Experimental Wireless

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Experimental Topics.

The Mechanics of Components.

IN conversation with one of our readers just recently, we were rather interested to hear him say, "Why do you publish articles on the construction of components? I do not want to make switches or condensers. Why not use the space for more experimental matter?" This is a perfectly fair comment, but it represents the viewpoint of an individual; we should be interested to know what our readers think generally as to the type of article they like best. We were induced to take up the subject of mechanical construction because, in so many of the home-made instruments sent to our Laboratory for calibration, we found evidence of a total lack of knowledge of constructional principles and methods. An instrument may be perfectly designed from an electrical point of view, but if it is deficient in mechanical construction it gives very poor service. Not only is it likely to work badly through defective joints, or contacts, or bearings, but it must have a short life, and must ultimately be scrapped because of the constant trouble it gives, or even because it eventually falls to pieces. There is always a pleasure in using a well-made article, and we could not help feeling that many of our readers would get much greater pleasure from their radio experimenting if we could assist them to make their components correctly and well.

Wireless experimental work is broadening so rapidly in its field of interest that the needs of our readers so far as technical advice or assistance through our pages is concerned are bound to vary. One reader may be wholly interested in transmission problems; another in reception, and so on, and so far as we are concerned editorially we endeavour to divide the space at our disposal as fairly as possible. We are always glad to have opinions or suggestions as to the type of matter most likely to be helpful, and if we took a general vote we feel quite sure that our articles on "The Mechanics of Components" would not be entirely unapproved.

Short-Wave Transmission.

In a paper read before the Royal Society of Arts on July 2, Senatore G. Marconi, G.C.V.O., LL.D., D.Sc., disclosed the result of considerable experimental work which he has been conducting with Mr. C. S. Franklin for some time past. The paper was essentially of a statistical nature and practically summarised the course of development since the year 1916 when the investigation of short waves was taken up in Italy. It is somewhat interesting to study the course of events as outlined in Senatore Marconi's paper. Investigation was first commenced with the idea of providing a directional system, and this obviously pointed to the use of reflectors which in turn necessitated the use of very short waves in order that the size of the reflectors might be kept within reasonable limits. Preliminary experiments seem to have been encouragingly successful and further investigation was accordingly conducted along the same lines but with a considerable increase in power. These experiments which took place in 1919 showed that the received signal strength was approximately 200 times as weak when the reflectors were removed, which indicated that the reflectors actually functioned in the desired manner. The input was then gradually reduced and the reflectors replaced, it being found ultimately possible to establish communication over a very great distance with an absurdly small power. More experiments were undertaken in the early part of last year and some very peculiar results were obtained. Amongst other things, it was proved that the coefficient of the Austin-Cohen formula did not hold for very short waves, that the night ranges were considerably greater than expected, and that the presence of any intervening land had no appreciable effect on the propagation of the waves. In concluding his paper Senatore Marconi described how on May 30 of this year they succeeded in transmitting telephony to Australia on 92 metres with an input of 28 kilowatts. It is somewhat unfortunate that Senatore Marconi did not disclose any details of the apparatus which was used, or the circuital arrangements which were employed, but perhaps this was not possible for commercial reasons. What strikes us more forcibly, however, is the fact that no explanation whatever was offered which will account for the observed facts. The statistics given when compared with those relating to any ordinary long-wave station are certainly striking and to the lay mind may easily appear revolutionary. Such, however, is not really the case as the actual signal intensity at these high frequencies is probably capable of very easy explanation. The relation of signal strength to the sun's altitude, the deviation from the Austin-Cohen formula and the absence of appreciable fading to which Senatore Marconi referred in his paper are certainly subjects which require further investigation. Moreover, they are surely not beyond the field of amateur experimental work and it is hoped that perhaps several amateurs may be able to co-operate successfully in some useful research work. So far as the results which Senatore Marconi attained are concerned, communication with America on a power of 12 kilowatts should not frighten several British amateurs who regularly worked America and Canada last winter on a power of only 30 *to* 50 *watts*. It is probably safe to prophecy that some lucky enthusiast will be working regularly on speech to America with very little more power, before next season's tests are completed, but then let us hope that some very definite facts may be deduced from his experiments.

Broadcasting and Spark Interference.

We are very interested in some correspondence which has recently passed between the Postmaster-General and the Radio Association, who have asked us to bring the subject before the attention of our readers. It appears that many broadcast listeners have complained of considerable interference to reception owing to constant working of ship traffic. The Radio Association have written to the Postmaster-General on their behalf, and have enquired if he is in a position to take any steps necessary to minimise the interference. In their communication they suggested that it might be possible to reduce considerably ship transmissions between the hours of 8 and 11 p.m. The Postmaster-General's reply is very illuminating, as it not only shows his attitude towards broadcasting in its relation to wireless telegraphy, but also serves to indicate the lines upon which ship traffic is likely to develop within the next ten years. The use of the 300 and 600 metre wave for ship-to-shore traffic is permitted by the International Convention governing radiotelegraphic services, and he points out that so long as both British and foreign ships are equipped with spark apparatus, the maintenance of suitable spark stations on shore for the purpose of communicating with ships is imperative. On the other hand, it is pleasing to note that a large and increasing number of the more important liners are transmitting all their traffic by continuous waves and there is every indication that a more extensive use of the system is likely to become general, with, of course, greater freedom from jamming. In concluding his reply, the Postmaster-General adds that he has good reason to assume that much interference is caused by the use of flatly-tuned receivers, and suggests that much improvement could be effected. Our own experience confirms this view, and we hope that our readers may prevail upon their broadcast friends to realise not only the importance of ship traffic, but also the need for selective receivers.

Receiving Aerials of Low Resistance.

By N. W. McLACHLAN, D.Sc., M.I.E.E., F.Inst.P.

It is probable that many experimenters do not consider the effect of the ohmic resistance of their antenna systems on reception, this subject being fully dealt with in the following article.

THE influence of a low decrement receiving circuit on a radio-telegraphic signal of square formation is to transform it into one akin to that illustrated in Fig. 1 (*b*). The initial and final stages of the morse character, *i.e.*, the growth and decay epochs, are somewhat similar respectively to those obtained (1) when a circuit is completed containing a battery and a constant inductance of relatively low resistance (large L/R); (2) when the inductance is short-circuited upon itself after the current due to the battery has attained a definite value.* An

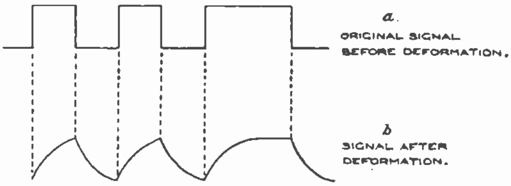

Fig. 1, a and b—Diagram showing the mis-shaping due to transmitting or receiving circuits of low decrement. Curve (b) represents the upper envelope of the audio frequency oscillations.

experimental arrangement facilitating these operations is depicted in Fig. 1 (*c*), in which a key or a relay with a back stop is used. If the relay is operated to give the letter "u" in the morse code, the relationship between current and time is of the form exhibited in Fig. 1 (*b*). In the case of a radio receiver, curves of this nature represent the upper "*envelope*" of the oscillatory current of radio- or audio-frequency. If these radio-frequency waves were rectified, the result would not be the envelope of Fig. 1 (*b*), and in certain respects curves of this class, when applied to oscillatory currents, may be misleading. The curve obtained from the morse signal after rectification and the customary smoothing process, will depend, amongst other things, upon the shape (curvature) of the rectifier characteristic. Moreover, in the process of rectification prior to utilising the resulting unidirectional varying current for operating a recording apparatus, we can encounter distortion which is superposed on that introduced by low decrement circuits. Under certain conditions, however, such distortion may be beneficial, since—when a three-electrode valve is set well back on its rectifying point—it tends to give the signal in the recording circuit a more rectangular profile. In fact, *in the absence of atmospheric disturbances* it is possible to obtain *recorded* signals of square formation which, owing to the "ringing" of the circuit,* are aurally unreadable. This is accomplished by setting one or more of the recording valves well back on their rectification points, as illustrated in Fig. 2.† This diagram shows the shape of the signal applied to the grid and the anode current corresponding thereto. It will be evident

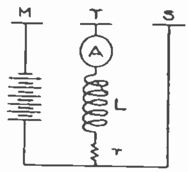

Fig. 1c—Circuit for illustrating "mis-shaping." T is a contact which moves alternately from contact M to contact S.
L = Large inductance.
r = Resistance of L $\frac{L}{r}$ is large.
A = Instrument to indicate current changes.

that the signal is more rectangular in shape *after* than before rectification. An effect of

* The damping factor of an inductive circuit is L/R, whereas that of an oscillatory circuit is L/2R.

* See EXPERIMENTAL WIRELESS, April, 1924, p. 401.

† In Fig. 11, *Journal I.E.E.*, vol. 61, p. 903, 1923, the valve V_2 would be given extra grid bias by augmenting battery B_2.

like nature can be obtained by setting one of the note magnifying valves well back on its rectification point. The action of the valve on the audio-frequency signals is similar to that illustrated in Fig. 2, and a highly-rounded and unreadable signal has its beginning and end clipped, thereby being rendered fairly intelligible in a telephone headpiece.*

Pursuing the problem of low decrements (supertuned circuits) still further, we may consider what happens when a circuit has zero *ohmic* loss. In surveying this side of the subject, we are reminded of the super-conductivity experiments of Kamerlingh-Onnes.† By immersing a lead spiral in liquid helium at a temperature about 2 degs. above absolute zero (−271° C.), the conductivity was augmented 2×10^{10} times that at ordinary temperatures, and a unidirectional current in the spiral took one and a half days to decay to half its initial value. Superficially it would seem that the reduction in current was due entirely to the usual ohmic influence. This, however, is by no means true. Whenever the current varies in an inductive circuit, electro-magnetic energy is radiated into space. Moreover, a certain fraction of the energy loss in the lead spiral was caused by radiation. The spiral can therefore be considered to possess an auxiliary resistive quality, which for convenience is usually termed the "radiation" resistance. Under the peculiar conditions stipulated here, the value of the radiation resistance would vary with the current. When the current is a varying unidirectional one, the radiation resistance will be correlated in some manner with the rate of change of the current. In analytical language the radiation resistance will be a function of the current and the time, *i.e.*,

$r_a \times f^1(i) = \frac{d}{dt} f\ (i)$. Owing to the variation

in the total resistance of the circuit (radiation plus ohmic, the latter being assumed constant), the value of R/L will depend upon the current, or more accurately on its rate of change. The relationship between current and time will therefore depart in some measure from the customary exponential equation $i = Ie^{-Rt/L}$, owing to inconstancy of R/L.

After this preamble, the action of an aerial circuit of zero ohmic loss can be treated. So long as the aerial carries an oscillatory current, energy is radiated into space, and the circuit has a so-called radiation resistance. For a given open aerial this quantity increases as the square of the frequency, *i.e.*, it is augmented by accelerating the rate of change of current. *When the frequency is constant* an approximate formula for a certain class of aerial is $r_a = kh^2$, where k is a constant and h is the effective height of the aerial. The latter quantity depends upon the geometrical configuration, the loading inductance, shortening condenser and the influence of the ground and of neighbouring structures—aerial or otherwise. Now the frequency of a sinusoidal alternating current is constant and single valued during the "steady state." The amplitude is also constant. During the transient epochs, at the beginning and end of a morse character, the foregoing conditions are violated in the aerial circuit. The varying alternating currents can then—during growth and decay—be resolved into frequency spectra,* just as composite "white" light can be analysed into its constituents by a spectroscope. The principal frequency, *i.e.*, that of major importance, is numerically equal to that during the steady state. Owing to variation in frequency during the transient epochs—or more accurately to the fact that many frequencies are present—there will be a corresponding variation in the radiation resistance. With a circuit of adequately low decrement it is probably permissible for present purposes to disregard the variation in radiation resistance. Accepting this elementary hypothesis, the transients will take the exponential forms—

$$(a)\quad i = I\ (1 - e^{-at}\ \sin \omega t)\ \text{(growth)}$$

$$(b)\quad i = Ie^{-at}\ \cos \omega t\ \text{(decay)}$$

where $\omega = 2\pi n$, $a = r_a/2L$, r_a being the radiation

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* The rectifier introduces distortion and yields higher frequencies.

† *Sc. Abs.* A, 101, 1915.

* The equation to a damped sine wave is of the form $i = e^{-at} \sin \omega t$. This is equivalent to the Fourier integral $i = \frac{a}{\pi} \int_{-\infty}^{\infty} \frac{\sin(\omega + x)t dx}{a^2 + x^2}$, where a must not be zero. See also EXPERIMENTAL WIRELESS, p. 292, February; p. 397, April, 1924.

resistance, assumed constant, and L the inductance to be regarded as constant and located wholly at the loading coil.

Consider the case of a steady train of electric waves of *single* frequency to impinge on a tuned aerial of zero ohmic and constant radiation resistance. The current at the base of the aerial will grow according to the above expression (*a*). On the cessation of the electric wave train acting on the aerial, the current dies away in accordance with the formula (*b*). When the steady state is reached, no more energy will be supplied to the aerial system, and electrical equilibrium will therefore accrue. The aerial, in virtue of the current flowing in it, will then radiate energy into space at a mean rate equvalent to that supplieu bv the incoming electric waves.

Since the radiation resistance of an open aerial increases as the square of the frequency (assuming the usual formula to be applicable), the duration of the transient epochs—that is to say, the periods of time during which the numerical value of the current is of practical importance—decreases with increase in frequency, *i.e.*, decrease in wave-length. With an aerial of 10,000 metres wave-length* possessing resistance solely due to radiation, the time taken for the current to reach, say, 95 per cent. of its steady value would be considerable, whereas with a 100-metre aerial the time would be comparatively inappreciable. Some idea of the relative times of current growth will be gained when it is stated that the radiation resistance of the short-wave aerial of *equal effective height* is 10,000 times that of the long-wave aerial.

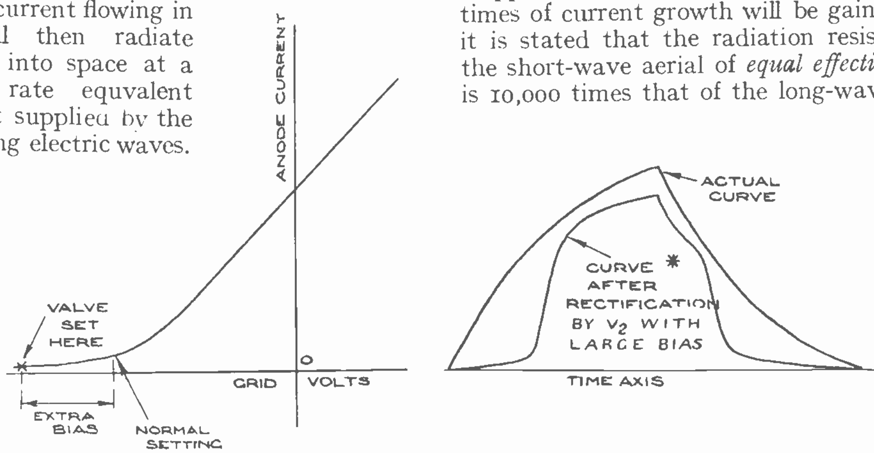


Fig. 2—Diagram showing the "shaping" due to a rectifying valve with a large negative grid bias. The record obtained from an instrument of the magnetic drum class (see Journal I.E.E., August, 1923, also "Experimental Wireless," April, 1924), is of the form shown in Fig. 1a.

In this respect it should be noted that the aerial receives energy from one direction only, but it is capable of radiating energy in many directions. The relative radiating propensity in any particular direction depends upon the *solid* polar diagram of the aerial. For example, the *horizontal* radiation from a frame aerial resembles the familiar figure eight. If we assume the aerial to be vertical and the voltage gradient to be vertical also, it is possible to suggest an approximate thermal analogy. This takes the form of a cylinder of metal placed coaxially in a cylindrical chamber, one half of whose curved surface is at a higher temperature than the other. Energy is absorbed by the central cylinder from the first half of the chamber and radiated to the second half of the chamber.

In practice, of course, the latter is the higher aerial of the two, so that the preceding figure will then probably be of the order of 500 to 1,000. The value of L must, of course, be much greater for the long-wave aerial, and hence for aerials of zero ohmic resistance the ratio of the time constants, *viz.*, $\frac{\alpha \text{ for } 100 \text{ metres}}{\alpha \text{ for } 10{,}000 \text{ metres}}$ will generally exceed 10,000. We conclude, therefore, that the response of a long-wave aerial of zero ohmic resistance to variations in the intensity of electric waves will be severely sluggish, whereas that of a short-wave aerial will be particularly prompt in comparison. The requisite degree of response is a question of

* The aerial is assumed to be associated with a loading inductance.

conditions. In modern radio-telephony it is imperative, in order to secure minimum distortion of the signal, that the aerial should respond rapidly to the variations in the electric field of the incoming waves. Moreover, in this respect ohmic resistance is sometimes a blessing in disguise.

Having broached the subject of telephony, we may digress for a few moments to examine the effect of variation in radiation resistance on very long-wave telephony. Suppose the length of the carrier wave to be 30,000 metres, *i.e.*, 10,000 cycles, and let the highest audio-frequency be 8,000. The side frequencies—with which everyone is now so familiar—concomitant with symmetrical modulation of the carrier wave by choke control, will range from 2,000 to 10,000 and 10,000 to 18,000 cycles. (This is, of course, only a hypothetical case, so that it is unnecessary to consider how many receiving stations are jammed.) For simplicity assume that the modulation on audio-frequencies from, say, 20 to 8,000 cycles is uniform.* At the receiver—which is taken to be distortionless—the modulation will depend upon the radio-frequencies of the side waves. This can be explained in the following way. The radiation from an aerial varies directly as the square of the frequency, assuming the effective height to be independent of frequency. Thus the energy radiated by the two radio-frequencies of 8,000 and 12,000 (corresponding to an audio-frequency of 2,000) will be proportional to $8^2=64$ and $12^2=144$ respectively (total 208). The corresponding figures for an audio-frequency of 4,000 are 36 and 196 (total 232), and those for 10,000 are 0 and 400 (total 400). Hence the total energy radiated by both side frequencies increases with the audio-frequency. Also it should be observed that for any given modulating audio-frequency the energy radiated is greater for the upper than for the lower side frequency. At an audio-frequency of 10,000 there is zero radiation from the lower side band, because the aerial current never changes. In Fig. 3 is portrayed a curve showing the energy radiated at various frequencies, using the elementary hypothesis stated above. If one of the side bands is to be suppressed, clearly on an energy basis the lower one would be chosen, since the radiation from the upper is much the greater of the two. At the receiver, which is assumed to receive all frequencies in the band from 2,000 to 18,000 cycles equally well, there would be perceptible distortion, owing to the accentuation of the higher tones. If the upper band were suppressed and the lower band retained, the lower tones would be accentuated.* The foregoing discussion is based on currents of different audio-frequencies from 20 to 8,000 cycles after the steady state has been attained. It is quite independent of the dead-loss ohmic resistance of the aerial—which may, therefore, have any finite value—since we assumed all the side frequencies in the aerial circuit to be of equal amplitude. When we penetrate the realms of practical radio there are numerous obstacles to be encountered in long-wave telephony, but these are beyond our present purpose. The object of our remarks was merely to illustrate in a somewhat exaggerated manner the eccentricities of appreciable variations in the radiation resistance of a radio telephonic transmitting aerial.

Having dealt with aerials of zero ohmic but actual radiation resistance, we are tempted to inquire what happens when the radiation as well as the ohmic resistance is evanescent. The aerial circuit then possesses capacity, but no resistance. It would appear that in the event of a steady train of electric waves falling on the aerial, the current would grow without cessation, the system *thus continuously absorbing but never radiating energy.* This is directly opposed to a proper physical conception concerning the phenomena of absorption and radiation of electro-magnetic energy. It is known from experiments on heat that a good thermal absorber (a dull black kettle) is also efficient as a thermal radiator, whereas an inferior absorber (a highly polished silver kettle) is a poor radiator. Moreover, an aerial of zero radiation resistance would be incapable of abstracting energy from electric space waves. The citation of a concrete example may make the

* The steady state is now being discussed.

* A flat tuning curve from 2,000 to 18,000 cycles is, of course, out of the question in practice, but as we have stated already, the illustration is purely hypothetical. Also the attenuation of the waves travelling through space depends upon the frequency, so that the curve of Fig. 3 as applied to a receiver necessitates equal attenuation for all frequencies.

matter clearer still. Suppose an inductionless coil of thin insulated wire is formed by doubling the wire back on itself and then winding it closely on a circular ebonite cylinder. The coil will have zero radiation resistance and an electro-magnetic field will not induce a current therein.* Thus the property of radiation imbues electrical circuits with something approximately analogous to a safety valve, inasmuch that it prevents the current from running riot and attaining an extremely large value.

Generally speaking, it is impracticable to test even approximately the validity of the foregoing analysis pertaining to aerials of zero ohmic resistance, by resorting to elaborate experiments at temperatures in the neighbourhood of absolute zero. Until some enterprising metallurgist presents us with a metal, pure or alloyed, having superconductivity at ordinary temperatures, the only suitable weapon at our disposal is the thermionic valve with its reactive propensities. For example, using controlled reaction on a wave-length of 12,000 metres, it is possible to adjust the decrement of the circuit to such a low value that a fairly strong impulse, *e.g.*, an atmospheric, is audible for five seconds or more after the impulse itself has subsided. A suitable succession of impulses reminds one of a bell being tolled. The depth of tone can be varied by altering the beat-note due to the local oscillation generator.

During the reception of electro-magnetic energy by an aerial, there are two actions which may be discussed. (1) Energy is dissipated in heat due to ohmic resistance, resulting from eddy currents in the aerial and in the ground, leakage to earth and dielectric loss. The total energy lost up to any time t can be represented by

$$\int_0^t i^2 r\,dt$$

where i is the current at the base of the aerial at any instant, and r is the resistance responsible for the occurrence of loss. The power or rate of energy loss at any instant is i^2r. (2) Energy is radiated into space from the aerial due to the oscillatory current which flows in it. This can be represented up to any time t by

$$\int^t i^2 r_a\,dt,$$

where r_a is the radiation resistance. The power loss is at a rate equal to i^2r_a. It should be observed that the value of r_a is referred to the current at the base of the aerial. If the current at some point above the loading coil were chosen, the value of r_a would, according to this way of viewing the matter, be greater than that when i is taken at the base of the aerial. Moreover, the radiation resistance of the aerial is really a mean value obtained from all the i^2r_a components on the aerial.

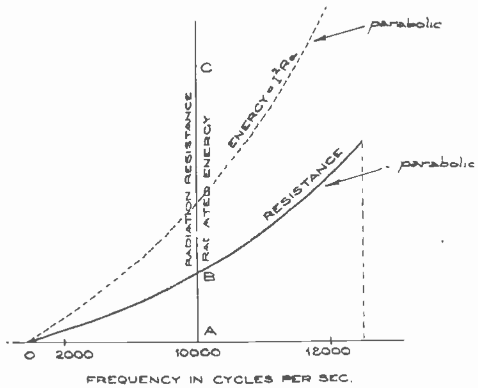


Fig. 3—Diagram showing radiation resistance and radiated energy for transmitting aerial. The amplitude of the current is assumed to be the same for all frequencies, also the usual formula for the radiation resistance of an open aerial is assumed valid.

When a steady train of waves arrives, the aerial current builds up until the energy dissipated in heat is equal to the *net* amount supplied from the waves. Energy is also radiated at the frequency of the waves at a steady rate equal to i^2r_a. Absorption from the electric waves occurs at an equal rate, in addition to that dissipated in heat. When there is no dead loss, the energy absorbed is equal to that radiated, so that in the analytical sense the net transfer of energy is zero. A rough comparison can be made between the aerial and a direct-current motor.* The rotation of the armature causes a back E.M.F. When the impressed and back E.M.F.'s are equal the efficiency of the machine is 100 per cent. Now the current

* In practice, of course, the coefficient of coupling between the go and return paths of the wire would not be quite unity, owing to the thickness of the wire and insulation. The illustration is adequate for the purpose in view, in spite of this slight defect.

in the aerial can, for the sake of rough analogy, be regarded as creating an E.M.F. which opposes that due to the electric waves. The smaller the difference between the two the less the energy dissipated in heat. Equality of the E.M.F.'s is attained when the dead loss is zero and the energy absorbed is identical in value with that radiated.

Coming now to the application of reaction to reduce the resistance of an aerial, we are apt to ask if one or both of the aerial resistances (ohmic and radiation) are reduced. It is well to remember that the latter has more of a mathematical than a physical significance, being a useful artifice to facilitate calculation. Radiation is an inherent property of any inductive circuit—in general all electric circuits possess inductive and radiative properties, accidental or otherwise—whilst dead loss due to ohmic resistance is an inherent defect, which is capable of rectification up to a point by the aid of reaction. It is usually accepted that reaction is mathematically equivalent to a reduction in the high-frequency resistance of a circuit. The result is simply that the energy dissipated in a resistance whose value is equal to that compensated by the valve, is diverted from the anode battery by the valve acting as a timing device which controls the amount and phase of the supply. It must not be inferred that the energy tapped from the anode battery has the same physical significance as an increase in the intensity of the electric waves which would, in the absence of reaction, yield an aerial current of like magnitude. The employment of reaction is accompanied by a decrease in the decrement of the circuit, as well as by the aforesaid action of the anode battery. Starting with a definite degree of reaction, the aerial current due to a steady train of waves has a corresponding value. As the reaction is augmented, the current rises until it attains the same value as that in an aerial of zero dead loss—provided, of course, the reaction can be controlled adequately up to this point. Reaction beyond this stage entails radiation (in addition to that equal to the amount absorbed from the incoming waves) into space ; in fact, the aerial acts as a transmitter. Generally it will be found that the set bursts into oscillation before the zero dead-loss stage is reached.

Summary.

The cardinal features in this article can be summarised thus :—

(1) The effect of a very low resistance aerial* circuit—that is, one in which the value L/R is relatively large—is to distort an incoming morse signal of square formation to one which is rounded. If the envelope of the telegraphic signal is sufficiently rounded after rectification it is aurally incomprehensible. In radio-telephony the higher acoustic tones are attenuated appreciably.

(2) The current in an aerial of zero ohmic resistance is finite in value. In growth and decay it follows approximately the usual exponential-sinusoidal law, the damping factor being $r_a/2L$, where r_a is the radiation resistance arising from the radiation of energy into space, which occurs whenever a current flows in the aerial.

(3) A short-wave aerial of zero ohmic resistance is more responsive than a long-wave aerial of zero ohmic resistance, since the damping factor ($r_a/2L$) of the former is many times that of of the latter owing (*a*) to larger radiation resistance ; (*b*) smaller inductance.

(4) An electric circuit of zero radiation resistance can neither absorb nor radiate electro-magnetic energy. (Neither heat nor light waves are included here.)

* An open aerial is implied unless otherwise stated.

Telephony and C.W. Transmitters for 100 Metres.

By G. E. MINVALLA, A.C.G.I. (6BN).

To those amateurs interested in long distance C.W. telegraphic communication, the following article should be of great interest. Useful information is given with regard to the elimination of losses which are so likely to occur at very high frequencies.

It is clear to all students of wireless engineering that the present tendency to reduce the wave-length of long-range transmitters has by no means reached finality. It is therefore appropriate to recapitulate a few points in the design of such transmitters, since these points have often been overlooked in the construction of transmitters for longer wave-lengths.

The first point to which attention may be drawn is the use or presence of iron in any part of the transmitter. It is common practice in long-wave commercial stations to mount the transmitter on insulating panels, carried on an iron frame-work. Now the eddy-current losses in iron for low frequencies can be found from the expression :—

$$W_E = K\, t^2 f^2 B^2 v.$$

Where W_E = loss.
K = constant depending on the grade of iron.
t = thickness.
f = frequency.
B = flux-density.
v = volume of iron used.

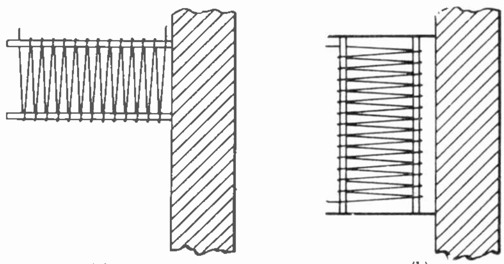
While this expression is not strictly accurate for very high frequencies, it is nevertheless a sufficiently close approximation to show the enormously increased losses at high frequencies, as compared with commercial frequencies.

The next point with regard to iron is the hysteresis loss. This can be expressed by $W_H = HvfB^{1\cdot7}$, where H is a small constant. This has been found to be accurate over a wide range of frequencies, and may therefore be regarded as substantially correct for radio work.

To summarise, then :—The total losses in iron may be expressed as $W_E + W_H = Af^2 + Cf$, where A and C are constants for any particular framework.

Considering a frame of ordinary iron comprising 1,000 c.c., 2·5 mm. thick, and carrying an effective flux-density of 100 lines per sq. cm., these constants come out to approximately $10^{-5} f^2 + 5{\cdot}10^{-4} f$.

Now when f is 30,000 cycles and the input power 10 k.w., the loss is negligible. But,



(a) (b)

Fig. 1.—(a) This method of mounting a transmitting inductance near a wall is liable to introduce losses, while (b), with the magnetic axis of the coil parallel to the wall, is more efficient.

if the input power is 10 watts and f is three million cycles the state of affairs is very different.

It may easily happen that 90 per cent. of the energy supplied is wasted in the iron framework.

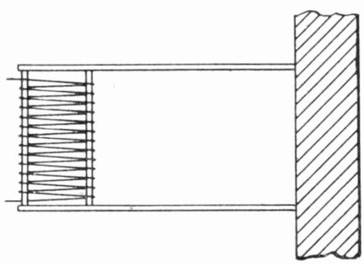


Fig. 2.—A still more efficient arrangement which embodies the advantages of the Fig. 1 (b) method and at the same time reduces the eddy current losses, etc., to a very small value.

The remedy for this is obvious. Iron must be avoided at all costs. If a nonmagnetic metal such as brass is used, the hysteresis losses will for all practical purposes disappear. The eddy-current losses will be reduced, as the flux-density will be lower, but they will still exist, and may be important. Hence it is well to avoid any metal in the framework of the transmitter. Hard dry wood is quite as good mechanically, is easier to work, and is incomparably better electrically.

The transmitter having been assembled in a wooden frame, the next point is its position in the room. Walls (especially outside walls) are usually slightly damp. They therefore conduct. In consequence eddies will be induced in them and energy wasted, if the magnetic lines of force are allowed to cut them.

Hence the transmitter should be installed so that the magnetic axes of any coils carrying H.F. currents are parallel to the nearest wall and as far from it as possible. This is illustrated in Figs. 1 and 2.

If an aerial current of ·2*a* (input ten watts) is obtained with the A.T.I. as in Fig. 1 it is probable that moving the latter to the position shown in Fig. 2 will double the aerial current!

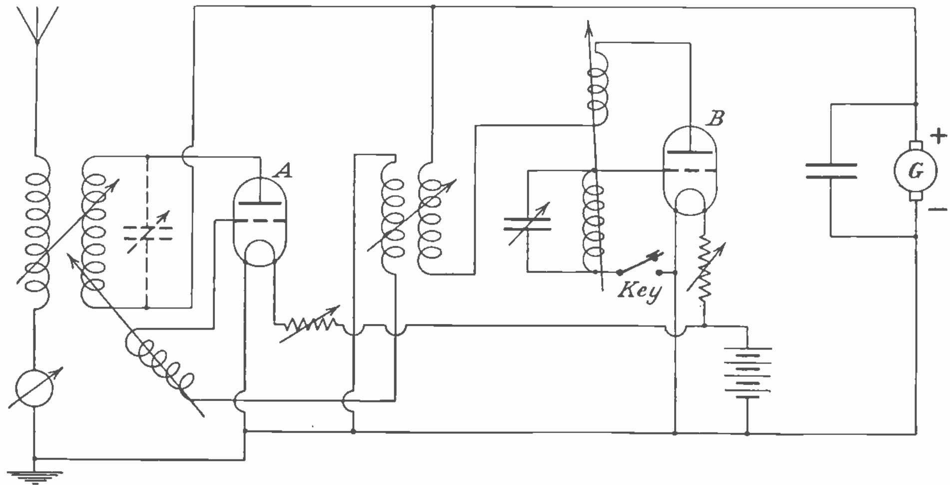


Fig. 3.—A short-wave C.W. circuit wherein a master valve is used to drive the main power system.

The A.T.I., closed circuit inductance, and grid coils, may well be wound with copper strip. No appreciable advantage will be derived from the use of litzendraht.

Next, as to the circuit to be employed. The writer is strongly in favour of the "independent drive" circuit, as it is of the utmost importance that the wave-length should remain constant. The principles of this circuit are shown in Fig. 3.

The valve B is arranged as an oscillator by coupling its grid and plate together. A coupling coil is connected in series with either the grid or the plate coil, and is coupled to the grid of the valve A. The grid and plate of valve A are coupled together in such a manner as to suppress oscillation, and the valve acts merely as a high-frequency power amplifier. If necessary the grid is biassed so that it works on the straight part of its characteristic; the alternating grid voltage applied by the oscillator valve thus produces currents of the same frequency in the plate circuit, and hence the radiated wave is entirely independent of the aerial constants.

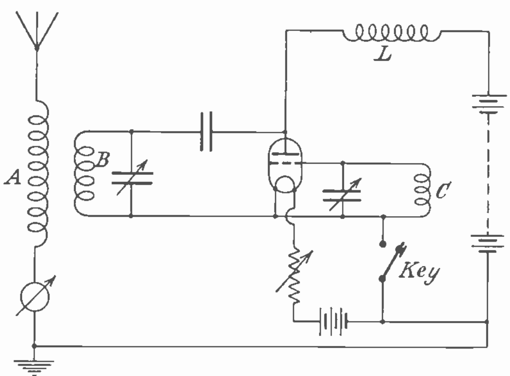


Fig. 4.—This circuit embodies the desirable properties of loosely coupling a closed circuit to the A.T.I. which tends to keep the frequency of the oscillations constant.

Modulation is obtained by coupling a control valve to the aerial circuit.

When once set up, this circuit is quite straightforward and is capable of giving exceptionally long ranges owing to the facts that (1) The wave-length is absolutely constant, and (2) both valves are working at maximum efficiency. For telephony, a further advantage is that the carrier wave is perfectly sinusoidal, and if the same is true of the receiver heterodyne no distortion will result.

Fig. 4 shows a very simple transmitter for low power work which nevertheless gives quite good results.

It has not the same advantages as the circuit shown in Fig. 3, but it is cheap to assemble and simple to handle. The coils A and B may be tightly coupled together, no coupling at all being required with C.

The valve oscillates, of course, through its own natural capacity. A further simplification may be obtained by eliminating the closed circuit of B, but the writer does not recommend this.

L is, of course, a high frequency choke coil, and may well be wound in the "frame-aerial" fashion which came into prominence some months ago.

In conclusion, the reader is reminded that the frequency to be dealt with is exceedingly high, and in consequence stray capacities must be avoided like the plague. The valve capacities must be utilised if possible, otherwise cut down to a minimum by careful spacing of the leads.

No more metal than is essential should be used anywhere. In this connection it is of interest to remember that the quantity of metal in a condenser may be reduced by closer spacing of the plates, or by introducing mica between them, the capacity remaining constant.

Telephony Reception.

By H. J. NEILL.

The ideals to be aimed at with a view to the most faithful reproduction of broadcast telephony are given in the following article. For those desirous of obtaining perfect loud-speaker reception, the information on resistance-coupled amplifiers should be of interest.

THE object of these notes is to set forth some of the main considerations in obtaining a good and faithful reproduction in telephony.

It seems that the transmissions of speech and music from the B.B.C. stations are very satisfactory, and yet the number of equally satisfactory receptions of the broadcast concerts seems to be few. This is probably due to the fact that most experimenters blame their loud speaker and not the receiving system, whereas in many cases the receiver itself is mainly to blame.

For the reproduction of speech it is sufficient if all frequencies from about 500 to 5,000 cycles per second are satisfactorily amplified and reproduced. Although the same frequency band will permit of some sort of musical reproduction, much of the quality is necessarily lost.

It is not excessively difficult to design a wireless receiver and amplifier which will deal with a much wider band of frequencies than this. If, however, such a design is attempted making use of iron-cored coupling transformers for audio-frequency amplification, almost insuperable difficulties are met. If either the resistance or reactance-capacity methods of coupling are used the problem becomes easier.

The resistance coupling provides the easier design and will therefore be considered. The extra H.T. supply required does not appear to be a drawback because a high value is necessary for any valve suitable for the operation of a loud speaker.

It is not the intention to discuss loud speakers themselves nor yet to discuss any part of the wireless receiver except the detector and low-frequency amplifier. It may be helpful, therefore, to work out the main points in a design for a receiver to work say three miles from a B.B.C. main station with a good aerial. If conditions are other than these, high-frequency amplification must be resorted to. For simplicity the set will be loose coupled to the aerial, and the design of the aerial circuit will not be considered.

In order to get a good "detected" signal strength a valve detector is probably best. The effect in the anode circuit of a valve depends only upon the voltage applied to the grid and not upon the current or energy in the grid circuit. Now, assuming the energy available constant, the voltage across the grid and filament of the valve is inversely proportional to the capacity in the closed circuit. Therefore that capacity should be kept as small as possible. The capacity of the valve and connections is generally of the order of 25-30 $\mu\mu$F. In order to get a respectably wide tuning band a condenser of five times this value is sufficiently large, say 0.00015 μF. A square law condenser is a great advantage and should be shielded. The closed circuit inductance must be designed so as to tune to the required wave-length with about 0.00005 μF capacity in shunt, and should be of an efficient form, say No. 20 S.W.G. wire wound in a hexagonal frame 6″ across and spaced about 10 or 12 turns per inch. This, of course, means a large coil, but it is worth it. As an example, at three miles from 2LO with Igranic plug-in coils only 2 volts could be obtained on the grid of the detector valve, while with carefully-made coils of the above type 5.5 volts was obtained without the use of reaction.

Method of Rectification.

The question of the detector next arises. There are several methods of using a valve as a detector, the best known of which is that using a leaky grid condenser. This method is admirable if signals are weak, say under 1 volt, and the circuits are properly designed. If, however, signals are strong, the grid leak does not work so well, and the use of the lower bend of the anode-current/grid-volts curve appears more effective. The latter method is, of course, not so effective if signals are weak. It has, however, one great advantage, and that is that no grid current need flow. A negative grid-bias, of which the value will be determined later, should be used.

The next step is to decide on the valve to be used as a detector, bearing in mind that it is to be resistance-coupled to the next valve. The valve should exhibit a sharp lower bend on the anode-current/grid-volts curve and have a high voltage amplifying factor. Certain valves sold as detectors have a magnification factor of only about two or three, and an anode impedance of a very low value, and while these are excellent in some arrangements they are useless for the purpose of resistance-coupling to a subsequent valve. An R valve is suitable, and the writer has found the Phillips E valve very good indeed, both as a detector and amplifier.

The Anode Resistance.

The anode resistance next claims attention. The alternating voltage on the anode is :—

$$\frac{\mu VgR}{R+Ra}$$

where μ=voltage magnification factor of valve

Ra=Anode impedance of valve

R =Added resistance in anode circuit

Vg=Alternating P.D. applied to grid/filament.

It is desirable, therefore, to make R as high as convenient compared to Ra. A value of three times Ra is very suitable. Then

$$Va=\tfrac{3}{4}\mu Vg$$

i.e., the amplification is $\frac{3}{4}$ of the maximum possible. A higher value of R would be better, if sufficient H.T. were available. This valve however, is to work as a detector, and so the H.T. and grid bias must be so adjusted that when no signal is arriving the anode-current is practically nothing. The adjustment is best carried out practically by means of a good milliameter temporarily connected in the anode circuit of the valve. The calculation of the values is somewhat clumsy. Actually it is best to make the grid so much negative that no grid current can pass with any signal likely to be received, if necessary, increasing the H.T. voltage. In a particular case of a Phillips E valve the grid was fixed at −12 volts with respect to the negative end of the filament; the anode resistance was 150,000 ohms, and the H.T. supply was 120 volts exactly.

It may be desirable to use some reaction, and in any case it is not desirable further to amplify the radio frequency impulses which will be present in the anode of the detector valve. A by-pass condenser is necessary, connected from the anode end of the anode-resistance either directly to the filament or to the H.T. positive terminal. It is frequently stated that the value of this condenser is immaterial and may be 0.001 or 0.002 μF.

The impedance of a condenser is inversely proportional to the frequency of the E.M.F. across it, and at the higher audible frequencies, say at 10,000 cycles per second, a 0.001 condenser has impedance of only about 15,900 ohms. This low impedance is shunting the anode resistance, and hence the frequencies of the higher order will be only feebly amplified or even not amplified at all. Now, it is our desire to amplify all frequencies in the audible range equally, so the impedance of the by-pass condenser must be much higher than the anode resistance, so that its shunting effect is negligible at all times. This condenser, however, must be large enough to by-pass effectively the radio frequency impulses. It is easy to select a suitable condenser by the aid of the formula

$$Z_f = \frac{10^6}{2\pi f C}$$

where Z_f=impedance at f ∽
f=frequency
C=capacity in μF.

For example, a condenser of 0.00005 μF has an impedance at 16,000 ∽ of about 199,000 ohms at 300,000 ∽ (1,000 metres wave-length) of about 10,600 ohms, and at a million cycles (300 metres) of 3,180 ohms. This would be a suitable value for a set to receive wave-lengths from the shortest waves up to about 1,000 metres. The shunting effect on audio-frequency currents is practically nil, while the amplification of radio-frequency currents is reduced to something very small. If longer wave-lengths are to be received a compromise must be effected by reducing the anode resistance while slightly increasing the by-pass capacity.

If it is desired to use reaction, a suitable coil may be connected between the anode of the detector and the junction of the anode resistance and by-pass condenser. Reaction must, however, be used to a very small degree.

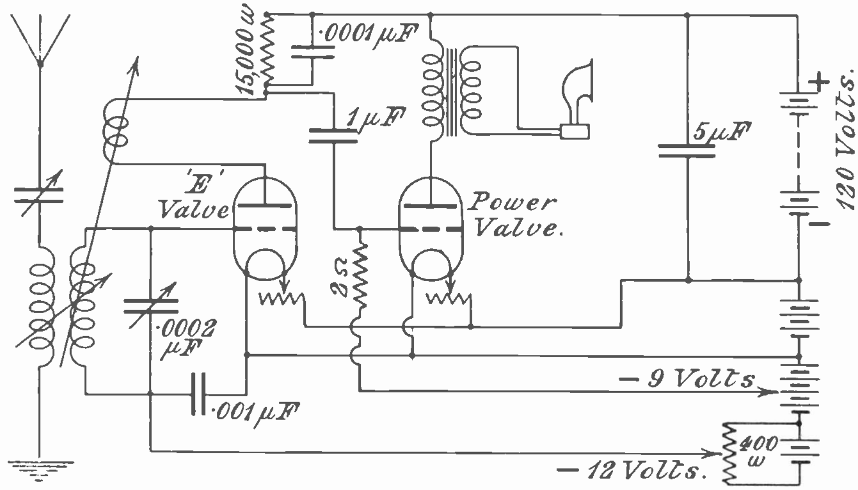


Fig. 1.—A Two-valve Resistance-coupled Amplifier.

Value of Coupling Condenser.

The next consideration is the size of the coupling or grid condenser, and the size of the grid leak resistance of the next valve. It is assumed that a hard valve is to be used in the next stage, and that all grid current is to be eliminated by appropriate grid bias, probably about 9 volts if signals are really strong. If grid current is absent the leak resistance may be made high, say one or more megohms. It must be remembered, however, that the grid leak is shunting the anode resistance of the first valve as far as alternating currents are concerned, and therefore it must not be reduced to equality therewith. A value of 2 megohms is very suitable.

The coupling condenser must be sufficiently large to offer negligible impedance to currents of the lowest frequency to be amplified, say 16 cycles. A one μF condenser offers an impedance of 10,000 ohms at 16 cycles, and this value is low compared with other values in the circuit. This coupling has a long time constant, which means that the amplifier takes some seconds to stabilise after switching on and adjusting. This may be a defect, but can only be overcome by decreasing the grid leak resistance or the size of the coupling condenser, or both, all of which it is undesirable to do. Although such an amplifier may get the "staggers" occasionally when being adjusted the good results obtainable are worth a little trouble in tuning.

If the signals are really strong the second valve may be the last, and in this case must be a valve suitable for the operation of a loud speaker. This valve should have a low anode impedance and be capable of large emission from the cathode. The grid potential is determined by the strength of signal expected, and must exceed the peak value of signal voltage. A value of 9 volts has been found suitable when using the previously described detector arrangement at a distance of three miles from 2LO, with a moderately good aerial. The H.T. voltage applied to the anode of this valve must be adjusted so that the tube is operated about the centre of the straight portion of its anode current/grid volts characteristic. If more than one power valve is available a tube should be selected which shows a flat characteristic surface surrounding the operating point.

The loud speaker, if of a high resistance type, may be connected directly in the anode circuit of the last valve. It is generally preferable, however, to use a transformer and low-resistance telephone, since then capacity in long leads to the telephone has less effect upon the quality of reproduction and also the risk of injury to the instrument is less. It is not proposed to deal with the design of an output transformer, but mention may be made of one or two points.

An open core is to be preferred of very generous sectional area and not too long. The primary winding should be wound in sections or in some form to reduce its self capacity as far as possible, and should be of generous gauge of wire. Resistance does not help. Inductance is required. The same remarks apply to the secondary or output winding. The turn ratio should be chosen to match the impedances of the two circuits which the transformer is to couple. It is worth noting that the resistance of a loud speaker is practically no guide to its impedance. The makers should be consulted as to the value of impedance. If the valve and telephone impedances are properly matched at about 1,000 cycles, the results are satisfactory.

Additional Amplification.

There are occasions when the above-suggested two-valve arrangement does not give sufficient volume, and a further stage of amplification is required. In this case the power valve should be replaced by an amplifying valve, an R valve being suitable, although special valves with a high value of μ are obtainable. A power valve for resistance-coupled amplification is unnecessary.

The anode of the amplifying valve should be connected to a suitable value of H.T. through an anode resistance. The anode resistance, coupling condenser and grid leak for coupling and amplifying valve to the next in sequence are determined in the same manner as previously set forth. The amplifying valve and anode resistance and H.T. voltage must be chosen so that the valve shall operate about a point in the centre of a plane portion of the characteristic surface. The grid potential is already fixed by the signal strength.

When the three valves are used the last or power valve requires further consideration. The signal voltage applied to its grid will be large. If the peak voltage delivered by the detector is 6 and the voltage magnification of the intermediate stage is 8 (both of which figures are very easily exceeded) the voltage applied to the grid of the power valve will be 48. This necessitates a grid bias on the last valve of at least 50 volts. Hence the anode potential requisite for most tubes suitable for dealing with this grid voltage and working a loud speaker will be of the order of 500 to 1,000 volts. Of course, the volume obtainable by such an arrangement is immense. It may be mentioned that on a 3-valve receiver similar to that described above a peak voltage of 64 volts upon the grid of the power valve was recorded on signals from 2LO.

In order to control the volume of the 3-valve arrangement the anode resistance of the amplifying valve may consist of a number of small resistances in series. Connections from the junctions of these may be brought to a multi-point switch and the switch arm connected to the coupling condenser so that only a portion of the total potential charge upon the anode resistance is applied to the grid of the power valve. A nice adjustment of volume can thus be obtained, without upsetting the amplifier. Volume must not be controlled by dimming filaments or lowering the H.T. supplies of the amplifying and detecting tubes. With less volume the grid bias and anode potential of the power valve may be lowered if the characteristics of the tube permit.

In conclusion, the author has had a 2-valve receiver designed on the above lines in operation for some time at about a distance of three miles from 2LO. This set has at all times given ample volume for a high room 19 ft. by 17 ft., and a satisfactory reproduction. On several occasionsthree valves were used. The last valve was a special valve, and the anode potential was 600 volts and grid bias 70 volts. Signals were clearly audible 500 yards from the house. It does not seem, therefore, that, if a 3-valve receiver will give this volume with resistance-coupling the use of transformer coupling is advantageous. True, transformers give a greater amplification per stage, but resistance coupling seems to provide all the amplification which is required. Choke-capacity coupling is quite satisfactory, but the chokes are not so easy to design, since their impedance at the lowest frequencies to be amplified must be very high, and this requirement is apt to lead to excessive self-capacity which reduces the amplification of the higher frequencies and which may also lead to resonance of the choke at certain frequencies.

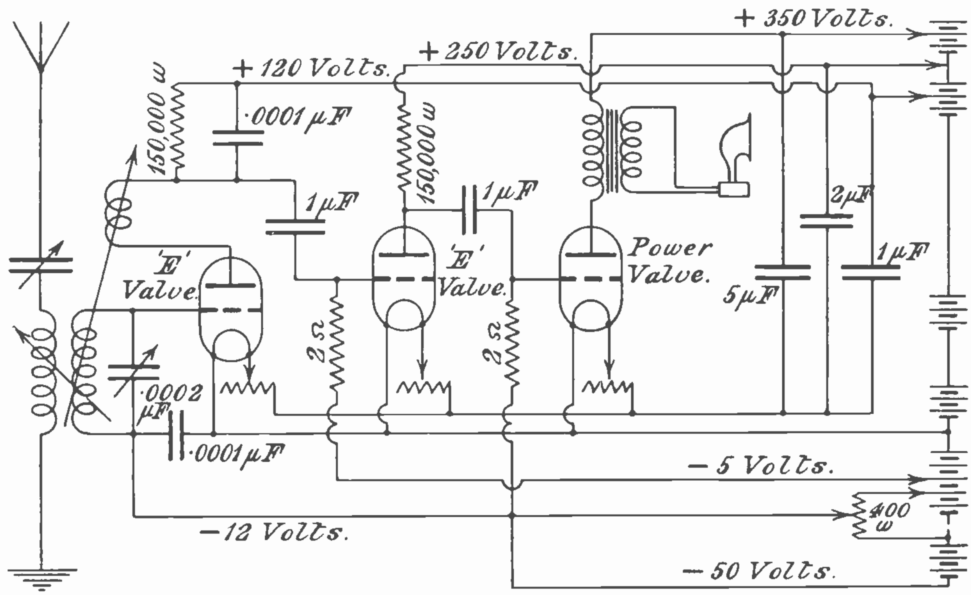


Fig. 2.—A Three-valve Resistance-coupled Amplifier giving Values of the Components.

Some Applications of the Thermionic Electric Triode to Purposes other than Radio Communication.

By H. A. THOMAS, M.Sc.

The amateur experimenter is sometimes handicapped by lack of suitable measuring instruments, though, as here shown, a valve can often be made to take their place. The author describes below numerous applications of the thermionic triode for electrical measurements.

THE thermionic three-electrode valve has undoubtedly opened the gate to a new branch of science, since it has made possible the measurement of very small electrical quantities. It is by virtue of these properties that the technique of radio communication has been suddenly elevated to a position that stands without parallel as far as delicacy and precision is concerned.

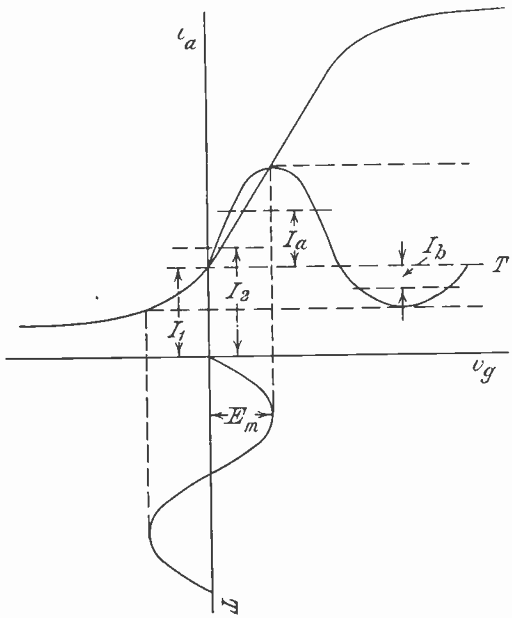


Fig. 1.

It has been the author's policy for several years to exploit the unlimited applications of the valve to general physical science and engineering, and I venture to set down a few of the most important results that have been obtained, results which I hope will demonstrate that the scope of the instrument is not limited solely to radio communication.

The Measurement of Small A.C. Voltages.

It is always a difficult problem to measure a potential difference without absorbing power, and in the case of an alternating P.D. it is theoretically impossible. Yet, we can in practice limit the power taken by the measuring instrument to an exceedingly small amount. The most effective method is to use an electrostatic voltmeter, since the power taken can only be that due to the constants of the medium between the two vanes of the instrument which virtually form a very small condenser. The forces of attraction which are utilised to operate such an instrument are exceedingly small, especially when the capacity must be reduced to a minimum so as not to modify seriously the circuit across which the instrument is connected.

This soon becomes the limiting factor in the sensitivity of electrostatic meters, and it is exceedingly difficult to build an instrument which will read less than 1 volt.

However, it is possible by means of the valve to convert a small A.C. voltage change into a D.C. change which will affect a delicate galvanometer. It is well known that the application of an alternating potential wave to the grid of a valve produces a change in the direct anode current, and we will now consider the theory of this phenomena in detail.

Let Fig. 1 represent the v_g-i_a characteristic curve for any particular filament current and anode potential.

The D.C. anode current will be I_1 if the grid be at zero potential with respect to the negative end of the filament. Now apply a sinusoidal wave of R.M.S. value E to the grid, represented by the amplitude $E_{max.} = \sqrt{2}\,E$, and the vertical time scale. The corresponding anode current curve will be represented on the horizontal time scale as shown, where T is the periodic time and equals $1/f$, where f is the frequency of the applied wave.

The new mean anode current I_2 will now be the mean between the means of both halves of the waves Ia and Ib plus the original current I_1.

The complete circuit diagram would be as in Fig. 2.

E = Unknown H.F. E.M.F. to be measured.
I_1 and R_2 are known
or V_1, R_1, and R_2 are known.

In practice this is a very delicate method of measuring small A.C. voltages.

The power taken is small, and only in exceptional cases does the self capacity of the grid to filament modify the H.F. circuit.

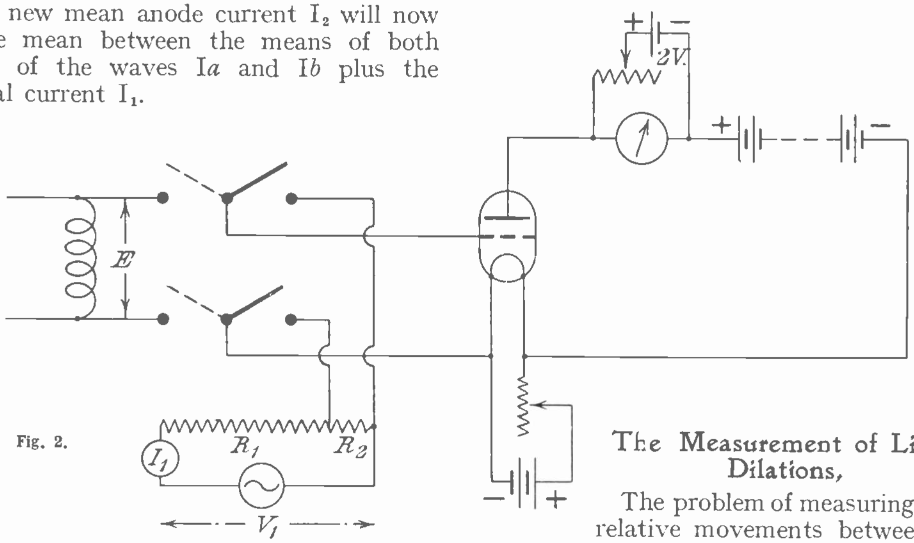


Fig. 2.

If the part of the original characteristic curve under consideration is represented by $ia = f\ (vg)$

$$\text{we have mean + ve. value} = \int_0^{\frac{T}{2}} f\ (E_{max}\sin \omega t.)$$

$$\text{and mean - ve. value} = \int_{\frac{T}{2}}^{T} f\ (E_{max}\sin. \omega t.)$$

giving—

$$I_2 = I_1 + \int_0^{\frac{T}{2}} f(E_{max.}\sin \omega t.) - \int_{\frac{T}{2}}^{T} f\,(E_{max}\sin \omega t.$$

If the damping of the D.C. instrument is high it will give a constant deflection if the applied grid frequency is low and therefore we can calibrate at quite a low frequency from a commercial supply.

The normal anode current can be balanced out, and then the change can be observed on a delicate galvanometer.

The Measurement of Linear Dilations,

The problem of measuring small relative movements between two mechanical members by an apparatus which produces no constraint on the members is one which can only be solved by one of two available methods: (*a*) optically; (*b*) electrically.

The optical method consists of attaching a tiny mirror to the moving body and observing the movement of a beam of light as shown in Fig. 3.

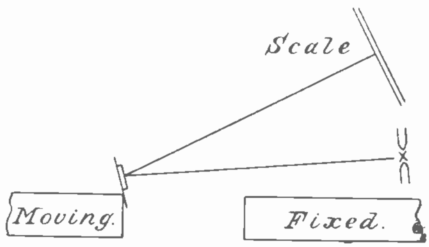


Fig. 3.

This method has very definite limitations, since the mirror cannot be reduced below a certain size.

The electrical methods consist of moving mechanical members which constitute an electrical circuit, perhaps the most obvious of which is to make the two ends form a condenser, the plates of which will then move and vary the capacity.

This variable capacity can be converted in several ways into a suitable observable change of an electrical quantity, such as a current, which will be proportional to the capacity, if an A.C. voltage be applied in a series circuit.

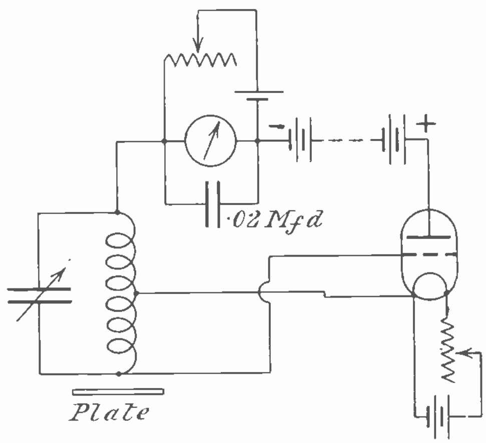


Fig. 4.

However, the author has invented a far more delicate method, which is capable of great precision and sensitivity.

The general arrangement of the apparatus is as shown in Fig. 4, and consists essentially of a Hartley Oscillating Circuit, in which the oscillations are reduced by absorbing energy by means of a local moving plate in which eddy currents are introduced.

Let us consider the vector diagram of such a circuit, Fig. 5.

The E.M.F. current and flux vectors E, I and ϕ respectively for an oscillating circuit will be in phase at resonance, and the flux vector will induce a back E.M.F. E_b in the plate, lagging 90° behind the flux.

The E.M.F. will produce circulating currents in the metal, the magnitude and phase of which will depend on the resistivity and ratio of $\frac{L}{R}$. The inductance L will be a constant depending only on the form of the generating oscillatory coil, and R will vary for different metals, the lagging angle ϕ being a minimum when $\frac{L}{R}$ is a minimum.

This secondary current I_b, with its associated flux ϕb will produce a back E.M.F. in the original coil E_2, which in turn will produce its current I_2 still in phase with E_2 since the frequency is that of the original.

The net E.M.F. and current will thus be the vectorial sum of E_1 and E_2 and I_1 and I_2, namely E and I, and we see that the effect of the metallic member is to virtually increase the high frequency resistance of the oscillating coil, and thus to reduce the oscillating grid volts, and as we have seen before, this will mean a D.C. anode current change.

The type of curve obtained for the current plotted against the distance of the plate from the coil is as shown in Fig. 6, and it will be seen that over the range δx the current variations are linear.

If the plate be so adjusted that the current is at about the mean of these two values, any further small relative movement will produce a big change in anode current.

The apparatus has been used as an extensometer by making the coil about ¾″ in diameter and moving a 1″ steel or lead plate near to it. It is possible to measure one hundredth of a millionth of an inch in this way, the linear part being approximately

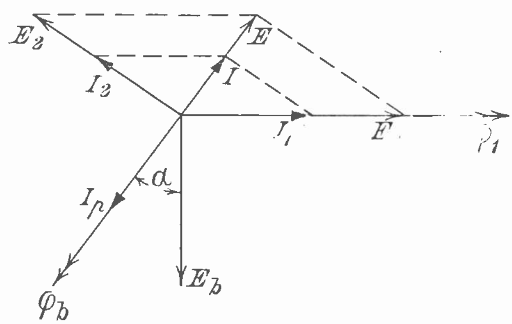


Fig. 5.

over a range of at least one hundredth of an inch.

If the movements are vibratory or pulsating we can photograph them accurately by employing an Einthoven String Galvanometer as our recording instrument. Frequencies up to 600 per second can easily be recorded and the wave form of the mechanical vibration obtained. No attachment is necessary to the moving metal body, as usually it is large enough to act directly as the plate in the electrical circuit.

The method is now being used as an extensometer for vibratory stresses, and can be applied to any problem connected with tortional or longitudinal stresses. The calibration is, of course, performed mechanically by shifting the coil or plate by a definite known amount.

The type of record obtained from a vibrating bar is as shown in Fig. 7, and is marked by times lines of a twenty-fifth of a second by a suitable optical marker incorporated in the galvanometer.

The Measurement of Small Thermal Changes.

If we use a delicate thermo-couple as a means of indicating temperature, we find that there is a lower limit below which no galvanometer will give readable deflections, We can, of course, apply our small E.M.F. to the grid of a valve, and measure the anode current change by means of a balanced galvanometer.

The limits of this method are imposed by the difficulties of maintaining both battery voltages and valve conditions, at which "point creeps" in the anode current are larger than the change to be observed. With a view to extending the possibilities of the triode in this direction, the following method is suggested.

The source of thermal energy is allowed to affect the couple intermittently by means of a shutter similar to a cinematograph shutter, the time during which the couple is affected being considerably larger than the natural lag of the instrument.

If the couple has a lag of 1/100 sec. the shutter would cut out the source 50 times per second.

The E.M.F. wave thus obtained is applied to an audio frequency amplifier and the output, which can be made as large as desired, is measured by a vibration galvanometer. The difficulties of creeps are eliminated, and although the wave applied may be of a peculiar shape, the comparison of sources can be calibrated by means of a known audio source and a potentiometer.

The general arrangement is shown in Fig. 8.

The vibration galvanometer (V.G.) is tuned to the frequency of the interruption of the source, and since this is quite low, the galvanometer can be very robust in construction.

The Measurement of Minute Fluid Pressures.

An apparatus similar to Fig. 4 has been utilised for measuring very small water and air

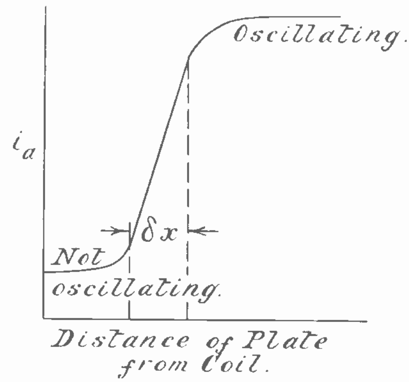


Fig. 6.

pressure changes, by recording the motion of a diaphragm, the one face of which is exposed to the pressure under consideration. No decrement is added to the diaphragm, and since the movement can be very small, the latter can be made so stiff that its natural period is far higher than the pressure changes to be measured. The apparatus is shown diagrammatically in Fig. 9.

The Maintenance of Mechanical Vibrations.

Consider the case of a metallic plate lightly held by a spring, so that it can vibrate axially as shown in Fig. 10.

If the plate move to position 1 the oscillation will increase and the anode current will increase. If it move to position 2 the current will decrease.

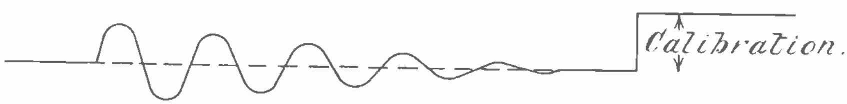


Fig. 7.

Now this changing anode current passes through the high frequency oscillatory coil itself, as well as through the plate and H.T.

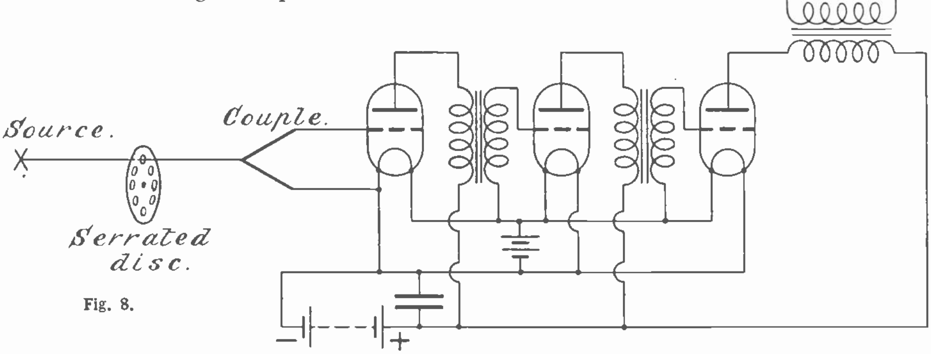


Fig. 8.

battery, and since the coil possesses inductance, there will be a lag between the current and the movement of the plate.

In Fig. 11 if the total periodic time be T we shall have a time of $\frac{T}{4}$, for each quarter movement to and away from the datum to the point of maximum amplitude of vibration.

The mean pull of the magnet during the first quarter period is represented by P_1, which is the area ABGF divided by FG, the mean pull as the fork returns is P_2, which again is area $\frac{BCHG}{GH}$. Similarly the mean pulls for the third and fourth periods will be P_3 and P_4.

Now from this diagram it is evident that the restoring pull in the second period is greater than the pull in the first period, thus assisting the motion, and the assisting pull P_3 in the third period is greater than the pull P_4 during the fourth period, still assisting the vibration.

The displacement of the flux curve due to the inductance of the coil thus maintains the mechanical system, by applying a small amount of power during both half swings.

A lightly damped mechanical system is easily maintained and a tuning fork, especially at low frequencies can be easily operated by this method with one small "R" valve.

The circuit arrangement is shown in Fig. 12.

The advantages of this method over the ordinary type of contact maker are apparent,

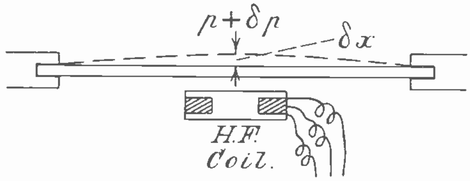


Fig. 9.

the applied pull is not sudden, and the decrement which is added to the vibrating system is negligible; in fact this may become zero under many cases, as is shown in the next section.

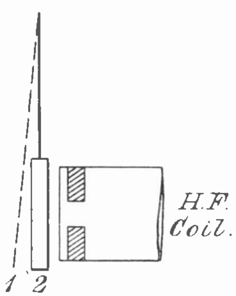


Fig. 10.

The Maintenance of Pendulum Vibrations.

It is possible by a slight modification to utilise this method to sustain a pendulum and operate a clock dial without adding to the natural damping of the mechanical system.

The original suggestion has been published* and the completed clock may be seen in The Royal Society Exhibit in the Govern-

* *Journal of Scientific Instruments*, Vol. 1, No. 1.

ment Pavilion at the British Empire Exhition at Wembley.

The arrangement is illustrated in Fig. 13. On the bottom of the pendulum bob a special shoe is fixed, the two surfaces, AB and CD, about 1" wide, being covered with thin sheet iron.

This shoe swings above the Hartley high frequency oscillating coil, and the changes in the anode current affect the magnet, which operates upon the armature F, affixed to the pendulum. The type of anode current curve is shown in Fig. 14 the current Io being that due to no oscillation. The transition stage is very sudden, and there will be a lag due to two factors, firstly, because the critical resistance of the circuit to start oscillations is not the same as that required to stop them, this resistance being of course dependent upon the position of the eddy plate with respect to the coil, and, secondly, because the inductance possesses a time lag.

Thus the accelerating pull given at the dead centre will be greater than the next de-accelerating pull, thus imparting work to the pendulum.

The work which the pendulum has to perform is to drive its metallic relay shoe through the high frequency magnetic field produced by the oscillating circuit. It can readily be shown that this work will be the same as that of moving the iron through a field of constant magnitude equal to the R.M.S. value of the original alternating field.

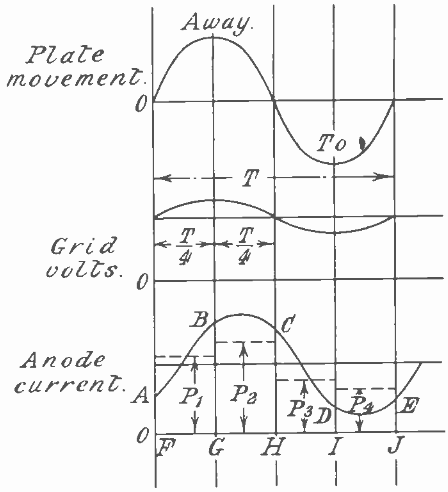


Fig. 11.

The direct anode current change, however, passes through the oscillatory coil, as well as the magnet, and so coincides with the position of the shoe that a small auxiliary pull is added by the tripping shoe. Decrement curves for the pendulum have been obtained, and are shown in Fig. 15.

From these curves it is apparent that the work which is imparted by the tripping shoe is exactly equal to the work performed by the pendulum on the input of the relay at two particular amplitudes, and also that at any amplitude between these two the

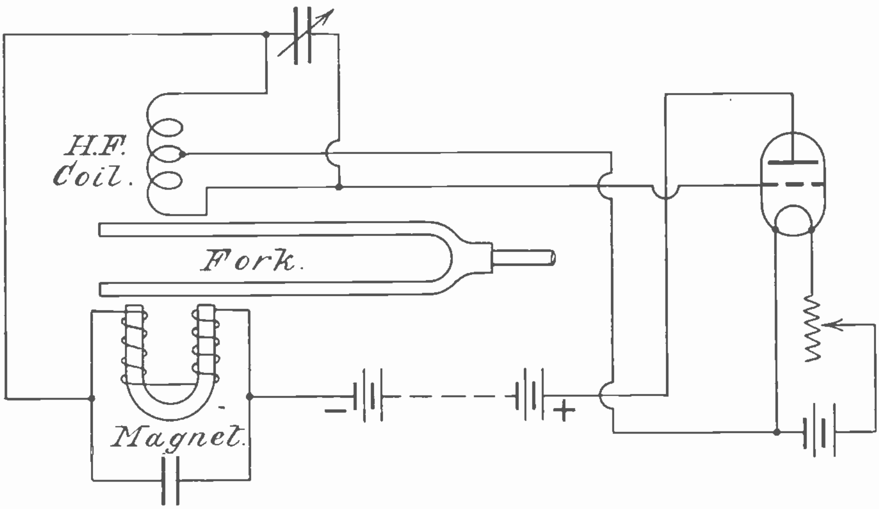


Fig. 12.

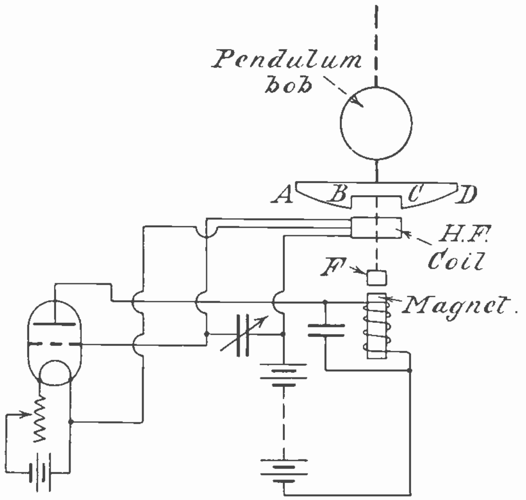


Fig. 13.

percentage error from the natural decrement is less than $\frac{1}{4}$ per cent. The maximum amplitude at which this is true is greater than any amplitude required in practice. At higher amplitudes the work performed on the pendulum by the tripping shoe is greater than the work which is taken from the pendulum, and the decrement consequently is less than that of the free pendulum at the same amplitude of swing.

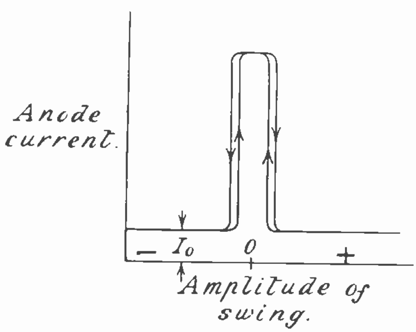


Fig. 14.

In practice the control of the amplitude is obtained by an adjustment of the filament brightness.

Conclusion.

In conclusion, it must be postulated that in any physical applications of the triode, such as those suggested, the calibration of the valve must never be depended upon. In every case this fact has been strictly borne in mind and the apparatus is calibrated in terms of a positive physical quantity. It has been found by careful experiment that the characteristics of a triode vary

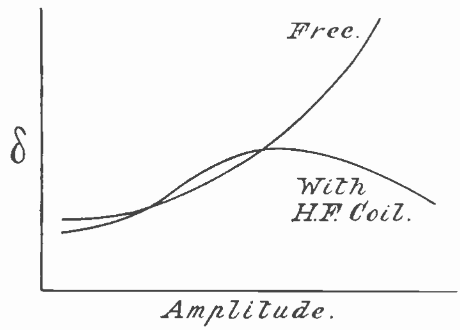


Fig. 15.

under normal usage during quite a short period of time. In less than fifteen minutes a change has been observed and the characteristics rarely repeat over periods of one hour.

Therefore, if a valve must be used, recalibrate each time the apparatus is used.

If a high inductance choke is inserted in the anode circuit, this must, in every case, be shunted by a small capacity to allow the high frequency pulses to pass through the anode circuit to maintain the oscillation.

It is hoped that these few illustrations will serve to demonstrate the fact that the scope of the thermionic vacuum tube is not limited solely to radio communication.

Note on Systems of Modulation Employed in Radio Telephony.

By H. S. WALKER, A.M.Inst.R.E.

We give below some notes on the most up-to-date practical systems employed to modulate a valve transmitter for telephonic transmission. The choke and grid control systems are fully discussed and the efficiencies of various methods compared, while mention is made of the well-known relay valve system of modulation.

An ideal system for effecting modulation in radio-telephony has not yet been devised, but an approach to some such system would be the introduction of some agency or device whereby the voice might vary at will the ohmic resistance of an aerial system between rather wide limits. Such a system should act on the resistance of the radiating system alone and only affect the oscillator circuits as a result of a changing load in the aerial circuits. In addition, while there was a great increase or decrease in the ohmic resistance of the aerial, the constants of the modulating system itself should remain unchanged. Such a system has however yet to be devised, for while it is not a difficult matter to increase the resistance of an aerial, yet it is not practicable to decrease that resistance where much energy is employed.

Choke Control System.

As is well-known, all the broadcasting stations in this country use the choke-control system, but it does not seem to be generally realised that as much and sometimes more energy is absorbed by the modulators in a control system than is actually delivered to the oscillator. In addition to this, the valves employed for modulation purposes are of necessity the same size at least as the oscillator and two or more valves of this kind are used in parallel. Thus it is obvious that the outlay in valves in this system is very great. In addition, as already stated, the system is very wasteful in power: an experimenter having a generator available delivering 50 watts, would only have about 20 watts of energy available for the oscillator, the remainder being absorbed by the control system.

This system admittedly gives excellent speech, is robust and very stable, but the initial expense in valves and the consumption of energy involved, rule this system out, more often than not, for the experimenter with a limited pocket.

It is moreover doubtful if the quality of speech by this method far excels that given by a good grid-control system. Complicated musical sounds are not, as a rule, part of the experimenter's programme and stability can be maintained by the experimenter himself. Nevertheless, where expense is not such an important factor as reliability and quality, this system has undoubtedly much to commend it. In order that the operation of the system may be readily understood, Fig. 1 shows a sketch of a typical choke-control transmitter. It will be noted that three large valves are used in parallel in the modulating system and another smaller valve in addition to effect complete modulation.

In considering any modulation system there is naturally involved the question of the relative importance of the amplitude of the carrier wave in the non-modulating condition, and the variation taking place in this due to the modulation brought about at the transmitting station. For a given amplitude of non-modulated carrier wave which may reach a receiving station, the response in the telephone receiver is, of course, proportional to the change in amplitude of the carrier wave, this in turn depending upon the modulation at the transmitting station. The actual amplitude of the carrier is also an important factor. Even if complete modulation obtains, the current amplitude cannot have a minimum value less than zero or a maximum greater than twice the non-modulated value. It is well known with the choke-control system that energy from the modulators will cause an increase of energy in the oscillator when modulation takes place and it can be shown that an instantaneous increase of 400 per cent. of power may take place in the oscillator circuits when complete modulation obtains. If, however, complete modulation does not obtain, an increase of 200 per cent. may take place notwithstanding. If then we adjust the oscillator circuits to give their maximum output during quiescent conditions, *i.e.*, when there is no modulation, it is obvious that the oscillator valves will be subjected to a very considerable overload when modulation takes place. Notwithstanding the fact that the overload is more or less intermittent it will no doubt tend to soften the oscillator valves, unless these be of sufficient size, *i.e.*, greater than would normally be required for a current of the normal non-modulating intensity. This is therefore a further source of expense in the choke-control system.

We may of course reduce the output of the valves to avoid overloading, but in that case the value of the non-modulated carrier will be less. As already stated, the current amplitude cannot have a maximum value greater than twice the normal non-modulated value, hence by reducing the output of the valves to avoid overloading the signal strength is likewise diminished.

Grid Control System.

The simple method of introducing the secondary of a modulation transformer in the grid circuit of a radio frequency oscillator valve is well known. Such a system, in its crude form, is not altogether satisfactory for use in sets utilising much power. The essential feature of the grid control method is that the electrical pulsations from the microphone are made to operate directly on the grid of the oscillator valve thus, in turn, controlling the amplitude of the energy delivered to the aerial. Such a system possesses the great advantages from the experimenter's point of view that the oscillator may be run full out as the change in amplitude of the non-modulated current may be arranged to be a decrease in amplitude only, when modulation is taking place. Secondly, no expensive power valves are employed for modulation purposes, neither is there any great deal of energy from the generator required to operate the modulator system.

There are several possible improvements on the original method of grid-control, but two of the best systems use a small valve, which may be of the receiving variety only, to assist modulation. The two systems

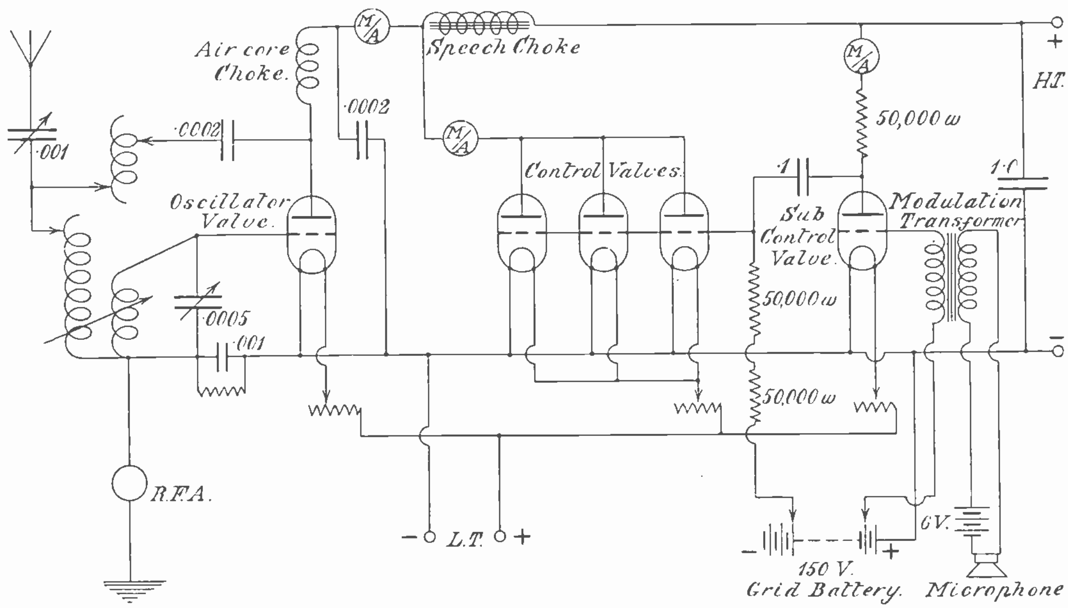


Fig. 1.—A Typical Choke-control Transmitter.

employ these valves in different ways : they may be described as

(1) Grid-leak method of modulation.
(2) Relay valve method of modulation.

The Grid-Leak Method of Modulation

is shown in Fig. 2. It will be seen that the usual grid-leak resistance is replaced by a small three-electrode valve and the plate-to-filament resistance of this valve is controlled by means of the voice through the usual modulation transformer connected to its grid. In this system the control valve functions as a variable resistance. It will be evident that for a given value of grid-condenser, the direct current potential of the grid of the oscillator valve will be determined by the magnitude of the inductive reactance in the anode-grid circuit, and also by the value of the grid-leak which latter consists of the plate filament circuit of the control valve. If the value of this resistance changes the direct current potential of the grid of the oscillator valve will correspondingly change, and control thus be effected.

The control valve used for effecting modulation by this method must be of such a nature that the valve will withstand the potential developed between the grid and filament of the oscillator; it must also be able to dissipate the heat developed by the grid-leak current.

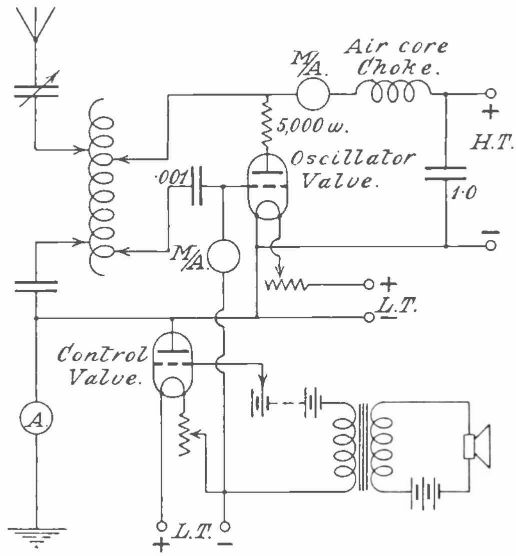


Fig. 2.—The Grid Leak Method of Modulation.

Relay Valve Method of Modulation.

This is shown in Fig. 3. It will be seen that the control valve has its anode-filament circuit connected directly across the grid filament circuit of the oscillator valve. The

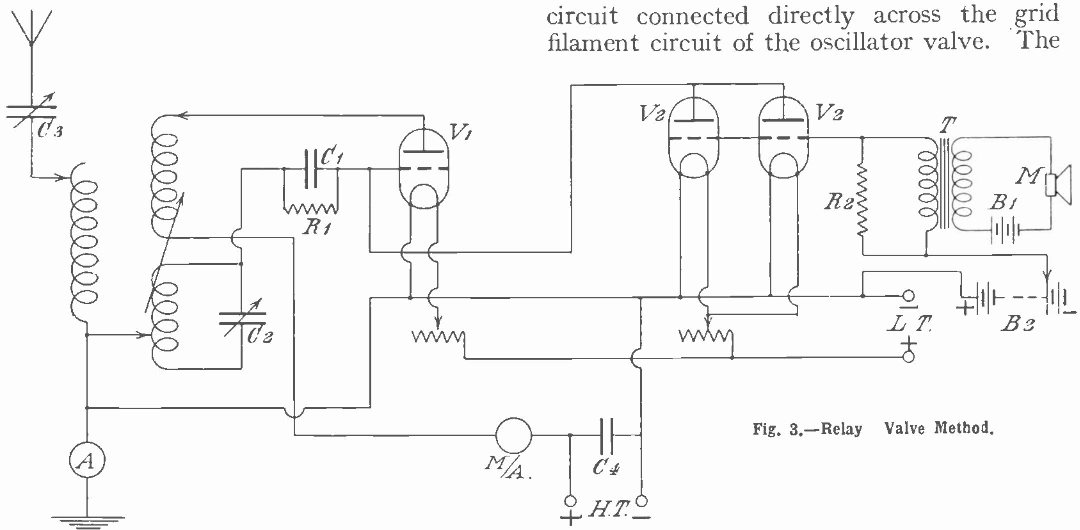


Fig. 3.—Relay Valve Method.

C1 = ·001 mf. 1,000 volts.
C2 = ·0003 mf.
C3 = ·001 mf.
C4 = 1 mf. 2,000 volts.
V1 = 0/150 valve.
V2 = L.S.5 valve.
B1 = 6-volt battery.
B2 = 45-volt tapped grid battery.
R1 = 5,000 ohms.

R2 = 50,000 ohms.
T = Modulation transformer 20/1. Primary resistance 1 ohm. Secondary 4,000 ohms.
A = Thermo ammeter 0—3 amps.
M/A = Milliammeter 0—150 milliamps.
M = High-resistance microphone.
L.T. = 12 volts.
H.T. = 1,500 volts.

grid of the control valve is connected to the secondary of a modulation transformer and coupled to the microphone in the usual manner. This system was the subject of a Patent No. 188,483, granted to the writer in 1921. It will be seen that in this system of modulation the modulating or control valve has its anode-filament circuit connected in parallel across the grid condenser and leak. The control valve therefore constitutes a variable resistance in parallel with the grid leak in addition to impressing pulsations of potential on the grid of the oscillator.

The control valve used for this system of modulation should possess similar properties to that used in the grid leak method.

In practice, this system has been found by the writer to possess more stability and to give purer speech than the grid-leak method, though both methods have their own particular advantages and disadvantages.

Those wishing to experiment with this system will find in the list below Fig. 3 the sizes and capacities of various components connected as in the diagram, for an oscillator having a maximum of 100 watts applied to its anode. The adjustment here of the grid circuit of the oscillator is rather critical and should be adjusted so that the oscillator is just tending to lose radiation with a slightly weakened grid coupling.

It should be noted that all the systems of modulation mentioned above may be used in conjunction with any of the other well-known oscillating organisations other than those shown in the diagrams.

Comparison of Efficiency.

The above table shows a comparison of efficiency for the various systems of modulation described above. It should be mentioned that the choke-control method shows lower efficiency for actual wattage input, in addition to the initial expense for valves, etc., but the observations made in a preceding paragraph in this connection should be borne in mind. No allowance has been made for the inclusion of a master oscillator or "drive" as, although its use may be warranted in the case of a broadcasting station for commercial service, it is a source of considerable loss of energy and not necessary as a rule for experimental stations.

INPUT POWER CONSUMPTION.
TABLE I.

	Choke-Control System.	Grid-Leak System.	Relay Valve System.	Average Aerial Current.
Power consumed by Oscillator Valves	80 watts.	100 watts.	110 watts.	2 amps.
Power consumed by Modulator Valves	80 watts.	none.	none.	——
Power consumed by Sub-Modulator Valve	15 watts.	none.	none.	——
Total Power Consumption ...	175 watts.	100 watts.	110 watts.	——

FILAMENT CURRENT CONSUMPTION.
TABLE II.

Oscillator Valve Filament ...	40 watts.	40 watts.	40 watts.	——
Modulator Valve Filaments.	120 watts.	5 watts.	10 watts.	——
Sub-Modulator Valve Filament.	15 watts.	none.	none.	——
Total Filament Consumption.	175 watts.	45 watts.	50 watts.	——

Tables Comparing Efficiency of Modulation Systems Described.

The Problem of High-Tension Supply.—III.

By R. MINES, B.Sc.

(*Continued from July issue, page* 585.)

III.—Chemical Generators.

(1) *The " Dry " Battery.*

THE primary battery is one of the oldest established methods of producing electrical energy. First used by Volta and Galvani, many different types have been developed ; but, except for the continued use of the Daniell cell for purposes of telegraph and railway signalling, it may be said that the Leclanché type is the most generally used. The small-size " dry " cell was developed to meet the need for portability (*e.g.*, in pocket torches) and is the kind that so soon won its way to popularity among a majority of radio workers as a source of high-tension supply.

The dry cell undoubtedly has the advantages of being simple in construction and use, and of necessitating no attention until the final replacement. Its capital cost is moderate and it has a reasonably long life on small sets, if of a reputable make. There remain, however, certain inherent disadvantages. The output P.D. of a Leclanché cell falls continuously during discharge over a range as great as 2 : 1, and, further, a point in the discharge is soon reached where, due partly to inevitable " local action," the P.D. becomes unsteady, causing troublesome " noise " and unstable operation of one's wireless apparatus. These conditions necessitate the continual addition of new cells to the battery and the scrapping of " noisy " ones long before their economical life is over. These cells show a deterioration of similar nature with age, irrespective of whether they are in use.

When the demands for high-tension power grow beyond the few score volts and the few milliamperes of the broadcast receiver the advantages of the dry battery method begin to disappear. An increase in the current demand necessitates using a larger type of cell, to avoid temporary polarisation setting in after a short period of use, and to secure reasonable life and freedom from " noise," and the cost of renewal will also be proportional to the P.D. in use. It soon becomes more satisfactory, therefore, and cheaper in the long run to instal some other method of supply.

(2) *The " Wet " Battery.*

The original types of " wet " cell such as mentioned above are not suitable material

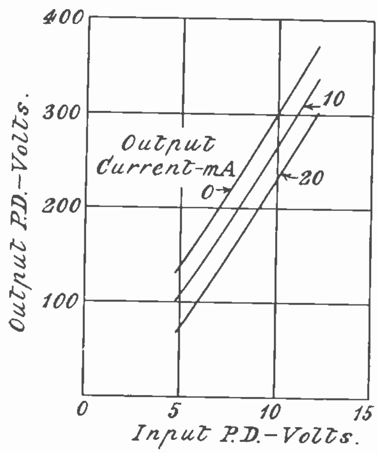


Fig. 1.

for building a high-tension battery ; but following the advent of the small wet Leclanché cell, specially designed for wireless purposes, the installation of a wet battery is a practicable proposition, since it has become comparable in capital cost and in space occupied with a dry battery of similar power output. The wet battery has advantages over the dry battery—in general it will give a steadier output, and maintenance, though more troublesome, is not so expensive, as the active materials (zinc, electrolyte, and depolariser) may be renewed separately as required. An instance of the use of larger size cells of the wet type is the high-tension battery described by N. K. Jackson in EXPERIMENTAL WIRELESS for November last.

There has recently been developed (in France, by Féry) and now marketed in England under the name of the "A.D. Primary Cell," a new type of wet cell, which uses the Leclanché combination (zinc—ammonium chloride—carbon), but which dispenses with the usual solid depolariser. Instead of a thin carbon rod or plate, surrounded by a porous vessel containing a chemical oxydising agent (manganese dioxide) as depolariser, the positive electrode consists of a large block of specially-prepared porous carbon, which, by its catalytic property, allows the oxygen of the atmosphere to depolarise the cell. On test, it is found that after an initial quick drop the P.D. of these cells remains practically constant until the whole of the zinc electrode is consumed, the value being about one volt, and the discharge (in the case of a telegraph battery) being about 20 m.a. An account of these cells (and some further tests on them) is to be found in the *Electrical Review* for March 14, 1924. An illustration is shown also of a high-tension battery designed for wireless work,

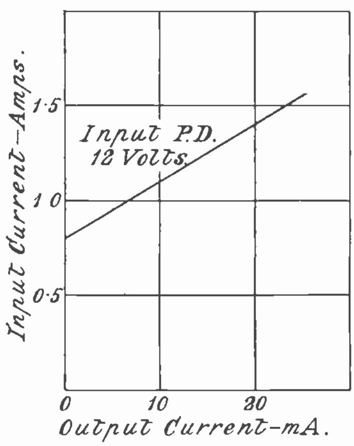


Fig. 2.

a box of cells (in the "dry" form) rated to give 40 volts. It will be seen that the advantages of these cells over the original manganese dioxide depolariser type, *viz.*, constancy and economy, are especially important for wireless purposes.

(3) *The Secondary Battery.*

The "lead-acid" storage battery or accumulator is already familiar to radio workers in connection with supplying valve filaments, but not many use it as yet for high-tension supply. This may be attributed largely to its comparatively recent development, in a form suitable for wireless work, and its higher capital cost even in this form. There are the further disadvantages of excessive weight, and the necessity for regular attention if maintenance costs are to be kept at a minimum.

In the "nickel—iron—alkali" type of battery, however, these disadvantages have been largely eliminated. The weight for a given output has been reduced, and the attention required is very little, coupled with a much longer life. Unfortunately, the initial cost is considerably higher than for the "lead-acid" type.

The great advantages of the secondary battery are more apparent on the electrical side. It has long been recognised among research workers as the best obtainable source of electrical energy, and, in fact, is used as the only method of obtaining a perfectly constant and reliable source of electricity. It will be seen, therefore, that this method is inherently the best suited to the supply of high-tension power for radio purposes.

A further discussion on the relative merits of primary and secondary batteries, together with details of different kinds of the former, will be found in an article by Ward and Goldsmith in *World Power* for January, 1924.

Electro-Magnetic Generators

The high-tension generator was principally developed for the application of wireless telegraphy to aircraft, it having been found necessary to find a substitute for the dry battery method which up till then had been the only one available. This fact alone emphasises its superior reliability and freedom from maintenance troubles, two factors of prime importance in the Services.

(1) *Dynamos.*

Aircraft generators are usually wind-driven, and the first machine to use this drive was the "52 A" alternator; this was not a high-tension machine however—it was used in conjunction with a transformer. Its output was 20 amps. at 10 volts and 660 cycles per second, and its weight was 8 lbs., giving the remarkable figure of 25 watts per lb., which is easily ten times that obtainable from a lead-acid accumulator at its maximum discharge rate.

Following this were the actual D.C. high-tension generators. One type, by B.T.-H., gave 40 watts at 600 volts, with a weight of 18 lbs. ; another, by Newton, gave 75 watts at 1,200 volts, weight 11 lbs. These machines were produced early in 1918, and, naturally, they have been improved upon since that time.

As a source of high-tension power, the generator may be said to rank next to the secondary battery from the electrical point of view. The constancy of the P.D. supplied by the machine is little affected by the amount of power drawn from the machine, being mainly dependent on the constancy of the driving power ; there is no irregular falling off, as with the dry battery method, and no powerful periodic pulsation, as with the rectifier methods used on alternating supply. On the other hand, it is inherent in D.C. generators that they produce a " ripple," due usually to the armature slots, and sometimes to the commutator bars. This ripple is an alternating P.D. superimposed on the steady value, and in some cases may be a great trouble if the radio apparatus is connected direct to the generator. Usually, however, the frequencies present in the ripple are high, and the amplitude limited, so the problem of its elimination by means of a filter is, as we shall see later, comparatively easy.

(2) *Motor Generators.*

Motor generators were developed on similar lines to the dynamos ; one example, by Newton, gave 100 m.a. at 1,200 volts when supplied from a 12-volt battery, its speed being 6,000 revs. per min., and its weight 12 lbs. (giving a figure of 10 watts per lb.—note that this includes the driving motor). This machine was designed for use on " lighter-than-air " aircraft, and hence " sparkless commutation " was an essential condition.

The self-contained motor-generator unit is naturally better suited to the radio experimenter's requirements than the dynamo, which has to be fitted with a motor or other driving device, and it is possible nowadays to select from a range of models differing

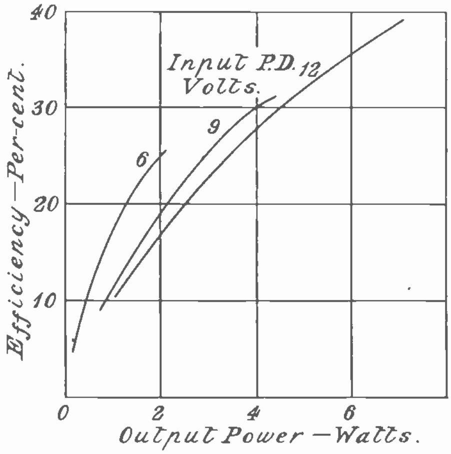


Fig. 3.

in P.D. and power outputs—a typical range is 40 to 300 watts, giving P.D's from 700 to 1,200 volts. Such machines cover well the requirements of the larger experimental transmitting stations, but they leave the small " 10-watt " transmitters and the receiving stations uncatered for. Of course, the larger machines will not fail to supply the smaller sets, but, owing to the unfortunate fact that such machines are relatively very expensive, the radio worker tends to look elsewhere for his small-power high-tension supply.

(3) *Rotary Transformers.*

In this apparatus the two machines, the motor and the generator, are now merged into

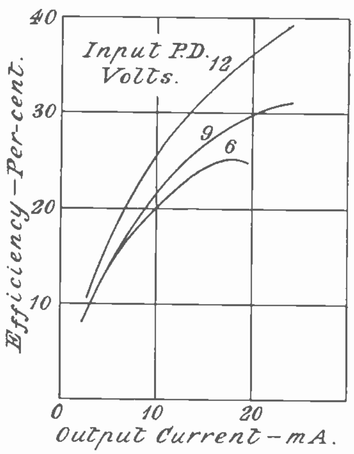


Fig. 4.

one unit. This straightway entails disadvantages :

(1) The possibility of a failure (*e.g.*, of insulation) on the generator side affecting the motor windings, and the impossibility of using a high P.D. (other than that generated) between the two elements, as is sometimes necessary when " series valve " circuits are used.

(2) The inability to control the value of the output P.D. independently of the driving side of the machine ; however, it is usually possible to control the supply to the motor side.

Nevertheless, there are distinct advantages in this system :—

(1) The overall efficiency of conversion (from low-tension power to high-tension power) will be higher, due to the use of one field system and one armature core, instead of two of each, in which parts the major losses of power take place.

(2) A corresponding reduction in the weight and the size of the machine for a given output, or, alternatively, the use of a lower running speed, giving a more reliable machine. From the point of view of the radio worker not the least advantage of a reduction in speed is the quieter operation of the machine.

(3) If, as is the usual practice, the motoring and generating wires are wound in the same slots of the armature core the ripple produced may be considerably lessened ; this effect is most valuable when the machine is on load, for under this condition a plain generator tends to give an enhanced ripple due to " armature reaction."

Of modern rotary transformers one example is that made for Marconi by Mortley, Sprague, which gives 72 watts at 1,200 volts, taking about 13 amps. from a 12-volt supply (*i.e.*, efficiency 46 per cent.). This type of machine, however, still does not cater for the small-power requirements of the radio worker of to-day.

Difficulties in Design of Small Machines.

It has been said that one of the factors against the use of the high-tension machine is its cost, and it will be seen that one way of reducing cost is to reduce the size of the machine to the minimum that will deal with the electrical loading required. Another factor to be considered by the radio worker is the power input required to run the machine—this is commonly as much as half the maximum (full-load) value even when the load on the output (H.T.) side has been reduced to zero. This factor of itself necessitates the reduction of the size (rating) of the apparatus to the minimum, as above, apart from the question of its efficiency when on full load. It will be evident, too, that if in designing smaller machines the efficiency is allowed to fall (as it tends to do rapidly, due to the difficulty in reducing the losses) the advantage gained in reduction of input power may be largely nullified.

One of the sources of loss of power in the electro-magnetic generator is the field-magnet system. This has been made of electro-magnet type since quite early days of dynamos, partly to permit control of the machine by variation of the field strength, but also to economise material and bulk of the machine. In the case of the rotary transformer type of machine, there is no call for variation of field strength. From the electrical point of view, therefore, the substitution of a permanent magnet field is possible, with the resulting elimination of the field magnet winding and the power consumed in its excitation. From the mechanical point of view, such a substitution involves considerable increase in size and weight if tungsten steel magnets are used ; but the introduction of cobalt steel for magnets has enabled the substitution to be made with little change in weight.

The M.L. Anode Converter.

The M.L. Magneto Syndicate, who for some time have been producing magnetos with cobalt steel magnets, have applied this principle successfully to the rotary transformer in their " Anode Converter." This application and other refinements of design have led to the production of a machine of much smaller power rating and with an efficiency comparing favourably with the larger machines, examples of which have been quoted. Anode converters suitable for transmission purposes are in production, and there are three standard sizes now on the market for receiving and amplifier work, particulars of which I have arranged in the table on the following page.

Through the courtesy of the manufacturers the author has had the privilege of using a " C " model anode converter, and in

MODEL.	PURPOSE.	OUTPUT. P.D.	OUTPUT. Current.	INPUT. P.D.	INPUT. No-Load Curr.
		Volts.	m a.	Volts.	Amps.
A.	Receiving	35 to 70	15*	6	0·9
B.	Do. and Power Amplifiers ...	60 to 120		6	1·1
C.	Do. and Do.	150 to 300		12	0·8
D.	Transmitting	250 to 500	20	12	1·2

* This is the maker's rating, for continuous loading, and with the machine in position in its box.

Quantity.	Unit.	Dry Battery.	Wet Battery.	Lead Accumulator (10 hr. Discharge).	Alkali Accumulator (4 hr. Discharge).	Rotary Transformer (Model C.)
Output	m.a.	5	10 to 20	100 to 200	500	20
Weights	lbs./volt. lbs./watt.	1/10 20	$\frac{1}{4}$ to 1 25 to 50	$\frac{1}{4}$ to $\frac{2}{3}$ $2\frac{1}{2}$	($\frac{2}{3}$) ($1\frac{1}{2}$)	1/20 $2\frac{1}{2}$
Costs	shillings/volt. £/watt.	$\frac{1}{4}$ $2\frac{1}{2}$	$\frac{2}{3}$ to $1\frac{1}{2}$ $3\frac{1}{2}$	1 $\frac{1}{4}$ to $\frac{1}{2}$	$2\frac{3}{4}$ $\frac{1}{4}$	1 $2\frac{1}{2}$

In the above table the various methods are arranged in the order of the length of their useful life, that of the generators being indefinitely long.

order to determine to what extent this machine " filled the gap " in the matter of a satisfactory low-power high-tension supply for radio purposes it has been tested at East London College by Mr. M. Stern, B.Sc., who has kindly placed the results at the author's disposal.

The machine is provided with a variable resistance (of a type used for controlling valve filaments) connected in series with the motor armature ; this enables one to vary the P.D. acting across the motor terminals, and hence to control the output (high-tension) P.D., over a range of from half value to full value. Fig. 1 gives the relationship ; the three curves are for different values of output current.

Fig. 2 gives the relation between input current (to motor) and output current (high-tension). Here the input current is a measure also of the input power, since the P.D. acting on the motor is held constant at 12 volts ; it will be seen that the input power corresponding to zero output (*i.e.*, " no-load " input) is over half its value for full load, indicating a high proportion of lost power.

However, considering the difficulties inherent in the production of machines of such small ratings, the efficiency attained quite a high value at full load ; this may be seen from Figs. 3 and 4. Three curves are shown, for three values of the P.D. across the motor armature (as controlled by the resistance). The efficiency given is that of the machine only, *i.e.*, taking no account of the power loss in the resistance ; this loss is zero, however, for the 12-volt curve, and similarly for the 6-volt curve if a 6-volt supply is used.

The machine as supplied is mounted on rubber buffers inside a cast aluminium box, the lid having a machined joint ; this reduces external mechanical noise of the machine practically to nil. This box houses also a complete filter circuit. The machine in question has been used on a power amplifier (audio frequency), and on receiving circuits (including a sensitive super-regenerative set), and the effectiveness of the filter in reducing the " machine note " or ripple was demonstrated to be sufficient for radio purposes.

The author has measured the ripple under varying circumstances, using a Cathode-Ray Oscillograph. The magnitude of the ripple is expressed by the percentage variation of the P.D. on either side of its mean value. With the filter disconnected the ripple is 15 per cent. at full P.D. and no load. With the filter connected (which here is almost equivalent to putting a condenser across the terminals) and measuring the ripple across the machine terminals as before, the ripple is reduced to 4 per cent. at full P.D. and no load; at full load it further decreases to 3 per cent. If, now, with the filter in circuit as before, the measurement is made at the output terminals of the filter (whence supply is taken for radio apparatus), the amount of ripple is found to be under ½ per cent.

Some Comparisons of Generator Methods.

Some approximate particulars of weights, capacities, and costs for some of the different methods of high-tension supply have been extracted from catalogues of the following makers:

Dry Battery: Ever-Ready.

Wet Battery: Siemens (Leclanché) and Darimont.

Lead Accumulator: Hart, Fuller (block) and Exide.

Alkali Accumulator: Alklum.

Rotary Transformer: M.-L. (Anode Converter.)

The Poulsen Arc.

By DALLAS G. BOWER.

The function of an arc as a generator of continuous waves is treated in an elementary manner in the following article. Methods used at commercial stations are also briefly outlined.

It is the object of the writer in this article to explain the function of the Poulsen arc system for producing continuous wave oscillations. It is felt that many amateurs are not entirely acquainted with the arc, and a short explanation of its working may be of interest. There are three methods commercially used for communication by continuous wave radio, namely, the thermionic triode, the Poulsen arc, and the Alexanderson high-frequency alternator. The function of the arc will now be explained.

Suppose two electrodes to be placed in proximity to each other, one made of copper and the other of carbon, and let them be connected to a high voltage D.C. source as shown in Fig. 1. The positive pole of the source is in contact with the copper and the negative with the carbon. If the carbon is gradually placed nearer the copper a large current will flow which will heat up these two electrodes to a very high temperature. In practice the anode (positive copper electrode) is cooled by water, otherwise it would melt. The cathode, or negative carbon electrode, gets white hot at its tip, and in consequence of this fact shoots off a great number of electrons. If the distance from the cathode to the anode is made larger these electrons will travel from the cathode to the anode. Hence a collision will occur between the electrons and air molecules, thus positive and negative ions are formed. This produces a gaseous arc which carries a convection current consisting of negative ions and electrons moving to the anode and positive ions moving to the cathode. The distance between the electrodes can be prolonged until the energy supplied to the aforesaid electrodes is insufficient to maintain the arc. The resistance of an arc of this nature does not remain constant, but drops as the current through it is increased,

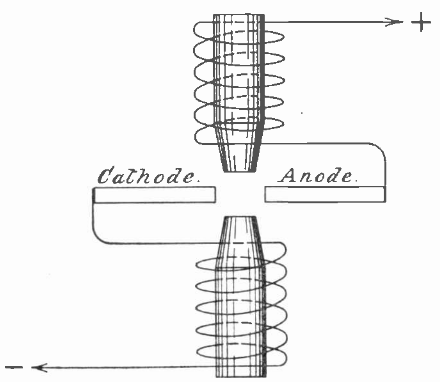


Fig. 1.

and rises as the current is decreased. It will be seen that unless the positive ions are absorbed quickly by the cathode, and the negative ions by the anode, on an increase in convection current clouds of positive ions will gather around the cathode and negative ions around the anode. This tends to reduce the P.D. across the gap, and thus the resistance is lowered. The voltage drop across the arc varies inversely with the current. An arc of this kind can be made to produce undamped oscillations, providing it is placed in a circuit possessing inductance and capacity. Referring to Fig. 2 it will be seen to have a D.C. supply, two iron core chokes L_1 and L_2, an arc A, and a circuit LC with a suitable switch at Q. Owing to there being a P.D. across the arc the condenser will commence to charge up. It will be seen that this charge cannot come from the D.C. source on account of the inductance of the two chokes. It will therefore have to come from the arc itself. During this charge the switch Q is, of course, closed.

As the charge is increased the current in the arc falls off, the P.D. across it rises, hence a further charge into the condenser. The voltage across the condenser eventually becomes the same as that across the arc. Now the inductance L tends to make the current in the arc keep on, with the result that a further charge is introduced into the condenser. Eventually the voltage across the condenser reaches a maximum, and will fall off as the condenser discharges, and it will be seen that the discharge of the condenser increases the arc current. This will result in a decrease of P.D. across the arc, and allow the condenser to discharge still further. When the condenser is fully discharged the inductance L comes into operation and starts to charge up the condenser in the opposite way. Providing the arc is kept burning, the condenser current will become oscillatory, and continuous oscillations will be set up in the circuit ALC. The production and building of oscillations may be made more clear by referring to Fig. 3. At the point marked O the switch Q (Fig. 2) has not been closed. The current through the arc is 15 amperes at a pressure of 250 volts. At A the switch is closed, and a current of 3 amperes is flowing into the condenser. Thus the arc current is —3 amperes, which is 12 amperes. From the arc voltage curve it will be seen that the arc voltage has increased to 280 on account of the decrease of arc current. The P.D. across the condenser will now rise to the same as that across the arc. At B it will be seen that the condenser current has fallen to zero, while the P.D. across the condenser has risen to 460 volts. At this state of affairs the arc current and arc voltage are their normal value, as shown. After B, the P.D. across the condenser is greater than that across the arc, so current starts to flow out of it into the arc. This lowers the P.D. across the arc. At C the arc current has risen to 4 amperes by reason

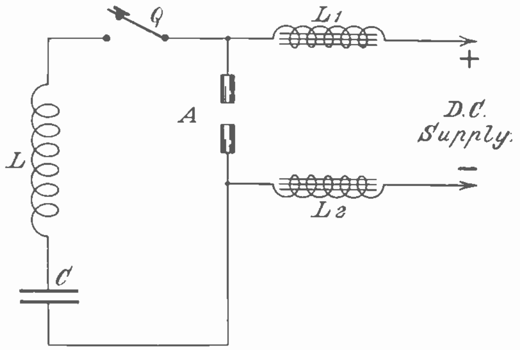


Fig. 2.

of the fact that the condenser current flow is of the same figure. It will be seen that the arc voltage and condenser voltage are now the same. After C the energy stored in the magnetic field of the coil L tends to keep the current flowing out of the condenser and reduces the P.D. across it to zero. The complete operation will now commence again. It will be seen that the condenser current curve is in exact phase with the arc voltage curve. It is the fact that the condenser current is in phase with the arc voltage that maintains oscillations in the circuit ALC.

It must be remembered that any arc will not maintain oscillations in an oscillatory circuit. Various precautions have to be taken into account. The most important matter for successfully running an arc is to keep it cool. If the arc is not able to radiate its heat away quickly enough the change in arc voltage will lag behind the change in arc current, and only feeble oscillations will be set up. In commercial practice three methods are used for keeping the arc cool, namely, burning the arc in hydrogen gas; burning the arc in a strong magnetic field; water-cooling the chamber containing the arc and cooling the tip of the anode

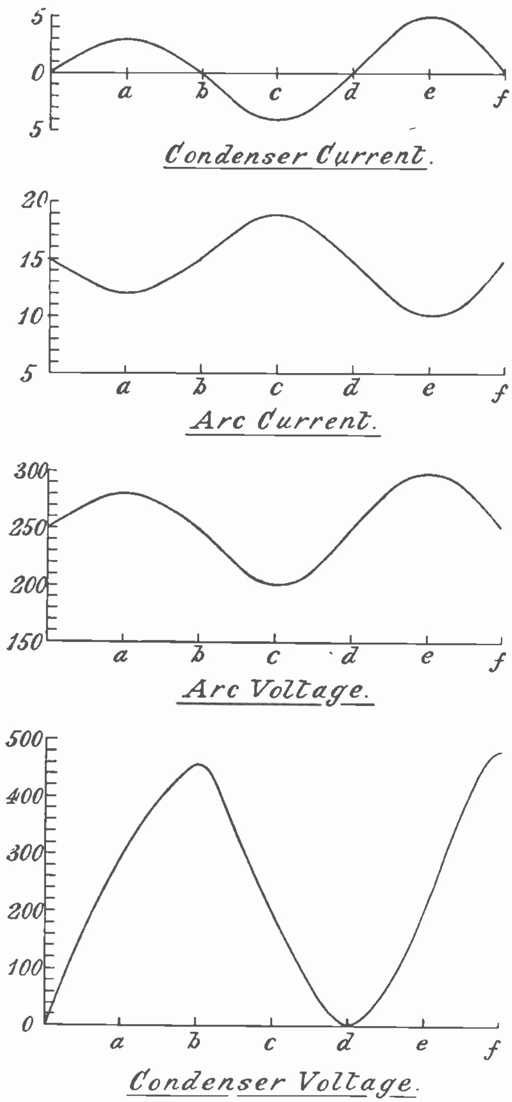


Fig. 3.

with water. Referring to Fig. 1 it will be seen that the arc is placed in suitable position to two field-magnets, in order to produce a strong magnetic field across it. The windings of the magnets are wound over soft iron cores whose tips project near the arc electrodes. These windings are connected in series with the D.C. supply and the arc electrodes. They sometimes serve a dual purpose as they also function as the chokes shown in Fig. 4. The arc, then, will burn in a strong magnetic field. Providing the field windings are connected correctly, the magnetic influence on the arc tends to bow it upwards. It will be understood that the arc under these conditions is much longer for a given distance between the electrodes, so it will therefore have more chance of radiating its heat away quickly. The magnetic influence also tends to make the arc burn on the top edge of the electrodes, and it is therefore stabilised.

For successful operation it is absolutely essential that the arc be steady in burning, and to this end the carbon must burn evenly. This is usually accomplished by rotating the carbon by some auxiliary means. The object of burning the arc in hydrogen gas is to convey the heat away more quickly. Since hydrogen gas is lighter than air this operation is successfully accomplished. If the arc is burnt in air a number of positive ions from the cathode combine with negative ions of oxygen and so produce carbon dioxide, and so many of the ions that would have gone to reduce the P.D. across the gap are lost. In order to keep the whole of the arc equipment cool distilled water is pumped round the sides of the arc chamber and the tip of the anode. The water must, of course, be absolutely pure, otherwise the anode would have a path to earth. The length of the wave transmitted by the Poulsen arc is dependent on the constants, etc. In order to signal with the arc a system known as the "Marking and Spacing Wave" is adopted. It is not possible to make and break the D.C. supply circuit, as, of course, the arc would go out. In the marking and spacing wave system a portion of the inductance is shortened and so alters the wave-length transmitted. The antennæ is kept in an oscillating condition, when the key is up, at a given wave-length. When the key is down a portion of the inductance in the antennæ circuit is shorted and so a different wave transmitted. This wave is called the marking wave and is the actual signal. It is, of course, of a lower wave-length than the spacing wave. The difference in fre-

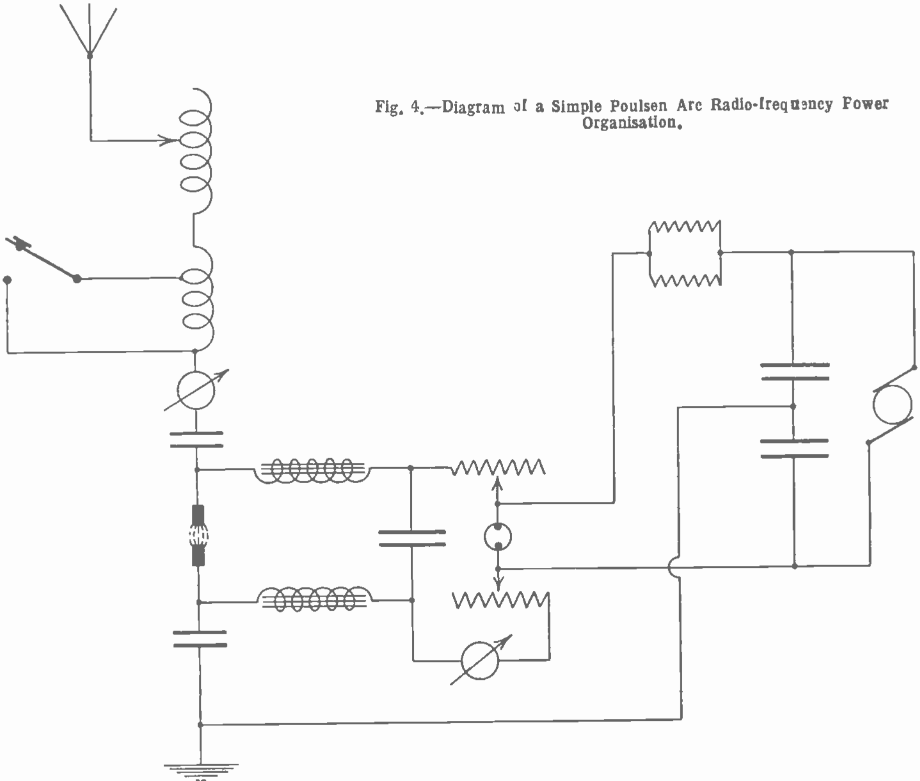


Fig. 4.—Diagram of a Simple Poulsen Arc Radio-frequency Power Organisation.

quency between the marking and spacing wave is about 2,000. The type of equipment usually employed in commercial working is shown in Fig. 4. The various apparatus is readily discernible. The D.C. circuit is usually fed by a D.C. generator. The arc starter, which is shown in the circuit diagram as a double-pole resistance is used to prevent a violent rush of current when the arc starts. As the arc starts functioning the resistance is decreased. A D.C. ammeter is placed in the negative pole lead of the D.C. circuit, and a R.F. ammeter in the antennæ circuit. When the arc has been adjusted this meter will read the R.M.S. value of the D.C. meter, *e.g.*, D.C. meter reading = 20 amperes; antennæ meter will read 14 amperes. The usual protection of the D.C. supply from the oscillatory circuit has to be taken into account. This is effected by shunting a series of condensers across the output terminals of the D.C. generator. The bank is earthed as shown. The arc functions most efficiently on long wave-lengths and will not work very well below 1,500 metres wave-length. As the transmitting frequency is increased, and hence the wave-length lowered, the arc voltage tends to lag behind the arc current and so the arc becomes unsteady. Recent experimental work has been conducted, however, using the arc on very high frequencies with quite considerable success.

A Vernier Condenser with Micrometer Adjustment Suitable for Use on 100 Metres.

By G. A. V. SOWTER, B.Sc. (2OS).

No doubt many amateurs have found tuning to be difficult on 100 metres and below. We give here information on the design and construction of a condenser which is particularly suitable for tuning purposes on very low wave lengths.

THERE must exist a large number of amateurs who have interested themselves in the reception of transatlantic signals on about 100 metres during the last few months, using the conventional circuits, and, no doubt, many of them have experienced the difficulties of obtaining that precise tuning necessary on these wavelengths. It is frequently found that capacity effects due to the body of the operator may entirely detune the set, and as the result of a fair amount of experience, including the reception of KDKA on 100 metres more than a year ago, the writer has evolved the following novel condenser, to which he attributes the overcoming of most tuning difficulties.

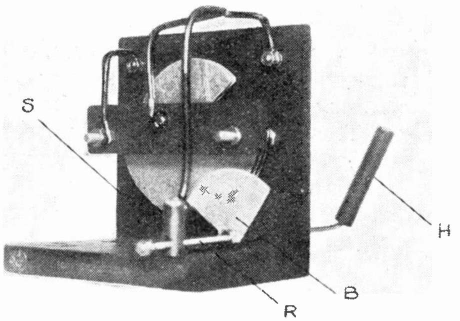


Fig. 1.

As indicated in Fig. 1, this condenser is of the normal two-plate vernier type, but with the refinement of a small auxiliary plate B connected electrically to the moving elements through S. Sector B can be caused to rotate through 90° by means of the handle H, the bearings being a small bush in the ebonite front and a spring terminal S in the rear. The novelty of this auxiliary is that the distance between the fixed plates and the sector B can be adjusted to any value between 1-16th of an inch and two inches by merely depressing S and pushing the rod R into the desired position. To reduce the minimum of this condenser to as low a value as possible the moving plates rotate about an axis which is not at the geometric centre of the fixed plates; this is clear from the dimensioned figures (Figs. 2a and b).

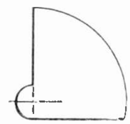


Diagram showing the shape of the Plates.

Accurate measurements of the values of capacity were made on a modified form of Wien Bridge, and the following results obtained:

Maximum capacity 41 $\mu\mu$F.
Minimum capacity 7 $\mu\mu$F.

When B was 1-16th inch from the fixed plates a 90° movement of H caused a variation of capacity of 3·5 $\mu\mu$F.

When this distance was two inches, the variation was 1 $\mu\mu$F.

Variation of capacity due to translational movement from "fully in" position at X to "fully in" position at Y (Fig. 2a) was 5·5 $\mu\mu$F.

As is natural, the condenser was first constructed, and these values measured subsequently. Consideration of the value of minimum capacity would indicate the advisability of making the distance between the geometric centre of the fixed plates and the axis of rotation of the moving ones ½″ instead of ¼″ as in the original condenser.

It is seen that a 90° rotation of the sector B can cause any variation of capacity from 1 to 3·5 $\mu\mu$F., and since it is a comparatively easy matter to adjust the position of H to within, say, 5°, even when using a long ebonite rod for this adjustment, it follows

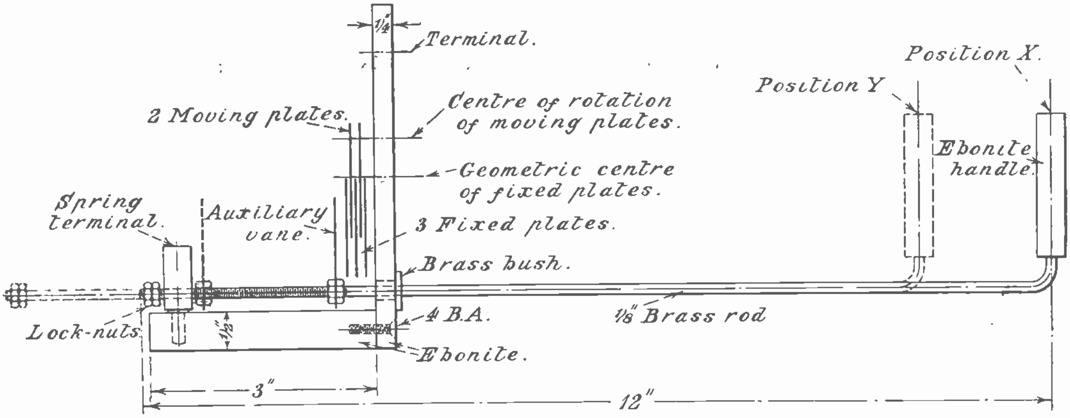


Fig. 2 (a).

that a setting of the condenser to within 1-10th $\mu\mu$F. is not difficult.

It is more than probable that the variations of capacity due to B are not directly proportional to the angular movement of H, but since this is not essential for the purpose in question, no effort was made to effect this.

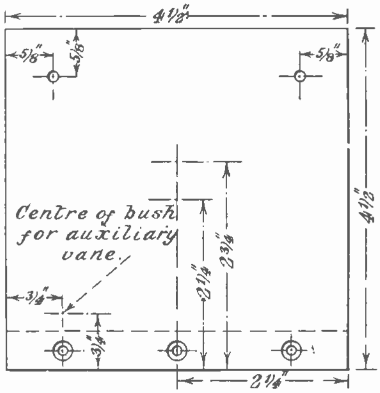
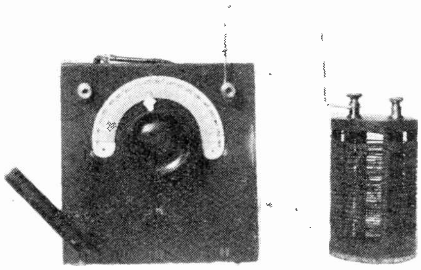


Fig. 2 (b).

In practice, it was observed that on 100 metres the tuning had to be exact to within 1 $\mu\mu$F. for the station to be audible, and that for best results adjustment was necessary to within about 1-5th $\mu\mu$F., but, obviously, these figures will depend upon the other constituents of the tuning circuit.



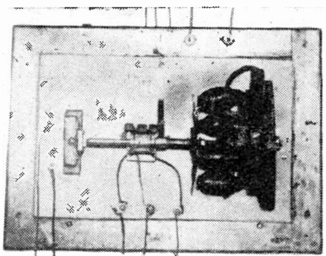
The Complete Condenser.

A Simple Rotary Rectifier.

By A. BUTEMENT.

One of the greatest problems of the transmitting experimenter who possesses A.C. mains is efficient and inexpensive rectification in order to give him D.C. for his transmitter. We give below a description of a rotary rectifier, which is one of the most efficient of its kind.

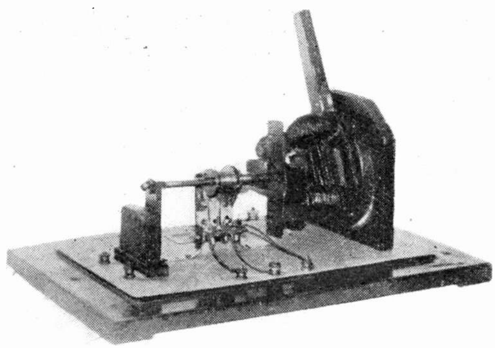
A RECTIFIE such as described here is very useful to the radio experimenter for obtaining D.C. from A.C. mains for accumulator charging, etc. The system may also be applied to a variety of other purposes.



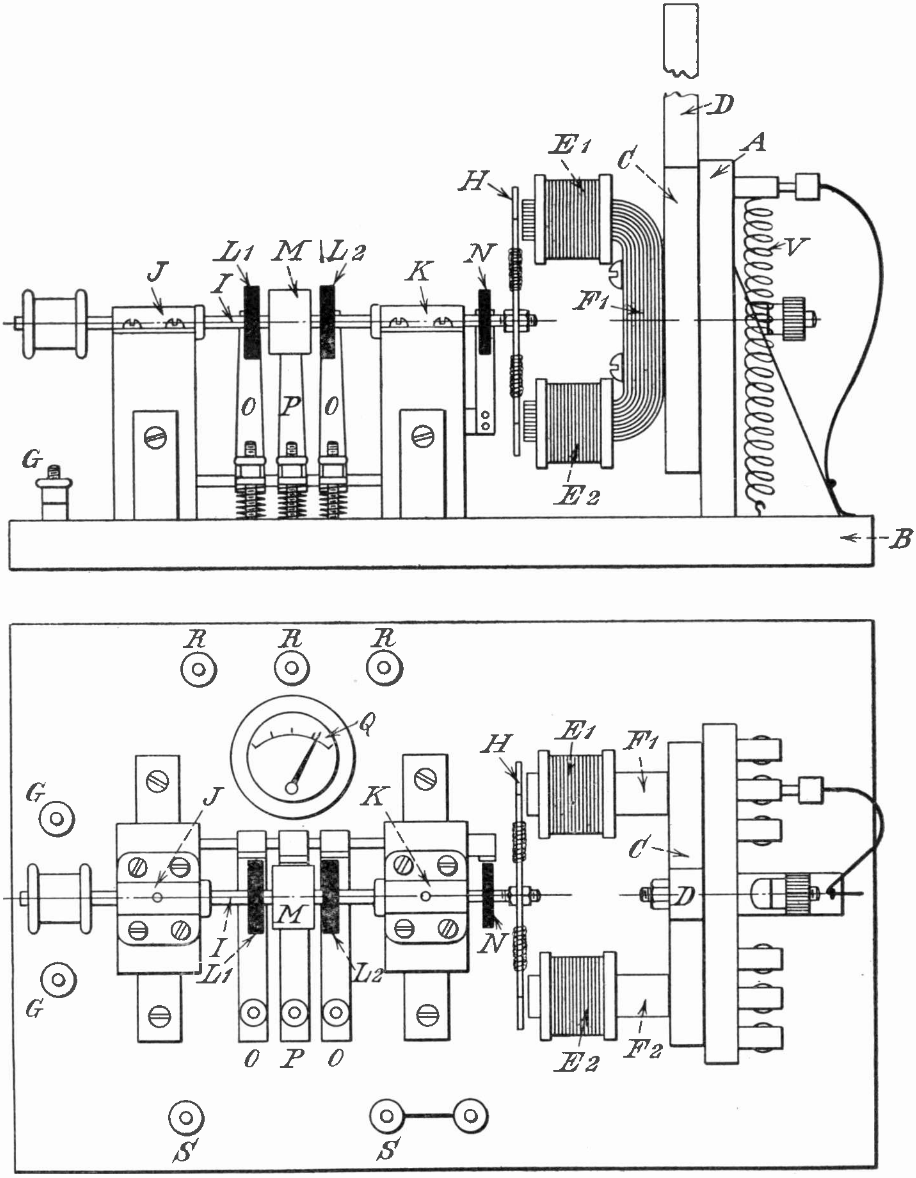
The Completed Rectifier.

With reference to Figs. 1 and 2, no dimensions are given, but only a diagram approximately to scale, as every amateur would make this machine up to suit the materials in his possession. A is a wooden support fixed vertically to a substantial base B, and kept perpendicular by a bracket at the back. Behind A a tapped resistance V for varying the current through the cells on charge is mounted. C is a disc of wood with a handle D extending, of which the use will be subsequently described; C is bolted through its centre, about which it can swivel, to the support A. E_1, E_2, etc., are bobbins, four in all, wound with insulated copper wire to suit the voltage applied to them. If about 16 volts is to be used, they may contain ¾ lb. of gauge 22 D.C.C. between them, or 3 ozs. each. F_1 and F_2 are cores made of soft iron, and bent as indicated in the figure. These, on which the bobbins are fitted, are screwed to the bat-shaped piece of wood C, so that the centres of the four bobbins are equally spaced round a circle whose centre is the pivot holding C to A. These four magnets are connected in series, so as to give N, S, N, S, poles as one goes round the circle; the ends are connected with flex to the terminals G.

H is a piece of sheet iron, say 1-10th inch thick, cut to the shape indicated in Fig. 3. This is bolted to a shaft I, which is mounted on two firm bearings J and K. A wooden cylinder is fixed on the end of the shaft, and is used for starting up. A cotton reel will do. Two slip rings L and an eight-pole commutator M, of substantial design, are fixed between the bearings on the shaft. (The slip ring N does not concern us here, but will be dealt with later. This applies also to the winding on H.) The two slip rings L are connected to the commutator in a manner indicated in Fig. 4. Two pairs of opposite sections are connected to the two slip rings, and the other four alternate sections are dead. O and P are brushes making contact with L and M respectively; they may be of any design, but should be capable of fine adjustment. Q is a moving coil ammeter, used to measure the current flowing through the accumulators and should not be omitted. R and S are terminals connected as shown in Fig. 5.



The Rectifier Showing Mounting.



Figs. 1 and 2.—Diagram Showing Construction of the Machine.

A fuse should be included in the accumulator circuit in case of accidents.

A transformer will also be needed to step the main's voltage down to that required for the accumulators ; if this is a six-volt battery, then the voltage should be stepped down to 16 volts, 8 volts either side of a central tapping.

If a central tap is not available, then 8 volts may be applied to the slip rings and D.C. obtained from two brushes, exactly opposite to one another, on the commutator.

To start the rectifier, switch on the transformer and the current to the bobbins E_1, E_2, and give the rotor a twist, by drawing the hand over the cotton reel. After a little experience it will be found that it is quite easy to start the rotor at the correct speed to fall into synchronism ; this will probably be accompanied at first by a rhythmic bumping, something like a car starting up, but this should quickly die out as the motor truly synchronises. It will then run at a steady speed, at half the frequency of the mains, *i.e.*, if the input is 50 cycles, the motor will make 25 revolutions per second, or 1,500 revolutions per minute. Harmonic speeds are possible, but are rarely met with.

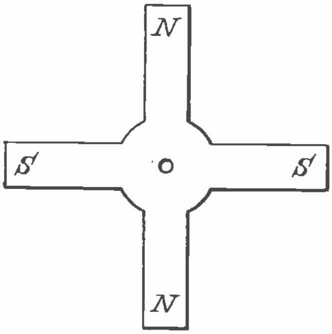


Fig. 3.—The Armatures.

When everything is steady the brushes may be lowered into contact with the slip rings and commutator, and the output terminals dipped in acidified water to find the polarity (the pole which gases most being the negative). Having found the polarity, the accumulators may be connected (positive to positive) in circuit, with the maximum value of the resistance in circuit. The field coils are then rotated by the handle until sparkless running is obtained, and the current through the cells increased to the value specified on them.

If the rectifier is made as described above, and if the four bobbins form exactly a square,

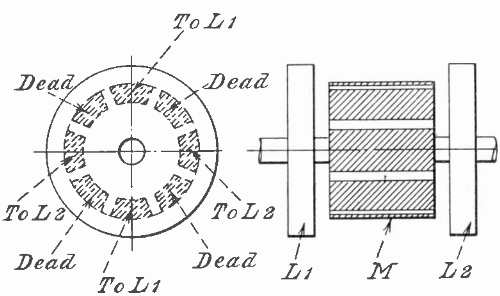


Fig. 4.—Method Used to Fix the Slip Rings on the Commutator.

there is no reason why it should not give satisfactory and reliable results.

Now, if the four points of the rotor possessed a permanent magnetic polarity, as shown in Fig. 3, the motor would obviously run much more smoothly, also the polarity could be determined once for all. In practice, however, such magnets would be difficult to obtain, and the continual vibration would quickly depolarise them. But, if the rotor is wound, and the four bobbins thus formed are connected in series to give the polarity indicated in Fig. 3, and the two ends connected to the slip ring N, and the shaft, and if the cells are connected to the bearings, and

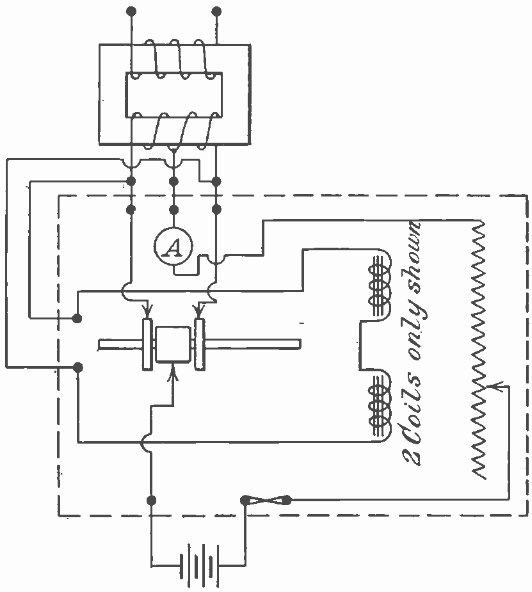


Fig. 5.—Simplified Connections.

the brush on N, then the same result will be obtained.

Now if, instead of the cells, we substitute the output from the rectifier, while it is stationary, then (assuming the handle to be in the correct position and the brush gear and bearings free), on giving the rotor just half a turn it will accelerate, and finally fall into synchronism, accompanied as before by a series of beats, which get fainter, and finally die out. Now, although the system has been made self-starting, we no longer know the polarity, because there is no permanent magnetism in the rotor to decide into which phase it will fall, so, obviously, this rotor must, in some way, be magnetised.

An addition which has not yet been tried to do this, is to put another high-resistance winding over that already on the rotor, and connect it to two slip rings and their brushes across the accumulator. A high-resistance winding, many turns of fine wire, is sufficient, as very little extra magnetism (of a definite polarity) is required to decide in which phase the motor will start. This coil, when once the rectifier is running, may be switched out of circuit.

The method by which the rectifier works should be quite clear from a consideration of the diagrams. If the accumulator voltage is

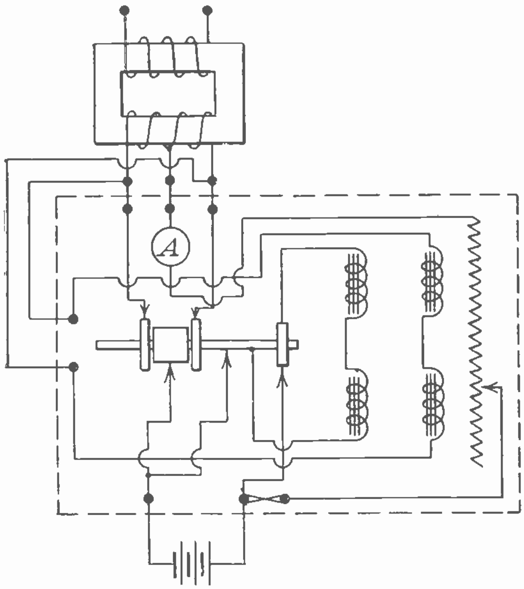


Fig. 6.—A More Elaborate Scheme.

6, and the charging voltage 8, then the field coils can be adjusted till almost no current flows both at make and break (see Fig. 8), and thus sparkless running is obtained. If the charging voltage is in excess of this, then the field coils must be turned till there is no current flowing at break (the sparking at make being negligible).

Rectifiers of this type, with a 1-in. commutator, will deliver, if required, up to 12 amps. when charging a four-volt accumulator with 8 volts.

There are other uses to which such a synchronous motor may be put ; if a disc of

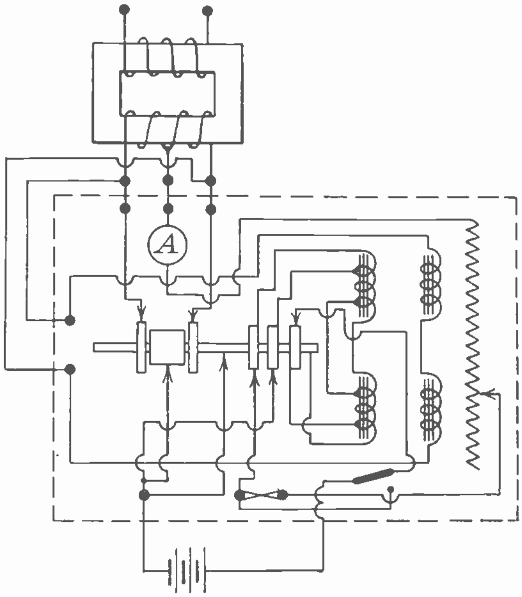


Fig. 7.—Circuital Arrangement of the Complete Accumulator Charging Plant.

wood or ebonite is fixed on the shaft, with a number of contact studs equally spaced around its circumference, and a brush allowed to make contact with it, this may be used as an interruptor for I.C.W. transmission. The chief advantage lies in the fact that it will (assuming the main's periodicity to be constant) always emit a note of constant frequency ; further, knowing the main's periodicity, the note can easily be calculated. The system could advantageously be applied to Morse transmission by the difference of note system.

If for the synchronous motor described above, a D.C. motor is substituted, and if D.C. is applied to the two slip rings, then, when the motor is running A.C. will be obtainable from two brushes opposite one another on the commutator. These must be exactly opposite or bad sparking will occur.

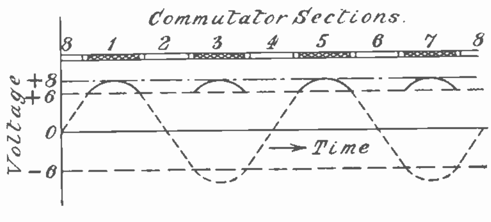


Fig. 8.—The Conditions for Sparkless Running.

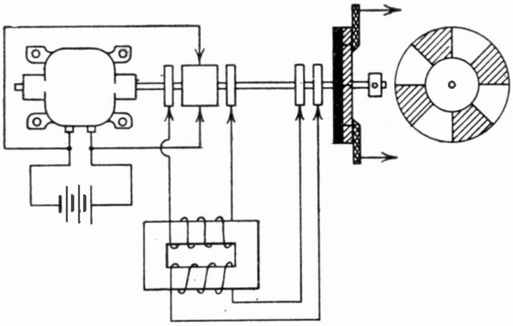


Fig. 9.—Circuit Employing a Synchronous Rectifier to Obtain High Voltage D.C. for a Transmitter.

Finally, this A.C. may be transformed up to a high voltage, suitable for transmitters, and applied to two more slip rings, on the same shaft, which are connected to another commutator. Then pulsating D.C. will be obtained, when the commutator angle is correctly set, from the brushes collecting from it. A large commutator with big ebonite dead sections should be used to prevent flash-over due to the high voltage.

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. 3.—Switch Construction.

FIG. 1 with this instalment shows, in scale section, a type of multiple-contact switch having a fixed stud as a pivot in place of a rotary spindle. Switches like this are much easier to construct on account of the fact that there is no need to fit to the panel any form of bush. The pivot stud is shown to consist of a 1½" length of No. 2 B.A. screwed brass bar, passing through a similar size clearing hole in the ebonite panel. This clearing hole should be drilled by means of a 3-16th" drill in the first place, the resultant hole from which will, if the bar is not under size, probably be a fairly tight fit, mainly because ebonite tends to settle inward after drilling, and may present thereby an under-size hole. It is better not to force the stud through such a hole, but to ease the hole out very slightly by means of a broach. The resultant fit, in any case, of the stud to the hole should show no appreciable play, as if it does so, all the stability of the stud depends upon the pressure of its washers on the ebonite surfaces, which is not a good construction to rely upon. If the experimenter is equipped with suitable screwing tackle (such as No. 2 B.A. stock and die, as well as the corresponding taps), and he is willing and able to do the work, much better studs for the purpose can be made from 3-16th" round brass bar. The difference is that he will still have the same length of stud, but will screw it down from the top to a point about level, or a shade below, the surface of panel; and similarly screw it up from the bottom, in which case the portion of the stud shank in the hole is left plain, a construction much less likely to become unstable. It is advisable to make sure that there is sufficient length of thread up and down beyond the level of the face of the nuts to allow the nuts to take a firm bearing on the washers, otherwise they may seize on the screw before taking their bearing, and, though appearing to be tight, are really not holding the stud enough to prevent it turning in the panel when apparently adjusted somewhat tightly.

Referring to the same figure, it is noted that above the panel is a washer against which bears a standard 2 B.A. nut (*i.e.*, not a lock nut) which is bevelled (or chamfered) on one edge only. Put the chamfer downward, and lock this by a pair of locknuts bearing on a washer on the underside of panel. The actual locking of the stud is done between the large nut at top and the upper locknut at bottom, the pur-ose of the washers being to extend the bearing surface on the ebonite, and to prevent the nuts turning on the softer material. The lower locknut can be used to bind the lead

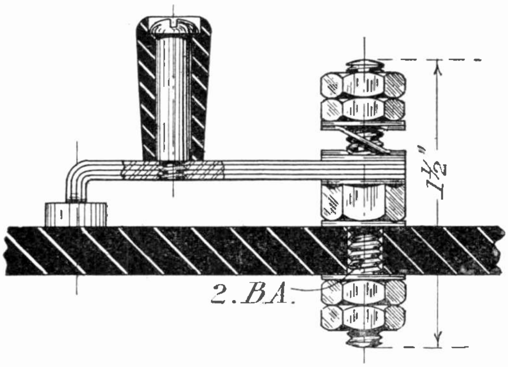


Fig. 1.

from the switch, or the latter may be sweated to the point of the stud. In either case the second locknut should be used.

Above the switch arm is fitted first a washer, next a copper spring washer, followed by another washer, the whole being bound down by a pair of locknuts. These should give a firm adjustment to the spring, so that the rubbing contact of the arm is maintained with just sufficient resistance to turning to keep the switch arm on the requisite stud at its working end. The upper nuts should be locked to each other quite firmly to ensure that the friction of the arm in turning neither releases nor tightens them, as either of these contingencies may throw the switch out of action.

The arm shown is the standard pattern laminated copper switch-arm sold by all the wireless dealers. It consists of four laminations, each about 1-32nd" thick, and connected by a rivet or clip at the position shown for the handle. The idea as drawn, is to remove the rivet, and keeping the laminations carefully clipped together in their correct relative positions, to drill a No. 26 hole (*i.e.*, No. 26 drill is the tapping size for 2 B.A.) and tap it 2 B.A. To this is fitted a round-headed, plain-shanked set-screw which carries a bored ebonite handle. Handles of the kind shown, which for preference and easy working should be fitted on the screw spindle capable of revolving, are made and sold in the general electrical trade (not necessarily the wireless trade). They are to be procured in ebonite, moulded ebonite, "ebonestos," "erinoid" and similar insulating materials all quite suitable for switch handles. The general fitting up and arrangement of the switch has already been dealt with in the May issue of EXPERIMENTAL WIRELESS. This form of arm, while requiring, when off the contact studs, to spring down 1-16th", just like the single strip arm, requires to be fitted, not only so that it bears on the stud evenly across, but also so that each lamination springs down and also bears evenly across. The object of this is to give the switch the largest stud contact of which such an arm is capable.

If current-carrying capacity is a point to be considered, a good way to fit these laminated arms to decrease contact-resistance is as shown in Fig. 2. Instead of having the arm bent down at right angles, it should be set down approaching the stud, either with a curve or straight down at an angle of 45°, or less, to the horizontal. Then, if it be filed flat at an angle to the curve, on a plane parallel with the arm itself, it presents about its maximum contact-surface to the stud. Rather more care in this case is required to ensure that each lamination has a spring effect on its own account, and therefore bears

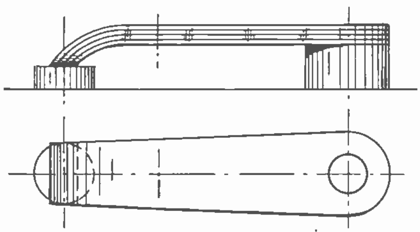


Fig. 2.

well on the stud and also along the whole of its bottom edge length. It is usual to note that each lamination makes a distinct polished line on each and every stud of the switch as evidence that the contact resistance is reduced to the minimum.

Fig. 3 shows a form of solid pivot stud which is shouldered and fitted with a solid slotted arm, shown in the views (Fig. 4) below the pivot stud. The stud may be either made solid, turned from a piece of $\frac{1}{2}''$ round brass, or built up as follows:—The fixed collar on the panel is 7-16th" diameter by $\frac{1}{4}''$ thick, and the journal above (*i.e.*, a journal is a portion of a stud or shaft which runs in a bearing, or upon which, in this case, the switch arm turns) is $\frac{1}{4}''$ diameter by 3-16th" long. Thus the switch-arm matches the large collar in diameter of boss, and is holed $\frac{1}{4}''$ to run on the journal. There is a shoulder above the journal so that first a washer can be put on followed by a knurled nut. The nut and washer are screwed down tightly to the shoulder, in which position they do not confine the switch-arm, which is made free to revolve on the journal. The arm is of solid brass and has a fine saw-cut made up its horizontal centre and parallel with the base of the boss. By opening this saw-slot out a little spring tension is put on the swivel end of arm, so that, with the washer and nut bearing on it, it has a certain frictional resistance to turning which makes it smooth in action and free from end play. To build up the stud, procure a $1\frac{1}{2}''$ length of No. 2 B.A. screwed bar and a tapped collar. These collars have been purchased among regular wireless fitments. Tin the screw where the collar is to be and screw it on together with some flux while the screw is hot. It will then solder on tightly if held in a flame. The journal portion can be made from a 3-16th" No. 2 B.A. spacing washer as used in condenser building, and this need not be soldered on as it is held tightly by the nut and washer. The remainder of the switch construction involves the fitting of a handle similar to that shown in Fig. 1, and a small spoon-shaped spring for stud contact. The writer, in making a switch like this, made the spoon-shaped spring first by cutting out a small circle or disc of silver sheet having a tang on one side. This disc was dished by laying it on a block of lead and giving it a blow with a rounded punch. After this a strip of light

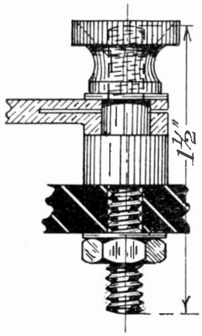


Fig. 3.

clock spring about 3-16th" wide was soldered to the silver tang. The spring was then softened over the area where the screws are, in order to drill it for the two No. 9 B.A. set screws by which it is screwed to the arm. Care was taken to solder it very rapidly to the silver in order not to take the temper out of the main portion of the spring, as it depends on its springy character to maintain a good rubbing contact on the studs. The leads to the fixed pivot stud on the underside of panel can be attached as described for Fig. 1. This type of switch is very smooth in working, and, if correctly made, is particularly adaptable for working over a complete circle of studs, and if each stud be faced by a disc of silver or German silver sweated on, there is very little trouble on the score of bad contact. The studs, of course, must be put sufficiently close together to allow of the spoon-shaped end sliding

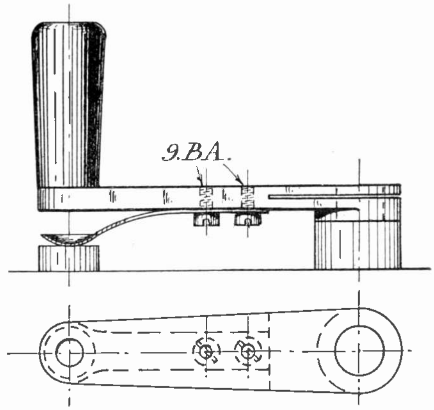


Fig. 4.

from one to the other without any marked jump in the change. There is more work, however, in making this switch than in those previously described.

Fig. 5 shows a simple method of adding to the contact area of a single spring strip switch arm. A second spring of lighter material, such as German silver, is riveted to the underside of the arm, and is brought

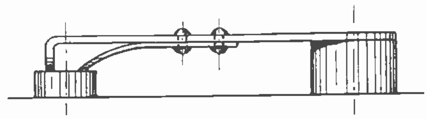


Fig. 5.

forward by an easy bend on to the back of the face of the stud. The front contact of the main arm, instead of being on the centre of the stud, is set forward. This is a simple construction and will work well if the second spring is made much lighter so that it does not affect the contact of the main arm.

Fig. 6 shows a method of balancing a switch arm which can be applied to both a single strip or laminated arm. A fixed pivot stud is used, but it is not of necessity in the circuit, the arm being continued beyond it on the side remote from the multiple studs, set down, and formed to

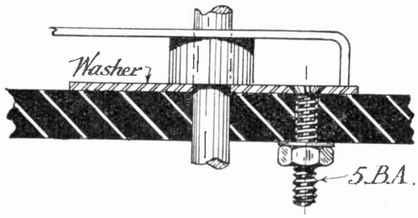


Fig. 6.

make a rubbing contact with a thin washer, preferably of copper, held under the shoulder of the pivot stud. The washer may be held from revolving by one or more countersunk-head No. 5 B.A. set-screws carrying a nut and washer on the underside of panel. One of the latter forms the lead-out, which need not now be taken from the pivot stud. Quite a fair degree of pressure can be put on the studs by the arm, and by reaction the same pressure is carried over to the other end and ensures a similar pressure on the washer. Any inadequate contact with the pivot stud does not matter, as this stud is not used to convey current to the leads either way. The only two rubbing contacts are that between the arm and studs and arm and washer, and, as explained above, the more effective the pressure on the one the more it is on the other. It will be realised that this method of balancing a switch arm can be, if anything, more effectively applied to rotary spindle switches than to those with fixed pivot studs; but, in the latter case, although only part of a fixed stud is shown, this can be of a similar form to that shown in Fig. 1. The idea does not lend itself readily for application to the type shown in Fig. 3.

Fig. 7 is a section of the fixed studs of the double-pole collector switch, which was illustrated by a photograph described on page 484 of this volume of EXPERIMENTAL WIRELESS. Without going into much detail it may be as well to state that the switch is used to collect in series three out of four 2-volt accumulators, and can be set to vary the series in sequence, 1, 2, 3; 2, 3, 4; 3, 4, 1 and 4, 1, 2. One arm is always on the positive and the other on the negative, and the arms being set at a fixed distance, and maintained so by an ebonite connector, only 6 volts, neither more nor less, can be collected. If the whole battery were mounted in complete series it would, of course, be permanently short-circuited; therefore the series connection is broken between cells 2 and 3, and also between 4 and 1. The two-way turn button switch, shown in detail, Fig. 8, connects either of these two junctions, but, being a cross-over switch, it cannot be set to connect both junctions at once. If the double-pole switch be set on either the series 1, 2, 3 or 2, 3, 4, then the cross-over must be set to the left, but if it be upon either 3, 4, 1 or 4, 1, 2 the junction must be made to the right. Should these not agree, for instance, if the series 3, 4, 1 be set with the junction made to the left, the only ill effect is that cell No. 2 is put alone into circuit the reverse way, which is immediately noticed and corrected. In most straight-forward valve circuits the H.T. negative goes to the L.T. positive, whereas, in some reflex circuits, the H.T. negative goes to the L.T. negative. This switch is arranged so that all the leads-in from batteries are on the underside, hence a terminal is put at the bottom of each fixed stud in order to attach the H.T. negative. There is an independent terminal (not seen in the photo) for the attachment on the underside of the H.T. positive and to lead off on the upper side. All leads-out to the valves, etc., are made at the top, therefore the

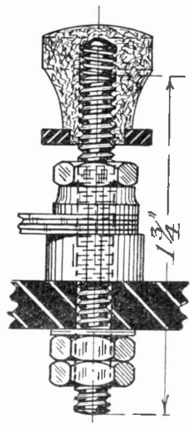


Fig. 7.

fixed studs have to be fitted with terminals at their tops also. Referring to Fig. 7, the stud consists of a $1\frac{3}{4}''$ length of 2 B.A. screwed bar, to which is sweated a $\frac{1}{2}'' \times \frac{1}{4}''$ tapped collar, with its under face 11-16th" up from the bottom. This is lock-nutted to a washer on the underside of panel tightly, the second lock-nut being for attachment of a H.T. lead. Surmounting the collar, and making rubbing contact to it, is the four laminated copper switch-arm

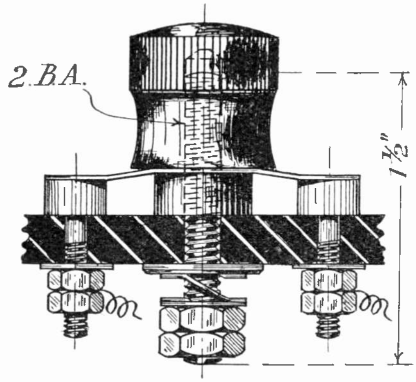


Fig. 8.

holed 2 B.A. clear size. The tension on the arm is effected by a second tapped collar (the base of a 2 B.A. terminal) locked to a lock-nut above. The collar is actually filed flat on each side to take a spanner. The top terminals are made from a pair of knurled " Erinoid " handles, made and sold in the wireless trade attached to H.T. battery plugs. The red one is on the positive stud, and the black on the negative. Both were removed from their pegs, chucked bottom outward in the lathe running true, and drilled up No. 26 drill, or 2 B.A. tapping and tapped that size in a blind hole (*i.e.*, not through the top). They were also, in the same setting, turned down to a shoulder on the outside and fitted with a 9-16th" diameter by 3-22nd" thick ebonite washer, holed 9-32nd", which was tapped on tightly. The washer acts as a hood to protect the joint from accidental short circuiting with the second stud, about $2\frac{1}{2}''$ from it. All contacts are made under these insulating terminals. It would be better, however, to put a $\frac{1}{2}''$ diameter by 3-16th" holed brass washer on the top of the nut, as the latter does not offer a very good terminal face for the wires.

The turn-button switch (Fig. 8) consists of a large black tapped " Erinoid " knurled knob, locked tightly down on to a tapped brass collar sweated to a $1\frac{1}{2}''$ length of 2B.A. screwed rod. Between it and the collar is clipped tightly a 1-32nd" thick German silver balanced arm riding upon studs at both ends. It is spring strip, and is set down in the manner shown to bed evenly on the stud faces. The spindle is not a terminal, but is lock-nutted with plain and spring washers between on the underside of panel. The leads are on the studs only. The upper washer on the ebonite is extra large and thick and does not turn with the spindle. The spring washer should be oiled slightly to effect a running joint against this washer. No bush is needed, as the series switches are only seldom operated. The cross-over movement is to 90°, and there is on both sides a black fibre rider screwed to the panel not touching any of the studs. The stops on either side are fibre blocks similarly screwed to the panel. This is an instance of a balanced arm rotary spindle switch.

Fig. 9 shows the method of fitting fibre riders between studs of the main collector

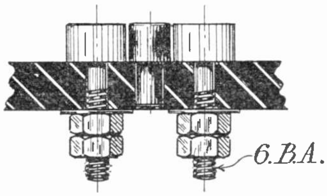


Fig. 9.

switch. The riders are shouldered down and driven into holes in the ebonite midway between studs, but not touching them. The top is a shade above the stud tops, and is rounded on the edges, and as the contact passes from one to the other by its rounded edge it rides up over the fibre and prevents short circuiting neighbouring studs of the collector.

Radio Station G5RZ.

By A. G. WOOD.

SO much has been said about successful trans-Atlantic transmitters that perhaps a few words about unsuccessful ones might be of interest. Possibly the more serious experimenter may be annoyed at the levity with which the subject is treated, but unless the humorous side of a breakdown at 3 a.m. on a cold morning is seen the results to the mental systems of the operators involved are liable to be extremely detrimental.

Somewhere about April 1—a suitable date for its inception—we decided to combine for the next autumn trans-Atlantic tests. It was realised that the strain of continual sitting up, combined with the drain on one's finances for the replacement of transmitting valves, were likely to prove too much for one person.

The details were finally worked out at Shoreham during an early holiday while gathering inspiration listening to 2LO on a single-valve Armstrong. On completion of the holidays there was a temporary hold-up experienced owing to financial straits. This, however, rectified itself towards the end of July, when a preliminary application for a high-power permit was passed to the G.P.O. and inquiries instigated regarding suitable valves for the attempt. Both eventually materialised, and preliminary experiments were started to determine as far as possible on low power the most suitable type of circuit to work with the aerial on high power. Alternating current from the company's mains was available at a pressure of 220 volts 50 cycles, and it was at first hoped to rectify this and transmit on pure C.W.

Accordingly various methods of rectification were discussed, and a start was made with the synchronous rectifier. The first attempts were extremely crude, consisting of a magneto fed with 4 volts A.C. on the low-tension winding and run into synchronism by a small D.C. motor. The only available motor was rather old-fashioned, taking about 6 amperes at 10 volts on no load, and even with a big step-up gearing the required synchronous speed of 3,000 r.p.m. was scarcely obtainable.

Mounted on the end of the magneto shaft was a metallic pointer revolving between two fixed electrodes. At a pressure of 2,500 volts the arc produced rendered external lighting unnecessary, and, although looking extremely businesslike, was rather inefficient from the direct-current point of view. The construction of a correct commutator was then undertaken; this, while proving very efficient, was found to have a short life, and it was estimated that to transmit test schedules for one week the demand of new commutators would exceed the probable supply even if mass production was resorted to.

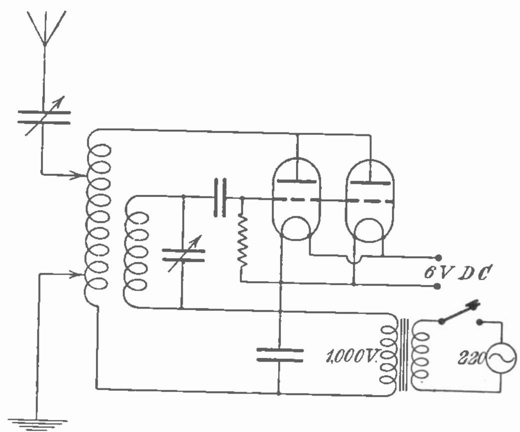


Fig. 1.

Attempts were next made to obtain a high-tension direct-current generator of suitable wattage. This, however, proved unsuccessful. (The only person whom we knew possessed one had seen our earlier attempts at "Sink. Rectification," and was out every time we called!)

A strong discussion then ensued regarding unrectified A.C., and it was decided, after test, that 50 cycles was too low a note to be read at long distances through heavy QRM. The tests that this conclusion was based on were carried out with ex-W.D. "B" valves working at about 1,000 volts anode potential. It was found at this stage that the expenditure curve of the station began to rise in rather a surprising manner. At this anode voltage heavy mechanical vibration was experienced within the valves; and, owing to the use of only one half-cycle, serious low-frequency surges were produced, necessitating the liberal introduction of chokes. Excessive heating was also noticed. A radiation in the neighbourhood of 1 ampere was obtained, and on August 18 tests with Danish 7ZM were undertaken, but, owing to local jamming on either side, communication was not established, although by a later report it would appear that Denmark heard our signals at a strength of approximately R6. The distance was 620 miles. This 50-cycle note spread rather badly, and was apt to prove unpopular with neighbouring amateurs.

It was next decided to use some form of self-rectification circuit, and, procuring a fresh stock of "B" valves, operations were recommenced on August 22, employing the circuit shown in Fig. 2. This circuit is similar to that employed by WNP, the *Bodowin* exploration ship which is at present "iced in" near the North Pole, the only real difference being the frequency of the high-tension input, the latter being about 500 cycles.

From the very first this circuit proved a success, radiation increasing at once with a decrease in input, the whole being much more stable and controllable and the life of the valves being slightly longer. Surges were practically eliminated with the exception of those in the grid circuit, and after the operator had noticed one or two of these by touching the brass part of the key whilst transmitting a relay was constructed.

Except when absolutely impossible, these tests were carried out on an artificial aerial constructed to approximate to the outside aerial system.

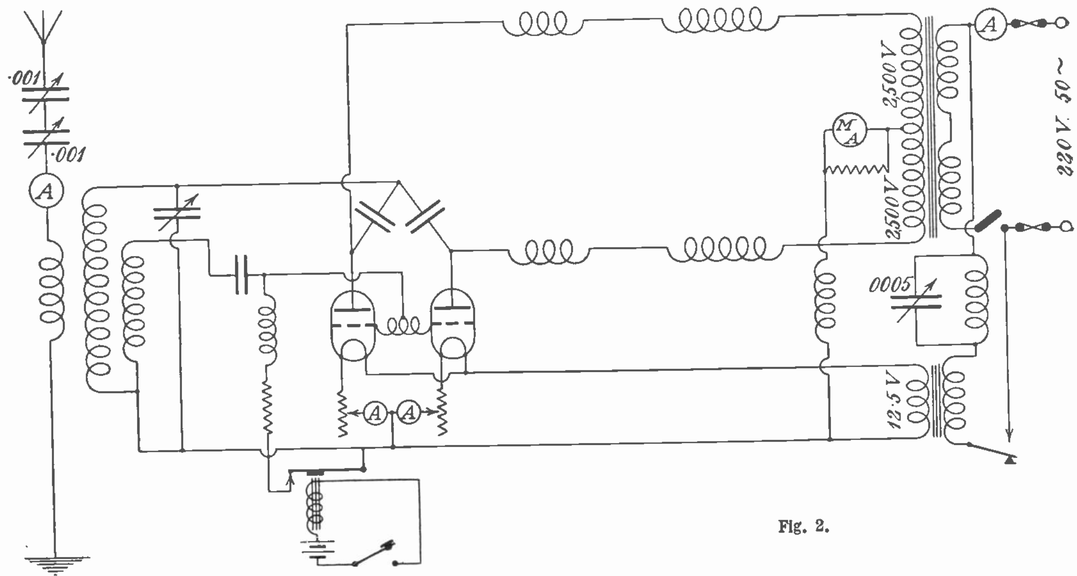


Fig. 2.

During these tests intermittent reception of American signals was going on, resulting in average week-end logs of five stations. Note was made of the more persistently-received stations in order to endeavour to communicate later on in the year. It is of interest to note that at the end of one such sittings at about 6.15 a.m. the aerial gently subsided from no apparent cause. This has always remained a mystery, as there was no wind blowing at the time.

Looking back on our logs, it was decided that the standard of reception was not sufficiently reliable, although in the light of future experience this was probably more due to weather conditions than to the receiver.

However, some thorough groundwork was put in on the receiver, twisted wires becoming soldered joints and stray capacities being reduced to a minimum, which resulted in better efficiency all round.

From then on until November 15 alternate week-ends were spent in listening-in and

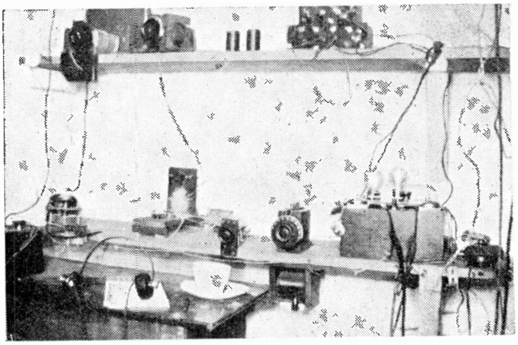


Fig. 3.

re-erecting the aerial, which, owing to an eight-wire twin cage system and the small available base line for guys, showed a disconcerting tendency to subside during any unusually high winds. Finally, a fairly sound job was made of it, resulting in an aerial about 70 ft. high one end and 65 ft. the other.

On November 15 the two 0/250C Mullard valves arrived, and with the G.P.O. permit already obtained serious work was started. The station was completely ready for the new valves, and as it remained practically constant throughout the tests some idea of the general lay-out may be obtained from the photographs.

Fig. 3 shows a general view of the three-valve receiver. This consisted of one H.F. valve rectifier and one L.F., with provision for two L.F. (Note the cup of tea, which was heartily appreciated at the time that these photos were taken—between 3 a.m. and 5 a.m.)

Fig. 4 shows the transmitting helices, the aerial series condenser (in the jam pot), below the helices the two valves, and above the two hot-wire aerial ammeters in parallel. On the extreme right can just be seen the H.T. transformers (shown elsewhere). The filament transformer can be seen in the lower left-hand corner. This was tested when completed on overload of 72 amperes at $12\frac{1}{2}$ volts, and stood this without becoming *very* warm for some considerable time!

Fig. 5 gives another view of the receiver with two operators listening in. (Yet another cup of tea is in evidence here!)

Fig. 6 gives a clearer view of the H.T. transformers. These were connected in series parallel (for centre tap), and gave 2,500-3,000 volts when working. Note the cut-out switch, the series resistance in the input lead and the electro-static voltmeter. The circular object seen in the middle of the photo is one of the low-frequency "surge" chokes.

Fig. 7 shows another view of the transmitter. The coil of lead-covered cable on the extreme right top is the stopping condensers described elsewhere in this article. (Note operator's hat and coat hanging on the door!)

Fig. 8 is a more general view of transmitter, valves, etc.

Almost from the first troubles were experienced in balancing the valves, and it

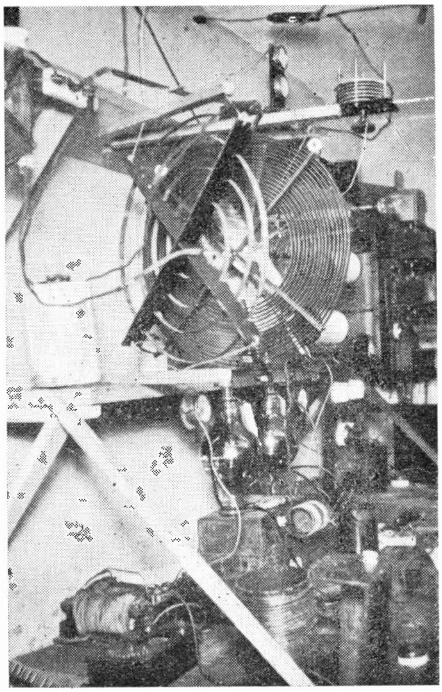


Fig. 4.

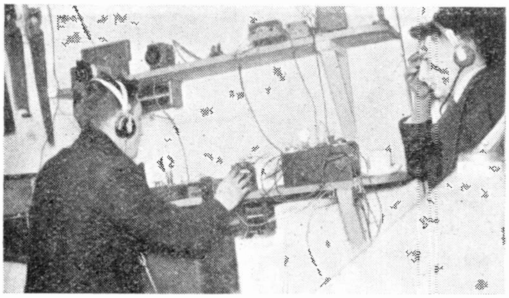


Fig. 5.

was found that one possessed widely different characteristics from the other. Upon communication with the makers they readily agreed to change them, and spent much time and trouble to procure us an exactly similar pair.

In Fig. 7 can be seen the hastily improvised H.T. condenser after a breakdown one morning. This consisted of a short length of twin lead-covered wire, the capacity of each core to lead forming one condenser and the lead the centre point. This was rushed in at five minutes notice and was used

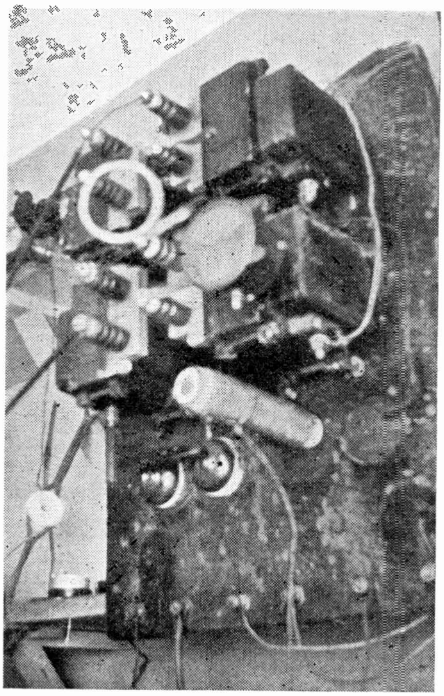


Fig. 6.

for two or three nights whilst fresh condensers were being constructed. Towards the end it was repeatedly breaking down, so that the operator on duty was compelled to keep one hand on his key and the other on the main switch (see Fig. 9). After each breakdown the damaged portion was cut away—if not already blown out—a splice was made and the cable reconnected. Owing to frequent practice the time necessary for this operation was reduced to two minutes, the cable eventually being dissected into 6-in. lengths!

The only satisfactory grid leak proved to be a liquid one. Bicarbonate of soda was

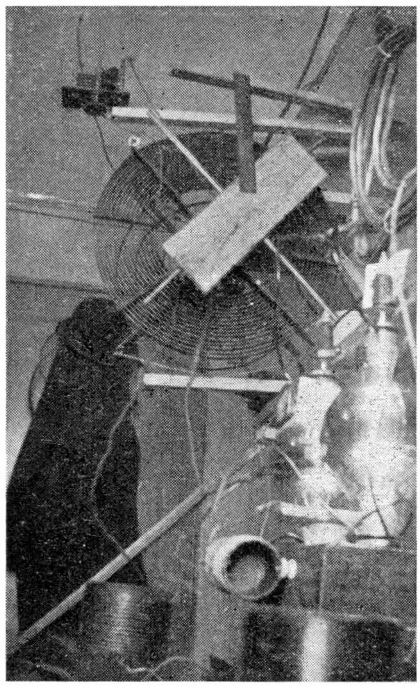


Fig. 7.

added to the water to reduce it to the necessary resistance, but on one occasion, in the early hours of the morning when no soda was available, cold tea proved an efficient substitute!

The value of the grid leak was found to be critical, either side of the correct value producing severe surges. These were finally eliminated by a large grid choke. That this effectively worked was repeatedly shown by the large voltage rises across it being sufficient to break down $\frac{1}{4}$ in. gap in air.

Some various tuning phenomena were experienced. On one setting of the transmitter an increase of the series aerial condenser actually resulted in a decrease in wave-length, and the two aerial condensers that were employed in series both showed a tendency to spark over, while a double-spaced ·0003 microfarad across the anode coil would at times maintain a small arc.

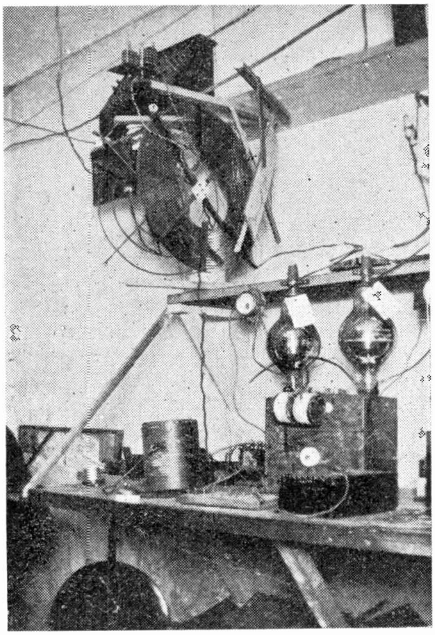


Fig. 8.

Another curious fact was revealed by a long-distance report during some adjustments that at times our signals were unintelligible owing to the fact that there were two distinct wave-lengths on each half-cycle; thus a dot would be transmitted on one, whilst the following symbol occurring on the opposite half-cycle would be on a different wave-length. Owing to their closeness this was not noticeable in the wave-meter, nor for that matter even at a distance of 200 miles, but with the increase in distance and the resultant reduction in signal strength only one wave-length at a time could be tuned in. At the conclusion of the R.S.G.B. tests, and in the absence of definite reports from the other side, it was decided to drop to a wave-length lower than 160 metres, as successful reception both of KDKA and many American amateurs had been carried on for some time with complete absence of QSS and QRM. No trouble was experienced in getting the transmitter down to this wave-length with the exception of the hot-wire ammeters proving useless owing to the effect of the capacity of the terminals to the case at this high frequency. Other methods to measure the radiation were therefore adopted. These consisted of a single turn of wire looped over the aerial lead-in and at least 3 ins. clear from it. This loop was connected in series with a permanently set crystal and a Weston galvanometer heavily shunted. The latter was calibrated against the hot-wire ammeters on the longer wave-lengths and the calibration assumed constant for the shorter wave-lengths. While the reading would not be very accurate, this at any rate provided a comparison for different adjustments.

Although apparently unsuccessful in our endeavours, much interesting experience has been gained from the tests, and we look forward to better luck next year. In conclusion we would like to tender our best thanks to the Mullard Radio Valve Co., Ltd., for their kindness in the loan of the valves and the great trouble they took to provide two that were exactly matched.

The valves worked admirably throughout the tests, and gave us no cause for any anxiety, comfortably handling their full rated load.

Some Experiments with Electrolytic Rectifiers at High Periodicities.

Little is known about the action of the electrolytic valve except on the usual commercial frequencies. The following notes may be of interest to experimenters who desire to utilise sources of higher periodicity for H.T. supply.

THE opinion is prevalent that the aluminium rectifier will not work with any practical degree of efficiency at frequencies much in excess of 100 cycles per second. This is either definitely stated or implied in most of the available literature on the subject, and the present writer is also guilty of making such an assumption in an earlier issue of this journal.* Indeed, if an ordinary rectifier designed for 50 cycles is connected straight to a 500-cycle supply, it

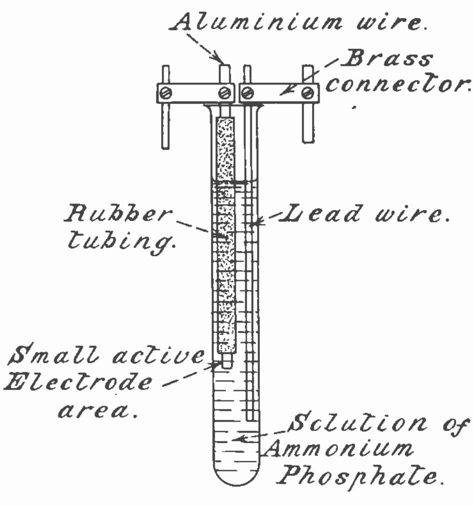


Fig. 1.—Details of a Rectifier Cell Designed to Rectify Small Currents at 500 Cycles.

is found in most cases to act as a short circuit, taking a large current from the supply and yielding no appreciable rectified output. Such hasty tests have probably been responsible in some degree for the existing conceptions of the frequency limits of the electrolytic valve. We have been making some tests lately, however, in the EXPERIMENTAL WIRELESS Laboratory over a wide range of frequencies, and have obtained some interesting and encouraging results.

That the efficiency of an electrolytic rectifier must fall off as the frequency is raised is, of necessity, the case, for at least two reasons. In the first place, given an aluminium electrode of fixed dimensions, a certain amount of work must be done in alternately forming and removing the insulating film on the aluminium surface; this represents a certain amount of electrolytic action determined by the thickness of the film and the area to be covered, and the electrical energy used in effecting this electrolysis constitutes an unavoidable loss. The more times per second the film has to be formed and destroyed, the greater will be this loss. It will, in fact, be directly proportional to the frequency if other things are kept constant. We have also to consider the fact that the film must take a certain time to form during one half of each cycle sufficiently to stop inverse currents and clear away in the other half of each cycle sufficiently not to constitute an undue resistance. The time available for these changes to take place obviously decreases as the frequency is raised, so that with comparatively high frequencies, such as 500 cycles, a large proportion of leakage current to rectified output is to be expected.

A third and rather different effect which comes into play is the condenser action of an aluminium electrode when polarised. The insulating film which forms on an aluminium electrode when it is made positive with respect to the solution is so thin that the aluminium and surrounding solution act as a condenser of quite large capacity. With an area of only a square inch or so of aluminium, a capacity of over a microfarad may quite easily be obtained. The effect of this capacity in even a 50-cycle rectifier is quite appreciable; it has a marked effect on the power factor of

* Vol. I, No. 3.

the A.C. input circuit, and gives rise to capacity currents through the rectifier cell, which are distinct from and additional to any leakage or polarising current. Since the reactance of a condenser is given by $\frac{1}{2\pi f C}$, where f is the frequency and C the capacity, it follows that an aluminium electrode of given size has a much greater capacity by-pass effect on higher frequencies. At frequencies of about 500 cycles, this capacity effect plays an important part, while at 10,000 cycles it is one of the most important problems to be dealt with. Owing to resonance phenomena between the capacity of the rectifier and the inductance of the H.T. transformer windings, all sorts of unexpected things may occur.

A few simple experiments were made to examine the rectifying action of an aluminium electrode in a solution of ammonium phosphate at frequencies of 500 and 10,000 respectively. The 500-cycle supply was derived from a small Newton alternator, while the 10,000 supply was generated by a low-power laboratory arc working off the 200-volt D.C. mains. From the considerations stated above, it was evident that the surface of immersed aluminium must be kept very small in comparison with the current to be handled if any appreciable fraction of the total power expended is going to appear as useful rectified output. When, for instance, the input terminals of the 50-cycle H.T. rectifier shown in the December issue of EXPERIMENTAL WIRELESS (Vol. 1, No. 3, p. 155) were connected across the 500-cycle supply transformed up to 800 volts, a heavy load on the supply resulted, but practically no D.C. could be drawn from the output terminals, although the rectifier was in excellent working condition for 50 cycles. Next, some special cells were made up, having aluminium electrodes consisting of strip only, three millimetres wide, and dipping a centimetre below the surface of the electrolyte. Quite an appreciable amount of rectification took place, and for an A.C. input to the rectifier of 100 milliamperes, about 50 milliamperes of D.C. output was obtained.

The arrangement of having small aluminium electrodes dipping just below the surface of the solution has, however, practical disadvantages. In the first place, owing to the high current density, there is a good deal of local heating up of the electrolyte immediately around the electrode, and as the heated liquid always rises to the surface, the aluminium is surrounded by hot liquid, where it enters and the rectifying action is destroyed Once rectification ceases, the heating effect becomes worse ; in fact, the heating up of a rectifier is cumulative. Another disadvantage of the local heating is that the aluminium is rapidly corroded where it enters the solution. A third disadvantage, and an important one, is that owing to surface tension, the solution creeps up the electrode to a height considerably above the surface level, thus increasing

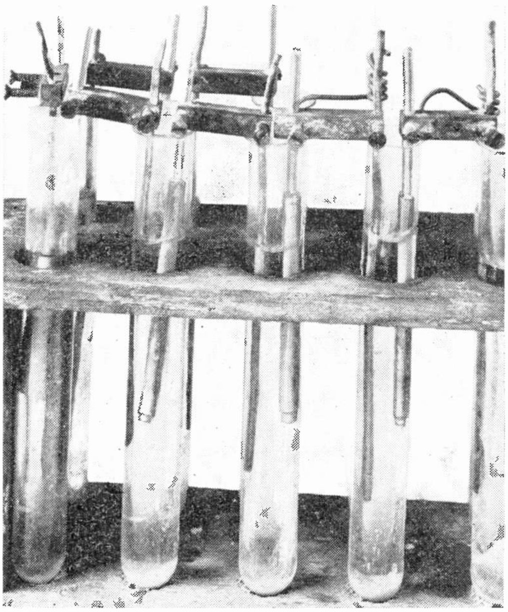


Fig. 2.—Close View of a few Cells of the 500 Cycle Rectifier. Note the Small Aluminium Electrode Area.

the effective electrode area, and probably making it too large.

Next an attempt was made to construct a high-tension rectifier, making use of the experience already gained, which would be capable of supplying about 30 milliamps. of D.C. at a few hundred volts to the anode of a small transmitting valve.

The following points had to be complied with :

(1) The smallest possible surface of alu-

minium in contact with the solution consistent with sufficient D.C. output.

(2) No aluminium in contact with the solution at the surface.

(3) The active part of the aluminium to be sufficiently low down in the solution to be kept cool by convection.

Accordingly, a bank of cells was made up, having electrodes as in Fig. 1. The aluminium electrodes were straight lengths of No. 12 gauge aluminium wire sheathed with rubber tubing, such as is used in bicycle tyre valves. Owing to the necessity of the tubing being a tight fit, some difficulty was at first experienced in drawing it on to the aluminium wire without damaging the tubing. This difficulty was overcome by wetting the lengths of rubber tubing with paraffin oil just before putting them on to the aluminium; this made them go on quite easily. The rubber tubing must extend from at least 1·5 centimetres above the surface of the solution to within three or four millimetres of the lower end of the aluminium wire, thus confining the active portion of the electrode to an area of about 0·2 sq. cm. below the surface of the solution. The other electrode, shown in Fig. 1, is a piece of thick lead wire. A solution of ammonium phosphate was used as electrolyte during the experiments. A close-up photograph of one cell is shown in Fig. 2, and the general assembly of 24 cells is shown in Fig. 3. The usual Gratz or bridge connections were used, there being four groups of six cells, giving full-cycle rectification. The rectifier was only designed to give about 20 watts maximum output.

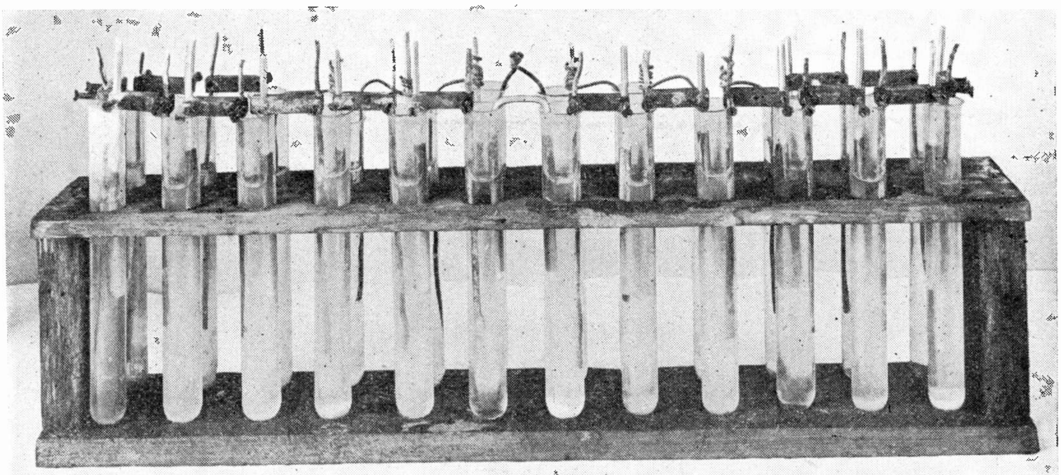


Fig. 3.—General View of Rectifier.

This rectifier was tested on alternating voltages up to 400 volts. It was first formed upon a 50-cycle supply to make sure that it was at least in good working condition for this frequency, and then the 500-cycle input was applied from a step-up transformer specially designed for this frequency. With an applied voltage of 300 R.M.S., results were quite encouraging. While no D.C. load was being taken from the output, the load on the input was about 5 watts, but when the D.C. output was short-circuited, the load on the input went up to about 30 watts. This does not, of course, imply a rectification efficiency of 75 per cent., or anything like it, but it does show that the rectifier was quite appreciably efficient on 500 cycles. In spite of what might be considered the absurdly small electrode area of the aluminium, the rectifier would pass 100 milliamps. quite readily on about 400 volts, and the indications were that small electrodes do not occasion such large resistance losses as would at first be expected. The polarizing or "no-load" currents were undoubtedly greater on 500 cycles than on 50 cycles. Also, when, say, a valve oscillator was being applied from the D.C. output, the voltage drop across the rectifier itself was greater on 500 cycles. Nevertheless, we did supply a valve oscillator quite satisfactorily, and, needless to say, the smoothing proved very easy at this periodicity. With two 1 mf. condensers and a small iron-cored choke, there was no trace of hum in the C.W. produced; undoubtedly the smoothing could have been effected with much smaller condensers.

The same rectifier was next tested on the 10,000 cycle supply—more as a practical joke than practical politics. The arc circuits are shown in Fig. 4. The H.T. transformer was air-cored, the primary forming the inductance in the arc oscillatory circuit. We were rather surprised to find that rectification most decidedly took place with a certain rather low efficiency, which might conceivably find certain practical applications. With an alternating input of 100 milliamps., a D.C. output of 20-30 milliamps. was easily obtained, but at what pressure this was delivered was not ascertained accurately. The arrangements for supplying the 10,000 cycle current were very rough and ready, and conditions were such as not to permit the usual simple calculation of voltage from the transformer ratio. Under certain circumstances it was even found that the load on the input went down when the D.C. output was short-circuited; this is one of the unexpected things previously referred to which arise from the resonance effects, due to the condenser action of the rectifier. The rectifier had been built more with the idea of rectifying 500 cycles than 10,000 cycles, and the fact that there was any rectification at all on the latter frequency is worthy of note. Further experiments with different electrolytes and various designs of electrodes might enable a better rectifier to be obtained for these high frequencies.

A further experiment was made on a frequency of 1,000,000 cycles (300 metres wave-length). One cell constructed as in Fig. 1 was connected in series with a D.C. milliammeter, and an inductance containing one or two turns of wire. This inductance was tightly coupled to a closed-circuit valve oscillator generating about 30 watts on 300 metres wave-length. A D.C. current of one or two milliamperes was registered by the milliammeter in the rectifier circuit, showing that even alternating currents of a million periods are rectified to a slight extent by an electrolytic rectifier. The efficiency is so low that this is now only of academic interest.

Possibly the electrolytic rectifier, even if not an efficient proposition for power work on medium high frequencies, might find a useful application in recording work.

Conclusions.

(1) The electrolytic rectifier is capable of rectifying to a certain extent from the lowest frequencies to a frequency of a million cycles.

(2) The efficiency falls off as the frequency is raised. Useful efficiencies may be obtained up to 500 cycles.

(3) The higher the frequency, the greater must be the working current density at the aluminium electrode. For 500 cycles, this is of the order of 0·25 amps. per sq. cm.

(4) At 500 cycles allow 50-80 volts (R.M.S.) per cell.

The experiments referred to are only of a preliminary nature. We hope to give further details when available.

E. H. R.

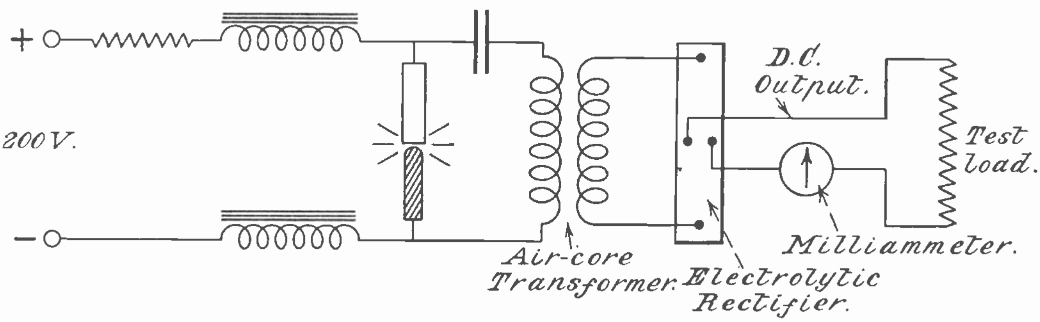


Fig. 4.—Arrangement of Arc Generator for Testing Rectifier on 10,000 Cycles.

Amateur Transmission.

2KW on the Amateur's Position.

The news that amateur communication with countries other than our own is banned has come as a severe shock to the transmitting fraternity in this part of the country. Although we agree that a tightening up of the regulations is, in some cases, necessary, we are of the distinct opinion that the wholesale curtailment is simply the thin end of the wedge. Amateurs have, for a long time, enjoyed comparative freedom from attentions of the Post Office authorities ; now the shock is all the more resented, and it is as sudden as it is complete.

In the past, transmitting permits have been granted to applicants who should not have been in possession of a transmitting permit at all. Now we find that, owing to the tightening up of regulations governing the issue of such permits, many experimenters of undoubted ability are the unhappy sufferers. They are paying for the sins of others. Thus, many are debarred from the experimental field just because they did not apply for a permit sooner ; they may have waited until they considered themselves honestly fit and proper persons to hold a permit. The writer personally knows one of these unfortunates who, after holding the P.M.G. 1st Class Certificate and operating different sets up to five kilowatts power during the war, has been refused a permit for a ten watt set. He has designed a transmitter which, with 0·1 ampere in the aerial, has been heard 1,000 miles away over land. Although this amateur possesses the necessary knowledge in designing, working and operating sets, he is refused the permit, whilst his neighbour is allowed to grind out misused gramophone records by the hour, to the discomfort and distraction of all serious men.

So little is known of the theory of the propagation of wireless waves over the surface of the earth that any quantitative work that can be done by private experimenters would be of the utmost scientific value. Before it is possible for a private individual to carry out such investigation, he must first of all spend some considerable time in getting together the necessary apparatus. He must first set up his gear, and if his spare time is limited, it will be quite a respectable time before he is ready to test the arrangement. When all is ready it will very often be necessary to test the apparatus over a long period ; for if the range to be covered is great, then the gear will have to be made as efficient as possible. All this preliminary work will take time. It will also be necessary for the experimenter to obtain the co-operation of other men in different countries, and the only effective way for him to obtain this vital assistance is by working with them "over the air." Learning their little peculiarities, and gradually finding out that they are, perhaps, interested in the same line of research as he is himself, tests may be fixed up and work begun in earnest.

At the end of a season's work, when we have spent, some of us, considerable sums of money on apparatus—sacrificed no end of sleep—put in practically all our spare hour—we are told that working outside the country is forbidden. After our attempts to enter into a friendly spirit of co-operation with amateur radio men of other nations, we see no immediate prospect of the imposition being removed. Amateur radio is now world-wide in its interests. By its means we are able to converse with a man hundreds of miles away, gradually growing to know him until when we do meet him we feel that we are greeting a very old friend. The International Amateur Radio Union, which was formed in Paris last March, the conference of which the writer had the honour of attending, seeks to bind together the amateurs of the different countries. It can be easily foreseen that if the present restrictions are not greatly moderated, "Great Britain and Northern Ireland"—to use the P.O. phrase, will be virtually debarred from becoming an active member.

With the increasing commercial use of the wave-lengths below the usual band 300-25,000 metres, the position of the private experimenter would seem to be fraught with considerable uncertainty. No one can deny that the permission to use the bands of wave-lengths of 115-130 metres and 150-200 metres is a very liberal concession on the part of the P.O. authorities. At present it seems that everything will go on swimmingly for the next hundred years. One has, however, but to review the recent history of amateur radio in this country to see that the wave-lengths allotted us have been chopped and changed about in a very unsatisfactory manner. At one time we were allowed the free use of all wave-lengths up to 180 metres, because it was generally thought that such high frequencies were of little use for commercial use. Amateur investigation showed that as the frequency was increased, the signal did not fade below waves of 150 metres. What will be the future of the use of wave-lengths below 300 metres, and above all, what will be the future of amateur radio development on these short wave-lengths ? These questions are well worthy of consideration by all who have the future well-being of amateur radio at heart.

Some little time ago Dr. Palmer, of the College of Technology, Manchester, delivered his first address to the Manchester and District Radio Transmitters' Society, as first President of that society. Dr. Palmer chose for his subject, " The Propagation of Electromagnetic Waves over the Earth's Surface." It was well known, the lecturer said, that the speed of a wireless wave depended upon the substance through which it was passing. By a happy stroke of luck, it so happened that the speed of 186,000 miles per second was true for air as well as for a vacuum. It was not true, however, for a substance such as water. Thus, if a wireless wave were passed through water, the speed would be very much less than 186,000 miles per second. From the formula :

$$\lambda = \frac{v}{n}$$

where λ = wavelength, v = velocity, n = frequency

it will be at once seen that if the speed changes, the wave-length of the signal will change as well, the frequency remaining constant. It will be seen that if the wave-length varies according to the nature of the substance through which it is passing, it would be incorrect to use the term " Wave-length " to denote a definite quantity at the receiving end. It would be far more accurate to mention the frequency in cycles, or kilocycles for convenience, than to speak of something that might have any value at any particular moment, as a constant.

The practical operation of sets has gone steadily on during the last three months, though nothing has been done by the writer. He was, however, glad of the opportunity of conversing across the Atlantic with Mr. Marcuse, G2NM, when that transmitter was at C1BQ a couple of months ago. The speech from C1BQ was at times quite clear, and it was not difficult to make out most of what 2NM said. Three stations in this district using powers under ten watts have been heard in the States and Canada during the past winter. They are 5IK, 2IJ and 6NG. 5IK used 220 volts H.T., with about 0·25 ampere in the aerial. Several stations are rebuilding at the present time. The writer would especially like to hear from amateurs in the district with regard to definite transmission experiments which they have performed. Let us have also definite suggestions for schedule tests—and remembering that we hold our permits for experimental work—let us use them to that end, and all will be well.

Experiments by 2TO.

One is constantly hearing of the ever-increasing use of short waves for amateur communication, and the favourite for Trans-atlantics now seems to be 110 and thereabouts. We have read of FL sending across short distances with a wave of about three metres, but has anybody descended below the 100-metre band to explore the region ? Again, our old frield FL is sending test transmissions on 25 metres in an endeavour to get across to the States. So far as amateurs are concerned, no real attempt has been made to go much lower than 100 metres. 2TO, therefore, thought some good might come from forcing a Hartley single coil radiator designed after Ballantyne down. A few details may be useful before describing results. A four-wire flat top 60 ft. long was used, with an extra 25 ft. twin down lead. Earth was obtained by means of a buried plate and the water mains. The helix consisted of 42 turns on a four-inch side square former. After a few preliminary adjustments, a short test message was sent, and the wave-length was found to be 100 metres. Whilst the radiation was only ·3 of an ampere, a report was received from 1NA in Finland that the transmission was heard at R6 on two valves. A series condenser was then inserted in the aerial lead, having a capacity of ·0005 and immersed in transformer oil. With four turns of inductance and only 20° of series condenser, a radiation of ·35 was obtained, and a test elucidated the fact that the wave-length in use was 77 metres. In confirmation of this, a card is to hand from 1CF, situated at Créfeld, reporting the test received at R7 with two valves. A further test was made, using a single ¾-in. strip counterpoise instead of earth, the radiation jumping to ·42 amp., but a test on this arrangement seemed to be below the general run of wavemeters and receivers, for 2TO could not be located by the station keeping observation, neither were any reports received. Without doubt, the radiation was less than would have obtained if a better hot wire ammeter were in use. The type actually used is the ex W.D. variety, and has a resistance, when cold, of 4·5 ohms. This, of course, represents a high loss when operating at the wave-lengths mentioned.

It would, therefore, seem that, although so much attention is being devoted to the 100-metre band, quite a huge field of experimentation is available, and is only waiting exploitation by some of our interested enthusiasts. Unless we (the transmitters) stake our claim, we can rest assured the commercial gang will annex it.

The Trend of Invention.

Loud-Speaker Diaphragms.

The idea of making a telephone diaphragm vibrate as a whole instead of confining it at its periphery is not in itself new. The Brown A type receiver, with its reed and conical aluminium diaphragm, will be familiar to most of our readers. The reason for the conical shape is that it gives the diaphragm rigidity, even though it may be made of very thin material, so that it vibrates as a whole instead of only bowing slightly at the middle. Our Fig. 1 this month illustrates a recently-patented development of the same basic idea. Two cones, A and B, made of suitable light material, are united at their bases and supported from a ring F attached at the base of the apparatus. This support is effected by means of light, flexible members, E, between the circumference of the diaphragm and the ring F, the supporting members E being of such material as not to transmit vibrations to or from the diaphragm. The diaphragm is excited at the apex of one of the cones, which is connected by a link G to an aperiodic telephone movement C, supported from the main frame by a bracket D. The movement C may be of the Baldwin type. The device requires no horn, and it is stated that it reproduces sounds over the entire audible range without resonance or interference. (British Patent 216,946, Western Electric Co., Ltd.).

Another similar patent is illustrated in Fig. 2 (British Patent 197,958, Société Française Radio-Electrique). This patent deals specifically with the means of support of the diaphragm rather than with the actual form of the diaphragm itself. The diaphragm A is supported from a frame D by a large number of radial elastic bands B, stretched between points round the periphery of the diaphragm, and corresponding points on the frame. It is stated in the specification that it has already been proposed to support a diaphragm at two or three points, but this causes uneven stressing of the diaphragm. By having a large number of points of support, as in Fig. 2, the diaphragm is evenly stressed while still being capable of moving freely as a whole. A variety of means of attaching the rubber bands to the diaphragm and the frame may be adopted without departing from the scope of the invention.

Interaction between High-Frequency and Low-Frequency Components in Dual Amplification Circuits.

In spite of the present transient vogue for dual or "reflex" circuits, very few people seem to give any consideration to what actually occurs, or is likely to occur, when high-frequency and low-frequency inputs are simultaneously applied to the same amplifying valve. The prevalent idea appears to be that the valve first magnifies the H.F. energy in the usual way, and then, after rectification, the L.F. currents may be passed back to the input of the same valve and amplified just as if there were no H.F. component to be dealt with. This would be true in the case of a valve with a long, straight characteristic operated by very weak signals. These conditions do not obtain, however, in practice, as the signals dealt with are not particularly weak, and the characteristic of the valve is not straight at the operating point. The result is that the

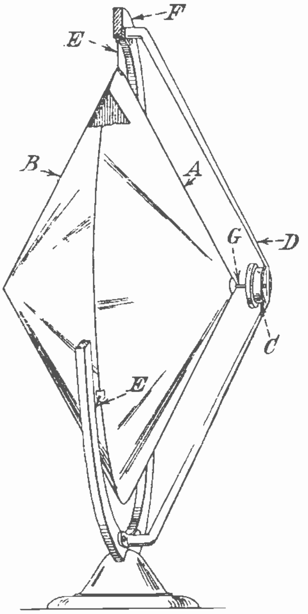


Fig. 1.

H.F. component is modulated by the "reflexed" L.F. component in a manner similar to the action of a grid-control transmitter. this tends to produce a certain amount of low-frequency reaction with attendant inefficiency and tendency to distortion and howling. In a recent patent, however, this effect has been taken into consideration and even turned to good account (British Patent 217,409, P.G.A. H. Voigt). The invention is best explained with reference to Fig. 3. An ordinary one-valve dual circuit is shown. In addition to the ordinary grid potentiometer, some extra grid biassing cells B are introduced so as to give the grid G a negative potential sufficiently to make the valve operate well down on the lower bend of its characteristic. This normally reduces the efficiency, but the low frequency potentials derived from the L.F. transformer take the operating point alternately up and down the characteristic curve, thus varying the amplification of the H.F. signal currents accordingly. This

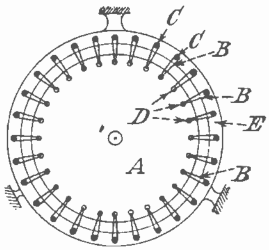


Fig. 2.

variation of the amplified H.F. output causes a variation in the detected currents and in the L.F. potentials produced across the secondary of the L.F. transformer. In fact, the effect is cumulative, and is, in fact, a species of low-frequency reaction taking place through the medium of high-frequency oscillations. The inventor adjusts his grid bias to suit the particular signal strength being received, and obtains sufficient audio-frequency reaction to effect an overall increase in signal strength. The circuit may be particularly adapted to be unresponsive to weak signals, but to respond to signals greater than a certain strength. The specifi-

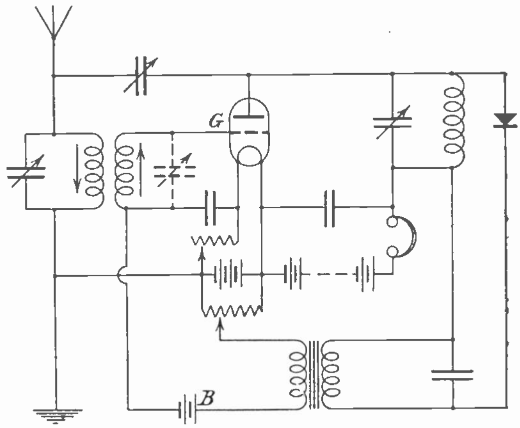


Fig. 3.

cation describes other modifications of this circuit which embody the same principles.

"Soft" High-Power Electronic Discharge Tubes.

The standard practice in thermionic devices has hitherto been either to pump them dead hard, so as to eliminate all but purely electronic conduction, or to allow the presence of sufficient gas to give rise to an arc-like discharge (as in the Tungar tubes and S-tubes). A kind of compromise between these two cases has been patented by the British Thomson-Houston Co., Ltd. (British Patent 216,562). The discharge tube has the usual incandescent electron-emitting cathode which may be thoriated to increase the emissivity. Just enough residual gas may be left to allow a certain amount of ionisation by collision. The positive ions thus formed serve to neutralise the space-charge between anode and cathode, thereby greatly reducing the unwanted potential drop in the device; this reduction of space-charge by ionisation is the main feature of the invention. Certain precautions, however, have to be taken to prevent arcing over by undue ionisation. The residual gas may be argon under a pressure of 20 to 100 microns. Fig. 4

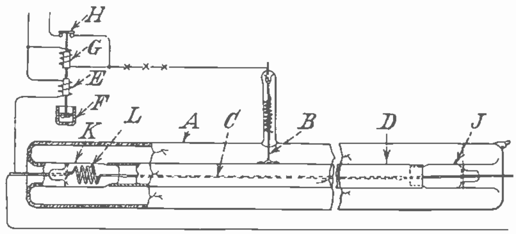


Fig. 4.

shows how the tube may be constructed. The chief point to note is that the cylindrical anode D completely encloses the filament C, and is closed at its ends by insulating re-entrant closures L which may be extensions of the pinches J and K. The electron path is thereby prevented from extending to an undue length at the ends, and producing too much ionisation by collision.

Business Brevities.

Messrs. Burndept, Ltd., realising the possibilities of a great future in the wireless industry in Australasia, have established a branch to be known as Burndept of Australasia, with their head office at 219, Elizabeth Street, Sydney, New South Wales.

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EDISON-BELL PRODUCTS.

Messrs. J. E. Hough, Ltd., have asked us to announce that in our reference to their moulded ebonite products in our June issue we referred to them as being moulded from Ebonite. This, however, is incorrect, as the material used is Eboneum, their own proprietary material.

* * *

IGRANIC ELECTRIC CO., LTD.

A press visit has recently taken place at the Bedford works of Messrs. Igranic Electric Co., Ltd., when the various processes in the manufacture of the well-known Igranic components were a subject of considerable interest to those present. The manufacture, in particular, of Igranic duolateral coils and intervalve transformers is accomplished with the aid of extremely complicated machinery, which is responsible in no small degree for the excellence of the finished articles, although, of course, Igranic components as we know them to-day are the outcome of considerable experiment and research on the part of the technical staff.

* * *

LE CARBONE BATTERIES.

We have received for test an A.D. high-tension battery which has recently been placed on the market by Le Carbone, of Coventry House, South Place, London, E.C.2.. The A.D. cell is somewhat similar to the ordinary Leclanché dry battery, but the chief difference lies in the depolariser, which is not manganese dioxide, but merely air. The cells in the battery submitted are of liberal dimensions, and are capable of withstanding a heavy discharge for a considerable time. It is interesting to note that the terminal voltage was found to be slightly above the rated value, and this did not tend to fall after a long period on load. It was also found that the cell was extremely stable in operation, there being no tendency to crackle or hiss. These features should make it particularly valuable for use on power amplifiers.

POLAR WIRELESS.

Messrs. Radio Communication Co., Ltd., of 34-35, Norfolk Street, London, W.C.2, have just issued an extremely comprehensive catalogue of their receiving apparatus and accessories. Special mention is made of the "Polar Blok" unit system of construction, which should appeal particularly to the experimenter, as it provides almost unlimited scope for the arrangement of circuits. Another particularly interesting feature is a series of special Polar components such as valve fuses, triple condensers, micrometer condensers, universal and cam-vernier coil holders. Altogether, it is one of the most interesting catalogues we have seen for some time, and our readers would do well to acquire a copy, which will be sent post free for the sum of sixpence.

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.

KDKA, THE RADIO TELEPHONE BROADCASTING STATION OF THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, EAST PITTSBURGH, PENNSYLVANIA.—D. C. Little. (*Proc. I.R.E.*, 12, 3).

THE DESIGN OF TRANSMITTING VALVES—I.—G. L. Morrow (*Exp. W.*, 1, 10).

STOPPING THE KEY-THUMP.—James H. Turnbull (*Q.S.T.*, 7, 10).

II.—RECEPTION.

TELEPHONE DIAPHRAGM RESONANCES.—Prof. E. Mallet, M.Sc. (*W. World*, 253 and 254).

COLLOIDS, THEIR USE IN DETECTORS AND AMPLIFIERS. (*W. World*, 254).

UN NOUVEAU RADIOGONIOMÉTRE AVEC LEVÉE DU DOUTE.—El Bellini. (*L'Onde Elec.*, 29).

L'INFLUENCE DU BROUILLAGE SUR LES RÉCEPTEURS À REACTION.—L. Brillouin and E. Fromy (*L'Onde. Elec.*, 29 and 30).

ÉTUDE EXPÉRIMENTALE DE QUELQUES PROCÉDÉS DE DÉTECTION DES OSCILLATIONS DE HAUTE FRÉQUENCE.—M. Raymond Dubois (*L'Onde Elec.*, 30).

ALIMENTATION DES RÉCEPTEURS RADIOPHONIQUES PAR LE COURANT ALTERNATIF DU SECTEUR.—M. Podliasky (*L'Onde Elec.*, 30).

LA RÉCEPTION DES ONDES DE 50 À 200 MÉTRES (*R. Elec.*, 5, 62).

ON OPTIMUM HETERODYNE RECEPTION.—E. V. Appleton and Mary Taylor (*Proc. I.R.E.*, 12, 3).

THE SCREENING OF RADIO RECEIVING APPARATUS.—R. H. Barfield, M.Sc. (*Exp. W.*, 1, 10).

BUILDING SUPERHETERODYNES THAT WORK.—Part II (*Q.S.T.*, 7, 12).

III.—MEASUREMENT AND CALIBRATION.

RECEIVING MEASUREMENTS AND ATMOSPHERIC DISTURBANCES AT THE BUREAU OF STANDARDS, WASHINGTON, DECEMBER AND NOVEMBER, 1923.—L. W. Austin (*Proc. I.R.E.*, 12, 3).

ON THE MEASUREMENT OF VERY SMALL CAPACITY CHANGES.—Ross Gunn, B.S.E.E., M.S. (*Phil. Mag.*, 283).

A UNIVERSAL METER.—H. E. Dyson (*Exp. W.*, 1, 10).

A HANDY CALIBRATED OSCILLATOR.—N. J. Buckeye (*Q.S.T.*, 7, 10).

IV.—THEORY AND CALCULATION.

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

REGENERATION IN COUPLED CIRCUITS.—E. Leon Chaffee (*Proc. I.R.E.*, 12, 3).

V.—GENERAL.

CONDENSERS: RADIO FREQUENCY AND THE DESIGN OF AN EFFICIENT CONDENSER.—(*W. Age*, 11, 10).

ÉTUDE DE L'EVANOUISSEMENT SUR LES ONDES COURTES.—M. Lardry (*L'Onde Elec.*, 29).

LE PROBLÈME DU VERROUILLAGE EN TÉLÉMÉCANIQUE.—M. Guéritot. (*L'Onde Elec.*, 29).

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

NOUVEAUX ÉTALONS DE LONGUEUR D'ONDE: LES RÉSONATEURS PIÉZOÉLECTRIQUES.—Michel Adam (*R. Elec.*, 5, 62).

ON PROPOGATION PHENOMENA AND DISTURBANCES OF RECEPTION IN RADIO TELEGRAPHY.—F. Kiebitz (*Proc. I.R.E.*, 12, 3).

THE CAPE COD MARINE SYSTEM OF THE RADIO CORPORATION OF AMERICA.—F. H. Kroger (*Proc. I.R.E.*, 12, 3).

SIGNAL-TO-STATIC RATIO IN RADIO TELEPHONY.—Marius Latour (*Proc. I.R.E.*, 12, 3).

DIGESTS OF UNITED STATES PATENTS RELATING TO RADIO TELEGRAPHY AND TELEPHONY, ISSUED MARCH 4, 1924—APRIL 29, 1924.—John B. Brady (*Proc. I.R.E.*, 12, 3).

A NEW PHOTO-ELECTRIC AND IONIZATION EFFECT.—U. A. Oschwald, B.A., and A. G. Tarrant, B.Sc., F.Inst.P. (*Proc. Phys. Soc.*, 36, 3).

NOTES ON SOME ELECTRICAL PROPERTIES OF THE NEON LAMP.—U. A. Oschwald, B.A., and A. G. Tarrant, B.Sc., F.Inst.P. (*Proc. Phys. Soc.*, 36, 3).

ON CERTAIN PROPERTIES OF THE "OSGLIM" NEON-FILLED LAMP.—J. H. Shaxby and J. C. Evans (*Proc. Phys. Soc.*, 36, 3).

THE PREVENTION OF INTERFERENCE BETWEEN "WIRED WIRELESS" CIRCUITS AND WIRELESS STATIONS.—By E. M. D. (*Exp. W.*, 1, 10).
THE PROBLEM OF HIGH-TENSION SUPPLY—II.—R. Mines, B.Sc. (*Exp. W.*, 1, 10).
THE DESIGN AND CONSTRUCTION OF A 50-CYCLE TRANSFORMER FOR PRODUCTION OF HIGH-TENSION VOLTAGES.—L. E. Owen (*Exp. W.*, 1, 10).
A FEW OBSERVATIONS ON THE RECENT AMERICAN RE-RADIATION TESTS.—Ernest W. Braendle (*Exp. W.*, 1, 10).
THE HEAVISIDE LAYER AND HOW IT MAY BE PRODUCED.—O. F. Brown, M.A. (*Exp. W.*, 1, 10).
ON THE INFLUENCE OF INPUT CONNECTIONS UPON THE OPERATION OF TRIODES.—William D. Owen (*Exp. W.*, 1, 10).
VARIABLE CONDENSER CONSTRUCTION.—George Gentry (*Exp. W.*, 1, 10).
CONSTRUCTIONAL NOTES ON LOUD-SPEAKING TELEPHONES.—E. Siméon (*Exp. W.*, 1, 10).
OSCILLATING CRYSTALS.—H. S. Shaw (*Q.S.T.*, 7, 10).

Correspondence.

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

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—May I be allowed to point out a rather bad point in the otherwise good design of a variable condenser by George Gentry in your July issue ?

The spindle is shown as a 2 B.A. rod, and thus the bearings consist of threaded rod in bushes, a detail that does not make for accuracy. The constancy of capacity is to a great extent governed by the fit of the bearings and, by attending to this point, a condenser of laboratory standard could be made from the instructions in the article.—Yours faithfully,

J. L. JEFFREE, F.R.A.
(5FR).

[We showed our correspondent's letter to Mr. Gentry, who replies as follows :—

In reply to Mr. Jeffree's criticism of the fact that the journals of the vane spindle are threads running in plain holes. The fit of these, or rather maintenance of fit, depends to a great extent upon the care taken in producing the threads. If good quality screw dies be used, and accurately applied (that is to say, started truly upon a tapered down point, with care used to see that the original truth of the thread is maintained), there should be little trouble on the score of lack of truth in the spindle. There is no doubt that if the threads were screw-cut on a lathe the bearings could be made to work as smoothly as if plain.

The whole idea of the design is to avoid as far as possible complicated mechanical procedures involving the use of machine tools. The right method, of course, would be to turn a spindle from a $\frac{1}{4}''$ bar, and making the portion corresponding to the space between the bearings—less $\frac{3}{16}''$ at top and bottom—$\frac{1}{4}''$ diameter and threaded each end for the locknuts No. 0 B.A. The remainder top and bottom would then be shouldered down to No. 2 B.A. size and only threaded down and up the required distance for the bottom locknuts and the knob and its locknuts at the top, leaving plain $\frac{3}{16}''$ journals. This would entail drilling the vanes and their spacing washers $\frac{1}{4}''$, and fitting No. 0 B.A. locknuts above and below the vanes. The latter nuts could pass up to their threads over the plain journals because their core size is rather over $\frac{3}{16}''$.

A modification that might appeal to those who can use a soldering outfit would be to sheath the portion of the screwed journals (not the full length) top and bottom, after all vanes, washers, and locknuts between bearings were put on by sweating on a short length of thin brass tube $\frac{3}{16}''$ in the bore and about $\frac{1}{4}''$ or a little larger outside diameter. To fit these—now plain journals—the bushes would have to be opened out preferably by the use of a taper broach first and finishing to size with a $\frac{1}{4}''$ reamer.

Nevertheless, the designer does not anticipate that any marked variation in the matter of capacity would occur in this condenser from this cause if the journals were made truly in the first place and fitted without side shake].

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—With reference to Mr. Clarke's letter in your June issue, might it not be advisable to point out to your readers the advisability of fitting spark gaps between their aerial and earth terminals. I believe that I am correct in saying that whereas at one time the Post Office always earthed their overhead lines during a thunderstorm, they now rely upon lightning arresters and spark gaps only.

On one occasion my aerial was disconnected and sparks were passing very rapidly, and upon disconnecting the gap sparks up to half an inch in length were obtained. A friend, however, who was not so fortunate one day found his curtains alight owing to a similar discharge.

At the time mentioned, and, indeed, almost invariably, these discharges have been observed during a fall of rain or sleet.

It seems to be a general impression that the inclusion of a spark gap leads to inefficiency. This may be so if one of the carbon block type is used, and I have known such a one to effectively prevent short-wave working owing to its capacity, but if two fine steel points are utilised the efficiency does not appear to be impaired at all. All spark gaps should be enclosed.

Another popular fallacy—at least, so I find it—is that all is well if the aerial is earthed during a thunderstorm, or when it is not in use. This is not so, as pointed out by Mr. Clark, but even when the set is connected, and especially if a series condenser is being used, spark discharges can be obtained. In this latter case it is often useful to connect the largest size honeycomb coil in shunt with the main tuning coil and condenser to discharge the aerial.—Yours faithfully,

M. BLIGH.

174, Wightman Road,
Hornsey, N.8.

DEAR SIR,—The correspondence *re* sparks from the aerial has interested me greatly, as it recalled an experience which occurred to me in the summer of 1922. At the time I was using a straight circuit with a series condenser in the aerial lead. The set worked quite well except for a continuous clicking, which was sometimes heard, but for a long time could not be traced. At last it was found to be due to small sparks jumping across the series condenser which were the source of the trouble. The aerial became charged up to a certain potential, and then sparked through the set. Since then, sparks from 1-32 in. to $\frac{1}{8}$ in. have been obtained from rain and sleet. No sparks have ever been obtained from snow.

During the thunderstorm of Monday, May 19, the matter having been recalled by the letter signed "KiloWatt," I lifted the aerial earthing switch and got a fine shower of small sparks from the rain—sufficient to give a weak shock, in fact. The switch was then inadvertently left wide open, and suddenly, as a flash of lightning was seen outside, a fat noisy spark about $1\frac{1}{4}$ ins. long jumped the switch in the room (and I had just been getting shocks from the thing!) Three times this large spark was obtained, each time being due to discharges from cloud to earth. As found later, discharges between clouds themselves do not induce sufficient potentials in the aerial-earth circuit and this seems to have been the experience of Mr. H. A. Clark.—Yours truly,

L. B. COOK.

P.S.—The aerial used in all cases was 55 ft. long, double wire, 9 ft. apart, and about 25 ft. high, rather badly screened.

4, Milton Road.
Bedford.

IN A COAL MINE.

An interesting experiment carried out by the Bristol and District Radio Society. The members are seen in a coal-mine at Midsomer Norton, where they received Morse very strongly, but found speech highly distorted.

Book Review.

THE ELECTROLYTIC RECTIFIER. By N. A. de Bruyne. (Sir Isaac Pitman & Sons, Ltd.). 3s. 6d. net.

This work is a collection of the rather scattered information on electrolytic rectifiers and gives the reader an idea of the work which has been done and the data which has been obtained concerning their action. A brief historical survey is given and numerous references are made to the work of Gunther-Schulze and others on electrolytic valve action. The electrolytic rectifying properties of elements other than aluminium are dealt with, and the effects of temperature and concentration on rectification are discussed with the aid of curves and tables of data. A chapter is devoted to the theory of the action by which anodic rectification takes place, the gas-layer theory being preferred to the older oxide-layer theory. Reasons are given for considering the latter theory untenable and why it is more likely that a thin layer of gas is responsible for non-conduction in the reverse direction. Mention is made of the condenser effect of a rectifier. The last three chapters are of a practical nature, giving details of the construction of charging rectifiers, and the use of electrolytic lightning arresters on power lines is described.

We do not find much to criticise in this book as it is to a large extent a summary of established facts, and a summary does not lend itself to criticism. It is perhaps somewhat brief and we feel that certain portions of the ground—especially those of interest to wireless experimenters—have not been very fully covered. For instance, nothing is said as to the highest periodicity of alternating current at which an electrolytic rectifier will work with sufficient efficiency for practical purposes. Numerous references are given, however, which add to the value of the book. It is well written and the author has evidently taken some pains in collecting his material. As far as we are aware it is the only book dealing exclusively with electrolytic rectifiers and no one seriously interested in the subject can afford to miss reading it.

E. H. R.

Experimental Notes and News.

The Australian Government have entirely altered their regulations governing broadcasting. Hitherto receiving sets were sealed with the particular wavelength allotted to the company to which the purchaser subscribed. The new scheme adopts the principle of the open set, charging a licence fee ranging from 25s. to 30s., according to the radius of the broadcasting station. Two classes of station are authorised, one giving advertising and the other entertainment, the latter receiving revenue licence fees, less 5s. retained by the Government. This scheme limits the number of broadcasting stations in each state. Under the new conditions popular wireless interest in Australia should receive a great impetus.

* * *

It is pleasing to know that the British scheme of broadcasting is very highly thought of by wireless experts from other countries. America in particular envy our freedom from wireless chaos, since they suffer themselves from far too many broadcasting stations. A number of their large stores have stations broadcasting advertisements.

* * *

An extremely up-to-date portable wireless installation is that run by the Belfast-Liverpool Air Line, from Belfast. The aerial is a twin-wire, and there are two portable steel tube masts, one of 50 feet and the other 70 feet. The apparatus is set up in a Leyland motor lorry, and has a 300-watt valve transmitter. In the centre of the floor of the lorry is a petrol-electric generating unit, which supplies power for a motor generator, H.T., and accumulator charging.

* * *

The second exhibition devoted exclusively to the development of wireless, organised by the National Association of Radio Manufacturers, will be held from September 27 to October 8, at the Albert Hall, Kensington.

* * *

On September 22 in Madison Square Garden and the 69th Regiment Armoury, New York, the first Radio World's Fair will be held. It will be run on a very large scale, and among the interesting exhibits will be a section devoted to "New Inventions," where a hundred devices will be shown, including at least three different instruments for transmitting motion photographs by wireless. It is hoped that the first motion pictures will be broadcasted on the opening night of the Fair. There will also be an amateur builders' competition, in connection with which twenty-five prizes are to be awarded. Full particulars may be obtained from James F. Kerr, Hotel Prince George, New York.