THE

WIRELESS ENGINEER

NUMBER 153 VOLUME XIII JUNE 1936

A JOURNAL OF

RADIO RESEARCH

AND

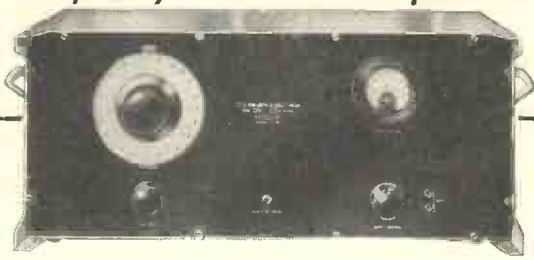
PROGRESS

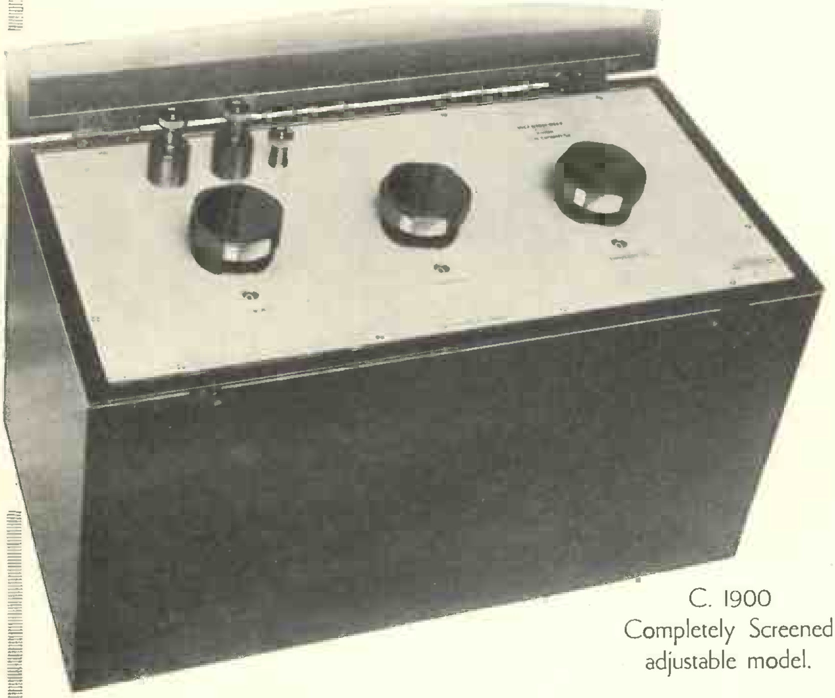
2/6 NET

PUBLISHED BY

ILIFFE & SONS LTD.

DORSET HOUSE STAMFORD STREET LONDON S.E.1.





AS

The

WIRELESS ENGINEER

A Journal of Radio Research & Progress

Editor
HUGH S. POCOCK

Technical Editor
Prof. G. W. O. HOWE, D.Sc. M.I.E.E

VOL. XIII. No. 153

JUNE 1936

C O N T E N T S

Published Monthly on the first of each Month

SUBSCRIPTIONS Home and Abroad: One Year, 32/-, 6 Months, 16/-. Single Copies, 2/8 post free

Editorial, Advertising and Publishing Offices

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1

Telegrams: "Experiwyr Sedist London" Telephone: Waterloo 3333 (50 lines)

Branch Offices

COVENTRY	BIRMINGHAM	MANCHESTER	GLASGOW
19 Hertford Street	Guildhall Bldgs., Navigation St., 2	260 Deansgate, 3	26B Renfield Street, C.2
Telegrams: "Autocar, Coventry"	Telegrams: "Autopress, Birmingham"	Telegrams: "Iliffe, Manchester"	Telegrams: "Iliffe, Glasgow"
Telephone: 5210 Coventry	Telephone: Midland 2971 (4 lines)	Telephone: Blackfriars 4412 (4 lines)	Telephone: Central 4587

The Editor invites the submission of articles with a view to publication. Contributions which are not exclusive should be so described when submitted. MSS. should be addressed to the Editor, "The Wireless Engineer," Dorset House, Stamford Street, London, S.E.1. Especial care should be taken as to the legibility of MSS. including mathematical work.

291

THE

WIRELESS ENGINEER

VOL. XIII. JUNE, 1936. No. 153

Editorial

A New Type of Wave Transmission

WHEN one speaks of the transmission of electromagnetic waves along wires, one usually pictures either two wires or a single wire and the earth, between which the electric and magnetic fields are guided. It has been known for many years, however, that waves can be transmitted along a single wire in the manner indicated in Fig. 1, without any return wire or earth. Although

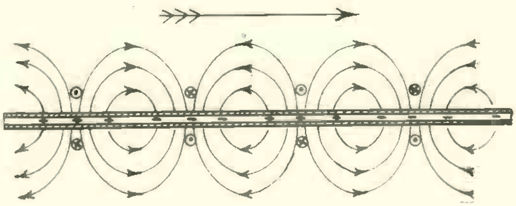


Fig. 1.—*The crosses and dots in circles indicate the direction of the concentric magnetic field. The curves represent the electric field.*

a paper on the subject was published in 1910 by Hondros and Debye,* it is not so well known that the guiding wire in Fig. 1 need not be a conductor, but can be a dielectric. The effectiveness of the dielectric wire as a wave guide depends upon its dielectric constant, decreasing with decreasing constant, and, of course, ceasing entirely when the wire has the same dielectric constant as the surrounding medium.

It is not generally known that electromagnetic waves can be transmitted along the interior of a metal tube, but a number of different ways in which this can be done are described in the current number of the Bell System Technical Journal.†

Fig. 2 illustrates the propagation of what the authors call the E_0 type of wave inside a metallic tube. Instead of the magnetic and electric fields being outside the tubular conductor as is usual, they are confined inside the tube which serves both as guide and screen carrying the electromagnetic waves in much the same way as a speaking-tube carries the sound waves. The frequency at which such transmission is possible is very high, the wavelengths being of the same order as the diameter of the tube.

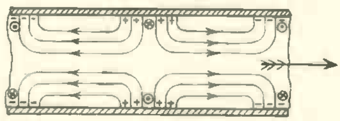


Fig. 2.—*The crosses and dots in circles indicate the direction of the concentric magnetic field. The curves represent the electric field.*

On comparing Figs. 1 and 2 it will be seen that whereas in Fig. 1 the central core is

* *Ann. d. Phys.* 32, p. 465. See also "On the Passage of Electric Waves through Tubes, or the Vibrations of Dielectric Cylinders," by Lord Rayleigh, *Phil. Mag.*, Vol. 43, 1897, pp. 125–132.

† April, 1936. "Hyper-frequency Wave Guides," by Southworth, Carson, Mead and Schelkunoff. Unfortunately the directions of the magnetic field are incorrect in Southworth's diagrams.

either a conductor carrying high-frequency conduction currents or a dielectric of high dielectric constant carrying displacement currents, in Fig. 2 the central core is air carrying longitudinal displacement currents,

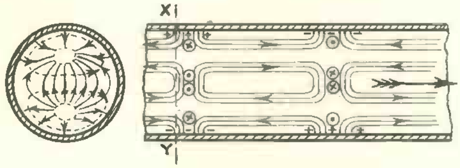


Fig. 3.—*The crosses and dots in circles indicate the direction of the magnetic field. The curves represent the electric field. (Left) Section through XY in the direction of arrow; dotted curves represent the magnetic field.*

and it is the rapid reversal of displacement which produces the magneto motive force corresponding to the concentric magnetic field. In Fig. 1 the electric and magnetic fields spread out into the surrounding medium, being guided by the central conducting core; in Fig. 2 the fields are confined within the conducting tube. In Fig. 2 high-frequency conduction currents flow on the inner surface of the tube, but it does not follow that there will be any external magnetic field, because these conduction currents are equal and opposite to the displacement currents in the internal dielectric.

A combination of Figs. 1 and 2 could be employed by inserting in Fig. 2 a central core of an insulating material of high dielectric constant.

Another type of wave is shown in Fig. 3; this the authors call the E_1 type. It is the analogue of a two-core cable in a metallic sheath; the conducting cores are absent and the go and return conduction currents are replaced by longitudinal displacement currents. Some of the lines of electric dis-

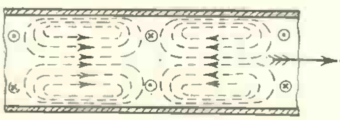


Fig. 4.—*The dotted curves represent the magnetic field, the crosses and dots in circles indicate the direction of the concentric electric field.*

placement form closed curves in the dielectric while others end in charges on the sheath, the charges and currents in the upper half of the sheath being opposite to those in the lower half.

An entirely different type of wave, designated H_0, is shown in Fig. 4. Here the curved lines represent the magnetic field, so that the longitudinal central core consists of a rapidly reversing magnetic field, whereas the electric field is concentric. The m.m.f. required to produce the axial magnetic field is provided by the circular displacement currents. It should be noted that with this type of wave, no electric lines end on the conducting sheath and there are consequently no conduction currents primarily engaged in the transmission. This accounts for the fact that, whereas for the other types of transmission there is an optimum value of the frequency at which the attenuation per mile is a minimum, for this type the attenuation decreases continually as the frequency is raised.

An entirely different type of wave is shown in Fig. 5; this is called the H_1 type and, like that shown in Fig. 4, has longitudinal magnetic and lateral electric fields. Here, however, instead of a central magnetic core,

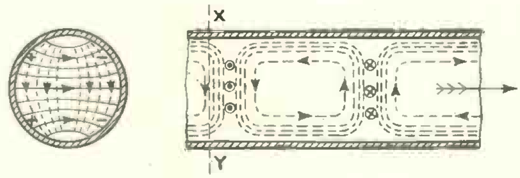


Fig. 5.—*The crosses and dots in circles indicate the direction of the electric field. The dotted curves represent the magnetic field. (Left) Section through XY in the direction of arrow; dotted curves represent the magnetic field.*

we have the magnetic flux flowing along the upper part of the tube, and then sweeping across and returning along the bottom of the tube. Instead of closed concentric circles of electric displacement we have here a lateral field passing across the tube from positive charges on one side to negative charges on the other.

For a tube of a certain diameter there is a critical frequency below which transmission is impossible; this cut-off frequency is different for the different types of waves. For the H_1 type shown in Fig. 5 and a tube of 5.85 cm. diameter containing air, the minimum frequency is 3,000 megacycles per sec. ($\lambda = 10$ cm.) If the tube contains a dielectric with a constant of κ, this cut-off frequency will be reduced to $3{,}000/\sqrt{\kappa}$ Mc/s.

The other types of waves have even higher cut-off frequencies. When waves are transmitted along a dielectric wire without an outer metallic tube, if the dielectric constant is high and the frequency well above the cut-off frequency, the fields are confined almost entirely within the dielectric and do not spread into the surrounding medium as shown in Fig. 1. This being so, it is not surprising that the velocity of propagation depends on the frequency. With such a very high frequency that the wave is confined entirely within the dielectric wire, the velocity is the same as that of light in the dielectric, viz., $c/\sqrt{\kappa}$ where $c =$ the velocity of light in vacuo, but as the frequency is lowered and the fields spread into the surrounding space, so that the wave is partly in the dielectric and partly in the surrounding space, the velocity of propagation increases and approximates to that in free space as the cut-off frequency is approached. It is interesting to note, however, that a somewhat similar increase of velocity with decreasing frequency occurs when the dielectric core is closely enclosed in a metallic tube.

Calculations of attenuation of the various types of waves when transmitted along a copper pipe 5 inches in diameter show that for the types shown in Figs. 2, 3 and 5 it reaches a minimum for frequencies between 3,000 and 5,000 Mc/s ($\lambda = 10$ to 6 cm.) ; as already mentioned, the attenuation of the type shown in Fig. 4 continues to decrease with increasing frequency.

A simple way of obtaining a general idea of the necessity for the extremely high frequencies employed in all these transmissions is to consider the fact that the magnetic field is produced not by conduction currents but by displacement currents in the dielectric. In an electromagnetic wave, the magnetic field strength H is equal to the electric field strength E in air, or to $\sqrt{\kappa}E$ in an insulating medium of dielectric constant κ. Now consider a disc of radius r normal to E ; the m.m.f. around the disc is $A\kappa\frac{dE}{dt}\cdot\frac{1}{3.10^{10}}$ where A is the area of the disc. This is equal to Hl, where H is the tangential magnetic field strength and l is the periphery of the disc. If we put $E = E_{max.} \sin \omega t$ then,

$$\pi r^2 . \kappa\omega E_{max.} = H_{max.} 2\pi r . 3 . 10^{10}$$

and putting $H = \sqrt{\kappa}E$,

$$\omega = \frac{2 . 3 . 10^{10}}{r\sqrt{\kappa}}$$

or $$f = \frac{3 . 10^{10}}{\pi . r\sqrt{\kappa}}$$

Hence we obtain a rough idea of the minimum frequency necessary by putting $f = \frac{10^{10}}{r\sqrt{\kappa}}$. For a pipe 10 cm. diameter containing air this gives 2,000 megacycles per second. In the paper referred to, the cut-off frequencies for the various types of waves in a copper tube 5 inches diameter were found to lie between 1,500 and 3,000 megacycles.

The experimental production and measurement of these new types of transmission involves a very special technique. Both magnetrons and valves operating on the Barkhausen-Kurz principle have been successfully employed as generators up to frequencies of over 3,000 Mc/s. The exploration of the waves in the tubes has been done principally by means of probes acting as minute aerials, their pick-up current being rectified by small silicon crystal detectors connected to a galvanometer.

In conclusion we may quote Mr. Southworth in answer to the natural question as to the practical use of these transmissions ; he says " the art at these extreme frequencies is not yet at a point which permits a satisfactory evaluation of practical use."

G. W. O. H.

Modulated High-Frequency Power Amplifiers*

By T. C. Macnamara

THE designer of a high-frequency power amplifying stage intended for the faithful reproduction of a high-frequency wave modulated at audio frequency has to take into consideration numerous factors concerned with the general characteristics of the valves to be employed.

It is assumed that some definite case exists where it is necessary that a modulated signal be raised to a certain predetermined power level with the minimum introduction of audio-frequency distortion, and with the maximum of efficiency.

It is probable that the designer has a range of transmitting valves from which to choose, each subject to certain limitations as to maximum permissible power dissipation, filament emission, anode H.T. voltage, as well as the limitations imposed by the maximum current carrying capacity of the anode and grid seals. In the case of water-cooled valves, the difficulty with regard to the anode connection disappears, and in any case, the current capacity of the grid seal does not constitute a serious limitation except at the shorter wavelengths. For the purpose of this article it is proposed to disregard limitations imposed by electrode connections and assume that the operating wavelength lies within the medium broadcast band.

Having carefully reviewed the types of valve at his disposal, the designer will narrow down the choice to those types that appear to offer possibilities. When the obviously unsuitable types have been eliminated, the final choice of the type and number of valves to be employed becomes very much a matter of trial and error, taking into account for each type of valve the various limitations imposed by its particular characteristics.

It is proposed at this juncture to consider the various factors which determine the operating conditions of any valve in order to see what particular attributes it should possess so that the maximum power output may be obtained from it under satisfactory conditions, and hence how many valves in parallel will be required to give the stipulated power output. The significance of the statement that trial and error methods are more or less unavoidable will be appreciated, in that it may be found that whereas valve "*A*" will give the desired output if ten are operated in parallel; valve "*B*" will give equally satisfactory conditions using only six in parallel, which may be preferable from the economic point of view. Again, it might be found that a further valve, type "*C*," will also give satisfactory results employing eight in parallel, but with an efficiency of conversion appreciably higher than that obtained from the other combinations.

It is, therefore, desirable for the designer to consider exhaustively the various combinations which might be suitable, weighing up the possibility of each from all points of view in turn.

It is now proposed to consider some of the conditions which influence the operation of valves as non-distorting modulated amplifiers. The reader will notice that it has been found convenient in many cases to treat the valve anode circuit as if it were a rectifier valve circuit, but a little reflection will show that in order to obtain the best efficiency, it is essential that Class B operation be resorted to, so that the valve is, in effect, a rectifier in the majority of cases.

Every valve possesses certain characteristics which are indicated by the makers and which may be briefly listed as follows :—

(1) Maximum permissible H.T. voltage.

(2) Maximum filament emission.

(3) A.C. Resistance.

(4) Magnification.

(5) Maximum permissible anode dissipation.

It is generally found in practice that the limiting factor in valves used in the class of circuit under consideration, is the available filament emission, and in this connection a figure has been established

* M.S. accepted by the Editor, October, 1935.

relating the mean anode D.C. in the unmodulated condition, with the peak anode current under conditions of 100 per cent. modulation. This figure is usually taken as 7, which implies that if a valve has available 7 amperes emission, the mean anode D.C. in the unmodulated condition must not exceed 1 ampere. This factor is obtained in the following manner :—

In order to obtain the best efficiency of conversion from a power amplifier, it is necessary to employ operating conditions representing the limit of Class B, i.e., that the valve is so biased negative on the grid that no anode current flows during the negative half-cycle. This condition cannot be quite fulfilled, because if a valve is so biased that, with full H.T. voltage applied but no high-frequency grid excitation, no anode current flows ; it will be found that on applying high-frequency grid excitation and plotting the applied grid voltage against the voltage developed across a tuned circuit associated with the anode, a non-linear relationship exists.

The slope of the resultant curve increases rapidly up to a point after which it remains sensibly constant, the non-linearity being limited to the extreme lower portion of the characteristic, and being, of course, due to the "bottom-bend" of the valve. The effect is obviously undesirable as it can be shown to introduce audio-frequency distortion into the output modulated wave.

If, however, the grid be somewhat less negatively biased so that the anode draws a certain "standing feed" in the grid unexcited condition, it will be found on re-plotting the anode-grid voltage relationship, that the bottom-bend effect is reduced, and in the limit will disappear if the value of standing feed is increased to a sufficient extent. It must be remembered, however, that this process must not be carried too far, as it reduces the efficiency of conversion by causing the operating conditions to approximate more closely to Class A. The improvement in linearity brought about by the establishment of the standing feed and the reduction in negative bias, results from the fact that the whole characteristic is effectively slid along so that the bottom bend disappears out of the picture. Fig. 1 illustrates this effect.

It has been shown that the anode must draw a standing feed at zero excitation in the interests of linearity, and consequently a certain anode current is drawn during part of the negative half-cycle. This means that the valve is not a true half-wave rectifier, so that the relation between peak and mean current must be less than if pure rectification were taking place. In a half-wave rectifier the relationship between peak and mean is known to be $\pi/1$, but in the case under consideration this ratio has been found in most cases to be of the order 3.08/1. This implies that if the mean anode current in the operating unmodulated condition be 1 ampere, the peak anode current is 3.08 amperes, and, allowing for the current doubling, the peak anode current at 100 per cent. modulation is 6.16 amperes. To provide a margin of safety for the existence of grid current the peak anode current at 100 per cent. modulation is taken as 7 times the mean anode D.C.

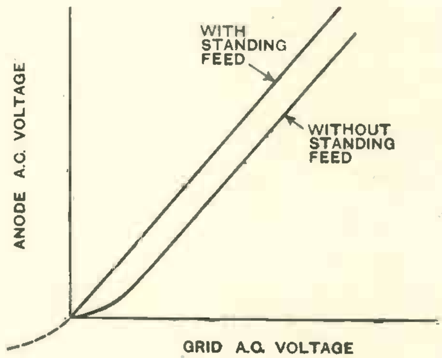


Fig. 1.

From the knowledge of the maximum available emission, therefore, the mean anode D.C. may be determined, (viz., I emission $\times$ 1/7) and it has been found in practice that a satisfactory value of standing feed is approximately 0.3 of the mean anode D.C. It will be necessary to check, when the conversion efficiency has been extracted, that the maker's maximum anode dissipation has not been exceeded, a state of affairs which rarely arises in practice when water-cooled valves are used.

It will be remembered that the anode A.C. potential is 180° out of phase with the grid A.C. potential, so that when the grid is most positive, the anode will be least positive. It has been found in power amplifiers of the type under consideration, that the anode response falls off seriously as soon as the grid positive peak value begins to get anywhere near the anode potential at its most depressed value ; as the grid begins to draw an unfair share of the space current—it begins to act as an anode in its own right.

In practice it is found that when the amplitude of grid excitation is progressively increased, the anode responds in a linear manner until the condition is reached when the minimum anode potential is about 0.2 of the steady H.T. voltage, whereupon the slope of the anode-grid voltage characteristic falls off and a "top-bend" appears. The appearance of top-bend corresponds with the point at which the grid starts to rob the anode. This effect is usually noticed when the grid reaches a peak positive potential equal to about 7 per cent. of the steady anode D.C. voltage.

For the purpose of design it is convenient to assume that linearity is maintained until the anode minimum voltage falls to 0.2 of the steady H.T. voltage, subsequently checking up that, with the particular valve contemplated, and under the conditions which it is to be operated, the grid peak positive potential does not exceed 7 per cent. of the steady H.T.

It is unnecessary to take into account the effect of anode circuit loading at this juncture, as this factor is taken into account when the grid sweep is investigated.

Here again a trial and error operation is involved, but it is difficult to determine the magnitude of the grid sweep until certain other constants have been determined, all of which depend on the permissible anode excursion.

It has been stated that the anode must not be allowed to fall to a potential below 0.2 of the steady H.T. voltage, otherwise non-linearity will result ; consequently the maximum anode excursion at 100 per cent. modulation cannot exceed 0.8 of the steady H.T., and in order to allow for the voltage doubling which occurs at full modulation, the anode excursion in the unmodulated condition must clearly not be permitted to exceed half of the total permissible excursion, and hence becomes 0.4 of the steady H.T. voltage.

The anode circuit radio-frequency voltage is thus fixed, and from this value, the efficiency of conversion from D.C. to A.C. may be determined as follows :—

$$\text{Efficiency} = \frac{0.77 \times PVA}{\text{H.T.}}$$

where PVA = Peak anode A.C. voltage.
H.T. = Steady applied D.C. anode voltage.

This expression is deduced in the following manner :—

Under normal operating conditions (anode standing feed set equal to 1/3 mean anode current.)

$$\frac{IA \text{ peak}}{IA \text{ mean}} = 3.08$$

$$\text{Power output} = \frac{IA \text{ peak} \times PVA}{\sqrt{2} \times \sqrt{2}} \div 2$$

(as valve is operative over ½ cycle only).

Substituting for IA peak in terms of IA mean :

$$\text{Power output} = \frac{3.08 \times IA \text{ mean} \times PVA}{4}$$

watts.

Input power = H.T. $\times$ IA mean, and

$$\text{efficiency} = \frac{\text{Power out}}{\text{Power in}}$$

∴ efficiency may be expressed as

$$\frac{3.08 \times IA \text{ mean} \times PVA}{4 \times IA \text{ mean} \times \text{H.T.}} \text{ or } \frac{0.77\,PVA}{\text{H.T.}}$$

Having determined the efficiency, the anode dissipation may be worked out from :

Dissipated watts = input power (1 − coefficient of efficiency).

This figure must, of course, not exceed the maker's permissible maximum. If it should do so, an adjustment in operating conditions must be made in a manner which will be described later. For the moment let us assume that it does not.

From the foregoing, the following quantities have been determined :—

(1) Proper value of mean anode D.C.
(2) Input power.
(3) Radio-frequency output power.
(4) Proper value of anode A.C. voltage.
(5) Anode standing feed.
(6) Grid negative steady bias.

It immediately becomes apparent that the one quantity which has not been determined is the resistance (radio-frequency) of the anode circuit, which constitutes the load on the valve ; but as the output power and the voltage across the anode circuit are both known, the appropriate resistance is given by :—

$$R = \frac{0.5 \times PVA^2}{W}$$

where W = output power in watts.
R = Anode circuit radio-frequency resistance in Ω.

Knowing the output resistance of the stage, the overall gain may be determined from the expression :—

$$M = \frac{\mu \times R}{R + R_1}$$

where M = magnification of stage.
μ = magnification of valve.
R_1 = A.C. resistance of valve.

Having determined the stage magnification, the requisite grid excursion, in the unmodulated condition, is given by :—

$$PVG = \frac{PVA}{M}$$

where PVG = peak grid A.C. voltage.

The peak positive potential of the grid is, of course, equal to $PVG - V$ grid negative bias, and it may now be checked that this value does not exceed 7 per cent. of H.T., a condition which, as has been explained, must not be violated otherwise the grid begins to rob the anode and non-linearity results.

It is possible at this juncture for the designer to say whether the valve under consideration is satisfactory for the purpose in view or not. If the desired operating conditions are very nearly fulfilled it will clearly be possible to make slight adjustments here and there to bring the circuit into line. If, however, the conditions are hopelessly unfulfilled, the designer must abandon the idea of using the particular valve under consideration, and seek another, and more suitable type.

For instance, let us suppose that the maker's maximum anode dissipation were exceeded in the proposed condition. Under these circumstances, it would be necessary to cause the valve to draw less input by reducing its output. This would be effected by increasing the resistance of the circuit into which the valve works—say by loosening the output coupling—at the same time reducing the amplitude of the A.C. excitation applied to the grid so that the anode A.C. voltage remains constant (at 0.4 H.T.).

Under these circumstances, the efficiency of conversion is unaltered, but the input reduced ; so that the dissipation of power is reduced proportionally. This operation also reduces the ratio of peak grid positive potential to minimum anode voltage, so that it may be practised to improve this condition. It must be remembered, however, that the output power is thereby reduced, so that the number of valves in parallel may have to be increased, which may result in an uneconomic condition of operation. It is important also to remember that adjustments to power will always be made by varying the output resistance, with appropriate adjustments to the applied PVG, always keeping the anode A.C. voltage constant.

It is interesting to note that an apparent contradiction may exist when considering valves of various A.C. resistance and magnification, each operating under the optimum conditions. For instance, if a high-magnification valve were under consideration, it would be reasonable to suppose that the necessary grid excursion would be less than that required by a valve having a lower magnification. Whilst undoubtedly this is the case, the latter valve may make a better power amplifier than the former. The reason for this is, that owing to the lower A.C. resistance of the latter, the grid excursion for the same extremes of instantaneous resistance, although greater, is more nearly confined to the negative region. In other words, in the case of the low-μ valve, it is not necessary to sweep the grid nearly so positive in order to reach the desired instantaneous minimum value of internal resistance ; with the consequence that the ratio of peak grid potential to minimum anode potential is better than it would be with a high-μ valve.

Another advantage in favour of the low-μ valve is that for lower values of peak grid positive, and consequently lower peak grid current, the load due to the latter on the preceding stage is reduced, which may mean that the power of this stage can be reduced in view of the fact that it has less work to do in swamping the effects of grid current in the succeeding stage.

Again, it must be remembered that for the same power output at the same anode A.C. voltage, the anode circuit resistance will be the same regardless of whether a high or low-μ valve be used. Consequently the stage gain with a low μ (low A.C. resistance) valve may be comparable with the μ of the valve; whereas, with a high-μ (high A.C. resistance) valve the stage gain may be only a fraction of the μ of the valve, so that the necessary grid excursion required for a low-μ valve is not so much in excess of that required for a high-μ valve as might at first be imagined.

From the foregoing the reader may have come to the conclusion that the designing of power amplifiers is a somewhat tricky business, as it is, undoubtedly; the writer, however, feels that if it is tackled in the manner described, no insuperable difficulty should be encountered, and a satisfactory solution to the problems under consideration should ultimately be found.

Beat Effects*

An Investigation in "Extra Radiations" and "Backgrounds" Observed at Brentwood

By Wm. L. Hafekost

DURING the early part of 1935 the writer was greatly mystified by intermittent appearances of several English commercial telegraph stations on frequencies well apart from their fundamental transmissions.

On the 2nd March, 1935, after casually observing some ship to shore telephony around 8,860 kc/s, during a quiet period GIN, Oxford, was heard. Approximately 40 kc/s lower, DHA, Nauen, also came in. Now the fundamental frequencies of GIN and DHA are 10,960 and 10,920 kc/s respectively and the difference here is also 40 kc/s. It was then realised that the cause of the extra radiations lay outside the transmitting stations themselves, and it was decided to obtain measurements of the radiations.

Being in the extremely fortunate position of having access to efficient frequency measuring equipment, results soon began to assume a very interesting form.

* MS. accepted by the Editor, May, 1936.

Measurements of the stronger "extra radiations" of English and foreign stations on 14–50 metres band showed that the differences from the fundamental transmissions were 272 kc/s, 2,026 kc/s, or multiples of these frequencies.

The characteristics of the fundamental transmissions appeared unchanged on the extra radiations, except for a slight "woolly" effect. At the time, this was attributed to the weakness of the signal. Also some of the extra radiations were almost drowned by a mush surround of approximately 15 kc/s band width. One evening an extra radiation from OEK, Vienna, was measured on 5,361.6 kc/s. Upon tuning to the fundamental frequency on 7,387 kc/s approximately, this was found to be of poor strength. Observations for extra radiations from strong distant transmissions were mainly unsuccessful at that time.

The search was then extended to 2,026 kc/s. Exactly on that frequency was a very weak carrier mutilated by a slow beat. No modulation was audible and altogether further progress seemed extremely doubtful. Fortunately, however, two GBR, Rugby (fundamental 18 kc/s) transmissions were heard nearby, after a few days. These were measured, and the frequencies found to be 2,044 and 2,008 kc/s. Substracting the fundamental frequency of 18 kc/s from 2,044 kc/s gave the usual figure 2,026 kc/s. This encouraged and extended the observations on the 2,026 kc/s carrier. Eventually modulation on this became audible, two simultaneous programmes being noted. These were found to be similar to the London National and Regional transmissions from Brookmans Park on 1,149 and 877 kc/s respectively. It was then realised that 2,026 kc/s and 272 kc/s was the sum and difference of the London National and Regional frequencies.

A close search was made on the short-wave band for extra radiations differing 877 or 1,149 kc/s from the fundamental transmissions. This gave negative results.

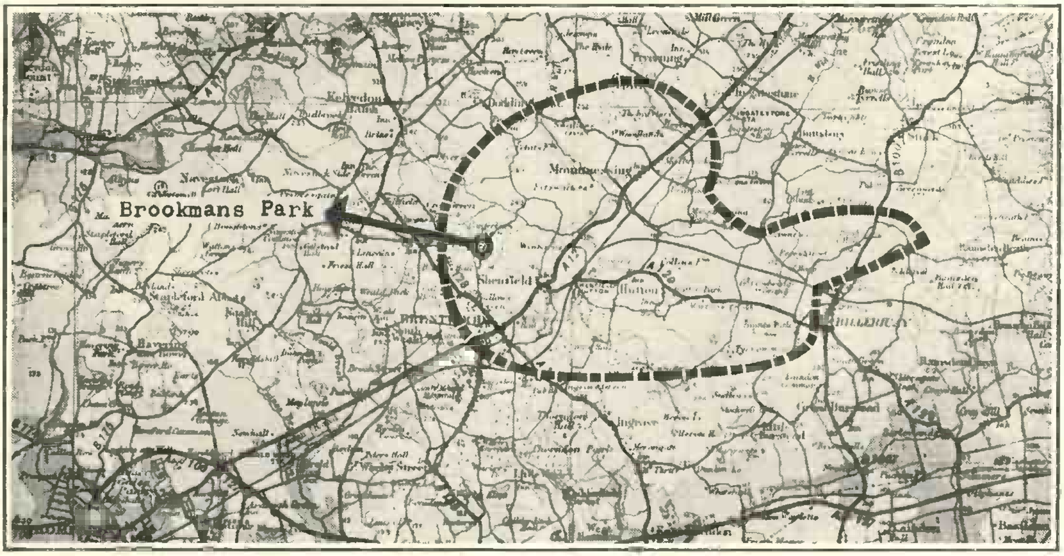
Further investigations around 2,026 kc/s revealed quite strong radiations from the London National (1,149 kc/s) and Regional (877 kc/s) upon 3,175 and 2,903 kc/s respectively. Each of these transmissions had quite a definite background of the other and each faded independently. On some days rapid variations in the depth of modulation were very prevalent, causing distortion, mush and occasionally scraping noises. Another noticeable feature was light grating noises due to abrupt over-emphasis of the lower modulation frequencies. This was mostly noticeable to the London Regional backgrounds on both radiations.

Observation on broadcast frequencies disclosed occasional weak interaction between the London National and Regional transmissions. Similarly, a faint background of the London Regional transmission was noticed on Leipzig, 785 kc/s. At 10.15 p.m. on 3rd April, 1935, due to an abrupt and considerable increase in strength, another London National and Regional radiation was measured on 605 kc/s. At the same time there appeared to be a simultaneous increase of "Droitwich" effects on Cologne and Brussels. Owing to the short duration of all these effects no definite correlation was possible. However, adding 272 kc/s to the measured 605 kc/s gives us 877 kc/s (the London Regional). Attempts were made to pick up the 272 kc/s radiation, but this has only rarely been heard and then only for short periods.

Meanwhile, in spare moments, observations were also being made upon a number of long wave extra radiations around 2,026 kc/s. Here the opinion was formed that the strengths of these radiations were proportional to the fundamental frequency of the transmitter. On the days when most of the long wave extra radiations were inaudible, GLA (Ongar), 102.3 kc/s fundamental, and Droitwich, 200 kc/s extra radiations could still be heard although at reduced strength. The "woolliness" previously mentioned was noticeable also on these radiations and was traced to the slight modulation transferred from the 2,026 transmission.

At this point it was found that apparent extra radiations were to be heard when only one broadcast station was on the air. To clear up the position it was thought necessary to attempt some form of classification. First, it was decided to name the 272 and 2,026 kc/s radiations "Primary Beats." These being radiations caused by interaction between the fundamental transmissions of any two stations. At Brentwood the Brookmans Park beat created the strongest extra radiations. The 3,175 kc/s and 2,903 kc/s Brookmans Park transmissions were named "Secondary Beats." The definition given is that a radiation created by interaction between the second harmonic of one transmitter and the fundamental transmission of another, is a secondary beat. It can be calculated that there are eight secondary beat radiations, two of which coincide with others. In the case of Brookmans Park these beats are on 605, 877, 1,149, 1,421, 2,903 and 3,175 kc/s. From these figures can be seen the reason for "Backgrounds." The strength of these transmissions appear definitely proportional to frequency during the day. It has been observed that the 2,903 and 3,175 kc/s secondaries are normally 20 decibels up on the 2,026 kc/s primary beat. The 605 kc/s radiation is chiefly audible around sunset and the late evening. The secondary beats also create extra radiations at Brentwood but to a lesser degree. Thirdly, there is the "Tertiary Beat," this being created by interaction between the two primary beats and their harmonics, and one of the fundamental transmissions and its harmonics. The Brookmans Park tertiary beats are audible in profusion although usually at very weak strength. These beats are also responsible for extra radiations but to a very minor degree. The beats are audible on 1,482, 1,693, 1,815, 1,965, 2,359, 2,570, 7,227 kc/s to quote but a few. "Extra radiations" are defined as transmissions spaced equally either side of the fundamental, and are created by beat radiations from another source. Where the beat frequency happens to be higher than the fundamental of the station which has extra radiations imposed upon it, these latter frequencies will be spaced equally around the beat source.

One of the peculiarities noticed on all the effects created by the Brookmans Park transmitters was the abrupt fading. It was found, however, that at a distance of a mile or so from the usual observation point that this abrupt fading appeared to have been somewhat smoothed down. Also, the long-wave effects were only occasionally audible at this second spot. In an endeavour to collect more information, a series of outdoor tests were made with a specially calibrated car receiver. At Brookmans Park it was found that the strength ratio of the 2,026 kc/s radiation to that of the 2,903 and 3,175 kc/s radiations was about the same as at Brentwood. It was noticeable that the strength improved on all radiations as the receiver was brought nearer to the aerial system.



Area of the observations.

Primary and secondary beats between either of the London transmissions and foreign broadcast stations have intermittently been identified. Secondary beats have been noted in the early morning between Hilversum, 995 kc/s, and several English long-wave telegraph stations. Primary beats have been observed between Italian, Dutch and Norwegian short-wave stations. In the latter case, the two Norwegian stations LCD, Tryvasshögda, 36.58 kc/s fundamental and LCP, Jeloy, 14,550 kc/s fundamental, are several miles apart.

Abrupt fading, due to a distant thunderstorm, was noticeable up to about $\frac{1}{4}$ of a mile of the aerials. It was found that the effects appeared very susceptible to shielding by trees. No long-wave extra radiations were heard around Brookmans Park, although it is not certain whether the conditions that day were suitable. The limit of radiation of the Brookmans Park secondary beats in an easterly direction appears to be about 30 miles. The 2,903 and 3,175 kc/s radiations are just audible at Ramsden Heath, Essex. The 2,026 kc/s primary beat faded out about 20 miles east of Brookmans Park, but has been identified at Shellhaven, Essex, a distance of about 32 miles. The secondary beats were inaudible at this point. As the time of this observation was about an hour before sunset, it may have been a sunset effect.

A series of tests were then conducted upon a GLA, Ongar (fundamental 102.3 kc/s) extra radiation upon 2,128 kc/s, this being one of the most consistent stations received and usually clear of interference. This was found to be audible within 5 miles from the receiving site at Brentwood, chiefly to the east and east-south-east, giving what might be described as a "shadow effect." This radiation was also found to be very susceptible to shielding.

Care was always necessary to avoid any pick-up from telephone wires, it having been found possible to hear practically all the effects at freakish distances when within 30 yards from the nearest Post Office wires. This is possibly due to a "wired wireless" effect. The frequent rapid strength variations often noticed on these radiations were never so obvious when within the near vicinity of overhead telephone wires.

and comparatively small barometric variations the signals are almost steady. During 1935, one particularly heavy gale, lasting several days, was predicted up to 48 hours previously by abrupt and violent strength changes exceeding 20 db. The rapidity of these changes created troublesome aperiodic scraping noises and clicks. These practically disappeared when the B.B.C. stations shut down. The few remaining disturbances were mostly traced to variations of secondary beats between adjacent commercial short-wave stations.

The greatest attenuation of all the effects has been found to be due to thunderstorms. The presence of these storms was nearly always apparent by abrupt fade-outs or surges immediately following certain sharp atmospherics. "Fizzlies" also have suddenly ceased after some atmospherics, slowly building up again. Heavy continuous rain has been found to cause noticeable attenuation.

Having regard to the fact that these effects appear to be a purely local phenomenon, during daylight at all events, one would naturally expect no correlation with normal wireless reception over long distances. Evidence, however, has been collected that the

Transmitter.	Fundamental Measurement—(kc/s.)	Extra Radiation (kc/s.)	Kc/s Difference from Fundamental	Strength Approximately.
		19236.6	− 272	R4−2
GLN (Ongar) ..	19508.7	18965	− 544	Weak to inaudible.
		15729	−3780	R4−2
DHA (Nauen) ..	10920 approx.	12945.8	+2026	R4−1
		8894.1	−2026	R3−1
GOT (Ongar) ..	7602.9	7875	+ 272	R6−2
		5577	−2026	R3−1 QRM
OEK (Vienna) ..	7387 (Slow frequency drift)	5361.6	−2026	R4−1
London National ..	1149	5201	+4052	R5−1
		7227	+6078	R5−1

3780 = (877 × 3) + (1149). 4052 = 2026 × 2. 6078 = 2026 × 3.

Daily observation has shown that the variations noticed on the Brookmans Park secondary beats of 2,903 and 3,175 kc/s follow barometric variations very closely. Changes in the direction of lines of pressure appearing to exert effect upon signal strength. Daily pressure variations of 0.1 inch and over coincide with frequent abrupt strength variations. During calm settled weather

variations of all the "effects" correspond in several definite cases with published reports of distant short-wave reception. The writer has also noticed correlation, up to certain limits, between the day-to-day strength comparison of WIK, Rocky Point, N.Y., 13,930 kc/s, and his own measurements of the 2,903 kc/s secondary beat from Brookmans Park.

The Frequency Stability of Tuned Circuits*

By J. H. Piddington, B.Sc., B.E.

SUMMARY.—Variations in temperature, pressure and humidity may affect the resonance frequency of a tuned circuit. The problem of temperature compensation involves the maintenance of a steady value for the product $L'C$, where L' is the inductance of a coil with its shield and C is the capacity of the condenser.

The problem of compensation of the unshielded inductance L has been treated in detail by Griffiths whose design is used in the first example mentioned below. It is found to be sufficient and of some advantage to proceed with the compensation of the product $L'C$, thus allowing for expansion effects in the condenser, the coil and the shield collectively.

Three methods are given, namely :—

(1) Compensation of L' and C separately,

(2) Compensation of $L'C$ by making the temperature coefficient of capacity negative,

(3) Compensation of $L'C$ by making the temperature coefficient of inductance negative.

A complete design is given in each case together with a set of test results showing the accuracy with which compensation may be obtained.

I. Resonance Frequency

THE resonance frequency of a tuned circuit, consisting of an inductance L and a capacitance C, depends on the value of the product LC. Changes in L and C may result from various causes. Long period changes, due to warping of materials, have a definite trend and may be corrected at intervals. Materials such as marble or quartz should be used if such changes need to be reduced to a minimum.

Short period changes which are usually much more troublesome are due to variations in temperature, pressure and humidity. Of these causes the first is the most important, leading to variations in the product LC of the order of 50×10^{-6} per degree Centigrade. With normal temperature fluctuations of 10° C. the resonance frequency of the circuit would vary by about 250 parts in 10^6.

Variations in atmospheric pressure are also of importance, a change of 25 mm. of mercury, by its effect on the dielectric constant, causing a change in the capacity of an air condenser of 20 parts in 10^6. The effects of changes of humidity are difficult to estimate but are probably less than those of changes of pressure. It is therefore advisable to seal the condenser hermetically if a stability better than 30 parts in 10^6 is required. This does not apply to the stable oscillators of a beat frequency oscillator, where two approximately equal condensers are used, for variations in pressure and humidity affect these to an approximately equal extent. The effect of change in temperature on the dielectric constant is only about 1 in 2×10^6 per 1° Centigrade, which is unimportant.

II. Temperature Compensation of Shielded Inductance

The method for compensating the coil so that changes in temperature do not affect its inductance has been fully outlined by Griffiths in previous papers (Ref. 1, 2). The effect of the shield may, however, be considerable, so a brief analysis will be made of this with the help of a formula derived by Howe (Ref. 4).

If L is the inductance with the shield in position and L_0 that without the shield, then—

$$L = L_0\left(1 - \frac{V_c}{V_s}\frac{k_m^2}{k_c k_s}\right) \quad \ldots \quad (1)$$

where V_c = Volume of the coil,

V_s = Volume of the shield,

k_m, k_c, k_s are constants depending on l_c/d_c and l_s/d_s, l_c and l_s are the lengths of coil and shield respectively, and d_c and d_s are the diameters of coil and shield respectively.

This formula is derived for a cylindrical can, but should give close enough approximations for other shapes of can.

The quantities k_m and k_s are independent of temperature since l_s/d_s does not vary with the latter.

Assuming L_0 to be a constant provision-

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

ally* and differentiating (1) with regard to temperature t, we have

$$\frac{1}{L_0}\frac{dL}{dt} = -\frac{V_c k_m^2}{V_s k_c k_s}\left(\frac{1}{V_c}\cdot\frac{dV_c}{dt} - \frac{1}{k_c}\frac{dk_c}{dt} - \frac{1}{V_s}\frac{dV_s}{dt}\right) \quad \ldots \quad \ldots \quad (2)$$

If α = coefficient of linear expansion of coil ends,
β = coefficient of linear expansion of coil former,
λ = coefficient of linear expansion of can,

equation (2) becomes :—

$$\frac{1}{L_0}\frac{dL}{dt} = -\frac{V_c k_m^2}{V_s k_c k_s}\left(2\alpha + \beta - 3\lambda - \frac{1}{k_c}\cdot\frac{dk_c}{dt}\right) \quad \ldots \quad \ldots \quad (3),$$

which gives the temperature coefficient of inductance due to the shield alone.

When the coil is of solid construction we have

$$\alpha = \beta \text{ and } \frac{dk_c}{dt} = 0.$$

Equation (3) then simplifies to :—

$$\frac{1}{L_0}\frac{dL}{dt} = -\frac{3V_c k_m^2}{V_s k_c k_s}(\beta - \lambda) \quad \ldots \quad (4)$$

For an ebonite coil-former in a brass shield, with the dimensions such as to make L_0 ten per cent. greater than L, we find from equations (1) and (4) that

$$\frac{1}{L_0}\frac{dL}{dt} = -15 \times 10^{-6},$$

which is quite considerable.

With composite coils such as in Griffiths' construction the effect of the can may be found from equation (3) and curves representing k_c, k_m, k_s in terms of l_c/d_c and l_s/d_s (see Ref. 4).

The quantity $\frac{dk_c}{dt}$ is found from the slope $\frac{dk_c}{d(l_c/d_c)}$ of the k_c — curve by means of the following relationship :—

$$\frac{dk_c}{dt} = \frac{dk_c}{d(l_c/d_c)}\left[\frac{1}{d_c}\cdot\frac{dl_c}{dt} - \frac{l_c}{d_c^2}\frac{dd_c}{dt}\right],$$

i.e., $$\frac{dk_c}{dt} = \frac{l_c}{d_c}\frac{dk_c}{d(l_c/d_c)}\cdot(\beta - \alpha) \quad \ldots \quad \ldots \quad (5)$$

Values of $\frac{1}{L_0}\frac{dL}{dt}$ for a bakelite-ebonite coil in a brass shield are of the order of 5×10^{-6} to 10×10^{-6} per degree Centigrade for normal sizes of coil and shield.

* The variation of L_0 due to temperature change is considered in Section IV *et seq.*

III. Temperature Condensation of Condenser

The capacity of a condenser is given by

$$C = \frac{A}{4\pi x}$$

where A = total plate area, and
x = distance between the plates.

Its temperature coefficient of change is given by

$$\frac{1}{C}\cdot\frac{dC}{dt} = (2u - v) \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where u = coefficient of linear expansion of the plates, and
v = coefficient of linear expansion of the washers used to space the plates.

To give zero temperature coefficient we must have $2u - v = 0$. Thus with brass plates for which $u = 19 \times 10^{-6}$ we must have $v = 38 \times 10^{-6}$. If a mixture of brass and "loaded ebonite" washers be used, this required result is obtained; in the above instance about 40 per cent. of ebonite washers are needed. By varying the proportion of ebonite washers, it is possible to change the temperature coefficient of capacity over the range from $+19 \times 10^{-6}$ to -27×10^{-6} per degree Centigrade. This suggests that if the coil has a temperature coefficient of inductance not exceeding 25×10^{-6} per degree Centigrade, it is unnecessary to compensate both inductance and capacity separately, since the frequency depends on their product. The allowance for the effect of the screening can may be calculated by means of equation (4).

The air dielectric condenser constructed for tests, consisted of 1/16″ brass plates mounted on 8 vertical brass rods screwed into ebonite blocks which were screwed to a brass bed plate. Powerful spring washers under nuts were used at the top of each supporting column to prevent the rods or plates from controlling the amount of expansion of the dielectric gap.

IV. Temperature Compensation of the Product L.C.

1.—*Compensation in the Condenser alone.*— It has been shown in Section III that the temperature coefficient of capacity of a condenser may, by suitable design, be made negative. With the construction outlined in III, having all the washers of loaded ebonite, a coefficient of -27×10^{-6} per degree Centigrade may be obtained.

If the coil is of normal construction, i.e., of one solid piece, its temperature coefficient of inductance is equal to the temperature coefficient of linear expansion of the material of which it is made. With a bakelite former a coefficient of $+25 \times 10^{-6}$ is obtained, provided the winding is in slots so that dimensions are controlled entirely by the bakelite.

The effect of the screening can may also be of importance and is derived from formula (4) by putting

$$\beta = 25 \times 10^{-6}$$
$$\lambda = 19 \times 10^{-6}$$
$$V_c/V_s = 1/8$$

This leads to the following result :

$$\frac{1}{L_0}\frac{dL}{dt} = -3 \times 10^{-6}$$

Thus the effective temperature coefficient of inductance of the coil is about 22×10^{-6} and it is then necessary to use about 10 per cent. of brass washers to reduce the absolute coefficient of capacity of the condenser to about -22×10^{-6} per degree Centigrade so that the product LC may have a temperature coefficient of zero.

The advantage of this construction lies in its simplicity when compared to that previously described. It cannot however always be used if the condenser determining frequency is variable, since this would involve the complete rebuilding of the variable condenser, with ebonite washers in the correct proportion. A third method may then be used in which the coil only is compensated.

2. *Compensation in the Inductance alone.*—This method permits of the use of any type of condenser, fixed or variable. It is thus applicable to the design of wavemeters, signal generators and any oscillator required to have a large range of frequency. By suitable design the coil is given a temperature coefficient of inductance of negative sign. The resonance frequency of a circuit consisting of an inductance L and a capacitance C is given by :

$$f = \frac{1}{2\pi\sqrt{LC}}.$$

Differentiating logarithmically with regard to the temperature t, we have :

$$-2/f \,.\, df/dt = 1/C \,.\, dC/dt + 1/L \,.\, dL/dt \quad .. \quad (6)$$

Thus if the frequency is to be independent of temperature, we must put :

$$1/C \,.\, dC/dt + 1/L \,.\, dL/dt = 0 \quad .. \quad (7)$$

For a condenser made of one material, of coefficient of linear expansion δ

$$1/C \,.\, dC/dt = \delta$$

The inductance of a coil is given by*

$$L = \frac{\pi^2 d^2 N^2}{l} \cdot \frac{m}{m + d/l} \quad .. \quad .. \quad (8)$$

The value of m varies between the limits 2.2 and 2.4 for values of d/l between 0.01 and 6 (see Reference 6) and a mean value of m equal to 2.25 gives L within 2 per cent. within the range of d/l from 0.2 to 4.0.

The temperature coefficient of inductance of the coil is found by differentiating (8) with regard to temperature and putting

$$\frac{1}{d}\frac{dd}{dt} = \alpha, \quad \frac{1}{l}\frac{dL}{dt} = \beta, \quad m = 2.25$$

Then $$\frac{1}{L}\frac{dL}{dt} = 2\alpha - \beta - \frac{\alpha - \beta}{1 + 2.25\, l/d} \quad .. \quad (9)$$

Allowance for the effect of the shield may be made, if necessary, when the dimensions are nearly finally determined.

So by (7) the product LC is temperature compensated if

$$2\alpha - \beta - \frac{\alpha - \beta}{1 + 2.25\, l/d} + \delta = 0 \quad .. \quad (10)$$

It is possible by using Griffiths' construction to satisfy this equation if δ is not larger than about 18×10^{-6}, but as the value of l/d necessary would then be very large, the construction shown in Fig. 1 is adopted permitting the use of any value of l/d and any value of δ. Brass end-plates are used and an ebonite former B, divided into four segments with projecting collars A at the ends to allow the screws fixing the former to the end-plates to be on a circle of diameter D, greater than the diameter d of the winding circle.

Diametral expansion of the coil is controlled by the expansion of the brass and by the expansion of the ebonite between the two concentric circles of diameter D and d. The expansion of the coil diameter d is equal

* See Reference 6.

to the expansion of the quantity D, less the expansion of the quantity $(D - d)$.

We have : $d\alpha = D\alpha' - (D - d)\beta$ .. (11)

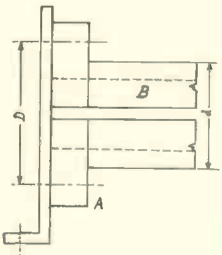


Fig. 1.—*Former of coil having negative temperature coefficient of inductance.*

where

α' = coefficient of linear expansion of the brass,

β = coefficient of linear expansion of the ebonite, and

α = equivalent coefficient of expansion of the coil diameter.

Hence this construction permits of the variation of α in equation (10) over a wide range by simply varying the ratio d/D.

The example constructed had the value 0.83 for l/D, and was used with a brass condenser.

Thus $\beta = 70 \times 10^{-6}$

$\alpha' = 19 \times 10^{-6}$

$\delta = 19 \times 10^{-6}$

From equation (10)

$\alpha = 16.1 \times 10^{-6}$

Hence from equation (11)

$d/D = 18/19$

Suitable values were

$d = 2\frac{1}{4}''$

$D = 2\frac{3}{8}''$

The correction for shield effect can be calculated from equation (3) and compensated by a small variation in l/d.

V. Practical Arrangements and Tests

A series of tests was carried out to determine the degree of temperature compensation attained in the apparatus described above. The double-beat method of frequency change measurement was used, the diagram of connections of the apparatus being shown in Fig. 2. Two very stable high-frequency valve oscillators (H.F. Osc. 1 and 2) were constructed, each having a frequency of oscillations of 100 kilocycles per second.

The frequency of one of these oscillators was changed by about 100 cycles per second and the two high-frequency oscillations applied to a valve acting as a mixer or frequency changer, by virtue of the non-linearity of its plate characteristic.

The output from the mixer valve consisted of high-frequency oscillations which were suppressed by a suitable filter, and a low-frequency oscillation which was amplified. This latter had a frequency equal to the difference of the frequencies of the two high-frequency oscillations, namely, 100 cycles per second. The beat oscillation was applied to one pair of plates of a cathode ray oscillograph, on the other plates of which was applied an oscillation of equal frequency from a stable low-frequency oscillator. The resultant figure traced by the spot on the fluorescent screen was therefore in general an ellipse, which rotated slowly if the frequencies of the two applied voltages differed slightly. By setting the low-frequency oscillator so that the ellipse was stationary and then varying slightly the frequency of one high-frequency oscillator, keeping the other unchanged, such variations could be accurately measured.

The condenser and inductance of each oscillator was completely enclosed in a heavy brass shield, and in the one to be tested for effect of temperature was placed a 15 watt

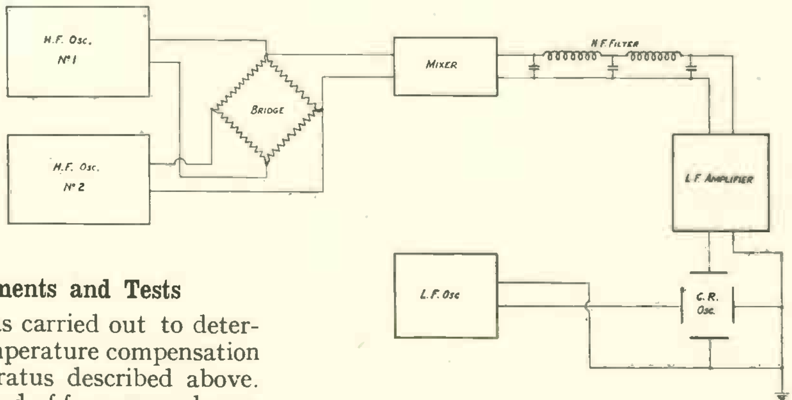


Fig. 2.—*Schematic diagram of apparatus for measuring oscillator frequency changes.*

lamp, screened to prevent direct radiation. It was placed at the bottom of the shield to give the best convection effect. The shield was lagged and a thermometer inserted The voltage to the lamp could be varied and for each test was set to give a steady rise of about 25° C. over a period of several hours. Great care was taken to ensure a slow rise in temperature (about 5° to 10° C. per hour) as otherwise warping and uneven expansion of the coil former ensued, resulting in large irregular changes in the frequency. Even with the slow rate of heating mentioned above a non-uniformity of expansion followed, resulting in the frequency-temperature curve taking the shape shown in Fig. 3. If the upper temperature is maintained for a period of several hours a steady state results which

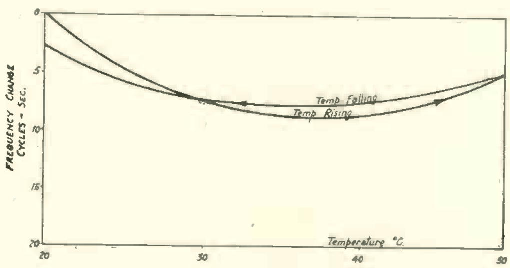


Fig. 3.—*Frequency-temperature curve showing effect of large temperature changes in the coil.*

gives the frequency-variation due to the total temperature change. With a coil using Griffiths' method of construction and the compensated condenser described in III, temperature runs were taken, various percentages of ebonite washers were used in the condenser and the following results were obtained :

TABLE I.

Percentage of Ebonite Washers	Min. Temp. t_0	Max. Temp. t_1	Beat Frequency at t_0. cycles/sec.	Beat Freq. at t_1	Beat Freq. Change for 1° C.	Temp. Coeff. of LC $\times 10^6$
100	25° C.	57° C.	174	226	1.6	−32
60	20	45	120	140	0.80	−16
30	19	44	136	130	−0.24	5
0	20	45	140	116	−0.96	19

The fixed frequency oscillator had 30 per cent. ebonite washers in its condenser, and as the room temperature did not vary more than 5° C. the errors introduced by temperature changes in its tuned circuit were negligible.

The results clearly indicate that compensation to within 5 parts in 10^6 is possible in the value of LC, that is to within $2\frac{1}{2}$ parts in 10^6 per degree Centigrade in the frequency. With a value of 40 per cent. of ebonite washers compensation to well within this limit can be obtained.

Similar tests were carried out on the LC combinations described in sections IV.1 and IV.2. In each case temperature changes of about 25° C. were made and the frequency change measured.

TABLE II.

Coil and Condenser	Minimum Temp.	Maximum Temp.	Frequency Change	Temp. Coeff. of LC per °C.
IV.1	18	42	− 8 c/s	7×10^{-6}
IV.2	20	45	+ 5 c/s	-4×10^{-6}

Conclusion

It would appear from the above results that compensation by either of the methods mentioned is possible, the temperature coefficient of frequency being reduced from about 25 or 40 parts in 10^6 to as low as 1 part in 10^6, when due care is taken with the design and construction of the apparatus (condenser, coil and shield).

Acknowledgements

The author is indebted to D. F. Martyn, Ph.D., A.R.C.S. for valuable suggestions and criticism, to Professor V. A. Bailey, M.A., D.Phil. for suggestions with regard to the presentation of the paper, and to Professor J. P. V. Madsen, D.Sc. for his continued interest and advice.

Bibliography

1. W. H. F. Griffiths, "Inductance of High Permanence," *W.E.*, 6, 543 (1929).
2. W. H. F. Griffiths, "Inductances for Radio Frequencies," *W.E.*, 11, 305 (1934).
3. J. H. Piddington, "A Temperature Compensated Dynatron Oscillator of High Frequency Stability," *Proc. Inst. Eng. Aust.*, 7, 2 (1935).
4. G. W. O. Howe, "Electromagnetic Screening," *W.E.*, 11, 347 (1934).
5. F. M. Colebrook, "Valve Oscillators of Stable Frequency," *Radio Research Special Report*, No. 13.
6. W. G. Hayman, "Approximate Formulae for the Inductance of Solenoids and Astatic Coils," *W.E.*, 8, 422 (1931).

Ganging a Superhet*

By C. P. Singer

IN designing a superhet, where the signal and oscillator circuits are kept in step by a padding condenser, it is well known that exact tracking can be established theoretically at three frequencies. The usual procedure is to design the signal and oscillator circuits together, but in practice the actual strays and wiring capacity may make an appreciable difference to this calculation. On practically trimming up the circuits this may not mean much at the highest and lowest wavelength, to which the set is required to tune, which will merely suffer a slight displacement, but not so with the third tracking point. By the time the limiting frequencies are adjusted, this may be badly out, and in some extreme cases had been found to drift out of the tuning range. It therefore becomes desirable to retain a check on the position of the intermediate ganging point in such a manner, that instead of this being dependent on a multiplicity of constants, it can be checked up by its relation to a single constant.

The analysis has been carried out from this point of view for a capacity-coupled bandpass filter, which furnishes particularly symmetrical and simple formulae for calculation, while the check on the intermediate tracking frequency is provided by its relation to the strays across the oscillator circuit. According to this method the signal circuit is designed first, which considerably narrows down the factors that might cause the third tracking point to drift when actually trimming up the circuits.

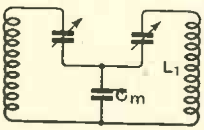


Fig. 1.

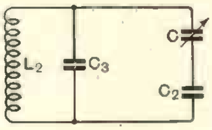


Fig. 2.

No approximations have been introduced into the analysis and if the calculation has been carried out accurately the third ganging point must fall within the tuning range, while the practical adjustment of the circuits can be carried out by the usual matching procedure.

It has been found necessary to divide the work into two sections, referring to the medium and long-wave bands.

A. The Medium-Wave Band

Let it be required to find the dimensions of an oscillator circuit for a superhet, consisting of a coil L_2 and padding capacity C_2 to work in conjunction with a capacity-coupled bandpass filter (see Figs. 1 and 2). The equivalent theoretical signal circuit is shown in Fig. 3. C_1, C_3 are strays and trimmer capacities.

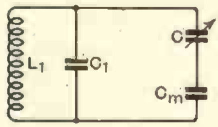


Fig. 3.

Let the minimum and maximum frequencies to which the set is required to tune accurately be f_γ and f_a respectively for the signal circuit ; then neglecting resistance, also denoting the I.F. by f_i, we get the following equations :

$$\left.\begin{aligned}
\left(\frac{C_{\text{min.}}C_m}{C_{\text{min.}}+C_m}+C_1\right)L_1 &= \frac{1}{4\pi^2 f_a^2} = a \\
\left(\frac{C_{\text{max.}}C_m}{C_{\text{max.}}+C_m}+C_1\right)L_1 &= \frac{1}{4\pi^2 f_\gamma^2} = \gamma \\
\left(\frac{C_{\text{min.}}C_2}{C_{\text{min.}}+C_2}+C_3\right)L_2 &= \frac{1}{4\pi^2(f_a+f_i)^2} = \delta \\
\left(\frac{C_{\text{max.}}C_2}{C_{\text{max.}}+C_2}+C_3\right)L_2 &= \frac{1}{4\pi^2(f_\gamma+f_i)^2} = \eta
\end{aligned}\right\} \quad (1)$$

Here C_1—as distinguished from the minimum capacity $C_{\text{min.}}$ of the tuning condenser —is made up of a fixed portion C_0 representing the distributed capacity of the tuning coil L_1, circuit strays (including the internal valve capacity), switching elements, wiring, etc., and of a variable portion C_Δ depending on the trimmer capacity across C.

We therefore have

$$C_1 = C_0 + C_\Delta,$$

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

and if the set is to tune down to a frequency f_a, C_1 is determined by (1), since $C_{min.}$, C_m, L_1 are invariables, being the given constants of the signal circuit.

If the value so found for C_1 is such that

$$C_1 < C_0 + (C_\Delta)_{min.},$$

the set will not tune down to f_a, but the lowest frequency, to which the set will tune, follows from (1) by making $C_1 = C_0 + (C_\Delta)_{min.}$ While the stray capacity C_1 of the signal circuit is determined by the lowest frequency, to which the set is required to tune with a given coil L_1, the stray capacity C_3 of the oscillator circuit is not so far subject to any condition and we could arbitrarily fix the same, when by the two oscillator equations the values for C_2 and L_2 would be determinate.

Again, it may be shown theoretically that the constants of the oscillator circuit can be found so that the difference between the oscillator and signal frequencies becomes exactly equal to the I.F. at three points, *i.e.*, at two limiting frequencies chosen by the designer (which need not necessarily be the highest and lowest frequencies to which the set will tune) as well as at an intermediate point in the frequency scale, defined by a signal frequency f_0.

Since we are free arbitrarily to fix C_3, we can therefore require that C_3 be found so that accurate tracking is established at an additional signal frequency f_0 at the choice of the designer.

Let K be the capacity of the tuning condenser at the frequency f_0, when the conditions of resonance for the additional tracking point are defined by the equations :

$$\left.\begin{aligned}\left(\frac{KC_m}{K+C_m}+C_1\right)L_1 &= \frac{1}{4\pi^2 f_0^2}=\beta\\ \left(\frac{KC_2}{K+C_2}+C_3\right)L_2 &= \frac{1}{4\pi^2(f_0+f_i)^2}=\epsilon\end{aligned}\right\} \quad (2)$$

Having decided on the three signal frequencies, $f_{min.}$, f_0, $f_{max.}$, at which the circuits are to be exactly in step, the values of the LC products α, β, γ, δ, ϵ, η, must first be calculated from the right-hand side of equations (1) and (2).

The tuning capacities at the three tracking points $C_{min.}$, K and $C_{max.}$ can now be found from (1) and (2).

Let

$$\left.\begin{aligned}\frac{\alpha}{L_1}-C_1 &= r\\ \frac{\beta}{L_1}-C_1 &= m\\ \frac{\gamma}{L_1}-C_1 &= s\end{aligned}\right\} \text{ then } \begin{aligned}C_{min.} &= rC_m/(C_m-r)\\ K &= mC_m/(C_m-m)\\ C_{max.} &= sC_m/(C_m-s)\end{aligned}\quad (3)$$

It remains to find the constants of the oscillator circuit C_2, C_3, L_2.

Eliminating L_2 from (1) and (2) we get successively :—

$$\frac{1}{\epsilon}\left(\frac{KC_2}{K+C_2}+C_3\right)=\frac{1}{\delta}\left(\frac{C_{min.}C_2}{C_{min.}+C_2}+C_3\right),$$

$$\frac{1}{\epsilon}\left(\frac{KC_2}{K+C_2}+C_3\right)=\frac{1}{\eta}\left(\frac{C_{max.}C_2}{C_{max.}+C_2}+C_3\right);$$

or in the form

$$\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)C_3=\left(\frac{1}{\delta}\right)\frac{C_{min.}C_2}{C_{min.}+C_2}-\left(\frac{1}{\epsilon}\right)\frac{KC_2}{K+C_2},$$

$$\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)C_3=\left(\frac{1}{\eta}\right)\frac{C_{max.}C_2}{C_{max.}+C_2}-\left(\frac{1}{\epsilon}\right)\frac{KC_2}{K+C_2};$$

from which by elimination of C_3

$$\frac{1}{\delta}\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)\frac{C_{min.}C_2}{C_{min.}+C_2}-\frac{1}{\epsilon}\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)\frac{KC_2}{K+C_2}$$

$$=\frac{1}{\eta}\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)\frac{C_{max.}C_2}{C_{max.}+C_2}-\frac{1}{\epsilon}\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)\frac{KC_2}{K+C_2},$$

and after a somewhat lengthy transformation (shown in detail in the appendix) :

$$C_2 = \frac{KC_{max.}(\epsilon-\eta)+C_{min.}C_{max.}(\eta-\delta)+KC_{min.}(\delta-\epsilon)}{K(\eta-\delta)+C_{max.}(\delta-\epsilon)+C_{min.}(\epsilon-\eta)} \quad .. \quad .. \quad (4)$$

Next, to find C_3, eliminate L_2 from equations (3) and (4) :

$$\frac{1}{\delta}\left(\frac{C_{min.}C_2}{C_{min.}+C_2}+C_3\right)=\frac{1}{\eta}\left(\frac{C_{max.}C_2}{C_{max.}+C_2}+C_3\right)$$

or

$$\delta\left(\frac{C_{max.}C_2}{C_{max.}+C_2}+C_3\right)=\eta\left(\frac{C_{min.}C_2}{C_{min.}+C_2}+C_3\right)$$

Let

$$\left.\begin{aligned}&\frac{1}{C_{max.}}+\frac{1}{C_2}=\frac{1}{D};\ \frac{1}{C_{min.}}+\frac{1}{C_2}=\frac{1}{E}\\ &\text{Then}\quad C_3=\frac{\eta E-\delta D}{\delta-\eta}\end{aligned}\right\}\quad (5)$$

If the value found for C_3 is such that

either $C_3 < C'_0 + (C'_\Delta)_{\text{min.}}$,
or $C_3 > C'_0 + (C'_\Delta)_{\text{max.}}$,

where the symbols C'_0, (C'_Δ) have a meaning analogous to that already defined for the signal circuit, but with reference to the oscillator circuit, then the frequency f_0 corresponding to the intermediate tracking point will have to be increased or diminished until C_3 assumes a value compatible with the actual circuit elements (distributed capacity across the oscillator coil, wiring capacity, strays and trimmer capacity limits).

Finally from (2) :

$$\frac{KC_2}{K + C_2} + C_3 = \frac{\epsilon}{L_2}$$

Let

$$\left.\begin{aligned} &\frac{1}{K} + \frac{1}{C_2} = \frac{1}{p}, \\ &\text{Then} \quad L_2 = \frac{\epsilon}{p + C_3} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (6)$$

Here L_2 is a function of C_2 and C_3, but it will be observed from the expression given above for C_2 that this does not depend on the stray capacity C_3 across the oscillator circuit, and C_3 therefore directly determines the size of L_2.

B. The Long-Wave Band

To track accurately at three points, we require three independent circuit elements to adjust, *i.e.*, the oscillator coil, padding condenser and a separate trimmer across the oscillator circuit (or across C). Little would be gained, however, by doing so since it is well known that on the L.-W. range the maximum ganging error is only about 10 per cent. of that on the M.-W. range. It will therefore suffice in practice if for the L.-W. band a separate trimmer be dispensed with and the circuits adjusted at only two frequencies, which, however, should be somewhat removed from the highest and lowest wavelengths, to which the set is required to tune.

Also, since any difference between the actual values of C_3 on the medium- and long-wave bands respectively can only be due to the distributed capacity across the additional long-wave winding, an allowance added to the value calculated for C_3 on the medium waves is all that is required. If pile-wound in two spaced sections, an allowance of 3 $\mu\mu$F will be sufficient. Any possible error thus introduced into the calculation is so slight as to be absolutely of no importance on the L.-W. band.

The calculation of the oscillator circuit constants under the conditions assumed can then be carried out as follows :

The LC products, α, γ, δ, η, and $C_{\text{min.}}$, $C_{\text{max.}}$ (the lowest and highest wavelengths at which the circuits are required to track accurately) are first calculated as for the medium-wave band.

To find C_2 we have from (1) :—

$$\frac{C_{\text{min.}}\, C_2}{C_{\text{min.}} + C_2} + C_3 = \frac{\delta}{\eta}\left(\frac{C_{\text{max.}}\, C_2}{C_{\text{max.}} + C_2} + C_3\right)$$

or $$\frac{C_2(C_{\text{min.}} + C_3) + C_{\text{min.}}\, C_3}{C_2(C_{\text{max.}} + C_3) + C_{\text{max.}}\, C_3} = \left(\frac{\delta}{\eta}\right)\frac{C_{\text{min.}} + C_2}{C_{\text{max.}} + C_2},$$

when after a transformation shown in the Appendix we get for C_2 the quadratic :

$$\frac{n}{2}C_2^2 - qC_2 - \frac{t}{2} = 0,$$

where

$$\left.\begin{aligned} n &= 2\,\frac{(C_{\text{max.}} + C_3)\delta - (C_{\text{min.}} + C_3)\eta}{\eta - \delta} \\ q &= C_{\text{max.}}\, C_{\text{min.}} + C_3\,(C_{\text{max.}} + C_{\text{min.}}) \\ t &= 2C_{\text{max.}}\, C_{\text{min.}}\, C_3, \\ &\text{and from which} \\ C_2 &= \frac{q + \sqrt{q^2 + nt}}{n} \end{aligned}\right\} \quad (7)$$

Here the root will always be positive over the broadcast range from 1,000—2,000 metres.

Finally, to find L_2 we have from (1)

$$L_2 = \frac{\eta - \delta}{\dfrac{C_{\text{max.}}\, C_2}{C_{\text{max.}} + C_2} - \dfrac{C_{\text{min.}}\, C_2}{C_{\text{min.}} + C_2}}$$

$$= \frac{(\eta - \delta)\,(C_{\text{max.}} + C_2)\,(C_{\text{min.}} + C_2)}{(C_{\text{max.}} - C_{\text{min.}})\, C_2^2},$$

Whence writing

$$\left.\begin{aligned} C_{\text{max.}} + C_2 &= R \\ C_{\text{min.}} + C_2 &= S \end{aligned}\right\} \text{we have } L_2 = \frac{\eta - \delta}{R - S}\left(\frac{RS}{C_2^2}\right) \quad (8)$$

Appendix

Referring to equation (4), the following shows the intermediate workings omitted in the text :

Let $\dfrac{1}{C_{\text{min.}}} = A$, $\dfrac{1}{C_{\text{max.}}} = B$, $\dfrac{1}{K} = C$, $\dfrac{1}{C_2} = X$;

then

$$\left.\begin{array}{l}\frac{1}{\delta}\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)\frac{1}{A+X}+\frac{1}{\epsilon}\left(\frac{1}{\eta}-\frac{1}{\epsilon}\right)\frac{1}{C+X} \\ +\frac{1}{\eta}\left(\frac{1}{\delta}-\frac{1}{\epsilon}\right)\frac{1}{B+X}+\frac{1}{\epsilon}\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)\frac{1}{C+X}\end{array}\right]=0$$

or

$$\left.\begin{array}{l}\frac{1}{\delta}\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)(B+X)(C+X)+\frac{1}{\eta}\left(\frac{1}{\delta}-\frac{1}{\epsilon}\right)(A+X)(C+X) \\ +\frac{1}{\epsilon}\left(\frac{1}{\eta}-\frac{1}{\epsilon}\right)(A+X)(B+X)+\frac{1}{\epsilon}\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)(A+X)(B+X)\end{array}\right] \\ =0$$

The coefficient of X^2 reduces to zero and we get :

$$\left[\begin{array}{l}\frac{1}{\delta}\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)(B+C)+\frac{1}{\epsilon}\left(\frac{1}{\eta}-\frac{1}{\epsilon}\right)(A+B) \\ +\frac{1}{\eta}\left(\frac{1}{\delta}-\frac{1}{\epsilon}\right)(A+C)+\frac{1}{\epsilon}\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)(A+B)\end{array}\right]X$$

$$+\left[\begin{array}{l}+\frac{1}{\delta}\left(\frac{1}{\epsilon}-\frac{1}{\eta}\right)BC+\frac{1}{\epsilon}\left(\frac{1}{\eta}-\frac{1}{\epsilon}\right)AB \\ +\frac{1}{\eta}\left(\frac{1}{\delta}-\frac{1}{\epsilon}\right)AC+\frac{1}{\epsilon}\left(\frac{1}{\epsilon}-\frac{1}{\delta}\right)AB\end{array}\right]=0,$$

$$X=\frac{(\eta-\delta)AB+(\delta-\epsilon)AC+(\epsilon-\eta)BC}{(\delta-\eta)(A+B)+(\epsilon-\delta)(A+C)+(\eta-\epsilon)(B+C)},$$

$$=\frac{\frac{1}{C}(\eta-\delta)+\frac{1}{B}(\delta-\epsilon)+\frac{1}{A}(\epsilon-\eta)}{\frac{1}{C}\left(\frac{1}{B}+\frac{1}{A}\right)(\delta-\eta)+\frac{1}{B}\left(\frac{1}{C}+\frac{1}{A}\right)(\epsilon-\delta)+\frac{1}{A}\left(\frac{1}{C}+\frac{1}{B}\right)(\eta-\epsilon)}$$

$$=\frac{\frac{1}{C}(\eta-\delta)+\frac{1}{B}(\delta-\epsilon)+\frac{1}{A}(\epsilon-\eta)}{\frac{1}{BC}(\epsilon-\eta)+\frac{1}{AC}(\delta-\epsilon)+\frac{1}{AB}(\eta-\delta)},$$

which reduces to (4).

The following is the intermediate working omitted in the text when deriving equation (7) :—

Let $C_{\text{min.}}+C_3=M$

$C_{\text{max.}}+C_3=N$

then
$$\left.\begin{array}{l}C_2{}^2(M\eta-N\delta) \\ +\eta C_2(MC_{\text{max.}}+C_{\text{min.}}C_3) \\ -\delta C_2(NC_{\text{min.}}+C_{\text{max.}}C_3) \\ +(\eta-\delta)C_{\text{min.}}C_{\text{max.}}C_3\end{array}\right]=0$$

and since

$$C_{\text{max.}}(M-C_3)=C_{\text{min.}}(N-C_3),$$

$$MC_{\text{max.}}+C_{\text{min.}}C_3=NC_{\text{min.}}+C_{\text{max.}}C_3$$

and therefore

$$\left(\frac{M\eta-N\delta}{\eta-\delta}\right)C_2{}^2+(MC_{\text{max.}}+C_3C_{\text{min.}})C_2 \\ +C_{\text{max.}}C_3C_{\text{min.}}=0$$

which reduces to (7).

Standard Radio Receivers

Opposition to a Recommendation

THE Committee appointed to advise the Government on the future of the Broadcasting Service included in its proposals the suggestion that "the B.B.C. and the wireless trade should jointly examine the possibility of designing and putting on sale at a low fixed price a standard receiving set." This suggestion has met with strong opposition from the radio industry mainly on the grounds that it would be official interference with the free and competitive production of receivers by private enterprise.

There is, however, a more serious aspect of the matter which should discourage the B.B.C. from taking any part either in designing sets or attempts to standardise them.

To standardise and distribute receivers in large quantities throughout the country would be to commit the Broadcasting authority to maintain transmissions suitable to the receivers. Any possible change in transmitting policy which might make the standard set less effective would have to be abandoned however valuable it might be as improving the efficiency of the service, because the B.B.C. could not suddenly inform its listeners that the receivers it had sponsored were to become obsolete.

No other argument seems necessary to show how inadvisable it would be for the Broadcasting Authority to attempt to standardise receivers unless and until standardisation of the transmitting side—with all which that implies—could be contemplated with complacency.

H. S. P.

Einführung in die Angewandte Akustik (Introduction to Applied Acoustics).

By BRAUNMÜHL and WEBER. pp. 216, 154 Figs. S. Hirzel, Leipzig. Paper 9.20 M. Bound, 10.70 M.

The authors are both with the German Broadcasting Company and write from practical experience in the application of the principles of acoustics. Although the book is thoroughly practical, and any mathematics are of an elementary character, the treatment is scientific and references are always given to original papers, so that one can easily look up any point upon which he requires more detailed information. Two sizes of type are employed, and anyone who needs only a general outline can skip the sections in small type. The book is confined mainly to those problems which have not only been solved, but which have emerged from the laboratory stage and attained practical application. The ground covered is indicated by the following list of sections: physical and physiological principles, microphones, loud speakers, sound measurement, gramophone records, photoelectric recording, steel band recording, the composition of speech and music, the acoustics of rooms and buildings, transmission of sound waves. The book is well illustrated and it is a very welcome addition to the literature of this important subject.

G. W. O. H.

Secondary Emission in Valves *

By D. A. Bell, B.Sc.

THE announcement of the new Harries power output valve,† a tetrode which is claimed to avoid the ill effects of secondary emission without employing a suppressor grid, is a reminder that the conditions governing secondary emission are by no means well known. Some experiments made by the author on a standard H.F. screened pentode which has the suppressor grid brought out to a separate pin (Marconi VMP 4) throw light on this question.

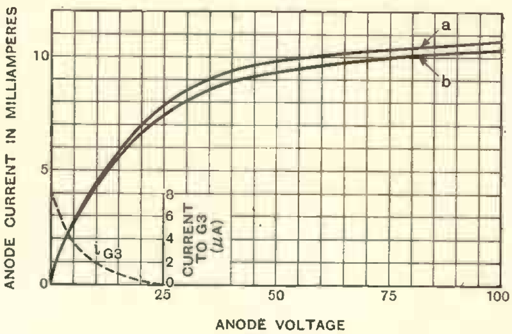


Fig. 1.

For convenience all observations on this valve were made with the control grid (G_1) at the same potential as the cathode, since this is a standard condition for valve characteristics; the screen potential used throughout was 102 volts. The normal pentode characteristic of anode-current/anode-voltage with the suppressor grid (G_3) connected to cathode, is shown in Fig. 1 curve (*a*). The current to the suppressor grid in microamperes is also shown by the dotted line, and will be seen to be negligible over the working range of anode potentials. But it is interesting to note that as far as D.C. characteristics are concerned it is not necessary to connect the suppressor grid to cathode: it may equally well be left free. For from the curves of Fig. 1 for the anode currents with this grid earthed—curve (*a*)—and free—curve (*b*)—it will be seen that the sole effect of leaving it free is to reduce the anode current slightly; and since the anode current is not very sensitive to the potential of the suppressor, this grid must have acquired a considerable negative potential, say, of the order of 10 volts, when left free. But if the insulation of the suppressor grid (apart from electronic conduction) be 50 megohms, this potential of 10 volts will be maintained by a current of 1/5 microampere; and reference to the dotted curve of Fig. 1 shows that it is easily possible for the suppressor grid to collect a current of this order.

Since the tetrode characteristic, showing the secondary emission which might be expected in the absence of the suppressor grid, was not obtained with the suppressor free, the screen and suppressor grids were next joined together and to a potential of 102 volts. The anode characteristic was then as shown in Fig. 2, of the usual tetrode type. There is, however, another arrangement which might be expected to give a tetrode characteristic, namely, suppressor grid joined to anode: but in fact the characteristic obtained for this condition is that of Fig. 3*a*, with the effect of secondary emission very greatly reduced. On connecting separate meters in the circuits of anode and G_3, still joined to a common supply voltage, it was found that the majority of the current was collected by the anode, whose characteristic showed *no indication of secondary emission*. The small current collected by G_3 on the other hand, showed marked secondary emission, and was thus

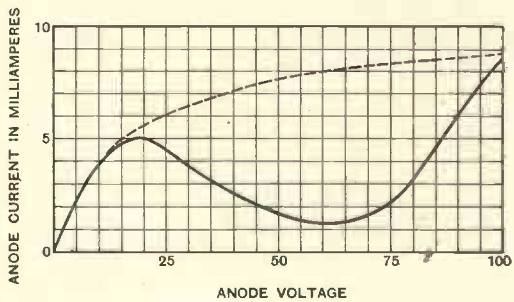


Fig. 2.

responsible for the whole of the "tetrode kink" tendency of the joint characteristic of G_3 and anode. It seemed then that secondary emission from the anode could be checked by producing approximately zero field at its surface, without the necessity for a large field definitely attracting electrons

* MS. accepted by the Editor, October, 1935.
† *Wireless World*, 2nd August, 1935, p. 105.

towards the anode. (Of course, a small attracting field may have existed at the anode, due to space-charge between it and G_3.) The curve of Fig. 3*a* may be compared with 3*b*, which is the characteristic of a power output valve of "pentode type," actually a tetrode which was expected to eliminate secondary emission by the use of an anode of special shape, without a suppressor grid. (This valve, manufactured in 1934, has, of course, no connection with the Harries valve.) In this particular specimen the negatively sloping portion of the characteristic, though by no means non-existent, is less marked than in a normal tetrode; such a valve apparently gave reasonable quality of reproduction as judged by ear.

A further test with small fields in the neighbourhood of the anode was made by connecting the anode and screen (G_2) to the same potential, and varying the potential of the suppressor grid (G_3) between zero and equality with the anode and screen potential. Now inserting in Fig. 2 the dotted curve for the course which the anode current might be expected to take in the absence of secondary emission from the anode, we see that the secondary emission amounts to something of the order of 7 mA. But Fig. 4 shows that when at the same potential as the anode and screen the current collected by the suppressor grid at the expense of *both* is only 2.76 mA, and part of this will presumably represent the interception of primaries on their way to the anode and the attraction of primaries which would otherwise have arrived at the screen: with G_2 G_3 and anode all at the same potential, not more than a fraction of the secondary emission leaves the anode. It is probable that the rise of screen current between the values of 50 and 90 volts on G_3 represents the secondary electrons which are either emitted by the suppressor grid, or else emitted by the anode and pass through the suppressor grid, and are caught by the screen; the final fall in the currents to both anode and screen are presumably due to the diversion of primaries to G_3. It again appears that, either due to space-charge or some other reason, the effective secondary emission due to a moderate anode voltage‡ can at least be very greatly reduced without actually making the potential of the anode higher than that of the nearest electrode, provided the field at the surface of the anode is small. In other words, much can be done by reducing the field tending to remove electrons from the anode, without actually introducing a field attracting them towards the anode.

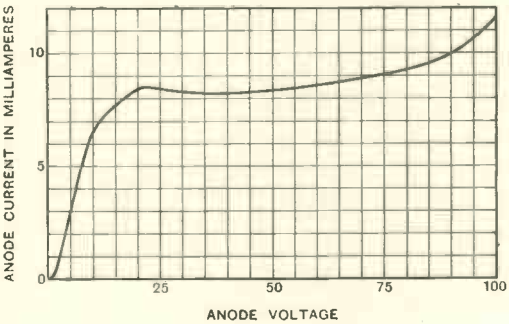


Fig. 3a.

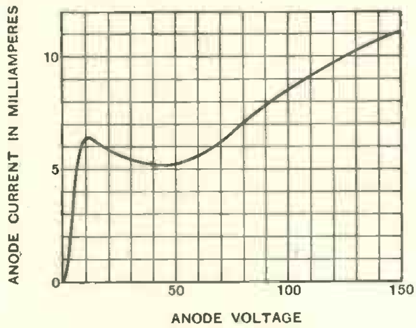


Fig. 3b.—*Special tetrode. Screen voltage*=150.

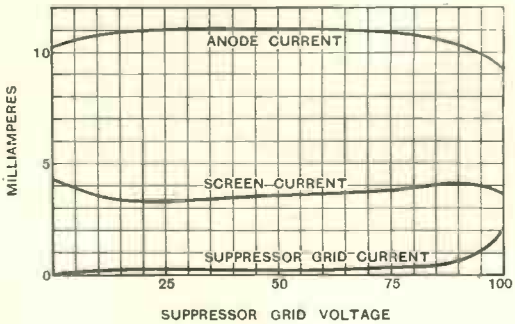


Fig. 4.

The next step is to compare the characteristics to be expected from hypothetical valves of three types, (*a*) "ideal" tetrode with no secondary emission, (*b*) actual

‡ Secondary emission tends to increase rapidly at voltages beyond those commonly employed on receiving valves.

tetrode, (*c*) pentode, the primary anode and screen currents at full anode voltage being assumed the same in each case. The curves are given in Fig. 5, and are based on the following reasoning. In all three cases, with anode at zero there will be considerable space-charge in the neighbourhood of the screen, including the space between screen and anode in (*a*) and (*b*) or suppressor grid in (*c*). (Apart from other evidence from the resistance and capacity of the anode-screen space, this is confirmed by the fact that with anode and suppressor grid both at zero, there is an appreciable current to the suppressor grid—*see* Fig. 1.) When the anode is made positive, it immediately collects a proportion of this charge, and all three curves show a rapid initial rise of anode current; but not quite so rapid with the pentode as with the tetrode, since the suppressor grid tends to shield the space-charge from the field of the anode. But as with rising voltage this space-charge is absorbed by the anode, the rate of increase of anode current must become less, even in (*a*) and (*c*) where there is no secondary emission, since there is less accumulation of charge upon which to draw; finally, with the anode at a potential well above that of the screen, all electrons passing the screen are collected on the anode, and a state of "saturation" of the anode-screen space is reached. The anode current of all three types then rises only very slowly, in fact, only by virtue of that portion of the anode field which penetrates the screen into the screen-cathode space and so causes more electrons to pass the screen. An extra feature in the usual tetrode—curve (*b*)—is the fall in current owing to secondary emission as soon as the anode potential exceeds a certain value, and when the anode potential considerably exceeds that of the screen there is, in addition to the cessation of loss by secondaries from the anode, a slight rise of anode current due to secondaries from the screen being collected by the anode; for this reason curve (*b*) is drawn slightly higher than either (*a*) or (*c*) at the upper end.

Now even curve (*a*), the "ideal" tetrode, is not perfect from a working point of view, since it must be curved for the whole range of anode voltage up to equality with the screen voltage. But a judicious combination of types (*a*) and (*b*) could clearly yield a curve of the type of Fig. 6, which resembles that given for the Harries valve (*Wireless World*, *loc. cit.*), and is not unrelated to Fig. 3*a*. The author tentatively suggests, therefore, that this is the detailed mechanism of the Harries valve. The fact that it is a tetrode, not a pentode, is responsible for the steep initial rise of anode current; the subsequent straight characteristic is due to the fact that secondary emission from the anode, though not absolutely non-existent, is reduced to so small a value that it merely serves to counteract the natural convexity

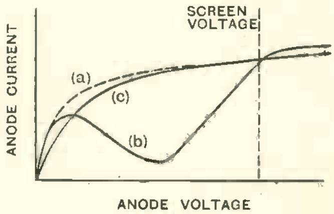


Fig. 5.

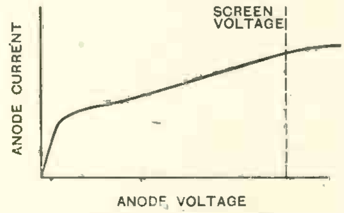


Fig. 6.

of a secondary-free characteristic. The wider spacing of the anode from the other electrodes reduces secondary emission since it decreases the field at the anode: for the field is naturally diminished by an increase of spacing while the difference of potential remains constant, and in addition the field in a cylindrical condenser tends to be concentrated near the inner electrode. (The capacity per unit length of a cylindrical condenser is $C = \frac{1}{2\log(b/a)}$, and the corresponding charge on each plate at potential V is then $Q = \frac{V}{2\log(b/a)}$. But the field just inside the outer electrode is $2Q/b = \frac{V}{b.\log(b/a)}$. The field at the outer electrode thus decreases rather more rapidly than as the inverse of the radius.)

The experimental work mentioned in this paper was carried out in the Engineering Laboratory, Oxford University, and in this connection the author wishes to acknowledge his indebtedness to Mr. E. B. Moullin for various suggestions.

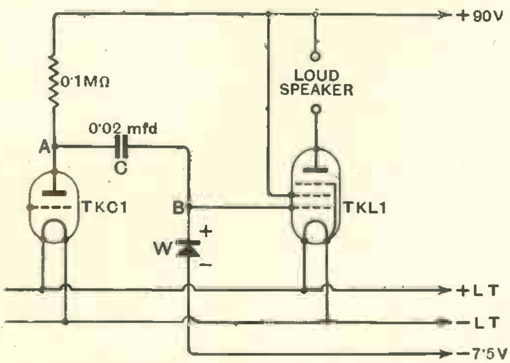
Current-Economising Circuit for Battery Receivers*

By Joseph Frommer

IT is a common usage to operate the output pentode of battery sets with a low zero-signal current and to increase the average current automatically on the arrival of signals. This is accomplished at present by rectifying a small part of the anode-current of the output valve and connecting the rectified voltage, after having smoothed it, in series with the grid bias.

This method has the disadvantage that its data must be chosen in accordance with the actual load impedance, and in the case of frequency-dependent magnetic loud speakers the values are only correct at a certain frequency.

The author has developed in the Research Laboratory of the Tungsram Works for the same purpose a much simpler device, which is quite independent of the anode-load and therefore also of the frequency characteristics of the loud speaker. The coupling is shown in the accompanying diagram. It consists simply in using a metal rectifier instead of the usual grid-lead resistance, the positive terminal being connected to the grid and the negative terminal to a bias supply sufficiently high to secure low zero signal current.



Using a metal rectifier instead of the usual grid-lead resistance.

In this coupling the A.C. potential of the grid (point B) is controlled through the condenser C by the L.F. valve. The D.C. potential is controlled by the rectifier. If there is no signal, the potential of point B will be equal to the biasing voltage, for the rectifier carries then theoretically no current and consequently no potential-drop can exist between its terminals. When receiving a signal, the anode voltage of the L.F. valve, acting across the coupling condenser C and the rectifier, will draw through the rectifier an asymmetric current, the D.C. component of which will carry a positive charge to the condenser C till the average potential of B is raised to a new state of equilibrium in which the flow of current in one direction through the rectifier is equal to that in the inverse direction.

The data of the circuit must be chosen so that:

(1) The conductance (reciprocal resistance) of the rectifier must be so high that the grid leakage of the output valve does not cause serious voltage-drop on its terminals.

(2) The resistance of the rectifier at every point of its voltage-current curve must be high in comparison with the resistance of the L.F. valve anode circuit. As the former resistance varies at different points of the curve its substantial participation in the voltage-division would cause distortion.

(3) The impedance of the coupling condenser must be low in comparison with the rectifier resistance even at the lowest frequency.

(4) The capacity of the coupling condenser must be low enough to be charged by the rectified current in such a short time that the ear should not notice the distortion prior

* MS. accepted by the Editor, January, 1936.

to the new state of equilibrium with rapidly increasing signals.

(5) To get efficient rectification the characteristics of the rectifier must be bent as much as possible.

(6) To get low distortion the curvature of the same characteristics must not increase too rapidly at any point.

Between these contradictory requirements a reasonable compromise may readily be found.

The internal resistance of the Tungsram TKC1 valve is 60,000 ohms. The rectifier is a Westector Type W4, which has a zero point resistance of about 2.5 megohms, and in its conducting-direction, in the utilised section of its curve, a minimum of 0.5 megohm. The 0.02 μF. condenser C has at 25 cycles an impedance of about 0.3 megohm. The highest potential-loss due to the condenser at this extremely low frequency is consequently no more than

$$\frac{\sqrt{0.3^2 + 0.5^2} - 0.5}{\sqrt{0.3^2 + 0.5^2}} = 26\,\%\,;$$

on the other hand, the time-constant of charging the condenser has the order of magnitude $RC = 0.5 \cdot 10^6 \cdot 2.10^{-8} = 10^{-2}$ sec.

With the data of the figure we attained with a 3 mA zero-signal consumption and an 8 mA maximum consumption a very satisfactory reproduction. For further investigation we connected points A and B through two separate amplifiers to the deflecting plates of a cathode-ray tube, the amplifier being of the D.C. type for point B. With this arrangement the variation of the potential of point B as a function of the potential of point A could be observed. The luminous spot gave a straight oblique line, and no curvature could be observed by the eye. When the input was varied the line travelled, parallel to its initial position with no noticeable inertia, showing the increase in the average current.

Correspondence

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

"The Anode to Accelerating Electrode Space in Thermionic Valves"

To the Editor, The Wireless Engineer

SIR,—I have read with considerable interest the paper by J. H. Owen Harries on "The Anode to Accelerating Electrode Space in Thermionic Valves" (*The Wireless Engineer*, April, 1936, p. 190).

It appears to me that although all the statements on p. 194, column 1, are correct, the author has not indicated the true reason why the rise in anode current is not infinitely steep. The theory of the steep part of the I_a characteristic has been worked out in considerable detail by Below, and Schulze ("Zur Theorie der Bremsfeldkennlinie" Hochfrequenztechnik v. Elek. Akus. Oct. 1934, p. 118), and the effect depends on the angular *deflection* of electrons in the neighbourhood of an accelerating grid wire.

Furthermore, it seems difficult to account for the straightness of the I_a characteristic at $E_g = -20$v. (in Fig. 16) on the assumption that space charge is sufficient to prevent the retrograde passage of secondary electrons from the anode; presumably at a sufficiently negative grid bias there will be an inadequate quantity of charge between accelerating grid and anode to depress the minimum voltage below the anode potential.

Enfield. Mddx. SIDNEY RODDA.

To the Editor, The Wireless Engineer

SIR,—In reply to Mr. Rodda's second statement, it is necessary to point out that the negative space charge potential in the anode space is a function, not of the current density only, but of the current density and of the distance over which the space current has to travel. If a valve is so constructed that its current density is extremely high for any electrode potentials, then at a sufficiently negative grid bias there may be an inadequate quantity of charge in the anode space to prevent the retrograde passage of secondary electrons. This corresponds to Mr. Rodda's expectations, but also corresponds to a badly designed valve. If, alternatively, the valve is so designed that the working space current density is low, and the negative space charge potential is produced largely because of comparatively wide spacing, instead of largely by space charge, then variations in current density due to variations of control grid potential may be made much greater without allowing the retrograde passage of secondary radiation to take place. In practice, it is remarkable how straight the characteristics may be maintained, even at very high values of negative grid bias outside the working range. Even here, although these characteristics may depart from a straight line to some extent, there need be no actual negative resistance effect. I attach a great deal of weight to the question of linearity, because careful distortion analysis, using complex wave and not sine wave inputs, shows that a perfectly straight line to the right of the knee is of great importance.

Mr. Rodda's first point is that the primary reason for the shape of the anode characteristics at the knee is concerned with the angular deflection of electrons in the manner set out by Below and Schulze.

Below and Schulze are concerned with valves in which the anode space is extremely small (two or three millimetres) and is of the same order as the cathode space in length. The anode voltages then investigated are extremely small—much less, in general, that the knee voltages of critical distance valve.

Schulze assumes that there is no space charge dip of potential between the wires of the accelerating grid ; but such a dip is produced with critical distance valves and may be shown to be of considerable magnitude in many cases, as Mr. Rodda agrees. This will modify the behaviour of the electrons. Electrons passing throught the middle of the space between any two wires will be shielded from the deflecting field and will be deflected very much less that the others. Electrons near the wires will be deflected, but not to a great extent, because when deflected to one side past the wire they will enter another falling potential field which will tend to return them to a straight path. One would expect the final angle of deflection therefore to be only very small. This is confirmed by experiment with critical distance valves by the examination of the patterns on anodes coated with fluorescent material. A valve of the kind illustrated in my Fig. 12, which has no focusing or directing means in the anode space, is found to produce a perfectly well defined patch of fluorescence on the anode, indicating that the electrons have travelled in almost straight lines from the positive grid. There seems, therefore, no theoretical or practical reason to suppose that Below and Schulze's work is applicable directly to critical distance valves, at any rate without very substantial modification and extension.

For reasons concerned with the space available, it was not possible to deal in detail with effects having very small magnitudes but, if Mr. Rodda will read page 194 of my paper again, he will see that the fact that deflection occurs is inferred by the mention of variations in potential between the wires of an accelerating electrode.

I am unaware at present of any phenomenon, found during the development of long space valves, which leads to angular deflection as anything but a very subsidiary part of the theory.

Should Mr. Rodda have any information of which I am not aware which bears on the theoretical aspect of the matter, I should be very interested to hear about it in detail.

HARRIES THERMIONICS LTD.
London, W.C.1. J. H. OWEN HARRIES,
Director.

Book Review

Electric Circuits and Wave Filters

By A. T. STARR. Pp. xiv + 375. Sir Isaac. Pitman and Sons Ltd., 39, Parker Street, London, W.C.2. 1934. 21s. net.

In this book the author has set out to give within the compass of a single volume a complete account of the theory of electric circuits and networks and in particular of the subject of wave filters. Such a subject can not be discussed in terms of elementary mathematics, but the author has taken pains to smooth a path for the reader who is merely equipped with a moderate knowledge of algebra and elementary calculus. Accordingly the first chapter introduces in a lucid manner the theory of complex numbers and the trigonometric functions of real and complex numbers, so that the theory of alternating current which follows in the second chapter loses most of its inherent difficulties, and the algebraic and graphical treatments of the behaviour of alternating current can be readily followed.

The author then proceeds to develop his main subject, the theory of electric circuits and networks. Several interesting mechanical and acoustic analogies are given ; including the acoustic network system of the gramophone and acoustic filters.

The chapter on four-terminal networks is remarkable in that the parameters or constants used are those which express the input currents and voltages in terms of the output currents and voltages as two linear equations with four linear parameters, a system which is commonly used in the theory of the transmission of power. Attenuation pads of various types are analysed and the methods of design are explained. Considerable attention is given to wave filters, which are important in telephony and radio work. Low, high, and band pass filters receive separate treatment, and a nomogram is given for the rapid design of band pass filters. The effect of resistance in the filter coils is included and attenuation curves show the effect on the behaviour of the filter. This book can be recommended to teachers and designers in the subject of communication engineering. It is complete in itself and covers adequately the field of present-day practice. R. T. B.

Reports on Progress in Physics. Vol. II (to Dec. 1934), published by the Physical Society, 1, Lowther Gardens, Exhibition Road, London, S.W.7. Pp. 371. Price, 21/-.

This volume contains among others sections on Radio Exploration of the Upper Atmosphere by Prof. Appleton, on Sound by Dr. E. G. Richardson, on Electrical and Magnetic Measurements by Dr. Hartshorn, and on Electron Tubes by Prof. Finch and others.

Abstracts and References

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

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

2069. MICRO-RAY COMMUNICATION [Experiences with the England/France Circuits: Most Stable Conditions coincide with Very Stable Atmospheric Conditions].—W. L. McPherson and E. H. Ullrich. (*Nature*, 11th April, 1936, Vol. 137, p. 628: abstract of recent I.E.E. paper.) *See* also 1341 of April.

2070. MICRO-WAVE THROUGH METALLIC NET.—K. Morita. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, p. 1082: Japanese only.)

2071. PROPAGATION OF ULTRA-SHORT WAVES [Short Report of 1936 U.I.R Paper on Diffraction of Waves around 8 Metres].—B. van der Pol. (*Alta Frequenza*, March, 1936, Vol. 5, No. 3, p. 219.)

2072. SOME MEASUREMENTS OF THE REFLECTION COEFFICIENT OF THE IONOSPHERE FOR WIRELESS WAVES.—F. W. G. White and L. W. Brown. (*Proc. Roy. Soc.*, Series A, 1st Feb. 1936, Vol. 153, No. 880, pp. 639–660.)

For previous work *see* 1934 Abstracts, p. 143. In the present work "the sender-receiver system is calibrated so that the reflection coefficient may be determined for a wave of any frequency within the range 2.80 to 6.50 Mc/s, from the relative amplitudes of the direct and the singly-reflected atmospheric waves. The method of calibrating the system is described." Typical results are given, showing variation of reflection coefficient with frequency. "The total absorption suffered by the waves is very much dependent upon the critical phenomena at the transition of reflection from one region to another. The influence of the absorbing regions is estimated from the results." The collisional frequency is estimated to be of the order of 5×10^3 per sec. at a height of about 250 km. "Some indication of the variation of this quantity with altitude is given."

2073. THE TEMPERATURES AND CONSTITUENTS OF THE UPPER ATMOSPHERE.—D. F. Martyn and O. O. Pulley. (*Proc. Roy. Soc.*, Series A, 1st April, 1936, Vol. 154, No. 882, pp. 455–486.)

See also 1728 of 1935. Authors' abstract:—Radio measurements of the heights and electron densities of the ionised regions are found to show considerable cooling of the upper atmosphere during the night. The absolute temperatures between the E and F regions of the ionosphere are found, from consideration of the electron collision frequencies, to reach values of the order 1 000° K. Such high temperatures exist both in summer and in winter daytime. From the observed rate of cooling at night it is found that considerable water vapour is present in the ionosphere. . . . The high temperatures found are attributed mainly to the absorption of solar ultra-violet energy by ozone. . . . The ionisation densities in the E and F regions are found to correlate directly, and the height of the F region indirectly, with the barometric pressure at the ground. This correlation is attributed to the temperature changes in the ionosphere occasioned by changes in ozone concentration. . . . The attachment of electrons to neutral particles is the main process by which free electrons are removed from the ionised regions. The process is so rapid that no free electrons would be observed 5 minutes after sunset but for the presence of a detaching agency. The energy necessary for detachment is given out mainly during the recombination of atomic oxygen, the non-polar aurora being a by-product. This view is supported by consideration of Rayleigh's absolute measurements of the intensity of the green line of the night sky, and by the correlation of the seasonal and diurnal variations of the intensity of the green line with the similar variations of electron density in the F_2 region. Consideration is given to temperatures below 100 km. A maximum temperature is found at 60 km and a minimum of 160° K at 82 km. Noctilucent clouds are found to be formed of ice crystals. This temperature distribution is found to give an air pressure of 10^{-3} mm at a height of 105 km, in good agreement with the electron collision frequency measured at that height.

An addendum shows that the correction of an approximation in Lindemann and Dobson's calculations (1923) gives close agreement between densities calculated from meteor and from radio data.

2074. Terrestrial Magnetism and Its Relation to World-Wide Short-Wave Communications [Results of R.C.A. Investigations: Direct Relationship between Short-Wave Communication Effectiveness and North Latitude: East-West *versus* West-East Communication: Magnetic Retentivity of Earth's Core: etc.]—H. E. Hallborg. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 455–471.) Joint I.R.E. and U.R.S.I. Meeting paper.

2075. Observations on the Absorption of Electromagnetic Waves in the Ionophere [Simultaneous Reflections from E and F_2 Regions and Their Explanation].—I. Ranzi and C. Savorelle. (*Nuovo Cimento*, December, 1935, Vol. 12, No. 10, pp. 610–615.)

The authors assume that these simultaneous reflections are due to a rather steep gradient of the ionic density with height in E. The observations here described show that if the band of wavelengths on which the observations of simultaneous reflections are carried out is made wide, the echoes from F_2 become more intense. This confirms the above hypothesis, because the steeper the ionic gradient in E the smaller should be the ionisation in the lower part of E; that is, in the region where the wave suffers the greatest absorption.

2076. Low-Frequency Transmission over Transatlantic Paths [Simultaneous Reception at Different Points: Different Directional Aerials Not Mainly Responsible for Large Day/Night Ratio Differencies: Relation to Earth-Potential Changes: Abnormally Low Group Velocities Not Found].—H. H. Beverage and G. W. Kenrick. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 472–482.)

Joint I.R.E. and U.R.S.I. Meeting paper: for previous work *see* 1934 Abstracts, p. 314. "There appears, therefore, to be little evidence, at the time these observations were taken, for any large difference in propagation time, certainly not of the order of 20 msecs. such as would be indicated by the values reported by Loomis and Stetson."

2077. Ionospheric Studies in India [Summarising Notes on Recent Work: Increase of E-Region Ionisation during Thunderstorms].—S. K. Mitra. (*Nature*, 21st March, 1936, Vol. 137, pp. 503–504: notes on lecture.)

2078. The D Layer [Absorbing Layer in Ionosphere at Height of about 55 km: Apparent Decrease of E-Layer Height explained as due to Gradual Disappearance of D Layer with Approaching Sunset: etc.].—P. Syam. (*Indian Journ. of Phys.*, January, 1936, Vol. 10, Part 1, pp. 13–21.) For a preliminary communication *see* 2539 of 1935.

2079. Effect of Lunar Eclipse on the Ionosphere [Echoes from F Region become Weaker during Totality].—S. S. Banerjee and B. N. Singh. (*Nature*, 4th April, 1936, Vol. 137, p. 583.)

2080. Ionospheric Height at Allahabad [Pulse Observation on 75 m Wave: Average Speed in Ionosphere at most only about 1/25th of Velocity of Light *in Vacuo*: 66-Day Variation of Time of First Echo before Sunrise? Momentum Effect of Layer of Max. Ion Density to explain "Rebound" of Virtual Height: Many Layers of Max. Density, or else a Time Retardation of Quantum-Like Character: Lunar Effects found: etc.].—T. D. Bansal. (*Tech. Phys. of USSR*, No. 2, Vol. 3, 1936, pp. 111–134: in English.) For the first part of these tests *see* Toshniwal & Pant, 1934 Abstracts, p. 432. Also *see* 1735 of 1935.

2081. A Preliminary Report on the Investigation of the Ionospheric Layers over China.—M. K. Ts'en and N. H. Chang. (*Chinese Journ. of Phys.*, No. 3, Vol. 1, 1935, pp. 92–100: in English.)

Using the differential pulse generator dealt with below (2082). The measurements were made at Shanghai, on a frequency of 6.2 Mc/s, for 24 hrs on a summer day. Reception was on a c-r oscillograph, using a narrow-loop sinusoidal time base. The curves show, among other things, a diurnal variation of F-layer height between about 220 and 305 km, and an almost steady height of about 100 km for the E layer (between 3 and 9 p.m.); simultaneous reflections from E and F layers, and the reappearance of reflections resembling E-layer reflections, around 2 a.m.

2082. A Differential Pulse Generator [Simple and Reliable Generator with Equal Abruptness of Rise and Fall: by Superposition of Similar and Opposite Pulses from Two Glow-Discharge Tubes].—M. K. Ts'en. (*Chinese Journ. of Phys.*, No. 3, Vol. 1, 1935, pp. 68–78: in English.) Having "all the advantages of phase control over amplitude control, yet the simplicity of amplitude control is preserved." Duration and amplitude are separately controlled.

2083. Apparatus for the Investigation of the Ionosphere [System of Electrical Linkage between Tuning Systems of Transmitter and Receiver maintains Automatic Synchronism].—R. Naismith. (*Nature*, 11th April, 1936, Vol. 137, pp. 615–616.) *See* also 1934 Abstracts, p. 607.

2084. THE CONSTITUTION OF THE STRATOSPHERE [including Heights of 100–400 km] FROM ELECTROPHYSICAL INVESTIGATIONS.—J. Fuchs. (*Meteorol. Zeitschr.*, No. 8, 1935, pp. 278–284.)

"A critical discussion of the mechanism of ionisation phenomena in the ionosphere, and of the hypotheses required to explain the occurrence of long-delay radio echoes, enabled estimates of atmospheric pressure and corresponding heights to be made for two points of the highest stratosphere [E and F ionised regions]. A curve could then be drawn, using the known pressure at the level of maximum occurrence of aurorae, to show the probable variation of atmospheric pressure for heights 0–300 km above the earth's surface. This curve shows that it is impossible for the very high atmosphere to consist principally of hydrogen and helium, and thus agrees with Vegard's spectroscopic auroral observations." The theory is further found to agree with Chapman's view that gases (oxygen in particular) are dissociated at great heights; otherwise the high values of F-region ionisation could not be explained. For a subsequent paper *see* 1705 of May.

2085. SOME OBSERVATIONS ON SIGNAL FADING OF SHORT WAVES.—Nakagami and Miya. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, p. 1080: Japanese only, with records.)

2086. DETERMINATION OF THE MINIMUM VOLTAGE [6.3 V] FOR OZONE FORMATION BY ELECTRON IMPACT.—F. Kruger and Charlotte Zickermann. (*Zeitschr. f. Physik*, No. 5/6, Vol. 99, 1936, pp. 428–452.)

2087. DISTRIBUTION OF ENERGY IN THE SPECTRUM OF THE LIGHT OF THE NIGHT SKY AT DIFFERENT HOURS OF THE NIGHT.—Cerniajev, Khvostikov and Panschin. (*Journ. de Phys. et le Radium*, March, 1936, Vol. 7, No. 3, pp. 149–152.)

2088. CONTRIBUTION OF THE COSMIC RADIATION TO THE IONISATION OF THE UPPER ATMOSPHERE.—T. H. Johnson. (*Journ. Franklin Inst.*, March, 1936, Vol. 221, No. 3, pp. 417–421.) Same as 421 of February.

2089. A STUDY OF GROUND-WAVE RADIO TRANSMISSION [Tests for Highway Patrol Network show Excellent Agreement with van der Pol Ground-Wave Approximation to Sommerfeld Theory: Occasional Irregularities in *E.R/R* Graph usually traced to Topographic or Geologic Discontinuities: Wavelengths 178 and 188 m].—R. C. Higgy and E. D. Shipley. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 483–486.)

2090. THE NEBULAR REDSHIFT [Experimental Investigation of Effect of Free Electrons on Frequency of Light traversing Ionised Gas: Null Result].—R. J. Kennedy and W. Barkas. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, pp. 449–452.)

2091. DISTRIBUTION OF ELECTRON VELOCITIES IN A MAGNETIC FIELD [Curves of Anode Current as Function of Grid/Anode Voltage for Various Field Strengths].—T. V. Jonescu and C. Mihul. (*Comptes Rendus*, 30th March, 1936, Vol. 202, No. 13, pp. 1160–1162.)

2092. A DIFFRACTION PROBLEM [Spherical Waves diffracted at Infinite Plane: Integral Equation completely Integrable in Finite Terms], *and* A DIFFRACTION PROBLEM [Infinite Plane separating Media of Different Electrical Constants].—J. Delsarte. (*Comptes Rendus*, 9th March, 1936, Vol. 202, No. 10, pp. 826–828; 23rd March, No. 12, pp. 1026–1028.)

2093. THE THEORY OF DIFFRACTION BY A STRAIGHT-EDGED METALLIC SCREEN [Effect of Optical Properties of Screen Metal on Ellipticity of Diffracted Wave].—J. Savornin. (*Comptes Rendus*, 16th March, 1936, Vol. 202, No. 11, pp. 935–937.)

2094. DIFFRACTION OF LIGHT BY THIN WIRES [Displacement of Pattern for Various Polarisations of Incident Light: Assumptions necessary for Theoretical Explanation].—B. Eichstädt. (*Zeitschr. f. Physik*, No. 5/6, Vol. 99, 1936, pp. 301–340.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2095. BRITISH THUNDERSTORM SURVEY: INVITATION TO HELP.—Morris Bower. (*Electrician*, 10th April, 1936, Vol. 116, p. 482.)

2096. RESULTS OF MEASUREMENTS MADE DURING THE STORMS OF 1934/1935.—K. Berger. (*Bull. Assoc. suisse des Élec.*, No. 6, Vol. 27, 1936, pp. 145–163.)

2097. STUDY ON THE LIGHTNING FLASH.—Dauzère. (*Ann. des Postes T. et T.*, February, 1936, Vol. 25, No. 2, pp. 166–198.)

(i) The earth's electric field. (ii) Ionisation and electric conductivity of the air: causes of ionisation (radio-activity of earth and air; penetrating radiation; ultra-violet light): ionisation in the different layers. (iii) Storm clouds and their formation: electrification (Simpson's theory and its criticism; author's theory, not excluding but rather completing that of Simpson; reconciliation with night storms): formation and propagation of lightning: bibliography.

2098. LIGHTNING-STROKE DISCHARGES IN THE LABORATORY [Description of Apparatus].—P. L. Bellaschi. (*Nature*, 21st March, 1936, Vol. 137, pp. 491–492.) *See* also 3781 of 1935.

2099. INVESTIGATIONS ON THE PRELIMINARY STAGES OF SPARK FORMATION IN VARIOUS GASES BY THE USE OF THE WILSON CHAMBER [Photographs: Characteristics of Different Gases: Effect of Admixture of Organic Vapours].—U. Nakaya and F. Yamasaki. (*Proc. Roy. Soc.*, Series A, 1st Feb. 1936, Vol. 153, No. 880, pp. 542–554.) *See* also 47 and 1337 of 1935; *also* Raether, 2580 of 1935.

2100. INVESTIGATION WITH THE CATHODE-RAY OSCILLOGRAPH OF AIR BREAKDOWN AT LARGE STRIKING DISTANCES [Retardation Times: Oscillograms].—M. Messner. (*Arch. f. Elektrot.*, 18th Feb. 1936, Vol. 30, No. 2, pp. 133–137.)

2101. THE OSCILLOGRAPH ELECTRIC TRANSIENT ANALYSER.—N. Rohats. (*Gen. Elec. Review*, March, 1936, Vol. 39, No. 3, pp. 146–149.)

2102. DISCUSSION ON "STANDARDISATION OF IMPULSE-VOLTAGE TESTING."—Allibone and Perry. (*Journ. I.E.E.*, April, 1936, Vol. 78, No. 472, pp. 473–480.) *See* 1718 of May.

2103. THE MEASUREMENT OF SURGES [Investigation of the Steel-Bar Remanence Methods (German and American): Effect of Successive Currents in Same or Opposed Directions].—H. Zaduk. (*E.T.Z.*, 16th April, 1936, Vol. 57, No. 16, p. 443: summary only.)

2104. EARTH MAGNETISM: LARGE LUNAR DIURNAL WAVE DETECTED AT HUANCAYO OBSERVATORY [1927–1932: Combined Solar and Lunar 12-Hourly Waves vary from 34γ when in Phase to 16γ when in Opposite Phase].—Schneider and Bartels. (*Electrician*, 10th April, 1936, Vol. 116, p. 480: summary only.)

2105. RELATION BETWEEN SOLAR ACTIVITY AND DIURNAL AMPLITUDE OF NORTH-SOUTH EARTH CURRENTS REGISTERED AT THE EBRO OBSERVATORY [Harmonic Analysis shows Components of Equal or Neighbouring Periods with Phase Difference of Several Months].—P. Rougerie. (*Comptes Rendus*, 16th March, 1936, Vol. 202, No. 11, pp. 967–968.) For previous work (including the question of lunar influence) *see* 58 of 1935.

PROPERTIES OF CIRCUITS

2106. A FURTHER STUDY OF OSCILLATORY CIRCUITS HAVING PERIODICALLY VARYING PARAMETERS.—W. L. Barrow, D. B. Smith and F. W. Baumann. (*Journ. Franklin Inst.*, March, 1936, Vol. 221, No. 3, pp. 403–416.)

For previous papers *see* 1934 Abstracts, p. 204. The series circuit studied is composed of a positive resistance, an inductance and a periodically varying capacitance. New features of the discussion are: "(1) the forced oscillations produced by an impressed sinusoidal voltage are explored and a method is developed for calculating the steady state current; (2) a series of *quantitative* curves of the current wave form and amplitude are obtained for natural, spontaneous and forced conditions by employing mathematical, experimental and machine methods of analysis." Many curves of charge and current obtained with the differential analyser (Bush, 1933 Abstracts, p. 231) are given.

2107. EXPERIMENTAL INVESTIGATION [with Cathode-Ray Oscillograph] OF THE PHASE SPACE OF SELF-OSCILLATING SYSTEMS.—V. Bovscheverov. (*Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 43–47: in German.)

"Every motion of a self-oscillating, or in general a dynamic, system can be represented as a path curve in phase space. The whole combination of all possible motions can be shown as a phase space divided up in phase curves. The knowledge of the structure of the phase space gives, from a certain standpoint, a considerably [more] exhaustive knowledge of the self-oscillating system than that given by knowing the individual motions (*e.g.* the current and voltage amplitudes of one single motion), since it gives information not only on the individual motions but also on the relation between the whole of these. The experimental determination of the phase space is therefore of direct interest, apart from all theory.

"On the other hand, in theoretical investigations of self-oscillating systems it is usually necessary to idealise the problem considerably, otherwise insurmountable mathematical difficulties are encountered. One is forced to assume, for example, that the characteristic curves can be replaced by simple functions (*e.g.* polynomials of not very high orders): similarly, one often has to neglect the effect of anode potential, grid current, etc. These simplications allow qualitative properties of the phase space to be determined: but one is never certain whether, owing to such idealisation, one or other property is not missed [*cf.* Chaikin, 1727 of May]. Specially great difficulties are involved if the dimension of the phase space, n, is much greater than 3."

The scheme given in Fig. 1 allows the phase plane for an ordinary valve oscillator to be observed directly or to be photographed. The two deflecting systems of the oscillograph are supplied with potentials proportional to, and in phase with, the voltage across the oscillatory-circuit condenser and the current through that condenser, respectively. At every contact of the rotating commutator p, a current flows through the inductance of the oscillatory circuit and charges the condenser, but no oscillations are set up because the oscillatory circuit is shunted by the potentiometer. At every break of contact, oscillations set in if the necessary conditions are satisfied. The commutator rotates 10–15 times per second, so that the process is repeated and the individual curves are seen as one steady curve. In Figs. 2 and 3 the coupling is too small to maintain oscillations: in Fig. 4 the coupling is closer, and a stable limiting cycle is seen with an unstable cycle and a stable singular point inside it (photographed by two successive exposures). *See* also Bendrikov & Gorelik, 486 of February.

2108. THE CONVERSION OF POWER BY MEANS OF TRIODES.—Matteini. (*Alta Frequenza*, March, 1936, Vol. 5, No. 3, pp. 180–207.) *See* 1723 of May: conclusion.

2109. THE "PLATE CIRCUIT THEOREM" [proved on Physical Lines and applied to Solution of D.C. Amplifier Problems].—W. Richter. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 19–21.) The theorem, usually proved mathematically, is that a voltage e_g on the grid is equivalent to the introduction of μe_g in the plate circuit.

2110. The Negative Feed-Back Amplifier: a Mechanical Analogy [Steam Turbine and Governor].—A. C. Timmis. (*P.O. Elec. Eng. Journ.*, April, 1936, Vol. 29, Part 1, pp. 71–72.)

2111. Co-ordination of the Various Types of Oscillation [Mechanical, Acoustical, Optical and Electrical].—L. Bouthillon. (*Bull. de la Soc. franç. des Élec.*, February, 1936, Series 5, Vol. 6, No. 62, pp. 151–182.)

Part I—Oscillations of linear systems. Part II—Non-linear electricity and mechanics. Part III—Mechanical, electrical and optical waves. Part IV—Oscillations and wave mechanics.

2112. Equivalent Circuits—2 Coupled Circuits [having Distributed Self- and Mutual Impedance and Admittance].—Balsbaugh & others. (*Elec. Engineering*, April, 1936, Vol. 55, No. 4, pp. 366–371.)

2113. The Derivation of Electrical Circuits Equivalent to Mechanical Oscillating Systems.—A. I. Belov. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 5, 1935, pp. 1545–1551.)

The paper is confined to the derivation of equivalent electrical circuits from "idealised" mechanical systems, *i.e.* systems with lumped constants, and the method proposed is based on the analogy between the differential equations representing the forces in mechanical systems and the voltages in electrical circuits. The various constants in a mechanical system are defined, and conventional signs to represent them are suggested. The electrical equivalents of these constants are found, and fundamental laws corresponding to Kirchoff's laws in electrical circuits are established. The application of the method is illustrated by two examples.

2114. Oscillator with a Capacity Control [Derivation of Design Formulae for Regenerative Circuits with Capacitive Retroaction, by Input-Conductivity Theory, without solving Kirchoff Equations].—N. M. Isumov. (*Izvestia Elektroprom. Slab. Toka*, No. 2, 1936, pp. 11–14.) The theory used "considerably reduces the calculations and increases the physical clearness of the analysis." The results correspond to Slepian's original formulae.

2115. Some Remarks on the Effect of Grid Currents on the Operation of an Auto-Oscillating System.—E. S. Antseliovich. (*Journ of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1421–1425.)

The operation of an oscillator with inductive back coupling and tuned grid circuit is examined. A general differential equation (3) is deduced in which account is taken of the grid currents, and the effect of these currents on the operation of the oscillator is studied for the cases in which the relationship between the grid currents and oscillating grid voltage is (a) assumed to be linear and (b) assumed to be non-linear. The conclusions reached are illustrated by a number of curves, and a short study is also presented of the case in which an external e.m.f. is applied to an under-excited oscillator, as for instance when a signal is received in a regenerative receiver.

2116. On Transient Phenomena in a Tuned Amplifier.—A. Ageev and J. Kobzarev. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1408–1420.)

Using the approximate method of slowly varying parameters proposed by van der Pol, the operation of a multi-stage tuned amplifier is investigated. The building up and falling off of the oscillations when a harmonic e.m.f. is applied to and removed from the amplifier is examined, and also the processes taking place in the amplifier when a constant e.m.f. is applied to it. In the light of the results obtained the immunity of the amplifier from atmospherics is considered, and formulae are derived for estimating this immunity and for calculating the optimum damping factor.

2117. The Operation of an Auto-Oscillating System with Two Applied Harmonic Forces.—G. Petrosyan. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 5, 1935, pp. 1552–1562.)

The case under consideration is of practical importance since similar conditions arise in a regenerative receiver employed for reception of suppressed-carrier telephony. A theoretical investigation of the system is presented, based on the approximate methods proposed by Poincaré and Liapunov. The investigation is divided into the following sections:—(1) derivation of differential equations, (2) determination of stationary amplitudes, and (3) the stability of the system. It is carried out for various degrees of de-tuning of the oscillator, and the results obtained are shown in a number of curves.

2118. On the Mechanism of the Establishment of Forced Synchronism.—P. Riazin. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 5, 1935, pp. 1809–1833.)

For previous work *see* 1380 of April. The operation of an auto-oscillator with inductive back coupling and tuned anode circuit is examined when an external e.m.f. of frequency twice the natural frequency of the oscillator is applied to the anode circuit. The differential equations of the system are investigated at great length, and the necessary conditions for synchronism are determined. The operation of the oscillator outside the zone of synchronism (régime of beats) is studied, and the process of synchronisation which takes place when the parameters of the system are continuously varied is analysed in detail. It is shown that the state of synchronism is established by one of the following two processes: (a) the frequency of the beats is reduced to zero, or (b) the amplitude of the beats is reduced to zero. A number of experimental results are shown confirming the theoretical results obtained.

2119. Several Stable Equilibrium States in the Series Connection of Iron-Cored Choke and Condenser.—E. Aretz. (*E.T.Z.*, 12th March, 1936, Vol. 57, No. 11, pp. 305–310.)

It has been shown theoretically (*e.g.* Rouelle, 981 of 1935) that in addition to the commonly found low- and high-current stable régimes for a given applied voltage there must exist a third current value between these; this third current, however, was considered to be unstable and has hitherto been established experimentally only for some 3–5 periods. The present writer finds that this third régime is a stable one, very close to the low-current régime and with a curve differing considerably from that expected from theory. He also finds that if a resistance (voltmeter) is connected in parallel with the choke, a fourth stable régime may appear: this is difficult to obtain.

TRANSMISSION

2120. THE FUNDAMENTAL OSCILLATION OF SPACE-CHARGE VIBRATIONS IN A RETARDING ELECTRIC FIELD.—M. Dick. (*E.N.T.*, Extra Number, 1936, pp. 1–100.)

The aim of this investigation of space-charge oscillations is to combine into one theory all the physical phenomena which play any part in oscillation production. In order to reduce the work to manageable proportions, it is restricted to the treatment of the fundamental oscillation of a generator with an electrical retarding field in an absolute vacuum and with parallel electrodes arranged in one plane. Indications are however given of the natural extension of the theory (involving no new principles) to the discussion of overtones.

The experimental study was made with a generator of special design (circuit Fig. 2). The valve used was "a two-filament valve, whose two parallel filaments, which could be separately heated, form the middle portion of a continuous closed system of parallel wires, stretching out on both sides (Fig. 1). The heating current is led in by a parallel wire, the hot filament being the cathode. The grid voltage is connected to the other parallel wire. The glass wall of the valve forms the anode." The external circuit is thus very simple and exactly defined. The circuit for measuring the h.f. voltages in the parallel wire system is shown in Fig. 2. The decrease of anode current is read on a galvanometer. The wavelength is measured by a second, loosely-coupled Lecher-wire system, with adjustable bridge for tuning. Disturbances of the pure oscillations are mainly due to traces of gas in the valve and to the form of the cathode. These are investigated and experimental characteristic curves are given to show their effect (Figs. 10–14). Measured curves showing the dependence of the pure oscillations on grid voltage (Figs. 15–20) and on the tuning of the external system (Figs. 23, 24) are given and described. Typical "ziehen" phenomena of coupled circuits are shown. The curves of Fig. 21 were taken without an external resonance system (circuit Fig. 22); oscillations were produced whose frequency depended only on the grid voltage. This case was found to be explicable as a special case of the usual oscillation with an external system.

The theoretical treatment begins with an analysis of the potentials and field strengths inside the valve. Each is regarded as the vector sum of a constant and a variable part; the latter is again divisible into two parts of different origin (vector diagrams Figs. 27–31). Two fundamental laws are deduced: "1. There is always in the valve an invariable oscillating charge, which is composed of the space charge oscillating weakly as a whole and of three charges situated on the electrodes. 2. The alternating voltage across the valve is composed of the condenser voltage, determined by the external current, and the space-charge voltage, produced by the oscillating space charge and the variable electrode charges." The phenomena inside the valve are discussed, starting with the equation of motion of an electron under perfectly general conditions. This is solved graphically under certain assumptions; the vectorial paths of the electrons are shown in Fig. 32. Figs. 36, 37 give the paths after corrections have been applied; Figs. 38–41, 46–49 show the results of calculations of the space-charge density, field strength and potential distribution, Fig. 50 the potential and field strength due to the current in the external system. The investigation of the charge captured by grid and anode is illustrated by Figs. 51–64. "The oscillatory energy of the generator is due to the fact that electrons which are decreasing the amplitude of their vibration can give out energy, whereas those whose amplitude is increasing are immediately sorted out and do not consume an appreciable amount of energy." The combined effect of oscillating space charge and the captured charges is discussed and illustrated by Figs. 65–72; Figs. 73, 74 illustrate the formation of a Langmuir cathode region, when the valve is not operating in the region of saturated characteristics. It is found that oscillations can only occur in the saturation region. Investigation of the effect of the external Lecher-wire system is illustrated by the curve for its impedance (Fig. 76); skin effect spreads this out into a spiral, whose minima give the oscillation regions. A study of the connection between the internal and external systems, which form coupled circuits, shows that the oscillatory working points occur when a certain capacity ratio is the same for the two systems. Considerations of the balance of energy in the valve show that it is impossible on principle to obtain as high a degree of efficiency with a space-charge generator as with the usual valve generators.

After this discussion of the physical phenomena inside the valve, the actual working is discussed mathematically under various simplifying assumptions as to the constitution of the space charge. Curves of the coupled oscillations and intensity as functions of the natural frequency of the connected external system without attenuation (Figs. 81, 82), of the whole external system without (Figs. 84–88) and with attenuation (Figs. 90, 91), are calculated. An equation is found for the power produced (p. 68). The working of the real generator is dealt with graphically on the basis of the oscillating characteristic of the valve, shown vectorially in Figs. 94, 95. The circuit for its experimental determination is given in Fig. 96; its theoretical derivation is also given. The curves for the waves produced by the coupled internal and external circuits and for the intensity are constructed point by point from this characteristic; their variations with grid voltage, external tuning and ohmic resistance, and saturation current are discussed. All agree with those found experimentally and some hitherto inexplicable phenomena are explained, including the greater intensity of the coupled oscillation of higher frequency.

Stable and unstable oscillation regions are found to occur as with the usual two-circuit valve generator. Self-excitation conditions are discussed; Fig. 123 gives the stable, unstable and semi-stable oscillation regions and is the analogue, for space-charge generators, of Rukop's diagram for valve generators. The working conditions for the generation of the maximum amount of oscillatory power are finally deduced from the oscillatory characteristic (Figs. 125, 126). In an appendix the close theoretical connection between the retarding-field and magnetron generators is pointed out; a list of literature references is given.

2121. THE RELATION BETWEEN TWO ELECTRON OSCILLATIONS IN A TRIODE.—K. Awaya. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, p. 1083: Japanese only.)

2122. ATTENUATION AND GROWTH OF DECIMETRE WAVES.—H. Lotze. (*Hochf:tech. u. Elek: akus.*, February, 1936, Vol. 47, No. 2, pp. 37–43.)

The explanation is sought of the relatively low energy produced by B-K oscillations; the energy lost in the valve and the Lecher-wire system is estimated, and the question is investigated as to whether the motion of the electrons themselves is unfavourably influenced by hitherto unknown effects. Measurements of attenuation in the Lecher-wire system (circuit Fig. 1: wavelength 56 cm) gave the results shown in Fig. 2. The values were lower than those obtained by Krause (2351 of 1935); possible explanations of the difference are suggested. § II describes measurements of attenuation in the unheated valve (circuit Fig. 3), the Lecher-wire system being fed by a second valve. Results for different positions of the valve relative to the system are shown in Fig. 5. § III discusses the matching of the valve in working conditions; this needs careful adjustment, as the "under-matching" increases rapidly with the frequency. Conditions for the growth of oscillations are investigated in § IV; curves for the effect, on the negative impedance of the valve, of the heating (Fig. 7) and of the grid voltage (Figs. 8–10), and for the variation of attenuation with anode voltage (Fig. 11), are given. The results agree with those of Hollmann (1934 Abstracts, p. 205). Production of oscillations in a retroaction circuit is also investigated (Figs. 12–18). Hollmann's "inversion" oscillation region is not found; dynatron oscillations could however be produced.

2123. ELECTRON OSCILLATION WITH A THERMIONIC VALVE OF CONCENTRICALLY ARRANGED SPHERICAL ELECTRODES (THREE-DIMENSIONAL ELECTRON OSCILLATION).—T. Hayasi. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, pp. 16–23: long English summary pp. 1–2.) "The output . . . was about one watt. The efficiency was relatively small, but this is chiefly due to lack of knowledge of the design principle for the spherical valve. The further study for the design will show that the efficiency of the 3-dimensional oscillation is the best."

2124. CATHODE-RAY METHOD OF GENERATING ULTRA-SHORT WAVES.—O. Heil. (French Pat. 785 967: *L'Onde Élec.*, April, 1936, Vol. 15, No. 172, p. 22 B.)

The cathode ray passes through a Faraday cage to which is applied an alternating potential with respect to the cathode: during the positive half-period more electrons leave the cage than enter it, during the negative half-period the reverse is the case. If it is arranged that the ray current acts on the potential of the cage, self-maintained oscillations are produced. The anode to which the ray attains, after its passage through the cage, consists of a number of perforated plates so combined as gradually to deviate and "brake" the electrons, instead of stopping them suddenly, which would be liable to produce reflections and secondary emission.

2125. INFLUENCE OF A UNIFORM MAGNETIC FIELD ON THE ULTRA-SHORT WAVES OBTAINED WITH A TRIODE VALVE [Production of Oscillations of Higher Frequency than with Normal Magnetron].—E. Pierret and C. Biguenet. (*Comptes Rendus*, 15th April, 1936, Vol. 202, No. 15, pp. 1334–1336.)

The writers have previously (2599 of 1935) found a rapid rise in anode current in the neighbourhood of the critical field, accompanied by oscillations of frequency higher than that of normal magnetron oscillations. The effect of a magnetic field on triode oscillations in pre-determined regions and of frequency above that of B-K oscillations is here summarised. The form of the valve characteristics is modified and the oscillation regions are displaced in the direction of positive anode voltage, for constant grid voltage. Within an oscillation region, the frequency increases with the magnetic field intensity. An abnormal increase of grid current is found with close-coiled grids when the magnetic field is near the critical value corresponding to the case when the grid is considered as an anode. Oscillations of higher frequency than that given by the normal magnetron are obtained. *See* also 2126.

2126. ON THE ANOMALOUS INCREASE OF THE ANODE CURRENT IN MAGNETRONS [near the Critical Field Value: connected with Existence of Two Different Régimes: Possibility of Use for generating Still Shorter Waves].—E. Pierret and C. Biguenet. (*Journ. de Phys. et le Radium*, March, 1936, Vol. 7, No. 3, pp. 33–34 S.)

Further development of the work dealt with in 2599 of 1935. The writers now find that the phenomenon only occurs if the filament, though parallel to the magnetic lines, is not parallel to the anode axis; or if it is parallel to this, but not to the magnetic lines. In the region of abnormal anode current, the electrons are displaced towards the ends of the anode, where they form two different zones and cause two régimes, one giving the normal magnetron oscillations (*e.g.* 20 cm); the other gives more rapid oscillations (*e.g.* 11–12 cm) which appear to propagate particularly on the wires connected to the filament. The investigations are proceeding in the hope of results of practical application. *See* also 2125.

2127. THE DISTRIBUTION OF THE ELECTROSTATIC FIELD IN SPLIT-ANODE MAGNETRONS.—J. Groskowski and S. Ryżko. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, pp. 55–58.)

Diagrams are given (Figs. 4–7) of the electrostatic equipotential lines for various anode potentials inside the electrodes of the split-anode magnetron with two segments. They were obtained experimentally by the compensated probe method, using a magnified model of the magnetron in air. Space charge is not considered. The method used is described (circuit Fig. 1). In Fig. 8 there are two additional internal electrodes; Fig. 9 gives the field inside a four-segment anode.

2128. A NEW ELECTRON BEAM TUBE FOR THE MEASUREMENT OF FIELDS OF MAGNETIC FORCE [such as Those used with Magnetrons].—M. von Ardenne. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, pp. 43–45.)

The principle of the method is to find, by observations of fluorescence, the point at which the electron paths in a magnetic field are just tangential to the interior surface of the anode. A magnetron of special construction is used (Fig. 3); its emitting surface is reduced to a point and it produces no disturbing electron oscillations. The circuit scheme is shown in Fig. 1, in which the path of the electrons is indicated. Fig. 2 shows observations of the intensity of fluorescence as a function of the magnetic field-strength; measurements can be made in a range of 200 to 1 000 gauss. *See* also Grechowa, 1786 of May.

2129. THE ACTION OF A SPLIT-ANODE MAGNETRON [as regards "Dynatron Type" Oscillations only, not Micro-Wave: Two Types found (i) True Dynatron and (ii) "Resonance" Oscillations due to "Precession" of Electrons giving Amplified Form of Negative Resistance: Theory and Experimental Verification].—E. W. B. Gill and K. G. Britton. (*Journ. I.E.E.*, April, 1936, Vol. 78, No. 472, pp. 461–468.)

2130. CONCENTRIC TUBE LINES ["Resonant Lines" for Oscillator Frequency Control: Calculation of Z and Q-Value, and of Frequency-Stabilising Effect: Experimental Confirmation].—B. J. Witt. (*Marconi Review*, Jan./Feb. 1936, No. 58, pp. 20–25.)

2131. PROBLEMS OF "DEGREE OF EXCITATION," AMPLITUDE, POWER AND EFFICIENCY OF DYNATRON OSCILLATORS.—R. Usui. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, pp. 23–30: English summary p. 3.)

2132. DISCUSSION ON "THE GRID-COUPLED DYNATRON" [and Its Relation to Hayasi's "Retroactive Dynatron Oscillator"].—Gager. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 534–535.) *See* 3849 of 1935; for Hayasi's work *see* 1934 Abstracts, p. 613.

2133. THE GENERATION OF OSCILLATIONS BY THE TRIODE VALVE.—J. Dacos and F. Frenkel. (*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, p. 25 A: critical summary only.)

"This little work presses much further than is usual the study of the oscillating triode. Besides the service which it may render to all those who have to design self-excited oscillators, it has a great interest from the instructional point of view."

2134. THE FOUNDATIONS OF MODULATION WITH VARIABLE CARRIER.—H. Wehrlin. (*E.T.Z.*, 2nd April, 1936, Vol. 57, No. 14, pp. 396–397: summary of Brunswick Dissertation.)

2135. NOTE ON A METHOD OF CONSTANT-DEPTH MODULATION [Efficiency of Modulating and Modulated Stages Trebled].—G. de Burlet. (*Rev. Gén. de l'Élec.*, 28th March, 1936, Vol. 39, No. 13, p. 99 D.) Using a pentode whose suppressor grid is kept at a varying bias proportional to the amplitude of the modulation, by a transformer actuated by the microphone.

2136. ERRORS IN HEISING METHOD OF MEASURING DEPTH OF MODULATION [Comparatively Small Harmonic Distortion produces Large Errors: Preferable Double-Rectification Method].—E. Green. (*Marconi Review*, Jan./Feb. 1936, No. 58, pp. 15–19.)

2137. AN ANALYSIS OF DISTORTION IN CLASS B AUDIO AMPLIFIERS [for High-Level Modulation].—T. McLean. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 487–509.)

In spite of the large economies attainable, "the high-level system has not won universal acceptance even in large units, largely because there remains a lingering suspicion that Class B audio amplifiers cannot be constructed and operated with as low audio harmonic distortion as a well-built low-level system. It is the purpose of this paper to present a fairly complete analysis [based on Malti's methods] of the imperfections of Class B audio amplifiers, and to indicate some ways the difficulties can be overcome without resorting to the design of special tubes."

2138. AMPLIFICATION AND MULTIPLICATION OF STABILISED FREQUENCIES BY THE SYNCHRONISATION METHOD.—M. S. Neumann. (*Izvestia Elektroprom. Slab. Toka*, No. 2, 1936, pp. 1–11.)

Author's summary:—For the amplification of stabilised frequencies in valve transmitters three different methods can be applied: automatic control, separate excitation, and synchronisation. This article considers the conditions for the application of the third method. Circuits of neutralisation for three- and four-electrode valves are discussed, and the advantages and drawbacks of this method are ascertained in comparison with the method of separate excitation.

Experimental data for cases of amplification and multiplication of frequency are given. An indicator permitting the checking of the presence of synchronisation is described. The possibility is pointed out of applying the effects of "mutual synchronisation" of two or more oscillators, partly self-excited and partly working with separate excitation.

2139. Notes on Piezoelectric Quartz Crystals [particularly the Manufacture of Zero-Temperature-Coefficient Plates for Short-Wave Transmitters, eliminating Thermostatic Control: Special Oscillator Circuits of Improved Stability using Second Crystal either replacing Plate Circuit or in Series or Parallel with First Crystal].—I. Koga. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 510–531.) *See* also 1020 & 2374 of 1935.

2140. Young's Modulus of a Crystal in Any Direction [Derivation of New, Simple General Expression].—I. Koga. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 532–533.) Owing to the development of crystals cut in various forms and directions for special characteristics, the writer expects that the expression for the Young's modulus of a crystal in any direction will be employed frequently in the near future; hence the present work.

2141. Tuning the Crystal [" A " Cut Low Temperature Coefficient Crystals given Adjustable Frequency by Variable Air Gap: Commercial Models].—J. H. Hollister: Koga. (*QST*, April, 1936, Vol. 20, No. 4, pp. 31–32.)

2142. Electron-Coupled *versus* Crystal Transmitter Control: Practical Circuit and Operating Considerations for Frequency-Flexibility.—D. H. Mix. (*QST*, April, 1936, Vol. 20, No. 4, pp. 50–51 and 94, 96, 98.)

2143. Time-Delay Circuits for the Starting-Up of Radio Transmitters.—C. Felstead. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 38 and 40.)

RECEPTION

2144. Distortions accompanying High-Frequency Amplification and Frequency Changing.—M. Lambrey. (*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 226–239.)

Elementary theory of distortions accompanying r.f. amplification, after Snow & Ballantine (Abstracts, 1931, p. 156) and Carter (1932, p. 587): extension to frequency conversion with weak heterodyning voltages from a separate oscillator: examination of Strutt's theory for single-control-grid converters, for very weak and very strong heterodynes (1934, p. 209: *see* also 1934, p. 614) and comparison with the author's formulae: two-grid converters and Strutt's proposed formula (xviii) for these, and the author's experimental results not conforming to it: derivation of a coefficient allowing the calculation of modulation distortion and intermodulation, from the simple formulae v & vi, and viii, respectively: all results valid for weak signals only.

2145. Non-Linear Distortion by Band-Pass Filters [Graphical Method of determining Characteristics: Application to Design].—Feldtkeller. (*Electronics*, February, 1936, Vol. 9, pp. 48 and 50.)

Long summary of the paper dealt with in 105 of January. It is suggested that before all programmes deserving high-fidelity reception a signal modulated by 1 700 (mis-print for 1 900) and 2 500 c/s should be sent out; the listener would then adjust his set so that the combination tone of 600 c/s disappeared.

2146. Intermittent Reception in Broadcast Receivers [Analysis of Causes from Service Calls Data].—A. C. Bradford. (*Electronics*, February, 1936, Vol. 9, p. 44.) 40% represent defective r.f. or i.f. plate or screen by-pass condensers; 35% defective resistors; and so on.

2147. Variable Selectivity and the I.F. Amplifier. Part II—Coupling the I.F. Amplifier to the Detector.—W. T. Cocking. (*Wireless Engineer*, April, 1936, Vol. 13, No. 151, pp. 179–189.) For Part I *see* 1756 of May. Part III will deal with the design of the i.f. amplifier as a whole.

2148. Automatic Frequency Control [Tuning Correction: a New Method].—S. W. Seeley. (*Electronics*, March, 1936, Vol. 9, No. 3, p. 48.) Based on the 90° phase difference between primary and secondary of a double-tuned loosely coupled transformer, for a resonant frequency, and its variation as the frequency moves away from resonance.

2149. New Switching Arrangements for Silent Tuning: Suggestions for the Design of Automatic Switches [actuated by Displacement of Tuning Knob parallel to Its Axis].—H. Boucke. (*Funktech. Monatshefte*, March, 1936, No. 3, pp. 112–114.)

2150. Cathode-Ray Monitoring of Received Signals: Pointers on Connecting the Oscilloscope to a Superhet.—E. C. Ewing. (*QST*, April, 1936, Vol. 20, No. 4, pp. 35 and 114, 118.)

2151. Study of Level Regulators and " Anti-Fading " Devices [Criticism: Baudot-Verdan System protects against Interference as well as against Fading].—Verdan: Espinasse. (*Ann. des Postes T. et T.*, March, 1936, Vol. 25, No. 3, pp. 297–298.) *See* Espinasse, 1418 of April.

2152. Relations between the Non-Linear Distortion of Amplitude Regulators and the Regulation Requirements.—Hölzler. (*See* 2232.)

2153. Light-Bulb Volume Expander.—Crosley Company. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 9 and 48.)

A bridge circuit between output transformer and voice coil has 2 fixed resistances and 2 miniature bulbs with specially processed filaments (high thermal inertia and usual property of increasing resistance with increasing current), in series with bass-boosting circuits for the lower levels.

2154. Grid Bias Scheme eliminates Feed-Back Trouble [Type 27 or 56 Valve connected as Diode across Half the H.T. Transformer Winding supplying the Full-Wave Rectifier].—W. Richter. (*Electronics*, March, 1936, Vol. 9, No. 3, p. 42.) Particularly useful for d.c. amplifiers.

2155. Characteristics of Thermal Agitation Noise in a High-Gain Receiver [Methods of Reducing: Formula for Relation between Max. Overall Amplification, Noise Voltage and Band Width].—H. Seki. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, pp. 1046–1051: English summary p. 135.)

2156. Fog Beacons: a "Sympathetic Effect" resembling the Luxembourg Effect [North Foreland received only when Round Island is operating].—P. Port. (*World-Radio*, 20th March, 1936, Vol. 22, p. 9.) But *see* also 17th April, p. 8.

2157. Trolley Buses: Methods of Suppressing Radio Interference.—(*Electrician*, 10th April, 1936, Vol. 116, p. 482: short survey.)

2158. Interference Source Discovered [the Tracking of the "Inductotherm"].—Mimno. (*Electronics*, February, 1936, Vol. 9, p. 19.) *See* also 1410 of April.

2159. "Cours de Dispositifs antiparasites à l'Usage des Installations électriciens" *and* "Leitfaden der Rundfunkentstörung" [Reviews of Books on Interference Suppression].—M. Adam: Dennhardt and Himmler. (*Bull. Assoc. suisse des Élec.*, No. 7, Vol. 27, 1936, p. 206.)

2160. The Application of the [French] Regulations for the Protection against Interference with Broadcast Reception [Certain Unsatisfactory Points].—J. Toupet. (*Bull. des Assoc. franç. de Propriétaires d'Appareils à Vapeur*, January, 1936, No. 63, pp. 44–46.)

2161. Some Cases of Broadcast Interference from D.C. Machines.—(*E.T.Z.*, 9th April, 1936, Vol. 57, No. 15, p. 418.)

2162. More Developments in the Noise-Silencing I.F. Circuit: Noiseless Reception with Crystal-Type "Single-Signal" Receivers: Circuits for Single I.F. Stage Types.—J. J. Lamb. (*QST*, April, 1936, Vol. 20, No. 4, pp. 16–18 and 78, 80, 82, 84, 86.)

The combination of the i.f. noise-silencing device dealt with in 1761 of May with a crystal filter is extremely effective; the crystal is protected from shock excitation due to high-amplitude pulses and is thus left to look after hiss and general background noise.

2163. Review of Broadcast Reception in 1935 [Basic Industry Figures: Increased Fidelity of Medium-Priced Receivers: Extension to Ultra-Short-Wave Band: etc.].—R. H. Langley. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 376–384.)

2164. A High-Quality 3-Waveband Receiver including Ultra-Short Waves.—Hertel. (*World-Radio*, 20th March, 1936, Vol. 22, p. 18.) On the German receiver referred to in 987 of March.

2165. A 5- and 10-Metre Converter: a Superhet Input Unit using Acorn Tubes.—J. J. Long, Jr. (*QST*, April, 1936, Vol. 20, No. 4, pp. 55–56.)

2166. British Short-Wave Receivers [for India: Necessity for Provision for D.C., for 13-Metre Tuning, and for Lower Prices].—(*World-Radio*, 13th March, 1936, Vol. 22, p. 13.)

2167. Metal Valves in Short-Wave Receivers.—(*World-Radio*, 3rd April, 1936, Vol. 22, p. 14.)

2168. Radio Receivers for Motor Cars [Survey].—(*Engineering*, 3rd April, 1936, Vol. 141, pp. 361–363.)

2169. The Technique of German Car Receivers.—E. Schwandt. (*Funktech. Monatshefte*, March, 1936, No. 3, pp. 91–96.)

2170. New Portable Receivers at the Leipzig Fair.—E. Schwandt. (*Funktech. Monatshefte*, March, 1936, No. 3, pp. 97–101.)

2171. The "Imperial 65W": an 8-Circuit 6-Valve Superhet for A.C. Mains [with 6-Watt Triode Output].—(*Funktech. Monatshefte*, March, 1936, No. 3, pp. 117–118.)

2172. A Battery Superhet with Class B Output [using the New Battery Valves: Comparable with Mains 3-Valve Set: Good Life for 120-Volt Battery].—F. C. Saic. (*Funktech. Monatshefte*, March, 1936, No. 3, pp. 107–111.)

2173. Sales Data of the German "People's Set."—(*World-Radio*, 3rd April, 1936, Vol. 22, p. 11.)

AERIALS AND AERIAL SYSTEMS

2174. Losses in Twisted-Pair Transmission Lines at Radio Frequencies [1—15 Mc/s: Measurements on Lines frequently used for Aerial/Receiver Link: Magnitude of Losses not generally Appreciated].—C. C. Harris. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 425–432.)

The tests were on lines made from conductors frequently employed but not designed for the purpose. High losses are not limited to high frequencies but have been noted in the voice range. "Improved" twisted pairs on the market are claimed to have losses below 1.5 db per 1000 ft. at 3.5 Mc/s, and so on: "there is obviously some error in these figures, as they will be found to be less than the calculated loss neglecting leakance at each frequency. None of these improved types of conductor has been investigated by us, but it would appear from Fig. 2 that very great improvements, perhaps beyond practical limits, will have to be made in twisted pairs before the losses will be comparable with those for open-wire or air-spaced types of lines at frequencies above 1 or 2 Mc/s."

2175. A Presentation of Some Asymptotic Bessel Function Expansions analogous to Heaviside's Generalised Exponential Series [in connection with Dipole Radiation].—W. H. Wise. (*Bell Tel. System Tech. Pub.*, Monograph B-903, 7 pp.)

2176. Antennas for Air Navigation.—Fink. (*See* 2211.)

2177. A 28-Mc Rotary Beam [3 Half-Wave Aerials stacked Vertically End-to-End, backed by Corresponding Radiation-Excited Reflectors].—H. J. Breuer. (*QST*, April, 1936, Vol. 20, No. 4, pp. 28–30 and 62.)

2178. A Multi-Band Aerial for High Frequencies [Details of the Collins Aerial and Transmission Line System], *and* Transmission-Line Loss Calculation.—Collins Company. (*Television*, February, 1936, Vol. 9, No. 96, pp. 113–114: March, 1936, No. 97, pp. 175–176.)

2179. The Diffusion Resistance of Heavy-Current Earths and Its Dependence on the Nature of the Soil and Weather.—K. A. Henney. (*Berlin Thesis*, 1935: at Patent Office Library, London: Cat. No. 75934: in German.)

2180. The Determination of the Current required to Melt the Ice on Overhead Lines in the Wind.—H. Gaudefroy. (*Rev. Gén. de l'Élec.*, 14th March, 1936, Vol. 39, No. 11, pp. 397–398: summary only.)

2181. The Mechanical Calculation of Overhead Lines [including Effect of Snow, etc.]—E. Maurer. (*Bull. Assoc. suisse des Élec.*, No. 3, Vol. 27, 1936, pp. 65–73: in French.) Concluded from previous number.

VALVES AND THERMIONICS

2182. The Anode to Accelerating Electrode Space in Thermionic Valves [and Its "Critical Distance": Part I—Experimental Method of Attack and Analytical Interpretation of Results: Part II—Characteristics of Ideal Valves, Design of Anode Space, Examples and Conclusions].—J. H. O. Harries. (*Wireless Engineer*, April, 1936, Vol. 13, No. 15, pp. 190–199.)

Leading to the conclusion that "the correct design of the anode space of a multi-grid valve should use the anode critical distance [*see* also 3450 of 1935] and that the design of very long stream valves should be in accordance with the methods of spacing accelerating electrodes described herein."

2183. Deflection-Control Tubes [Cathode-Ray-Tube Principles applied to General Purpose Valves: Wide Applications].—A. Hazeltine. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 14–16.) From an I.R.E. talk. Among other advantages, such tubes would be specially useful as detectors for single sideband signals, eliminating the distortion given by ordinary linear detectors.

2184. New Electronic Tubes and New Uses [Electron-Ray Tubes: Photo-Tubes: Low Grid Current Triodes: H.F. Oscillators: Short-Wave Therapy: Biological Applications: High Temperature Production: Secondary Emission Multipliers: Gas Triodes: Ignitrons].—D. Ulrey. (*Physics*, March, 1936, Vol. 7, No. 3, pp. 97–105.)

2185. The Secondary Emission Multiplier—a New Electronic Device [Theory, Construction and Performance of Various Types].—Zworykin, Morton and Malter. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 351–375.) The full I.R.E. paper dealt with in 1091 of March and back reference.

2186. On the Preliminary Experimental Results regarding the "Magnetic Electron Multiplier" of A.C. Type.—K. Okabe. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, p. 83: letter, Japanese only, with diagrams.)

2187. Other Papers on the Electron Multiplier.—(*See* under "Phototelegraphy and Television.")

2188. Anomalous Secondary Electron Emission: A New Phenomenon [with Oxidised Aluminium treated with Caesium and Oxygen: Intense Potential Gradient across Resistive Oxide Film].—L. Malter. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, p. 478: preliminary letter.)

2189. Relation between Secondary Emission and Work Function [with Experimental Curve agreeing with Theory].—L. R. G. Treloar. (*Nature*, 4th April, 1936, Vol. 137, p. 579.)

2190. Shot Effect of Secondary Emission. I. [Theory and Experimental Verification].—M. Ziegler. (*Physica*, January, 1936, Vol. 3, No. 1, pp. 1–11: in English.)

For a preliminary paper *see* 2293 of 1935. It is assumed that the primary impact and the secondary emission are practically simultaneous, so that the n electrons liberated by one primary electron can be considered as a single "multiple electron" as regard the current pulse which they produce. The theory developed shows that in a triode where the grid and plate are positive to the cathode and can each emit secondary electrons, and where, moreover, the densities of charge between the electrodes are negligible, the difference of the fluctuations of the grid and plate currents must be proportional to the difference of these currents.

2191. Measurement of the Richardson Work Function.—E. N. Gribanov. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1356–1361.)

A brief description is given of a method in which use is made of Dushman's formula. This is followed by a more detailed discussion of another method which is based on measuring the "latent heat of electron evaporation," by the fall in temperature of the filament when electron current is drawn therefrom. The theory of the method is given and the circuit used for these experiments is described. The results obtained for a thoriated filament are shown in a table and it is stated that the average error of these measurements did not exceed 4%.

2192. Graphite Anodes in Split-Anode Magnetrons.—A. P. Maidanov. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 5, 1935, pp. 1563–1565.)

An account of experiments which have shown that magnetrons with graphite anodes are not less efficient than those with metallic anodes and are capable of much higher dissipation. This is of importance in the operation of magnetrons on ultra-short-waves, when high dissipation per unit of surface area of the anode is required.

2193. THE ACTION OF A SPLIT-ANODE MAGNETRON.—Gill and Britton. (*See* 2129.)

2194. DISTRIBUTION OF ELECTRON VELOCITIES IN A MAGNETIC FIELD [Curves of Anode Current as Function of Grid/Anode Voltage for Various Field Strengths].—Jonescu and Mihul. (*See* 2091.)

2195. SPHERICAL-ELECTRODE VALVES FOR MICRO-WAVE GENERATION.—Hayasi. (*See* 2123.)

2196. ON THE INITIAL CURRENT FLOWING THROUGH AN ELECTRONIC VALVE AT THE SUDDEN APPLICATION OF AN IMPULSE POTENTIAL.—G. Grünberg. (*Tech. Phys. of USSR*, No. 2, Vol. 3, 1936, pp. 101–110: in German.)

Application of the method dealt with in 1790 of May to the calculation of the initial current which flows through a plane-electrode diode, on the sudden action of an impulse voltage, during the time before the first electrons emerging from the cathode under the influence of the applied field (front or "head" electrons) have reached the anode, or (if this occurs first) until the electric field at the cathode disappears. For the case of an anode voltage not varying with time, the derived formula becomes simplified to eqn. 26; and the use of this equation is shown by a numerical example in section 3. Finally the case is considered when the valve forms a part only of a circuit to which an external e.m.f. is suddenly applied.

2197. VALVE MEASUREMENTS AT 60 Mc/s [Methods, and Data on Philips Valves].—Philips Company. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 46–47: summary only.)

2198. AN INTERFEROMETRIC METHOD OF MEASURING TEMPERATURES AND TEMPERATURE GRADIENTS VERY CLOSE TO A HOT SURFACE.—Ramdas and Paranjpe. (*Current Science*, Bangalore, March, 1936, Vol. 4, No. 9, pp. 642–644.)

2199. THE DISTRIBUTION OF TEMPERATURE IN A CYLINDRICAL CONDUCTOR ELECTRICALLY HEATED *in Vacuo*.—H. G. Baerwald. (*Phil. Mag.*, March, 1936, Vol. 21, No. 141, pp. 641–658.)

"It is shown that the transversal variations are negligible. A simple method is given for deriving the longitudinal temperature distribution directly from the empirical data of the emissivity, thermal and electrical conductivity functions. If the conductor can be regarded as 'infinite', for which a criterion is given, the dependence of the temperature gradient on temperature is given at once in terms of functions which are known for every metal for which measurements exist. This is of importance for the design of cooling devices for thermionic valves. The temperature distribution itself is obtained simply by integration. If the conductor is not 'infinite', the determination of a constant is necessary; it is shown, for different end conditions, how it can be obtained conveniently."

2200. CONTACT POTENTIAL MEASUREMENTS ON TUNGSTEN FILAMENTS [Effects of Variation of Temperature and of Amount of Thorium on Surface: Increase of Work Function with Rising Temperature for Thoriated Surfaces, Decrease for Pure Tungsten].—D. B. Langmuir. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, pp. 428–435.)

2201. AN ELECTRON MICROSCOPE FOR FILAMENTS: EMISSION AND ADSORPTION BY TUNGSTEN SINGLE CRYSTALS [Variation of Emission with Crystallographic Direction].—R. P. Johnson and W. Shockley. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, pp. 436–440.) The full paper, a summary of which was dealt with in 1023 of March.

2202. TESTS TO INSURE TUBE QUALITY [particularly Transmitting Valves].—H. F. Dart. (*Electronics*, February, 1936, Vol. 9, pp. 32–33.)

2203. GRID TEMPERATURE AS A LIMITING FACTOR IN VACUUM TUBE OPERATION [Method of determining Grid Dissipation at which Thermionic (Primary) Emission begins: Limits for Well-Known Valve Types: Effect of Gas: etc.].—I. E. Mouromtseff and H. N. Kozanowski. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 447–454.) "The described methods . . . may be of assistance to the manufacturer in checking and improving his manufacturing processes. The knowledge of the real physical limitation inherent in the grid may contribute to more clear-cut rating of tubes."

2204. TRANSMITTING PENTODES [Advantages and Characteristics: the Philips PC/1/50, PC/1.5/100 and PC/3/1000 for 50, 100 and 1000 Watts].—E. Leone: Philips Company. (*Alta Frequenza*, March, 1936, Vol. 5, No. 3, pp. 211–218.)

2205. THE 6F7 [R.F. Pentode and Triode with Common Cathode] AS OSCILLATOR-MIXER.—B. P. Hansen. (*QST*, April, 1936, Vol. 20, No. 4, p. 59.) With the coupling method shown the converter circuit is said to be the quietest and most stable the writer has encountered.

2206. NEW EDISWAN OUTPUT VALVE [Type ES 100: Output 30 Watts].—(*Wireless Engineer*, April, 1936, Vol. 13, No. 151, p. 200.)

2207. OSRAM VALVES FOR MICROPHONE AMPLIFIERS [Type MH 40: Very Low Microphony and High Electrode Insulation].—(*Wireless Engineer*, April, 1936, Vol. 13, No. 151, p. 199.)

2208. ELECTRON COUPLING [for Oscillators (including "Tritet" Connection), Wavemeters and Receivers: Survey].—R. Wigand. (*Radio, B., F. für Alle*, April, 1936, pp. 80–86.)

DIRECTIONAL WIRELESS

2209. Recent Developments in Marconi-Adcock Direction-Finding.—S. B. Smith and G. F. Hatch. (*Marconi Review*, Jan./Feb. 1936, No. 58, pp. 1–14.)

Daytime overland field intensity of an aircraft: sensitivity of Marconi-Adcock direction finders: selectivity: the need for very sensitive receivers associated with Adcock aerials (steady day-time 6 db gain of loop over Adcock, increases at night to over 34 db for periods of several minutes and to short-period values of 50 db); the Marconi-Adcock Type DFG.10 aerial system: night-time accuracy: comparative statistical accuracy of short- and medium-wave shielded "U" aerials: limiting accuracy due to site location: quadrature zero clearing: fineness of minima: quadrature "standbi" position: remote control: twin-channel Adcock d.fs: shielded radiogoniometers: etc.

2210. Radiogoniometric Deviations on board an Aeroplane.—Fromy. (*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 244–253.)

Conclusion of the work dealt with in 1813 of May. Experimental confirmation of the theoretical results is discussed: in general, very clear minima and often excellent zeros are obtained, indicating that the disturbing circuits met with in normal fuselages have resistances small compared with their reactances, so that the hypothesis made in the first part of the paper is justified. Larivière's curves of quadrantal error at various wavelengths, taken on Goliaths on the ground, are discussed. Figs. 11 and 12, taken on one and the same aeroplane, are of special interest, for they show that the usual effect of dissymmetry is to produce a displacement of the curve parallel to the ordinate axis, the displacement parallel to the abscissa being small, and also show the difference between the curves of error for an exterior shielded frame, above the disturbing circuits, and an interior unshielded one, in the midst of them.

Practical methods of compensation, derived from the above work, consist in first establishing a good electrical symmetry of fuselage and frame, so that the curve of error has an exact quadrantal form, and then either finding the exact spot in the plane of symmetry where the sum $m + n$ of the fundamental coefficients changes its sign, or establishing in the fuselage, near the frame, auxiliary circuits creating a disturbing field for which the sum $m + n$ is equal and opposite to that existing in its absence. Serra's tests have shown that such circuits may consist of a single frame perpendicular to the plane of symmetry, of two symmetrically placed frames parallel to the plane of symmetry, or of a metallic loop, inside the frame, parallel or perpendicular to the plane of symmetry.

2211. Antennas for Air Navigation [Table of U.S.A. Broadcasting Stations suitable for D.F., giving "Interference Rating" and Other Data].—D. G. Fink. (*Electronics*, February, 1936, Vol. 9, pp. 34–35 and 66.) "Stations with an interference rating higher than 40 should be used with caution", owing to the distortion of effective wave-front leading to directional errors; synchronised operation and shared-time operation are both dangerous.

2212. Considerations on the Removal of Ambiguity in Radiogoniometry [Principle of Equality of Action and Reaction explains Discrepancy between Theory and Practice in Frame/Vertical-Aerial Combinations].—M. H. Bellini. (*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 254–257.)

The behaviour of vertical aerials and frame aerials with regard to screens of different kinds, and to neighbouring conductors, seems at variance with theory, since the e.m.f. produced by an electromagnetic field in a frame or aerial should be calculable by considering, indifferently, the action either of the electric or the magnetic field. Explanation of this discrepancy by energy considerations leads to the conclusion that the problem of the removal of ambiguity will only be solved really effectively by the discovery of a directive and a non-directive aerial system both acted on exclusively either by the electric or by the magnetic field. If it were not for its defect of low receptivity, the Adcock aerial would no doubt immediately replace the frame.

2213. Patent claims that Television can Land an Aeroplane in Fog [Small Lamp representing Aeroplane moves over Map at Airport, controlled by Radio or Acoustic Direction Finder: Whole Picture transmitted to Pilot by Television].—Hays Hammond. (*Sci. News Letter*, 7th March, 1936, Vol. 29, p. 158.)

ACOUSTICS AND AUDIO-FREQUENCIES

2214. Editorial on "Acoustic Relief" [Stereophonic Broadcasting: Desirability of Experimental Combined Transmissions from Paris P.T.T. and Eiffel Tower].—P. Besson. (*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 205–207.)

2215. Loudspeaker Design [Analysis in Terms of Electrical Engineering: Choice of Diaphragm and Throat Area in Horn Loudspeakers: Voice-Coil Design (including Heat Generation): etc.].—F. Massa. (*Electronics*, February, 1936, Vol. 9, pp. 20–24.)

2216. A Two-Way Horn System [for Sound Films, but with Potential Applications to P.A. and Home Use: Power and Frequency Requirements of Sound Film Reproduction].—J. K. Hilliard. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 24–27.)

2217. An Analytical Treatment of the Horn/Diaphragm Coupling Chamber for [Telephone] Receiver Measurements [Formula for Acoustic Impedance at Diaphragm and Mechanical Impedance of Diaphragm].—C. K. Stedman. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 411: abstract only.)

2218. The Magnetic Recording of Sound [particularly the Lorenz Company's Steel-Band Recorders as used in Germany for Outdoor Broadcasts].—G. W. O. H. (*Wireless Engineer*, April, 1936, Vol. 13, No. 151, pp. 175–178: Editorial on a *Lorenz Berichte* paper.)

2219. A New Sound Recorder, the "Magnetophone."—AEG. (*Bull. Assoc. suisse des Élec.*, No. 3, Vol. 27, 1936, pp. 84–85: in German.) *See* also 196 & 197 of January and 1831 of May.

2220. Phonographic Recording by Engraving on Film [Philips-Miller System].—M. Adam. (*Génie Civil*, 21st March, 1936, Vol. 108, p. 284.) *See* also 602 of February: and *cf.* Huguenard, 1932 Abstracts, p. 646.

2221. New German Dictating Phonograph uses Discs [of Gelatin Compound].—(*Sci. News Letter*, 7th March, 1936, Vol. 29, p. 152.)

2222. On the Reduced Equation of an Oscillating Diaphragm.—S. M. Rzhevkin. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1440–1453.)

The study of forced oscillations of a circular diaphragm is greatly simplified if the equation of the oscillations is reduced to that for an equivalent diaphragm with lumped constants. Methods are indicated for deriving this equation and certain incorrect assumptions in the 1917 studies by Hahnemann and Hecht are pointed out.

2223. The Transverse Vibration of a Square Plate clamped at Four Edges [Theoretical Values of Vibration Frequencies].—S. Tomotika. (*Phil. Mag.*, April, 1936, Series 7, Vol. 21, No. 142, pp. 745–760.)

2224. On the Radiation Resistance of Acoustic Radiators.—G. A. Ostroumov. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 5, 1935, pp. 1801–1808.)

It is customary to represent the radiation resistance of an acoustic radiator by an equivalent electrical circuit with series-connected components, the values of which depend on the radiating frequency. It is shown in this paper that if an equivalent electrical circuit is derived in which the components are connected in parallel, their values are much less dependent on the frequency, and in the case of the spherical radiator of zero order are completely independent of it. This simplification is of great advantage in studying complex systems containing acoustic radiators. Methods are also indicated for calculating the components of the parallel circuit for the cases of a spherical radiator of the first order (oscillating sphere) and of a piston radiator. Tables are given in order to simplify the necessary calculations.

2225. Propagation and Resonance of Composite Waves in Prismatic Rods [Cubic Equation for Frequency].—R. Ruedy. (*Canadian Journ. of Res.*, March, 1936, Vol. 14, No. 3, Sec. A, pp. 66–70.)

2226. Electrically Produced Music [Phenomena shown by Ethonium].—G. G. Blake. (*Nature*, 4th April, 1936, Vol. 137, p. 588: abstract of recent lecture.)

2227. Photophone uses Ultra-Violet [for Sound-on-Film Recording: Superior Definition on Higher Frequencies].—Dimmick. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 7–8.)

2228. Measurements of Noise on Broadcast Programme Circuits [Special Apparatus].—R. S. Tucker. (*Bell Lab. Record*, March, 1936, Vol. 14, No. 7, pp. 233–236.)

2229. Theory and Application [*e.g.* in Machine Design] of the Frequency Analysis of Noise.—V. Kazanski. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 5, 1935, pp. 1535–1544.)

2230. The Basic Causes of the Noises of Electrical Machinery [Mechanical, Air-Flow and Magnetic].—V. G. Springman. (*Elektritchestvo*, No. 4, 1936, pp. 1–9: in Russian.)

2231. The Acoustical Design of Broadcasting Studios [Results of B.B.C. Experience and Research: Reverberation Time and Its Frequency Dependence the Most Important but Not the Only Factor: Curved Contour undesirable for Ceilings: Accuracy of Millington's Formula: Acoustical "Expedients" (Corrugations, Non-Rectangular Plan, "Mixed Acoustics"): etc.].—H. L. Kirke and A. B. Howe. (*Journ. I.E.E.*, April, 1936, Vol. 78, No. 472, pp. 404–423: Discussion pp. 423–431.)

2232. Relations between the Non-Linear Distortion of Amplitude Regulators and the Regulation Requirements.—E. Hölzler. (*E.N.T.*, February, 1936, Vol. 13, No. 2, pp. 29–36.)

§ 1 describes the general principles underlying the use of regulators. Two groups with non-linear characteristics are distinguished: (1) those whose attenuation or amplification is controlled by the arithmetic mean of the acting forces, *e.g.* an exponential valve, and (2) those in which control depends on temperature effect. The distortions are characterised by the "klirr" factor. § 2 gives the theory of the inertialess systems (1). The non-linear equation to the characteristic of the system is developed in a Taylor series; the "klirr" factors corresponding to the harmonics are calculated (eqn. 2). This enables the characteristic giving the widest regulation range to be calculated (Fig. 3) so that the largest "klirr" factor does not exceed the permissible value. Examples are given of the variation of non-linearity with the regulation required. § 3 deals with the theory of resistances with a relatively large temperature coefficient, starting from the equation expressing the thermal equilibrium. Expressions for the "klirr" factors are found (eqn. 9). The special cases of small output and use with pure alternating current are considered, with numerical examples.

2233. Class B and AB Audio Amplifiers [Hints on Transformer Design: Approximate Determination of Load Resistance, Power Output, Distortion: etc.].—G. Koehler. (*Electronics*, February, 1936, Vol. 9, pp. 14–16.)

2234. AN ANALYSIS OF DISTORTION IN CLASS B AUDIO AMPLIFIERS.—McLean. (*See* 2137.)

2235. DUPLEX TELEPHONE AMPLIFIER EMPLOYING THE PHENOMENON OF PERSISTENCE OF HEARING [Commutation at 25–35 p/s allows Speech both Ways on One-Way Circuit].—M. Marro. (*Rev. Gén. de l'Élec.*, 28th March, 1936, Vol. 39, No. 13, pp. 458–461.)

2236. A NOTE ON A NEW DESIGN OF TRANSFORMER [for Coupling a Balanced with an Unbalanced Circuit].—F. M. G. Murphy and C. D. Colchester. (*Marconi Review*, Jan./Feb. 1936, No. 58, pp. 26–29.)

The input transformer of an amplifier with single-valve stages interposed between parts of a balanced line is called upon to couple a balanced circuit to the grid of a valve and bias (or earth): *i.e.* to an unbalanced circuit. " Hitherto this has been accomplished with either some appreciable effect on the line balance or by means of costly transformer constructions. It is the purpose of the present design [line winding of 2 similar parts wound or assembled in opposition, and special screening arrangements] to provide a simple means of accomplishing this coupling and at the same time a wide frequency band throughout which the coupling is uniformly efficient." A modified design is included for the case of low-impedance unbalanced circuits, *e.g.* for coupling an incompletely balanced microphone to the cable leading to its amplifier.

2237. A THEORY OF SHIELDING [of Carrier Telephony Lines: Interference and Shielding Effects in terms of Impedance Characteristics of Radial Transmission Line].—S. A. Schelkunoff. (*Bell Lab. Record*, March, 1936, Vol. 14, No. 7, pp. 229–232.) Mougey's experiments show very close agreement with the results of the theory.

2238. NEW METHODS FOR MEASUREMENT OF THE ABSORPTION OF SOUND AT OBLIQUE ANGLES OF INCIDENCE.—L. Cremer. (*E.N.T.*, February, 1936, Vol. 13, No. 2, pp. 36–47: abstract only in *Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 568–569.)

For previous work *see* 1933 Abstracts, p. 571. Here work is described in which a large sheet of the absorbing substance under investigation was placed in the acoustic field of a spherical emitter at a distance of 5 m in the open air, at the desired angle of incidence. Fig. 1 shows the paths of the rays. A pressure-gradient receiver was used to measure the maxima and minima of the standing wave system (§ 3, Fig. 3) and also, by making use of its directional properties, to measure the incident and reflected waves separately (§ 4, Figs. 5, 6) and obtain the amount of absorption by comparison. The angular position of the receiver for minimum pick-up also gave a measure of the absorption (§ 5, Figs. 7, 8). The results obtained by the different methods for the same material and frequency are compared (§ 6). Simplifications of the apparatus for technical measurements are described (§ 7; wind-screen, Fig. 10), with the modifications for use in rooms.

2239. AN ELECTRODYNAMIC INSTRUMENT FOR THE MEASUREMENT OF THE MECHANICAL IMPEDANCES OF MATERIALS FOR STOPPING SOUND TRANSMISSION THROUGH SOLID BODIES, ESPECIALLY UNDER CONDITIONS OF STRESS [Improved Vibrometer for Measurements on Cork, Rubber, " Funda ", Composite Materials, etc.: Results and Conclusions].—C. Costadoni. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, pp. 108–115.)

2240. CORRECTION TO " A DIRECT-READING FREQUENCY METER OF WIDE RANGE."—Keller. (*Bull. Assoc. suisse des Élec.*, No. 3, Vol. 27, 1936, p. 86.) *See* 1071 of March.

2241. SEARCH-TONE PROCESS FOR NOISE ANALYSIS.—K. Schoeps. (*Naturwiss.*, 27th March, 1936, Vol. 24, No. 13, pp. 202–203.)

The Fourier components of the noise are indicated by the summational combination tone frequencies in the product of exploring-note voltage and noise voltage, using a quartz resonator at the upper limit of the frequency range under investigation. " The whole noise spectrum can be analysed with one simple quadratic rectifier."

2242. THE INVESTIGATION OF SOUND SPECTRA: APPARATUS FOR ELECTROACOUSTICAL ENGINEERS AND MUSICIANS.—P. E. Klein. (*Funktech. Monatshefte*, March, 1936, No. 3, pp. 101–106.)

2243. " THE ACOUSTIC DIFFRACTION GRATING AND ITS USE FOR SOUND SPECTROSCOPY " [Book Review].—E. Thienhaus. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, p. 139.) For papers on this method *see* 630 of February.

2244. A SENSITIVE AUDIO-FREQUENCY NULL INDICATOR [Rectifier-Type Microammeter with Transformer Coupling to Amplifier Output].—N. I. Adams, Jr. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, pp. 180–181.)

2245. A LOW-LEVEL WATTMETER [Valve-Aided Electrostatic Milliwattmeter for Direct Measurement over Very Wide Frequency Range].—A. L. Albert and H. P. Beckendorf. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 28–29.)

2246. SHOCK WAVES AND CONTINUOUS WAVES IN CERTAIN GASES [Fundamental Equations].—E. Jouguet. (*Comptes Rendus*, 9th March, 1936, Vol. 202, No. 10, pp. 796–799.)

2247. SOUND PROPAGATION [in Mixtures: Theory of].—D. A. Bourgin. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 411: abstract only.)

2248. THE DEBYE-SEARS DIFFRACTION PHENOMENON AND THE BALANCE OF ENERGY IN THE PRODUCTION OF SUPERSONIC WAVES [with Optical Method of Measurement].—H. E. R. Becker. (*Ann. der Physik*, Series 5, No. 4, Vol. 25, 1936, pp. 373–384.) *See* Debye, 1933 Abstracts, p. 167.

2249. MODULATION OF LIGHT BY SUPERSONIC WAVES.—Kharizomenov. (*See* 2302.)

2250. Diffraction of Light at Supersonic Waves [in Liquid and in Quartz: Transition from Diffraction at Two-Dimensional to Selective Reflection at Three-Dimensional Lattice, as Wavelength is Decreased].—S. M. Rytov. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 8, 1935, pp. 626–643: in German.)

2251. [Experimental Confirmation of] the Existence of Diffusion of Supersonic Waves in Liquids.—P. Biquard. (*Comptes Rendus*, 13th Jan. 1936, Vol. 202, No. 2, pp. 117–119.) *See* also Lucas, 645 of February.

2252. Theory of Diffraction of Light by Progressive Supersonic Waves.—E. Hiedemann and E. Schreuer. (*Zeitschr. f. Physik*, No. 5/6, Vol. 99, 1936, pp. 363–368.)

2253. Optical Diffraction Phenomena with Oscillating Glass [Analysis of Effects due to Longitudinal and Transverse Vibrations]: Argument.—E. Hiedemann and K. H. Hoesch: C. Schaefer and L. Bergmann. (*Naturwiss.*, 11th Oct. and 22nd Nov. 1935, 24th Jan. 1936: pp. 705, 799, and 60, 61.)

2254. The Diffraction of Light by Supersonic Waves [Raman and Nath's Hypothesis not valid under Usual Experimental Conditions].—R. Lucas. (*Comptes Rendus*, 30th March, 1936, Vol. 202, No. 13, pp. 1165–1166.)

2255. [Experimental] Proof of the Frequency Change of Light by Doppler Effect in the Diffraction of Light by Supersonic Waves in Liquids, *and* Frequency Changes of Light in Diffraction by Supersonic Waves [Theoretical].—L. Ali: F. Levi. (*Helvetica Phys. Acta*, Fasc. 2, Vol. 9, 1936, pp. 63–83: Fasc. 3, pp. 234–244: both in German.)

2256. Measurements of Sound Insulating Properties at Supersonic Frequencies: Refutal of Criticism.—Malov and Rschevkin: Rodewald. (*Tech. Phys. of USSR*, No. 4, Vol. 2, 1935, pp. 369–370: in German.) For the work criticised *see* 1933 Abstracts, p. 44, r-h column.

2257. The Production of Acoustic Waves with Piezoelectric Quartz Crystals [Circuits: Frequency Response Curve].—A. de Gramont and D. Beretzki. (*Comptes Rendus*, 6th April, 1936, Vol. 202, No. 14, pp. 1229–1232.)

2258. Supersonic Oscillations and Their Application [Construction of Compound Oscillators, and Their Spectrum: Investigation with Help of Rochelle-Salt "Indicator": Detection of Heterogeneities (Cracks, Flaws, etc.) in Metal Parts and Samples: Propagation through Wires (Theoretical Range 10 000 km for 1 Watt)].—S. Sokolov. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 522–544: in English.)

2259. The Acoustic Air-Jet Generator: a Means for the Production of Sound and Supersonic Waves of Very Great Intensity in Air.—Hartmann. (*Journ. de Phys. et le Radium*, February, 1936, Vol. 7, No. 2, pp. 49–57.) For a preliminary note *see* 1074 of March.

2260. Supersonic Waves in the Service of Deep Sea Fisheries [and the Debeg "Radiolot" Sounder with Quenched-Spark Drive].—(*Radio, B., F. für Alle*, April, 1936, pp. 74–76.) *See* also Mainka, *Funktech. Monatshefte*, April, 1936, pp. 143–147.

2261. The Echo Sounding Equipment of the Zeppelin "LZ 129" ["Hindenburg"].—Hilligardt. (*E.T.Z.*, 26th March, 1936, Vol. 57, No. 13, pp. 361–362.)

2262. The Law of Blackening of Photographic Plates by Supersonic Waves [Identical Photochemical Action of Light and Supersonic Waves].—N. Marinesco. (*Comptes Rendus*, 2nd March, 1936, Vol. 202, No. 9, pp. 757–759.) For previous work *see* 1940 of 1935.

2263. The Influence of Supersonic Waves on Chemical Reactions [Colloidal Particles may be Coagulated *or* Dispersed: Inversion of Cane Sugar, only in presence of a Catalyst: etc.].—S. Sokolov. (*Tech. Phys. of USSR*, No. 2, Vol. 3, 1936, pp. 176–182: in French.)

2264. Sound-Absorption in Liquids at Supersonic Frequencies [Temperature-Rise Measurements: Dependence not on Viscosities but on Special Characteristics: Maxima and Minima at Definite Frequencies, etc.].—H. Oyama. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 985–989: English summary pp. 124–125.)

2265. Temperature Variation of the Absorption of Supersonic Waves by Liquids [Measurements agree with Theory].—E. Baumgardt. (*Comptes Rendus*, 20th Jan. 1936, Vol. 202, No. 3, pp. 203–204.)

PHOTOTELEGRAPHY AND TELEVISION

2266. On the Mode of Action of the Electron Multiplier: I.—W. Henneberg, R. Orthuber and E. Steudel: Farnsworth. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, pp. 115–120.)

Authors' summary:—For the elucidation of the mode of action of the Farnsworth electron multiplier a simple model is considered consisting of two plates, opposite one another, with an alternating potential between them; the motion of electrons in this model is investigated, their initial velocities being neglected. If the gap between the plates is chosen (after Farnsworth) so that the "phase-pure" electrons [*i.e.* those liberated at the instant when the alternating field passes through zero] reach the other plate in a half-period of oscillation, it is found that the electrons emerging later, up to a 65° phase difference, also come gradually into phase and thus take part in the multiplying process. If the multiplier is de-tuned in the direction of higher frequencies or smaller amplitudes, the zone of the electrons continuously taking part in the multiplying process, originally extending from 0° to 65°, becomes narrower and narrower, till for a de-tuning of $(\omega - \omega_r)/\omega_r = 8.9\%$ or $(E_0 - E_{0r})/E_{0r} = - 15\%$, it is halved, and with further de-tuning disappears. With a de-tuning towards lower frequencies or larger amplitudes, the electrons no longer come into phase.

2267. On the Preliminary Experimental Results regarding the "Magnetic Electron Multiplier" of A.C. Type.—K. Okabe. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, p. 83: letter, Japanese only, with diagrams.)

2268. Dr. Zworykin on the Electron Multiplier [Report of I.E.E. Lecture].—Zworykin. (*Television*, March, 1936, Vol. 9, No. 97, pp. 153–154 and 191.)

2269. New Type of Electron-Optical System: Dr. Zworykin's Lecture to the German Society for Technical Physics [Secondary Emission Electron Multiplier: Electron Telescope and Microscope].—Zworykin. (*Funktech. Monatshefte*, March, 1936, No. 3, pp. 115–116.) A critical report of the lecture and demonstration.

2270. Electron-Optics and Electron Multipliers.—Zworykin. (*Génie Civil*, 28th March, 1936, Vol. 108, pp. 311–312: summary of paper to Société des Radioélectriciens.)

2271. Other Papers on Electron Multipliers and Secondary Emission.—(*See* under "Valves and Thermionics.")

2272. New Italian Television Scanner ["Telepantoscope" Cathode-Ray Device].—A. Castellani. (*Electronics*, March, 1936, Vol. 9, No. 3, p. 46.) Picture and caption of the device dealt with in 1087 of March.

2273. Experiences with a Cathode-Ray Scanner on 120 Lines.—J. H. Reyner. (*Journ. of Television Soc.*, December, 1935, Vol. 2, Part 3, pp. 62–67.) *See* also 1086 of March.

2274. A New Method of Interlaced Scanning [avoiding the Odd Half-Line and Its Consequent Complications: Time-Base Circuit of Electrical Research Products Inc.].—L. S. Kaysie. (*Television*, March, 1936, Vol. 9, No. 97, pp. 161–162.) By switching out the biasing battery the receiving circuit is ready for ordinary "straight" scanning.

2275. Addendum to "The Importance of the Choice of Suitable Fluorescent Material for Television Scanning with the Cathode-Ray-Light-Scanner."—Schnabel: von Ardenne. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, p. 139.)

Schnabel's suggestion that the decay rate is different for different parts of the spectrum (1503 of April) had already been proved by von Ardenne's measurements (1947 of 1935) and to some extent by Lenard's researches.

2276. Fluorescent Screens for Cathode-Ray Tubes.—Levy and West. (*Television*, April, 1936, Vol. 9, No. 98, pp. 241–243 and 250, 252.) Very full summary of the I.E.E. paper referred to in 1870 of May.

2277. A New Glow-Discharge Phenomenon and Its Possible Application to Cathode-Ray Tubes with Low Cathode Voltages.—W. Krug. (*E.T.Z.*, 16th April, 1936, Vol. 57, No. 16, p. 444: summary only.) *See* 3552 of 1935.

2278. The Ediswan Cathode-Ray Tube for Television [Type CH].—Edison Swan Company. (*Television*, March, 1936, Vol. 9, No. 97, p. 144.)

2279. An Experimental Television Receiver using a Cathode-Ray Tube [primarily for Berlin Transmissions].—M. von Ardenne. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 409–424.) *See* 1946 of 1935 for German paper covering much the same ground.

2280. Researches on Relaxation Oscillation Circuits used for the Synchronisation of Television Images [particularly the Kallirotron and Negadyne Circuits].—F. Ring. (*Ann. des Postes T. et T.*, February, 1936, Vol. 25, No. 2, pp. 199–201.) Long French summary of the German paper dealt with in 3135 of 1935.

2281. Note on the Sense and Form of the Synchronising Signal in Television [Advantages of *Increase* of Aerial Current for "Blacks" and Synchronising Signals].—R. Barthélémy. (*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 240–244.)

"Germany and America (and, following in their footsteps, London) *decrease* the signal to produce both 'blacks' and synchronising pulse." The writer's system does just the opposite; he attributes the difference to the fact that he considers above all the simplicity at the receiver, whereas the others are more concerned with convenience at the transmitter. His viewpoint seems recently to be approved by the Americans, for recent R.C.A. tests have employed "negative transmission." With "positive" transmission the line-synchronising signal is produced by 100% modulation of the carrier, *i.e.* by annulling the aerial current. Theoretically, the signal is rectangular and lasts 5/100ths the duration of the line: in reality it is distinctly rounded and is tangential to the axis of time. From what is known of the essential organ of synchronisation, the thyratron, in the receiver, serious difficulties are to be expected in obtaining a precise action; which perhaps explains the inclination, abroad, to neglect the thyratron in favour of a group of 3 or 4 valves.

With "negative" transmission as used by the writer, the greatest possible precision of action is obtained by making the synchronising signal very short (1/100th of line) and pointed, and in order that this pointed signal may be transmitted perfectly, with maximum energy, it (together with the "blacks") is produced by an increase of aerial current. At the receiver, this means added reliability (at the moment of synchronisation the energy in the aerial is almost quadrupled): the image is synchronised before it becomes visible, which is impossible with the rival system: separation of the synchronising signal from the rest of the modulation is greatly simplified: the accuracy of action at the thyratron is at worst equal to the duration of the voltage "point," which is of the order of an image point, so that the thyratron is controlled practically rigidly and its degree of liberty cannot influence the quality of the image: protection against parasites is greatly increased both by the high energy level of the pulse and by its short duration: and, finally, at the detector output the control electrode of the cathode-ray tube can be modulated directly to give a positive image, so that it is possible to apply to this electrode the d.c. component to create ("in the future") the "background shade" without any additional device.

Possible objections from the transmitting point of view are discussed briefly and dismissed. Finally, "the only reproach which can be addressed to us is that a receiver imported from Berlin or London cannot, without modification, work in Paris; but will the French manufacturers complain of this?"

2282. MARCONI-E.M.I. TELEVISION EQUIPMENT FOR THE ALEXANDRA PALACE.—(*Journ. of Television Soc.*, December, 1935, Vol. 2, Part 3, pp. 75–81.) *Cf.* 1513 of April.

2283. THE FIRST COMPLETE DETAILS OF THE MARCONI-E.M.I. TELEVISION SYSTEM FOR THE ALEXANDRA PALACE.—(*Television*, March, 1936, Vol. 9, No. 97, pp. 132–136 and 192.)

2284. THE G.E.C. AND TELEVISION [Some Notes on Work at Wembley].—(*Television*, April, 1936, Vol. 9, No. 98, pp. 227–228.)

2285. SCOPHONY TELEVISION: DETAILS OF A HIGH-DEFINITION SYSTEM DEVELOPED IN ENGLAND: THE "SPLIT-FOCUS" OPTICAL ARRANGEMENT, AND A DOUBLE-IMAGE KERR CELL.—(*Electronics*, March, 1936, Vol. 9, No. 3, pp. 30–33.)

2286. MECHANICAL FILM TRANSMISSION: A DISCUSSION OF ITS POSSIBILITIES WITH WELL-KNOWN SYSTEMS, *and* THE SCOPHONY SYSTEM: AN ANALYSIS OF ITS POSSIBILITIES.—L. M. Myers. (*Television*, March, 1936, Vol. 9, No. 97, pp. 145–147: April, 1936, Vol. 9, No. 98, pp. 201–204.) With comments (on p. 204) by the Scophony Company.

2287. NEW DEVELOPMENTS IN TELEVISION RECEIVERS [Two German Sight-Sound Receivers].—Telefunken: Lorenz. (*Electronics*, February, 1936, Vol. 9, pp. 46 and 48.) Summary of an article by Roosenstein (for an English version *see* 1516 of April) followed by the translation of a descriptive folder issued by the Lorenz Company.

2288. PHONE AND TELEVISION: A DEMONSTRATION IN LONDON [Booking Cinema Seats at Selfridge's].—(*Television*, April, 1936, Vol. 9, No. 98, pp. 205–206.)

2289. THE BERLIN/LEIPZIG TELEVISION-TELEPHONE SERVICE OPENED.—(*Funktech. Monatshefte*, March, 1936, No. 3, Supp. pp. 17–19.) *See* also 1873 of May.

2290. WIRED TELEVISION [and Its Possibilities].—F. Ring. (*Funktech. Monatshefte*, March, 1936, No. 3, Supp. pp. 19–20.) From the German P.O. Discussion of the possible application to television of the methods tested in Berlin for sound broadcasting—*see* 2872 of 1935.

2291. TRANSMISSION AT VERY HIGH FREQUENCIES OVER TELEPHONE CIRCUITS IN CABLE. PART I—THEORETICAL FOUNDATIONS [of Screened Pairs and Coaxial Cables, up to 4 Mc/s and over] AND EXPERIMENTAL DATA [American, German and French].—S. Treves. (*Alta Frequenza*, March, 1936, Vol. 5, No. 3, pp. 147–179.)

2292. THE NEW BERLIN TELEVISION TRANSMITTER.—(*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 258–260.)

2293. TELEVISION AT THE BERLIN RADIO EXHIBITION.—E. H. Traub. (*Journ. of Television Soc.*, December, 1935, Vol. 2, Part 3, pp. 53–61.) Report, with Discussion, of lecture to the Society.

2294. TWENTY FIVE YEARS' CHANGE IN TELEVISION.—J. C. Wilson. (*Journ. of Television Soc.*, December, 1935, Vol. 2, Part 3, pp. 86–93: with references and table of early disclosures.)

2295. TELEVISION ABROAD: A YEAR'S PROGRESS.—(*World-Radio*, 27th March and 3rd April, 1936, Vol. 22, pp. 8, 10, and 9, 11.)

2296. FOG LANDING OF AIRCRAFT BY TELEVISION.—Hays Hammond. (*See* 2213.)

2297. SINGLE *versus* MULTI-SPIRAL DISCS FOR TELEVISION SCANNING.—E. B. Kurtz. (*Journ. of Television Soc.*, December, 1935, Vol. 2, Part 3, pp. 94–95.)

2298. VALVE COUPLINGS FOR TELEVISION FREQUENCIES: DETAILS OF A NEW METHOD ["Filter Coupling"].—J. Beardsall. (*Television*, February, 1936, Vol. 9, No. 96, pp. 95–97.)

2299. THE DESIGN OF HIGH-DEFINITION AMPLIFIERS.—Walker. (*Television*, March, 1936, Vol. 9, No. 97, pp. 151–152 and 171.) Contd. from 1103 of March.

2300. THE TELEPHOTOGRAPH LINE [Specially Equalised Telephone Line required for Rapid Working on "Western Electric" Telephotograph System, using Carrier Transmission by Single Sideband] *and* DELAY EQUALISERS FOR TELEPHOTOGRAPH TRANSMISSION.—P. Mertz: F. A. Hinshaw. (*Bell Lab. Record*, February, 1936, Vol. 14, No. 6, pp. 178–184: 193–197.)

2301. PHOTOGRAPHS BY TELEPHONE [Wide-World Photos (Cooley) System].—Cooley. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 5, 6 and 7.)

2302. Modulation of Light by Supersonic Waves.—V. K. Kharizomenov. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1518–1520.)

The method is based on passing a beam of light through a dispersing liquid in which a quartz crystal is oscillating at a supersonic frequency. If a modulating frequency is superimposed on the oscillations of the crystal, the intensity of the beam will vary in accordance with this frequency. Experiments have shown that this method presents certain advantages over the use of a Kerr cell.

2303. Kerr Effect and Molecular Association in the Benzol Derivatives.—Dallaporta and Dascola. (*Nuovo Cimento*, January, 1936, Vol. 13, No. 1, pp. 1–10.)

2304. Magneto-Rotation for Rapid Field Changes [up to 3 Mc/s by Experiment: Theoretical Investigation of Higher Frequencies: Allison's "Time Lag" of Faraday Effect].—E. Bretscher. (*Helvetica Phys. Acta, Fasc.* 1, Vol. 9, 1936, pp. 42–62.)

The conclusion is that the amount of rotation is actually affected by the field frequency, but only when this is extremely high: for caesium vapour the field would have to be produced by oscillations of about 75 cm wavelength. Allison's phenomena (1934 Abstracts, p. 633, last item), interpreted as due to time lag, must certainly be attributed to other causes.

2305. On the Nature of the Barrier Layer in Selenium Photocells.—S. I. Freiwert. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 5, 1935, pp. 1847.)

A preliminary account of experiments which have shown that when a photocell is placed in a vacuum its sensitivity decreases and is not restored after the removal of the cell from the vacuum. This leads the author to suppose that the barrier layer is made up either from SeO_2 or from a layer of gas between the selenium and the semi-transparent anode.

2306. Data Curves on G.E. Barrier-Layer Photocells [Selenium-Platinum].—General Electric Company. (*Electronics*, March, 1936, Vol. 9, No. 3, p. 42.) An output of about one-twentieth of a watt per square foot in direct sunlight can be obtained.

2307. On the Nature of the Barrier Layer in the Cuprous Oxide Photovoltaic Cell. II.—J. W. Ballard and E. Hutchisson. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 410: abstract only.) For I *see* 2747 of 1935.

2308. A Copper Sulphide Photocell [Amount of Sulphur forming Sulphide controlled by Molecular Beam].—J. J. Brady and W. F. Sprengnether. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 420: abstract only.)

2309. The Glow-Discharge Amplifier and Its Use for the Amplification of Photo-currents.—Weber. (*See* 2475.)

2310. Sensitivity of Photon Counters [with Distilled Mg Surface].—S. W. Barnes and L. A. DuBridge. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 409: abstract only.)

2311. The Geiger-Müller Photon Counter—Quantitative Aspects, Detection of Small Intensities, Use in Absorption Spectroscopy.—W. D. Claus and A. Hollaender. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, pp. 409–410: abstract only.)

2312. The Cooling of a Surface due to Photo-electric Emission [Measured Value of Energy Loss per Electron].—H. M. Zenor. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 421.) *Cf.* 2191.

2313. The Theory of the Surface Photo-electric Effect in Metals—II [Calculation of Spectral Distribution Curves shows Selective Maxima and Polarisation Selectivity: Energy Distribution Curves: Agreement with Experiment for Alkali Metals: Velocity Distribution Curves].—K. Mitchell. (*Proc. Roy. Soc.*, Series A, 1st Feb. 1936, Vol. 153, No. 880, pp. 513–533.) For I *see* 230 of 1935: for other work (temperature dependence) 3989 of 1935.

2314. The Mobility of Potassium on Tungsten [Diffusion Measurements: Activation Energy].—R. C. L. Bosworth. (*Proc. Roy. Soc.*, Series A, 2nd March, 1936, Vol. 154, No. 881, pp. 112–123.) For previous work on sodium *see* 2752 of 1935.

2315. Photoelectric Properties of Sodium Films on Aluminium [Maximum Sensitivity with Film Thickness of 100 Molecular Layers: Work Function the Same for All Film Thicknesses].—J. J. Brady and V. P. Jacobsmeyer. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 410: abstract only.)

2316. Photoelectric Effect of Aluminium Films evaporated in Vacuum [Threshold Value 2830 Å: Selective Maximum 2700 Å: Gases emitted by Vacuum-Producing Charcoal influence Position and Inclination of Sensitivity Curves].—E. Gaviola and J. Strong. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, pp. 441–443.)

2317. Contribution to Knowledge of the Primary Photoelectric Current in NaCl Crystals.—W. Thiele. (*Ann. der Physik*, Series 5, No. 6, Vol. 25, 1936, pp. 561–568.)

Former experiments (Gudden & Pohl, 1925; Gyulai, 1925) are repeated and extended, using rock-salt with colour centres produced by the thermal diffusion method. The previous results are confirmed. No connection is found between excitation and polarisation of the centres.

2318. Photoelectric Activity of Iron and Its Oxides [Insensitivity of Fe_2O_3: for Iron, Gas Absorption rather than Instantaneous Oxidation is Initial Change of Clean Metal Surface in Air].—J. S. Hunter. (*Nature*, 14th March, 1936, Vol. 137, p. 460.)

2319. Fowler's Photoelectric Theory, assuming Quantum Absorption Probability a Function of Electronic Energy.—A. T. Waterman. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 410: abstract only.)

2320. "New Theories of the Photoelectric Effect" [Book Review].—L. A. Du Bridge. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, p. 165.)

MEASUREMENTS AND STANDARDS

2321. Piezoelectric Forces of Attraction [and Their Practical Application in the Construction of an Electrical Relay: Measurement of Attractive Force due to Piezoelectric Charges: Necessity of considering These Forces in the Construction of Crystal Holders].—J. Gruetzmacher. (*Arch. f. Elektrot.*, 18th Feb. 1936, Vol. 30, No. 2, pp. 122–126.)

2322. Variation with Temperature of the Piezoelectric Effect in Quartz [with Graph of Piezoelectric Activity between 4° K and 813° K: Sudden Decrease at about 5° K].—A. Pitt and D. W. R. McKinley. (*Canadian Journ. of Res.*, March, 1936, Vol. 14, No. 3, Sec. A, pp. 57–65.)

2323. On the Variation of the Piezoelectric Modulus of Quartz as a Function of the Temperature [Avoidance of Causes of Error gives Linear Variation: 10% Drop between 20° and 200°].—A. Langevin. (*Journ. de Phys. et le Radium*, February, 1936, Vol. 7, No. 2, pp. 95–100.) Previous workers had found that the modulus was independent of temperature, that it increased up to 60° and then decreased, and so on.

2324. Notes on Piezoelectric Quartz Crystals [particularly of Zero Temperature Coefficient, for Short-Wave Transmitters], *and* Young's Modulus of a Crystal in Any Direction.—Koga. (*See* 2139 and 2140.)

2325. Development of Electricity by Torsion in Quartz Crystals.—Tsi-Zé and Ling-Chao. (*Chinese Journ. of Phys.*, No. 3, Vol. 1, 1935, pp. 41–53: in English.) For *Comptes Rendus* Notes *see* 1578 and 2027 of 1935.

2326. A Piezoelectric Chronograph [using Changes in Optical Properties of Vibrating Quartz Crystal: Very Small Subdivisions of a Second recorded on Moving Film].—E. P. Tawil. (*Comptes Rendus*, 23rd March, 1936, Vol. 202, No. 12, pp. 1016–1017.)

2327. The Variation of the Adiabatic Elastic Moduli of Rock Salt with Temperature between 80° K and 270° K [Piezoelectric Method of Measurement of All Elastic Moduli of Solid Crystal at Temperatures below 0° C].—F. C. Rose. (*Phys. Review*, 1st Jan. 1936, Series 2, Vol. 49, No. 1, pp. 50–54.)

2328. A Theory of an Ultra-Short-Wave Wavemeter with an Auxiliary Coil.—H. Ataka. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, pp. 1040–1041: Japanese only.) For this wavemeter *see* 1169 of 1935.

2329. An Electron-Coupled Frequency Meter [1.5–30 Mc/s].—A. C. Weston. (*Television*, April, 1936, Vol. 9, No. 98, pp. 213–214.)

2330. A Thyratron Stroboscope suitable for Frequency Measurement [demanding only 0.6 VA from Standard-Frequency Source].—R. S. J. Spilsbury. (*Electrician*, 10th April, 1936, Vol. 116, p. 484: summary of I.E.E. paper.)

2331. On the Force between Two Coaxial Single Layer Helices carrying Current [Method of Calculation: Mean Correction for Spirality].—R. Glazebrook and H. M. Lyon. (*Proc. Roy. Soc.*, Series A, 2nd March, 1936, Vol. 154, No. 881, pp. 1–3: abstract only.)

2332. Voltage Measurements at Very High Frequencies—II (Concluded).—Megaw. (*Wireless Engineer*, April, 1936, Vol. 13, No. 151, pp. 201–204.) *See* 1898 of May: comparison of peak voltmeter with a thermal method of measuring: calibration of other valve voltmeters against peak voltmeter.

2333. Valve Voltmeter [for Frequencies 30 c/s to 10 Mc/s: Mains Driven].—Everett, Edgcumbe Company. (*Journ. Scient. Instr.*, April, 1936, Vol. 13, No. 4, pp. 132–134.)

2334. Double-Element Recording Voltmeter [13 Ranges, 2.2 mV–5 V].—Tinsley Company. (*Journ. Scient. Instr.*, April, 1936, Vol. 13, No. 4, pp. 131–132.)

2335. The Corona-Wind Voltmeter.—R. Uenisi. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, p. 85: letter, Japanese only.)

2336. On the General Theory of Electrometer Design [and a Proposed Design giving Limiting Useful Sensitivity, Short Period and Other Advantages].—W. W. Hansen. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, pp. 182–191.)

2337. Extending the Range and Usefulness of the Zeleny Electroscope by Automatically and Mechanically Counting Rapid Oscillations [Measurement of Very Small Currents].—R. W. Boydston. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 420: abstract only.)

2338. Discussion on "The Compensated Thermocouple Ammeter" [and the Question of Errors at High Frequencies].—Goodwin. (*Elec. Engineering*, April, 1936, Vol. 55, No. 4, pp. 407–409.) *See* 1543 of April.

2339. R.F. Power Measurements [within 10%, from Peak Grid-Driving Voltage or by Use of Rectifier-Type Dummy Load].—G. F. Lampkin. (*Electronics*, February, 1936, Vol. 9, pp. 30–31 and 64.)

2340. Power Measurement at High Voltage, High Frequency and Large Phase Displacement and Any Wave Form [Applicable to the Testing of Insulating Materials under Working Conditions].—J. Krutzsch. (*E.T.Z.*, 16th April, 1936, Vol. 57, No. 16, pp. 439–442.)

The writer's method (developed after trying dynamometer, three-ammeter and other methods) uses a duant electrometer and a capacitive voltage divider. It functions admirably up to 6 kc/s and can probably be extended to much higher frequencies. Some results on Condensa and quartz are given.

2341. The Use of Electronic Valves for the Measurement of the Angle of Lag [Combination of Two Diodes and a Triode as Phase Meter].—L. I. Gutenmacher. (*Elektritchestvo*, No. 2, 1936, pp. 40–45: in Russian.)

2342. High-Frequency Losses in Polar Solutions [Variation with Dipole Moment and Viscosity].—G. Martin. (*Physik. Zeitschr.*, 1st March, 1936, Vol. 37, No. 5, pp. 164–165: long abstract only.)

2343. High-Frequency Measurements of Dielectric Constants and Dipole Losses [and Connection with Debye-Hückel-Falkenhagen Theory].—M. Wien and others. (*Physik. Zeitschr.*, 1st March, 1936, Vol. 37, No. 5, pp. 155–164.)

The subjects discussed by the different writers are: Introduction: dipole loss measurements for liquids with long waves: measurements on sugar solutions: measurements on various kinds of glass: measurements of losses in various liquids by the thermometer method.

2344. Measurements of Dielectric Constants [of Some Nitrogen Derivatives] for Very Short Waves [2–4 m] with a Recording Apparatus.—R. Freymann. (*Comptes Rendus*, 16th March, 1936, Vol. 202, No. 11, pp. 952–954.) For a similar arrangement *see* Müller, 260 of January.

2345. Electric Moments of Solute Molecules [Formulae for Calculation: Comparison with Clausius-Mosotti Formula].—E. A. Guggenheim. (*Nature*, 14th March, 1936, Vol. 137, pp. 459–460.)

2346. The Measurement of Strong Magnetic Fields [*e.g.* 50–10 000 Gauss].—Briggs and Harper. (*Journ. Scient. Instr.*, April, 1936, Vol. 13, No. 4, pp. 119–126.)

2347. Generalised Bridge Circuits [Wheatstone Bridge for Measurement of Resistances coupled with E.M.Fs].—G. Barth. (*Physik. Zeitschr.*, 1st March, 1936, Vol. 37, No. 5, pp. 167–169.)

2348. Absolute Values of the Electron Mobility in Hydrogen [with Electrical Shutter Method for Mobility Measurement].—N. E. Bradbury and R. A. Nielsen. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, pp. 388–393.)

2349. "Electrical Measurements and Measuring Instruments" [Book Review].—E. W. Golding. (*P.O. Elec. Eng. Journ.*, April, 1936, Vol. 29, Part 1, p. 73.)

2350. Life Test Recorder [Waxed-Paper Disc Recorder showing Time of Failure of Any of 120 Different Elements].—D. A. McLean. (*Bell Lab. Record*, April, 1936, Vol. 14, No. 8, pp. 273–274.)

2351. The New Giorgi System of M.K.S. Units [Fundamental Magnitudes reduced to Length and Time].—L. Roy. (*Comptes Rendus*, 6th April, 1936, Vol. 202, No. 14, pp. 1232–1234.)

SUBSIDIARY APPARATUS AND MATERIALS

2352. [Gravitational] Models of the Electric and Magnetic Fields of Electron Optics [with Discussion of Störmer's Auroral Work, Farnsworth's Electron Multiplier, Positive-Ion and Electron Accelerators, etc.].—Brüche and Recknagel. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, pp. 126–134.)

It is shown that sliding point-masses (actually rolling spheres) on very flat "potential mountains" (plastic models) describe the same paths as electrons in corresponding electric-potential fields. A three-dimensional model in the ordinary way can only deal with *plane* paths, such as that of an electron which crosses once the optical axis of an electrostatic lens. An electron which did not so cross the axis would have a three-dimensional path and would thus require a four-dimensional model, and this applies also to electrons in a magnetic field. To deal with such cases, while keeping to the three-dimensional model, the writers introduce a special translatable co-ordinate system, from which the paths appear as plane: the recurrent electron paths (Poincaré's spirals) in electric and magnetic fields with converging lines of force are thus treated. Finally the writers consider the model-representation of linear electron motion in fields which change during the electron path times (B-K oscillations, electron multipliers and accelerators, etc.), and a "rocking" or see-saw model for such cases is discussed.

2353. The Application of the Wetthauer Method to the Investigation of Electron-Optical Systems.—K. M. Janchevski. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 5, 1935, pp. 1659–1660.) A preliminary communication on a system in which a longitudinal section of an electronic beam can be observed and adjustable electromagnets are used for centering the beam.

2354. Applied Electron Optics [Electron Gun, Electron Microscope: Image Tube: Pin-Cushion Distortion and Its Correction by Current passing Radially through Resistive Cathode Layer, or by Shaping the Cathode Surface: Infra-Red Microscope and Telescope].—Zworykin and Morton. (*Journ. Opt. Soc. Am.*, April, 1936, Vol. 26, No. 4, pp. 181–189.)

2355. A Sensitive Cold-Cathode Oscillograph of High Efficiency for Low Excitation Voltages.—E. Westermann. (*Arch. f. Elektrot.*, 18th Feb. 1936, Vol. 30, No. 2, pp. 109–122.)

For a short paper *see* 4025 of 1935. The construction and action are described of a cold-cathode oscillograph with a narrow metallic discharge tube, suitable for low excitation voltages (4–13 kv). § II discusses the blackening of photographic films by electrons and electron density for low voltages; Fig. 1 gives curves connecting the blackening with the electron velocity (up to 80 kv) for some known oscillographs. To obtain maximum sensitivity a metallic discharge tube has been designed (§ III); Fig. 2 shows details of the cathode insulation and Fig. 3 a vertical cross-section through the tube, of which technical constructoinal details are given. Figs. 4 and 5 show photographs of various parts. Experimental results are described and illustrated by the electron-optical photographs in Figs. 6, 7. The crater produced after 8 hours' running is shown in Fig. 8. § IV describes the whole oscillograph, of which the metallic discharge tube is an integral part. The vacuum requirements are discussed in § IV 1 and the electron-optical arrangements for beam concentration in § IV 2. Fig. 9 shows a section of the whole oscillograph; the construction is described in § IV 3. Provision is made for internal and external photography. The efficiency is discussed in § V. Examples of records obtained under various conditions are given; the highest internal recording velocity was 10 500 km/s, for external work 2 500 km/s.

2356. A Prerecording Oscillograph and Its Use in Studying Rectifier Operation.—Hull and Laub. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 409: abstract only.)

Electrical conditions just before, during and after an unpredictable event can be recorded by utilising the phosphorescence of the screen of a cathode-ray oscillograph (for previous references *see* 1575 of April). The event operates a camera shutter by means of a thyratron. The arc-backs of phanotrons and thyratrons so far observed "occur at the middle of the inverse cycle, *i.e.*, when the voltage is maximum."

2357. Super-Rapid Recording Speed of Momentarily Acting Cathode-Ray Oscillographs [Contact Recording at 60 000 km/s].—Slashtchev. (*Elektritchestvo*, No. 6, 1936, pp. 8–10: in Russian.)

2358. Electronic Relay trips Cathode-Ray Sweep Circuit in 0.2 Microsecond.—Brown Boveri Company. (*Electronics*, February, 1936, Vol. 9, pp. 42 and 44.)

2359. A New Method of Synchronisation for the Cathode-Ray Oscillograph [by Spark Light influencing Under-Excited Greasy Gap].—Stekolnikov. (*Elektritchestvo*, No. 6, 1936, pp. 5–7: in Russian.)

2360. Theory of the Fall of Striking Voltage of an Irradiated Spark Gap.—Fucks. (*Zeitschr. f. Physik*, No. 11/12, Vol. 98, 1936, pp. 666–671.)

2361. Direction of Motion of Oscilloscope Spot [sometimes Important to Know: Method of Determining, by Superposition of Saw-Tooth Wave].—Haynes. (*Bell Lab. Record*, March, 1936, Vol. 14, No. 7, pp. 224–225.)

2362. Developments in Cathode-Ray Oscillographs [White Fluorescent Screens with ZnS: Gas and Electron-Lens Focusing: Direct Measurement of High-Voltage Transients].—Levy and West: Piggott: Nuttall. (*Nature*, 14th March, 1936, Vol. 137, p. 465: short notes on recent I.E.E. papers.)

2363. Fluorescent Screens for Cathode-Ray Tubes.—Levy and West. (*See* 2276.)

2364. Ionisation and Luminescence of Atomic Jets in a High Vacuum.—Planiol. (*Comptes Rendus*, 23rd March, 1936, Vol. 202, No. 12, pp. 1032–1033.)

2365. Production of Intense Beams of Slow Electrons [with Magnetic Field and Auxiliary Grid at High Positive Potential].—Planiol. (*Comptes Rendus*, 6th April, 1936, Vol. 202, No. 14, pp. 1267–1268.) For previous work (on ion production) *see* 2466 of 1935.

2366. Measurement of the Electron Distribution at the Anode Spot of X-Ray Tubes [Electron-Microscope Method with Faraday-Cage for Intensity Measurement: Results].—Dosse. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, pp. 121–125.)

2367. A Flexible Attachment for Use in Vacuum Apparatus [Ball-and-Socket Joint, from Components of Achromatic Pair of Lenses, permits Rotation and Translation of Cathode of C-R Tube].—Lloyd. (*Journ. Scient. Instr.*, April, 1936, Vol. 13, No. 4, pp. 117–119.)

2368. Limitations of Tubular Ground Glass Joints [in Vacuum Apparatus].—Skellett. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, 179–180.)

2369. A New Capillary Phenomenon and Its Application, particularly to Micromanometric Measurements. — Röbbelen. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 17, 1936, pp. 95–98.)

2370. The Ionisation Gauge for Atomic Beam Measurements [Use with Amplifier for Measuring Pressure Changes: Influence of Various Factors on Design: Performance Tests].—Huntoon and Ellett. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, pp. 381–387.)

2371. Vacuum Pumps and Pump Oils. Part 1: Some Fractionation Pumps. Part 2: A Comparison of Oils.—Hickman. (*Journ. Franklin Inst.*, February, 1936, Vol. 221, No. 2, pp. 215–235: March, No. 3, pp. 383–402.)

2372. Retarding Corrosion in the Water Systems of Power Rectifiers.—Van Brunt and Remscheid. (*Gen. Elec. Review*, March, 1936, Vol. 39, No. 3, pp. 128–130.)

2373. On the Potential- and Current-Distributions of the Cylinder Wall and the Interior Parts of the Mercury-Arc Rectifiers.—Matuura and Yoshihara. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, pp. 9–15 : English summary p. 1.)

2374. Investigation on the Distribution of Mercury - Vapour Pressures in a Mercury-Vapour Rectifier by means of a Model.—Hada. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, pp. 40–46 : English summary pp. 6–9.)

2375. Steel-Clad Tube for Schools [10 kw Mercury Rectifier capable of being Disassembled and Modified].—Durand. (*Electronics*, February, 1936, Vol. 9, pp. 18 and 29.)

2376. Rectifiers with Hot Cathodes : Functioning with Filter with Inductive Input [Analysis for Single- and Polyphase Rectification, with Experimental Confirmation on Mercury-Vapour Type RCA 83].—Cocci and Sartori. (*L'Elettrotec.*, 10th March, 1936, Vol. 23, No. 5, pp. 122–128.)

2377. A New Application of the Rectifier [Defects of Half-Wave and Full-Wave Rectification, supplying an Inductive Circuit, removed by Shunting the Load Circuit by a Rectifier, *e.g.* of Copper-Oxide Type].—Hoffman and Marchal. (*Rev. Gén. de l'Élec.*, 21st March, 1936, Vol. 39, No. 12, pp. 407–414.) *Cf.* Babat, 1934 Abstracts, p. 336, r-h column.

2378. Rectifiers for Charging Alkali Accumulators.—Landsmann. (*E.T.Z.*, 5th March, 1936, Vol. 57, No. 10, pp. 271–272.)

2379. High-Tension Hot-Cathode Tubes with Mercury-Vapour Filling, with and without Grid Control [" Guided-Arc " compared with " Open-Arc " Types : New Types with Hood Grid surrounded by Bell-Shaped Anode].—Kluge. (*E.T.Z.*, 12th and 19th March, 1936, Vol. 57, Nos. 11 and 12, pp. 301–304 and 333–334.)

2380. Dynamic Characteristics of the Mercury Arc.—Elenbaas. (*Physica*, January, 1936, Vol. 3, No. 1, pp. 12–30 : in German.)

2381. On the Dynamic Characteristics of a High-Frequency Arc.—Katayama. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, p. 1081 : Japanese only.)

2382. Pre-Discharge Current Measurements on a Gas-Filled Discharge Tube with Two Grids.—Mahla. (*Zeitschr. f. tech. Phys.*, Nos. 1 and 2, Vol. 17, 1936, pp. 19–25 and 36–41.) For previous work *see* 1176 of March.

2383. The Stabilisation of a Glow Discharge in a Homogeneous Field in Air at Atmospheric Pressure by means of Electrolytically Produced Films of Aluminium Oxide.—Rummel. (*Naturwiss.*, 6th March, 1936, Vol. 24, No. 10, p. 158.)

2384. Electron Emission of the Cathode of an Arc [may be due to Thin Insulating Layer covering Metallic Cathode].—Druyvesteyn. (*Nature*, 4th April, 1936, Vol. 137, p. 580.)

2385. Calculation of Townsend's α for Neon.—Druyvesteyn. (*Physica*, February, 1936, Vol. 3, No. 2, pp. 65–74 : in English.)

2386. Low-Pressure Arc Characteristics [Re-ignition Potential a Linear Function of Gas Pressure].—Cobine. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, p. 479 : abstract only.)

2387. Electron Temperatures and Mobilities [in Gas Discharge : Concept of Temperature invalid for Non-Maxwellian Distribution].—Allen. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, p. 480 : abstract only.)

2388. The Theory of Tube Discharges [in Electronegative Gases : Electrons become Negative Ions by Attachment and Return towards Centre of Tube : Two Fundamental Forms of Discharge].—Seeliger and Sommermeyer. (*Zeitschr. f. Physik*, No. 11/12, Vol. 98, 1936, pp. 733–739.)

2389. The Fine Structure of the Luminous Flashes obtained by Discharging a Condenser across a Tube of Gas [Similarity of Anode and Cathode Flashes].—Laporte and Pierrejean. (*Comptes Rendus*, 24th Feb. 1936, Vol. 202, No. 8, pp. 643–645.)

2390. The Analysis of the Very Short Luminous Flashes obtained by Discharging a Condenser through a Gas-Filled Tube.—Laporte and Pierrejean. (*Journ. de Phys. et le Radium*, February, 1936, Vol. 7, No. 2, pp. 8–9 s.)

2391. The Periodic Emission of Light from a Discharge Tube excited at High Frequency [Lag of Illumination behind Driving Potential : Persistence of Light emitted from Excited Atoms : Rough Determination of Velocity of Light].—Frey. (*Phys. Review*, 15th Feb. 1936, Series 2, Vol. 49, No. 4, pp. 305–308.)

2392. The " Effective " Capacity of an Intermittent Glow Discharge Tube.—Clark and Bockstahler. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 409 : abstract only.)

2393. Combination of Glow-Discharge Relay and Intermittent Glow-Discharge Principles to form a " Glow-Discharge Amplifier."—Weber. (*See* 2475.)

2394. Piezoelectric Forces of Attraction [and Their Use in a Relay].—Gruetzmacher. (*See* 2321.)

2395. Voltage Sources and Amplifiers for Geiger-Müller Tube Counters [Neon Lamps in Pentode Circuit and in Amplifier, acting as Thyratron: Strobotron Tube].—Gingrich. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, p. 481: abstract only.)

2396. A Simple Arrangement for Interrupting the Thyratron Current in Tube-Counter Amplifiers [Thyratron Anode Voltage supplied by Condenser large enough to Actuate the Counting Mechanism].—Staub. (*Helvetica Phys. Acta*, Fasc. 2, Vol. 9, 1936, pp. 84–86: in German.)

2397. Electrolytic Platinum Coatings for Electrical Contacts, etc.—Sadakata. (*E.T.Z.*, 16th April, 1936, Vol. 57, No. 16, p. 446.)

2398. Heavily Loaded Silver Contacts in Telephone Apparatus, and the Calculation of Spark-Suppressing Circuits.—Krüger. (*E.T.Z.*, 16th April, 1936, Vol. 57, No. 16, pp. 443–444: summary only.)

2399. R.F. Resistance of Copper Wire [500 kc/s to 100 Mc/s: Chart].—(*Electronics*, February, 1936, Vol. 9, p. 38.)

2400. The Performance of Physical Voltage Regulating Devices [Comparison of Barretter, Bridge, and Series Combination of Both].—Higgs. (*Journ. Scient. Instr.*, April, 1936, Vol. 13, No. 4, pp. 114–117.)

2401. Stabilisator for Large Currents [150 mA D.C.] at an Adjustable Secondary Voltage [between 0 and 1 500 V].—Fejér and Sanger. (*Bull. Assoc. suisse des Élec.*, No. 5, Vol. 27, 1936, pp. 131–135.)

A combination of a triode, a h.f. pentode, a 40 v dry battery and six 2-volt accumulators. A variation of ± 100 v in the input voltage causes a variation of ± 0.2 v in the output. The voltage drop in the stabilisator amounts to 650 v, which must be allowed for in the input voltage.

2402. Vibrators [Survey of Modern Practice, including New Mallory 8-Contact Vibrator: Materials: the Advantages of Monel Metal: Power Vibrators: etc.].—(*Electronics*, February, 1936, Vol. 9, pp. 25–29.)

2403. Discussion on "Vibratorily Commutated Stationary Conversion." — Southgate. (*Elec. Engineering*, April, 1936, Vol. 55, No. 4, pp. 404–406.) *See* 1221 of March.

2404. The Electrical Behaviour of Cuprite Crystals [Conductivity: Hall Effect: Influence of Water Vapour in Surrounding Air].—Brauer. (*Ann. der Physik*, Series 5, No. 7, Vol. 25, 1936, pp. 609–624.)

2405. Combinations of Circular Currents for producing Uniform Magnetic Field Gradients.—McKeehan. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, pp. 178–179.) Further development of the work referred to in 1982 of May.

2406. Electro-Magnetic A.C. Relay with a Magnetic Tap.—Kovalenkov. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1936, pp. 12–23.)

A short-circuited winding on part of the split end of the core considerably reduces the vibrating of the armature under the influence of the alternating current. The conditions for the best design are found.

2407. The Non-Linear Relation between Magnetomotive Force and Flux in Ferromagnetic Cores [producing Distortion in Transformer-Coupled Amplifiers].—Wood. (Discussed in McLean's paper, 2137.)

2408. H.F. "Iron-Cored" Coils for Short Waves [without Central Core: Overhanging Iron-Powder Ends improve Flux Distribution and decrease Damping Effect of Screening Cover].—Lorenz Company. (French Pat. 792 077, pub. 21.12.1935: *Rev. Gén. de l'Élec.*, 28th March, 1936, Vol. 39, No. 13, pp. 102–103 D.)

2409. Age-Hardening Alloys and Their Applications.—Harrington. (*Gen. Elec. Review*, March, 1936, Vol. 39, No. 3, pp. 124–127.)

2410. Magnetic Powder Experiments on Rolled Nickel Iron [to Investigate Nature of Internal Stresses in this Material—used in Pupin Coils].—Snoek. (*Physica*, February, 1936, Vol. 3, No. 2, pp. 118–124: in English.)

2411. Permanent Magnets: with Special Reference to Aluminium/Nickel Alloys.—Griffiths. (*B.T-H Activities*, Jan./Feb. 1936, Vol. 12, No. 1, pp. 30–33.)

2412. The New Development of Materials for Permanent Magnets [with Data, including Oerstit Types: Optimum Ratios of Length to Cross Section].—Pölzguter: Jellinghaus. (*E.T.Z.*, 2nd April, 1936, Vol. 57, No. 14, p. 398: summaries only.)

2413. Paramagnetic Study of Some Nickel Alloys.—Manders. (*Ann. de Physique*, February, 1936, Series 11, Vol. 5, pp. 167–231.)

2414. On the 'Permalloy Problem' [Properties due to Neighbourhood of Three Singular Points in Nickel/Iron System].—Snoek. (*Nature*, 21st March, 1936, Vol. 137, p. 493.) *See* also 738 of February.

2415. High Permeability and Plastic Flow in Magnetic Fields.—Dillinger. (*Bell Lab. Record*, April, 1936, Vol. 14, No. 8, pp. 265–269.)

2416. The Internal Energy of Ferromagnetics [Experimental Data analysed to show Dependence on Intrinsic Magnetisation and Temperature].—Stoner. (*Phil. Trans. Roy. Soc.*, Series A, 15th Feb. 1936, Vol. 235, No. 750, pp. 165–193.)

2417. Technical Problems of Ferromagnetism in Weak Fields [Survey: particularly the Additional Loss Component (independent of Frequency and Amplitude) and Its Explanation—Lag Effect or Impurities Effect ?].—Goldschmidt. (*Helvetica Phys. Acta*, Fasc. 1, Vol. 9, 1936, pp. 33–41: in German.)

2418. An Atomic Theory of the Magneto-Caloric Effect [Explanation of Reversible Temperature Variation of Magnetisation: Volume Change due to Magnetostriction: Increase in Kinetic Energy of Magnetic Atoms associated with Rotational Vibration].—Honda and Hirone. (*Nature*, 21st March, 1936, Vol. 137, p. 492.)

2419. Theory of the Volume Anomalies of Ferromagnetic Substances [Temperature Effects]: *also* Effect of the Thermal Variation of the Molecular Field on the Curie Constant, *and* Attempt at Interpretation of the Saturation Moment of Ferromagnetics.—Néel. (*Comptes Rendus*, 2nd & 23rd March and 6th April, 1936, Vol. 202, Nos. 9, 12 and 14, pp. 742–744, 1038–1040, and 1269–1272.)

2420. Magnetic Properties of the Metallic State, and the Energy of Interaction between Magnetic Atoms.—Néel. (*Ann. de Physique*, February, 1936, Series 11, Vol. 5, pp. 232–279.)

2421. The Electronic Transformer [L.T. Alternating Current converted to H.T. Direct Current by Method of Speeding-Up Electrons to Very High Velocities (without Use of High Voltages) by Circular Field produced by Magnetic Flux Variations].—Jassinski. (*Elektritchestvo*, No. 3, 1936, pp. 38–41: in Russian.)

2422. Comparison of Methods to reduce Edge Effects in High-Voltage Static Condensers.—Miura. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No 569, pp. 1042–1046: English summary p. 134.) The writer's new method appears to be to use a number of metal-foil sheets separated by dielectric sheets and connected in parallel by tabs, the whole forming one electrode of considerable thickness.

2423. On the Dielectric Losses in Ebonite at Ultra-High Frequencies.—K. A. Wodopianov. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1376–1379.)

A report on experiments carried out on wavelenths between 2.5 and 50 metres. It was found in these experiments that the angle of loss remains independent of the frequency and that it increases with rise in temperature. It is pointed out that the latter phenomenon at ultra-high frequencies cannot be explained by changes in conductivity and dipole structure of ebonite.

2424. Calculation of Various Physical Constants of Heterogeneous Substances. II. Dielectric Constants and Conductivities of Multiple Crystals of Non-Regular Systems.—Bruggeman. (*Ann. der Physik*, Series 5, No. 7, Vol. 25, 1936, pp. 645–672.) For I *see* 1284 of March.

2425. Micalex, a Refractory Insulating Material with Very Low Dielectric Loss [with Comparative Data].—Lozza. (*L'Elettrotec.*, 10th Feb. 1936, Vol. 23, No. 3, pp. 78–80.)

2426. Plastics: Mechanical and Electrical Properties of Phenolic, Urea, Cellulose Acetate and Styrol Materials commonly used in Electronic Apparatus.—Chase. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 10–13 and 34, 36.)

2427. Conductivity of Quartz at High Temperatures.—Darmois and Radmanèche. (*Journ. de Phys. et le Radium*, February, 1936, Vol. 7, No. 2, pp. 16–17 s.) For previous work *see* 4015 of 1935.

2428. On the Change of Physical Property of the Electrical Insulator by Heat: Second Report [Oils].—Shimizu and others. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, pp. 1007–1013: short English summary p. 129.) Continued from 1286 of March.

2429. Some Considerations on the Heat Theory of Breakdown Mechanism by K. W. Wagner.—Shimizu and Nishifuji. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, p. 1078: Japanese only.)

2430. Discussion on "Breakdown Curve for Solid Insulation."—Montsinger. (*Elec. Engineering*, April, 1936, Vol. 55, No. 4, pp. 399–403.) *See* 774 of February.

2431. The Surface Charge and the Surface Discharge [Simple Theory of Distribution of Potential Gradient due to Surface Leakage Current and Surface Charge on Insulators: Experimental Confirmation].—Okitsu, Matsumoto and Chou. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, pp. 1052–1055: English summary p. 135.)

STATIONS, DESIGN AND OPERATION

2432. "Telediffusion" or "Radio Distribution" [Distribution from Central Radio Receiving Station *versus* "Teleprogramme" by Line from Studio to Loudspeaker: Low-Frequency and Carrier-Current Teleprogrammes: Swiss and German Developments: Discussion].—de Lanouvelle. (*Bull. de la Soc. franç. des Élec.*, February, 1936, Series 5, Vol. 6, No. 62, pp. 183–202.)

2433. Carrier-Frequency Broadcasting Transmission by Overhead Lines [in Norway].—Haag: Siemens & Halske. (*E.T.Z.*, 16th April, 1936, Vol. 57, No. 16, p. 448.)

2434. Wireless Relay Broadcasting through the Agency of Telephone Wires.—Hase and Hiraga. (*Journ. I.E.E. Japan*, December, 1935, Vol. 55 [No. 12], No. 569, p. 1079: Japanese only.)

2435. The Broadcasting Committee's Report [Summary of Recommendations].—(*Television*, April, 1936, Vol. 9, No. 98, pp. 246–249 and 256.)

2436. Discussions on "The Droitwich Broadcasting Station."—Ashbridge, Bishop and MacLarty. (*Journ. I.E.E.*, April, 1936, Vol. 78, No. 472, pp. 432–438.) *See* 330 of January: comparison with "phase-modulated" Radio-Luxembourg: high-voltage generators *versus* rectifiers: usefulness of transducer: no apparent effect of large r.f. fields on animal life (apart from diathermy at close quarters): etc.

2437. The New Northern Ireland Regional Station.—(*World-Radio*, 20th March, 1936, Vol. 22, pp. 13, 15 and 16.)

2438. Progress in European Broadcasting [the New Linz, Motala and Droitwich Transmitters: the German Network: France: Other Countries].—Singer. (*Elektrot. u. Masch:bau*, 8th March, 1936, Vol. 54, No. 10, pp. 114–118.)

2439. Radio Developments during 1935 [Broadcast Transmission].—Jansky. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 385–389.)

2440. Present Practice in the Synchronous Operation of Broadcast Stations as exemplified by WBBM and KFAB.—Young. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 433–446.)

Dealing first with the "derived-carrier" systems as developed by Westinghouse, and then describing the Bell and Western Electric system of continuous comparison (and continuous automatic correction) of local carrier with standard frequency conveyed by wire line.

2441. A Review of Radio Communication in the Fixed Services for the Year 1935.—C. H. Taylor. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 390–395.)

2442. A Review of Radio Communication in the Mobile Services [Marine, Aviation, and Automobile].—Anderson. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, pp. 396–407.)

2443. Dialling Ships at Sea [and the 103A Selector Set].—Wadsworth. (*Bell Lab. Record*, April, 1936, Vol. 14, No. 8, pp. 255–259.)

2444. Wireless Equipment for Empire Flying Boats.—Marconi Company. (*Engineering*, 3rd April, 1936, Vol. 141, pp. 380–381.)

2445. The Wireless Equipment of the Zeppelin "LZ 129" ["Hindenburg"].—Hilligardt. (*E.T.Z.*, 26th March, 1936, Vol. 57, No. 13, pp. 360–361.)

2446. "Useful Information on Police Radio Systems."—National Elec. Manufacturers Assoc. (At Patent Office Library, London: 24 pp.: Cat. No. 75 994.)

2447. Suggestion for a Feed-Back Suppressor with Speech-Controlled Relay for Wireless Telephony.—Koll. (*E.N.T.*, January, 1936, Vol. 13, No. 1, pp. 20–25.)

The application to wireless telephony is suggested of an arrangement already used for ordinary telephony. The relay is shown in Fig. 1 and the fundamental principles of the circuit in Fig. 2. The advantages are said to be (1) the relay can make a large number of contacts; (2) either speech direction retains the possibility of working the relay, even when it is itself choked out (circuit Fig. 3); (3) control is regulated by one direction only (preferably the transmitting one); it is independent of the received field strength; (4) one speech direction (that of reception) is switched in when the circuit is at rest. Use of the relay makes wireless conversations possible with only one carrier frequency and one transmitting aerial (circuit Fig. 5).

2448. Remote Control *via* 5 Metres [Signal Corps select, stop and start One of Several Transmitters across New York Harbour Ship Channel].—(*Electronics*, February, 1936, Vol. 9, pp. 17 and 64.)

GENERAL PHYSICAL ARTICLES

2449. The Nature of Light [Impossibility of Occurrence of Thomson's Solution of Maxwell's Equations in Actual Media].—C. Hurst: Thomson. (*Nature*, 4th April, 1936, Vol. 137, p. 582.) *See* 1621 of April.

2450. The Electronic Nature of Light [Photon may consist of Positive and Negative Electron with No Resultant Momentum relative to Centre of Gravity].—Destouches. (*Comptes Rendus*, 16th March, 1936, Vol. 202, No. 11, pp. 921–923.)

2451. The Direct Detection and Measurement of the Angular Momentum of Light.—Beth. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 411: abstract only.)

2452. On the Foundations of Dynamics [Modifications in Classical Laws suggested by Natural Time Origin and Standard of Local Rest].—Milne. (*Proc. Roy. Soc.*, Series A, 2nd March, 1936, Vol. 154, No. 881, pp. 22–52.)

2453. The Total Carrier Formation of Slow [Photoelectric] Cathode Rays in the Neighbourhood of the Carrier Formation Voltage.—Breunig. (*Ann. der Physik*, Series 5, No. 5, Vol. 25, 1936, pp. 467–480.) *See* 3793 of 1935 and 817 of February.

2454. Chemical Reactions in Ionised Gases [Reacting Particles are All Neutral].—Emeléus and Lunt. (*Nature*, 7th March, 1936, Vol. 137, p. 404.)

2455. Correction to a Note on the Magnetic Change of the Dielectric Constant of Liquids [Revised Results obtained with More Rigid Condenser]. — Piekara and Schérer. (*Comptes Rendus*, 30th March, 1936, Vol. 202, No. 13, pp. 1159–1160.) *See* 3712 of 1935; *also* 1627 of April.

2456. On the Photomagnetic Effect [Comparison of Results].—Specchia: Bose and Raha. (*Nuovo Cimento*, November, 1935, Vol. 12, No. 9, pp. 549–550.) *See* 3262 of 1935.

2457. "Atomic Physics" [Book Review].—Born. (*Electronics*, March, 1936, Vol. 9, No. 3, p. 56.)

MISCELLANEOUS

2458. Numerical Solution of an Integral Equation [occurring in Work on Electronic Movements].—Coles. (*Phil. Mag.*, April, 1936, Series 7, Vol. 21, No. 142, pp. 760–764.)

2459. Asymptotic Solutions of Linear Differential Equations [Most Accurate Formulae for Equation satisfied by Airy Integral].—Jeffreys. (*Phil. Mag.*, March, 1936, Series 7, Vol. 21, No. 141, pp. 544–546.)

2460. A Method of Numerical Solution of [Non-Linear] Differential Equations [Modification of Adam's Method].—Falkner. (*Phil. Mag.*, March, 1936, Series 7, Vol. 21, No. 141, pp. 624–640.)

2461. Derivation of Legendre Function Formulae from Bessel Function Formulae.—MacRobert. (*Phil. Mag.*, March, 1936, Series 7, Vol. 21, No. 141, pp. 697–703.)

2462. Some Bessel Function Expansions.—Wise. (*See* 2175.)

2463. On the General Properties of Electric Network Determinants and the Rules for finding the Denominator and the Numerators.—Ting. (*Chinese Journ. of Phys.*, No. 3, Vol. 1, 1935, pp. 18–40: in English.)

2464. Correction to my Paper, "On the Theoretical Determination of Earth Resistance from Surface Potential Measurements" [Reasons for Withdrawal of Conclusions].—Stevenson. (*Phil. Mag.*, April, 1936, Series 7, Vol. 21, No. 142, pp. 829–830.) *See* 1271 of 1935.

2465. Progress in 1935 in Allied Fields to Radio.—Caldwell. (*Proc. Inst. Rad. Eng.*, March, 1936, Vol. 24, No. 3, p. 408: summary only.)

2466. Electro-Medicine as a Field for Research and a Therapeutic Means [Lecture].—Holzer. (*Elektrot. u. Masch:bau*, 5th April, 1936, Vol. 54, No. 14, pp. 157–161.)

2467. The Effect of the Ultra-Short Wave on the Velocity of Chemical Reaction.—Sasada and Wakabayashi. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, p. 84: letter, Japanese only.) For previous work (on physiological and biological effects) *see* 1934 Abstracts, p. 516, and 1275 and 3286 of 1935.

2468. The "Time Lag" of the Kerr Cell [and the Magneto-Optical Method of Chemical Analysis].—Bretscher: Allison. (*See* 2304.)

2469. "Radiobiologia Vegetale" [Book Review].—Rivera. (*La Ricerca Scient.*, 15/31 Jan. 1936, Series 2, 7th Year, Vol. 1, No. 1/2, pp. 73–74.)

2470. Some Applications of the [Loop] Oscillograph to the Investigation of Non-Electrical Processes.—Keller. (*Bull. Assoc. suisse des Élec.*, No. 6, Vol. 27, 1936, pp. 163–165: short survey.)

2471. An Electrical Stethoscope for the General Practitioner.—Betts. (*Bell Lab. Record*, April, 1936, Vol. 14, No. 8, pp. 270–272.)

2472. Electrical Device guards Radium Workers [Pocket Tell-Tale indicating Daily Effective Exposure of Operators].—(*Electronics*, February, 1936, Vol. 9, pp. 40 and 42.) At Westminster Hospital.

2473. The Determination of the Thickness of an Electrolytic Layer on Iron.—Radchenko and Shestakovski. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 5, 1935, pp. 1372–1375.) By measuring the force required for detaching a magnetic needle from an iron surface covered with a non-magnetic electrolytic layer: particularly suitable for thicknesses between 0.0005 and 0.02 cm.

2474. The Production of Large Single Crystals of Lithium Fluoride.—Stockbarger. (*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, pp. 133–136.) *See* also 1606 of April.

2475. The Glow-Discharge Amplifier and Its Use for the Amplification of Photo-currents.—J. G. C. Weber. (*Elektrot. u. Masch:bau*, 12th April, 1936, Vol. 54, No. 15, pp. 172–174.)

By a combination of the principles of the non-self-restoring "glow-discharge relay" of Geffcken and Richter and the intermittent-flash "glow-discharge oscillator" (with its parallel condenser and series resistance connection), a simple, cheap and robust "glow-discharge amplifier" has been constructed which has many applications, such as to electricity-meter testing. With the arrangement described for this purpose the available change of photocurrent, amplified by the glow-discharge amplifier alone, is 0.15 mA, which is enough to work a moving-coil relay with certainty. The photocell here used was of the potassium type.

2476. Light-Sensitive Cell Circuits [collected from Various Sources, notably *Radio-Craft* and *Electronics*].—(*Television*, February, 1936, Vol. 9, No. 96, pp. 73–76.)

2477. Colour Analyser plots Its Own Curve.—General Electric Company. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 17–18.)

2478. THE DETERMINATION OF FREQUENCY DISTRIBUTION CHARACTERISTICS WITH A PHOTOELECTRIC INTEGRATOR [Illumination of Photocell activates Relay which closes Stop-Watch Contacts].—Saxl. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, p. 479: abstract only.)

2479. THE PHOTOELECTRIC RELAY AS CHRONOMETRIC RECORDING INSTRUMENT [in Manufacturing Processes, Laboratory Research, and Psycho-Technical Measurements].—Pospelov and others. (*Elektritchestvo*, No. 3, 1936, pp. 41–43: in Russian.)

2480. "ELECTRIC-EYEING" TELEGRAMS [Use of Photocell Control of Conveyor Belts, by Western Union].—Bennett. (*Electronics*, March, 1936, Vol. 9, No. 3, pp. 22–23 and 34.)

2481. TUBES AID EARTHQUAKE STUDY ["Shaking Table" Motion controlled by "Optical Cam," reproducing Seismograph Record of Actual Earthquake].—Ruge. (*Electronics*, February, 1936, Vol. 9, p. 40.)

2482. SELF-OPENING DOORS.—Raymond. (*Electronics*, February, 1936, Vol. 9, pp. 36 and 66.)

2483. REVERSING PILOT-MOTORS BY MEANS OF PHOTOCELLS.—P. P. Koptjaev. (*Izvestia Elektroprom. Slab. Toka*, No. 2, 1936, pp. 56–63.)

Author's summary:—Experimentally checked circuits of reversing pilot-motors by means of photocells are given in this article. In the first part, the d.c. circuits, with application of valves to amplify the photocurrents, are described. In the second part, a.c. and d.c. circuits are dealt with, with application of thyratrons. These circuits can be applied with success in various controlling and regulating devices.

2484. A PHOTO-TELEMETERING SYSTEM [for the Electricity Grid].—(*Engineer*, 10th April, 1936, Vol. 161, pp. 396–397.)

2485. PHOTOELECTRIC METHOD FOR THE INVESTIGATION OF GRANULAR SUSPENSIONS IN WATER.—Esterer. (*Zeitschr. V.D.I.*, 18th April, 1936, Vol. 80, No. 16, pp. 486–487.)

2486. HETEROCHROMATIC PHOTOMETRY OF THE ULTRA-VIOLET REGION [Use of Fluorescent Substances with Photoelectric Cell].—Bowen. (*Proc. Roy. Soc.*, Series A, 1st April, 1936, Vol. 154, No. 882, pp. 349–353.)

2487. THE EMISSION OF ULTRA-VIOLET RADIATION IN THE REBOUL EFFECT [with Semi-Conductors between Electrodes with High Potential Difference].—Viktorin. (*Comptes Rendus*, 16th March, 1936, Vol. 202, No. 11, pp. 941–943.) *See* Reboul, 1934 Abstracts, p. 633.

2488. RESEARCHES ON THE POSSIBLE ACTION OF GAMMA RAYS EMITTED BY THE EARTH ON WATER DIVINING.—Trénel. (*Génie Civil*, 28th March, 1936, Vol. 108, p. 316: summary only.)

2489. THE ESTIMATION OF REJECTION PERCENTAGES IN RANDOM TESTS [*e.g.* in Valve Manufacture].—Runge. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 17, 1936, pp. 134–138.)

2490. A NEW ELECTRICAL METHOD FOR THE CONTINUOUS RECORDING OF THE SPEED AND ACCELERATION OF A MOVING BODY.—Brileev and Kazakov. (*Elektritchestvo*, No. 6, 1936, pp. 13–14: in Russian.)

2491. "PHENOMENA IN HIGH FREQUENCY SYSTEMS" [Book Review].—Hund. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, p. 169.)

2492. "FORTSCHRITTE [Latest Developments] DER FUNKTECHNIK," VOL. I.—(*Radio, B., F. für Alle*, April, 1936.) First instalment (dealing with valves) of a Supplement to the "Handbuch," now nearing completion.

2493. A LOUDSPEAKER BURGLAR ALARM [Sustained, Silent Air Vibrations pervading Vault: Bridge Circuit controlling Alarm Gongs].—Bell Telephone Laboratories. (*Science*, 20th March, 1936, Vol. 83, Supp. p. 10.)

2494. GRID-CONTROLLED RECTIFIERS FOR WELDING CONTROL.—Fröhmer. (*Rev. Gén. de l'Élec.*, 28th March, 1936, Vol. 39, No. 13, p. 474.)

2495. INDUSTRIAL X-RAY PRACTICE [in Production Testing, Inspection, etc. (including Valve-Electrode Alignment): Possibilities of Chemical and Bio-Chemical Effects].—Woods. (*Electronics*, February, 1936, Vol. 9, pp. 7–11.)

2496. "THE RADIO AMATEUR'S HANDBOOK, 1936 EDITION" [Book Review].—(*Wireless Engineer*, April, 1936, Vol. 13, No. 151, pp. 199–200.)

2497. "DIE PHYSIKALISCHEN GRUNDLAGEN DER RUNDFUNKTECHNIK," VOL. 3 [Valves and Circuits: Book Review].—F. Weichart. (*Funktech. Monatshefte*, March, 1936, No. 3, p. 118.)

2498. "NATIONAL ASSOCIATION OF BROADCASTERS' ENGINEERING HANDBOOK" [Book Review].—(*Electronics*, March, 1936, Vol. 9, No. 3, p. 56.)

2499. PITY THE PARTS SUPPLIERS! SET-MAKERS PROFIT, PARTS SUPPLIERS LOSE MONEY.—Eby. (*Electronics*, February, 1936, Vol. 9, pp. 12–13.)

2500. FRENCH IMPORTS AND EXPORTS IN 1935 [Electrical Apparatus, Valves, etc.].—Reyval. (*Rev. Gén. de l'Élec.*, 28th March, 1936, Vol. 39, No. 13, pp. 475–485.)

2501. THE THIRD EXHIBITION OF RADIO COMPONENTS, ACCESSORIES AND VALVES.—(*L'Onde Élec.*, April, 1936, Vol. 15, No. 172, pp. 208–225.)

Cathode-ray light-tuning devices analogous to the American 6E5: single-knob-tuning condenser with specially profiled plates to obviate padding and give a strictly constant i.f.: tuning scales: pre-set air condensers up to 55 $\mu\mu$F: h.f. iron-cored coils: wave-change switches: etc.

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.

TRANSMISSION CIRCUITS AND APPARATUS

440 877.—Stabilising the frequency of an oscillation generator by controlling the magnetic permeability of a transformer in the supply circuit.

W. J. Polydoroff and Aladdin Industries. Application date 27th October, 1934.

440 993.—Modulating system in which low-frequency reverse reaction is used to reduce "envelope" distortion of the modulated wave.

Standard Telephones and Cables (assignees of E. B. Ferrell.) Convention date (U.S.A.) 9th June, 1934.

441 341.—High-frequency generating valve of the Barkhausen-Kurz type in which in-phase oscillations are applied to a screening grid interposed between the cathode and the positively-biased control grid.

I. Hausser. Convention date (Germany) 17th July, 1933.

2 006 440.—Transmitting circuit designed to be used either for normal modulation or to produce a self-generated C.W. note.

H. Chireix (assignor to Cie Generale de T.S.F.).

2 007 211.—Method of signalling by applying modulated high-frequency waves to a piezoelectric crystal embedded in concrete. The crystal transmits compressional waves through the earth to distant piezo-electric detector circuits coupled to valve amplifiers.

A. McL. Nicolson (assignor to Communication Patents Inc.).

2 007 637.—Compensating for inter-electrode feedback in a crystal-controlled oscillator either of the single valve or push-pull type.

I. F. Byrnes (assignor to Radio Corporation of America).

RECEPTION CIRCUITS AND APPARATUS

440 276.—Method of mounting or securing valveholders and other components on the chassis or panel of a wireless set.

L. H. Reid. Application date 18th July, 1934.

440 295.—Programme-selecting device for items broadcast over telephone wires.

Fabriques "Zenith." Convention date (Switzerland) 2nd December, 1933.

440 333.—Method of "tapping down" or minimising the Miller effect in a tuned high-frequency amplifier.

Marconi's W.T. Co.; N. M. Rust; and F. M. G. Murphy. Application date 28th May, 1934.

440 535.—Tuning dial in which the indication depends upon the movement of a magnetically-controlled ball sliding in a slot.

Ideal Werke Akt. Convention date (Germany) 16th April, 1934.

440 745.—Calibrated coupling device for use in a method of estimating the distance of a wireless beacon station by the rate of attenuation of the radiated waves.

Marconi's W.T. Co.; S. B. Smith; and F. M. Wright. Application date 6th July, 1934.

441 626.—Amplifier with negative phase feed-back arranged to reduce distortion.

Standard Telephones (assignees of L. A. Ware). Convention date (U.S.A.) 21st December, 1933.

441 851.—Remote control of the tuning of a wireless set by means of an impulse-sender.

E. Cohn. Application date 20th July, 1934.

442 741.—Short-wave super-generative receiver in which a valve having a duplex set of electrodes is operated with a high positive grid bias.

Marconi's W.T. Co. and E. W. B. Gill. Application date 14th August, 1934.

2 005 772.—Eliminating image-frequency interference from a superhet receiver by inserting a multiple-tuned circuit between the H.F. amplifier and frequency-changing valve.

H. Chireix (assignor to Cie Generale de T.S.F.).

VALVES AND THERMIONICS

440 378.—Thermionic generator for very short waves in which radial grid-like emissive electrodes alternate with similarly-arranged non-emissive electrodes.

Telefunken Co. Convention date (Germany) 21st July, 1933.

442 326.—Ultra-short-wave generator or amplifier valve fitted with a control grid as well as an accelerating grid and braking electrode.

N. V. "Meaf." Convention date (Germany) 23rd February, 1934.

443 364.—Thermionic valve tube in which the steepness and form of the grid-volts anode-current characteristic curve is controlled by a transverse deflection of the electron stream.

Radio Akt. D. S. Loewe. Convention date (Germany) 26th July, 1933.

2 003 371.—Thermionic oscillation-generator in which the frequency is stabilised by a grid or control element mounted outside the glass bulb.

E. L. Koch (assignor to E. L. Koch Holding Corporation).

2 006 969.—Four-grid valve serving as combined H.F. and L.F. amplifier.

K. Steimel and E. Klotz (assignors to Telefunken Co.).

DIRECTIONAL WIRELESS

441 370.—Visual indicator for direction-finding receivers co-operating with radio beacons of the equi-signal type.

Telefunken Co. Convention date (Germany) 4th June, 1934.

2 022 459.—Radio-beam navigation system for aircraft, in which the directional indication is given by the response of two piezo-electric crystal circuits at the receiving end.

B. J. Chromy.

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

441 061.—Loudspeaker in which a small, adjustable, tone-regulating cone is placed inside the main cone.

R. R. Glen. Application date 4th July, 1934.

441 367.—Mounting and guiding means for the steel-ribbon record of an electromagnetic sound-recording machine.

C. Lorenz Akt. Convention date (Germany) 9th June, 1934.

TELEVISION AND PHOTOTELEGRAPHY

440 106.—Cathode-ray tube for producing large-sized television pictures, *i.e.*, larger than 9 × 12 cm., in which electrostatic control is used for line scanning and magnetic control for the framing frequency.

Radio Akt. D. S. Loewe. Convention date (Germany) 27th June, 1933.

440 560.—Magnetic deflection-control system for a cathode ray receiver in which an outside winding is associated with pole-pieces mounted inside the glass bulb.

Radio Akt. D. S. Loewe. Convention date (Germany) 27th May, 1933.

440 729.—Method of televising from a standard kinema film at fifty frames a second and, at the same time, transmitting from the sound track on the same film at standard frequency.

C. O. Browne. Application date 4th July, 1934.

440 810.—Cathode ray tube fitted with a magnetic control of low hysteresis and high permeability in order to offset "trapezoidal" error.

Radio Akt. D. S. Loewe. Convention date (Germany) 8th July, 1933.

440 917.—Scanning apparatus in which the size of the aperture is varied during the course of traversal in order to correct for line curvature.

J. L. Baird and Baird Television. Application date 19th December, 1934.

441 410.—Mirror drum in which the reflecting elements form a number of convolutions of a continuous helical track, particularly suitable for interleaved scanning.

J. C. Wilson and Baird Television. Application date 26th July, 1934.

441 558.—Preparing a record of combined sound and picture signals, suitable for use with a television receiver.

C. P. Hall and H. Flynn. Application date 25th July, 1934.

441 969.—Television system based on the use of a "bank" of luminous sources controlled by the received signals.

A. Karolus. Convention date (Germany) 19th April, 1934.

2 017 883.—Telephone system in which the head and shoulders of each speaker is televised over the line-wires.

V. K. Zworykin.

SUBSIDIARY APPARATUS AND MATERIALS

440 350.—Method of producing a fluorescent material suitable for use in cathode ray tubes from a mixture of the sulphides of zinc and cadmium.

J. D. Riedel-de Haen A.G. Convention date (Germany) 22nd July, 1933.

440 468.—High-frequency transformer with a powdered-iron core which is deformed in the process of assembly so as to hold the bobbin parts together.

R. Bosch Akt. Convention date (Germany) 28th April, 1934.

440 726.—Loud speaker fitted with an adjustable iris diaphragm located inside the cone to modify the tone response.

R. R. Glen. Application date 4th July, 1934.

440 818.—Fluorescent material comprising a mixture of zinc and cadmium sulphides with small traces of silver and nickel to prohibit after-phosphorescence.

L. A. Levy and D. W. West. Application date 20th July, 1934.

441 107.—Dry-contact "oscillator" comprising a number of flat-ended metal electrodes which are adjustable relatively to an oxide-coated plate forming a common electrode.

W. Ludenia and Helmut Bros. Convention date (Germany) 16th July, 1934.

441 158.—Supporting and centring device for the moving-coil of an electrodynamic loud speaker.

W. Lissauer. Convention dates (Germany) 15th December, 1933, *and 10th September*, 1934.

441 194.—Light control system utilising a pair of photo-electric cells operating on opposite half-cycles of an A.C. mains supply.

H. Baron (communication from A. S. Fitzgerald) Application date 6th April, 1934.

441 274.—Light valves in which certain organic substances, such as cinnamates, are utilised to produce the Kerr effect.

Marconi's W.T. Co., B. Levin, and N. Levin. Application dates 13th July and 3rd August, 1934.

441 438.—Piezo-electric oscillator which is cut so that the electrode faces are askew to the X, Y and Z axes of the mother crystal.

Marconi's W. T. Co. (assignees of C. F. Baldwin and S. A. Bokovoy). Convention date (U.S.A.) 21st April, 1934.

2 002 343.—High-tension power supply unit in which one half of a full-wave rectifier valve supplies anode current for the valves, and the other half current for the field windings of a moving-coil speaker.

F. H. Engel (assignor to Radio Corporation of America.).

2 017 130.—Ribbon clamping members for light valves of the Wente type, whereby each ribbon is supported in proper relation to the pole-piece.

G. E. Perreault (assignor to Bell Telephone Labs.)

AIR CONDENSERS

"...... the finest example of instrument engineering I have ever seen"—an expert's opinion of the Muirhead, type 11 Variable Air Condenser.

SALIENT FEATURES:

Quartz insulation.

Reading accuracy 1 part in 20,000 of total scale.

Back lash negligible compared with reading accuracy.

A discrimination of 0.005 mmfd. is obtainable with the type 11-D instrument.

Robust construction capable of withstanding constant use without change of calibration.

These Air Condensers are fully described in Section 7 of our Catalogue, a copy of which will be sent on request.

MUIRHEAD & CO. LTD.

MAKERS OF PRECISION INSTRUMENTS FOR OVER 50 YEARS.

ELMERS END, Telephone: BECKENHAM 0041-2. KENT.

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.