THE RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. III MARCH, 1922 No. 3

Editor:
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Editor: Prof. G. W. O. HOWE, D.Sc., M.I.E.E. Asst. Editor: PHILIP R. COURSEY, B.Sc., A.M.I.E.E.

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THE

RADIO REVIEW

VOL. III MARCH, 1922 NO. 3

Editorial.

The "Radio Review."—We regret to have to inform our readers that after this month it will no longer be possible to issue the RADIO REVIEW as a separate publication devoted to the scientific developments of radio communication. The continued excessive cost of printing has rendered necessary this suspension of the publication, in spite of the recently increased subscription rate.

In order, however, to retain in this country a medium for the publication of articles of a technical nature dealing with the developments of radio apparatus, and giving the results of research and experimental work, arrangements have been made for the incorporation in the pages of the *Wireless World* of some of the characteristic features of the RADIO REVIEW. On and after April 1st, the former publication will be issued weekly, and it is intended to devote a few pages of each issue to articles and other matter of the type that has in the past been published in the RADIO REVIEW. It is hoped that as many as possible of our past contributors and readers will avail themselves of these facilities for the publication of articles and other matters of interest to the radio engineer, research worker and student of the technical development of radio communication in its various branches.

The Amateur Licence Problem.—In this and in all other countries the problem of the licensing of the radio amateur is becoming ever more acute. So long as the amateur is content to receive and to employ only such methods as do not radiate any appreciable power, there can be little, if any, objection to an unlimited increase in their number. Experimenting in the reception of radio signals must have considerable educational value and is therefore highly desirable. The construction of apparatus and the reading and discussion of papers at the many wireless societies must do much to disseminate a knowledge of practical physics among thousands who would not otherwise have obtained this knowledge. It will, moreover, guarantee an immediate supply of partially trained operators in case of war, and operators who are keenly interested in their work. Since the possession of radio apparatus, and especially of an antenna, puts it into one's power to transmit electromagnetic waves and cause interference, and also because of the desirability of ensuring some degree of privacy for messages transmitted by wireless, it appears essential that some authority should exercise control by the granting of licences.

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To cover the expense thus involved it is improbable that any amateur would object to the payment of a small fee. At one time, however, the British authorities demanded a fee of three guineas from any clockmaker for the privilege of being allowed to pick up from the ether the time signals sent out from the French or German wireless stations. This demand, which is rather suggestive of Alice in Wonderland, was ultimately withdrawn, and an Englishman with a receiving licence is now at liberty to pick up the time signals which are sent out from Paris, Moscow, and other centres, and to regulate his chronometer with mixed feelings of gratitude and shame by means of this second-hand Greenwich time.

But the amateur, even if he is content to receive, is not yet satisfied ; for some time he has been asking for special signals to be sent out for his benefit. This demand has arisen in consequence of the great improvements in radio-telephony, and the desire to pick up speech and music rather than the prosaic Morse signals. The amateurs have now persuaded the authorities to give their permission for a central transmitting station to send out programmes of music similar to those given out at present from the Hague and from Paris.

There can be no objection to this course so long as no interference is caused with radiotelegraphy and telephony of a more serious character. There is no doubt a much greater fascination in picking up speech and music because of its direct appeal to the senses and of its varied character giving much greater scope to the receiver in gradually improving both its loudness and its quality. It is also a much newer field with greater prospects of discovery and development. Some cynics have suggested, however, that the post-war radio amateur is made of poorer stuff than the type of ten years ago and cannot be bothered to learn the Morse code, but needs to be amused in order to maintain his interest in his hobby, for there is surely no shortage to-day of wireless signals of every description for his delectation. The proceedings at any of the meetings of the various wireless societies are sufficient refutation of this suggestion.

Theoretical and Practical Aspects of Low Voltage Rectifier Design when employing the Three-electrode Vacuum Tube.

By R. D. DUNCAN, Jun.

Chief Engineer, U.S. Signal Corps Research Laboratory, Bureau of Standards.

(Concluded from page 71.)

Percentage Amplitude of " Ripple " Voltage over Load Resistance.—On the assumption that the maximum amplitude of the alternating component of the condenser voltage, which in this case is also the voltage applied to the load resistance, is equal to one-half of the total variation, this quantity is given by

$$\Delta V_{r0} = \frac{\Delta V_c}{2} = (E_0 - V_0)\frac{1-K}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The ratio of equation (11) to (6) is a measure of the percentage fluctuation of the final load voltage. Thus,

$$\mu = \frac{\Delta V_{r0}}{V_{dc}} \times 100 = \frac{1-K}{1+K} \times 100 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

If an inductance is connected in series with the load resistance the voltage given by equation (11) is impressed across both it and the resistance. The resulting maximum current which will flow will be of the form

$$\Delta I_{r0} = \frac{E_0 - V_0}{\sqrt{r^2 + \omega^2 L^2}} \cdot \frac{1-K'}{2} \quad . \quad (13)$$

The voltage developed over the resistance r will then be,

$$\Delta V_{r0} = \frac{r(E_0 - V_0)}{\sqrt{r^2 + \omega^2 L^2}} \cdot \frac{1-K'}{2} \quad . \quad (14)$$

As before the amount of voltage fluctuation is determined from the ratio of equations (14) to (6), *i.e.*,

$$\mu = \frac{\Delta V_{r0}}{V_{dc}} \times 100 = \frac{r}{\sqrt{r^2 + \omega^2 L^2}} \cdot \frac{1-K'}{1+K'} \times 100 \quad . \quad (15)$$

In equations (13), (14) and (15),

$\omega = 2\pi f$ for half-wave rectification,

$\omega = 4\pi f$ for double wave rectification,

where f represents the frequency of the supply voltage.

As noted from equations

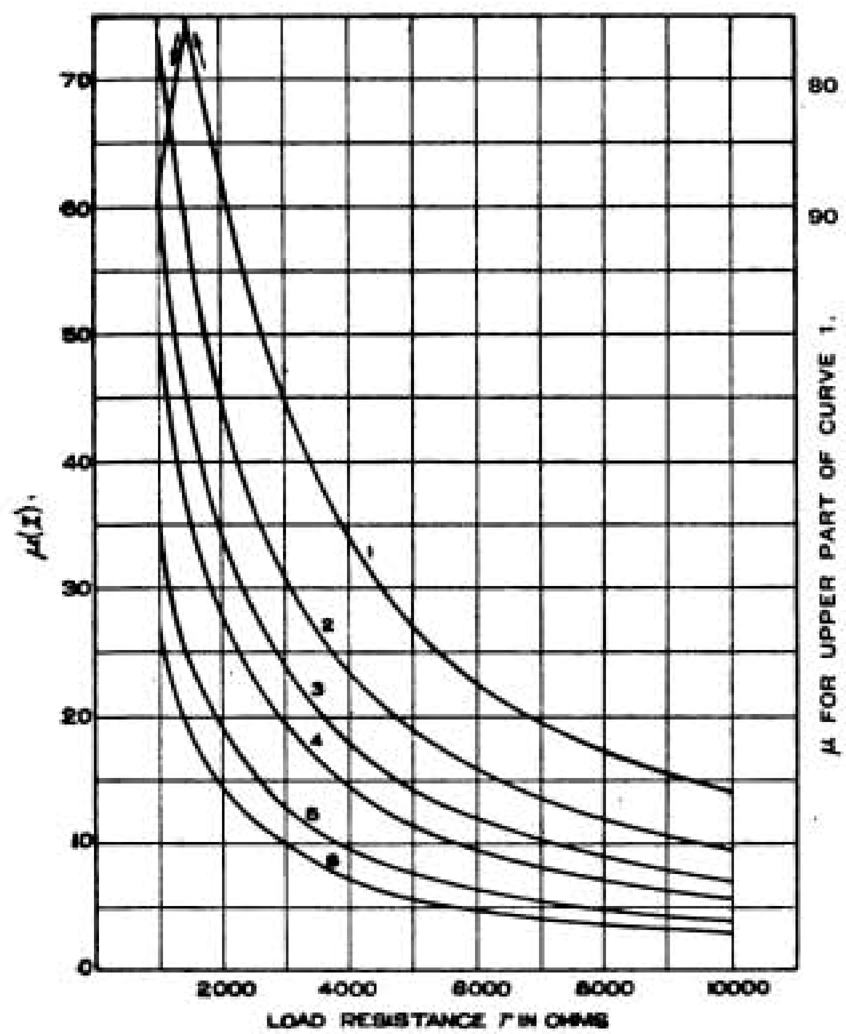

FIG. 6.—HALF-WAVE RECTIFICATION.

Frequency = 60 ~; $t_2 - t_1 = 1/87$ sec.
Inductance $L = 0$.

Curve No.	Capacity C.
1	4 μ F
2	6 μ F
3	8 μ F
4	10 μ F
5	15 μ F
6	20 μ F

(3), (8), (12), and (15) μ, the percentage ripple voltage, is a function of the circuit constants and of K or K', themselves functions of the time interval $t_2 - t_1$ and also of the circuit constants. Values of $t_2 - t_1$ were determined from a large number of oscillograms taken with different circuit conditions; a representative number are shown in Figs. 4 and 5. As a result of this oscillographic study and of transmission and reception tests, it was determined that with values of smoothing condensers and inductances which would give satisfactory telephonic and telegraphic operation as regards suppression of the ripple voltage, the following values of $t_2 - t_1$ are effective:

For 60 cycle operation:

Half-wave rectification, $t_2 - t_1 = 1/87$ second.

Double wave rectification, $t_2 - t_1 = 1/250$ second.

Based on these average values the curves of Figs. 6, 7, 8 and 9 were computed. In Figs. 6 and 7 are plotted values of μ as a function of the circuit constants, for both half-wave and double wave rectification. In Figs. 8 and 9 are plotted values of the factor $\frac{\sqrt{2}}{1+K}$ appearing in equation (7), for the same circuit conditions.

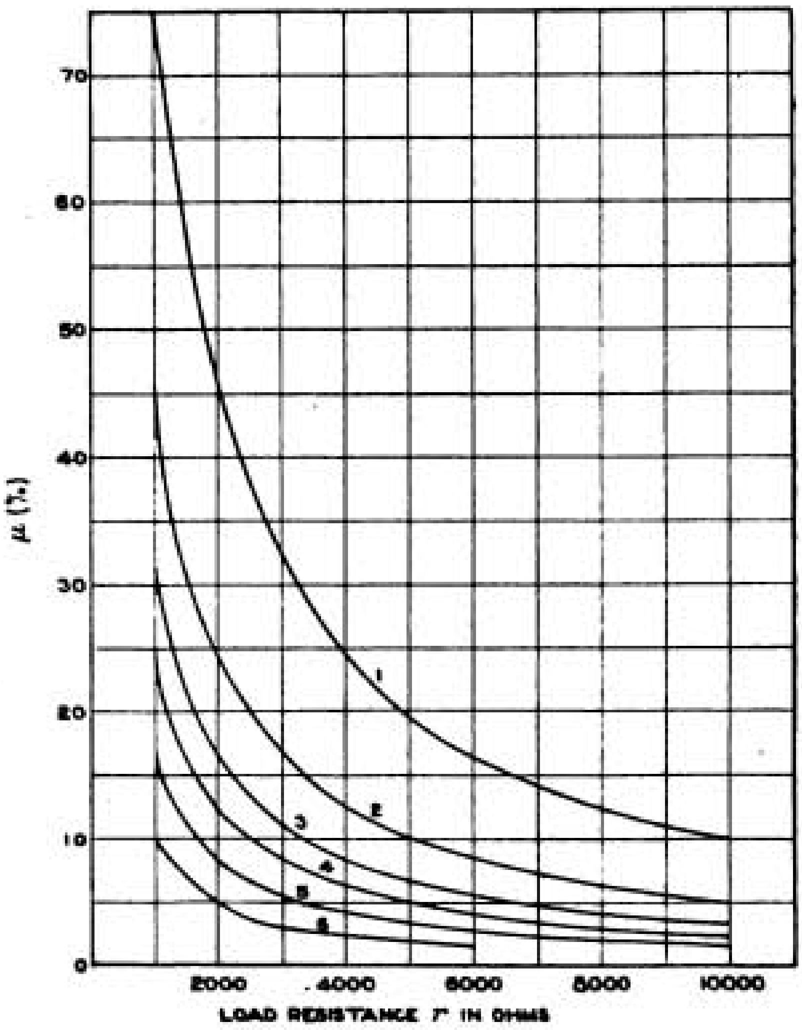

FIG. 7.—DOUBLE-WAVE RECTIFICATION.

Frequency = 60 ~ ; $t_2 - t_1 = 1/250$ sec. Inductance $L = 0$.

Curve No.	Capacity C.
1	2 μ F
2	4 μ F
3	6 μ F
4	8 μ F
5	12 μ F
6	20 μ F

A comparison of the curves shows the marked reduction in the values of μ obtained with double wave rectification as against half-wave rectification. The advantage of employing a large smoothing capacity, particularly for low value load resistances, is also manifest. As illustration, where the frequency is 60 cycles per second, for a resistance of 3,000 ohms, which is a representative value, with a condenser of 4 microfarads, the values of μ as obtained from Figs. 6 and 7 are respectively, for half-wave and double wave rectification, 45 per cent. and 17 per cent. It is interesting to note that with a frequency of 500 cycles per second, these two figures are reduced to 7·5 per cent. and 2·5 per cent. respectively.

In the experimental work it has been found unnecessary to resort to the use of the multi-mesh filter circuit to obtain the desired degree of smoothing of the rectified voltage.

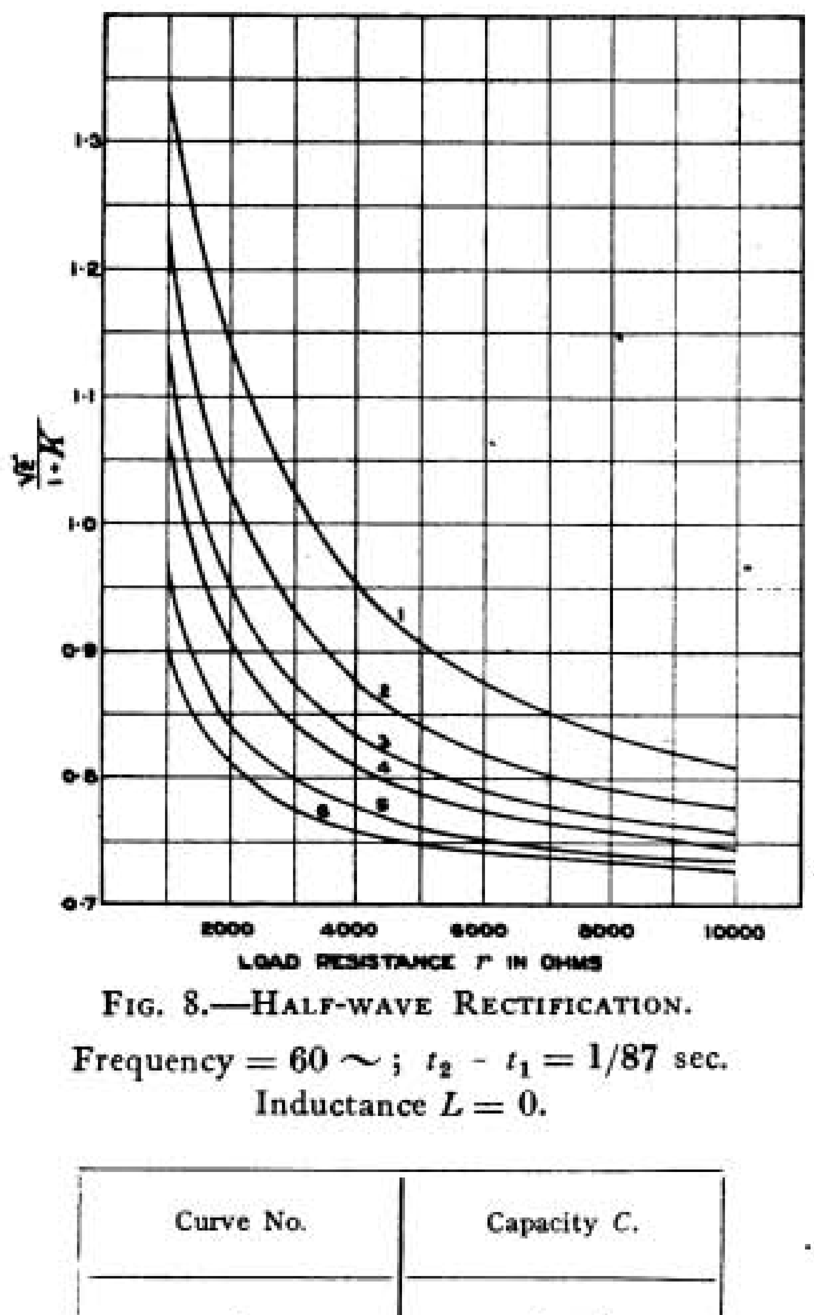

FIG. 8.—HALF-WAVE RECTIFICATION.

Frequency = 60 ∼ ; $t_2 - t_1 = 1/87$ sec.
Inductance $L = 0$.

Curve No.	Capacity C.
1	4 μ F
2	6 μ F
3	8 μ F
4	10 μ F
5	15 μ F
6	20 μ F

The factor $\frac{\sqrt{2}}{1+K}$ which appears in equation (9) and which is plotted in Figs. 8 and 9, when proper account is taken of maximum voltage drop in the rectifier tube, determines the value of the effective transformer secondary voltage, in terms of the average rectified voltage. From the curves it is observed that with increasing capacity and resistance values, the lower is this effective voltage required for a given rectified voltage. The limit to this of course is the physical size which the large value condenser will assume and the fact that the magnitude of the resistance is determined by the load characteristics and in general may not be varied at will.

Determination of the Voltage Consumed by the Rectifier Tube.—The voltage consumed within the rectifier tube, *maximum* value V_0, has been determined experimentally by means of the oscillograph, calibrated in terms of voltage, as previously explained. Values of V_0 were so obtained for both half-wave and double-wave rectification and for different load conditions.

V_0 is determined largely in value by the current flowing through the tube, and as shown in the experimental portion of this paper, this latter quantity bears a very direct relation to the direct current in the load resistance. To identify the voltage V_0 with the tube, relations have been determined between it and D.C. plate voltage which produces a direct plate current (plate and grid connected) equal in value to the R.M.S. tube current which flows under load conditions. By this means the voltage drop is based upon, and may be determined from the D.C. plate current—plate voltage characteristic (plate and grid connected) of the tube, which is easily obtainable.

The following approximate relations, representing average values, were determined to hold for a frequency of 60 cycles per second, and with different types of coated filament rectifier tubes. Though not entirely general, they were found to have sufficient accuracy for design purposes.

Half-wave rectification :

$$V_0 = 1{\cdot}5 \times \text{(D.C. plate voltage)} \quad . \quad . \quad . \quad . \quad (16)$$

Double wave rectification :

$$V_0 = 1{\cdot}3 \times \text{(D.C. plate voltage)} \quad . \quad . \quad . \quad . \quad (17)$$

In using these relations the R.M.S. tube current is first determined, as explained in the second section following; this value of current is then referred to the D.C. plate current characteristic of the tube obtained with the plate and grid connected, and the corresponding D.C. plate voltage noted; the value of V_0 is then obtained from the above relations.

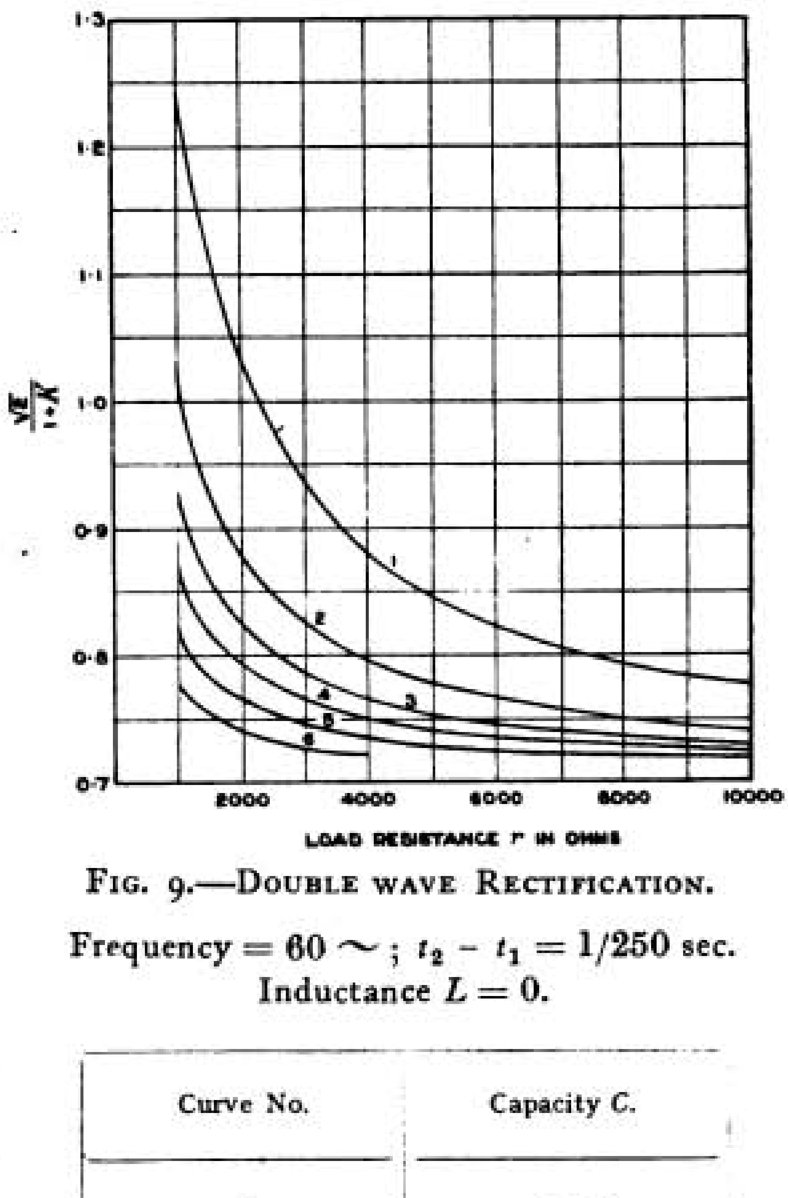

FIG. 9.—DOUBLE WAVE RECTIFICATION.

Frequency = 60 ~ ; $t_2 - t_1 = 1/250$ sec.
Inductance $L = 0$.

Curve No.	Capacity C.
1	2 μF
2	4 μF
3	6 μF
4	8 μF
5	12 μF
6	20 μF

Voltage Regulation.—The regulation of the rectified voltage enters into the design as from it is determined the factor of safety which must be allowed in the insulation design of the smoothing out capacity. With normal values of the load resistance the rectified voltage is as given by equation (6); with very large values of this resistance, or with an infinitely large resistance, such as would be the case with the load disconnected, the rectified voltage will rise to a higher value and will become approximately equal to the peak value, E_0, of the applied voltage. The smoothing out capacity must therefore be constructed to withstand this latter voltage.

Current and Power Delivered by Transformer Secondary.—The current flowing through the rectifier tube is determined in value by the tube resistance, the type of load and by the amplitude of the applied voltage ; the root mean square (R.M.S.) value of this current is that which the secondary of the transformer must be designed to carry. In the hard type of tube the full saturation current may be obtained and hence during the major portion of the time the current is flowing it is fixed at this value. With the coated filament tube, due to the fact that the saturated condition is not obtainable for continuous operation, the current at every instant during its time of flow, is varying. In the latter case were the exact current function known its R.M.S. value could be computed, a result, however, which would hold only for a given condition of loading and would have no general significance. Furthermore, with a given condition of loading, the current will have a different R.M.S. value with half-wave and with double wave rectification, due to the difference in time of charge and discharge of the condenser for the two cases. A determination, therefore, of a root mean square current function which will hold for tubes of different characteristics and for different conditions of loading, though theoretically possible, would have limited practical value.

The same remarks apply when it is attempted to compute the power which will be delivered by the transformer secondary, since this quantity is a function of the products of the instantaneous values of the transformer secondary current and voltage.

Experimental methods have been resorted to for the solution of this phase of the problem. In general the quantities that are initially known, and upon which the design of the rectifying apparatus is based, are, the final load resistance, and the voltage and current requirements of the same; from these the rectified or D.C. power output is determined. On the other hand the transformer must be designed to supply a certain power at a definite terminal voltage and with a definite current flowing. An empirical relation, therefore, between the rectified power developed, *i.e.*, the power expended in the final load resistance and the power furnished by the secondary of the transformer, and between the direct current and R.M.S. transformer secondary current would permit of the immediate determination of these two important design quantities from the known load requirements.

By experiment the following relations have been established, which hold for the coated filament type of three-electrode (plate and grid connected) rectifier tube, when working in the infra-saturated condition. The numerical values given represent the average of a number obtained with different load conditions.

60 *Cycles.*

Half-wave rectification :

R.M.S. transformer secondary current = 2·00 × (direct current flowing in final load resistance) . . . . (18)

$$\frac{\text{Power expended in final load resistance}}{\text{Power delivered by transformer secondary}} \times 100 =$$

$$= \text{rectification efficiency} = 60 \text{ per cent.} \quad \quad (19)$$

Double wave rectification :

R.M.S. transformer secondary current = 0·93 × (direct current flowing in final load resistance . . . . (20)

Rectification efficiency = 70 per cent. . . . . (21)

Illustration of Use of the Design Equations.—As an illustration of the method of use of the design equations and relations let it be required to design a transformer which, operating in conjunction with a rectifier tube of known characteristics, will develop a power of 200 watts in a load resistance of 1,250 ohms, at a terminal voltage of 500. Let it be assumed that the rectifier tube is of the coated filament type through which the maximum current (R.M.S.) which may be safely passed is 0·200 ampere, and in which condition the maximum voltage consumed in the tube is 100 volts. Let it be further assumed that the source of supply is 112 volts 60 cycles.

The first quantity to be determined is the percentage ripple voltage μ.

TABLE I.

VERIFICATION OF EQUATION (6).

Load Resistance.	Smoothing Condenser.	Smoothing Inductance.	V_{dc} (measured).	V_{dc} (computed).	V_{dc} (computed, $V_0 = 0$).
Ohms.	μF	Henrys.	Volts.	Volts.	Volts.
		Half-wave Rectification, 60 cycles.			
3,000	4·38	0	270	307	359
5,000	4·38	0	320	365	436
3,000	8·78	0	265	282	374
5,000	8·78	0	305	329	395
		Double Wave Rectification, 60 cycles.			
3,000	4·38	0	345	332	415
4,000	4·38	0	375	372	416
5,000	4·38	0	383	393	424
6,000	4·38	0	395	400	454
3,000	8·78	0	345	338	389
4,000	8·78	0	378	375	409
5,000	8·78	0	370	375	400
6,000	8·78	0	380	380	430
1,000	4·38	0	262	250	322
1,500	4·38	0	318	300	376
2,000	4·38	0	340	334	415

The value of this is generally specified by the load requirements. Assume, for simplicity, a value of 13 per cent., which is a normal one. Comparison of

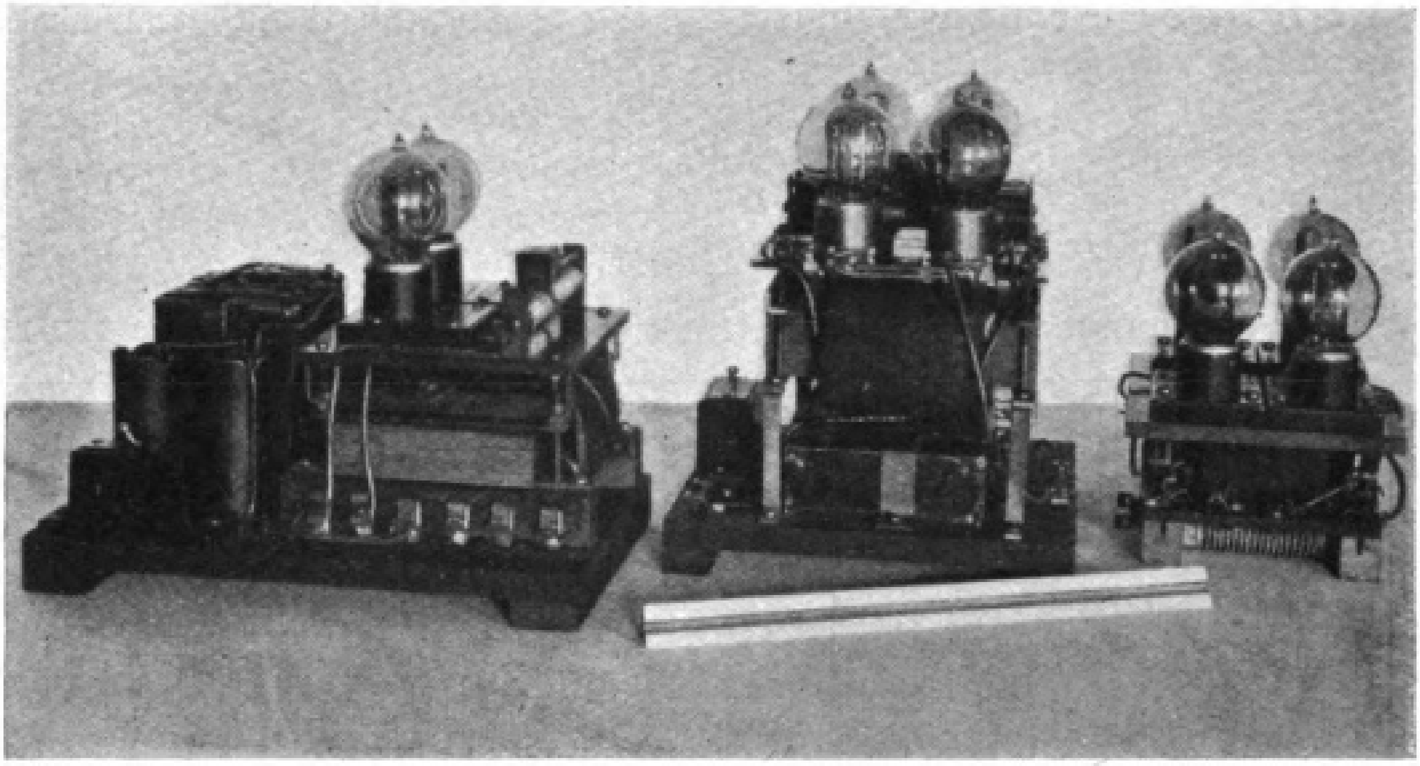

FIG. 10.

Figs. 6 and 7 shows immediately that with a load resistance of 1,250 ohms, half-wave rectification is not to be considered. Adopting double wave rectification, it is found from Fig. 7 that a smoothing capacity of 12 microfarads will give the value of μ desired.

TABLE II.

VERIFICATION OF EQUATIONS (12) AND (15).

Load Resistance.	Smoothing Condenser.	Smoothing Inductance.	μ (measured).	μ (computed).
Ohms.	μF.	Henrys.	Per cent.	Per cent.
		Half-wave Rectification, 60 cycles.		
4,000	4·24	0	33·3	31·3
4,000	8·96	3·30	12·6	14·0
		Double Wave Rectification, 60 cycles.		
4,000	4·24	0	14·5	13·3
4,000	4·24	2·20	10·0	12·5
8,000	4·24	2·20	6·5	8·3

Referring now to Fig. 9 it is observed that for a capacity of 12 microfarads and a load resistance of 1,250 ohms, the value of the voltage factor $\frac{\sqrt{2}}{1+K}$ is 0·797. By equation (9) the value of *one half* the R.M.S. transformer secondary voltage is,

$$E_{eff} = 0{\cdot}797 \times 500 - 100/\sqrt{2}$$
$$= 470 \text{ volts.}$$

TABLE III.

VERIFICATION OF RELATIONS (18) TO (21) INCLUSIVE.

Load Resistance.	Smoothing Condenser.	Smoothing Inductance.	(R.M.S. Transformer, Secondary Current) / Direct Load Current.	Rectification Efficiency.
Ohms.	μF.	Henrys.		Per cent.
		Half-wave Rectification, 60 *cycles.*		
3,000	4·38	0	1·96	56·5
4,000	4·38	0	1·97	60·5
5,000	4·38	0	2·08	61·1
6,000	4·38	0	2·14	64·1
3,000	8·78	0	1·93	59·3
4,000	8·78	0	2·00	61·1
5,000	8·78	0	2·08	66·0
6,000	8·78	0	2·09	68·0
			(Av. 2·03)	(Av. 62 per cent.)
		Double Wave Rectification, 60 *cycles.*		
2,000	4·38	0	0·900	61·0
3,000	4·38	0	0·910	71·5
4,000	4·38	0	0·937	74·0
5,000	4·38	0	0·988	77·8
6,000	4·38	0	1·010	77·2
2,000	8·78	0	0·905	66·0
3,000	8·78	0	0·915	72·1
4,000	8·78	0	0·905	73·1
5,000	8·78	0	0·908	75·2
6,000	8·78	0	0·985	72·6
			(Av. 0·93)	(Av. 72 per cent.)

The direct current through the load is equal to $500/1250 = 0{\cdot}400$ ampere. The R.M.S. current and power which will be delivered by the secondary transformer by empirical relations (20) and (21) will be respectively,

R.M.S. secondary current $= 0{\cdot}95 \times 0{\cdot}40 = 0{\cdot}38$ ampere.

Power $= 200/0{\cdot}70 = 286$ watts.

The transformer will therefore be designed to furnish a power of 286 watts at a total secondary terminal voltage of 940 volts; the secondary winding will be designed to carry a R.M.S. current of 0·38 ampere and will have a tap brought out from the middle of the coil. The ratio of transformation will be $940/112 = 8{\cdot}39$.

Since it was assumed that the safe R.M.S. tube current which could be passed was 0·200 ampere, whereas the R.M.S. current which will flow under full load conditions is, by the above relation, 0·380 ampere, it will be necessary to operate two rectifier tubes in parallel in each side of the double-wave circuit, thereby reducing the current per tube to 0·190 ampere which is below the safe maximum.

Experimental Verification of the Design Relations.—The design equations and relations have been verified experimentally; verification data for the more important relations are given in Tables I., II., and III.

Comparing the values in these Tables, it is observed that there is a fair agreement between the computed and measured values of V_{dc}, when the tube voltage V_0 is taken into account. This agreement is closer with double wave than with half-wave rectification, since the former condition of operation more nearly approaches that under which the theory was deduced. With half-wave and with double wave rectification, taking V_0 into account, the maximum error does not exceed 14 per cent. and 3 per cent. respectively for the two conditions; since the rectifier tubes themselves differ 5 per cent. or more in their characteristics, it is evident that an error in computed results of 3 per cent. or even 14 per cent. is not prohibitive of sufficiently accurate design. If V_0 is neglected, an error of 30 per cent. or more may be incurred, which is needlessly large in design computations.

A view of three experimental transformer rectifier units, constructed in accordance with the preceding design relations, is shown in Fig. 10. Each of these transformers contains one high voltage and two low voltage windings, the latter for furnishing the power required for energising the filaments of the rectifier and radio-transmitting tubes. The transformer to the left and the one in the centre are for operation on 60 cycles; the high voltage power output of the former is 35 watts, and of the latter 80 watts. The transformer to the right is of the same power output as the centre one, but is constructed for operation on 500 cycles.

The three units are arranged for double wave rectification; the type VT-2 tube is employed as the rectifier.

It is desired to acknowledge the active support and interest taken in this investigation by Major-General George O. Squier, Chief Signal Officer, U.S. Army. The valuable assistance rendered throughout the experimental work by Mr. Samuel Isler, Assistant Radio Engineer U.S. Signal Corps, is also acknowledged with pleasure.

U.S. Signal Corps, Research Laboratory,
Bureau of Standards, Washington, D.C., U.S.A.
July 7th, 1921.

The Amplification of Weak Alternating Currents.

III.—THE AMPLIFICATION AND MULTIPLE AMPLIFIERS.

By H. BARKHAUSEN.

4. The Amplification.

(a) The Efficacy of the Connections.

Corresponding to the efficiency of machinery the ratio of the amplified power P_v produced in the secondary to the unamplified power P_u supplied to the primary, should be denoted as the "amplification." In the technology of weak currents however calculations are made less often with power than with pressures and currents and therefore the root

$$W = \sqrt{P_v/P_u}$$

will be used to denote the linear amplification or simply the amplification.

If one inquires to what extent the amplification is contributed by the tube and to what extent by the external apparatus, the difficulty arises that one cannot speak of the amplification of the tube alone when, as is usual, the grid is made so strongly negative that it consumes no current and therefore also no power. The amplification would be infinitely great. As the measure of the usefulness of the tube, therefore, its figure of merit

$$G_r = \frac{4(P_a)_{\text{max.}}}{(V_g)^2_{\text{eff.}}} = S\mu$$

can serve; this is equal to four times the maximum alternating power $(P_a)_{\text{max.}}$ delivered from the tube when an alternating pressure $(V_g)_{\text{eff.}}$ of 1 volt is applied to the grid. This being given, the object of the input connections is to produce the highest possible alternating pressure V_g on the grid with a very small unamplified power P_u. Besides G_r, there is also the figure of merit of the transformer and other apparatus G_s, which in a corresponding way is put as

$$G_s = (E_g)^2_{\text{eff.}}/P_u.$$

The square of the pressure must also enter here since a fourfold expenditure of power is required for a doubled pressure. It will be remembered that the ratio of the power actually delivered to the maximum possible power on the anode side, $P_v/(P_a)_{\text{max.}}$, has been denoted as the efficiency of the anode circuit η_a, so that one obtains for the amplification,

$$W = \sqrt{\frac{P_v}{P_u}} = \tfrac{1}{2}\sqrt{G_s \,.\, G_r \,.\, \eta}.$$

When, as we have seen, the grid together with the leads associated with it possesses a definite effective impedance $\mathbf{Z_g}$, a fixed current consumption $I_g = V_g/\mathbf{Z_g}$ and consequently also a fixed power consumption P_g * is associated with the maintenance of the pressure V_g,

$$P_g = (V_g)_{\text{eff.}}\,(I_g)_{\text{eff.}} = \frac{(V_g)^2_{\text{eff.}}}{\mathbf{Z_g}} \approx P_u.$$

This is thus to be given by the source of current to be amplified, *i.e.*, it is essentially nothing else but the unamplified power P_u itself which is given up to the production of the pressure V_g in the grid circuit. Thence it follows that

$$G_s = (V_g)^2_{\text{eff.}}/P_u = (V_g)^2_{\text{eff.}}/P_g = \mathbf{Z_g},$$

i.e., the figure of merit of the apparatus is essentially equal to the effective impedance in ohms possessed by the grid, together with the connections associated with it, with respect to the heater. It is the impedance which, after disconnecting the source of current to be amplified, but with otherwise normal conditions for working the amplifier, can be actually measured between the grid and heater terminals, *e.g.*, by the Wheatstone bridge.

Strictly, there is a small difference between P_g and P_u with an input transformer. They will only be equal when the transformer losses with excitation on the secondary side (P_g) are just as great as with excitation on the primary side (P_u), both relative to the same secondary pressure E_g. The ratio of both will be denoted by η_g, the efficiency of the grid transformer,

$$\eta_g = \frac{P_g}{P_u}, \text{ thus } G_s = \mathbf{Z_g}\eta_g.$$

When a transformer is only essentially loaded with its own coil capacity an efficiency, in the normal meaning, cannot be spoken of; η_g is however dependent in a nearly similar way on the iron and copper losses as well as on the correct adaptation of the impedances, as is the normal efficiency of a normal transformer of the same type. An exact treatment is practically impossible on account of the distributed coil capacity.

For the linear amplification is obtained finally,

$$W = \tfrac{1}{2}\sqrt{G_s\,.\,G_r\,.\,\eta_a} = \tfrac{1}{2}\sqrt{\eta_g\,.\,\eta_a}\,\sqrt{\mathbf{Z_g}}\,\sqrt{S\mu}.$$

The magnitude of the attainable amplification is thus, apart from the correct adaptation and other losses in transformers belonging to the input and output sides ($\sqrt{\eta_g\eta_a}$), only dependent on the figure of merit of the tube ($G_r = S\mu$), the effective grid impedance $\mathbf{Z_g}$ being made as high as possible.

(b) *Magnitude Relations.*

With single-grid tubes the figure of merit of the tube $G_r = S\mu$ rarely rises above 10^{-3} watt/volt². Assuming 40 per cent. for the product $\eta_g\,\eta_a$ the value

$$W = \tfrac{1}{2}\sqrt{0{\cdot}4\,.\,10^{-3}\,\mathbf{Z_g}} = \sqrt{\mathbf{Z_g}}/10{,}000 \quad (\mathbf{Z_g} \text{ in ohms})$$

* The simplification is due to neglecting the phase-displacement, the power thus being put equal to the volt-amperes.

is obtained for the amplification. The effective grid impedance must thus exceed 10,000 ohms before any amplification is obtained at all. With $Z_g = 100{,}000$ only 3·2-fold, with 1 megohm 10-fold and with 10 megohms 32-fold amplification is obtained.

With double-grid tubes the figure of merit of the tube is about 10 times as great. Thus one obtains the same amplification with $\frac{1}{10}$ the value of Z_g, or with the same Z_g 3·2 times greater amplifications.

In note amplifiers the effective coil-capacity of the input transformer, as previously mentioned, amounts to about 80 cm. Without resonance this gives an effective grid impedance $Z_g = 1/\omega C = 2$ megohms. By resonance with the coil inductance Z_g is increased to about 10 megohms, but only over a narrow range of frequency.* With single-grid tubes this gives a 14 to 32-fold amplification; which is in fact the magnitude which is obtained with good amplifiers.

Transformers for low frequencies have about the same capacity; that of the measuring transformer described by Gewecke (*loc. cit.*) was about 80 cm. At 50 cycles per second this corresponds to a 20-fold greater impedance $1/\omega C = 40$ megohms. Gewecke found that at resonance with 1 volt on the primary a current of only 0·05 milliampere was required to produce 70 volts on the secondary. This gives for the figure of merit of the device

$$G_s = (E_g^2)_{\text{eff.}}/P_u = 70^2/1 \times 0{\cdot}05 \times 10^{-3} = 10^8 \text{ ohms.}$$

Including the transformer loss a primary power of only 10^{-8} watts was necessary to maintain a pressure of 1 volt on the secondary. With this transformer and a single-grid tube a 100-fold amplification would thus be possible, but only with very good insulation. Except for the high number of turns which the transformers must have (**Gewecke's** had 150,000) low frequency amplifiers offer few difficulties.

On the other hand still greater difficulties arise with increasing frequencies. Though the coil capacity be reduced to a few centimetres by proper winding the effective grid capacity will however hardly be less than 10 cm in consequence of the unavoidable connecting leads. This gives :—

λ metres = 20,000 .	10,000	2,000	1,000	600	300	100
$1/\omega C$ ohms = 10^6 .	500,000	100,000	50,000	30,000	15,000	5,000

Below a wavelength of 600 metres no amplification at all is produced by single-grid tubes without resonance tuning. Resonance can easily be made pretty sharp with high frequencies; $d = 0{\cdot}1$ is easily obtained. The effective grid impedance will be made thereby $\frac{\pi}{d} = 31{\cdot}4$ times as great and the amplification thus nearly 6 times higher. A difficulty is moreover still found, since with such sharp resonance only quite a narrow range of fre-

* From the considerations of **Schottky** in the *Archiv. für Elektrotechnik*, 8, p. 6, it follows that a figure of merit of the connections $G_s = 4 \times 10^6$ ohms may be regarded as normal.

quency will be well amplified, so that retuning is continually necessary, which is not desirable. It is also not easy to carry out, since the means of tuning should not appreciably increase the capacity of 10 cm.

Since the capacity of the anode to earth (to the filament) can also hardly be reduced to less than 10 cm the difficulty arises, as the above table shows, with short waves and large R_i in the tube (100,000 ohms) of making the external impedance $\mathbf{Z}_a$ in the anode circuit sufficiently big. One must here definitely work with resonance, or better employ tubes with space-charge grids and smaller voltage ratio for which R_i is small. It is to be noticed with respect to the action of C_{ga}, the capacity between grid and anode which was considered above, $\mathbf{Z}_a$ is preferably made about 4 times smaller than R_i. According to Table I. this is still no unfavourable adaptation and reduces the effective grid capacity from μ times to $\mu/5$ times C_{ga}. Tubes with large μ are disadvantageous, since with them the amount of grid capacity arising from C_{ga} will be very large. The inclination to self-excitation is proportionately great. To suppress this, inductive coils must be inserted in the anode circuit with very many turns which will let through little current. $\mathbf{Z}_a$ then remains already capacitive through the capacity of the connecting leads, since these let through a capacity current, and self-excitation due to C_{ga} cannot occur.

(c) *Back Coupling.*

It has already been mentioned that the figure of merit of the device can be enhanced to any desired extent by means of back coupling, a reaction of the amplified on the unamplified current which reduces as much as desired the power P_u necessary for the production of a specified power P_v. The back coupling acts as a negative resistance which annuls the damping effect of an equally great positive resistance. By means of an adjustable back coupling the total damping can therefore easily be brought to zero. The effective grid impedance $\mathbf{Z}_g$ will then be infinitely great at resonance and, theoretically, an infinitely great amplification can be produced. It should be noticed, however, that the neutralisation of the damping resistance R can only produce the desired effect so long as $\omega L - 1/\omega C$ is correspondingly reduced, and the resonance is sufficiently perfect. Now by means of the back coupling the effective inductance and capacity will also be altered, in general. Besides the variable back coupling one must therefore still employ effective means of fine tuning, so that resonance with the currents to be amplified is maintained. The optimum will only be obtained when both adjustments are simultaneously correctly made, which necessitates no small skill in operation.

The difficulty of adjustment is increased by the fact that with a small over-shooting of the most favourable back coupling the total damping becomes negative and self-excitation sets in ; the normal amplifying action being thus destroyed. Self-excitation once produced often remains long continued. The back coupling must then be largely reduced so that it ceases. If the back coupling be then carried forward again in order to adjust the optimum one runs into danger of starting self-excitation again with some strong impulse; it is then continuous. Since small external impulses are always present the optimum cannot be at all accurately adjusted.

Notwithstanding these difficulties one succeeds in producing in this way with high frequencies surprisingly high amplifications from one single-grid tube, but only with very skilful adjustment. Such apparatus—audion receivers with back coupling—though not quite so simple to employ are much in use. The reason lies partly in this, that, as mentioned, it is so difficult—and for short waves nearly impossible—to produce normal high frequency amplifiers capable without special tuning of covering a wide range of wavelengths.

With low, audible and long wave frequencies, on the other hand, even with quite flat resonance one can still keep the grid impedance $\mathbf{Z_g}$ easily over 1 megohm and thus produce more than 10-fold amplification over a wide range of frequency without any adjustment. Higher amplifications can then be obtained without difficulty with multiple amplifiers. (See the following section.) With audible frequencies it is usual to employ no back coupling but, on the contrary, carefully to avoid it, since it favours certain frequencies and easily leads to self-excitation. Alterations in the insulation, changing a tube (particularly with not quite good vacuum), alteration of the capacity by movement of the connecting leads or neighbouring conductors, alters also the effective back coupling; once self-excitation sets in one is, without adjusting apparatus, quite powerless. With stronger reduction of damping due to back coupling the long echoes—which will be excited with low and audible frequencies shortly before self-excitation, not only by the signals but also by each amplified current impulse—will be very troublesome.

5. Multiple Amplifiers.

(a) Limits of Amplification.

Although a certain amplification is obtainable in general with one tube there is a much better means of securing higher amplifications, namely: to lead the current amplified in one tube into a second, thence after amplification to a third and so on. If one tube amplifies 10-fold, an amplification of 100 with two tubes and of 1,000 with three tubes is obtained,* so that nearly unlimited amplification can be secured.†

A practical limit will be reached, on the one hand, since the disturbances (proceeding in part from the tube itself) also become amplified, so that finally with a higher amplification weak signals are not improved but actually made worse; and on the other hand since it will still be difficult to suppress back coupling and the self-excitation to which it leads.‡ Self-excitation

* In experiments on earth current telephony by the firm of **Siemens and Halske** a larger amplifier was connected after a four-tube amplifier which amplified 10,000-fold; by means of this, signals only audible in the telephone after the 10,000 times amplification were made quite audible over the whole room. This corresponds at least to a further 100-fold amplification, altogether 10^6-fold linear or a 10^{12} power amplification being obtained. On account of the augmented disturbances reception was clearer and better without the second amplifier.

† A theoretical limit is according to **Schottky** (*Verhandlungen der deutsche Physikalischen Gesellschaft*, 20, p. 71, 1918) given by this, that finally the separate electrons flying across become audible.

‡ Details will be published later.

can already occur very easily in a tube when the back-coupling impedance is equal to the effective grid impedance; thus when, *e.g.*, the back-coupling capacity is about equal to 50 cm, as mentioned above in connection with audible frequencies. If the pressure is amplified 1,000-fold perhaps by means of three tubes, a capacity about 1,000 times as small will suffice, *i.e.*, about $\frac{1}{2}$ mm or about that of a sphere 1 mm diameter. Thus then a lead of about the size of a pin's head associated with the grid of the first tube can give rise to self-excitation when it is not electrostatically screened from the amplified pressure. Such protection will be most effectively obtained by enclosure within a conducting screen which can receive no alternating potential, *e.g.*, is earthed. With high amplifications, therefore, not only are the triodes and the transformers surrounded by well earthed metallic casings (shown dotted in Fig. 15), but also the leads from the transformer to

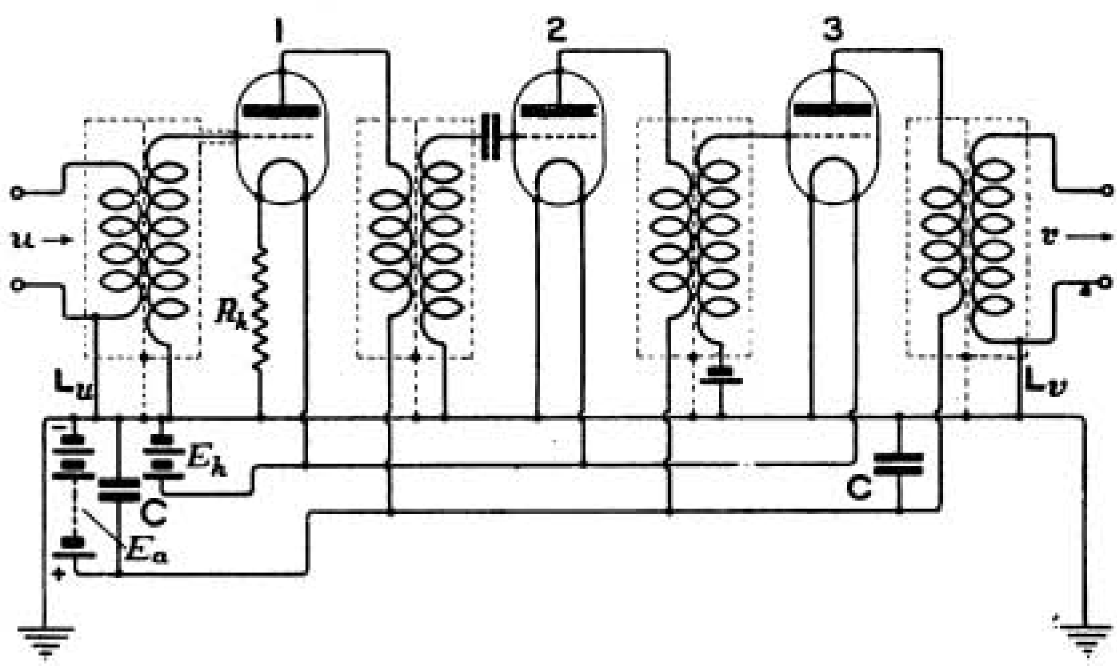

FIG. 15.

the triode are taken through an earthed lead tube. (See Fig. 15, first tube.) The effective grid capacity will certainly be increased thereby and the figure of merit of the apparatus somewhat impaired, but the inclination to self-excitation will be enormously reduced. In spite of such protection self-excitation often still occurs in consequence of the capacity between the outgoing (v) and the incoming (u) leads. Since these and the apparatus connected to them cannot be sufficiently protected against one another, it is then well to make the connecting apparatus of the lowest possible ohmic resistance and to earth one pole. (See Fig. 15, leads L_u L_v.) High potential differences can then nowhere be induced between them. Inductive influences, in consequence of stronger currents with apparatus of low ohmic resistance, are not so dangerous and can easily be made harmless.* An earthed metallic screen between the primary and the secondary windings

* The following fact shows this: Often input and output transformers have tappings for the adaptation of various external apparatus resistances. It is then nearly always found that self-excitation occurs much more easily with the high resistance sections.

of the input and output transformers will also be a good thing. (See Fig. 15.) Such thorough-going protective measures are only necessary with very high amplifications, say over 1,000-fold.

(b) Practical Performance.

Common heating and anode batteries can be employed for all the tubes (Figs. 15 and 16, E_h and E). The internal resistances of these must be so small that they can act as a short-circuit to the alternating current. Otherwise the resulting alternating pressure forms a back coupling which easily leads to self-excitation. According to the amplification, perhaps 100 to 10 ohms is still permissible. With audible frequency a sufficient short-circuit is produced, if necessary, by means of a condenser in parallel with E_a (C, C in Fig. 15). With high frequency the inductive pressure drop in the common connecting leads forms a considerable back coupling.

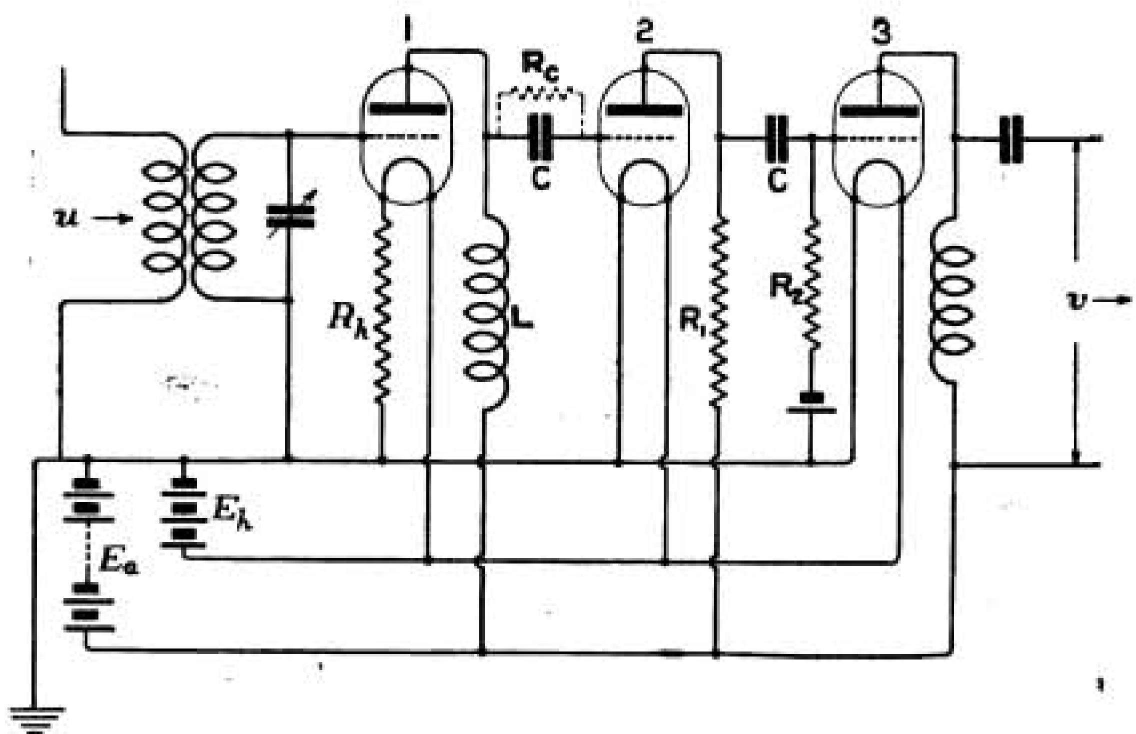

FIG. 16.

Fig. 15 shows the connections of a 3-fold amplifier with intermediate transformers. These lead the current amplified in one tube to the grid of the following tube and must thus adapt the internal resistance R_i of a tube to the effective grid impedance of the next tube, Z_g. As mentioned above, these grid transformers work most suitably by coil-resonance. If, as with tubes with a large voltage ratio or with a second protective grid, the internal resistance R_i is very great, or, as with high frequencies, the effective grid impedance Z_g is pretty small, then very nearly $R_i = Z_g$. A transformer between two tubes then gives no further advantage. Fig. 16 shows such a scheme of connections without transformers. The anode direct current flows through a choking coil (L in Fig. 16 for the first tube) or an ohmic resistance (R_1 for the second tube). In the latter case the ohmic pressure drop is generally balanced out by a corresponding increase in the anode battery E_a. The choking coil works most suitably with coil resonance since it then possesses the greatest impedance. It is, then, dimensioned exactly as the secondary winding of the intermediate transformers. The alternating pressure will be led to the grid of the following tube through a small condenser C (about 200 cm) which must be large compared with the capacity of the tube. The grid pressure V_g is then equal to the anode pressure V_a of the foregoing tube. The amplification of a tube is the ratio of the pressure on its two sides, *i.e.*,

$$V_g/V_a = W = \frac{\mu}{1 + R_i/\mathbf{Z}_a} = \frac{1}{\frac{1}{\mu} + \frac{1}{S\mathbf{Z}_a}}.$$

It is to be understood that the total impedance between the connecting leads anode-grid and earth (filament) is included in $\mathbf{Z}_a$. Therefore, $\mathbf{Z}_a$ is identical with the $\mathbf{Z}_g$ of the next tube. So long as $\mathbf{Z}_g$ remains great compared with $R_i = \mu/S$ then $W = \mu$. For $\frac{1}{\mu} = 7$ per cent., for example, a 14-fold amplification is obtained. Tubes with a large voltage ratio μ, in particular double-grid tubes with protective grids, are peculiarly suited to this method of connection. An increase of μ is no more advantage so soon as $R_i = \mu/S$ becomes great compared with $\mathbf{Z}_a$, which certainly soon occurs with high frequencies. Double-grid tubes with space-charge grids—in which S is large—are then more favourable. Quite generally, the amplification will be a maximum with a given figure of merit of the tube $G_r = S\mu$ when $\mu = S\mathbf{Z}_a$, thus again when $R_i = \mathbf{Z}_a$.

The small negative applied pressure, which the grid must have can be produced by means of a resistance R_h (shown in Figs. 15 and 16 with the first tube) in the negative filament current lead, since the negative end of the filament will then be positive to the grid by the potential drop $I_h R_h$. This certainly means a waste of energy and a correspondingly higher filament battery P.D., but, notwithstanding, this is a most usual method of connection since it easily allows of any desired potential by suitable choice of R_h. A condenser can also be put in the lead to the grid (shown in Figs. 15 and 16 with the second tube).* As previously mentioned the isolated grid then becomes slightly negatively charged, but only if the tube has a very good vacuum and very good insulation. With the connections shown in Fig. 16 the condenser C must be excellently insulated (*i.e.*, large R_c, shown dotted) to protect the grid from the high anode potential. This is certainly only necessary when the impedance $\mathbf{Z}_a \doteq \mathbf{Z}_g$ can otherwise be maintained high. If this is not at all possible—as with high frequency on account of the capacitive shunting—the electron current I_g to the grid in the tube will not become perfectly zero. The theory shows that in tubes with a good vacuum such a current acts as a leak of resistance,

$$R_g = 1/4I_g \text{ ohm } (I_g \text{ in amperes}).$$

* In an American amplifier the middle of the secondary winding of the grid transformer was simply broken. The capacity between the neighbouring halves of the winding replaced the condenser.

R_g may become, *e.g.*, 100,000 ohms because Z_g is essentially smaller, and thus I_g may become 1/400,000 ampere. With an anode pressure of 100 volts in this case the insulation resistance is $R_e = 100 \,.\, 400{,}000 = 40$ megohms.* Often an effective resistance of this very magnitude is connected in parallel with the condenser, independently of the otherwise quite indeterminate condition of the insulation; but particularly because otherwise a strong negative charge on the grid excited by an excess pressure with higher insulation can only leak away quite slowly; the tube during this time being inoperative.

A third possibility which will produce the negative applied pressure on the grid is the connection of a separate auxiliary pressure thereto (*e.g.*, quite a small dry cell, as shown with the third tube in Figs. 15 and 16). With the transformerless connections shown in Fig. 16 this is put in series with a resistance R_2 (or a choking coil) which must be large compared with Z_g. The pressure drop in this can then appreciably displace the grid potential.

(*c*) *Particular Properties.*

On account of the resonance properties of the secondary windings the connection using transformers (Fig. 15) amplifies for audible frequencies a range of only about 1 to 2 octaves (1:2 to 1:4), and also within this range more or less markedly prefers certain frequencies according to the sharpness of resonance of Z_a and the ratio of Z_a to R_i (see the discussion of Figs. 4 and 5). This is generally a disadvantage, especially for the amplification of telephonic currents. This can be partially adjusted by tuning the transformers to various frequencies, any transformer being preferably tuned still lower than that preceding it, in order to prevent the back coupling and consequent danger of self-excitation due to the capacity C_{ga} (see Section **3** (*c*)). The varied tunings can be obtained by different arrangements of the windings of similar transformers. The whistling of an amplifier can often be entirely removed merely by changing the polarity of a transformer. By this changing of polarity all other back couplings—so far as they go through the transformer, *i.e.*, between the leads before and behind a transformer—become converted from positive, reducing the damping, to negative, increasing the damping or the reverse; and with simultaneous alterations of the natural frequency. This must be particularly attended to with high amplifications, since a capacitive back coupling between the unprotected, unearthed leads u and v to the apparatus turns out negative. For frequencies above and below resonance the currents have nearly 180° phase displacement; therefore, though by changing the polarity of a winding one sustained whistling sound can be suppressed, another may be set up with a different natural frequency. In order radically to destroy the resonance properties of the transformers the secondary can be loaded with a resistance of about 1 megohm (see Fig. 13). This is done most simply by giving to the grid too small a negative potential, so that the electron current to the grid I_g will not be

* If as is the case with audible frequencies, Z_g is equal to or greater than 1 megohm R_g must be 10 megohms and R_e over 4,000 megohms. Here therefore insulation questions play a much greater part than with the connections using transformers.

quite zero. By small alterations of the pressure an effective loading resistance R_g of any size can be secured.* As mentioned, with 1 megohm and a normal single grid tube an amplification of 10 is still obtained equally over a wide frequency range ; self-excitation is then hardly to be feared. Amplifiers are often found in which an increase in the negative grid potential causes self-excitation, so that this means of suppression has thus already been made use of more or less unwittingly.

The method of connection without intermediate transformers, but with the choking coil L (Fig. 16) in the anode circuit, is strictly only a variety of that with transformers. The choking coil can be thought of as an auto-transformer with a transformation ratio of unity. High amplifications are also only obtained here with large impedances $\boldsymbol{Z}_g \doteqdot \boldsymbol{Z}_a$, and then on account of the coil capacity exactly the same resonance phenomena occur as with the transformer. All that has been said above is also valid here. Theoretically, the transformer connection still gives a little higher value since it renders possible a perfect adaptation of impedances $\tau^2 R_i = \boldsymbol{Z}_a$. Only when $R_i = \boldsymbol{Z}_a$ will both arrangements be equivalent. In this the coil capacity of the primary winding is neglected ; with high frequencies this can be rejected and the transformer is then thought of as a coupling between two oscillatory circuits. The most favourable relations are present with resonance when both coils have equal natural oscillations, *i.e.*, essentially equal numbers of turns. Then, since the transformation ratio is 1:1, the choking coil is theoretically equivalent to the transformer and simpler in practice. Thus, while the transformer connection is somewhat more favourable for audible frequencies, preference will be given to the transformerless connection for high frequencies. The greater insulation difficulties belonging to this method—see above—are not of such importance with high frequencies, since all the effective impedances arising from the unavoidable capacitive shunts are so much smaller.

The use of a resistance (R_1 in Fig. 16) in the anode circuit in place of the choking coil L has the advantage that the amplifier does not obtain any resonance properties therefrom ; thus the lowest frequencies (telegraphic signals) are just as well amplified as the highest, up to the limit where the capacitive shunts and the back coupling due to them become effective. Self-excitation can also occur here, particularly with quite short wavelengths where the inductance of the connecting leads already plays a part. Here again high amplifications imply high resistances ; 1 megohm is, as mentioned, necessary for a 10-fold amplification. On account of the direct current pressure drop this introduces difficulties. The slope of the characteristic is not very considerable with less than about 0·2 milliampere ; the anode direct current must therefore be about this value. Hence one megohm implies a pressure drop of 200 volts with 0·2 milliampere, and the anode battery must be increased by this amount as compared with that required with a connection using practically resistanceless choking coils. If the

* According to the rule mentioned in the former section R_g is 1 megohm for $I_g = 2{\cdot}5 \times 10^{-7}$ amp. Such a small current thus forms a considerable load.

internal impedance $\mathbf{Z}_u$ of the source of current to be amplified is not extraordinarily great an input transformer is used, which again brings resonance properties with it. The difficulty of amplifying telegraphic signals depends chiefly on this since an input transformer for frequencies of about 1 per second will assume large dimensions and have a huge number of turns. Without a transformer and with an internal impedance $\mathbf{Z}_u$ of the leads of 1,000 ohms there is obtained with a grid impedance of only 1 megohm—according to Table I.—a 15·8-fold smaller amplification than for the case of the most favourable adaptation. At least one tube more is used to obtain the same amplification ; the more so as on the output side the most favourable adaptation will seldom be obtained.

Summary.

(1) The power delivered on the anode side is greatest when the resistance of the load apparatus is equal to the internal resistance of the tube, R_i. Practically they need only be of the same order of magnitude. Deviations from the optimum condition in the ratio of 1:4 or of 4:1 only produce a just perceptible weakening (25 per cent. linear).

(2) If the resistance of the apparatus is not in itself high an increase in its effective resistance can be obtained by means of an intermediate transformer, or, with inductive apparatus, by connecting a condenser tuned to resonance in parallel with it ; or by both means.

(3) The power supply on the grid side is dependent upon the magnitude of the "effective grid resistance." With sufficient negative potential this is only limited by capacity or insulation.

(4) The higher the effective grid resistance the greater is the influence of disturbances due on the one hand to stray potentials and on the other to the amplified currents themselves. The latter lead to self-excitation and whistling.

(5) The input transformer must adapt the internal resistance of the source of current to be amplified to the high grid resistance. The number of its secondary turns is limited by the coil-capacity which acts as a condenser in parallel with the grid, thereby reducing the effective grid resistance. It is best to work with resonance. (See (2).)

(6) The capacity between the grid and anode, lying partly in the tube and partly in the connecting leads, represents a back coupling which cannot be neglected. According to the magnitude and phase of the impedances lying in the anode circuit it can, on the one hand, act as a considerable grid capacity which diminishes the grid impedance ; or, on the other hand, as a negative leak which diminishes the damping and finally causes self-excitation. This self-excitation cannot occur when the impedance of the anode circuit is capacitive when, for example, it is tuned to a lower frequency than the effective grid impedance.

(7) The amplification (apart from the efficiency of the output transformer) is equal to half the geometric mean of the figure of merit of the tube and the figure of merit of the connections.

(8) The figure of merit of the connections (apart from the efficiency of the input transformer) is identical with the effective grid impedance.

(9) An effective grid impedance of 1 megohm gives a 10-fold amplification with single-grid tubes and about 32-fold with double-grid tubes. With low and audible frequencies the grid resistance can rise to about 10 megohms; this corresponds to a 3·2 times higher amplification. On account of the low capacitive impedance with high frequencies, and particularly with short waves, it is difficult to obtain any amplification at all. Double-grid tubes are here most favourable.

(10) By means of an adjustable back coupling and simultaneously sharp resonance tuning, the effective grid resistance, and therewith the amplification can be carried very high. However, expert operation is necessary so that this means will only be employed with high frequency where difficulties are otherwise encountered.

(11) With low and audible frequencies, and with long waves, any desired amplification is obtained simply by connecting normal amplifiers one behind the other. This allows of the construction of apparatus which is handy and requires no attention.

(12) A limit to the amplification is then given by the amplified disturbances, which finally make higher amplifications worthless. Also with very high amplification—over 1,000-fold—self-excitation can only be suppressed with difficulty.

The Report of the Wireless Telegraphy Commission.

The publication of the Report of the Commission appointed by the Cabinet on December 23rd, 1920, marks an epoch in the development of radio-telegraphy. The terms of reference were (i.) To decide upon the wireless plant most suitable for carrying out the scheme of Imperial Wireless Communications recommended by the Imperial Wireless Telegraphy Committee, bearing in mind the necessity for the co-ordination of the chain with existing telegraph services and to design the necessary stations. (ii.) To make recommendations regarding the actual sites for the stations. (iii.) To advise generally upon the preparation of specifications for machinery and apparatus, the making of contracts and the construction of the stations.

The Report is signed by Dr. Eccles, Mr. L. B. Turner and Mr. E. H. Shaughnessy and is prefaced by an explanatory summary by Dr. Eccles.

The hands of the Commission were tied in so far as they were bound by the recommendations of the Committee (1) to communication by steps of about 2,000 miles, (2) to adopt thermionic valves as generators, and (3) to certain locations for the stations. In view of the fact, however, that the Commission consisted almost entirely of the technical members of the Committee, they were in reality only carrying out their own recommendations.

The first technical section of the Report deals with the development of high-power thermionic sets. As is well known, since the Committee recommended the adoption of thermionic transmitters for the Imperial chain, great progress has been made in the equipment of such transmitting stations by the Marconi Company and the Commission report on their visit to Carnarvon to examine the set of forty-eight glass valves with an input of 100 kilowatts which was pushed up to 150 during the trial. Messages were successfully transmitted to America, India and Australia. The relative merits of glass and silica valves are discussed; it is stated that 2½ kilowatt silica valves are being produced at the rate of four or five per week at a cost of about £60 each, whereas the glass valves, of which about four times as many would be required, can be produced in ample numbers at a cost of about £15. Hence there appears little to choose between them at present as regards cost, but the manufacture of glass valves is undoubtedly simpler and more standardised at present. It is stated that valve renewals will be from 50 to 66 per cent. heavier if alternating current is used instead of direct current, presumably due to the use of thermionic rectifiers.

With regard to wavelength it has been found as the result of tests between Horsea and Egypt that the best results over this distance can be obtained by the use of a relatively short wave during the night and of a long wave during the day time. The aerial tuning coil is therefore to have tappings so that the wavelength can be varied from 3,000 to 16,000 metres. It is to be designed to carry 500 amperes and its high-frequency resistance must not exceed a third of an ohm. In view of our present knowledge everyone will agree with the recommendation to adopt a symmetrical form of antenna supported by four masts at the corners of a square not exceeding 400 metres side, with the station and down lead at the centre. The capacity of the aerial is to be about 0·025 microfarad. Although no one doubts the superiority of the high over the low antenna, many readers will await with interest further details of "the deeper study of the better wave-making properties of high as compared with low antennæ."

It is recommended that the masts be of steel, 250 metres high, insulated not only at the base but at intermediate points, the insulating [insulated ?] portions being suitably dimensioned presumably with a view to a better distribution of potential and consequent diminution of losses.

In view of the recent experiences at Clifden and Carnarvon it is not surprising to find that earth screens or counterpoises, not less than 8 feet above the ground are recommended.

The Commission appear to have considered or tried a large number of panaceas for atmospheric interference but to be enamoured of none of them. Finding some benefit in the Horsea-Egypt trials from each of three different devices, viz., balancing, limiting and barraging, they recommend that all three be applied simultaneously.

With regard to duplex working it is recommended that each receiving station should have a separate antenna and receiving apparatus for each distant station with which it may have to communicate, so as to allow of simultaneous reception from all.

The transmitting set is to be capable of delivering at least 120 kilowatts to the antenna and is to be capable of extension to double this power. The D.C. supply is to be at 10,000—12,000 volts, the method of its production being left open. The set is to be capable of transmitting continuously either at hand speed or at ninety words per minute at full power.

It is noteworthy that although the Commission recommend that arc transmitters (two each of 250 kilowatts) be installed at East Africa, Singapore and Hong Kong, they also recommend that space be provided in every case for the subsequent installation of thermionic plant. They also recommend that the arc station recently installed in Egypt should be duplicated by a thermionic valve station. Nowhere in the Report is the slightest reference made to the radio-frequency alternator, whilst the arc is obviously regarded as a temporary expedient.

The Committee had recommended that the old German station at Windhuk should be modified to form the South African Chain Station, but the Commission report that the Union authorities favour the erection of a new station near Johannesburg on account of the long and costly land lines which the adaptation of the Windhuk station would entail.

The attitude of Canada with regard to the scheme seems to be in some doubt and the Commission recommend a conference with the Canadian authorities.

The cost of the five stations for which the Imperial Government is presumed to be responsible is estimated not to exceed £853,000; these stations are England, Egypt, East Africa, Singapore and Hong Kong, the three last being those stations for which arc generators are recommended for the present.

Perhaps one of the most striking things in the Report is the suggestion that the Marconi Company should be invited to tender for the valve set, tuning coil and earth screen for the British station. It is not quite clear, however, whether it is intended that only the one company should be invited to tender, to the exclusion of other firms, but the wording of the Report would certainly lead one to conclude that this is intended.

The Report concludes with a number of plans with leading dimensions of the ground required for the various stations, and of the power houses, transmitting and receiving buildings.

G. W. O. H.

Review of Radio Literature.

1. Abstracts of Articles and Patents.

(A.) Radio Stations and Installations.

3015. Wireless Telegraphy in the French Colonies. (*Radioélectricité*, 1, pp. 129—140, August; pp. 189—197, September; and pp. 248—255, October, 1920. *Génie Civil*, 78, p. 119, January 29th, 1921.)

3016. **L. M. Clement, F. M. Ryan** and **De Loss K. Martin.** The Avalon-Los Angeles Radio Toll Circuit. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 469—505, December, 1921.)

Describes in great detail the radiotelephone link which enables subscribers of the Bell Telephone System to call any subscriber at Avalon on Santa Catalina Island (off southern California). The system used is duplex using two different carrier frequencies (wavelengths 400 and 470 metres) and is connected through special two-way repeaters to the telephone systems both on the island and on the mainland.

Loop antennæ are used at both radio stations for reception. These are of the solenoid type, 6 feet square and consist of four or five turns each. Filter circuits are used to prevent the transmitting frequencies from entering the receiver. The transmitters are of the "constant current" type (anode choke control).

Various special points of the system are discussed, among them being an automatic alarm system which indicates when the transmitter ceases to oscillate for any reason.

(B.) Spark Transmitting Apparatus.

3017. **G. B. Crouse** [Sperry Gyroscope Company]. Spark Gap. (*U.S. Patent* 1399005, June 14th, 1918. Patent granted December 6th, 1921.)

This invention relates to a spark-gap construction for a buzzer transmitter, operated from a direct-current source. The spark-gap construction comprises a vibratory electrode, a portion thereof being magnetic material whereby the electrode may be vibrated by energising an adjacent electromagnet. A plurality of insulated electrodes are arranged to be normally bridged across the vibratory electrode.

(C.) Arc Apparatus.

3018. **P. O. Pederson.** Some Improvements in the Poulsen Arc, Part I. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 434—441, October, 1921.)

A Poulsen arc may be run with either one or two peaks of the arc voltage during one cycle. One-peak operation is the ideal method since it gives a radio frequency current wave of almost perfectly pure sinusoidal shape. This type of operation, though rather unstable in ordinary sets, has been satisfactorily attained by the use of a water-cooled copper shoe on the cathode which prevents the arc from travelling along the cathode. Other advantages of the use of this cooling shoe are that it permits the use of weaker magnetic fields and also that a great increase in the steadiness of the arc is found to accompany its use.

(F.) Thermionic Valves and Valve Apparatus.

3019. **T. Johnson, Jun.** Naval Radio Tube Transmitters. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 381—433, October, 1921.)

Deals exhaustively with the development of valve transmitters in the Navy Department of America. The superiority of tube transmitters over spark and arc sets has been shown by a long series of tests carried out at Washington in 1919. Signals from sets of the three types mentioned were sent out on a wavelength of 1,900 metres the antenna current in each case being 8 amperes. In order to permit a simple review of the results the audibilities obtained at the eleven receiving stations have been turned unto factors giving comparative audibilities, the actual audibility of spark signals received by detection only being assumed as unity. The average results are tabulated below.

TRANSMITTER.	RECEIVER.	AVERAGE AUDIBILITY.
Spark.	Detection only.	1
Spark.	Detection and Regeneration.	3·5
Continuous wave modulated.	Detection only.	12
Spark.	Oscillating.	24
Arc.	Oscillating.	105
Valve.	Oscillating.	205

The standard transmitters are described in detail. The circuits in use are either (*a*) those in which the plate and grid circuits are inductively coupled to the antenna circuit or (*b*) examples of Colpitt's circuit in which the grid receives its excitation from a condenser in the antenna circuit.

A careful investigation of the antenna characteristics is made in the case of stations to be equipped with valve transmitters a special test set having been developed for the purpose by the author and manufactured in quantity by the General Electric Company.

The article is copiously illustrated with photographs showing constructional details of the 5-, 150-, 300-, and 750—1,500-watt equipments.

3020. **J. H. Payne, Jun.** [General Electric Company]. Method of and Means for producing Alternating Currents. (*U.S. Patent* 1400235, September 14th, 1916. Patent granted December 13th, 1921.)

This patent shows a vacuum tube circuit for the production of alternating currents. The coupling between the grid and the plate circuits is provided by condensers. The main inductances and the capacities are preferably so chosen that radiofrequency oscillations will be set up in the circuit which includes these inductances and capacities. Other inductances and condensers are so proportioned that the circuit including these inductances and capacities will be resonant to a different and preferably an audible frequency.

(G.) Transmitter Control or Modulation.

3021. **H. F. Elliott, assignor to Augustus Taylor.** Radiotelegraphy. (*U.S. Patent* 1399945, July 24th, 1920. Patent granted December 13th, 1921.)

This patent relates to a high-power arc signalling system in which the signals are produced by a variation in wavelength of the radiated wave. The antenna inductance is changed to produce the signals by the closing of a plurality of pairs of contacts in a system of loops inductively associated with the antenna inductance.

3022. **C. D. Ehret.** Electrical Wave Transmission. (*U.S. Patent* 1400591, March 12th, 1919. Patent granted December 20th, 1921.)

This invention relates to the transmission of radiotelephone signals wherein high-frequency oscillations are not existent or produced except when the microphone is actuated. The oscillator employed in the system includes a pair of anode circuits, a heated cathode and a grid circuit. An amplifier may be inserted between the microphone circuit and the oscillator and between the oscillator and the antenna radiating system. In the operation of the system modulating energy is impressed by a transformer upon the anode circuits of the oscillator with the result that all of the frequencies of positive polarity are converted by one of the anode circuits while all of the frequencies of negative polarity are converted by the other of the anode circuits. Thus, there are directly produced, by conversion of the amplified telephonic energy, high-frequency oscillations varying in amplitude in accordance with speech waves. The telephonic energy is the only energy supplied to the plate or anode circuits as distinguished from systems wherein a battery supplies the anode circuit and wherein only the telephonic energy is employed merely to vary the potential of the grid of the oscillator.

(H.) Radio Receiving Apparatus.

(4) HETERODYNE AND C.W. RECEIVERS.

3023. **V. Bush** [American Radio and Research Corporation]. Radio Receiving System. (*U.S. Patent* 1389026, May 19th, 1920. Patent granted August 30th, 1921.)

Radio receiving system for the reception of sustained oscillations which are broken up or modulated into groups at an audible frequency by periodically varying the resistance of the receiving circuit at audible frequency. (See Fig. 1.)

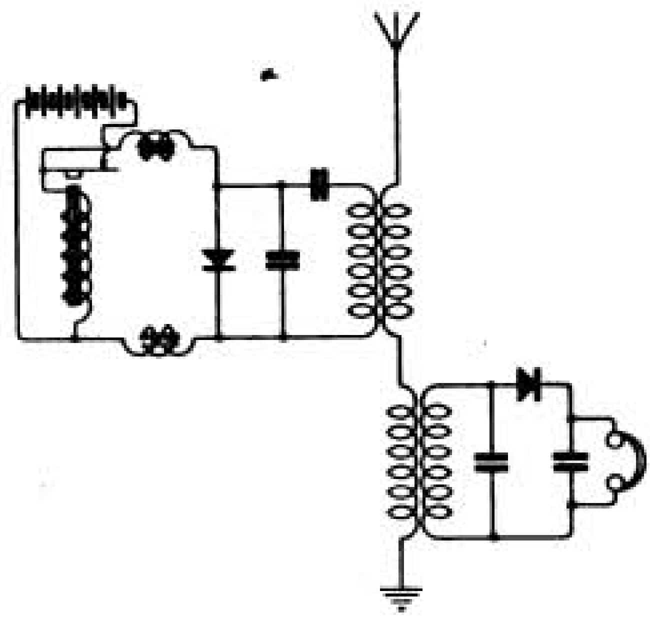

FIG. 1.

(5) RELAYS, RECORDERS AND AUTOMATIC CALLING APPARATUS.

3024. **H. J. J. M. de R. de Bellescize.** Type Printing. (*French Patent* 508833, January 22nd, 1920. Published October 25th, 1920.)

The specification describes wireless type-printing telegraph apparatus which consists in modifications of the Baudot system. See also *British Patent* 158556, and RADIO REVIEW Abstract No. 3013, February, 1922.

3025. **L. B. Turner.** Wireless Receiving Apparatus. (*British Patent* 152915, February 13th, 1920. Patent accepted October 28th, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 222—223, September, 1921—Abstract.

For high-speed reception the slow dying away of the oscillations sets a limit to the working speed. A relay is used (operated by the signal) so that as soon as the signal is received an additional damping means is inserted in the circuit to promote the rapid quenching of the oscillations.

3026. **Siemens and Halske Akt. Gesellschaft.** Thermionic Relays. (*British Patent* 146354 July 2nd, 1920. Convention date May 27th, 1919. Patent not yet accepted.)

An arrangement of thermionic valves for high speed reception, as indicated in Fig. 2. The current through the relay R is reversed on the receipt of a signal.

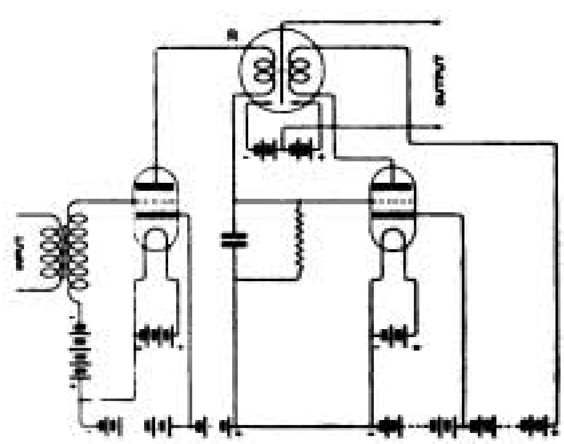

FIG. 2.

3027. **F. A. Johnsen** and **K. Rahbek.** Relays. (*British Patent* 151997, October 4th, 1920. Convention date February 15th, 1919. Patent not yet accepted.)

3028. **M. Compare** [Comparri Wireless Control Syndicate]. Wireless Type-printing Telegraphy. (*British Patent* 150008, March 7th, 1919. Patent accepted September 2nd, 1920.)

Each letter is represented by a combination of two or more trains of impulses of different group frequency transmitted in quick succession and received by resonance relays.

3029. **A. H. Brantom, E. A. Bitton, A. W. Dransfeld** and **S. E. Boyce.** Relays. (*British Patent* 152153, July 24th, 1919. Patent accepted October 14th, 1920.)

A tuned contact-making relay, consisting of a plurality of adjacent diaphragms influenced by a single electromagnet. The arrangement is applicable to reducing interference in wireless reception.

3030. **C. A. Hoxie.** A Visual and Photographic Device for Recording Radio Signals. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 506—528, December, 1921.)

Describes an instrument originally designed for aeroplane use which enables signals to be seen instead of being read by ear. The apparatus consists of a type of vibration galvanometer in which the vibrator is a thin strip of wire stretched between the pole pieces of two permanent magnets. The currents due to received signals pass through coils placed round the poles of the magnets. The resulting motion of the vibrator is indicated optically. Signals can be read visually up to a speed of fifteen words per minute but such a method is trying to the eyes so that photography has been used, moving tape methods being employed. In this way signals have been recorded up to a speed of 600 words per minute.

3031. **A. E. Blondel.** Recording Apparatus for Radiotelegraphic Signals. (*U.S. Patent* 1400517, April 26th, 1919. Patent granted December 20th, 1921.)

This patent shows a galvanometer or oscillograph which is adjusted to resonance with an alternating current of any given frequency. The circuit employed includes a receiving antenna system, a detector and a vibrating galvanometer connected in a low resistance tuned circuit. The galvanometer winding may operate the usual mirror for oscillograph reception.

3032. **J. B. Bolitho.** Wireless Receiving Apparatus. (*British Patent* 156330, October 6th, 1919. Patent accepted January 6th, 1921.)

In a "trigger" relay oscillations initiated by incoming signals are periodically quenched by a second valve which intermittently neutralises the reactance between the grid and anode circuits of the "triggered" valve.

3033. **Société Anonyme des Ateliers Brilles frères.** Relays for Synchronising Clocks, etc. (*British Patent* 157438, January 10th, 1921. Convention date, September 26th, 1919, Patent not yet accepted.)

A relay for synchronising clocks and applicable to a wireless receiver for synchronising clocks.

3034. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 147848, July 9th, 1920. Convention date February 8th, 1916. Patent not yet accepted.)

Means for enabling a D.C. relay to be operated by a receiving valve amplifier.

3035. **F. Duroquier.** Radiotelegraphic Recording. (*La Nature*, 49 (1), Supplement pp. 187—188, June 11th; Supplement pp. 195—197, June 18th, 1921.)

Constructional details are given of a relay for use in recording radio messages.

3036. **H. Abraham** and **R. Planiol.** The Use of the Baudot Telegraph in Wireless Communication. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 193—207, June, 1921. *Post Office Electrical Engineers' Journal*, 14, pp. 163—169, October, 1921—Abstract.)

A general *résumé* of earlier work and experiments made in 1920 and 1921.* The second part of the paper gives practical details of the valve transmitting and receiving apparatus. The connections of the modulating valve controlled by the Baudot relay are given as well as details of the amplifying arrangements. It is concluded as a result of the test that the Baudot telegraph apparatus is very easily adaptable to wireless transmission without the need for any modification of its working.

3037. **Toche.** War-time Communications from a Military Telegraphic Point of View. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 246—262, June, 1921.)

Includes some references to the uses of wireless in war-time communication.

3038. **D. A. E. A. Bontekoe.** Einthoven Galvanometer as Photographic Recorder. (*Radio Nieuws*, 4, pp. 49—54, February 1st, 1921.)

A popular illustrated description of the apparatus used years ago in the Lyngby-Knockroe experiments.

3039. **H. de A. Donisthorpe.** A Method of Recording Wireless Signals by Means of a Morse Inker. (*Model Engineer*, 45, pp. 55—56, July 21st, 1921.)

Describes a bridge arrangement of circuit using valves to operate the inker relay.

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* See also RADIO REVIEW Abstract No. 3005, February, 1922.

3040. **S. R. Winters.** A New Automatic Recorder. (*Radio News*, 3, p. 9, July, 1921. *Wireless Age*, 8, pp. 14—15, September, 1921.)

An illustrated description of a recording apparatus, operated by a valve amplifier, which has been developed by the Bureau of Standards.*

3041. **H. Pratt.** Radio Controlled Recorder. (*Wireless Age*, 8, p. 21, April, 1921. *Radioélectricité*, 2, p. 19D, September, 1921—Abstract.)

Briefly describes a mechanical vibrator arranged for inscribing the signals on a rotating drum.

3042. New Wireless Receiver Types Incoming Message. (*Popular Science*, 99, p. 34, October, 1921.)

A short illustrated description of the Creed printing receiver.

3043. **Gesellschaft für drahtlose Telegraphie.** Controlling Relays by Thermionic Valves. (*British Patent* 166881, May 25th, 1921. Convention date July 23rd, 1920. Patent not yet accepted.)

(I). Amplifiers.

(1) General.

3044. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valves. (*British Patent* 162288, April 25th, 1921. Convention date April 27th, 1920. Patent not yet accepted.)

Relates to the use of an iron wire resistance in series with a valve filament to maintain constancy of filament current.

3045. **P. L. Welke.** Audio or Radio Frequency Amplifier. (*Radio News*, 2, p. 441, January, 1921. *Radioélectricité*, 1, p. 115D, April, 1921.)

A comparison of their relative merits for reception purposes.

3046. **H. E. Metcalf.** Power Amplification of Audio Frequencies. (*Radio News*, 3, p. 96, August, 1921.)

(2) Multi-stage Amplifiers (H.F. and L.F.).

3047. **C. W. Rice** [General Electric Company]. Method of and Apparatus for Amplification of Small Currents. (*U.S. Patent* 1401644, July 31st, 1917. Patent granted December 27th, 1921.)

The amplifier shown in this patent employs a plurality of vacuum tubes in which all of the plate circuits are supplied with current from a common source and a high resistance is inserted in each plate circuit. The current to be amplified is applied to the grid circuit of the first amplifier of the series and the current in the plate circuit of that amplifier is varied proportionally. As a result there will be a variation in potential difference between the cathode and anode of the amplifier and this variable potential is applied to the grid circuit of the second amplifier. The variable potential between cathode and anode of the second amplifier is in turn applied to the grid circuit of the third amplifier and so on throughout the series. The plate circuit of the last amplifier includes a telephone receiver or other device for detecting the received signals.

3048. **M. I. Pupin.** Relay. (*French Patent* 507607, December 20th, 1919. Published September 20th, 1920.)

The system described employs a multi-step thermionic amplifier and the electric constants of the circuit are such that reaction between the tubes is destroyed with respect to internal and external disturbances, but not with respect to the desired wave signals. See also *British Patent* 139494 (Radio Review Abstract No. 1174, November, 1920.)

3049. **W. H. F. Griffiths.** Resistance Coupled Thermionic Amplifiers. (*Wireless World*, 8, pp. 833—840, March 5th, 1921. *Technical Review*, 9, p. 79, May 3rd, 1921—Abstract.)

Discusses the amplification factor of resistance coupled amplifiers, and its variation with wavelength.

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* See also Radio Review Abstract No. 3004, February, 1922.

3050. **Siemens and Halske Aktiengesellschaft,** Berlin. Valve Amplifier. (*German Patent* 300144, July 8th, 1916.)

An alternating current amplifier in which the inter-valve linkages are maintained by means of choking coils. The grids of the valves are maintained at favourable potentials by means of these coils and the various anode batteries. (See Fig. 3.)

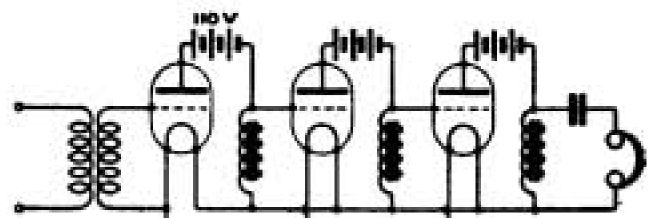

FIG. 3.

3051. **E. V. Appleton** and **Miss Mary Taylor.** A Method of Amplifying Electrical Variations of Low Frequency. (*Electrician*, 85, p. 235, August 27th, 1920.)

Correspondence that refers to the article abstracted in RADIO REVIEW Abstract No. 1173, November, 1920, stating that the writers have conducted similar experiments using somewhat different arrangements and obtaining a low frequency voltage amplification of about 40 with a tube having a natural amplification factor of 10.

3052. **H. J. Round.** Multi-stage Amplifying Receivers. (*British Patent* 149433, May 13th, 1919. Patent accepted August 13th, 1920.)

In a multi-stage amplifier particularly adapted for short wavelengths, but also capable of being used over a range of wavelengths a flat characteristic is obtained by winding the inter-valve transformer with resistance wire. The two windings of each transformer may also be connected to the condensers. Greater stability and less liability to self-oscillation is claimed.

3053. **W. H. Eccles** and **F. W. Jordan.** Thermionic Relays. (*British Patent* 149702, June 21st, 1918. Patent accepted August 26th, 1920.)

The arrangement referred to in this specification is described in RADIO REVIEW Abstract No. 1173, November, 1920.

3054. **P. Jessop.** Indoor Aerials and Choke Coil Amplifiers. (*Radio News*, 2, p. 686, April, 1921.)

Describes a multi-stage amplifier using reactance capacity coupling in place of inter-valve transformers.

3055. **J. Scott-Taggart.** Continuous Wave Multi-stage Receiving Circuits Employing Retroaction and Self-heterodyne Principles. (*Radio News*, 2, pp. 690—748, and 750, April, 1921.)

Describes various arrangements of multi-stage amplifiers with retroaction coupling.

3056. **R. E. Lecault.** Notes on the Functioning and Construction of Resistance Coupled Amplifiers. (*Radio News*, 2, pp. 596 and 648—650, March, 1921.)

Details are given of the construction and mode of operation of an eight-valve resistance capacity coupled instrument.

3057. **W. Schottky.** High Vacuum Amplifiers. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 276—296, October, 1920.)

A long abstract by **Alberti** of Part 2 of Schottky's paper * (*Archiv für Elektrotechnik*, 8, pp. 1—31, and pp. 299—328, 1919). It consists of a discussion of the characteristics of three-electrode valves, their relation to the dimensions and design of the electrodes and the dependence of the amplification upon these various factors.

3058. **K. Mühlbrett.** On Amplifier Transformers. (*Archiv für Elektrotechnik*, 9, pp. 365—390, December 8th, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 220—221, March, 1921. *Elektrotechnische Zeitschrift*, 42, p. 706, June 30th, 1921—Abstract. *Radioélectricité*, 1, pp. 143D—145D, June, 1921—Abstract.)

An important experimental investigation of the properties of transformers for amplifiers.

3059. **E. F. Huth.** Thermionic Detectors and Amplifiers. (*British Patent* 149009, July 12th, 1920. Convention date October 19th, 1915. Patent not yet accepted.)

Relates to methods of coupling thermionic valves in cascade by means of a large inductance

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* Part 1 of this article was abstracted in the *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 326—340, April, 1920.

in the plate circuit of the first valve, and a coupling condenser in series with the grid connection to the next (impedance-capacity coupling). Alternatively the inductance may be replaced by a resistance, and an inductance may be joined in series with the grid coupling condenser.

3060. **S. Loewe** [E. F. Huth Gesellschaft]. Thermionic Valve Amplifiers. (*British Patent* 159213, July 12th, 1920. Convention date October 25th, 1918. Patent not yet accepted.)

To prevent howling and self-oscillation in thermionic valve amplifiers means are provided for maintaining constant the potential of the anode battery, and for eliminating the effects of mutual capacity between the windings of the inter-valve transformers. For the former a large condenser or a small resistance may be joined across the anode battery.

3061. **E. F. Huth.** Wireless Receiving Apparatus. (*British Patent* 149239, July 12th, 1920. Convention date April 26th, 1919. Patent not yet accepted.)

Relates to a multi-stage valve receiver in which the number of valves in circuit can be varied by suitable switching arrangements.

3062. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Amplifiers. (*British Patent* 159322, November 25th, 1919. Patent accepted February 25th, 1921.)

In order to prevent the production of high-frequency oscillations in an amplifier consisting of a number of valves in parallel, a small inductance may be inserted in the grid connection of one or more of the valves.

3063. **S. Loewe.** Thermionic Relays. (*British Patent* 159472, February 23rd, 1921. Convention date February 23rd, 1920. Patent not yet accepted.)

In multi-valve amplifiers in which the energy is transferred from one valve to the next by a resistance coupling, the internal resistance of an extra valve is used as a variable resistance coupling. The internal resistance of this auxiliary valve may be controlled by subjecting its grid to a potential derived from the receiving aerial circuit, or alternatively its grid potential may be controlled by the local heterodyne, so as to reduce interference from disturbing signals.

3064. **J. Robinson** and **H. L. Crowther.** Amplifying Electric Currents. (*British Patent* 159694, December 24th, 1919. Patent accepted March 10th, 1921.)

Relates to an inductance-capacity coupled amplifier using inductances for the plate and grid impedances and a variable coupling condenser. The detector valve may be provided with a retroactive coupling.

3065. **J. Massolle, J. Engl** and **H. Vogt.** Thermionic Valve Amplifiers. (*British Patent* 157733, January 10th, 1921. Convention date April 16th, 1919. Patent not yet accepted.)

A multi-stage amplifier in which the grid-filament of each succeeding valve is joined in series with the anode-filament circuit of the previous valve as indicated in Fig. 4. The arrangement is described in connection with a selenium cell S in the input circuit of the first valve.

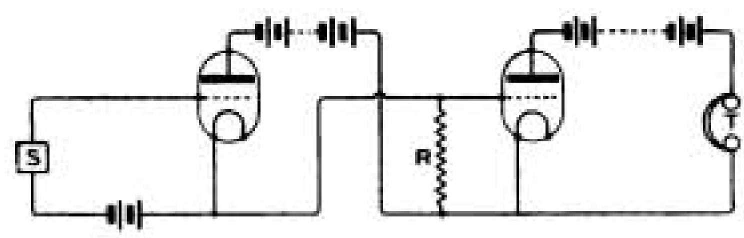

FIG. 4.

3066. **J. Massolle, J. Engl** and **H. Vogt.** Thermionic Valve Amplifiers. (*British Patent* 155744, January 10th, 1921. Convention date October 9th, 1919. Patent not yet accepted.)

An addition to *British Patent* No. 157733, incorporating additional means for controlling the grid potentials.

3067. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Amplifiers and Receivers. (*British Patent* 147446, July 7th, 1920. Convention date May 21st, 1919. Patent not yet accepted.)

Relates to capacity and similar means for obtaining retroaction in a multi-stage amplifier.

3068. **M. Latour.** Thermionic Valve Amplifiers. (*British Patent* 147758, July 8th, 1920. Convention date November 30th, 1918. Patent accepted August 22nd, 1921.)

An addition to *British Patent* 127318.* Switching means are provided for reversing the connections of the inter-valve transformers to reduce howling.

3069. **Siemens and Halske Akt. Gesellschaft.** Thermionic Relays. (*British Patent* 154925, December 6th, 1920. Convention date December 5th, 1919. Patent not yet accepted.)

Relates to the use of damping resistances, etc., to avoid speech distortion in multi-stage L.F. amplifiers.

3070. **E. F. W. Alexanderson** [British Thomson-Houston Company]. Wireless Receiving Apparatus. (*British Patent* 147147, July 7th, 1920. Convention date October 29th, 1913. Patent accepted October 6th, 1921.)

Relates to a cascade series of valves for high frequency amplification in which each grid circuit is tuned so as to obtain greater selectivity.

3071. **I. Langmuir** [British Thomson-Houston Company]. Wireless Receiving Apparatus. (*British Patent* 147148, July 7th, 1920. Convention date October 29th, 1913. Patent not yet accepted.)

A similar arrangement to that outlined in preceding abstract. Part of the series of valves is used for H.F. amplification, one valve for rectifying and the remainder for L.F. amplification. The grid circuits of the last valves are tuned to the group frequency of the signals.

3072. **W. H. Eccles** and **F. W. Jordan.** Thermionic Relays. (*British Patent* 148582, June 21st, 1918. Patent accepted August 5th, 1920.)

A thermionic relay or amplifier comprises a pair or an even number of valves connected in cascade by resistances, with a return connection so that the magnified P.D. along a resistance in the anode circuit of the last valve is communicated to the grid of the first to obtain further amplification by retroaction. (See RADIO REVIEW, 1, pp. 143—146, December, 1919, for further description of this apparatus.)

3073. **H. L. Crowther.** Transformers. (*British Patent* 148679, June 27th, 1919. Patent accepted August 5th, 1920.)

Relates to high-frequency inter-valve transformers having the primary and secondary wound as twin wires in the form of two flat coils. The relative position of the coils can be varied for tuning purposes.

3074. **Siemens and Halske Akt. Gesellschaft.** Thermionic Amplifiers. (*British Patent* 146353, July 2nd, 1920. Convention date July 7th, 1916. Patent accepted October 3rd, 1921.)

Relates to the earthing of suitable points of a cascade amplifier to stop howling.

3075. **L. N. Brillouin.** Rectifier. (*French Patent* 507761, October 19th, 1917. Published September 23rd, 1920.)

The amplifier is intended for use in telephone installations or for wireless telegraphy. A number of tubes are employed having a filament heated by an electric current and plate and grid electrodes. Between the plate electrode of one tube and the grid electrode of the next tube is interposed a transformer in which the primary winding is employed to form part of the secondary winding.

3076. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Valve Amplifier. (*French Patent* 509769, February 10th, 1920. Published November 19th, 1920.) Also **General Electric Company.** (*British Patent* 151346, June 20th, 1919. Patent accepted September 20th, 1920.)

A number of electric valve amplifiers are arranged in cascade and have a shunt connection from the plate to the filament, consisting of a condenser in series with a tuned circuit, the potential differences across the tuned circuit being applied to the grid and filament of the succeeding valve.

3077. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Valve Amplifiers. (*British Patent* 150415, May 29th, 1919. Patent accepted August 30th, 1920.

In a cascade arrangement of thermionic amplifying valves, filters are provided in the

* RADIO REVIEW Abstract No. 83, December, 1919.

anode supply circuits to minimise low-frequency disturbances, and the last valve of the series is tuned to pick out the second harmonic of the original input frequency in order to reduce the tendency of the whole amplifier to generate oscillations by retroaction.

3078. **J. Erskine-Murray.** Amplifiers. (*British Patent* 152086, July 3rd, 1919. Patent accepted October 4th, 1920.)

In a multi-stage transformer-coupled L.F. amplifier, the valve characteristics and the anode voltages are graduated throughout the amplifier. The first valve has the lowest voltage.

3079. **B. S. Gossling** [General Electric Company, London]. Electric Current Amplifiers. (*British Patent* 155328, August 14th, 1919. Patent accepted December 14th, 1920.)

A cascade amplifier using resistance couplings only. Separate H.T. batteries may be used for each valve, or a common battery may be employed. One arrangement of the latter scheme is indicated in Fig. 5. In this diagram LL represent current-limiting devices, such as iron wire resistances, or low-impedance two-electrode thermionic valves worked above the saturation point. All the current-limiting devices should have the same saturation current. Other modifications are also described.

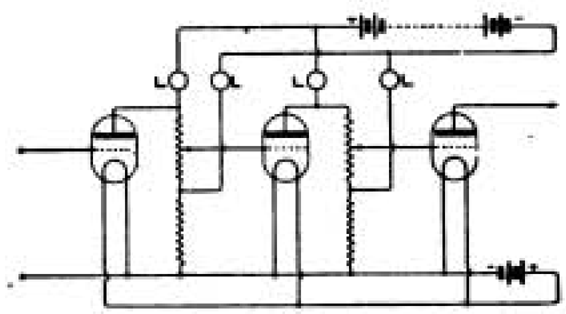

FIG. 5.

3080. **J. Engl, J. Massolle** and **H. Vogt.** Sound Reproduction. (*British Patent* 157436, January 10th, 1921. Convention date July 25th, 1919. Patent not yet accepted.)

Relates to apparatus in which the sound is reproduced electrically by photo-electric cell, microphone or telephone in combination with a valve amplifier.

3081. **Gesellschaft für drahtlose Telegraphie.** Thermionic Relays. (*British Patent* 145630, June 30th, 1920. Convention date November 16th, 1915. Patent accepted September 1st, 1921. *Engineer*, 132, p. 387, October 7th, 1921—Abstract.)

The inter-valve transformers of a cascade amplifier are provided with a metal sheathing (*e.g.* of copper).

3082. **Siemens and Halske Akt. Gesellschaft.** Relays. (*British Patent* 145777, July 2nd, 1920. Convention date October 25th, 1916. Patent accepted April 21st, 1921.)

Relates to screening of cascade amplifiers to reduce whistling or howling.

3083. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 147853, July 9th, 1920. Convention date July 22nd, 1918. Patent not yet accepted.)

Relates to a multi-stage H.F. amplifier with filtering circuits between the valves.

3084. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Amplifiers. (*British Patent* 148183, July 9th, 1920. Convention date November 16th, 1915. Patent not yet accepted.)

Relates to the screening of inter-valve transformers of a cascade amplifier.

3085. **W. Ison.** Ex-military Wireless Apparatus. (*Everyday Science*, 3, pp. 163—165, July, 1921.)

Circuit diagrams are given of the C Mark III., C Mark IV., and A Mark IV. amplifiers.

3086. **R. Evans.** Sound and Voice Magnifiers. (*Sea, Land and Air*, 4, pp. 154—156, May 1st, 1921.)

3087. **N. H. Edes.** The Design of High-frequency Resistance Amplifiers. (*Wireless World*, 9, pp. 233—237, July 9th, 1921.)

A paper read before the Wireless Society of London. (See RADIO REVIEW, 2, p. 481, September, 1921, for Abstract.)

3088. **A. A. C. Swinton.** A Universal Amplifier Suitable for all Wavelengths. (*Wireless World*, 9, pp. 198—204, June 25th, 1921.)

A paper read before the Wireless Society of London describing a six and a two-valve amplifier with interchangeable inter-valve transformers described to the author by H. H. T. Burbury. Construction details are supplied. The discussion which followed the paper is included.

3089. **E. Hoghton** and **Portholme Aircraft Co., Ltd.** Wireless Receiving Systems. (*British Patent* 163810, February 26th, 1920. Patent accepted May 26th, 1921.)

In a high-frequency amplifier for wireless reception, one side of a variable condenser of very small capacity is connected to the grid of the first valve, whilst the other side is connected to the grid of the last H.F. amplifying valve.

3090. New Amplifying Apparatus. (*Radio News*, 2, p. 277, November, 1920.)

An illustrated description with circuit diagrams of apparatus manufactured by **A. H. Grebe & Co., Inc.**

3091. **Société Française pour l'Exploitation des Procédés Thomson-Houston.** Valve Amplifier. (*French Patent* 509843, February 12th, 1920. Published November 20th, 1920.)

A number of valve amplifiers are arranged in cascade and filters are arranged in the anode supply circuits to minimise low-frequency disturbances. The last valve of the series is tuned to pick out the second harmonic of the original frequency so as to reduce the tendency of the whole arrangement to generate oscillations by retroaction.

See also *British Patent* 150415 (RADIO REVIEW Abstract No. 3077).

3092. **Marconi's Wireless Telegraph Co., Ltd.** Receiving Apparatus. (*French Patent* 512780, March 30th, 1920. Published January 31st, 1921.)

The thermionic receiver is particularly adapted for the reception of short wavelengths, though it is stable over a large range. A flat characteristic is obtained by linking a cascade series of valves by means of air core transformers.

See also **H. J. Round** (*British Patent* 149433, and RADIO REVIEW Abstract No. 3052).

3093. **L. M. Hull.** Measurements on Audio-frequency Amplifiers. (*Wireless Age*, 8, pp. 12—16, June, 1921. *Science Abstracts*, 24B, p. 415, Abstract No. 847, August 31st, 1921—Abstract.)

This paper gives the results of a series of measurements of the voltage amplification of audio-frequency amplifiers of various types. The amplifiers dealt with were (1) a two-stage transformer-coupled amplifier with iron core transformers; (2) a two-stage amplifier with air-core transformers; (3) a four-stage resistance-coupled amplifier.

3094. **H. de A. Donisthorpe.** A Simple Form of Low-frequency Amplifier. (*Model Engineer*, 45, p. 185, September 1st, 1921.)

3095. **M. Latour.** Relay. (*French Patent* 512295, April 15th, 1916. Published January 19th 1921.)

The specification describes a method of amplifying high-frequency currents, such as are used in wireless telegraphy or telephony, by vacuum tube relays in combination with iron core transformers. To prevent arcing in the tubes the potentials of certain parts are fixed by connecting them to points on the supply battery.

For further particulars see *British Patent* 127318.

3096. A New Inter-tube Audio-frequency Amplifying Transformer. (*Wireless Age*, 8, pp. 17—18, July, 1921.)

A short description giving details of a low-frequency inter-valve transformer manufactured by the **Radio Corporation of America.**

3097. **F. J. Rumford.** Detector and Three-stage Radio-frequency Amplifier. (*Wireless Age*, 8, pp. 25—26, September, 1921.)

Gives constructional details.

3098. **A. Reisner.** A Transformer-coupled Radio-frequency Amplifier. (*Wireless Age*, 8. pp. 26—27, September, 1921.)

3099. **S. Burdett.** Two-stage Radio-frequency Amplifier. (*Wireless Age*, 8, pp. 27—30, September, 1921.)

3100. **E. H. Armstrong** A New System of Short-wave Amplification. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 3—27, February, 1921. *Sea, Land and Air*, 4, pp. 462—470, September 1st, 1921.)

The problem of receiving weak signals of short wavelength is of importance in direction finding where loop antennæ are very often used. After discussing critically the old methods of attacking this problem the author describes a method of reception developed by the Signal

Corps of the American Army. This scheme is shown diagrammatically in Fig. 6. Here LC represents the usual tuned circuit, H a separate heterodyne and D_1 a detector. The beats between the received signals and the heterodyne are arranged to be of ultra-audio or radio-frequency and after rectification by D_1 are amplified by A as such. The amplified signals are then modulated at an audio-frequency by M and the resulting oscillations rectified by D_2 and received in T.

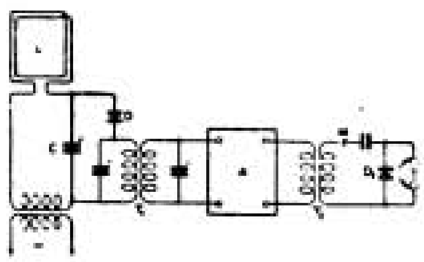

FIG. 6.

Complete triode circuits of the types of H.F. amplifiers, which have been used successfully with this method are given. (See also RADIO REVIEW Abstract No. 1668, April, 1921.)

In the discussion of the paper, a lengthy theoretical consideration of the subject is contributed by **A. S. Blatterman.**

3101. The Construction of a Frame Aerial Receiving Set. (*L'Électricité pour Tous*, 3, pp. 253—257, September 30th, 1921.)

3102. **E. O. Hulburt.** The Detecting Efficiency of the Resistance Capacity Coupled Electron Tube Amplifier. (*Physical Review*, 18, pp. 165—177, September, 1921; p. 140, August, 1921—Abstract.)

Theoretical formulæ are derived and compared with results of measurements made by using a condenser potential divider to vary the high-frequency input voltage and a sensitive galvanometer to measure the rectified high-frequency component output plate current. Satisfactory agreement was found and the effect of a third tube was determined experimentally. Curves are also given comparing the detecting efficiency of resistance coupled and tuned transformer-coupled amplifiers.

3103. **C. A. Hoxie** [General Electric Company]. Amplifying System. (*U.S. Patent* 1382914, May 10th, 1920. Patent granted June 28th, 1921.)

A multi-stage amplifier designed to avoid undesirable production of oscillatory currents in cascade amplification and to be highly selective of a particular frequency without producing an appreciable amplification of currents of other frequencies. The different stages of the amplifier have substantially no electrostatic coupling and are shielded to entirely prevent any feed-back action from an output circuit to the input circuit of a preceding stage.

3104. **S. E. Adair** [International Radio Telegraph Company]. Amplifier. (*U.S. Patent* 1383275, August 14th, 1919. Patent granted July 5th, 1921.)

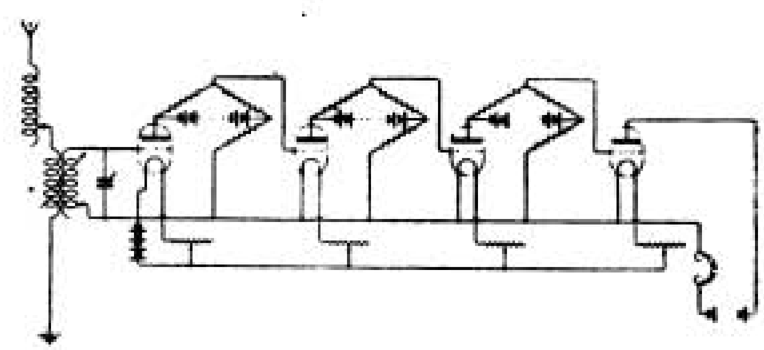

FIG. 7.

Amplifier designed to be free from oscillation disturbances which result in producing howling, and is also free from paralisation due to the production of negative charges on the grids of the tubes. In this amplifier the vacuum tubes in the several stages are connected in one branch of a series of Wheatstone bridge circuits, as indicated in Fig. 7.

3105. **M. C. A. Latour.** Amplifying Apparatus. (*U.S. Patent* 1382738, June 8th, 1918. Patent granted June 26th, 1921.)

Amplifying apparatus constructed to eliminate objectionable noises due to the setting up of oscillations. (See corresponding *British Patent* 127318, RADIO REVIEW Abstract No. 83, December, 1919.)

3106. **H. C. Harrold.** Thermionic Valves and their Application to Wireless Telegraphy. (*Signal*, 1, pp. 19—20, July; pp. 9—13, August, 1921.)

A continuation of the series of articles referred to in Abstract No. 1667, April, 1921.

3107. **G. A. Mathieu.** Thermionic Valve Amplifying Apparatus. (*British Patent* 166913, May 3rd, 1920. Patent accepted August 4th, 1921.)

Relates to the design of inter-valve transformers for multi-stage amplifiers.

3108. **Arthur Haddock** [Western Electric Company, Inc.]. Vacuum Tube Circuits. (*U.S. Patent* 1396745, May 19th, 1919. Patent granted November 15th, 1921.)

This patent relates to a multi-stage amplifier. Switching means are provided for varying the number of effective tubes between the input and output circuit of the amplifier and also for regulating the potential between the incoming line and one of the tubes. The object of the circuit is to vary the amplification to any desired degree between the input circuit and the output circuit.

3109. **L. De Forest** [De Forest Radio Telephone and Telegraph Company]. Selective Audion Amplifier. (*U.S. Patent* 1397575, April 9th, 1915. Patent granted November 22nd, 1921.)

This patent describes a vacuum tube amplifier having in its output circuit a plurality of oscillating circuits associated therewith to amplify impressed currents of certain input frequencies to a greater degree than impressed currents of other frequencies.

3110. **W. Schottky.** Hard Valve Amplifiers. Part 3. Multiple Grid Valves. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 344—371, November, 1920.)

A very full abstract by Alberti of Schottky's paper in *Archiv für Elektrotechnik*, 8, pp. 1—31, 299—328, 1919.

This part deals exclusively with valves having two grids between the filament and anode. The theory is discussed and experimental characteristics given for various types of double grid valves.*

(4) MISCELLANEOUS APPLICATIONS OF AMPLIFIERS.

3111. On the Use of Amplifiers on Submarine Cables. (*Annales des Postes, Télégraphes et Téléphones*, 10, p. 316, June, 1921.)

A brief note with regard to researches carried out by the French Postal Telegraph Administration.

3112. **K. Höpfner.** Amplifiers in Telephone Cables. (*Telegraphen- und Fernsprech-Technik*, 9, pp. 126—129, October; pp. 139—141, November, 1920. *Annales des Postes, Télégraphes et Téléphones*, 10, pp. 346—355, June, 1920—Abstract.)

3113. **V. H. Laughter.** A Method of Producing Musical or Other Suitable Notes. (*Radio News*, 2, p. 363, December, 1920.)

3114. The Installation of Amplifiers on the Brest-Dakar Cable. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 491—492, September, 1921.)

3115. Long-distance Telephony in France. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 492—500, September, 1921.)

(5) AND (8) MICROPHONIC, ETC., AMPLIFIERS; POWER AMPLIFIERS.

3116. **D. Reichinstein.** Reinforcing Direct Currents. (*British Patent* 159499, January 21st, 1921. Convention date February 25th, 1920. Patent not yet accepted.)

Relates to a combination of electrolytic cell and commutator so that the polarisation E.M.F. reinforces the feeble rectified current in a radio receiver.

3117. **D. McLennan** [Creed & Company]. Electric Relays. (*British Patent* 150025, May 14th, 1919. Patent accepted August 16th, 1920.)

A microphone relay.

3118. **G. Gatis.** Crystal Amplifier. (*Radio News*, 3, pp. 17 and 70, July, 1921.)

Describes an arrangement of a multi-stage amplifier using crystal detectors in place of valves to perform the amplification.

3119. **Gesellschaft für drahtlose Telegraphie.** Producing Electric Oscillations. (*British Patent* 147431, July 7th, 1920. Convention date December 31st, 1915. Patent accepted September 15th, 1921.)

High-frequency oscillations are produced in the output circuit of a thermionic valve containing conducting gas, by supplying oscillations of the required frequency but of small amplitude to its input circuit.

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* See RADIO REVIEW Abstracts Nos. 235, March, 1920, and 3057 in this issue for references to previous parts.

(J.) Subsidiary Wireless Apparatus.

(1) Power Supply; H.T. Batteries, etc.

3120. **K. Schmidt.** Generators for Wireless Telegraphy. (*Elektrotechnische Zeitschrift*, 42, pp. 245—249, March 17th; pp. 280—284, March 25th, 1921. *Revue Générale de l'Électricité*, 9, p. 167D, May 21st, 1921.)

A general summary of the generators both for D.C. and A.C. used in various systems of wireless telegraphy. Most consideration is given to alternators for about 500 cycles per second, the various types being discussed. Iron loss curves are given for different thicknesses of lamination at various frequencies. Photographs and particulars are given of small units intended for aircraft wireless, also of petrol-electric sets designed by the author who is the chief engineer of the Lorenz Company. In the section on radio-frequency alternators there are vague references to a greatly improved system of frequency transformation devised by the author but no details are given.

3121. **E. F. Huth.** Portable Electrical Machine. (*German Patent* 315727, May 11th, 1918.)

A portable electric generator for use in wireless telegraphy. The instrument is carried by means of shoulder straps and is worked by hand.

3122. **E. F. Huth.** Inductor Alternators. (*British Patent* 148320, July 9th, 1920. Convention date February 1st, 1916. Patent accepted July 14th, 1921.)

The exciter an inductor alternator for use for supplying W.T. apparatus on aircraft is increased in size so as to enable it to supply the lamps, searchlight, etc., on the machine. Alternatively such circuits may be fed from a special commutator winding included in the slots of the main alternator.

3123. **H. G. Wheeler.** Balance of High-speed Electric Dynamos and Motors. (*Electrician*, 87, pp. 136—138, July 29th, 1921.)

3124. **M. Héroux.** On the Use of Alternating Current for Lighting Valve Filaments. (*La Nature*, 49(2), Supplement pp. 119—120, October 15th, 1921.)

A circuit diagram is given for this purpose, the main feature being the use of a potentiometer across the valve filament, the slider being connected in the grid circuit.

3125. **A. H. Lynch.** Is the Storage Battery to be Replaced as a Source of Auxiliary Power for Marine Radio? (*Radio News*, 3, p. 280, October, 1921.)

Describes and illustrates a petrol-driven auxiliary set for use on shipboard.

3126. **K. Schmidt.** D.C. and A.C. Generators for Wireless Telegraphy. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 2—28, July, 1921.)

A general review of the various types of machines specially employed in radiotelegraphy with special reference to some of telephonic frequencies designed by the author for the Lorenz Company. Photographs, sections and characteristic curves are given for some of these machines.

(2) and (3) Transformers and Power Rectifiers.

3127. **Gesellschaft für drahtlose Telegraphie.** High-frequency Power Transformers. (*British Patent* 147754, July 8th, 1920. Convention date July 29th, 1915. Patent accepted May 12th, 1921.)

3128. **C. H. Thordarson.** Electrical Transformer. (*U.S. Patent* 1378151, November 6th, 1916. Patent granted May 17th, 1921.)

3129. **E. F. Huth.** Wireless Signalling Arrangements. (*British Patent* 149198, July 12th, 1920. Convention date October 13th, 1917. Patent not yet accepted.)

The same thermionic valve is arranged to be used either for transmitting or receiving. A commutator arrangement is provided, by which the aerial may be coupled with the plate circuit for transmitting or with the grid circuit for receiving.

3130. **L. M. Clement** [Western Electric Company]. Oscillation Generating System. (*U.S. Patent* 1395390, September 30th, 1918. Patent granted November 1st, 1921.)

The object of this invention is to provide a vacuum transmitter with means for varying the frequency of the oscillator and simultaneously to automatically provide the proper plate coupling and feed-back coupling for any particular frequency at which the oscillator is set to operate. A form of wave change switch is employed which cuts in contacts to vary the inductances in the plate circuit and likewise to change the capacity between the grid and cathode circuit of vacuum tube.

(4) POWER RECTIFIERS, ETC.

3131. **J. Kremenezky.** Electrolytic Valves. (*British Patent* 150958, September 9th, 1920. Convention date March 14th, 1918. Patent not yet accepted.)
Relates to the construction of an electrolytic rectifying valve.

3132. **Société des Ateliers de Constructions Électriques du Nord et de l'Est.** Electric Rectifier. (*British Patent* 158237, January 10th, 1921. Convention date December 13th, 1918. Patent not yet accepted.)

3133. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Valves. (*British Patent* 158458, January 19th, 1920. Patent accepted February 10th. 1921.)
The rectifying valve has an anode and an incandescent tungsten cathode in a filling consisting mostly of helium.

3134. **J. Slepian** and **E. Justin** [Metropolitan-Vickers Electrical Company]. Electrolytic Rectifier. (*British Patent* 155579, December 2nd, 1920. Convention date December 9th, 1919. Patent not yet accepted.)

3135. **Naamlooze Vennootschap Philips' Gloeilampenfabrieken.** Thermionic Valve Rectifiers. (*British Patent* 154872, May 8th, 1920. Convention date December 2nd, 1919. Patent accepted May 5th, 1921.)
All the electrodes of the rectifier are in the form of filaments so that if one is burnt out it can subsequently be used as an anode.

3136. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Electric Discharge Apparatus. (*British Patent* 152694, March 4th, 1916. Patent accepted October 28th, 1920.)
Relates to rectifying and similar apparatus in which the cathode is maintained incandescent by an arc discharge inside the tube, which is filled with mercury or similar vapour, or with an inert gas.

3137. **Siemens-Schuckertwerke.** Rectifiers. (*British Patent* 145029, June 14th, 1920. Convention date May 15th, 1919. Patent accepted February 3rd, 1921.)
An addition to *British Patent* 142465 * relating to the use of A.C. of 500 to 5,000 ~, and to the heating of the valve filament from the same A.C. source.

3138. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Rectifier (*French Patent* 507198, December 9th, 1919. Published September 7th, 1920.)
The rectifier has a current and pressure range similar to those of mercury vapour rectifiers. It consists of a glass envelope containing a heated refractory cathode, and one or more anodes of large heat-dissipating capacity. The glass envelope contains an inert gas such as nitrogen, argon or neon. See also *British Patent* 5557/1915.

3139. **J. F. G. P. Hartmann.** Rectifier for Alternating Current. (*French Patent* 508996, March 20th, 1919. Published October 28th, 1920. *British Patent* 130936, April 19th, 1919. Convention date November 14th, 1918. Patent accepted August 14th, 1919.)
The patent is based on a corresponding Danish patent, and describes a rectifier for alternating current of the mercury jet type.

3140. **Siemens-Schuckertwerke.** Rectifying Apparatus. (*British Patent* 145423, June 17th, 1920. Convention date October 23rd, 1915. Patent accepted September 15th, 1921.

3141. **Brown, Boveri et Cie. Akt. Gesellschaft.** Converting Electric Currents. (*British Patent* 151612, September 22nd, 1920. Convention date September 22nd, 1919. Patent not yet accepted.)
Rectifier apparatus.

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* RADIO REVIEW Abstract No. 809, September, 1920.

3142. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Electric Discharge Devices. (*British Patent* 157041, March 4th, 1916. Patent accepted January 20th, 1921.)

The cathode of a rectifier is maintained incandescent by the discharge itself.

3143. **Siemens-Schuckertwerke.** Rectifiers. (*British Patent* 145481, June 21st, 1920. Convention date June 10th, 1916. Patent accepted November 4th, 1920.)

3144. **Siemens-Schuckertwerke.** Rectifier. (*British Patent* 145677, June 30th, 1920. Convention date October 29th, 1915. Patent accepted September 30th, 1921.)

3145. **A. W. Hull** [British Thomson-Houston Company]. Converting Electric Currents. (*British Patent* 148129, July 9th, 1920. Convention date December 22nd, 1915. Patent accepted September 22nd, 1921.)

A constant potential direct current is obtained from a variable voltage source by means of series and shunt devices which offer respectively high and low impedances to the alternating components of the current.

3146. **Brown, Boveri et Cie. Akt. Gesellschaft.** Rectifiers. (*British Patent* 163686, April 4th, 1921. Convention date May 15th, 1920. Patent not yet accepted.)

3147. **D. R. Clemons.** A New Device to obtain A.C. from a D.C. Source. (*Radio News*, 2, p. 771, May, 1921.)

A rotary variable resistance arrangement.

3148. **R. Vallette.** Converting Electric Currents. (*British Patent* 164721, May 2nd, 1921. Convention date June 20th, 1920. Patent not yet accepted.)

Alternating currents are rectified by means of a thermionic valve in series with a condenser. The alternating current serves to heat the valve filament through a transformer. The alternating current may be supplied to the valve either directly or through a transformer. A condenser is placed in shunt with the direct current supply terminals.

3149. **W. J. L. Chinn.** Rectifier. (*French Patent* 512527, March 29th, 1920. Published January 25th, 1921.)

This specification describes a mercury vapour rectifier.

3150. **Siemens Schuckertwerke.** Rectifiers. (*French Patent* 512518, March 29th, 1920. Published January 25th, 1920.)

This specification describes a high-tension rectifier for alternating currents.

3151. **Siemens Schuckertwerke.** Rectifiers. (*French Patent* 512517, March 29th, 1920. Published January 25th, 1920.)

This specification describes a high-tension rectifier for alternating currents.

3152. A New Rectifier Scheme. (*Q.S.T.*, 5, pp. 23—24, September, 1921.)

Describes an electrolytic rectifier with sliding condensers.

3153. **T. W. Benson.** Construction of a Synchronous Rectifier. (*Wireless Age*, 8, pp. 22—23, April, 1921.)

3154. **W. T. Birdsall** [Westinghouse Lamp Company]. Vacuum Rectifier. (*U.S. Patent* 1388793, January 5th, 1917. Patent granted August 23rd, 1921.)

A vacuum type converter wherein the discharge is not dependent upon an auxiliary heating current through a filamentary cathode. The discharge is maintained by virtue of electron emission and operates in the absence of auxiliary means for maintaining one or more electrodes at an electron-emitting temperature. The apparatus comprises two filamentary electrodes, means for supplying either a direct or alternating current across the electrodes and means for initially passing a heating current through each of the electrodes until they are brought to an electron-emitting temperature.

3155. **H. H. Smith.** The Hulbert Transrectiformer. (*Radio News*, 3, p. 294, October, 1921.)

(5) Choke Coils and Protective Apparatus.

3156. **G. Faccioli** and **H. G. Brinton.** High-frequency Absorbers. (*General Electric Review*, 24, pp. 444—454, May; pp. 656—658, July, 1921.)

The article discusses the effect of resistance in series with a condenser for use as a "high-frequency absorber." It is shown that such an absorber is a valuable adjunct to a lightning arrester for protection against transient disturbances which are of too low a voltage to spark over the arrester but which would otherwise be dangerous on account of their steep wave-front. The second part of the article discusses the similar case of resistance and inductance in series.

3157. **J. Bethenod.** On the Design of Filters and Choke Coils. (*Radioélectricité*, 1, pp. 629—632, June; 2, p. 11, July, 1921. *Annales des Postes, Télégraphes et Téléphones*, 10 pp. 510—518, September, 1921.)

A mathematical discussion of the design of iron core choke coils and protective devices used for stopping the passage of high-frequency currents in the circuit. Two cases are considered: (1) given the dimensions of the iron core to determine the number of turns which will produce the maximum self-inductance when a given steady continuous current is flowing through the winding; and (2) given the dimensions of the iron core and the number of turns on the winding to determine the air gap which will give the maximum self-inductance when a given continuous current is traversing the winding.

3158. **S. Edgar.** A Common Cause of Induction from the Ship's Dynamo and its Remedy. (*Radio News*, 3, p. 286, October, 1921.)

(6) TELEPHONES, AND TELEPHONE TRANSFORMERS.

3159. **S. Hockly.** Telephone Receivers and Transmitters. (*British Patent* 161241, December 29th, 1919. Patent accepted March 29th, 1921.)

Relates to constructional details of telephones and microphones.

3160. **V. F. Feeny** [Magnavox Company]. Telephone Transmitters. (*British Patent* 161277, January 6th, 1920. Patent accepted March 6th, 1921.).

Relates to a transmitter in which both sides of the diaphragm are exposed to the sound waves.

3161. **H. P. Rees.** Telephone Receivers. (*British Patent* 150956, April 15th, 1920. Patent accepted September 16th, 1920.)

Relates to receiving telephones having the windings tapped to adjust the number of turns in circuit.

3162. **A. Johnsen** and **K. Rahbek.** Electrostatic Attraction. (*Electrical Industries*, 21, p. 658, May 25th, 1921. *Electrical Review*, 88, p. 722, June 3rd, 1921. *Engineer*, 131, p. 597, June 3rd, 1921.)

An abstract of a lecture delivered before the Institution of Electrical Engineers. (See RADIO REVIEW, 2, p. 373, July, 1921.)

3163. **A. A. Campbell Swinton.** The Johnsen-Rahbek Electrostatic Loud-speaking Telephone and Relay. (*Electrical Review*, 88, p. 710, June 3rd, 1921.)

Discussion *re* matter referred to in Abstract No. 3162, and pointing out prior discovery of the phenomenon by Elisha Gray.

3164. Electrostatic Adhesion. (*Electrical Review*, 88, p. 721, June 3rd, 1921. Also pp. 744—745, June 10th, 1921.)

Extracts from an article by **W. H. Preece** in the *Telegraphic Journal* of September 1st, 1877, dealing with experiments of Elisha Gray; also from same journal of April 1st, 1879, describing Edison's telephone receiver. (See RADIO REVIEW Abstracts Nos. 3162 and 3163.)

3165. The Johnsen-Rahbek Effect. (*Engineer*, 131, p. 614, June 10th, 1921. *The Times Engineering Supplement*, 17, No. 560, p. 197, June, 1921. *La Nature*, 49(2), pp. 87—88, August 6th, 1921—Abstract. *Engineering*, 111, pp. 685—686, June 3rd, 1921. *Nature*, 107, p. 439, June 2nd, 1921—Abstract. *Radio Nieuws*, 4, pp. 232—233, August, 1921—Abstract. *Radio Review*, 2, p. 373, July, 1921—Abstract. *Radio News*, 3, p. 286, October, 1921—Abstract.)

A summary of the comments made about this effect (RADIO REVIEW Abstracts Nos. 3162, 3163, 3164.)

3166. **R. Appleyard.** Retentive Force and a Tale of a Tub. (*Electrical Review*, 88, p. 748, June 10th, 1921; also *The Times*, No. 42733, p. 5, May 30th, 1921.)

Further correspondence with reference to Johnsen and Rahbek's telephone, the author's experiments, Edison's telephone receiver and Elisha Gray's experiments. (See also RADIO REVIEW Abstracts 3162, 3163, 3164, 3165, 3179, in this issue.)

3167. **W. F. Barrett.** A New Electric Device. (*The Times*, No. 42734, p. 6, May 31st, 1921.)
Correspondence *re* Johnsen and Rahbek's electrostatic telephone, and some experiments of the author made in 1880.

3168. **C. Kearton** and **G. B. Riley.** Telephone Receivers. (*British Patent* 159776, December 19th, 1919. Patent accepted March 10th, 1921.)

3169. **Siemens and Halske.** Telephones. (*British Patent* 159897, March 9th, 1921. Convention date March 9th, 1920. Patent not yet accepted.)
A loud-speaking receiver also applicable to under-water signalling.

3170. **Siemens and Halske.** Telephones. (*British Patent* 159904, March 10th, 1921. Convention date March 10th, 1920. Patent not yet accepted.)
Constructional details of a loud-speaking telephone.

3171. **R. L. Murray** [Telephone Manufacturing Company]. Telephones. (*British Patent* 160243, December 13th, 1919. Patent accepted March 14th, 1921.)

3172. **G. Seibt.** Telephone Receiver. (*British Patent* 147153, July 7th, 1920. Convention date March 1st, 1916. Patent not yet accepted.)
A special construction for the pole pieces.

3173. **The Magnavox Company.** Telephone Transmitter. (*French Patent* 508443, January 15th, 1920. Published October 11th, 1920.)
The transmitter has both sides of the diaphragm exposed to sound and the plane of the electrodes is oblique to that of the diaphragm, so that the transmitter operates in either a vertical or horizontal position.
See also *British Patent* 161277 (RADIO REVIEW Abstract No. 3160.)

3174. **K. Rahbek** and **F. A. Johnsen.** Telephonic Apparatus. (*British Patent* 146747, September 6th, 1919. Patent accepted July 15th, 1920.)
An addition to *British Patent* 144761, covering loud-speaking telephones of the type described in RADIO REVIEW, p. 373, July, 1921.

3175. **K. Rahbek** and **F. A. Johnsen.** Telephones. (*British Patent* 144761, March 6th, 1919. Patent accepted June 7th, 1920.)
Relates to electrostatic loud-speaking telephones of the type described in RADIO REVIEW, 2, p. 373, July, 1921.

3176. **J. H. Dellinger.** The Radio Work of the Department of Commerce. (*Q.S.T.*, 4, pp. 18—21, June, 1921.)
An account of the work of the U.S. Radio Inspection Service and the Bureau of Standards.

3177. **J. Valasek.** Piezo-electric and Allied Phenomena in Rochelle Salt. (*Physical Review*, 17, pp. 475—481, April, 1921. *Science Abstracts*, 24A, p. 448, Abstract No. 1152, June 30th, 1921—Abstract.)

3178. **P. R. Coursey.** Loud-speaking Telephones—II. (*Wireless World*, 9, pp. 225—228, July 9th; pp. 256—261, July 23rd; pp. 289—292, August 6th; pp. 311—314, August 20th, 1921.)
A general consideration of electrostatic attraction effects and their application to sound production culminating in a description of the apparatus of **A. Johnsen** and **K. Rahbek.**

3179. **A. Johnsen** and **K. Rahbek.** A New Electrostatic Phenomenon and its Applications. (*Elektroteknisk Tidsskrift*, 33, pp. 269—272, November 25th, 1920.)
A description of the electrostatic adhesion effects referred to on p. 373 of the July, 1921, issue of the RADIO REVIEW together with some of their applications (see also below).

3180. **A. Gradenwitz.** A New Phenomenon of Electrical Attraction. (*Popular Science Monthly*, 99, p. 26, July, 1921.)
Deals with the Johnsen and Rahbek apparatus. (See RADIO REVIEW Abstracts Nos. 3162, 3163, 3164, 3165, 3174, 3175. 3178 and 3179.)

3181. **J. Corver.** The Magnavox Loud-speaking Telephone Receiver. (*Radio Nieuws*, 4, pp. 75—77, March, 1921.)
This American apparatus consists of a pot electromagnet in the circular gap of which is the moving coil carrying the speech current and fixed to the centre of the diaphragm.

3182. The Electro-dynamic Receiver. (*Radio News*, 2, p. 434, January, 1921.)
An illustrated description of the Magnavox loud-speaking telephone.

3183. **C. Stille.** Telephone Receivers. (*British Patent* 10669/1915, July 22nd, 1915. Addition to *British Patent* 9644/1913, dated April 24th, 1912. Patent published July 11th, 1921.)
A pneumatic relay arrangement operated by a telephone receiver.

3184. "The Phonetron." (*Radio News*, 3, p. 13, July, 1921.)
A short note describing a new pattern of loud-speaking telephone.

3185. The Vocaloud. (*Radio News*, 3, p. 102, August, 1921.)
A short note describing and illustrating a new pattern of loud-speaking telephone.

3186. **J. Brun.** Telephone Receivers for Radio Purposes. (*Radioélectricité*, 2, pp. 6—11 July, 1921.)
Descriptions are given of various patterns of telephone receiver.

3187. Loud-speaking Telephone Equipment. (*Science and Invention*, 9, p. 320, August, 1921. *Electrical World*, 78, p. 156, July 23rd, 1921.)
An illustration of a multiple horn loud-speaking apparatus mounted on a tower. The energy of the amplification is said to be 10^{10}. An illustration and circuit diagram of the valve amplifying apparatus are also given.

3188. **P. R. Coursey.** The Piezo-electric Properties of Rochelle Salt Crystals. (*Radio Review*, 2, pp. 480—481, September, 1921.)

3189. **R. Atkinson.** Operating Notes on Electrolytic Rectifiers. (*Q.S.T.*, 5, p. 27, September, 1921.)

3190. **H. Marchand.** The Magnavox. (*La Nature*, 49, pp. 252—254, October 15th, 1921—Abstract.)
See RADIO REVIEW Abstract No. 1178, November, 1920.

3191. **C. T. Zahn.** The High-frequency Impedance of Radio Telephone Receivers. (*Physical Review*, 18, p. 150, August, 1921.)
An abstract of a paper read before the American Physical Society giving the results of measurements on various types of head telephone receivers. It was found that for all receivers there was a critical frequency where the reactance changed sign and near which the resistance was a maximum. This critical frequency varied between 8,000 and 50,000 cycles per second the maximum values of resistance and capacity being of the order of 100,000 ohms.

(7) MATERIALS FOR CONSTRUCTION OF RADIO APPARATUS.

3192. **B. Speed** and **C. W. Elmen.** Magnetic Properties of Compressed Powdered Iron. (*Journal of the American Institute of Electrical Engineers*, 40, pp. 594—609, July, 1921. *Science Abstracts*, 24B, p. 432, Abstract No. 874, September 30th, 1921—Abstract.)
Discusses the manufacture and measurement of the magnetic properties of cores constructed of compressed powdered iron for use in inductances and transformers.

3193. **G. B. Crouse** and **I. H. Mills.** Receiving Panel. (*U.S. Patent* 1370093, March 10th, 1919. Patent granted March 1st, 1921.)

3194. **W. Steinhaus.** Dielectric Losses in Colophonium, Wax, and Similar Materials. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 29—33, July, 1921. *Science Abstracts*, 24B, pp. 463—464, Abstract No. 429, September 30th, 1921—Abstract.)

3195. **H. H. Poole.** On the Electrical Conductivity of some Dielectrics. (*Philosophical Magazine*, 42, pp. 488—501, October, 1921.)
A method is described of testing the conductivity by rectified high voltage currents. Results are given for mica, glass, paraffin wax, shellac and celluloid.

3196. **W. Steinhaus.** The Dielectric Losses in Resin, Wax, and Similar Substances. (*Jahrbuch Zeitschrift für drahtlose Telegraphie und Telephonie*, 18, pp. 29—33, July, 1921.)
Results of experiments made in 1916 under M. Wien to discover the cause of the great losses in glass condensers made with specially good glass. The cause was found in the wax

which was employed to prevent brush discharge from the edges of the electrodes. The losses in various waxes were then determined by finding the decrement of a condenser made up with the material as dielectric. In many materials the losses were found to increase very rapidly with increasing temperature until the melting point was reached, when the losses fell to a very small value. Paraffin and ozokerite do not show this phenomenon.

3197. **E. Schott.** High-frequency Losses in Glass and some other Dielectrics. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 82—122, August, 1921.)

A very thorough investigation of the losses at radio frequencies in condensers made up with various qualities of glass. Every care appears to have been taken to avoid experimental errors. The loss expressed as an angle varies from 22·6 to 1·39 minutes in various qualities of glass. Approximate compositions of the glasses are given. The losses are greatest in those containing large percentages of sodium and potassium. Some other dielectrics were tried and the author gives the following table: glass 1·5′ to 25′ (highest value 90′), quartz 0·4′, good mica 0·6′, reconstructed amber 18′, presspahn about 100′. The effects of variations of frequency and temperature were also investigated and curves are given of the results.

(9) RESISTANCES FOR VALVE CIRCUITS, ETC.

3198. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Resistance. (*French Patent* 509747, November 9th, 1918. Published November 18th, 1920.)

The specification describes a method of manufacturing high resistance units of constant value. The resistance comprises a film of conducting material on the interior of an exhausted glass tube. The film is produced by volatilising a metal within the tube. Wires are sealed in the tube to form connecting terminals.

3199. **F. Pellin** and **G. Pelletier.** Electric Resistances. (*British Patent* 165099, June 2nd, 1921. Convention date June 22nd, 1920. Patent not yet accepted.)

Non-inductive resistances of predetermined value are prepared by depositing a thin layer of metal on an insulating support by cathodic bombardment in a vacuum.

3200. **P. H. Boucheron.** Concerning Grid Leaks.* (*Wireless Age*, 8, p. 15, April, 1921.)

Emphasises the importance of the proper resistance of the grid leak and sets out various standardised values.

3201. A Constant Resistance Unit. (*Wireless Age*, 8, p. 32, July, 1921.)

The resistance unit described can be constructed for practically any value between 1 ohm and 1 megohm. It consists of a thin film of platinum and gold deposited chemically on a strip of clear mica.

(10) SPEED REGULATING APPARATUS FOR H.F. MACHINES.

3202. A Sensitive Governor for Electric Motors driving High-frequency Alternators. (*Zeitschrift des Vereines deutsche Ingenieure*, 65, p. 598, June 4th, 1921.)

A short description of a relay governing arrangement.

3203. **Dornig** and **Kühn.** Speed Regulation of Motors driving Radio-frequency Alternators. (*Elektrotechnische Zeitschrift*, 42, p. 1019, September 8th, 1921.)

Correspondence concerning priority in the development of the frequency doubling transformer and of the centrifugal speed regulator.

3204. **E. F. W. Alexanderson** [General Electric Company]. System of Radio Communication. (*U.S. Patent* 1400847, December 31st, 1918. Patent granted December 20th, 1921.)

This patent shows a speed regulating mechanism for a high-frequency alternator employed at the transmitter in a radio system. The high-frequency alternator shown in the drawings is driven by a three-phase electric motor supplied with power from a distribution system, and a regulator relay is employed to control the power delivered to the shaft of the alternator. The regulator comprises a tuned circuit energised by current derived from the high-frequency alternator. A rectifier is associated with the tuned circuit and delivers rectified current to the relay for controlling the power to the motor. Various means are described for amplifying the variations of energy acting upon the regulator relay whereby great sensitivity is obtained to maintain constant the speed of the alternator.

(11) AND (12) ACCESSORIES FOR RADIO CIRCUITS.

3205. **Gesellschaft für drahtlose Telegraphie.** Conductors for H.F. Currents. (*British Patent* 147447, July 7th, 1920. Convention date May 28th, 1919. Patent accepted April 7th, 1921.)

3206. **A. K. Macrorie** and **H. Morris-Airey.** Holders for Thermionic Valves. (*British Patent* 162772, February 2nd, 1920. Patent accepted May 2nd, 1921.)

3207. **H. P. Doule** [Connecticut Telephone and Electric Company]. Vacuum Tube Base. (*U.S. Patent* 1374832, September 27th, 1919. Patent granted April 12th, 1921.)

3208. **R. F. Gowens** [De Forest Radio Telephone and Telegraph Company]. Inductance Coil Mounting. (*U.S. Patent* 1365170, August 20th, 1919. Patent granted January 11th, 1921.)

3209. **R. M. Allen** [Western Electric Company]. Mounting for Vacuum Tubes. (*U.S. Patent* 1401121, May 24th, 1918. Patent granted December 27th, 1921.)

This invention relates to a resilient support for vacuum tubes to reduce the effect of an external vibration upon the structure of the tube.

(K.) Aerials and Earthing Systems.

(1) GENERAL.

3210. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Aerials. (*French Patent* 507653, December 23rd, 1919. Published September 21st, 1920.)

The aerial is of the type having horizontal wires and these are grounded through additional vertical wires. The generator is an oscillating arc generator and the ground connections comprise a wire network mounted a short distance above the earth. See also *British Patent* 144075 (RADIO REVIEW Abstract No. 2037, July, 1921).

3211. **C. S. Franklin.** Aerials. (*British Patent* 155330, August 14th, 1919. Patent accepted December 14th, 1920.)

Relates to the tuning of a distant loop aerial by the use of a series of tight-coupled untuned circuits between the distant aerial and the tuning station. Earthed screens are used between the coupling transformers to prevent oscillations being set up on the connecting circuits.

3212. **Gesellschaft für drahtlose Telegraphie.** Wireless Transmitters. (*British Patent* 148180, July 9th, 1920. Convention date November 6th, 1918. Patent not yet accepted.)

A filtering circuit to eliminate harmonics from the transmitted waves.

3213. **H. J. Round.** Wireless Signalling. (*British Patent* 164506, March 11th, 1920. Patent accepted June 13th, 1921. *Engineering*, 123, p. 81, July 15th, 1921—Abstract.)

An arrangement for counterbalancing automatically the variations in the wavelength of an aerial due to such causes as swinging in the wind during transmission.

3214. **H. de A. Donisthorpe.** Some Notes on Aerial and Earth Systems. (*Model Engineer*, 45, pp. 160—161, August 25th, 1921.)

3215. **M. Buchbinder.** The Effect of Counterpoise on Antenna Resistance. (*Radio News*, 3, p. 197, September, 1921.)

3216. **C. M. Grabson.** A Study of the Antenna System. (*Radio News*, 3, p. 290, October, 1921.)

3217. **H. J. Round** [Radio Corporation of America]. Wireless Signalling Apparatus. (*U.S Patent* 1 95987, March 24th, 1921. Patent granted November 1st, 1921.)

The object of this invention is to provide means whereby the wavelength of a radio transmitter may be kept constant automatically. The antenna circuit and the closed oscillator circuit of the transmitter is combined with a small rotating field motor comprising two windings. One winding is connected in the closed circuit and the other winding in the antenna circuit or in any circuit whose period varies with that of the antenna. When the antenna is exactly in tune with the closed circuit there will be no rotating field produced by the two windings at right angles, but if the antenna increases its wavelength then the phase of the antenna current will tend to produce a rotating field in one direction whereas if the antenna decreases its wavelength the rotating field will be in the other direction. The rotation of the shaft of the armature of the rotating field motor controls a variometer, a variable condenser, or other means for varying the period of the antenna. Thus when the antenna increases its wavelength the variometer decreases it until there is no longer any rotating field and *vice versa*, so that the wavelength of the antenna is kept practically constant. The system is intended for all types of sets such as a vacuum tube transmitter, an alternator, or an arc transmitter.

(2) ELEVATED AERIALS.

3218. **W. Reiss.** The Directional Effect of the Marconi Bent Antenna. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 294—299, April, 1921. *Science Abstracts*, 24B, p. 313, June 30th, 1921—Abstract. *Radioélectricité*, 2, p. 3D, July, 1921—Abstract.)

Experiments were made at Lärz in Mecklenburg with two identical bent aerials arranged back to back, *i.e.*, pointing in opposite directions. A valve transmitter was normally coupled to one of them, but by means of a rotating switch this aerial was disconnected and the other one connected in its stead in such a way that one aerial sent the signals and the other the spaces. The adjustments were made so that 1·5 km away broadside-on a continuous dash was heard. Observations at an end-on station 30 km away were then made at various wavelengths. Here also a continuous dash was received, although on inserting 15 ohms in one aerial and thus reducing its current 5 per cent. the signals could be distinguished. The conclusion is drawn that if there is any difference in the radiation in the two directions it does not exceed 3 per cent.

3219. **S. R. Winters.** A Condenser Type Wireless Antenna. (*Wireless Age*, 8, pp. 11—14, April; also p. 13, September, 1921. *Technical Review*, 9, p. 158, June 7th, 1921—Abstract. *Radioélectricité*, 2, p. 13D, August, 1921—Abstract.)

3220. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Aerial Structures. (*British Patent* 152422, July 14th, 1919. Patent accepted October 14th, 1921.)

Relates to means for thawing sleet and snow on aerial wires by the application of A.C. heating current. The arrangements are particularly applicable to multiple aerials provided with several ground connections.

3221. **G. O. Squier.** Aerials. (*British Patent* 149917, August 3rd, 1920. Convention date August 3rd, 1919. Patent not yet accepted.)

Covers the use of trees, etc., to form wireless aerials.

3222. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Aerials. (*French Patent* 512209, January 13th, 1920. Published January 18th, 1921.)

For thawing sleet and ice from aerials, heating current is supplied thereto. An arrangement for doing this is described. (See also *British Patent* 152422, RADIO REVIEW Abstract No. 3220.)

3223. **A. Hund.** Formulæ for the Real and Effective Constants of a Horizontal Antenna. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 349—368, May, 1921. *Science Abstracts*, 24B, p. 364, Abstract No. 751, July 30th, 1921—Abstract.)

Develops the known formulæ for the effective inductance and capacity of an aerial. Only the simple case of a uniform horizontal antenna is considered.

3224. **G. W. Grauel.** An Ideal Cage Antenna and Counterpoise Ground. (*Wireless Age*, 8, pp. 25—26, July, 1921.)

3225. **G. J. Smith.** A Practical Cage Antenna. (*Wireless Age*, 8, pp. 26—27, July, 1921.)

3226. **G. F. Patrick.** Cage Aerials and Counterpoise Grounds. (*Wireless Age*, 8, p. 27, July, 1921.)

3227. **M. I. Pupin** and **E. H. Armstrong.** Multiple Antenna for Electrical Wave Transmission. (*U.S. Patent* 1388441, October 1st, 1915. Patent granted August 23rd, 1921.)

Multiple antenna for electrical wave transmission screened against the disturbing effects of electrical impulses of short duration. A receiving antenna, of such high resistance as to effectively screen the system against disturbing electromagnetic waves impressed upon the conductor, is employed in inductive relation with a low-resistance antenna which serves as a screen protecting the high-resistance antenna against electromagnetic pulses of short duration.

3228. **C. S. Franklin** [Radio Corporation of America]. Aerial System for Wireless Signalling. (*U.S. Patent* 1370735, September 30th, 1920. Patent granted March 8th, 1921.)
See corresponding *British Patent* 158927, RADIO REVIEW Abstract No. 3231.

(3) LOOP OR COIL AERIALS.

3229. **Société Française Radio-électrique.** (*British Patent* 146204, June 26th, 1920. Convention date November 3rd, 1916. Patent accepted July 28th, 1921. *British Patent* 148954, July 10th, 1920. Convention date November 3rd, 1916. Patent not yet accepted.)

These two specifications are identical, and deal with coil aerials for reception or transmission having their turns arranged in groups which may be connected in series or in parallel so as to tune the aerial to the wavelength employed. Capacities may be distributed along the turns of the aerial to reduce its wavelength. The transformation ratio of the first trans former of a high-frequency amplifier used with the apparatus may be similarly varied.

A form of aerial consisting of two horizontal plates is also described.

3230. **H. J. Round** and **G. M. Wright.** Aerials for Directive Signalling. (*British Patent* 149066, May 6th, 1919. Patent accepted August 6th, 1920.)

In order to avoid accurate tuning of the aerials of the Bellini-Tosi type the mutual inductance between the field and moving coils of the radiogoniometer is made as large as possible so that the loops themselves can be aperiodic. The necessary tuning is effected in the circuit of the moving coil of the radiogoniometer.

3231. **C. S. Franklin.** Uni-directional Wireless Reception. (*British Patent* 158927, September 24th, 1919. Patent accepted February 24th, 1921. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 226—227, September, 1921—Abstract.)

Two or more uni-directional receiving systems of the type described in *British Patents* 24098/1914 and 5783/1915 are spaced a fraction of a wavelength apart in the direction of the signals to be received. Oscillations in these two systems are combined by suitable phasing circuits with a common receiver. Each system is arranged to give a similar polar curve, and the resulting curve obtained by combining the two systems is better than either taken separately and gives almost zero reception in one direction (behind the station). Examples using four frame aerials in one plane, or four sets of two frame aerials at right angles in conjunction with radiogoniometers are mentioned as particularly suitable for duplex working as zero reception can be secured in six different directions.

3232. **C. S. Franklin, W. J. Picken,** and **J. G. Robb.** Aerials for Wireless Reception. (*British Patent* 159003, November 17th, 1919. Patent accepted February 17th, 1921.)

A modification of the arrangements described in RADIO REVIEW Abstract No. 3231, consisting of the addition of non-directive aerials to give more pronounced uni-directional results when combined with the directive aerials.

3233. **Gesellschaft für drahtlose Telegraphie.** Direction Finding Apparatus. (*British Patent* 147755, July 8th, 1920. Convention date June 3rd, 1918. Patent not yet accepted.)

An addition to *British Patent* 145629. One or both ends of the receiving frame aerial or amplifier may be earthed through condensers, or resistances, for increasing the energy absorbed by the receiving apparatus.

3234. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Aerials. (*French Patent* 509305, January 31st, 1920. Published November 6th, 1920.)

The receiving conductor for directive working consists of a coil having a large number of turns of insulated wire placed over copper sheets or coils having low impedance. The coil is mounted so as to be rotatable. (See also *British Patent* 127675, RADIO REVIEW Abstract No. 43, November, 1919.)

3235. **S. R. Winters.** The Resonance Wave-coil. (*Radio News*, 2, p. 766 and 822—823, May, 1921.)

A description of the mode of operation of long helix coils for receiving wireless signals, with illustrations of some apparatus used for this purpose at the U.S. Signal Corps Research Laboratory.

3236. Recent Developments in Loop Aerials. (*Radio News*, 2, p. 775, May, 1921.)

Describes various arrangements for screening receiving loop aerials including their use buried in the ground.

3237. **R. E. Lecault.** The Loop Aerial and its Application. (*Science and Invention*, 9, pp. 152—153, June, 1921.)

An illustrated description of some French loop aerial and amplifier installations.

3238. **H. K. Sandell** [Herbert S. Mills]. Wireless Transmitting System. (*U.S. Patent* 1391855, November 28th, 1919. Patent granted September 27th, 1921.)

A system employing a vacuum tube oscillator circuit having a loop antenna series connected in the input circuit of the oscillator and rotatably mounted and another loop antenna in series with the output circuit of the oscillator and arranged in proximity to the first-mentioned loop. In the circuit illustrated in the patent the oscillator is modulated by a telephone transmitter connected in the input circuit.

3239. **F. A. Kolster.** Apparatus for Transmitting Radiant Energy. (*U.S. Patent* 1394560, November 27th, 1916. Patent granted October 25th, 1921.)

A transmitter comprising a closed radiating circuit including a coil inductance and a capacity made up of large separated areas and serving with the inductance as radiating elements. The circuit is placed in oscillation by coupling a source of either damped or sustained energy to the system modulated in accordance with the signals.

3240. **W. H. F. Griffiths.** Frame Aerial Reception. (*Wireless World*, 9, pp. 195—197, June 25th, 1921.)

Some theoretical notes on reception with frame aerials.

3241. **J. O. Mauborgne** and **G. Hill.** Transmitting Aerials. (*British Patent* 165038, June 16th, 1921. Convention date June 16th, 1920. Patent not yet accepted.)

Relates to arrangements of helixes or "resonance coils" for transmission apparatus.

3242. **J. O. Mauborgne** and **G. Hill.** Resonance Wave-coil Antennæ. (*Science and Invention*, 9, pp, 348 and 385, August ; pp. 444 and 474, September, 1921.)

An illustrated description of the development of resonance wave-coil receiving antennæ with circuit diagrams of the amplifying apparatus used with them.

3243. **A. A. Campbell Swinton.** The Reception of Wireless Waves on a Shielded Frame Aerial. (*Philosophical Magazine*, 42, pp. 502—506, October, 1921. *Electrical Review*, 89, p. 356, September 9th, 1921—Abstract. *Engineering*, 112, p. 434, September 23rd, 1921—Abstract. *Electrician*, 87, p. 353, September 16th, 1921—Abstract. *English Mechanic*, 114, p. 120, September 30th, 1921—Abstract. *Chemical News*, 123, p. 189, October 7th, 1921—Abstract.)

See RADIO REVIEW, 2, pp. 545—547, October, 1921.

3244. **S. R. Winters.** A New Type of Condenser Antenna. (*Wireless Age*, 8, pp. 11—14, April, 1921.)

Describes experiments carried out at the Bureau of Standards on an aerial consisting of two parallel metallic plates arranged in either a horizontal or vertical plane. Photographs and circuit diagrams are given of the arrangement of the apparatus. Experimental measurements of the resistance and directional properties (polar curves) are set out and it is concluded that this type of antenna should be particularly promising both for the reception and transmission of short waves.

3245. **H. de A. Donisthorpe.** An Efficient Frame Aerial System. (*Model Engineer*, 45, pp. 335—336, October 28th, 1921.)

Gives constructional details.

(4), (5) AND (6) BURIED AERIALS ; AIRCRAFT AND SUBMARINE AERIALS.

3246. **Peperkorn.** Earth Antennæ and their Use during the War in German East Africa. *Telegraphen- und Fernsprech-Technik*, 10, pp. 36—41, April; pp. 55—60, May, 1921. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 300—305, April, 1921—Abstract. *Elektrotechnische Zeitschrift*, 42, pp. 440—441, April 28th, 1921—Abstract. *Radio-électricité*, 1, p. 139D, June; and p. 19D, September, 1921—Abstract.)

An interesting account of the successful use of long horizontal wires suspended a few feet above the ground. When oscillating at their fundamental there was little directive effect, but if made longer so that the signal wave was a harmonic of the aerial wire the directive action was very pronounced and enabled interference from other stations to be avoided.

To their surprise these so-called earth aerials gave better signals from Europe than were obtained on the 100-metre umbrella antenna at Dar-es-salam. The possibility of rapid construction and removal and the invisibility of this type of aerial are great advantages in time of war. Many details of experiments with various arrangements of the wires are given in the paper. (See also RADIO REVIEW, 2, p. 281, June, 1921.)

3247. **Signal Gesellschaft m.b.H.** Subaqueous Telegraphy. (*French Patent* 510605, January 9th, 1915. Published December 18th, 1920.)

Ships and stations located near the water are provided with submerged antennæ and such a frequency is employed that the capacity of the water is not more than its resistance. See also *British Patent* 398/1915.

3248. **G. W. O. Howe.** Earth Aerials. (*Radio Review*, 2, pp. 281—282, June, 1921.)

3249. **E. C. Hanson.** Underground and Submarine Antenna. (*U.S. Patent* 1388336, February 25th, 1919. Patent granted August 23rd, 1921.)

Underground and submarine antenna wherein the antennæ are formed by a pair of extended inductances connected to radio signalling apparatus. The inductances are buried horizontally in the earth and have their ends electrically free.

3250. **E. R. Clarke.** Wireless Systems for Aircraft. (*British Patent* 150747, August 16th, 1916. Patent accepted February 4th, 1920. Published October 7th, 1920.)

Means for directing aircraft by wireless telegraphy comprise a single receiving coil aerial of any suitable number of turns mounted on the aircraft so that its effective plane is normally perpendicular to the fore and aft line of the machine but can be rotated through a small angle on each side of this position, so as to obtain zero effect from the incoming waves. Alternatively the centre parts of the loop or coil may be fixed and the two end sections hinged to turn in opposite directions.

3251. **L. A. McDougald** and **J. M. Poyntz.** Aerials for Aircraft. (*British Patent* 151115, July 2nd, 1919. Patent accepted September 23rd, 1920.)

Relates to open-ended aerials attached to the fuselage of the machine.

3252. **E. F. Huth.** Aerials for Aircraft. (*British Patent* 148315, July 9th, 1920. Convention date July 1st, 1915. Patent accepted October 10th, 1921.)

Relates to reels for coiling up the aerial wire on aircraft.

3253. **E. F. Huth.** Aerial Winches. (*British Patent* 148318, July 9th, 1920. Convention date January 16th, 1918. Patent not yet accepted.)

Relates to means for winding up the aerial on aircraft by means of power derived from an air-driven propeller or by other similar means.

3254. **E. F. Huth.** Reels or Winches. (*British Patent* 148319, July 9th, 1920. Convention date May 16th, 1918. Patent accepted October 10th, 1921.)

Relates to a reel for an aircraft aerial having an electric motor for winding up the wire.

3255. **P. R. Coursey.** The Submarine's Wireless. (*Wireless World*, 8, pp. 603—605, November 27th, 1920. *Electrical World*, 77, p. 441, February 19th, 1920—Abstract.)

Describes various forms of aerials used for underwater communication.

3256. **B. Rosenbaum** [E. F. Huth Gesellschaft]. Aerial Construction. (*British Patent* 149194, July 12th, 1920. Convention date December 8th, 1916. Patent not yet accepted.)

Submersible boats are fitted with horizontal antennæ a small height above the deck to enable them to maintain radio communication whether submerged or on the surface. The shore stations may be provided with similar antennæ for communication with these vessels.

3257. **J. H. Rogers.** Radio Signalling System. (*U.S. Patent* 1395454, March 9th, 1920. Patent granted November 1st, 1921.)

This patent shows an antenna for a submarine vessel having a metallic hull comprising conductors extending longitudinally within and entirely enclosed by the hull and electrically connected at their ends to the metallic walls of the hull. The radio signalling apparatus is inductively coupled to this antenna system. A modification of the system shows a loop antenna contained entirely within the metallic hull of the submarine.

(7) SPECIAL D.F. AERIALS.

3258. **J. O. Mauborgne** and **G. Hill.** Receiving Aerials. (*British Patent* 163709, May 24th, 1921. Convention date May 24th, 1920. Patent not yet accepted.)

Relates to the use of a long helix (" resonance-wave coils ") for receiving wireless signals, and deals with its directional properties.

3259. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Receiving System. (*French Patent* 512838, March 31st, 1920. Published February 1st, 1921.)

The receiving system employs a loop aerial, whereby two separate currents are obtained, one from the action of the aerial as a directive-electromagnetic loop, and the other from the action of the aerial as an earthed symmetrical non-directional aerial. These currents are produced in separate couplings and are impressed upon intermediate phase modifying circuits. For further particulars see *British Patent* 142074, in the name of E. F. W. Alexanderson.

3260. **Gesellschaft für drahtlose Telegraphie.** Wireless D.F. Apparatus. (*British Patent* 167490, August 4th, 1921. Convention date August 6th, 1920. Patent not yet accepted.)

The polar diagram of a wireless D.F. installation may be varied by changing the constants of the antenna system which comprises a combination of directional and non-directional antenna.

(8) AERIAL INSULATORS, ETC.

3261. **A. Renaudin.** High Tension Suspension Insulators. (*British Patent* 159198, February 18th, 1921. Convention date February 28th, 1920. Patent not yet accepted.)

3262. **C. T. Wilkinson.** Wireless Aerials. (*British Patent* 151063, June 12th, 1919. Patent accepted September 13th, 1920.)

Relates to a means of keeping aerial wires taut by counterweights.

3263. **G. V. Tuiss.** Strain Insulators. (*British Patent* 158689, November 10th, 1919. Patent accepted February 10th, 1921.)

3264. **E. H. Fritz** and **G. I. Gilchrest.** Modern Production of Suspension Insulators. (*Journal of the American Institute of Electrical Engineers*, 40, pp. 470—479, June, 1921.)

An illustrated article describing the processes.

3265. **G. Castelnuovo-Tedesco.** A New High-voltage Suspension Insulator. (*L'Elettrotecnica*, 7, pp. 366—368, July 15th, 1920. *Electrical World*, 77, p. 498, 1921—Abstract. *Elektrotechnische Zeitschrift*, 42, p. 379, April 14th, 1921—Abstract.)

A solid porcelain rod with metal clamps at the top and bottom without cement. The upper clamp carries a metal umbrella which can arc across to the bottom clamp without damaging the porcelain.

3266. **Brown, Boveri & Cie.** Bakelite. (*B.B.C. Mitteilungen*, 7, p. 229, 1920. *Elektrotechnische Zeitschrift*, 42, pp. 381—382, April 14th, 1921—Abstract.)

An illustrated description of the various modifications and applications of bakelite in the manufacture of various types of insulators.

(9) EARTHING SYSTEMS.

3267. **R. Goldschmidt.** Earthing Systems. (*British Patent* 148786, July 10th, 1920. Convention date November 8th, 1917. Patent not yet accepted. Also *British Patent* 148788, July 10th, 1920. Convention date March 22nd, 1917. Patent not yet accepted.)

The earth connections of radio stations may be arranged in the form of radial insulated conductors each leading to star-like arrangements of earth wires of comparatively short length. Condensers may be inserted in the radial insulated leads.

3268. **A. F. Wallis.** Ground System at Arlington Station. (*Radio News*, 2, p. 354, December, 1920.)

A short note about the arrangement with photograph.

3269. **L. Lichtenstein.** Earth Currents in Theory and Practice. (*Elektrotechnische Zeitschrift*, 42, pp. 841—846, August 4th, 1921.)

A mathematical investigation of the effective resistance of earthing systems.

(11) MASTS AND TOWERS.

3270. **C. F. Elwell.** Wooden Masts for Radiotelegraphy. (*L'Électricité pour Tous*, 3, p. 145, May 31st, 1921.)

3271. **J. Harrison.** Masts. (*British Patent* 160027, December 31st, 1919. Patent accepted March 17th, 1921.)

A telescopic mast for wireless and other purposes.

3272. **R. St. George-Moore** and **G. S. Whitmore.** Supporting Wireless Aerials. (*British Patent* 158353, November 3rd, 1919. Patent accepted February 3rd, 1921.)

Relates to methods of supporting wireless antennæ so that the resultant stress upon the mast shall be vertical.

3273. **S. P. Wing.** Wind Pressures and the Design of Radio and High Transmission Towers. (*Electrician*, 87, pp. 6—10, July 1st, 1921.)

In this paper the author deals with the problem of wind pressures at varying heights above ground and their consideration in the design of masts and towers. It is pointed out that the literature on the subject is very meagre and in the erection of well-known constructions the assumptions for wind pressures have been greatly at variance. The author gives the results of a large number of observations and readings taken at Ballybunion, Co. Kerry, Ireland, and from these draws the conclusions that where the elevation is close to sea level the wind velocity increases considerably with the increase in elevation above ground and has not reached the limit of increase at 500 feet; that the increase is limited by the "gradient wind" and will probably not exceed 15 per cent. of that reached at 500 feet; that the extreme variation in wind velocity at 750 feet is between 140 and 170 per cent. of the ground velocity; and that an equation supplied by the author gives an approximation of actual pressures within 15 per cent. for high pressures.

3274. **S. Moehl.** Aerial Masts. (*British Patent* 164100, February 27th, 1920. Patent accepted May 27th, 1921.)

An aerial mast suitable for wireless telegraphy has a self-supporting tower at the top of which a slender column is attached by means of a universal joint and anchored by means of stays attached to the ground.

3275. **F. Omori.** Measurement of the Vibration of the 660-foot Wireless Telegraph Station at Haranomachi. (*Engineering*, 112, pp. 196—199, July 29th, 1921.)

3276. Latticed Wireless Towers for Amateur Stations. (*Wireless Age*, 8, pp. 32—33, September, 1921. *Radio News*, 3, p. 193, September, 1921.)

3277. **A. Heinemeyer.** Formulæ for the Rigidity of Lattice Masts. (*Elektrotechnische Zeitschrift*, 42, pp. 825—827, July 28th, 1921.)

(L). Radio Wave Transmission.

(2) TRANSMISSION TESTS AND MEASUREMENTS.

3078. **M. S. Kinter.** The Variation of Radio Signals. (*Telegraph and Telephone Age*, 39, p. 277, June 16th, 1921.)

An abstract of a paper read before the Institute of Radio Engineers giving the results of experiments carried out by the International Radio Telegraph Company on the variation of transatlantic signal strengths. These variations were compared with the corresponding variations of atmospheric disturbances, and the effects of sunrise and sunset were also investigated.

3079. **L. W. Austin.** Measurement of the Signals received in Washington from the Lafayette Station. (*Science Abstracts*, 24B, p. 415, August 31st, 1921—Abstract.)

See RADIO REVIEW, 2, pp. 301—303, June, 1921.

3080. **A. H. Lynch.** S.S. *Aeolos* Works 3,013 Miles with 2 kW Arc Set. (*Science and Invention*, 9, p. 151, June, 1921.)

An illustrated description of the installation.

3081. **S. R. Winters.** Fading of Signals. (*Radio News*, 2, p. 529, February, 1921.)

An outline of the scheme developed by the Bureau of Standards in conjunction with the American Radio Relay League for the investigation of transmission phenomena on short wavelengths. (See also RADIO REVIEW Abstract No. 2066, July, 1921.)

3082. Radio Telephony over 4,340 Kilometres. (*Telefunken Zeitung*, 4, pp. 39—43, May and June, 1921. *Telegraphen- und Fernsprech-Technik*, 10, p. 94, July, 1921—Abstract.)

It is reported that telephonic messages from Nauen were received by the Argentine liner *Bahia Blanca* at a distance of 4,340 km, the antenna power being 130 kilowatts; Königswusterhausen using 10 kilowatts was heard up to 3,500 km.

3083. Reception Experiments in Argentine. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 366—368, May, 1921. *Science Abstracts*, 24B, p. 364, Abstract No. 752, July 30th, 1921—Abstract.)

A report of tests made by the Telefunken Company preparatory to the establishment of wireless communication between Germany and Argentine. Reception tests were made at several widely separated stations. Apparently frame aerials of large size, in one case 28 × 68 metres, were employed. Records are given for six months, the strengths of the signals from Nauen and of the atmospherics being given in parallel ohms shunted across the telephone receivers. In only one of the six months could Nauen be read on more than half the days of the month. The relative strengths of the signals and atmospherics can be judged from the parallel ohms which varied from 2·83 for atmospherics and 4·74 for signals in July (Nauen read on twenty-eight days) to 1·45 for atmospherics and 10·5 for signals in November (Nauen read on ten days). The tests are to be continued with the most modern apparatus.

3084. **J. H. Dellinger** and **L. E. Whittemore.** Radio Signal Fading Phenomena. (*Journal of the Washington Academy of Science*, 11, pp. 245—259, June 4th, 1921. *Science Abstracts*, 24B, p. 460, Abstract No. 924, September 30th, 1921—Abstract. *Physical Review*, 18, pp. 148—149, August, 1921—Abstract.)

Paper read before the Philosophical Society of Washington, January 29th, 1921, and before the American Physical Society, April, 1921. The mechanism of the fading of signals is discussed from the point of view of its variation with distance, place and wavelength, sunrise and sunset, and similar effects on the phenomena and on atmospherics are also considered. It is concluded that the causes or sources of fading and of atmospherics are in the atmosphere between the earth's surface and the Heaviside surface, but that the origin of these causes is either from below the ground or from outside the earth's atmosphere. The grid variations in signal strength experienced at night are attributed to irregularities in the surface of the Heaviside layer.

3085. **H. de Bellescize.** Resonance and the Continuity of Radio Communications. (*Radioélectricité*, 2, pp. 25—29, July; pp. 69—76, August, 1921.)

A critical discussion of the influence of atmospherics on radio communications and in particular of the importance of the ratio of the field strength due to atmospherics and signals. Formulæ are given for determining this ratio under different conditions. The importance of resonance and particularly of low-frequency resonance is emphasised.

3086. **F. Addey.** Eclipse of the Sun, April 8th, 1921—Effects Produced at Wireless Stations, (*Radio Review*, 2, pp. 226—227, May, 1921. *Telegraph and Telephone Age*, 39, p. 390. September 1st, 1921—Abstract.)

3087. **R. C. Gray.** Wireless Telegraphy in Western Australia. (*Radio Review*, 2, pp. 507—508, October, 1921.)

3088. The Fading of Radio Signals. (*Experimental Science*, 1, p. 181, August-September, 1921.)

The suggestion is made that some of the fading phenomena may be due to changes in the wavelength to which the transmitter or receiver is tuned.

3089. An International Series of Radio Audibility and Direction Measurements. (*Physical Review*, 18, pp. 150—152, August, 1921.)

An abstract of paper read before the American Physical Society on similar lines referred to in RADIO REVIEW Abstract No. 1070, November, 1920.)

(M.) Atmospherics, including Anti-atmospheric Devices.

3290. **G. M. Wright** [Radio Corporation of America]. Wireless Telegraph Receiver. (*U.S. Patent* 1394600, June 8th, 1916. Patent granted October 25th, 1921.)

A receiver having a circuit for the reduction of noises due to atmospherics. The natural resistance of the antenna may be made of such a value as to damp the atmospherics while the effective resistance is reduced by the interaction of the incoming and outgoing circuits of a vacuum tube connected between the antenna system and the receiver. The filament of the vacuum tube is heated so slightly as to produce only very small magnification and to all practical degree no magnification of the signals, but sufficient to neutralise the antenna resistance for the weaker amplitudes of signals and yet render effective the resistance for the larger amplitudes of atmospherics.

(N.) Interference and Interference Prevention, including Secrecy. Methods of Signalling.

3291. **R. H. Wilson** and **J. P. Schafer** [Western Electric Company.] Secret Signalling. (*U.S. Patent* 1395378, September 29th, 1919. Patent granted November 1st, 1921.)

This patent shows a radiotelephone secret signalling system. The transmitter comprises two branch circuits and separate modulators coupled thereto. The microphone circuit is coupled to filters which transmit freely only a limited range of the essential voice frequencies. For example, one filter may transmit frequencies between 500 and 900 while the other filter will transmit frequencies between 900 and about 1,500. Separate carrier wave frequencies may be employed modulated in accordance with the frequencies transmitted through the filters. At the receiving station branch circuits are employed to combine the component frequencies forming the signal wave. An outsider in attempting to pick up the conversation would tune his receiving set to the frequency of one or the other of the transmitted carrier waves but would obtain only unintelligible sounds from either wave alone.

(O.) Duplex and Multiplex Radio Communication.

3292. **A. N. Goldsmith** and **J. Weinberger** [General Electric Company]. Radio Receiving System. (*U.S. Patent* 1396571, September 13th, 1918. Patent granted November 8th, 1921.)

The object of this invention is to provide a receiving system which is adapted to be used in close proximity to a transmitting system and which is capable of receiving signals from a distant station at the same time that signals are being sent from the transmitting station.

(P.) High-frequency Circuits and Measurements.

3293. **E. A. Bayles** and **H. Higham** [assigned one-third to Ernest Richard Royston]. Electrical Condenser. (*U.S. Patent* 1393602, December 22nd, 1919. Patent granted October 11th, 1921.)

A condenser comprising a plurality of condenser units, each unit made up of a series of spaced longitudinally-aligned tubular condensers electrically connected and supported in removable racks within an oil container.

3294. **W. C. Brinton, Jun.** [Philbrin Corporation]. Electrical Condenser. (*U.S. Patent* 1393077, October 8th, 1918. Patent granted October 11th, 1921.)

A condenser comprising layers of conducting material and layers of fibrous dielectric material of different degrees of hardness and compressibility, the harder and less compressible layers being of greater weight than the softer and more compressible layers. The entire condenser is enclosed in a tight-gripping casing compressing the layers in inter-relation.

3295. **W. Dubilier.** Electrical Condenser. (*U.S. Patent* 1391672, August 1st, 1918. Patent granted September 27th, 1921.)

A condenser constructed of rectangular plates having one dimension substantially greater than the other and interleaved with larger rectangular insulating sheets of greater length than width. The novelty in this condenser lies in the construction of the stack. The side edge portions of the longer dimension of the condenser plates project alternately beyond the two longer sides of the dielectric sheets, the similarly projecting edge portions of the plates being connected together throughout their whole length to constitute the terminals for the condenser. The terminals are thus constructed to provide the shortest mean heat conduction path and the path of lowest mean resistance to the exterior of the condenser.

3296. **W. Dubilier** [Dubilier Condenser Co., Inc.]. Antenna Shortening Device. (*U.S. Patent* 1391673, March 7th, 1919. Patent granted September 27th, 1921.)

A series antenna condenser comprising a plurality of condenser sections connected in series and tapped to different terminal posts arranged on a casing containing the condenser sections. A switch arm is provided movable over the terminal posts to connect in circuit the respective condenser sections in series with an antenna system to shorten the wavelength to the desired value. A short-circuiting contact is provided whereby the series condenser may be entirely cut out of the antenna circuit.

3297. **C. F.** and **W. H. Smith.** Electric Condenser. (*U.S. Patent* 1395931, May 17th, 1920. Patent granted November 1st, 1921.)

An electric condenser unit is shown in this patent comprising a base or body of thin fibre board and a wrapping of dielectric and metallic foil encircling the fibre board. The sheets of metal foil are smaller in size than the sheets of dielectric and the stack is folded around the fibre board and the leads brought out to eyelet terminals on the ends of the board. A number of units may be associated in parallel by building up a structure with bolts passing through the eyelet terminals.

3298. **P. Thomas** [Westinghouse Electric and Manufacturing Company]. Condenser. (*U.S. Patent* 1396897, October 8th, 1917. Patent granted November 15th, 1921.)

This patent shows a construction of condenser having means for filling the space which remains at the edges of the conducting foils in condensers constructed in the usual manner. A U-shaped strip of dielectric material is cut to closely fit around the margin of a conducting foil, the strip being substantially of the same thickness. The conducting sheets assembled with the U-shaped strips are stacked with intermediate sheets with one side of the conducting sheet extending to form the terminals of the condenser.

3299. **Albert Pruessman** [Western Electric Company]. Condenser and Method of Making the Same. (*U.S. Patent* Reissue No. 15241, June 14th, 1920. Patent granted November 29th, 1921.)

This patent relates to a method of treating a condenser which is impregnated in the presence of heat which consists in applying pressure to the impregnated condenser as it cools and then removing the pressure, reheating the condenser to a temperature of not less than 120° F. for a period of not less than three hours without pressure applied thereto.

3300. **W. Dubilier.** Variable Condenser. (*U.S. Patent* 1396030, July 25th, 1917. Patent granted November 8th, 1921.)

A variable condenser is shown in this patent comprising a number of fixed condenser units connected to contacts, a switch for cutting in the units, and a variable condenser having a maximum capacity substantially equal to the common difference between the capacities of the fixed condenser units. Intermediate capacities between the fixed capacities are thereby obtained by manipulating the variable condenser while the errors due to changes in the variable condenser are minimised.

(R.) Radio Direction Finding.

3301. **L. M. Knoll** [Thomas Appleby]. Radio System. (*U.S. Patent* 1394026, April 2nd, 1920. Patent granted October 18th, 1921.)

A receiving system for the location of the actual direction of a transmitting station as an improvement over systems which merely indicate the course of the signals but do not differentiate between the true and converse directions. The system comprises the combination of an antenna circuit with a pair of rectangular loop collectors rotatably mounted and adapted to have their mutual coupling varied.

3302. **James Erskine-Murray** and **James Robinson.** Wireless Receiving and Transmitting Apparatus. (*U.S. Patent* 1398848, March 30th, 1920. Patent granted November 29th, 1921.)

This patent shows a radio transmitting and receiving system wherein a receiving station determines its bearing relatively to the transmitting station. The transmitting apparatus employs a plurality of antennæ arranged in different directions, while the receiving station employs an antenna having branch circuits to ground which are alternately connected in the antenna circuit. Two identical coils are included in the branch circuits and arranged at an angle with each other. An adjustable receiving inductance is coupled with the two circuits and adjusted for comparison of the received signals which permits a bearing to be obtained on the distant transmitting station on minimum signal.

3303. **R. L. Williams** [Submarine Signal Company]. Device for Estimating Distances. (*U.S. Patent* 1396491, June 24th, 1919. Patent granted November 8th, 1921.)

This patent shows a combination radio system and submarine sound signal system wherein a radio transmitter is operated to give a single signal simultaneously with the operation of a submarine sound signal. The operator at the receiving station gets the single instantaneous radio signal and later hears the first blow of the submarine signal and by measuring the time between the receipt of the radio signal and the first blow of the submarine signal can calculate the distance from the transmitting station.

(S.) Distance Control by Wireless.

3304. **J. H. Hammond, Jun.** System of Radiodynamic Control. (*U.S. Patent* 1399254, June 30th, 1917. Patent granted December 6th, 1921.)

This patent shows a radio transmitter control circuit for use in a system of radiodynamic control for torpedoes and the like. The transmitter includes two sets A and B, the set A being intended to transmit different wavelengths through any desired variable range to disturb the enemy. The set B is provided with a plurality of control circuits, whereby the frequency transmitted may be changed over a series of wavelengths to control the distant object.

3305. **E. L. Chaffee.** Means for Changing the Intensity of Signals in Radiodynamic Receiving Systems. (*U.S. Patent* 1399251, July 31st, 1917. Patent granted December 6th, 1921.)

This patent shows a circuit for the reduction of the intensity of strong signals in radiodynamic control work without reducing the intensity of weak signals. The object of the invention is to reduce interference in radiodynamic control circuits from near-by transmitters and from static.

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2. Books.

WIRELESS TELEGRAPHY. By B. Leggett. (London: *Chapman and Hall, Ltd.* 1921. $8\frac{1}{2}'' \times 5\frac{1}{4}''$. Pp. xv + 485. With 230 figures. Price 30*s*. net.)

Although the title on the outer cover is merely "Wireless Telegraphy," one finds, on opening the book, the sub-title "With Special Reference to the Quenched-spark System." It would have been more honest to have entitled the book "The Quenched-spark System of Wireless Telegraphy," since it is confined almost entirely to descriptions of that system. Among the many amazing things to be found in this book is the following, which we presume is the author's apology for having written it. "Whilst at the present day a very large number of books dealing with wireless telegraphy are published, yet with very few exceptions *these are not written by actual wireless engineers*. This leads to two types of books, either those written by the pure scientist, which are highly mathematical and whilst of great theoretical interest are relatively unimportant in practical work; or to a more popular class of book which deals with actual wireless apparatus, *but whose matter is largely obtained second-hand from other books such as the admirable treatise by Fleming*, which chiefly deals with the Marconi system, the excellent practical handbook on the same system by Hawkhead; or the smaller but perhaps more general and useful book by Eccles." The italics are ours. It would be interesting to have the author's definition of a wireless engineer. It would apparently exclude pure scientists and such writers of popular books as Fleming, Hawkhead and Eccles; but we have a shrewd suspicion that it would include Mr. B. Leggett.

The book opens with a historical summary in which the author never misses any opportunity of attacking the Marconi Company or of drawing comparisons between the super-excellence of the Telefunken Company and the marked inferiority of all others. It is perhaps fortunate, however, that it is so overdone that any ordinary reader will see through it and smilingly discount the statements made. Having ourselves a great admiration for the work done by the Telefunken Company we cannot but feel that the author has done them a disservice in publishing such a book.

The book contains a large number of excellent diagrams and photographs, the type, paper and binding are all very good, and the apparatus is clearly described in the manner of a high-class descriptive catalogue. Very little numerical technical data is given, however, and what little theory is attempted only makes one thankful that there is no more. The explanation of this is to be found on p. 30, where we read that "The large number of technical engineers who visited this station and were often given demonstrations of the new apparatus by the present writer. . . . The technical side of the wireless section was in charge of Mr. H. A. Machen. . . ." It is a pity that a similar distribution of duties was not adopted in writing the book.

We can only refer to a few of the points which struck us on looking through the book. In the historical introduction Poulsen becomes a Swede, Sir Henry Babington Smith becomes Postmaster-General, and the Nobel Prize, which was awarded to Wilhelm Wien in 1911, is taken away from him and awarded to Max Wien, presumably as a reward for the discovery of the quenched gap. We are told that in June, 1912, "Wireless communication was established by the Australian Telefunken licensees across Australia between Perth and Freemantle" [the distance between these places is about 8 miles]. Throughout the book the reader is impressed with the fact that the number of kilowatts by which the Telefunken Company designate a station is the "*energy radiated from the aerial, which is 50 to 75 per cent. of the prime energy.*" From the frequency of this and similar misstatements one is forced to the conclusion that the author is ignorant of the fundamental principles of the subject. On p. 12 we read that "It must, however, be borne in mind that many of these other systems employ Quenched-Spark Gaps little different to the *original* Telefunken Gap; for example, the Lepel system employs a spark-gap whose chief difference is the *replacement* of the mica discs between the spark-gap plates by paper discs." We wonder whether the author knows which was the original and which the replacement.

The author follows the usual German plan of referring to the plain aerial as the Marconi Aerial and comparing it with the Coupled or Braun Aerial. When the aerial is tapped directly on to the inductance of the oscillatory circuit, *i.e.*, with auto-transformer coupling, the author calls it electrostatic coupling. Although the purely descriptive diagrams are good, the author gets into deep water as soon as he leaves the Telefunken pamphlets and essays to explain resonance phenomena in his own words; for example, both the ordinates and abscissæ of the lower curve in Fig. 15 appear to have got hopelessly muddled.

After all that has gone before one reads with surprise on p. 72 that "The most important difference between typical Quenched-spark and Marconi Commercial stations is that of the A.C. source which in the first case is a motor generator and in the second a rotary converter." If this is so, what is all the fuss about?

In a chapter on detectors, we read "Magnetic detectors:—The chief type of such detectors is that of the Marconi Company which whilst known as the 'Marconi' Magnetic detector was first evolved by Rutherford in 1896." This is typical of the tone which pervades the whole book.

On p. 113 occurs the following choice paragraph (the italics are ours): "Many, such as carborundum and steel, work best when an external E.M.F. is applied by means of *dry* cells. This *obviously* causes the contact to be heated until maximum variation of generated E.M.F. is obtained. The *maximum temperature* is easily found practically by variation of a resistance or potentiometer."

The cover bears the inscription "The D. U. Technical Series"; on opening the book we are informed that D. U. stands for directly useful, but we regret to have to say that the volume under review suggests another interpretation, the second word of which is Unreliable.

G. W. O. H.

LA THÉORIE ET LA PRATIQUE DES RADIOCOMMUNICATIONS, Vol II.—La Propagation des Ondes Électromagnétiques à la Surface de la Terre. By Léon Bouthillon. (Paris : *Librairie Delagrave.* 1921. Pp. xv + 340. With 133 figures. 10" × 6½". Price 20 fr.)

This forms the second volume of a comprehensive work covering the whole range of radiotelegraphy and telephony. The publishers announce that six further volumes are in preparation, viz., III. Oscillations électriques ; IV. L'antenne—La direction des ondes ; V. Les méthodes de transmission ; VI. Les méthodes de réception ; VII. Les divers genres de radiocommunications ; VIII. Formulaire du radiotélégraphiste. When M. Bouthillon has completed this ambitious programme he will have provided us with the most comprehensive work on the subject in existence. The first volume which was called an introduction to the subject was reviewed in the RADIO REVIEW of May, 1920. The preface to the second volume contains not only a general review of the subject dealt with in the volume but also an essay on the rival claims of theory and practice, and of the relation of the mathematician to both. The book is divided into two parts, the first dealing with the observed facts and the second and larger part with what are modestly called "tentatives d'explications." The first part is further subdivided into five chapters entitled respectively, I. Propagation over short distances ; II. Over long distances ; III. Effect of geographical configuration ; IV. Meteorological effects ; V. Parasitic signals. The second or theoretical part is subdivided into three chapters, viz., VI. Effect of the soil ; VII. Effect of the earth's curvature ; and VIII. The *rôle* of the atmosphere.

The first part consists of a general review of the experiments made in transmission from the early experiments of Marconi, Tissot, Duddell and Taylor and Admiral Jackson down to the recent work of de Groot, Vallauri and Eckersley, and the cruise of the *Aldebaran.* It consists largely of translations from the original together with reproductions of the original curves and diagrams. The second part is similarly a review of the work done by various workers on the theoretical and more purely physical side. It deals fully with the work of Poincaré, Sommerfeld, Hoerschelmann, Zenneck, Macdonald, Nicholson and Watson. The meteorological theories of Arrhenius, Störmer, Eccles and others are explained and discussed.

One must not turn to this volume expecting to find new theories or new methods of presentation. It consists almost entirely of a review of the literature of the subject. Papers which are scattered throughout the Proceedings of various learned societies are here brought together, summarised and arranged in their prôper places in the development of the subject. The authors' names are always given in large type together with references so that one can consult the original papers if one desires.

In writing the well-known Austin-Cohen formula we notice that the author, as in the preceding volume, always separates the effective resistance of the aerial into two parts, viz., that associated with dissipation of power and that associated with radiation of power, the former is called the resistance and the latter the *radiance.* The total effective resistance, as usually understood, is written $R + \omega^2 S$. Although the radiance $\omega^2 S$ is not a real resistance, the same might be said of R ; when multiplied by the square of the current at the foot of the antenna, the former gives the sum total of the power dissipated in various ways, including dielectric hysteresis, whilst the latter gives the power radiated. As written by Bouthillon the expression suggests that R is independent of the frequency, which is in many cases far from true, although its variations are small and irregular compared with those of the radiance. It is, however, undoubtedly advantageous to separate in this way two components which are so fundamentally different in their nature.

From what we have said above as to the character of the volume it is obvious that it will prove an indispensable work of reference to all serious students of radio communication. In conjunction with the first volume it would form a very suitable text-book for a post-graduate course of study on the nature of Hertzian waves and their application to radio communication.

G. W. O. H.

THE ELECTRICIAN'S HANDY-BOOK. By T. O'Conor Sloane. (London : *Hodder and Stoughton.* Fifth Edition. 1921. Pp. 823. 6½" × 5". With 600 illustrations. Price 27*s.* 6*d.* net.)

This volume is a comprehensive reference book suitable either for the student or the electrical engineer. It contains forty-six chapters, each being devoted to a separate branch of the subject, commencing with an introduction on elementary mathematics as applied to electrical calculations. Subsequent chapters deal with electrical units, the electric current, magnetism, etc., following the general sequence found in most electrical engineering text-books.

The formidable task of keeping a book of this type quite up to date probably explains the omission of references to the most modern practice or apparatus in some cases, such, for instance, as in the section devoted to wireless telegraphy in which no mention is made of the thermionic valve. Doubtless future editions will rectify these small defects.

A very comprehensive index adds considerably to the general utility of the volume, and facilitates reference to unusual items.

P. R. C.

Books Received.

THE "PRACTICAL ENGINEER" ELECTRICAL POCKET BOOK AND DIARY, 1922. (London: *The Technical Publishing Co., Ltd.* 1922. Pp. cxxx + 610. $5\frac{1}{2}'' \times 3\frac{1}{2}''$. Price 2*s.* net.)

HANDBUCH DER DRAHTLOSEN TELEGRAPHIE UND TELEPHONY. By E. Nesper. (Berlin: *Julius Springer.* 1921. Two vols. Pp. l + 708, and pp. 545 respectively. $9\frac{3}{4}'' \times 6\frac{1}{2}''$. With 1,321 illustrations. (Price not stated.)

CONTINUOUS WAVE WIRELESS TELEGRAPHY. By B. E. G. Mittell. (London: *Sir Isaac Pitman & Sons, Ltd.* 1922. Pp. xv + 114. $6\frac{1}{4}'' \times 4''$. With 58 illustrations. Price 2*s.* 6*d.* net.)

Correspondence.

NOTES ON A DIRECT-READING RADIO DIRECTION FINDER.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—In the January issue of the RADIO REVIEW Mr. Artom, in an article under the above title, describes a direct-reading radiogoniometer, the pointer of which would materially indicate the direction of a sending station. This apparatus would certainly realise a very important progress upon the Bellini-Tosi radiogoniometer, were it possible to make it work.

As a matter of fact, from the point of view of the conception of the apparatus, the presence of a detector in each of the two circuits produces an ambiguity as to the direction of a station, as a station making an angle $+\alpha$ with one of the fixed aerials would give exactly the same bearing as a station making an angle $-\alpha$ with the same aerial. One would always be uncertain whether the direction indicated by the apparatus would be the real one or the symmetrical of this in respect of each aerial.

From the point of view of the practical construction of the apparatus it appears impossible to obtain sensitiveness and exactitude sufficient for practical purposes.

E. BELLINI.

Enghien-les-Bains,
January 21st, 1922.

The above letter has been submitted to Mr. Artom who has replied as follows:—

SIR,—Mr. Bellini's letter is a great violation to my rights.

Professor Artom's Italian (April 11th, 1907), French and German Patents, the public act of April 5th, 1912, the judgments of County Court and Cassation Courts of Turin, establish that the priority of the invention of the Radiogoniometer belongs to Professor Artom and not to Mr. Bellini, who has been an employee of the concessionaires of my patents.

I do not acknowledge to Mr. Bellini either the authority, or the necessary impartiality, to judge my scientific studies, and I do not take notice of his technical observations, which are absolutely without any foundation.

ALEXANDRE ARTOM.

Turin,
January 30th, 1922.

TRIODE CHARACTERISTICS WITH HIGH GRID POTENTIAL.

To the Editor of the "Radio Review."

SIR,—Mr. Appleton's Fig. 1 in his letter in the January number is quite irrelevant. The only changes of slope that we are discussing are those in which (as he said in his first letter) "the grid potential approaches that of the anode." Nor is his exposition of electrostatic principles relevant, for my argument can be expressed in the manner he desires in terms of potentials and fields.

I do not assume "that the electrons (always) tend markedly to follow the lines of force." But I do assume that their paths, whatever they may be, are determined by the field; and, consequently, that a change in the type of field is accompanied by a change in the type of paths. Whether the change will be great enough to produce an experimentally perceptible kink in the characteristic can only be determined by a complete theory, which I do not pretend to have given. But I contend that, when such a kink is found at the point where theory predicts the change of type (and it is so found, according to my experience, in the type of curve to which Mr. Appleton first drew attention), then it is highly probable that it represents that change of type.

This argument is not necessarily inconsistent with the presence of secondary emission for it does not assume that all electrons leave the filament. I am ready to admit that the absence of the kink at low voltages suggests that secondary emission plays some part in determining the kink. But if so it is secondary emission from the grid and not from the anode as Mr. Appleton suggests, for when v_a exceeds v_g the electrons excited at the anode cannot reach the grid, and on the other hand the theory I gave explains why the kink occurs at $v_g = 0{\cdot}8v_a$— the point above which secondary emission from the grid must cease owing to the adverse field at the surface.

A. C. BARTLETT.

Research Laboratories of the General Electric Co., Ltd.,
London.
February 23rd, 1922.

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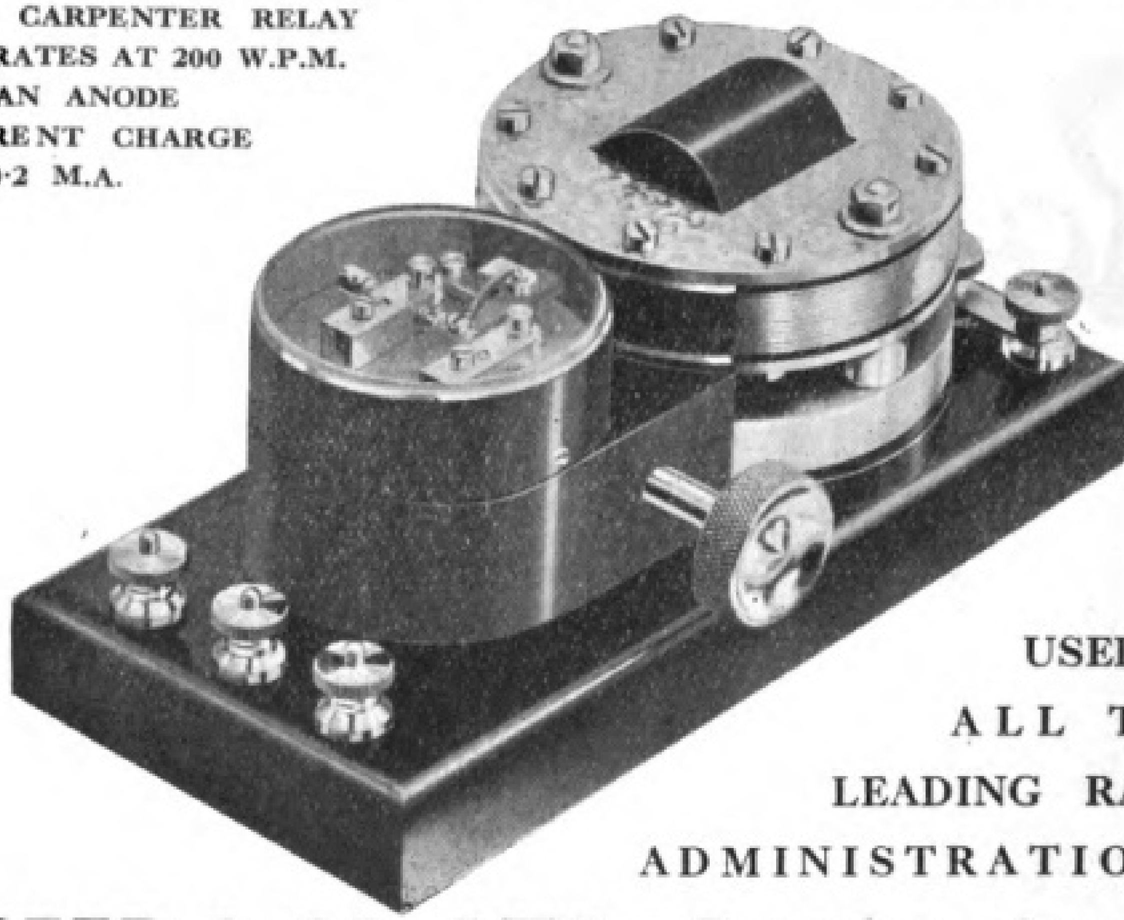

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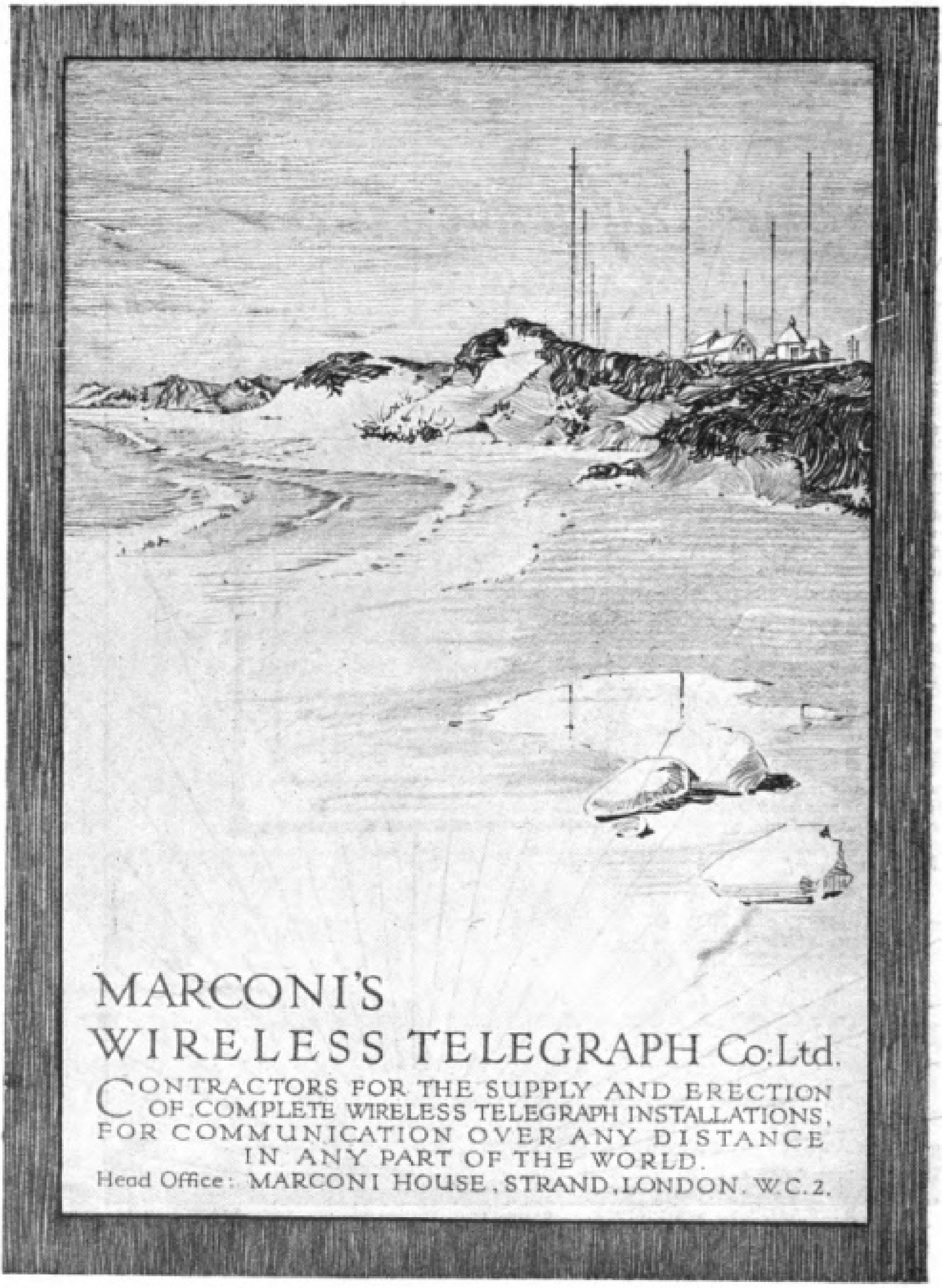
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