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Radio Exhibitions

Scientific Aspect Neglected

LONDON, Berlin, and Paris have recently held their annual radio shows, and with the exhibition season over the opportunity presents itself for commenting on the gradual disappearance from these shows of material of interest to the scientist and technician.

In Berlin the exhibition was mainly one of propaganda for broadcasting conducted by the State. Here it was propaganda for the radio industry. In Paris the Salon was made up of a number of exhibitors all acting independently to push the sales of their own sets.

Radio exhibitions of some years ago were scientific rather than commercial, but to-day they are staged for the general public, and the scientific minority is practically ignored. Whilst it must be recognised that from a small scientific beginning wireless has grown into a great industry, and that consequently it is natural and proper that an exhibition should be held which represents wireless to the general public in a manner which will appeal to the non-technical mind and serve to establish the wireless set as an article of domestic furniture and utility, yet we ought not to allow the scientific aspect to be lost sight of.

If we continue to sell wireless sets only on the strength of a good name and a pleasing appearance, the time will come when practically all manufacturers will find themselves on the same footing and competition in technical achievement, which is such a valuable incentive to progress, will disappear.

There is at present no wireless exhibition which provides a fitting place to display scientific apparatus, such as measuring instruments and testing equipment, which are the tools of the radio designer.

There is room for an important section at every wireless exhibition where a technical and scientific atmosphere would predominate, where circuit diagrams would take the place of cabinets and where exhibitors would stress, not the beauty of their products as furniture and musical reproducers alone, but would point out the technical advances and ingenuity incorporated to achieve the results in their sets. The radio industry as a whole would have much to gain by fostering, not only amongst the technically inclined but also in the minds of the general public the importance of technical efficiency and sound engineering design.

Whilst recognising that broadcasting has brought into existence a large and prosperous industry, we ought not to allow our public to forget that it is founded upon a science.

H. S. P.

Modifications of the Push-Pull Output Stage

Part I.

By *K. A. Macfadyen, M.Sc.*

(From the Staff of the Research Laboratories of The General Electric Company, Limited, Wembley)

SUMMARY.—Several types of output-stage in which the circuit closely resembles the well-known push-pull circuit have been widely employed. Of these the " quiescent " push-pull arrangement and the so-called " Class B " system are examples. The exact behaviour of these circuits can be analysed by means of graphical methods. It is shown in this way that the fundamental feature governing the operation of such circuits is the curvature of the load-lines on the I_a–E_a characteristics. A classification is thus made, and the properties of the different types of circuit outlined.

1. Introduction

DURING the last few years several types of output stage employing the push-pull principle have been receiving particular attention. For various reasons, the " quiescent " push-pull circuit and the so-called Class B (positive-drive) circuit have achieved a considerable vogue in the domain of receiving sets. In larger amplifiers, the method of employing valves in push-pull operating partly in the grid-current region has been employed, while more recently special valves have appeared which, when used in push-pull, give a very large output without the need for " grid-current-driving " and its attendant difficulties. The latter arrangement falls in the category referred to as " partial " push-pull in the following discussion.

The behaviour of the circuits just enumerated is, in general, quite different from that of the familiar push-pull circuit in which two ordinary power triodes are operated with an anode-to-anode load equal to twice the load normally required for each triode separately. In order to understand their operation a graphical method of analysis must be employed. In the simple case just described it can be assumed with tolerable accuracy that each valve works with its normal anode-load, and that the total output is twice that available from each valve by itself. It will be shown that these assumptions can be made only when the valve-characteristics are linear in the regions employed. If non-linearity exists (*i.e.*, if the characteristics in these regions are not equidistant parallel lines) the load lines on the $I_a - E_a$ characteristics cannot, in general, be straight, but must be curved. The physical significance of this curvature is that each valve appears to be loaded with a non-linear resistance.

The idea of curved load-lines becomes obvious as soon as one is confronted with the case of " quiescent " operation, but it is not limited to this operating-condition and, in fact, is fundamental in most of the considerations presented in this paper. Attention has been called by Kilgour[1] to the widespread nature of the phenomenon.

2. Graphical Treatment of General Case

A graphical construction published by Thomson[2] may be extended to give the exact course of the curved load-lines, and is productive of a great deal of valuable information concerning the operation of valves in push-pull.

Let the grid-potentials of the two valves[3] be referred to as E_{g1} and E_{g2} respectively. Then, assuming the valves are being worked correctly,

$$\left.\begin{aligned} E_{g1} &= E_{b1} + e \\ E_{g2} &= E_{b2} - e \end{aligned}\right\} \qquad \ldots \quad \ldots \quad (1)$$

where E_{b1} and E_{b2} represent the bias-voltages (constant) and e is the " signal voltage " instantaneously applied by the secondary of the input transformer, T_1 (Fig. 1a).

Similarly, if we assume that the output

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[1] *Electronics*, 6, p. 73 (1933).

[2] *Proc. I.R.E.*, 21, p. 591 (1933).

[3] The treatment is valid for either triodes or pentodes.

transformer has a high coupling-factor (a condition almost invariably satisfied to a high degree of accuracy) we can write the following relations connecting the separate anode voltages, E_{a1} and E_{a2}, with the constant H.T. supply voltage E_s :—

$$\left.\begin{array}{l} E_{a1} = E_s - E \\ E_{a2} = E_s + E \end{array}\right\} \quad \ldots \quad \ldots \quad (2)$$

where E is the "anode voltage displacement." The voltage-drop due to the primary wire-resistance is neglected.

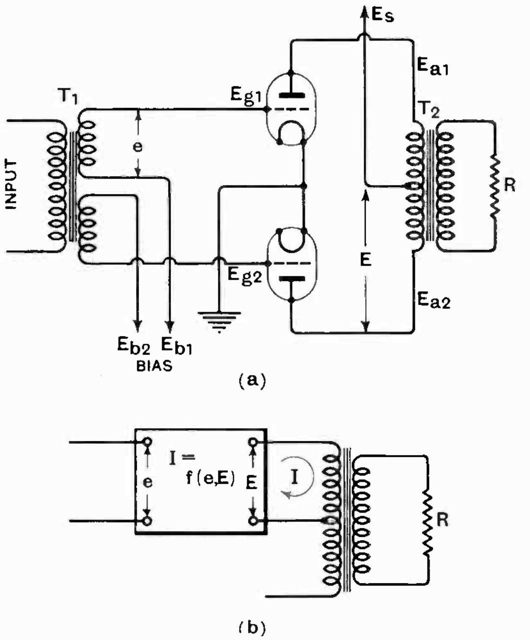

Fig. 1.—(a) *Push-pull circuit.* (b) *Composite generator.*

Notice that we have not yet assumed a sinusoidal waveform for either e or E, neither have we supposed the two valves to be similar. We have, however, assumed electrical symmetry in the two transformers in the circuit. With this supposition, it can be said that if the respective anode-currents in the two valves are I_{a1} and I_{a2} then the magnetic effect on the core of the output-transformer is the same as if a current $(I_{a1} - I_{a2})$ were flowing in a winding of half the number of turns present in the actual primary illustrated in Fig. 1a. Let this be called the "effective primary current," I.

We are now in a position to replace the two valves with their associated transformer-windings by an imaginary "generator" (Fig. 1b), whose properties are easily deduced from the $I_a - E_a$ characteristics of the two valves. It will be noticed that the independent variables of the problem are now only three in number, namely, e, E and the time, t.

To determine the properties of the composite generator just referred to, the characteristics of the two valves are put together in the manner shown in Fig. 2. If any point on the voltage axis is chosen, it expresses the relation contained in equations (2) since it assigns potentials to the respective anodes equally above and below the supply-voltage.

Also, if it is borne in mind that whenever the grid-voltage curve $(E_{b1} + e)$ is considered on the upper graph, it must be associated with the curve $(E_{b2} - e)$ on the lower one, the boundary condition expressed in equations (1) is satisfied.

The value of I, the effective primary current, may be plotted by algebraically adding the ordinates of corresponding curves in Fig. 2. This gives rise to the set of "composite characteristics" shown by the dotted lines in Fig. 2. These curves are respectively characteristic of the signal voltages e', 0 and $-e'$. The addition of a dash to a variable symbol is to denote the maxi-

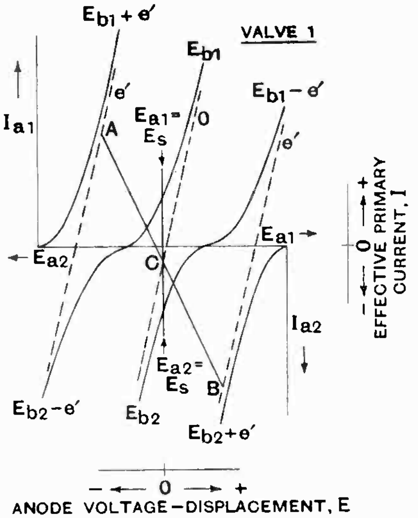

Fig. 2.—*Combining of characteristics.*

mum value of the variable. The ordinates, measured from the origin indicated to the right of the figure, represent the value of effective primary current, while the abscissae measured from the old supply voltage (see scale at foot of figure) measure the anode-voltage displacement, *i.e.*, the voltage across the winding associated with the composite generator (see Fig. 1b).

This new set of characteristics now forms the basis on which we assess the power-output, percentage of harmonics, etc., given by the original circuit.

Since the generator voltage and current must follow Ohm's law (assuming the transformer (Fig. 1b) to be resistively loaded) the load-line on Fig. 2 will be straight. It must pass through the point C (Fig. 2) corresponding to $e = o$ and $E = O$ and its slope corresponds to the impedance across the generator, *i.e.*, to the impedance presented by half the original primary. We, therefore, have the important result that the impedance represented by the load-line on the composite characteristics is equal to one-quarter of the "anode-to-anode" load, since the apparent impedance of the total primary is four times that of half the primary.

In calculating the power-output from the new diagram, care must be taken to employ a formula which gives the power in the fundamental only, otherwise an error due to the d.c. component of the effective primary current will occur. In the simple case shown in Fig. 2, if the *algebraic* values of the current I at A, C and B are respectively I_3, I_2, and I_1, the amplitude of the fundamental is $\frac{I_3 - I_1}{2}$, hence the power output is $\frac{(I_3 - I_1)^2 Z}{8}$ where Z is the impedance represented by the slope of ACB. Similarly the percentage of second harmonic is

$$\tfrac{1}{2}\,\frac{I_3 - 2I_2 + I_1}{I_1 - I_3}$$

More complicated formulae, based on seven values of I at equally-spaced values of signal-voltage e are available[1] for calculating the proportions of the harmonics up to the sixth. These calculations are exactly similar to those commonly performed on the characteristics of single valves.

3. Behaviour of Individual Valves

In Fig. 3 a more complete set of combined characteristics is illustrated. In this case it is possible to deduce the course of the curved load-line representing the behaviour of each of the valves separately. For we have only to remember that when the representative point on the straight load-line AB is at A, valve No. 1 experiences the anode-potential corresponding to the ordinate through A and the grid potential characteristic of the first curve in the upper diagram, *i.e.*, $E_{g1} = 0$. These conditions fix the state of valve No. 1 as that represented by A_1. Similarly the points P_1, C_1, Q_1 and B_1 may be deduced and the curved load-line drawn. The same process is applicable to valve No. 2. Geometrical reasoning based on the above construction will show that the existence of straight load-lines on the individual characteristics is incompatible with equation (2) (previous page) if harmonic distortion of the unsymmetrical type (even-order harmonics) is indicated on the load-lines. Fig. 4 will make this clear. The more nearly linear are the

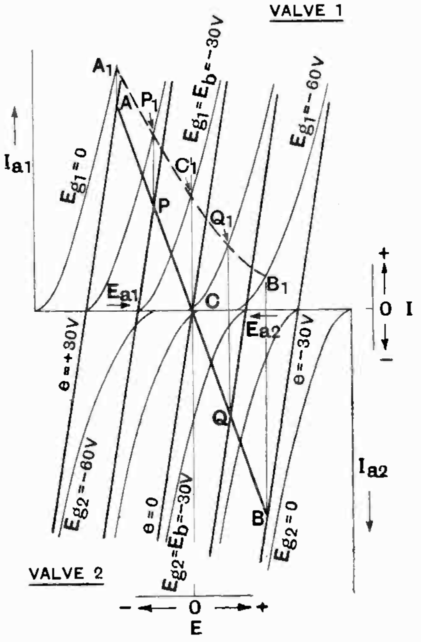

Fig. 3.—*Set of 5 "Composite Characteristics" and curved load-line.*

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[1] Espley, *Proc. I.R.E.*, 21, p. 1439 (1933).

separate characteristics the straighter will be these load-lines.

The most important practical result of load-line curvature is that the average anode feed-current to the whole stage increases when a signal is applied to the grids. Also, this current contains a component of the second harmonic frequency. These effects become more marked as the "quiescent" state is approached.

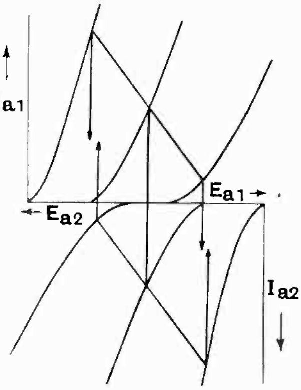
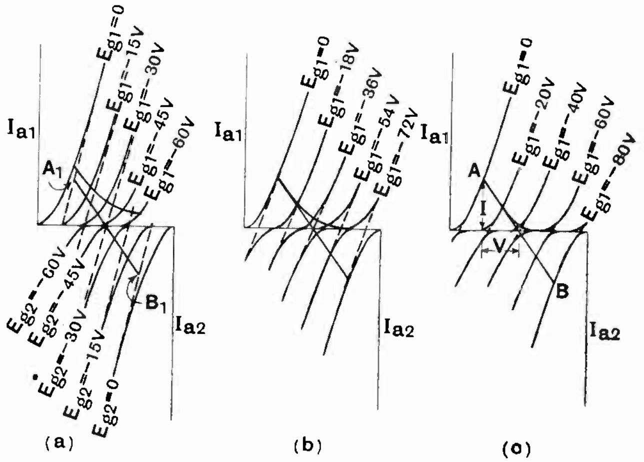


Fig. 4.—*Straight load-line incompatible with push-pull working, when usual type of characteristic is present.*

We have not yet assumed that the valves are identical, but in order to secure some results of more general interest we shall now make this assumption. It will be evident from the method of constructing the composite curves that on any given ordinate the slope will equal the sum of the slopes of the component curves. Hence, in the ideal case of a pair of equal, distortionless triodes, the composite characteristics consist of a set of equidistant straight lines having double the slope of the component-characteristics. By a simple geometric construction it can easily be shown that if impedance Z be applied to the composite generator, the apparent impedance imposed on each valve will be $2Z$, or half the anode-to-anode load ($4Z$). This is a well-known approximate result and can be applied in cases when the input-voltage is vanishingly small. It breaks down for larger amplitudes since the impedance presented to each valve is not constant, but depends on the phase.

4. Special Cases of Push-Pull Operation

When the valves employed are power-triodes of the usual type, operated under normal conditions, of anode voltage and grid-bias, it is found that the composite characteristics are linear to a high degree of accuracy. In many cases (*e.g.*, type PX25) the load impedance can be varied from zero to infinity, or made inductive or capacitive, without introducing more than 2 or 3 per cent. of harmonics (Fig. 5a).



(a) (b) (c)

Fig. 5.—*Effect of grid-bias on shape of load-line.*

This normal case presents some features of interest in connection with the choice of load-line. When the load impedance is decided by the simple rule of making the anode-to-anode load double the value employed for a single valve, the load-line assumes the position A_1B_1, giving individual load-lines of only slight curvature. But since the "composite generator" is practically a linear one, it is evident that the maximum power output will not be realised until the slope of the load line A_1B_1 is increased to a value numerically equal to that of the composite characteristics. In the case of ordinary power triodes (*e.g.*, types PX4, PX25, etc.) an increase of 30–50 per cent. in the power output is obtainable in this way. Some curvature of the individual load-lines accompanies this increase in output, but the distortion remains small.

It will be seen that if the composite characteristics are very steep, *i.e.*, the valve-impedance very low, the increase in power available by choosing the optimum load-line is more marked. As an example, the following figures for the PX25 and PX25A (extra-low impedance triode) at 400 volts may be quoted :—

Type.	Power from a single valve.	Maximum power from a pair in push-pull.
PX25	5.5 watts.	13 watts.
PX25A	7.0 watts.	32 watts.

Returning to our general survey of the form of the composite characteristics, we must consider the effect of increasing the grid-bias so that the "quiescent" state is approached. The effect on the composite characteristics is that shown in Fig. 5b. The effect on the power-output is usually slight, but a small increase in the percentage of out-of-phase third harmonic results.

When the quiescent state is fully reached, we find that, over a large proportion of their length, the composite characteristics coincide with those of the individual valves and that the "operative" portion of the load-curves become identical with the straight line AB. This fact makes it possible to predict a number of properties of the "quiescent" circuit from the ordinary valve-characteristics. By assuming that the anode-current waveform in each valve is a rectified sine-wave, we deduce the following useful approximate formulae (for the meanings of V', and I' see Fig. 5c) :—

Average full load anode current per pair of valves : $\frac{2}{\pi} I'$ . . . . . . (3)

Maximum power output $\frac{V'I'}{2}$ . . . . (4)

Power supplied by H.T. unit $\frac{2}{\pi} I'E_s$ . . (5)

where E_s is the supply voltage

Efficiency $\frac{\pi V'}{4 E_s}$ . . . . . . (6)

Since the maximum possible value of V' is E_s, the theoretical limit to the efficiency of this system is $\frac{\pi}{4}$ or 78 per cent.

This is a convenient point to make a slight digression to consider the factors deciding the most favourable slope for the load-line, and hence the correct load-impedance to be employed, in the "quiescent" case. When we are dealing with triodes and pentodes, the load-line can be assumed to end on the $E_g = O$ characteristic, and it is the form of this curve which decides (subject to one other limitation) the proper load-impedance to be used. In the case of Class B valves, we have as yet no such boundary-curve at hand, but it will be shown in a subsequent paper that a knowledge of the power available from the "driver valve" enables us to draw, on the characteristics of the output valve, a curve on which the load-line must end. Hence in these three important cases we have a "boundary curve" on which we can imagine the end of the load-line to slide. A very simple theorem, illustrated in Fig. 6, shows how the best slope for the load-line can be deduced. Suppose LM is the boundary curve and PC the load-line. If the co-ordinates of P are (E_a, i_a) and $OC = E_s$, the power output is represented by the area PCN.

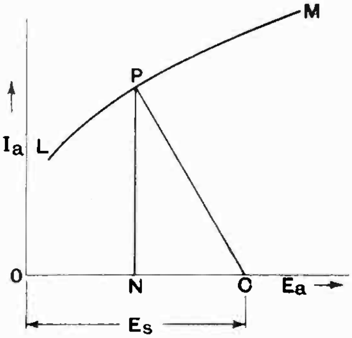


Fig. 6.

$$\text{Area } PCN = \tfrac{1}{2} I_a (E_s - E_a) = A$$

To find the maximum value of A, equate $\frac{dA}{dE_a}$ to zero :

$$\frac{dI_a}{dE_a}(E_s - E_a) - I_a = 0 \qquad \text{. . (7)}$$

$$\therefore \frac{dI_a}{dE_a} = \frac{I_a}{E_s - E_a}$$

Hence we should choose P so that the slope of the tangent there is numerically equal to the slope of the load-line. The equation (7) also expresses the condition for minimum area, but this case is unmistakable in practice and seldom causes trouble. The limitation in the validity of this method of determining the optimum load-line is that the line so chosen may lie in non-linear parts of the characteristic curves, though it has been found in practice that revision is seldom necessary on this score.

The use of the above theorem leads to some important results. The peculiar form of pentode characteristics causes the optimum load-line to end well over to the left, on the $I_a - E_a$ diagram. This results in high efficiency at full input, an approach to the theoretical figure of 78 per cent. being made.

When triodes are used, however, even when the $E_g = 0$ curve is nearly straight, the condition of maximum output (equal slope theorem) sets an upper limit of $E_s/2$ on V'. As long as we try to elicit the maximum output from triodes in *Q.P.P.*, therefore, we limit the possible efficiency to 39 per cent. In practice, the efficiency is sometimes of secondary importance, the major consideration often being the relation between the power-output and the initial cost of the system.

5. "Partial" Push-Pull Circuits

If we wish to classify push-pull output stages into categories which give some general idea of their behaviour, the most obvious method is to specify the type of load-line on the individual characteristics. Thus, if the load-lines are practically straight we may call the system a "pure" push-pull stage. It is characterised by constant anode supply-current free from alternating components. This condition is ideal, in so far as it can be only approximately realised in practice. If considerable load-line curvature is present, but the anode-currents do not fall to zero for an appreciable fraction of the cycle, we may term the state of affairs "partial" push-pull amplification. The anode feed-current varies with the loudness of the programme-matter being handled. When the curvature is such that the anode-currents vanish for almost a complete half-cycle, the condition is generally called "quiescent" push-pull amplification.

It has become customary to regard these differences in behaviour as due to the choice of grid-bias, but it must be emphasised that the load-impedance has just as great an effect on deciding the form of the load-lines. Thus, almost any push-pull stage is "pure" when the load-impedance is very high, the load-line curvature progressively increasing as the load-impedance is reduced.

The properties of "pure" push-pull systems have been exhaustively dealt with, but in view of the widespread use of valves expressly intended for "quiescent" operation (*e.g.*, the double pentode, type QP21) and of the recent introduction of a triode designed for "partial" push-pull amplification (type PX25A) it is desirable to review the advantages peculiar to each of these two systems.

The primary advantage in the "quiescent" system, namely, economy of anode-current, is an important consideration when batteries are the source of supply, but for mains-supplied amplifiers this advantage is extremely questionable. While it must be admitted that the mains-unit might conceivably be reduced in size so as to be "overloaded" during loud passages of programme-matter, the uncertainty regarding the probable maximum duration of these overloads makes this type of economy rather unattractive to the designer of reliable apparatus. Moreover, the large component of second-harmonic frequency in the feed-current may necessitate extra outlay on smoothing equipment, to prevent loss of power and to avoid distortion due to feeding back the distorted wave-form to the earlier amplifying-valves.

The quiescent system may be introduced as a means of reducing anode dissipation and hence enabling higher voltages to be employed with any given valve-type. This process involves great risk of breakdown due to internal electrolysis, electronic bombardment, etc., in the valves, and may lead to distortion consequent upon excessive demand for cathode-emission during loud passages. The system should be employed only when sanctioned by exhaustive trials by the valve-manufacturer.

When "partial" push-pull conditions prevail, as in the case of pairs of PX25A triodes, the difficulties of operation are not so great. The range of the variation in the anode feed-current is only about 2 : 1 and at no time do the anode-currents in the individual valves fall to zero. This fact, combined with the low impedance of the valves, makes for high electrical damping of the output transformer windings, a necessary condition for the satisfactory reproduction of transients.

The harmonic distortion in this type of stage becomes less as the amplitude decreases. Thus, quiet passages, during which the ear is most sensitive to distortion, are reproduced with extreme purity. This state of affairs is not invariably found in amplifiers; for instance, in Class B stages a maximum of harmonic content is found at a fairly low volume-level.

Since the PX25A valve has been designed for " partial " push-pull operation, the high peak anode-currents demanded by this running condition have been provided for in the activation of the filament. The only necessary precautions are to ensure that the filament-voltage is correctly maintained and that the load-impedance is adjusted to the recommended value.

End of Part I.

The Late Mr. J. F. Herd

WITH deep regret we have to record the death on July 22nd last of Mr. James Fleming Herd, M.I.E.E., M.Inst.Rad.E., Senior Scientific Officer in the Radio Department of the National Physical Laboratory. Mr. Herd, who was only 47, was born and educated in Dundee. He entered the Post Office and became a highly skilled officer of the telegraph service.

He served as an instructor in the R.A.F. in that part of the service which developed into the Wireless and Electrical School.

After the war he joined the Meteorological Office as a Senior Professional Assistant, for service at M.O. Radio Station, Aldershot, then engaged in a study of atmospherics in relation to thunderstorm detection. On the formation of the Radio Research Board that station was taken over by the Department of Scientific and Industrial Research. The formation of the Radio Department, National Physical Laboratory, in 1933 brought him to the rank of Senior Scientific Officer as Officer-in-Charge of the Slough Division of the new entity, and as secretary of a number of committees of the Radio Research Board.

His published scientific work falls far short of representing his notable contributions to the progress of fundamental radio research. His contributions to the Proceedings of the Royal Society, the *Journal of the Institution of Electrical Engineers*, the *Wireless Engineer* and other papers, and his monograph (jointly with two departmental colleagues) on " The Cathode Ray Oscillograph in Radio Research " give some evidence of his rare gifts as an investigator, gifts in which an " infinite capacity for taking pains," a genius for making experimental apparatus " go," an extremely wide range of reading, a tenacious and exact memory, were intermixed with a fine enthusiasm and a basic common-sense.

He leaves a widow and an only son.

R. A. W. W.

The Response of Modulators at High Audio-frequencies*

By D. A. Bell, B.A.

IN a tuned radio-frequency amplifier there is always a loss of the higher modulation frequencies, of easily calculable magnitude, owing to persistence of oscillation in a tuned circuit of low decrement. The effect of the valve in an amplifying stage is allowed for by regarding it as a constant resistance shunted across the tuned circuit, but the assumption of a constant resistance is not legitimate in an oscillator or modulator, so that a more detailed examination of the mechanism is required here. Two types of modulating circuit will be considered: an oscillating valve which is modulated, and a valve driven from an independent oscillator and modulated by variation of its anode potential. Although the second arrangement is normal practice for transmitters of any size, some method of modulating on the actual oscillator valve might be used for small mobile transmitters, and for this reason the behaviour of the system will be discussed qualitatively.

Modulation of an Oscillating Valve

As we are not here concerned with the minor corrections to the frequency of an oscillator which arise from various valve and circuit constants, we may represent any valve oscillator by the differential equation

$$LC\frac{d^2i}{dt^2} + \left(RC - \frac{L}{\rho}\right)\frac{di}{dt} + \left(1 - \frac{R}{\rho}\right)i = 0 \quad \ldots \quad (1)$$

Whereas in the dynatron $-\rho$ is simply dependent upon the shape of the characteristic, in triode oscillators it will be a function of the circuit values as well as of the valve parameters; thus for the ordinary inductively coupled tuned-anode circuit, with mutual inductance M between anode and grid coils,

$$-\rho = -\rho' \Big/ \left(\mu\frac{M}{L} - 1\right) \quad \ldots \quad \ldots \quad (2)$$

where ρ' is the effective value† of the anode resistance under working conditions.

The solution of this equation indicates an oscillation of frequency

$$f = \frac{1}{2\pi}\sqrt{\frac{1 - R/\rho}{LC} - \left(\frac{RC - L/\rho}{2LC}\right)^2} \quad \ldots \quad (3)$$

and amplitude changing at the rate e^{-kt} where the factor k is

$$k = \frac{RC - L/\rho}{2LC}$$

It should be noted at this point that in a steady state the amplitude will take up a value such that k vanishes, i.e., $\rho = L/RC$, and the frequency can then be expressed in the form $f = \frac{1}{2\pi}\sqrt{\frac{1 - F^2}{LC}}$

where F is the ratio of the total circuit resistance R to the reactance at the resonant frequency of either inductance or capacitance, and may be termed the power factor of the circuit as a whole. This power factor is $1/\pi$ times the decrement of the circuit. This is the only form of expression for the frequency which is of importance for the design of unmodulated oscillators; but if the oscillator itself is modulated, there must be growth and decay of oscillation, and the second term under the square root in (3) no longer remains zero. This means that even if the oscillator frequency is independent of anode and grid voltages for slow changes, frequency modulation may occur if it is modulated at high frequencies.

The exponent k can be written in the alternative forms

$$k = (1/2C)\ (RC/L - 1/\rho) = (1/2C)\ (1/\rho_0 - 1/\rho)$$

where ρ_0 is the equilibrium value of ρ, which must of necessity be equal to the dynamic resistance L/RC of the tuned

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* MS. accepted by the Editor, January, 1935.

† For a discussion of "effective value," see "Investigation of Valve Performance by an Electrodynamometer Method." Journ. I.E.E. April, 1935. Vol. 76, p. 415.

circuit. Thus for a tuned circuit of given dynamic resistance the rate of growth is proportional to the change which has been made in ρ, and inversely proportional to the tuning capacity. The latter enters into the problem since the potential energy stored in the tuned circuit for a given potential difference between its ends is proportional to the capacity, while the energy dissipated in the circuit per second depends only upon the dynamic resistance. (P. H. Osborn in " A Study of Class B and Class C Amplifier Tank Circuits," *Proc. I.R.E.* (1932), Vol. 20, p. 813, refers to these two energies as the "volt-amperes" and " watts" of the tuned circuit.) The different operating conditions and methods of modulation available for the type of oscillator under consideration are so varied that no detailed investigation is possible. But if we assume that at frequency ω the modulation loss factor is x (i.e., a modulating voltage which at low frequency would produce a depth of modulation m, in fact modulates only to a depth xm) it can be shown in various ways that there is a phase difference ϵ between the modulating voltage and the amplitude of the oscillation in the tuned circuit where $\cos \epsilon = x$. For since the rate of growth of tuned circuit voltage is proportional to the difference between its actual value and the equilibrium value for the instantaneous value of modulating voltage, the point where the two curves cross (see Fig. 1) must be a point of zero gradient, i.e., maximum or minimum, on the tuned circuit curve. The difference between the two curves varies over the cycle, but is of the order of $m \sin \epsilon$ or $m\sqrt{1 - x^2}$ where the oscillation amplitude is changing most rapidly. We therefore write

$$-k = (1/2C)B(m\sqrt{1-x^2}) \quad \ldots \quad (4)$$

where B is a function of the valve characteristic and indicates the manner in which the effective value of ρ varies with amplitude. The maximum rate of change which actually occurs in the amplitude of oscillation is ωmx, so that we may equate these two expressions :

$$\omega mx = exp.\ (1/2C)B(m\sqrt{1-x^2}) \quad \ldots \quad (5)$$

It is clear that if x is to approach unity for any given value of ω, the function B must be large, and C must be small. The function B will normally be increased by increasing the extent to which the amplitude of oscillation exceeds the linear part of the valve characteristic, a tendency which is also favourable to high power efficiency ; but an alternative is the use of some form of amplitude control, such as that suggested by Arguimbau for other reasons. (" An Oscillator having a Linear Operating Characteristic," *Proc. I.R.E.*, Vol. 21 (1933), p. 14.) The anode load impedance is presumably fixed by the operating conditions desired for the valve, but there is still some scope for variation of the L/C ratio. For good response to rapid modulation therefore we should increase the L/C ratio and restore the dynamic resistance of the circuit to its original value by increasing the resistance ; the necessary resistance will normally be available in the load which the oscillator is required to drive, either an aerial or the input circuit of a following valve, so that there need be no waste of energy as the result of this adjustment. If, however, the valve is to be run at high efficiency, with the anode current flowing for a fraction only of each cycle, there is a lower limit to the value of capacity if radio-frequency output of satisfactory wave-form is to be secured. (P. H. Osborn, *loc. cit.*, suggests a volt-ampere/watt ratio of 10 or 12.)

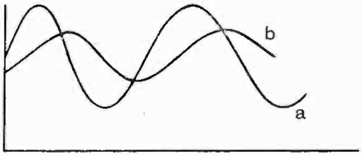

Fig. 1.—(*a*) $1 + m \sin \omega t$,
(*b*) $1 + xm \sin (\omega t - \epsilon)$.

Modulation of a Driven Valve

If a modulated valve has a linear characteristic, the amplitude of radio-frequency anode current is proportional to the modulating voltage, and we may write

$$i_a = i_c(1 + m \sin \omega t) \quad \ldots \quad \ldots \quad (6)$$

where i_c is the value corresponding to the unmodulated state, m the desired depth of modulation, and $\omega/2\pi$ the modulation frequency. This is strictly true only for one special case, the case which will first be considered, namely, a valve whose internal resistance is very great compared with the anode load resistance. We shall assume that the amplitude of $r.$-f voltage across the tuned circuit is then

$$V = V_c[1 + xm \sin (\omega t - \epsilon)] \quad .. \quad (7)$$

Since the oscillatory circuit behaves at its resonant frequency as a resistance of magnitude Z say, $V_c = Zi_c$; also the dissipation of energy in it is V^2/Z watts if V is the r.m.s. voltage. But it must be noted that during modulation V is not necessarily equal to Zi_a, owing to persistence of oscillation in the resonant circuit. The power supplied to the circuit at any moment is the product of the anode current and the voltage across the circuit, which from (6) and (7) is

$$Vi_a = V_c i_c(1 + m \sin \omega t)[1 + xm \sin (\omega t - \epsilon)] \quad (8)$$

The power dissipated in the circuit is

$$V^2/Z = (V_c^2/Z)[1 + xm \sin (\omega t - \epsilon)]^2 \quad .. \quad (9)$$

and the difference between (8) and (9) must be accounted for by a change in the potential energy of the tuned circuit. This latter energy is

$$CV^2 = CV_c^2[1 + xm \sin (\omega t - \epsilon)]^2$$

and on differentiating, the power absorbed in changing it is

$$2xm\omega CV_c^2[1 + xm \sin (\omega t - \epsilon)] \cos (\omega t - \epsilon) \quad (10)$$

Since at the end of a complete modulation cycle the tuned circuit has returned to its original state, with no net change of potential energy, the integral of (8) minus (9) taken round a cycle of modulation frequency must vanish. On performing the integration only square and product terms of the modulation frequency have any effect, and we find

$$\pi x m^2 \cos \epsilon - \pi x^2 m^2 = 0$$

whence $x = \cos \epsilon$, the relation deduced above from Fig. 1. From expressions (8), (9), and (10) the equation for balance of instantaneous values of power is

$$\begin{aligned} V_c i_c(1 + m \sin \omega t)[1 + xm \sin (\omega t - \epsilon)] \\ - (V_c^2/Z)[1 + xm \sin (\omega t - \epsilon)]^2 \\ = 2xm\omega CV_c^2[1 + xm \sin (\omega t - \epsilon)] \cos (\omega t - \epsilon) \end{aligned} \quad .. \quad .. \quad (11)$$

On dividing through by the factor

$$1 + xm \sin (\omega t - \epsilon),$$

which is obviously not zero, and writing $\cos \epsilon = x$, $\sin \epsilon = \sqrt{1 - x^2}$, the equation can be reduced to the form

$$\begin{aligned} (1 - x^2) \sin \omega t - x\sqrt{1 - x^2} \cos wt \\ = 2x\omega CZ\{x \cos \omega t + \sqrt{1 - x^2} \sin \omega t\} \end{aligned} \quad .. \quad .. \quad (12)$$

which is satisfied by $2x\omega CZ = \sqrt{1 - x^2}$, or

$$x = \frac{1}{\sqrt{1 + 4\omega^2 C^2 Z^2}} \quad .. \quad .. \quad (13)$$

This value for the loss of modulation is identical with that obtained from a tuned circuit on its own; for if the factor CZ be expressed in terms of the resonant frequency, p, and the power factor, $F = R/Lp$, of the tuned circuit, ωCZ becomes ω^2/p^2F^2, and (13) can be reduced to

$$x = \frac{1}{\sqrt{1 + 4\omega^2/p^2F^2}} \quad .. \quad (13a)$$

In fact, however, we shall normally be working with a valve of finite resistance; and it will be assumed that modulation is to be carried out by varying the anode voltage. The voltage across the tuned circuit should still be very nearly given by (7), but (6) is no longer true since the anode current now depends upon the voltage across the tuned circuit as well as upon the modulating voltage. If the anode circuit were a resistance or other non-resonant load, the effect could be allowed for by a constant multiplying factor depending on the ratio of anode load resistance to valve resistance; but in the present case the anode voltage amplitude is not in phase with the current amplitude, so that the same method will not apply. Moreover, a driven valve which is to be modulated by its anode voltage must have a negative grid bias which would be sufficient to cut off anode current, at the highest anode potential resulting from modulation, if there were no radio-frequency input; consequently its characteristic is far from linear, and it cannot be replaced by an equivalent resistance.

Fig. 2 represents the anode-current/anode-potential characteristics of a valve, and the line BA the operating cycle in the absence of modulation: the slope of BA is then equal to the conductance of the anode load $(1/Z)$ and that of OA equal to the anode conductance of the valve $(1/\rho)$. At a negative peak of the modulation the anode voltage will be reduced from OB to OB', where $OB' = (1 - m)OB$; but the voltage across the tuned circuit at this instant is by (7) reduced only in the ratio

$$(1 - xm.\cos\epsilon) : 1,$$

and may be represented by

$$B'N_1 = (1 - xm\,.\cos\epsilon)BN.$$

The anode current is therefore proportional to A_1N_1 instead of to $A'N'$, and is thus less than it would be in the absence of an anode load. Thus the anode current is less during "down" modulation, and greater during "up" modulation, owing to the finite resistance of the valve, a state of affairs which naturally assists the process of modulation; it may be said that the effective resistance of a tuned circuit at resonance depends upon the rate of change of the radio-frequency current supplied to it, as indicated by the slope A_1B', as compared with $A'B'$ which is the steady-state operating cycle for the anode voltage OB'. Now in the steady state, say for the unmodulated carrier, we have $NB = OB\,.\,Z/(Z + \rho)$; so that if $OB = V_c(1 + m\,.\sin\omega t)$, then

$$N_1B' = [V_cZ/(Z + \rho)]\,[1 + xm\,.\sin(\omega t - \epsilon)].$$

But

$$i_a = A_1N_1 = ON_1\tan\phi = (OB' - N_1B')/\rho.$$

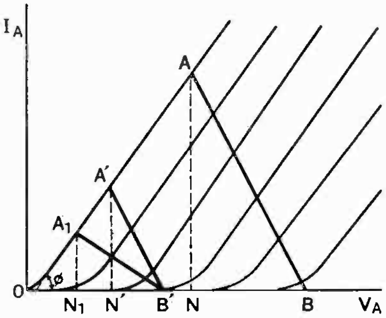

Fig. 2.

The power dissipation and the rate of change of potential energy in the tuned circuit are still given by (9) and (10), but the supply of power to the circuit is now

$$Vi_a = (V_c{}^2/\rho)[1 + xm\sin(\omega t - \epsilon)]$$
$$\left\{1 + m\sin\omega t - \frac{z}{z+\rho}[1 + xm\sin(\omega t - \epsilon)]\right\} \quad \ldots \quad \ldots \quad (14)$$

The corresponding equation for balance of power is therefore

$$(1/\rho)\{1 + m\sin\omega t - [z/(z + \rho)][1 + xm\sin(\omega t - \epsilon)]\} - (1/z)[1 + xm\sin(\omega t - \epsilon)] = 2xm\omega C\cos(\omega t - \epsilon) \quad (15)$$

In this form the value of x is not independent of ωt; consequently the envelope of the actual tuned circuit voltage is not simply a reduced copy of the modulating voltage, but is of different wave-form, i.e., it is distorted. The amount of distortion is proportional to the extent to which x varies with ωt, but in any case is small if x is small; the distortion will also be a function of the depth of modulation.

However, some idea of the magnitude of the modulation loss can be gained by considering the particular point of the cycle at which $\sin(\omega t - \epsilon) = 0$. After writing

$$\cos\epsilon = x,\ \sin\epsilon = \sqrt{1 - x^2},$$

equation (15) then reduces to

$$(1/\rho)[1 - z/(z+\rho) + m\sqrt{1 - x^2}] - 1/z = 2xm\omega C \quad \ldots \quad \ldots \quad (16)$$

which can be written as

$$2x\omega Cz\rho/(z + \rho) = [z/(z + \rho)]\sqrt{1 - x^2} - \rho^2/m(z + \rho)^2 \quad \ldots \quad (17)$$

If the valve behaved simply as a load across the tuned circuit, of resistance ρ, the equivalent anode impedance would be reduced from Z to $Z\rho/(Z + \rho)$; equation (12) would then be satisfied by

$$2x\omega Cz\rho/(z + \rho) = \sqrt{1 - x^2} \quad \ldots \quad (18)$$

By comparison of (17) and (18) it will be seen that although the finite anode resistance of the valve does assist modulation, it is less effective than would be a pure resistance load, shunted across the circuit, having a value equal to the nominal resistance of the valve. In addition, its effectiveness depends to some extent upon the depth of modulation.

If the anode resistance of the valve is reduced so far as to be negligible in comparison with the dynamic resistance of the tuned circuit, i.e., ρ/Z approaches 0, equation (16) reduces to

$$2x\omega C\rho = \sqrt{1 - x^2} \quad \ldots \quad \ldots \quad (19)$$

which is independent of depth of modulation, but being derived from (16), not (15), does not imply that the value of x is constant throughout the cycle, as would be required for perfect freedom from distortion. This value may also be regarded as the limit to which (18) tends as ρ/Z tends to O, so that the valve is now equivalent to a shunt resistance if we disregard the variation of x over the modulation-frequency cycle.

Conclusions

1. In all cases the response to modulation of high frequency is improved by reducing the ratio of the potential energy stored in the tuned circuit to the energy dissipated in it per second. Assuming that the tuned circuit is to have a fixed value of dynamic resistance, a change in this energy-ratio requires a simultaneous adjustment of L, C, and R; the change may be regarded either as a decrease in the L/C ratio, or as an increase of the decrement of the circuit.

2. The modulation of a self-oscillating valve depends upon the energy-ratio above, and upon the radio-frequency operating conditions of the valve (linear or high-efficiency cycle).

3. The anode modulation of a driven valve depends upon the anode tuned circuit's energy-ratio, and on the ratio of its dynamic resistance Z to the nominal anode resistance ρ of the valve. For $\rho >> Z$, the modulation loss is the same as would occur in the tuned circuit alone, and for $\rho << Z$ the loss is that which would occur in the tuned circuit if it were shunted by the small resistance ρ. For intermediate values of ρ/Z, however, the loss is slightly greater than it would be in the tuned circuit when shunted by a resistance ρ.

Join-up Distortion in Class B Amplifiers

By F. R. W. Strafford

WHEREVER a thermionic valve is used to deliver power into a resistance some distortion of the original input waveform must occur, due to the inherent curvature of the I_a/V_g characteristic of the valve.

Since this curvature is substantially smooth, in most cases, the derived series of harmonics due to the application of a sinusoidal input will reveal a rapid convergency of their coefficients.

Under normal operating conditions, within the rated power capacity of the stage, the distortion is, therefore, generally tolerable in its resultant acoustic effect and rises with increasing input.

In Class B operation it is usual to expect distortion of this type although, if the curved characteristics of each triode section are identical, no even harmonics will be introduced. There may be, in addition, a new and more serious form of non-linearity which will give rise to a *slowly convergent* series of odd harmonics whose percentage, relative to the fundamental, will *rise* with *decreasing* input.

The resultant acoustic effect is painfully marked and has been named "Class B distortion" by many pundits of valve and circuit technique. The reproduction, particularly of speech and pianoforte renderings, can then only be compared with similar reproductions from old-fashioned mechanical gramophones using worn records and needles.

A typical dynamic characteristic for a pair of low power triodes arranged for Class B operation is exhibited in Fig. 1, in which an attempt to produce anode current cut-off at zero grid voltage has been made by suitably increasing the magnification of each triode. This is the procedure generally adopted in marketed forms of Class B battery power valves as it dispenses with the need for grid biasing batteries.

It will be seen that some asymmetry, within the region $V_g \rightarrow 0$ has occurred, and is due to stray emission and other unavoidable manufacturing errors. Also, the initial curvature is due to the inherent thermionic emission characteristic obeying a power law.

Nevertheless, the mean characteristic, produced by summing the ordinates of each characteristic in the region of zero grid voltage, is approximately a straight line, and the resultant distortion is thus quite small at inputs providing useful outputs of entertainment value. It will be noticed that a projection of the straighter portion of each characteristic passes very nearly through the origin of the co-ordinate system, in which case, any curvature within the overlapping region approaching $V_g = 0$ will not give rise to distortion, providing each triode exhibits identical curvature.

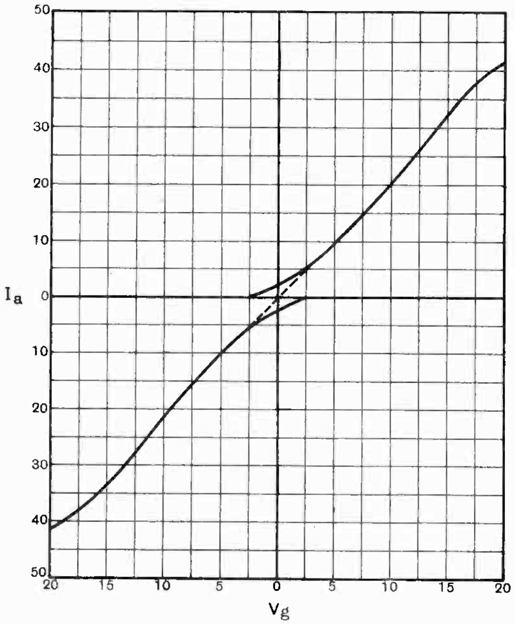

Fig. 1.—*I_a/V_g dynamic characteristic for normal class B valve. Dotted line represents resultant sum of ordinates where the two curves overlap.*

On the other hand, it is not unusual to find a triode which exhibits the dynamic characteristics depicted in Fig. 2, and such a characteristic will produce "Class B Distortion" to a marked degree.

In order to study, analytically, this intolerable form of distortion one must set aside the normal curvature effects, and regard a simple classical case of a paired characteristic of the form exhibited in Fig. 3, which is Fig. 2 divested of smooth curvature.

It will be required to find the series representing the waveform of the anode current produced by the application of a sinusoidal potential to the input grids.

Figs. 4 and 5, respectively, show the form of initial voltage application to the paired characteristics, and the resultant anode current waveform.

The instantaneous anode current may thus be expressed by two equations, valid only between specified angles. Thus :—

$$i_a = K\{(V \operatorname{Sin} \theta) - E\} \text{ from } \theta = \phi \text{ to } \theta = \pi - \phi \quad \ldots \quad \ldots \quad (1.0)$$

$$i_a = K\{(V \operatorname{Sin} \theta) + E\} \text{ from } \theta = \pi + \phi \text{ to } \theta = 2\pi - \phi \quad \ldots \quad \ldots \quad (1.1)$$

In the above the following notation is observed :—

$v = V \sin\theta =$ instantaneous input voltage to grids.

$i_a =$ instantaneous resultant anode current.

$K = \dfrac{d \,.\, i_a}{d.v.} =$ unity.

$\dfrac{d \,.\, i_a}{d.v.}$ has been made unity in order to eliminate it from the resultant analysis since it appears only as a constant.

The angle ϕ will hereafter be referred to as the distortion angle, and depends for its value upon the voltage at which anode current cuts off, and the peak value of the applied signal respectively.

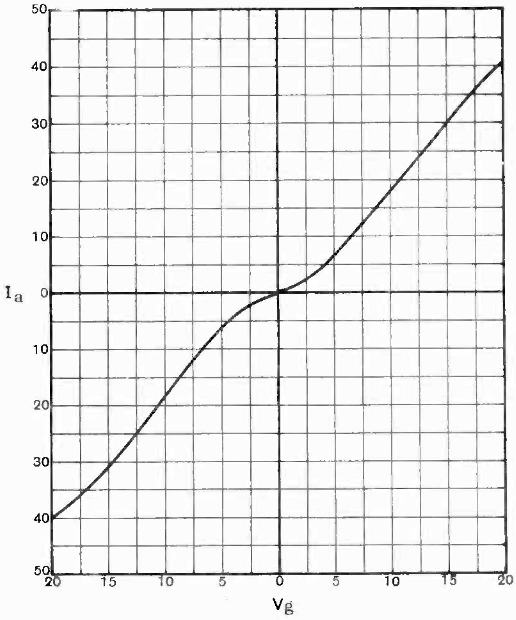

Fig. 2.—*I_a/V_g dynamic characteristic of class B valve exhibiting excessive "join-up" distortion.*

By inspection it may be seen that when $V = E$, $\phi = \frac{\pi}{2}$, and the resultant anode current will be zero for all values of the angular component of $V \sin \theta$.

On the other hand, when $E = 0$, $\phi = 0$, and no reduction of output or distortion of the resultant waveform will occur.

Since the two functions expressed by Eqs. 1.0 and 1.1 repeat over equal epochs of 2π radians, they may be expressed by an appropriate Fourier series derived from the general form :—

$$f(\theta) = [a_0 + a_1 \operatorname{Sin} \theta + a_2 \operatorname{Sin} 2\theta \; . \; . \; . \; . \\ + b_1 \operatorname{Cos} \theta + b_2 \operatorname{Cos} 2\theta \; . \; . \; .] \quad . \; . \quad (1.2)$$

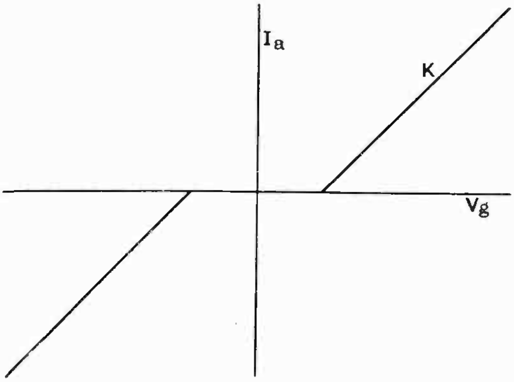

Fig. 3

The coefficients will thus be :—

$$a_0 = \frac{1}{2\pi}\int_{\phi}^{\pi-\phi}[(V \operatorname{Sin} \theta) - E] \, . \, d\theta, \\ + \frac{1}{2\pi}\int_{\pi+\phi}^{2\pi-\phi}[(V \operatorname{Sin} \theta) + E] \, . \, d\theta \quad . \; . \quad (1.3)$$

From which :—$a_0 = 0$.

$$a_n = \frac{1}{\pi}\int_{\phi}^{\pi-\phi}[(V \operatorname{Sin} \theta) - E] \operatorname{Sin} n\theta \, . \, d\theta \\ + \frac{1}{\pi}\int_{\pi+\phi}^{2\pi-\phi}[(V \operatorname{Sin} \theta) + E] \operatorname{Sin} n\theta \, . \, d\theta \quad . \; . \quad (1.4)$$

When $n = 1$,

$$a_1 = \frac{1}{\pi}[V\{(\pi - 2\phi) + \operatorname{Sin} 2\phi\} - 4E \operatorname{Cos} \phi] \quad (1.5)$$

When n is odd and $\neq$ unity,

$$a_n = \frac{4}{\pi}\left[\frac{Vn}{n^2 - 1}(\operatorname{Cos} n\phi \operatorname{Sin} \phi - \operatorname{Sin} n\phi \operatorname{Cos} \phi) \\ - \frac{E}{n}\operatorname{Cos} n\phi\right] \quad . \; . \quad (1.6)$$

By rewriting $E = V \operatorname{Sin} \phi$ Eqs. 1.5 and 1.6 may be arranged into

$$a_1 = \frac{V}{\pi}[(\pi - 2\phi) + \operatorname{Sin} 2\phi - 4 \operatorname{Sin} \phi \operatorname{Cos} \phi] \quad (1.7)$$

$$a_n = \frac{4V}{\pi}\left[\frac{1}{n(n^2 - 1)}\operatorname{Sin} \phi \operatorname{Cos} n\phi \\ - \frac{n}{n^2 - 1}\operatorname{Sin} n\phi \operatorname{Cos} \phi\right] \quad . \; . \quad (1.8)$$

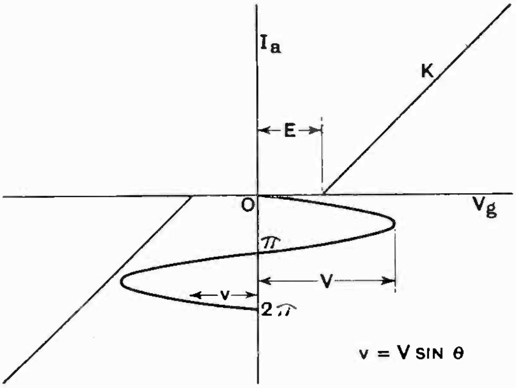

Fig. 4

The coefficient b_n is given by :—

$$b_n = \frac{1}{\pi}\int_{\phi}^{\pi-\phi}[(V \operatorname{Sin} \theta) - E] \operatorname{Cos} n\theta \, . \, d\theta \\ + \frac{1}{\pi}\int_{\pi+\phi}^{2\pi-\phi}[(V \operatorname{Sin} \theta) + E] \operatorname{Cos} n\theta \, . \, d\theta \quad . \; . \quad (1.9)$$

from which

$b_n = 0$ for all values of n.

The anode current for the classical case of Class B Distortion may therefore be represented by the series :—

$$i_a = \frac{V}{\pi}[(\pi - 2\phi) + \operatorname{Sin} 2\phi - 4 \operatorname{Sin} \phi \operatorname{Cos} \phi] \operatorname{Sin} \theta$$

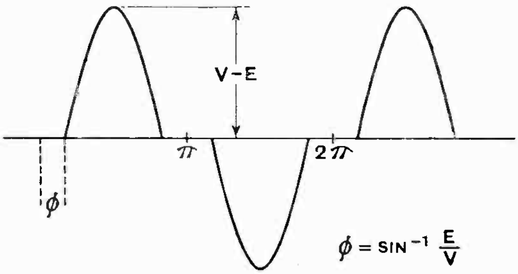

Fig. 5

$$+\sum_{n}^{\infty}\frac{4V}{\pi}\left[\frac{1}{n(n^2-1)}\operatorname{Sin}\phi\operatorname{Cos}n\phi - \frac{n}{n^2-1}\operatorname{Sin}n\phi\operatorname{Cos}\phi\right]\operatorname{Sin}n\,.\,\theta \quad .. \quad (2.0)$$

Where $n = 2p + 1$.

p = any integer.

An inspection of this series reveals that when

$$\phi = 0,\ i_a = V\operatorname{Sin}\theta$$

and when $\phi = \frac{\pi}{2}$, $i_a = 0$.

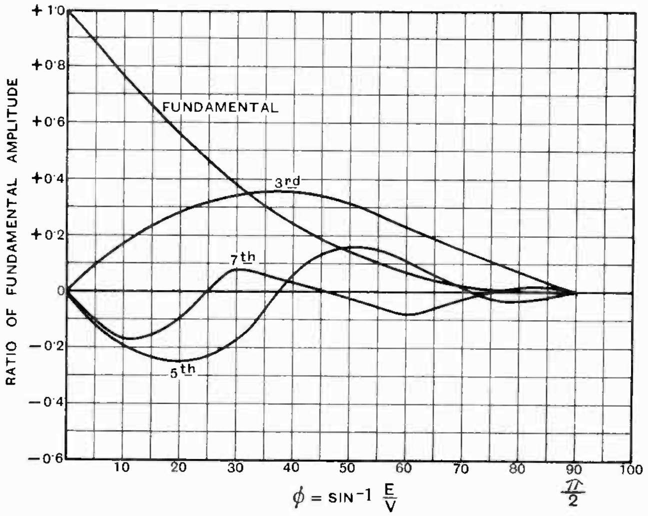

Fig. 6.—*Fundamental and harmonic amplitudes as a function of the distortion angle* ϕ.

Fig. 6 shows how the fundamental, 3rd, 5th and 7th harmonics vary with the magnitude of the distortion angle ϕ. The tedium of plotting these characteristics has precluded any further harmonics from the graph, but it can easily be seen that a slow convergency exists. Also the higher frequencies execute an increasing number of phase reversals before tending to zero amplitude in the limit.

It can also be seen that the percentage distortion rises very rapidly with ϕ, since the fundamental amplitude is decreasing at the same time as the harmonic amplitude rises.

For small values of ϕ Eq. 2.0 may be rewritten, with negligible error, as :—

$$i_a = \frac{V}{\pi}[\pi - 4\phi]\operatorname{Sin}\theta$$

$$+\sum_{n}^{\infty}\frac{4V}{\pi}\left[\frac{n}{n^2-1}\operatorname{Sin}n\phi\right].\operatorname{Sin}n\theta \quad .. \quad (2.1)$$

The individual percentage harmonic relative to the fundamental will thus be given as :—

$$\frac{4\left[\frac{n}{n^2-1}\operatorname{Sin}n\phi\right]}{\pi - 4\phi}\times 100\ \% \quad .. \quad (2.2)$$

This equation is of particular interest because one is chiefly concerned with a small value of ϕ in practice. It may therefore be used for calculation purposes, providing ϕ is not greater than 6°.

If the effects of curvature at the join-up are to be included in the expression for the harmonic series, the foregoing method cannot be used. It is then necessary to present the characteristic in the form of a suitable trigonometric polynomial derived from a mechanical Fourier analysis of the curves, and then to substitute the applied voltage $V\operatorname{Sin}\theta$ in the expression. The coefficients must then be determined by referring to the appropriate Bessel function tables, and on account of the slow convergency of the series presents an unwelcome task. Although a classical case has been analysed, the neglect of curvature is not likely to cause serious errors, providing $V >> E$; a condition with which one is chiefly concerned in practice.

Electro-Acoustical Problems*

A Graphical Method of Solution

By C. N. Smyth, B.Sc., Eng.

(From the Staff of the Research Laboratories of The General Electric Company, Wembley)

A METHOD is described of deducing the resultant motion of a stiffness controlled device when supplied with a current of known waveform.

A series of characteristics of a driving system is shown, on which load lines, representing the driven system, may be drawn. The diagram is analogous to the electrical case of load lines drawn on valve characteristics. The method is applicable to the solution of some non-linear stiffness controlled arrangements, and as a method of comparing the linearity of driving systems. It is shown that load lines representing mass and resistance controlled systems may be drawn in certain cases.

Introductory

ELECTRO-ACOUSTICAL devices throughout the article are taken in a general sense to mean any mechanism in which some member moves in accordance with the electric current supplied to the device. For example, a moving coil loud speaker.

The method enables the motion of a device in which the chief mechanical restoring force is a stiffness, to be accurately determined, providing the waveform of the current supplied to the device is known. In practice, the current waveform is often undetermined due to the back e.m.f. containing harmonics. The condition, however, makes a useful basis of comparison and may be simulated in practice by using a pentode—a constant current device—to serve as the source of power.

In considering the behaviour of a device it will be best to consider it as two separate units. First, the arrangement which turns the electric current into a driving force—called the driving member. In a moving coil loud speaker this would correspond to a field magnet system with an unconstrained voice coil. The second part—called the driven member—comprises all the moving parts. In a moving coil loud speaker this would comprise the voice coil again with the spider and diaphragm, including the air which moves with it.

The method is based on interpreting a series of graphs representing the behaviour of the driving system alone. These curves illustrating the relation between current displacement and force are shown in Fig. 1. The study of them enables the linear working range of the device to be decided and the most suitable values for the elements of the driven system to be chosen.

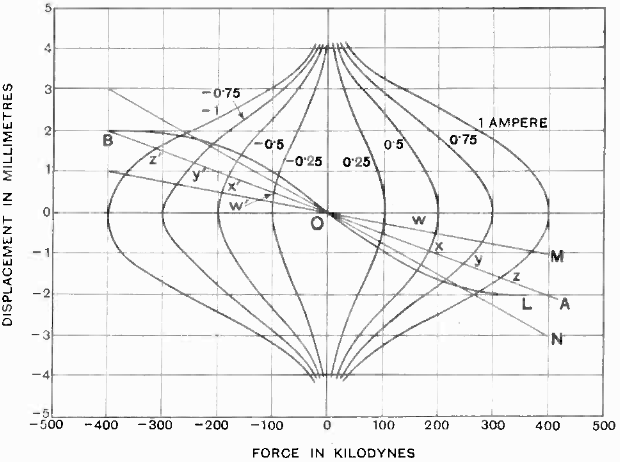

Fig. 1.—*Force-displacement-current characteristics for moving coil loud speaker.*

The Method

Common to the two parts of the device, the driving and driven elements, are relations

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* MS. accepted by the Editor, April, 1935.

between force and displacement. For every position of the driving element there is a force corresponding to the current flowing. While for the driven element there is a relation between force, deflection, and frequency. We may express these facts symbolically.

$$(1) \quad F = \Phi[I, x]$$

$$(2) \quad F = M\frac{d_2x}{dt^2} + R\frac{dx}{dt} + \phi(x)$$

where F denotes force, I current, x displacement, M mass, R resistance, and t time. The term $\phi(x)$ is inserted to represent the general case, for any type of stiffness element. For a linear stiffness S the term would become simply Sx. Both these relations may be exhibited graphically and the resultant motion can be deduced by their simultaneous solution, which in a certain number of cases, is possible graphically.

Consider first the driving member, a series of measurements may be taken by giving it definite displacements and measuring the static force for various values of current, and then obtaining a family of curves by plotting force against displacement for each of the values of current chosen.

In many examples the force will vary linearly with current, but no such assumption is necessary to the application of the method; but when this is the case, for example, with a moving coil loud speaker, the curves may be calculated from the measured flux distribution. The curves are obtained by integrating the flux acting on the coil at each displacement and multiplying by the current; for within very wide limits the force will be proportional to the current, in fact until such time as the current in the voice coil modifies the flux distribution.

A series of curves for a moving coil loud speaker is drawn in Fig. 1. The force for a given current is seen to be a maximum when the coil is centrally disposed in the gap and to fade off as the coil is moved out of the flux.

Secondly, considering the driven member, at any given instant in its history equilibrium exists between the driving and counteracting forces—with the moving parts the moving member of the driving system must be included—the F of equation (1) is equal and opposite to the F of equation (2). The two simultaneous equations can be solved graphically by superimposing the graph of equation (2) upon the curves of equation (1): only the force axis of equation (2) must be plotted with reversed sign.

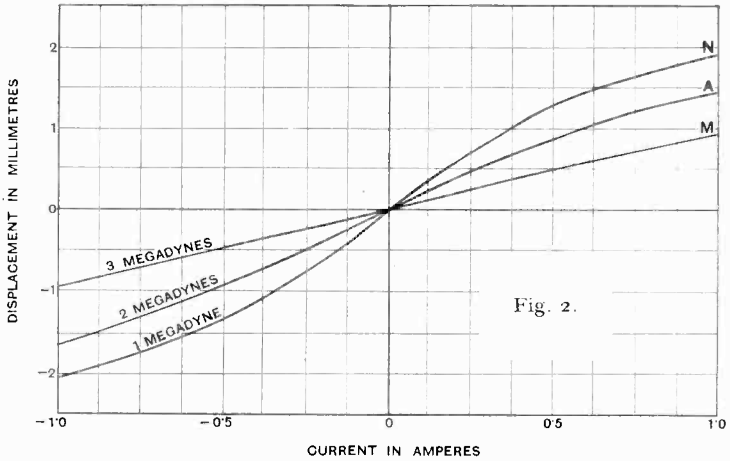

Fig. 2.

Now considering the ideal case where the driven member consists of a pure stiffness, we can write $F = Sx$, if the stiffness is linear, which is represented graphically by a straight line. For example, the line AOB on Fig. 1. Reading now the displacements corresponding to various currents from the points x, y, z, etc., at the intersection of the line AOB with the various current curves, a graph may be plotted of displacement as a function of current. Fig. 2 shows the relations between current and displacement for stiffnesses of 1, 2 and 3 megadynes per centimetre obtained from the lines $A.M.N.$ drawn on Fig. 1.

For a sinusoidal variation in current the motion is plotted on graph (3), curve (4). The harmonics produced in the resultant waveform may be calculated by Fourier Analysis, or from the intercepts cut off on the stiffness line by the current curves of Fig. 1*.

For a non-linear stiffness $F = \phi(x)$ a curved or discontinuous stiffness line may

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* D. C. Espley, *J.I.R.E.*, Oct., 1933, Vol. 21, No. 10.

be drawn and the resulting waveform obtained as before. It is stressed that this is possible since the stiffness is not a function of frequency and the relation $F = \phi(x)$ still obtains, no matter in what manner F chooses to vary. A line (L) for a non-linear stiffness is drawn on Fig. 1, and the resultant waveform for a sinusoidal variation in current is drawn on Fig. 3, line (L).

For a stiffness controlled system the exact motion of the driven member can be accurately deduced for any given current input to the coil, no matter how non-linear the field or stiffness may be.

From the graph of the resultant waveform it is interesting to deduce two things, the harmonics produced and the constant term in the Fourier Analysis. The constant term represents the mean displacement of the coil under dynamic conditions. In general, the mean dynamic position will differ from the rest position. This effect, often referred to as rectification, is well known to occur in practice.

It is suggested that this method of drawing a stiffness load line is the best way of comparing the performance of various driving systems, and in particular for determining the most suitable flux distribution in field magnets of moving coil speakers.

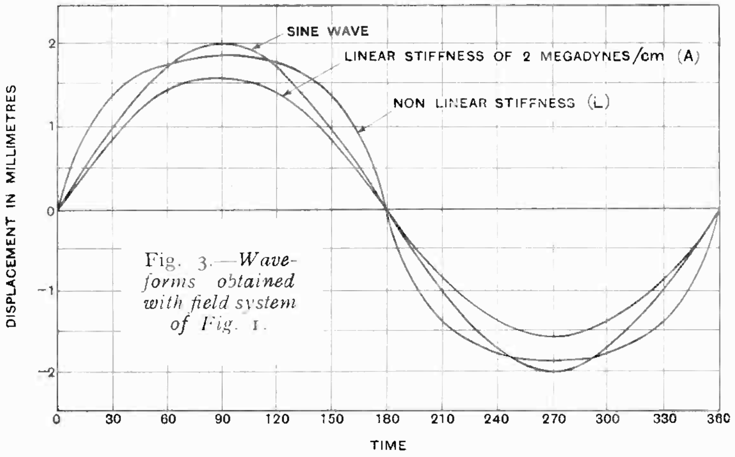

Fig. 3.—Waveforms obtained with field system of Fig. 1.

In considering the remaining two elements in equation (2), mass and resistance, it is noticed that a time element is included. For mass :—

$$F = M\frac{d_2x}{dt^2}$$

and for resistance

$$F = R\frac{dx}{dt}$$

The introduction of t makes it impossible to represent the relations graphically unless a known form of variation is given to say F. For this reason, the method breaks down in these cases for an exact solution, although some approximate results may be obtained. More accurate results may be obtained though by using a method of successive approximations.

If the load is a pure mass we have :—

$$F = M\frac{d_2x}{dt^2}$$

This relation contains a time element and can only be represented graphically if we give a definite form of variation to F. Assuming a sinusoidal variation in force of pulsatance ω, the relation after integrating twice becomes $F = -\omega^2Mx$, which represents a straight line, only with the opposite slope to a stiffness line. It must be emphasised that the slope of the line depends on the value of ω, and consequently it is correct for only one particular frequency, and if F does not vary sinusoidally the line has a different slope for each of the harmonics introduced. Under such conditions an exact solution is impossible graphically, except in a perfectly linear field, as a sinusoidal variation in current would not produce a corresponding sinusoidal variation in force.

In practical cases, where the field does not violently depart from uniformity over the working range, the errors introduced will be slight, and although the mass line cannot be used to give an accurate interpretation of waveform, it will give a good idea of the amplitudes of motion experienced.

Taking now the third case of a resistance load, which may be produced practically by a moving coil loud speaker working on its bass resonance, we have the condition

$$F = R\frac{dx}{dt}$$

and assuming a sinusoidal variation in F and integrating if

$$F = F_0 \sin \omega t$$

$$x = \frac{F_0}{\omega R} \cos \omega t$$

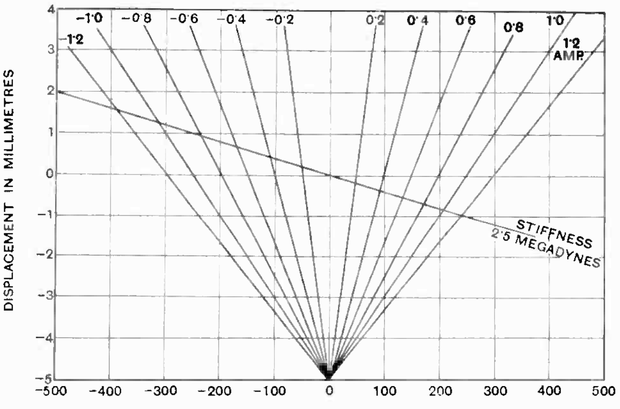

Fig. 4.—*Example with linearly increasing field.*

which two equations together represent an ellipse, or a circle if the scales are suitably chosen.

The foregoing remarks in regard to mass apply again, as the dimensions of the resistance ellipse are functions of the frequency. Although, therefore, not suitable for the accurate determination of waveform, two interesting facts emerge from its application to a uniform or substantially uniform field. First, the limits of travel of the system may be approximately determined, and secondly, its area is proportional to the energy supplied to the moving parts, for the area is given by

$$A = \int F dx$$

This energy is used for the production of sound and to overcome internal friction.

Load lines may be drawn representing combined lumped values of Mass, Resistance, and Stiffness, but care must be taken over the interpretation of the resultant motion unless the conditions imply a sinusoidal variation in force.

As an example in the use of the curves the motion for a stiffness controlled system in a linearly increasing field is worked out, and the rectification effect calculated.* The field system curves are drawn in Fig. 4, and the waveform obtained is shown in Fig. 5. It will be seen there is a tendency for the coil to move, under dynamic conditions into a stronger field. This result would appear to apply generally to "steady state" examples.

Comparison with Electrical Case

It will be seen that these curves are analogous to those drawn for Inductance, Resistance and Capacity on thermionic valve characteristics. The major difference is that, whereas in the electrical case, current is plotted against voltage for various values of, say, grid bias; in the mechanical case actual displacement is plotted against force. Current is analogous to velocity and not to displacement in the general comparison between mechanical and electrical systems,

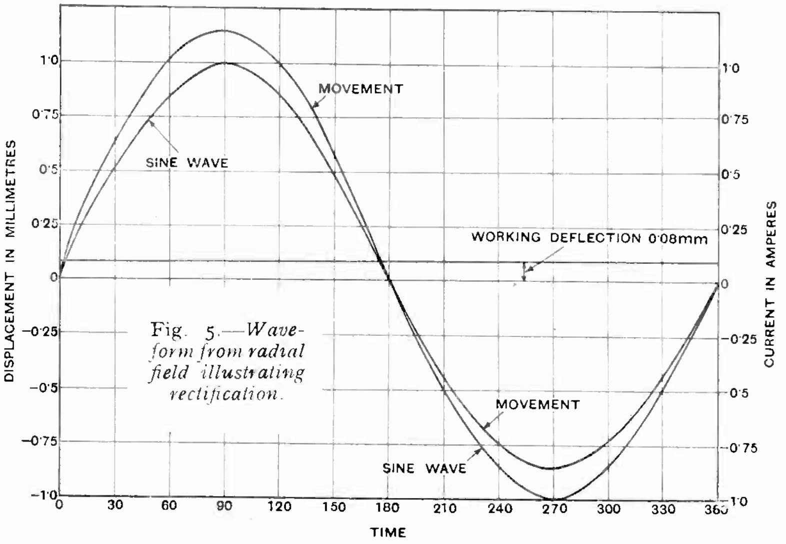

Fig. 5.—*Waveform from radial field illustrating rectification.*

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* See also McLachlan "Loud Speakers," page 245.

and for this reason the types of the load lines employed are not strictly comparable, but exhibit an inversion illustrated in the table below.

Electric Quantity	Analogous Mechanical Quantity	Type of load " line "	
		Electrical	Mechanical
Inductance . .	Mass	O ellipse	/ line
Resistance . .	Resistance	\ line	O ellipse
$\frac{1}{\text{Capacitance}}$	Stiffness	O ellipse	\ line

New Books

The Measurement of Inductance, Capacitance, and Frequency.

By ALBERT CAMPBELL and ERNEST C. CHILDS, pp. XXIV. + 488. Macmillan and Co., Ltd., St. Martin Street, London, W.C.2. 30s. net.

Those who are acquainted with Mr. Albert Campbell's papers on alternating current measurements will not be surprised to find that this book is of outstanding merit. It forms a valuable work of reference on all matters connected with the measurement of inductance, capacitance and frequency. Wireless engineers may perhaps be somewhat disappointed at the comparatively small proportion of the volume allotted to radio-frequency metals, but for audio-frequency work the book is likely to become a standard work.

The scope of the book is a good deal wider than its title might suggest. It is by no means a mere list of alternating current bridge methods. There are, for example, very useful sections on wave-form analysis ; the construction and testing of transformers ; and the measurement of very small time-intervals by methods involving the charging of a condenser. There are also four chapters dealing with the alternating current potentiometer, including one giving a detailed treatment of phase-splitting circuits, i.e., circuits for the production of voltages which are in quadrature. Bridge methods of measurement are of course discussed in considerable detail ; also the construction and properties of condensers, inductors and resistors. Other chapters deal with oscillators of all kinds, and other sources of current ; detectors ranging from the ballistic galvanometer to the pentode amplifier, and including a particularly valuable section on the vibration galvanometer. It is interesting to note that the theory of this instrument is treated by the vector method.

A valuable feature of the book is that it is written from the point of view of the experimentalist, that is, the man who is really setting out to make measurements and not merely to read or write about other people's measurements. Thus data that are likely to be required by the experimentalist are collected for his convenience. We find, for example, the constants of the materials used as heaters for thermal instruments, the constants of the magnetic materials that are most useful for measurement purposes, including the new nickel-iron alloys ; data concerning the capacitance and inductance of parallel wires such as are likely to be used for leads ; and details concerning the construction of screened transformers.

The book is not particularly well balanced, inasmuch as the amount of detail presented in the various sections is hardly proportional to their importance, but enough has been said to show that it is a book that may be consulted with profit in connection with many problems that the wireless engineer is likely to meet. L. H.

" Radiotecnica." Vol. I.

By E. Montù, Member of the Radio Committee of the Italian National Research Council : pub. by U. Hoepli, Milan, 1935 : 20 Lire, xix + 216 pp., with 160 illustrations, glossary in Italian, English, French, and German, tables, and abacs. The present volume deals with " Fundamental Principles " ; Vol. II will be entitled " Electronic Valves," and Vol. III " The Practice of Radio Transmission and Reception."

The Industry

A NEW company, Harries Thermionics, Ltd., of Avenue Chambers, Vernon Place, Southampton Row, London, W.C., has been formed with the object of carrying out research and development work in connection with valves, etc. Manufacturing will not be undertaken, but licences will be issued for the commercial exploitation of its productions. A new type of output valve developed by Mr. J. H. Owen Harries, which is now being manufactured by the Hivac firm, represents the first-fruits of the company's activities.

Technical data given in the new Dubilier list of condensers and resistances has been brought up-to-date, and useful information is given on the subject of anti-interference devices.

Mellowes & Company, Corporation Street, Sheffield, issue a booklet describing the " Mellozing " process of zinc spraying, which is now being used on a large scale for anti-interference screening.

A booklet intended for distribution among technicians and manufacturers has been issued by R. A. Rothermel of Canterbury Road, London, N.W.6. It deals with piezo-electric appliances.

Acheson colloidal graphite (Aquadag) with its peculiar property of permanent adhesion to various surfaces, chemical inertness, and electrical conductivity, is continually finding new applications. It is now being used as a coating for the bulbs of Plictron and Thyratron valves, and the makers, E. G. Acheson, Ltd., of Thames House, Millbank, London, S.W.1., are in a position to give advice on methods of application for various purposes.

Abstracts and References

Compiled by the Radio Research Board and reproduced by arrangement with the Department of Scientific and Industrial Research.

PROPAGATION OF WAVES

3304. SOME FURTHER MEASUREMENTS OF UPPER-ATMOSPHERIC IONISATION.—E. V. Appleton and R. Naismith. (*Proc. Roy. Soc.*, Series A, 1st July, 1935, Vol. 150, No. 871, pp. 685–708.)

See also 2920 of September: for reference to previous work *see* 1932 Abstracts, p. 575. Here further measurements by the critical frequency method are described, referring to regions E_1, F_1 and F_2 of the ionosphere. The experimental determination of critical frequencies is discussed and the fine structure of the ionosphere as deduced from them described. The experimental results are illustrated by specimen records, and graphs showing seasonal and diurnal variation in upper-atmospheric ionisation are given: they are compared with the theoretical predictions of Chapman (*see* Abstracts, 1931, p. 202; 1932, p. 27) and it is found that "the seasonal variation of the noon values of maximum ionisation in E_1 and F_1 is satisfactorily explained by the simple theory of ionisation by ultra-violet light from the sun, recombination with ions being the electron-dissipative process. The seasonal variation of region F_2 . . . . cannot be explained on this simple theory. Reasons are given for believing that the discrepancy is chiefly due to a pronounced seasonal variation of molecular temperature. Such considerations lead to the conclusion that the summer temperature at this level of the ionosphere must be at least 1200° K. Examples are given of a special condition of region E ionisation, occurring very frequently in summer, in which reflection of wireless waves can take place from both the lower and upper surfaces of a thin stratum of the ionosphere. Such a condition frequently gives rise to abnormally favourable conditions for long-distance high-frequency wireless transmission, the usual restriction at the upper frequency limit, due to electron limitation in region F_2, being then inoperative. The occasional occurrence of a region of slightly higher electron density than that of the normal region F_2 has been noted." An appendix describes a frequency-variation method of modulation for ionospheric investigations.

3305. REPORT ON IONISATION CHANGES DURING A SOLAR ECLIPSE [Survey of 1932, 1933 and 1934 Eclipse Results: Discussed at U.R.S.I. 1934 Assembly].—E. V. Appleton and S. Chapman. (*Proc. Inst. Rad. Eng.*, June, 1935, Vol. 23, No. 6, pp. 658–669.)

3306. THE APPLICATION OF THE MAGNETO-IONIC THEORY TO THE IONOSPHERE.—H. G. Booker. (*Proc. Roy. Soc.*, Series A, 1st June, 1935, Vol. 150, No. 870, pp. 267–286.)

For previous work on this subject *see* 355 of February. The present paper makes "an attempt to investigate, by methods of approximation, the general problem in which both ionisation density and collisional frequency vary with height, and to show how the phenomena depend on wave frequency." Vertical propagation only is considered. The case of no magnetic field is first discussed, to demonstrate the principles used; N (the electron density) and ν (the frequency of electronic collisions) are taken as exponential functions when it is desirable for purposes of illustration to specify them. Diagrams for the height of reflection as a function of frequency are drawn and the absorption in "deviating" and "non-deviating" regions is calculated. An external magnetic field is then introduced and the occurrence of the "anomalous" frequency and regions of quasi-longitudinal and quasi-transverse propagation are deduced from the formula for the complex refractive index. It is found that propagation may be described fairly completely with these two approximate modes only. The effect of the earth's field on the height of reflection is shown diagrammatically and its effect on absorption is analysed. The reflection of very long waves is also discussed. The writer's general conclusions are: "Friction imposes a lower limit to the frequency for which a wave can be gradually reflected from the ionosphere, although very long waves can be specularly reflected from the height where the index of attenuation ceases to be small. A region of absorption can exist below the deviating region of the ionosphere and, for propagation through it at quite large angles to the earth's magnetic field, only the longitudinal component of the earth's magnetic field is effective. Near the magneto-ionic frequency there is never an appreciable extraordinary reflected wave. The dependence of relative absorption on frequency for very high frequencies is found to be different according as it takes place mainly in the non-deviating region or mainly in the neighbourhood of the point of reflection. No simple phenomenon which depends in a striking manner on the value of the 'Lorentz term' has been brought to light."

3307. Diurnal and Seasonal Variations in the Ionosphere during the Years 1933 and 1934.—J. P. Schafer and W. M. Goodall. (*Proc. Inst. Rad. Eng.*, June, 1935, Vol. 23, No. 6, pp. 670–681.)

Noon ionic density of F_1 region always decreased on magnetically active days, although there is no such correlation for the E layer which is also supposed to be due to ultra-violet light, and although the longer u-v radiation measured at low altitudes is greater on the average during times of maximum solar disturbance. Perhaps the observed reduction (which is never greater than 20%) may be due to changes in other solar emanations normally only minor factors in F_1 ionisation. It may, moreover, help to account for the greater adverse effect produced by magnetic disturbances on the higher daylight frequencies in transatlantic short-wave communication. Noon ionic densities of E and F_1 regions were maximum in summer and minimum in winter; for F_2 this was reversed. Also the time of maximum density for F_2 varied with the season, being near noon in winter and near sunset in summer: "no entirely satisfactory explanation has been brought forth for these phenomena, but it seems to us that no single agency or mechanism can be responsible for these effects." A series of virtual height contour maps for the four seasons is included.

3308. Recent Studies of the Ionosphere.—Kirby and Judson. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 733–751.) *See* 2551 of August, where the 1934 reference should read "p. 374."

3309. Deepening of Modulation in the Ionosphere?—T. Sturm. (*E.N.T.*, June, 1935, Vol. 12, No. 6, p. 190.)

A note suggesting that the deepening of modulation, occurring when a sufficiently strongly modulated frequency passes through a non-linear element in a valve circuit, may have its analogy in the ionosphere, just as "cross-modulation" in valve technique is analogous to the Luxembourg effect. Signals from Luxembourg received at various places, *e.g.* Kaiserslautern, have been found to be distorted, showing a depth of modulation of more than 100%, while simultaneous reception at Berlin and Niemegk gave normal depth of modulation and undistorted signals. Reception in different places of experimental emissions with a definite degree of modulation at the emitter would test the point. If it were verified, an upper limit for emitter strength would be imposed by natural ionospheric conditions.

3310. The Propagation of Radioelectric Waves round the Earth [Critical Survey of the Phenomena and Their Various Interpretations: Luxembourg Effect: Reaction of Receiving Aerial Field on the Signal Field: etc.].—G. Rutelli. (*L'Elettrotec.*, 25th June, 1935, Vol. 22, No. 12, pp. 426–443.)

3311. Electrical Constants of Very Dry Ground, and Long Distance Propagation through It.—Löwy. (*See* 3430.)

3312. Eclipse veiled by Clouds studied with the Radio [Improved Propagation during Eclipse of Moon].—Stetson and McCaleb. (*Sci. News Letter*, 27th July, 1935, p. 56.)

3313. The First Suggestion [1911] of the Earth's Magnetic Field as a Factor in Radio Propagation?—G. W. O. H: Monckton. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, p. 371.)

3314. Further Results of a Study of Ultra-Short-Wave Transmission Phenomena [Over-Water Diffraction and Refraction].—C. R. Englund, A. B. Crawford and W. W. Mumford. (*Bell S. Tech. Journ.*, July, 1935, Vol. 14, No. 3, pp. 369–387.)

For previous work on this subject *see* 1933 Abstracts, p. 318. The results of a further study of the diffraction phenomena there referred to form the data of the present paper. Over-water transmission from an emitter on shore was received and recorded by apparatus in an aeroplane whose distance from the emitter increased. The experimental set-up is described; the wavelengths used were 1.58 and 4.6 m. Sets of typical observations are plotted, with the values calculated from the height and distance data and the constants of the sea-water, assuming ordinary optical reflection from an earth of 5 260 miles radius. The calculated values for free space variation are given for comparison. Transmission to regions beyond the optical range was found to be "determined by conditions which are not constant and which, in fact, can produce great signal strength changes. The variable percentage of water vapour normally present in the atmosphere is suggested as a possible cause. The explanation seems, therefore, to involve a combination of diffraction and refraction, this latter variable with time, and at times predominant."

3315. Resonance Phenomena in Ionised Gases [Dispersion Measurements in the Ionic Plasma of a Low-Potential Arc in Argon: the Presence of Quasi-Elastically Bound Charges with a Definite Resonance Frequency].—W. Sigrist. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 8, 1935, pp. 317–320: in German.)

3316. High-Frequency Losses of Ionised Gases [including Losses under Influence of Magnetic Field: Various Resonance Effects: for Wavelengths 6.5–300 m].—Y. Asami and M. Saito. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 338: English summary p. 47.)

"It was studied, especially, in this paper whether the resonance effect connected with the plasmoidal oscillations discussed by Tonks and Langmuir, the quasi-resonance effect obtained by Gutton, or the magneto-ionic resonance should occur for the range of wavelengths of from 6.5 to 300 m . . . The numbers and distributions of the ions and electrons in the discharge tubes vary in a complex manner according to the variation of the discharge current and also due to the magnetic field, and the secondary phenomena of their variation may give the peculiar characters under certain conditions." The pressure range used was from one-thousandth to one mm, and the fields ranged up to 50 gauss.

3317. ZONES OF SILENCE [in Guatemala, Greenland, Valley of Kings in Egypt, etc.].—R. Stranger. (*World-Radio*, 23rd Aug. 1935, p. 21.)

3318. THE INFLUENCE OF THE STRATOSPHERE ON THE DEVELOPMENT OF METEOROLOGICAL CONDITIONS.—H. von Ficker. (*Naturwiss.*, 9th Aug. 1935, pp. 551–555.)

3319. THEORY OF THE GENERAL CIRCULATION OF THE ATMOSPHERE. THE MEAN FIELD OF TEMPERATURE [Theory agreeing with Tropopause and other Observed Results].—Dedebant, Schereschewsky and Wehrlé. (*Comptes Rendus*, 29th July, 1935, Vol. 201, No. 5, pp. 346–348.) For a previous paper *see* 675 of March.

3320. THE VERTICAL STABILITY OF THE ATMOSPHERE, *also* THE METEOROLOGICAL CONDITIONS IN THE LOWER STRATOSPHERE, FROM THE POINT OF VIEW OF AERONAUTICS, *and* THE STRUCTURE OF THE WIND IN THE LOWER LAYERS OF THE ATMOSPHERE.—Anxionnaz : Guiraud : de Fériet. (*Génie Civil*, 13th July, 1935, Vol. 107, No. 2, pp. 48–49 : 49 : and 49–50 : summaries only.)

3321. THE LUMINOUS NIGHT CLOUDS [Survey of Recent Research].—R. Süring. (*Naturwiss.*, 9th Aug. 1935, pp. 555–557.)

3322. OZONE IN THE POLAR NIGHT [Tromsö Results last December and January].—Tönsberg and Götz. (*Naturwiss.*, 31st May, 1935, p. 354.)

3323. THE DISTRIBUTION OF THE OZONE IN THE EARTH'S ATMOSPHERE [Survey of Recent Researches].—W. Grotian. (*Naturwiss.*, 3rd May, 1935, pp. 295–296.)

3324. THERMAL DECOMPOSITION OF OZONE [Part played by Reaction Chains a Small One].—M. Ritchie. (*Nature*, 10th Aug. 1935, Vol. 136, p. 221.)

3325. ATMOSPHERIC SIGHT-RANGE AND ITS MEASUREMENT.—K. Kähler. (*Naturwiss.*, 19th April, 1935, pp. 253–256.)

3326. LIGHT ABSORPTION IN THE ATMOSPHERE AND ITS PHOTOCHEMISTRY, *and* VISIBILITY OF SIGNALS THROUGH FOG.—O. F. Wulf : G. Mili. (*Journ. Opt. Soc. Am.*, August, 1935, Vol. 25, No. 8, pp. 231–236 : 237–240.)

3327. ON THE COHERENCE OF LUMINOUS RADIATIONS AND THE POSSIBILITY OF EMPLOYING INTERFERENCE APPARATUS AS MONOCHROMATORS.—Cau and Esclangon. (*Comptes Rendus*, 22nd July, 1935, Vol. 201, No. 4, pp. 270–273.)

3328. ON THE DIFFRACTION OF LIGHT BY LIGHT, ACCORDING TO DIRAC'S THEORY.—Euler and Kockel. (*Naturwiss.*, 12th April, 1935, pp. 246–247.) *Cf.* Mohler, 1934 Abstracts, p. 86.

3329. A SIGNIFICANCE OF PHASE VELOCITY IN CLASSICAL MECHANICS.—L. Laboccetta. (*La Ricerca Scient.*, 15/31 July, 1935, 6th Year, Vol. 2, No. 1/2, p. 33.)

3330. EXACT SOLUTION OF EQUATION OF PROPAGATION OF WAVES WITH QUADRATIC DAMPING [*e.g.* Certain Types of Flood Waves].—M. A. Biot. (*Proc. Nat. Acad. Sci.*, July, 1935, Vol. 21, No. 7, pp. 436–443.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3331. LIGHTNING CURRENTS AND THEIR VARIATIONS [Records of Magnetic Field Variations].—H. Norinder. (*Journ. Franklin Inst.*, July, 1935, Vol. 220, No. 1, pp. 69–92.)

The writer has recorded the magnetic field variations caused by lightning by using frame aerials connected to cathode-ray oscillographs (for method *see* back reference in 2182 of July). He first discusses the theoretical principles of the measurements and the calculation of the lightning currents, with the assumptions made as to the length of the lightning path and the variation of the magnetic field with distance, and describes the observations and their reduction. Examples of oscillograms with high and low recording velocities are given. Weak pre-discharges, shown on records taken with a horizontal aerial, were not visible on the oscillograms obtained with the frames. The percentage time differences between consecutive current pulses and the percentage distribution of crest values on individual current pulses are shown graphically. The maximal changes with time in lightning currents, the percentage distribution of duration in time of individual current pulses, and the percentage distribution of time intervals for lightning current crest variation values, are also shown. The lightning surges on transmission lines as caused by direct strokes are considered and calculated diagrams are given of the surges from known current variation forms. The total charge carried by a lightning flash was estimated from the measurements to be less than 2 coulombs.

3332. THE PRODUCTION OF HIGH VOLTAGES WITH AN AIR CURRENT CONTAINING CHARGED PARTICLES OF ONE SIGN.—E. Burkhardt. (*Ann. der Physik*, Series 5, No. 4, Vol. 23, 1935, pp. 339–370.)

3333. THE VARIATION OF SPARKING POTENTIAL WITH INTENSE ULTRA-VIOLET ILLUMINATION [Static Breakdown a Space-Charge Phenomenon : Amount of Space Charge generated at Breakdown must be approximately Constant].—H. J. White. (*Phys. Review*, 15th July, 1935, Series 2, Vol. 48, No. 2, pp. 113–117.)

3334. On the Relation between the Electrical Conductivities of the Air and the Danger from Lightning.—G. Viel and R. Gibrat. (*Bull. Soc. franç. des Élec.*, July, 1935, Vol. 5, No. 55, pp. 731–739.)

3335. Dauzère's Theory of the Conductivity of the Air in Regions prone to Lightning Strokes.—E. Mathias: Dauzère. (*Comptes Rendus*, 29th July, 1935, Vol. 201, No. 5, pp. 314–317.)

3336. Lightning and Protective Measures against It.—Müller-Hillebrand. (*Teknisk Tidskrift*, 3rd Aug. 1935, Vol. 65, No. 31, Supp. pp. 113–125.) Paper read before the Swedish Institute of Electrical Engineers: with long discussion.

3337. Cloud Chamber Investigations of Corona Discharges [Photographs of Discharges from Various Electrodes].—H. Kroemer. (*Zeitschr. f. Physik*, No. 9/10, Vol. 95, 1935, pp. 647–651.)

3338. Ionic Spectrum of Air [Variation of Distribution over Mobility Spectrum and Variability depending on Meteorological Conditions].—K. Shiratori. (*Mem. of Fac. of Sci. and Agric., Taihoku Imp. Univ.*, April, 1935, Vol. 15, No. 1, pp. 1–37: in English.)

3339. Condensation Nuclei and Particles in Suspension in the Atmosphere.—O. Thellier. (*Comptes Rendus*, 29th July, 1935, Vol. 201, No. 5, pp. 348–350.)

3340. Cosmic Rays suggested as Cause of Light of Night Sky.—Kaplan. (*Sci. News Letter*, 13th July, 1935, Vol. 28, No. 744, p. 28.)

3341. Results of the Dutch Cosmic Ray Expedition, 1933: VI. The Variation of the Radiation with Magnetic Latitude. The Energy Distribution of the Particles.—J. Clay. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 299–308: in English.)

3342. Comparison of the Decrease of Intensity of the Primary Cosmic Radiation in Different Materials.—J. Clay. (*Physica*, July, 1935, Vol. 2, No. 7, pp. 645–649: in English.)

3343. Absolute Intensity of Cosmic Rays: Additional Note to "Ionisation by Cosmic and Radioactive Radiation at Different Gas Pressures."—J. Clay. (*Physica*, July, 1935, Vol. 2, No. 7, pp. 650–651: in English.) *See* 2202 of July.

3344. The Transformation of Cosmic Radiation in Matter [probably Two Photon Radiations between Primary Corpuscular and Final Corpuscular Radiations].—J. and P. H. Clay. (*Physica*, June, 1935, Vol. 2, No. 6, pp. 551–556: in English.)

3345. Diurnal Variation of Cosmic Rays [Results near Equator: No Diurnal Variation greater than 0.1%: No Effect from Nova Herculis].—J. Clay and H. R. Woltjer. (*Physica*, June, 1935, Vol. 2, No. 6, pp. 582–584: in English.)

3346. Cosmic Rays from Nova Herculis? [No Effect Proved].—Hess and Steinmaurer: Barnóthy and Forró. (*Nature*, 20th April, 1935, Vol. 135, pp. 617–618.) *See* 1355 of May.

3347. Remark on the Paper by W. Kolhörster: "Cosmic Rays and Nova Herculis" [Increase of Intensity may be due to Usual Daily Variation].—J. Barnóthy and M. Forró. (*Zeitschr. f. Physik*, No. 11/12, Vol. 94, 1935, pp. 773–774.) *See* also 3346.

3348. "Cosmic Ultra-Radiation in Northern Sweden: Annals of the Observatory of Lund No. 4" [Book Review].—A. Corlin. (*Naturwiss.*, 24th May, 1935, pp. 339–340.)

3349. Measurements of the Angular Distribution of Cosmic-Ray Intensities in the Stratosphere with Geiger-Müller Counters.—W. F. G. Swann and G. L. Locher. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 326: abstract only.)

3350. The Nature of the Cosmic Radiation [Primary Radiation, if Charged Corpuscles with Exponential Intensity Law, must have Same Quality at All Altitudes].—W. F. G. Swann. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 575–577: *Journ. Franklin Inst.*, May, 1935, Vol. 219, No. 5, pp. 636–639.)

3351. Cosmic Rays [General Account].—A. H. Compton. (*Nature*, 4th May, 1935, Vol. 135, pp. 695–698.)

3352. What to Believe about Cosmic Rays.—R. A. Millikan. (*Science*, 1st March, 1935, Vol. 81, No. 2096, pp. 211–215.)

3353. Nature of Cosmic Rays [Existence of Two Primary Components of Great Energy but Differently Absorbed by Matter].—P. Auger. (*Nature*, 18th May, 1935, Vol. 135, pp. 820–821.)

3354. The Nature of the Cosmic Radiation [Summarising Discussion].—T. H. Johnson. (*Journ. Franklin Inst.*, July, 1935, Vol. 220, No. 1, pp. 41–67.)

3355. Coincidence Counter Studies of the Variation of Intensities of Cosmic-Ray Showers and Vertical Rays with Barometric Pressure [Showers more sensitive than Total Radiation to Barometric Changes].—E. C. Stevenson and T. H. Johnson. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 578–580: *Journ. Franklin Inst.*, May, 1935, Vol. 219, No. 5, pp. 639–641.) A summary was referred to in 1934 Abstracts, p. 435.

3356. Nature of the Penetrating Cosmic Radiation at Sea-Level [90% of Coincident Counts due to Passage of Single Electrons].—E. C. Stevenson and J. C. Street. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 643: abstract only.)

3357. Shower Groups in the Cosmic Radiation [Curves for Various Thicknesses of Lead].—J. C. Street and R. T. Young. (*Phys. Review*, 1st April, 1935, Series 2, Vol. 47, No. 7, pp. 572–573.)

3358. Experiments on the Secondary Effects of Cosmic Radiation on the Hafelekar (2 300 m).—J. A. Priebsch. (*Zeitschr. f. Physik*, No. 1/2, Vol. 95, 1935, pp. 102–114.)

3359. Statistical Fluctuations of Cosmic-Ray Ionisation in New Recording Meter.—R. L. Doan. (*Phys. Review*, 15th July, 1935, Series 2, Vol. 48, No. 2, p. 167.)

3360. Note on Cosmic-Ray Ions and the Shower-Producing Radiation [which may be Secondary Nuclear Gamma-Radiation due to Interaction between High Speed Ions, the Primary Cosmic Radiation, and Nuclei of Atmospheric Elements].—F. H. Newman and H. J. Walke. (*Phil. Mag.*, August, 1935, Series 7, Vol. 20, No. 132, pp. 263–266.)

3361. Secondary Effects of Primary Cosmic Radiation [Secondary Radiation does not explain All Observed Coincidences].—A. Schwegler. (*Zeitschr. f. Physik*, No. 1/2, Vol. 96, 1935, pp. 62–75.)

3362. The Penetrating Power of Secondary Cosmic Rays [Proportional to Mass: "Additional" D-Radiation: Effect of Geometrical Arrangement of Counters].—O. Zeiller. (*Zeitschr. f. Physik*, No. 1/2, Vol. 96, 1935, pp. 121–136.)

PROPERTIES OF CIRCUITS

3363. Detuning an Oscillating Circuit by Earthing the Coupling Coil.—E. Fischer and H. Dietrich. (*E.N.T.*, June, 1935, Vol. 12, No. 6, pp. 172–175.)

The detuning of an oscillating circuit due to capacitative currents between the coil of the oscillating circuit and a coil coupled to it, which change when a terminal of the coupling coil is earthed, is here investigated theoretically. The detuning phenomena observed with the oscillating circuit of Fig. 1 are first described; they are then explained on the basis of the simplified circuit in Fig. 2. The effect of the magnitude of the condenser C_2 is discussed and represented graphically in Fig. 3, which shows the imaginary component of the current through C_2 when a small ohmic resistance is assumed present. To obtain resonance for any position of C_2, the value of the condenser C_1 (Fig. 2) must be adjusted, and the way in which this must be done is described from Fig. 3.

The case when the coils in Fig. 2 are inductively coupled is then treated by giving the equations 1 and 2 which govern their behaviour; the vector diagrams corresponding to these are given in Figs. 4–7 for the cases of capacitative and inductive current in C_2, with the same and opposite directions of coil windings. The final results are summarised in Fig. 8, which shows the changes of C_1 required to obtain resonance as C_2 is varied continuously for the different classes.

3364. Mutual Impedances of Parallel Wires [Theoretical Investigation including Non-Uniform Current Distribution]. Parts 1 and 2.—R. S. Hoyt: Sallie P. Mead. (*Bell S. Tech. Journ.*, July, 1935, Vol. 14, No. 3, pp. 509–519 and 519–531: Appendix to Part 1, pp. 531–533.)

Part 1 contains an exposition of the physical theory of the mutual impedance of two or more straight parallel wires. The current in a wire is regarded as composed of "a large number of parallel filamentary current elements." The current distribution over the cross-section of each conductor is shown to be necessarily non-uniform; this "gives rise to a mutual resistance term in the mutual impedance, besides a change in the mutual reactance term." Part 2 gives an application of two-dimensional electromagnetic wave theory to the development of "formulas for the mutual- and self-impedances of a pair of long straight parallel transmission circuits in close juxtaposition. Calculations of the mutual impedance made with these formulas over a very wide range of frequencies (1 to 1 000 kc/s) are found to be in very satisfactory agreement with available experimental results," as is shown by diagrams of the real and imaginary components, calculated and measured, of the mutual inductance between wires of various sizes. An appendix discusses the fundamental theoretical basis of the production and properties of electric field intensities and voltages.

3365. Frequency- and Phase-Distortion: Note on Compensation by a So-called "Negative Impedance" Method [using L.F. Retroaction at Output Valve: Almost Perfect Compensation, for Transients also].—M. Marinesco. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, pp. 375–378.) For the writer's retroaction method using a dry-plate rectifier *see* 2985 of September.

3366. Contribution to the Theory of Non-Linear Distortions and "Trip" Oscillations.—C. L. Kober. (*Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 23–26.)

General oscillation phenomena in a circuit with non-linear resistance are considered and the methods for numerical solution are given. The fundamental equations are stated (§ I) and transformed into forms of Meissner's, Hill's and Mathieu's equations (§ III 1). The Meissner equation has "leaping" coefficients (Figs. 1–3) which correspond to Klutke's theory of "trip" oscillations (*Anz. d. Wien. Ak.*, 26. IV. 1934). The solution (eqn. 13) of Mathieu's equation is discussed (§ III 2): a "combination-tone 'klirr'-factor" (eqn. 15) is defined; the development of the solution in a Fourier series is also given. Regions of stable and unstable oscillation are defined (§ III 3: Fig. 4); forced oscillations (§ III 4) give a distorted resonance curve (Fig. 5). The superposition of two harmonic disturbances is worked out (§ III 5) and the combination tones are found.

3367. Anomalous Transmission in Filters [when Terminating Impedance approximates to Negative of Usual Iterative Impedance: Resonance in a Suppression Band: Possible Uses of the "Inversion" Effect].—J. G. Brainerd. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 781–784.)

3368. Theory of Reactance Transformer [for Converting a Resistive Load of Value *R* into a Load *nR*, or *vice versa*].—E. Green. (*Marconi Review*, May/June, 1935, No. 54, pp. 5–7.)

With curves to aid in practical design: a further paper is promised. "One point that stands out is the small range of capacity and inductive reactance required to deal with a large transformation ratio."

3369. How to Calculate Oscillation Phenomena in Circuits with Periodically Varying Parameters [General Account of Mathematical Methods for the Solution of Differential Equations with Periodic Coefficients: Practical Methods for Approximate Solutions].—A. Erdélyi. (*Arch. f. Elektrot.*, 3rd July, 1935, Vol. 29, No. 7, pp. 473–489.)

3370. Resonance of the n-th Order in a System with Two Degrees of Freedom for the Case of a Tight Coupling.—S. M. Rytov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 3–37.)

A detailed mathematical investigation of a system with two degrees of freedom (*i.e.* possessing two resonant frequencies ω_1 and ω_2) and actuated by an external force with a frequency equal to either $n\omega_1$ or $n\omega_2$. The oscillations of the system at frequencies which are a multiple of ω_1 and ω_2 are excluded from consideration.

A theory of the system, based on the works of Poincaré ("Méthodes nouvelles de la Mécanique céleste," Vol. 1, 1897) and Liapunov ("On the General Theory of the Stability of Movement": Kharkov, 1892), is developed, and a system consisting of a valve oscillator inductively coupled to a tuned circuit is examined as an illustration. Conditions are determined for which oscillations of frequency ω/n, where ω is the frequency of the applied e.m.f., appear in the system, and particular attention is paid to the case when $n = 2$. Resonance curves are plotted and the phenomenon of "synchronisation" studied in detail. This phenomenon consists of the "pulling-in" of the system oscillating at a certain frequency into another frequency ω/n when an e.m.f. of frequency ω is applied to the system. The interesting point about this phenomenon is that when the applied e.m.f. is removed the system under certain conditions continues to oscillate at the new frequency; in other words it is possible to change the frequency of the system without altering its constants. Moreover, under certain conditions the oscillating system can be brought by these means to a state of equilibrium, *i.e.* the oscillations will cease. A complete examination of this phenomenon would require a further study of the quasi-periodic circuits.

3371. The Graphical Measurement of the Input Resistance of Various Quadripoles [Four-Terminal Networks].—H. Reppisch. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 261–264.)

3372. Graphical Representation of the Conductance, Current and Power Characteristics of the T-Section with Constant Input Voltage and Arbitrary External Load [with Application to the Multiphase Asynchronous Motor].—H. Kafka. (*Arch. f. Elektrot.*, 3rd July, 1935, Vol. 29, No. 7, pp. 443–458.)

3373. Effective Resistance of Conductors of Unequal Current Distribution [Calculation confirmed by Tests up to 1 000 c/s]. Somiya and Takahashi. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 394: English summary p. 54.)

TRANSMISSION

3374. On Vacuum Tube Electronics [Transit-Time Effects even at 50 m Wavelength and longer: Theoretical Considerations and Experimental Confirmation].—C. J. Bakker and G. de Vries. (*Physica*, July, 1935, Vol. 2, No. 7, pp. 683–697: in English.)

For previous work *see* 1390 of May. Among the effects discussed are losses in grid and anode circuits of gauze-anode valves, and the increase in grid damping (in sheet-anode valves) when the static grid potential is made more negative.

3375. Time of Flight of Electrons [Alternative Treatment: Transit Time = Anode Charge/Anode Current: a New Factor *S*].—E. B. Moullin: Fortescue. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, pp. 371–372.)

Prompted by Fortescue's paper (2967 of September). In the equation used by Moullin, $T = 3(r_a - r_c)S\sqrt{m/2eV}$, S is a factor expressing the transit time in a cylindrical diode as a fraction of the transit time in a planar diode having the same anode/cathode separation. S varies from 0.876 (for $r_a/r_c = 2$) to 0.57 (for $r_a/r_c = 40$) and appears to tend to $\frac{1}{2}$ for larger values of the ratio.

3376. The Barkhausen Oscillator [for Micro-Waves: Simple Explanation of Its Action].—F. B. Llewellyn. (*Bell Lab. Record*, August, 1935, Vol. 13, No. 12, pp. 354–358.)

3377. New Types of Micro-Wave Valves [with Continuous Range of Wavelength].—Müller and Tank. (*See* 3443.)

3378. The Theory of the Electron Oscillations appearing in Magnetron Valve Transmitters.—F. Müller. (*E.N.T.*, June, 1935, Vol. 12, No. 6, pp. 183–189.) *See* 2598 of August.

3379. Production of Oscillations with the "Habann" [Split Anode] Valve.—K. Fritz. (*Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 16–22.)

A "magnetic field valve" is here defined as a discharge tube in which a constant or variable magnetic field determines the path of the electricity carriers. The name " magnetron " is reserved for the case in which a variable magnetic field controls the oscillations. The " Habann " valve has a split anode, here taken in two parts, and Fig. 1 shows its electrode arrangement and circuit, Fig. 2 the electrical field in the anode, where f_1 represents the electrostatic field and f_2 the superposed oscillatory field. The effect of space charge is neglected. Fig. 3 shows the partial-current anode characteristics for the two halves. The general principles of oscillation are considered in § II, with the different types of valve requiring a magnetic field. The electron paths are worked out, with their possible cycloidal or screw-like forms, and various special known valves are described (Fig. 7–9). The theory of the " Habann " valve in a symmetrical circuit is then considered in detail (§ III), with its electron paths and anode current characteristics ; the alternating electric fields in a split anode with four sections, with round or square cross-section, are discussed. The oscillation regions as the magnetic field is increased are illustrated in Fig. 20 and explained on the basis of electron circulation. Experimental " displacement curves " for various anode voltages are given (Fig. 23) and the effect of varying the angle between the axis of the electrodes and the magnetic field is illustrated by Figs. 24, 25.

3380. A New Method for the Production of Short [Micro-Wave] Undamped Electromagnetic Waves of Great Intensity [Pulsating Space-Charge in Faraday Cage inside Cathode-Ray Tube].—A. Arsenjewa-Heil and O. Heil. (*Zeitschr. f. Physik*, No. 11/12, Vol. 95, 1935, pp. 752–762.)

The principle of a new generator of waves of length less than 1 m, here described and calculated, is that of a pulsating space-charge in the interior of a Faraday cage through which an electron beam is passing. The writers claim that the arrangement avoids two difficulties in the usual methods of producing centimetre waves by means of valves : " (1) The finite time of flight of the electrons, which usually has a disturbing effect, is actually used to control the electron current. (2) The electrons never come in contact with the oscillating electrodes. An electron beam shoots through these electrodes and the oscillation energy is taken from the beam by induction. Thus heating of the small oscillating electrodes is entirely avoided." The principle is explained by means of Fig. 1, in which (a) and (b) give the electrode arrangements and (c) the corresponding potential diagram. " Electrons are emitted from the cathode *A* and accelerated to the electrode *B*, which is at a constant positive potential. They are then retarded and enter the electrode *C*, a Faraday cage. After shooting through this, they are again accelerated by the electrode *D*, which is connected to *B* and at the same potential. Electrons passing through *D* can be retarded again and captured. The mechanism of oscillation production occurs in the range between *B* and *D*. *C* is the electrically oscillating electrode." The time spent by the electrons inside the cage *C* controls the current ; it depends on the electron velocity. If the length of the cage is suitably chosen, the oscillation is built up. By calculating the energy losses of the individual electrons and summing over a period, the maximum energy transferable to the oscillating circuit is calculated as 35% of the energy of the electron beam. The final retardation of the electrons by an opposing field (beyond *D*) makes it possible for the efficiency of the generator to be nearly 100% ; the calculation also shows that the oscillation is self-starting and stable.

These calculations are given and the results represented graphically in Figs. 3 (loss of energy during a period), 4 (transferable energy as a function of the amplitude *A* of the oscillation and the mean potential *V* on the Faraday cage), 5 (curves for constant *V*), 6 (oscillation building factor), 7 (oscillation factor for constant *V*). Two regions of stable oscillation are found, one for small and one for large amplitudes, limited by the dotted line in Fig. 6. Fig. 8 illustrates the behaviour of the generator for constant *V* and variable load. The mode of onset of the oscillation is explained. Almost the whole energy of the generator may be modulated without distortion. The limits of the method are considered ; the higher the density of the electron beam, the shorter the waves which can be produced, so that electron-optical concentration methods are advisable. Ohmic losses are decreased by using broad metal arcs as self-inductances ; dielectric losses, by placing the whole oscillating circuit in the interior of the cathode-ray tube. The approximations used in the calculation are discussed and suggestions for putting the idea into practice are made : a push-pull arrangement is recommended (Fig. 9). A system of parallel plates placed obliquely to the direction of the beam (Fig. 10) is recommended for retarding and catching the electrons when they emerge from *D*. Finally, a numerical example is given of a tube with appropriate electrode arrangements to produce 100 watts ; the length of the Faraday cylinder for a 20 cm wave would be about 5 mm.

3381. On Frequency Modulation by the Resistance Tuning Circuit.—Narumi and Saito. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 444 : English summary p. 61.)

" It is preferable to use the resistance rather than the reactance as the variable element. . . . The frequency of an oscillator using the resistance tuning circuit with suitable circuital constants varies remarkably over a relatively wide range with very small amplitude variation."

3382. Interference Elimination by Frequency Modulation ?—Klimke : Armstrong. (*See* 3395.)

3383. Crystal Control for Ultra-Short Waves [Effect of Crystal Capacity decreased by Connection of Condenser].—H. Straubel. (*Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 4–6.)

For previous work *see* Abstracts, 1932, pp. 235, 355, and 1934, p. 332. Direct control of ultra-short waves with quartz crystals is difficult because (1) eddy currents flow in the conducting film covering the crystal and give rise to attenuation ; this causes definite places on the crystals, determined by the oscillating mode, to emit sparks (Fig. 2) : (2) the large electrostatic capacity of the crystal short-circuits the alternating potential between grid and cathode. Quartz and tourmaline are alike in this. Using suitable valves, quartz crystals can be made to work on a wavelength of 6 m (Fig. 3). The effect of the capacity can be decreased by connecting a condenser in front of the crystal (Fig. 4); the crystals will then work on their third or fifth harmonic down to a wavelength of 1.6 m. The stabilisation of ultra-short waves with tourmaline crystals was effected with an "acorn tube" (Fig. 5). Fig. 6 shows an emitter for 66 cm waves using a 2 m tourmaline; the curve of anode current during the tuning process is given in Fig. 7. Reference is made to experiments on reception of modulated waves across a room; the quality of the stabilisation diminishes as the coupling becomes looser, but this method represents the only possible way of using crystal control for ultra-short waves. The condenser has very little effect on the crystal frequency. Fig. 8 shows the equivalent circuit for an 80 cm tourmaline crystal. It was also attempted to obtain a heterodyne note with a Barkhausen valve, but only a rustling noise was heard. These oscillations could not be stabilised by a crystal. The same result is to be expected from a magnetron.

3384. ON THE STABILITY OF OSCILLATORS.—E. S. Antseliovich. (*Izvestia Elektroprom. Slab. Toka*, No. 6, 1935, pp. 28–39.)

A survey is given of various factors affecting the stability of self-excited oscillators of continuously variable frequency. The paper is divided into two main sections:—(A) Frequency variations caused by changes in the operating conditions of the oscillator and in the load into which it works, and (B) Frequency variations with time (assuming that the above changes do not take place).

Under section (A) the following factors are examined separately and their relative importance established:—(*a*) *Changes in the oscillator grid current and load.*

It is shown that the relative variation of the frequency ($\Delta f/f$) caused by changes in the grid current is of the order of 0.01 to 0.00001%. It is also shown that when the load on the oscillator is varied $\Delta f/f$ is of the order of 0.1% or more.

(*b*) *Changes in the valve constants.*

Of these the most important are changes in the internal resistance of the valve. $\Delta f/f$ due to these is calculated and is found to be of the order of 0.005 to 0.0001%.

(*c*) *Changes in the temperature of the valve.*

As a result of these the dimensions of the electrodes and their spacing are altered, and also the capacity between the supply leads through the socket of the valve. $\Delta f/f$ due to this was found experimentally to be of the order of 0.1%. $\Delta f/f$ due to changes in the anode dissipation of the valve is of the order of 0.005 to 0.075%.

(*d*) *Changes in the shape of the oscillation curve.*

It is shown that in this respect the non-linear theory of oscillations does not contradict the findings based on the linear theory, and that $\Delta f/f$ can be as high as 0.01%.

Under section (B) a brief examination is given of the following factors causing the frequency to vary until a stable thermal condition is reached:—(*a*) changes in the temperature of components of the oscillating circuit (max. $\Delta f/f = 0.1\%$); (*b*) changes in the temperature of the valve (max. $\Delta f/f = 0.05\%$); and (*c*) displacement of components of the oscillating circuit due to temperature variations, and the consequent changes in capacity to ground (max. $\Delta f/f = 0.5\%$). It is pointed out in conclusion that thermal compensation and structural features of the oscillatory circuit components should be primary considerations in the design of oscillators.

3385. A NEW SYSTEM OF FREQUENCY STABILISATION FOR VALVE OSCILLATORS [with No Anode-Current D.C. Component flowing through Stabilising Resistance: Advantages over Previous Method].—T. Hayasi. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 438: English summary pp. 60–61.)

The diminution of output is very slight compared with that in Kusunose and Ishikawa's stabilising-resistance circuit (1932 Abstracts, p. 342), and the value of the resistance is not critical. The action is also very effective for change of filament voltage.

3386. CRYSTAL OSCILLATORS FOR RADIO TRANSMITTERS: AN ACCOUNT OF EXPERIMENTAL WORK CARRIED OUT BY THE POST OFFICE.—C. F. Booth and E. J. C. Dixon. (*Journ. I.E.E.*, August, 1935, Vol. 77, No. 464, pp. 197–236: Discussion pp. 237–244.) The full paper, summaries of which were referred to in 1811 of June.

3387. MONITORING THE STANDARD FREQUENCY EMISSIONS.—Lapham. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 719–732.) *See* 2367 of July.

3388. REQUIREMENTS OF HIGH QUALITY BROADCAST TRANSMISSION [Lower Frequencies modulate Transmitter much More Deeply than Higher, producing Low-Frequency Over-Modulation: etc.].—J. A. Hutcheson. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, p. 696: summary only.)

3389. ANALYSIS OF THE OPERATION OF VACUUM TUBES AS CLASS C AMPLIFIERS [by Graphical Method using Constant-Current Charts: Different Behaviour of Self-Bias and Fixed-Bias Operation: Audio Distortion due to Amplifier itself, and Its Elimination: etc.].—Mouromtseff and Kozanowski. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 752–778.) The full paper, a summary of which was referred to in 2981 of September.

3390. ADJUSTING THE CLASS B LINEAR POWER AMPLIFIER IN BROADCAST STATION EQUIPMENT [by Calculation].—L. B. Hallmann. (*Electronics*, July, 1935, p. 219.)

3391. A HIGH-QUALITY BROADCAST TRANSMITTER OF MEDIUM POWER [up to 5 kW or, with Minor Modifications, to 15 kW: Flat Characteristic 20–10 000 c/s].—R. E. Poole. (*Bell Lab. Record*, August, 1935, Vol. 13, No. 12, pp. 374–378.)

RECEPTION

3392. ON SUPER-REGENERATION OF AN ULTRA-SHORT-WAVE RECEIVER [Theoretical and Experimental Investigation].—H. Ataka. (*Proc. Inst. Rad. Eng.*, August, 1935, Vol. 23, No. 8, pp. 841–884.) Based on the Japanese papers dealt with in 1934 Abstracts, p. 614.

3393. SHORT [and Ultra-short ?] WAVE RECEPTION WITH THE SUPERHETERODYNE RECEIVER [converted from Broadcast Band by switching, the Mixing Valve acting as Oscillating Audion]. — F. L. Papst. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 267–269.)

3394. NEW ULTRA-SHORT-WAVE DEVELOPMENT [Armstrong's Frequency Modulation Work].—(*Wireless World*, 14th June, 1935, Vol. 36, p. 603.) *See* also 2972 of September.

3395. INTERFERENCE ELIMINATION BY FREQUENCY MODULATION ? [Newspaper Rumours, and the Real Object of Armstrong's Invention]. —S. Klimke: Armstrong. (*Funktech. Monatshefte*, July, 1935, No. 7, p. 252.)

A discussion of Armstrong's patent 1 941 069 shows that it has nothing whatever to do with the elimination of "ordinary" interference (*e.g.* on broadcast wavelengths) but deals only with ultra-short waves and the overcoming of the trouble due to the "interfering waves," fluctuating both in amplitude and frequency, produced by the shot effect. The amplitude fluctuations, which interfere with amplitude modulated signals, cause little trouble with frequency-modulated signals in a suitable receiver; as regards the frequency fluctuations, these are found by Armstrong to keep within a certain maximum "stroke" (a new word "frequenzhub" is here used, the analogy being with the stroke of an engine or pump) which can be greatly exceeded by the "stroke" of the frequency-modulated signal, however weak this signal may be.

3396. ELECTRIC OSCILLATIONS [and Interference] DUE TO MAGNETO IGNITION SPARKS.—S. Kumagai and M. Yamanaka. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 385: English summary p. 53.)

The oscillation frequency depends on the ignition circuit constants and is practically independent of the magneto constants. If the sparking-plug electrodes are not symmetrical, a remarkable polarity effect is found in the strength of the interference, the latter being much more severe, in general, if the electrode of greater curvature is negative.

3397. NOISE SUPPRESSION IN AUTO RADIOS [and the Motorola Method using Balancing Pick-Up Wire to Chassis].—(*Rad. Engineering*, July, 1935, Vol. 15, No. 7, p. 23.)

3398. NEW METHOD FOR ELIMINATING STATIC CAUSED BY TROLLEY AND ELECTRIC CARS [by Use of Carbon Sliding Bow].—E. W. Schumacher. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 779–780.)

3399. AT THE LISTENER'S END [Interference Suppression Methods].—H. F. Smith. (*Wireless World*, 9th Aug. 1935, Vol. 37, pp. 136–137.)

3400. THE QUESTION OF THE ELIMINATION OF RADIOELECTRIC INTERFERENCE [Progress, chiefly in France].—M. Adam. (*Génie Civil*, 10th Aug. 1935, Vol. 107, No. 6, pp. 134–137.)

3401. TEST BENCH FOR MEASURING THE INTERFERENCE PROPERTIES OF ELECTRICAL APPARATUS.—J. Schmied. (*Elektrot. u. Masch:bau*, 11th Aug. 1935, Vol. 53, No. 32, pp. 373–377.)

3402. AIDS TO THE MEASUREMENTS OF HIGH-FREQUENCY IMPEDANCE [Slide-Rule and -Disc].—H. Reppisch. (*E.N.T.*, June, 1935, Vol. 12, No. 6, pp. 181–183.)

Drawings and descriptions of a slide-rule (Fig. 1), and a slide-disc (Fig. 2) with the same scales but more easy to manufacture. These enable the calculations described in a former paper (2619 of August), on the measurement of the h.f. impedance of high-tension mains, to be quickly and accurately performed.

3403. ON THE IMPROVEMENT OF THE CHARACTERISTICS OF THE VALVE DETECTOR AND AMPLIFIER, *and* CIRCUITS FOR REGENERATIVE DETECTORS, AND THEIR ADJUSTMENT.—Y. Morita: S. Kanazawa. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, pp. 446 and 447: Japanese only.)

3404. THE SIGNAL AT THE DETECTOR.—M. S. Graham. (*Wireless World*, 9th Aug. 1935, Vol. 37, pp. 133–134.) The influence of "low level" or "high level" detection on receiver design and performance is discussed.

3405. ANODE BEND DETECTION [with Tetrodes and Pentodes: Calculation and Measurement of Detection Slope: Distortion Effects: Relation between Detection Slope and Conversion Conductance: etc.].—M. J. O. Strutt. (*Proc. Inst. Rad. Eng.*, August, 1935, Vol. 23, No. 8, pp. 945–957.) Using the analytical expression previously arrived at (1934 Abstracts, pp. 148 and 614).

3406. RADIOELECTRIC COMMUNICATIONS [a Study of Present Problems: Chapter I.—Selection and Intermodulation]. — de Bellescize. (*L'Onde Élec.*, June, 1935, Vol. 14, No. 162, pp. 337–372.)

3407. GANGING [and Its Inevitable Errors]: A POSSIBLE COMPROMISE.—D. A. Bell. (*Wireless World*, 28th June, 1935, Vol. 36, pp. 648–649.)

3408. REASONABLE AND UNREASONABLE DEMANDS ON VALVES IN RECEIVER CIRCUITS [Trouble-Producing Technique still met with, *e.g.* in Volume Control, Over-Modulation of Output Valve in Binode Circuits, etc.].—K. Steimel. (*Telefunken-Röhre*, July, 1934, No. 1, pp. 28–42.)

3409. The Problem of Dual Volume Control in Broadcast Receivers [Simultaneous Regulation of Input and Amplification].—H. Wechsung. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 249–251.)

It is only a certain type of receiver that can be regulated really satisfactorily by a single process. In most types such a system gives rise to a liability to interference, valve noise, upsetting of the fading compensation, cross-talk, and the occurrence of whistling points. The avoidance of these troubles by dual regulation, and the question of the choice between the r.f. and the a.f. stages for the regulation of amplification, are here discussed. Special attention is given to the case of receivers with AVC. Fig. 4 shows an arrangement for single-knob control in such a receiver.

3410. Automatic Control [Full Advantages not yet Realised: Editorial].—(*Rad. Engineering*, July, 1935, Vol. 15, No. 7, p. 4.)

3411. A New Idea in Short-Wave Amplification.—Bakker and de Vries. (*Wireless World*, 19th July, 1935, Vol. 37, pp. 55–56.) *See* 1390 of May; also 3374, above.

3412. Recent Tendencies in Short-Wave Receiver Design.—(*World-Radio*, 26th July and 2nd Aug. 1935, p. 15: p. 14.)

3413. Short-Wave Programmes for Waldorf Guests.—H. T. Budenbom. (*Bell Lab. Record*, July, 1935, Vol. 13, No. 11, pp. 343–349.)

3414. The All-Wave Set [and Its Special Problems].—W. T. Cocking. (*Wireless World*, 9th Aug. 1935, Vol. 37, pp. 153–154.)

3415. Aperiodic Aerial Transformers [with "Stalloy" Cores: for Wide-Range Receivers].—R. I. Kinross. (*Wireless World*, 21st June, 1935, Vol. 36, p. 617.)

3416. How many Watts? [Correspondence on Necessary Undistorted Output for a Broadcast Receiver].—P. K. Turner. (*World-Radio*, 9th Aug. 1935, p. 8.)

Prompted by a paragraph in the issue of 26th July. Agreed "most natural" reproduction, in typical room, of symphony concert gave peak readings from 25 mw to over 17 w; mean power over 3 seconds, during loudest passages, did not exceed 5 w. *See* also p. 11.

3417. Scandinavian Radio is "Different."—P. R. Coursey. (*Wireless World*, 14th June, 1935, Vol. 36, pp. 582–584.)

3418. The Trend of Design at Radiolympia.—J. May. (*Elec. Storage*, Aug./Sept. 1935, Vol. 4, No. 20, pp. 46–48.)

3419. The Present and Future of the Battery Set.—T. E. Goldup. (*Elec. Storage*, Aug./Sept. 1935, Vol. 4, No. 20, pp. 38–40.)

3420. Six-Volt Receiver Design [for Farms and Rural Communities: H.T. from Filament Battery].—(*Rad. Engineering*, July, 1935, Vol. 15, No. 7, pp. 14–16.)

3421. The Modern Quality Receiver [Latest Developments].—W. T. Cocking. (*Wireless World*, 19th July, 1935, Vol. 37, pp. 50–52.)

3422. Variable Selectivity [Wide Range given by Pivoted-Coil Variable Couplings in I.F. Circuits, if Frequency is not Too Low].—W. T. Cocking. (*Wireless World*, 5th July, 1935, Vol. 37, pp. 2–4.)

3423. Choosing the Intermediate Frequency.—W. T. Cocking. (*Wireless World*, 12th July, 1935, Vol. 37, pp. 26–27.)

3424. Super-Regenerative [Headphone] Midget Sets.—C. Begbie. (*Wireless World*, 14th June, 1935, Vol. 36, p. 585.)

3425. Considerations in the Design of a High-Fidelity Radio-Gramophone [15-Valve Superheterodyne, Gramophone Company].—W. J. Brown. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, pp. 379–382: from I.E.E. Paper.)

3426. The Telefunken "Deutschland" Receiver [as adopted by German Administration for Retransmissions, Quality Monitoring, etc.: Five Valves and Rectifier].—P. Besson. (*L'Onde Élec.*, July, 1935, Vol. 14, No. 163, pp. 470–479.)

3427.—The Wireless World 1936 Monodial A.C. Super [with Variable Selectivity and QAVC].—(*Wireless World*, 26th July, 2nd and 9th Aug. 1935, Vol. 37, pp. 74–78, 98–104 and 147–148.)

3428.—Construction of an Intermediate-Frequency Filter for the Single-Span "People's" Superhet, *and* Improvements to the Single-Span Superhet.—H. J. Wilhelmy: H. Sutaner. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 276–278: 279–280.) For previous work *see* 2257 of July.

AERIALS AND AERIAL SYSTEMS

3429. Investigations on the Radiation Field of Ultra-Short-Wave Aerials.—P. von Handel and W. Pfister. (*Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 8–15.)

The radiation characteristics of ultra-short-wave aerials are calculated, taking into account the electromagnetic constants of the ground, for distances large compared with the wavelength and for the case of a plane earth. A vertical quarter-wave aerial on the earth is first considered (§ II 1); Fig. 2 shows the ratio of amplitudes of and the phase angle between the reflected and direct ray as a function of angle of incidence, with a fixed value of the dielectric constant and various values of conductivity. Fig. 3 gives the vertical radiation characteristic for different types of ground. Fig. 4 shows a comparison of one of these characteristics with a measured curve taken in an aeroplane. Good agreement is obtainable and the method may be used to determine the electromagnetic constants of the ground; the radiation is chiefly directed upwards and only small values of field strength are found on the earth's surface. Aerials at great heights above the earth are next considered and their vertical characteristics for various cases are calculated and measured (Figs. 5–10); the interference between the direct and reflected waves is clearly shown, also Brewster's angle. Calculated curves for various relations between the electromagnetic data are given in Figs. 11–14.

Propagation to greater distances is discussed in § III; the earth's curvature must now be taken into account, and no calculations are made but various curves of field-strength measurements for $\lambda = 9$ m are given in Figs. 15–19. With vertically polarised waves, the rays appeared to bend round the earth's surface and signals could be received beyond the optical horizon. The decrease in field strength was rather more rapid than that of the inverse square of the distance. With horizontal polarisation, no signals were received beyond the optical horizon. This is attributed to the metallic construction [and so presumably shielding effect] of the aeroplane. Diffraction round and refraction through the earth are stated to be the two reasons for reception beyond the optical horizon. The relations between the propagation of ultra-short and long waves are considered in § IV, in order to deduce the effects to be expected near the aerial. Figs. 20, 21 show measured vertical characteristics of broadcast emitters at distances of 4 and 150 km respectively. The latter are compared with Feldman's curves (Fig. 22: *see* 1933 Abstracts, p. 497). A second theoretical approximation is obtained by Strutt's method (1930 Abstracts, p. 278) and calculated curves of the reflection coefficient and the $1/R$ and $1/R^2$ terms of the radiation characteristics of a dipole and a $\lambda/4$ aerial are given in Figs. 23–25. Fig. 26 shows the calculated field strength at a distance of 8 wavelengths for a dipole and a quarter-wave aerial. This gives a good explanation of the measurements shown in Figs. 21, 22.

3430. The Constants of a Symmetrical Aerial stretched over Dry Ground [Measurements in Jerusalem: the Possibility of Long Distance Propagation through such Ground, and the consequent Reduction of Interference from Atmospherics].—H. Löwy. (*Naturwiss.*, 19th April, 1935, p. 259.)

In the dry season the dielectric constant of the ground was found to have the surprisingly small value of 1.1. Obviously the sun dries the Jerusalem soil better than the artificial partial drying-out used by Smith-Rose, who found values between 2 and 3 (1933 Abstracts, p. 382). A few days after the first rains the value had risen to 1.5–1.9, the smaller figure being obtained with a longer aerial which would involve deeper ground layers, less affected by the rain.

3431. Some Comments on [Anti-Fading] Low-Angle Vertical Radiation for Broadcasting [and the Imitation of a Vertical Radiator with Unlimited Electrical Height].—R. N. Harmon. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 692–693: summary only.)

3432. A Broadcast [Anti-Fading] Antenna for "Low Angle" Radiation [Vertical Radiating Wire with Horizontal Shield or Disc near Top: Theoretical Investigation and Experimental Confirmation on Ultra-Short-Wave Model].—J. W. Labus. (*Proc. Inst. Rad. Eng.*, August, 1935, Vol. 23, No. 8, pp. 935–944.)

3433. The Metal Lattice Tower of the 314-Metre Lakihegy [Budapest] Aerial.—K. Massanyi. (*Rev. Gén. de l'Elec.*, 3rd Aug. 1935, Vol. 38, No. 5, pp. 39–40D: summary only.)

3434. Wind Pressure on Latticed Towers—Tests on Models [Report (ref. F/T84) of British E.R.A.].—(*Journ. I.E.E.*, August, 1935, Vol. 77, No. 464, pp. 189–196.)

3435. The Calculation of the Maximum Static Effect of the Wind on Overhead Lines.—E. Francesio. (*L'Elettrotec.*, 10th Aug. 1935, Vol. 22, No. 15, pp. 546–549.)

3436. Feeders for Short-Wave Reception.—J. H. Reyner. (*Wireless World*, 5th July, 1935, Vol. 37, pp. 11–14.)

VALVES AND THERMIONICS

3437. The Motion of Electrons in Electric and Magnetic Fields, taking into consideration the Action of the Space Charge.—S. J. Braude. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 565–571: in English.)

The present paper deals with the case of a plane condenser: a cylindrical condenser will be treated in a subsequent paper. The Langmuir potential distribution will not hold when the electron paths are curved by an external magnetic field, and J. J. Thomson's treatment of the electron motion under the influence of electric and magnetic fields neglects the effect of the space charge. The writer takes both factors into account and obtains eqn. 13 for the potential distribution, eqn. 11 for the electron paths, and eqn. 15 for the space-charge density in the condenser. This last equation shows how an increase of magnetic field strongly increases the space-charge density; the latter depends also on the cathode distance, as is seen in Fig. 4, where the curves represent the distribution of space-charge density.

3438. Resonance Phenomenon in Ionised Gases.—Sigrist. (*See* 3315.)

3439. High-Frequency Losses of Ionised Gases [including Losses under Influence of Magnetic Field: Various Resonance Effects: for Wavelengths 6.5–300 m].—Asami and Saito. (*See* 3316.)

3440. On Vacuum Tube Electronics [Transit-Time Effects even at 50 m Wavelength and longer].—Bakker and de Vries. (*See* 3374.)

3441. Time of Flight of Electrons [Alternative Treatment: Transit Time = Anode Charge/Anode Current: a New Factor S].—E. B. Moullin: Fortescue. (*See* 3375.)

3442. A New Vacuum Tube for Ultra-High Frequencies [30–300 Mc/s: about 100–25 Watts Output: the Western Electric 304A Triode, Oscillator or Amplifier].—C. E. Fay. (*Bell Lab. Record*, August, 1935, Vol. 13, No. 12, pp. 379–382.) Small cylindrical electrodes (anode of graphite) supported by short heavy-wire leads through top of hard-glass bulb: cathode as usual to base.

3443. New Types of Micro-Wave Valves [using Grid Oscillations: Adjustable Wavelength].—J. Müller and F. Tank. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 8, 1935, pp. 309–310: in German.)

Further development of the valves dealt with in 1934 Abstracts, p. 33, and 1803 of June. Type LG 5 has a d.c. lead-in to the grid centre, so that the parallel-wire system can be branched off directly into a dipole and all d.c. voltages be led in through the valve base. Type LG 6 has a two-part grid spiral, allowing a closely-spaced (and therefore low-radiating) parallel-wire system to be used as feeder, connected to the inner sides of the halves of the grid. The useful power of the valves is about 0.01 w with an efficiency of at most 1%; the optimum waveband of the LG 5 is around 15 cm, that of the LG 6 around 25 cm.

3444. Stray Electrons in Amplifier Valves [Bad Effects and Their Elimination].—G. Jobst and F. Sammer. (*Telefunken-Röhre*, July, 1934, No. 1, pp. 8–27.

3445. The [Theoretical] Determination [from the Working Characteristics] of the Data of a Valve Emitter.—H. H. Plisch. (*Hochf: tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 26–33: to be continued.)

The aim of this paper is to give a useful account of the data of a valve emitter as required for its design, construction and practical working. The working characteristics of the valve are taken as the basis and the symbols used are defined. Formulae for current angle, anode current, grid bias, valve efficiency and its optimum value, mean steepness of characteristic, effect of space charge, maximum available power for given direct voltage on the anode and for control without grid current, frequency doubling and efficiency of grid control, are worked out in the present instalment, and illustrated by diagrams.

3446. The Fluctuations of Current [Thermal Agitation, Shot Effect, and Flicker Effect].—J. B. Pomey. (*Rev. Gén. de l'Élec.*, 3rd Aug. 1935, Vol. 38, No. 5, pp. 163–170.) Survey supplemented by summaries of the papers by Johnson and Nyquist (1928 Abstracts, p. 581.)

3447. Non-Linear Distortion in H.F. Amplifier Valves [Calculation of the "Modulation Factor" of the Valve, and of the Maximum Permissible Grid Input Amplitude].—K. Wilhelm. (*Telefunken-Röhre*, September, 1934, No. 2, pp. 77–84.) On the assumption that the characteristic can be represented by an exponential function.

3448. Measured Input Losses of Vacuum Tubes.—C. J. Franks. (*Electronics*, July, 1935, pp. 222–223.)

"A study of the sort described emphasises the danger of taking circuit components too much on faith. Even our modern tubes cannot be used in any critical measuring applications until they themselves have been carefully measured and their possible contributions to the errors determined." Poor-quality mica supports contribute largely to the observed losses.

3449. On the Magnetic Control of the "Side-Current" [Radial Component] Mercury-Vapour Tube.—I. Yamamoto and T. Ono. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 341: English summary p. 47.)

"The magnetic control of the side-current in the multi-electrode mercury-vapour tube may be efficiently applied for relay action, h.f. amplification, h.f. oscillation, etc." The side-current anode is cylindrical and is situated mid-way between the cathode and the main anode maintaining the arc current. If a side-current cylindrical grid is provided inside the side-current anode, the static characteristic shows a fair similarity to that of a triode vacuum tube.

3450. A New Power Output Valve ["Critical Distance" of Anode from Outer Grid].—J. H. O. Harries. (*Wireless World*, 2nd Aug. 1935, Vol. 37, pp. 105–106.)

The author describes the effect of applying a new principle to the construction of a power valve, which is that if the anode of a multigrid valve is spaced from the outer grid at a certain "critical distance," special characteristics are obtained. Thus the sensitivity is of the same order as that of a pentode, while the distortion is as unobjectionable as that of a triode.

3451. New Output Valve [American Type 6B5: Advantages over Class B System].—M. G. Scroggie. (*Wireless World*, 5th July, 1935, Vol. 37, pp. 8–9.)

3452. Families of Characteristics, Output, and Distortion of Amplifier Valves, especially Output Valves.—W. Kleen. (*Telefunken-Röhre*, September, 1934, No. 2, pp. 58–71.) Using the method dealt with in 1934 Abstracts, p. 618.

3453. A New Detector Valve [Single Diode of Very Low Resistance: Tungsram D418]. (*Wireless World*, 14th June, 1935, Vol. 36, pp. 593–594.)

3454. A New British Frequency Changer [Marconi X-41].—(*Electronics*, July, 1935, pp. 228–229.)

3455. Grid-to-Top Tubes on British Market [R.F. Pentode-Double Diode].—(*Electronics*, July, 1935, p. 228.)

3456. The 6F7 [Pentode-Triode with Common Cathode, for Oscillator and First Detector] as an Amplifier and Second Detector.—J. R. Nelson. (*Rad. Engineering*, July, 1935, Vol. 15, No. 7, pp. 12–13.)

3457. Metal-Tube Characteristics [Ten RCA-Radiotron Types: with Operating Data and Detail Drawings].—(*Rad. Engineering*, July, 1935, Vol. 15, No. 7, pp. 18–19.)

3458. The Introduction of Improvements into Mass-Produced Valves [illustrated by the Development of the RENS Type].—E. Schwandt. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 265–267.)

3459. A Sixty-Cycle Bridge for the Study of Radio-Frequency Power Amplifiers [and Some Typical Data on a Type 10 Class C Amplifier].—A. Noyes, Jr. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 785–806.) Using an elaboration of the 60 c/s method of Kimball and Chaffee (1934 Abstracts, p. 570). A very simple circuit, useful for rough measurements, is also derived.

3460. The Thermionic Valve in Scientific Research.—Ambrose Fleming. (*Science*, 28th June, 1935, pp. 625–628: *Journ. Franklin Inst.*, August, 1935, Vol. 220, No. 2, pp. 151–165.)

3461. "Electron Emission and Adsorption Phenomena" [translated with English: Book Review].—J. H. de Boer. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, p. 271.)

3462. The Distribution of Emission on an Incandescent Crystalline Cathode.—D. Schenk. (*Ann. der Physik*, Series 5, No. 3, Vol. 23, 1935, pp. 240–254.)

Measurements of the specific emission of the single crystals composing a nickel cathode activated with barium were made with an electron microscope which is described in § A (Fig. 2). Magnetic focusing was used (*cf.* Ruska & Knoll, 1931 Abstracts, p. 625; Knecht, 299 of January) and the image of the cathode on the screen was scanned by moving it magnetically across a circular hole behind which was a Faraday cage. A test was made to secure that spots on the cathode giving no emission really appeared so in the measurements, by drilling a hole in the cathode and filling it with graphite. The specific emission for various crystals is tabulated.

The variation of emission across a diameter of the cathode was also recorded (§ B, Figs. 9–13). Fig. 7 shows the measured and real variation of emission at the boundary of a grain in the cathode structure. The finite diameter of the scanning spot has the effect of rounding off the corners. Finally, observed differences in the emission of single crystals with a ratio of 1 : 6 are explained by differences of 0.2 volt in the work function, agreeing with photoelectric investigations (Nitzsche, 1932 Abstracts, p. 650; Underwood, 3166 of September).

3463. The Interaction of Atoms and Molecules with Solid Surfaces. I—The Activities of Adsorbed Atoms to Higher Vibrational States [Theoretical Investigation: Application to Theory of Migration of Atoms along Surfaces] *and* II—The Evaporation of Adsorbed Atoms [Theoretical Investigation].—Lennard-Jones and Strachan: Strachan. (*Proc. Roy. Soc.*, Series A, 1st June, 1935, Vol. 150, No. 870, pp. 442–455: 456–464.)

3464. Determination of the Heat of Evaporation, and Its Temperature Coefficient, of Electrons from Molybdenum, Tungsten and Tantalum Filaments, by the Cooling Method.—F. Krüger and G. Stabenow. (*Ann. der Physik*, Series 5, No. 8, Vol. 22, 1935, pp. 713–734.)

The principle of the method of measurement used was to compensate the cooling due to electron evaporation by increasing the heating current: the compensation was determined by measuring the resistance of the filament in an a.c. Wheatstone's bridge (Fig. 1). The temperature coefficient is expressed in the Richardson equation by writing, instead of the constant A, the expression $Ae^{-\alpha'}$, where $\alpha' = \alpha \log_e T$. The measurements and their theoretical implications are discussed in detail.

3465. The Ratio of the Electron and Ion Currents at a Hot Cathode in a Mercury-Vapour Discharge.—S. Gvosdover. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 7, 1935, pp. 274–291: in German.)

3466. Ionic Rays [Emission from Salts on Nickel Wires: Effect of Temperature, Pressure and Surface Area].—H. Mentrup. (*Physik. Zeitschr.*, 1st May, 1935, Vol. 36, No. 9, pp. 335–340.)

3467. The Hollow Cathode as an [Positive] Ion Source.—P. G. Kruger and B. T. Darling. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 790–791: abstract only.)

3468. On the Theory of the Surface Ionisation at Incandescent Metals [and a Formula for the Positive Ion Current for Alkali Metal Atoms].—A. Anselm. (*Physik. Zeitschr. der Sowietunion*, No. 5, Vol. 6, 1934, pp. 505–512: in German.)

3469. Sputtering of Thorium and Barium from Tungsten [Number of Ions required for Removal].—L. R. Koller. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 806: abstract only.)

3470. The Rate of Gas Emission from Heated Wires in Vacuo [Nickel Wires, charged with Adsorbed Hydrogen: Experimental Curves and Calculations of Diffusion: Values of Solubility and Diffusion Coefficient of Hydrogen in Nickel].—G. Euringer. (*Zeitschr. f. Physik*, No. 1/2, Vol. 96, 1935, pp. 37–52.)

3471. Free Path and Thermoelectric Effects [General Expression for Mean Free Path in Metals].—L. W. Nordheim. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 794–795: abstract only.)

3472. Colloidal Graphite: Its Properties and Some Applications [particularly "Aquadag" and "Varnodag"].—H. Higinbotham. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, pp. 373–374.)

DIRECTIONAL WIRELESS

3473. On the Subject of Radiogoniometers [recalling 1916/1919 Researches on the Effects of Quadrantal Field, in Ships and on Land: Corsican Results: Defects of Hill Tops and the Need for Flat Surrounding Land].—R. Mesny. (*L'Onde Élec.*, July, 1935, Vol. 14, No. 163, pp. 417–420: Editorial.)

3474. A Method of Exciting the Aerial System of a Rotating Radio Beacon [Adcock-Aerial Type: Limitations of Rotating-Coil Goniometer Method: the Double-Amplifier System with Mechanical Input Controller].—H. A. Thomas. (*Journ. I.E.E.*, August, 1935, Vol. 77, No. 464, pp. 285–290.)

3475. Micro-Waves for Guiding Ships in Fog [" Leader Beam " Demonstrations in Germany].—(*Wireless World*, 2nd Aug. 1935, Vol. 37, p. 113.)

ACOUSTICS AND AUDIO-FREQUENCIES

3476. Loudspeaker with Double Baffle, forming a Resonance Chamber, for Improved Reproduction of Wood-Wind Harmonics, etc.—J. Kressman. (French Pat. 778 727, pub. 22.3.1935: *Rev. Gén. de l'Élec.*, 29th June, 1935, p. 213D.)

3477. The Use of Loudspeakers in Groups.—E. Petzold. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 76: summary only.)

3478. On Forced Vibrations of a Circular Plate with Free Edge by Point Excitation.—H. Backhaus and R. Schünemann. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 77: summary only.)

3479. Subharmonics in Forced Oscillations in Dissipative Systems. Part II.—P. O. Pedersen. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 64–70.) For Part I *see* 2665 of August.

3480. The Permanent Magnet Industry.—(*Wireless World*, 28th June, 1935, Vol. 36, pp. 634–636.) Continued from 1918 of June.

3481. Considerations in the Design of a High-Fidelity Radio-Gramophone.—Brown. (*See* 3425.)

3482. Auditory Perspective for Gramophones?—(*Electronics*, July, 1935, p. 227.)

3483. Broadcast Programmes from Records [Recent Developments in Disc Recording for Immediate Replaying].—J. C. G. Gilbert. (*Wireless World*, 21st June, 1935, Vol. 36, pp. 612–614.)

3484. The Dramatic Use of Controlled Sound.—H. Burris-Meyer. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 74: summary only.)

3485. Influence of a Screen surrounding a Telephone Cable on the Circuit Characteristics, and the Protecting Action of the Screen.—Fargeas. (*See* 3584.)

3486. Recording Telephone Conversations [the " Telecord," with Delayed AVC].—(*Wireless World*, 5th July, 1935, Vol. 37, pp. 5–6.)

3487. A Method of Determining the Constancy of Sound Film Motion.—S. R. Eade. (*B.T-H. Activities*, May/June, 1935, Vol. 11, No. 3, pp. 93–94.)

3488. Four-Part Sound Film for Chorus Instruction.—(*Electronics*, March, 1935, p. 91.

3489. Deaf Aids.—N. W. McLachlan. (*Wireless World*, 9th Aug. 1935, Vol. 37, pp. 155–158.)

Dealing with scientific tests on the normal and abnormal ear, and discussing the technical requirements of scientifically-designed deaf-aids intended to cope with the various forms and degrees of deafness. *Cf.* Kalden, 3094 of September.

3490. Recent Advances in [Carbon] Microphone Research, *and* Measuring Displacements of Microphone Contacts [by Ultramicrometer using Very Steep Curve in " Wavemeter " Circuit].—F. S. Goucher: J. R. Haynes. (*Bell Lab. Record*, July, 1935, Vol. 13, No. 11, pp. 332–336: 337–342.)

3491. How many Watts? [Correspondence on Necessary Undistorted Output for a Broadcast Receiver].—Turner. (*See* 3416.)

3492. Frequency- and Phase-Distortion: Note on Compensation by a So-called " Negative Impedance " Method [using L.F. Retroaction at Output Valve: Almost Perfect Compensation, for Transients also].—Marinesco. (*See* 3365.)

3493. Resistance-Capacity Amplifiers at Low Frequencies [for High-Fidelity Music, etc.].—Theile. (*See* 3590.)

3494. On the Applications of the Resistance-Stabilised Feed-Back Amplifier, with Special Reference to Its Linear Frequency Characteristics [Amplification nearly Directly Proportional to Frequency: for Audio- and Supersonic Frequencies].—Z. Kamayachi. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 445: English summary p. 61.)

3495. Correction Circuits for Amplifiers: I. Below the A.F. Range.—(*See* 3586.)

3496. Loaded Transformers [such as Output, Driver and Microphone Types].—W. T. Cocking. (*Wireless World*, 21st June, 1935, Vol. 36, pp. 606–609.)

3497. Design of Output Chokes [and the Use of Gapped Cores for Windings carrying both A.C. and D.C.].—(*Wireless World*, 28th June and 5th July, 1935, Vols. 36 and 37, pp. 641–643 and 18–20.)

3498. On the Principle of Uncertainty in Sound [including the Analysis of a Formant into a Fourier Series and Explanations of Vibrato Problems].—W. E. Kock. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 56–58.) Based on Stewart's work (1930 Abstracts, p. 576, and *Journ. Acoust. Soc. Am.*, 1931, p. 325).

3499. On the Tone Quality of Pianoforte [and the Question of "Emotional Touch"].—R. N. Ghosh. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 27–28.)

3500. The Physics of the Concert Grand Piano.—II. Striking the Strings and the Generation of Vibration.—W. Lange. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 159–167.) Including a capacity-change method of recording the string vibrations.

3501. Kinks on Impact Diagrams of Struck Strings.—R. N. Ghosh and H. G. Mohammad. (*Phil. Mag.*, February, 1935, Series 7, Vol. 19, No. 125, pp. 260–277.)

3502. Relative Measurement of the Standing Wave System in a Mechanically Blown Flute Tube.—R. W. Young and D. H. Loughridge. (*Phys. Review*, 1st Feb. 1935, Series 2, Vol. 47, No. 3, pp. 258–259: abstract only.)

3503. Experimental Studies on the Sound and Vibration of Drums.—J. Obata and T. Tesima. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 267–274.)

3504. Quantitative Studies on the Singing Voice.—Wolf, Stanley and Sette. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 255–266.)

3505. An Analysis of the Vibrato from the Viewpoint of Frequency and Amplitude Modulation.—J. R. Tolmie. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 29–36.)

3506. Microphonic, Macrophonic and Myokinetic Speech.—E. W. Scripture. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 78: summary only.)

3507. The Melodies of Verse [Phonophotographic Researches].—Schramm. (*Science*, 19th July, 1935, Vol. 82, No. 2116, pp. 61–62.)

3508. Failure of Fourier Analysis applied to Vowel Vibrations [Series of Sine Functions of Amplitude Constant but Diminishing along the Series does not render obvious the Exponentially Decreasing Character of its Sum].—E. W. Scripture. (*Nature*, 10th Aug. 1935, Vol. 136, p. 223.)

3509. Film Tracks of English Vowels.—E. W. Scripture. (*Journ. Acoust. Soc. Am.*, January, 1935, Vol. 6, No. 3, pp. 169–172.)

3510. Organ Pipes and Vowel Quality.—A. T. Jones. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 282–283.)

3511. The Aural Loudness Level Observations of 100 Observers [by Automatic Recording Machine for Rapid Measurements].—J. C. Steinberg and W. A. Munson. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 78: summary only.)

3512. Loudness Level Contours and Intensity Discrimination of Ears with Raised Auditory Thresholds.—S. N. Reger. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 73: summary only.)

3513. Influence of Experimental Technique on the Measurement of Differential Intensity Sensitivity of the Ear.—H. C. Montgomery. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 39–43.)

3514. Beats and Combination Tones at Intervals between the Unison and the Octave [More than 19 Beat Regions readily Observed: Application to Subjective Tone and "Asinic" (Phase-Relation) Theories].—J. C. Cotton. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 44–50.)

3515. The Electrical Phenomena of the Cochlea and the Auditory Nerve.—Hallowell Davis. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 205–215.)

3516. Physical Problems of the Physiology of Hearing [Mechanical Nature of Frequency Analysis].—G. von Békésy. (*E.N.T.*, March, 1935, Vol. 12, No. 3, pp. 71–83.)

The anatomy of the ear is described in § 1; the schematic arrangement is shown in Fig. 1 and photographs of the bones in Figs. 2–7. Fig. 8 shows a cross-section of the cochlea of a guinea-pig, which is particularly suitable for experiments. § 2 discusses shortly the various theories of hearing and § 3 refers to the electric currents in the auditory nerves. § 4 describes phenomena which indicate that mechanical analysis of frequency takes place in the cochlea; insensibility to high frequencies corresponds, in the human ear, to destruction of the nerves near the stirrup bone (Fig. 9). Fig. 10 illustrates the variation of pitch in a tired ear. § 5 discusses the similarity of sounds heard *via* the air and the head-bones respectively: this agrees with the mechanical nature of frequency analysis ["Einortstheorie"]. An investigation of oscillations of the liquids in the ear by means of models is described in § 6, and transient phenomena in the ear are discussed in § 7. Non-linear distortions are not of nervous origin, since they do not change when the ear is fatigued (§ 8); they are due to motion of the stirrup bone and cochlea.

3517. Apparent Duration of Sound Perception [and the Musical Optimum of Reverberation].—S. Lifshitz. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 73: summary only.) *See* also 1934 Abstracts, p. 213, and 2308 of July.

3518. Technical Arrangement for Measuring the Distortions in Electroacoustic Apparatus and for Spectral Analysis.—C. A. Hartmann and H. Jacoby. (*E.N.T.*, June, 1935, Vol. 12, No. 6, pp. 163–172.)

Technical details of the construction of an apparatus for the measurement of electroacoustic distortion and for spectral analysis are here fully described. The development of the apparatus was based on known methods for the measurement of acoustic pressure [*see*, for example, Hartmann, Abstracts, 1930, pp. 162 and 401; Ballantine, 1929, p. 155, and 1932, p. 412; Küpfmüller, 1929, p. 104; Grützmacher and Just, 1931, p. 389; and Sivian, 1931, p. 216] which are first discussed. Fig. 1 shows the scheme adopted for measuring the pressure in the free sound wave, including apparatus for control measurements with a Rayleigh disc. The basis of calibration by measurement of a direct voltage and a direct pressure is described. Constructional details of the arrangement for producing constant voltages and acoustic pressures and that for selective recording of sound pressures and voltages produced electroacoustically (Fig. 2) are then given. Fig. 3 shows the scheme for producing constant voltage (automatic voltage regulation); Fig. 4 gives details of the regulating amplifier (*RV*) used in Fig. 3. Fig. 5 gives the regulating curve for *RV*; Fig. 6a demonstrates the rapidity of regulation by means of an oscillogram of the output voltage of the power amplifier, when the amplification is suddenly diminished. Fig. 6b shows transient phenomena in the regulating action. Fig. 7 gives the arrangement for the regulation of acoustic pressure; consideration of the effect of transients shows that the distance between the loudspeaker and the pressure meter must not be too great. The writers have developed a special type of condenser microphone for accurate measurement, which is described. Fig. 8 shows the transmission ratio of the pressure meter with its amplifier; this is almost independent of frequency. The choice of loudspeaker is then discussed; two are chosen, one for high and one for low frequencies.

The apparatus for selective recording of the voltage is shown schematically in Fig. 9 and its action is discussed; a heterodyne method is used and details as to the choice of frequencies are given. Fig. 10 shows a filter without attenuation, Fig. 11 the complete circuit scheme and Fig. 12 a photograph of the apparatus.

The most important uses of the apparatus are then described; the measurement of the transmission ratio of microphones as a function of frequency (Fig. 13) with an actual frequency curve (Fig. 14), and of loudspeakers (Fig. 16), is discussed. Fig. 16 shows the arrangement for spectral analysis. Reference is shortly made to non-linear distortions and the analysis of motor noise or other such disturbances (Fig. 17). A list of literature references is given.

3519. Tests on a Recording Analyser for the Audible Frequency Range.—H. H. Hall. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 76–77: summary only.) For the magnetostriction filter employed *see* 1934 Abstracts, p. 43.

3520. Method for Very Rapid Analysis of Sounds.—E. Meyer. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 76: summary only.) *See* 453 of February.

3521. Novel Frequency Generator [giving 7 Fixed A.F. Tones between 150 and 4 000 c/s when driven off 50 c/s Mains].—(*Wireless World*, 2nd Aug. 1935, Vol. 37, p. 121.)

3522. A Simple and Precise Standard of Musical Pitch [Microphone-Driven Tuning Forks of Special Design].—H. W. Lamson. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 51–55.)

3523. Further Notes on Precision Heterodyne Oscillators [Frequency Change due to given Small Capacity Change is proportional to Cube of Frequency: the Choice of Scale "Law": etc.].—W. H. F. Griffiths. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, pp. 357–362.) For the previous paper *see* 1934 Abstracts, p. 387: also 1510 of May.

3524. Acoustical Instruments.—E. C. Wente. (*Bell S. Tech. Journ.*, July, 1935, Vol. 14, No. 3, pp. 388–412: *Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 1–15.)

3525. Ekco Output Meter [5 μW—2 W and over: Frequency Errors not above 2.5% up to 12 kc/s].—(*Wireless Engineer*, July, 1935, Vol. 12, No. 142, p. 378.)

3526. Acoustic Measurements in Engineering [Survey, including Subjective and Objective Noise-Meters: with Bibliography].—K. Fürnberg. (*Elektrot. u. Masch:bau*, 21st and 28th July, 1935, Vol. 53, Nos. 29 and 30, pp. 337–342 and 353–357.)

3527. Noise [Anti-Noise League Exhibition].—N. W. McLachlan. (*Wireless World*, 14th June, 1935, Vol. 36, p. 595.)

3528. "Noise" [Book Review].—N. W. McLachlan. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, p. 492.)

3529. Summaries of a Symposium on Noise Reduction.—(*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 75–76.)

3530. Noise.—A. C. Hutchinson. (*Engineer*, 24th and 31st May, 1935, Vol. 159, Nos. 4141 and 4142, pp. 549–550 and 574–576: long summary.)

3531. The Degree of Disturbance caused by the Noise from Machines.—I. Katel. (*Génie Civil*, 27th July, 1935, Vol. 107, No. 4, pp. 85–87.)

3532. Summaries of a Symposium on Soundproofing.—(*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 72–73.)

3533. Recent Sound-Transmission Measurements at the National Bureau of Standards [on Floor and Wall Panels].—V. L. Chrisler and W. F. Snyder. (*Journ. of Res. of Nat. Bur. of Stds.*, June, 1935, Vol. 14, No. 6, pp. 749–753.)

3534. Molecular Sound Absorption in Gases [and the Failure of the "Classic" Sound Absorption Formula: Comprehensive Survey].—H. O. Kneser. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 16, 1935, pp. 213–219.)

3535. Anomalous Dispersion of Sound in Solid Cylindrical Rods.—R. Ruedy. (*Canadian Journ. of Res.*, Sections A and B, July, 1935, Vol. 13, No. 13, No. 1, pp. 10–15.)

3536. Velocity of High-Frequency Sound in Small Tubes [10–80 kc/s: Support to Helmholtz-Kirchhoff Reduction Law, but with Smaller Observed Constant: etc.].—G. A. Norton. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 16–26.)

3537. Dust Figures in a Kundt's Tube [Striations photographed under Different Conditions: Electrostatic Charge near Tube prevents Figures forming only when It is in Motion].—B. B. Hastings and D. H. Ball. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 59–63.)

3538. Sound Velocity in Gas Mixtures at High Temperatures.—H. Poritsky and C. G. Suits. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 335: abstract only.)

3539. The Rotational Dispersion of Sound in Hydrogen.—A. S. Roy and M. E. Rose. (*Proc. Roy. Soc.*, Series A, 10th April, 1935, Vol. 149, No. 868, pp. 511–522.)

3540. The Velocity of the Shock Wave [in Air] not Affected by the Rate of Detonation of an Explosive.—D. B. Gawthrop. (*Journ. Franklin Inst.*, April, 1935, Vol. 219, No. 4, pp. 471–476.)

3541. Effect of Intensity on Supersonic Wave Velocity [Velocity approaches Limiting Value $(\gamma P/\rho)^{\frac{1}{2}}$ at Comparatively Low Intensities].—W. H. Pielemeier. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, pp. 37–38.) Further evidence in support of the writer's theory (1932 Abstracts, p. 100).

3542. A Theory of Two-Dimensional Longitudinal and Flexural Vibrations in Rectangular Isotropic Plates, *and* Longitudinal, Shear and Transverse Modes of Vibration in Quartz and Tourmaline.—Osterberg and Cookson. (*See* 3602.)

3543. The Making Visible of Supersonic Waves in Gases [by an Improved "Schlieren" Method] and Its Use for Intensity Measurement.—R. Pohlmann. (*Naturwiss.*, 19th July, 1935, p. 511.)

3544. The Making Visible of the Longitudinal and Transverse Vibrations of a Quartz Oscillator.—E. Hiedemann and K. H. Hoesch. (*Naturwiss.*, 19th July, 1935, pp. 511–512.) Further development of the work referred to in 195 and 247 of January.

3545. The Magnetic Barkhausen Effect and Supersonic Irradiation [and a Probable Similar Action on Electrical Barkhausen Effect].—Hollmann and Bauch. (*Naturwiss.*, 11th Jan. 1935, p. 35.)

3546. Beneficial Effects, on Growth of Potatoes, of Supersonic Waves [400 Million Cycles/Sec.].—(*Science*, 19th July, 1935, Vol. 82, No. 2116, Supp. p. 7: Russian results.)

3547. Ring-Form, Toothed-Wheel and Cylindrical Magnetotostriction Supersonic Generators.—Nukiyama and Aoyagi. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 442: English summary p. 61.)

3548. "Sound" [Recent Experimental and Applied Acoustics: Review of Second Edition].—E. G. Richardson. (*Journ. Acoust. Soc. Am.*, July, 1935, Vol. 7, No. 1, p. 71.)

3549. "Akustic" [Authorised Translation of "Acoustics": Book Review].—Stewart and Lindsay. (*E.T.Z.*, 4th July, 1935, Vol. 56, No. 27, p. 780.)

PHOTOTELEGRAPHY AND TELEVISION

3550. The Magnitude of Halation in Cathode-Ray Tubes with Different Types of Fluorescent Screen.—M. von Ardenne. (*Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 1–4.)

A former paper by the writer (1934 Abstracts, p. 44) stressed the importance, for weak halation, of the fluorescent crystals having only small optical contact with the glass surface of the screen (Fig. 1a, b). Measurements are given in the present paper which indicate how far it is possible to weaken the haloes by this means. Experiments with various materials for fixing the crystals to the glass were also made. Fig. 2 shows a cross-section of calcium tungstate crystals fused into the glass, and Fig. 3, of crystals dusted on the glass and held by a binding material. Microphotographs of views of these films from above, showing the surface structure, are given in Figs. 4, 5. Fig. 6 shows a microphotograph of the screen of a commercial television tube; Fig. 7 is the same screen, photographed by the light of its own fluorescence. Fig. 8 gives the scheme of an optical arrangement for investigating the optical contact of the crystal film with the glass surface; it was found that the fraction of the total illumination of the spot and its halo produced by the halo was 25 to 28% for normal fused screens and 1½ to 4% for "bound" screens, depending on whether little or much of the binding material was used and on the kind of crystal. The figure for the commercial screen of Figs. 6, 7 was 2%. Fig. 9 shows a highly magnified piece of a television image illustrating the contrast interval for a black/white transition; this may be greater than 1 : 50. The general appearance of the halo also depends on the optical contact of the crystals with the glass; with fused screens it shows a gradual decrease of illumination intensity from the centre outwards, while with "bound" crystals there are several weak rings of light due to multiple reflection. Screens with small haloes have also poor heat conductivity, but the specific heat load is so small that critical temperatures are not reached.

3551. Post-Acceleration in Cathode-Ray Tubes. Part II.—E. Schwartz. (*Funktech. Monatshefte*, July, 1935, No. 7, Supp. pp. 47–49.)

For Part I *see* 3131 of September. The writer deals with the experimental testing of the conclusions previously reached regarding post-acceleration by a current-carrying high-resistance layer on the wall of the tube. The first tube of this kind was constructed in January, 1935, and results were found to agree well with theory. By the use of a fluorescent screen whose useful output increased with higher electron speed, the brightness factor was considerably increased. Thus with an initial anode voltage of 2.35 kv and a post-acceleration voltage of 5.8 kv the brightness factor was 15 and the figure of merit 9.

3552. A New Glow-Discharge Phenomenon and Its Possible Application to Cathode-Ray Tubes with Low Cathode Voltages [Well-Concentrated Axial Ray of Very Small Cross Section and High Intensity, from a Hollow Cold Cathode].—W. Krug. (*Naturwiss.*, 31st May, 1935, p. 355.)

3553. Principles underlying the Design of Television Electron-Optical Systems [and an Experimental Technique].—L. S. Polotovsky. (*Izvestia Elektroprom. Slab. Toka*, No. 6, 1935, pp. 13–27.)

Author's summary:—A method of designing electron-optical systems whose field cannot be calculated is given, and an experimental method for determining such fields is described [Fig. 1]. Two types of electron-optical systems are closely examined, consisting of (1) two diaphragms and (2) two cylinders. The relations here obtained between the optical data, the configuration of the system, and the potentials, are represented graphically.

3554. The Potential Distribution in Screens with Slits and with Circular Openings [Theoretical and Experimental Investigation].—A. Glaser and W. Henneberg. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 16, 1935, pp. 222–230.)

Extension of the work dealt with in 1933 Abstracts, p. 111 (Glaser) and 2039 of June. The experimental diagrams (for the slit screen only) were obtained by electrolytic trough tests. For the circular-hole screen the corresponding diagrams are calculated, using elliptical coordinates.

3555. The Chromatic Error in Electron-Optical Arrangements, especially "Image Converters."—W. Henneberg and A. Recknagel. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 16, 1935, pp. 230–235.)

Early patents (Farnsworth, Holst) containing the fundamental ideas of the "image converter" are referred to, and the published methods of Brüche (*e.g.* Abstracts, 1934, p. 107, two), of Holst and his co-workers (1934, p. 331), and of Farnsworth (207 of January) are outlined (Figs. 1 a and b). The third arrangement (Fig. 1 c) was first given and used by Pohl (mentioned in "Geometrische Elektronenoptik" by Brüche and Scherzer—*see* 1181 of April, and *cf.* 3556): "it represents the first electron-optical image formation, produced by a lens, of a photo-cathode on which a diapositive is projected": among other differences between this arrangement and the other two is the fact that the fields do not act on the electrons over their whole path, so that according to the position of the lens the electron image is either enlarged or reduced, instead of being of the same size as the object as in the other arrangements. It has been developed further by Schaffernicht (1949 of June) and Heimann (1951 of June). As regards chromatic error, also, it requires different treatment: the first two arrangements allow the electron paths to be calculated directly, but the third requires optical methods.

The writers therefore first give the mathematical treatment of the first two arrangements ("homogeneous fields") and then that of the third ("inhomogeneous fields—short lens"): Table I gives the comparative results, and shows that while the diameter of the dispersion circle is 2×10^{-2} and 5×10^{-3} cm for the first and second arrangements respectively, for the third it is only 1.7×10^{-3} cm. A footnote states: "Farnsworth, it is true, works with only 600 v, but for a comparison of the difference in principle of the various arrangements this is unimportant: we have therefore calculated, in this case also, for 5 000 v." It is pointed out that, with the third arrangement, the error will be greater than that given in the table, for points on the object far from the optical axis ("influence of Δ' in formula 9"). The end part of § 4 discusses the effect of enlarging the image (as can be done with the third arrangement) in increasing the resolving power.

3556. Electron-Optical Image Formation with Photoelectrically Liberated Electrons [for Investigation of Metal and Mineral Surfaces, Alkali Metal Photo-Cathodes, Molten Metals, etc.].—H. Mahl and J. Pohl. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 16, 1935, pp. 219–221 and Plate). For previous work *see* 855 of March. One improvement in the apparatus is the magnetic bending of the beam so that no stray light from the cathode can reach the screen.

3557. The Conversion of Light Images into Electron Images.—Henneberg: Schaffernicht. (*See* 3632.)

3558. Scanning System without Moving Parts [Periodic Rotation of Plane of Polarisation by Kerr Cell combined with Passage through Tapered Quartz Plate].—G. Tarel. (French Pat. 780 842, pub. 4.5.35: *Rev. Gén. de l'Élec.*, 27th July, 1935, Vol. 38, No. 4, pp. 29–30D.)

3559. Scanning with an Arc: Details of a Novel System employing a Moving Arc [between Interleaved Wires forming a Sinuous Path].—(*Television*, August, 1935, Vol. 8, No. 90, pp. 445–446 and 448.)

3560. New Scanning Methods in Television [Outline of Zworykin and Farnsworth Systems].—W. Heimann. (*E.T.Z.*, 4th July, 1935, Vol. 56, No. 27, pp. 751–762.)

3561. A Practical Outline of Television.—A. G. D. West. (*Television*, August, 1935, Vol. 8, No. 90, pp. 464–470.) Extracted from the address referred to in 3147 of September.

3562. When did Television begin? [Early Schemes from 1854 onwards].—(*Television*, August, 1935, Vol. 8, No. 90, pp. 481–482 and 484.)

3563. The Television Prospect: Some Commercial and Technical Considerations.—H. Warren. (*Electrician*, 9th Aug. 1935, Vol. 115, No. 2984, pp. 161–163.)

3564. Television Advances Abroad.—(*Electronics*, July, 1935, pp. 229–230.)

3565. On Television [Address to VDE Hamburg Meeting].—Banneitz. (*E.T.Z.*, 11th July, 1935, Vol. 56, No. 28, pp. 785–789.)

3566. Television at the VDE Meeting in Hamburg: Two-Way Sound-Sight [Cable] Communication: Van Transmitter: etc.—(*Funktech. Monatshefte*, July, 1935, No. 7, Supp. pp. 45–46.)

3567. The First Television Transmitting Van using the Intermediate Film Process.—G. Schubert. (*Funktech. Monatshefte*, July, 1935, No. 7, Supp. pp. 49–51.)

3568. The Present Position of Television [Nancy Conference, 1935: including the Desirability of Auxiliary Transmissions, on about 200 m, of 60 or 90-Line Pictures].—R. Barthélémy. (*L'Onde Élec.*, June and July, 1935, Vol. 14, Nos. 162 and 163, pp. 391–405 and 455–469.)
An untouched photograph of a 60-line image is included. Such a service should have a range of 150–200 km, to supplement the high-definition u.s.w. service.

3569. "Television" [Book Review].—M. G. Scroggie. (*World-Radio*, 2nd Aug. 1935, p. 9.)

3570. There is Something Lacking in Television: What Happens to the D.C. Component?—J. McPherson. (*Television*, August, 1935, Vol. 8, No. 90, pp. 471 and 496.)

3571. [The Difficulties in the Way of] Television in Natural Colours.—G. Krawinkel. (*E.T.Z.*, 1st Aug. 1935, Vol. 56, No. 31, p. 866.)

3572. The Debye Effect and the Kerr Effect Lag in Pure Nitrobenzene.—I. Ranzi. (*Nuovo Cimento*, May, 1935, Vol. 12, No. 5, pp. 285–289.)

The writer has measured, by an interferometer method, the index of refraction of pure nitrobenzene for waves of 7.2 and 3.8 cm, and obtains the values 3.6 and 2.7 respectively. From these he deduces that the relaxation time for the nitrobenzene dipole is of the order of 2×10^{-10} sec., in agreement with his direct measurements of the lag in Kerr effect ("if it exists, it is smaller than 3×10^{-10} sec.").

3573. Note on a Modified Kerr Cell for 240-Line Operation [Diverging-Plate Type (for Reduced Capacity) working with Circular Polariscope: Power Consumed reduced by Combined Electrical and Optical Biasing].—(*Marconi Review*, May/June, 1935, No. 54, pp. 12–14.)

3574. The Neon Tube as a Light Modulator in Television Systems.—N. D. Smirnov. (*Izvestia Elektroprom. Slab. Toka*, No. 6, 1935, pp. 44–50.)

Author's summary:—The results of the work carried out were as follows:—(1) It was found that the brightness of the neon-tube glow was proportional to the current intensity through it; (2) the neon tube was investigated from the point of view of linear, phase, and non-linear distortion; (3) circuit diagrams are given for testing television amplifiers by taking amplitude, phase, and frequency curves with the help of the neon tube; (4) the number of light gradations given by the neon tube in television was determined; and (5) the effect of amplifier noise on the number of gradations was found.

3575. The Problem of the Artificial Generation of Light [by Electron Collision, Electromagnetic Radiation, Chemical Luminescence, etc.].—Lax, Pirani, and Rompe. (*Naturwiss.*, 21st June, 1935, pp. 393–405.)

3576. The Spectral Photoelectric Sensitivity of Composite Photocathodes [with Oxide Intermediate Film] when the Carrier Metal and the Alkali Metal are Varied.—W. Kluge. (*Zeitschr. f. Physik*, No. 11/12, Vol. 95, 1935, pp. 734–746.)

For previous work by the writer on composite photocathodes *see* Abstracts, 1933, p. 221. The present paper investigates and compares the effects obtained with the carrier metals Ag, Cu, Ni and Au. The photocell had the usual spherical form with central anode, which carried the arrangement for vaporising the carrier metal. The spectral distributions measured with alkali metal Cs are shown in Fig. 1 a–d. There are throughout two maxima in the ultra-violet region (*see* also 1934, p. 102, and Fleischer and Görlich, 1934, p. 331). No long-wave maximum was found for Au and Ni, though it is not certain whether this might not occur with other methods of cell manufacture. The experimental results clearly show that "the carrier metal forms part of the intermediate layer and thus exerts an influence on the action, so that the selective absorption of light by the adsorbed Cs, and therewith the corresponding long-wave selective photoelectric effect, occur in definite spectral regions."

Curves with Ag as the carrier metal and Na, K, Rb and Cs respectively as the alkali metal are given in Fig. 2 a–d. All show two selective maxima in the short-wave region, with no marked difference in their position for the various alkali metals. The long-wave maxima occur in the order (taken from the long-wave end) Cs, Rb, K (Na showed no maximum). A third short-wave maximum was found at 240 mμ for a cell of the type $Ag - Cs_2O - Cs$, when measurements were taken beyond the previous limit 254 mμ. The long-wave maximum is explained as an optical absorption band of alkali atoms adsorbed on the surface (Gudden and Pohl, *Zeitschr. f. Physik*, 1925, Vol. 34, p. 245). The centres exerting the short-wave selective action are thought to be in the alkali metal itself; they may possibly not be on the actual surface.

3577. ADSORPTION OF ALKALI METALS ON METAL SURFACES. IV. ADSORPTION OF ATOMS NEXT TO IONS. V. INFLUENCE OF TEMPERATURE ON THE NORMAL PHOTOELECTRIC EFFECT.—J. H. de Boer and C. F. Veenemans. (*Physica*, June, 1935, Vol. 2, No. 6, pp. 521–528: 529–534: in English.) For previous parts *see* 1934 Abstracts, p. 564, and 1550 of May (Parts II and III).

3578. "ELECTRON EMISSION AND ADSORPTION PHENOMENA" [translated with English: Book Review].—J. H. de Boer. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, p. 271.)

3579. ON THE INFLUENCE OF THE [Dielectric Constant of the] BASE MATERIAL ON THE "PHOTO-EFFECT FROM METAL TO DIELECTRIC" [*i.e.* Internal Photo-Effect in Rock Salt coloured by Colloidal Copper: in connection with Researches on Lenard Phosphors].—L. W. Groschew. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 619–630: in German.)

3580. ON THE VELOCITY DISTRIBUTION OF THE PHOTOELECTRONS IN THIN METALLIC FILMS (ALUMINIUM).—E. Wasser. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 532–546: in German.)

3581. TEMPERATURE EFFECTS OF BARRIER-LAYER PHOTOCELLS [between about + 50 to − 50°].—H. Suzuki. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 347: English summary p. 48.) Results "somewhat differ from those reported by Mittmann" (1934 Abstracts, p. 331).

3582. ON THE PHOTO- AND DARKNESS-CONDUCTIVITY OF CUPROUS OXIDE [and the Existence of a Badly-Conducting Intermediate Layer between Metal and Oxide: High-Voltage Polarisation: Tests at Liquid-Air Temperatures: etc.].—D. Nasledow and L. Nemenow. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 513–531: in German.)

3583. RÔLE OF THE PHOTOCONDUCTIVITY OF THE BARRIER LAYER IN THE PHOTOEMISSION AT THE BORDER SURFACES OF SEMI-CONDUCTORS.—G. Liandrat: Jusé. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 670–671: in French.)

The writer dissociates himself from Jusé's conclusions (2048 of June: for Liandrat's own papers *see* 1934 Abstracts, p. 568). The fact that the barrier layer is the site of secondary effects of photoconductivity must not be given primary importance. The rôle of the barrier layer is to form an obstacle to the return of the photoelectric current: it is responsible for the appearance of a potential difference, but has nothing to do with the genesis of the primary photoelectric current.

3584. INFLUENCE OF A SCREEN SURROUNDING A TELEPHONE CIRCUIT ON THE CHARACTERISTICS OF THIS CIRCUIT, AND THE PROTECTING EFFECT OF THE SCREEN AGAINST ELECTROMAGNETIC COUPLINGS BETWEEN THE CIRCUIT AND NEIGHBOURING CIRCUITS.—L. Fargeas. (*Rev. Gén. de l'Élec.*, 22nd June, 1935, Vol. 37, No. 25, pp. 787–796.)

Mathematical analysis leading to practical conclusions, particularly regarding the incomplete action of an aluminium-ribbon sheath and the necessity, for modern requirements, of an approach to a continuous cylindrical sheath: the line of discontinuity, if any, should describe a helix in the same sense and of the same pitch as the twist of the ciruit itself. The formulae derived are of assistance in choosing the metal for the screen and its spacing from the conductors, for working out the cheapest construction, etc.

The increase of effective resistance due to the screen tends towards a limiting value as the frequency increases, the more rapidly the lower the d.c. resistance of the screen. The limiting value is proportional to this d.c. resistance, and is the lower the farther the screen is from the conductors. The mutual inductance between screen and circuit is a complex quantity which, as the frequency is raised, also tends towards a real limiting value, the more rapidly the lower the d.c. resistance of the screen. The limiting value itself is quite independent of this d.c. resistance, but is the smaller the greater the distance between screen and circuit. The mutual inductance between the screen and a neighbouring interfered-with circuit is a complex quantity which, when the frequency is raised, tends towards a real limit, the more rapidly the lower the d.c. resistance of the screen. The limiting value itself is quite independent of the screen. It is equal and of opposite sign to the mutual inductance between the interfering circuit and the interfered-with circuit, and annuls this.

3585. COAXIAL CONDUCTOR SYSTEMS [and the New York/Philadelphia Million-Cycle Line].—M. E. Strieby. (*Bell Lab. Record*, July, 1935, Vol. 13, No. 11, pp. 322–327.)

3586. CORRECTION CIRCUITS FOR AMPLIFIERS [for extending and controlling Response beyond A.F. Range: *e.g.* for Television and Medical Research. Part I. Below the A.F. Range].—(*Marconi Review*, May/June, 1935, No. 54, pp. 15–29.) Including a treatment of the effect of auto-bias arrangements.

3587. THE DESIGN OF HIGH-DEFINITION AMPLIFIERS. PART I—THE RESPONSE OF AMPLIFIERS TO SIGNALS OF A TRANSIENT NATURE.—L. E. Q. Walker. (*Television*, August, 1935, Vol. 8, No. 90, pp. 473–475.)

3588. THE TRANSIENT ASPECT OF WIDE-BAND AMPLIFIERS [Indicial- or Time-Admittance Curves and the Specification of Television Networks].—N. W. Lewis: Puckle. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, p. 372.) Prompted by Puckle's article (2339 of July).

3589. Television I.F. Amplifiers [with Design Details].—W. T. Cocking. (*Wireless World*, 14th June, 1935, Vol. 36, pp. 586–588.)

3590. Resistance-Capacity Amplifiers at Low Frequencies [for Television and High-Fidelity Music: Calculation of Amplification Factor, Limiting Frequency, Self-Excitation and Its Prevention: Practical Values for Design: etc.].—R. Theile. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 245–248.)

MEASUREMENTS AND STANDARDS

3591. A Static Voltmeter for Ultra-High Frequencies [*e.g.* for 3.5 m Waves: Voltages up to 1 600 V].—N. N. Malov. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 583–589: in German.)

There are two fixed electrodes in the same horizontal plane: between these, with an adjustable gap at each, moves a light vane carried on a horizontal stretched-thread axis. This vane bears a light vertical rod whose lower end moves through an oil bath and whose upper end is fitted with a small mirror, the movements of which are observed through a telescope. The capacity of the instrument, with rigid vertical connectors rising from the fixed electrodes, is around 2 cms. By suitable design of the electrode ends an almost linear characteristic can be obtained.

3592. Measurement of Radio-Frequency Impedance with Networks simulating Lines [and Some New Methods: Factors affecting Accuracy: Suitability for Frequencies 50 to Several Thousand Kilocycles: etc.].—W. L. Barrow. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 807–826.)

3593. Electrical Measurements at Ultra-High Frequencies [Mathematical and Experimental Foundations of Use of Parallel-Wire Methods].—R. King. (*Proc. Inst. Rad. Eng.*, August, 1935, Vol. 23, No. 8, pp. 885–934.)

(1) Outline of mathematical theory (*see* also 2586 of August). (2) Experimental technique:—the measurement of current and voltage (using improved form of the apparatus dealt with in Abstracts, 1932, p. 637, and 1933, p. 618: the technique of the "tandem" bridge: the symmetrical s.g. voltmeter—*see* 1934, p. 510) and of reactance, including series and parallel resonance circuits; the measurement of resistance (wires, coils, high-resistance leaks) and of the permeability of wires ("this part of the paper presents, to the best knowledge of the writer, the first theoretically derived and experimentally demonstrated method for measuring the effective resistances of circuit elements at ultra-high frequencies"); and the analysis of complex frequencies.

3594. Method of Measuring Potential Differences at Ultra-High Frequencies, 10^7—10^8 c/s [particularly in Therapeutic Researches].—P. Mercier and G. Joyet. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 8, 1935, pp. 310–313: in French.)

Using a modification of Rohde's diode compensation method (1931 Abstracts, p. 393 and 616) which avoids the trouble caused, in the original method, by the leakage current due to the capacity of the apparatus to earth. A filter is used which prevents the h.f. voltages from reaching the main part of the apparatus, and also acts as a blocking choke to any leakage current.

3595. Measuring the Ultra-Shorts [Simple Absorption Wavemeter].—H. B. Dent. (*Wireless World*, 12th July, 1935, Vol. 37, pp. 28–29.)

3596. A Linear, Multi-Range Electronic Voltmeter [primarily for Television Work: with High Input Resistance and Low Input Capacity: 0.1 to 200 Volts, 20 c/s to Several Mc/s].—L. C. Paslay and M. W. Horrell. (*Rad. Engineering*, July, 1935, Vol. 15, No. 7, pp. 7–9.)

3597. A Detecting Instrument [Voltage and Current Indicator] for Frequencies from 30 c/s to 1.6 Mc/s.—R. Tamm and F. Bath. (*Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, pp. 6–7.)

The instrument is a copper-oxide-rectifier/microammeter combination. Fig. 1 shows the vector diagram and equivalent circuit of the rectifier for small amplitudes and audio-frequencies. Fig. 2 shows, in principle, the voltmeter in a one-way circuit; point rectification is used. The Greinacher circuit (Fig. 3) nullifies the effect of the second harmonic. The third harmonic may, however, cause errors up to 3%. Fig. 4 gives the curve of the voltmeter scale, which is nearly linear above 0.2 volt, and Fig. 5 shows how the reading depends on frequency; this error is less than 2% throughout the range. The input impedance is non-linear (Fig. 6) and decreases with increasing frequency. The voltmeter becomes an ammeter by connecting an ohmic resistance in parallel. Data are given of the frequency limits for the different ranges. Smaller detectors are being developed (curve in Fig. 6). *See* also 3617 and 3618.

3598. Field Strength Measurements [with Vertical-Aerial and Loop-Aerial Adaptor Units for extending Type 476 Set down to 0.15 μV/m on Short-Wave Bands and up to 2 V/m on Broadcast Bands].—F. M. Wright. (*Marconi Review*, May/June, 1935, No. 54, pp. 1–4.) *See* 1932 Abstracts, p. 593.

3599. On the Stability of [Self-Excited] Oscillators.—Antseliovich. (*See* 3384.)

3600. Principles in Designing a Crystal Holder for a Piezo-Quartz Stabilisator [for a Stationary Transmitter: and a New Type of Holder].—M. M. Venkov. (*Izvestia Elektroprom. Slab. Toka*, No. 6, 1935, pp. 39–44: to be concluded.)

In the new holder the quartz is vertical and rests loosely on a special system of horizontal pins. "The undesirable pressing of the crystal is entirely eliminated, while it is absolutely unable to move along the electrode under the action of base tilt. The formulae for the calculation of the location of the pins are derived. As to the question of the proper air gap, the author points out the special effect of considerable expansion of the 'dangerous zones'—Fig. 5. Neglect of this effect may lead to a very unstable performance at certain temperatures, even in the case of a perfect crystal holder and quartz plate."

3601. Examples of the Electrical Twinning of Quartz [and Its Importance for Quartz Oscillators, etc.].—L. Essen. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, pp. 256–257.)

3602. A Theory of Two-Dimensional Longitudinal and Flexural Vibrations in Rectangular Isotropic Plates [Solution of Differential Equation: Formation of Coupled Vibration Systems].—H. Osterberg and J. W. Cookson. (*Physics*, July, 1935, Vol. 6, No. 7, pp. 234–246.)

3603. Longitudinal, Shear and Transverse Modes of Vibration in Quartz and Tourmaline [Theoretical Analysis of Various Possible Types of Vibration, with Experimental Verifications: No Experimental Evidence for Free Simple or Pure Shear Modes or Transverse Vibrations].—H. Osterberg and J. W. Cookson. (*Physics*, July, 1935, Vol. 6, No. 7, pp. 246–256.)

3604. The Making Visible of the Longitudinal and Transverse Vibrations of a Quartz Oscillator.—Hiedemann and Hoesch. (*See* 3544.)

3605. Piezoelectric Quartz [Comprehensive Survey: Introduction and Part I: Conclusion, including the Problem of Low Temperature Coefficients].—R. Jouaust. (*L'Onde Élec.*, June and July, 1935, Vol. 14, Nos. 162 and 163, pp. 373–390 and 421–443.) An appendix deals with the recent work, on parallel lines, of Lack, Willard and Fair and of Koga (1934 Abstracts, p. 570: 1021 of April).

3606. Inversion Phenomena in the Polarisation of Rochelle Salt Crystals [and Landau's Theory of the Analogies with Ferromagnetic Behaviour].—Kurtschatow and Schakirow. (*Physik. Zeitschr. der Sowietunion*, No. 5/6, Vol. 7, 1935, pp. 631–638: in German.)

3607. On a Method for the Study of Magnetostrictive Vibrations.—B. Gurewitch. (*Comptes Rendus*, 5th Aug. 1935, Vol. 201, No. 6, pp. 387–389.)

The movements of one end of the bar produce a l.f. modulation of a r.f. oscillation, by means of capacity change as in an electrostatic microphone. The oscillographic records obtained allow the following points relating to the decay of the oscillations ("a problem which has not yet been treated completely") to be studied:—(i) measurement of the elongations as a function of the permanent and alternating magnetic fields, (ii) measurement of the decrement, and (iii) determination of the cause of the decay by the study of the inverse magnetostrictive effect as a function of the elongations. No results are given in the present Note, but the apparatus is described and illustrated schematically.

3608. The [Transverse] Magnetostriction of Bismuth Single Crystals.—D. Shoenberg. (*Proc. Roy. Soc.*, Series A, 1st July, 1935, Vol. 150, No. 871, pp. 619–637.)

3609. A Stroboscopic "Flick" Circuit [Flash Time down to 1 μsec.: Analysis of Multivibrator Circuit and Its Modifications].—W. S. Mortley. (*Marconi Review*, May/June, 1935, No. 54, pp. 8–11.)

The writer's examination of the ordinary Abraham-Bloch arrangement, of which the circuit used is a modified form, shows that (contrary to general belief) it will oscillate without the inclusion of any inductance whatever.

3610. An Automatic Frequency Comparator [primarily for checking Nominal 100 c/s A.C. (by Its Tenth Harmonic) against Standard 1 000 c/s Supply].—N. F. Astbury. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, pp. 245–249.)

3611. New Frequency Meter: Tuning Fork Device [also for Control: Tuning Sliders on Valve-Driven Fork moved by Motor controlled by Frequency Difference].—Lepaute. (*Electrician*, 2nd Aug. 1935, Vol. 115, No. 2983, p. 135.)

3612. Measurement of Small Capacities in Terms of Mutual Inductance and Resistance [by Modification of Campbell A.C. Bridge].—W. H. Watson. (*Canadian Journ. of Res.*, Sections A and B, July, 1935, Vol. 13, No. 1, pp. 5–9.) As described, the arrangement is sensitive to within 0.01 μμF. Small condensers can be measured to within 1% with ease.

3613. "The Measurement of Inductance, Capacitance, and Frequency" [Book Review].—A. Campbell and E. C. Childs. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, p. 271.)

3614. Some Approximate Formulae for the Calculation of H.F. Circuits [Selection and Short Discussion of Self- and Mutual-Inductance Formulae].—K. E. Müller. (*Bull. Assoc. suisse des Élec.*, No. 15, Vol. 26, 1935, pp. 418–419: in German.)

3615. Aids to the Measurements of High-Frequency Impedance [Slide-Rule and -Disc].—Reppisch. (*See* 3402.)

3616. High Resistance Measurement with Vacuum Tubes [Floating-Grid Circuit for A.C.-Operated Ohmmeter for Resistances up to 1000 Megohms].—A. Preismann. (*Electronics*, July, 1935, pp. 214–215.)

3617. Bridge-Type Detector [Copper-Oxide Rectifier] Indicating Instruments.—J. S. Averbukh. (*Izvestia Elektroprom. Slab. Toka*, No. 6, 1935, pp. 51–61.)

Author's summary:—"A method of designing indicating instruments with bridge-connected copper-oxide rectifiers is described. The effect of the resistance in the diagonal is pointed out and the relation between it and the potential-drop distribution . . . is given. The scale law of the instrument is investigated and it is found that readings are nearly proportional to mean values even with rectifiers having square-law characteristics." *See* also 3597.

3618. The Action of Non-Linear Resistances (Barrier-Layer Rectifiers) in Measuring Instruments with Several Ranges with Common Scale Divisions [Theoretical Investigation of General Conditions under which One Scale will read correctly for Several Ranges: Generalisation to Alternating Currents and Voltages].—H. Pfannenmüller. (*Arch. f. Elektrot.*, 3rd July, 1935, Vol. 29, No. 7, pp. 490–495.) *Cf.* Terman, 2356 of July.

3619. Characteristics of the "Ionisation Voltmeter" [for A.C. Kilovolts].—Abe, Yamamoto and Ando. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 353: English summary pp. 49–50.)

3620. Some Improvements on a Crest Voltmeter [Chubb's Principle: for High Tensions].—K. Honda and Y. Gosho. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 352: English summary p. 49.)

3621. An Electrodynamic Moving-Iron Mechanism for Electrical Measuring Instruments [Crossed Coils replaced by Parallel Coils and Magnetic Vane: Analysis of Operation: Suitable Control Circuits].—T. A. Rich. (*Gen. Elec. Review*, July, 1935, Vol. 38, No. 7, pp. 334–338.)

3622. Notes on Modern Electrical Measuring Instruments: a Brief Survey of the Types of Electrical Instrument used To-day.—H. Cobden Turner. (*G.E.C. Journ.*, August, 1935, Vol. 6, No. 3, pp. 182–192.)

3623. Universal Test Meter.—E. M. Martin. (*Wireless World*, 19th July, 1935, Vol. 37, pp. 58–61.)

3624. A New A.C. Potentiometer of Induction Type [using Ring-Type Mutual Inductance Coils and Coreless Dynamometer Galvanometer].—M. Tanaka. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 350: English summary pp. 48–49.)

3625. The Galvanometer Constant of a Circular Coil of Many Windings [Calculation of Corrections].—R. Glazebrook. (*Proc. Roy. Soc.*, Series A, 1st July, 1935, Vol. 150, No. 871, pp. 487–494.)

3626. Apparatus for the Measurement of Very Large Continuous Currents [by Action of Magnetic Field on Magnetron Diode].—Th. Vogel. (French Pat. 778971, pub. 27.3.1935: *Rev. Gén. de l'Élec.*, 29th June, 1935, p. 215D.)

3627. Radio-Frequency Power Measurements with the Quadrant Electrometer [Mathematical Theory and Practical Difficulties].—C. I. Bradford. (*Proc. Inst. Rad. Eng.*, August, 1935, Vol. 23, No. 8, pp. 958–971.)

3628. Giorgi System of Units [Actions of I.E.C. at the Hague and Brussels].—Giorgi. (*Journ. I.E.E.*, August, 1935, Vol. 77, No. 464, p. 292.)

3629. International Electrotechnical Commission: Decisions on Practical Electrical Limits: Adoption of the Giorgi M.K.S. System.—Brylinski. (*Rev. Gén. de l'Élec.*, 20th July, 1935, Vol. 38, No. 3, pp. 73–74.) For past references to this system *see* 1934 Abstracts, p. 334.

3630. A Sixty-Cycle Bridge for the Study of Radio-Frequency Power Amplifiers [and Some Typical Data on a Type 10 Class C Amplifier].—Noyes. (*See* 3459.)

3631. The Electric Moments of the Alkyl Monohalides [Measurement of Temperature Sensitivity of Dielectric Constants of Vapours].—P. C. Mahanti. (*Phil. Mag.*, August, 1935, Series 7, Vol. 20, No. 132, pp. 274–287.)

SUBSIDIARY APPARATUS AND MATERIALS

3632. The Electron Microscope [Survey, including the Conversion of Light Images into Electron Images].—Henneberg. (*E.T.Z.*, 1st Aug. 1935, Vol. 56, No. 31, pp. 853–856.)

Schaffernicht's improved arrangement is illustrated: the light image is thrown on the photoelectric layer by a prism in such a way that the electrons emerge in the same direction as that in which the light falls. An example of a reproduction by this arrangement is given. *See* also 1949 of June.

3633. The Chromatic Error in Electron-Optical Arrangements, especially "Image Converters," *and* The Potential Distribution in Screens with Slits and Circular Apertures.—Henneberg and Recknagel: Glaser and Henneberg. (*See* 3555 and 3554.)

3634. Electron-Optical Image Formation with Photoelectrically Liberated Electrons.—Mahl and Pohl. (*See* 3556.)

3635. Principles underlying the Design of Television Electron-Optical Systems.—Polotovsky. (*See* 3553.)

3636. A New Glow-Discharge Phenomenon and Its Possible Application to Cathode-Ray Tubes.—Krug. (*See* 3552.)

3637. A High-Frequency Sweep Circuit [for Cathode-Ray Oscillograph: High-Vacuum Valve biased past Cut-Off except when Grid is driven Positive by Auxiliary Generator: Photographs of A.C. Voltages up to 12.6 Mc/s].—Goldsmith and Richards. (*Proc. Inst. Rad. Eng.*, June, 1935, Vol. 23, No. 6, pp. 653–657.)

3638. The "Flashing" Phenomena of Neon Lamps.—Terada. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 28.)

3639. A Stroboscopic "Flick" Circuit.—Mortley. (*See* 3609.)

3640. Work relating to Influence of Dielectric Constant of Base Material of Lenard Phosphors.—Groschew. (*See* 3579.)

3641. Influence of the Magnetic Field on the Fluorescence of Diatomic Molecules of Selenium.—Genard. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 328–334: in French.)

3642. The X-Ray Examination of Selenium Crystals.—Tanaka. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 22.)

3643. Photographic Plates for Use in Spectroscopy and Astronomy. IV.—Mees. (*Journ. Opt. Soc. Am.*, March, 1935, Vol. 25, No. 3, pp. 80–83.) *See* 1934 Abstracts, p. 51.

3644. The Blackening of Photographic Plates by Long-Wavelength X-Rays.—Hirsh. (*Journ. Opt. Soc. Am.*, August, 1935, Vol. 25, No. 8, pp. 229–230.)

3645. Vapour Pressure Measurements on "Apiezon" High-Vacuum Greases.—Seydel. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 16, 1935, pp. 107–109.)

3646. The Temperature Coefficients of Hot-Wire Vacuum Meters and Vacuum Thermoelements.—Kobel. (*Bull. Assoc. suisse des Élec.*, No. 8, Vol. 26, 1935, pp. 196–199.)

3647. An Improved Form of High-Vacuum Cut-Off.—Lobb and Bell. (*Journ. Scient. Instr.*, January, 1935, Vol. 12, No. 1, pp. 14–17.)

3648. A [Very Simple] Water-Flow Minimum Relay for the Protection of Water-Cooled Apparatus.—Burstyn. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 16, 1935, pp. 82–83.) Prompted by Beck's relay (1934 Abstracts, p. 512.)

3649. The Correction of Loop Oscillographs [Extension of Undistorted Frequency Range on Rheograph Principle].—Schütz. (*Elektrot. u. Masch:bau*, 14th April, 1935, Vol. 53, No. 15, pp. 174–177.)

3650. Testing of Electric Machines with the Electric "Co-ordinograph" [M.C. Galvanometers with Mirrors and Prisms, for Recording Two Varying Electrical Quantities in a Rectangular System].—Setoh and others. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 408: English summary p. 55.)

3651. Oscillographic Response-Curve Examination [and Design Precautions necessary to avoid Distortions]: an Equipment for the Visual Delineation of the Response Curves of R.F. Filters.—Proctor and Horgan. (*Wireless Engineer*, July and August, 1935, Vol. 12, Nos. 142 and 143, pp. 363–371 and 421–429.) From the G.E.C. Laboratories.

3652. Corrections to "Designing Resistive Attenuating Networks."—McElroy. (*Proc. Inst. Rad. Eng.*, June, 1935, Vol. 23, No. 6, p. 682.) *See* 2412 of July.

3653. Mercury Vapour Rectifier [Type MU2 re-designed for Max. Peak Reverse Voltage of 10 000 V, for Cathode-Ray Tubes].—Edison Swan Company. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, p. 269.)

3654. On the Magnetic Control of the "Side-Current" [Radial Component] Mercury-Vapour Tube.—Yamamoto and Ono. (*See* 3449.)

3655. A Vacuum Discharge with Cold Cathode [actually the Anode] as Cause of the Time Lag in certain H.T. Rectifier Tubes.—Penning and Mulder. (*Physica*, July, 1935, Vol. 2, No. 7, pp. 724–730: in German.)

3656. Protection of Cathode of Discharge Tube from Electronic Bombardment, by Disc Anode.—Philips Company. (French Pat. 780 964, pub. 7.5.1935: *Rev. Gén. de l'Élec.*, 27th July, 1935, Vol. 38, No. 4, p. 30d.)

3657. Investigation of Grid-Controlled Rectifiers with Zero Anodes.—Babat. (*Izvestia Elektroprom. Slab. Toka*, No. 6, 1935, pp. 61–70.) Concluded from No. 5: for previous work *see* 2399 of July.

3658. Calculation of the Current and Voltage Relations in a Self-Excited Parallel Alternating [Push-Pull] Rectifier.—T. Kuo. (*Zeitschr. f. Physik*, No. 11/12, Vol. 93, 1935, pp. 769–788.)

3659. Investigation of Frequency Constancy in Self-Controlled and -Driven Parallel Rectifiers in a Condition similar to Resonance [Theoretical Investigation of Effect of Load and Automatic Compensation: Experimental Tests, with Oscillograms].—Neidhardt. (*Arch. f. Elektrot.*, 5th April, 1935, Vol. 29, No. 4, pp. 241–258.)

3660. Experiments with the Mercury-Arc D.C. Transformer invented by Dr. R. Mitsuda.—Matuura and others: Mitsuda. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55, [No. 5], No. 562, p. 415: English summary p. 55.)

3661. The Dangers to which a Rectifier is Exposed, and Its Protection against Them.—Gottmann. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 253–256.)

3662. Rectifying Tubes: Oxide Cathode Gas-Filled Rectifiers. II.—Movements of Electrons and Ions in a Gas.—van Sluiters. (*Electrician*, 19th July, 1935, Vol. 115, No. 2981, pp. 65–66.) For Part I see *ibid.*, 12th July.

3663. The Influence of Chemical Reactions on the Cathode and Anode of an Arc Discharge.—von Engel. (*Naturwiss.*, 10th May, 1935, pp. 305–306.)

3664. INVESTIGATIONS ON THE ELECTRIC ARC [Transition from Glow to Arc Discharge for Various Metals].—Plesse. (*Ann. der Physik*, Series 5, No. 5, Vol. 22, 1935, pp. 473–499.)

3665. DISCUSSION ON "THE APPLICATION OF A GAS-COOLED ARC TO CURRENT CONVERSION, WITH SPECIAL REFERENCE TO THE MARX-TYPE RECTIFIER."—Thompson: Marx. (*Journ. I.E.E.*, April, 1935, Vol. 76, No. 460, pp. 407–414.) *See* 330 of January.

3666. RECTIFIERS [Inverters, Frequency Transformers] USING AN ARC IN GAS AT ATMOSPHERIC PRESSURES.—Di Pieri. (*La Ricerca Scient.*, 15/31 July, 1935, 6th Year, Vol. 2, No. 1/2, pp. 24–32.)

3667. IONIC CONVERTERS: THEIR ANALOGIES WITH THE COLLECTORS ON ROTATING MACHINES AND THEIR APPLICATIONS AS RECTIFIERS AND "ONDULEURS" [Inverters, D.C./A.C.].—Laurent. (*Bull. Soc. franç. des Élec.*, August, 1935, Vol. 5, No. 56, pp. 751–800.)

3668. MOVING STRIATIONS IN NEON GAS AT THE BEGINNING OF THE DISCHARGE.—van Gorcum. (*Physica*, June, 1935, Vol. 2, No. 6, pp. 535–540: in English.)

3669. OSRAM GASFILLED [Argon] RELAY TYPE GT.1.A.—G.E.C. (*Journ. Scient. Instr.*, April, 1935, Vol. 12, No. 4, pp. 124–126.)

3670. INCANDESCENT LAMPS WITH ATMOSPHERE OF KRYPTON AND XENON.—Claude. (*Génie Civil*, 18th May, 1935, Vol. 106, No. 20, p. 495: *Comptes Rendus*, 6th May, 1935, Vol. 200, No. 19, pp. 1585–1588.)

3671. THE QUARTZ-MERCURY LAMP AS IONISATION PRODUCER [Intensity Fluctuations render Constancy Unreliable].—R. Hellmann. (*Zeitschr. f. Physik*, No. 7/8, Vol. 91, 1934, pp. 569–572.)

3672. THE ELECTRICAL BEHAVIOUR OF THE BARRIER LAYER IN LEAD SULPHIDE.—Schade. (*Physik. Zeitschr.*, 15th July, 1935, Vol. 36, No. 14, pp. 499–508.)

The writer observed, when tuning a resonant circuit fed by a h.f. generator, that the current in a PbS-detector in series with a milliammeter first increased but, after reaching a maximum, fell to zero and finally flowed in the opposite direction. The same effect appeared with all the detectors tried and the present paper describes in detail a close experimental investigation of the effect. Fig. 1 shows the circuit used, which was designed to work at a frequency of about 500 kc/s; its operation is described. The measurements made dealt with (1) the normal detector effect, *i.e.* the rise of direct current in the detector circuit as the tuning improved and (2) the inversion effect, *i.e.* the decrease and subsequent reversal of the current, with increasing voltage. Many experimental curves are given and described (Figs. 2–8), illustrating the effect of increasing the voltage and the current under various conditions. Experiments were also made using a cathode-ray oscillograph to take current/voltage characteristics, and also a time-base to determine the forms of the current and voltage variations over a period of the alternating voltage supplied, for the two cases enumerated above (Figs. 9–17). Fig. 18 shows the characteristic obtained with unsymmetrical alternating current. A large number of experiments seemed to show that the detector current was an electron current emitted from the lead sulphide (Fig. 19). The external resistance was found to exert a great influence on the quality of the rectification. Increase and subsequent decrease of voltage gave hysteresis loops in the current. The experimental results are classified and a general basis for a theoretical explanation is discussed; it is suggested that the charged molecules in the metal form a space-charge which hinders the emission of electrons; this is particularly noticeable at the detector point. If the point is negative, the current will be small; if positive, it will be large. Reversal of current with increasing voltage is attributed to the properties of discharge from a point, from which negative current flows more easily than positive current. The phenomena are finally compared to those occurring with selenium.

3673. RED THRESHOLD OF THE INTERNAL PHOTO-EFFECT AND THE ENERGY VALUE IN SEMI-CONDUCTORS [Objections to Wilson's Theory: Semi-Conduction as an Ionisation of Internally Adsorbed Atoms: etc.].—de Boer and van Geel. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 286–298: in German.) For Wilson's paper *see* 1932 Abstracts, p. 108.

3674. REMARKS ON "SOME RESULTS ON THE WORKING MECHANISM OF THE DRY-PLATE ELECTRONIC RECTIFIER."—Liandrat: Jusé. (*See* 3583.)

3675. THE INFLUENCE OF WATER VAPOUR ON THE CONDUCTIVITY OF CUPRITE CRYSTALS [Dry Crystals conduct better: Surface Effect].—Brauer. (*Physik. Zeitschr.*, 15th March, 1935, Vol. 36, No. 6, p. 214: abstract only.)

3676. THE CONSTRUCTION OF AUTOMATIC MAINS VOLTAGE REGULATORS [using Iron-in-Hydrogen or Urdox Resistance in combination with Transformer and Interference Suppressor].—Klein. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 257–259.)

3677. A NEW SMALL AUTOMATIC VOLTAGE REGULATOR [based on Use of Ferraris Disc and Saturated Magnetic Circuit].—von Ratkovsky. (*Elektrot. u. Masch:bau*, 4th Aug. 1935, Vol. 53, No. 31, pp. 361–365.)

3678. A USEFUL ELECTRON TUBE MANUAL REGULATOR ["Kathetron" used for Voltage Manipulation in A.C. Circuits].—Craig. (Note in *Journ. Franklin Inst.*, July, 1935, Vol. 220, No. 1, p. 120.)

3679. ASTATIC REGULATION OF FREQUENCY OF D.C. MOTORS BY MEANS OF VALVES [Mathematical Investigation and Experimental Illustration with Oscillograms].—Ratzke. (*Arch. f. Elektrot*, 5th April, 1935, Vol. 29, No. 4, pp. 223–241.)

3680. The Resistance Characteristic of the "Half-Watt" Lamp and Its Use in the Automatic Control of Alternator Excitation.—Rougé. (*Rev. Gén. de l'Élec.*, 4th May, 1935, Vol. 37, No. 18, p. 582.)

3681. The Glow-Discharge "Stabilisator" Current-Supply System.—Seidelbach. (*E.T.Z.*, 7th March, 1935, Vol. 56, No. 10, pp. 299–302.)

3682. Floating Grid Direct-Current Amplifier [Limiting Current Sensitivity approached by using Commercial Screen-Grid Valves].—P. A. Macdonald and E. M. Campbell. (*Physics*, July, 1935, Vol. 6, No. 7, pp. 211–214.)

Curves for effect of screen-grid potential on potential of floating grid: grid impedance characteristics: theoretical limit for shot effect also limit of sensitivity, tested experimentally: graphs for practical amplifier: balanced circuit.

3683. Shielded Coil Inductance: Graphical Determination of Decrease in Inductance produced by a Coil Shield.—(*Rad. Engineering*, July, 1935, Vol. 15, No. 7, p. 11.)

3684. The Effective Impedance of a Thin-Walled Metal Cylinder [Theoretical Investigation].—Heymann. (*E.N.T.*, June, 1935, Vol. 12, No. 6, pp. 175–180.)

This paper starts from the differential equation for the electric field in cylindrical co-ordinates, with the boundary conditions appropriate to the problem, and deduces, in terms of Bessel and Neumann functions, the exact solution for the effective impedance (eqns. 12, 13). This is then reduced to a practical form (eqn. 21) which reduces to known results for very low and very high frequencies and also when the diameter is indefinitely increased. A numerical example is given, demonstrating that the formula found really does provide the link hitherto missing between high and low frequencies.

3685. Crackles produced by Rotating Condenser attributed to Induced Currents in Rotor-Vane/Spindle/Frame Circuit: suppressed by Special Spindle Construction.—André. (French Pat. 778 993, pub. 27.3.1935: *Rev. Gén. de l'Élec.*, 29th June, 1935, p. 216d.)

3686. Electrophotography [and the Investigation of Discharges in Insulating Materials: Caution in accepting Conclusions ?].—Morris Thomas: Gemant. (*World Power*, August, 1935, Vol. 24, No. 140, pp. 86–87.) Prompted by Gemant's paper, 3219 of September.

3687. Diacond—New Ceramic Material with High Dielectric Constant.—(*Electrician*, 19th July, Vol. 115, No. 2981, p. 69.) *See* 1630 of May: also *cf.* 2800 of August.

3688. The Increase of Output by the Thermal Improvement of Insulating Materials [by the Admixture of Quartz, etc.].—Meissner. (*Elektrot. u. Masch:bau*, 23rd June, 1935, Vol. 53, No. 25, pp. 289–293.) For a previous paper *see* 1192 of April.

3689. The Permanent Magnet Industry.—(*See* 3480.)

3690. Incremental Magnetisation: Experiments upon Stalloy.—Sims and Clay. (*Wireless Engineer*, May and June, 1935, Vol. 12, Nos. 140 and 141, pp. 238–245 and 312–320.)

Further development of the work referred to in 1934 Abstracts, p. 452 (Gall and Sims) and 1516 and 1583 of May.

3691. Time Lags in Magnetism [Experiments show Super-position Principle not Valid].—Preisach. (*Zeitschr. f. Physik*, No. 5/6 Vol. 94, 1935 pp. 277–302.)

3692. New Magnetic Alloy "1040" [Fe-Ni-Cu-Mo].—H. Neumann. (*Elektrot. u. Masch: bau*, 28th July, 1935, Vol. 53, No. 30, p. 360: summary only.)

3693. Theory of Reactance Transformer.—Green. (*See* 3368.)

3694. The Behaviour of High Resistances at High Frequencies: Errata.—G.W.O.H. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, p. 374.) *See* 3226 of September.

STATIONS, DESIGN AND OPERATION

3695. Deepening of Modulation in the Ionosphere? [Upper Limit of Station Power may perhaps be imposed by Ionospheric Conditions].—Sturm. (*See* 3309.)

3696. A Single Side-Band Short-Wave System for Transatlantic Telephony [and the 1933/1934 Comparative Tests].—F. A. Polkinghorn and N. F. Schlaack. (*Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 701–718.)

The London/New York comparative tests between single and double side-band systems showed that the former gave an equivalent improvement in radiated power averaging 8 db, the possible theoretical improvement being 9 db (6 from omitting the carrier and 3 from reduced receiver band width and consequent noise reduction). Other advantages, evident upon occasions, relate to phase shift in double side-band transmission and to fading. The single side-band apparatus employed is described.

3697. An Unattended Ultra-Short-Wave Radio Telephone System.—N. F. Schlaack and F. A. Polkinghorn. (*Bell S. Tech. Journ.*, July, 1935, Vol. 14, No. 3, pp. 534–541: digest only.)

A short description, with map, schematic diagrams of transmitter and receiver, and photographs of apparatus, of an experimental ultra-short-wave circuit between Green Harbour and Provincetown, Massachusetts. The radio circuit was extended by wire from Green Harbour to Boston. An optical path across the bay was secured and transmission took place on frequencies of 65 and 63 Mc/s. The aerials used are also described. The insertion of a cord into a jack on the operating switchboard started the radio transmitter at that end of the circuit; the receivers at both ends were kept in constant operation while the circuit was available for traffic. The transmitters were crystal controlled and could deliver 15 watts of carrier power which could be completely modulated. The receivers were of the double detection type with a crystal oscillator as the source of beating frequency.

3698. Around the World by Telephone [Two-Way Telephone Conversations at New York City, April, 1935: Four-Wire Circuit: Note on Radio Links].—(*Bell S. Tech. Journ.*, July, 1935, Vol. 14, No. 3, pp. 542–543: short note only.)

3699. Radioelectric Communications [Variations of the Factors influencing Communication: the Calculation of Probabilities and Its Importance in Practice].—H. de Bellescize. (*L'Onde Élec.*, July, 1935, Vol. 14, No. 163, pp. 444–454: to be continued.)

3700. New Scheme for "Mixed" Radiotelephony [Telephone Subscriber linked by Radio when travelling by Car, etc.: a Step towards the "Pocket" Telephone].—Mastini. (*La Ricerca Scient.*, 15/31 July, 1935, 6th Year, Vol. 2, No. 1/2, pp. 41–42.)

3701. The Droitwich Broadcasting Station.—(*Engineering*, 26th July, 1935, Vol. 140, No. 3628, pp. 82–84: conclusion.)

3702. Radio on board the "Normandie" [Photos with Descriptive Captions].—(*Electronics*, July, 1935, p. 218.)

3703. Broadcast Programmes from [Disc] Records.—Gilbert. (*See* 3483.)

GENERAL PHYSICAL ARTICLES

3704. Contribution to Born's New Theory of the Electromagnetic Field [New Representation by Complex Six-Vectors].—Schrödinger. (*Proc. Roy. Soc.*, Series A, 1st June, 1935, Vol. 150, No. 870, pp. 465–477.)

3705. An Absolute Definition of the Value of the Charge of the Electron.—Laboccetta. (*La Ricerca Scient.*, 15/31 July, 1935, 6th Year, Vol. 2, No. 1/2, pp. 37–38.)

3706. Measurements of the Change of Mass of the Electron in Swift Cathode Rays [show Agreement with Lorentz' Theory rather than Abraham's].—Nacken. (*Ann. der Physik*, Series 5, No. 4, Vol. 23, 1935, pp. 313–329.)

3707. A Conformal Wave Equation [somewhat Analogous to Dirac Equation for the Electron].—Veblen. (*Proc. Nat. Acad. Sci.*, July, 1935, Vol. 21, No. 7, pp. 484–487.)

3708. Koenig's Theory in Wave Mechanics.—de Broglie and Destouches. (*Comptes Rendus*, 3rd Aug. 1935, Vol. 201, No. 6, pp. 369–371.)

3709. "Researches with Positrons" and Other Papers: Withdrawal.—Rupp. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 16, 1935, p. 242.) On the grounds of illness, the writer entirely withdraws certain of his 1934 papers, including the one named (2463 of July).

3710. Theories of Ionisation [Attribution to Single Collisions of Electrons and Positive Ions with Gaseous Molecules, *not* to Formation of Metastable Atoms].—Townsend. (*Phil. Mag.*, August, 1935, Series 7, Vol. 20, No. 132, pp. 242–263.)

3711. The Optical Constants of the Copper-Nickel Alloys.—Lowery, Bor and Wilkinson. (*Phil. Mag.*, August, 1935, Series 7, Vol. 20, No. 132, pp. 390–410.)

3712. New Experiments on the Effect of a Magnetic Field on the Dielectric Constant of Liquids.—Piekara and Schérer. (*Comptes Rendus*, 29th July, 1935, Vol. 201, No. 5, pp. 335–337.) For previous work *see* 593 of February.

3713. Fundamental Properties of Paramagnetic Substances: Interpretation.—Dupouy. (*Rev. Gén. de l'Élec.*, 13th July, 1935, Vol. 38, No. 2, p. 52: summary only.)

3714. On the Periodic Solutions of S. Chapman's Equation [in Study of Brownian Movement].—Popovici: Chapman. (*Comptes Rendus*, 5th Aug. 1935, Vol. 201, No. 6, pp. 378–380.)

MISCELLANEOUS

3715. Characteristic Values of the Mathieu Equation.—Weinstein. (*Phil. Mag.*, August, 1935, Series 7, Vol. 20, No. 132, pp. 288–294.)

3716. Electric Lines of Force and Faraday Tubes [and the Question of Their Reality: the Case of the Rotating Charged Sphere], *and* The Question of Unipolar Induction.—G.W.O.H.: Fleischmann. (*Wireless Engineer*, July, 1935, Vol. 12, No. 142, pp. 355–356: *Naturwiss.*, 12th April, 1935, pp. 238–240.)

3717. Fourier Analysis of Trains of Curves made up of Sections of Sinusoidal Curves.—Feinberg. (*Elektrot. u. Masch:bau*, 14th July, 1935, Vol. 53, No. 28, pp. 334–335.)

3718. The Differential Analyser [at Manchester University: Detailed Description].—(*Engineer*, 19th July, 1935, Vol. 160, No. 4149, pp. 56–58: to be continued.)

3719. On the Adoption of the Decimal Classification [of Scientific Papers: now adopted in *E.T.Z.*].—Müller. (*E.T.Z.*, 4th July, 1935, Vol. 56, No. 27, pp. 749–750.)

3720. Fundamental Industrial Research.—Langmuir. (*Gen. Elec. Review*, July, 1935, Vol. 38, No. 7, pp. 324–333.)

3721. "Theory of Alternating Current Wave Forms" [Book Review].—Kemp. (*Rad. Engineering*, July, 1935, Vol. 15, No. 7, p. 17.)

3722. U.R.S.I. Meeting in London, September, 1934.—Picault. (*Rev. Gén. de l'Élec.*, 13th July, 1935, Vol. 38, No. 2, pp. 45–52.)

3723. Summary of the Report of the Radio Group at the VDE Hamburg Meeting.—Leithäuser. (*E.T.Z.*, 11th July, 1935, Vol. 56, No. 28, pp. 794–795.)

3724. Radio Problems of the Day discussed at the VDE Meeting in Hamburg [Titanium Oxide Insulating Materials, Magnetrons, Luxembourg Effect].—(*Funktech. Monatshefte*, July, 1935, No. 7, pp. 281–282.)

3725. National Radio Exhibition, a Technical Review, *and* Radiolympia, 1935: as a Long-Distance Man saw It: etc.—(*World-Radio*, 23rd Aug. 1935, pp. 15–18: pp. 3–5.)

3726. The Berlin Radio Exhibition.—(*World-Radio*, 23rd Aug. 1935, pp. 6 and 20.)

3727. On Learning Morse [by "Sound," not by "Signs"].—Forsyth. (*Wireless World*, 14th June, 1935, Vol. 36, pp. 591–592.)

3728. Most People are "Ear-Minded" [as contrasted with "Eye-Minded": Harvard Tests].—Allport, Cantril and Carver. (*Electronics*, June, 1935, p. 192.)

3729. The Electronic Licence Situation.—(*Electronics*, May, 1935, pp. 143–144.)

3730. "Air Law—Outline and Guide to Law of Radio and Aeronautics" [Book Review].—Le Roy. (*Proc. Inst. Rad. Eng.*, May, 1935, Vol. 23, No. 5, p. 541.)

3731. Modifications and Additions to ASE Regulations on Interior Wiring Systems [including Those for Electrical Sound and Image Reproduction].—(*Bull. Assoc. suisse des Élec.*, No. 15, Vol. 26, 1935, pp. 426–437: in French.)

3732. On the Question of "Point-Warmth" in an Alternating Electric Field [Theoretical Investigation of Rise of Temperature of Spherical Body between Condenser Plates with Alternating Voltage: Application to Physiological Effects of Short Electric Waves].—Krasny-Ergen. (*Ann. der Physik*, Series 5, No. 4, Vol. 23, 1935, pp. 304–312.)

3733. On the Influence of the Wavelength on the Destructive Action of High-Frequency Electrical Fields.—Malov: Szymanowski. (*Physik. Berichte*, No. 13, Vol. 16, 1935, p. 1133: summary only.)

3734. Electrotaxis and Electronarcosis.—Scheminzky. (*Elektrot. u. Masch:bau*, 7th July, 1935, Vol. 53, No. 27, pp. 316–320.)

3735. Correction Circuits for Amplifiers [*e.g.* for Medical Research].—(*See* 3586.)

3736. The Dependence of the State of Health on Sudden Eruptions on the Sun, and the Existence of a 27-day Period in Mortality Statistics.—Traute and Düll. (*Naturwiss.*, 29th March, 1935, pp. 210–213.)

3737. "Radiotellurie et Radiesthésie devant la Science" [Water- and Mineral-Divining, and a Theory based on Induction Phenomena: Book Review].—Joly. (*Génie Civil*, 27th July, 1935, Vol. 107, No. 4, p. 100.)

3738. The Divining Fork as a Radio Problem [and a Comparison between Aerial-Capacity Curves and Divining-Fork Curves over Subterranean Caves, etc.].—Fritsch. (*Funktech. Monatshefte*, July, 1935, No. 7, pp. 269–270.)

3739. Bactericidal Power of Water submitted to the Combined Action of Metallic Silver and a Continuous Electric Current [Greatly Improved Results].—Metalnikoff. (*Comptes Rendus*, 5th Aug. 1935, Vol. 201, No. 6, pp. 411–412.) *See* Abstracts, 1930, p. 587 (Tammann) and 1932, p. 541 (Nadson and Stern).

3740. New [and Improved] Danish Method of Artificial Respiration.—Holger Nielsen. (*Industrial Chemist*, July, 1935, Vol. 11, No. 126, pp. 279–281.)

3741. Electric Fish.—Besnard. (*Bull. Soc. franç. des Élec.*, June, 1935, Vol. 5, No. 54, pp. 605–615.)

3742. On the Resistance and Capacity of Fishes [and Judgment of Degree of Freshness].—Ueda, Izumi and Itow. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 358: English summary p. 50.)

3743. Lamp Polar Curves on the Cathode-Ray Oscillograph [with Possible Application to Polar Curves of Loudspeakers and Small Short-Wave Aerials].—Tyler and Brown. (*Journ Scient. Instr.*, August, 1935, Vol. 12, No. 8, pp. 253–255.)

3744. The Determination of Young's Modulus for Building Materials by a Vibration Method [Longitudinal Vibration photographed with Cathode-Ray Oscillograph and Time-Base].—Grime. (*Phil. Mag.*, August, 1935, Series 7, Vol. 20, No. 132, pp. 304–310.)

3745. Investigation regarding the Tension of Cotton Yarns during Pirning and Coning [using a Liquid-Resistance Device with Oscillograph].—Reiners. (*Journ. Textile Inst.*, July, 1935, Vol. 26, No. 7, pp. P 289–P 306.)

3746. Applications of Electronic Engine Indicators [Carbon-Pile, Piezoelectric, and Condenser Types].—Bloch. (*Electronics*, July, 1935, pp. 212–213 and 223.)

3747. Advance Notice of Flood's Approach given by Automatic Radio.—Ingerson. (*Electronics*, July, 1935, p. 221.)

3748. Watch Ticks analysed to locate Errors [Equipment giving Printed Record].—Young and Artzt. (*Electronics*, July, 1935, pp. 220–221: *Proc. Inst. Rad. Eng.*, July, 1935, Vol. 23, No. 7, pp. 694–695.)

Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

MULTI-GRID VALVES

Application date, 21st June, 1933. No. 421476

The invention relates to what is called a "regulating cathode" valve, comprising a grid A, Fig. 1, adjacent to the cathode to regulate the density of the electron stream, a second grid B to regulate the velocity of the stream, and a third or control grid G. The various grids are so biased that, in the absence of any input to the control grid, the total current through the valve is shared between the various electrodes in such a way that the anode current AC, Fig. 1A, shows a "falling" characteristic. In addition the biasing voltages are set to the particular operating point W which corresponds to the steepest part of the curve AC. This gives maximum sensitivity to any variation of the voltage P on the input grid G.

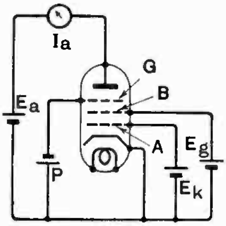


FIG. 1

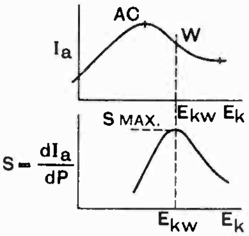


FIG. 1A

No. 421476.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

REGULATING VOLTAGE-SUPPLY

Application dates, 16th June and 4th August, 1933. No. 421546

In an arrangement for feeding electrical energy to a load which varies with frequency, the supply is stabilised by adding "mirror-image" impedances so as to give the source, and its associated circuits, a resultant resistive impedance, as viewed from the load. For instance, if the source (including the "smoothing" circuit) can be represented by a pure source of E.M.F. connected through a resistance (representing regulation) and an inductance to the output terminals, together with a condenser connected across these terminals, then the desired effect is obtained by connecting a resistance in series with the condenser of a value which is calculated in the specification in terms of the other circuit elements.

Patents issued to Electric and Musical Industries, Ltd. and A. D. Blumlein.

TUNING COILS

Application dates, 18th April and 22nd September, 1933. No. 421564

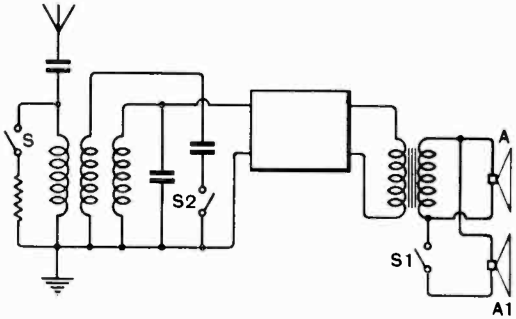
An aerial tuning coil is made of such a length as to cover the longest wavelength required by virtue of its inherent inductance and distributed capacity, i.e., without the provision of any variable condenser. Tuning is then effected by moving a sliding contact along the "standing-wave" created along the windings. The coil is wound on a former provided with longitudinal strips of metal foil. A movable core of powdered magnetic material may also be used, either as an alternative method of tuning, or for "trimming" the coil to a desired fixed frequency.

Patent issued to S. G. Brown.

WIRELESS RECEIVERS

Application date, 27th October, 1933. No. 427747

The "local-distance" switch is arranged to be operated jointly and simultaneously with a switch controlling the tone-response in the low-frequency stages of the set. The local-distance switch S is ganged to a switch $S1$ which cuts out or brings into circuit a loud-speaker $A1$ capable of responding to the full range of frequencies from the local station. A second loud-speaker A with a cut-off at about 4,000 cycles is used for distant reception.



No. 427747.

Instead of using two loud-speakers the switch $S1$ may be used to bring in a shunt condenser across the primary winding of the output transformer. A third switch $S2$ may be provided to control the selectivity of the high-frequency input circuits, and is ganged to the other two.

Patent issued to E. K. Cole, Ltd., and E. J. Wyborn.

DIRECTIONAL SYSTEMS

Application date, 29th March, 1934. No. 427674

The input circuits of a directional aerial system of the Adcock type are coupled to high-mu valves. This is stated to discriminate against unwanted signals, because if the horizontal component of an incoming wave does induce a residual voltage in the connecting wires of the aerial system, it is not subject to the same voltage-amplification as the desired signal from the vertical component of the same wave. The result is to increase the accuracy of the D.F. readings. Incidentally the sensitivity of the system as a whole is improved on the longer wavelengths.

Patent issued to R. H. L. Bevan and C. E. Horton.

GENERATING OSCILLATIONS

Convention date (Germany), 28th December, 1932.
No. 427830

The gas-filling of a discharge valve used for generating relaxation-oscillations is adjusted during manufacture to a pressure of between 0.15 and 1 millimetre. There is then little or no variation in the frequency of the oscillations over a considerable range of cathode-heating voltage. Preferably the grid carries a constant biasing voltage, and the anode voltage is limited to a maximum of 220.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.h.

AERIAL COUPLINGS

Application date, 26th August, 1933. No. 427886

A lead-in system for reducing local interference comprises a step-down transformer at the aerial end, a low-impedance transmission-line, and a step-up transformer for coupling the line to the receiver. In order to cover two wave-bands, both transformers are made aperiodic or "multi-peaked," and a wave-band switch is provided at the receiver, which either short-circuits portions of the input transformer, or else inserts one or other of a series of graded shunt-condensers across the coil as a whole.

Patent issued to Philco Radio and Television Corporation, F. R. Hornby, and G. S. Holiday.

MAGNETRON VALVES

Convention date (Germany), 21st February, 1934.
No. 427954

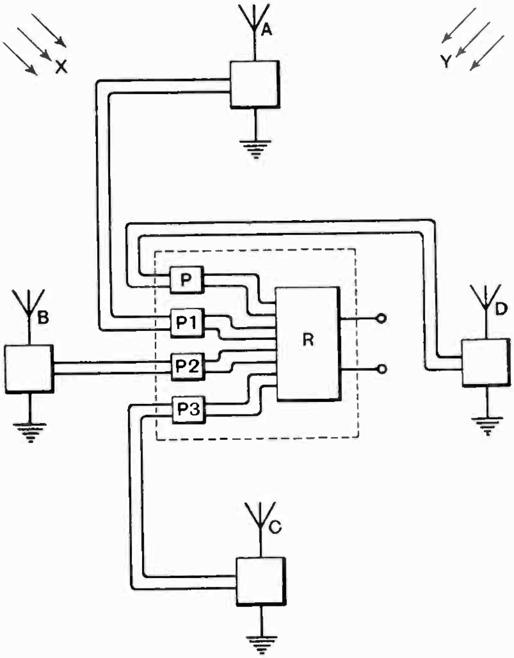
In a valve of the kind in which the main discharge stream is subjected to the influence of a magnetic control-field, the electrodes are made wholly or in part of ferro-magnetic material, and are maintained, when the valve is in operation, at a temperature above the so-called Curie point (*i.e.* 750° C. for iron and 370 for nickel). There is then no screening of the discharge-stream from the external control-field, since the normal magnetic property of the electrodes disappears at the temperature mentioned. The fact of being able to use normally magnetic materials for the electrodes simplifies the manufacture of such valves and considerably reduces their cost.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.h.

SELECTIVE RECEPTION

Application date, 7th November, 1933.
No. 428081

Relates to means for reducing interference, particularly that due to the heterodyning of unwanted carrier-waves arriving in a direction different from that of the desired signal. A series of "spaced" aerials *A . . . D* are coupled by transmission lines to a central receiver *R* through phase-adjusters *P . . . P3*, which add the desired signals and balance-out the unwanted ones.



No. 428081

Desired signals coming, say, from the direction of the arrows *X* arrive at the aerials *A* and *B* simultaneously, whilst unwanted signals, say, from the direction *Y* reach the same aerials in succession. If the distance apart is equal to half the wavelength of the undesired signals, the resulting beat-note will be in phase-opposition with the beat-note, say, from the aerial *A*. In general the heterodyne beat-notes from the different aerials will vary in phase, and can thus be combined vectorially to produce a substantially zero effect.

Patent issued to J. Robinson.

LIGHT VALVES

Convention date (Germany), 12th August, 1932, and 1st February, 1933. No. 427092

The use of a doubly-refracting crystal for controlling the passage of light to a television receiver is already known. According to the invention, in addition to the controlled crystal, there is provided in the direction of the ray a second doubly-refracting crystal, which is arranged so as to compensate for the double-refraction effect of the first. In this way the rays pass through both crystals practically undeflected. The light traverses the crystal valve in a direction at right-angles to both the optical and electrical axes, whilst the signal voltage is applied along the electrical axis. The phase-shift between the ordinary and extraordinary rays is then a maximum though no deflection of either ray occurs. The arrangement is particularly advantageous for reducing chromatic aberration in the case of white light. The second crystal also serves to compensate for temperature and other variations.

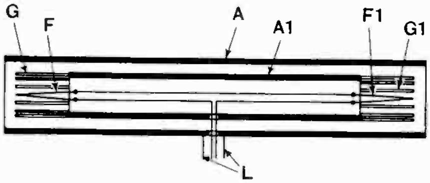
Patent issued to Radio-Akt. D. S. Loewe.

SHORT-WAVE VALVES

Convention date (Germany), 21st July, 1933. No. 428258

The electrodes of a valve for ultra-short-wave working are combined with a resonating system which serves as a transmitting or receiving aerial. The figure shows a symmetrical arrangement in which the two filaments *F*, *F*1, and associated grids *G*, *G*1, are mounted at each end of two concentric conductors *A*, *A*1. The latter form a " resonating " lecher-wire system, which serves either as a half-wave transmitting aerial, when excited to sustained oscillation ; or, when freed from damping by the electron flow, as a receiving aerial.

The radiated waves are polarised in the direction of the axis of the cylinder. The end portions of the outer conductor *A* form the anodes of the two valves, the energising leads *L* being connected at voltage-nodes on the resonator. The valve-aerials may be arranged at the focal point of a parabolic set of reflectors in order to enhance the directive effect.



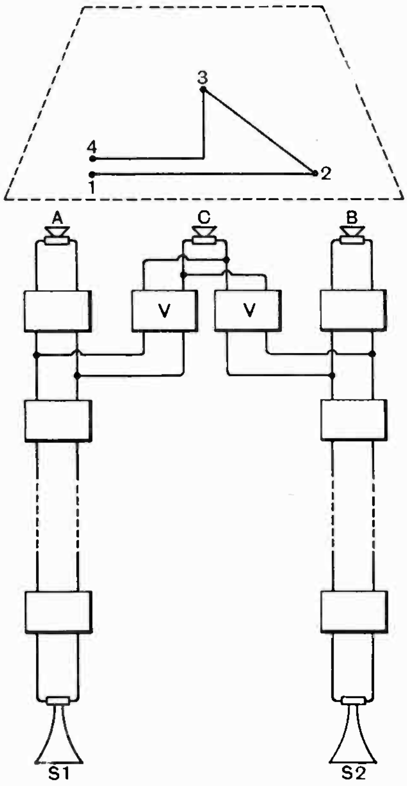
No. 428258

Patent issued to N. V. " Meaf."

STEREOPHONIC REPRODUCTION

Convention dates (U.S.A.), 21st November, 1933, and 2nd February, 1934. No. 428277

The Specification refers (*a*) to the known binaural system in which two pick-up microphones are spaced the same distance apart as a listener's ears, and are connected through separate transmission lines to a pair of similarly separated speakers, so as to preserve the phase-difference required to reproduce the stereophonic effect, and (*b*) to the Rosenberg system in which the pick-up microphones are positioned at each of the front corners of the stage, say, at *A* and *B* in the figure, and are connected through separate lines to speakers *S*1, *S*2 similarly positioned near a stage on which the combined sight and sound programme is to be reproduced.



No. 428277

The Rosenberg system depends for the stereophonic effect upon differences in intensity, rather than upon differences in phase, and is subject to the defect known as " bowing "—*i.e.*, the movement of an artist directly across the stage from left to right produces the same effect on the distant audience as if he had moved in a deep arc.

In order to overcome this drawback a third microphone *C* is placed between the first two, and is connected not to a third independent transmission line but to the existing lines through a bridge circuit containing one-way amplifiers *V*. With this arrangement the movements of an artist along the path from 1 to 4 are accurately followed, so far as the sound effect is concerned, by an audience viewing the stage fitted with the loud-speakers *S*1, *S*2.

Patent issued to Electrical Research Products, Inc.

VALVE CONSTRUCTION

Convention date (Germany), 17*th May*, 1933.
No. 428165

In known constructions of valves it is possible for electrons to leave the main discharge stream and to set up space-charges either on the glass wall or on the insulated parts of the electrode system. Here they are in an unstable condition, and so are liable to make sudden changes which, particularly in the first stages of a chain of amplifiers, give rise to crackles and similar forms of tube " noise." Sometimes a periodic " swinging " of such stray electrons will take place, similar to that which occurs in a Barkhausen-Kurz oscillator. Also there is a noticeable tendency for the " unstable " electrons to respond to any disturbing fields which may exist outside the tube.

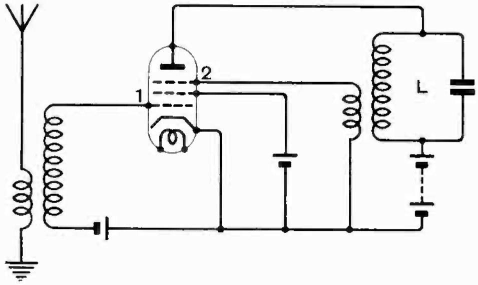
In order to avoid these effects, wire-gauze screens are mounted over each of the open ends of the anode. The screens are of such size as to prevent any stray electrons from emerging into the open space between the electrode-system and the glass walls of the valve. The screens are kept at a fixed potential, preferably that of the cathode.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.h.

RECEIVING CIRCUITS

Convention date (Germany), 10*th October*, 1932.
No. 428285

Two amplifying stages are used in parallel, one having a positive and the other a negative internal resistance, and measures are taken to prevent variation in the selectivity of the associated tuned circuits as the degree of overall amplification is changed. The figure shows a " double " valve in which the pitch or winding of the two grids 1, 2 is so adjusted that the left-hand side of the valve has a positive, and the right-hand side a negative resistance. Otherwise the grids are of the same length as the common cathode and carry the same biasing voltages, so that the valve is easy to assemble.



No. 428285

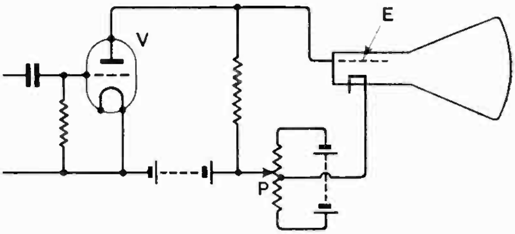
Since the left-hand discharge-path has the effective high internal resistance of a standard screen-grid valve, it serves substantially to reduce any damping of the load circuit *L* by the right-hand discharge-path, as the overall amplification is pushed up by increasing the back-coupling. The invention is also described as applied to " double-path " valves of the pentode and hexode type.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.h.

TELEVISION SYSTEMS

Application date, 13*th April*, 1933. *No.* 422906

Since the absolute level of illumination of the received picture has a definite significance to the eye, it is necessary to reproduce in the final picture all changes in brightness of the original scene, however slowly these changes may occur, *i.e.*, even if they involve frequencies too slow to be handled directly by the amplifier valves.



No. 422906

According to the invention, frequencies of this order are reinserted by special control impulses, which are superposed on the synchronizing signals, preferably in the " blacker than black " direction. The signals are derived at the transmitter from the combined outputs of the photo-electric cells generating the picture signals and synchronizing impulses respectively.

At the receiving end the tapping of the potentiometer *P* is adjusted so that in the absence of a picture signal, when the synchronizing pulses have reduced the grid potential of the valve *V* to a steady value at which grid current just flows, the potential on the control electrode *E* of the cathode ray tube has a value corresponding to " black." Thereafter the incoming signals will make this electrode more positive by amounts which are truly representative of the actual brightness of the scene being televised.

Patent issued to Electric and Musical Industries and P. W. Willans.

ELECTROSTATIC LOUD SPEAKERS

Application date, 3*rd November*, 1933. *No.* 422299

In theory the efficiency of this type of speaker can be improved by increasing the fixed polarizing-voltage, but in practice a limit is set by the resulting tendency to spark across the dielectric. Also a high polarizing voltage is liable to deform the plates.

According to the invention the usual layer of air between the plates is replaced by a fluid whose pressure and specific inductive capacity are both greater than that of air under atmospheric pressure. This allows the polarizing voltage to be increased without any danger of sparking. The internal pressure also opposes any tendency to deformation.

Patent issued to The General Electric Co., Ltd., and D. A. Oliver.

FILMS FOR TELEVISION

Convention date (Germany), 15th November, 1932.
No. 428227

When transmitting a television programme by the so-called "intermediate" or film method, practical difficulties arise in handling a film-strip longer than, say, 600 metres, which sets a time-limit of roughly 20 minutes to any particular item. It has already been proposed to employ a film in which the same light-sensitive layer can be used repeatedly, but, according to the specification, no such film is known in the photographic art.

It is now intended to use a continuous band of celluloid strip, on to which a second light-sensitive layer is automatically deposited as soon as the original layer is exhausted. The film strip is first covered with emulsion by passing it under a slotted funnel in known manner, and is then dried and passed through the camera. The image is developed and fixed, and the film strip presented to the scanning device. Subsequently the same strip is passed between revolving brushes, which strip off the emulsion. It is then put through a drying-chamber, preparatory to being again covered with a new layer of sensitised emulsion, and so on indefinitely.

Patent issued to Fernseh A.G.

CATHODE-RAY TUBES

Convention dates (Germany), 27th June and 12th August, 1932. No. 423427

The line and picture scanning voltages are applied to the deflecting plates of a cathode-ray television-receiver in phase-opposition, so that, as one plate of one pair rises in voltage, the other plate of the same pair falls. For instance, as shown in the figure, the output from a saw-toothed oscillation-generator *O* is applied in push-pull across the electrodes *H*. A similar arrangement is used for feeding the second pair of scanning electrodes *V*, a mid-point tapping on the resistance *R* being connected to a point of fixed potential.

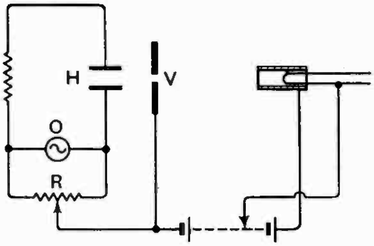


FIG. 1

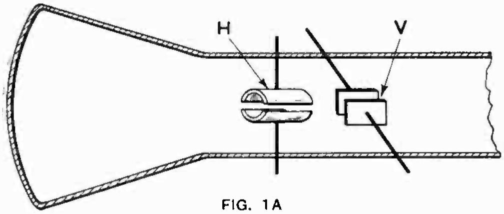


FIG. 1A

No. 423427

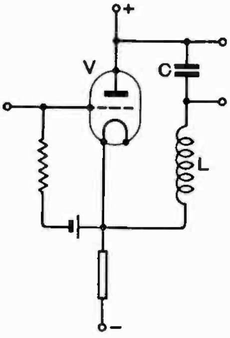
The arrangement is stated to eliminate irregularities due to the interaction of the scanning and signal voltages on closely adjacent electrodes. The plates of the horizontal scanning-electrodes are made curved instead of straight, as shown in Fig. 1*a*, so as to offset the tendency of the "raster" to develop a concave upper edge.

Patent issued to Radio Akt. D. S. Loewe and K. Schlesinger.

SCANNING CIRCUITS

Application date, 8th November, 1933. No. 423963

An inductance *L* is included in series with the condenser *C* across the anode and cathode of a gas-filled tube *V* used for producing saw-toothed oscillations, or time-base control voltages, to be applied to a cathode ray tube.



No. 423963

The purpose of the inductance *L* is twofold. In the first place it increases the output voltage-swing for the same D.C. supply, owing to the effect of the residual voltage across it at the end of the first half-cycle of discharge. In the second place the magnetic field of the coil can be used to deflect the cathode ray during the "flyback" traverse, so that the spot of light is thrown off the fluorescent screen instead of returning across the area of the picture.

Patent issued to General Electric Co., Ltd., and C. R. Dunham.

REDIFFUSION SYSTEMS

Application date, 11th December, 1933. No. 423274

When distributing broadcast programmes by "wired wireless" it is necessary to know at the supervising station the number of subscribers who are on the line at any given moment, so that the local amplifier may be properly matched to the load. The required information is obtained, according to the invention, by superposing on the supply lines a direct current, over and above the signal current. The reading of a series ammeter is then taken as a measure of the total line-resistance and therefore of the number of loudspeakers in circuit. A variable resistance, shunted across the supply at the control station, enables the operator to adjust the total load as required for optimum efficiency.

Patent issued to British Thomson-Houston Co., Ltd.; G. S. C. Lucas; and E. S. Hall.

SCREENING COMPONENTS

Application date, 21st August, 1934. No. 422455

The grid condenser and leak resistance used with a detector valve are made as a single unit. The condenser consists of a hollow tube of ceramic material coated on both sides with a layer of metal. The resistance is housed inside the condenser tube, so that it is completely screened from local fields of disturbance.

Patent issued to E. K. Cole, Ltd.