theory of light and other ether disturbances and of the theory of relativity is based on the fact that in the same medium disturbances of all wave-lengths travel at the same velocity. In different media, of course, this velocity varies ; hence the phenomena of refraction.

In any case, retardation of a wave is not the same as absorption, though the phenomenon usually occur together.

The problem is complicated by the fact that we signal through a tunnel, whose roof and floor are partial conductors (and therefore reflectors of our waves), through a medium which is, figuratively, sometimes thick, sometimes clear soup and very often a stratified mixture.

I would, however, suggest that it is well-known that really short waves (*i.e.*, light) experience selective absorption in most transparent media, *e.g.*, solution of a dye.

It has not till now been shown that air or any other medium has not a selective absorption on waves of length suitable for radio-signalling, and any fact of this sort would at once explain why certain waves are more favoured than others in long distance travel.

In fact, the power of penetration apparently possessed by waves of $\lambda = 50$ to 200 metres rather goes to prove that this selective absorption exists.—I am, Sir, Yours faithfully,

I. A. J. DUFF, B.A.

To the Editor EXPERIMENTAL WIRELESS.

DEAR SIR,—I wish to make the columns of your valuable journal the medium for thanking those experimenters who have written to me reporting on reception of telegraphy and telephony purporting to emanate from my experimental station 2KG.

This would be highly gratifying to me were it not for the fact that these reports prove the existence of something that I have suspected for some considerable time ; I refer to the misuse of my registered call sign by some person or persons who evidently are aware of my continued absence from the United Kingdom, and are taking advantage of this knowledge in making regular and persistent illicit transmissions using my call-sign for the same.

To those gentleman who have been so kind as to write me respecting these transmissions, and also to my former confrères, I take this opportunity of pointing out that I returned to marine wireless operating in November of 1922, when I joined the wireless staff of the Cunard Line, and served for 12 months continuously aboard their R.M.S. *Tyrrhenia*, where it is obvious I would have neither time our opportunity for making experimental transmissions. Nevertheless, I understand that during the whole of that time 2KG was regularly " on the air."

Naturally, I have the strongest objection to this misuse of my call-sign, and I would be more than grateful if my correspondents would continue to advise me of transmissions made with my call, and should this meet the eye of the person or persons responsible I would proffer the information that I have a rather efficient experimental direction-finding receiver at my home address in Aberdare (South Wales) by means of which I can get bearings up to within a maximum error of two degrees, and as I am able to be at home for six days each month, I intend to take the necessary steps to trace the delinquent.

My sincere thanks are extended to all those gentlemen who have been to considerable trouble in forwarding me these reports.

Unfortunately they are much too numerous to admit of my replying to them individually, but in particular I thank the following experimenters: Messrs. Herbert Etheridge, of Hanwell, W.7; S. D. Simmons, of Ockenden Road, N.1; P. Sutherland, Clancarty Road, Fulham; William E. Edge, of Kensall Rise, N.W.10; W. Durban, 35, Ulysses Road, West Hampstead; S. E. Smith, of Gordon Avenue, Twickenham; W. White, Medway Street, Westminster; P. A. Camp, of Balchier Road, Dulwich; Station 5LF, of Barnes, and Station 5GL, of Newark-on-Trent. It is significant that the majority of my correspondents are in London or district.

It is noted that station 6IM works frequently with the station that signs himself with my call-sign (2KG).

Possibly 6IM is prepared to volunteer some information concerning the matter.

May I also take this means of pointing out to the guilty party that, on receipt of any further reports of reception of Morse or speech signed 2KG I fully intend taking the matter to the Department of the Inspector of Wireless Telegraphy.

With apologies for thus far trespassing on your valuable space.—I am, dear Sir, Yours faithfully,

A. E. Hay,
Chief Wireless Operator,
R.M.S. *Avoceta*, Yeoward Line.

Lisbon,
January 31, 1924.

EFFICIENT INDUCTANCES.

To the Editor, Experimental Wireless.

The mild " battle of the gauges " which has been proceeding for some time in the various wireless periodicals indicates that the importance of really efficient inductances is at last being realised by an increasing circle of amateurs. A well-known writer not so very long ago informed us that " It didn't matter much if the inductance was wound with 40 S.W.G. wire or what it was like since any losses could be made good by reaction," and it is just possible that inductances which require such gingering up are a prolific cause of the oscillation nuisance.

With the ever-growing mass of modern literature and the knowledge that valve R.T. is new, we stand in some danger of forgetting the researches of the pioneers. Now, high-frequency resistance was given considerable attention by J. Zenneck, amongst others, as far back as 1905, for he treated the matter exhaustively in his " Elektromagnetische Schwingungen," and later in his " Lehrbuch," of 1912.

In Seelig's English version of the latter work—1915—there is given a very interesting table (pp. 396-397) showing the increases in resistance of various wires at frequencies corresponding to 100 to 6,000 metres.

S.W.G. Approx.	MM.	" Steady Current " resistance length of 1 metre.	Effective Resistance at 300 metres W.L.
36	0·2	0·554	0·61
24	0·6	0·0615	0·156
19	1·0	0·0221	0·108
14	2·0	0·00554	0·0432

If, then, an inductance of exceedingly large diameter be considered for ordinary reception, it appears that although 19 S.W.G. used at 300 metres has an effective resistance nearly five times its steady value, it would be advantageous to use it in preference to 24 S.W.G., which shows an increase of less than three times, or than 36 S.W.G. which shows practically no increased resistance at all.

Before dismissing the conclusions of Zenneck lightly the reader should remember that upon such work was built up the finest system of spark telegraphy ever devised, which even at the present date is carried by something like 80 to 90 per cent. of the world's fitted shipping.

Very heavy currents, both damped and undamped, have been dealt with for many years past, so that any errors would have been brought to light long before the advent of broadcasting reception.

If we reduce the inductance to workaday dimensions, we find that the effective resistance becomes further increased (perhaps ×2) owing to the tendency for the current to flow round the innermost side of the winding, but here again the larger wire appears likely to score by reason of its greater circumference. In all this, there is, however, the implied condition that the inductance, whether large or small in diameter, shall have negligible self capacity, and it occurs to me that some workers who have recently pronounced for fairly small wire as against thicker may have had some difficulty in separating the apparent resistance due to self capacity from that due to the wire *per se*.

In passing, it may be noted that when the current travels in the skin of a wire, and is equally distributed, there is practically no magnetic field within the wire, and, therefore, but little eddy current loss due to the use of reasonably large wire.

Even copper-clad steel wires have been found to have but little greater H.F. resistance than solid copper in the straight, so that for low eddy current losses coils of not too small diameter are indicated.

It is possible that a comparison between a coil which happens to be wound with fairly fine wire but is of good design, as against one of the many " good enough for amateurs " varieties with which the market is flooded, might lead to ascribing merit to the smaller wire which more properly belongs to the better design.

So far as the writer knows, there are two short-wave multi-layer coils on the English market which have any real pretensions to low self capacities of the order of 2 μμF., one being issued by Gambrell, and the other by the Rimar firm (H. Type).

Two different methods of arriving at much the same result as regards spacing of layers and turns are used, and the makers appear to represent different schools of thought as regards the gauges which are best for H.F. work. The whole subject is of great interest and importance, and also, one may add, of some difficulty on account of the lack of easily applied methods of self capacity measurement.

Two are in common use, the first due to Howe, making use of the natural time period of the coil, and the second, due to Meissner, depending on the increase in self capacity which follows immersion of the coil in an insulating fluid K, for which is greater than 1.

The drawbacks to the former method are, firstly, that since there can be no definite natural period to a coil which has no self capacity, small self capacities in small coils produce natural periods outside the range of ordinary wavemeters, and, secondly, that as all measurements are made at very different frequencies from those for which the coils will be used, the figures obtained are often quite misleading, if not wholly inaccurate.

The other method measures the self capacity at the frequency at which the coil is intended to be used and, being capable of adaptation to beat note methods, is of great delicacy.

The drawback here is that the starting point is assumed to be a copper coil surrounded by air in every direction, instead of a wire surrounded by cotton, wax, varnish, etc., in all of which cases the figures may err, sometimes very seriously, on the low side, so that experience and some precautions are necessary to secure a true result.

I apologise for trespassing on your space at such length, but do so in the hope that we may " draw " some of the more experienced workers on the subject, for does it not run Poor Inductance—Low Pressures—Weak Signals—More Valves—Bad Speech ?—I am, yours very truly,

WM. A. RICHARDSON,

18, Wellesley Road,
Ashford, Kent.

DEAR SIR,—I have often been able to get $\frac{3}{16}$th" sparks from a 100-ft. aerial, with an average height of 35 ft.

I have only noticed this effect while it is raining, snowing, hailing, or sleeting. Hail seems to produce the most E.M.F., and I have sometimes been able to get $\frac{1}{4}$" sparks during sharp hail showers.

I got the same results with a rubber-insulated aerial as with the other, showing that the current is set up by inductional effects, and not by the charged flakes of snow, etc., coming into contact with the aerial.

Re the effect noticed by Mr. A. L. Williams, mentioned in the last issue of EXPERIMENTAL WIRELESS, I have noticed the same effect when receiving on wave-lengths up to 1,000 metres, with the receiving set 5 ft. from the end of the lead-in.

Here is a use for harmonics which I have not seen mentioned previously :

The transmissions from the Birmingham broadcasting station and the S.P.T. Paris are often badly jammed by oscillation and spark transmissions ; with a three-valve set, however, I can receive the first harmonic of these stations quite loudly (on headphones) without any interference at all.—Yours truly, KILO WATT.

Bolton,
April 14, 1924.

Points from Letters.

We have received the following letter from the Jewell Electrical Instrument Co., which indicates the interest with which EXPERIMENTAL WIRELESS is followed overseas.

The Technical Editor, EXPERIMENTAL WIRELESS.

DEAR SIR,—I have before me your March number of EXPERIMENTAL WIRELESS, and have been reading it with much interest, as usual.

Your article on high frequency resistance, however, impels me to write and question some of your statements.

On p. 320 in the second column you state : " The only apparatus necessary is a high frequency ammeter, such as a hot wire ammeter—which, although notoriously inaccurate, may be calibrated, etc." A little further down you state : " In the case of the last method, if a reliable high frequency ammeter (if such a thing exists) is not available, etc."

I will admit that your statements hold with reference to ordinary expansion type of hot wire instruments. They most decidedly do not hold when applied to the modern thermo-couple type of high frequency ammeter, which has practically displaced the expansion type in the United States.

The old expansion type of high frequency hot wire instrument was notoriously inaccurate, and made a much better thermometer than an ammeter. It was always off zero, and usually had a considerable lag.

The modern type of thermo-couple instrument, as manufactured by ourselves and some of our worthy competitors, is a real instrument, and one which can be relied upon. It has no zero shift due to its basic principle. It has very little thermo lag. Its calibration may be relied on very closely, and in the small instruments, say, three inches in diameter, which are so popular with the American amateur, it is rare that an instrument is more than 2 per cent. in error. . . . . . . and we would suggest that you look into the matter of high frequency instruments more thoroughly, as we feel that you are either misinformed or unaware of recent developments in high frequency meters.—Yours very truly,

JEWELL ELECTRICAL INSTRUMENT CO.,
JOHN H. MILLER,
Electrical Engineer.

We publish the above letter in case any other readers should have been misled by the article in question. Mr. H. Andrewes, the contributor of the article, was referring to the cheap type of hot wire ammeter which is popular among many amateurs, and not to thermo-couples. The article was written for the benefit of the impecunious amateur, and not for those who have at their disposal an unlimited supply of instruments.

It may interest both our readers and the Jewell Electrical Instrument Co. to know that thermo-junctions of various degrees of sensitivity are used in our own laboratory with reasonable accuracy.

Re FRAME AERIALS.

Mr. Jowett, of Halifax, sends us the following letter, giving details of his experiments with inside aerials. Readers' experience under similar conditions will be of interest.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—For some time I have experimented with inside aerials, and I notice most writers advise beginners to erect an outside aerial. After many tests with my own and friends' aerials I have come to the conclusion that if properly erected, *and insulated*, an inside aerial is quite as efficient as an outside one, and signals are equally as loud. No doubt inside aerials are condemned because those trying them have erected them anyhow. My aerial is fixed on four pieces of wood about 2″ × 1″ × 2½ ft. long, nailed vertically on the purlins near the roof of my house in a large under-drawing which goes over the whole area of the house, almost like a large attic. There is no lead on the roof, except at the top perhaps. The pieces of wood are nailed on the purlins so as to form a square about five or six yards square. Pieces of old motor tyre were tacked on the woods first, as insulation. Enamelled wire (22) is used for the aerial. The commencing end was fastened to one of the pieces of wood about 9″ below the top, and then complete turns taken round, each being 8″ or 9″ below the previous turn. The finishing end is led through insulating tubing through a trap-door down an open staircase into a dining-room, being kept about 12″ away from a wall, and the end of the wire is attached to the receiver. The length of wire used in the aerial is about 200 ft. to 230 ft. The earth of the receiver consists of a piece of 7/22 cable fixed to a water-pipe, and the length of this cable to the pipe is about four yards. The length from pipe to ground outside is two yards. Now, using the tuned anode circuit given in your first issue, I can work a small Brown loud speaker with three valves (from Manchester, 32 miles) and get enough volume to fill a room 5 yards by 5 yards. By switching on a fourth valve (resistance coupled) the sound is too loud for comfort. Two valves will work the loud speaker quite audibly. Also with phones I can get Cardiff, London, etc., quite audibly on one valve, or Paris 450 on two valves: all this with clarity and purity of tone. Bournemouth comes in almost as loud as Manchester. I am situated at the top of a hill and about 200 trunk wires run down the road. I can also receive transmitting amateurs over a big area. No doubt this will be of interest to you, and I should like to have your views.—Yours faithfully,

ARNOLD JOWETT.

Business Brevities.

MONEY, HICKS & MILLS, LTD.

Messrs. Money, Hicks & Mills, Ltd., of 297, Haydon's Road, London, S.W.19, have sent us their latest price list of Ivorex and Ebonex scales and terminal labels. These labels, it may be mentioned, are engraved either on black or white, and give a very neat appearance to a receiving set.

* * *

"BATY'S PRODUCTS."

Readers are, no doubt, familiar with the peculiar tuned anode receiver described some time ago by Mr. Ernest J. Baty, B.Sc., of 157, Dunstable Road, Luton. We have recently received a price list of the various components which can now be obtained separately, as well as the complete receiver. The condensers are of the circular plate variety, the dielectric being a combination of mica and air. One plate is fixed, and the other is fitted to the end of a screwed rod, by means of which its distance from the other can be varied at will. The price of the ·001 μF size is 5s. 3d., post free.

* * *

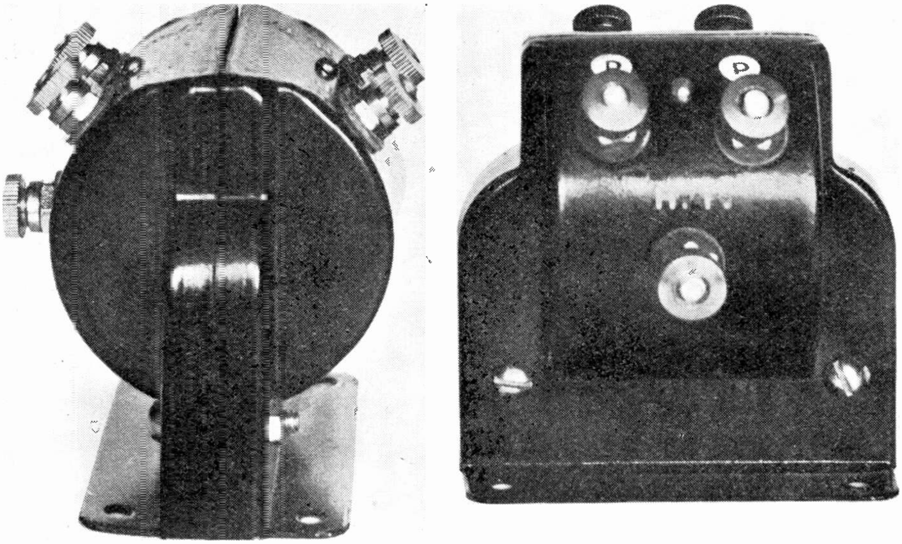
GENERAL RADIO COMPANY, LTD.

The head offices of the General Radio Co., Ltd., are now established in their new quarters Radio House, 235, Regent Street, London, W.1, and all communications should be addressed there. A showroom is provided, and all dealers are extended a cordial invitation to call. The General Radio Co., Ltd., distributes its products through dealers and factors, and does not sell direct to the public. Branches of the General Radio Co., Ltd., are located as follows: 6, Imperial Buildings, Oxford Road, Manchester; Cannon Chambers, Cannon Passage, Birmingham; 71, Middle Abbey Street, Dublin, Ireland; 37, Jamaica Street, Glasgow; 46, Above Bar, Southampton. A capable dealers' service department will gladly give demonstrations for dealers or their customers at any of the above addresses.

* * *

GRAFTON ELECTRIC COMPANY.

The latest edition of the Grafton Electric Company's catalogue, which we have recently received, contains some thirty pages devoted exclusively to wireless components. We notice that many of the leading manufacturers' productions are to be found among the list, which should prove of interest to our readers.



The push pull transformers by the Economic Electric, Ltd., are of the enclosed type.

THE ERLA TRANSFORMER.

It was with considerable interest that we tested the Erla transformer of the Electrical Research Laboratories, Chicago, Illinois, as it afforded us an opportunity of examining typical American apparatus. As will be seen from the accompanying illustration, the transformer is of the enclosed type, with the four terminals mounted on the top. The core seems to be of ample dimensions and did not appear to saturate when used in a power stage. The ratio of the turns is one to three and a half, but we did not have time to calculate the actual number of turns or to measure the impedance of the primary at various frequencies. The transformer was tested in three different stages of a speech amplifier and in each gave excellent results, the quality and volume being very good. In passing, we may mention that it functioned particularly well with a low impedance power valve.

The Erla transformer.

* * *

PUSH PULL TRANSFORMERS.

Messrs. Economic Electric, Ltd., of 10, Fitzroy Square, London, W.1, have recently put on the market a pair of push pull transformers which we show in the accompanying illustration, and are to be congratulated upon catering for the needs of the advanced experimenter. In order to test the transformers two similar amplifiers were arranged, one including the push pull transformers. Comparative tests showed that the push pull circuit effectively balanced out the distorted component, and the resulting speech was of much better quality and also of increased volume. Further tests showed that the secondaries are nicely balanced, but are, perhaps, a little on the small side, but this is not of really great importance. The price of the input or output transformer is 31s. 6d., and we can recommend either to any reader who is experimenting with differential amplification circuits.

* * *

"A.J.S." WIRELESS EQUIPMENT.

Messrs. A. J. Stevens & Co., Ltd., of Wolverhampton, have sent us their price list of sets and a copy of their instruction book. The latter gives very complete instructions for the successful installation and operation of their various receivers, and appeals to us as being an extremely valuable asset to those who are unaccustomed to radio receivers.

V. ZEITLIN & SONS.

Messrs. V. Zeitlin & Sons ask us to announce that they have now opened an additional showroom at 41, High Holborn, W.C.1, where their technical adviser, Mr. C. W. Thompson, will be pleased to assist their clients in technical matters.

Recent Wireless Publications.

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

I.—TRANSMISSION.

LOOSE-COUPLED TRANSMITTING CIRCUITS.—Maurice G. Goldberg. (*Q.S.T.*, 7, 9).

THE ELECTROSTATIC TRANSMITTER.—E. K. Sandeman, B.Sc. (*W. World*, 241).

FURTHER DISCUSSION ON "AN IMPROVED SYSTEM OF MODULATION IN RADIO TELEPHONY."—By Charles A. Culver, by R. A. Heising (*Proc. I.R.E.*, 12, 1).

ELECTROSTATIC TRANSMITTER AMPLIFIER CIRCUITS. —(*Exp. W.*, 1, 7).

RADIO-BROADCASTING STATION KGO.—Adam Stein, Jr. (*Gen. Elec. Rev.*, 27, 3).

II.—RECEPTION.

VARIATIONS SUR LE MONTAGE FLEWELLING (*R. Elec.*, 5, 56).

ALIMENTATION DES RÉCEPTEURS RADIOPHONIQUES PAR LE COURANT ALTERNATIF DU SECTEUR.—I. Podliasky (*R. Elec.*, 5, 57).

DISTORTIONLESS BROADCAST RECEPTION.—H. J. Round, M.C., M.I.E.E. (*Mod. W.*, 2, 7).

A NEW FRAME CIRCUIT.—J. H. Reyner, B.Sc. (*W. World*, 242).

SELECTIVITY.—L. J. Voss (*Exp. W.*, 1, 7).

IN SEARCH OF A REAL RECEIVER.—H. Andrewes, B.Sc. (*Exp. W.*, 1, 7).

FILTER CIRCUITS IN RADIO TELEGRAPHY.—N. W. McLACHLAN, M.I.E.E., F.Inst.P. (*Exp. W.*, 1, 7).

A TWO-VALVE RADIO-FREQUENCY AMPLIFIER.—P. D. Tyers (*Exp. W.*, 1, 7).

H.F. TRANSFORMERS.—P. K. Turner (*W. Trader*, 2, 14).

III.—MEASUREMENT AND CALIBRATION.

NOUVELLES MÉTHODES PERMETTANT DE MESURER EXACTEMENT LA RÉSISTANCE D'UNE ANTENNE OU D'UN CIRCUIT QUELCONQUE À HAUTE FRÉQUENCE WATTMÈTRE POUR HAUTE FRÉQUENCE.—H. CHIREIX (*R. Elec.* 5, 77).

RECEIVING MEASUREMENTS AND ATMOSPHERIC DISTURBANCES AT THE RADIO PHYSICAL LABORATORY, BUREAU OF STANDARDS, WASHINGTON, JULY AND AUGUST, 1923.—L. W. Austin (*Proc. I.R.E.*, 12, 1).

THE USE OF NEON TUBES FOR ELECTRICAL MEASUREMENTS.—Gerald R. Garratt (*Exp. W.*, 1, 7).

V.—GENERAL.

L'ATTRIBUTION DES LONGEURS D'ONDE AUX ÉTATS-UNIS.—(*R. Elec.*, 5, 56).

NOUVEL AMPÈREMÈTRE À THERMOÉLÉMENT POUR LES COURANTS DE HAUTE FRÉQUENCE (*R. Elec.*, 5, 57).

TELEVISION. AN ACCOUNT OF THE WORK OF D. MIHALY.—Nicholas Langer (*W. World*, 241).

A PRACTICAL DEMONSTRATION OF SOME APPLICATIONS OF THE CATHODE RAY OSCILLOGRAPH (DISCUSSION).—N. V. Kipping (*W. World*, 241).

AN EXPERIMENTAL DIRECTION FINDING STATION.—R. Keen, B. Eng. (*W. World*, 242 and 243).

THE POSSIBILITIES OF TELEVISION.—A. A. Campbell Swinton, F.R.S. (*W. World*, 243).

DESIGN OF LOOP ANTENNAS, PART III.—Ralph Batcher (*W. Age*, 11, 7).

THE RADIO EQUIPMENT OF THE STEAM YACHT "ELETTRA."—Eric A. Payne (*Proc. I.R.E.*, 12, 1)

THE DEVELOPMENT OF THE STANDARD DESIGN FOR SELF-SUPPORTING RADIO TOWERS FOR THE UNITED FRUIT AND TROPICAL RADIO TELEGRAPH COMPANIES.—Albert W. Buel (*Proc. I.R.E.*, 12, 1).

DIGESTS OF UNITED STATES PATENTS RELATING TO RADIO TELEGRAPHY AND TELEPHONY; ISSUED OCTOBER 30, 1923—DECEMBER 18, 1923.—John B. Brady (*Proc. I.R.E.*, 12, 1).

THE ELECTROMAGNETIC SCREENING OF RADIO APPARATUS.—R. L. Smith-Rose, Ph.D. (*Exp. W.*, 1, 7).

A VALVE GENERATOR FOR AUDIBLE FREQUENCIES.—E. Simeon (*Exp. W.*, 1, 7).

DULL EMITTER VALVES (*Electn.*, 2395).

SPEECH SOUNDS.—Sir Richard Paget (*Electn.*, 2395).

EXPERIMENTS ON SCREENING RADIO RECEIVING APPARATUS.—R. H. Barfield, M.Sc. (*J.I.E.E.*, 62, 327).

DISCUSSION ON "LOUD-SPEAKERS FOR WIRELESS AND OTHER PURPOSES" (*J.I.E.E.*, 62, 327).

A SINGULAR CASE OF ELECTRON TUBE OSCILLATIONS.—G. Breit (*J. Frank. Inst.*, 197, 3).

Experimental Notes and News.

In the Chancery Division, Mr. Justice Russell granted to the Igranic Electric Co., Ltd., of Bedford, and 149, Queen Victoria Street, London, an injunction against the London Variometer Company restraining them until judgment in the action from infringing the registered trade mark of the Igranic Electric Co., Ltd., and from selling or offering for sale electrical apparatus under or in connection with any circular, notice, or advertisement containing the word " Ivanic " or any other colourable imitation of the word " Igranic." And from supplying in response to orders for " Igranic " apparatus goods not of the manufacture of the Igranic Electric Co., Ltd., and from otherwise passing off goods not of the manufacture of the Igranic Electric Co., Ltd., as being of the manufacture of that company.

* * *

Mr. C. Ellison asks us to announce that the address of his experimental station 2JP is now Brockfield Hall, Dunnington, York.

* * *

The site of the Liverpool Relay Station still remains unsettled. It is understood, however, that the B.B.C. are negotiating for St. George's Church, which is one of the highest in the city, and would seem to be very suitable. It is not likely that the station will be in operation before June 1 at the very earliest.

* * *

It is understood from the British Broadcasting Company that the opening date of the Edinburgh relay broadcasting station will be May 1. Regret is expressed at the delay, which is said to be due to the fact that the delivery of the generators for the station have been held up. On account of strikes, and the failure to get material from abroad, delivery could not be promised so rapidly as the company were led to expect.

* * *

The Sheffield relay station 6FL, which works on 303 metres, is shortly to have its power increased from 100 to 200 watts, which suggestion has given great satisfaction to owners of wireless apparatus in the city, and particularly to those who are dependent upon crystal sets.

* * *

A contract has been granted to the Radio Communication Company of Great Britain for the erection and equipment of a chain of seven high-powered wireless stations on the islands of St. Kitts, Antigua, Dominica, St. Lucia, St. Vincent, Grenada and Barbados, the crescent-shaped archipelago which flanks the Caribbean. Private enterprise, it is stated, is to be confined to the erection, equipment, and initial testing. The stations are to be operated by the Pacific Cables Board, which is under the joint control of the Imperial Government and the Governments of Canada, Australia, and New Zealand. The contract cost is £62,670, which is shared by the Colonies concerned, the Canadian Government, and the Imperial Government.

* * *

The perfection is announced of an electric ultra-audible microphone, invented by Dr. Phillips Thomas, which, it is claimed, will permit scientists to record sound vibrations which now are too rapid or too faint for the human ear to catch. In its experimental stage the microphone has been used successfully to transmit by radio the highest notes of the voice and of musical instruments which the ordinary transmitter and receiver reproduce as mere noises.

* * *

For the first time the songs of birds have been broadcast. Major Corbett Smith, the Cardiff broadcasting station director, yesterday afternoon mounted the towers of Llandaff Cathedral and placed a microphone in position. The chimes of the cathedral sounded the hour of five, and there followed a full-throated chorus of birds hovering about the towers. All this was faithfully recorded in every listening-in set in Wales and the West of England.

* * *

Wireless enthusiasm in Southampton and district has been damped by the decision of a meeting of accumulator recharging businesses—mainly garages—to increase their charges. It was intended to increase the charge of 1s. 6d. for the most-used type of accumulator to 3s., and although, because of criticism, a slightly smaller increase may result, the prices will tend to restrict amateur wireless activities. The local radio society is organising enthusiasts to fight against any increase, holding that the more recharging that can be found the cheaper the operation should become.

* * *

Important developments in wireless in South Africa are likely in the near future, and a scheme is being discussed for communication between Salisbury and Pretoria by wireless by means of a six-kilowatt duplex installation at both towns. It is anticipated that the scheme will be in full working order in about a year's time, but it has yet to be approved by the Rhodesian Government. It is expected that the cost will be in the neighbourhood of £25,000.

* * *

During the spring it is hoped to broadcast the song of the nightingale. It is proposed to drive a motor car carrying a microphone and a transmitting set into the heart of Oxfordshire. The song of the nightingale would be received, if all went well, at some place near a trunk telephone line where it would be put on to the studio in London, and from there broadcast.

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The total number of receiving licenses in existence on March 31 was approximately 720,000.