THE
WIRELESS ENGINEER

NUMBER 149 VOLUME XIII FEBRUARY 1936

A JOURNAL OF
RADIO RESEARCH
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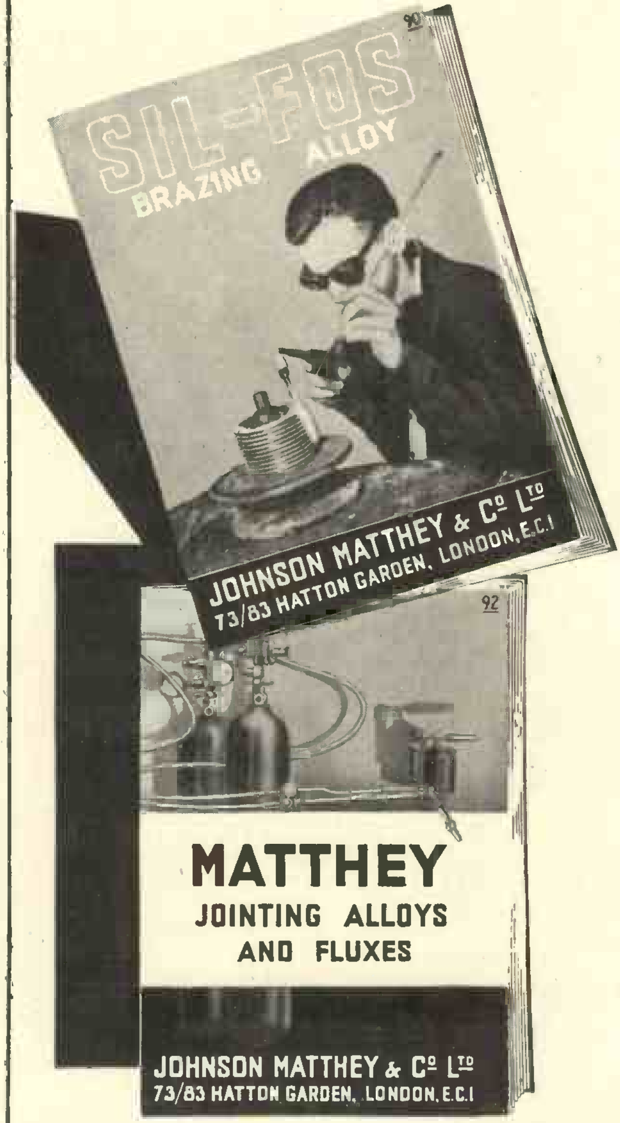
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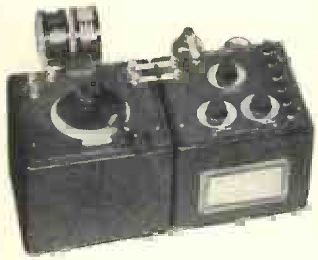

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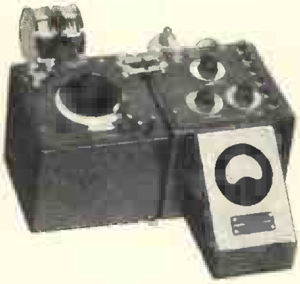

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VOL. XIII. No. 149

FEBRUARY 1936

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Published Monthly on the first of each Month
SUBSCRIPTIONS Home and Abroad: One Year, 32/-, 6 Months, 16/-. Single Copies, 2/8 post free

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THE
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Vol. XIII. FEBRUARY, 1936 No. 149

Editorial

Radiation Resistance of Aerials

AN interesting paper on this subject, with special reference to aerials, the length of which is comparable with the wave-length, was read before the Wireless Section of the Institution of Electrical Engineers by Mr. E. B. Moullin on January 8th. Much attention has recently been paid to the design of aerials intended to give a strong ground or horizontal wave with a minimum of radiation in other directions, not only in order to obtain the best results in their own service area with the smallest expenditure of power, but also to lessen interference with distant stations working on neighbouring frequencies. The most important factor in this problem is the relation between the height of the aerial and the wave-length. If the height is equal to a quarter wave-length, the effects of all parts of the aerial are in phase and simply additive in the horizontal plane; in other directions this is not so, but the phase difference even in the vertical direction only reaches 180 degrees for the extreme points of the aerial and its image where the current is zero; for the lower parts of the aerial where the current is considerable the phase difference is much less, and it must be remembered that the resultant of two forces at 90 degrees is over 70 per cent. of their arithmetical sum; hence a large amount of the radiated power is lost to the service area of the transmitter. If the height is increased to a half the wave-length the effects of all parts are still additive in the horizontal plane, but the upwardly directed radiation is greatly reduced, since every element of the aerial has a corresponding element half a wave-length away in the image carrying the same current, and therefore causing complete neutralisation in directions approaching the vertical. According to the calculations given in the paper, the best result is obtained by going a little farther and making the height of the aerial about five-eighths of the wave-length. This will cause a slight decrease of field in the horizontal which is, however, more than compensated for by the decrease of upward radiation.

Mr. Moullin does not follow the usual method of calculating the power crossing a spherical surface with the aerial at its centre, but he confines his calculations to the aerial itself by determing the back electric force against which the current is flowing at every point along the aerial. The resultant of all the electric forces acting at any point of a wire must be equal to the product of the current and the resistance per unit length, and if this latter is assumed negligible the resultant must be zero. Electric forces are induced both magnetically due to the variation of current in the aerial and electrically due to the charges on the aerial. These electric forces are retarded in phase by an amount corresponding to the time taken for the effects to travel from the various parts of the aerial to the point under consideration. It is easy to see that the effect of this retardation in the case of the magnetically induced electric force is to shift it from a purely quadrature force to one having a component in opposition to the current, whereas in the case of the electrostatically induced force the effect is to shift it from a purely quadrature force to one having a component in the direction of the current. The excess of the former component over the latter is the resultant back electric force at the point due to the radiation of power. The function of the generator is to produce at every point an electric force equal and opposite to this back force in addition to the force necessary to overcome the resistance of the wire with which we are not now concerned. To do this the generator must superpose upon the distribution of current and charges already considered another distribution of current and charges having such a magnitude and phase that they produce this electric force.

As the back electric force is calculated at every point for the assumed sinusoidal current one is able to allocate a definite radiation resistance to each centimetre of the wire. Mr. Moullin replaces the integrals by series and neglects all but the first few terms: he defends this procedure on the grounds of physical interest as well as practical utility.

The results recorded agree with those obtained by other workers, notably by Ballantine, but the methods employed open up new lines of attack on such problems and are especially valuable in that they give new physical pictures of the process of radiation from an aerial.

A section of the paper is devoted to "aerials with folded roofs." Mr. Moullin says that this folding "might be done by coiling the roof into a flat spiral centred on the top of the up lead, an arrangement which would be reminiscent of the Franklin phasing coils used in beam arrays." This idea is celebrating its jubilee, for to an older generation of radio engineers it will be much more reminiscent of the Bethenod-Girardeau "Antenne Spirale" of 1911, the patent claim for which was for "an antenna in which the conducting wire or wires consists of two parts, that is to say, of one part which forms the active (wave-radiating) part, and of a generally horizontal part which radiates little or no waves and which serves for increasing the wave-length, characterised by the fact that this latter part is coiled and is constructed as a flat sensibly horizontal spiral, presenting angles or affecting a more or less rounded form." The object of the Société Française Radioélectrique was to obtain an aerial with a low natural frequency for use with the radio-frequency alternators which they were then employing, and to do this with masts of a reasonable height. A station at Brussels was equipped with an aerial of this type. As Mr. Moullin says, "a given length of wire disposed in an up-lead and folded roof is never as economical of power as the same total length of wire disposed vertically, but in general a mast of given height can be used more economically if fitted with a suitable folded roof." This was the *raison d'être* of the French invention. G. W. O. H.

An Appreciation

Comment from America

IN the November issue of the *Review of Scientific Instruments*, published by the American Institute of Physics, there appeared an article entitled "A Study of Scientific Periodicals." This paper was released for publication by the Navy Department, on whose instructions it was presumably compiled. The importance of periodicals covering various scientific fields was compared in terms of the frequency of references to original articles in them in other periodicals in their class.

In the section devoted to radio periodicals of the world *The Wireless Engineer* was placed third on the list. In addition, it was stated in the article that the valuable abstracts in *The Wireless Engineer* would alone make this journal indispensable for radio research.

Oscillograph Amplifiers for Very Wide Frequency Ranges*

By Manfred von Ardenne

IN an article in the *Elektrotechnische Zeitschrift* for 31st October, 1935, the writer pointed out the importance of amplifiers for increasing the sensitivity of cathode-ray oscillographs, discussed the special requirements of such amplifiers, and briefly described arrangements which fulfil these requirements. In the following paper these requirements will again be set out shortly, and then a more extensive account of the design, construction and properties of the special amplifier will be given.

Properties for a Cathode Ray Amplifier

Oscillogram distortions may arise from variations of amplification with frequency, from phase shifts, and from non-linear amplitude response. If an amplifier possesses the same amplification at all the frequencies contained as components in the oscillogram, the only distortions are those due to amplitude-dependence. The most dangerous stages are the final and penultimate stages. These two must be so designed that alternating output voltages of some 100 volts amplitude, necessary for the control of modern cathode-ray tubes, can be delivered

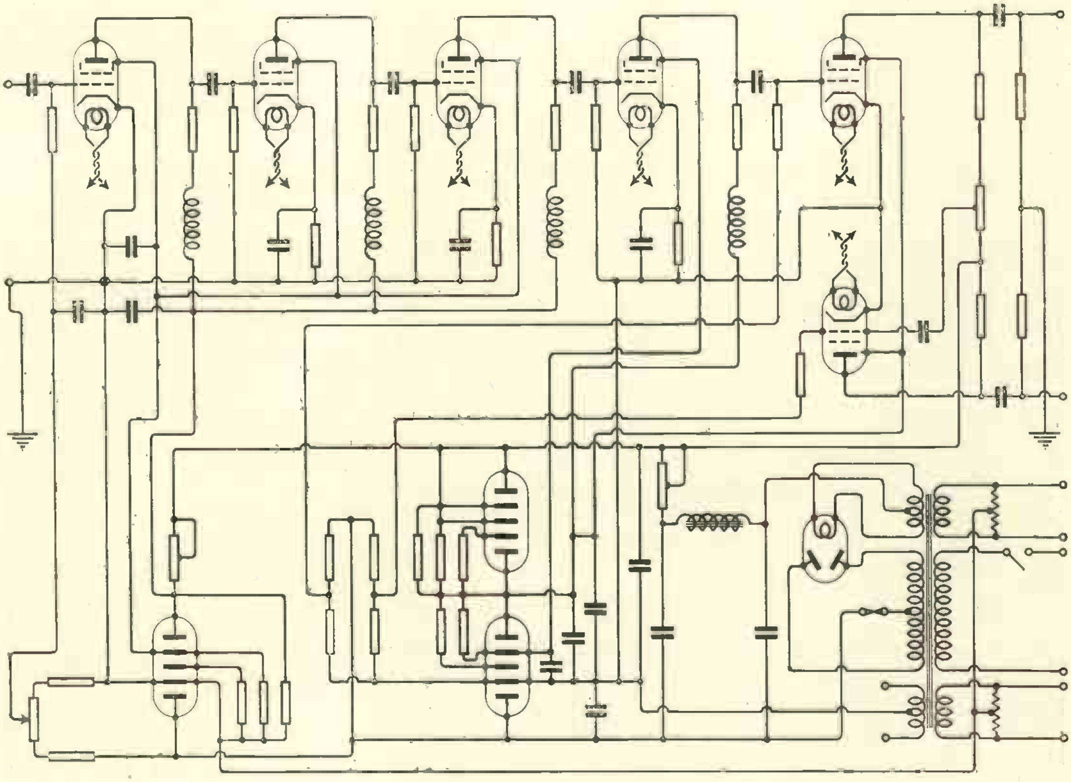

Fig. 1.—*Circuit diagram of the oscillograph amplifier.*

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

without distortion. Finally, in view of the deflection conditions in high-vacuum tubes, a push-pull output stage is desirable.

Typical Circuit of the Amplifier

The characteristic circuit of such an amplifier is shown schematically in Fig. 1. Six screen-grid valves of steep slope take part in the amplification. The large amount of energy for the supply of the five valve stages is provided by a mains unit having double voltage-stabilisation by glow-discharge stabilisers. Sensitivity control is accomplished by adjusting the working point on the characteristic of the variable-mu valve in the first stage. This method of control gives, in the very wide frequency range amplifier described below, an over-all sensitivity regulation of 20 : 1, without the appearance of distortions in the oscillograms due to over-modulation of the regulating stage. The push-pull connection of the output stage, shown in the diagram, is adopted not merely to give symmetrical deflecting potentials but also because it provides a simple method of doubling the possible undistorted output-potential amplitude. This doubling is of great importance in practice, since in view of the very high frequencies used only small anode resistances, giving comparatively small a.c. potential drops, are permissible even with cathode-ray tubes with low-capacity deflecting systems.

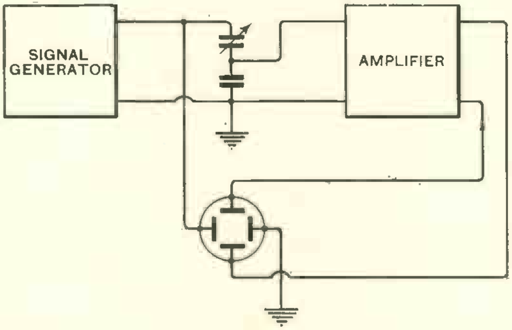

Fig. 2.—*Circuit for the measurement of phase shift in the amplifier at high frequencies.*

Very High Frequencies

In connection with the development of television amplifiers, a great deal has been published by a large number of workers, including the present writer, on the design and calculation of suitable stages. In the present paper, therefore, it is only necessary to refer to a few salient points. The requirement, even at high frequencies, of true-

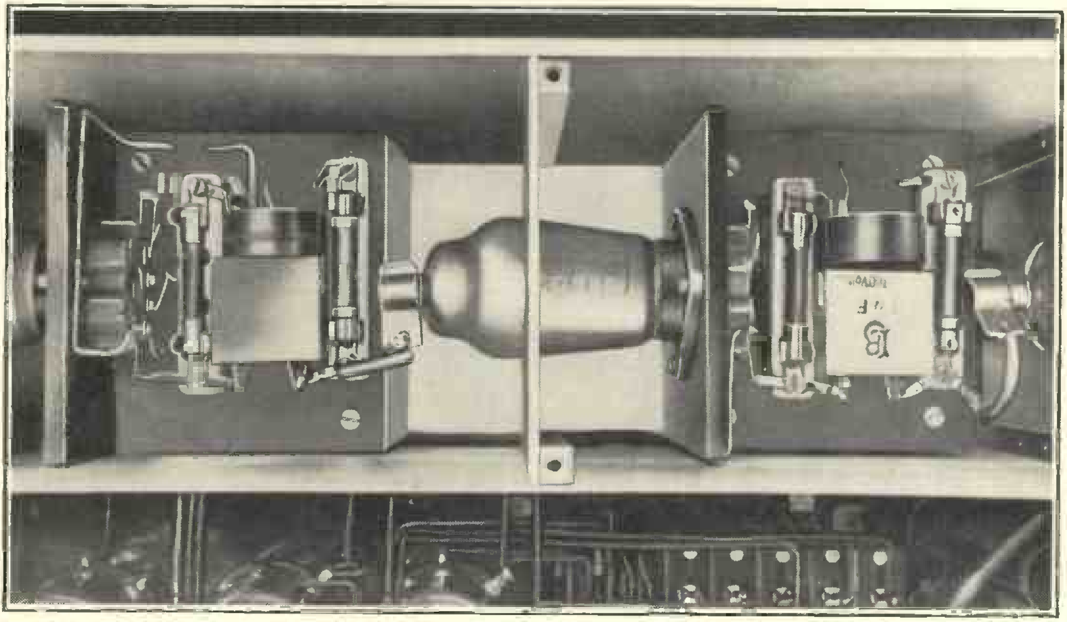

Fig. 3.—*The low-capacity design of the individual stages.*

to-phase working of the amplifier (checked by the measuring circuit shown in Fig. 2) demands a specially careful working out of the individual stages.

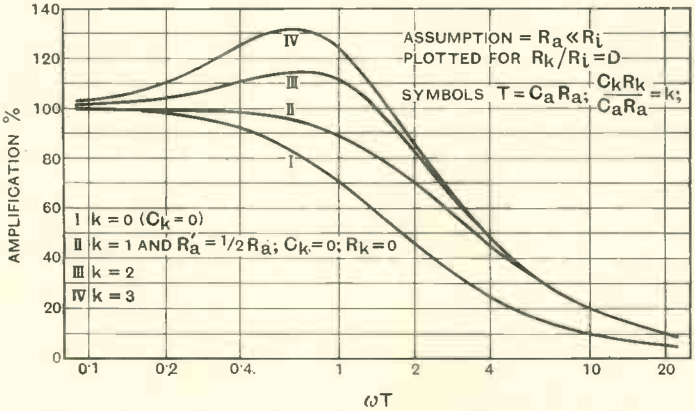

Fig. 4.—*Curves relating to the correction at high frequencies, by capacitive bridging of the cathode resistances.*

One of the most important points is to arrange the lay-out in such a way that the stray capacity is not unduly increased by connections and couplings between the stages. This is accomplished in the stage construction shown in Fig. 3, where—in spite of careful screening between stages, and comparatively large coupling capacities—the total circuit capacity amounts to only 10 $\mu\mu$F compared with the pure valve capacity (for the type of valve chosen) of 17.5 $\mu\mu$F. The total unwanted capacity, therefore, for the stage shown is 27.5 $\mu\mu$F. This low value makes it possible to obtain, with the normal steepness of slope of the modern type of valve shown, and with the aid of simple correcting methods, an almost uniform amplification up to the frequency 3.5×10^6 c/s, without the amplification per stage becoming unreasonably small.

The correcting process is accomplished partly by the small chokes visible in Fig. 3, partly by capacitive bridging of the cathode resistances. Since the latter method provides a particularly convenient, regulable correction, some calculated curves are shown in Fig. 4 which indicate that the region of uniform amplification can be extended a full frequency octave by means of correction. Curve I shows the fall in amplification when there is no capacitive bridging of the cathode resistance. Curve II represents the course of the curve when the time-constant of the cathode-resistance R_k—bridging-capacity C_k combination is made equal to the time-constant in the anode circuit. The remaining curves, representing over-compensation, are given when the cathode-circuit time-constant is made 2 or 3 times as great as that of the anode circuit. It is interesting to note that curve II is also given when no cathode resistance at all is provided and the value of the anode resistance halved. The amplification in this case remains the same, but the working conditions are less favourable, since the inclination to relaxation oscillations, and also the anode-current consumption, are both increased.

The simultaneous use of correction by chokes and by bridging the cathode resistances considerably complicates a theoretical treatment. The effect actually obtained by correction by cathode-resistance shunting and by chokes is shown in the experimental curves of Fig. 5. The cathode-circuit correction is an excellent means of fine adjustment of compensation in the direction of the high frequencies.

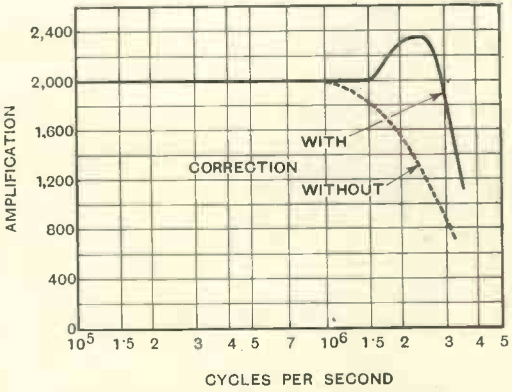

Fig. 5.—*Upper part of the amplification curve with and without correction by capacitive bridging of the cathode resistances.*

Very Low Frequencies

Amplifiers with galvanic coupling between the valves—direct-current amplifiers—are not very satisfactory in practice, especially when high amplification is required, because very small, hardly avoidable displacements of the working point in the first stage lead to serious working-point displacements, or even to a blocking, in the output stage. Since these working-point shifts in the first stage occur as the result of slow fluctuations of the sources of current, or of slow variations in the properties of the valves, they are not in evidence in those amplifiers which do not amplify very slow changes (period of more than one minute, for instance). It is to-day fundamentally possible so to design the coupling links in a.c. amplifiers that frequencies of as much as one minute period can be transmitted. Practical experience with such amplifiers shows, however, that it is not advisable to go quite so far, for several reasons :—

(1) The delay occurring before the amplifier gets into action again after switching-on, after the occurrence of over-modulation while in service, or after an adjustment of the amplification control, takes on seriously high values such as 10 minutes, so that work with such an amplifier involves much waste of time. In order to obtain a lower frequency limit as low as possible with as short as possible a building-up time, the time constants of the coupling links in the various stages must agree with one another. In the units described below the resulting building-up time is of the order of one minute.

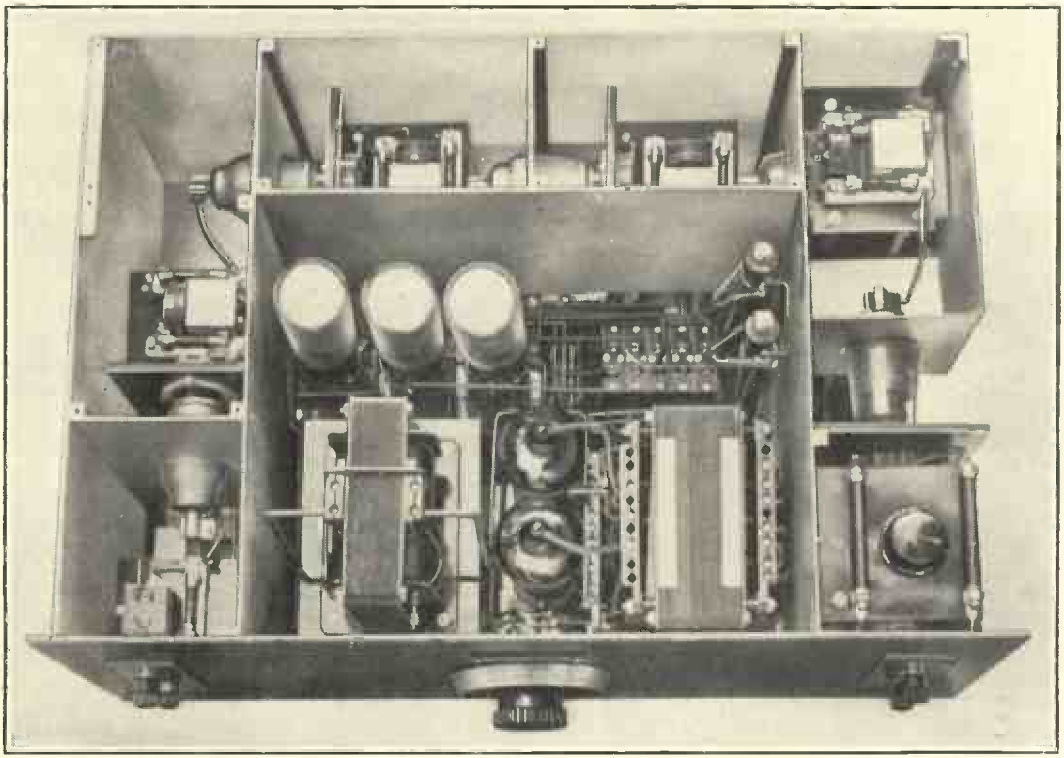

Fig. 6.—*Interior view of the amplifier made by the Leybold and von Ardenne Oscillograph Company, Cologne, for the range* 0.2 *c/s to* 3×10^6 *c/s.*

(2) For the sake of the required shape of the amplification curve at the higher frequencies it is necessary to work the valves —particularly those of the final stage—to their full extent ; that is, to load them heavily. With very slow oscillations the thermal inertia of the valve electrodes, especially of the grids, is not sufficient to maintain a mean temperature value through-

out the whole period. As a result, during those half-periods when the grids are only slightly negative the electrodes begin to glow, while during the other half-periods, a few seconds later, an unnecessarily strong cooling of the electrodes takes place.

For these two reasons the introduction of compensation in the direction of low frequencies is avoided in the units here described, and the coupling links are so designed that the amplification falls off sharply at frequencies below about 0.2 c/s. At such unusually low frequencies it is, as is well known, no longer possible to keep down the internal resistance of a common anode-current source by means of capacitive bridging, since the bridging capacities would have to be of impracticably high value. Oscillation generation through the internal resistance R_{an} of the anode-current source can only occur, on the presumption of correct phase position, if the product $S_{res} \times R_{an} > 1$. Here S_{res} stands for the resulting slope of the stage fed from the anode-current source. The problem, therefore, of building a stable amplifier for extremely low frequencies resolves itself into the subdivision of the amplifier into several groups of stages, in which each group must satisfy the condition $S_{res} \times R_{an} < 1$.

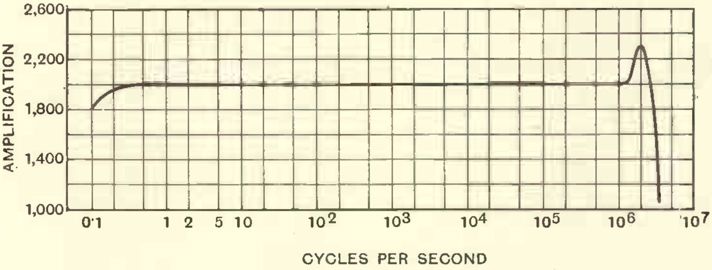

Fig. 7.—*Amplification curve of the new amplifier shown in* Fig. 6.

Such a subdivision is seen in Fig. 1 ; here four groups are shown. The first stage cannot contribute to the excitation of oscillations, since its grid is not coupled to the anode-current source. In the case of the second and third stages, which are supplied from a common glow-discharge voltage-divider, the condition mentioned is fulfilled as a consequence of the cathode resistances which reduce the steepness of slope ; for the total internal resistance of the glow-discharge voltage-divider employed is under 200 ohms. For the fourth and push-pull output stages a separate current source is provided, since they are fed from a unit of two glow-discharge tubes in series. The grid of the fourth stage can therefore be regarded as isolated from the anode-current source. The output stage by itself obviously cannot " relax." Thus the whole amplifier is rendered, by this subdivision, free from all tendency towards relaxation oscillations.

It should be specially pointed out that in no group must the product $S_{res} \times R_{an}$ be so great that any regeneration occurs. This fact is important, for if this point is neglected the amplification curve in the region of frequencies around 10^2 c/s, where R_{an} has a maximum, may take on pronounced fluctuations.

Amplifier for Frequency Range 0.2 to 3×10^6 c/s

Fig. 6 shows an interior view of an amplifier conforming in all important points with the circuit diagram of Fig. 1, discussed above. In the centre is seen the mains unit, designed for a total current consumption of over 200 milliamperes. Outside this are arranged the screen-grid-valve stages, carefully shielded from each other. The amplification curve of this unit, which is manufactured by the Leybold and von Ardenne Oscillograph Company, Cologne, is given in Fig. 7. As this shows, the amplifier gives practically uniform amplification from 0.2 c/s to 3×10^6 c/s. From about 0.5 c/s to about 10^6 c/s the phase shift in the amplifier can be neglected. This is only the case, and the curve only has the form, at the higher frequencies, shown in Fig. 7, provided a cathode-ray tube with low-capacity deflecting system (plates led out at the sides) is used, and in conjunction with the shortest possible connections. The undistorted voltage changes delivered by the output stage amount to 500 volts, and therefore are sufficient to produce adequate oscillogram depths even with such cathode-ray tubes as are driven, for the sake of high recording speeds, at anode voltages of 4 000 to 7 000 volts.

Amplifier for Frequency Range 0.2 to 2×10^4 c/s

For many applications, for example for physiological research, electro-acoustical investigations in conjunction with condenser microphones, and other measurements of purely low-frequency processes, the high upper frequency limit of the amplifier just described is not necessary, while on the other hand a higher degree of amplification is required. For these purposes the writer has developed another amplifier of considerably simpler construction, an interior view of which is shown in Fig. 8. This amplifier, as the measured curve of Fig. 9 shows, has a uniform amplification between 0.2 c/s and 2×10^4 c/s. The phase shift in the amplifier can be neglected in the range 0.5 c/s to 10^4 c/s. In spite of the high voltage amplification of 10^5, and in spite of being fully mains-driven, it has been possible—by special care in designing and arranging the first stage—to keep the hum component so low that it causes no trouble in the oscillograms. This model is so arranged that a condenser microphone may be connected straight to the input ; the auxiliary voltage then required is taken from a special terminal. The maximum undistorted voltage change delivered by this model is 700 volts.

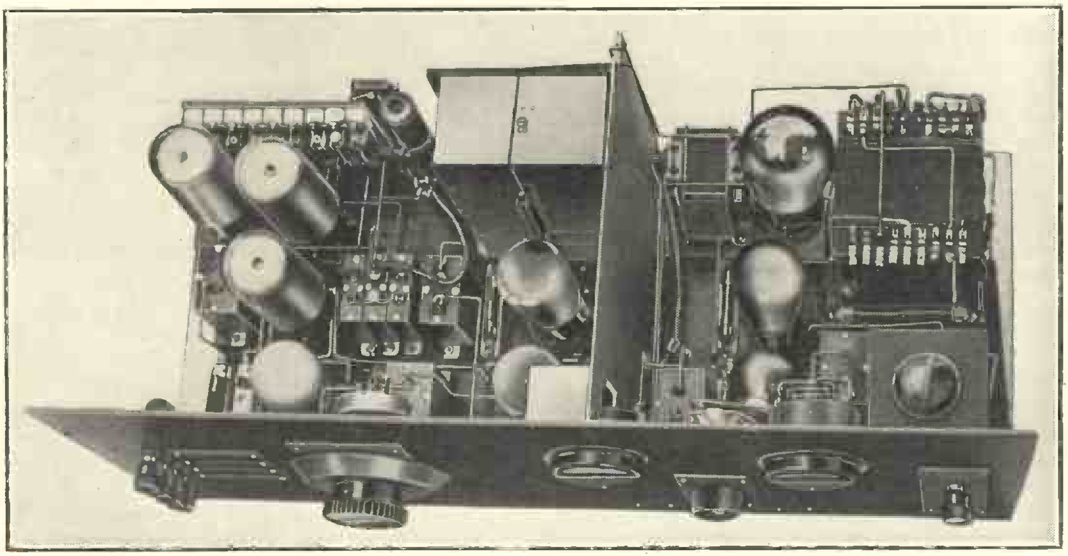

Fig. 8.—*The special model giving a voltage-amplification of 10^5 in the frequency range 0.2 c/s to 2×10^4 c/s.*

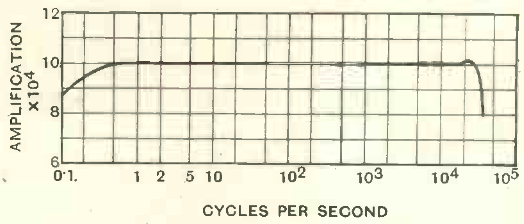

Fig. 9.—*Amplification curve of the special model shown in* Fig. 8.

The high amplification and wide frequency range of the new amplifiers here described should bring them wide application in the field of oscillographic measuring technique.

The Industry

ONE of the most interesting of the Mullard cathode ray tubes introduced for television is the Type 6001, with a heater rated at 4 volts, 1 amp. The diameter is 22 cms., overall length is 49 cms., and the screen is of a green-yellow colour. This tube is of the three-anode type, rated for a third-anode potential of 6,000 volts, but the normal operating conditions are 5,000 volts for the third, 1,000 volts for the second, and 400 volts for the first anode. The deflection sensitivity is given as 0.11 mm/V for the P1, and 0.08 mm/V for the P2 plates.

The Osram high-voltage low-current rectifier, Type U16, has been introduced primarily for use in conjunction with cathode ray tubes for television. Anode voltage is 5,000 volts R.M.S. and rectified output is 2mA. In view of the high voltage, the anode connection is led out to a top cap.

Voltage Measurement at Very High Frequencies—I.*

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SUMMARY.—The arrangement in which a condenser, in series with a diode, is charged to the peak voltage is selected as the best suited to accurate measurements at frequencies of 10^7 or higher. After a brief summary of previous work the factors deciding the best value for the condenser are stated and the conditions for negligible leakage error are determined. The errors peculiar to high frequency working, resulting from the finite inter-electrode capacitance of the diode and the finite inertia of the electrons, are then discussed. Expressions for the former are given for two simple special cases with some suggestions for minimising errors of this type. Finally the error due to electron inertia is worked out with certain simplifying assumptions and the probable effect of these assumptions is indicated.

The results given in the paper indicate that accurate measurement of voltages of about 10V. or higher should be possible at frequencies up to about 100 megacycles (3 metres wavelength) without high frequency calibration, and that a useful estimate can be made of similar voltages at frequencies up to about 1,000 megacycles (30 cm.).

An experimental investigation of this type of voltmeter will be dealt with in a further paper.

I. Introduction

A CONSIDERATION of the possible methods of measuring alternating voltages indicates that only two types of measuring apparatus, the electrometer and the thermionic rectifier, are likely to be suitable for frequencies of the order of 10^7 or higher. Other methods such as cathode ray deflection[1]† and the Kerr cell[2] have also been used but are much less convenient. While electrometer methods have the advantage of simplicity and are probably capable of further development for this purpose, they are usually less satisfactory than thermionic methods in practice except for rather high voltages. Accordingly when the need for a reliable voltmeter arose during an investigation of the behaviour of short wave oscillators carried out in the Laboratories of the City and Guilds (Engineering) College during 1928–1930 the familiar arrangement shown in Fig. 1 (a) was adopted as the most promising. This arrangement was considered preferable to any of the well-known triode circuits‡ on account of the importance of making the input impedance as high as possible. When the same need arose recently for still shorter wavelengths, in the course of the author's work in the Research Laboratories of the General Electric Co., Ltd., this type of voltmeter was subjected to a further study. The combined results of both investigations are presented here.

In the arrangement of Fig. 1 (a) the condenser C is charged up by rectified current passing through the diode D. Ideally, in the equilibrium condition, the condenser voltage read by the voltmeter V is equal to the peak value of the applied voltage and no current flows through the valve. Since the voltages encountered in high frequency technique are usually very nearly sinusoidal, it is clear that a measurement of the peak value is sufficient. When V is an electrostatic voltmeter the ideal condition can be approached very closely in practice, at least for low frequencies. For low voltages V is often replaced by the potentiometer arrangement shown in Fig. 1 (b), giving the

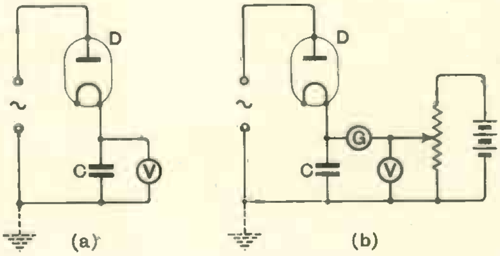

Fig. 1.—*Peak Voltmeter circuits.*

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

† Numerals refer to the bibliography at the end of the paper.

‡ See, for example, Moullin *Journ. I.E.E.* 61, 315, 1923 and 66, 886, 1928.

so-called "slide-back" circuit; and a high resistance moving coil voltmeter is also sometimes used. In both these cases more care in selecting the circuit components is necessary if accuracy is to be achieved without calibration.

This type of peak voltmeter was described as long ago as 1916 by Sharpe and Doyle[3] and the conditions for accuracy at low frequencies have been discussed by Paterson and Campbell[4] and, more recently, by Davis, Bowdler and Standring.[5] Its use for radio frequencies was described by Bartlett[6] more than 10 years ago and since then it has found considerable application in this field. A similar arrangement, actually the circuit of Fig. 1 (b) without the condenser C, was used by Gill and Donaldson[7] for measurements on gas discharges at very high frequencies. The omission of the condenser is unimportant in this circuit at low frequencies, but, as Penning[8] has pointed out, it may lead to appreciable errors at high frequencies. Penning's paper, also concerned with gas discharges, describes what was probably the first serious attempt to obtain accurate readings from this type of voltmeter at very high frequencies. His analysis of the error due to electron inertia, of which the author was unaware during his own work, is similar to the first part of the discussion of this effect given here, but is applicable only to the graphical solution of particular cases. It is satisfactory, therefore, to find, in spite of two mistakes in Penning's equation (1), which may well be printer's errors, that the results for the particular cases quoted by him are in substantial agreement with the results given in this paper. Rohde[9] has also discussed the electron inertia error in a recent paper, but his estimates of its magnitude appear to be very much too small. He draws attention to the errors which may arise from the impedance of any connecting leads between the voltmeter and the point at which the voltage is to be measured. This type of error was also investigated by the author in his earlier work.

II. General Considerations

There is always a finite resistance in parallel with the condenser C (Fig. 1) even if it is merely the leakage resistance of the condenser itself and of an electrostatic voltmeter. In the latter case the value of the resistance can be determined from the rate of discharge of the system since

$$R = \frac{t_2 - t_1}{C \log_e \dfrac{v_1}{v_2}}$$

if the voltage falls from v_1 at time t_1 to v_2 at t_2.

One of the fundamental conditions[4] for accuracy is that the condenser voltage shall not fall appreciably during a cycle of the applied voltage. For a voltage drop of 0.1 per cent. per cycle

$$C = 10^{15}/fR \ \mu\mu\text{F}.$$

(f in cycles per second, R in ohms).

Thus, for frequencies of 10^7 or more a capacity of about 100 $\mu\mu$F. is sufficient if R is of the order of 1 megohm, a value which is practicable in the worst case, *i.e.* with a moving coil voltmeter. With an electrostatic voltmeter R may be more than 10^{10} ohms. If R is very high the slow response of the instrument to a fall in applied voltage becomes a nuisance for most purposes. This can readily be overcome if a key is provided to switch a lower resistance across the condenser just before each reading is taken. A 10 megohm resistance reduces the lag to a negligible quantity, of the order of a millisecond when C is about 100 $\mu\mu$F.

Since it is an advantage to be able to use a diode with small electron emission, giving long life with small dimensions, C should not be made unnecessarily large in order to keep the charging time down to a negligible figure. The charging time is of the order of

$$10^{-8}\, C\hat{v}/I_e \text{ secs.}$$

(C in $\mu\mu$F., $\hat{v}$ = applied peak voltage,
I_e = diode emission in mA)

for moderately high voltages and negligible leakage. Thus if the emission is of the order of a milliampere the charging time is always negligible at ordinary voltages provided C is not more than about 1,000 $\mu\mu$F.

III. Leakage Error

A finite value of R must lead to a finite (negative) error even if the time constant CR is large compared with the oscillation period. This error can be determined by equating the charge lost by leakage to the charge passing through the diode, both per cycle. Davis, Bowdler and Standring[5] have shown how to compute the leakage error graphically when the diode characteristic is known. While this is probably the only method of calculating the magnitude of the error accurately it appeared that an approximate general solution would be of value if only to indicate under what conditions the error could safely be neglected.

If the applied voltage is represented by $\hat{v}\cos\omega t$ (Fig. 2) and the equilibrium value of the condenser voltage is $k\hat{v}$ the voltage across the diode is

$$v = \hat{v}(\cos\omega t - k)$$

If k is nearly 1

$$v \doteqdot \hat{v}(1-k)\left\{1-\left(\frac{t}{t_1}\right)^2\right\}$$

during the conduction period $2t_1$ since $\cos\omega t_1 = k$.

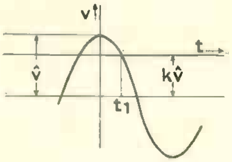

Fig. 2.

The charge received by the condenser per cycle is

$$2\int_0^{t_1} i\,.\,dt.$$

For the diode characteristic we can write

$$i = av^n$$

as an approximation over a small range of v.

Expanding i by Maclaurin's theorem, neglecting derivatives higher than the third, and integrating, we obtain for the charge received

$$2at_1\{\hat{v}(1-k)\}^n \times \left\{1-\frac{n}{3}+\frac{n(n-1)}{10}-\frac{n(n-1)(n-2)}{42}\right\}$$

$$= 2at_1\{\hat{v}(1-k)\}^n\,.\,F(n),\text{ say.}$$

With the same accuracy as before we have

$$t_1 = \frac{\sqrt{2(1-k)}}{\omega}.$$

Then equating charge lost to charge received per cycle

$$\frac{k\hat{v}}{R}\cdot\frac{2\pi}{\omega} = 2a\{\hat{v}(1-k)\}^n\,.\,\frac{\sqrt{2(1-k)}}{\omega}\,.\,F(n).$$

Hence when $k \doteqdot 1$

$$(1-k) \doteqdot \left\{\frac{\pi}{\sqrt{2}\,aR\hat{v}^{(n-1)}F(n)}\right\}^{1/(n+\frac{1}{2})} \quad \ldots \quad (1)$$

Thus the accuracy improves, in general, the higher the leakage resistance, the diode conductance and the applied voltage (since n is not ordinarily less than 1).

If the diode behaves as a unidirectional ohmic resistance ($n = 1$) the error is independent of the voltage and

$$(1-k) \doteqdot 2.2\left(\frac{R_a}{R}\right)^{2/3} \quad \ldots \quad \ldots \quad (2)$$

where $R_a = \frac{1}{a}$.

In this case the error is less than 0.1 per cent. when $R > 10^5 R_a$, or $R > 3 \times 10^3 R_a$ for less than 1 per cent. error.

If the diode characteristic is appreciably non-linear, as is usually the case, a and n in equation (1) can be found from a logarithmic plot of the characteristic. Alternatively we may use equation (2) as a rough approximation to find the lowest permissible value of R if R_a is the differential resistance of the diode at a voltage equal to half the permissible voltage error. In any case the leakage error will certainly be negligible for high frequency measurenents provided R exceeds 10^5 times the value of R_a at 1/1,000 of the voltage to be measured.

Without going into numerical examples at this stage it is clear that voltmeters other than electrostatic must not be used without some examination of their effect on the leakage error, especially for low voltages.

One further point must be mentioned before leaving the question of the leakage error. Owing to the initial velocity of the electrons and the existence in most cases of a contact potential between anode and cathode the diode characteristic is often better represented by

$$i = a(v + v_1)^n$$

for small values of v. When the applied voltage is zero the condenser will charge up to nearly v_1 which can usually be regarded with sufficient approximation as a constant positive "zero error." If, however, $\hat{v}$ is comparable with v_1 the simple power law may not represent the characteristic with sufficient accuracy and a low frequency calibration may be necessary.

IV. Impedance Errors

Impedance errors are those which arise from the finite inter-electrode capacitance of the diode. These may conveniently be considered under two headings, (1) the error which occurs when the voltmeter condenser is too small and (2) the error which occurs when the impedance of the connecting leads between the instrument and the source of voltage becomes appreciable.

The first is well known and approximates to $-100C_D/C$ per cent. This holds whatever type of voltmeter is used since the difference between the R.M.S. and mean voltages across C is small compared with the error due to C and C_D (the inter-electrode capacitance) acting as a potential divider, a fact not always recognised in previous discussions. The error will be slightly less than $-100\ C_D/C$ when an electrostatic voltmeter is used. As C_D is commonly about 1 μμF. this error can safely be neglected if C is of the order of 1,000 μμF. This value also meets the requirements discussed in Section II.

The second kind of impedance error ordinarily becomes appreciable at frequencies greater than about 10^6, while at 10^7 or more it may assume serious proportions. Of all the errors high frequency voltage measurements are liable to, this is perhaps the most intractable; for at the frequencies at which it becomes important the circuit can no longer be considered as consisting of discrete capacitances, inductances and resistances. At the highest frequencies (10^7 to 10^9) the best that can be done is to arrange the circuit so that capacity and inductance are as nearly as possible uniformly distributed in the connecting leads. At frequencies up to about 5×10^6 the circuit constants may usually be regarded as discrete with considerable accuracy. Expressions for the impedance error in these two special cases are given below, with the warning that their usefulness depends on the accuracy with which the assumptions made in deriving them are fulfilled in the actual circuits to which they are applied.

Considering the latter case first, with the assumptions that the impedance between cathode and earth (or the "earthy" side of the source of voltage) is negligible and that the connection to the anode may be regarded as a pure inductance L, the high frequency circuit reduces to L and $(C_D + C_A)$ in series, C_A being the stray capacitance of the anode. The error is then

$$100\left\{\frac{1}{1-\omega^2 L(C_D + C_A)} - 1\right\} \text{ per cent.}$$

provided resonance is not approached sufficiently closely for resistance to become comparable with reactance.

Thus, for less than 0.1 per cent. error the operating frequency must not exceed about 3 per cent. of the resonant frequency, or, for 1 per cent. error, about 10 per cent. of the resonant frequency.

In the former special case, with the assumptions that the impedance between cathode and the "earthy" side of the voltmeter condenser is negligible and that the connecting leads are equivalent to a uniform line of length l and characteristic impedance Z_0 the error is

$$100\left\{\frac{\cos(2\pi l'/\lambda)}{\cos\dfrac{2\pi(l + l')}{\lambda}} - 1\right\} \text{ per cent.}$$

where $\lambda = c/f$

and $\quad l' = \dfrac{\lambda}{2\pi}\tan^{-1}\omega Z_0(C_D + C_A),$

provided $(l + l')$ is small enough compared with the resonance value $\lambda/4$ for the line resistance to be neglected.

For less than 0.1 per cent. error

$$\frac{4\pi^2}{\lambda^2}(l^2 + ll')$$

must not exceed .001, or .01 for 1 per cent. error.

In the whole of this discussion it has been assumed that the pulsating conductance of the diode is always small enough compared with ωC_D to have a negligible effect on the high frequency circuit. This is usually true at least for frequencies greater than 10^7.

The question of the input impedance of the voltmeter may conveniently be considered at this point. The resistive component, which is made up of parts due to such things as insulator losses and conductor resistances as well as the losses in the diode and the leakage resistance, is usually negligible with proper design. If the leakage resistance R is low enough to be the only important source of loss the effective input resistance is approximately equal to $R/2$. When the resistive component and impedance errors are negligible the input impedance is simply $1/j\omega(C_D + C_A)$. C_A is ordinarily of the same order as C_D and their sum cannot be much less than 1 μμF. with diodes of ordinary construction. At frequencies of 10^7 or more it may be necessary to allow for the shunting effect of this capacitance on the source of voltage. If the leads and the electrodes are arranged to form a uniform line effectively terminated in C_D (C_A now being part of the distributed capacitance) the input impedance becomes approximately

$$\frac{Z_0}{j \tan \frac{2\pi(l + l')}{\lambda}}$$

with C_A put equal to zero in evaluating l'. With judicious choice of l and Z_0 this may give a higher impedance than $1/j\omega(C_D + C_A)$ since C_D can be reduced more easily than C_A.

V. Electron Inertia Error

At very high frequencies the voltmeter may read low by an appreciable amount owing to electrons failing to reach the anode before the electric field in the diode reverses.

If the leakage error is negligible at low frequencies the equilibrium value of k, the ratio of condenser voltage to peak voltage, will correspond closely to the maximum electron range. By the range of any electron is meant the greatest distance it travels from the cathode, measured in the direction of the nearest part of the anode. It is assumed that CR is large enough to prevent any appreciable change of k during a few cycles of the H.F. voltage.

The problem, then, is to find the relation between k and maximum electron range.

Consider an electron which is emitted from the cathode with negligible initial velocity at the moment $t = 0$, under the influence of an applied H.F. voltage $\hat{v} \sin(\omega t + \theta + \phi)$, where $\theta = \sin^{-1} k$ and ϕ/ω is the time interval between the instant at which the electric field in the diode becomes positive and $t = 0$ (Fig. 3). The potential difference across the diode is thus

$$v = \hat{v} \sin(\omega t + \theta + \phi) - \hat{v} \sin \theta.$$

If x is the distance of the electron considered from the cathode at time t and x_a is the cathode-anode distance the equation of motion is

$$\frac{d^2x}{dt^2} = \frac{e}{m} \cdot \frac{\hat{v}}{x_a} \{\sin(\omega t + \theta + \phi) - \sin \theta\} \quad .. \quad (3)$$

for a uniform electric in field the cathode-anode space.

Successive integrations yield

$$\frac{dx}{dt} = \frac{1}{\omega} \cdot \frac{e}{m} \cdot \frac{\hat{v}}{x_a} \{-\cos(\omega t + \theta + \phi) - \omega t \sin \theta + \cos(\theta + \phi)\} \quad .. \quad (4)$$

and

$$x = \frac{1}{\omega^2} \cdot \frac{e}{m} \cdot \frac{\hat{v}}{x_a} \{-\sin(\omega t + \theta + \phi) - \tfrac{1}{2} \sin \theta \, . \, (\omega t)^2 + \cos(\theta + \phi) \, . \, \omega t + \sin(\theta + \phi)\} \quad .. \quad (5)$$

Some general characteristics of the electron motion are evident from an inspection of the preceding equations. From (4) it appears that the motion consists of a steady drift, given by the second and third terms in { } brackets, which is initially towards the anode provided $(\theta + \phi) < \frac{\pi}{2}$, and upon which is superimposed an alternation of frequency $\omega/2\pi$ given by the first term. When ωt is large the motion is always away from the anode, since $0 < \theta < 2\pi$ is a physical condition of the problem. As θ decreases the rate of drift away from the anode also decreases. It is thus possible that the maximum range of an electron may not coincide with the first mathematical maximum in the path, particularly when θ is small.

For maximum and minimum values of x

$$\frac{dx}{dt} = 0.$$

Hence from (4)

$$\cos(\theta + \phi) = \cos(\omega t + \theta + \phi) + \omega t \sin \theta \, .. \quad (6)$$

Now the expression for x (equation (5)) has been obtained by double integration of the function defining v, that is of the curve of Fig. 3. The velocity is thus proportional to the area under this curve up to any selected value of ωt and the distance is proportional to the area under the velocity curve so obtained. With any fixed value of θ an increase in ϕ must decrease the area under the velocity curve up to its maximum point (the end of the conducting part of the cycle). Since the rate of increase of negative area under the original curve beyond this point is always

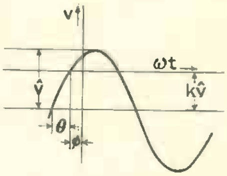

Fig. 3.

the same for fixed θ the total positive area under the velocity curve must also become smaller as ϕ increases. In other words the maximum value of x decreases as ϕ increases. To find the maximum electron range we need therefore only consider the case $\phi = 0$. This can be verified for any particular case by means of equation (5). The condition (6) for critical values of x then becomes

$$\cos\theta = \cos(\omega t + \theta) + \omega t \sin\theta$$

$$\text{Hence } \theta = \tan^{-1}\left\{\frac{\cos\omega t - 1}{\sin\omega t - \omega t}\right\} \quad (7)$$

The relation between k and the critical values of ωt obtained from (7) is shown graphically in Fig. 4. When $k > 0.217$ there is only one turning point, and when $k < 0.217$ the number of turning points increases as k approaches zero. The 1st, 3rd, 5th . . . turning points must be maxima and the 2nd, 4th . . . minima.

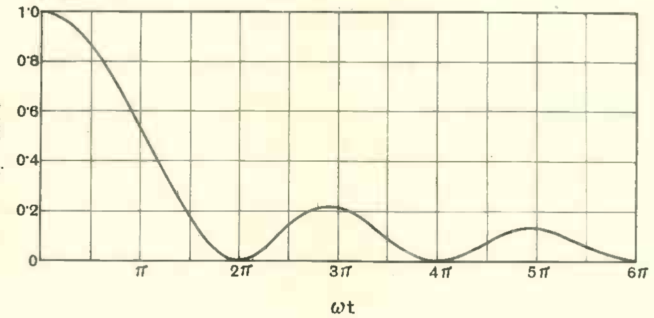

Fig. 4.—*Relation between ωt and k for electron turning points.*

The value of x at the nth turning point, found by integrating (4) between $t = 0$ and $t = t_n$ with $\phi = 0$, is given by

$$x_n = \frac{1}{\omega^2}\cdot\frac{e}{m}\cdot\frac{\hat{v}}{x_a}\left[-\sin(\omega t_n + \theta) + \sin\theta\left\{1 - \frac{(\omega t_n)^2}{2}\right\} + \cos\theta\,.\,\omega t_n\right] \quad (8)$$

It is evident from Fig. 4 that the maximum electron range will be given by putting $n = 1$ in equation (8) for all values of k down to something less than 0.217. From (8) the condition for $x_1 > x_3$ is

$$\sin(\omega t_3 + \theta) - \sin(\omega t_1 + \theta) + \tfrac{1}{2}\sin\theta\{(\omega t_3)^2 - (\omega t_1)^2\} + \cos\theta(\omega t_1 - \omega t_3) > 0 \quad (9)$$

Graphical solution of this inequality, making use of (7) to obtain ωt_1 and ωt_3, gives

$$\sin\theta > 0.13_0$$

Hence the maximum electron range occurs at the first turning point provided the condenser charges up to more than 13 per cent. of the applied peak voltage.

For values of k between 0.13 and 1 the maximum range is thus given by putting $n = 1$ in equation (8), which may then be written

$$\hat{x} = \frac{1}{\omega^2}\cdot\frac{e}{m}\cdot\frac{\hat{v}}{x_a}\cdot G(k) \quad (10)$$

where $G(k) = \left[-\sin(\omega t_1 + \theta) + \sin\theta\left\{1 - \frac{(\omega t_1)^2}{2}\right\} + \cos\theta\,.\,\omega t_1\right]$,

$$\theta = \sin^{-1}k$$

and ωt_1 is the lowest value of ωt determined by equation (7).

Equation (10) gives the formal solution of the problem subject to the condition $0.13 < k < 1$ which will probably cover most practical cases. By means of equations (7) and (8) the solution can be extended, if required, to smaller values of k.

To put the results in a more readily useful form we note that $\hat{x} = x_a$ in the equilibrium condition when electron inertia is the only important source of error. The voltmeter reading will then be $k\hat{v}$ where k is determined by

$$G(k) = \frac{\omega^2 x_a^2}{\frac{e}{m}\hat{v}} \quad (11)$$

The function $G(k)$ is plotted in Fig. 5 against the percentage error. To find the error under given conditions $G(k)$ is evaluated by means of (11) and the corresponding error read off the curve of Fig. 5.

Alternatively if the observed voltage is $\hat{v}_0 = k\hat{v}$ and the true peak voltage is required, we have

$$\frac{G(k)}{k} = \frac{\omega^2 x_a^2}{\frac{e}{m}\hat{v}_0} \quad (11A)$$

In Fig. 6 $G(k)/k$ is plotted against the correction factor $1/k$. To obtain the true peak voltage $1/k$ is found from (11A) and Fig. 6 and the observed voltage is then multiplied by this factor.

The relation between $\log G(k)$ and $\log (1 - k)$ is, from Fig. 5, very nearly linear when $(1 - k)$ is less than about 20 per cent. We can therefore write

$$G(k) = A(1 - k)^B$$

when the error is small.

From Fig. 5 we find

$$A = 4.5, \quad B = 2.0$$

$$\therefore 4.5(1 - k)^2 = \frac{\omega^2 x_a^2}{\frac{e}{m}\hat{v}}$$

$$\therefore (1 - k) = \frac{6.8 f x_a}{\sqrt{\hat{v}}} \text{ per cent.} \quad \ldots \quad (12)$$

(f in *megacycles* per sec., x_a in *cm.*, $\hat{v}$ in volts).

The inaccuracy introduced by using this simple formula for the error instead of equation (11) and Fig. 5 only amounts to about 10 per cent. for the largest values of voltmeter error covered by Fig. 5.

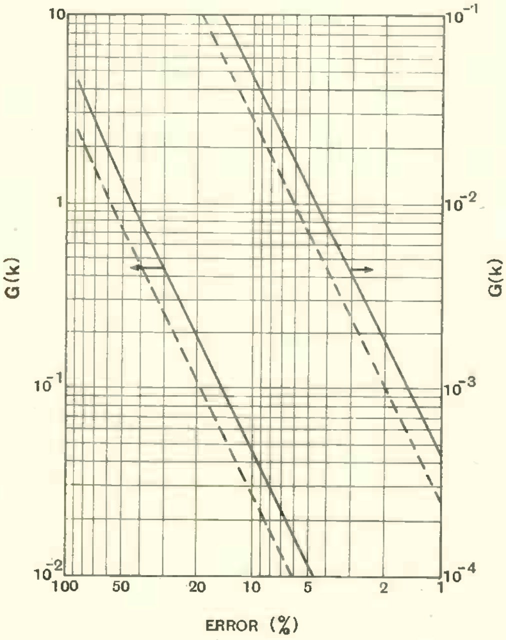

Fig. 5.—*Relation between the function $G(k)$ and the error due to electron inertia.*

It is now necessary to discuss the probable effect of the assumptions made in deriving equation (10). The assumption of zero initial velocity can be regarded as leading to a constant, measurable zero error as in Section III, at least for voltages of the order of 100 or more. The validity of this procedure is perhaps open to question for low voltages, pending experimental investigation, but the effect of finite emission velocity can hardly be other than to decrease the electron inertia error. The only other assumption made is that the electric field is uniform. The effect of this may be examined in the following way.

If we assume that the time of transit of an electron with zero initial phase angle ϕ (Fig. 3) to its first turning point is the same as that of an electron travelling in a constant field, equal to the average field during the time that the anode is positive, and further that the first turning point of such an electron coincides in time with the change of anode potential from positive to negative, we obtain the equation

$$\frac{\omega^2 x_a^2}{\frac{e}{m}\hat{v}} = \cos\theta(\pi - 2\theta) - \tfrac{1}{2}\sin\theta(\pi - 2\theta)^2 \quad (13)$$

$$= H(k), \text{ say,}$$

for the equilibrium condition with a uniform electric field.

The validity or otherwise of these assumptions taken individually is irrelevant to the present purpose. What is relevant is that $H(k)$, which is represented by the dotted lines in Fig. 5, is a function closely similar to $G(k)$, the error defined by (13) being very nearly 1.32 times that defined by (11) except for errors near the maximum covered by Fig. 5.

Now the electric field differs most widely from a uniform one: on the one hand when the electrodes are parallel planes with a maximum space charge between them, and, on the other, when the electrodes are concentric cylinders with an extremely small internal cathode and no space charge. Making use of the fact (which is readily calculable) that the time of transit in a time-constant field corresponding to the first extreme case is 1.5 times, and to the second extreme case very nearly 0.5 times, that in a uniform field, we obtain equations identical with (13) except that $H(k)$ is multiplied by a factor equal to 2.25 in the first case and to 0.25 in the second. Reference to Fig. 5 shows that the voltmeter error becomes 1.5 or 0.5 times that obtained from equation (13), corresponding to a uniform field, with only a small inaccuracy at the largest values of error. We can therefore say, at least as a useful approximation, that the true error for any electrode form and any space charge condition will never be more than 1.5 times nor less than 0.5 times that given by equation (11).

Thus the error will never exceed about 1 per cent. provided

$$\frac{fx_a}{\sqrt{v}} < 0.1$$

(units as in equation (12)).

Taking 0.3 mm. as the smallest practicable cathode-anode clearance, the electron inertia error will become appreciable for voltages less than 10 at 10 megacycles and for voltages less than 1,000 at 100 megacycles. By means of Fig. 6 a useful estimate can be made of voltages down to about 10 at frequencies up to 1,000 megacycles (30 cm. wavelength).

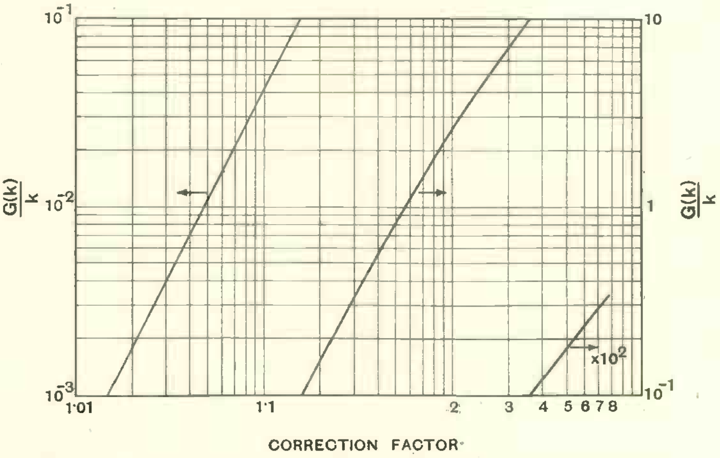

Fig. 6.—*Relation between the function $G(k)/k$ and the correction factor for electron inertia error.*

In conclusion, a possible criticism must be answered. It is that the results derived in this section are invalid because account has not been taken of the displacement current in determining the effect of electron inertia, and that an analysis starting from the Maxwellian total current, such as Benham[10] has carried out for another type of thermionic voltmeter, is necessary. The answer is that we are not concerned here with the magnitude of any current, so long as the assumption of negligible leakage is fulfilled, but simply with the condition for the existence of a conduction current. When the effects of both leakage and electron inertia are appreciable the problem becomes a good deal more complex, but it is clear that the displacement current cannot, by its nature, contribute directly to the static charge on the voltmeter condenser. It should, however, be added that when the electron inertia error is large the impedance error will be modified by a change in C_D from its low frequency value and the power factor will contain a term resulting from the energy transfer between the changing field and the moving electrons. But correction for the impedance error by calculation is, in any case, a process which cannot be carried out with great accuracy at the highest frequecnies.

The author desires to express his thanks to Professor C. L. Fortescue, under whose guidance the earlier part of the work described here was done, and to the Beit Trustees for the Fellowship awarded to the author in 1928 which made that part of the work possible ; he also desires to tender his acknowledgment to the General Electric Company and the Marconi Company, on whose behalf the later part of the work was done.

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Diode Frequency Changers*

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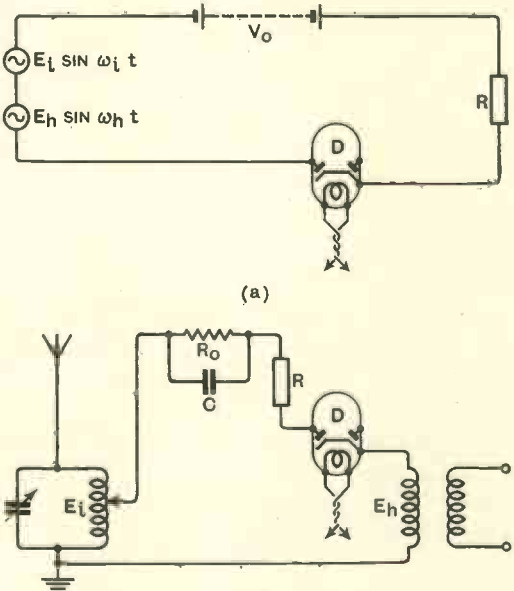
SUMMARY.—In this article the most important properties of diode frequency changers are set forth theoretically and experimentally. The conversion gain is shown to be $g = R/(R + R_i)$, where R is the tuned impedance at the primary side of the intermediate frequency transformer and R_i the effective internal resistance of the diode for the incoming signal. If oscillator voltages above 4 volts and a proper bias be used, the value of R_i may be about 0,1 Megohm. Because of the low input impedance, the diode may be used in sets with a h.f. valve before it. In this case shot effect noise is negligible; whistling notes are sufficiently low if the input signal amplitude on the diode is not more than some millivolts, and cross modulation and distortion are then negligible. The diode scheme does not compare unfavourably with other converters. Use of second or third oscillator harmonic for conversion, being sometimes advisable on short waves, does not cause loss of gain practically.

I. Introduction

IN two previous articles diode frequency changers were considered and some important features thereof calculated and checked by measurements (*see Zeits. Hochfrequenz*, Vol. 42, 1933, pp. 206–208 and *Proc. Inst. Rad. Eng.*, Vol. 22, 1934, pp. 981–1008). The treatment was rather mathematical and an attempt is made here to give a more elementary exposition to enable the reader to gain an insight into the processes involved.

The circuit, in which a diode serves as a converter is shown in Fig. 1*a*. The input voltage $E_i \sin \omega_i t$ is in series with an oscillator voltage $E_h \sin \omega_h t$, which are both acting on a diode D. In series with the diode is an impedance, tuned to a frequency ω_0, which is the difference between ω_h and ω_i and which impedance is very small at all frequencies, except at ω_0, where it is a pure resistance R. A bias voltage V_0 determines the working point of the diode characteristic. A practical application is shown in Fig. 1*b*, where the antenna circuit, tuned to ω_i, is tapped, while the oscillator voltage is derived from a cathode coil, which is coupled to the oscillator. The bias is obtained automatically by inserting the series resistance R_0, by-passed by a condenser C, which is large enough also for the intermediate frequency, *i.e.*, $1/\omega_0 C << R_0$. The impedance R may be the primary side of a tuned intermediate frequency transformer. On this primary side a voltage $E_0 \cos \omega_0 t$, where $\pm\omega_0 = \omega_h - \omega_i$, is formed by the converting action of the diode. The ratio E_0/E_i is called the conversion gain of the diode circuit. For small values of E_i (*e.g.*, 10^{-3} Volts) E_0 is proportional to E_i. Other-



(a)

(b)

Fig. 1.—(*a*) *Principle of diode converter.* (*b*) *Diode converter as used in a set. Tapped antenna coil. Automatic bias. Cathode coil injection of local oscillator voltage.*

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

wise we have :

$$E_0 = g_1 E_i + g_3 E_i^3.$$

Even powers of E_i do not occur in this development, as will be shown in this article. The first problem is the derivation of g_1 from the diode characteristic.

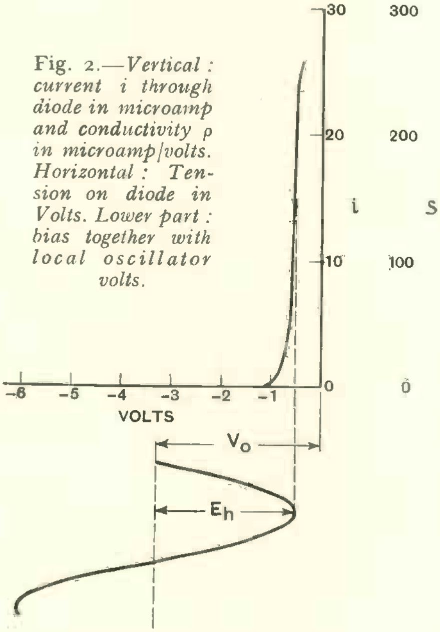


Fig. 2.—*Vertical : current i through diode in microamp and conductivity ρ in microamp/volts. Horizontal : Tension on diode in Volts. Lower part : bias together with local oscillator volts.*

II. Conversion Gain

The characteristic in Fig. 2 gives the current plotted against the voltage under d.c. conditions for a commercial diode. It may be remarked here, that up to about $V = -0{,}5$ Volts this characteristic is quite accurately represented by the formula $i = 3{,}5 \exp(10\,V)$, where i is in mA and V in volts. Generally we have :

$$i = f(V) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Let an alternating voltage $E_h \sin \omega_h t$ in series with a bias V_0 act on the diode, V being the sum of these expressions. The resulting voltage is shown in Fig. 2. We obtain a current against time curve, which is represented in Fig. 3 for $E_h = 2$ Volts and $V_0 + E_h = -0{,}5$ Volts and in Fig. 4 for $E_h = 8$ Volts and again $V_0 + E_h = -0{,}5$ Volts. The curves of these figures may readily be approximated by triangles as shown in Fig. 5.

At any point of the characteristic (1) the diode possesses a certain conductance to small a.c. voltages such as $E_i \sin \omega_i t$. This conductance, which is called ρ, is derived from (1) by differentiation :

$$\rho = \frac{di}{dV} = \frac{df(V)}{dV} = f'(V) \quad \ldots \quad (2)$$

If the curve (1) is given graphically the curve (2) may be found by differentiating in every point. Since $d(\exp x)/dx = \exp x$, if we do not use the characteristic beyond $-V = 0{,}5$ Volts, the ρ curve is equal to the i curve, simply using a different vertical scale, as shown in Fig. 2. Figs. 3 and 4 also represent ρ against time, using the vertical scale inserted on the right side of the diagrams. We have thus obtained curves, representing the diode conductance to a small applied signal $E_i \sin \omega_i t$, as a function of the time, with an oscillator voltage present. The current flowing through the diode due to this signal voltage if the external circuit has no impedance is given by :

$$i(t) = \rho(t) \,.\, E_i \sin \omega_i t \quad \ldots \quad \ldots \quad (3)$$

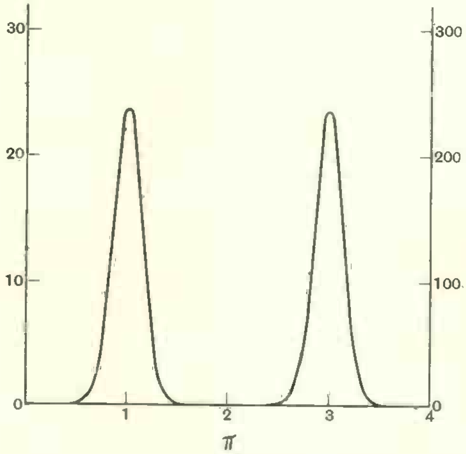


Fig. 3.—*Vertical left current i in microamp, right conductance in microamp/volts. Horizontal : time scale, 2π being one oscillator swing period.* $E_h = 2$ *Volts and* $E_h + V_0 = -0{,}5$ *volts.*

Now, as $\rho(t)$ varies periodically, but is not a pure sine curve, it may be represented by a Fourier series :

$$\rho(t) = A + A_0 \sin \omega_h t + A_2 \cos 2\omega_h t + A_3 \sin 3\omega_h t \ldots \quad (4)$$

We are specially interested in the coefficient

A_0 at present, as this gives rise to the term of intermediate frequency $\omega_0 = \omega_h - \omega_i$, viz.:

$$i_0 \cos \omega_0 t = \tfrac{1}{2} A_0 E_i \cos \omega_0 t \quad .. \quad (5)$$

This current $i_0 \cos \omega_0 t$ causes a voltage $E_0 \cos \omega_0 t$ on the primary of the intermediate frequency transformer, which is equivalent to a resistance R for the frequency ω_0.

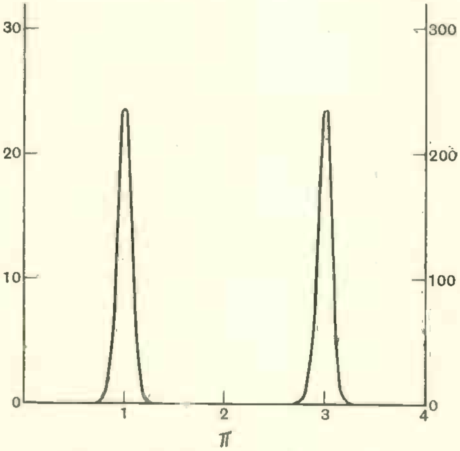


Fig. 4.—*As Fig. 3, but* $E_h = 8$ *volts.*

The internal resistance of the diode for the frequency ω_0 is called R_i. The current of frequency ω_0, if an external series resistance R for this frequency is inserted in the circuit, follows from

$$i_0 = \tfrac{1}{2} A_0 E_i - E_0 A,$$

where $E_0 = i_0 R$ and hence:

$$\frac{E_0}{E_i} = \frac{\tfrac{1}{2} A_0}{\dfrac{1}{R} + A} \quad .. \quad .. \quad .. \quad (6)$$

We come to the actual calculation of E_0 and hence, by (6) of A_0 and of R_i for the diode converter circuit considered. Approximating Figs. 3 and 4 by triangular curves, as in Fig. 5, we have:

$$A_0 = \frac{2}{\pi} \rho_{\text{max.}} \frac{1 - \cos b}{b} \quad .. \quad .. \quad (7)$$

where $\rho_{\text{max.}}$ is the maximum value of the conductivity ρ encountered during one oscillator swing period (*see* Figs. 3 and 4). If b is very small, which occurs for large oscillator voltages, the eq. (7) reduces to:

$$A_0 \text{ (for } b \text{ small)} = \frac{2}{\pi} \left\{ \rho_{\text{max.}} \cdot \frac{b}{2} \right\} \quad .. \quad (8)$$

The expression between brackets is evidently the area of one triangle in Fig. 5. It may be shown, that for sufficiently large oscillator voltages the exact form of the ρ against t curve does not matter, A_0 being $2/\pi$ times the area of the resulting figure in this case. As to the internal diode resistance R_i for the frequency ω_0, the value of $1/R_i$ can be found by observing, that it will be the *mean* value of $\rho(t)$, taken over a large time interval and hence $1/R_i = A$ by eq. (4). Using again the triangular approximation of Fig. 5, one obtains:

$$1/R_i = A = \frac{1}{\pi} \cdot \tfrac{1}{2} \rho_{\text{max.}} b \quad .. \quad .. \quad (9)$$

Hence, the gain can be calculated completely from eq. (6), if $\rho_{\text{max.}}$ and b are determined from the static diode characteristic. Considering the case that b is very small, which, as is seen from Fig. 3 and 4, corresponds to high oscillator voltage, eq. (6) simplifies by using (8) and (9):

$$E_0/E_i \text{ (for large oscillator voltage)} = \frac{R}{R + R_i} \quad .. \quad .. \quad (6a)$$

as $A_0/2$ is equal to A in this case. If, furthermore, the internal resistance R_i of the diode is small compared with the tuned impedance R, the conversion gain is approximately unity, this latter value being the greatest possible.

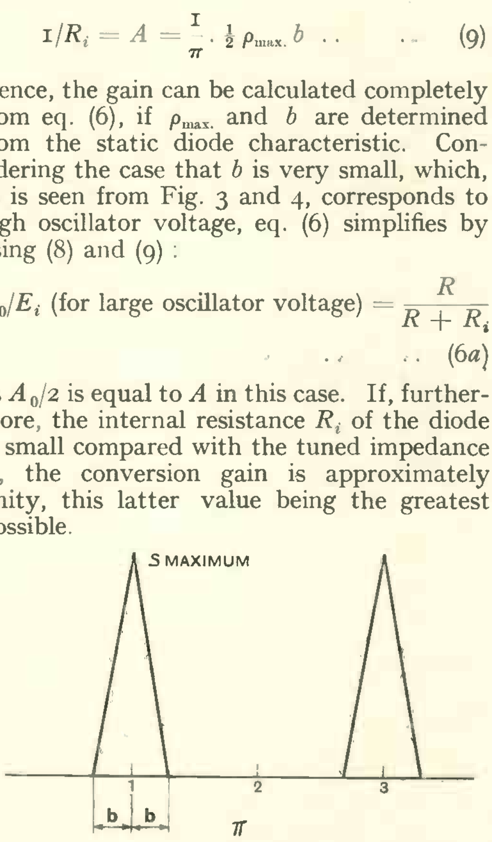


Fig. 5.—*Triangular approximation of curves in Figs. 3 and 4.*

On short waves, considerations of generator stability as well as of radiation and of coupling may lead to the use of the second or the third oscillator harmonic for conversion. This means, that the relations: $\omega_0 = 2\omega_h - \omega_i$ or $\omega_0 = 3\omega_h - \omega_i$ are satisfied, instead of $\omega_0 = \omega_h - \omega_i$. The conversion gain for this use of the diode can easily be obtained from the preceding calculations. If the oscillator voltage is large the diode current peaks in Fig. 3 and 4 are very steep and of negligible breadth. It is known, and may easily be verified by direct analysis from Fig. 5, that the Fourier components A_0, A_2, A_3 for such peaks are almost equal. Hence the conversion gains, by using the oscillator frequency itself or its second or third harmonic, are also almost equal. This involves *e.g.* an oscillator voltage of 6 Volts eff. value and a bias of -9 Volts.

III. Input Impedance and Output Impedance

If the diode circuits of Fig. 1*a* and Fig. 1*b* are considered from the input side, *i.e.*, for the signal $E_i \sin \omega_i t$, the first element in the series circuit which offers appreciable impedance at this frequency is the diode itself. Its resistance for the intermediate frequency ω_0 was shown to be given by $1/R_i = A$. For the input frequency the same reasoning holds, leading to the same result, *i.e.*, eq. (9). The dependance of R_i on the oscillator voltage will now be considered a little more closely. In the first place, $1/R_i$ is seen to be proportional to $\rho_{\text{max.}}$, which is the maximum diode conductance encountered during one oscillator swing period. This value $\rho_{\text{max.}}$ is determined by the point $E_h + V_0 = V$, E_h being the oscillator peak voltage and V the bias voltage, unto which the oscillator is permitted to swing. Its value may immediately be seen from the ρ against V characteristic, which is derived from the static diode characteristic eq. (1) by differentiation, according to eq. (2).

Furthermore $1/R_i$ is also proportional to b, which is smaller for greater values of E_h, if $\rho_{\text{max.}}$ is taken to be constant. Hence R_i is increased by increasing E_h, and decreases if $\rho_{\text{max.}}$ is increased.

Apparatus was set up for determining R_i, as shown in Fig. 6. A signal generator was loosely coupled by a capacity to a circuit CL, which was connected to the diode. On the circuit a signal voltage $E_i \sin \omega_i t$ was measured by means of a tuned triode voltmeter, the voltmeter circuit CL being tuned to the frequency ω_i. A voltage $E_h \sin \omega_h t$ was at the same time induced in the coil L from a second signal generator. While ω_i was 10^7, ω_h was about 10^6. The voltage E_h could be varied by varying the coupling, and it was measured with a second untuned triode voltmeter. As E_h was some Volts and E_i only some 10^{-2} Volts, the latter voltmeter did not indicate the voltage $E_i \sin \omega_i t$. The bias V_0 was in series with the diode. The relation $E_h + V_0 = -0{,}5$ Volts was satisfied during the measurements. R_i was evaluated from the damping of the circuit CL by the diode. The results were :

TABLE I.

E_h ..	1	2	4	8	12	Volts
R_i ..	0,033	0,047	0,067	0,095	0,117	Megohms

For large E_h values R_i is proportional to $E_h^{-\frac{1}{2}}$, as seen from Table I and as may also be derived from the exact theory, assuming $i = A \exp (a V)$.

Now that the order of magnitude of R_i is known, the conversion gain may readily be rated for the usual tuned intermediate frequency transformers, having impedances R at the primary, varying from some 50 000 to some 250 000 Ohms :

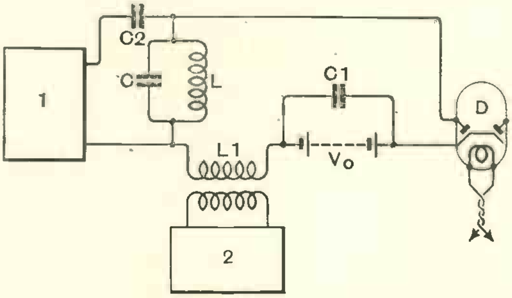


Fig. 6.—*Measuring arrangement for determining R_i of diode. 1 generator with tuned voltmeter of frequency ω_i. 2 generator of frequency ω_h. C_2 coupling capacitance of some $\mu\mu F$. Circuit CL tuned to frequency ω_i. L_1 coil for injecting local oscillator voltage. V_0 bias by-passed by C. D diode under consideration.*

TABLE II.

Conversion gain	1/3	1/2	2/3	3/4	0,9
Ratio R/Ri ..	1/2	1	2	3	10

These values for the conversion gain were verified by direct measurements on a circuit as shown in Fig. 1*a*, using the means described in connection with Fig. 6. The second and third harmonic of ω_h were also used for conversion, giving about equal conversion gains experimentally as with ω_h itself.

We now come to the total input impedance Z_i which the series circuit offers to the signal voltage on the input circuit, in other words to the damping of the converter circuit on the input circuit. This is found by calculating the current i_i of frequency ω_i flowing through the circuit. It is, by eq. (4) :

$$i_i \sin \omega_i t = AE_i \sin \omega_i t - \tfrac{1}{2} A_0 E_0 \sin \omega_i t,$$

as $\omega_i = \omega_h - \omega_0$,

whence, as $E_i = i_i Z_i$ and $E_0 = g_1 E_i$,

$$\frac{1}{Z_i} = A - \tfrac{1}{2} A_0 g_1.$$

Now, for large oscillator voltages

$$A = 1/R_i = A_0/2 \text{ and } g_1 = R/(R + R_i).$$

Thus $Z_i = R + R_i$

in words : The input resistance of the converter circuit for the frequency ω_i is equal to the sum of the internal resistance R_i of the diode and of the resistance R, which the primary side of the i.f. transformer has at the frequency ω_0.

It is, of course, possible to take ω_0 as input frequency and ω_i as intermediate frequency. Hence, by the above reasoning, the resistance of the converter circuit, as seen from the output side is equal to the internal diode resistance added to the resistance of the input circuit for the frequency ω_i.

IV. Shot Effect and Circuit Noise

As with the usual one-grid and two-grid frequency changers, shot effect noise is an important item with diode mixers. Looking through the many recent papers on shot effect noise in valves, one will find much controversy, on the experimental as well as on the theoretical side of the problem (*see* bibliography in the *W.E.*, 1934, p. 64). Therefore, only approximate values will be given here, inserting a factor f, which is of the order of unity, but may vary with individual valves and cathodes between 0,5 and about 1,3.

Using Schottkys original equation for the shot effect alternating current (effective value) i through a resonance circuit with a coil resistance r, a self-induction L and a capacity C, such that the tuned impedance is $R = L/C_r$, which circuit is connected between anode and cathode of a valve having a direct anode current i_a (amp.), one obtains :

$$i = f\sqrt{\frac{e i_a r}{2L}} \text{ amp.} \quad \ldots \quad \ldots \quad (10)$$

Here e is the electronic charge in coulombs, being $1{,}6 \,.\, 10^{-19}$, while r is in ohms and L in henrys. The shot effect voltage on the intermediate frequency circuit is $E_n = i \,.\, R$, where $R = L/C_r$. Obviously, we have first to find the current i_a. This is easily done from diagrams such as Figs. 2 and 3. It is only required to determine the area of the current peaks. Using the arrangement of Fig. 6 the current i_a was determined for some values of the oscillator voltage E_h :

TABLE III.

E_h ..	1	2	4	8	12	Volts
i_a ..	3,0	2,1	1,5	1,0	0,85	Microamps

From this table and also from theoretical reasoning it may be inferred that i_a is proportional to $(E_h)^{-\frac{1}{2}}$ for large oscillator voltages.

With these values, taking $f = 1$, $L/C_r = R = 10^5$ ohms and $r/L = 10^4$ one finds for $i_a = 1{,}5$ microamp an effective noise voltage E_n on the intermediate frequency circuit of 3,5 microvolts. The circuit noise voltage E_c of this circuit, due to Brownian motion of the electrons, is about 1 microvolt and hence, as addition is performed by the formula $(E_n{}^2 + E_c{}^2)^{1/2}$, is negligible compared with the shot voltage E_n.

V. Whistling Notes

As was pointed out in a recent discussion of whistling notes in superheterodyne receivers (*W.E.*, 1935, p. 194), two cases may be considered. In the first case only one input signal is put on the frequency changer and the resulting whistling notes are hence entirely due to the action of the mixing valve. In the second case, owing to lack of selectivity of the h.f. circuits before the mixing valve, or to rather strong local transmitters, more than one input signal acts on the mixing valve. The resulting whistling notes are hence partly due to circuit conditions and partly to the action of the frequency changer. While the first case will be chiefly considered here, the second one will also receive some attention.

In section II of this article it was remarked that in any part of the static diode characteristic the diode path represents a certain conductance to impressed voltages. For very *small* input voltages this conductance was shown to be $\rho = f^1(V) = di/dV$, the resulting current being given by

$$i(t) = \rho\, E_i \sin \omega_i t.$$

If the input voltage is no longer very small, the subsequent terms of the Taylor series development for the conductance come into play and we have :

$$i(t) = f' E_i \sin \omega_i t + \tfrac{1}{2} f''(E_i \sin \omega_i t)^2 + \tfrac{1}{6} f'''(E_i \sin \omega_i t)^3 + \quad .. \quad (11)$$

Now, every one of the coefficients f', f'', etc., is a function of the time, very similar to f^1, as shown in Fig. 2 and 3. Hence, one obtains :

$$f' \ (t) = A + A_0 \sin \omega_h t + A_2 \cos 2\omega_h t + A_3 \sin 3\omega_h t \ . \ . \ . \ .$$

$$f'' \ (t) = B + B_0 \sin \omega_h t + B_2 \cos 2\omega_h t + B_3 \sin 3\omega h t$$

$$f \quad (t) = C + C_0 \sin \omega_h t + C_2 \cos 2\omega_h t + C_3 \sin 3\omega_h t, + \ldots \text{etc.}$$

As was shown in the aforesaid article on whistling notes, in the case of one single input signal these are generated if the equations :

$$\omega_h - \omega_i = \omega_0$$

$$\pm m\omega_h \pm n\omega_i = \omega_0 \pm \delta,$$

where δ is small compared with ω_0, are satisfied simultaneously. A frequency combination $\pm m\omega_h \pm n\omega_i$ can only arise from a product sin (or cos) $m\omega_h t$ times sin (or cos) $n\omega_i t$. Thus we have to look for such products in eq. (11). As may be seen by looking into any compendium of elementary mathematical formulas, an expression (sin $\omega_i t)^n$, if decomposed, will contain one term sin (or cos) $n\omega_i t$ and other terms sin (or cos) $(n-2)\omega_i t$, sin (or cos) $(n-4)\omega_i t$, etc. Hence the lowest power of E_i, entering into a product sin $m\omega_h t$ sin $n\omega_i t$ is E_i^n. The strength of a whistling note arising from a combination $\pm m\omega_h \pm n\omega_i$ will thus be proportional to E_i^n. This result was obtained from a compact reasoning in the previous paper on whistling notes. As is already seen by eq. (11), the strongest whistling notes, for E_i increasing from very small values, will be proportional to E_i^2. Generally, the Fourier series for f', f'', etc., will have terms, decreasing if m increases. Hence the strongest whistling notes will come from $m = 0$ or $m = 1$. Of course, the prevalence of a very special ratio ω_i/ω_0 can in certain cases make these whistling notes evanescent and bring other ones into prominence. Their calculation, however, will be possible by following the same course, as indicated here for the specified notes. Take *e.g.* $m = 1$ and $n = 2$. As an example, the input signal is 230 kc/sec and the intermediate frequency 116 kc/sec, while the oscillator is at 346 kc/sec. Obviously 2 × 230 = 460 and 460 − 346 = 114 kc/sec, which will cause a bad whistle of 2 kc/sec, with the frequency 116 kc/sec. The current causing this note is, by eq. (11), using the Fourier expansion for f'' :

$$i(t) = \frac{1}{8} B_0 E i^2 \sin \omega_0 t,$$

where $\omega_0 = \omega_h - \omega_i$ as usual. By the same reasoning as used in section II this current causes a voltage on the primary side of the $i - f$ transformer :

$$\frac{E_0}{E_i} = \frac{RR_i}{R + R_i}\, i(t) E_i = \frac{1}{8} B_0 E_i \frac{1}{\frac{1}{R} + \frac{1}{R_i}}$$

Again, as in section II, for high oscillator voltages $B_0/2 = B$ and B is 10 A expressed in $(\text{Volts})^{-1}$, if the diode characteristic $i = 3{,}5 \exp{(10\ V)}$ mA. is used. As, furthermore $A = 1/R_i$, we have for this whistling note :

$$\frac{E_0}{E_i} = \frac{10}{4} E_i \frac{R}{R + R_i} = 2{,}5\ E_i g_1 \quad .. \quad (11a)$$

Here E_i is in Volts and the factor 2,5 has the missing dimension of $(\text{Volts})^{-1}$. Thus, with $E_i = 1$ millivolt and $g_1 = 1$, the ratio of whistling note and signal is 0,0025 in this case. This is proportional to the strength ratio observed behind a linear second detector (*see* article on whistling notes), the latter being 2,5 $g_1 E_i/M$, where M is the modulation depth of the incoming signal. In quite the same way one obtains for $m = 0$ and $n = 2$ the same value as for $m = 1$ and $n = 2$. This value, to the approximation used here, *i.e.*, for large E_h, holds for $n = 2$ and $m = 3$ or 4 also. If $m = 0, 1, 2, 3$ or 4 and $n = 3$ one obtains :

$$\frac{E_0}{E_i} = \frac{100}{24} E^2{}_i \frac{R}{R + R_i} 4 \cdot E_i{}^2 g_1,$$

which for $E_i = 1$ millivolt means

$$E_0/E_i = 4 \cdot 10^{-6}, \text{ if } g_1 = 1.$$

We now come to the case of more than one input signal. Assume two:

$$E_i \sin \omega_i t + E_1 \sin \omega_1 t.$$

Then the current as a function of t is given by

$$\begin{aligned} i(t) &= f'(E_i \sin \omega_i t + E_1 \sin \omega_1 t) \\ &\quad + \tfrac{1}{2} f''(E_i \sin \omega_i t + E_1 \sin \omega_1 t)^2 \\ &\quad + \tfrac{1}{6} f'''(E_i \sin \omega_i t + E_1 \sin \omega_1 t)^3 + \ldots \quad (12) \end{aligned}$$

instead of by eq. (10). The conditions for a whistling note are: $\omega_h - \omega_i = \omega_0$ and $\pm m\omega_h \pm n\omega_i \pm n_1\omega_1 = \omega_0 \pm \delta$, where δ is small compared with ω_0. A serious whistling note sometimes arises if $n = 0$ and $n_1 = 2$, while $m = 2$. As an example take a signal of 1000 kc/sec, an intermediate frequency of 150 kc/sec, a whistling (spurious) signal of 1076 kc/sec and an oscillator frequency of 1150 kc/sec. Then $2 \times 1150 - 2 \times 1076 = 148$ kc/sec, which causes a whistling note of 2 kc/sec with the i.f. of 150 kc/sec. The result is quite similar to the case considered previously in connection with eq. (11a). In fact, this eq. holds also for the present case, if E_i is replaced by E_1. The strength of the spurious signal $E_1 \sin \omega_1 t$ on the converter input depends on the selectivity of the foregoing h.f. circuits and must be calculated in every case.

VI. Cross Modulation and Distortion Effects

The distortion effects encountered in frequency changers may be treated in a quite general way, which is very similar to the treatment of the analogous effects in h.f. amplifiers (*see* R. O. Carter, *W.E.*, Vol. 9, pp. 429–438, 1932). In the first place a simple proof will be given for the development

$$E_0 = g_1 E_i + g_3 E_i^3 + \quad \ldots \quad \ldots \quad (13)$$

of the output i.f. amplitude E_0 as a function of the input signal amplitude E_i. Use is made of eq. (12), where the current $i(t)$ is expanded in powers of the input signal voltage. It is readily seen that the second term $0{,}5 f''(E_i \sin \omega_i t)^2$ does not contain sin (or cos) $\omega_i t$ and hence will not enter into E_0. This holds for all terms of even order. For the third term $1/6 f'''(E_i \sin \omega_i t)^3$ we may write $1/6 \cdot 1/4 f'''(-\sin 3\omega_i t + 3 \sin \omega_i t) \cdot E_i^3$. The expression for the intermediate frequency current component i_0 is hence, to a second approximation:

$$i_0 \cos \omega_0 t = \tfrac{1}{2} A_0 E_i \cos \omega_0 t + \frac{1}{48} C_0 E_i^3 \cos \omega_0 t.$$

Using the same procedure as in section I one obtains for the conversion gain the expression

$$\frac{E_0}{E_i} = \left\{ \tfrac{1}{2} A_0 + \frac{1}{48} C_0 E_i^2 \right\} \frac{1}{\frac{1}{R} + \frac{1}{R_i}},$$

whence, comparing with (13), the factor g_3 turns out to be:

$$\frac{g_3 E_i^2}{g_1} = \frac{1}{24} \frac{C_0 E_i^2}{A_0} \quad \ldots \quad \ldots \quad (14)$$

If the diode has an exponential characteristic $i = 3{,}5 \cdot \exp(10\,V)$ mA, and the oscillator voltage is sufficiently great, then $C_0 = 2C$ and $A_0 = 2A$ (*see* end of section I) and $C = 100\,A$, where the multiplier 100 has the dimension (Volts)$^{-2}$. Eq. (14) shows in this case, that the ratio $g_3 E_i^2/g_1$ is equal to about $4E_i^2$, which for E_i hundred millivolts is four per cent.

Now we come to expressing the distortion and the cross modulation effects by g_1 and g_3. For the distortion take $E_i = E\,(1 + M \cos pt)$, where M is the modulation depth of the input signal. Then one obtains:

$$\begin{aligned} E_0 &= g_1 E(1 + M \cos pt) \\ &\quad + g_3 E^3(1 + 3\,M \cos pt + \tfrac{3}{2} M^2 \cos 2\,pt \\ &\quad + {}^3 M^2 + \tfrac{1}{4} M^3 \cos 3pt + \tfrac{3}{4} M^2 \cos pt) + \ldots, \end{aligned}$$

or

$$\begin{aligned} E_0 &= g_1 E + g_3 E^3(1 + \tfrac{3}{2} M^2) \\ &\quad + (g_1 EM + 3 g_3 E^3 M + \tfrac{3}{4} g_3 E^3 M^3) \cos pt \\ &\quad + (g_3 E^3 \cdot \tfrac{3}{2} M^2) \cos 2pt + \tfrac{1}{4} g_3 E^3 M^3 \cos 3pt + \\ &\qquad \ldots \quad \ldots \quad (15) \end{aligned}$$

Hence the modulation, when the input signal has gone through the diode converter circuit, has frequencies which are twice and three times the modulation frequency of the antenna signal, which constitutes distortion. If more than one acoustic frequency is modulated on the input signal wave, as in the case of music, sums and differences of these acoustic frequencies arise during conversion, which is often more serious than the formation of overtones. The latter effect may also readily be calculated from the above formulas taking

$$E_i = E(1 + M_p \cos pt + M_q \cos qt).$$

From eq. (15) one finds that the modulation depth for the frequency $2p$ is

$$\frac{M_2'}{M} = \frac{g_3}{g_1} E^2 \tfrac{3}{2} M \quad .. \quad .. \quad (16)$$

and the modulation M' depth for the frequency p for the intermediate frequency signal is given by:

$$\frac{M' - M}{M} = \frac{g_3 E^2}{g_1} (2 - \tfrac{3}{4} M^2) \quad .. \quad (17)$$

which constitutes the modulation rise. If (16) is small, the acoustic combination tones mentioned above are also of the same small order.

Taking an input signal $E_i \sin \omega_i t + E_k(1 + M_k \cos pt) \sin \omega_k t$ where the latter constituent represents a crossing signal, one obtains, that after going through the conversion process the intermediate frequency $\omega_0 = \omega_h - \omega_i$ is modulated to a depth M_0, which is

$$M_0 = 4M_k \frac{g_3 E_k^2}{g_1} \quad .. \quad .. \quad (18)$$

This is called the cross modulation. Taking as mentioned above $E_k = 0{,}1$ Volts, then, for the case of the diode characteristic considered $M_0 = 16$ M_k per cent., which would be a very serious cross percentage. The crossing signal amplitude to be allowed for normal use will be about ten millivolts. This same input signal amplitude will keep distortion effects low.

VII. Comparison with Other Frequency Changers

Some circuit considerations in the use of diode frequency changers will be given first. If no valve stage is used before the diode mixer the question of radiation into the antenna poses itself. Here the scheme of Fig. 1*b* affords some cure, quite similarly to the well-known cathode injection circuit with pentode mixer tubes. The oscillator voltage is divided between the diode and the input circuit.

For the higher frequencies, *e.g.*, at 1500 kc/sec, the diode is practically a capacitance for the oscillator frequency. One finds that the percentage oscillator volts on the input circuit may vary between less than one to some 50 per cent. Radiation may be made negligible by using appropriate conditions.

Of course the low input impedance of the diode circuit for the h.f. signal input (about 100 000 ohms) will in most cases preclude the use of a mixing diode as a first stage in a receiver as tapping of the antenna coil results in low amplification and a high ratio of noise to signal. Hence one will start with a h.f. amplifying stage and then use a mixing diode. As compared with one-tube-mixers, such as *e.g.* the octode (of Philips Co.), three tubes are necessary: a pentode, a diode and a triode oscillator, the latter two tubes being sometimes combined as a triode-diode. Amplification across this whole combination will be only slightly, if at all, higher than with the use of one single octode mixer tube. Of course wiring and circuit elements will make the combination more expensive than a single valve mixer.

The pentode-diode-triode combination has the slight advantage, if compared *e.g.* with an octode, that it will in general be a little more adaptable to the short wave range. The triode, if well selected, may have such a slope that oscillation, even on the shortest waves (*e.g.*, television receivers on 7 m) will cause no difficulties. Furthermore, the use of an oscillator harmonic (e.g., input h.f. signal of 7 m and oscillator on 14 m) will cause practically no loss of gain, which, in other mixing valves, is often the case. Coupling of oscillator and input circuit requires a special study of the combination on short waves.

The input signal amplitude on the diode circuit being limited in the first place by the generation of whistling notes, this limit can be shown to be much lower (some millivolts) than with octode mixers (*see* article "Whistling notes in superheterodyne receivers"). The same holds for the input signal limit for a given amount of cross modulation and distortion.

The author wishes to thank Mr. N. S. Markus for his assistance in the measurements quoted and Mr. B. D. H. Tellegen for friendly discussion, which elucidated several points dealt with above.

The Physical Society's Exhibition

Notes on Exhibits of Radio Interest

As an industry grows older its requirements become more and more exacting. Radio has now got beyond the qualitative stage and specifications of apparatus for transmission and reception must be given to a fairly high degree of precision, especially in these days of keen competition. In the past we have been content to send out and to receive signals without worrying much about their wave form, so long as reception has been satisfactory to the average ear. Nowadays the radio engineer likes to have something a little more tangible than invisible electrons chasing hither and thither, and his desires have been fully met by the remarkable progress in cathode-ray tube oscillography. For this we must thank television, which we presume may arrive in the near future, although it seems to be somewhat behind the schedule time predicted in the lay Press.

A.C. Cossor, Ltd., hold a high place in cathode-ray oscillography and at the recent exhibition organised by the Physical Society they exhibited two unique instruments which should prove of value in radio practice and research. The high vacuum portable oscillograph illustrated in Fig. 1 enables individual cycles to be investigated over the enormous frequency range 3 cycles per second to 6 megacycles per second. The upper limit of 6 megacycles can be increased to 100 megacycles by using a radio frequency oscillator as a time base. Modulated envelopes may be examined with carrier frequencies up to 500 megacycles. An amplifier is incorporated and the oscillograph is arranged for continuous or single-stroke time-base action. The amplifying valve can be used for stepping up low voltages to increase the sensitivity of the instrument to 2.4 mm. per volt at the maximum anode volts, or to a correspondingly greater sensitivity at lower voltages. Balanced or unbalanced sources may be examined and measured, and a self-calibrating circuit is incorporated, together with a calibrating viewing screen, enabling the apparatus to be used for measuring peak voltages, currents and time intervals. The wave is delineated in a beautiful actinic blue colour. The instrument is operated from the A.C. mains, is very robust, flexible and simple to operate.


Fig. 1.—*Cossor portable oscillograph*

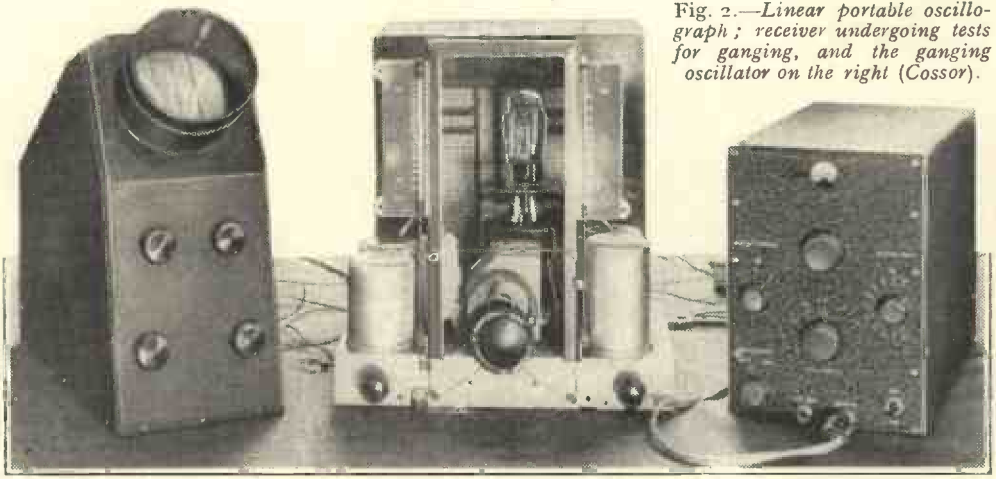


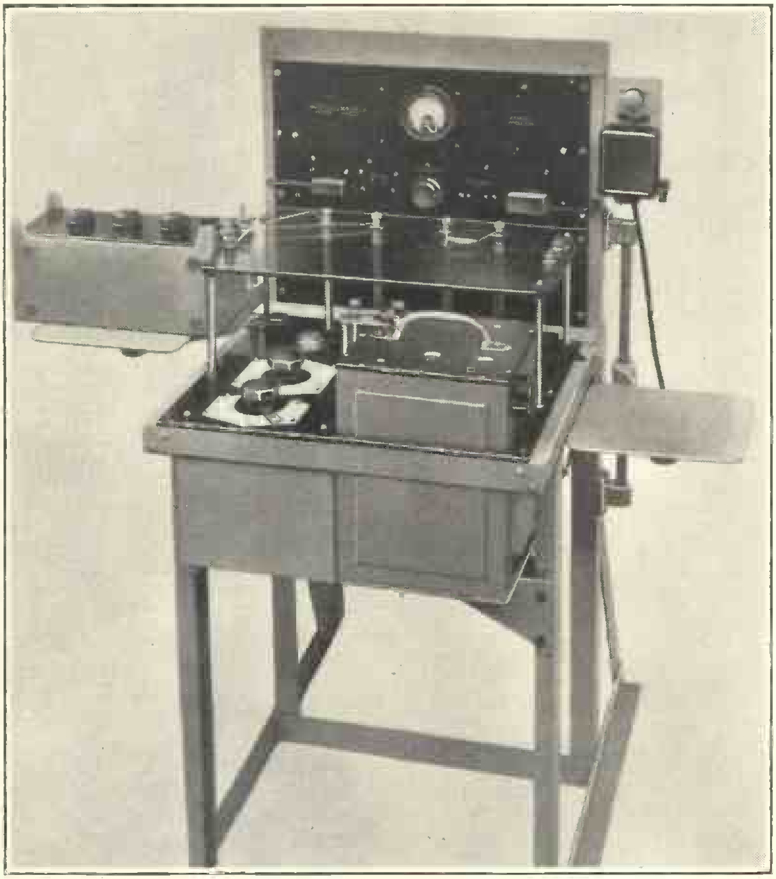
Fig. 2.—*Linear portable oscillograph; receiver undergoing tests for ganging, and the ganging oscillator on the right* (*Cossor*).

Cossor's were also showing a linear portable cathode-ray oscillograph for general laboratory and workshop use. This is illustrated on the left of

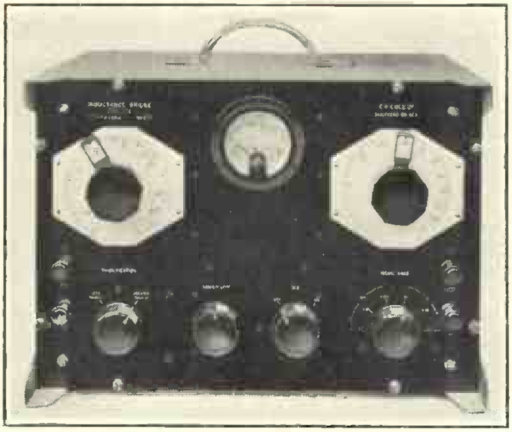
Fig. 2. The tube is housed in a Mu-metal shield, thereby screening it from stray magnetic fields, *e.g.* mains transformer. A linear time base provides a sweep of approximately one screen diameter, the velocity being variable over a range 4,000 to 1. The highest sweep frequency is about 10 kc/s. A separate terminal is provided for applying a synchronising voltage to the time base. The instrument can be used to examine output waveforms, mains ripple, modulated I.F., etc., in radio receivers. It is of value in power stations for examining wave forms of machines and transients: also for monitoring radio transmitters and for sound film work.

Another instrument by Cossor is the Ganging Oscillator shown on the right of Fig. 2. This is used in conjunction with the linear portable oscillograph for ganging the radio and intermediate frequency circuits of receivers, and for examining the resonance curves of tuned circuits. The instrument should prove invaluable in the above connection, as was admirably demonstrated to the writer. The centre unit in Fig. 2 is a radio receiver undergoing a test for correct ganging.

Leaving the pretty picture part of the exhibition, we pass on to something less spectacular, but nevertheless very essential in every branch of applied science, namely, the accurate measurement of component parts. E. K. Cole have a good range of instruments for measuring various radio components. Fig. 3 shows their precision capacity bridge which is a self-contained mains-operated instrument with a visual null indicator. Capacity measurements of 1 micromicrofarad and upwards can be made with as great an accuracy as is likely to be required in any engineering communications laboratory. To facilitate the determination of small capacities, a differential condenser is fitted which has a logarithmic scale shape. A charge of 1 $\mu\mu$F. is produced by moving the cursor about one inch at mid-scale, the range being ± 20 $\mu\mu$F. The phase balance scale is also logarithmic, and is calibrated directly in percentage power factor. Space has been allowed for a 1,400 $\mu\mu$F. precision air condenser, and the capacity range can be extended *ad lib.* by adding external standards.



(*Right*) Fig. 3.—*Precision capacity bridge (E. K. Cole).*



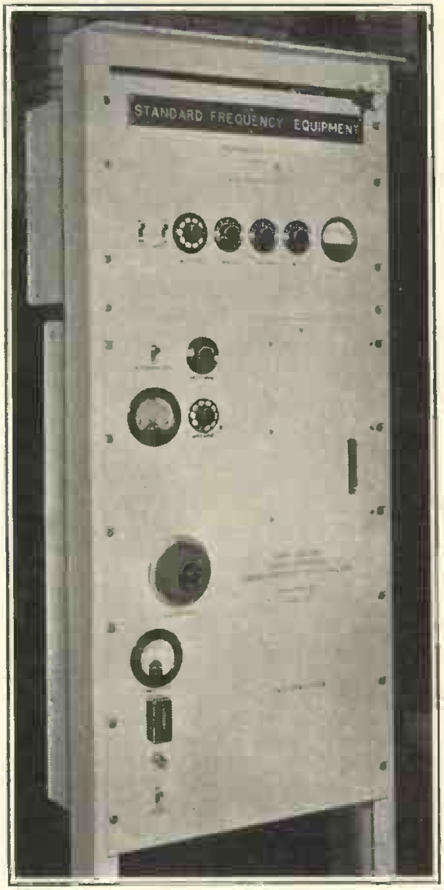
(*Below*) Fig. 4.—*E. K. Cole inductance bridge.*

E. K. Cole's bridge for measuring inductance up to frequencies of 1 megacycle is illustrated in Fig. 4. The range is from 0.05 to 50 microhenrys. The oscillator and visual-indicating detector are self-contained, and the bridge operates from the A.C. mains. A pair of equal resistance ratio arms is employed, and the comparison arms consist of a calibrated variable inductor and the test coil. A small variable inductor is included for initial balancing, whilst phase correction is accomplished by Schering method. The phase control provides for a difference of power factor between the two inductance arms of ±10 per cent. The accuracy of calibration is ±2 per cent. ±0.05 microhenry over the whole range.

The same firm have a standard signal generator, the frequency range being from 20 kc/s to 25 megacycles. It is portable and delivers either a modulated or an unmodulated signal having an amplitude adjustable from 1 μ volt to 1 volt. The instrument is worked from the A.C. mains, 200–250 volts, 40—100~. The output impedance never exceeds 52.5 ohms; the voltage accuracy is ±5 per cent. up to 5 megacycles, and at 25 m.c. it is 20 per cent. high.

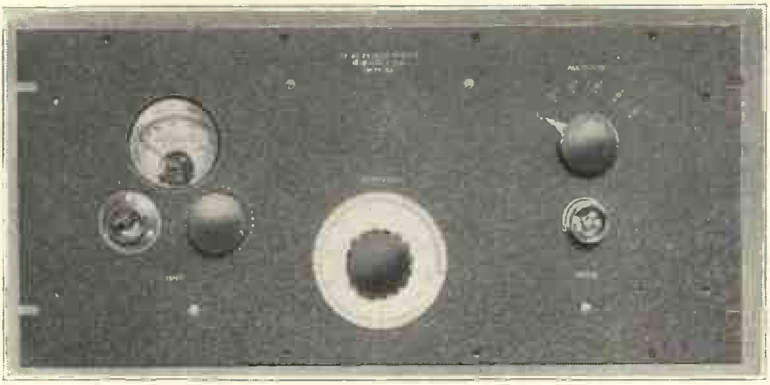
Fig. 6.—*Sullivan Heterodyne generator for use with the apparatus shown in Fig. 5.*

(*Below*) Fig. 5.—*Lucas-Sullivan crystal controlled frequency equipment.*



Sullivan's Exhibit

Sullivan's continue to produce instruments giving the highest degree of precision measurement. One of these is illustrated in Fig. 5, this being the Lucas-Sullivan crystal-controlled frequency equipment. The frequency range is from 1 kc/s to 10 megacycles. The instrument can be used as a standard wavemeter or as a control oscillator for broadcasting stations working on a common wavelength over the range 10 kc/s to 10 megacycles. The stability is 2 parts in 10^7, temperature coefficient zero, and the accuracy of adjustment to the nominal frequency is 5 parts in 10^7. The same firm also exhibited an interpolation heterodyne generator, having a stability of 1 part in 10^6, for use with the crystal-controlled frequency equipment (Fig. 6). The interpolation accuracy at a large number of definite frequencies at which synchronisation beating occurs is at least 1 part in a million. The interpolation accuracy at any other frequency is one part in a hundred thousand. The accuracy as an independent wavemeter without reference to a harmonic standard is one part in ten thousand. The instrument is fitted with direct reading harmonic scales in addition to an accurate degree scale and vernier.



(*Left*) Fig. 7.—*Radio frequency attenuator (Muirhead).*

Accurate radio frequency attenuators are few and far between. It is interesting to see that Muirhead & Co. have tackled the design problem and produced the instrument shown photographically in Fig. 7. The instrument has been checked up to 5 megacycles per second. It is calibrated directly in microvolts, the output voltage being read off in terms of a dial reading multiplied by a decimal factor which is determined by the position of a switch. The earthing conditions of component parts of the circuit have been studied carefully; as the instrument has to be used with an external source. A satisfactory design has been evolved and suitably screened couplings are available.

Muirhead & Co. also introduce a Thermionic Voltmeter, illustrated in Fig. 8. It is an attempt to produce a multi-range A.C. meter with a scale shape approximating to that of a D.C. moving coil instrument, and having at the same time an input impedance high enough to enable it to be connected across the majority of circuits without altering the conditions appreciably. A diode rectifier is employed and the rectified e.m.f. is measured using a triode as a D.C. voltmeter. The indicating instrument is a milliameter in the anode circuit of the triode from which the standing feed is backed off. Above 0.2 volt r.m.s. input to the diode, the voltage scale is sensibly linear. Range changing is obtained by tapping down a 2 megohm resistance across the diode. As this operation occurs after rectification, the frequency characteristics of the divider do not enter into the instrument calibration. The standard ranges are 0 to 2 and 0 to 10 volts.

Fig. 8.—*Muirhead's thermionic voltmeter.*

(*Below*) Fig. 9.—*Waveform equipment by Standard Telephones & Cables.*

Distortion of A.C. waveforms is a common occurrence, especially in broadcast reception. Standard Telephones and Cables exhibited a compact instrument (Fig. 9) by means of which the degree of distortion of a pure sine input can be measured. The instrument is a tuned four-arm bridge type. The ratio arms are resistances, whilst the balance arms are a resistance, and a variable inductance with capacitance in series, respectively. The out-of-balance current is passed on to an amplifier by means of a transformer. The frequency range is 20~ to 3,000~. The tuned arm is set to balance out the fundamental, so that the out-of-balance current represents the harmonics. Another measurement gives the relative strength of the fundamental plus harmonics, so the percentage harmonic content can be found.

The Marconi Co. exhibited a very compact form of ultra short wave signal generator, which is shown in Fig. 10. In view of the increasing use of ultra short waves, this instrument should be a boon to many. It consists of two units (*a*) the generator, and (*b*) the battery supply. The output control is calibrated in decibels and gives continuous variation of the output voltage. The output impedance (resistive) is variable in fixed steps up to a maximum of about 10 ohms. This feature, together with provision for the use of a rod aerial, into which known voltages can be introduced, makes the generator very flexible. The wave range is from 20 to 100 megacycles and the voltage output from 0.002 to 150 millivolts.

Marconi's also showed the aircraft equipment of Fig. 11, which has been specially designed for use on the smaller types of civil, military and naval aircraft, where space is restricted or service requirements preclude the use of a larger power equipment. Features of the design are as follows: Transmitter and receiver have quick-release shock absorbers. The transmitter has a special circuit with two multi-electrode valves in parallel which act as master oscillator, power magnifier and modulator. Provision is made for rapid wave selection. Telegraphy is conducted by C.W. or I.C.W., and there is also radio telephony. The wave range of the transmitter is continuous from 800 to 1,000 metres, whilst there is an alternative fixed wavelength of 600 metres. The receiver covers the continuous band 600 to 1,200 metres. The range is 150–180 miles for air to ground telephony, 150 to 200 miles air to ground I.C.W., and 200 to 300 miles air to ground telephony.

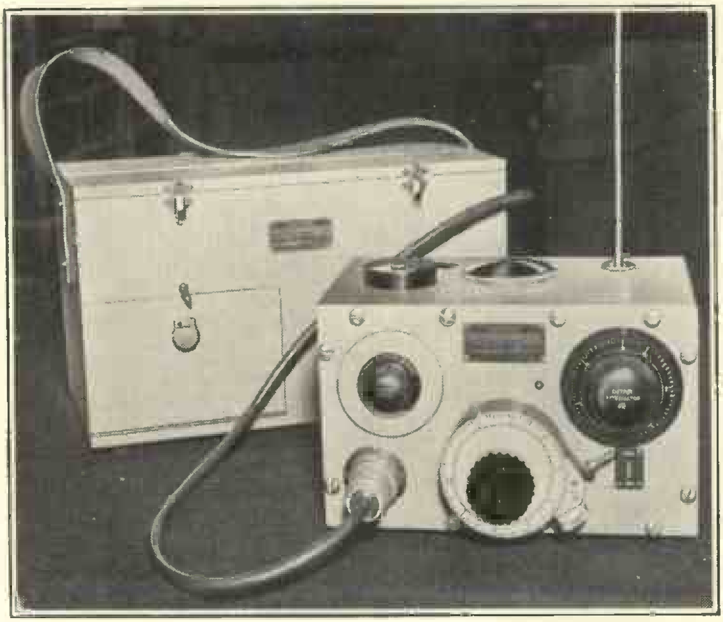


Fig. 10.—*Ultra short wave signal generator (Marconi).*

Ediswan exhibited valves specially designed for ultra short wave transmission and they can be worked at the full rated dissipation up to 60 megacycles. This is rendered possible by the special form of construction, the anode and grid being brought out in both cases to separate contacts at

Fig. 11.—*Marconi aircraft equipment designed for use where compactness is important.*

Fig. 12.

Ediswan E.S.W. 501 valve for use in ultra short wave transmitters.

the top of the glass envelope as shown in Fig. 12. By virtue of the use of Morganite anodes, the bulb dimensions have been kept small for the power capacity, and as the envelope becomes quite hot, free air circulation is necessary. The specifications of two of these special valves are tabulated below.

The same firm also showed the ES100 power valve with Morganite anode and carbonised thoriated filament. The amplification factor is 5.5, max. dissipation 100 watts at 1,000 volts, impedance 1,750 ohms, optimum load 7,000 ohms and A.C. power output 30 watts.

	E.S.W. 501	E.S.W. 204
Filament volts	6	11
Filament current	4 amp.	6.5 amp.
Max. anode voltage	1,500	2,000
Anode impedance	10,000 ohms	9,000 ohms
Amplification factor	15	20
Max. dissipation	60 watts	250 watts
Filament emission	1 amp.	2 amp.

Electrical Units

Intended Substitution of the Practical Absolute System for the Existing International System

FOLLOWING a revision in 1921 of the International Treaty known as the Convention du Mètre, under which at present 32 nations co-operate in the maintenance of the international prototype standards of the metre and kilogramme, the Conférence Générale des Poids et Mesures in 1927 gave authority to the Comité International des Poids et Mesures to take up also the question of electrical units. An advisory electrical Committee, including representatives of the principal National Laboratories, was appointed, and acting on the advice of this Committee, the International Committee in 1933 recommended, and the Conférence Générale of that year approved in principle, the eventual substitution of the Practical Absolute System of electrical units for the present "International" system. The Conférence further instructed the Comité International to take the necessary steps to give effect to this decision.

At its meeting in October, 1935, the Committee decided that the work on the subject which has been in progress for so many years in the various National Laboratories had reached a stage at which it was possible to fix a date for the change, and authorised the publication of the following statement, (translated from the original French text) :—

"1. In accordance with the authority and responsibility placed upon it by the General Conference of Weights and Measures in 1933, the International Committee of Weights and Measures has decided that the actual substitution of the absolute system of electrical units for the international system shall take place on the 1st January, 1940.

"2. In collaboration with the national physical laboratories, the Committee is actively engaged in establishing the ratios between the international units and the corresponding practical absolute units.

"3. The Committee directs attention to the fact that it is not at all necessary for any existing electrical standard to be altered or modified with a view to making its actual value conform with the new units. For the majority of engineering applications the old values of the international standards will be sufficiently close to the new for no change, even of a numerical nature, to be required. If for any special reason a higher precision is necessary numerical corrections can always be applied.

"4. The following table gives a provisional list of the ratios of the international units to the corresponding practical absolute units, taken to the fourth decimal place. Since differences affecting the fifth decimal place exist between the standards of the international units held by the various national laboratories and also because all the laboratories which have undertaken determinations of the values of their standards in absolute measure have not yet obtained final results, the Committee does not consider it desirable for the present to seek a higher precision. At the same time it hopes that it will be possible to extend the table of these ratios with a close approximation to the fifth decimal place well before the date fixed for the actual substitution of the practical absolute system for the international system."

TABLE

1 ampere	international	=	0.999 9 ampere	absolute
1 coulomb	,,	=	0.999 9 coulomb	,,
1 ohm	,,	=	1.000 5 ohm	,,
1 volt	,,	=	1.000 4 volt	,,
1 henry	,,	=	1.000 5 henry	,,
1 farad	,,	=	0.999 5 farad	,,
1 weber	,,	=	1.000 4 weber	,,
1 watt	,,	=	1.000 3 watt	,,

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

407. ULTRA-SHORT WAVES: DISTANT RECEPTION [Transatlantic and other Long-Distance Signals]—BEHAVIOUR OF THE IONOSPHERE [particularly the Lowest E Region]—ANGLE OF DESCENT [of Short Waves]—ETC.—R. A. Watson Watt. (*Electrician*, 6th Dec. 1935, pp. 715–716.) Based on part of Chairman's Address to I.E.E. Wireless Section. See *Journ. I.E.E.*, January, 1936, pp. 10–17.

408. ULTRA-SHORT-WAVE RECEPTION AT LONG DISTANCES [Results with the Witzleben Television Transmissions].—R. Theile. (*Funktech. Monatshefte*, September, 1935, No. 9, p. 343.)

409. 5-METRE LONG-DISTANCE TRANSMISSIONS [American Results].—(*World-Radio*, 22nd Nov. 1935, p. 16.) A letter prompted by Appleton's article (11 of January).

410. ON TEN METRES [Recent Long-Distance Amateur Results on Very Short Waves].—(*World-Radio*, 29th Nov. 1935, p. 16.)

411. THE IONOSPHERE [Ultra-Short-Wave Propagation "Types A and B"—connected with "Intense E Layer" and "G" Region respectively: Question of Anomalous Ionisation of F Region: etc.].—E. J. Alway. (*World-Radio*, 4th Oct. 1935, p. 15.)

412. ANOMALIES IN SHORT-WAVE TRANSMISSION [and the Effect of the "Intense E Region": Absorption- and Electron-Limitation: Atmospheric Heating accompanying Magnetic Storms: etc.].—E. V. Appleton. (*World-Radio*, 11th Oct. 1935, p. 13.) *See* also 1 of January.

413. THE IONOSPHERE, SUNSPOTS, AND MAGNETIC STORMS [Recent Experimental Data].—S. S. Kirby, T. R. Gilliland, E. B. Judson and N. Smith. (*Phys. Review*, 15th Nov. 1935, Series 2, Vol. 48, No. 10, p. 849.)

A note on ionospheric observations during October, 1935, at the end of which month there was a period of very high ionisation of F$_2$ region coinciding with a period of high sunspot activity and a series of magnetic disturbances. The day of greatest magnetic disturbance was however a day of low critical frequencies, poor transmission conditions, and great virtual height of F$_2$ region. No unseasonable conditions were observed for E or F$_1$ regions. The results "indicate the probability that some agency, acting during magnetic storms, heats the F$_2$ region to values abnormal for the season, causing the atmosphere there to expand, and in this manner reduces the ionisation density and increases the virtual height of this region" [*cf.* Appleton, 1 of Jan. and 2920 of 1935]. Sunspot activity appears to increase the ionisation density of F$_2$ region.

414. TRANSATLANTIC LONG-WAVE RADIO-TELEPHONE TRANSMISSION AND RELATED PHENOMENA FROM 1923 TO 1933.—A. Bailey and H. M. Thomson. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 680–697.)

"A correlation is presented between terrestrial magnetic activity, sunspot-numbers, solar limb-prominences, ultra-violet radiation, and transatlantic long-wave radio-telephone field strength observations during one 11-year sunspot cycle. By expressing the variables with different scales, better correlations have been obtained . . . Examples of delayed night and day field-strength changes accompanying long magnetic storms are included . . ." The questions of correlation with weather and with meteor showers are also discussed: "the authors favour the hypothesis that local weather storms are more a symptom of disturbed conditions in higher regions. The same could be said of earth currents. However, since reflection probably occurs at the surface of the earth one or more times on the transatlantic path . . . signals using these paths probably encounter surface weather conditions and earth current influences at least three times." "Evidence for major changes in field strength at times of meteoric activity apparently is lacking in our data."

415. YEARLY VARIATION OF SHORT-WAVE FIELD STRENGTH—PART I [Connection with Yearly Average of Number of Sunspots].—T. Nakai and K. Endo. (*Nippon Elec. Comm. Engineering*, September, 1935, No. 1, pp. 85–86: in English: summary in *Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts p. 12.)

" That the hours of imperceptibility, due to large attenuation in the day, remain practically unchanged year after year, and that waves reflected from the F layer were stronger in the year of more numerous sunspots, 1934, than in 1933, are new facts which may supply an important key . . .".

416. A NEW RADIO TRANSMISSION PHENOMENON [54-Day Wipe-Out: Amateur Reports: Collaboration Requested].—K. B. Warner: Dellinger. (*QST*, December, 1935, Vol. 19, No. 12, pp. 21, 29.) *See* also 2 of January.

417. COSMIC AND GOVERNMENTAL PHENOMENA [Criticism of Dellinger's " 54-Day " Wipe-Out Phenomenon and of Federal Regulations regarding Automatic Apparatus].—H. R. Mimno: Dellinger. (*Science*, 29th Nov. 1935, p. 516.) *See* 2 of January.

418. INVESTIGATIONS AND PROBLEMS OF THE IONOSPHERE [General Account: Formula for Variation of Ionisation with Height: Curves calculated for Various Absorption Assumptions].—A. Thoma: Elias. (*E.T.Z.*, 3rd Oct. 1935, Vol. 56, No. 40, pp. 1085–1087: Discussion pp. 1109–1111.)

A short account of a lecture by Elias, referring first to experiments at Delft (Abstracts, 1933, p. 496—Elias, von Lindern & de Vries); a short description is then given of theoretical work on reflection of waves from an ionised region (1931, pp. 315, 373—Elias) which leads to an expression (eqn. 9) and curves (Fig. 5) for the variation of atmospheric ionisation with height. The points of inflexion on curves II and III provide a possible explanation of reflection of waves between 40 and 100 m, absence of reflection from 150 to 200 m, and reflection of still longer waves. Elias does not believe that nocturnal ionisation is a continuation of that occurring during the day, but finds a gap to explain which new nocturnal causes of ionisation must be assumed. *See* 419, below.

419. [Review of] IONOSPHERIC INVESTIGATIONS AND PROBLEMS.—G. J. Elias. (*E.N.T.*, October, 1935, Vol. 12, No. 10, pp. 318–325.) The full paper, a summary of which is dealt with in 418, above. *See* also de Bruine, 2560 of 1935.

420. THEORY OF THE IONOSPHERE.—E. O. Hulburt. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, p. 31: abstract only.)

The full paper appears in *Journ. Terrestrial Mag. & Atmos. Elec.*, Vol. 40, 1935, pp. 193–200. " There is an apparent difficulty in accounting for permanent, or quasi-permanent, banks of ionisation at or above 250 km, as F and F_2 appear to be. Calculation indicates that diffusion would prevent the formation of ionised strata much above 220 km. If they actually exist at greater heights, probably the present tables of air-densities in these levels, or the recombination-formulae, among other possibilities, may require modification."

421. CONTRIBUTION OF THE COSMIC RADIATION TO THE IONISATION OF THE UPPER ATMOSPHERE.—T. H. Johnson. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 35–37.)

Taking 300 ions/cc/sec/atmos. as a " good estimate of the intensity of cosmic radiation at all points in the ionosphere," the writer concludes that " the cosmic-ray contribution to the conductivity of the upper atmosphere is negligible compared with that from other sources." *Cf.* Lenz, 382 of 1935.

422. FREQUENCY OF COLLISIONS IN THE IONOSPHERE [Reply to Criticisms: Graphical Example].—T. L. Eckersley. (*Nature*, 14th Dec. 1935, Vol. 136, p. 953.) *See* 2158 of 1935.

423. THE INFLUENCE OF A MAGNETIC FIELD ON THE HIGH-FREQUENCY CONDUCTIVITY OF AN IONISED MEDIUM.—E. V. Appleton and D.B. Boohariwalla. (*Proc. Phys. Soc.*, 1st Nov. 1935, Vol. 47, Part 6, No. 263, pp. 1074–1084.)

Authors' summary:—The relation between the transverse high-frequency conductivity and the pressure of ionised air under the influence of an imposed magnetic field has been studied experimentally. The pressure at which such conductivity is a maximum is found to vary with the intensity of the magnetic field as is to be expected on theoretical grounds if the high-frequency conductivity is due solely to electrons. The significance of the results in connection with ionospheric conductivity is discussed.

424. STUDIES ON THE HIGH-FREQUENCY CONDUCTIVITY OF RAREFIED IONISED GASES [and the Question of Plasmoidal Resonance].—Y. Asami. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 67, p. 910: Japanese only.)

425. REPORT ON THE PRESENT STATE OF OUR KNOWLEDGE OF THE IONOSPHERE.—S. K. Mitra. (*Proc. Nat. Inst. Sci. India*, No. 3, Vol. 1, 1935, pp. 131–215.)

426. THE IONISATION OF THE EARTH'S UPPER ATMOSPHERE [Survey].—L. V. Berkner. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 20–26.)

427. MEASUREMENTS OF THE HEIGHTS OF THE KENNELLY-HEAVISIDE LAYER IN JAPAN—IV. FROM APRIL, 1934, TO MARCH, 1935.—T. Minohara and Y. Ito. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, pp. L-17—L-50.)

428. AUSTRALIAN RADIO RESEARCH BOARD—7TH ANNUAL REPORT [for Year ended 30th June, 1935]: WORK ON FADING AND THE IONOSPHERE.—(*Journ. of Council for Sci. and Indust. Res.*, Australia, November, 1935, Vol. 8, No. 4, pp. 253–258.)

Lateral deviation of downcoming rays: instance of correlation between polarisation and direction of arrival, agreeing with theory regarding influence of earth's magnetic field on limiting polarisation of downcoming ray (Baker & Green, Abstracts, 1933, p. 614): comparison between modulation-frequency-change methods (ordinary, requiring double detection, and new, with carrier suppressed at transmitter: *see* 429, below) and the original carrier-frequency-change method: the suppressed-carrier technique and its application to fading control in long-distance communication as well as in ionospheric research: practical tests on telegraphy: possible application to telephony by use of supersonic corrective modulation: etc.

429. Modulation-Frequency-Change Technique for Ionospheric Measurements.—G. Builder and A. L. Green. (*Proc. Phys. Soc.*, 1st Nov. 1935, Vol. 47, Part 6, No. 263, pp. 1085–1097.)

"A critical examination of Appleton's suggestion that the carrier-frequency-change technique should be modified by varying the frequency of modulation instead of the carrier frequency." A suppressed-carrier modification is discussed and found to have marked advantages over the modulation-frequency-change device. Experimental results are given and conclusions are drawn as to the interpretation of the number and amplitude of the fringes produced. *See* also 428 above.

430. A Receiver discriminating between Right- and Left-Hand Circularly Polarised Wireless Waves.—O. O. Pulley. (*Proc. Phys. Soc.*, 1st Nov. 1935, Vol. 47, Part 6, No. 263, pp. 1098–1116.)

From the author's summary:—The principle employed is that of an effectively rotating loop, the rotation being simulated by the modulation in phase quadrature of two loops at right angles. The theory of operation, the errors and the method of adjustment are investigated. Adjustment can be made with the aid of a test wave of unknown polarisation. Some results obtained with the apparatus are discussed, and it is concluded that the two magneto-ionic components are almost circularly polarised and that the relative intensities are unpredictable unless the complete (P',f) curve appropriate to the time of observation is available. A Fourier-series treatment of the propagation of a pulse of energy of radio frequency in the ionosphere is given in an appendix.

431. Contribution to the Study of the Propagation of Short Waves.—Niculesco. (*See* 800.)

432. Conditions in the Upper Atmosphere as indicated by a Study of Meteor-Trains.—C. P. Olivier. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 32–34.)

The writer ends: "Of one conclusion we can be absolutely certain, however: meteor-trains prove that wind velocities between 100 and 300 km/hr are the usual and not the exceptional thing for that stratum in which the long-enduring trains appear at night, and there is good evidence of vertical as well as horizontal motion. . . ."

433. The Nature of the Transition from Troposphere to Stratosphere, and Upper-Air Temperatures over India in the Winter and Hot Season.—M. W. Chiplonkar. (*Current Science*, Bangalore, October, 1935, Vol. 4, No. 4, pp. 232–234.)

434. Further Ozone-Measures and Their Connection with the Sunspot-Cycle.—F. E. Fowle. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 164–165.) For previous work *see* 1321 of 1935.

435. Ultra-Violet Solar Radiation and Atmospheric Ozone.—E. Pettit. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 37–38.)

436. The Absorption of Light in the Atmosphere and Its Relation to Atmospheric Ozone [and the Indication of Presence of an Oxide of Nitrogen].—O. R. Wulf. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, p. 20: summary only.)

437. A New Afterglow Spectrum in Nitrogen [Intense Components Vegard-Kaplan Bands from Metastable Molecule].—J. Kaplan. (*Phys. Review*, 15th Nov. 1935, Series 2, Vol. 48, No. 10, pp. 800–801.)

438. The Aurora and Night-Sky Spectra and the Upper Atmosphere—Report of Recent Work [including the Estimation of Temperature].—L. Vegard. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 38–40.)

439. Correlations of Auroral and Magnetic Activity at Little America, First Byrd Antarctic Expedition.—C. C. Ennis. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 165–168.)

440. Auroral Observations at Point Barrow, Alaska, during the International Polar Year.—C. J. McGregor. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 147–151.)

441. Radiation and Reflection Problems of Radio-Telegraphy [Thesis].—P. G. Violet. (At Patent Office Library, London: Cat. No. 75609: in German.)

442. Rolf's Graphs to Sommerfeld's Attenuation Formula.—S. R. Khastgir: Norton. (*Current Science*, Bangalore, September, 1935, Vol. 4, No. 3, p. 155.)

"It is necessary to test how far this error [pointed out by Norton —*see* 2538 of 1935] would vitiate the attenuation curves drawn by Rolf. . . . So far as we can test Rolf's attenuation curves within the range of validity of the empirical formulae [Norton, van der Pol], the error . . . does not appear to alter these curves materially, at least for very short distances from the transmitter. Whether the peculiar features in Rolf's graphs, *viz.* the negative attenuation and the 'dips,' exist according to Sommerfeld's theory cannot, however, be ascertained from Norton's formula. Fresh mathematical investigation is necessary to test these points."

443. THE PROPAGATION OF ELECTROMAGNETIC WAVES IN HETEROGENEOUS CIRCUITS [containing "Concentrated" and "Semi-Concentrated" Elements as well as "Uniformly Distributed" Elements: Investigation with Cathode-Ray Oscillograph: Theoretical and Practical Conclusions].—S. Teszner. (*Rev. Gén. de l'Élec.*, 23rd, 30th Nov. and 7th Dec. 1935, Vol. 38, Nos. 21, 22 and 23, pp. 695–708, 723–737, and 763–777.)

444. THE QUASI-STATIONARY PROPAGATION OF ALTERNATING CURRENT IN THE EARTH BETWEEN TWO CIRCULAR ELECTRODES LYING IN THE EARTH'S SURFACE AND WITH CONSTANT DENSITY OF CURRENT FLOW IN AND OUT.—Buchholz. (*See* 581.)

445. THE CORRELATION OF DEEP-FOCUS EARTHQUAKES WITH LUNAR HOUR ANGLE AND DECLINATION.—H. T. Stetson. (*Science*, 29th Nov. 1935, pp. 523–524.)

446. COMPRESSIONAL WAVES IN MEDIA WITH COMPLEX VISCOSITY [Theory: Decrease of Attenuation Factor and Increase of Propagation Velocity with Frequency: Characteristic Frequency, Reciprocal of Relaxation Constant, divides Ranges of Vibration as Liquid and as Crystal].—A. Gemant. (*Physics*, November, 1935, Vol. 6, No. 11, pp. 363–365.)

447. ON SOME GRAPHICAL SOLUTIONS OF AIR LINE [Great Circle] PROBLEMS.—(*See* 582.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

448. AUSTRALIAN RADIO RESEARCH BOARD—7TH ANNUAL REPORT: WORK ON ATMOSPHERICS.—(*Journ. of Council for Sci. and Indust. Res.*, Australia, November, 1935, Vol. 8, No. 4, pp. 258–262.)

Wave-form (378 of 1935): polarisation, and its use to deduce mean height of point of origin (values comparable with mean height of observed lightning flash): "equivalent power" of a flash: properties of sources: thunderstorm areas of the world: interference with broadcast reception (degree-of-interference contours correspond closely with isobronts, for high signal amplitudes, and nearly with parallels of latitude, for very low signal amplitudes): meteorological aspects: "sea" sources (usually distinguishable from "land" sources by long duration of atmospherics, generally of the order of a second): etc.

449. COMPARATIVE INVESTIGATIONS OF BROADCAST DISTURBANCES [Atmospherics] OF LONG AND SHORT DURATION.—H. Norinder and R. Nordell. (*E.N.T.*, October, 1935, Vol. 12, No. 10, pp. 305–317.)

For previous work and preliminary investigations *see* Abstracts, 1930, p. 581; 1932, pp. 518–519; and 2182 of 1935. Here, the theory of the *E*- and *dE/dt*-methods of recording atmospheric wave-forms is first discussed and the practical advantages and disadvantages of the methods compared. It is found that the *E*-method must be used for disturbances of "long" duration (of the order of milliseconds), while the *dE/dt*-method is suitable for "short" disturbances (of the order of tenths of a millisecond). The paper is chiefly concerned with the division of atmospherics into these two types and with estimates of their total duration. The arrangements for the experiments are described; horizontal receiving antennae were used. Measurements were first made to show that the wave-forms obtained directly by the *E*-method and those found from the *dE/dt*-method by integration agreed (Fig. 6). Typical oscillograms obtained by the *dE/dt*-method (Fig. 7) and the *E*-method (Fig. 8) are shown: Fig. 9 gives types of wave-forms obtained by integration of *dE/dt*-oscillograms. The most common duration of the *dE/dt*-oscillograms were 100–200 μsec in the period August/December 1934 and 200–300 μsec during January/April 1935. Oscillograms of slow disturbances obtained by the *E*-method (Fig. 10) show that high-frequency oscillations are superposed on them. The number of slow disturbances was only 2 to 3% of that of the rapid ones. Fig. 11 shows types of slow disturbances and Fig. 12 the percentage variation of their duration. Fig. 13 shows slow disturbances with superposed high-frequency oscillations of large amplitude at the beginning. Fig. 14 gives the percentage distribution of the total period of these superposed oscillations and Fig. 15 the distribution of period duration in the *dE/dt*-curves.

450. RELATION BETWEEN THUNDERSTORMS AND ATMOSPHERICS IN SOUTH AFRICA [Bearings of Thunderstorms agree with Atmospherics: Correlation of Atmospherics over Sea with Depressions].—D. B. Hodges and B. F. J. Schonland. (*Roy. Soc. South Africa*, 16th Oct. 1935: *Nature*, 28th Dec. 1935, Vol. 136, p. 1039: reference only.)

451. PROGRESSIVE LIGHTNING—II.—B. F. J. Schonland, D. J. Malan and H. Collens. (*Proc. Roy. Soc.*, Series A, 15th Nov. 1935, Vol. 152, No. 877, pp. 595–625.)

For I *see* 1934 Abstracts, p. 262. "The present paper is concerned with further studies in the same field with improved technique and apparatus." 95 flashes with the Boys and other cameras were studied and "a general account . . . is given of the mode of development of the lightning discharge. A statistical study is made of the distribution of the strokes of a discharge in respect of number, time-interval, intensity, and manner of branching." The leader-return-stroke sequence was present in almost all the cases examined. An account is given of the nature of the stepped leader.

452. INTERMITTENT LIGHTNING DISCHARGES: A REDISCUSSION OF DR. H. H. HOFFERT'S LIGHTNING PHOTOGRAPH.—B. Walter. (*Phil. Mag.*, December, 1935, Series 7, Vol. 20, No. 137, pp. 1144–1155.)

The photograph in question was published in *Phil. Mag.*, Series 6, Vol. 28, p. 106, 1889, and is here reproduced. It is further investigated with special reference to the order of occurrence of the various strokes; the writer concludes that a remarkable shifting of the flash from the channel of the heaviest stroke occurred, but that the flash later returned to this channel.

453. [Estimates of] Lightning Stroke Currents.—P. L. Bellaschi. (*Nature*, 14th Dec. 1935, Vol. 136, p. 961 : note on recent paper at American I.E.E. Convention.)

454. Discharge Currents in Distribution Arresters [Max. Recorded 17 000 A (Negative) and 14 000 A (Positive) : "Expectancies" for Various Current Values : etc.] *and* Lightning Protection of Distribution Transformers [with Relation between Thunderstorm Days and Circuit Outages, etc.].—McEachron and McMorris : Flanigen. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1395–1399 : 1400–1405.)

455. The Effect of Impulse Wave Principal Parameters on the Form and Dimensions of Klydonograms.—J. K. Fedtchenko. (*Elektrichestvo*, No. 21, 1935, pp. 40–45 : in Russian.)

456. Magnetic and Electric [including Ionospheric] Investigations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, April 1934 to March 1935 [with List of Publications].—J. A. Fleming. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 195–197.)

457. Meteorological Periods and Solar Periods, *and* The 27-Day Period in Temperature-Data.—H. H. Clayton : K. F. Wasserfall. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 158–160 : 161–162.)

458. Papers on the Aurora.—(*See* 437/440, under "Propagation of Waves.")

459. Contribution of the Cosmic Radiation to the Ionisation of the Upper Atmosphere.—Johnson. (*See* 421).

460. [Lopsidedness of] the Earth's Magnetic Field [and Its Extension into Space for at least 10 000 Miles : Deductions from Cosmic-Ray Data].—R. A. Millikan. (*Nature*, 21st Dec. 1935, Vol. 136, p. 982 : short note on recent paper : *Sci. News Letter*, 30th Nov. 1935, p. 340.)

461. Earth-Magnetic Analysis of the Primary Cosmic Radiation.—T. H. Johnson. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 171–175.)

462. Extraterrestrial Effects of the Cosmic Rays [Suggested Investigation].—F. Zwicky. (*Helvetica Phys. Acta*, Fasc. 6, Vol. 8, 1935, pp. 515–516 : in German.)

463. Cosmic Rays and Nova Herculis [No Connection Proved].—E. G. Steinke. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 791–794 : report on experiments by Hess & Steinmaurer, O'Brolchain, Schonland & Delatizky, and Nie.)

464. The Solar Component of Cosmic Radiation [Existence not proved].—J. Barnóthy and M. Forró. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 789–791.)

465. Measurements of the Cosmic Radiation in the Stratosphere with a Triple Coincidence Apparatus [up to 37.5 mm Hg Pressure : Maximum at 100 mm, Hump at 300 mm].—G. Pfotzer. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 794–795 : preliminary communication.)

466. [Reasons for Equality in Numbers of] Positive and Negative Ions in the Primary Cosmic Radiation.—H. J. Walke. (*Nature*, 26th Oct. 1935, Vol. 136, p. 681.)

467. The Sign and Nature of the Ultra-Penetrating Particles in Cosmic Radiation [Positive and Negative Electrons in Comparable Proportion : Some Other Positive Particles].—L. Leprince-Ringuet. (*Comptes Rendus*, 9th Dec. 1935, Vol. 201, No. 24, pp. 1184–1187.)

468. Heavy Particles from Lead [Long-Range Particles on Cosmic-Ray Shower Photograph not due to Radioactive Contamination].—J. C. Street, E. G. Schneider and E. C. Stevenson. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p. 463.)

469. Absorption of Electrons [from Cosmic-Ray Photographs : Three Energy Groups].—S. H. Neddermeyer and C. D. Anderson. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p. 586 : abstract only.)

470. Conservation of Direction in the Impact of High Energy [Cosmic-Ray] Particles [Perpetuation of Direction of Primary Cosmic Rays by Secondaries : Theoretical Investigation].—W. F. G. Swann. (*Journ. Franklin Inst.*, September, 1935, Vol. 220, No. 3, pp. 373–376.)

471. The Corpuscular Theory of the Primary Cosmic Radiation [Extended Theory harmonising Experimental Facts].—W. F. G. Swann. (*Phys. Review*, 15th Oct. 1935, Series 2, Vol. 48, No. 8, pp. 641–648.)

472. The Effect of Primary Cosmic-Ray Energy upon Burst Production [Experiments with Vertical and Inclined Rays confirm the View that Intensity of Burst Production is a rapidly Increasing Function of the Energy of the Primary Cosmic Rays].—W. F. G. Swann and D. B. Cowie. (*Phys. Review*, 15th Oct. 1935, Series 2, Vol. 48, No. 8, pp. 649–651.)

473. Contribution to the Problem of [Cosmic Ray] Showers.—Bernardini and Bocciarelli. (*La Ricerca Scient.*, 15/31 Aug. 1935, 6th Year, Vol. 2, No. 3/4, pp. 83–90.)

474. Experimental Investigations on the Ionisation Collisions in Cosmic Radiation [Gas in Chamber plays Subordinate Part : Barometer Effect and Diurnal Variation].—A. Gastell. (*Zeitschr. f. Physik*, No. 7/8, Vol. 97, 1935, pp. 414–435.)

475. The Efficiency of the Tube Counter [Theory taking Account of Electrical Behaviour of Counter and Random Arrival of Particles].—S. M. Skinner. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, pp. 438–447.)

476. Geiger-Müller Counter with "Scale-of-Two" Thyratron Recording Circuit.—D. P. Le Galley. (*Review Scient. Instr.*, September, 1935, Vol. 6, No. 9, pp. 279–283.) For the "scale of two" counter *see* Wynn-Williams, 1932 Abstracts, p. 535.

477. Wilson Cloud Chambers with an Increased Time of Sensitivity.—J. A. Bearden. (*Review Scient. Instr.*, September, 1935, Vol. 6, No. 9, pp. 256–259.)

478. Apparatus with New Compensation Arrangement for Simultaneous Measurement of Ionisation Collisions and the Intensity of Cosmic Radiation [Two Rotating Condensers adjust Current].—A. Gastell. (*Zeitschr. f. Physik*, No. 7/8, Vol. 97, 1935, pp. 403–413.)

479. Use of Ultra-High Frequencies in Tracking Meteorological Balloons, *and* The Radio-Meteorograph Project of Blue Hill Observatory, Harvard University.—A. E. Bent : K. O. Lange. (*Trans. Am. Geophys. Union*, 16th Meeting, April, 1935, pp. 141–144 : 144–147.)

PROPERTIES OF CIRCUITS

480. A New Conception of "Pull-In" (Mitnahme) Phenomena.—Z. Jelonek. (*Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, pp. 164–171 : *Przeglad Radjotechniczny*, Vol. 13, p. 37, 1935.)

The theme of this paper is the physical action of the valve in altering the oscillation frequency of a circuit when an external e.m.f. is introduced *via* the grid. The path of the working point along the characteristics is considered, first (§ 1) in the case of an ideal dynatron with straight parallel characteristics, regarded as a two-terminal impedance in parallel with the resonant circuit. The imaginary part of the impedance depends on the external e.m.f., detunes the circuit and makes it oscillate in the frequency of the external e.m.f. In § 2 a real dynatron with non-linear characteristics is discussed theoretically by the integral method of Groszkowski (1933 Abstracts, p. 564). The effect of the external e.m.f. is to make the working point describe a closed circuit of non-zero area (eqn. 1); evaluation of the integral shows how the frequency depends on the area and on the harmonics of the voltage in the resonant circuit (eqn. 6). The calculation can also be applied to the study of frequency division (§ 3). The possibility of using any circuit for synchronisation or frequency division can thus be decided from a determination of the path of the working point along its characteristics. In § 4 the introduction of the external e.m.f. into (a) the anode circuit, (b) the resonant circuit, is similarly considered; § 5 deals with the synchronisation of triode oscillators in (a) the grid or anode circuit, (b) the resonant circuit. An example of a dynatron with secondary emission is given in § 6; an experiment to illustrate the small effect of harmonics on "mitnahme" phenomena is discussed in a supplement. The amplitude of the oscillations is assumed constant throughout.

481. [Theoretical] Contribution to the Study of the Synchronisation of Oscillators [Decay Coefficients and Amplitude Relations].—J. Mercier. (*Comptes Rendus*, 18th Nov. 1935, Vol. 201, No. 21, pp. 949–951.)

From the differential equations for oscillations in two coupled circuits the writer deduces that simultaneous production of two oscillations of different frequencies is only possible if the decay coefficients of the oscillators are separately zero, and finds relations giving the current amplitudes. *See* also 482.

482. Determination [from Circuit Equations] of the Region of Synchronisation of Two Oscillators [Increase of Power of More Powerful Oscillator increases Synchronisation Range, of Less Powerful Oscillator decreases It].—J. Mercier. (*Comptes Rendus*, 2nd Dec. 1935, Vol. 201, No. 23, pp. 1104–1106.) *See* also 481.

483. The Non-Linear Theory of Self-Excited Electric Oscillators.—R. Usui. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, pp. 39–68 : in English.)

"For the basic theory of all kinds of self-excited oscillators, the writer is confident that this paper gives the correct solutions. The determination of amplitude, the solution of transient state problems, the exact expression of the frequency with its variation mechanism, and the wave form, all receive rigorous treatment by both analyses and graphs. By means of the standard graphical solution herein established, the treatment of relaxation oscillators, which hitherto had been ambiguous, is now also standardised. With these fundamental theories, many further details of all the various kinds of oscillators can be investigated thoroughly and with ease, while it should be easy to enlarge the scope of their practical applications." *See* also 78 of January.

484. Oscillatory Circuits with Variable Parameters [Remarks on Paper : Reply].—A. Erdélyi : Kober. (*Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, pp. 178–179.) For the paper in question *see* 3366 of 1935.

485. A Self-Oscillating System using an Induction Motor.—N. P. Vlasov. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 641–653.)

An account of an investigation, based on non-linear theory, of an oscillating system consisting of an induction motor to the shaft of which a variable torsional moment is applied proportional to the angle of rotation of the shaft. The theoretical results are verified experimentally.

486. The Use of the Braun [Cathode-Ray] Tube in the Investigation of the Movement of the Light Spot on the Plane of van der Pol Variables [Study of Oscillations represented by Equations of Higher Order than Two].—G. Bendrikov and G. Gorelik. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 620–626.)

Oscillations conforming to a system of differential equations of the n-th order can be represented by points and lines (integral curves) in a phase space of the n-th order. When $n = 2$ the phase space becomes a plane, and if voltages proportional to the co-ordinate and the rate of its change are applied to the controlling condensers of a cathode-ray tube, the integral curves will be reproduced on the screen. In a number of cases, however, when $n > 2$, van der Pol abbreviated equations can be used with a sufficient degree of accuracy, with the result that the integral curves will still be obtainable on a plane (called by the authors the "plane of van der Pol variables") and therefore on the screen of the tube. The method proposed was used in studying two auto-oscillating circuits, each with two degrees of freedom, and an oscillating circuit to which an external force is applied. Photographs are shown of some of the curves obtained on the screen of the cathode-ray tube. A bibliography of 12 items is attached.

487. The Quasi-Periodic Oscillations at Sub-Harmonic Resonance.—J. B. Kobzarev. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 621–631.)

For a previous paper *see* 62 of January. A theoretical investigation is presented of the operation of an oscillator to which an external force is applied having a frequency twice the natural frequency of the oscillator. The investigation is confined to the case when the detuning is sufficiently large for the régime to be quasi-periodic, *i.e.* when the amplitude and phase of the resultant oscillations are periodically and slowly varying. It is assumed that the valve characteristic can be represented by an equation of the third degree, and on this assumption formulae are derived determining, as functions of time, the amplitude and phase of the resultant oscillations and also the frequency of the beats. Curves for the frequency of the beats and also "limiting" curves of the equations "of the first approximation" are plotted.

488. [Calculations of] the Critical Conditions for Coupled Oscillatory Circuits (Band Filters). Band Filters of Variable Band Width.—H. Frühauf. (*Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, pp. 160–164.)

A magnetically-coupled band filter (Fig. 2) is first considered and the condition for "critical coupling" (eqn. 6) determined (*i.e.* the coupling giving maximum voltage in the secondary circuit for a given current supplied to the primary). Fig. 3 shows how the secondary voltage varies with the coupling. The "selection" (ratio of resonance voltage to voltage for a small amount of detuning) for more general types of coupling is given by eqn. 17, of which eqn. 18 is the form for critical coupling. Possibilities of broadening the resonance curve are next investigated; Fig. 4 gives curves for various degrees of fixed coupling. To lessen the dips in these it is recommended that a simple oscillating circuit should be added to every band filter, separated by an amplifying valve. The "selection" curve would then be given by eqn. 21; eqn. 22 gives the ratio of output to input voltage for the whole circuit combination. The corresponding curve is very flat if the quadratic terms in the denominator are zero and still better if the terms of degree four also vanish. For every degree of coupling this condition leads to a definite ratio a of the band-filter impedance to the circuit impedance (Fig. 6); Fig. 7 shows the resonance curves obtained thereby. The same device can be applied to capacitively-coupled band filters (Fig. 8).

489. One Method of Design for Band-Pass Filters [Symmetrical T-Type considered as a Transformer Circuit].—K. Hashida and H. Asada. (*Nippon Elec. Comm. Engineering*, September, 1935, No. 1, pp. 83–85: in English.) For previous work *see* 974 of 1935.

490. On the Characteristic Loci for Dissipative Filters of Lattice Type [and Their Application to Zobel's U-V Charts, giving Detailed Information with respect to Attenuation and Phase].—E. Takagishi. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts pp. 13–14: *Nippon Elec. Comm. Engineering*, September, 1935, No. 1, pp. 82–83: both in English.)

491. Frequency Division in a Vibrating Mechanical System.—Rusakov and Ryabinina. (*See* 682.)

492. Further Extensions of the Theory of Multi-Electrode Vacuum Tube Circuits.—S. A. Levin and L. C. Peterson. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 666–679.)

Extension of the work dealt with in 392 of 1935, removing the restrictions as to 3 electrodes only, constant "mu," and absence of conductive grid current.

493. Note on the Theorem of the Addition of Transducive Attenuations.—M. Bélus, (*Ann. des Postes T. et T.*, November, 1935. Vol. 24, No. 11, pp. 993–996.)

494. Contribution to the Problem of Alternating Currents of Arbitrary Curve Forms [Three Cases in which Effective Vectorial Values of Voltage and Currents of Two Alternating Current Circuits in Parallel can lie in a Plane].—P. Andronescu. (*Arch. f. Elektrot.*, 5th Nov. 1935, Vol. 29, No. 11, pp. 802–806.)

495. A Note on Some Proposed Applications of the Miller Effect.—Maynard. (*See* 514.)

TRANSMISSION

496. THE ELECTRON-OSCILLATION CHARACTERISTICS OF AN EXPERIMENTAL PLANE-ELECTRODE TRIODE.—R. A. Chipman. (*Proc. Phys. Soc.*, 1st Nov. 1935, Vol. 47, Part 6, No. 263, pp. 1042–1059.)

The triode had a plane emitting surface and the cathode/anode distance was continuously variable. Oscillations with no external circuit obeyed the Barkhausen equation $\lambda^2 V =$ const. [$V =$ grid voltage]; the mechanism appeared to be confined to the grid/cathode space and the oscillations were produced only when the grid current was space-charge limited. Oscillations with an external circuit were maintained at very low emissions and were of the same frequency as some resonant frequency of the circuit. " It is shown that much more complex experimental results can be analysed on the basis of the conclusions drawn from the simplified experiments. A brief discussion of the applicability of the existing theories to the simplified experiments is given."

497. THE BARKHAUSEN OSCILLATOR: NEW LIGHT ON ITS FUNCTIONING, WHICH DISCLOSES A CLOSE RELATION IN CONCEPT TO THE OPERATION OF THE FEEDBACK OSCILLATOR.—F. B. Llewellyn. (*Rad. Engineering*, October, 1935, Vol. 15, No. 10, pp. 12–13.) *See* 3376 of 1935.

498. A NEW ELECTRON OSCILLATION IN CONNECTION WITH WHICH THE PRESENCE OF SECONDARY ELECTRONS SHOULD BE TAKEN INTO CONSIDERATION.—T. Hayasi. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, pp. 105–113: in English.) *See* 2602 of 1935.

499. PRODUCTION OF ULTRA-SHORT WAVES BY MEANS OF THE DYNATRON OSCILLATOR.—R. Usui. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 567, p. 911: Japanese only.)

500. SPACE CHARGES AND ELECTRON OSCILLATIONS IN MAGNETRON TRIODES [leading to a Method of Accurate Adjustment in the Magnetic Field].—H. A. Schwarzenbach. (*Helvetica Phys. Acta*, Fasc. 7, Vol. 8, 1935, pp. 565–586: in German.)

Author's summary:—A triode with cylindrical electrode arrangement is set up in a coaxial magnetic field and investigated. A description is given of space-charge phenomena of a new kind [" zacken "—jagged outline] in the grid current $J_g = f(H)$ when the magnetic field is below the critical value H_k. It is also found that the known maximum [" buckel "—gentle hump] in the grid current $J_g = f(H)$ above H_k is a pure space-charge phenomenon, and moreover that it does not occur if the valve is accurately adjusted in the magnetic field. This last fact offers a simple electrical way of accurate adjustment of the valve in the magnetic field. Then the transition zone is examined between the space-charge-free and the stable space-charge-impeded electron motions, as expressed by instabilities in the $J_g = f(H)$ curve—that is, by oscillations. Finally, a case of a purely electrical action imitating the magnetic-field action is described [Fig. 13], together with some experiments on electron oscillations in the valve.

501. ON THE PRODUCTION OF ULTRA-SHORT-WAVE OSCILLATIONS WITH DOUBLE-ANODE MAGNETRONS [with Two Pairs of Split Anodes].—K. Okabe. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, pp. 69–75: in English.)

See 2600 of 1935. " Oscillations obtained with the double-anode magnetron of type 2 [concentric split cylinders] were generally much greater in intensity and considerably shorter in wavelength than those obtained with a two-split-anode magnetron of about the same size. They were likewise far stronger in intensity than those obtained with a four-split-anode magnetron of about the same size." For the type A oscillations the usual numerical factor in the wavelength formula was reduced from 13 000 to as little (in one case) as 7520. Type B oscillations, discovered by the writer (Abstracts, 1934, p. 90) and ' recently reported ' by Posthumus (91 of 1935: *see* also 2597 of 1935), were also successfully obtained. Both types went down to a wavelength of just under 40 cm.

502. [Theoretical] INVESTIGATIONS ON [Plane] ELECTRON STREAMS [in Presence of Oblique Magnetic Field and Heavy Ions].—J. Müller. (*Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, pp. 145–157.)

For previous work *see* Müller, Abstracts, 1933, pp. 443–444, and 1934, pp. 493–494: *also* Benham, 1931, p. 212, and 985 of 1935; Llewellyn, 1934, p. 265, and 1806 of 1935. In the present paper, the equations of motion of electrons of uniform velocity moving between a plane cathode and a plane anode in an oblique magnetic field are solved for any form of current variation, an expression for the space-charge density being found. The special case when an alternating current is superposed upon a constant one is then discussed; the impedance for small current variations is given by eqn. 29, where the effects of the transverse and longitudinal components of the field are separated. Fig. 2 shows the connection between voltage and transit time for various degrees of obliquity of the magnetic field; Fig. 3 gives current/voltage characteristics. Fig. 4 is an enlarged view of the type of characteristic producing " trip " oscillations, and Fig. 5 shows the " trip " circuit with a magnetron. Its action is explained. Fig. 6 shows electron paths and the variation of velocity with position between the electrodes. The formula for the impedance is next discussed (§ Ic) with special reference to low and high frequencies. Curves are given (Figs. 8–11) for the frequency variation of the capacity and resistance in the equivalent circuit under various conditions. It is found that the change from oscillations with an external oscillating circuit to those with no external circuit is continuous.

In §II the case of a transverse magnetic field with a homogeneous distribution of heavy ions is discussed, starting again from the equations of motion; the presence of the negative ionic space charge compensates the effect of the magnetic field. A short discussion of the effect of velocity distribution is given in §III.

503. "Electron Quantity" Modulation without Frequency Variations, for Electronic and Retroactive Oscillators, and a New Modulation System for Magnetron Oscillators.—T. Hayasi. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, pp. 89–104: in English.)

See also 3837 of 1935. "The electron quantity control principle . . . is not only applicable to the electronic oscillator but is also effective in minimising frequency modulation in ordinary retroactive oscillators . . . ," but here either a suppressor grid is necessary for averting the effects of secondary electron emission from the anode, or else a special tetrode (UZ-48) must be used which does not give secondary emission from the anode. With a pentode, the writer's method becomes a "new suppressor-grid modulation," giving a frequency variation only about one-twelfth of that of the conventional suppressor-grid modulation, and a wattless modulation. For magnetron working a special magnetron was designed, with the split anodes perforated and surrounded by a grid and a cylindrical anode.

504. Simultaneous Radio Telephony by Double Modulation [Transmission and Reception on Same Wavelength: Supersonic Frequency superposed on Critical Plate Voltage so that Oscillation and Detection alternate at Half Cycles: Tests on Ultra-Short Waves].—S. Ohtaka. (*Nippon Elec. Comm. Engineering*, September, 1935, No. 1, pp. 69–73: in English.) On 10 m "it is easy to communicate very clearly and noiselessly, like a city-telephone, over a distance of about 1 km."

505. A New System of High Efficiency Modulation.—A. L. Minz and V. L. Person. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1935, pp. 2–12.)

A theoretical discussion of a system proposed by Minz, and called "interval modulation." In this system the operating conditions and drive of the modulated amplifier are chosen to give square-topped rectangular impulses of anode current, one per cycle, combined with similarly shaped positive and negative impulses of anode voltage about the mean voltage, the negative anode-voltage impulses coinciding with the anode-current impulses. Modulation is effected by altering the width (duration) of the current impulses, their amplitude being kept constant.

In the circuit suggested, a modulated amplifier is followed by a final amplifier stage. The carrier-frequency drive is applied to the grid of the modulated amplifier, in series with the audio-frequency modulation. The latter thus varies the grid bias of the stage at audio frequency. A portion of the amplifier output is rectified by a thermionic rectifier and drives the final stage. A series of rejector circuits tuned to the fundamental and to its harmonics are connected in the anode circuits of the two stages to preserve the rectangular waveform.

It is claimed that with this sytem the rating of the valves can be reduced by 35 to 40% as compared with that required when sinusoidal impulses are used; also that although the system is slightly less efficient than high-power anode modulation (50% as against 55%, for 50% modulation) the average power consumption is actually lower, since the amplitude of the anode currents in the modulated amplifier and the final stage only increases very slightly when modulation is applied.

It is stated in conclusion that the system appears quite suitable for commercial telephony and probably also for broadcasting.

506. Method of Modulation [Alteration of Natural Frequency of Anode Circuit of Modulating Stage by Control worked by Modulating Voltage].—G. Krawinkel. (German Patent 613 356 of 3.11.33: *Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, p. 176.)

507. The "Sibori" Modulation and the Economy of Its Input Power.—Y. Takeda. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 567, p. 907: Japanese only.)

508. The Non-Linear Theory of [Self-Excited] Electric Oscillators.—Usui. (*See* 483.)

509. On the Stabilisation of the Frequency of Valve Oscillators [by Introduction of Suitable Impedances in Series with Plate and Grid Circuits].—Y. Rocard. (*Rev. Gén. de l'Élec.*, 14th Sept. 1935, Vol. 38, No. 11, pp. 364–365: long summary only.)

"The elimination of the terms in r and r_1, as well as those in ρ and ρ_g, in the equation determining the frequency, shows that it is possible, in the case of stabilised oscillators, to compose the circuits with inductance coils of medium quality. The interest of these results is particularly appreciable in the case of ultra-short-wave oscillators."

510. On the Stability of Oscillators: Corrections.—E. S. Antseliovich. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, inside of back cover.) *See* 3384 of 1935.

511. Oscillators using 14-Mc Quartz Crystals: Circuits for High Output with New Thick-Cut Plates.—J. M. Wolfskill. (*QST*, December, 1935, Vol. 19, No. 12, pp. 19–21.)

Owing to the increased thickness, "the attendant ills of previous 20-m crystals, such as brush discharges and high r.f. crystal current resulting in fracture, are not present. . . . The development of this type of crystal also . . . opens up new and greater possibilities of practical 10-m quartz crystals to control our transmitters."

512. A.W.A. Precision Frequency Control using Piezoelectric Crystals [for Broadcasting Transmitters: AT- or VW-Cut Discs].—(*A.W.A.* [*Amalgamated Wireless, Australasia*] *Tech. Review*, June, 1935, Vol. 1, No. 2, pp. 3–6.)

The comparative advantages are discussed of discs of AT- or VW-cut, accurately made so as to have a negligible temperature coefficient and very simple equipment, and Y-cut or other crystals having a coefficient of the order of 80 parts/million/degree Centigrade. The best compromise is thought to be a crystal with a coefficient of less than

5 parts/million/degree Centigrade, combined with a relatively simple form of bridge-circuit temperature control (here described). Such crystals can be obtained with the AT- or VW-cut by a comparatively inexpensive and straightforward procedure.

513. PAPERS CONNECTED WITH FREQUENCY STABILISATION.—(*See* also 678/689, under "Measurements and Standards.")

RECEPTION

514. A NOTE ON SOME PROPOSED APPLICATIONS OF THE MILLER EFFECT [Automatic Tone Control: Automatic Selectivity Control: Frequency Modulation: Measurement of Grid/Anode Capacities].—F. S. Maynard. (*A.W.A. Tech. Review*, October, 1935, Vol. 1, No. 3, pp. 3–12.)

In connection with his discussion of the action of the Miller effect in broadening the overall selectivity curve (by detuning the grid circuit) when the amplifier gain is varied, the writer considers the question of what degree of asymmetry of the selectivity curve can be permitted without introducing serious distortion. Two experimental methods of investigation are described, the second being based on the use of a cathode-ray oscillograph.

515. CATHODE-CIRCUIT DEGENERATION [Rising High-Note Response by Control of Cathode (Biasing) Resistor Bypass Condenser: Formulae and Graphs].—W. D. Shepard. (*Rad. Engineering*, September, 1935, Vol. 15, No. 9, pp. 9–10.)

516. CONTRAST EXPANSION [Suggested Experimental Transmissions from Ultra-Short-Wave Television Transmitters during "Idle" Hours].—G. Sayers. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, pp. 599–600.)

517. AUTOMATIC SELECTIVITY CONTROL [Band-Width restricted according to Prevailing Interference Level].—B. D. Corbett. (*Wireless World*, 29th Nov. 1935, Vol. 37, pp. 554–556.)

518. CRYSTAL FILTERS FOR RADIO RECEIVERS [Possibilities and Limitations].—C. F. Nordica. (*Rad. Engineering*, November, 1935, Vol. 15, No. 11, pp. 9–10 and 25.)

519. THE DETECTOR INPUT CIRCUIT [Single Detector *versus* Push-Pull, for Largest Possible Detector Output for Given Input to Preceding Valve].—W. T. Cocking. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, pp. 595–599.)

520. HOW SENSITIVE NEED A SET BE?—A. L. M. Sowerby. (*Wireless World*, 13th Dec. 1935, Vol. 37, pp. 610–612.)

In an endeavour to avoid the vague and misleading basis on which receiver-sensitivity is so often assessed, the author shows how the sensitivity of typical circuits can be estimated quantitatively with fair accuracy in relation to each other and to noise levels of various intensities.

521. CHOKE INPUT FILTERS.—N. Partridge. (*Wireless World*, 20th and 27th Dec. 1935, Vol. 37 pp. 644–645 and 672–673.)

In normal a.c. receiver practice the output from the h.t. rectifier is applied across the condenser which forms the input of the smoothing system. The author of this article describes the alternative use of a series-connected choke of special design, preceding his discussion of this system and its advantages by a detailed examination of the processes of rectification and smoothing.

522. SOME CIRCUIT HINTS FOR THE NEW VALVE PROGRAMME [Coupling Capacity between Two Anodes of Duo-Diode: Optimum Generator Matching in Duo-Diode Circuits: Variable Grid Leak with Output Valves: Change of Grid Bias in Radiogram Switch-Over].—K. Steimel and F. Neulen. (*Telefunken-Röhre*, November, 1935, No. 5, pp. 210–212.)

523. MODIFICATIONS OF THE PUSH-PULL OUTPUT STAGE. PART II [Graphical Analysis of Class B Amplifier: New "Cathode-Load" Driver Circuits: Suggested New Nomenclature for Output Stages].—K. A. Macfadyen. (*Wireless Engineer*, December, 1935, Vol. 12, No. 147, pp. 639–646.) For Part I *see* 107 of January.

524. ON THE RECEPTION OF FREQUENCY-MODULATED WAVES WITH A RESONANCE CIRCUIT [Optimum Point on Resonance Curve affected by Ratio of Modulating Frequency to Carrier Frequency].—S. Hase. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts p. 16.)

525. A NEW RECEIVING SYSTEM FOR THE ULTRA-HIGH FREQUENCIES: COMPLETE CONSTRUCTIONAL DETAILS OF METAL- AND GLASS-TUBE MODELS ["Superinfragenerator"].—R. A. Hull. (*QST*, December, 1935, Vol. 19, No. 12, pp. 31–37 and 98, 110.) *See* 88 of January. These models "have permitted a very striking improvement in the Hartford/Boston 60 Mc link."

526. "CODAN," A CARRIER-OPERATED ANTI-NOISE DEVICE [for Ultra-Short-Wave Police Receivers].—(*Rad. Engineering*, October, 1935, Vol. 15, No. 10, p. 17.) *See* 91 of January.

527. BROADCAST MONITOR. P-A SYSTEM [Lafayette Tuner-Amplifier Combination, for High Quality: 20 Watts Output].—H. L. Shortt. (*Rad. Engineering*, November, 1935, Vol. 15, No. 11, pp. 20–22.)

528. SOME RESULTS OF MEASUREMENTS MADE ON CERTAIN ELEMENTS OF A RECEIVER [Characteristics of Westector WX6 in conjunction with Colvern and Ferrocart Transformers and Variable-Mu Pentode, etc.].—J. Marique. (*L'Onde Elec.*, October, 1935, Vol. 14, No. 166, pp. 682–689.)

529. ON THE SUBJECT OF THE "MIDWEST RADIO CORPORATION" RECEIVERS [Corrections and Modifications: Two New 18-Valve Models: also the Zenith 25-Valve "Stratosphere"].—P. Besson. (*L'Onde Élec.*, October, 1935, Vol. 14, No. 166, pp. 690–693.) *See* 730 and 1847 of 1935.

530. THE CLASS B AMPLIFIER.—Th. Sturm. (*Funktech. Monatshefte*, September, 1935, No. 9, pp. 337–341.)

531. A RECEIVER WITH SWITCH FOR ALTERNATIVE CLASS A AND CLASS B AMPLIFICATION: 5 AND 12 WATT OUTPUT: FREQUENCY RANGE 30–9 000 C/S WITH LOW DISTORTION: TWO-STATION PRE-SET RECEPTION [and Supplementary Distant Reception].—Th. Sturm. (*Funktech. Monatshefte*, October, 1935, No. 10, pp. 377–384.)

532. THE RADIO COMPANION.—J. H. Reyner. (*Wireless World*, 29th Nov. 1935, Vol. 37, p. 568.) Further details of the receiver dealt with in 117 of January.

533. LOOKING AHEAD IN RECEIVER DESIGN. I—EXTERIOR.—M. L. Muhleman. (*Rad. Engineering*, November, 1935, Vol. 15, No. 11, pp. 11 and 14, 17.)

534. FOREIGN RADIO MARKETS.—A. W. Cruse. (*Rad. Engineering*, September, 1935, Vol. 15, No. 9, pp. 17–18 and 21.)

535. BERLIN AND LONDON: A COMPARISON OF THE TWO RADIO EXHIBITIONS.—(*Funktech. Monatshefte*, November, 1935, No. 11, pp. 412–414.)

536. TWELFTH GREAT GERMAN RADIO EXHIBITION: LATEST DEVELOPMENTS IN RECEIVERS.—E. Schwandt. (*Funktech. Monatshefte*, September, 1935, No. 9, pp. 325–336.) For a list of 1935/1936 types *see* pp. 359–366, and for components *see* October issue, No. 10, pp. 396–400.

537. AN IMPROVED CARRIER INTERFERENCE ELIMINATOR [with Cheap Components and eliminating Heterodyne Whistle completely].—W. Baggally. (*Wireless Engineer*, December, 1935, Vol. 12, No. 147, pp. 647–649.) For the writer's previous method, using the Campbell sifter circuit, *see* 1932 Abstracts, p. 523.

538. INTERFERENCE WITH ULTRA-SHORT-WAVE RECEPTION.—Scholz. (*See* 646.)

539. OSCILLATIONS IN THE SPARK FROM INDUCTION OR IGNITION COILS, AND THEIR SUPPRESSION [Mathematical Investigation of Production, of Influence of Added Resistance, etc.].—R. Ruedy. (*Canadian Journ. of Res.*, September, 1935, Vol. 13, No. 3, pp. 45–59.)

540. THE ELECTRIC OSCILLATION [and Interference] DUE TO MAGNETO IGNITION SPARKS.—S. Kumagai and K. Takeo. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 567, pp. 841–846: English summary pp. 108–109.) For previous work *see* 3396 of 1935.

541. SUPPRESSING ELECTRICAL INTERFERENCE.—Neale. (*Wireless World*, 27th Dec. 1935, Vol. 37, pp. 659–660.) A résumé of points from a paper recently read before the Institution of Post Office Electrical Engineers.

542. RADIO INTERFERENCE IS PROBLEM OF NEW ASA [American Standards Association] CO-ORDINATION COMMITTEE.—(*Indust. Standardisation and Commercial Standards Monthly*, November, 1935, Vol. 6, No. 11, pp. 293–295.)

543. A CALCULATING DISC [Circular Slide Rule] FOR WORK ON INTERFERENCE SUPPRESSION.—H. Reppisch. (*Funktech. Monatshefte*, September, 1935, No. 9, pp. 353-355.)

544. WHAT FREQUENCY? A NEW AND ORIGINAL METHOD FOR LOCATING THE FREQUENCY OF ANY RECEIVER BELOW 200 METRES [Rapid Identification of Harmonic of Calibrated Oscillator by Slide Rule].—C. H. Roof. (*Rad. Engineering*, October, 1935, Vol. 15, No. 10, pp. 7–9.)

AERIALS AND AERIAL SYSTEMS

545. BROAD-BAND SHORT-WAVE DIRECTIONAL AERIALS [Synphase and Horizontal Rhombic Types].—M. S. Neumann. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1935, pp. 12–30.)

The operating wavelengths for a radio link can only be determined very approximately beforehand, and even when they have been found by experience, it is usually necessary to alter them every few years, owing to changes in the ionised layers of the atmosphere. It is therefore highly desirable that the short-wave directional aerials used should be capable of operating over a certain wavelength range. In this paper the following two types of aerial having this characteristic are discussed:—

(a) *Synphase Aerial*. This aerial, developed in Russia, consists of a number of horizontal dipoles arranged in a vertical plane in a similar manner to a "fir-tree" aerial, but fed by a system of branching transmission lines so arranged that each dipole is fed through exactly the same length of line. The aerial is used with a reflector of similar construction, which may be directly fed or excited by radiation only. The standing waves in the radiators are all in phase and of the same amplitude, and this condition clearly remains the same when the wavelength is changed. It is, however, necessary in this case to change the phase of the reflector currents. It is shown that the gain and directional properties of the aerial remain satisfactory over a 2 to 1 wavelength range. For another paper on these aerials *see* 3031 of 1935.

(b) *Horizontal rhombic aerials*. A brief discussion is given of the properties of this type of aerial with special reference to its operation over a 2 to 1 wavelength range.

546. AN ANTI-FADING AERIAL.—G. J. Michelson. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, p. 738.)

A preliminary communication in which it is suggested that the sky-wave radiation from a medium-wave broadcasting aerial could be considerably reduced if the horizontal portion of the aerial were made in the shape of a rectangle, to one side of which the down-lead is connected. If the rectangle is tuned to the operating wavelength, the currents in the parallel sides will cancel out and give no radiation. A further advantage of this system is that the current antinode in the down-lead can be lifted much higher above the ground than in ordinary aerials.

547. THE CALCULATION OF CURRENTS AND VOLTAGES IN LONG-WAVE COMPOSITE AERIALS.—G. S. Ramm. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1935, pp. 30–47.)

Composite aerials such as long-wave directional aerials, Alexanderson aerials, etc., normally consist of a number of simple aerials having a common electromagnetic field so that an e.m.f. in one of them induces voltages and currents in all other elements of the system. In this paper an approximate method is proposed for calculating the distribution of voltages and currents in such systems on the assumption that the system is linear, *i.e.* that it can be represented by linear differential equations, and that the component aerials can be regarded as long transmission lines free from losses. Equations are deduced determining the standing as well as travelling waves in the aerials of the system, and methods are indicated for solving these equations. The case most frequently met with in practice, *i.e.* when all the aerials are similar, is considered separately in greater detail. Finally it is shown that from the general equations deduced, the impedance and radiation resistance of an aerial can be calculated.

548. SOME CALCULATIONS OF FIELD STRENGTH DISTRIBUTION IN THE VERTICAL PLANE OF DOUBLE-TAPERED MASTS [0.597λ Double-Tapered Tower Aerial with 0.250λ Self-Supporting Tower as Fed Reflector: Considerable Reduction of Sky Wave at Remote Distances].—K. A. MacKinnon. (*Canadian Journ. of Res.*, September, 1935, Vol. 13, No. 3, pp. 60–71.)

549. THE ALL-ROUND 14-MC SIGNAL SQUIRTER: DETAILS OF A COMPACT REMOTE-CONTROL DIRECTIONAL SYSTEM FOR SMALL SPACE [Half-Wave Radiator and Reflector Rotatable Combination].—M. P. Mims. (*QST*, December, 1935, Vol. 19, No. 12, pp. 12–17 and 104, 106.)

550. THE DEPOSITS OF SLEET AND GLAZED FROST ON OVERHEAD LINES [including Effects on Carrier-Current Working].—R. Demogue. (*Ann. des Postes T. et T.*, November, 1935, Vol. 24, No. 11, pp. 965–988.)

551. VIBRATIONS OF POWER LINES IN A STEADY WIND. II—SUPPRESSION OF VIBRATIONS BY TUNED DAMPERS.—R. Ruedy. (*Canadian Journ. of Res.*, November, 1935, Vol. 13, No. 5, pp. 99–110.)

VALVES AND THERMIONICS

552. OPERATION OF ULTRA-HIGH-FREQUENCY VACUUM TUBES.—F. B. Llewellyn. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 632–665.)

Author's summary:—Previous electronic analyses are extended by the introduction of more general boundary conditions. The results are applied to the calculation of the rectifying properties of diodes at very high frequencies and to the amplifying properties of negative-grid triodes at both low and high frequencies. The effect of space charge on the various capacitances in triodes is discussed, and formulas for the amplification factor and plate impedance are presented in terms of the tube geometry. Finally, a discussion of the input impedance of negative grid triodes is given together with a comparison of the theoretical value with the results of measurements made by several well-known experimenters.

553. PLANE MAGNETRON DIODE [Repeated Cycloidal Paths possible even in Space-Charge Limited Case].—W. E. Benham. (*Wireless Engineer*, December, 1935, Vol. 12, No. 147, p. 651.)

Criticism of Braude's conclusions as to absence of return path for the electrons, however great the magnetic field (3437 of 1935).

554. INVESTIGATIONS ON ELECTRON STREAMS [in Presence of Oblique Magnetic Field and Heavy Ions].—Müller. (*See* 502.)

555. MULLARD TRANSMITTING VALVES [for Short and Ultra-Short Waves].—Mullard Company. (*Wireless Engineer*, December, 1935, Vol. 12, No. 147, p. 652.)

556. THE EFFECT OF THE MASS AND TRANSIT TIME OF ELECTRONS AS REGARDS THE BROADCAST VALVES.—K. Steimel. (*Telefunken-Röhre*, November, 1935, No. 5, pp. 213–218.)

A description of an effect found in multiple-grid valves working at high frequencies, in which the transit time of the electrons across the valve produces a grid current and distorts the working characteristics. A physical explanation in terms of the variations of potential acting on the electrons as they cross the valve is given. In practice the effect is minimised by decreasing the distances between the electrodes. The steepness of the characteristics also is lessened rather than increased.

557. THE BROADCAST VALVES OF 1935/36.—W. Graffunder and F. Neulen. (*Telefunken-Röhre*, November, 1935, No. 5, pp. 185–209.)

A description of the points distinguishing the new German valves (table pp. 188–189). General characteristics are the design of valves with the same electrical properties but suitable for different heating voltages; decrease of heating-up time; smaller dimensions with stronger construction; stability as regards mechanical vibration (Fig. 2). Types of valves discussed include duo-diodes (Figs. 3–5), single-grid valves (characteristics Figs. 6, 7), h.f. pentodes (Figs. 9–16), regulating pentodes (Fig. 17), hexodes (Figs. 18–20), octodes (Fig. 21), output valves with small "klirr" factor and rapid heating, mains rectifier valves, 55 v "people's receiver" valves, and a series of 2 v battery valves.

558. SOME CIRCUIT HINTS FOR THE NEW VALVE PROGRAMME.—Steimel and Neulen. (*See* 522.)

559. THE QUESTION OF METAL VALVES.—E. Schwandt. (*Funktech. Monatshefte*, November, 1935, No. 11, pp. 417–420.) Pros and cons of the American development, from the German viewpoint.

560. THE 6F5 [All-Metal High-Mu Triode] AS A HIGH-GAIN A.F. AMPLIFIER.—(*Rad. Engineering*, October, 1935, Vol. 15, No. 10, pp. 18–19.)

561. RAYTHEON 6Q7 [Metal] DUO-DIODE TRIODE.—(*Rad. Engineering*, November, 1935, Vol. 15, No. 11, p. 23.)

562. OPERATION OF THE 6L7 [Metal-Shell Five-Grid Valve] AS A MIXER TUBE.—(*Rad. Engineering*, September, 1935, Vol. 15, No. 9, pp. 11–13 and 16.)

563. PENTAGRID-CONVERTER SHORTCOMINGS [Decreased Conversion Conductance at Frequencies above 15–20 Mc/s].—(*See* 562.)

564. METAL-TUBE SOCKET DESIGN [Type 39 Socket].—(*Rad. Engineering*, October, 1935, Vol. 15, No. 10, p. 19.)

565. "DIE DREIELEKTRODENRÖHRE UND IHRE ANWENDUNG" [Book Review].—F. Moeller. (*Naturwiss.*, 22nd Nov. 1935, Vol. 23, pp. 802–803.)

566. NOTE ON THE MEASUREMENT OF THE CONSTANTS OF A THREE-ELECTRODE VALVE [Modification of Miller's Method].—J. B. Pomey. (*Ann. des Postes T. et T.*, November, 1935, Vol. 24, No. 11, pp. 989–992.)

567. REMARK ON THE CALCULATION OF THE CONTROL VOLTAGE IN A ONE-GRID VALVE [Simple Derivation of Formula].—J. Wallot. (*Arch. f. Elektrot.*, 5th Nov. 1935, Vol. 29, No. 11, p. 781.) *See* 1443 of 1935.

568. HIGH-POWER DEMOUNTABLE TYPE OSCILLATING VALVES [200 kW].—A. L. Minz and N. I. Oganov. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1935, pp. 47–51.)

569. A CALCULATED VALUE OF THE GRID DRIVING POWER IN A HIGH POWER AMPLIFIER TUBE.—M. Simbori. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts p. 13.)

When the expressions obtained by Spitzer and Thomas for valves of medium size are applied to higher-powered valves, the values obtained are generally smaller than those observed, owing to secondary emission from the grid. The writer obtains a new formula which gives satisfactory results with commercial high-power valves.

570. POTENTIAL RELIEFS FOR VALVES WITH CONCENTRIC ELECTRODES.—Gottmann. (*Funktech. Monatshefte*, October, 1935, No. 10, pp. 385–386.) Extension of the work referred to in 2654 of 1935, which was confined to plane electrodes. *See* also 571, below.

571. THE MATHEMATICAL REPRESENTATION OF POTENTIAL RELIEFS IN H. F. TECHNIQUE.—H. Awender and A. Thoma. (*Funktech. Monatshefte*, November, 1935, No. 11, pp. 421–424.) Quantitative treatment of the subject dealt with qualitatively in 570, above.

572. POTENTIAL AND SECONDARY EMISSION OF BODIES IRRADIATED WITH ELECTRONS.—M. Knoll. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 861–869.)

573. THERMIONIC EMISSION AS A PURELY SURFACE-LAYER PHENOMENON.—Gehrts. (*See* 798.)

574. RADIATION AND ABSORPTION OF ENERGY BY TUNGSTEN FILAMENTS AT LOW TEMPERATURES.—I. Langmuir and J. B. Taylor. (*Journ. Opt. Soc. Am.*, October, 1935, Vol. 25, No. 10, pp. 321–325.)

575. EXCHANGE OF ENERGY BETWEEN DIATOMIC GAS MOLECULES AND A SOLID SURFACE [Theory, with Curves for Calculated Variation of Thermal Accommodation Coefficient with Temperature for Hydrogen/Tungsten and Oxygen/Tungsten].—J. M. Jackson and A. Howarth. (*Proc. Roy. Soc.*, Series A, 15th Nov. 1935, Vol. 152, No. 877, pp. 515–529.)

576. THE INTERACTION OF GASES WITH SOLIDS [Notes on Recent Work on Adsorption].—H. W. Melville. (*Nature*, 7th Dec. 1935, Vol. 136, pp. 899–900: short account of Chemical Society discussion.)

577. POSITIVE AND NEGATIVE THERMIONIC EMISSION FROM MOLYBDENUM [Work Function of Electron 4.17 V, of Positive Ion 8.35 V: Agreement with Saha Theory of Ion Formation].—H. B. Wahlin and J. A. Reynolds. (*Phys. Review*, 1st Nov. 1935, Series 2, Vol. 48, No. 9, pp. 751–754.)

DIRECTIONAL WIRELESS

578. ROTATABLE ADCOCK DIRECTION-FINDER [Hut, Rotatable with or without Contents, contains Apparatus and carries Dipoles].—A. Leib and W. Kühlewind: Telefunken. (German Patent 611 505 of 31.1.34: *Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, p. 177.)

579. SUBTERRANEAN AIRCRAFT BEACON [Equi-Signal Blind Landing System with Flat-Sided Beams and No Back-Radiation].—Sharman. (*Wireless World*, 29th Nov. 1935, Vol. 37, p. 567.)

Outline of the blind-landing system developed by Sharman and now installed experimentally at Croydon Aerodrome. Vertical "directors" and "reflectors" are used. The transmitting apparatus is housed in an underground chamber with metallically shielded back, floor, sides, and top in order to prevent back-radiation.

580. METHOD OF WORKING RADIO BEACONS [Same Signal indicates Deviation to Same Side when Beacon alternately approached from Different Directions: *e.g.* Starboard denoted by Dots].—Lorenz Company. (German Patent 612 825 of 9.5.34: *Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, p. 177.)

581. The Quasi-Stationary Propagation of Alternating Current in the Earth between Two Circular Electrodes lying in the Earth's Surface and with Constant Density of Current Flow In and Out [Mathematical Derivation of Field Components: Deduction of Earth Currents and Vector Diagram of Penetration Depth: Component Wave-Trains: Equivalent Resistance of Earth].—H. Buchholz. (*Arch. f. Elektrot.*, 5th Nov. 1935, Vol. 29, No. 11, pp. 741–774.) *See* also 180 of January.

582. On Some Graphical Solutions of Air Line [Great Circle] Problems.—(*A.W.A. Tech. Review*, October, 1935, Vol. 1, No. 3, pp. 13–19.)

No calculation and no mathematical tables are required: "the accuracy obtainable is not commensurate with the time required, as the slide rule gives a more accurate result in very much less time," but "the construction may be sketched freehand in a few seconds, and as it contains lines equivalent to the quantities A and B of the ABC tables, it is a safeguard against adding these quantities when they ought to be subtracted, or *vice versa*."

ACOUSTICS AND AUDIO-FREQUENCIES

583. Microphones for Broadcasting Purposes [Experimental Comparisons between Various Types].—W. Furrer. (*Bull. Assoc. suisse des Élec.*, No. 25, Vol. 26, 1935, pp. 719–724.)

The best compromise between conflicting requirements is found to be the ribbon type for studio working and the moving-coil for outside broadcasts.

584. New Crystal Microphones.—(*QST*, December, 1935, Vol. 19, No. 12, pp. 78, 80, and 82.)

Including a double-diaphragm type with diaphragms less than 1 inch in diameter, giving "very little sound-wave distortion, no cavity resonance, and no pressure doubling at the higher frequencies." Also the "Spheroid" non-directional type with "gra-foil" bimorph crystal, giving a flat characteristic between 40 and 10 000 c/s.

585. Papers on Rochelle Salt.—(*See* 685/687, under "Measurements and Standards.")

586. Electrostatic Microphone [Current Fluctuations amplified by Glow Discharge in Gas surrounding Fixed Electrode of Microphone Condenser].—S. Klein. (German Patent 602 491 of 12.12.33: *Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, p. 178.)

587. The Condenser Microphone [Theoretical Foundations and Practical Construction].—K. Eisenzapf. (*Funktech. Monatshefte*, October, 1935, No. 10, pp. 365–372.)

588. Sound Waves of Finite Amplitude [Distortion due to Curvature of Pressure/Volume Relationship for Air: Increased by Travel down Horn or Tube].—N. W. McLachlan. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, pp. 582–587.) For the other papers referred to *see* 3080 of 1935 and 187 of January. *See* also 589, below.

589. An Interesting Problem in Acoustics.—G. W. O. H. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, p. 581.) Editorial on 588. "Is it not possible that the distortion reaches some limit at which stability is maintained by a transfer of heat from the closely contiguous regions of high and low pressure?"

590. Sub-Harmonics.—N. W. McLachlan. (*Wireless World*, 27th Dec. 1935. Vol. 37, pp. 666–668.)

When a cone-diaphragm moving-coil loudspeaker is tested near its maximum power output with a beat frequency oscillator, the pure note often gives place to a raucous tone in the middle register (*see* von Schmoller, 1934 Abstracts, pp. 564–565.) The cause and cure of this form of distortion are here discussed.

591. On the Acoustic Radiation Pressure on Circular Discs: Inertia and Diffraction Corrections [Theoretical Solution for Discs of Circumference ≪ Wavelength].—L. V. King. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1935, Vol. 153, No. 878, pp. 1–16.)

592. Forced Oscillations of a Circular Plate with Free Edge [Excited at an Eccentric Point: Experimental Investigation: Nodal Zones].—R. Schünemann. (*Ann. der Physik*, Series 5, No. 6, Vol. 24, 1935, pp. 507–535.)

The circular plate was of aluminium, fixed at the centre but free at the edge, and excited sinusoidally at an eccentric point. The motion of individual points on the plate was determined with the test condensers used by Backhaus (1929 Abstracts, p. 275) in Riegger's h.f. circuit (*Wiss. Veröff. a.d. Siemenskonzern*, No. 2, Vol. 3, 1923/24, p. 85), so that the motion was represented in amplitude and phase by an alternating current. The compensating voltage required was obtained with an audio-frequency generator on Grösser's principle (1930 Abstracts, p. 390). A description is given of the audio-frequency generator with adjustable phase (Fig. 1), the quartz control, the frequency variations of the h.f. oscillator, the calibration of phase adjustment, the adjustments of the test condenser apparatus (Fig. 3) and its guard-ring (Fig. 4), the method of exciting the plate, and the compensating apparatus. Fig. 5 shows the general lay-out of the apparatus. The sources of error are also discussed. The results for the resonance frequencies showed good agreement with calculation. Figures of nodal lines at various frequencies are given (Figs. 6–14 for excitation at a point on the circumference, Figs. 15–18 for internal excitation) and fully discussed. Figs. 19–22 give the variation of phase round the plate for two different radii. The change of phase on crossing a nodal line was not discontinuous, so that no proper nodal lines were found, but rather nodal zones. A small load on the plate at a point of large amplitude had considerable influence on the form of the vibration figures and on the resonance frequencies.

593. ON THE TRANSFER OF ENERGY BY OSCILLATIONS DUE TO A VARYING DEGREE OF BENDING.—G. Ostroumov. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 681–684.)

The great majority of acoustic phenomena are produced by bodies subjected to varying bending, as, for instance, a telephone diaphragm, the sounding board of a musical instrument, etc. The energy imparted to such bodies is partly radiated as sound waves and partly absorbed in the bodies themselves. In this paper a study is presented of the flow of energy along a freely suspended beam when this is subjected to a varying degree of bending.

594. ACOUSTIC IMPEDANCE OF SMALL ORIFICES [Acoustic Reactance and Resistance Measurements, and Resulting Formulae].—L. J. Sivian. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 94–101.)

595. EXPERIMENTS ON OSCILLATIONS OF AIR AND CARBON DIOXIDE IN CLOSED SPHERICAL RESONATORS [Frequencies and Attenuations of Natural Vibrations].—K. Voeckler. (*Ann. der Physik*, Series 5, No. 4, Vol. 24, 1935, pp. 361–376.)

596. AN "A-F BROADCAST CHAIN" [Official Public-Address System of California-Pacific International Exposition].—(*Rad. Engineering*, September, 1935, Vol. 15, No. 9, pp. 19–21.)

597. THE PUBLIC ADDRESS SYSTEM AND COROLLARY INSTALLATIONS FOR THE THIRTY-SECOND INTERNATIONAL EUCHARISTIC CONGRESS.—Mulleady and White. (*Elec. Communication*, July, 1935, Vol. 14, No. 1, pp. 8–20.)

598. THE CONSTRUCTION OF A "FREE-SWINGING" PICK-UP [Rubber-Anchored Needle-Armature System, as used in Loudspeakers].—H. Wolff. (*Funktech. Monatshefte*, October, 1935, No. 10, pp. 393–395.)

599. ON THE AUTOMATIC RECORDING OF THE AUDIO-FREQUENCY CHARACTERISTICS OF GRAMOPHONE SOUND BOXES.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 730–737.)

A method is proposed in which the use of electro-mechanical or electro-acoustical devices is obviated. The output from the sound box is measured by means of a Rayleigh disc and the characteristic curve is traced by a beam of light on a photographic plate. The vertical deflection of the beam, proportional to the square of the velocity of the oscillating air particles, is effected by a mirror attached to the Rayleigh disc, while for the horizontal deflection a second mirror is used which is mechanically coupled to the sound box. The needle of the latter travels over a test disc on which a tone of gradually increasing frequency is recorded, so that the horizontal deflection of the beam is proportional to the frequency of the sound. A description is given of the apparatus developed for this purpose and of the method used for its calibration, and a few characteristic curves so obtained are shown.

600. SOUND REPRODUCTION FROM NEWSPRINT ["Fotoliptofono" Demonstration: Free from Background Noise: Cheap].—(*Electrician*, 1st Nov. 1935, p. 550.) *See* also *Engineering*, 1st Nov. 1935, p. 483.

601. THE PHONO-REEL [40 Minutes Playing Time by Parallel Tracks on 150 Feet of 16 mm Film].—W. E. Schrage: von Mihaly. (*Wireless World*, 29th Nov. 1935, Vol. 37, p. 557.)

602. MECHANO-GRAPHICAL SOUND RECORDING, PHILIPS-MILLER SYSTEM [Double-Edged Trace engraved on Three-Layered Film: Specimen Record of a 50 000 c/s Frequency].—P. Hatschek. (*Funktech. Monatshefte*, October, 1935, No. 10, Supp. pp. 71–72.)

603. PHOTOGRAPHIC ASPECTS OF THE CHOICE OF SOUND-ON-FILM METHODS [including the "Push-Pull" Two-Track Amplitude System].—P. Hatschek. (*Funktech. Monatshefte*, November, 1935, No. 11, Supp. pp. 82–83.)

604. A DELAY APPARATUS USING MAGNETIC RECORDING [Special Piano Wire wound in Single Layer round Aluminium Disc: Delays up to One Second].—Nagai, Nisimura and Hasimoto. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts p. 20.)

605. EXPERIMENTAL DETERMINATION OF THE CONSTANTS OF A STRING-SOUNDING-BOARD MODEL [representing a Piano].—P. A. Matveev and A. V. Rimski-Korsakov. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 685–702.)

An account of experiments carried out to investigate the process involved in the transfer of energy from the strings to the sounding board in a piano. A simplified model of the sounding board was made and special electro-mechanical measuring apparatus, using a cathode-ray oscillograph, was developed. With the aid of this apparatus it was possible to measure the input impedance of the sounding board, *i.e.* the impedance in mechanical ohms (dynes/sec/cm) at the point of attachment of the string to the board, and the amplitude and phase of oscillations at various points of the board. From the experimental results obtained the equivalent mass and flexibility of the board can be calculated. It is stated in conclusion that the method evolved has been tested successfully directly on a piano. For Lange's work on the physics of the piano *see* 2688 and 3500 of 1935.

606. RESPONSE MEASUREMENT AND HARMONIC ANALYSIS OF VIOLIN TONES.—R. B. Abbott. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 111–116.)

607. "A FUGUE IN CYCLES AND BELS" [Book Review].—J. Mills. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 725–726.)

608. NOTES ON THE DESIGN OF ATTENUATING NETWORKS [Underlying Principles: Formulae: Ambiguity in Definition of Output Impedance: etc.].—W. G. Baker. (*A.W.A. [Amalgamated Wireless, Australasia] Tech. Review*, June, 1935, Vol. 1, No. 2, pp. 19–26: to be continued [not in No. 3, October].)

609. HIGH RESISTANCE VOLUME CONTROLS [Mathematical Analysis: Serious Alteration of Fidelity Curve unless Stray Capacity (Moving-Arm/Earth) is made Low].—L. G. Dobbie. (*A.W.A. Tech. Review*, June, 1935, Vol. 1, No. 2, pp. 13–15.)

610. A.W.A. SPEECH CONTROL EQUIPMENT FOR BROADCASTING.—R. R. Davis. (*A.W.A. Tech. Review*, June, 1935, Vol. 1, No. 2, pp. 7–12.)

611. VOICE-OPERATED ANTI-SINGING EQUIPMENT [Vodas] FOR RADIOTELEPHONE LINKS.—L. S. Thomas. (*A.W.A. Tech. Review*, June, 1935, Vol. 1, No. 2, pp. 16–18.)

612. AN AUDIO POWER AMPLIFIER UNIT SUITABLE FOR HIGH-FIDELITY RECEIVERS AND OTHER PURPOSES [10 Watts Output with not more than 5% Harmonic Distortion: Substantially Flat Characteristic from 50 to 7 000 Cycles/Sec.].—A. F. Martin and G. J. Hicks. (*A.W.A. Tech. Review*, October, 1935, Vol. 1, No. 3, pp. 20–22.)

613. THE MODERN GLOW-DISCHARGE TUBE AMPLIFIER [with G-D Tube as Coupling Element: Almost Flat Characteristic 30–10 000 c/s: 3–4 Watts Output: Design Details].—P. Miram. (*Funktech. Monatshefte*, October, 1935, No. 10, pp. 373–376.) For papers on this coupling method *see* 1097 of 1935, and 1934 Abstracts, p. 267.

614. A NEW MULTIPLEX FEEDING-BACK SYSTEM.—Y. Watanabe and Z. Kamayachi. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts pp. 16–17.)

The input voltage is impressed upon two or more amplifiers simultaneously, a part of their output voltage being connected in series so that there is feed-back into the input terminals. The most important application is as a duplex feed-back circuit.

615. FREQUENCY AND PHASE DISTORTION [and the Use of L.F. Retroaction].—Marinesco: Tanasescu. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, p. 599.) Refutal of the criticism referred to in 3829 of 1935.

616. ANTIPARASITIC DEVICES FOR TELEPHONIC CIRCUITS [disturbed by Neighbouring Power Lines].—Bigorgne and Marzin. (*Ann. des Postes T. et T.*, November, 1935, Vol. 24, No. 11, pp. 1016–1025.)

617. LONG-DISTANCE TELEPHONE CABLES [Review of Modern Requirements and Cable Construction].—U. Meyer. (*Arch. f. Elektrot.*, 5th Nov. 1935, Vol. 29, No. 11, pp. 733–741.)

618. MEASUREMENT OF TELEPHONE NOISE AND POWER WAVE SHAPE.—Barstow, Blye and Kent. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1307–1315.)

619. REDUCING NOISE IN AIRPLANE SOUND LOCATORS.—E. R. House. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 127–134.)

620. PROGRESS IN THE THEORY OF SOUND ABSORPTION BY POROUS WALLS [with Review of Theory and Experiment].—L. Cremer. (*E.N.T.*, October, 1935, Vol. 12, No. 10, pp. 333–346.)

Perpendicular incidence of the sound on the walls is alone considered; the approximate theory already given (Abstracts, 1933, p. 510: *see* also pp. 571–572) is first reviewed (§ 1) and compared with experimental results, which are summarised in § 2. Table 1 shows the measured values of acoustic constants obtained by various experimenters. § 3 gives an extension of the theory to the case when the wall is of arbitrary thickness; the variation of the degree of absorption with thickness is calculated. Fig. 2 shows the variation of degree of absorption with frequency for different thicknesses and Fig. 3 for different acoustic current impedances of the wall. These curves enable an estimate of the optimum impedance for given thickness to be made. In § 4 the theoretical bases are extended to investigate the influence of the values assumed for ρ_0, the mean density of the air enclosed in the porous material, and c, the velocity of sound in air, with special reference to the experiments of Wüst (172 of 1935). Eqns. 22, 22a are forms of the fundamental dynamical equation and show that the mass of the wall is (in electrical language) in parallel to the acoustic impedance of the currents of enclosed air. Thermodynamic effects are also considered but all the corrections made are found to have little influence on the results given by the simple theory.

621. THE CHARACTERISTICS OF SOUND TRANSMISSION IN ROOMS [Transmission/Frequency Curves made with High-Speed Level Recorder].—E. C. Wente. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 123–126.)

Hitherto, measurements of the acoustics of rooms have been confined largely to a study of transient phenomena: " since steady-state transmission measurements have been of geeat service in the development of electrical communication systems, it is of interest to inquire into the value of such measurements in the study of the acoustics of rooms."

622. THE ACOUSTICS OF AUDITORIUMS AND THE METHODS OF IMPROVING THEM.—Gavronsky and Kahan. (*Génie Civil*, 12th Oct. 1935, pp. 344–347.) Concluded from the issue of 5th Oct.

623. " ACOUSTIQUE DES SALLES " [Book Review].—van den Dungen. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 148–149.)

624. The Sound Insulating Properties of Certain Building Constructions.—J. S. Parkinson. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 117–122.)

625. A Reverberation Indicator based on the Hand-Clap Method of estimating Reverberation Time [Condenser Discharge through Loudspeaker: Rotating Neon Bulb connected to Microphone/Amplifier Combination].—J. C. Cotton. (*Review Scient. Instr.*, Nov. 1935, Vol. 6, No. 11, pp. 344–346.)

626. Acoustical Work of the National Bureau of Standards.—V. L. Chrisler. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 79–87.)

627. Electro-Acoustics and Bells.—G. M. Giannini. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, pp. 293–295.)

628. Suggested Acoustical Improvements in the Architectural Design of Bell Towers.—G. M. Giannini. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 135–138.)

629. A Recording Analyser for the Audible Frequency Range.—H. H. Hall. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 102–110.) With examples of various records, including some on the subject of the response of a resonant element to a driving force whose frequency varies with time.

630. A Method for Very Rapid Analysis of Sounds: Sound Grating Spectroscopy.—E. Meyer. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 88–93.) Full English version of the paper dealt with in 453 of 1935.

631. Registration of Speech Sounds.—E. W. Scripture. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 139–141.)

632. The Phenomenon of Masking [Term should apply to Peripheral as well as Central Phenomena].—S. S. Stevens. (*Science*, 25th Oct. 1935, pp. 390–391.)

633. Investigations on Oscillations of the Vocal Chords [by Condenser Microphone Method: Analogy with Stringed Instruments: Oscillograms].—W. Trendelenburg and H. Wullstein. (*Sitzungsber. der preuss. Akad. der Wiss.*, No. 21, 1935, pp. 399–426.)

634. The Growth of Recognition of the Frequency of a Tone.—W. Bürck, P. Kotowski and H. Lichte. (*E.N.T.*, October, 1935, Vol. 12, No. 10, pp. 326–333.)

An experimental determination of the least time for which a sine wave must be heard for its frequency to be correctly recognised. A Helmholtz pendulum with three contacts (Fig. 1), connected between a source of audio-frequency energy and a telephone, switched on the sine wave for various adjustable periods of the order of 10^{-2} sec. Experimental curves taken with different observers are given in Fig. 3, which shows the frequency variation of the least time necessary for the correct recognition of a tone. The results are discussed in relation to those of former observers. In § 3 the development of noise into tone sensation is discussed theoretically, with calculations of the spectrum of a tone switched on for a given time, of the frequency carrying the maximum amount of energy (eqn. 7), and of the energy concentration in the spectrum; Fig. 4 compares the experimental curves with those calculated for an ear tuned to two different frequencies and with one calculated from the energy concentration in the neighbourhood of the frequency of the sine wave. The conclusion is reached that the least time required for recognition of a tone is that for which it must be switched on in order that a sufficient fraction (about one-third to one-tenth) of the total energy in its frequency spectrum may be concentrated in the neighbourhood of the tone frequency.

635. On the Physics of Speech Sounds.—F. Trendelenburg: Franz. (*Journ. Acous. Soc. Am.*, October, 1935, Vol. 7, No. 2, Part 1, pp. 142–147.)

636. Integrating Noise Meter [Microphone, Amplifier and Watt-Hour Meter Combination].—F. B. Haynes. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, p. 321.)

637. A Portable Programme Meter [Direct-Reading Logarithmic Instrument, primarily for Outside Broadcasts but applicable as Noisemeter, etc.].—E. L. Payne and J. G. Story. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, pp. 588–594.)

638. On the Theory of the Inertia and Diffraction Corrections for the Rayleigh Disc.—L. V. King. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1935, Vol. 153, No. 878, pp. 17–40.)

639. An Audio-Frequency Direct-Reading "Detector" Frequency Meter.—I. I. Ivanova. (*Elektrichestvo*, No. 14, 1935, pp. 32–34: in Russian.)

A crossed-coil "logometer" measures the ratio of two rectified currents. This ratio depends on the frequency, and the equipment constitutes a simple and accurate frequency meter with negligible power consumption.

640. On the Measurement of Supersonic Velocity in Heavy Water.—R. Bär. (*Helvetica Phys. Acta*, Fasc. 6, Vol. 8, 1935, pp. 500–502: in German.)

641. The Coherence Relations in the Diffraction Spectra excited at Standing Supersonic Waves in Liquids.—R. Bär. (*Helvetica Phys. Acta*, Fasc. 7, Vol. 8, 1935, pp. 591–600: in German.)

642. Compressional Waves as Optical Grating [New Diffraction Results].—Heidemann and Hoesch. (*Naturwiss.*, 11th Oct. 1935, Vol. 23, pp. 705–706.) For criticism and comments *see* Schaefer and Bergmann, *ibid.*, 22nd Nov. 1935, pp. 799–800.

643. Proof of the Frequency Change of Light by the Doppler Effect at Diffraction by Supersonic Waves.—L. Ali. (*Helvetica Phys. Acta*, Fasc. 6, Vol. 8, 1935, pp. 502–505: in German.)

644. Deflagration of Explosive Substances by Supersonic Waves.—N. Marinesco. (*Comptes Rendus*, 9th Dec. 1935, Vol. 201, No. 24, pp. 1187–1189.)

645. The Propagation of Supersonic Waves in Liquid Media [Large Experimental Absorption of Supersonic Beam in Liquid may be due to Diffusion from Symmetrical Molecular Groups].—R. Lucas. (*Comptes Rendus*, 9th Dec. 1935, Vol. 201, No. 24, pp. 1172–1174.)

PHOTOTELEGRAPHY AND TELEVISION

646. Interference with Ultra-Short-Wave Reception.—W. Scholz. (*Funktech. Monatshefte*, September, 1935, No. 9, Supp. p. 68.)

Ultra-short-wave reception is not, in practice, nearly so free from interference as one might expect from the supposition that only car ignition systems produce true u.s.w. disturbances (actually, certain quenched-spark diathermy plants must be added here): interference from the same sources which trouble ordinary reception is liable to be introduced into any mains-driven receiver with i.f. amplification. "Further development of picture-sound broadcasting depends very much on u.s.w. technique both at the transmitter (generation of higher outputs) and at the receiver. On the receiving side the conditions as regards freedom from interference are, as experience has shown, hardly better than in the broadcast band."

647. Ultra-Short-Wave Reception at Long Distances [Results with the Witzleben Television Transmissions].—R. Theile. (*Funktech. Monatshefte*, September, 1935, No. 9, p. 343.)

648. Wide Band Transmission in Sheathed Conductors.—O. B. Blackwell. (*Bell Telephone Quarterly*, July, 1935, Vol. 14, pp. 145–155.) Discussion of the work dealt with in 1933 Abstracts, p. 628 (Clark & Kendall) and 435, 810 and 1525 of 1935.

649. The "Line Jump" Method [Interlaced Scanning] for Mechanical Systems.—F. von Okolicsanyi. (*Funktech. Monatshefte*, October, 1935, No. 10, Supp. pp. 69–70.) Using a Nipkow disc with auxiliary line-changing "wobble disc" at the transmitter, and a special mirror screw at the receiver.

650. A New Method of Picture Analysis: One-Dimensionally Defined Pictures: Application to Television and Film [Scophony Process].—F. Raeck: Walton. (*Funkteck. Monatshefte*, October, 1935, No. 10, Supp. pp. 72–75.)

651. Successful Open-Air Television Tests in Holland, using the Iconoscope.—Philips Company. (*Radio, B., F. für Alle*, December, 1935, p. 231.) On a 7 m wave with a max. modulation frequency of 3 Mc/s.

652. Television at the Universal and International Exposition, Brussels, 1935 [including the Strelkoff Device for Avoiding Discontinuity between Lines].—R. Barthélémy. (*Rev. Gén. de l'Élec.*, 21st Sept. 1935, Vol. 38, No. 12, pp. 405–410.)

653. Eiffel Tower [High-Definition] Television Transmissions.—(*Wireless World*, 29th Nov. 1935, Vol. 37, pp. 558–559.)

654. The New Television Transmitter installed on the Eiffel Tower.—M. Adam. (*Génie Civil*, 30th Nov. 1935, pp. 521–522.)

655. Time-Table of Experimental Television Transmissions from Low-Power 7.02 m Transmitter replacing the Witzleben Transmitter, Destroyed by Fire.—(*Funktech. Monatshefte*, September, 1935, No. 9, Supp. p. 68.)

656. Television at the 1935 Berlin Radio Exhibition.—G. Kette. (*Funktech. Monatshefte*, September, 1935, No. 9, Supp. pp. 61–68: *T.F.T.*, November, 1935, pp. 283–289.)

657. New Developments in Television Design [Telefunken Receiver], *and* The Lorenz Television Receiver.—Roosenstein: Messner. (*Funktech. Monatshefte*, November, 1935, No. 11, Supp. pp. 77–79: 79–81.)

658. The Present Position of Television [British Association Paper, Abridged].—A. G. D. West. (*Engineering*, 1st Nov. 1935, pp. 485–486: concluded from previous issue.)

659. Television Receivers—100-Line Television.—Takayanagi, Yamashita and Yamaguchi. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, Abstracts pp. 20–21.) For papers on other aspects of the same experiments *see* 1131/3 of 1935.

660. Dispersion of Kerr Effect with Certain Colloidal Solutions [*e.g.* Vanadium Pentoxide: where Kerr Effect is some 10^5 Times greater than with Nitrobenzol].—Errera, Overbeek and Sack. (*Helvetica Phys. Acta.*, Fasc. 6, Vol. 8, 1935, pp. 507–508: in German.)

661. The Neon Tube as a Light Modulator in Television Systems: Corrections.—N. D. Smirnov. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, inside of back cover.) A number of corrections to formulae, etc., in the paper dealt with in 3574 of 1935.

662. A New Lamp Development [Extra High Pressure Mercury-Vapour Discharge Tubes, of Very Small Dimensions].—L. J. Davies: Bol. (*BT-H Activities*, Sept/Oct. 1935, Vol. 11, No. 5, p. 157.) A note on BT-H research on the lines of Bol's work in the Philips Laboratories. *See* also *Electrician*, 11th Oct. 1935, p. 439

663. The Philora High-Pressure Mercury-Vapour Discharge Lamp.—Philips Company. (*Engineering*, 18th Oct. 1935, pp. 415–416.) *See* also 723.

664. INVESTIGATIONS ON COUNTERS [of Light Quanta] WITH ALKALI CATHODES.—W. Christoph. (*Ann der Physik*, Series 5, No. 8, Vol. 23, 1935, pp. 747–760.)

For relevant papers *see* Rajewsky, 1931 Abstracts, p. 276; Christoph & Hanle, 1934, p. 32; Locher, 1933, p. 170. The present paper discusses the possibility of constructing Geiger-Müller counters for the visible part of the spectrum; their behaviour could not be stabilised, owing probably to reactions between the contained gas and the alkali cathodes. The construction of the counters is described; characteristic curves, and curves showing the fall of the number of discharges with time under various conditions, are given.

665. MEASUREMENT OF SMALL LIGHT INTENSITIES USING COUNTERS. II [Photoelectric Yield from Zn-, Cd- and Cu- Counters in Range 400–185 mμ for Massive and Evaporated Film Cathodes in Counter].—K. H. Kreuchen. (*Zeitschr. f. Physik*, No. 9/10, Vol. 97, 1935, pp. 625–632.)

For I *see* 2750 of 1935. Description of calibrating monochromator with double spectral separation (§ 2, Fig. 1), of construction of counter (§ 3, Fig. 3); curves of photoelectric yield for Zn (Figs. 4, 5), Cd (Figs. 6–8: effect of hydrogen Fig. 7), Cu (Fig. 9). For pure cathodes the yield is the same as that of photocells of the same metal. Traces of Hg vapour cause marked diminution in the yield. With Cd- and Zn- counters, massive cathodes treated with activated hydrogen are as sensitive as evaporated cathodes; the sensitivity of the latter is not increased by treatment with hydrogen. It thus appears possible to use counters instead of photocells in investigations where their special property of registering each individual photoelectron can be of use. Further investigations will show whether it is possible to treat the cathodes chemically so as to increase their yield to values above those obtained from modern photocells.

666. ALKALI FILMS OF ATOMIC THICKNESS ON PLATINUM [Method of Production and Measurement: Change of Photoelectric Sensitivity of Pt with Increasing Thickness of K Film].—H. Mayer. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 845–848.)

667. THE PHOTOEFFECT AT THIN ADSORBED FILMS OF ALKALI METALS [without Metallic Foundation: Free from Oxides or Hydrates: Ohmic Electric Conductivity: Red Limits for K and Cs 7 800 Å and 9 550 Å respectively: Normal Photocurrent Curves: No Selective Maxima].—W. Gei and I. Truten. (*Physik. Zeitschr. der Sowjetunion*, No. 3, Vol. 8, 1935, pp. 342–351: in German.)

668. THE PHOTOELECTRIC EFFECT OF ALUMINIUM FILMS DEPOSITED BY THE VACUUM EVAPORATING PROCESS [Long Wavelength Limit of Sensitivity Curve and Selective Maximum].—E. Gaviola and J. Strong. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p. 483: abstract only.)

669. PHOTOELECTRIC PROPERTIES OF PURE AND GAS-CONTAMINATED MAGNESIUM [Threshold Values: Effect of Hydrogen and Oxygen].—R. J. Cashman and W. S. Huxford. (*Phys. Review*, 1st Nov. 1935, Series 2, Vol. 48, No. 9, pp. 734–741.)

670. PHOTO-ELECTROMOTIVE FORCES AND CURRENTS IN SINGLE CRYSTALS OF SELENIUM.—R. M. Holmes. (*Journ. Opt. Soc. Am.*, October, 1935, Vol. 25, No. 10, pp. 326–329.)

671. LIMITS OF USEFULNESS OF THE SELENIUM BARRIER-LAYER PHOTOCELL [particularly in Photometry: Improved Consistency obtained by "Ballistic" Method: etc.].—H. König. (*Helvetica Phys. Acta*, Fasc. 6, Vol. 8, 1935, pp. 505–507: in German.)

672. THEORY OF SOME PHOTOELECTRIC AND PHOTO-MAGNETO-ELECTRIC PHENOMENA IN SEMI-CONDUCTORS [Quantitative Theory of Dember Effect and Kikoin-Noskov Effect in Solid Electronic Semiconductors: Equations for Number of Free Electrons and Positrons (Holes)].—Frenkel. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 8, 1935, pp. 185–203: in English.)

673. THE QUANTUM EQUIVALENT IN THE PHOTO-ELECTRIC CONDUCTIVITY OF NaCl CRYSTALS [Deviation from Quantum Rules explained by Colloid Formation].—Z. Gyulai and P. Tomka. (*Zeitschr. f. Physik*, No. 5/6, Vol. 96, 1935, pp. 350–354.)

674. THE ENERGY DISTRIBUTION OF ELECTRONS IN THE PHOTOELECTRIC EFFECT.—E. Rudberg. (*Phys. Review*, 15th Nov. 1935, Series 2, Vol. 48, No. 10, pp. 811–817.)

Expressions for the effect of the distribution of electron levels, and of the transition probabilities from these levels, on the character of photoelectric emission from a metal are discussed, and equations for the energy distribution derived. A comparison is made with experimental data for molybdenum (Roehr, 1934 Abstracts, p. 161). The predicted proportion of low-energy electrons is found to be too high. The best fit with experimental data over the low energy range is given by Mitchell's theory (230 of 1935). The Fermi factor is discussed; the low energy range is found to be of greatest importance for studies of the electronic structure of metals.

675. THE INFLUENCE OF LIGHT ON THE BROWNIAN MOVEMENT [and Explanation in terms of the Photoelectric Effect].—R. Fürth and O. Zimmermann. (*Ann. der Physik*, Series 5, No. 2, Vol. 24, 1935, pp. 183–208.)

676. PHOTO-IONISATION IN GASES [Experiments using Balanced Space-Charge Detector: Ionisation not produced by Absorption of Two Quanta of Fractional Energy].—R. N. Varney and L. B. Loeb. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p. 481: abstract only.)

677. The Absorption of Monochromatic X-Ray Beams, of Wavelength in the Region 50 to 20 X-Units, in Lead, Tin, Copper and Iron [with Variation of Photoelectric Absorption Coefficient per Electron with Atomic Number of Absorbing Element].—J. Read. (*Proc. Roy. Soc.*, Series A, 1st Nov. 1935, Vol. 152, No. 876, pp. 402–417.)

MEASUREMENTS AND STANDARDS

678. The Temperature Coefficient of Inductance [Experiment suggesting Eddy Current Effect as Cause of Inductance Variation higher than Value calculated from Change in Dimensions].—J. Groszkowski. (*Wireless Engineer*, December, 1935, Vol. 12, No. 147, pp. 650–651.) For an Editorial *see* pp. 637–638. For recent papers on this subject *see* 1379 & 1380 of 1935 and 82 & 326 of January.

679. Papers connected with the Frequency Stabilisation of Valve Oscillators.—(*See* also 509/512, under "Transmission.")

680. Wedge-Shaped Piezoelectric Resonators [Very Narrow Normal Resonance Curve: Increased Absorption: Subsidiary Dips in Absorption Curve].—A. Záček and V. Petržílka. (*Hochf:tech. u. Elek:akus.*, November, 1935, Vol. 46, No. 5, pp. 157–159.)

An investigation of wedge-shaped quartz plates by Dye's absorption method (*Proc. Phys. Soc.*, Vol. 38, 1926, p. 399). Each plate is found to oscillate as a unit, with various natural frequencies; no resonance curve analogous to that of a band filter has been found. This is contrary to the statements in two recent patents (Guerbilsky and Ménard, 1934 Abstracts, p. 439 and back references). Dye's method is shortly described (§ I), with an experimental curve for a wedge-shaped quartz crystal in Fig. 3. Fig. 5 (§ II) shows the arrangement actually used; measured data are given in § III. The wedge shape is found to increase the absorption and to cause subsidiary minima in the absorption curve.

681. Thermal Characteristics of Piezoelectric Oscillating AT-Cut and YT-Cut [Quartz] Plates.—H. Yoda. (*Rep. of Rad. Res. in Japan*, July, 1935, Vol. 5, No. 2, pp. 77–87: in English.)

The AT-cut plate is cut at approx. 54°45′, the YT-cut plate at approx. 138°43′, the principal planes in both types being parallel to the electrical axis. "It is evident, from the frequency/thickness and frequency/temperature characteristics of both cuts, that for use at high frequencies the YT-cut plates are superior to the AT-cut plates." For the AT-cut plates *see* also 1579 of 1935.

682. Frequency Division in a Vibrating Mechanical System [with Application to Quartz Oscillators].—I. G. Rusakov and N. N. Ryabinina. (*Journ. Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 670–680.)

When a body is in contact with an oscillating surface it may be set into a complex vibration with a frequency lower than that of the oscillating surface. Such a phenomenon can, for example, be observed in the case of the electrodes of a quartz crystal when these are not rigidly clamped against the crystal. In this paper a mathematical investigation is presented of the movement of a point in contact with an oscillating point. An account is also given of experiments conducted in connection with this investigation.

683. An Interference Method for Measuring the Piezoelectric Moduli of Alpha-Quartz; the Moduli.—H. Osterberg and J. W. Cookson. (*Review Scient. Instr.*, November, 1935, Vol. 6, No. 11, pp. 347–356.)

684. The Action of Ultra-Violet Rays on the Electrical Conductivity of Quartz [Current/Time Curves at Various Voltages].—R. Radmanèche. (*Comptes Rendus*, 25th Nov. 1935, Vol. 201, No. 22, pp. 1021–1022.) *See* also 4015 of 1935.

685. Anomalous Expansion of Rochelle Salt [and the Ferromagnetic Analogy].—J. Hablützel. (*Helvetica Phys. Acta*, Fasc. 6, Vol. 8, 1935, pp. 498–499: in German.)

686. Dielectric Anomalies of Rochelle Salt.—H. Staub. (*Naturwiss.*, 25th Oct. 1935, Vol. 23, pp. 728–733.)

687. A New Substance behaving like Rochelle Salt [KH_2PO_4].—G. Busch and P. Scherrer. (*Naturwiss.*, 25th Oct. 1935, Vol. 23, p. 737.)

688. The Magnetostriction Volume Effect of Nickel and Magnetite [Measurements: Comparison of Expected Values of Thermal Expansion with Available Measurements].—M. Kornetzki. (*Zeitschr. f. Physik*, No. 9/10, Vol. 97, 1935, pp. 662–666.)

689. Broadcast Frequency Monitor employing Luminous Quartz Resonator [using One Resonator only, by Local Modulation of Carrier till Crystal Frequency is reached: Practical Accuracy within 15 Cycles].—H. Mitsui. (*Nippon Elec. Comm. Engineering*, September, 1935, No. 1, pp. 86–87: in English.)

690. Broadcast Frequency Measurements at the A.W.A. Research Laboratories [using Cathode-Ray Oscillograph: Measurements to an Accuracy of 2 c/s].—(*A.W.A. Tech. Review*, October, 1935, Vol. 1, No. 3, pp. 26–28.)

691. Apparatus for the Measurement of H.F. Damping [between 10 000 and 10 000 000 Ohms: using an AVC Broadcast Receiver as Oscillator, etc.: for Comparative or Absolute Measurements].—L. Heiss. (*Funktech. Monatshefte*, November, 1935, No. 11, pp. 405–411.)

692. The Dielectric Loss Characteristics of a Chlorinated Diphenyl [Variation with Frequency and Temperature: Appearance of Debye Power Factor Maximum at Low Frequencies].—W. Jackson. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1935, Vol. 153, No. 878, pp. 158–166.)

693. Measurement of the Variation of the Dielectric Constant of Water with Extent of Adsorption [on Cellulosic Material].—G. H. Argue and O. Maass. (*Canadian Journ. of Res.*, September, 1935, Vol. 13, No. 3, pp. 156–166.)

694. The Discontinuity in the Dielectric Constant of Liquids and Their Saturated Vapours at the Critical Temperature [and a Special Dielectric Cell].—Marsden and Maass. (*Canadian Journ. of Res.*, November, 1935, Vol. 13, No. 5, pp. 296–307.)

695. Variation of the Dielectric Constants of Anisotropic Fluids with Field-Strength and Frequency.—W. Kast. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 869–873.)

696. Note on the Measurement of the Constants of a Three-Electrode Valve [Modification of Miller's Method].—J. B. Pomey. (*Ann. des Postes T. et T.*, November, 1935, Vol. 24, No. 11, pp. 989–992.)

697. A New [Valve] Method of Measuring Polarisation Voltages [in Liquids].—B. Gross. (*Physik. Zeitschr.*, 1st Oct. 1935, Vol. 36, No. 19, pp. 648–649.)

698. Comparative Measurements of the Conductivity of the Bunsen Flame with Direct and Alternating Current [A.C. Measurements of Change in Condenser Impedance due to Flame: Penetration into Condenser Interior of Electrode Disturbance with Pure and Sodium Bunsen Flames].—H. Ullmann. (*Zeitschr. f. Physik*, No. 7/8, Vol. 97, 1935, pp. 496–510.)

699. A Sensitive Visual Detector for A.C. Bridge Measurements [Rectifier/Galvanometer Combination].—C. K. Strobel. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, pp. 319–320.)

700. A Permanent-Magnet Device for enabling a More Uniform Division of the Scale of A.C. Indicating Instruments to be Readily Obtained [Whole or Greater Part of Torque from Repulsion between Like Poles].—H. E. M. Barlow. (*Journ. I.E.E.*, November, 1935, Vol. 77, No. 467, pp. 618–623: Discussion pp. 623–628.)

701. A Portable Low-Voltage Megohmmeter, reading directly from 0.07 to 10 000 Megohms.—L. B. Turner. (*Journ. Scient. Instr.*, November, 1935, Vol. 12, No. 11, pp. 355–361.)

702. Ballistic Galvanometer [Modification of original Moll Galvanometer].—(*Journ. Scient. Instr.*, November, 1935, Vol. 12, No. 11, pp. 368–369.)

703. Measuring Instruments: a Survey of Recent Developments, *and* Meters and Instruments [Developments].—C. L. Lipman: Anon. (*Electrician*, 25th Oct. 1935, Vol. 115, No. 2995, pp. 493–496: 504–515.)

704. Electrical Standards for Research and Industry.—H. W. Sullivan, Ltd. (*Wireless Engineer*, December, 1935, Vol. 12, No. 147, p. 652.)

705. International Electrotechnical Commission [and the Giorgi System of Units].—Giorgi. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, p. 600.)

706. Adoption of the Metre-Kilogram-Mass-Second (M.K.S.) Absolute System of Practical Units by the I.E.C., Brussels, June, 1935.—Kennelly: Giorgi. (*Proc. Nat. Acad. Sci.*, October, 1935, Vol. 21, No. 10, pp. 579–583.) *See* also 3628/9 of 1935.

SUBSIDIARY APPARATUS AND MATERIALS

707. High-Speed Oscillography: Apparatus with Drum Camera rotating *in Vacuo*: Performance and Applications [Film moving at 100 Metres/Second].—Whipple. (*Electrician*, 20th Dec. 1935, Vol. 115, No. 3003, pp. 769–770.)

708. The Instantaneous Cathode-Ray Oscillograph [Advantages over Continuously Acting Type: Recording Velocities 100 km/s with Potentials 10–12 kV].—Stekolnikov and Slashtchev. (*Elektrichestvo*, No. 21, 1935, pp. 34–39: in Russian.)

709. New Constructions and Development Work on the Cold-Cathode Cathode-Ray Oscillograph [leading to a Reliable and Easily Transportable Equipment for Lightning, Electrobiological, and other Investigations].—Induni. (*Bull. Assoc. suisse des Élec.*, No. 24, Vol. 26, 1935, pp. 687–693: in German.)

710. Amplifying Apparatus for the Measurement of Small Potentials [*e.g.* Voltage Amplification 110 000 for Frequencies up to about 10 000 c/s: suitable for Cathode-Ray Oscillographs].—Holzer. (*Elektrot. u. Masch:bau*, 27th Oct. 1935, Vol. 53, No. 43, pp. 505–508.)

711. Calculation of the Scattered Field of a Condenser with Field limited by a Stop [including Special Cases of Very Thin and Very Thick Stops: Numerical Evaluation: Asymptotic Formulae for Axial Region: Area of Condenser for Homogeneous Field: Application to Electron Optics].—Herzog. (*Arch. f. Elektrot.*, 5th Nov. 1935, Vol. 29, No. 11, pp. 790–802.) *See* also 712.

712. Deflection of Cathode and Canal Rays at the Edge of a Condenser whose Scattering Field is Limited by a Stop [Theory: Formulae giving Length of Equivalent Ideal Condenser: Relation between Stop Diameter and Distance for Case when Real and Ideal Condenser coincide: Possible Application to Cylindrical Condensers].—Herzog. (*Zeitschr. f. Physik*, No. 9/10, Vol. 97, 1935, pp. 596–602.) *See* also 711.

713. The Use of the Cathode-Ray Tube in the Study of Oscillations represented by Equations of Higher Order than Two.—Bendrikov and Gorelik. (*See* 486.)

714. Some Methods and Results of Modern Microscopic Time Measurement [with the Cathode-Ray Oscillograph].—Berger. (*Bull. Assoc. suisse des Élec.*, No. 23, 1935, pp. 651–659 : in German.)

715. Machine with a Memory records Lightning Strokes [and studies Failure of Valves : Event photographs Its Record on Cathode-Ray Screen and includes After-Glow Record of Preceding Conditions].—Hull. (*Sci. News Letter*, 30th Nov. 1935, p. 348.)

716. A Modulation Monitor for Broadcast Stations : the A.W.A. Cathode-Ray Oscillograph Type R 580.—(*A.W.A. Tech. Review*, October, 1935, Vol. 1, No. 3, pp. 23–25.)

717. Cloud-Chamber Investigations on the Diffusion of Cathode Rays [Fall in Intensity along Ray : Combined Effects of Absorption and Diffusion].—Günther. (*Ann. der Physik*, Series 5, No. 4, Vol. 24, 1935, pp. 377–392.)

718. Device to Compensate for Magnetic Field Fluctuations in a Mass Spectrograph [using a Magnetron Valve].—Nier. (*Review Scient. Instr.*, September, 1935, Vol. 6, No. 9, pp. 254–255.)

719. The Luminescence of Frozen Solutions of Certain Dyes.—Wick and Throop. (*Journ. Opt. Soc. Am.*, November, 1935, Vol. 25, No. 11, pp. 368–374.)

720. The Mechanism of Light Emission [and an Experiment with Zinc Sulphide Screen excited by Ultra-Violet Light in Liquid Air Bath].—Pohl. (*Zeitschr. V.D.I.*, 21st Sept. 1935, p. 1152 : summary only of lecture.)

721. Further Developments in Gas-Discharge Lamps : White Light by the Use of Fluorescent Materials.—Ewest. (*E.T.Z.*, 7th Nov. 1935, Vol. 56, No. 45, pp. 1225–1226.)

722. Generation of Light by Radiation Transformation.—Larché and Wiegand. (*Zeitschr. V.D.I.*, 26th Oct. 1935, Vol. 79, No. 43, pp. 1316–1317 : extract only.)

723. A New Discharge Tube [" Super High Pressure " Mercury] Vapour Lamp [with Increased Light-Giving Power : Absence of Thermal Inertia : Concentrated Beam].—(*Nature*, 26th Oct. 1935, Vol. 136, p. 688 : short note only.) *See* also 663.

724. A Simple Neon-Tube Oscilloscope for Amateur Use [for checking Modulation, etc.].—Vollmer. (*QST*, October, 1935, Vol. 19, No. 10, pp. 48–49.) With special neon tube starting its glow at its centre, and viewed in rotating mirror.

725. " Discharge-Characteristic Control," a New Type of Control for Gaseous-Discharge Rectifier Tubes [using a Second, " Displacing," Grid].—Jacobi and Kniepkamp. (*E.T.Z.*, 10th Oct. 1935, Vol. 56, No. 41, p. 1126.)

726. The Theory of Operation and Design of Low-Power Rectifier Circuits [as used in Wireless Eliminators].—Whitehead and Hackett. (*World Power*, Oct. and Nov. 1935, Vol. 24, Nos. 142 and 143, pp. 180–185 and 238–248.)

727. The Structure of the Oxides of the Copper/Cuprous-Oxide Rectifiers.—Gvozdov, Turkulets and Sidorov. (*Izvestia Elektroprom. Slab. Toka*, No. 7, 1935, pp. 55–61.)

The rectifying property of these rectifiers is due to the unidirectional conductivity of the oxide layer. The performance of this layer is affected by direct exposure to light and heat, and it is therefore desirable to have more information on the actual structure of the layer. In this paper an account is given of a micro-photographic investigation carried out with finished samples of both Soviet and foreign manufacture, as well as with samples at different stages of the manufacturing process. The effect of mechanical pressure of the order of 6 000 kg/cm^2 has also been investigated. Photographs were taken of sections at various depths and some of these are reproduced in the paper.

It is pointed out that although there still remains a considerable amount of work to be done, the experiments so far carried out lead to the following conclusions :—(a) An oxidised plate comprises three layers, *viz* : copper, cuprous oxide and cupric oxide ; in addition there is an eutectic layer between the copper and the cuprous oxide. (b) The crystals of the oxide layers and of the copper layer have different structure and orientation. (c) It is, therefore, incorrect to assume that the rectifying property of the element is due to similar orientation of crystals in all layers.

728. On Ionisation in Electrical Machines.—Kanonykin. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 664–669.) A theoretical investigation of the conditions under which ionisation of the air layers in the insulation of h.t. electrical machines occurs.

729. The Microphonic Effect in Leclanché Cells.—Nikitin and Frolov. (*Izvestia Elektroprom. Slab. Toka*, No. 7, 1935, pp. 61–63.)

It has been noticed that amplifiers using Leclanché cells are sometimes extremely sensitive to the slightest outside disturbances such as walking in the room, moving of objects on the table on which the amplifier is mounted, etc. After a careful investigation the source of this effect was traced to Leclanché cells used for power supply. A number of experiments were then carried out with a cell having one electrode of carbon and the other of zinc, both 10 cm^2 in area, 0.5 cm thick and spaced 1 cm apart. It was found that when a 10% solution of NH_3 was used and the current flowing through the cell was 20 mA, the microphonic effect was very pronounced. The authors suggest that the causes of this effect are purely mechanical, such as the formation of unstable air bubbles on the surface of the electrodes.

730. A New Ballast Resistor [Tungsten-Filament Barretter].—(*Wireless World*, 15th Nov. 1935, Vol. 37, pp. 522–523.) Depending for its action on the varying density of the gas inside the bulb due to the heating action of the filament.

731. Litz Wire and Its Use in the Construction of Coils [Air and Iron-Powder Cored].—Saic. (*Funktech. Monatshefte*, November, 1935, No. 11, pp. 425–429.)

732. Ferrocart, the High-Frequency Iron [Illustrated Notes on Recent Developments in Coils].—Vogt. (*Hochf:tech. u. Elek: akus.*, November, 1935, Vol. 46, No. 5, pp. 179–180 : Industrial Review.)

733. The Manufacture and Uses of Metal Powders [as used for Magnetic Cores, Condensers, etc.]—Chaston. (*Elec. Communication*, October, 1935, Vol. 14, No. 2, pp. 133–144.)

734. Crolite Magicore Data : a New Metallic Core Material for R.F. and I.F. Transformers [Magnesium Ferrous Alloy Particles in Crolite Binder].—(*Rad. Engineering*, October, 1935, Vol. 15, No. 10, p. 11.)

735. Cores—Design, Production [for Radio Receivers].—(*Rad. Engineering*, October, 1935, Vol. 15, No. 10, pp. 14–15.)

736. Improvements in Communication Transformers.—Ganz and Laird. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1367–1373.)

737. Heat Treatment in Magnetic Fields [Method of obtaining High Permeability].—Kelsall. (*Bell Lab. Record*, September, 1935, Vol. 14, No. 1, pp. 26–28.) *See* also 1934 Abstracts, p. 629.

738. Heat Treatment of Magnetic Materials in a Magnetic Field. I. Survey of Iron-Cobalt-Nickel Alloys [Changes in Magnetic Properties] : II. Experiments with Two Alloys [and Interpretation in Terms of Domain Theory].—Dillinger and Bozorth. (*Physics*, September, 1935, Vol. 6, No. 9, pp. 279–284 : 285–291.)

739. Iron of High Purity [Physical Properties].—Adcock and Bristow. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1935, Vol. 153, No. 878, pp. 172–200.)

740. New Materials for Permanent Magnets.—Kussmann. (*Zeitschr. V.D.I.*, 28th Sept. 1935, Vol. 79, No. 39, pp. 1171–1173.)

741. Permanent Magnets [including the Effect of Material Characteristics on Design : Alnico and Chromium Steel : etc.].—Edgar. (*Gen. Elec. Review*, October, 1935, Vol. 38, No. 10, pp. 466–469 : Editorial p. 447.)

742. A New Magnetic Alloy [for Permanent Magnets : Aluminium, Cobalt, Nickel and Iron Alloy].—General Electric Company. (*Sci. News Letter*, 2nd Nov. 1935, p. 286.)

743. Magnetic Alloys of Iron, Nickel, and Cobalt.—Elmen. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1292–1299.)

744. Iron-Platinum Alloys of High Coercive Force [valuable for Galvanometer Needles, etc.].—Graf and Kussmann. (*E.T.Z.*, 19th Dec. 1935, Vol. 56, No. 51, p. 1384 : summary only.)

745. Silicon Steel in Communication Equipment.—Crawford and Thomas. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1348–1353.)

746. Estimating Permanent Magnets [Simplified Method using Sanford's Demagnetisation Curve—confirmed for New Magnetic Materials].—Kanter. (*Elektrichestvo*, No. 17, 1935, pp. 34–40 : in Russian.)

747. The "Coercimeter," working on the Principle of Refraction of Lines of Force [New Method of Measuring the Retentivity of Magnetic Materials].—Neumann. (*E.T.Z.*, 31st Oct. 1935, Vol. 56, No. 44, pp. 1204–1205 : summary only.)

748. Graphico-Analytical and Theoretical Methods of Designing Electro-Magnetic Systems.—Kovalenkov and Sotskov. (*See* 66 of January.)

749. Research Work in Magnetics—1933/34 [Bibliography].—Spooner. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1354–1359.)

750. Multi-Lamellar Cylindrical Magnetic Shields [Shielding Ratio rapidly computed by Recurrence Formulae].—Sterne. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, pp. 324–326.)

751. Electro-Magnetic Relay and Copper-Oxide Rectifier Combination as Telephone Relay [with Sensitivity at 50 c/s 32 times higher than usual Laminated-Core Type].—Vitenberg. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1935, pp. 42–50.)

752. Design of [Power] Transformers for Amateurs [Labour-Saving Graphs and Practical Hints].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, October, 1935, Vol. 220, No. 4, pp. 497–498 : note on Circular C 408.)

753. On the Theory of the Dispersion of Magnetic Permeability in Ferromagnetic Bodies [Ferromagnetic Crystal consists o Elementary Layers magnetised to Saturation].—Landau and Lifshitz. (*Physik Zeitschr. der Sowjetunion*, No. 2, Vol. 8, 1935 pp. 153–169 : in English.)

754. A Refinement of the Heisenberg Theory of Ferromagnetism, applicable to Simple Cubic Crystals.—Fay. (*Proc. Nat. Acad. Sci.*, September, 1935, Vol. 21, No. 9, pp. 537–542.)

755. Present Status of Ferromagnetic Theory.—Bozorth. (*Elec. Engineering*, November, 1935, Vol. 54, No. 11, pp. 1251–1261.)

756. Some Variations of the Barkhausen Phenomenon [observed by Acoustical Method].—Lebedinsky. (*Izvestia Elektroprom. Slab: Toka*, No. 9, 1935, pp. 39–40.)

757. The Phenomenon of Negative Hysteresis in Nickel.—Sharan. (*Current Science*, Bangalore, September, 1935, Vol. 4, No. 3, p. 157.)

758. Magnetic Reversal Nuclei. Part V. Propagation of Large Barkhausen Discontinuities [in Ni-Fe Wire under Tension].—Sixtus. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, pp. 425–430.)

759. The Validity of Becker's Relation for the Initial Permeability of Nickel Wire under Great Tension [Initial Susceptibility as Function of Temperature: Validity of Becker's Magnetoelastic Theory up to Curie Point].—Scharff. (*Zeitschr. f. Physik*, No. 1/2, Vol. 97, 1935, pp. 73–82.)

760. The Negative Matteucci Effect [Extension of Becker's Magnetisation Theory to Twisted Nickel Wires: Measurement of Temperature Dependence of Negative Matteucci Effect and Magnetisation of Twisted Wire].—Englert. (*Zeitschr. f. Physik*, No. 1/2, Vol. 97, 1935, pp. 83–93.)

761. Cinematographic Record of the $\alpha \rightleftarrows \gamma$ Iron Transition as seen by the Electron-Microscope.—Burgers and van Amstel. (*Nature*, 2nd Nov. 1935, Vol. 136, p. 721.) *See* 537 of 1935.

762. Measurement of the Longitudinal Magnetogalvanic and Magnetothermoelectric Effects.—Perrier and Meylan. (*Helvet. Phys. Acta*, Fasc. 6, Vol. 8, 1935, pp. 493–494: in French.)

763. The Specification of Magnetic Qualities [British Association Paper].—Sims. (*Engineering*, 13th Sept. 1935, pp. 290–291.)

764. The Research Work on the New Insulating and Ferromagnetic Materials for the Radio Industry.—Vaneev, Deisenroth and Popov. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1935, pp. 58–72.) With numerous literature references, including Russian.

765. The Properties of Dielectrics at High Frequencies [Measurements between 10^4 and 10^7 c/s].—Sharpe and O'Kane. (*Engineering*, 11th Oct. 1935, pp. 403–404.)

The materials tested included Pyrex glass, tulip wood, Pernax, red fibre, etc. " It is shown that below 250 000 c/s a conductivity effect is the predominant factor in determining the shape of the power-factor/frequency curve, whilst above that frequency the shape of the curves is governed by the effect of the permanently polarised molecules present in the material."

766. Alsimag 196: a New Ceramic [Steatite] Insulating Material for High-Frequency Purposes [including Ultra-High Frequencies].—Thurnauer. (*Rad. Engineering*, November, 1935, Vol. 15, No. 11, pp. 15–16 and 25.)

767. Pyrochemical Behaviour of Cellulose Insulation.—Clark. (*Elec. Engineering*, October, 1935, Vol. 54, No. 10, pp. 1088–1094.)

768. Some Notes on Glass and Its Manufacture.—Cameron. (*P.O. Elec. Eng. Journ.*, October, 1935, Vol. 28, Part 3, pp. 186–193.)

769. Dielectric Losses in Glasses.—Bogoroditzki and Malyschew. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 612–619.) *See* also pp. 739–740 for a discussion by Sackheim.

770. The Dielectric Properties of Paper [British E.R.A. Report].—Hartshorn and Ward. (*Journ. I.E.E.*, November, 1935, Vol. 77, No. 467, pp. 723–725.)

771. Two Types of Dielectric Polarisation [Debye and Maxwell-Wagner Types: Investigations on Paper, etc.].—White. (*Bell Lab. Record*, September, 1935, Vol. 14, No. 1, pp. 7–12.)

772. Recent Progress in Dielectric Research.—Whitehead. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1288–1291.)

773. The Dielectric Behaviour of Camphor [Abnormally High Dielectric Constant: Readjustment of Molecular Orientation in Solids].—Yager: Pauling. (*Bell Lab. Record*, September, 1935, Vol. 14, No. 1, pp. 22–25.)

774. Breakdown Curve for Solid Insulation [with Three Distinct Regions: Times up to 8.16 Minutes].—Montsinger. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1300–1301.)

775. The Modern Views on the Mechanism of Electrical Breakdown in Solid Dielectrics.—Wolkenstein. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 5, 1935, pp. 583–611.)

776. True Conductivity and Opposing Voltages in Stratified Dielectrics [Quantitative Theoretical Discussion applied to Rock Salt: Simple Stratified Model does not explain Observed Phenomena].—Quittner. (*Physik. Zeitschr. der Sowjetunion*, No. 3, Vol. 8, 1935, pp. 275–288: in German.)

777. On the Thermal Breakdown of the Insulator.—Toriyama & others. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 567, p. 913: Japanese only.)

778. The Molecular Structure of Dielectrics [Kelvin Lecture].—Bragg. (*Journ. I.E.E.*, December, 1935, Vol. 77, No. 468, pp. 737–748.)

779. " Elektrophysik der Isolierstoffe "[Book Review].—Gemant. (*Bull. Assoc. suisse des Élec.*, No. 24, Vol. 26, 1935, p. 701.) Published, unless there is a misprint, in 1930.

780. On the Phenomena of Electrical Breakdown in Gases [Corona, Glow and Spark Mechanisms in Various Gases: Theoretical and Experimental Investigations].—Miyamoto. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 567, pp. 856–863: English summary pp. 109–111.)

781. Contribution to Knowledge of the Preliminary Processes in Spark and Corona Discharges, using a Cloud Chamber [Stereoscopic Photographs: Positive Space Charge in Canals: Influence of Electrode Surfaces and Different Gases].—Kroemer. (*Arch. f. Elektrot.*, 5th Nov. 1935, Vol. 29, No. 11, pp. 782–789.)

782. Effect of Total Voltage on Breakdown in Vacuum [Inverse Relation between Cathode Gradient at Breakdown and Gap Length, leading to Conclusion as to Part played by Positive Ions from Anode].—Anderson. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1315–1320.)

783. The Effect of the Resistance of the Electrolyte on the Performance of Electrolytic Condensers.—Porfirov and Petrovsky. (*Izvestia Elektroprom. Slab. Toka*, No. 7, 1935, pp. 63–66.)

In this paper an examination is made of the effect of the resistance of the electrolyte on the angle of loss and the sparking voltage of an electrolytic condenser. The angle of loss is obviously reduced with a decrease in electrolyte resistance. This can be achieved in one of the following two ways: (a) by increasing the specific conductivity of the electrolyte, *i.e.* raising its concentration, and (b) by choosing electrodes of suitable shape. A table is given showing that the effect of conductivity on the angle of loss is very considerable. Still more important is the shape of the electrodes. For a spiral anode, for instance, the angle of loss in a certain condenser was found to be 18°. This was reduced to 4° 40′ when the electrodes (one anode and two cathodes) were made in the shape of plates and the anode was mounted between the two cathodes. With regard to the sparking voltage, this is increased with an increase of electrolyte resistance, *i.e.* when the concentration of the electrolyte is lowered. A tentative explanation of this phenomenon is offered.

784. Dry Electrolytic *versus* Wet Electrolytic Condensers.—Twiss. (*Brit. Rad. Annual*, 1934/5, pp. 67–73.)

785. The A.C. Electrolytic Capacitor.—Lomont and Dunleavey. (*Elec. Engineering*, October, 1935, Vol. 54, No. 10, pp. 1058–1063.)

786. Problems of Ionic and Electronic Conduction in Non-Metallic Solid Bodies [Introduction to Symposium].—Gudden and Schottky. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 323–327: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 717–721.)

The theme of a symposium at the Stuttgart meeting of German physicists. These problems are of great importance in connection with theory and also with practical applications such as high resistances with low temperature coefficients, dry-plate rectifiers and photocells, insulating films in electrolytic condensers, composite hot cathodes and photo-cathodes, and the possibility of more efficient transformation of chemical energy into electrical by the use of solid electrolytes with a concentration gradient. The following references deal with other papers at this symposium.

787. " Gap " Phenomena in Ion Lattices as the Foundation of Ionic and Electronic Conduction.—Wagner. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 327–331: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 721–725.)

788. Theory of Electron Motion in Non-Metallic Crystal Lattices [Treatment by Wave Mechanics].—Hund. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 331–335: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 725–729.)

789. Contributions of X-Ray Analysis to the Problem of the Electrons in Ionic Lattices.—Kronig. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 335–338: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 729–732.)

790. Electronic Conduction in Alkali-Halogen Crystals [KBr Crystals with Stoichiometric Excess of Alkali-Metal Ions behave as Semi-Conductors, etc.].—Pohl. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 338–341: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 732–735.)

791. The Thermal Formation of Colour Centres and Their Life, *and* The Thermal Diffusion of Colour Centres.—Hilsch :Stasiw. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 341–343: 343–346: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 735–737: 737–740.)

792. Electrical Conduction in Fused Alkali Salts with a Stoichiometric Surplus of Alkali Metal.—Mollwo. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 346–348: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 740–742.)

793. The Production of Counter-Potentials in Solid Ionic Conductors [Dielectric Anomalies explained by Counter-Potentials due to Hindering of Migration of Conduction Ions in Structurally Inhomogeneous Crystal].—Smekal. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 348–355: *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 742–749.)

794. Contribution to the Electrical Conduction in Semi-Conducting Materials [Investigation of the *A* Constant in Conductivity/Temperature Formula, particularly for Titanium-Dioxide Materials].—Meyer. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 355–361 : *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 749–755.)

795. Thermo-Potential, Peltier Heat and Photo-Potential in the Copper/Copper-Oxide/Copper Element [New Experimental Results].—Mönch. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 361–363 : *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 755–757.)

796. Calculation of the Values and Pressure-Dependence of the "Gap" [Fehlordnungs] Energies and Mobilities in Crystals.—Jost. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 363–366 : *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 757–760.)

797. On the Electrical Conductivity of Cuprous Oxide in Equilibrium with Its Adjacent Layers.—Waibel. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 366–370 : *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 760–764.)

798. Thermoelectronic Emission and Electronic Conduction of Solid Bodies [Thermionic Emission purely a Surface-Layer Phenomenon, whether from Plain Metal or Coated Cathode : No Points of Comparison with Metallic Conduction].—Gehrts. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 370–373 : *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 764–767.) At the end of this paper, Schottky remarks that he does not agree with it in all points.

799. The Influence of Heat Removal on the Electrical Behaviour of Temperature-Dependent Resistances.—Lueder and Spenke. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 373–379 : *Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 767–773.)

STATIONS, DESIGN AND OPERATION

800. Contribution to the Study of the Propagation of Short Waves [Method of Calculating the Periods of Possible Communication, on Given Wavelengths, between Two Points more than 3 000 Kilomètres apart].—Niculesco. (*L'Onde Élec.*, October, 1935, Vol. 14, No. 166, pp. 675–681.)

The basic relation on which the method is founded is that the duration Δ of the period of good propagation for a frequency F is a function of the length of daytime D and of the logarithm of the frequency : $\Delta = f(D, \log F) = f(\delta, \phi, \log F)$, where δ is the declination and ϕ the latitude (propagation factors other than solar illumination are assumed to be normal). Figs. 1 and 2, based on observational results, are graphical representations of these functions, for periods of minimum and maximum solar activity. They show the existence of the well-known "day," "night" and "transitional" wavelengths. Various points on the great circle path have to be considered : thus for day waves and the transitional waves nearest them, the upper limit of the propagation characteristic is that corresponding to the point where sunrise is latest, while the lower limit is the more advanced of (a) the lower limit corresponding to the point where sunset is earliest, and (b) the lower limit corresponding to the point where the absolute value of $\phi\delta$ (giving the minimum zenithal distance of the sun) is maximum. The power is assumed to be of several kilowatts ; a future paper will deal with the behaviour of quite small powers.

801. The Year's Progress in Commercial Wireless.—Chetwode Crawley. (*Wireless World*, 27th Dec. 1935, Vol. 37, pp. 656–658.)

802. The New Motala Broadcasting Station [with Field-Strength Map].—Magnusson and Ekstrom. (*Teknisk Tidskrift*, 7th Dec. 1935, pp. 182–190.)

803. Marine Radio-Telephone Service for Boston Harbour.—Gifford and Meader. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 702–707.)

804. Ship Sets for Harbour Ship-to-Shore Service.—Willets. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 713–717.)

805. The Micro-Wave in the Royal Italian Navy.—(*La Ricerca Scient.*, 15/31st Oct. 1935, 6th Year, Vol. 2, No. 7/8, pp. 247–250.) Continuation from 2455 of 1935 : dealing chiefly with magnetron transmitters.

806. The Applications of [Ultra-Short-Wave] Wireless, at the Port of Rouen, to the State Railway System.—(*Génie Civil*, 19th Oct. 1935, pp. 376–377.)

807. Radio-Telephone System employed for the Intercontinental Broadcast of the 32nd International Eucharistic Congress.—Stevens. (*Elec. Communication*, October, 1935, Vol. 14, No. 2, pp. 106–114.)

808. A Modulation Monitor for Broadcast Stations : the A.W.A. Cathode-Ray Oscillograph Type R 580.—(*A.W.A. Tech. Review*, October, 1935, Vol. 1, No. 3, pp. 23–25.)

809. Broadcast Frequency Monitor employing [Single] Luminous Quartz Resonator.—Mitsui. (*See* 689.)

GENERAL PHYSICAL ARTICLES

810. A Theory of Elementary Particles. Part II. Electromagnetic Whirls and Elementary Particles [Material Particles identified with Compound Whirls, Photons with Incomplete Simple Whirls : Quantum and Relativity Relationships, including Gravitation, explained on Basis of Classical Electrodynamics].—Japolsky. (*Phil. Mag.*, October, 1935, Series 7, Vol. 20, No. 134, pp. 641–706.) For Part I *see* 4108 of 1935.

811. The Velocity of Light and the Generalised Lorentz Transformations [Theory of Relativity when Origin of Coordinate Frame moves in Two or Three Dimensions].—Tavani. (*Phil. Mag.*, November, 1935, Series 7, Vol. 20, No. 135, pp. 835–840.)

812. Quantised Field Theory and the Mass of the Proton [Estimate agrees with Experimental Value].—Born. (*Nature*, 14th Dec. 1935, Vol. 136, pp. 952–953.)

813. Quantum Velocity Losses of Slow Electrons and Effective Cross-Sections in Molecular Gases [Velocities at which Onset of Inelastic Reflection occurs: Analysis of Effective Cross-Section into Deviating Cross-Section and Retarding Cross-Section].—Löhner. (*Ann. der Physik*, Series 5, No. 4, Vol. 24, 1935, pp. 349–360.)

814. The Present Situation in Quantum Mechanics.—Schrödinger. (*Naturwiss.*, 29th Nov. and 6th and 13th Dec. 1935, Vol. 23, pp. 807–812, 823–828, and 844–849.)

815. Electromagnetic Field Theory [based on Maxwell's Equations and Principle of Least Action leads to Theory of Electron].—Lewis. (*Phil. Mag.*, November, 1935, Supp. No., Series 7, Vol. 20, No. 136, pp. 1000–1025.)

816. Collisions of Slow Electrons with Methane Molecules [Measurements of Drift Velocity and Velocity of Agitation: Selective Absorption of Methane for Slow Electrons: etc.].—Brose and Keyston. (*Phil. Mag.*, November, 1935, Series 7, Vol. 20, No. 135, pp. 902–912.)

817. The Ionising Action of Cathode Rays in Air [Measurements of Energy Loss per Ion Pair: Empirical Formula for Variation with Accelerating Voltage].—Gerbes. (*Ann. der Physik*, Series 5, No. 7, Vol. 23, 1935, pp. 648–656.)

818. Energy Losses of Electrons in Helium, Neon and Argon [Accurate Critical Potential Determinations: Interpretation of Observed Excitations].—Whiddington and Woodroofe. (*Phil. Mag.*, December, 1935, Series 7, Vol. 20, No. 137, pp. 1109–1120.)

819. Ionisation by Collision of Ions.—Rostagni. (*La Ricerca Scient.*, 15/31st Oct. 1935, 6th Year, Vol. 2, No. 7/8, pp. 268–269.) Continued from 3255 of 1935: results for Ar, Ne and He.

820. A New Effect with Wires with a Corona Discharge [Rotation of Suspended Wire loaded with Heating Current and Corona Discharge].—Güntherschulze and Hesse. (*Zeitschr. f. Physik*, No. 1/2, Vol. 97, 1935, pp. 113–123.)

821. The Rôle of Space Charge in the Study of the Townsend Ionisation Coefficients and the Mechanism of Static Spark Breakdown [Theory: Effect of Space-Charge Distortion of Spark-Gap Field].—Varney, White, Loeb and Posin. (*Phys. Review*, 15th Nov. 1935, Series 2, Vol. 48, No. 10, pp. 818–822.)

822. Photoionisation in Gases [Experiments show Unlikelihood of Photoionisation by Radiation of Energy materially less than Ionisation Potential of Gas].—Varney and Loeb. (*Phys. Review*, 15th Nov. 1935, Series 2, Vol. 48, No. 10, pp. 822–824.)

MISCELLANEOUS

823. Resonant Functions [and Their Use in Circuit Calculations: "Reactance Transformation" as a Special Branch of "Frequency Transformations"].—Laurent: Baggally. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, p. 599.)

Referring to Baggally's article (4117 of 1935) the writer cites recent papers of his own on these "frequency transformations" which "present many interesting possibilities and great practical values which do not appear from Baggally's article."

824. A Method of Calculating Vector Potential Fields [with Application to Toroids].—Schlomka. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 873–875.)

825. On the Use of Operators in the Theory of Alternating Currents.—Boveri. (*Bull. Assoc. suisse des Élec.*, No. 22, Vol. 26, 1935, pp. 613–622: in German.)

826. Meaning of Certain Constants in Use in Physics [Many Equations are Consequences of Theory rather than Fundamental Definitions of Coefficients].—Glazebrook. (*Nature*, 21st Dec. 1935, Vol. 136, pp. 986–987.)

827. Method of Graphical Construction of the Curve representing the Derived Function of a Function whose Equation is Unknown.—Antoniu. (*Rev. Gén. de l'Élec.*, 9th Nov. 1935, Vol. 38, No. 19, pp. 631–633.)

828. The Problem of Dirichlet for an Ellipsoid.—Sokolnikoff. (*Proc. Nat. Acad. Sci.*, November, 1935, Vol. 21, No. 11, pp. 617–618.)

839. An Unbiassed Correlation Ratio Measure.—Kelley. (*Proc. Nat. Acad. Sci.*, September, 1935, Vol. 21, No. 9, pp. 554–559.)

830. A Proposed Method for the Direct Measurement of Correlation.—Price. (*Science*, 22nd Nov. 1935, pp. 497–498.)

831. Recent Investigations on Electrets.—Gemant. (*Phil. Mag.*, November, 1935, Supp. No., Series 7, Vol. 20, No. 136, pp. 929–952.)

For earlier papers on the electret *see* Abstracts, 1932, pp. 540, 660 (Tiku: Eguchi); 1933, p. 232 (Eguchi). The present writer deals with:—heterocharge and homocharge: orientation of dipole molecules accompanied by secondary piezoelectric effect: influence of different chemical constituents: technical applications—electrometers with linear scale, electrostatic microphone.

832. Theory *versus* Experiment in Radioelectricity.—Mesny. (*L'Onde Élec.*, October, 1935, Vol. 14, No. 166, pp. 615–626.)

833. Similarity Relations in Electrical Engineering [and the Possibility of Translating μ and K in Terms of Fundamental Dimensions L, M and T].—Coe: Brainerd. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1421–1422.) Prompted by Brainerd's paper (2121 of 1935) and subsequent correspondence.

834. "Practical Radio Communication" [Book Review].—Nilson and Hornung. (*Wireless Engineer*, November, 1935, Vol. 12, No. 146, p. 587.) A qualification of this review is made in a letter in the December issue, pp. 651–652.

835. The Engineer Administrator.—Byng. (*Journ. I.E.E.*, October, 1935, Vol. 77, No. 466, pp. 491–502 : Discussions pp. 502–513.)

836. International Electrotechnical Dictionary [Notice of Forthcoming Publication by the I.E.C.].—(*E.T.Z.*, 7th Nov. 1935, Vol. 56, No. 45, p. 1241.)

837. On the International Unification of Scientific and Technical Terms.—Mesny: Drezen. (*Rev. Gén. de l'Élec.*, 30th Nov. 1935, Vol. 38, No. 22, pp. 759–760.)

838. The Use of Foreign Words [such as "Flicker Effect"] in Technical Language.—(*Rev. Gén. de l'Élec.*, 5th Oct. 1935, Vol. 38, No. 14, pp. 457–458.)

839. A Study of Scientific Periodicals [for Physics and Radio : indicating Those Most Used in Each Field].—Hooker. (*Review Scient. Instr.*, November, 1935, Vol. 6, No. 11, pp. 333–338.)

840. A Mathematical Suggestion [Printing of Long and Involved Indices avoided by Use of Asterisks enclosing the Index].—Turnbull. (*Electrician*, 18th Oct. 1935, p. 472.) Thus $y^{f(x)+F(x)}$ would be written $y{*}f(x) + F(x){*}$.

841. "Mitteilungen aus dem Reichspostzentralamt" [German State Post Office Reports : Book Review].—(*E.T.Z.*, 19th Dec. 1935, Vol. 56, No. 51, p. 1402.)

842. Recent Progress in Radio Technique at the 12th Paris Radio Exhibition.—Adam. (*Rev. Gén. de l'Élec.*, 23rd Nov. 1935, Vol. 38, No. 21, pp. 713–718.)

843. The 12th Radio Exhibition, Paris, September, 1935.—Adam. (*Génie Civil*, 12th Oct. 1935, pp. 337–340.)

844. Investigation on the Design of Non-Loaded Cable System for Carrier-Current Communication.—Matsumae and Shinohara. (*Nippon Elec. Comm. Engineering*, September, 1935, No. 1, pp. 44–69 : in English.) *See* also pp. 79–80 for test of trial cable. For previous work *see* 1934 Abstracts, p. 155.

845. Some Aspects of Low-Frequency Induction between Power and Telephone Circuits.—Huntley and O'Connell. (*Bell S. Tech. Journ.*, October, 1935, Vol. 14, No. 4, pp. 573–599.)

846. Method for Mapping Ultra-Violet Absorption Spectra, using . . . a Microphotometer of Simple Design.—Gull and Martin. (*Journ. Scient. Instr.*, December, 1935, Vol. 12, No. 12, pp. 379–388.)

847. A New Recording Spectrophotometer.—Hardy. (*Journ. Opt. Soc. Am.*, September, 1935, Vol. 25, No. 9, pp. 305–311.) Improved version of the colour analyser dealt with in 1929 Abstracts, p. 346.

848. An Experimental Method of studying Substitution and Decomposition Reactions by means of the Photoelectric Cell.—Hamai. (*Physik. Berichte*, No. 15, Vol. 16, 1935, p. 1378.)

849 The Design of Precision Commercial Photoelectric Photometers.—Winch and Machin. (*G.E.C. Journ.*, November, 1935, Vol. 6, No. 4, pp. 205–212.)

850. The Photox [Copper Oxide Photovoltaic Cell with Natural Unfiltered Spectral Response close to That of Human Eye : Use in Instruments].—(*Journ. Franklin Inst.*, September, 1935, Vol. 220, No. 3, pp. 401–402 : short note only.)

851. Applications of a [Dry-Disc] Photoelectric Cell.—Lamb. (*Elec. Engineering*, November, 1935, Vol. 54, No. 11, pp. 1186–1190.)

852. Photoelectric Relays : Their Use for the Control of Street Lighting.—(*Electrician*, 25th Oct. 1935, Vol. 115, No. 2995, p. 522.)

853. The Control of Public Lighting by Photoelectric Relays [and the B.T-H. Equipment].—(*Engineer*, 11th Oct. 1935, p. 385.)

854. The Use of the Photoelectric Cell in Physiological Experiments [Continuous Curve traced by Interposition of Graded Wedge of Glass].—Marrazzi. (*Science*, 13th Sept. 1935, pp. 254–256.)

855. Three Useful Tube Circuits [Light-Ratio Indicator, Relaxation-Type Photocurrent Amplifier, and Capacity-Operated Relay : for 110-Volt A.C.].—Shepard. (*Electronics*, September, 1935, p. 38.)

856. Tubes enter the Automobile Plant.—Powers. (*Electronics*, September, 1935, pp. 10–13.)

857. Talking Books [for the Blind].—(*See* 198 of January.)

858. Phototube "translates" Books for Blind Readers [Impulses interpreted by Sense of Touch].—Goldman. (*Electronics*, September, 1935, p. 44.)

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. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

436 012.—Matching the impedance of a high-frequency transmission line or feeder to that of the aerial.

E. L. C. White and E. C. Cork. Application date, 17th April, 1934.

436 233.—Aerial input circuit for feeding several receiving sets simultaneously.

E. W. Hobbs. Application date, 13th April, 1934.

436 254.—Directive aerial comprising a series of wire elements coupled together by condensers, each element being less than one-half of the working wavelength.

H. L. Kirke. Application date, 18th July, 1934.

436 341.—Short-wave receiving aerial less than a quarter-wave in height and provided with a "loading" inductance which is coupled to the receiving set.

Radio Akt. D. S. Loewe. Convention date (Germany) 9th January, 1934.

437 507.—Demountable coupling for aerial feed-lines of the concentric type.

H. Cave and Baird Television. Application date, 23rd May, 1935.

438 649.—High-frequency feed-line, particularly for a wireless transmitting aerial, in which compensation is made for the distributed line inductance and shunt capacity.

Marconi's W.T. Co. (communicated by the Telefunken Co.). Application date, 2nd July, 1935.

1 998 322.—Aerial coupling-unit designed to allow a transmitter valve to work into a pure resistive load, even when the aerial is not tuned to the transmitted frequency.

I. J. Kaar (assignor to General Electric Co.).

TRANSMISSION CIRCUITS AND APPARATUS

1 999 656.—Crystal-controlled valve generator adapted for a rapid change-over from one wavelength to another.

DeW. R. Goddard (assignor to Radio Corporation of America).

RECEPTION CIRCUITS AND APPARATUS

435 933.—Multigrid valve and circuit for receiving combined sound and television signals.

C. S. Bull and C. S. Agate. Application date, 27th March, 1934.

436 228.—A "tunable" band-pass circuit, comprising inductances with movable iron cores, arranged to maintain a constant width of channel over a wide range of frequencies.

Marconi's W.T. Co. and N. M. Rust. Application date, 6th April, 1934.

436 403.—Variable-selectivity receiver comprising a number of tuned coupling circuits all of which are simultaneously adjusted either to the carrier frequency or immediately above or below it.

Hazeltine Corporation (assignees of W. A. Macdonald). Convention date (U.S.A.) 20th December, 1933.

436 948.—Arrangement for eliminating local interference when a frame aerial is used for broadcast reception.

Telefunken Co. and P. Hermanspan. Application date, 13th April, 1934.

437 481.—Visual tuning-indicator controlled by the varying impedance of a valve subsequent to the A.V.C. stages.

Murphy Radio and I. Davies. Application date, 5th October, 1934.

437 538.—Column-of-light tuning indicator in which means are provided to neutralise the "squelch" bias when a desired station is being received.

A. C. Cossor, Ltd., and R. Pollock. Application date, 13th June, 1934.

438 255.—Visual tuning indicator coupled to the intermediate frequency stages of a superhet receiver through a rectifier valve in series with an incandescent lamp or glow-tube.

N. V. Philips. Convention date (Holland) 2nd July, 1934.

438 628.—Tuning indicator in which a marker is carried between two pulley-cords across the face of the scale.

General Electric Co. and W. H. Peters. Application date, 20th September, 1934.

1 975 441.—Switching arrangement for throwing the filament heaters of a wireless set into series, so that they can be heated from an A.C. or D.C. mains supply, or into parallel for battery operation.

R. P. Wuerfel (assignor to International Research Corporation).

VALVES AND THERMIONICS

435 927.—Electrode assembly for multiple valve rectifier or amplifier.

Radio Akt. D. S. Loewe. Convention date (Germany) 6th February, 1933.

436 023.—Reducing the variability of emission in photo-electric cells of the caesium type.

General Electric Co. and C.H. Simms. Application date, 31st May, 1934.

436 166.—Electrode-assembly in a multi-stage valve.

E. Y. Robinson and Associated Electrical Industries. Application date, 25th April, 1934.

436 940.—Hexode valve, particularly for use in a superhet circuit, in which modulation or mixing is effected by the formation of a " virtual cathode " between the grids.

Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 30th January, 1933.

438 961.—Gas-filled discharge tube in which an electrostatic shield or electrode is interposed between the grid and anode so as to secure a quantitative response instead of the usual " trigger " action.

S. Ruben. Convention date (U.S.A.) 5th May, 1933.

438 181.—Multigrid valve in which the electrodes are grouped so that the mutual conductance or other operating characteristic of the valve can be changed as required by external switching means.

Telefunken Co. Convention date (Germany) 2nd March, 1934.

439 032.—Multigrid " mixer " valve for a superhet circuit in which the electron stream to the local-generator anode is restricted within limits.

Marconi's W.T. Co. (assignees of D. G. Haines). Convention date (U.S.A.) 28th March, 1933.

DIRECTIONAL WIRELESS

436 186.—Combination of frame and dipole aerial used to ascertain the absolute direction of a transmitting station from a point in space, for example, on an aeroplane.

Telefunken Co. Convention date (Germany) 23rd January, 1934.

436 355.—Short-wave directive aerial, designed to concentrate the radiated or received energy in two stages, both being kept in correct phase.

N. V. " Meaf." Convention date (Germany) 13th April, 1934.

2 003 240.—Automatically steering an aeroplane by means of two overlapping radio beams, provision being for following a course which is offset from the zone of equi-signal strength, and for compensating for wind drift.

T. E. Brocksted (assignor to Washington Institute of Technology).

2 008 522.—Loop aerials mounted on the wings of an aeroplane and arranged to be operated in combination with the ordinary trailing aerial for directive or non-directive work.

L. A. Taylor (assignor to General Electric Co.).

2 012 412.—Radio beam system for assisting a pilot to land during fog and for indicating his altitude as he approaches the aerodrome.

R. M. Wilmotte (assignor to Radio Corporation of America).

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

435 878.—Resistance-coupled amplifier in which the relative frequency-response to high and low frequencies is variable.

Ferranti, Ltd., and others. Application date, 30th April, 1934.

1 997 762.—Wide-range tone-control for a low-frequency amplifier comprising a series impedance, a shunt impedance, and a single manually-variable potentiometer.

R. A. Bierwirth (assignor to Radio Corporation of America).

TELEVISION AND PHOTOTELEGRAPHY

435 639.—Method of ensuring linearity between applied signal voltage and fluorescent response on the screen of a cathode-ray tube.

General Electric Co. and D. C. Espley. Application date, 10th August, 1934.

435 749.—Film scanning system in which automatic compensation is made for variations in the transparency of the film.

Cie Compteurs. Convention date (France) 5th May, 1934.

435 814.—Scanning system in which the area of the spot on the fluorescent screen is made to vary with the applied signal voltage.

Marconi's W.T. Co. and others. Application dates, 29th March and 12th October, 1934.

436 142.—Television system in which the synchronizing signals are radiated from a transmitter separate from that which radiates the picture signals.

Radio Akt. D. S. Loewe. Convention date (Germany) 6th March, 1933.

436 301.—Arrangement of the viewing-screen in the cabinet of a television receiver.

C. S. Agate. Application date, 9th April, 1934.

436 314.—Method of eliminating the " white cross " effect in a cathode-ray television receiver.

Fernseh Akt. Convention date (Germany) 11th May, 1933.

438 285.—Saw-toothed oxidation-generator, as used in television, in which an inductive coupling is provided between the charging-circuit and the output circuit of the triggered valve, in order to vary the amplitude without affecting the frequency of the resulting oscillations.

J. C. Wilson and Baird Television. Application date, 31st August, 1934.

SUBSIDIARY APPARATUS AND MATERIALS

435 643.—Light valve comprising two pairs of electromagnetically-excited plate resonators, one of which is provided with a light-sensitive layer.

J. Y. Johnson (Ternion A-G). Application date, 15th December, 1933.

1 994 902.—Combination of low-frequency valve-generators designed to reproduce the " striking " notes of Big Ben and to be used for broadcasting time-signals.

V. E. Trouant (assignor to Westinghouse Electric and Manufacturing Co.).

MISCELLANEOUS

436 159.—Impulse generator of the magnetostrictive type for sounding the depth of the sea.

Hughes & Son and D. O. Sproule. Application date, 6th April, 1934.

1 989 086.—To prevent collisions, particularly in the air, the receipt of a signal from a near-by craft automatically starts a transmitter which sends out a corresponding warning signal from the first craft.

H. Diamond and F. W. Dunmore (assignors to the U.S.A. Government).

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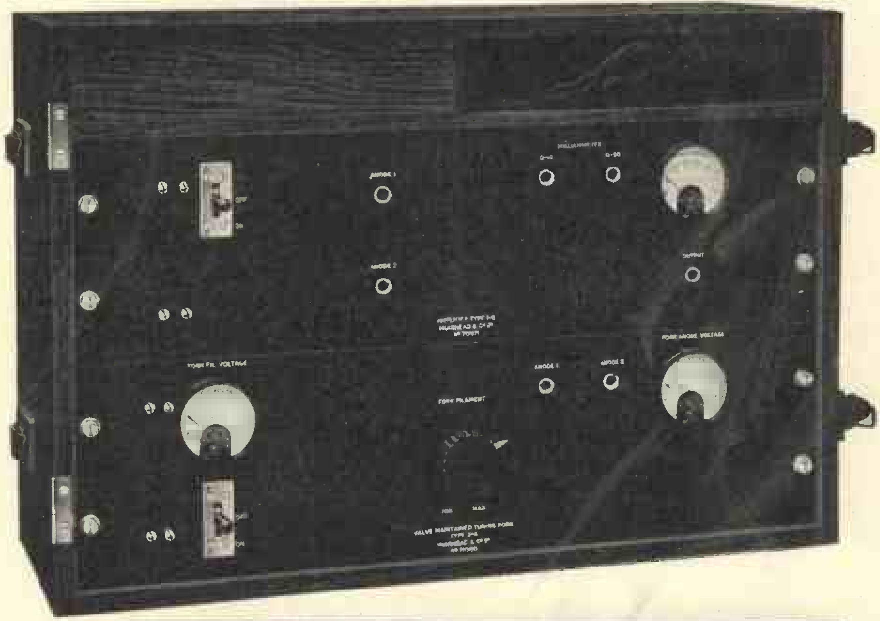

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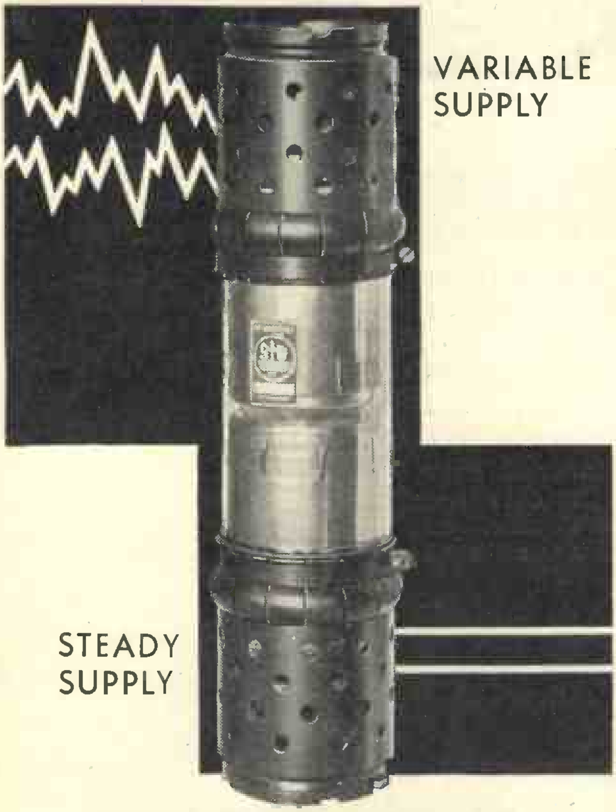
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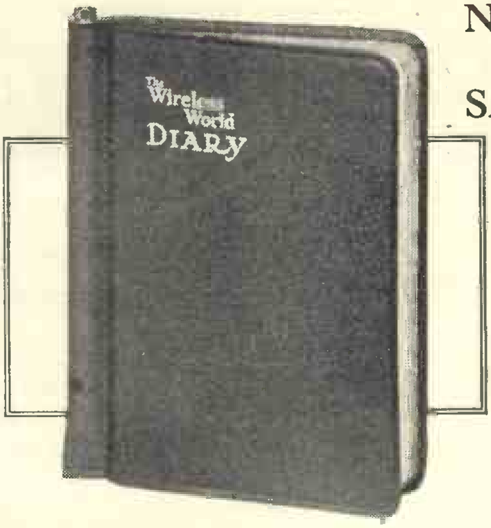
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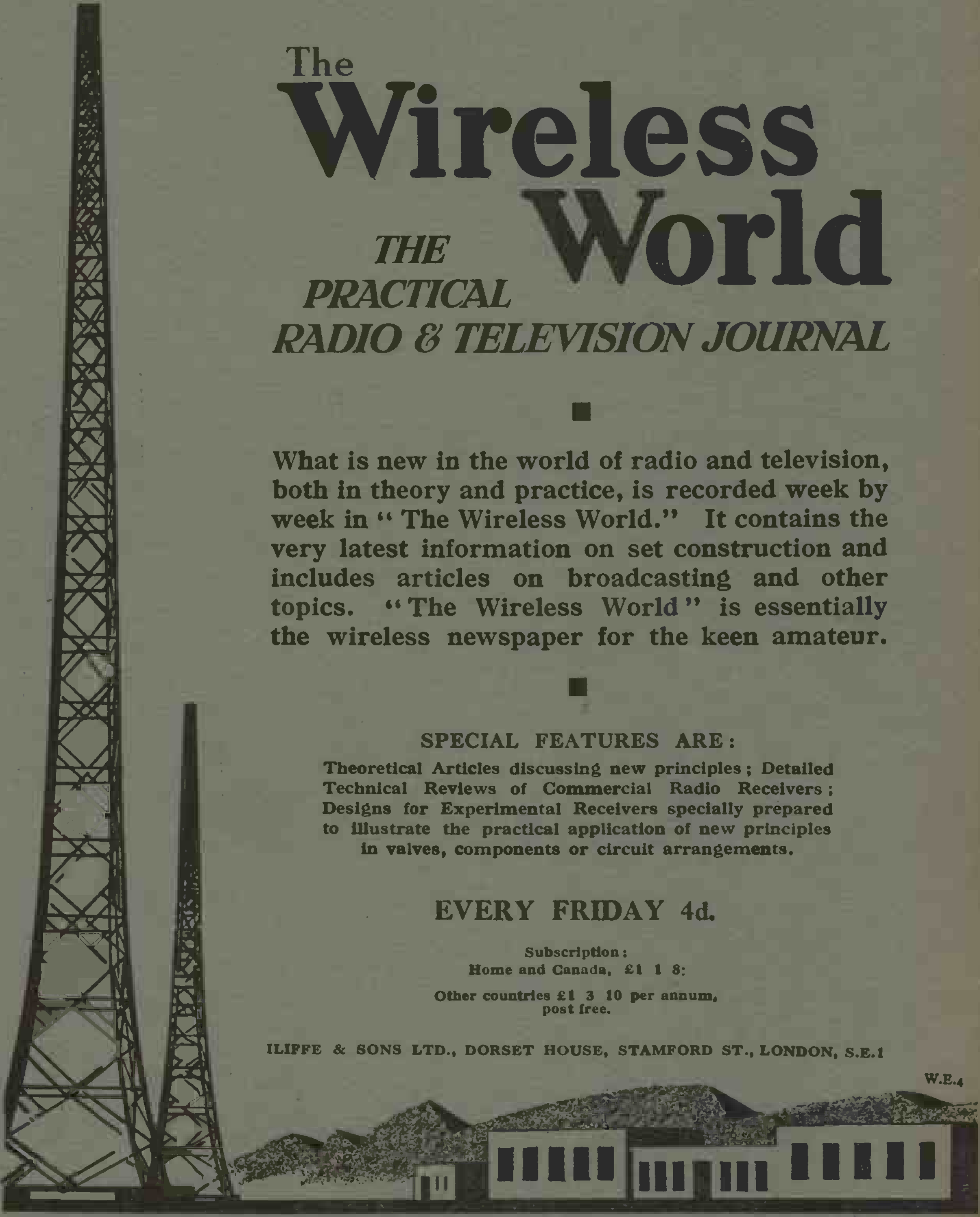

Printed in England for the Publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1,
by The Cornwall Press Ltd., Paris Garden, Stamford Street, London, S.E.1.