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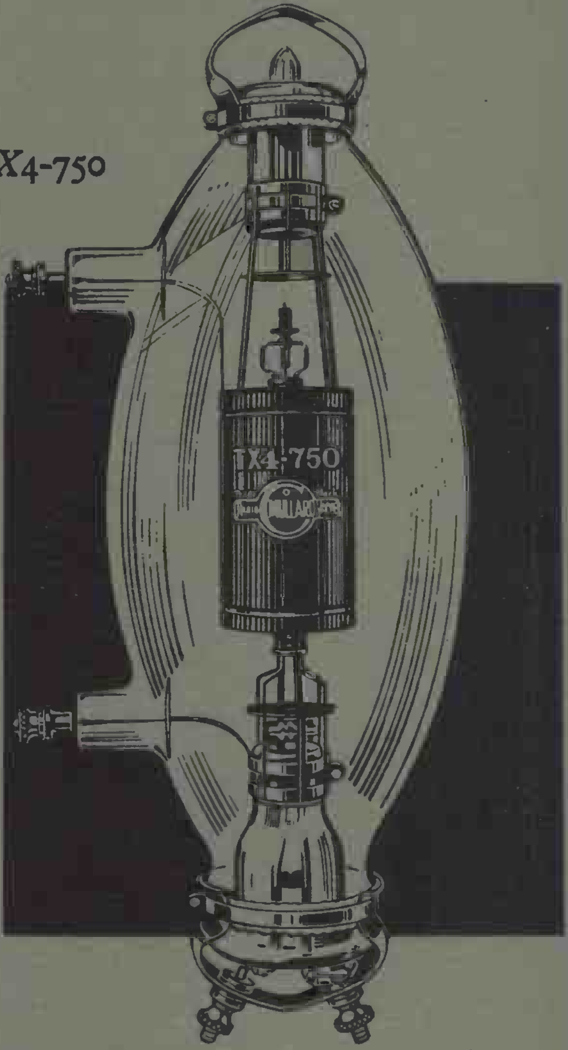
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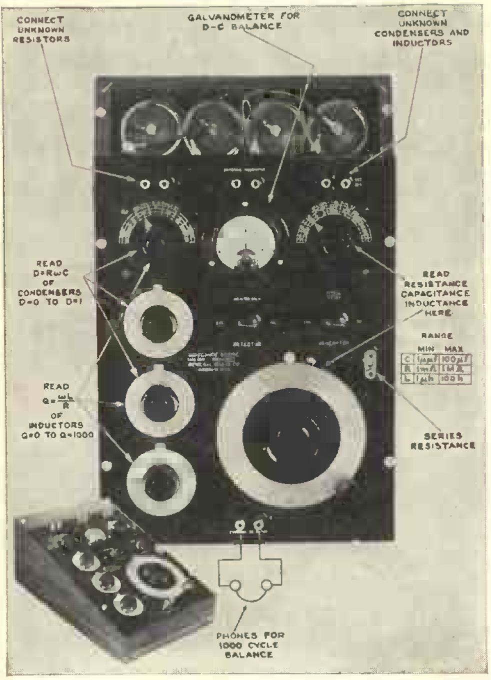

SPECIFICATION

	MIN.	MAX.
RESISTANCE ..	0·001ω	1 MΩ
CAPACITANCE ..	1μμF.	100μF.
INDUCTANCE ..	1 micro-henry	100 henrys
DISSIPATION FACTOR (R/X)	·002	1
ENERGY FACTOR (X/R)	·02	1,000

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1. D-C Resistance
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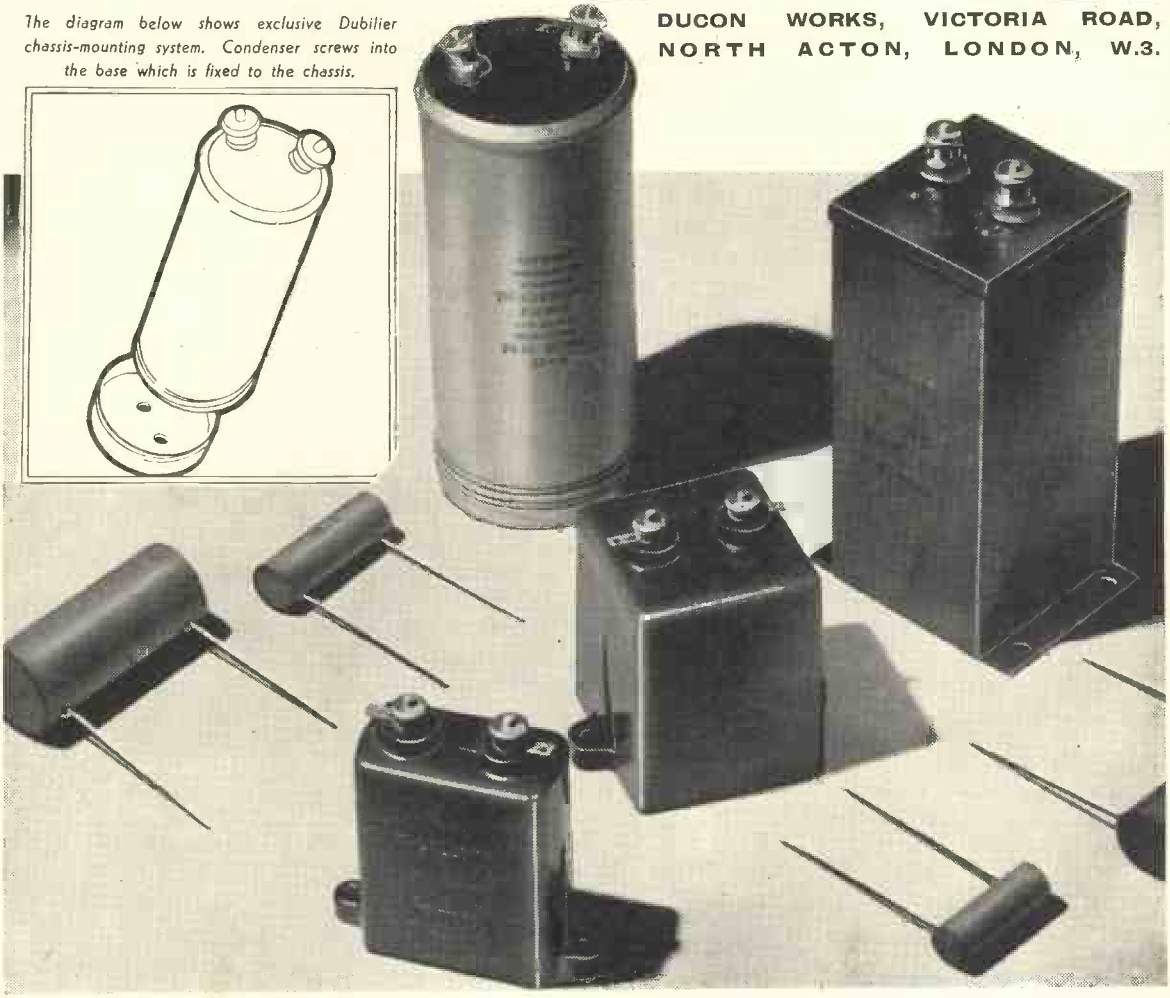

The diagram below shows exclusive Dubilier chassis-mounting system. Condenser screws into the base which is fixed to the chassis.

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THE
WIRELESS
ENGINEER

VOL. XIII. MARCH, 1936. No. 150

Editorial

A New Superheterodyne Principle

A SUPERHETERODYNE receiver which involves some novel features was recently described in a paper read before the Australian Institute of Radio Engineers by Mr. E. G. Beard.* The essence of the invention appears to be in the use of a part of the received wave to produce the heterodyne oscillation which is then mixed with the remainder of the received wave in the usual manner. Although a separate oscillator is maintained its output is not mixed with the modulated received wave in the usual manner. When the arriving signal ceases or is tuned out, the set is completely dead; no heterodyne oscillation is fed into the mixing valve. In practice, however, the received signal is heterodyned in the usual way as a preliminary step and the 100 kc/s output of the frequency converter is fed into the new receiver, which is, therefore, only called upon to handle a modulated input of one fixed frequency, viz.: 100 kc/s. The preliminary frequency converter is designed to pass the complete band of frequencies 100 ± 10 kc/s without attenuation of the side-bands. This divides between two channels, the main channel and a branch channel. The latter passes to a frequency converter supplied also with 60 kc/s current from a separate oscillator. The output of this frequency converter would consist of the two beat frequencies (100 ± 10) + 60 and (100 ± 10) − 60. This is passed through a very selective filter, such as a quartz oscillator, which eliminates all but a pure 40 kc/s current, which, it must be noticed, ceases if the received 100 kc/s oscillation ceases. This 40 kc/s current constitutes the real heterodyne oscillation of the receiver, and it is mixed with the modulated 100 kc/s current in the main channel and rectified in the usual way. The intermediate circuits are tuned, however, to the sum and not to the difference frequency, i.e., to 140 kc/s and not to 60 kc/s. This is then rectified in the usual way. The intermediate stages are designed not to be highly selective but to have a substantially flat-topped band-pass characteristic sufficiently wide to pass all the side-bands within the range 140 ± 10 kc/s. The selectivity is obtained through the 40 kc/s filter in the heterodyne supply, which is dependent for its supply upon the received wave containing a sustained oscillation of exactly 100 kc/s. If the received carrier departs slightly from 100 kc/s the set loses its heterodyne supply and becomes dead, but if the 100 kc/s carrier is present the set transmits the whole band between 90 and 110 kc/s. The set will respond to all signals

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* *The Radio Review of Australia*, III., p. 4, August, 1935.

in this range, from whatever source they may emanate, provided that it is also receiving a sustained wave of exactly 100 kc/s. Such a set is very suitable for the reception of Morse signals on the interrupted continuous wave system. During a dot or a dash any interference signal between 10 kc/s above and below the carrier frequency will be superposed upon the dot or dash, but in the spaces between the dots and dashes the set will be mute. It is claimed that this enables greatly increased accuracy in direction-finding owing to the sharp minimum setting of the coils made possible by the muting of the intervals between the signals. A part of the filtered 40 kc/s oscillation can also be used for automatic volume control without any further filtering since it has already been robbed of its audiofrequency components.

In a receiver of this type it is desirable that the final intermediate frequency channel should operate at a frequency considerably different from the frequencies used in any of the earlier channels, in order to avoid the risk of the earlier frequencies getting through to the final detector. This has led to a further refinement by subjecting the output of the highly selective filter to a further change of frequency before mixing it with the signal oscillation. As an example, the preliminary frequency changer may be made to supply the set at a frequency of 400 ± 10 instead of 100 ± 10 as previously assumed. A portion of this is tapped off and mixed with the output of a 360 kc/s oscillator, giving an output at 40 ± 10 kc/s which is filtered as before so as to give a pure 40 kc/s oscillation. This is now mixed with a portion of the output of the 360 kc/s oscillator, and the resulting 320 kc/s oscillation is used as the heterodyne supply to the main mixing valve where it gives with the signal of 400 ± 10 kc/s an output at a frequency of 80 ± 10. This intermediate frequency is far enough removed from any of the earlier frequencies to avoid the penetration of any of the latter to the end detector.

According to the author, this new type of receiver has given very good results, especially in the reception of modulated signals below the noise level.

G. W. O. H.

The Nature of Atmospherics

In the January number we drew attention to the work of Norinder in photographing atmospheric wave-forms, and in connection therewith we mentioned the pioneer work of Appleton, Watt and Herd. Our attention has been drawn to some more recent work carried out at King's College and at Slough on the photographic registration of atmospheric wave-forms, and described in a paper read by E. V. Appleton and R. A. Watson Watt at a meeting of the U.R.S.I. in London in September, 1934. In this paper it was shown that the low-frequency pulse was preceded by a group of high-frequency oscillations, which, in transit, tended to travel faster and draw ahead of the low-frequency pulse. The date of this meeting, at which Professor Norinder also described the results of somewhat similar observations in Sweden, is more than a year earlier than that of Norinder's paper, which must consequently be regarded as confirming the work of the Radio Research Board.

G. W. O. H.

Variable Selectivity and the I.F. Amplifier[*]

Part I.—The Design of Transformers for Variable Selectivity

By W. T. Cocking

THE increasingly high standard of quality of reproduction which is demanded in broadcast reception leads to considerable difficulty in the design of those circuits which discriminate between the wanted and unwanted signals. Faithful reproduction demands that all modulation frequencies up to some 10,000 c/s be fully reproduced, but with the present spacing of broadcasting stations the reproduction of such high frequencies can hardly be tolerated unless the field strength of the wanted station is so much stronger than that of its neighbours that interference is below the level of audibility. In practice this condition is found only in local reception, and high selectivity, together with a curtailment of the modulation frequency response, is necessary for distant reception.

It is common to find, however, that some degree of interference can be tolerated, and that a more pleasing effect is obtained by reproducing up to, say, 5,000 c/s and permitting a little interference than by restricting the response to, say, 3,500 c/s and avoiding all interference. Since the interference conditions are likely to be the same on no two stations, it is clear that the ideal receiver would include continuously variable selectivity so that the optimum degree could be found for any and every station. It is, however, by no means easy to achieve it in an economical manner which is at the same time technically sound, and it is obvious that it will be far more difficult in the case of a straight set, where the tuned circuits must be tunable over a wide range of frequencies, than in the I.F. amplifier of a superheterodyne where the operating frequency is fixed. Only the latter, therefore, will be considered in this article.

It is well known that if a pair of tuned circuits are coupled together by a mutual reactance the resonance curve exhibits two peaks if the coupling exceeds a certain critical value, and that the frequency separation of the peaks depends on the degree of coupling. It is clear, therefore, that variable selectivity can be achieved by the simple expedient of employing variable, instead of fixed, coupling in the I.F. transformers, for the usual transformer consists of a pair of coupled tuned circuits. Although such a course will give good results when the intermediate frequency is fairly high, particularly when the efficiency of the coils is low and a wide band-width is not required, the best results cannot be secured by any such haphazard arrangement.

The defect of the system embodying two coupled circuits is that if the coupling be tight and the coils good there is a big difference between the response at the peaks and the response at the trough between them. In other words, the response in the pass region is far from uniform. It is pointed out in the June, 1935, Proceedings of the *I.R.E.*, however, that the combination of a pair of coupled circuits with a single circuit of one-half the efficiency permits a combined response curve to be obtained which has only minor irregularities in the pass-band, and since a variation in the selectivity can be obtained merely by varying the coupling

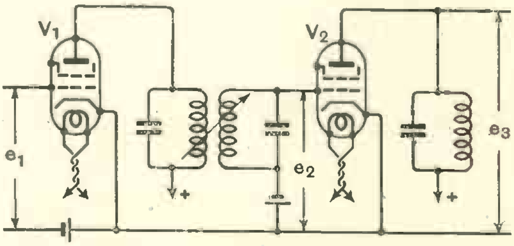

Fig. 1.—*Three tuned circuits, two of which are variably coupled, enable a good control of selectivity to be obtained.*

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

between the coupled pair, this system will well repay detailed investigation.

The basic arrangement is shown in Fig. 1, and ignoring feed-back effects in V_2, the circuit can be separated into two sections, shown in Figs. 2 and 3, in which the former is responsible for producing a two-peaked response curve and the latter a single-peaked curve, and the overall amplification will equal the product of that of the individual stages. That is,

$$\frac{e_3}{e_1} = \frac{e_2}{e_1} \times \frac{e_3}{e_2}$$

Referring to Fig. 2,

$$\begin{aligned} -\mu_1 e_1 &= i_1 Z_1 - j i_2/\omega C \\ 0 &= i_2 Z_2 - j i_1/\omega C - j\omega M i_3 \\ 0 &= i_3 Z_3 - j\omega M i_2 \\ e_2 &= -j i_3/\omega C \end{aligned}$$

where $Z_1 = R_{a1} - j/\omega C$

$$Z_2 = Z_3 = R + j\omega L - j/\omega C = R + j\beta$$

from which

$$\frac{e_2}{e_1} = \frac{-j\mu_1 \omega M/\omega^2 C^2}{(R_{a1} - j/\omega C)(R^2 + \omega^2 M^2 - \beta^2 + 2j\beta R) + (R + j\beta)/\omega^2 C^2}$$

When $R_{a1} >> 1/\omega C$, as is usually the case with screened tetrodes and pentodes

$$\frac{e_2}{e_1} = \frac{-jg_1 \omega M/\omega^2 C^2}{(R^2 + \omega^2 M^2 - \beta^2 + 2j\beta R) + \{(R + j\beta)/\omega^2 C^2 R_{a1}\}}$$

where $g_1 = \mu_1/R_{a1}$

When R_{a1} is large, the second group of terms in the denominator is very small compared with the first, and the equation can be simplified to

$$\frac{e_2}{e_1} \approx \frac{-jg_1 \omega M/\omega^2 C^2}{R^2 + \omega^2 M^2 - \beta^2 + 2j\beta R}$$

$$= \frac{g_1 \omega M/\omega^2 C^2}{\sqrt{[(R^2 + \omega^2 M^2 - \beta^2)^2 + 4\beta^2 R^2]}} \quad \ldots \quad (1)$$

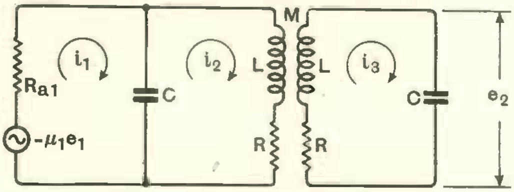

Fig. 2.—*The equivalent circuit of the first stage of the amplifier of Fig. 1.*

It is the variations of e_2/e_1 with small changes in frequency which are of chief importance, and over the limited range covered by the modulation frequencies it is permissible to consider the reactance terms as constant except where the difference of two such terms is involved. Consequently, for many purposes equation (1) can be considered as including only one term variable with frequency, the term β, and in equation (1) it is the value of the denominator which is of chief interest.

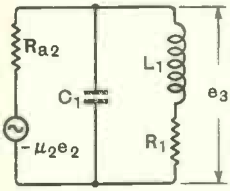

Fig. 3.—*The second stage of Fig. 1 can be represented by this equivalent circuit.*

Now with the circuit of Fig. 3,

$$\frac{e_3}{e_2} = \frac{\omega^2 L_1{}^2 g_2}{\sqrt{R_1{}^2 + \beta_1{}^2}} \quad (2)$$

where $\beta_1 = \omega L_1 - 1/\omega C_1$

$g_2 = \mu_2/R_{a2}$

when $R_{a2} >> \omega^2 L_1{}^2/R_1$ and $\omega L_1 >> R_1$

Consequently

$$\frac{e_3}{e_1} = \frac{g_1 g_2 \omega^5 M L^2 L_1{}^2}{\sqrt{[\{(R^2+\omega^2 M^2-\beta^2)^2+4R^2\beta^2\}(R_1{}^2+\beta_1{}^2)]}} \quad \ldots \quad \ldots \quad (3)$$

$$\frac{e_3}{e_1} = \frac{g_1 g_2 a Q Q_1 \omega^2 L L_1}{\sqrt{[\{(1+a^2-y^2Q^2)^2+4y^2Q^2\}(1+y^2Q_1{}^2)\}]}} \quad \ldots \quad \ldots \quad (4)$$

$$= \frac{g_1 g_2 a Q Q_1 \omega^2 L L_1}{AB}$$

where $\omega M/R = a$

$\omega L/R = Q$

$\omega L_1/R_1 = Q_1$

$y = (\omega^2 LC - 1) = (\omega^2 L_1 C_1 - 1)$

It is the variations of AB which are of chief interest, and in particular the values of y for which it is a maximum or a minimum. These can be found by differentiating AB with respect to y and equating to zero. Performing these operations, the general solutions for y are

$$y = 0$$

$$y = \pm\sqrt{\left[\frac{(2a^2 - 2 - Q^2/Q_1{}^2) \pm \sqrt{[Q^4/Q_1{}^4 + 1 - 14a^2 + a^4 - 2Q^2/Q_1{}^2 + 2a^2Q^2/Q_1{}^2]}}{3Q^2}\right]}$$

and for the particular case when $Q/Q_1 = 2$ this simplifies to

$$y = 0 \text{ or } \pm\sqrt{a^2 - 3}\sqrt{\frac{2 \pm 1}{3}}\Big/Q \quad \ldots \quad (5)$$

The resonance curve is of the type shown in Fig. 4, the central peak occurring for $y = 0$ the two outer peaks for $y = \pm\sqrt{a^2 - 3}/Q$ and the troughs for $y = \pm\sqrt{(a^2 - 3)/3}/Q$

The choice of $Q/Q_1 = 2$ has not yet been justified, and this may readily be done by inserting the different values for y leading to peaks into the expression for AB. When $Q/Q_1 = 2$ equation (4) becomes

$$\frac{e_3}{e_1} = \frac{g_1 g_2 a Q^2 \omega^2 L L_1/2}{\sqrt{[\{(1 + a^2 - y^2Q^2)^2 + 4y^2Q^2\}(1 + y^2Q^2/4)]}} \quad \ldots \quad \ldots \quad (6)$$

$$= \frac{g_1 g_2 a Q^2 \omega^2 L L_1}{2\,AB} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

When $y = 0 \quad AB = (1 + a^2)$ .. .. (8)

When $y = \pm\sqrt{a^2 - 3}/Q \quad AB = (1 + a^2)$

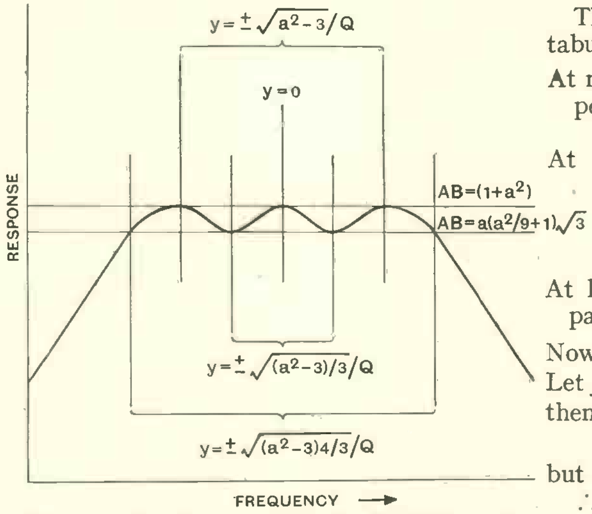

Fig. 4.—*This diagram shows the positions of the peaks and troughs in the resonance curve. When the modulation frequency n is small compared with the carrier frequency f,* $y \simeq 2\,n/f$.

Thus when $Q/Q_1 = 2$ the important result is obtained that all three peaks in the resonance curve have the same height. The response obtained at the troughs is dependent upon the value of AB when

$$y = \pm\sqrt{(a^2 - 3)/3}/Q$$

and for uniformity of response in the pass region it should not be very different from the value obtained when $y = \pm\sqrt{a^2 - 3}/Q$.

When $y = \pm\sqrt{(a^2 - 3)/3}/Q$

$$AB = (a^2/9 + 1)a\sqrt{3} \quad \ldots \quad \ldots \quad (9)$$

Referring to Fig. 4, it can be seen that there are in all four values of y for which the response is equal to that given by equation (9) and that two of them are further removed from resonance than any peaks. It is convenient to make these frequencies the limits of the pass-band and the values of y corresponding to these frequencies must now be determined. The values of y for which $AB = (a^2/9 + 1)a\sqrt{3}$ are obtained by writing

$$(AB)^2 = 3a^2(a^2/9 + 1)^2 = \{(1 + a^2 - y^2Q^2)^2 + 4y^2Q^2\}(1 + y^2Q^2/4)$$

which reduces to

$$(y^2Q^2 + 1 - a^2/3)^2(y^2Q^2 + 4 - 4a^2/3) = 0$$

and the required solution is

$$y = \pm\sqrt{(a^2 - 3)4/3}/Q \quad \ldots \quad \ldots \quad (10)$$

The important values of y can thus be tabulated as follows:

At resonance (centre peak) $\quad y = 0 \quad \ldots \quad \ldots \quad (11)$

At troughs $\quad y = \pm\dfrac{\sqrt{(a^2 - 3)/3}}{Q} \quad \ldots \quad (12)$

At peaks $\quad y = \pm\dfrac{\sqrt{(a^2 - 3)}}{Q} \quad \ldots \quad (13)$

At limits of pass-band $\quad y = \pm\dfrac{\sqrt{(a^2 - 3)4/3}}{Q} \quad \ldots \quad (14)$

Now $y = (\omega^2 LC - 1)$

Let f = the frequency for which $y = 0$

then $y = \{4\pi^2 LC(f \pm n)^2 - 1\}$

$\quad = 4\pi^2 f^2 LC + 4\pi^2 n^2 LC \pm 8\pi^2 fnLC - 1$

but $4\pi^2 f^2 LC = 1$

$\therefore y = (n^2 \pm 2fn)/f^2$

$\quad = (1 \pm 2f/n)n^2/f^2$

$\quad \approx \pm 2n/f$

when $1 << 2f/n$ as is usually the case.

It is possible, therefore, to work directly in terms of the modulation frequency n, and writing n_{PB}, n_P, and n_T for the modulation frequencies corresponding to the limits of the pass-band, the peaks, and the troughs respectively the following relationships can be derived from equations (12), (13), and (14).

$$\left.\begin{aligned} n_{PB} &= \pm\frac{\sqrt{(a^2 - 3)4/3}}{4\pi L/R} \\ n_P &= n_{PB}\sqrt{3}/2 \\ n_T &= n_{PB}/2 \end{aligned}\right\} \quad \ldots \quad (15)$$

Now the ratio P/T of the response at the peak frequencies to that at the trough and limits of the pass-band is of importance in design and is readily obtained from equations (8) and (9).

$$\frac{P}{T} = \frac{(a^2/9 + 1)a\sqrt{3}}{a^2 + 1} \quad \ldots \quad \ldots \quad (16)$$

and the variation of P/T with a is shown in the form of a curve in Fig. 5.

Turning now to amplification, at resonance $y = 0$ and

$$\frac{e_2}{e_1} = \frac{g_1 \omega L Q a}{1 + a^2} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

and this is a maximum when $a = 1$, being

$$\frac{e_2}{e_1}_{\text{max.}} = g_1 Q \omega L/2 \quad \ldots \quad \ldots \quad (18)$$

In the second stage

$$\frac{e_3}{e_2} = g_2 Q_1 \omega L_1 = g_2 \omega L_1 Q/2 \quad \ldots \quad (19)$$

since $\quad Q_1 = Q/2$

The total amplification is thus

$$\frac{e_3}{e_1} = \frac{g_1 g_2 Q^2 \omega^2 L L_1 a}{2(1 + a^2)} \quad \ldots \quad \ldots \quad (20)$$

Equations have now been developed which enable the performance of any filter of this type to be readily calculated. In practical design, however, it is the reverse which is more often required; it is necessary to be able to calculate the circuit values to give the required performance. This is not always so easily accomplished, but fortunately there is no difficulty in this case and the equations already given can readily be turned into suitable form. In order to design a filter it is necessary to know the resonance frequency f, the maximum modulation frequency n_{PB} corresponding to the limit of the pass-band, the permissible variation in response between the peaks and troughs of the filter, the mutual conductance of the valves, and the gain required from each stage. In the case of the stage embodying coupled circuits the gain will depend on the coupling and should usually be taken at optimum coupling ($a = 1$) for a filter with variable coupling, otherwise the gain with this coupling may exceed expectations and lead to difficulties from feed-back effects.

From equation (15)

$$\frac{L}{R} = \frac{\sqrt{(a^2 - 3)4/3}}{4\pi n_{PB}} \quad \ldots \quad \ldots \quad (21)$$

whence $Q = 2\pi f L/R \quad \ldots \quad \ldots \quad (22)$

and $\quad Q_1 = Q/2 \quad \ldots \quad \ldots \quad \ldots \quad (23)$

From equations (17), (21), and (22)

$$L = \frac{(e_2/e_1)(1 + a^2)}{g_1 a \omega Q} \quad \ldots \quad \ldots \quad (24)$$

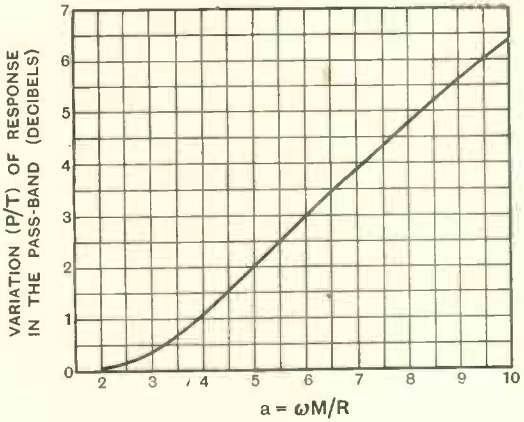

Fig. 5.—*The variation in response in the pass-band depends upon the value assigned to the coupling factor a.*

which reduces to

$$L = \frac{2e_2/e_1}{g_1 \omega Q} \text{ when } a = 1 \quad \ldots \quad (25)$$

From (21) and (24), R can be evaluated and since $a = \omega M/R$

$$M = aR/\omega \quad \ldots \quad \ldots \quad (26)$$

and, of course, $C = 1/\omega^2 L \quad \ldots \quad \ldots \quad (27)$

From (19)

$$L_1 = \frac{2e_3/e_2}{g_2 \omega Q} \quad \ldots \quad \ldots \quad \ldots \quad (28)$$

$$C_1 = 1/\omega^2 L_1 \quad \ldots \quad \ldots \quad (29)$$

$$R_1 = \omega L_1/Q_1 \quad \ldots \quad \ldots \quad (30)$$

As an example, take the case where

$g_1 = g_2 = 2 \times 10^{-3}\ A/V.$
$e_2/e_1 = 50$ when $a = 1$
$e_3/e_2 = 100$
$f = 4.65 \times 10^5\ c/s$
$n_{PB} = 10^4\ c/s$
$P/T = 1$ db.

From Fig. 5, $a = 3.9$ for $P/T = 1$ db. consequently equations (21) to (30), give $L/R = 3.2 \times 10^{-5}$, $Q = 93.5$, $Q_1 = 46.75$, $L = 380\ \mu\text{H.}$, $R = 11.9\Omega$, $M = 15.9\ \mu\text{H.}$, $C = 308\ \mu\mu\text{F.}$, $L_1 = 367\ \mu\text{H.}$, $R_1 = 22.9\Omega$, and $C_1 = 319\ \mu\mu\text{F.}$

Using these values, the gain of the first stage is 50 times when the coupling is optimum. As the coupling is increased to broaden the band-width the gain falls and becomes 24.1 times when $a = 3.9$, as may readily be calculated from equation (17). This variation is less important than might be thought at first, for in practice the full band-width and the full sensitivity are rarely required together; interference will usually prevent the full band-width from being used on any but strong signals.

The performance to be expected from an amplifier of the type shown in Fig. 1 with the circuit values just derived is shown by the curves of Fig. 6, which have been calculated with the aid of equation (4). It can be seen that when $a = 3.9$ the response only varies in the ratio of 1 : 1.2 (1 db.) for frequencies up to ± 10,000 c/s away from resonance, but that for frequencies further removed from resonance the selectivity is quite good. As the coupling is reduced the pass-band is narrower and the variations within it are smaller as shown by the curve for $a = 3.0$. When $a \leqslant 1$ the band-pass effect disappears completely and the conventional resonance curve for loosely coupled circuits is obtained.

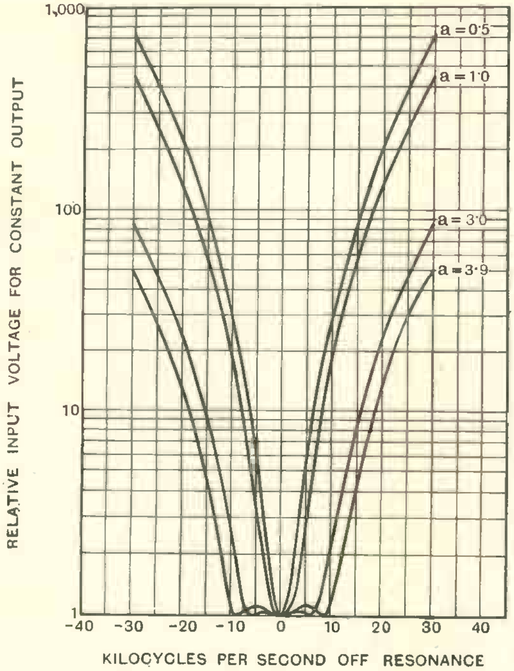

Fig. 6.—*Resonance curves showing the effect of varying the coupling between two coupled coils.*

It can be seen that if the coupling be made variable over the range of $a = 0.5$ to $a = 3.9$, a very wide variation in selectivity is secured, the input necessary at ± 10,000 c/s off resonance for constant output varying from 29.2 to 1.2 times that needed at resonance. With the circuit values suitable for this particular case this means a variation in mutual inductance of 2.04 μH. to 15.9 μH., which is by no means difficult to obtain. The variation of selectivity is, of course, accompanied by a change in the amplification and this is shown in Fig. 7. When $a = 0.5$ the gain is 80 per cent. of its maximum value, which is secured when $a = 1$. On further increasing the coupling the gain falls, and becomes 48 per cent. when $a = 3.9$, the maximum coupling used in the case under consideration. In practice, the change in amplification with coupling is not very important, for when the receiver is tuned to a station the automatic volume control system very largely compensates for it. There is, furthermore, an effect due to the change in quality which largely offsets it. When the coupling is so adjusted that the gain is optimum there is a considerable degree of sideband cutting and the reproduction is lacking in the higher modulation frequencies. When the coupling is increased the gain falls, but the sideband cutting is reduced. Now the apparent volume depends very largely upon the frequency response and if the gain of an amplifier be maintained constant and the high-frequency response changed, the greatest apparent volume is secured with the full high-frequency response. This effect, therefore, tends to compensate for the changes in amplification found when the coupling is increased beyond the optimum, and it is probable that with the levelling provided by A.V.C. the volume will appear to increase with the coupling! When the coupling is varied below optimum, of course, this effect has the reverse action, for then the sideband cutting increases as the gain falls.

The practical use of filters of this nature must now be considered. An examination of Fig. 6 shows that at least two such filters will usually be needed to provide adequate selectivity, for with a single filter with $a = 0.5$ the response is 29.5 times down at ± 10 kc/s off resonance and a drop to 1,000 times is usually considered necessary in a selective receiver. Obviously two filters will provide nearly this degree of selectivity and the problem is how best to arrange them in practice. It is clear that if arranged on the lines of Fig. 1 the number of valves necessary will be excessive for many purposes, and it has consequently been suggested that they be arranged as two conventional variably-coupled pairs to give the side peaks with a third pair of circuits of $Q/2$ with fixed loose coupling, as shown in Fig. 8, for the central peaks. This will, of course, only lead to the correct results if the coupling of the fixed pair be very loose so that the resonance curve of this transformer approximates to the square of that of a single circuit of $Q/2$. Now this is the one point in a receiver where the use of optimum coupling is desirable. It is the modern practice to operate the detector V_3 at a large input, and as this valve often provides A.V.C. the detector input may be very large on a strong signal. It is often difficult to obtain sufficient undistorted output from the last I.F. valve V_2 even under conditions of an efficient transfer of energy to V_3, and it will obviously be much more difficult to obtain it if the coupling in the transformer be loose, as it must be for the filter conditions as a whole to be approximately fulfilled. The position is, of course, greatly eased if the A.V.C. circuit be fed from the primary of this last I.F. transformer, and this is rapidly becoming standard practice.

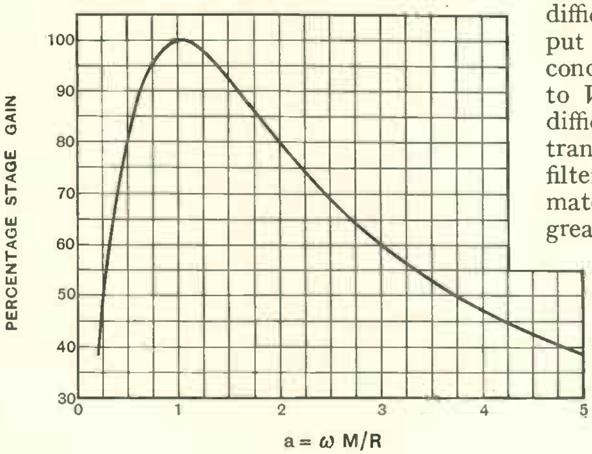

Fig. 7.—*The variation of amplification with coupling is shown by this curve.*

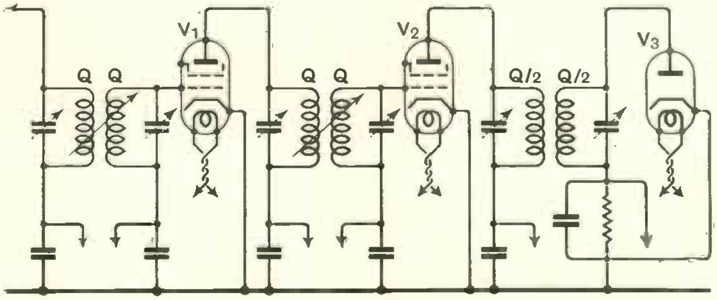

Fig. 8.—*One method of connecting six tuned circuits in an amplifier. For the correct results the fixed-coupled pair must be loosely coupled.*

The difficulty cannot be got over by transferring this transformer to a previous stage and employing one with variable coupling between V_2 and V_3, for in this stage the circuits are damped by the detector and A.V.C. system. In order to obtain the correct value of Q for the circuits under operating conditions, therefore, the coils in this transformer would have to be exceptionally, and perhaps impossibly, good. If the arrangement of Fig. 8 be adopted, however, this difficulty solves itself, for circuits of only one-half the normal Q are needed in the coupling to the detector, and it will often be possible to use the same coils as in the earlier circuits and to adjust the detector input resistance to provide the requisite damping.

In view of these points it will be apparent that although the system provides a good solution to the problem of obtaining variable selectivity, it is not an ideal one unless the detector conditions are such as to permit sufficiently loose coupling to be used in the filter preceding it. This is even more evident when greater selectivity is needed than can be obtained from a total of six tuned circuits. If the correct response is to be maintained the number of circuits used must be a multiple of three, so that nine circuits are needed to give increased selectivity. The addition of three tuned circuits to the system of Fig. 8 will call for two extra valves if they are to be properly separated from the other circuits, and it is obvious that the receiver will become impracticably large for any ordinary needs. Two I.F. stages can provide all the amplification normally required and the use of four I.F. valves seems very wasteful. There is no doubt, however, that higher selectivity than can be obtained with the six circuits of Fig. 8 is often necessary, and in this connection it should be pointed out that although the curves of Fig. 6 are calculated for a frequency of 465 kc/s, they hold at any frequency provided that L/R is maintained constant. It is thus no solution of the selectivity problem to employ a lower intermediate frequency, for the Q of the tuned circuits will have to be reduced to prevent an increase in the variation of response in the pass-band.

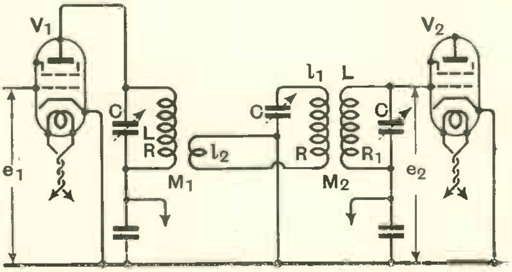

Fig. 9.—*An arrangement of three coupled circuits simulating the circuit of Fig. 1; for a close approximation M2 must be very small.*

Now it will be apparent that the real difficulty with this system lies in the need for isolating the single circuit, which corrects for the double-humped response of the coupled circuits alone, from the coupled circuits themselves, for an increase in the number of circuits leads to an addition of two valves for every three circuits. If it were possible to dispense with this isolation and employ three circuits coupled together the position would be greatly relieved, for every three circuits added would need only one extra valve and moreover the position as regards the detector coupling would be easier. It is important, therefore, to investigate in detail the characteristics of three coupled circuits.

The system under consideration is shown in Fig. 9 and the basic circuit in Fig. 10, to which the following equations for the circuit conditions apply, if $l_1 + l_2 = L$

$$\begin{aligned} -\mu e_1 &= i_1 Z_1 - j i_2/\omega C \\ 0 &= i_2 Z_2 - j i_1/\omega C - j\omega M_1 i_3 \\ 0 &= i_3 Z_3 - j\omega M_1 i_2 - j\omega M_2 i_4 \\ 0 &= i_4 Z_4 - j\omega M_2 i_3 \\ e_2 &= -j i_4/\omega C \end{aligned}$$

whence

$$\frac{e_2}{e_1} = \frac{\mu M_1 M_2/C^2}{Z_1\{Z_2(Z_3 Z_4 + \omega^2 M_2^2) + \omega^2 M_1^2 Z_4\} + \{(Z_3 Z_4 + \omega^2 M_2^2)/\omega^2 C^2\}} \quad (31)$$

where

$$\begin{aligned} Z_1 &= R_a - j/\omega C \approx R_a \text{ when } R_a >> 1/\omega C \\ Z_2 = Z_3 &= R + j\omega L - j/\omega C = R + j\beta \\ Z_4 &= R_1 + j\omega L - j/\omega C = R_1 + j\beta \end{aligned}$$

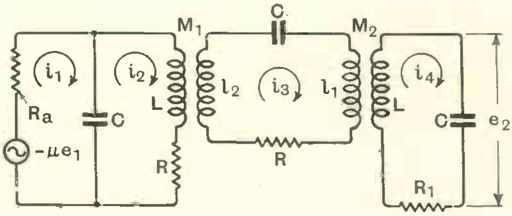

Fig. 10.—*The equivalent circuit of Fig. 9 is shown here.*

Consequently, when $g = \mu/R_a$

$$\frac{e_2}{e_1} \approx \frac{g M_1 M_2/C^2}{(R+j\beta)\{(R+j\beta)(R_1+j\beta)+\omega^2 M_2^2\} + \omega^2 M_1^2 (R_1 + j\beta)} \quad (32)$$

when the terms in the right-hand bracket in the denomination of equation (31) are small compared with those in the left-hand bracket.

Writing
$$\begin{aligned} a_1 &= \omega M_1/R \\ a_2 &= \omega M_2/R \\ Q &= \omega L/R \\ y &= (\omega^2 LC - 1) \end{aligned}$$

equation (32) reduces to

$$\frac{e_2}{e_1} = \frac{ga_1a_2\omega LQ}{\sqrt{[\{R_1/R + a_1^2R_1/R + a_2^2 - y^2Q^2\,(2 + R_1/R)\}^2 + y^2Q^2\{1 + 2R_1/R + a_1^2 + a_2^2 - y^2Q^2\}^2]}} \quad (33)$$

$$= ga_1a_2\omega LQ/A \quad \ldots \quad \ldots \quad \ldots \quad (34)$$

Now if all three circuits be made identical and the couplings be made the same and varied together, a three-peaked response curve will be obtained if the coupling be great enough[1], but the centre peak will be higher than the others and the ideal to be aimed at is that of approximate equality. Inspection of the circuits of Figs. 1 and 9 shows that if the coupling to the third circuit of the latter be made loose enough the shape of the response curve will approximate to that given by the arrangement of Fig. 1. It can be seen, therefore, that the results of the system of Fig. 1 are likely to be approached by those of Fig. 9 by making M_2 fixed and small, and that if M_2 be small enough approximate equality of peaks will be obtained by making $2R = R_1$ as before. Inserting this value in equation (33)

$$A = \sqrt{[4(1 + a_1^2 + a_2^2/2 - 2y^2Q^2)^2 + y^2Q^2(5 + a_1^2 + a_2^2 - y^2Q^2)^2]} \ldots \quad (35)$$

differentiating with respect to y, equating to zero, and solving for y we have

$$y = 0$$

$$\text{and } y = \pm\sqrt{\left[\frac{(a_1^2 + a_2^2 - 3)}{3Q^2}\left\{2 \pm \sqrt{1 - \frac{24a_2^2}{(a_1^2 + a_2^2 - 3)^2}}\right\}\right]} \ldots \quad (36)$$

Unfortunately there is no general solution to this equation, so that the procedure must be different from that adopted in the case of the system previously described. It is clear, however, that if a_2 be small an approximate solution can be obtained which will be nearly the same as for the first system. It will be remembered that with that arrangement the Q of the circuits was determined on the basis of the permissible variation in the pass-band and that the other circuit constants followed from this. In this case there is an extra variable, the coupling to the third circuit, and as a weak coupling leads to the nearest approximation to the results of the first system, it is clear that it will pay to make the tuned circuits of as high dynamic resistance as possible and to control the amplification by means of the coupling. This scheme will lead to the loosest coupling possible for a given degree of amplification and hence give the nearest approximation to the results with the first system. This will only be true, however, provided that the relation $\omega LQ >> R_a$ is still maintained.

Now for a given value of Q the dynamic resistance is proportional to the inductance, so that, assuming that the required Q can be obtained with any inductance, it will pay to use as high an inductance as possible. In the limit, the inductance which can be used depends upon the minimum circuit capacities, and the capacity which must be allowed in the trimmers to compensate for the inevitable circuit variations. In the case of the first circuit of Fig. 9, the capacity will include the output capacity of V_1, about 12 $\mu\mu$F. for an average valve, the self-capacity of the coil, about 10–15 $\mu\mu$F., and the stray wiring capacities some 5–10 $\mu\mu$F. The total capacity apart from the trimmer is thus likely to be about 27–37 $\mu\mu$F. In the second circuit there is no valve capacity and wiring capacities are likely to be smaller, so that the total will be only about 12–22 $\mu\mu$F. In the third circuit the capacities will be of the same order as those in the first save that the input capacity of V_2 will be about 2–3 $\mu\mu$F. higher than the output capacity of V_1; the capacity of this circuit, therefore, will be some 29–40 $\mu\mu$F. If the same values of inductance be used in each circuit the trimmers must have sufficient capacity to compensate for variations in capacity between the circuits. The trimmers themselves will have a minimum capacity which must be taken into account, and in the case of air-dielectric components this is usually 3 $\mu\mu$F. It is necessary, therefore, to legislate for a minimum circuit capacity of 15 $\mu\mu$F. and a maximum of 43 $\mu\mu$F., including the minimum capacity of the trimmer.

The coils, however, will not have exactly the same inductance values and the trimmer capacity must also correct for the variations in inductance. The latitude allowed will

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[1] "The Analysis and Design of a Chain of Resonant Circuits," by M. Reed, M.Sc., A.C.G.I., D.I.C., *The Wireless Engineer*, May and June, 1932.

naturally depend upon the accuracy with which the coils are matched. In commercial production accurate matching appreciably increases the cost, and as ganged tuning is not involved its absence does not very greatly affect the performance. An accuracy of ± 5 per cent. is probably sufficient and is readily obtained in practice.

For convenience in estimating the effect on capacity the variation may be taken as one of capacity and it can be seen that a maximum capacity of 46 $\mu\mu$F. must be permitted and the trimmer must have a variation of not less than 31 $\mu\mu$F. For resonance at 465 kc/s this calls for an inductance of 2,550 μH. In the foregoing, however, only the likely circuit variations in the particular arrangement of Fig. 9 have been allowed for, and it must not be forgotten that the filter may not always be used in this particular way. With battery valves and with diode detectors the valve capacities are usually smaller, while in certain cases screening of leads may render the total capacity higher than these figures. To leave a factor of safety, therefore, it is wise to choose a somewhat lower value of inductance and 2,000 μH. seems a suitable maximum figure. The capacity for resonance is 58.8 $\mu\mu$F. and as the minimum circuit capacity is of the order of 15 $\mu\mu$F., a trimmer giving a variation of 60 $\mu\mu$F. will give an ample range of 15–75 $\mu\mu$F., and permit the stray capacities to vary between zero and 58.8 $\mu\mu$F. Thus in practice it is only necessary to make sure that the maximum circuit capacity, including the figure allowed for inductance variations, does not exceed 58.8 $\mu\mu$F.

The best method of evaluating the values of components to give the requisite performance is to assume values of inductance and stage gain and to use these values to simplify the formulae concerned.

At resonance, when $y = 0$, equation (33) becomes

$$\frac{e_2}{e_1} = \frac{g a_1 a_2 \omega L Q}{2(1 + a_1^2 + a_2^2/2)} \quad .. \quad (37)$$

Differentiating with respect to a_1 and equating to zero

$$a_1^2 = 1 + a_2^2/2 \quad .. \quad .. \quad (38)$$

for a maximum value of e_2/e_1.

Inserting this value of a_1 in equation (37)

$$\frac{e_2}{e_1} = \frac{g a_2 \omega L Q}{4\sqrt{1 + a_2^2/2}} = \frac{g \omega L Q}{2\sqrt{2(2/a_2^2 + 1)}} \quad .. \quad (39)$$

Consequently,

$$a_2 = \frac{4\, e_2/e_1}{\sqrt{[g^2 Q^2 \omega^2 L^2 - 8\,(e_2/e_1)^2]}} \quad .. \quad (40)$$

Now although the coil inductance can be selected in the manner already described and the stage gain can be fixed at any convenient figure, a value for a_2 cannot be found without knowing Q. If equation (36) be examined, however, it can be seen that it will reduce to equation (5) when a_2 is very small. It is necessary to make a_2 as small as possible consistent with the required amplification if the performance of the original system is to be approached, so that equation (5) may be taken as an approximate solution of equation (36) and the value of Q found for the previous system may tentatively be used in this case also. For reproduction up to 10,000 c/s with a variation 1 db. in the pass-band it was found that $Q = 93.5$. If a stage gain of 50 be assumed, the following values may be inserted in equation (41)

$e_2/e_1 = 50$
$L = 2 \times 10^{-3}$ H.
$Q = 93.5$
$g = 2 \times 10^{-3}\ A/V$
$f = 4.65 \times 10^5$ c/s.

Then

$$a_2 = 0.185$$

The insertion of this value in equation (36) gives

$$y = \pm\sqrt{\left[\frac{(a_1^2 - 2.986)}{3Q^2}\left\{2 \pm \sqrt{1 - \frac{0.336}{(a_1^2 - 2.986)^2}}\right\}\right]}$$

The value of a_1 previously found was 3.9. Inserting this in the above equation

$yQ = \pm\ (3.48 \text{ or } 2.038) = 4.02 \times 10^{-4} n$
$n = \pm\ (8650 \text{ or } 5060)$ to slide rule accuracy.

$\therefore n_p = \pm\ 8650$ c/s
$n_r = \pm\ 5060$ c/s.

The values of n_p and n_r for the original circuit were found to be 8,660 c/s and 5,000 c/s respectively. For any practical design purposes, the error is negligible, and provided that a_2 be small, the relevant formulae of the first circuit can be employed in the determination of component values. The starting point in design is a knowledge of the pass-band required, the permissible variation in it, the frequency, the coil inductance and tuning capacity, the mutual conductance of the valve, and the stage gain required.

The first step is to evaluate a_1 from Fig. 4 and then to calculate L/R from equation (21). Equations (22) and (23) then give Q and Q_1, while a_2 is calculated from (40). The stage gain is, of course, for the optimum value of a_1 and the corresponding value of a_1 is given by equation (38). Since L/R and L are known R can be obtained and $R_1 = 2R$ by definition. Then $M_1 = a_1R/\omega$ and $M_2 = a_2R/\omega$. The validity of the results should be checked by solving (36).

If the same example as before be taken namely

$$g = 2 \times 10^{-3}\ A/V.$$

$$e_2/e_1 = 50 \text{ at } a_{1\,\text{opt.}}$$

$$f = 4.65 \times 10^5 \text{ c/s.}$$

$$n_{PB} = 10^4 \text{ c/s.}$$

$$P/T = 1 \text{ db.}$$

$$L = 2 \times 10^{-3}\ H.$$

the following values for the circuit constants result.

$L/R = 3.2 \times 10^{-5}$	$R = 62.5\ \Omega$
$Q = 93.5$	$R_1 = 125\ \Omega$
$Q_1 = 46.75$	$M_1 = 83.5\ \mu$H. for $a_1 = 3.9$
$a_1 = 3.9$	$M_1 = 21.55\ \mu$H. for $a_1 = 1.0084$
$a_{1\text{opt.}} = 1.0084$	$M_2 = 3.96\ \mu$H.
$a_2 = 0.185$	$C = 58.8\ \mu\mu$F.

In order fully to justify this method of calculation, which is undoubtedly open to criticism on exact scientific grounds, but which has the great practical merit of permitting the rapid evaluation of circuit values with sufficient accuracy for practical purposes, the resonance curve for the foregoing values has been calculated from equation (33) and is shown in Fig. 11. It is instructive to compare the curves for $a = 3.9$ in Figs. 6 and 10 for the two-stage plus single circuit and three-stage filters respectively. The calculations involved have been made to slide-rule accuracy only, but the tendencies shown are the expected. As nearly as can be read on the curves, the peaks and troughs occur at the same frequencies, but the side peaks are not quite as prominent in the case of the three-stage filter. With the first circuit the three peaks are at the same level, but in the case of the second about 1.05 times the input is necessary for the same output as at resonance. At 30 kc/s off resonance the input must be increased by 49.5 times with the first circuit, but by 46.6 times with the second.

It can be seen, therefore, that, as one might expect, the effect of coupling the third tuned circuit to the coupled pair, instead of isolating it, is to reduce the selectivity and to make the centre peak more prominent than the others instead of being equal to them. In this case, by virtue of the loose coupling adopted, the effect is negligible and is less than the variations to be expected in practice due to changes in component values from those calculated and to the effects of

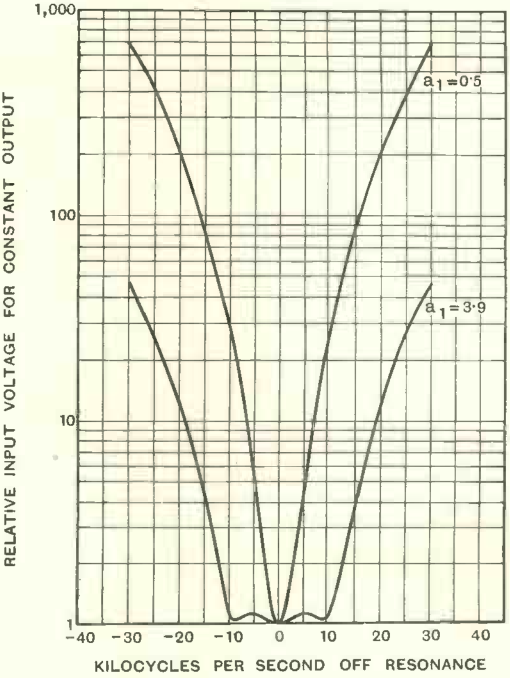

Fig. 11.—*Resonance curves illustrating the performance of the circuit of Fig. 9.*

stray couplings. It should be noted that it is improbable that a closer approach to the first system could be obtained by making Q_1 have a different relationship to Q. The selectivity of the two systems could be equalised by increasing Q_1, but this will increase the variation in the pass-band. For equality here a lower value of Q_1 would be needed, but this would increase the difference in selectivity.

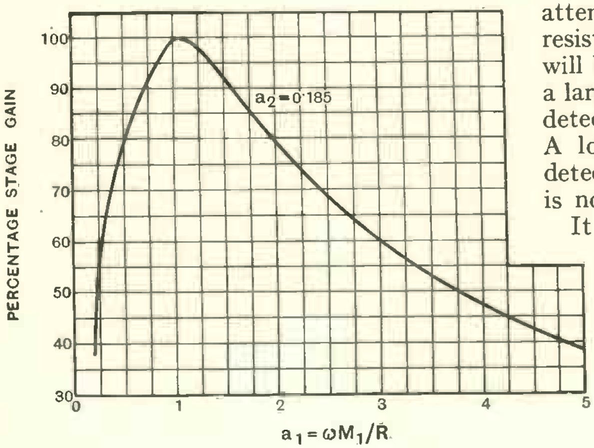

Fig. 12.—*The variation of amplification with coupling for the three-circuit filter.*

When a_1 is reduced in the three-stage filter the selectivity increases in the same way as when the circuits are separated and for the same values of coupling in the two cases the selectivity is very slightly lower with the three-stage filter. The variation in amplification with a_1 is very nearly the same as with the first system as shown by the curve of Fig. 12.

It is now necessary to consider how such a three-stage filter is best used in practice. The three-circuits are basically the same except for the resistance of the third. Where the filter is used to couple two I.F. stages, or a frequency-changer to an I.F. valve, the H.F. resistance of the third circuit must be deliberately increased above that of the others, for the input and output resistances of such stages are usually high. Where the filter is used to couple an I.F. valve to a detector, however, the third circuit will be damped by the input resistance of the detector and it may be possible to arrange for this resistance to be of the right value for making $Q_1 = Q/2$. This applies also to the case where the transformer is used to feed an amplifier of definite input resistance such as the double-triode system due to Colebrooke[2]. The transformer will be most generally useful, therefore, built with identical circuits and the resistance of the third circuit increased by external loading. This external load most conveniently takes the form of a shunt resistance across the output terminals equal in value to the dynamic resistance, or ωLQ. In the case discussed this is a resistance of 0.545 MΩ. If it be attempted to make the detector input resistance serve, a load resistance of 1.09 MΩ will be needed for a diode detector, for with a large input the input resistance of a diode detector is one-half the D.C. load resistance. A load of 1 MΩ is unusually high for a detector in a high-quality receiver, but it is not always impossibly so.

It should be remembered, of course, that the formalae given in this article take no account of the effects of those stray couplings in a receiver which may cause regeneration or degeneration, whether they be due to imperfect screening and decoupling or to the grid-anode interelectrode valve capacity. The latter is bound to have some effect and will tend to increase the stage gain, make the resonance curve asymmetrical, decrease the width of the pass-band, and increase the variations within the pass-band. It is not intended to discuss this question in any detail here, for it has already been very fully treated in the pages of this journal[3]. The input impedance of a valve having a resonant load and an appreciable grid-anode capacity, however, will change greatly with small changes in frequency about resonance. The impedance can be considered as made up of a reactance and resistance in parallel, each having values which change in a com-

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[2] "A Study of the Possibilities of Radio-Frequency Voltage Amplification with Screen-Grid and with Triode Valves," by F. M. Colebrook, B.Sc., *Journ. I.E.E.*, February, 1934.

[3] "The Grid-Anode Capacity of Valves," by M. O'Connor Horgan, M.Sc., *The Wireless Engineer*, September, 1934.

plex manner with frequency. The changes in reactance are likely to broaden the response of the input circuit, for the variations are such that they can be represented by a condenser, the capacity of which is a function of frequency. Over a small range of frequencies close to resonance, therefore, the third filter circuit is resonant to any frequency within that very small band, for the circuit capacity is automatically changed the appropriate amount. The input resistance varies greatly with frequency and is positive on one side of resonance and negative on the other. Degeneration will consequently occur on one side of resonance and regeneration on the other, with disastrous effects on the symmetry of the resonance curve.

It is no complete solution to correct for the feed-back by decreasing the value of the shunt resistance to the third filter circuit, for although instability may be prevented in this way, the loading on the filter will still vary with small changes in frequency. The true solution is to employ a type of amplifier stage which has an input impedance which is constant, or nearly so, with small changes in frequency. Such a stage is obtained when the valve following the filter has a non-resonant load impedance, and the Colebrooke double-triode amplifier should be entirely free from the defects which have just been discussed. The input impedance of a stage of this nature can be made to have almost any desired value and it is nearly constant with small changes in frequency if the load of the first valve of the pair be correctly designed. It is not, of course, essential to use triodes with this system, and tetrodes or pentodes are equally applicable and show some advantage.

It should be pointed out that these feed-back effects are not peculiar to the types of coupling dealt with in this article, but are found with all types of tuned intervalve couplings. The effects become more noticeable, however, with any increase in perfection in the width and flatness of the pass-band of the amplifier, so that they are likely to be more important with the more perfect types of filter discussed here than with the coupled pairs of tuned circuits conventionally employed.

It is worthy of mention that when a screen-grid or pentode valve is both preceded and followed by a three-stage filter, the effects of the valve capacity will be more complex than those described above. The load on the valve when tight coupling is used will have two resonance frequencies, both of which are different from the central frequency of the pass-band. Consequently, there will be several bands of frequencies for which the input resistance is positive and others for which it is negative.

It may be remarked that the double-triode amplifier, although ideal for following a filter, does not lend itself to use before a filter designed from the data in this article, for the output resistance of the amplifier is the A.C. resistance of the second valve, and if a triode be used is likely to be some 3,000–30,000 ohms. The effect of this resistance on the filter must be taken into account and will undoubtedly lead to a considerable modification of the design. From the point of view of input impedance, however, triodes are by no means essential with the Colebrooke amplifier, although they may be desirable when a large voltage output is needed. If screen-grid or pentode valves be used, there is no reason why the filter should not follow such an amplifier as well as precede it.

Although the primary purpose of this article has now been accomplished, namely, the description of the theory and practice of a new type of I.F. coupling device, the results which are obtained in a practical amplifier depend so much on the design of that amplifier as distinct from the filters that the writer deems it advisable to enter as briefly as possible into the rather large subject of I.F. amplifier design. Only the case of amplifiers for high quality receivers will be considered, for it seems unlikely that adequate amplification can be secured from a single I.F. stage using the three-circuit filters, and in small receivers the distortion introduced by other stages is likely to be such that there is no point in retaining the highest audible frequencies, and a simpler form of I.F. transformer will then give sufficiently good results and higher amplification.

(*To be continued.*)

Retroaction in Audio Amplifiers*

By Matei Marinesco

(Electrical Communication Research Laboratory of the Polytechnic School, Bucharest)

In a previous article† it was shown that retroaction can successfully be employed in audio frequency amplifiers to improve efficiency and frequency distortion characteristics of such amplifiers. Non-linear distortion was not then dealt with.

We shall now take into account this distortion and prove that it can also be removed by suitable retroaction.

Theoretical Consideration

Let us consider the circuit of Fig. 1, where :

R_e = resistance of the load (electromechanical receiver device) on the valve; it is through this resistance that alternating electrical power delivered by the valve is converted into mechanical or acoustic power.

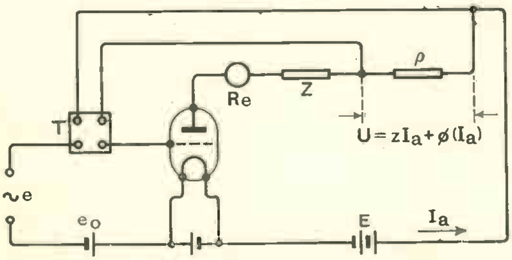

Fig. 1.

Z = impedance of the load on the valve; this impedance has 2 components, a real one in phase with the current, which accounts for iron losses, and an imaginary one in quadrature with the current, which accounts for the self-induction of the windings of the electro-mechanical receiver device, excited by the valve. It is this impedance which causes frequency distortion of current in the valve amplifier anode circuit, as it varies with frequency: $Z = f(\omega)$; it also reduces the sensitivity of the valve, for we need larger grid e.m.f. to produce the same anode current as in the ideal case where this impedance is missing.

ρ = compensation impedance, the components of which will be given later.

T, coupling transformer of ratio $\mu = \frac{n_2}{n_1}$, n_2 being the number of turns of secondary (in grid circuit), n_1 being the number of turns of primary (in anode circuit).

Between grid tension V_g, anode tension V_a and anode current I_a we have the well-known relation :

$$V_a + kV_g = F(I_a)\,; \quad .. \quad .. \quad \text{(a)}$$

k being the amplification factor of the valve and F a function of the anode current I_a. On the other side, supposing that ρ is small with respect to Z and R_e, :

$$V_a = E - (Z + R_e)I_a. \quad .. \quad .. \quad \text{(b)}$$

If T is an ideal transformer and the connections with the valve circuits (grid and anode) are such that the e.m.f. μu (u being the variable part of the p.d. at ρ) induced in the grid circuit is in phase with e (applied grid e.m.f.) we can also write :

$$V_g = -e_0 + e + \mu u. \quad .. \quad .. \quad \text{(c)}$$

Eliminating V_a and V_g among these 3 relations (a), (b), (c) we get :

$$\text{(a}_1\text{)} \quad .. \quad F(I_a) = E - R_eI_a - ZI_a + ke - ke_0 + \mu ku.$$

If $I_a = I_0 + i_a$, and $i_a < I_0$, where I_0 is the mean anode current, and i_a the superimposed alternating current, and if we separate in (a_1) alternating from constant terms by expanding $F\ (I_a)$ in series (Taylor), we obtain for the alternating terms the relation :

$$ke = R_e i_a + \left[F' i_a + \frac{F''}{2} i_a^2 + \ldots\right] + Z i_a - k\mu u \quad .. \quad .. \quad (\text{a}_2)$$

Now suppose ρ small with respect to the impedance of primary of T, and composed of an impedance z in series with a resistance varying with the current I_a flowing through it (it may be, for instance, a copper oxide rectifier, or any other suitable detector).

Under these conditions the p.d. U across ρ will be :

$$U = zI_a + \phi(I_a)\,; \quad .. \quad .. \quad \text{(d)}$$

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

† M. Marinesco : "Frequency and Phase Distortion," July, 1935.

ϕ being a function of I_a representing the p.d. across the resistance varying with the current.

Substituting $I_0 + i_a$ for I_a in (d) and separating again alternating from constant terms, by expanding $\phi(I_a)$ in series (Taylor), we get for the alternating terms the relation :

$$u = zi_a + \phi' i_a + \frac{\phi''}{2} i_a^2 + \ldots \quad (\mathrm{d}_1)$$

Substituting this value of u in relation (a_2) we obtain :

$$ke = R_e i_a + (Z - \mu kz) i_a + (F' - \mu k\phi') i_a + \tfrac{1}{2}[F'' - \mu k\phi''] i_a^2 + \ldots . \quad (\mathrm{a}_3)$$

now if we make :

(1) $Z = \mu kz$; (2) $F' = \mu k\phi'$; $F'' = \mu k\phi''$; . . etc., we see that we obtain finally :

$$i_a = \frac{ke}{R_e} \quad \ldots \quad \ldots \quad (\mathrm{a}_4)$$

All happens in the anode circuit as if the e.m.f. ke of the valve has to do in this circuit with only the resistance R_e of the load on the valve. All kinds of anode current distortions are cancelled. In the same circuit, without retroaction, the current is given by :

$$i_a = \frac{ke}{R_e + Z + \left[F' + \frac{F''}{2} i_a + \ldots\right]} \quad \ldots \quad (\mathrm{a}_5)$$

where $(F' + \frac{F''}{2} i_a + \ldots)$ is usually designed by R_i (internal resistance of valve). This relation can immediately be deduced from (a_2) by putting $\mu = 0$.

Let us now consider for a moment the two conditions (1) and (2). Condition (1) concerns the frequency distortion compensation and gives us the value of the compensation impedance z, so that this kind of distortion completely vanishes ; the case was treated in detail in the previous article (†).

As regards condition (2) we must distinguish between the first relation, *i.e.*, $F' = \mu k\phi'$, and the others.

Relation $F' = \mu k\phi'$ concerns the compensation of the internal resistance $F' I_0$ of the valve for $I_a = I_0$; graphically it represents the slope of the tangent to the curve : $V_a = F(I_a)$ for $I_a = I_0$ so that we may also state, according to this relation, that the two curves : $V_a = F(I_a)$ and $U' = \mu kU = \mu k\phi(I_a)$ must have the same slope for $I_a = I_0$.

The other equalities concern the non-linear distortion compensation, and if these are also fulfilled the terms in i_a^2, i_a^3 . . . etc. disappear from relation (a_3) ; translating this into geometrical language we may state that the two curves $V_a = F(I_a)$ and $U' = \mu kU = \mu k\phi(I_a)$ must have identical shapes in the proximity of $I_a = I_0$. Analytically, we may also say that the larger the current oscillations about I_0 the greater the number of equalities (2) which must be fulfilled for a given non-linear distortion factor of i_a.

Experimental Proofs

Experiments to prove non-linear distortion compensation by suitable retroaction were carried out as follows. The non-linear distortion factor of anode current in a valve was measured by a non-linear distortion-factor meter at 400 c.p.s., when a 400 c.p.s. pure sine wave e.m.f. was applied to the grid :

(a) First without retroaction ; (b) secondly by linear retroaction ; and (c) thirdly by non-linear retroaction obtained through a copper oxide rectifier and the results compared.

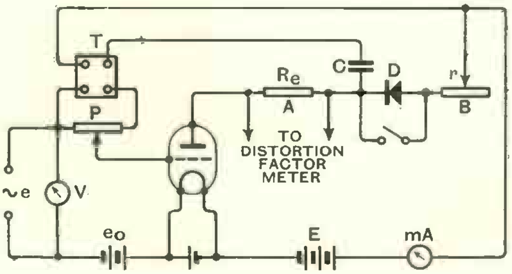


Fig. 2.

The circuit used for this is to be seen in Fig. 2. D is the copper oxide rectifier, r a variable resistance, and P a potential divider of 1MΩ, by which the degree of retroaction could be varied by taking a fraction of the total p.d. μu fed back to the grid through T. The distortion factor meter was a "General-Radio" instrument with a very high input impedance, acting therefore as a voltmeter giving by direct reading for a 400 c.p.s. alternating p.d. applied to the input, the value of:

$$\frac{\sqrt{a_1^2 + a_2^2 + a_3^2 + \ldots}}{a_0},$$

a_1, a_2, . . . etc., being the amplitudes of the first, second . . . etc. harmonics of the applied p.d. and a_0 the amplitude of the fundamental of the same p.d.

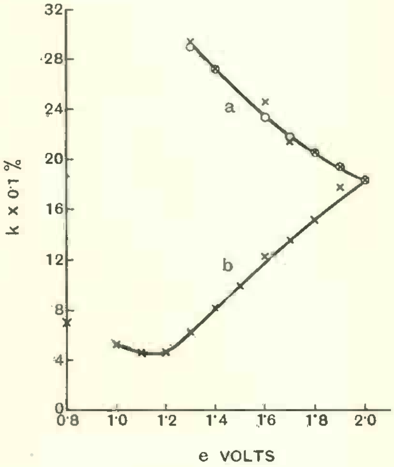


Fig. 3.

The instrument was arranged as shown in Fig. 2, between the terminals of the load R_e, on the valve a pure resistance of 2,000 Ω. The valve used was a Philips' B 405; for a pure sine wave e.m.f. of 2 volts applied to the grid the distortion factor, with no retroaction applied, was 1.82 per cent.; the working point of the valve being defined by the following constants:

$e_0 = -7$ volts; $I_0 = 10$ mA; $V_a = 67.5$ volts; i_f (filament current) $= 150$ mA.

The alternating current i_a was 2 mA. On applying linear retroaction only (D being short circuited), and increasing it by increasing r or P, the anode current increases as well as the distortion factor; but to obtain comparable results with the case where retroaction was absent we maintained i_a constant at 2 mA by decreasing e. In Fig. 3 (curve a) we have plotted $\Sigma = f(e)$, (Σ being the value of the distortion factor).

We see that k increases continually with increasing linear retroaction, *i.e.*, with decreasing of e.

This is to be expected if we consider the relation giving us the anode current with linear retroaction:

$$i_a = \frac{ke}{(R_e + F' - \mu kr) + \left[\frac{F''}{2} i_a + \frac{F'''}{3} i_a^2 + \ldots\right]} \qquad (a_6)$$

It can be shown, by solving (a_6) for i_a, if we neglect terms in i_a^3, . . . etc. and expanding in series, that the distortion factor Σ of current i_a is given by:

$$\Sigma = \frac{F''}{4(R_e + F' - \mu kr)^2} ke \ldots \qquad \ldots \quad (e)$$

Eliminating $(R_e + F' - \mu kr)$ between these two relations and neglecting again terms in i_a^3, i_a^4 . . . etc. we get:

$$\Sigma = \frac{F'' i_a^2}{4} \frac{1}{ke - F'' i_a^2} \ldots \qquad \ldots \quad (e_1)$$

On plotting this curve by assuming it to pass through the first point ($e = 2$ volts; $k = 1.82$ per cent.) of curve a (Fig. 3) and observing that i_a is kept constant (which gives us the value of $F'' i_a^2 = 0.67$) we obtain a very close approximation to the experimental results as is to be seen on the same fig. (the calculated points are marked o).

Let us consider now the non-linear retroaction; this was obtained, as already mentioned, by a copper-oxide rectifier D (Fig. 2), (r being maintained at zero); increasing this retroaction by varying P from 0 to 1MΩ; and maintaining again i_a constant by decreasing e as before, we see (curve b) (Fig. 3) that Σ decreases, reaching a minimum between $e = 1.2$ volt and $e = 1.1$ volt when $k = 0.4$ per cent.; we see, therefore, that we obtain a considerable improvement of the valve performance. Not only does the non-linear distortion factor decrease from 1.82 per cent. to 0.40 per cent., but the sensitivity of the valve is increased. We obtain by non-linear retroaction the same alternating current i_a with a voltage half as great as in the case where retroaction was absent.

Again the minimum of the curve (b) is to be expected if we consider the current i_a with non-linear retroaction; this will be:

$$i_a = \frac{ke}{(R_e + F' - \mu k\phi') + \frac{1}{2}[F'' - \mu k\phi'']i_a + \ldots} \qquad \ldots \quad \ldots \quad (a_7)$$

neglecting terms in i_a^3, i_a^4 . . . etc., it may be shown, as before, that

$$\Sigma = \frac{F'' - \mu k\phi''}{4(R_e + F' - \mu k\phi')^2} ke \quad .. \quad .. \quad (e_2)$$

from (a_7) and (e_2), eliminating ke we obtain :

$$\Sigma = \frac{F'' - \mu k\phi''}{4(F' + R_e - \mu k\phi')} i_a + \frac{1}{8}\frac{(F'' - \mu k\phi'')^2}{(R_e + F' - \mu k\phi')^2} i_a^2 \quad .. \quad (e_3)$$

As i_a is constant, Σ passes through a minimum, when μ varies (by varying P) for $\mu k = \frac{F''}{\phi''}$, and if the relation $\frac{\phi''}{\phi'} > \frac{F''}{F'}$ is satisfied.

In reality the value of this minimum for Σ is not zero, as the relation (e_3) gives it, for there are in the current i_a, third, fourth . . . etc. harmonics which have been neglected here.

As e is linearly related to μ, as can easily be seen from (a_7), the same remarks apply to the curve $\Sigma = f(e)$, which has been plotted experimentally as b in Fig. 3.

In conclusion, combining in an audio-amplifier both retroactions described here and in our previous articles, *i.e.*, the non-linear retroaction for non-linear distortion compensation and the linear retroaction for the frequency distortion compensation, we can greatly improve the efficiency and fidelity of such amplifiers.

This was tried with success on a model exhibited at the " Exhibition of Roumanian Industries " in Bucharest in September, 1934.

Correspondence

Johnson Noise

To The Editor, The Wireless Engineer

SIR,—During some recent work on high gain amplifiers for ribbon microphones, I became troubled with background noise due to the thermal agitation of electrons in the wire of the line to grid input transformer, i.e., Johnson noise.

I decided to examine this noise voltage with a General Radio Heterodyne Wave Analyser (a selective voltmeter which will discriminate 60 db. between two frequencies 50 c/s apart).

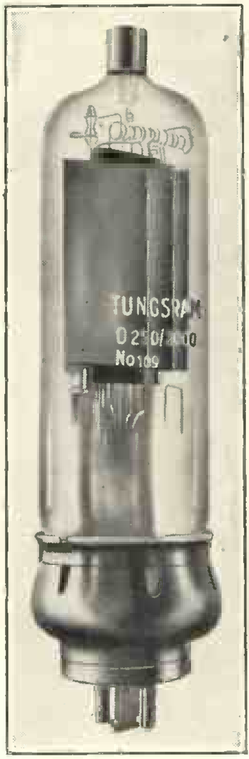
I was surprised to find that the voltage was not a steady one but that it caused the meter needle to be tossed up and down the scale in a series of kicks (of approximately equal amplitude) with a periodicity of the order of 5 per second. This meter performance was obtained at every frequency throughout the range of the instrument, 0—17,000 c/s.

How can this phenomenon be linked up with the usual theory of thermal agitation ? Surely a collision between an electron and an atom is of a transient nature and must necessarily radiate a long string of frequencies from zero to infinity. Working then on this hypothesis we would expect that several harmonic analysers set to different frequencies would give simultaneous kicks. I have not yet been able to try this experimentally, but if we did get simultaneous kicks at all frequencies we would have to expect a series of clicks in the loudspeaker connected to the noise voltage. But we do not ; because the sound is a velvety smooth hiss.

An alternative postulation is that a particular collision seems to like radiating on one frequency only and when the analyser is set to this frequency it kicks for each collision. This again is absurd for no one would suggest that there is a resonant system in copper wire for every frequency imaginable.

What then is the answer ? I would be interested to hear the views of some of your readers on this subject. HAROLD R. ROBIN.

London, S.W.16.



Tungsram
Transmitting Valve

A NEW valve which is claimed to be particularly suitable for use as an oscillator or a high-frequency power amplifier is being marketed by Tungsram. It bears the type number 0–250/2000 and is rated for an anode dissipation of 250 watts at 2,000 volts. It is fitted with an oxide cathode and its filament is rated to consume 2.5 amperes at 11.0 volts. A special base is used with a thimble type top-connector.

The valve has a mutual conductance of 9 mA/V. with an A.C. resistance of 2,800 ohms. In addition to its normal sphere of operation in transmitting apparatus, it is suitable for use as an output valve in large P.A. equipment. The makers are the Tungsram Electric Lamp Works, of 72, Oxford Street, London, W.1.

Voltage Measurements at Very High Frequencies—II.*

By E. C. S. Megaw, B.Sc., D.I.C.

(From the Research Staff of the M.O. Valve Company, Limited, Wembley)

SUMMARY.—The paper describes an experimental investigation into the performance of the diode-condenser type of peak voltmeter at frequencies over 30 Mc. (wavelengths below 10 m.) and is complementary to a theoretical study described in a previous paper. A preliminary investigation deals with the input capacitance of the diode, the error due to leakage of the condenser charge and the related effect of the initial electron velocities. In the section dealing with the high frequency measurements the error due to the voltmeter connecting leads is measured and found to be less than 1 per cent. at 100 Mc. The enhanced effect of leakage at very high frequencies is then examined to ensure that this does not invalidate the measurements of electron inertia error which follow. A new method, involving the use of a series of diodes with different inter-electrode spacings, is used for these measurements which lead to an equation for the inertia error of the same form as the approximate theoretical one, but with a constant about twice as great. The inertia error is negligible when $f(\text{Mc.}) \times x_a(\text{cm.})/\sqrt{\hat{v}(V.)} < 0.1$. This indicates that accurate measurements, with existing technical limitations, can be made, *e.g.*, down to about 100 v. at 100 Mc. (3 m.). An empirical correction curve extends this range, for approximate measurements, to about 10 v. at 1,000 Mc. (30 cm.), but at this frequency the difficulties due to connecting lead impedance are serious. The peak voltmeter readings are compared with a thermal method of measurement at 35.3 Mc. and 103 Mc. Discrepancies of about 3 per cent. and 9 per cent. respectively are observed and are possibly due to the form factor of the H.F. wave differing from the value $\sqrt{2}$ assumed in the comparison. Approximate calibration curves, relative to a diode peak voltmeter, are given for two voltmeters employing triodes, one of normal and the other of very small dimensions. Some general information is obtained regarding the performance of these voltmeters at frequencies over 30 Mc. and voltages down to about 5 (R.M.S.). A method for extending such calibrations to very low voltages is suggested.

I. Preliminary Investigation.

(*a*) *Description of the Diode for High Frequency Measurements.*

THE theoretical results described in Part I† indicate that the properties of a diode which make it suitable for peak voltage measurement at very high frequencies are low inter-electrode capacitance, short electrode leads and small inter-electrode distance. The type of diode used in this investigation (Fig. 1) was evolved in 1929 at the suggestion of Prof. C. L. Fortescue.‡ It has a loop filament of pure tungsten (0.09 mm. wire) and a hemispherical nickel anode of 2 mm. radius. The normal filament rating is 1.8 v. and 1.6 A. for about 3 mA. emission, which comes almost entirely from the central part of the loop. This design meets the requirements of long life, constant characteristics and robustness. The electrode leads are short and the design lends itself to the use of small and accurately measurable anode-filament clearances. The clearance in the original design, which has found considerable application at frequencies up to 15 Mc., was 2 mm. For the purposes of this investigation diodes were made up with clearances ranging from about 0.02 mm. to 9 mm., though not all of these were available for the final high frequency tests. The clearances were measured by optical projection to an accuracy of about 0.01 mm. (magnification 50 times). It was found that heating the filament to normal emitting temperature decreased the clearance by about 0.15 mm. Measurements were made on all diodes at the temperature used in the subsequent tests.

(*b*) *Capacitance Measurements*

Capacitance measurements were made at a frequency of about 1 Mc. by a substitution method using apparatus designed for routine

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

† This refers to the previous paper, *Wireless Engineer*, 13, 65 (April, 1936).

‡ See *J.I.E.E.*, 77, 429, 1935.

measurements of this sort. The anode was given a negative potential with respect to the filament to avoid inaccuracy due to damping and changes due to space charge. It was verified that the mechanical force between filament and anode resulting from this p.d. (about 100 v.) had no appreciable effect even with the smallest spacing.

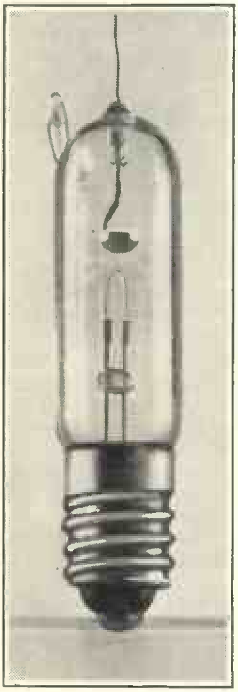

Fig. 1.—*Diode for high frequency measurements.*

In Fig. 2 the capacitance is shown as a function of anode-filament clearance. The filament was earthed and the anode lead length was about 5 cm. in each case. The spread in the experimental points corresponds mainly to constructional differences (particularly small differences in lead lengths) and not to measurement errors. The slow rate of increase of capacitance with decreasing clearance in the range covered was a welcome surprise. This is to be attributed to the fact that when the electrodes are close together the small clearance only obtains over a short length of the filament system.

The next step was to separate the C shown in Fig. 2 into its various components. By means of a "demountable" diode, in which the anode and filament ends could be separated, the direct anode-filament capacitance C_D was found to be approximately 0.045 $\mu\mu$F. at 2.5 mm. clearance, this being the difference between the measured C with the diode assembled in the normal position and the capacitance with the filament end completely removed. The error in this measurement is not likely to be very large since the stray capacitance between either half of the diode, when connected to the earth terminal of the measuring set, and the "live" terminal was found to be only about 0.005 $\mu\mu$F. This enables us to draw the upper dotted line in Fig. 2 at 0.44 $\mu\mu$F. which represents the average sum of the anode-earth capacitance C_A and the anode lead-earth capacitance C_L. The direct inter-electrode capacitance thus varies from about 0.02 $\mu\mu$F. at 7 mm. clearance to about 0.13 $\mu\mu$F. at 0.05 mm. Measurements with a removable anode gave $C_A = 0.05 \pm 0.01 \mu\mu$F. for distances to earth (the screening of the measuring set), and anode lead lengths, ranging from 4 cm. to 30 cm. It is surprising that this differs by so much from the theoretical value for a hemisphere,

$$1.11\, R\left(\tfrac{1}{2} + \frac{1}{\pi}\right) = 0.18\ \mu\mu\text{F.},$$

but the measurements were checked carefully and repeated consistently. By subtraction we now find $C_L = 0.39\ \mu\mu$F., which is of the right order by calculation. The capacitance of the 5 cm. anode lead is thus considerably greater than the capacitance due to the actual electrodes.

(*c*) *Leakage error and the effect of initial electron velocities.*

Before planning the high frequency measurements it was necessary to know the leakage error at low frequencies, at least approximately; and the related question of the precise effect of the initial electron velocities had also to be examined.

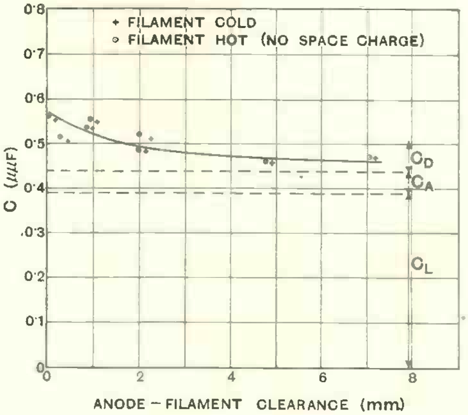

Fig. 2.—*Diode capacitance measurements* (1 *Mc.*).

In Part I an approximate expression for the leakage error—equation (1)—was derived in terms of the leakage resistance and the constants of the diode characteristic which was assumed to be representable by an equation of the form

$$i = a.v^n, \text{ or } a.(v + V_1)^n$$

if the effect of initial velocities or contact potential difference is appreciable. Actually for voltages of the order of 100 or less, the V_1 term is quite important as will be shown later. As a check on the usefulness of equation (1), and the criteria for negligible leakage error derived from it, the reduction in peak voltmeter reading with decreasing leakage resistance observed with a diode having an anode-filament clearance of 1.8 mm. was compared with the results calculated from the characteristic. The two curves are shown in Fig. 3. The peak value of the constant 50 cycle voltage, obtained by oscillograph measurements, was 184 ± 1.5 volts. The voltmeter condenser was increased with decreasing leakage resistance, to keep the time constant large compared with 1/50 second. The capacitance was 0.01μF. at 10^{10} ohms and 10 μF. at 10^6 ohms. Various resistances, wire-wound, graphite and sputtered film types, were used to provide the additional leakage, their values being checked by the rate of discharge of the system. V_1 was obtained by measurement as described below and was regarded as a constant zero error in the experimental readings. The best values for a and n were obtained from logarithmic plots of the characteristic. The theoretical points for the lower values of leakage resistance were calculated by successive approximations between (1) and the preceding equation. The agreement between the two curves indicates that the theoretical expression is of adequate accuracy for most practical purposes. The chief source of inaccuracy is probably the assumption of a simple power law for the characteristic; for low voltages and small errors this is only a rough approximation.

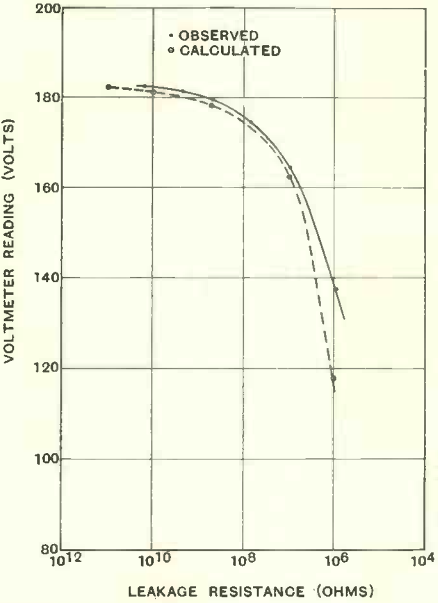

Fig. 3.—*Effect of leakage resistance on peak voltmeter reading* (50 *cycles*). *The curves relate to a diode with anode-filament clearance* 1.8 *mm.*

Fig. 4 shows the observed leakage error for a diode with 2.0 mm. anode-filament clearance as a function of the applied peak voltage in the range 5 to 100 v. The peak voltage was obtained from the measured R.M.S. value by using a form factor of 1.41_0, the mean of previous oscillographic measurements on the same supply. This may have been in error by about 1 per cent. The readings were taken at 50 cycles with a 0.01 μF. condenser using a reflecting galvanometer with 10^9 ohms series resistance as a voltmeter, except for the 5 v. point for which an electrometer triode was used with a shunt resistance of the same value. The possible error in this curve is rather greater than in most of the other curves in the

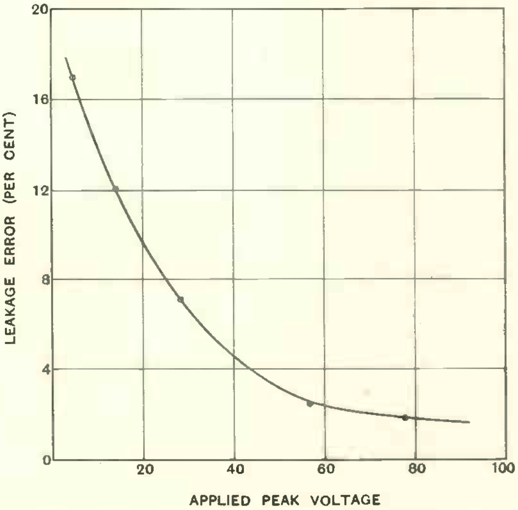

Fig. 4.—*Leakage error at low voltages.* (*Frequency* 50 *cycles, anode-filament clearance* 2.0 *mm., leakage resistance* 10^9 *ohms*).

paper relating to leakage error, but it serves to show the increasing importance of leakage at low voltages, which is a fundamental disadvantage of this type of voltmeter, at least with diodes which are suitable for very high frequencies.

As described in Part I the effect of the initial emission velocities of the electrons, and of any contact difference of potential between filament and anode, is to produce a finite charge on the voltmeter condenser with no applied voltage. For D.C. voltage measurement this leads to a constant zero error V_1, but with A.C. the true "zero error" is less than V_1 by an amount which depends on the leakage resistance. This is a result of the exponential "tail" of the diode characteristic produced by the Maxwellian distribution of emission velocities. This matter was investigated in some detail as little exact information appeared to be previously available.

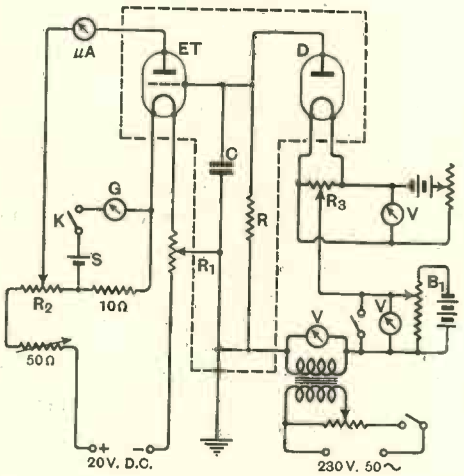

Fig. 5.—*Circuit arrangement used for checking performance at low voltages. D = peak voltmeter diode, ET = electrometer triode, C = voltmeter condenser* (.01μ*F.*), *R = leakage resistance, R*1 = 80 *ohms calibrated in* 1 *volt steps, R*2 = 70 *ohms calibrated in* 1 *volt steps, R*3 = 100 *ohms, centre-tapped. B*1 = *biassing battery, S = standard cell* (1.019 *v.*), *K = key for checking current in electrometer circuit.*

The initial reading V_1 was measured as a function of the leakage resistance by means of an electrometer triode using the circuit arrangement shown in Fig. 5, which includes facilities for low voltage calibration. The triode voltmeter arrangement was a standard testing panel supplied by a 20 v. accumulator on a constant current circuit. The details of the circuit are evident from the figure. The dotted line represents an earthed screen to avoid errors due to induced charges from neighbouring apparatus. A drying agent (phosphorus pentoxide) was placed inside the screen. The input resistance of the triode was of the order of 10^{13} ohms or more (anode voltage 6 or 8 v., grid bias − 1 to − 8 v.). The maximum value of R, with no additional leak, was about 10^{12} ohms.

Fig. 6 shows the relation between V_1 (voltage produced across C with no external e.m.f.) and the leakage resistance R for several diodes with different values of anode-filament clearance. The diode filament voltage was adjusted in each case to give 3 mA. emission at 200 v.

Two general results emerge from these curves. V_1 with usual values of leakage resistance (say 10^8 to 10^{11} ohms) is of the order of 3 or 4 volts which is about 10 times greater than the voltage corresponding to the *average* emission velocity; and V_1 tends to become independent of the diode impedance as R increases. When R is greater

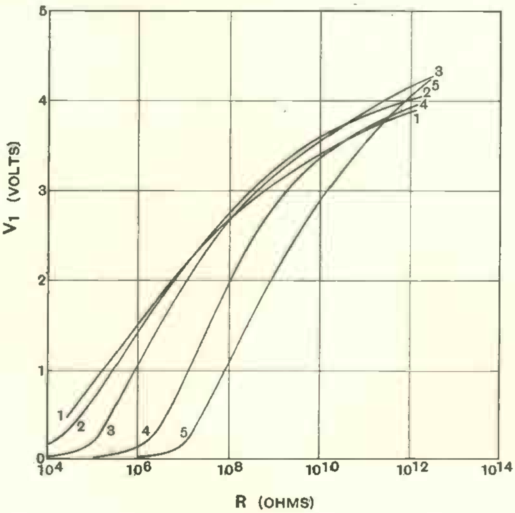

Fig. 6.—*Relation between initial condenser voltage V*1 *and leakage resistance R. Curve* 1 : *Anode-filament clearance* 0.28 *mm., filament voltage* 2.04 *v. Curve* 2 : *Anode-filament clearance* 0.82 *mm., filament voltage* 2.03 *v. Curve* 3 : *Anode-filament clearance* 1.99 *mm., filament voltage* 1.99 *v. Curve* 4 : *Anode-filament clearance* 4.76 *mm., filament voltage* 1.94. *Curve* 5 : *Anode-filament clearance* 7.04 *mm., filament voltage* 1.94.

than 10^7 ohms and the anode-filament clearance less than 2 mm., the results may be represented by a single curve to an accuracy of about ± 0.15 v. Within these limits V_1 is a function of leakage resistance and filament temperature only. The relation between V_1 and filament voltage, which may be taken as a measure of temperature with fixed filament dimensions, is shown in Fig. 7 for several values of leakage resistance. These curves represent average results obtained from several diodes with anode-filament clearances not exceeding about 2 mm. They may therefore be used to determine V_1 for such diodes with sufficient accuracy for most practical purposes at any value of R which is likely to occur with an electrostatic voltmeter. These curves are, of course, valid only for one particular set of filament dimensions.

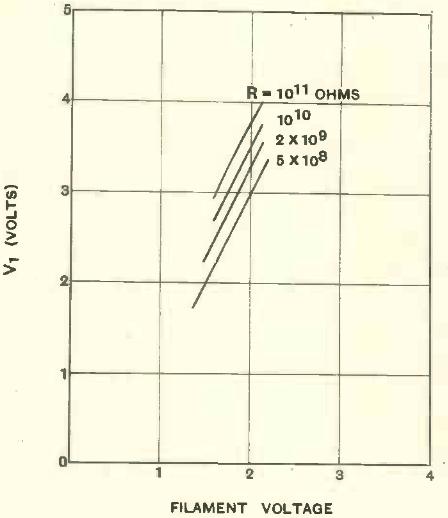

Fig. 7.—*Relation between initial condenser voltage V1 and filament voltage.*

The contact p.d. between anode and filament would be 0.5 v., in such a direction as to increase V_1, if the surfaces of both were perfectly clean. This may safely be assumed for the filament but is less certain for the anode which is bound to collect some of the evaporated tungsten atoms from the filament, apart from other possible contaminations. Variations in V_1, up to about half a volt are quite possible on this account and this may be a contributory cause of the spread in the curves of Fig. 6 at large values of R. The experimental results suggest that variations in contact p.d. did not, in fact, amount to as much as half a volt.

It is clear that under normal conditions the initial voltage is by no means negligible in measuring low voltages. It is now necessary to see what error remains when we assume that V_1 may be regarded as a constant positive zero error, to be subtracted from the observed condenser voltage. It is this remaining error which is generally referred to as the " leakage error " throughout the paper. In Fig. 8, two 50-cycle calibration curves are shown on this basis for a diode with 2.0 mm. anode-filament clearance at voltages comparable with V_1. These results were obtained with the arrangement shown in Fig. 5, with zero bias from the battery B_1. The error is approximately — 25 per cent. at 2 volts and — 15 per cent. at 5 volts with leakage resistance values in the normal range ; it does not vary rapidly with leakage resistance. These error figures remain of the same order for clearances less than 2 mm. and become approximately — 45 per cent. and — 30 per cent. with 7 mm. clearance. At voltages of the order of 100 or more the inaccuracy introduced by assuming a constant zero error equal to V_1 is negligible.

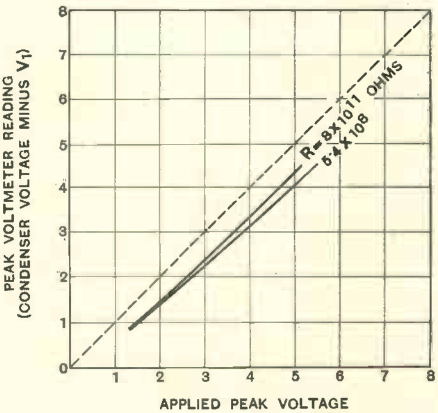

Fig. 8.—*Low voltage calibration (frequency 50 cycles, anode-filament clearance* 2.0 *mm., filament voltage* 1.99 *v.).*

Attempts to improve the accuracy at low voltages by introducing a bias from the battery B_1 in Fig. 5 showed that nothing could be gained in this way.

As an empirical rule, valid for $\hat{v} > 3$ v.,

$R > 10^8$ ohms and anode filament clearance < 3 mm., *the effects of leakage and initial velocities may be taken into account, to an accuracy of about 5 per cent. or better, by subtracting* ($V_1 - 0.8$ v.) *from the observed condenser voltage.*

II. High Frequency Measurements

(*a*) *Method of Measurement*

The voltmeters on which these measurements were made are intended for frequencies from about 30 Mc. (10 metres) up to more than 300 Mc. (1 metre), chiefly for measurement on concentric cylindrical systems. The diode and condenser (0.001 μF.) are arranged in a cylindrical brass case which forms the earthed terminal of the instrument. Terminals are provided for filament supply and for the D.C. voltmeter which may be connected by flexible leads of any convenient length. Accumulator filament supply was used for the tests described here, but it has since been found possible to use A.C. supply, with a gain in convenience, for most practical purposes and with no appreciable loss of accuracy provided a centre tap filament return is used. An insulation resistance of the transformer secondary to earth exceeding 10^{11} ohms can be obtained without serious departure from conventional design. A complete peak voltmeter with filament transformer is shown in Fig. 9.

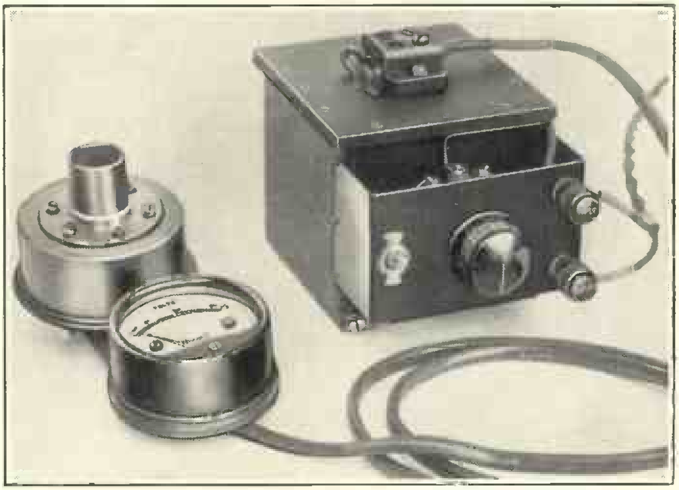

Fig. 9.—*Complete peak voltmeter for very high frequencies.*

The general method of measurement was to employ two peak voltmeters connected to the same point on a concentric line, one to enable a constant voltage to be maintained, while the other was subjected to some variation. The line was fed by an oscillator capable of delivering several kilowatts of H.F. energy and was terminated in a resistance of special design to be described later. The general arrangement of line, double-peak voltmeter head and terminating resistance is shown in Fig. 10 (*see* also Fig. 17).

(*b*) *Error Due to Impedance of Voltmeter Connecting Leads*

In the arrangement adopted the connecting leads from the concentric system to the voltmeters form a concentric line of about 225 ohms characteristic impedance terminated, to a first approximation, in $(C_D + C_A)$, the sum of the true inter-electrode capacitance and the anode-earth capacitance. The approximation arises from the fact that the impedance between the emitting part of the filament and the case of the voltmeter unit is not zero, though it was made as small as possible. This impedance is approximately equivalent to that of a 3 cm. length of 150 ohm line which would not amount to more than about 1/1,000 of the impedance of C_D at the highest frequency used (107 Mc.). The error introduced on this account must therefore be small.

The method adopted in checking the impedance error was to vary the length of the connecting line on the " test " voltmeter and note the change in reading, the applied voltage being kept constant by means of the " check " meter. This was done by using a telescoping arrangement for the outer conductor of the connecting line and cutting the anode lead to the required length. No solid insulation other than the diode bulb was used in the connecting line. Observation holes were provided in the central part of the voltmeter head to facilitate making contact between the ends of the anode leads and two small depressions in the inner conductor of the main transmission line.

The results of a test at 107 Mc. (2.8 m.) using the diode with the smallest anode-filament clearance (about 0.02 mm.) are shown in Fig. 11. A smooth curve through the experimental points was extrapolated to zero lead-length and the resulting voltage was used, with the capacitances measured at 1 Mc., to obtain the calculated curve shown in the figure by means of the expression given in Part I, Section IV. The agreement between experiment and calculation is satisfactory for lead lengths less than about 7 cm. ; for greater lengths the observed error is larger than the calculated. The cause of this discrepancy cannot be assigned with any certainty, but it is possible that C_D was greater than the value previously measured, as this diode failed by filament-anode contact after about 50 hours' further use. On the other hand, the observed error was also rather higher than the calculated at large values of lead length with other diodes having much larger inter-electrode clearances. For lead lengths between 2.5 and 8 cm. the observed error was nearly independent of the clearance, as might be expected since the " equivalent length " l' of the input capacitance is of the order of only 1 cm. at 107 Mc.

These tests show that for all the experimental diodes the lead impedance error does not exceed about 1 per cent. at 107 Mc., provided the lead length is less than 5 cm. Actually the lead length could be reduced to less than 3 cm., making the impedance error negligible for all ordinary measurements.

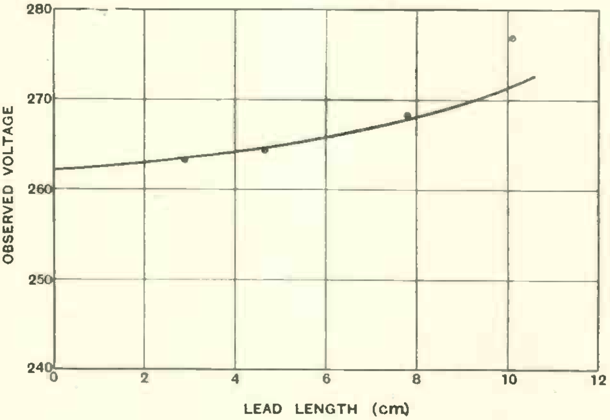

Fig. 11.—*Error due to impedance of connecting leads. (f = 107 Mc., anode-filament clearance about 0.02 mm. Curve calculated, points observed).*

The input impedance was not measured, but it is safe to assume, from the above results, that it does not differ much from

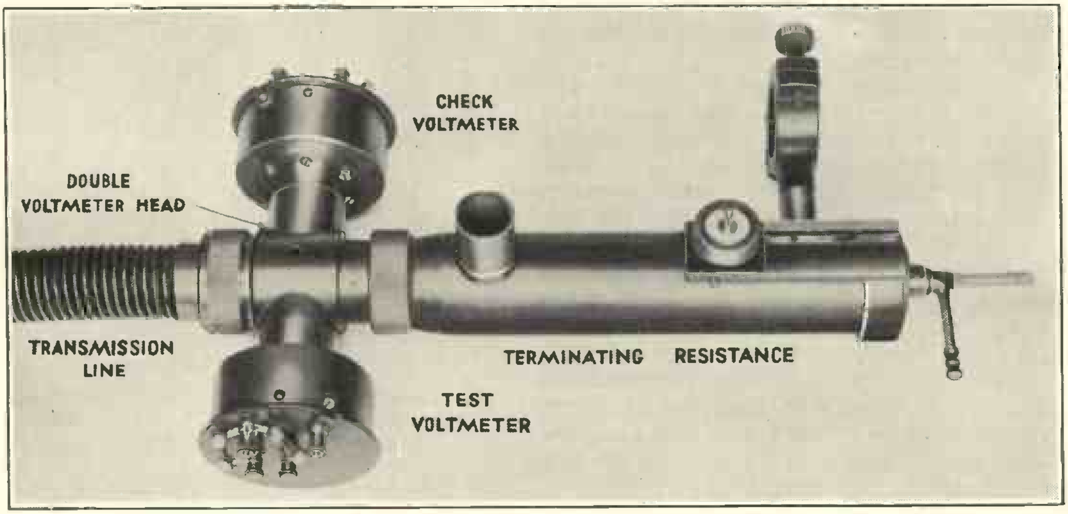

Fig. 10.—*Apparatus for H.F. measurements.*

the reactance of the input capacitance as measured at lower frequencies. For a 3 cm. connecting lead this amounts to about 4,000 ohms at 100 Mc. The resistive component is probably large compared with the resonant impedance of usual tuned circuits at this frequency.*

(c) *Electron Inertia Error.*

The approximate formula for electron inertia error derived in Part I (equation (12)) indicates that the error should be proportional to the anode-filament clearance. While this result was derived only for the case of a uniform inter-electrode field it suggested a method of measuring the error experimentally which gave satisfactory results with the diodes used in this investigation. The method is to plot the observed voltage as a function of inter-electrode clearance and extrapolate to zero clearance to find the true voltage. It is obvious that all other errors must be known or negligible and much of the work described in the earlier parts of the paper was carried out to ensure this.

The considerations that the inertia error should not be too small to be accurately observable, nor the voltage too low on account of leakage error, suggested a frequency of about 100 Mc. and a peak voltage of about 200 for the first tests. Apart from the limitations imposed by the oscillator available for the tests it was not thought desirable to use much higher frequencies on account of the increasing importance of impedance errors.

The apparatus described in the last two sections was used for these tests also. It was found that the check voltmeter reading increased by not more than about ½ per cent. when the test meter was removed altogether. This result, with those of the previous section, makes it reasonably certain that the constancy of the applied voltage depended only on the accuracy with which the check meter could be kept on a predetermined voltage. This was about ½ per cent. or better.

The range of anode-filament clearance was limited to between 0.12_5 mm. and 2.14 mm., on the one hand by the failure of the original 0.02 mm. diode, and on the other by the fact that the few diodes made up with clearances between 4 mm. and 9 mm. were found to give inconsistent results on H.F. This was due in one case to softness and in the others possibly to the effect of charges on the bulb walls, since the inter-electrode distance was comparable with the bulb diameter.

As a compromise had unfortunately to be made between accuracy and insulation resistance in choosing an electrostatic voltmeter for the test instrument, the leakage error was not entirely negligible. The total leakage resistance with the instrument finally chosen, which had a full scale reading of 200 v. and could be read to 0.2 v. near full scale, was between 2×10^9 and 3×10^9 ohms. The following average leakage-error figures were obtained at 50 cycles with 183 v. peak when R was 2.7×10^9 ohms:

Anode-filament clearance ..	0.5	1.0	1.5	2.0 mm.
Leakage error .	0.4	0.6	0.9	1.3 per cent.

These figures may be in error by about 0.5 per cent. owing to the uncertainty in the oscillographic measurement of the form factor.

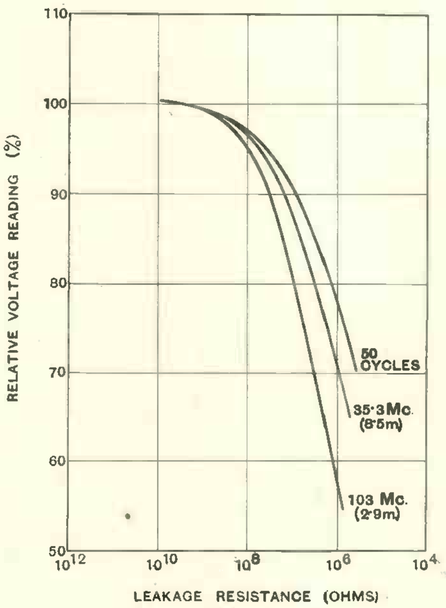

Fig. 12.—*Leakage error at very high frequencies. (Peak voltage approximately* 190 *v., anode-filament clearance* 1.80 *mm.).*

It is to be expected on theoretical grounds that the error produced by a given value of leakage resistance will be relatively greater

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* Subsequent measurements at 20 Mc. tend to confirm this, the resistive component being greater than 2 megohms at this frequency.

at frequencies high enough for the effect of electron inertia to be appreciable than at low frequencies. This point was investigated experimentally and some typical results for a diode with 1.80 mm. anode-filament clearance are shown in Fig. 12. Here the voltmeter reading for various values of leakage resistance is shown as a percentage of the reading at $R = 2.7 \times 10^9$ ohms for frequencies of 50 cycles, 35.3 Mc. and 103 Mc. The peak voltage was approximately 190 v. in each case. The voltmeter condenser was, of course, increased for the 50-cycle readings. The curves show the expected increase in relative error with frequency at the lower values of leakage resistance, but indicate that with $R > 10^9$ ohms the leakage error may be assumed equal to the 50-cycle value, even at 103 Mc., without serious inaccuracy for voltages of the order of 200 or more. For 0.12_5 mm. clearance the 103 Mc. curve does not depart appreciably from the 50-cycle curve provided $R > 3 \times 10^8$ ohms. This completes the information required before carrying out the inertia error tests.

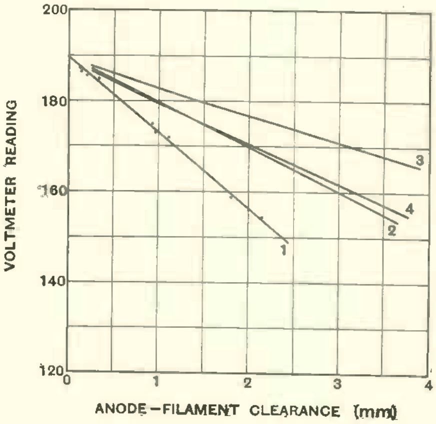

Fig. 13.—*Investigation of electron inertia error; relation between anode-filament clearance and voltmeter reading at* 103 *Mc.* (2.9 *m.*). *Curve* 1 : *observed. Curve* 2 : *calculated for uniform field. Curve* 3 : *estimated for actual electrode form; space charge negligible. Curve* 4 : *estimated for actual electrode form; maximum space charge effect.*

Fig. 13 shows the inertia error test results (curve 1) at a frequency of 103 Mc. The readings have been corrected for the effects of leakage and connecting-lead impedance, determined by the methods already described, though both these corrections are small. The relation between anode-filament clearance and observed voltage is substantially linear and the best straight line through the experimental points gives 189.5 v. for the true peak voltage. The error at 2 mm. spacing is thus 17.5 per cent. The relation of these results to the calculated performance is discussed in the next section.

Fig. 14 shows a similar set of test results for a frequency of 35.3 Mc. These also fit quite well to a straight line and the extrapolation gives $186._8$ v. at zero spacing. The error obtained from this line is 0.35 times the error observed at 103 Mc. (Fig. 13), while the frequency ratio is 0.34_2, indicating that the error is directly proportional to frequency (other things being constant) within experimental uncertainty.

Fig. 15 shows three sets of readings, all taken at 103 Mc., with different applied voltages and expressed as a percentage of the true voltage derived in each case by extrapolation. The upper line ($189._5$ v.) is the same as curve 1 in Fig. 13. The following table shows the relation between peak voltage and error for 2.0 mm. clearance :—

Peak voltage . .	189.5	100.3	61.3 v.
Error	17.5	23.8	29.4%
Error × $\sqrt{\text{voltage}}$.	241	238	231

The product of error and square root of voltage is nearly constant, indicating that the error varies as $1/\sqrt{v}$ (other things being constant) or slightly less rapidly.

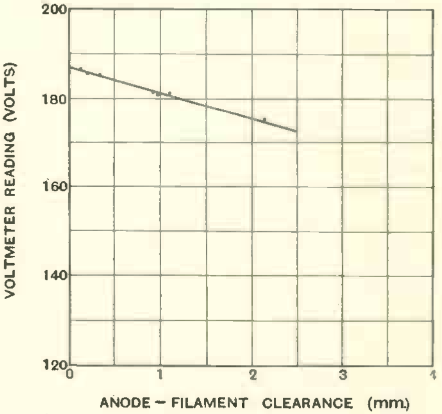

Fig. 14.—*Relation between anode-filament clearance and voltmeter reading at* 35.3 *Mc.* (8.5 *m.*).

(*d*) *Discussion of the Results.*

Before discussing the results just described it is necessary to make a correction to

Part I. This relates to the discussion, at the end of Section V, of the magnitude of the inertia error when the inter-electrode field is not uniform. It was shown there, by comparing an approximate solution for the uniform-field case, involving the static transit time, with the exact solution, that the inertia error was proportional to the transit time to a close approximation. It was hence argued from the known ratios of static transit-times that the error would never be more than about 1.5 times (parallel planes with maximum effect of space charge) nor less than about 0.5 times (cylindrical diode with small cathode and negligible space-charge) the uniform-field error. It becomes evident that there is something wrong if we consider the limiting case in which the whole of the potential drop in the diode occurs at the cathode surface. The transit time is then half that for a uniform field but, neglecting space-charge effects, *the error would always be zero*, because all the electrons leaving the cathode surface would reach the anode. Once the electrons have left the cathode changes in the inter-electrode p.d. would have no effect on their motion in this case. The fallacy in the original argument is, of course, that the approximate solution is not necessarily nearly the same as the true result for non-uniform fields.

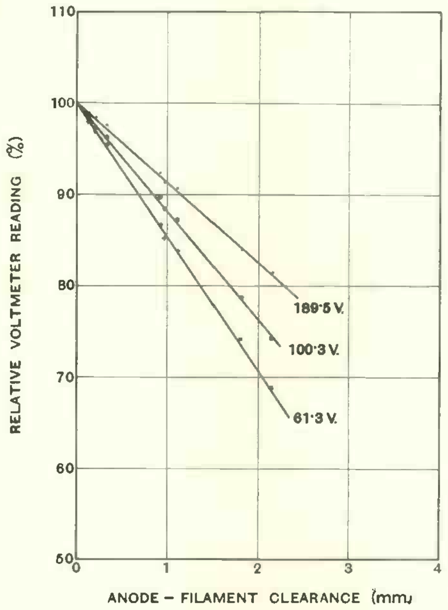

Fig. 15.—*Relation between anode-filament clearance and relative voltmeter reading at* 103 *Mc. for various values of applied voltage.*

Another special case yields an interesting result. If half the potential drop occurs at the cathode surface and half at the anode surface—this corresponds to parallel cylindrical electrodes whose diameters are limitingly small compared with their distance apart—it can easily be shown that the condition for which the electrons with the longest range are just able to reach the anode is

$$\frac{\omega^2 x_a{}^2}{\frac{e}{m}\hat{v}} = \{\sin(\theta + \phi_1) - \sin\theta\}\,\{(\pi - \theta - \phi_1)$$

$$- \sin^{-1}[2\sin\theta - \sin(\theta + \phi_1)]\}^2$$

$$= G'(k), \text{ say,}$$

where ϕ_1 is the value of ϕ, the initial electron phase angle, which makes the right-hand side a maximum and the other symbols have the same meanings as in Part I. This equation corresponds to (11) of Part I, the function $G(k)$ for the uniform-field case being replaced by $G'(k)$ for this special case. The following table gives $G'(k)$ and $G(k)$ for various values of error; the values of ϕ_1, expressed as a fraction of the angle in which the anode is positive (per cycle), are also given to bring out the fact that ϕ_1 is not zero here as it is in the uniform-field case :—

Error.	1	3	10	30	60%
$\phi_1/(\pi-2\theta)$	0.31	0.32	0.33	0.34	0.35
$G'(k)$	5.2×10^{-4}	4.8×10^{-3}	5.5×10^{-2}	5.1×10^{-1}	2.3
$G(k)$	4.5×10^{-4}	4.1×10^{-3}	4.6×10^{-2}	4.3×10^{-1}	1.9

These results show that the error is only slightly smaller in this case than in the uniform-field case.

To sum up, analytical treatment of cases other than that of uniform field presents, in general, an insoluble mathematical problem ;

graphical integration offers a possible solution in some cases, as Fortescue has pointed out, but it would be laborious in the extreme, the more so since the initial phase angle corresponding to maximum electron range would have to be found by trial; solution by mechanical methods* should be practicable and the problem is commended to those to whom a mechanical integraph is available, but such methods were beyond the scope of this investigation. On the other hand, the errors into which one may be led by approximations based on static transit-time, at least in extreme cases, are evident from the preceding paragraphs. The best that can be said is that such methods may reasonably be expected to give results which are not far from the truth when the electric field is not far from uniform.

For the purpose of comparing the theoretical with the observed inertia error, the electric field in the experimental diodes was assumed to be the same as between a cylinder of the same diameter as the filament wire and a parallel plane, separated by the anode-filament clearance. For the region of minimum distance, which alone is of interest, this is a fairly good approximation for clearances up to about 2 mm. A closer approximation or an electrolytic determination was not considered to be warranted. The ratio of static transit-time (T) in such a system to that in a uniform field (T_0), distance and p.d. being the same, is given in the following table for various values of clearance; the ratio of clearance to filament diameter is also included:

Clearance (x_a)	..	0.02	0.3	1.0	3.0	7.0 mm.
x_a/df	..	0.22	3.2	11.1	33	78
T/T_0	..	0.972	0.783	0.695	0.633	0.604

These figures were derived by graphical integration of the equation of motion.

In Fig. 13 curve 1 is experimental, curve 2 is given by the uniform-field solution and curve 3 is derived from curve 2 and the above table on the assumption that the error is proportional to static transit-time and that the effect of space charge is negligible; curve 4 allows for the maximum effect of space charge on the same basis assuming that the 3/2 transit-time ratio, which is correct for parallel planes and for cylinders with limitingly small cathode, holds here also. It is to be expected that the experimental points would lie between curves 3 and 4, and probably nearer 3 since the leakage error is small. Actually *the observed error is about twice as great as the value expected from these calculations.* Also the observed line does not show the slight upward curvature shown by curves 3 and 4, though some readings obtained with the larger clearance diodes did appear to indicate this tendency; but their value is doubtful. This two-to-one discrepancy in the error appears to be definitely beyond the range of experimental uncertainty, though the difference in curvature is not. It seems more likely that some relevant factor has been omitted from the theoretical treatment, or possibly the static transit-time approximation is untrustworthy even for this electrode system. The magnetic field of the filament current may have some appreciable effect but the theoretical anode-voltage for "cut-off" is only of the order of 0.1 v. for 2 mm. clearance. There will, however, be an appreciable curvature of the electron paths and lengthening of the transit time at larger voltages which would tend to increase the error, but the magnitude of the effect is difficult to estimate.

What is of more practical importance than this lack of perfect quantitative agreement between theory and experiment, is the fact that both agree substantially as to the variation of error with frequency and voltage in the range covered. The four different sets of experimental results (Figs. 13 to 15) can be expressed to a good approximation by an equation of the form

$$\text{error} = K\frac{fx_a}{\sqrt{\hat{v}}}$$

which is precisely the form derived for the uniform-field case for small values of error. The four values for K obtained from the experimental readings are: 11.7, 11.6, 11.2, 11.7. These give 11.6 as the average experimental value of the constant, which is 1.7 times the theoretical value for uniform field. The empirical equation then becomes

$$\text{error} = 11.6\frac{fx_a}{\sqrt{\hat{v}}}\text{ per cent.}$$

where f is in megacycles, x_a in cm. and $\hat{v}$ in volts as before.

The criterion for negligible error (less than

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* *Cf.* Sears, *Journ. Franklin Inst.*, 209, 459 (1930).

about 1 per cent.) given in Part I, namely

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

is thus confirmed. With this result the problem of accurate voltage measurement at very high frequencies may be considered solved within the limits imposed by constructional considerations, and these limits are fairly clearly definable. Experience in this investigation suggests that the smallest practicable inter-electrode clearance is of the order of 0.1 mm. with existing technique. With this figure accurate measurement is possible provided $f/\sqrt{\hat{v}} < 10$, that is, down to about 1 v. at 10 Mc., 15 v. at 40 Mc., 100 v. at 100 Mc., or 1,000 v. at 300 Mc. The lead-impedance error will become appreciable above about 200 Mc. with the minimum lead-length possible for the diodes described. Low-frequency calibration will usually be desirable for voltages under about 50 on account of leakage error. Within these limits an accuracy of about 1 per cent. appears to be definitely attainable, but under ordinary practical conditions errors of a few per cent. may occur. In spite of the fact that the diodes used to obtain the results shown in Figs. 13 to 15 were carefully selected for good vacuum, symmetrical electrode systems and stable emission, and were finally checked for uniform performance at low frequency, there are some signs of small discrepancies associated with individual valves. Larger discrepancies, amounting to several per cent. and not traceable to any obvious constructional fault, have since occasionally been observed between diodes having similar clearances, particularly when the inertia error is appreciable.

The extension of measurements to higher frequencies and lower voltages by means of theoretical or empirical correction formulae is necessarily attended by greater uncertainties. The correction curve of Fig. 6 in Part I can only be regarded as a rough guide to the true voltage when the inertia error is large, and theoretical corrections for impedance error are usually appreciably too small when it amounts to more than a few per cent. An empirical inertia error correction curve for the type of diode used here is given in Fig. 16 for correction factors up to 1.5, which is as far as the experimental results permit us to go. This curve extends the range of measurement down to about 10 v. at 1,000 Mc. (30 cm.) to an accuracy of perhaps 20 per cent., not forgetting the uncertainty in determining x_a. This extension is, however, only available if the impedance error can be kept small. For the shortest possible anode lead (about 2 cm.) the existing diodes would give impedance errors not less than the following values :

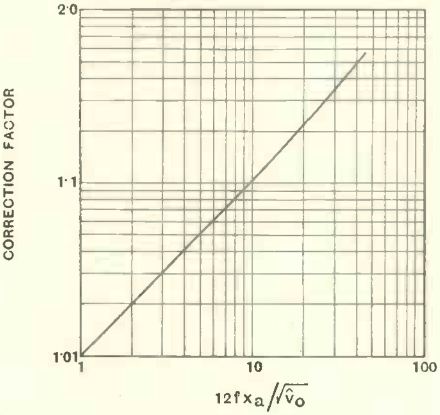

Fig. 16.—*Empirical correction curve for electron inertia error* (*f = frequency in Mc., x_a = anode-filament clearance in cm., $\hat{v}_0$ = observed peak voltage*).

Frequency	300	600	1,000 Mc.
Lead impedance error	2	8	25%

This error evidently becomes serious at frequencies of the order of 600 Mc. and higher. The experimental method outlined in Section II (*b*) would enable the order of magnitude of the error to be checked in this region but accurate correction would hardly be possible. At 1,000 Mc. the error doubles if the lead length is increased by 1 cm. Two methods are available by which the impedance error could be reduced : (1) by re-designing the diode with much smaller dimensions, and (2) by adjusting the lead length to an integral number of electrical half-wavelengths. It seems probable, however, that 1,000 megacycles is about the limit for voltage measurements of even moderate accuracy.

(*To be concluded.*)

Abstracts and References

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

PROPAGATION OF WAVES

859. INVESTIGATION, WITH GERMAN BROADCASTING STATIONS, OF THE MUTUAL MODULATION EFFECT [Luxembourg Effect] OF ELECTRIC WAVES.—M. Bäumler and W. Pfitzer. (*Hochf:tech. u. Elek:akus.*, December, 1935, Vol. 46, No. 6, pp. 181–186.)

A short account of present knowledge of the Luxembourg effect is given in § I; § II describes experiments with German broadcasting stations which were carried out by the German Post Office in order to obtain further information on and elucidation of the effect. The German National long-wave emitter radiated its interval signal and several other stations their unmodulated carrier waves. The geographical positions of the emitters and receivers are shown in Fig. 1; the results are tabulated. It was found that the intermodulation was strongest and most regular when the disturbance was due to a long-wave station and the disturbed emitter was on a medium wavelength. Interactions between two stations of medium wavelength were, however, also observed; in this case the interfering station could be of longer or shorter wavelength than the disturbed one. Interaction was also observed on emitters at quite short distances, when the interfering station was on a medium wavelength and the disturbed station on a long one. This was particularly noticed in experiments on interaction between the Berlin and German National emitters (Fig. 2, with table of results).

§ III gives details of the measurement of the degree of modulation m of the disturbance; an auxiliary emitter with calibrated m was used (scheme Fig. 3). The output voltage from the l.f. amplifier was proportional to m and the square of the input voltage U_e (eqn. 3). Fig. 4 shows the modulation characteristics for various values of U_e. The geographical lay-out for these measurements is shown in Fig. 5; measurements of m were made at several places as near as possible to the straight line joining the interfering station (German National) to the disturbed medium-wave emitter (Heilsberg). The results are tabulated and given in the form of curves of variation of m with distance (Fig. 6, where a decided maximum appears) and with the strength of the disturbed carrier wave (Fig. 7, showing increase of m with decreasing field strength). Fig. 8 gives simultaneous fading curves taken at different distances from Heilsberg. The interaction was definitely strongest on the continuation of the straight line from Heilsberg to Berlin, but has not hitherto been observed at places between the two interacting stations. The interaction modulation was found to decrease as the modulation frequency increased.

860. A METHOD FOR INVESTIGATING PARASITIC MODULATION [Luxembourg Effect].—Lvovich. (*See* 960.)

861. A NEW EXPERIMENTAL METHOD FOR STUDY OF THE UPPER ATMOSPHERE [30–70 km: Measurement of Light Scattered from Modulated Searchlight Beam will give Molecular Density and Other Characteristics].—M. A. Tuve, E. A. Johnson and O. R. Wulf. (*Phys. Review*, 1st Dec. 1935, Series 2, Vol. 48, No. 11, p. 917.) For the full paper see *Journ. of Terrest. Magnetism*, December, 1935.

862. NEW COSMIC PHENOMENON: UNUSUAL RADIO CONDITIONS [54-Day Fade-Outs] CORRELATED WITH SOLAR ERUPTIONS.—J. H. Dellinger. (*QST*, January, 1936, Vol. 20, No. 1, pp. 8 and 79.) Latest developments regarding the phenomenon dealt with in 416 and 417 of February.

863. ULTRA-SHORT-WAVE PROPAGATION OVER LAND.—Burrows, Decino and Hunt. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1507–1535.) The full paper, a summary of which was dealt with in 2917 of 1935.

864. Propagation of Ultra-Short Radio Waves [Boston Field-Strength Measurements and Conclusions derived Therefrom].—C. R. Burrows. (*Bell Lab. Record*, December, 1935, Vol. 14, No. 4, pp. 111–115.)

865. Long Distances on Very Short Waves: 21 Stations report Working All Continents on 10 Metres.—(*QST*, January, 1936, Vol. 20, No. 1, pp. 9–10 and 82–85.)

866. Long-Distance Transmission of 30 Mc Waves, *and* Radio Communication at 80 km Distance with Ultra-Short Waves of 68 cm between Mt. Tukuba and Tokyo University of Engineering.—S. Namba: K. Morita and K. Awaya. (*Journ. I.E.E. Japan*, September, 1935, Vol. 55 [No. 9], No. 566, p. 827: p. 828: Japanese only.)

867. The Ionosphere, Skip Distance of Radio Waves, and the Propagation of Micro- [and Ultra-Short] Waves [Calculation of Washington/Huancayo Skip Distances throughout Day and Season: Daylight Short-Wave Communication controlled by E Region in Summer and F_2 in Winter: Long-Distance Ultra-Short-Wave Communication due to Diffraction and to Temperature-Gradient Refraction: Effect of Water Vapour].—E. O. Hulburt. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1492–1506.)

868. The Structure of the Ionosphere and the Propagation of Short Electric Waves.—Jonescu and Mihul. (*Journ. de Phys. et le Radium*, September, 1935, Vol. 6, No. 9, pp. 388–396.) For *Comptes Rendus* Notes *see* 2156 of 1935.

869. Notes on the Propagation of 18.48 and 31.19 m Waves on the Saigon/Paris Path, and of 24.56 and 33 m Waves on the Algiers/Paris Path.—Picault and Espinasse. (*Bull. Soc. franc. des Élec.*, December, 1935, Vol. 5, No. 60, pp. 1226–1228 and 1229–1232.)

870. Reflection and Refraction of Electric Waves at the Earth's Surface [Theory giving Equivalent Virtual Radiators for Reflected and Refracted Fields].—P. G. Violet. (*Hochf:tech. u. Elek:akus.*, December, 1935, Vol. 46, No. 6, pp. 192–199.)

The fundamental equations of electrodynamics for quasi-stationary waves are given in § II in a form suitable for practical applications; the wave equation (eqns. 5, 6) is satisfied by the Hertzian vector (eqns. 7) from which the field components may be derived by eqns. 10. In § III the formulae for transforming differentiations from Cartesian into spherical polar co-ordinates are reviewed. The general nature of reflection at plane surfaces is discussed in § IV; in § V the boundary conditions at the surface are given (eqns. 17). The incident, reflected and refracted vectors are explained by Fig. 2; the reflected field appears to radiate from O_r and the refracted field from O_g. A new angular magnitude w is introduced (eqn. 32) and the equations are solved to give expressions determining the reflected field (eqns. 35, 36) and the refracted field (eqns. 37, 38), when the original radiator lies in the xz-plane. Eqns. 39 give more general expressions for any position of the radiator. Snell's law of refraction is deduced during the calculation (eqn. 31).

The co-ordinates of O_g are determined by eqns. 41 (§ VI); the direction of the principal ray is fixed by eqns. 42 and evaluated for the special cases of grazing (eqns. 43) and perpendicular (eqns. 44) incidence, and the case when the two media are alike (eqns. 45). Eqns. 47 give the limiting case when the complex refractive index tends to infinity, when complete reflection occurs, while eqns. 48 govern the passage of waves from a very dense into a less dense medium. In § VII various applications are discussed; (1) the vertical polar diagram of a horizontal emitter near the earth, (2) the presence of a third medium, and in particular the propagation of waves along a layer of earth bounded below by water (Fig. 3). Here the resultant characteristic defining the field in air is given by eqn. 54. § VIII discusses the relation of this work with complex vectors and virtual radiators to the known formulae of optics.

871. The Experiments at Ostrov and Macochy [Test of Radiogeological Results by Excavations].—V. Fritsch. (*Hochf:tech. u. Elek: akus.*, December, 1935, Vol. 46, No. 6, pp. 186–187.) *See* 20 of January.

872. Experimental Investigation on the Magnetic Double Refraction of Ionised Air [Curves of Refractive Index as Function of Wavelength and of Magnetic Field for Longitudinal Propagation: Agreement with Theory].—S. K. Mitra and A. C. Ghosh. (*Nature*, 11th Jan. 1936, Vol. 137, pp. 68–69: preliminary letter.) *See* 14 of January.

873. Measurements of the Electron Density in the Ionosphere.—Maeda and Konomi. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, pp. 691–694: Japanese only.) For a previous paper *see* 3756 of 1935.

874. The Influence of the Radiation Field from an Electrical Storm on the Ionisation Density of the Ionosphere [Theoretical Investigation of Influence of Highly-Damped Electric Wave on Ionosphere: Inappreciable Increase in Ionisation due to Radiation Field of Lightning Flash alone].—R. H. Healey. (*Phil. Mag.*, January, 1936, Series 7, Vol. 21, No. 138, pp. 187–198.) For mathematical methods *see* Bailey & Martyn, 1934 Abstracts, p. 606.

875. Electron Attachment and Ion Formation in Gases [Calculated from Law of Mass Action: Agreement with Experiment].—W. Rogowski. (*Zeitschr. f. Physik*, No. 5/6, Vol. 98, 1935, pp. 399–414.)

876. A Method of Measuring the Incident Angle of a Downcoming Wave at a Receiving Point.—Namba, Maeda and Yokoyama. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, p. 766: Japanese only.)

877. Preliminary Notes on a Pulse Generator [Neon Lamp and Saturated-Core Transformer, for Ionosphere Investigations].—M. K. Ts'en. (*Chinese Journ. of Phys.*, No. 1, Vol. 1, 1933, pp. 87–89 : in English.)

878. Field-Strength Recording [in Fading Investigations] by the Cathode-Ray Oscillograph, with the Use of an Intermediate Frequency.—J. Lončar. (*Elektrot. u. Masch:bau*, 3rd Nov. 1935, Vol. 53, No. 44, pp. 525–526.) For previous work *see* 1934 Abstracts, p. 552. The writer now obtains satisfactory photographic records with an ordinary superheterodyne receiver from which the second detector valve is removed.

879. A Test Car for Marine Radio-Telephone [Field-Strength] Surveys.—Hafner. (*Bell Lab. Record*, November, 1935, Vol. 14, No. 3, pp. 94–98.)

880. Crepuscular Tables [obtainable from Polish Meteorological Institute]. — J. Lugeon. (*Hydrographic Review*, November, 1935, Vol. 12, No. 2, p. 144.)

881. Study of Atmospheric Ozone by Visual Spectroscopy [Solar, Blue Sky and Lunar].—J. Gauzit. (*Ann. de Physique*, November, 1935, Vol. 4, pp. 450–532.)

Confirming the Dobson annual variation; evidence of the inequalities of distribution in the same horizontal layer. Assuming, as a first approximation, the validity of the "thin layer" idea, the height of this layer would average 33 km (ranging between 20 and 50 km); the height increases, in general, with the thickness. But the spectroscopy of the very low sun clearly shows the inadequacy of the "thin layer" hypothesis, and gives an approximate value for the quantity of ozone in the troposphere. The writer disagrees with the conclusion of Goetz, Meetham and Dobson that the principal changes in ozone content are situated between 10 and 20 km.

882. The Temperature of Atmospheric Ozone [is much below 0°C : No Great Diurnal or Seasonal Variation of Ozone Temperature or Height].—J. Devaux. (*Comptes Rendus*, 30th Dec. 1935, Vol. 201, No. 27, pp. 1500–1501.) For previous work *see* Abstracts, 1932, p. 160 : *also* 1934, p. 374.

883. The Ultra-Luminous Spectrograph of the Pic du Midi [Essential Characteristics: Wavelengths already observed in Night Sky Spectrum].—H. Garrigue. (*Comptes Rendus*, 6th Jan. 1936, Vol. 202, No. 1, pp. 44–45.)

884. The Continuous Spectrum of the Night Sky and the Diffusion of Light in Space.—J. Dufay. (*Comptes Rendus*, 23rd Dec. 1935, Vol. 201, No. 26, pp. 1323–1325.)

885. The Calculation of the Primary Constants of a Uniform Line from the Propagation Constants [Formulae applicable to All Types of Uniform Lines].—A. Rosen. (*P.O. Elec. Eng. Journ.*, January, 1936, Vol. 28, Part 4, pp. 274–275.)

886. A New Polarisation Phenomenon [Very Strong Polarisation of Oblique Light by Very Thin Metallic Mirror].—M. Cosyns. (*Nature*, 11th Jan. 1936, Vol. 137, p. 70.)

887. Dispersion of Air, Krypton and Xenon in Short-Wave Ultra-Violet [Measurements give Dispersion Formula with Absorption Frequencies Higher than those formerly measured].—W. Kronjäger. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 17–22.)

888. Selective Dispersion of Light in Mercury Vapour [Separation of "Molecular" and "Atomic" Components of the Radiation : Polarisation Measurements : etc.].—G. Landsberg and L. Mandelstam. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 8, 1935, pp. 378–400 : in German.)

889. Anomalous Diffraction Gratings [with Destructive Interference along Plane of Grating].—R. W. Wood. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, pp. 928–936.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

890. The Nature of Atmospherics.—G. W. O. H : Norinder & Nordell. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, pp. 1–2.) Editorial on the work dealt with in 449 of February.

891. Radioelectric Communications : Section 3—Variations of Atmospherics : Section 4—Ratio of Signal to Disturbances, and the Power necessary to assure Communication.—H. de Bellescize. (*L'Onde Élec.*, November, 1935, Vol. 14, No. 167, pp. 740–759.) For previous parts *see* 23 of January.

892. "Static Hiss" attributed to Interstellar Dust charged by Ultra-Violet Light from Stars.—Langer : Jansky. (*Sci. News Letter*, 4th Jan. 1936, Vol. 29, p. 15.)

893. Inappreciable Increase in Ionosphere Ionisation due to Radiation Field of Lightning Flash alone.—Healey. (*See* 874.)

894. A Curious After-Effect of Lightning [String of Luminous Beads remaining in Path of Flash].—D. G. Beadle. (*Nature*, 18th Jan. 1936, Vol. 137, p. 112.)

895. Measurements of the Electrical Conductivity of the Air for the Determination of Localities particularly Liable to Lightning Strokes.—G. Viel : Dauzère. (*Elektrot. u. Masch:bau*, 8th Dec. 1935, Vol. 53, No. 49, p. 585 : summary only.) For a previous paper *see* 961 of 1935.

896. Model Tests on Lightning Conductors.—A. M. Zalesski. (*Elektrot. u. Masch:bau*, 15th Dec. 1935, Vol. 53, No. 50, p. 598 : summary only.)

897. The Initiation of Electrical Discharges by Field Emission [Oscillograms of Overvolted and of Ordinary Discharges in Asymmetrical Fields between Spheres, Points and Planes, and of 60-cycle Magnesium Spark].—J. W. Flowers. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, pp. 954–959.)

898. Determination of the Saturation Ionisation Current from High Speed Electrons in Air.—L. S. Taylor. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, p. 970.)

899. Study of the Earth's Electrical Field, Atmospheric Ionisation and Vertical Current at Scoresby Sound during the Polar Year.—A. Dauvillier. (*Journ. de Phys. et le Radium*, October, 1935, Vol. 6, No. 10, pp. 420–426.) For a *Comptes Rendus* Note *see* 2942 of 1935.

900. Earth Current Measurements [along Atlantic Coast and in Mississippi Valley].—Mary K. Corr. (*Bell Lab. Record*, December, 1935, Vol. 14, No. 4, pp. 106–110.)

901. "A Manual of the Principles of Meteorology" [Book Review].—R. M. Deeley. (*Sci. Progress*, January, 1936, Vol. 30, No. 119, pp. 540–542.) In a combined discussion of this book and that of Brunt (3790 of 1935.)

902. The Scientific Equipment of the Stratosphere Balloon "Explorer II."—(*Electronics*, December, 1935, Vol. 8, pp. 31–34 and 38.)

903. Geiger-Counter Characteristics with Applied Potentials Reversed [Reduced Efficiency: Suggested Explanation].—D. B. Cowie. (*Phys. Review*, 1st Dec. 1935, Series 2, Vol. 48, No. 11, pp. 883–885.)

904. Investigations on [Cosmic Ray] Counters with a Cathode-Ray Tube [Impulse Forms and Duration of Discharge: Hints for Use and Gaseous Filling of Counters].—A. Trost. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 801–804.)

905. Evidence for Supernovae as Generators of Cosmic Radiation.—H. Zanstra. (*Naturwiss.*, 20th Dec. 1935, Vol. 23, pp. 867–868.)

906. The Directional Effect of Cosmic Radiation [Existence of Preferred Directions].—A. Ehmert. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 798–801: preliminary communication.)

907. Cosmic Rays and the Origin of Species.—H. H. Thomas. (*Nature*, 11th and 18th Jan. 1936, Vol. 137, pp. 51–53: 97–98.)

908. Production of Cosmic-Ray Showers at a Considerable Depth below Ground-Level [Positive or Negative Electrons form Considerable Part of Penetrating Radiation].—D. H. Follett and J. D. Crawshaw. (*Nature*, 28th Dec. 1935, Vol. 136, p. 1026.)

909. Analysis of the Corpuscular Cosmic Radiation at a Depth of 28 m in the Earth [One Group of Very High Penetrating Power: Very Soft Secondary Radiations].—P. Auger and A. Rosenberg. (*Comptes Rendus*, 2nd Dec. 1935, Vol. 201, No. 23, pp 1116–1118.)

910. The Variation of Intensity of Cosmic Radiation in the Magnetic Field of the Earth between Amsterdam and North Cape, *also* An Arrangement for Measuring the Cosmic Ray Ionisation in Deep Water, *and* The Decrease of Primary Cosmic Radiation and Showers in Water down to a Depth of 300 Metres.—Clay and others. (*Physica*, December, 1935, Vol. 2, No. 10, pp. 1033–1050: in English.)

911. Remark on a Secondary Effect of Cosmic Radiation [Screening Action of Lead Plates in Lateral Position].—A. Schwegler. (*Zeitschr. f. Physik*, No. 3/4, Vol. 98, 1935, p. 288.)

912. Vertical Intensity of Cosmic Rays by Threefold Coincidences in the Stratosphere [Curve with Maximum at Pressure of 100 mm Hg and Hump at 300 mm Hg].—E. Regener and G. Pfotzer. (*Nature*, 2nd Nov. 1935, Vol. 136, pp. 718–719.)

913. On the Showers of Rays which produce Bursts of Cosmic-Ray Ionisation [Probability that a Shower of a Given Number of Rays will Discharge a Number of Counters: No Marked Discontinuity between Small and Large Showers].—C. G. Montgomery and D. D. Montgomery. (*Phys. Review*, 15th Nov. 1935, Series 2, Vol. 48, No. 10, pp. 786–789.)

914. The Variation with Altitude of the Production of Bursts of Cosmic-Ray Ionisation.—C. G. Montgomery and D. D. Montgomery. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, pp. 969–970.)

915. Increased Frequency of Cosmic-Ray Bursts with Reduced Shielding.—R. L. Doan. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, pp. 470–471.)

916. The Impact of Very Rapid, Heavy Particles [Calculation of Energy and Number of Secondary Electrons which should be produced by the Passage of Heavy Cosmic-Ray Particles through Matter].—W. Braunbek. (*Zeitschr. f. Physik*, No. 9/10, Vol. 96, 1935, pp. 600–606.)

917. [Cosmic-Ray] Shower Production in Small Thicknesses of Lead and other Elements [Increase in Production of "Triple" Showers a Non-Linear Function of Thickness].—J. E. Morgan and W. M. Nielsen. (*Phys. Review*, 1st Nov. 1935, Series 2, Vol. 48, No. 9, pp. 773–774.)

918. The Frequency and Magnitude of the Showers produced by Cosmic Rays in Lead.—H. Geiger and O. Zeiller. (*Zeitschr. f. Physik*, No. 5/6, Vol. 97, 1935, pp. 300–311.)

919. Measurement of the Ionisation produced by Showers due to Cosmic Rays in Lead.—Rossi and Boldrini. (*La Ricerca Scient.*, 15/30th Nov. 1935, 6th Year, Vol. 2, No. 9/10, pp. 327–338.)

920. Analysis of Cosmic Ray Deflection Experiments. II. [Case where Region of Uniform Deflecting Field is Same Width as That of Counters: Application to Various Experiments].—W. E. Danforth, Jr. (*Journ. Franklin Inst.*, September, 1935, Vol. 22, No. 3, pp. 377–386.)

921. Absorption of Cosmic Radiation in Matter [Absorption Coefficients nearly Linear with Density].—A. W. Nye. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, pp. 481–482: abstract only.)

922. Rock Salt Absorption of Cosmic Rays.—S. Ziemecki. (*Acta Phys. Polonica*, Fasc. 1/2, Vol. 4, 1935, pp. 183–193: in English.)

PROPERTIES OF CIRCUITS

923. On the Rectifying Effect of a Thin Wire connected in a Circuit to which Two Voltages are applied having a 2 : 1 Frequency Ratio.—M. Backman and K. Teodorchik. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 850–854.)

If two sinusoidal e.m.fs, one of which has twice the frequency of the other, are applied in series to a thin wire having a high temperature coefficient of resistance and a low thermal lag, the current flowing through the wire will contain a d.c. component. This is proved by considering the variation in the temperature and therefore in the resistance of the wire. A formula (10) determining the d.c. component is derived, and it is pointed out that the rectifying effect depends very much on the phase displacement of the two e.m.fs. Experiments with thin tungsten and silver wires have given a satisfactory confirmation of the theory.

924. On a Mechanical Model of an Oscillating System.—I. S. Rabinovich. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 39–45.)

The usual models of harmonic motion, *i.e.* the pendulum or a weight attached to a spring, can only represent free damped oscillations. In order to demonstrate the various phenomena associated with the application of an external harmonic force to an oscillating system, a force F of variable frequency but constant amplitude should be applied to the suspended weight. From the examination of an equivalent electrical circuit, the author shows that the same effect can be obtained if, instead of applying the force F, that end of the spring which is normally fixed receives a periodical displacement of constant magnitude. This movement can be easily derived mechanically from a circular motion by a system of links. A number of experiments possible with this model are suggested and it is pointed out that by attaching to the weight a second spring and weight a system with two degrees of freedom is obtained.

925. Compensation of Capacity in a Valve Circuit.—M. E. Backman. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 14–17.)

It has been shown by Mandelstam and Papalexi [Russian Pat. 81 448 of 7.1.34] that any parameter in a valve circuit can be compensated by a suitable adjustment of the phase relationship between the drive and feed-back voltages. In the present paper this method is examined for the case of an aperiodic circuit in which a condenser C is connected between the grid and filament and a charging voltage is applied across C and the anode resistance R_a of the valve in series, the valve high-tension supply being connected between the anode and R_a.

A formula (5) is derived for determining the equivalent capacity of C. A number of experiments were carried out for measuring this capacity under various operating conditions. For this purpose C was momentarily charged and discharged by a Helmholz interrupter and the discharge current through a galvanometer noted. The results obtained show that by correct adjustment of the circuit constants the capacity C can be compensated up to 85 to 90%.

926. Tube Capacity put to Work [Utilisation of Miller Effect].—Hollywood and Wilder. (*See* 979.)

927. Relaxation Oscillations in a Permanent Régime.—J. Hak. (*Rev. Gén. de l'Élec.*, 28th Dec. 1935, Vol. 38, No. 26, pp. 895–899.)

" The explicit solution of the differential equation corresponding to relaxation oscillations not being known, the writer has systematically undertaken the graphical solution of this equation with a view to determining the principal characteristic values of the curve representing relaxation oscillations in a permanent régime. He determines the tangent at the origin, the period, the point of inflection and the tangent at that point, for different values of the constant which appears in the differential equation. He gives, in addition, some empirical formulae expressing these characteristic values as functions of this constant. . . . The curves representing these values as functions of ϵ are of very regular form. Above all, they have a very regular form for high values of ϵ, and it may be supposed that, even for values of ϵ exceeding the limit $\epsilon = 10$ so far examined, the formulae given represent with sufficient accuracy the period, angular coefficient of the tangent, and the other characteristic values of relaxation oscillations."

928. Spasmodic Oscillations [" Jumps "] in a Circuit containing Capacity and Inductance.—L. N. Loshakov and S. E. Chaikin. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 832–843.)

Discontinuities in oscillations are known to occur in circuits containing only one of the two reactive elements, *i.e.* either capacity or inductance. In the present paper an oscillatory circuit containing both capacity and inductance is examined. In this circuit the back voltage is applied to the grid of the oscillator valve through a second valve in which the necessary phase displacement is obtained. A mathematical analysis of the operation of the circuit is presented showing that rapid spasmodic changes can take place in the state of the system. Cathode-ray oscillograms confirm the theoretical conclusions. For a French version see *Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 181–194.

929. ON "FRACTIONAL" RESONANCE.—J. B. Kobzarev. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 815–820.)

As a further illustration of the quasi-linear theory (487 of February and back reference) the operation of an oscillator is examined when the ratio of the frequency of the applied e.m.f. to the natural frequency of the oscillator is 2 : 3.

Equations of the first approximation are derived on the assumption that the characteristic of the valve is a curve of the fourth order, and conditions for stable oscillations are established. It is pointed out, however, that owing to the inadequacy of the analytical method, *i.e.* the representation of the valve characteristic by an equation, the theoretical results may not be obtainable in practice. On the contrary, from certain considerations not discussed in the present paper, it appears that the 2 : 3 resonance is not possible with an ordinary thermionic valve.

930. ON THE THEORY OF "PULL-IN" IN THE CASE OF A "SOFT" RÉGIME.—V. I. Gaponov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 821–831.)

A theoretical investigation showing that when an external e.m.f. is applied to an oscillating circuit, the pulling-in may be accompanied by "hysteresis" phenomena, *i.e.* by delayed changes in the oscillations, even if the valve is operating under a soft régime. It is assumed that the characteristic curve of the valve can be represented by an equation of the 3rd order, and van der Pol abbreviated equations are derived. A graphical analysis of the integral curves of the equations is given, and the variation in frequency and amplitude of the forced oscillations is examined when (a) the frequency and (b) the amplitude (at certain frequencies) of the external e.m.f. is varied.

931. ELECTRIC FILTERS AND THE THEORY OF MATRICES [and the Use of Linear Transformations for Line and Filter Calculations].—L. Brillouin. (*Rev. Gén. de l'Élec.*, 4th Jan. 1936, Vol. 39, No. 1, pp. 3–16.)

932. REMARKS ON THE TUNING OF BAND FILTERS [Behaviour of Coupled Oscillatory Circuits discussed with help of Relief Contour Diagram: Practical Application].—F. Stejskal. (*Funktech. Monatshefte*, December, 1935, No. 12, p. 452.)

933. "COMMUNICATION NETWORKS, VOL. II" [Book Review].—E. A. Guillemin. (*Electronics*, December, 1935, Vol. 8, p. 35.) A long and enthusiastic review.

TRANSMISSION

934. A METHOD FOR THE PRODUCTION OF CENTIMETRE [Micro-] WAVES.—K. Okabe and M. Hisida. (*Journ. I.E.E. Japan*, September, 1935, Vol. 55 [No. 9], No. 566, p. 823: Japanese only, with diagram of new type of valve in magnetic field.)

935. THE MAGNETRON [History: Mode of Operation, for Electronic and Dynatron Oscillations: Latest Types: Guard Wires (in Dynatron Type) for protecting Filament from Electron Bombardment].—A. W. Ladner. (*Marconi Review*, Sept./Oct. 1935, No. 56, pp. 22–29.) For the use of these valves for medical purposes *see* 1721 and 1722 of 1935.

936. ON THE GENERATION OF ELECTROMAGNETIC [Micro-] WAVES SHORTER THAN 50 CM BY MEANS OF SPLIT-ANODE MAGNETRONS.—Vyshinski, Kopilovich, Lelyakov, Slutskin and Usikuv. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 844–849.) A full German version of this paper was dealt with in 89 of 1935.

937. R. I. E. C. [Leghorn] RESEARCHES ON MICRO-WAVES.—(*Alta Frequenza*, October, 1935, Vol. 4, No. 5, pp. 629–632.) For a previous report *see* 2226 of 1935.

938. 60 Mc M.O.P.A. [Ultra-Short-Wave Master-Oscillator Power-Amplifier with Resonant-Line Tuning Circuits].—C. J. Franks. (*Electronics*, October, 1935, Vol. 8, pp. 33–36.)

939. TRANSMITTERS FOR TEN METRES: SOME MEDIUM-POWER RIGS OF SIMPLE CONSTRUCTION.—G. Grammer. (*QST*, January, 1936, Vol. 20, No. 1, pp. 11–14 and 80.)

940. HIGH-FIDELITY RADIO TRANSMITTER FOR ULTRA-HIGH FREQUENCIES.—J. W. Smith. (*Bell Lab. Record*, November, 1935, Vol. 14, No. 3, pp. 99–102.) Type No. 16 crystal-controlled transmitter, 50 w, 30–60 Mc/s, alone or with No. 88 amplifier, 500 w, 30–42 Mc/s.

941. PHASE-FREQUENCY MODULATION.—E. H. Armstrong. (*Electronics*, November, 1935, Vol. 8, pp. 17–19 and 36.) Based on paper at November I.R.E. meeting and on interview. *See* also 3394 and 3395 of 1935.

942. "ELECTRON QUANTITY" MODULATION SYSTEM.—T. Hayasi. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, pp. 595–598: English summary pp. 75–76.) *See* also 503 of February, and 943, below.

943. THE NEW SUPPRESSOR-GRID MODULATION AT ULTRA-SHORT WAVES ["Electron-Quantity" Modulation System using Pentode].—T. Hayasi and S. Yamagiwa. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, p. 673: Japanese only.) See 942, above.

944. A LOW LEVEL MODULATION SYSTEM [Power wasted in Carrier Amplification saved by Class C Amplification for Carrier only, Sidebands supplied through Separate Channel using Class B Amplification].—W. E. Phillips. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, p. 1419: summary only.)

945. A NEW METHOD OF MODULATION.—Y. Takeda. (*Journ. I.E.E. Japan*, September, 1935, Vol. 55 [No. 9], No. 566, p. 820: Japanese only.)

946. Development of Theory of Grid-Bias Modulation and Amplification of Modulated Oscillations.—A. I. Berg. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 3–10.)

Author's summary :—From the general equation of the valve oscillator, fundamental equations of the theory of grid-bias modulation and of the amplification of modulated oscillations are derived. Based on the analysis of these equations, general requirements for linear grid-bias modulation and linear amplification of modulated oscillations are set forth. For grid-bias modulation the fundamental equation is $I_{ma1} = \mu . (E_{g0} - E_g)/(R_{a1} + R_{ae})$, where R_{ae} is the equivalent resistance of the anode tuned circuit ; the requirement for undistorted operation is $R_{a1} =$ const. For the amplification of modulated oscillations the fundamental equation is $I_{ma1} = \mu . U_{mg}/(R_{ae} + R_{a1})$, and the requirement for undistorted operation is $R_{a1} = 2R_i$. The results thus obtained are compared with the previously stated requirements for the distortionless anode modulation of the Class C amplifier [2611 of 1935].

947. High-Fidelity Technique [Reports on Tests with W2XR, Experimental Station broadcasting on 20 kc Channel : Compensation for Gramophone-Record Transmission : etc.].—Hogan and Barber. (*Electronics*, November, 1935, Vol. 8, pp. 26–29.)

948. Anode Modulation in Parallel and in Series [Comparison between Parallel (" Constant Current ") Modulation and Series (" Constant Voltage ") Modulation Methods : Some Characteristics of Valves suitable for Series Modulation].—P. Pontecorvo. (*Alta Frequenza*, October, 1935, Vol. 4, No. 5, pp. 508–529 : Editorial p. 505.)

949. Privacy Systems for Wireless Telephony [Classified Survey of Systems].—H. Iinuma. (*Circulars of Electrot. Lab.*, Tokyo, No. 101, 1935, 60 pp : in Japanese, with English synopsis.)

950. Short-Wave Radio-Telephony by the Carrier Depression System.—E. Takagisi and S. Syono. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, p. 676 : Japanese only.)

951. A Radio Transmitter for the Private Flyer.—R. S. Bair. (*Bell Lab. Record*, December, 1935, Vol. 14, No. 4, pp. 136–138.)

952. On the Variation of Stability with Frequency in Valve Oscillators covering a Wide Frequency Range.—E. S. Antseliovich. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 11–14.)

It is generally assumed that the frequency stability of a continuously variable oscillator remains approximately constant over the whole wavelength range of the oscillator. The object of this paper is to show that on the contrary the frequency stability depends on the operating wavelength. This is demonstrated by a number of tables based on a large amount of statistical data and showing the frequency variation of reactively coupled oscillators on wavelengths between 5 and 6 000 metres. A curve is plotted on the basis of these tables indicating that the frequency variation tends to increase with increase of wavelength. This is followed by a theoretical investigation in which the relative importance of the various factors affecting the frequency stability, and their dependence on the operating frequency, are presented in tabular form.

It is pointed out that from the point of view of frequency stability the position of the optimum frequency band depends to a great extent on the actual construction of the oscillator. For well designed and compact oscillators it can be taken as lying between 50 and 300 metres.

953. The Frequency Stability of Crystal-Controlled Valve Oscillators : Addendum.—Antseliovich. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, p. 76.) *See* 81 of January.

954. Electric Temperature Control of Thermostat for Broadcast Use.—Itow, Yokoyama and Nomura. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, p. 674 : Japanese only.)

955. A Quantitative Study of the Dynatron [Prediction of Performance by Use of Output Characteristics : with Experimental Confirmation : Behaviour with Crystal as Tuned Circuit : etc.].—F. M. Gager and J. B. Russell, Jr. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1536–1566.). For MacKinnon's experimental results with a crystal, which are explained by the present discussion, *see* 1933 Abstracts, p. 155.

956. On the Special High-Frequency Oscillations produced by Mercury-Vapour Tubes.—I. Yamamoto and T. Ono. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, p. 678 : Japanese only.)

957. An Analytical Method of Predetermining the Behaviour of the Vacuum Tube Oscillator, which yields Regions of Oscillation and Non-Oscillation, the Amplitude of Oscillation, and Wave Form.—E. A. Guillemin. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, p. 1417 : summary only.)

958. Filtering of Upper Harmonics.—Z. I. Model and S. V. Person. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 1–22.)

Authors' summary :—The causes of upper harmonics in vacuum-tube transmitters, and the methods of reducing them, are considered. The filtering action of antenna circuits, transmission lines, push-pull circuits and so forth are investigated in detail. Formulae suitable for calculation are derived for all these cases. In conclusion, a method of measuring the harmonic power in an antenna is described, and a series of numerical examples given.

959. The Choice of Coupling of the Short-Wave Transmitter to the Transmission Line.—Gonorovsky. (*See* 996.)

RECEPTION

960. A Method for Investigating Parasitic Modulation (Luxembourg Effect).—R. V. Lvovich. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 897–904.)

It is shown by simple calculations that if the theory of the Luxembourg effect as expounded by Bailey and Martin is correct, *i.e.* if parasitic modulation is due to non-linear processes in the ionosphere, then the following phenomena should take place :—

(1) Parasitic modulation when either of the two interfering stations is received ; (2) distorted reception ; (3) change in the depth of modulation ; and (4) the appearance of radio and audio frequencies other than those radiated.

It is suggested that experiments should be carried out to check these points and in this way either confirm or refute the theory. So far, (1) has been confirmed experimentally while (2) is contradicted by observations.

961. Investigation, with German Broadcasting Stations, of the Luxembourg Effect —Bäumler and Pfitzer. (*See* 859.)

962. Intermodulation produced in Ultra-Short-Wave Receivers [Reception of Broadcast and Long Waves possible on U.S.W. Receiver (Super-Regenerative or Regenerative Type) with help of Local Oscillator of Same Frequency Range as Receiver : Possible Applications].—S. Uda and S. Miki. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 981–985 : English summary pp. 123–124.)

963. A Simplified Circuit for the Quenching of Broadcast Interference [Superior Action of Condenser/Choke Combination (compared with Condenser or Chokes alone) obtained Economically in Cost and Space by Roll Condensers with Iron-Powder Cores].—H. A. Schwab. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 446–447.)

964. Short-Wave Interference traced to "Artificial Fever" Apparatus [Hundreds of Miles away].—Mimno & others. (*Sci. News Letter*, 4th Jan. 1936, Vol. 29, p. 9.)

965. On the Electric Oscillation due to Magneto Ignition.—G. Yahata. (*Journ. I.E.E. Japan*, July and August, 1935, Vol. 55, Nos. 564 and 565, pp. 675 and 764 : Japanese only, with graphs.)

966. Work of the British Electrical Research Association [on Interference and Its Suppression].—(*Wireless World*, 3rd Jan. 1936, Vol. 38, p. 22.)

967. The Work of the Mixed Committee on Interference with Broadcast Reception [Berlin, 1935].—R. Jouaust. (*Rev. Gén. de l'Élec.*, 19th Oct. 1935, Vol. 38, No. 16, pp. 525–529.)

968. A Portable Noise Detector [Use of a Midget Broadcast Receiver for tracing Interference].—(*Television*, December, 1935, Vol. 8, No. 94, pp. 723–724.)

969. Measurements on Broadcast Receivers [Survey of Test Room Methods : including the Danger of "Floating Carrier" Transmission to AVC Receivers and the Testing of "Expanders" to counteract This].—A. Wertli. (*Bull. Assoc. suisse des Élec.*, No. 26, Vol. 26, pp. 742–748 : in German.)

970. Description of an Equipment giving an Immediate Trace of the Selectivity Curves of a Receiver [comprising Small Cathode-Ray Oscillograph and Motor-Driven Saw-Tooth Generator and Condenser].—Meillon. (*Rev. Gén. de l'Élec.*, 11th Jan. 1936, Vol. 39, No. 2, pp. 49–50 : summary only.)

971. "The Cathode-Ray Tube at Work" [Book Review : Primarily for Radio Servicing].—Rider. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, p. 20 : *Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1567–1568.)

972. "Modern Radio Servicing" [Book Review]. —A. A. Ghirardi. (*Wireless World*, 7th Feb. 1936, Vol. 38, p. 139.)

973. Notes on Intermediate-Frequency Transformer Design [Measurement of "Q" for Coils and Condensers : Formulae for predicting Gain and Selectivity : High Fidelity and the Use of Band Expansion : etc.].—F. H. Scheer. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1483–1491.) *See* also 1495 of 1935.

974. Some Measurements on Iron-Cored Tuning Coils [Reasons for Comparative Lack of Popularity in England of Previous Types : the New Multi-Layer Litz Winding : Need for Loss-Free Insulating materials : etc.].—Kaschke : Vogt. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, pp. 14–20.)

975. Suppressing Second-Channel Interference [Discussion of Image-Rejection Methods].—W. T. Cocking. (*Wireless World*, 17th Jan. 1936, Vol. 38, pp. 55–56.)

976. Automatic Tuning Control.—W. T. Cocking. (*Wireless World*, 10th Jan. 1936, Vol. 38, pp. 33–34.)

977. Automatic Selectivity Control [Method giving Selectivity varying with Sensitivity, by Several Triodes with Plate/Cathode Impedances shunting Tuned Circuits in Aerial-Coupling and I.F. Transformers : Results with Experimental Model].—G. L. Beers. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1425–1440.) The full paper, a summary of which was referred to in 3008 of 1935.

978. Correction Circuits for Amplifiers. Part 2: High Frequency Correction [Calculation of Miller Effect in Two-Stage Amplifier: High Frequency Correction in Anode, Grid and Cathode Circuits].—O. E. Keall. (*Marconi Review*, Sept./Oct. 1935, No. 56, pp. 9–21.) For Part 1 *see* 3586 of 1935.

979. Tube Capacity put to Work [Utilisation of Miller Effect to give "Capacity Control Tube" for Noise-Suppressing Tone Control, Selectivity Analyser (with C-R Oscillograph), Automatic Tuning, "Sound Prism" for Acoustics, etc.].—J. M. Hollywood and M. P. Wilder. (*Electronics*, October, 1935, Vol. 8, pp. 30–32 and 42.)

980. Papers on Volume Control and Expansion.—(*See* 1054/6.)

981. Dial Mechanisms [Some 1936 American Types].—(*Electronics*, November, 1935, Vol. 8, pp. 21–24.) For a correction *see* December issue, p. 5, middle column.

982. Resistance Coupling for Push-Pull Amplification [Circuit avoiding Need for Balancing].—W. Richter. (*Electronics*, October, 1935, Vol. 8, p. 40.)

983. Modifications of the Push-Pull Output Stage [Identity of "Cathode-Load Circuit" and "Grid Compensation Circuit"].—W. Baggally: Macfadyen. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, p. 9.) Letter prompted by Macfadyen's paper (107 of January).

984. Stabilised Grid Bias [where Cathode-Resistance Method is Inapplicable: Avoidance of Unnecessary Duplication of Components].—C. Lawler. (*Wireless World*, 3rd Jan. 1936, Vol. 38, p. 12.)

985. Biasing the Output Stage [Three Systems in Most Common Use].—W. MacLanachan. (*Wireless World*, 3rd Jan. 1936, Vol. 38, pp. 8–9.)

986. Marconi Short-Wave Superheterodyne Receiver, Type RG.34 [13–200 m: for Dipole and Harmonic Aerials: suitable for General Purpose Telegraphy or Telephony Reception].—(*Marconi Review*, Sept./Oct. 1935, No. 56, pp. 1–8.)

987. A Local-Station Receiver for the Highest Quality [5 Watt Output: for Three Stations, including Ultra-Short Waves].—H. Hertel. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 453–463.)

988. The Graetzor-Granat [Two-Circuit Four-Valve Straight Receiver for A.C. Mains].—(*Funktech. Monatshefte*, December, 1935, No. 12, pp. 481–482.)

989. Telefunken 564 [Seven-Circuit Four-Valve Superheterodyne, A.C. or Universal].—(*Funktech. Monatshefte*, December, 1935, No. 12, pp. 483–484.)

909. The Centromatic Unit [for Multi-Wave Receivers].—(*Electronics*, October, 1935, Vol. 8, pp. 16–18.)

991. Imperial Short-Wave Six [6–100 m: Battery or Mains, by use of 13-Volt Indirectly Heated Valves: with AVC].—(*Wireless World*, 3rd and 10th Jan. 1936, Vol. 38, pp. 2–7 and 28–32.)

992. The Superheterodynes "Silver" ["Masterpiece I, II and III"].—P. Besson. (*L'Onde Élec.*, November, 1935, Vol. 14, No. 167, pp. 771–778.)

993. Pocket Super-Regenerative Receivers [*e.g.* 4″ × 1 27/32″ × 7 3/8″, including Frame Aerial: for Broadcast Wavelengths].—W. Van B. Roberts. (*QST*, January, 1936, Vol. 20, No. 1, pp. 22–25 and 68, 70.)

994. High-Speed Radio Production [RCA Camden Plant].—P. H. Jeryan. (*Electronics*, December, 1935, Vol. 8, pp. 21–25.)

995. The Small Appliance Load [including Mains-Operated Broadcast Receivers].—(*Electrician*, 3rd Jan. 1936, Vol. 116, pp. 1–2.)

AERIALS AND AERIAL SYSTEMS

996. The Choice of Coupling of the Short-Wave Transmitter to the Transmission Line.—I. S. Gonorovsky. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 22–37.)

Author's summary:—Comparing the conditions of transmission-line feeding for different powers, one can state that with the increase of transmitter power the widely used conductive coupling of the output circuit to the transmission line leads to a series of complications, hampering the normal performance of the transmitter. The elimination of these irregularities can be attained by using the inductive coupling, which however requires the introduction of an additional circuit in cases where the transmission line has a high surge impedance.

In order to decrease the dimensions of the transmission-line circuit it is necessary to increase the coupling, which requires the increase of the mutual inductance factor between the circuits. A comparison is then made of the coupling factors which can be obtained with different constructions of coupling elements, and it is stated that the strongest coupling can be obtained by means of concentric tubes. In conclusion, the construction is described of circuits allowing the realisation of the inductive coupling in a wide range of wavelength, with the possibility of quick readjustment of circuits for change of wavelength.

997. The Radiation Resistance of Aerials whose Length is Comparable with the Wavelength.—E. B. Moullin. (*Electrician*, 10th Jan. 1936, Vol. 116, p. 32: summary of I.E.E. paper.)

998. The Directive Property of Paraboloidal Reflectors as used on Ultra-Short Waves.—K. Morita. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, pp. 721–726: Japanese only.)

999. FILTERING FOR DOUBLE RADIATION [Simultaneous Broadcasting of Two Programmes from Same Aerial].—V. Andrew. (*Electronics*, October, 1935, Vol. 8, p. 13.) As at KRNT and KSO.

1000. THE CALCULATION OF CURRENT AND VOLTAGE DISTRIBUTION IN SIMPLE ANTENNAS [taking into account the Reaction of the Electromagnetic Field: with Curves showing Magnitude of that Effect in Different Cases].—G. S. Ramm. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 37–43.) For a previous paper *see* 547 of February.

1001. REFLECTION AND REFRACTION OF ELECTRIC WAVES AT THE EARTH'S SURFACE [and the Equivalent Virtual Radiators for Reflected and Refracted Fields].—Violet. (*See* 870.)

1002. ON THE CALCULATION OF CAPACITY OF AERIALS AND COUNTERPOISES: CORRECTIONS.—Kravetz. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 74–75.) *See* 128 of January.

1003. ANTI-INTERFERENCE AERIALS [Practical Problems involved in the Use of Screened Down-Leads].—L. A. Chapman. (*Wireless World*, 3rd Jan. 1936, Vol. 38, p. 15.)

VALVES AND THERMIONICS

1004. RECENT DEVELOPMENTS IN METALS SEALING INTO GLASS.—H. Scott. (*Journ. Franklin Inst.*, December, 1935, Vol. 220, No. 6, pp. 733–753.)

A description of the factors involved in the development and use of new seals of iron/nickel/cobalt alloys into hard glass. The expansion properties of glasses are discussed and compared with those of *Kovar*, an alloy with optimum cobalt content, which has been found to be most suitable for the seals. The alloy composition factors involved are described and the stresses in the seals investigated. Short reference is made to the practical preparation of the seals and the annealing.

1005. METAL IN RADIO TUBES: CHARACTERISTICS OF QUALITY IRONS AND COLD ROLLED STEEL [Advantages of Svea Metal].—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 14–15: microphotographs and captions only.)

1006. A BEND TESTER FOR VACUUM TUBE WIRES.—W. J. Farmer. (*Bell Lab. Record*, December, 1935, Vol. 14, No. 4, pp. 139–142.)

1007. RAYTHEON DEVELOPS NEW IMPROVED CONTROL-GRID INSULATION FOR ALL-METAL R.F. TUBES.—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, p. 26.) A wafer insulator of new phenolic material "near the best ceramic in low losses at the high frequencies."

1008. THE ALL-METAL VACUUM TUBE: A DISCUSSION OF METAL, METAL-GLASS AND GLASS TUBES IN RELATION TO THEIR CHARACTERISTICS AND APPLICATIONS.—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 8–11.)

1009. THE 6L7 AS A VOLUME EXPANDER FOR PHONOGRAPHS.—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, p. 24.)

1010. THE 6F6 AS A TRIODE-CONNECTED CLASS AB AMPLIFIER.—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 12–13 and 23.)

1011. A "RENODE" VALVE.—Jensen. (*Wireless World*, 17th Jan. 1936, Vol. 38, No. 3, p. 74: Patent summary.) *See* 148 of January.

1012. VACUUM TUBE FOR SMALL CURRENT MEASUREMENTS [Western Electric D-96475].—D. B. Penick. (*Bell Lab. Record*, November, 1935, Vol. 14, No. 3, pp. 74–78.)

1013. SUPPLEMENT TO THE GENERAL TABLE OF VALVES IN THE MAY NUMBER, 1935 [Corrections and Additions].—(*L'Onde Élec.*, November, 1935, Vol. 14, No. 167, pp. 760–770.) *See* 3062 of 1935.

1014. SECONDARY EMISSION ELECTRON MULTIPLIERS.—Zworykin. (*See* 1091.)

1015. THE MAGNETRON.—Ladner. (*See* 935.)

1016. ELECTRON BEAMS IN RECEIVING VALVES.—Knoll and Schloemilch. (*Wireless World*, 3rd Jan. 1936, Vol. 38, pp. 18–19.) Based on the work dealt with in 439 of 1935.

1017. A BRITISH 75-WATT R.F. PENTODE [RFP–362: and other New Valves].—(*Television*, December, 1935, Vol. 8, No. 94, pp. 733–734.)

1018. HIGH-POWER DEMOUNTABLE-TYPE OSCILLATING VALVES: CORRECTION.—Minz and Oganov. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, p. 76.) *See* 568 of February.

1019. MEASUREMENT OF THE CHARACTERISTIC PROPERTIES OF HIGH-FREQUENCY RECEIVING VALVES BETWEEN 1.5 AND 60 Mc/s.—M. J. O. Strutt and A. van der Ziel. (*E.N.T.*, November, 1935, Vol. 12, No. 11, pp. 347–354.)

For the calculation of valve amplification, four complex constants must be known which are analogous to the four parameters in the fundamental equations of a quadripole (§I). Measurements of these constants for pentodes (Philips-Valves AF3 and AF7) are here given, with descriptions of the apparatus. All the measurements were made by determining the voltage in an oscillating circuit (§ II). The method of screening is described. Fig. 1 shows the diode voltmeter, which was constructed with an acorn tube to minimise errors due to the electron transit time. Fig. 2 shows the arrangement used for measuring the anode impedance (§ III); the numerical results for various frequencies and states of the valve are tabulated. A small change in this arrangement makes it suitable for measuring the slope of the characteristics (§ IV) which is found to be equal to its statical value within the limits of experimental error. Another small change enables the grid impedance to be measured (§ V); the values obtained are tabulated. The reaction (§ VI) is due to the capacity between the control grid and the anode and is determined by the arrangement shown in Fig. 3; an empirical equation is found for the equivalent capacity as a function of the frequency. In § VII the results are discussed ; a rule is given for the avoidance of detuning the circuits when changing the valves or altering the volume. The input and output parallel impedances are found to be inversely proportional to the square of the frequency for short waves. Physical explanations of the variations are given. The valves investigated are found to be suitable for h.f. amplification down to 7 m. A list of literature references is appended.

1020. FLICKER EFFECT IN ELECTRONIC TUBES [Experimental Results: Variation with Age, and the Existence of a Period of Non-Variation: Variation with Condition of Cathode: etc.].—P. P. Di Roberto. (*Nuovo Cimento*, June, 1935, Vol. 12, No. 6, pp. 348–357.)

1021. THE ELECTRON-OPTICAL STRUCTURAL IMAGE AND ITS EVIDENCE AS TO EMISSION CONDITIONS WITH BARIUM/NICKEL CATHODES.—E. Brüche. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 77–107.)

The subjects discussed are :—Part I. *Formation of the structural image.* 1. The structural image as the final state of the cathode. 2. Wandering of metallic barium atoms on the cathode. 3. Nature of this wandering: vaporisation of atoms and re-condensation. 4. Nature of re-condensed films. Part II. *Structural image and work function.* 5. Current relations. 6. Differences in the work functions of the crystals. 7. Structural image with photoelectric electron emission. 8. Questions of covering density (number of atoms per unit area of crystal surface). Part III. *Some Consequences.* 9. Emission measurements as average values. 10. Electric fields at the cathode. 11. Importance of the boundaries of the grains. 12. Shot and flicker effects. Many reproductions of electron-optical images are given and form the basis of the discussion.

1022. ELECTRON-OPTICAL IMAGES OF INCANDESCENT FILAMENTS (PRELIMINARY COMMUNICATION).—H. Mahl. (*Zeitschr. f. Physik*, No. 5/6, Vol. 98, 1935, pp. 321–323.)

A negatively charged plate is placed behind the filament in order to smooth out the lines of force in the potential field round the filament (Fig. 1) ; a normal electron-optical arrangement (Fig. 2) can then be used to form an image. Fig. 3 shows a comparison of the optical and electron images of a tungsten wire ; Fig. 4 gives electron images of thoriated tungsten and molybdenum wires.

1023. INVESTIGATION OF THERMIONIC FILAMENTS WITH A SIMPLE ELECTRON MICROSCOPE [consisting of a Cylindrical Glass Tube coaxial with Filament: Emission Patterns formed on Wall of Tube].—R. P. Johnson and W. Shockley. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, p. 973 : abstract only.) *See* also 1024.

1024. CORRELATION OF EMISSION AND ADSORPTION PROPERTIES WITH LATTICE DIRECTION IN SINGLE-CRYSTAL TUNGSTEN WIRE [Emission Patterns obtained with Simple Electron Microscope].—W. Shockley and R. P. Johnson. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, pp. 973–974 : abstract only.) *See* 1023.

1025. ELECTRON-MICROSCOPICAL INVESTIGATION OF THE EMISSION OF ELECTRONS FROM COLD METALS [Method for Approximate Determination of Current Densities at Separate Point Emitting Centres].—A. Wehnelt and W. Schilling. (*Zeitschr. f. Physik*, No. 3/4, Vol. 98, 1935, pp. 286–287.)

1026. AFTER EFFECT OF ALUMINIUM [and Other Metals] BOMBARDED BY ELECTRONS [Electron Radiation: Half-Value Periods].—M. Tanaka. (*Phys. Review*, 1st Dec. 1935, Series 2, Vol. 48, No. 11, p. 916.)

1027. THEORETICAL CONNECTION BETWEEN THE EMISSION CONSTANTS OF SINGLE CRYSTALS AND OF MULTIPLE-CRYSTAL MATERIAL.—A. Recknagel. (*Zeitschr. f. Physik*, No. 5/6, Vol. 98, 1935, pp. 355–362.)

The Richardson constants, mass constant and work function, for multiple crystals of various types of crystal structure, are calculated on the general assumption that the thermionic emission of single crystals is determined by a Richardson equation in which the constants depend on the crystallographic orientation of the emitting surface. It is suggested that a possibility is hereby given of reconciling the measured values of the mass constant for metals with its theoretical value, which is in general much higher.

1028. THE SURFACE IONISATION OF POTASSIUM ON TUNGSTEN.—M. J. Copley and T. E. Phipps. (*Phys. Review*, 15th Dec. 1935, Series 2, Vol. 48, No. 12, pp. 960–968.)

For previous work *see* 1934 Abstracts, p. 619. The present paper describes a continuation of the work under improved conditions up to a temperature of 2 800°K. Numerical results for the relation between the ion/atom ratio and the temperature are given ; a value of the work function for tungsten is found, with evidence that it has a temperature coefficient.

1029. THE EMISSION OF POSITIVE IONS BY PLATINUM WHEN HEATED IN OXYGEN [Quantitative Formulation of Theory of Adsorption and Subsequent Emission of Oxygen Atoms: Comparison with Experiment: Value of Electronic Work Function].—T. B. Rymer. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1936, Vol. 153, No. 879, pp. 422–442.)

DIRECTIONAL WIRELESS

1030. POLARISATION ERRORS IN DIRECTION FINDERS [Comparison of Results with Screened-U, Unbalanced-Coupled and Balanced-Coupled Adcock Systems: the Merits of Spaced-Loop Systems].—R. A. Watson Watt. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, pp. 3–6.)

1031. RADIOGONIOMETRIC ARRANGEMENT FREE FROM NIGHT ERROR [Elimination of Indirect-Ray Signals by Transmission of Short Dots at Regular Intervals (*e.g.* 1/50th Sec.) and Cathode-Ray Reception].—Chireix. (French Pat. 788 796 of 20.7.1924 [unless printer's error], pub. 16.10.1935 : *Rev. Gén. de l'Élec.*, 28th Dec. 1935, Vol. 38, No. 26, p. 208 D.)

1032. THE AIRCRAFT RADIO COMPASS [and Some American Types of "Homing" Devices].—(*Electronics*, October, 1935, Vol. 8, pp. 7–10 and 29.) For Hell and Dieckmann papers on the basic principle *see* 1930 Abstracts, p. 161.

1033. A RADIO BEACON TRANSMITTER FOR WOR BROADCASTING STATION [as Additional Aircraft Warning of Proximity of Towers: High-Angle Radiation giving Practically No Signal at more than Two Miles].—A. A. Skene. (*Bell Lab. Record*, November, 1935, Vol. 14, No. 3, pp. 84–88.)

1034. THE POSITION AT SEA BY RADIOGONIOMETRIC BEARINGS [and a Method avoiding All Computation].—de Blavous. (*Hydrographic Review*, November, 1935, Vol. 12, No. 2, pp. 17–30.) For previous work *see* 1934 Abstracts, p. 97.

ACOUSTICS AND AUDIO-FREQUENCIES

1035. ANOMALIES IN THE PROPAGATION OF SOUND WAVES OF LARGE ["Finite"] AMPLITUDE.—E. F. Ghiron. (*Alta Frequenza*, October, 1935, Vol. 4, No. 5, pp. 530–581.)

The functional relation between the propagation velocity and the dilatation of a stratum of the medium: the consequent deformation of a sinusoidal wave, increasing until, at a certain distance from the source, a discontinuity occurs: analogy with the breaking of a wave of the sea: quantitative treatment and estimation of the distortion arising in the course of propagation: a new expression for the pressure of acoustic radiation in a system of plane progressive waves of arbitrary form: approximate study of stationary waves, and discussion of the theory of sound propagation in media with viscosity and thermal conductivity. *Cf.* McLachlan, 588 of February.

1036. SOUND TO 160 000 PEOPLE: DETAILS OF EQUIPMENT USED FOR THE 1935 NATIONAL EUCHARISTIC CONGRESS.—K. J. Banfer. (*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 18–20.) *See* also 597 of February.

1037. EXPERIMENTAL RESULTS WITH A CONDENSER MICROPHONE [Effects of Counter-Electrode Design, Air Cushion, Diaphragm Thickness, etc.].—K. Eisenzapf. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 473–475.) *See* also 587 of February.

1038. RECENT IMPROVEMENTS IN APPLIED PIEZOELECTRICITY [Rochelle Salt Pick-Ups, Microphones and Headphones].—A. W. L. Williams. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1420–1421 : summary only.)

1039. DIRECTIONAL CONDENSER MICROPHONES.—H. J. von Braunmühl and W. Weber. (*Hochf:tech. u. Elek:akus.*, December, 1935, Vol. 46, No. 6, pp. 187–192.)

A description of the construction of two types of condenser microphone with definite directional properties, independent of frequency. These are distinguished as *figure-of-eight* and *kidney* microphones, from the forms of their directional characteristics. § I gives a short discussion of the properties of the condenser microphones at present used; Fig. 1 illustrates their directional characteristics, which are entirely different for different frequencies. § II describes the figure-of-eight microphone (characteristic Fig. 2, a cosine diagram). A perforated electrode replaces the usual solid one (Fig. 3), so that the membrane receives sound waves from both sides and the difference of pressure is the force which moves the membrane. Frequency-independence of the membrane displacement is attained by introducing friction with the perforated electrode (Fig. 5). Fig. 6 shows the frequency curve (a) for electrostatic excitation, (b) of values obtained by multiplication of curve (a) by the frequency (corresponding to the case of a free acoustic field). A perforated electrode may be placed on the other side of the membrane for reasons of symmetry; it may be left electrically unused or the microphone may be used in a push-pull circuit (Fig. 7). For good sensitivity, the friction should not be too large; the enclosure of the microphone capsule in gauze is also recommended (Fig. 8) for increasing the length of effective path from front to back for the lower frequencies. Fig. 9 illustrates the rise of sensitivity at low frequencies in a spherical acoustic field for different distances from the source; Fig. 10 shows the measured frequency curve of the figure-of-eight microphone (a) without gauze, (b) with gauze, (c) with double layer of gauze. Fig. 11 gives the measured directional characteristic.

The kidney microphone described in § III has two membranes, one on each side of an electrode perforated completely in some places and partially in others (Figs. 12, 13). Its mode of action is described and illustrated by Fig. 14. The measured directional characteristic is given in Fig. 15. Some applications of the two microphones are indicated in § IV; the figure-of-eight may be used for duologues between persons sitting opposite to one another, and for sound-amplifying systems with big loudspeakers. The kidney microphone is recommended for orchestral performances or speeches before an audience where disturbances from the other side should be eliminated; it is also suitable for reproduction from acoustically inferior rooms. The distance of this microphone from extensive sources of sound may also be decreased in acoustically good studios. The sensitivity of the directional microphone in a diffuse field is relatively less than that of an ordinary microphone. The kidney microphone responds not to the pressure or velocity component of the acoustic field but to its energy.

1040. A MICROPHONE CONCENTRATOR.—J. I. Schneider. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 855–867.)

After a short survey of various methods used for concentrating the sound falling on a microphone and for providing the latter with directional selectivity, the parabolic reflector is examined in detail. The theory of the reflector is given and also approximate methods for calculating its gain. The theoretical results were checked experimentally and in addition polar curves were taken for a number of microphones. It is pointed out that the parabolic reflector presents certain advantages over the other types and it has therefore been adopted for use at the Moscow Radio Centre.

1041. On the Theory of the Parabolic Sound Reflector: Corrections.—Gutin. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 75–76.) *See* 192 of January.

1042. On the Electrical and Acoustic Conductivities of Cylindrical Tubes bounded by Infinite Flanges [Theoretical Value of Coefficient of End-Correction using Bessel Function Inversion Theorems].—L. V. King. (*Phil. Mag.*, January, 1936, Series 7, Vol. 21, No. 138, pp. 128–144.)

1043. Multiple Feed-Back Method and Some Applications of Duplex Feed-Back Amplifiers.—Watanabe, Kamayachi and Oizumi. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, pp. 715–720: English summary pp. 91–92.) Further development of the work referred to in 614 of February.

1044. The Compensation of Non-Linear Distortion in Amplifiers [Survey of Methods].—F. Falkenberg. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 447–451.)

1045. Correction Circuits for Amplifiers.—Keall. (*See* 978.)

1046. Considerations in Speech-Amplifier Design: Practical Pointers on building High-Gain Amplifiers.—R. O. Lund and W. C. Howe. (*QST*, January, 1936, Vol. 20, No. 1, pp. 15–18 and 72, 74, 76 and 78.)

1047. High Gain—Simplified [Two-Valve Ribbon-Microphone Amplifier, 25–10 000 c/s, 73 db Gain: Use of Mallory Electrolytic Cells for Grid Bias eliminates Interstage Shielding].—P. von Kunits. (*Electronics*, December, 1935, Vol. 8, pp. 18–20.)

1048. Universal Gramophone Amplifier [with Pentode Push-Pull Output].—W. T. Cocking. (*Wireless World*, 24th Jan. 1936, Vol. 38, pp. 76–80.)

1049. An Audio-Frequency Amplifier of High Fidelity [7-Watt Output: "Paraphase" Connection].—P. Colombino. (*Alta Frequenza*, October, 1935, Vol. 4, No. 5, pp. 626–628.)

1050. High-Fidelity Technique.—Hogan and Barber. (*See* 947.)

1051. Distortion Factor and Summation Tones in Radio Receivers.—Graffunder, Kleen and Wehnert. (*Electronics*, November, 1935, Vol. 8, pp. 48 and 50.) Long summary of the paper dealt with in 3902 of 1935.

1052. "Note on the Extension of Campbell's Formula to Lightly-Loaded Music Pairs": Correction.—H. J. Josephs. (*P.O. Elec. Eng. Journ.*, January, 1936, Vol. 28, Part 4, p. 313.) *See* 212 of January.

1053. Mechanical and Acoustical Impedances.—F. Bedeau. (*Journ. de Phys. et le Radium*, Sept. and Oct. 1935, Vol. 6, Nos. 9 and 10, pp. 383–387 and 407–416.)

1054. The Action of Automatic Regulating Apparatus [for Volume Control at Transmitter or Receiver].—H. Bartels and G. Ulbricht. (*E.N.T.*, November, 1935, Vol. 12, No. 11, pp. 368–379.)

A discussion of typical circuits (*see* for example Abstracts, 1929, p. 104—Mayer; 1933, p. 286—Sohon; 1934, p. 620—Nestel; 1934, p. 572—Mathes & Wright; and 1934, p. 379—Ballantine). The principle and characteristic properties of automatic regulation circuits and the requirements to be satisfied are described in § I. Figs. 1 and 2 show the potentiometer, which is the fundamental regulating element, and the auxiliary circuit delivering the regulating bias to alter the potentiometer impedance, in its two modes of connection before and after the potentiometer respectively. In § II the permissible time-constants of the switch-on and -off transients are determined for regulation at (a) the transmitter and (b) the receiver; experiments were made to determine when the transients just became audible. The most suitable slope of the regulating curve for various conditions is investigated in § III; § IV discusses the frequency variation required for the acoustic intensity to be the same at reception as at its original production, and the methods of approximating to the sensitivity curve of the ear (Fig. 6). In § V the methods of fulfilling these requirements in the actual regulating circuits are described; the effects of harmonics in the bias rectifier (§ Vc), of a d.c. impulse (§ Vd), of self-excitation in the regulating circuit (§ Ve), of coupling by a d.c. impulse (§ Vf), of transients and incomplete filtering (§ Vg), are also analysed.

1055. Practical Volume ["Contrast"] Expansion [RCA Victor Expander for Existing Records or Special Compressed Recording: Adaptable also to Radio].—C. M. Sinnett. (*Electronics*, November, 1935, Vol. 8, pp. 14–16 and 32 [not 36].)

1056. The 6L7 as a Volume Expander for Phonographs.—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, p. 24.)

1057. Apparatus for Gramophone Recording and Reproduction at Constant Linear Speed.—Dumont. (*Recherches et Inventions*, January, 1936, pp. 16–20.)

1058. "Proof-Read" Recording [High-Fidelity Gramophone Records on Aluminium Alloy by 3-Watt Piezoelectric Cutter give Immediate Play-Back].—Proctor. (*Electronics*, December, 1935, Vol. 8, pp. 39–40.)

1059. Hand-Drawn Sound [Russian Work on Synthetic Sound Tracks].—Vionov. (*Electronics*, November, 1935, Vol. 8, p. 34: photographs and captions only.) *Cf.* 1934 Abstracts, p. 44.

1060. THE TUNING OF GRAND PIANOS [Measurement of Deviations in Frequency of Newly-Tuned Piano Notes from Mathematically Exact Even Temperament: Proposed New Temperament].—M. Grützmacher and W. Lottermoser. (*Physik. Zeitschr.*, 15th Dec. 1935, Vol. 36, No. 24, pp. 903–912.)

1061. THE PROBLEM OF PIANO "TOUCH" [Experimental Investigation of whether Colour of Tone can be controlled without Change of Loudness: Positive Results].—A. Ferrari. (*Alta Frequenza*, October, 1935, Vol. 4, No. 5, pp. 582–602.)

1062. THE CALCULATION OF THE MECHANICAL RESISTANCE OF THE STRING–SOUNDING BOARD MODEL.—Rimski-Korsakov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 868–875.)

A method is developed for calculating the resistance with a view to checking the experimental results described in a previous paper (605 of February). The theoretical and experimental curves show a rather close agreement.

1063. THE PERCEPTIBILITY OF DIFFERENCES IN TRANSIT TIME [from Source to Ear of Tones of Different Frequencies].—W. Bürck, P. Kotowski and H. Lichte. (*E.N.T.*, November, 1935, Vol. 12, No. 11, pp. 355–362.)

See also Strecker, 2666 of 1935. An experimental determination is here described of the difference in time at which two sine waves must strike the ear in order that they may be recognised as following one another. Fig. 3 shows the arrangement; the acoustic generators were switched on simultaneously, but the loudspeakers could be moved about so that their positions determined the times of arrival of the sounds at the ear. Curves are given for the transit time difference Δt as a function of one frequency, the other being constant (Figs. 4–7), as a function of the mean frequency (Fig. 8), and as a function of the time constant of the switch-on rise of intensity for fixed frequencies (Fig. 9). Fig. 10 gives results for the case of Fig. 8 when the intensity increases with a fixed time constant; the values then obtained for Δt are greater than when the tones are suddenly switched on at full amplitude. The minimum values of Δt were throughout about 7 msec.

A second group of experiments dealt with the transit time differences between two frequency bands, the spectrum being divided by a filter and the two parts reproduced by loudspeakers as before (arrangement Fig. 11). Fig. 12 shows how Δt varies with f_0, the dividing frequency, for speech reproduction by a microphone and by gramophone records. The smallest perceptible transit time differences with microphone reproduction were again of the order of 8 msec but were noticeably higher with the gramophone records. Further investigations were made to see if this could be due to echo in the room where the records were made (scheme Fig. 13, results Figs. 14–16). Comparison with the results of a former paper (634 of February) shows that "the permissible transit time of tones of neighbouring frequencies is equal to the least time for which a tone must sound in order to be recognised." The idea of "transit time" is discussed in the light of this comparison.

1064. "A THEORY OF HEARING AS THE RESULT OF MICROPHONIC EFFECTS IN THE EAR" [Book Review: the Ear as an Electro-Acoustic Converter].—F. Leiri. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, p. 503.)

1065. "THE PROBLEM OF NOISE" [Book Review].—F. C. Bartlett. (*Sci. Progress*, January, 1936, Vol. 30, No. 119, pp. 581–582.)

1066. SOUND AND NOISE.—G. W. C. Kaye. (*Sci. Progress*, January, 1936, Vol. 30, No. 119, pp. 385–401.)

1067. ACOUSTICAL TEST CHAMBER WITH CLOTH WALLS.—E. H. Bedell. (*Bell Lab. Record*, November, 1935, Vol. 14, No. 3, pp. 79–82.)

1068. POROUS SOUND-ABSORBING MATERIALS WITH VARIABLE ACOUSTIC CURRENT IMPEDANCE.—L. Cremer. (*E.N.T.*, November, 1935, Vol. 12, No. 11, pp. 362–367.)

A previous paper (620 of February) is continued with a discussion of the question whether the penetration of sound into a wall and its absorption there could be increased by constructing the wall with layers of absorbing material instead of with the homogeneous packing previously discussed. This might give a gradual matching of the acoustic impedance of the air to the infinite impedance of the rigid wall, and also stronger absorption of the wave as it penetrated into the wall (Fig. 1). The problem is investigated theoretically with the same assumptions as in the previous paper; §2 treats the special case of an impedance varying continuously as the inverse square of depth of penetration (eqn. 7, impedance formula eqn. 18, graphical results Fig. 2). A comparison with the case of homogeneous packing is made in §3 (curves for frequency variation of degree of absorption in the two cases Fig. 3). The packing with continuously increasing impedance is found to satisfy the absorption requirements to a much worse degree than the homogeneous material; special cases at low frequencies are discussed numerically. In §4 a general discussion of the question is given; a non-homogeneous packing might be advantageous at very high frequencies but the thickness required would be so great that it could only be made for special laboratory rooms.

1069. THE STUDY OF SOUNDS IN CLOSED SPACES AS RELATED TO THEIR ACOUSTIC QUALITIES [Apparatus for recording Oscillographs of Sounds: Effect of Reverberation on Ear].—R. Fleurent. (*Comptes Rendus*, 6th Jan. 1936, Vol. 202, No. 1, pp. 30–32.)

1070. SOUND FLUTTER [due to Reflection along Diagonal Lanes] MARS ACOUSTICS OF COURTROOM.—(*Sci. News Letter*, 21st Dec. 1935, Vol. 28, p. 392.)

1071. A DIRECT-READING FREQUENCY METER OF WIDE RANGE [10–60 000 c/s: Condenser Charge-and-Discharge Principle with Valves as Switching Device: Mains Driven].—H. Keller. (*Bull. Assoc. suisse des Élec.*, No. 1, Vol. 27, 1936, pp. 13–14.)

1072. A CONTROLLED OSCILLATOR FOR GENERATING STANDARD AUDIO-FREQUENCIES [Discrete Frequencies between 10 and 20 000 c/s, for Radio Frequency Measurements by Beat-Note Method].—L. Essen. (*Journ. Scient. Instr.*, January, 1936, Vol. 13, No. 1, pp. 9–13.)

1073. ON THE BEHAVIOUR OF THE SENSE OF TOUCH TO VIBRATIONS [Variation of Sensitivity with Frequency: Measurements of Threshold Values: Equivalence Curves: Similarity to Kingsbury's Curves for the Ear: Probable Existence of a Pain Threshold].—A. Hugony. (*Alta Frequenza*, October, 1935, Vol. 4, No. 5, pp. 603–611.)

1074. THE AIR-JET ACOUSTICAL GENERATOR [up to Supersonic Frequencies of 125 000 c/s, or 500 000 c/s with Hydrogen: a Powerful Source with Many Applications].—J. Hartmann. (*Journ. de Phys. et le Radium*, November, 1935, Vol. 6, No. 11, pp. 123–124 s.)

1075. MAKING VISIBLE THE STANDING SUPERSONIC WAVES IN TRANSPARENT SOLID BODIES. III. OPTICAL TENSION ANALYSIS OF THE ELASTIC OSCILLATIONS.—E. Hiedemann and K. H. Hoesch. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 141–144.)

1076. THE [Photographic] PROPERTIES OF PEPTISED HALOGEN-SILVER GELATINE EMULSIONS PRODUCED UNDER THE ACTION OF SUPERSONIC WAVES [High Self- and Colour-Sensitivity].—Dangers. (*Zeitschr. f. Physik*, No. 1/2, Vol. 97, 1935, pp. 34–45.)

1077. THE DORSEY FATHOMETER [giving 20 Indications per Second], *and* PRECISION SOUNDINGS WITH THE MARTI HAMMER-BLOW SOUNDER.—Dorsey: Marti. (*Hydrographic Review*, November, 1935, Vol. 12, No. 2, pp. 50–53: 53–61.) *See* also 1944 of 1935.

1078. MULTIPLE ECHOES OBSERVED IN SONIC SOUNDING ON A SOFT BOTTOM.—H. Rust. (*Hydrographic Review*, November, 1935, Vol. 12, No. 2, pp. 106-109.)

PHOTOTELEGRAPHY AND TELEVISION

1079. PHASE DISTORTION IN TELEVISION [for Lowest Frequencies: Admissible Limits: Compensation Method for Resistance-Coupled Amplifiers: etc.].—R. G. Shiffenbauer. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, pp. 21–26.) *See* 1955 of 1935.

1080. ON THE CALCULATION OF THE PERMISSIBLE PHASE DISTORTION IN TELEVISION SYSTEMS.—N. D. Smirnov. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 17–23.)

Television of rectangles divided into black and white segments is considered and an examination is made of the distortion of the reproduced images due to phase displacement of the currents in the television apparatus. It is pointed out that the phase displacement may affect (a) the uniformity of the tones and (b) the sharpness of the boundaries between the tones. Methods are indicated for calculating the maximum permissible values of the phase displacement for satisfactory reproduction from the point of view of (a) and (b), and it is shown that these values depend on the depth of modulation and on the type of modulator used in the television receiver. Typical figures are calculated for modulators using neon tubes, Kerr cells and cathode-ray tubes.

1081. THE TOKIO ELECTRIC COMPANY'S CATHODE-RAY TELEVISION SYSTEM.—Nagashima. (*See* 1149.)

1082. THE PRESENT POSITION OF TELEVISION [British Association Paper].—A. G. D. West. (*Engineering*, 25th Oct. 1935, Vol. 140, pp. 457–459: to be continued.)

1083. TELEVISION DEMONSTRATION IN EINDHOVEN.—Philips Company. (*Radio Centrum*, 20th Dec. 1935, Vol. 1, No. 26, pp. 456–457.) *See* also 651 of February.

1084. TELEVISION IN GERMANY [Address: including Range Chart of Mobile Television Transmitter on Brocken].—Banneitz. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 89–91.)

1085. TELEVISION PROGRESS IN GERMANY: A DETAILED ACCOUNT OF THE EXHIBITS AT THE BERLIN RADIO EXHIBITION.—(*Television*, October, 1935, Vol. 8, No. 92, pp. 564–567.)

1086. A 120-LINE CATHODE-RAY-TRANSMITTER [as demonstrated at Stores in Kingston-on-Thames].—J. H. Reyner. (*Television*, October, 1935, Vol. 8, No. 92, pp. 579–581).

1087. THE TELEPANTOSCOPE [Cathode-Ray Scanning Device with Ray moving over Same Narrow Strip of Photosensitive Plate, Other Component being provided by Motion of Image over Plate].—A. Castellani. (*Television*, January, 1936, Vol. 9, No. 95, p. 14.)

1088. VARIABLE-VELOCITY SCANNING [Thun's Patents: von Ardenne's Modifications: Sellers's 1909 Patent for Phototelegraphy].—R. F. Davis. (*Electronics*, November, 1935, Vol. 8, pp. 30–32.)

1089. INTERLACED SCANNING [and a 1933 Belgian Patent].—M. Chauvierre. (*Television*, December, 1935, Vol. 8, No. 94, p. 736.)

1090. INTERLACING AND DEFINITION.—von Ardenne. (*Television*, December, 1935, Vol. 8, No. 94, pp. 719 and 721.) From the paper dealt with in 3128 of 1935.

1091. SECONDARY EMISSION ELECTRON MULTIPLIERS.—Zworykin. (*Electronics*, November, 1935, Vol. 8, pp. 10–13.) Report on October I.R.E. demonstration. *See* also 247 of January.

1092. A NEW ELECTRICAL "EYE" [Electron Image Tube with Fluorescent Screen acting as Artificial Retina: Cathode Emitter operated directly by Incident Light].—V. K. Zworykin and G. A. Morton. (*Nature*, 11th Jan. 1936, Vol. 137, p. 60: short note only.)

1093. Simplified Arrangement for the Production of "Kipp" Oscillations for Cathode-Ray Tubes [Voltages of 1 000 V from Thyratron without Amplification: One Mains Unit only for Tube and Time-Base].—G. Schweitzer. (*Funktech. Monatshefte*, December, 1935, No. 12, p. 445.) From the Heinrich-Hertz Institute.

1094. A New Valve "Kipp Oscillation" Apparatus for Cathode-Ray Oscillographs.—von Ardenne. (*See* 1160.)

1095. Controlling Background Effects [and the Need for Counteracting the "Toning Down" Action of the Receiver].—L. S. Kaysie. (*Television*, December, 1935, Vol. 8, No. 94, pp. 722 and 724.)

1096. Television Facts for the Public [RMA "Answers to Customers' Queries" and Some Suggested Alternative Replies].—(*Television*, October, 1935, Vol. 8, No. 92, pp. 585–587.)

1097. A List of Effects and Laws used in Television Physics.—(*Television*, December, 1935, Vol. 8, No. 94, pp. 712–714: to be continued.)

1098. Television over Cable.—Kieser: Valensi. (*Funktech. Monatshefte*, December, 1935, No. 12, Supp. pp. 85–88.) An account of part of Valensi's paper (3142 of 1935).

1099. Modern Cables for High-Frequency Currents [including Television].—(*Rev. Gén. de l'Élec.*, 19th Oct. 1935, Vol. 38, No. 16, p. 550: summary only.)

1100. Normal "Visual Hearing" [Quantitative Tests on Visual Assistance].—F. C. Cotton. (*Science*, 20th Dec. 1935, Vol. 82, pp. 592–593.) *Cf.* 245 of January.

1101. A Receiver for High-Definition Signals: Details of the B.T.S. Ultra-Short-Wave Receiver [5–80 m: 2½ Mc Response].—(*Television*, December, 1935, Vol. 8, No. 94, pp. 735 and 736.)

1102. Decoupling Screen-Grid Circuits in Television Amplifiers.—J. Beardsall. (*Television*, January, 1936, Vol. 9, No. 95, pp. 48–49 and 64.)

1103. The Design of High-Definition Amplifiers. Part IV.—L. E. Q. Walker. (*Television*, January, 1936, Vol. 9, No. 95, pp. 43–44 and 46.) Part I was referred to in 3587 of 1935.

1104. Correction Circuits for Amplifiers.—Keall. (*See* 978.)

1105. An American Idea of a Television Studio [Design by Television Research Institute of New York].—(*Television*, January, 1936, Vol. 9, No. 95, p. 20.)

1106. Photoradio Apparatus and Operating Technique Improvements [Survey, including CFVD (Constant-Frequency Variable-Dot) Keying and Its Mathematical Analysis: Distortion as a Function of Signal Slope, Fading, and Multi-Path Transmission: etc.].—J. L. Callahan, J. N. Whitaker and H. Shore. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1441–1482.)

1107. A New Method of Photo-Transmission: the Belin Company's Latest Apparatus [Paris/Algiers Tests: Fading overcome by Triangular Opening Device converting Current-Amplitude Variations into Variations in Time].—Belin. (*Television*, December, 1935, Vol. 8, No. 94, pp. 702 and 752.)

1108. Some Properties of Photoelectric Counters [Experiments with Numerous Photosensitive Materials: Sensitivities up to 5×10^{-11} erg/s/cm^2].—R. Audubert. (*Journ. de Phys. et le Radium*, November, 1935, Vol. 6, No. 11, pp. 451–456.)

1109. Adsorption of Alkali Metals on Metal Surfaces. VI—The Selective Photoelectric Effect.—de Boer and Veenemans. (*Physica*, November, 1935, Vol. 2, No. 9, pp. 915–922: in English.) For previous parts *see* 3577 of 1935.

1110. On the Measurement of the Quantity of Light [as contrasted with the Intensity] by the Photoelectric Cell [Ballistic Tests].—Gogate and Kothari. (*Indian Journ. of Phys.*, July, 1935, Vol. 9, Part 5, pp. 487–489.) *See* also 671 of February.

1111. Light-Sensitive Cell Circuits [Elimination of Selenium-Cell Inertia: Amplifying Circuits: etc.].—S. Wein. (*Electronics*, December, 1935, Vol. 8, pp. 36–38.) A collection of old and recent circuits, from the literature and patents.

1112. On the Photoelectric Effect of a Barrier Layer [Experiments to test whether purely a Hallwachs Effect, and whether a Vacuum or Air Gap can constitute a Barrier Layer].—R. Deaglio. (*Physik. Berichte*, No. 24, Vol. 16, 1935, p. 2376.)

1113. Photo-Electronic Effect of Incandescent Metals.—C. M. I. Vercelli. (*Physik. Berichte*, No. 24, Vol. 16, 1935, p. 2376.)

1114. Researches on Becquerel [Photovoltaic] Cells.—G. Athanasiu. (*Ann. de Physique*, November, 1935, Vol. 4, pp. 377–449.)

1115. Becquerel Effect and Photochemical Sensitivity of Some Fluorescent Colouring Materials [Xanthane Derivatives].—Cécile Stora. (*Comptes Rendus*, 6th Jan. 1936, Vol. 202, No. 1, pp. 48–50.)

1116. Note on an Apparatus for the Measurement of the Short-Circuit Current of Barrier-Layer Photocells.—G. Marchal. (*Rev. Gén. de l'Élec.*, 14th Dec. 1935, Vol. 38, No. 24, pp. 818–819.)

1117. The Nature of the U-Centres in Crystals of Alkali Halides [Experiments show they are Electrons in the Positions of Displaced Halogen Ions: Observations of Photoelectric Current with Short-Wave Ultra-Violet Light].—P. Tartakowsky and W. Poddubny. (*Zeitschr. f. Physik*, No. 11/12, Vol. 97, 1935, pp. 765–773.)

1118. Nomographs for Kerr Cell Design.—L. M. Myer. (*Television*, January, 1936, Vol. 9, No. 95, pp. 39–41.)

MEASUREMENTS AND STANDARDS

1119. A New Absolute Method for Measuring the Length of Short and Ultra-Short Electromagnetic Waves [and for the Absolute Calibration of Variable Condensers].—A. Chilaev. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 31–39.)

In this method use is made of a Lecher system, one end of which is terminated by a variable condenser, and the calculation of the wavelength is based on the Kirchoff formula $2\pi/\lambda \, . \tan 2\pi l/\lambda = C_1/C$, where l is the distance between the variable condenser and the movable bridge, C_1 the capacity of the Lecher conductors per unit length, and C the capacity of the variable condenser. The plotting of the correction curves for the variable condenser is explained, and also the calculation of the correction factor for the length l. The accuracy of the method is investigated and within practical limitations is shown to be of the order of 1%. The method can also be used for the absolute calibration of variable condensers, and a numerical example of this is given.

1120. The Theory, Design and Calibration of Absorption Wavemeter for the One-Metre Range.—M. K. Ts'en and C. T. Tsai. (*Chinese Journ. of Phys.*, No. 1, Vol. 1, 1933, pp. 82–86: in English.) *See* 4014 of 1935.

1121. A Cathode-Ray Wavemeter for Micro-Waves [Wavelength given by Anode Voltage yielding Zero and Maximum Sensitivities or Phase Shifts].—M. K. Ts'en. (*Chinese Journ. of Phys.*, No. 2, Vol. 1, 1934, pp. 76–92: in English.)

1122. Very Wide-Range Wavemeter without Coil Changing, etc: by Intermodulation of Ultra-Short-Wave Receiver.—Uda and Miki. (*See* 962.)

1123. Wind from Quartz Crystals [cut with Large Surface perpendicular to Electrical Axis: Valve Action at 1 Mc/s].—S. C. Hight. (*Bell Lab. Record*, December, 1935, Vol. 14, No. 4, pp. 121–123.)

1124. Pentode Tourmalin Oscillator.—Yoda. (*Journ. I.E.E. Japan*, September, 1935, Vol. 55 [No. 9], No. 566, p. 824: Japanese only.)

1125. The Sole Case of the Shear Mode of Thickness Vibration for a Thin Oscillating Quartz Plate.—I. Koga. (*Journ. I.E.E. Japan*, September, 1935, Vol. 55 [No. 9], No. 566, p. 822: Japanese only.)

1126. The Applications of Piezoelectric Crystals in Electrical Technique [Survey].—E. Hormann. (*E.T.Z.*, 5th Dec. 1935, Vol. 56, No. 49, pp. 1321–1325.)

1127. Recent Advances in Science: the Properties of Rochelle Salt Crystals.—L. F. Bates. (*Sci. Progress*, January, 1936, Vol. 30, No. 119, pp. 465–471.)

1128. Effect of X- and Gamma-Rays on Piezoelectric Crystals [Increase of Electrical Conductivity: Effect on Piezoelectric Constant not always in Same Sense].—F. Seidl and E. Huber. (*Zeitschr. f. Physik*, No. 11/12, Vol. 97, 1935, pp. 671–680.)

1129. Battery [Directly Heated] Valves for Mains-Driven Measuring Apparatus.—O. Limann. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 463–466.)

For measuring purposes, indirectly heated valves have the disadvantages of being inclined to vary in their properties and of taking too much current for ordinary commercial iron-wire barretters. The writer recommends the use of directly heated valves, with their filaments fed with a.c. from the glow-discharge "Stabilisator" which controls the anode supply. Examples given include a signal generator, a test equipment for h.f. iron cores, and a valve voltmeter. In the last case the special accuracy required calls for double stabilisation and leads to the use of the "reflex" connection. For the full description of this valve voltmeter *see* 1597 of 1935.

1130. Sensitive Moving-Coil Instruments with Short Coming-to-Rest Time [General Formula obtained for Condition of Minimum Time].—H. Dallmann. (*E.T.Z.*, 28th Nov. 1935, Vol. 56, No. 48, pp. 1299–1300.)

Further development of the work referred to in 2360 of 1935. The controlling factor is the ratio of the moment of inertia of the moving system to the available electrical power. The minimum coming-to-rest time is proportional to the cube root of this ratio.

1131. The Ballistic Galvanometer and the Measurement of Impulses of Exponential Form.—I. Lucchi. (*L'Elettrotec.*, 10th Nov. 1935, Vol. 22, No. 21, pp. 747–750.)

1132. Variation of the Resonance Curve of a String Galvanometer by a Condenser in Parallel [with Experimental Curves and Examples of Records].—Koch and Brötz. (*Arch. f. Elektrot.*, 5th Oct. 1935, Vol. 29, No. 10, pp. 688–692.)

1133. Anomalous Behaviour of a Vibration Galvanometer [Motion of Light Spot in Ellipse with Angle of Inclination of Axis a Function of Frequency of Applied Current].—L. M. Chatterjee. (*Zeitschr. f. Physik*, No. 11/12, Vol. 96, 1935, pp. 720–725.)

1134. A Transportabli Quadrant Electrometer [used for Ionisation Measurements and with Photocells: Construction Details and Sensitivity Curve].—J. Frank. (*Physik. Zeitschr.*, 1st Oct. 1935, Vol. 36, No. 19, pp. 647–648.)

1135. The Waidner-Wolff and other Adjustable Electrical-Resistance Elements [for Resistance-Measuring Apparatus and Potentiometers].—Mueller and Wenner. (*Journ. of Res. of Nat. Bur. of Stds.*, November, 1935, Vol. 15, No. 5, pp. 477–492.)

1136. A Search-Coil Method of Measuring the A.C. Resistivity of the Earth [based on Carson-Pollaczek Theory: Some Results obtained, with Particulars of Geological Formation].—J. Collard. (*Journ. I.E.E.*, January, 1936, Vol. 78, No. 469, pp. 100–104.)

1137. Dimensional Formula for the Electrical Capacity between Two Conductors.—L. B. Slepian. (*Elektritchestvo*, No. 19, 1935, pp. 45–47.)

1138. Measuring the Inductance of [Transmitter Hum Filter] Coils with Superimposed Direct Current [under Exact Service Conditions of High Voltage and Current: Special Bridge Equipment].—H. T. Wilhelm. (*Bell Lab. Record*, December, 1935, Vol. 14, No. 4, pp. 131–135.)

1139. On the Measurement of the Constants of Inductance Coils having Very Short Natural Wavelengths.—I. L. Krenhouse. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 23–30.)

A method is proposed for determining the constants of inductance coils having natural wavelengths of the order of a few decimetres. The method is based on measuring the natural wavelength of the coil by connecting it to the ends of two Lecher conductors and finding the resonant positions of the movable bridge for a number of frequencies induced in the system. It is proved that if a curve is plotted showing the relationship between the frequency and the distance of the bridge from the coil, the point of intersection of this curve with a straight line $y = \lambda/4$ will give the natural wavelength of the coil. Formulae are given for calculating from this the characteristic impedance, self-inductance and capacity of the coil.

1140. An A.C. Detector Bridge [for Approximate Measurement of Capacity].—K. B. Karandeev. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 893–896.)

Further development of the bridge described in a previous paper (1568 of 1935), making use of copper-oxide rectifiers in place of thermo-couples. The bridge is a.c. mains operated and covers a range of 0.25 to 10 μF. The accuracy varies from 1 to 6%.

1141. Influence of the Electrodes on the Measurement of the Resistivity, Dielectric Constant and Loss Angle of Solid Insulating Materials.—C. Chiodi. (*L'Elettrotec.*, 25th Nov. 1935, Vol. 22, No. 22, pp. 776–780.)

1142. On the Measurement of the High-Frequency Dielectric Loss and Power Factor of Insulating Materials by the Differential Transformer Method [Frequencies up to 10 Mc/s].—Yuasa, Nishizaki and Sasaki. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55, No. 8, No. 565, pp. 688–691: English summary p. 86.)

1143. On the Determination of the Dielectric Constants of Organic Liquids at Radio Frequencies. Part I. Carbon Tetrachloride and Chloroform [Resonant Circuit Comparison Method].—R. M. Davies. (*Phil. Mag.*, January, 1936, Series 7, Vol. 21, No. 138, pp. 1–41.)

1144. The Dielectric Constant of Liquids under High Pressure [up to 12 000 kg/cm²].—Chang. (*Chinese Journ. of Phys.*, No. 2, Vol. 1, 1934, pp. 1–55: in English.)

1145. "Electrical Measurements in Principle and Practice" [Book Review].—Cobden Turner and Banner. (*P.O. Elec. Eng. Journ.*, January, 1936, Vol. 28, Part 4, p. 323.)

1146. "Measurements in Radio Engineering" [Book Reviews].—F. E. Terman. (*Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, p. 1567: *Wireless Engineer*, January, 1936, Vol. 13, No. 148, p. 13.)

1147. Standard Signal Generator: All-Wave A.C. Operated Test Set.—E. K. Cole, Ltd. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, p. 6.)

SUBSIDIARY APPARATUS AND MATERIALS

1148. Cathode-Ray Tube with Modulation Chamber [Large-Surface Cathode, Two Grids and Anode inside Wehnelt Cylinder, Small Central Aperture in Anode acting as Virtual Cathode].—Comp. Fabric. Compteurs et Mat. d'Usines à Gaz. (French Pat. 787 229, pub. 19.9.1935: *Rev. Gén. de l'Élec.*, 28th Dec. 1935, Vol. 38, No. 26, pp. 205–206 D.) From the virtual cathode thus obtained "the electrons emerge with a very small initial velocity but in number a variable function of the modulation."

1149. Braun Tubes [Low-Voltage Cathode-Ray Tubes from Electron-Optical Standpoint: Types of Concentrating Electrode Structures: Tokio Electric Company's Television System with Magnetically Operated Scanning of Image on Photosensitive Cathode: etc.].—Nagashima. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, pp. 571–583: English summary p. 75.)

1150. Portable Gas-Focused Cathode-Ray Oscillograph.—A. C. Cossor, Ltd. (*Journ. Scient. Instr.*, January, 1936, Vol. 13, No. 1, pp. 27–28.) With mains-frequency sinusoidal time sweep: sweep in one direction can be modulated out, for clarification of complex images: with self-calibrating potential.

1151. The Advantage of Inclining the Deflecting Plates in a Cathode-Ray Oscillograph [Mathematical Investigation of Increased Max. Deflection: the Possibilities of Curved Deflector Plates].—Benham. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, pp. 10–13.)

1152. Braun [Cathode-Ray] Tubes in Radio Research.—Miyaji, Itoh and Yamaguchi. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, pp. 584–594: Japanese only.)

1153. "The Cathode-Ray Tube at Work" [Book Review: Primarily for Radio Servicing].—Rider. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, p. 20: *Proc. Inst. Rad. Eng.*, December, 1935, Vol. 23, No. 12, pp. 1567–1568.)

1154. Modern Technique of the Cathode-Ray Oscillograph [Survey].—Pontremoli. (*L'Elettrotec.*, 25th Dec. 1935, Vol. 22, No. 24, pp. 837–846.)

1155. Electron-Optical Images of Incandescent Filaments.—Mahl. (*See* 1022.)

1156. The Electron-Optical Structural Image and Its Evidence as to Emission Conditions with Barium/Nickel Cathodes.—Brüche. (*See* 1021.)

1157. Charge Potential and Secondary Emission of Bodies bombarded by Electrons [Experiments with Special Cathode-Ray Tube with Screen replaced by Disc of Metal, Carbon, etc.: Secondary-Emission Images of Carbon-on-Metal Subjects, by Scanning Method with Second, Synchronously Driven C-R Tube: etc.].—Knoll. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 467–475.)

1158. Backward Diffusion and Excitation of Secondary Radiation from Slow Cathode Rays incident on Thin Metal Films [Similar Effect of Heating and Hydrogen Treatment of Films].—Langenwalter. (*Ann. der Physik*, Series 5, No. 3, Vol. 24, 1935, pp. 273–296.)

1159. X-Ray and Electrical Investigation of the PdAgH Alloys [Relation of Hydrogen Atoms to PdAg Lattice].—Rosenhall. (*Ann. der Physik*, Series 5, No. 4, Vol. 24, 1935, pp. 297–325.)

1160. A New Valve "Kipp Oscillation" Apparatus [Time Base] for Cathode-Ray Oscillographs.—von Ardenne. (*E.T.Z.*, 28th Nov. 1935, Vol. 56, No. 48, pp. 1295–1298.)

Author's summary:—"A trip-oscillation apparatus with high-vacuum valves is described which allows trip frequencies up to 500 000 c/s to be reached with sufficiently small return-stroke times. Since a stable synchronisation is obtained with a frequency division of 1 : 12, the new time-base allows oscillographic curve-form investigations to be carried out at frequencies up to 6 Mc/s. Times of 10^{-8} second can also be read off the oscillograms, using ordinary high-vacuum cathode-ray tubes" [where 2 v changes are readable]. The apparatus will also provide medium and low-frequency trip oscillations (down to 20 c/s), and the amplitudes are of the order of 1 000 v (max. obtained with the final design, 1 600 v) symmetrical with regard to earth. In conjunction with the author's amplifier (231 of January) the time base is suitable for the most varied purposes, such as the investigation of building-up processes in television apparatus, short-time echo recording in propagation research, etc. It is valuable also for non-recurrent phenomena, since with modern tubes and anode voltages of 4 000–7 000 v the spot brightness is sufficient to impress the eye at speeds of over 1 000 km/s. The approved circuit is shown in Fig. 2 and described on p. 1297. The trip capacity is charged by a current pulse and discharged at constant current through a screen-grid valve. The charging process is carried out by the circuit given by Bedford and Puckle (1934 Abstracts, p. 506) using two high-vacuum valves.

1161. Simplified Arrangement for the Production of "Kipp" Oscillations for Cathode-Ray Tubes.—Schweitzer. (*See* 1093.)

1162. On the New Synchronising Switch for the Cathode-Ray Oscillograph [for Isolating One out of Several Recurrent Phenomena: primarily for Ignition Coil Investigations].—Mochizuki and Tsuyuguchi. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, pp. 685–687: English summary pp. 85–86.)

1163. Type 150 Electronic Switch [*e.g.* for Simultaneous Observation of Two Processes by Cathode-Ray Oscillograph].—Du Mont Laboratories. (*Rad. Engineering*, December, 1935, Vol. 15, No. 12, p. 26.)

1164. Cathode-Ray Technique Abroad [Colloidal Graphite Films: Binding Technique for Fluorescent Screens].—Porter. (*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 7 and 15.)

1165. Amplifier for Currents of the Order of 10^{-13} Amp.—H. Alfvén. (*Zeitschr. f. Physik*, No. 11/12, Vol. 97, 1935, pp. 708–717.)

The amplifier is designed for the oscillography of very small ionisation currents, which can only be amplified by making them charge up the grid capacity of a valve. The time integral of the current is proportional to the grid voltage at any time; this must therefore be differentiated with regard to the time if an undistorted oscillograph of the current is to be obtained. A resistance-capacity amplifier is here described (circuit Fig. 1), including a circuit (Fig. 2) with a very small time constant which performs the differentiation. The small distortions are theoretically and experimentally investigated (testing circuit Fig. 5) and the sensitivity estimated.

1166. Amplifying Apparatus for the Measurement of Small Potentials. Part II—For D.C. Potentials as in Electrocardiography.—Holzer. (*Elektrot. u. Masch:bau*, 29th Dec. 1935, Vol. 53, No. 52, pp. 613–618.) For Part I *see* 710 of February.

1167. A New Direct-Current Amplifier for Measuring Purposes [for Visual Indication or Inkwriter Recording: Automatic Back-Coupling Adjustment by Vane moved by M.C. Instrument so that Test Circuit is Unloaded during Measurement].—Brandenburger. (*E.T.Z.*, 28th Nov. 1935, Vol. 56, No. 48, pp. 1305–1306.)

1168. Floating-Grid Direct-Current Amplifier [Linear Working to 10^{-15} A: Valve greatly Under-Heated: Screen-Grid Voltage about 4 times Anode Voltage of 3.0 V].—Macdonald and Campbell. (*Physics*, July, 1935, Vol. 6, No. 7, pp. 211–214.) The anode-current change is not read directly but compensated by a change of s.g. voltage.

1169. A Simple Oil Micromanometer.—Beeck. (*Review Scient. Instr.*, December, 1935, Vol. 6, No. 12, pp. 399–400.)

1170. Recent Developments in Metals Sealing into Glass.—Scott. (*See* 1004.)

1171. On Rubber Connections for Mercury Systems.—Pike. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, p. 328.)

"Mercury will remain uncontaminated in contact with rubber through years of active use if the rubber is first thoroughly boiled out in strong caustic soda solution. . . ."

1172. Grid Controlling Method of the Current Mutator using Potentials of the Arc-Exciting Circuit.—Matuura. (*Journ. I.E.E. Japan*, October, 1935, Vol. 55 [No. 10], No. 567, p. 912: Japanese only.) For the word "mutator" *see* 2059 of 1935.

1173. Automatic Voltage Control of High-Voltage Mercury-Arc Rectifiers [for Valve Transmitters: Accuracy within ± 1%: Formulae for Higher Harmonics].—Spitzin. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1935, pp. 51–57.)

1174. Theory of the Immersion Mercury-Arc Ignitor.—Cage. (*Gen. Elec. Review*, October, 1935, Vol. 38, No. 10, pp. 464–465.)

1175. Diffusion of Electrons in the Chamber of the Mercury Rectifier [Discharge Phenomena in Dark Parts of Chamber: Linear Relation between Logarithm of Electron Current at Point on Axis and Distance from Cathode Spot, etc.; Theoretical Explanation].—Kanaskow. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 8, 1935, pp. 119–135: in German.)

1176. Ion Current Distribution in a Double-Grid [Mercury-Vapour] Tube.—Mahla. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 16, 1935, pp. 293–301.) Further development of the work dealt with in 1934 Abstracts, p. 629.

1177. Rectifying Systems for Plate Supply of High-Power Radio Stations [and the Superiority of Steel Mercury-Vapour Rectifiers].—Vologdin. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 63–65.)

1178. A Study of Multi-Stage Circuits of Grid-Controlled Rectifiers and Inverters [and a New "High-Frequency Grid Control"].—Babat. (*Izvestia Elektroprom. Slab. Toka*, No. 8, 1935, pp. 47–52.)

1179. Discussion on "The Grid-Controlled Rectifier with Zero-Point Anode."—Babat. (*Journ. I.E.E.*, January, 1936, Vol. 78, No. 469, pp. 105–106.) *See* 2058 of 1935.

1180. Raytheon OZ4 Gaseous Rectifier [primarily for Car Wireless].—(*Rad. Engineering*, November, 1935, Vol. 15, No. 11, p. 22.)

1181. Why No Gas-Filled Rectifier in a Broadcast Receiver? [Reasons for the now Universal Use of High-Vacuum Type].—Kleen. (*Telefunken-Röhre*, April, 1935, No. 4, pp. 125–129.)

1182. The Thyratron: Scope of Applications and Disadvantages of the Hot-Cathode Grid-Controlled Rectifier.—Whiteley. (*Electrician*, 3rd and 10th Jan. 1936, Vol. 116, pp. 5–6: 50: summary of I.E.E. paper and discussion.)

1183. The New Type of the Single-Tube Inverter [Grid-Controlled Tube in Diagonal of Bridge Circuit of Two Condensers and Two Inductances].—Nishiyama, Ito and Yuki. (*Journ. I.E.E. Japan*, June, 1935, Vol. 55 [No. 6], No. 563, pp. 543–545: English summary pp. 69–70.)

1184. Industrial Applications of the Grid-Controlled Current Director.—Hauffe. (*Zeitschr. V.D.I.*, 7th Dec. 1935, Vol. 79, No. 49, pp. 1475–1478.)

1185. New Rectifying Method using Mechanical Commutator and Grid-Controlled Mercury-Arc Rectifier.—Watanabe and Takano. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 958–965: English summary pp. 118–120.)

1186. A Self-Protecting Cathode [Hot Cathode for Mercury-Vapour Tubes protecting Itself against Damage during Warming-Up Period].—Lowry. (*Electronics*, December, 1935, pp. 26–28.)

1187. Probe Electrode Measurements in Discharges Varying with Time [A.C. Arc in Hg: Anomalies with Swift Electrons: Cathode-Ray Technique].—Koch. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 855–860.)

1188. Dynamical Similarity Laws of the Mercury High-Pressure Discharge.—Heller. (*Physics*, December, 1935, Vol. 6, No. 12, pp. 389–394.)

1189. Is There a Metallic Conductivity in Highly Compressed Metal Vapour?—Braunbek. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 497–498.)

1190. The Mechanism of the Arc Discharge [Experimental Investigation: New Form intermediate between Thermal Arc and Glow Discharge].—Becken and Seeliger. (*Ann. der Physik*, Series 5, No. 7, Vol. 24, 1935, pp. 609–635.)

1191. The Solution of Townsend's Stationary Equations for the General Case.—Tjagunow. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 5, 1935, pp. 889–892.)

1192. Extraneous Ionisation and Lowering of Breakdown Voltage in Gases [Experimental Test of Square Root Law: Slower Decrease of Breakdown Voltage for Very High Extraneous Ionisation].—Rogowski and Wallraff. (*Zeitschr. f. Physik*, No. 11/12, Vol. 97, 1935, pp. 758–764.)

1193. The Variation of Sparking Potential with Intense Ultra-Violet Illumination [Breakdown a Space-Charge Phenomenon occurring at Fixed Value of Field].—White. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p.482: abstract only.)

1194. The Sparking Potential of Hydrogen at High Frequencies [Minimum in Pressure/Sparking-Potential Curve: Effect of Mercury Vapour].—Zouckermann. (*Comptes Rendus*, 14th Oct. 1935, Vol. 201, No. 16, pp. 649–651.) *See* 1931 Abstracts, p. 340.

1195. The Development of a Spark from a Glow [Discharge: Distinction by Presence or Not of Unbroken Dark Space: Description of Experiments].—Wheatcroft and Barker. (*Phil. Mag.*, October, 1935, Series 7, Vol. 20, No. 134, pp. 562–571.)

1196. Paschen's Law [of Sparking Voltage] at Low Striking Potentials [Experimental Verification].—Wheatcroft and Barker. (*Phil. Mag.*, October, 1935, Series 7, Vol. 20, No. 134, pp. 571–578.)

1197. Gas Reactions in the Silent Discharge at Atmospheric Pressure: I—A New Type of Screened Point Discharge changing from High-Current to Lower-Current Type.—Thiessen and Bartel. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 16, 1935, pp. 285–293.)

1198. Cloud-Chamber Investigation of Gas Discharge Phenomena [Multiple-Canal Discharge preceding Breakdown].—Flegler and Raether. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 829–834.)

1199. Spectroscopic Observation of Recurrent Phenomena in Discharge Tubes [with Photocell Method for Synchronous Photography of Irregular Moving Striations].—Sloane and Minnis. (*Proc. Phys. Soc.*, 1st Nov. 1935, Vol. 47, Part 6, No. 263, pp. 1019–1028.)

1200. The "Counting" Phenomenon of Gaseous Discharges as a Space-Charge Problem.—von Hippel. (*Zeitschr. f. Physik*, No. 7/8, Vol. 97, 1935, pp. 455–481.)

1201. On Chemical Reaction in the Electric Discharge. I—The Chemical Effects of Impulse Discharges.—Willey. (*Proc. Roy. Soc.*, Series A, 15th Oct. 1935, Vol. 152, No. 875, pp. 158–171.)

1202. Air [and Oxygen] Afterglow [arises from Oxidation of Nitric Oxide by Ozone].—Newman. (*Phil. Mag.*, November, 1935, Series 7, Vol. 20, No. 135, pp. 777–781.)

1203. Electric Discharges in Vacuum and in Gases at Low Pressures.—Langmuir. (*Gen. Elec. Review*, October, 1935, Vol. 38, No. 10, pp. 452–457.) To be continued.

1204. The Cathode Bead Discharge [Current/Voltage Characteristic: Conditions for Occurrence: Effect of Magnetic Field: Hypothesis of Filament Beam].—Beck. (*Zeitschr. f. Physik*, No. 5/6, Vol. 97, pp. 376–381.)

1205. The Mechanism of the High-Frequency Discharge [Experiments show Its Explanation is Analogous to that of the Positive Column].—Beck. (*Zeitschr. f. Physik*, No. 5/6, Vol. 97, 1935, pp. 355–375.)

1206. The Striations of the Positive Column in the Hydrogen Glow Discharge.—Paul. (*Zeitschr. f. Physik*, No. 5/6, Vol. 97, 1935, pp. 330–354.)

1207. The Forms of the Glow on the Anode in Hydrogen Discharges [Radially Symmetrical Figures: Variation with Discharge Parameters].—Kiessling. (*Zeitschr. f. Physik*, No. 5/6, Vol. 96, 1935, pp. 365–385.)

1208. Effects of the Periodic Variation of the Concentration of Neutral Atoms in the Gas in an A.C. Sodium Lamp.—Uyterhoeven and Verburg. (*Comptes Rendus*, 14th Oct. 1935, Vol. 201, No. 16, pp. 647–649.)

1209. The Current/Voltage Variation of the Spray Discharge ["Spritzentladung"].—Schnitger. (*Zeitschr. f. Physik*, No. 7/8, Vol. 96, 1935, pp. 551–558.) *See* Fricke, 825 of 1935.

1210. Temperature Distribution and Electron Density in a Continuous Arc Discharge [at Atmospheric Pressure].—Hörmann. (*Zeitschr. f. Physik*, No. 9/10, Vol. 97, 1935, pp. 539–560.)

1211. Diffusion Effects in the Negative Glow in a Delayed Discharge.—Fischer and Weizel. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 827–829.)

1212. The Negative Glow: Investigations with the Delayed Discharge in Hydrogen [Diffusion Phenomena].—Weizel and Fischer. (*Ann. der Physik*, Series 5, No. 3, Vol. 24, 1935, pp. 209–230.)

1213. The Internal and Surface Conductivities of Cuprous Oxide [Humidity lowers Surface Conductivity only: Experimental Results].—Dubar. (*Comptes Rendus*, 12th Nov. 1935, Vol. 201, No. 20, pp. 883–885.)

1214. Determination of Metal/Cuprous-Oxide Contact Resistance [Conditions for Formation of Contact Resistance: Crystalline State of Surface required for High Resistances].—Roulleau. (*Comptes Rendus*, 18th Nov. 1935, Vol. 201, No. 21, pp. 947–948.)

1215. The Electron Conductivity of Cuprous Oxide (Correction and New Discussion).—Schottky and Waibel. (*Physik. Zeitschr.*, 15th Dec. 1935, Vol. 36, No. 24, pp. 912–914.)

In the paper here corrected (1934 Abstracts, p. 160) the sign of the Hall effect in Cu_2O was given wrongly throughout; the validity of other results in the paper and the theoretical explanations are discussed. *See* also the Stuttgart papers (786/799 of February).

1216. The Electrical Conductivity of Copper Oxide in Strong Electric Fields.—Borissow, Kara and Sinelnikow. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 8, 1935, pp. 425–429: in German.)

1217. Electrical Conductivity of Copper Oxide Films showing Interference Colours [High Resistance and Negative Temperature Coefficient of Activated Surfaces: Low Resistance and Positive Temperature Coefficient of Massive Copper Surfaces].—Constable. (*Nature*, 28th Sept. 1935, Vol. 136, p. 517.)

1218. Diffraction Experiments with Slow Electrons on Galena, Pyrites and Stibnite concerning the Change of the Crystal Surfaces of Semi-Conductors by Electron Bombardment and the Influence of Temperature on the Form of the Diffraction Curves [Disappearance and Gradual Reappearance of Diffraction Maxima].—Suhrmann and Haiduk. (*Zeitschr. f. Physik*, No. 11/12, Vol. 96, 1935, pp. 726–740.) For further work *see* pp. 741–753.

1219. The Electronic Contact [Experiments on Imperfect Contacts (*e.g.* between Tellurium and Chromium) and Their Action as Rectifiers and Microphones without External Current Source].—Anderheggen. (*Rev. Gén. de l'Élec.*, 14th Dec. 1935, Vol. 38, No. 24, pp. 837–838.)

Summary of a brochure. "If the tellurium/chromium contact preserves its properties at all frequencies—which has not yet been verified—it is possible that its use will extend itself in radio technique and microphony, and that it will be called upon to replace the copper-oxide rectifier, over which it has numerous and great advantages."

1220. A New Type of Synchronous Vibrator.—Sano. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, pp. 701–705: English summary pp. 89–91.)

1221. Vibratorily Commutated Stationary Conversion [" Xylophone Reed " and " Cantilever Reed " Rectifiers].—Southgate. (*Elec. Engineering*, November, 1935, Vol. 54, No. 11, pp. 1213–1221.)

1222. Vibrators—History, Design, Applications.—Garstang. (*Rad. Engineering*, November, 1935, Vol. 15, No. 11, pp. 18–19 and 23.)

1223. Power Supply Filter Curves.—Waltz. (*Electronics*, December, 1935, Vol. 8, pp. 29–30.)

1224. On a Method of removing Ripple Voltage.—Doté and Miyazaki. (*Journ. I.E.E. Japan*, August, 1935, Vol. 55 [No. 8], No. 565, p. 767: Japanese only, with circuit diagram.)

1225. The Cathode as a Current Limiter [Limiting Action of a Mercury Cathode with Very Small Surface confined by Tungsten Walls].—Nikivorov and Sviridov. (*Elektritchestvo*, No. 23, 1935, pp. 28–31.)

1226. The Melting-Time of Protective Fuses. II [for Large Currents: Measurements and Formulae].—van Liempt and de Vriend. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 133–140.) For I *see* 2433 of 1935.

1227. An Electronic Interrupter [Plate Current opens Relay, thus interrupting Filament Current].—Hanly. (*Electronics*, November, 1935, Vol. 8, pp. 35–36.) Useful, for example, for producing h.t. impulses for cable tests, and for safeguarding the life of a valve in emission tests.

1228. New Constant-Current Device [Barretter with Separate Heating Element gives Much Greater Constancy].—Ledward. (*Wireless World*, 10th Jan. 1936, Vol. 38, p. 45.) For another new barretter *see* 730 of February.

1229. A New Continuous Electrical Regulator [Various Methods of Regulation: Amplification: Requirements: Circuit Diagrams and Tests of Optical Regulator using Photocell].—Himmler. (*Arch. f. Elektrot.*, 10th Sept. 1935, Vol. 29, No. 9, pp. 577–599.)

1230. A.C. Voltage Stabiliser Unit [Iron-Core Choke Coil with Auxiliary Winding for Direct Current of Variable Magnitude: Automatic Regulation].—White and Gardner. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p. 480: abstract only.)

1231. The Stabilisator and Its Applications.—Schröter and Körös. (*Telefunken-Röhre*, April, 1935, No. 4, pp. 164–175.)

1232. Current Supply for Meter Calibrating Plant by Valve-Controlled Synchronous Generators, using Glow-Discharge Potential Dividers.—Reese. (*E.T.Z.*, 3rd Oct. 1935, Vol. 56, No. 40, pp. 1095–1099: contd. from No. 39.)

1233. Voltage Regulator for Constant Light Source.—Hughes and Hurka. (*Review Scient. Instr.*, September, 1935, Vol. 6, No. 9, p. 289.)

1234. Oscillations in [Valve] Voltage-Regulator Circuits [Defect generally Overlooked: Its Cure].—Larkin. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, pp. 314–315.)

1235. Regulation of D.C. Motors using Grid-Controlled Rectifiers.—Schilling. (*Arch. f. Elektrot.*, 10th Sept. 1935, Vol. 29, No. 9, pp. 622–631.)

1236. Fully Automatic Accumulator Charging with Very Close Voltage Limits [using A.C. Choke Coils with Parallel Condensers]. —Bohm. (*E.T.Z.*, 10th Oct. 1935, Vol. 56, No. 41, pp. 1117–1119.)

1237. An Impulse Generator using a Glow-Discharge Tube.—N. A. Livshits. (*Izvestia Elektroprom. Slab. Toka*, No. 11, 1935, pp. 45–55.)

After a brief survey of various systems used for the generation of d.c. impulses of constant shape and spacing, a detailed theoretical investigation is presented of an impulse generator consisting of a glow-discharge tube and relay connected across a condenser C. The theory of the glow-discharge tube is given and an equation (2) is derived for the currents in the circuit when the tube is discharging. Methods are indicated for calculating the duration of the discharge and the time interval between two consecutive discharges. It is shown that by varying the resistance r in series with the impulse generator, and the capacity C, it is possible to alter the frequency of the discharge from a few per hour to several thousand per second. In conclusion, formulae are derived for determining the maximum current flowing through the relay winding, and the time required for this to build up.

1238. [Preliminary Experiments] towards an Ionic Generator for High Potentials [Charges carried by High Velocity Particles from Corona Discharge borne along in Gaseous Current in Closed Circuit].—Pauthenier and Moreau-Hanot. (*Comptes Rendus*, 23rd Dec. 1935, Vol. 201, No. 26, pp. 1332–1334.)

1239. A Van de Graaff Electrostatic Generator operating under High Air Pressure.—Herb and others. (*Review Scient. Instr.*, September, 1935, Vol. 6, No. 9, pp. 261–265.)

1240. A Simple Method for the Production of High Alternating Voltages [Excitation of Tuned Circuit by H.F. Transformer].—Hasselbeck and Dänzer. (*Ann. der Physik*, Series 5, No. 1, Vol. 25, 1936, pp. 74–76.)

The method uses the over-voltage occurring at resonance; a h.f. transformer excites a tuned oscillating circuit consisting of condensers and inductances connected in series (Fig. 1); the over-voltage is taken off at P. The advantage of the method is said to be the control of the voltage obtained by good insulation. The effects of external loads and dielectric losses on the voltage obtained are considered. The value of the voltage is deduced as the product of the resonance current and the inductive impedance.

1241. Novel Accumulator Construction [Fuller Rechargeable Dry Cell].—Hallows: Fuller. (*Wireless World*, 17th Jan. 1936, Vol. 38, p. 67.)

1242. New 3-Volt and 4½-Volt Miniature Motors.—(*E.T.Z.*, 26th Sept. 1935, Vol. 56, No. 39, p. 1073.)

1243. The [Mallory] Grid-Bias Cell [for providing Bias to High-Mu A.F. Valves: 2½ Years without Change in Characteristics].—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 16 and 20.) For reference to this cell *see* 1047, under "Acoustics and Audio-Frequencies."

1244. The Design of Iron-Cored Inductance Coils and Transformers to carry D.C. [Practical Method of Calculating Turns, Optimum Gap Length, etc.].—Baggally. (*Wireless Engineer*, January, 1936, Vol. 13, No. 148, pp. 7–9.)

1245. Inductance of a Choke Coil magnetised by Direct Current [Method of Estimating, for Sinusoidal Voltage and Current].—Gussakov. (*Elektritchestvo*, No. 19, 1935, pp. 47–50.)

1246. Some Measurements on Iron-Cored Tuning Coils.—Kaschke: Vogt. (*See* 974.)

1247. Cores—Design, Production: Part 2.—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 21–23.) For Part 1 *see* 735 of February.

1248. Multi-Lamellar Cylindrical Magnetic Shields: Note on the Solution of the Difference Equations involved.—Walker: Sterne. (*Review Scient. Instr.*, December, 1935, Vol. 6, No. 12, p. 416.) *See* 750 of February.

1249. A Theoretical Expression for the Magnetising Curve of a Machine.—Carr: van Niekerk. (*Metropolitan-Vickers Gazette*, January, 1936, Vol. 16, No. 273, p. 21.) Extension of method referred to in 1934 Abstracts, p. 629.

1250. Magnetic Investigation of Precipitation Hardening.—Auer. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 486–488.)

1251. Magnetic Properties and Orientation of Ferromagnetic Particles [with Effect of Heat Treatment]. II—Pyrrhotite.—Davis. (*Physics*, December, 1935, Vol. 6, No. 12, pp. 376–379.) For previous papers *see* 2079 and 3233 of 1935.

1252. Lattice Distortion and Coercive Force in Single Crystals of Nickel-Iron-Aluminium [Mishima Alloys].—Burgers and Snoek. (*Physica*, December, 1935, Vol. 2, No. 10, pp. 1064–1073: in English.)

1253. DETERMINATION OF MAGNETIC HYSTERESIS WITH THE FAHY SIMPLEX PERMEAMETER.—Sanford and Bennett. (*Journ. of Res. of Nat. Bur. of Stds.*, November, 1935, Vol. 15, No. 5, pp. 517–522.)

1254. CRYSTALLINE PROPERTIES AND MAGNETIC ANISOTROPIES OF DISTILLED BISMUTH [Microcrystalline Film beneath Macrocrystalline Conglomerate : Distillation not a Suitable Purification Process].—Goetz, Stierstadt and Focke. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 118–127.)

1255. THE ADJUSTMENT OF SPIN IN FERROMAGNETIC CRYSTALS UNDER THE INFLUENCE OF MECHANICAL TENSIONS [Theory without Assumption of Isotropy : Effect on Magnetisation Curves].—Gans. (*Ann. der Physik*, Series 5, No. 8, Vol. 24, 1935, pp. 680–696.)

1256. THE MAGNETIC BEHAVIOUR OF A NICKEL WIRE UNDER STRONG TORSION [Theory : Matteucci Effect : Magnetisation Curves].—Gans. (*Ann. der Physik*, Series 5, No. 1, Vol. 25, 1936, pp. 77–91.)

1257. "PHYSICAL PRINCIPLES AND APPLICATIONS OF MAGNETO-CHEMISTRY" [Book Review].—Bhatnagar and Mathur. (*Current Science*, Bangalore, September, 1935, Vol. 4, No. 3, pp. 184–185.)

1258. DISPLACEMENT OF THE CURIE POINT BY TENSION [Too Small to be Detected].—Englert. (*Zeitschr. f. Physik*, No. 1/2, Vol. 97, 1935, pp. 94–96.)

1259. THE DIFFRACTION OF X-RAYS BY LIQUID Na-K ALLOY IN A MAGNETIC FIELD [No Change due to Field : No Magnetostriction detected in Alloy : Magnetoresistance in Liquid not due to Magnetic Field].—Heaps. (*Phys. Review*, 15th Sept. 1935, Series 2, Vol. 48, No. 6, pp. 491–493.) *See* Fakidow & Kikoin, 1933 Abstracts, p. 579 ; *also* 2472 of 1935.

1260. THE NEON LAMP AS A COUNTER : PART II.—Valle. (*Nuovo Cimento*, July, 1935, Vol. 12, No. 7, pp. 426–440.) For Part I *see* 2066 of 1935.

1261. [Theory of] DISTRIBUTION OF COUNTS IN A COUNTER [of Ionising Particles] WITH CONSTANT RECOVERY TIME.—Ruark. (*Phys. Review*, 1st Sept. 1935, Series 2, Vol. 48, No. 5, p. 477 : abstract only.)

1262. SIMPLE APPARATUS FOR THE COUNTING OF TUBE COUNTER IMPULSES.—Madsen. (*Naturwiss.*, 25th Oct. 1935, Vol. 23, pp. 738–739.)

1263. A SIMPLE [Electrostatic-Mechanical] RELAY FOR GREINACHER "SPARK COUNTERS."—Teichmann. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 843–845 : *Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 414–416.) To replace the hydraulic relays used by Greinacher in conjunction with his counters (2862 of 1935). For a preliminary letter see *Nature*, 30th Nov. 1935, Vol. 136, pp. 871–872.

1264. SPECIAL GLOW-DISCHARGE LAMP [with Ring and Crossed Electrodes] AS SWITCH-POSITION INDICATOR.—Pflier. (*E.T.Z.*, 28th Nov. 1935, Vol. 56, No. 48, p. 1303.)

1265. THE HEATING OF SLIDING-CONTACT RESISTANCES.—Moeller. (*E.T.Z.*, 17th Oct. 1935, Vol. 56, No. 42, pp. 1143–1146.)

1266. THE RESISTANCE OF VERY THIN EXTRANEOUS LAYERS IN METAL CONTACTS.—Holm and Kirschstein. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 882–888 : *Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 488–494.) For previous work on contacts *see* Abstracts, 1932, p. 237 ; 1929, p. 588 ; also 1669, 2085 and 2851 of 1935.

1267. ELECTRICAL CONDUCTANCE OF SHORT GAPS IN AIR [Reference to Closing Switch Contacts].—Hutchisson, Osgood and Fearon. (*Elec. Communication*, September, 1935, Vol. 21, No. 9, pp. 542–548.)

1268. CONTACT IN VACUUM [and the Design of Vacuum Switches giving 100 Interruptions per Second].—Ostroumov. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1935, p. 68.) *Cf.* 1931 Abstracts, p. 628 (Siemens & Halske).

1269. A NEW VACUUM SWITCH [10 A at 250 V ; Speeds above 30 Times per Second].—Kling. (*Gen. Elec. Review*, November, 1935, Vol. 38, No. 11, pp. 525–526.)

1270. ELECTRO-MAGNETIC RELAY AND COPPER-OXIDE RECTIFIER COMBINATION AS TELEPHONE RELAY : CORRECTIONS.—Vitenberg. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, p. 76.) *See* 751 of February.

1271. GAS-FILLED [Thyratron] RELAY APPLICATIONS.—Noble. (*Journ. I.E.E.*, October, 1935, Vol. 77, No. 466, pp. 569–570 : abstract only.) For Davidson's double-wave oscillograph device, here mentioned, *see* 857 of 1935.

1272. A GLOW DISCHARGE TUBE COOLED WITH LIQUID AIR [with Diagram of Construction and Cooling Arrangements].—Schüler and Schmidt. (*Zeitschr. f. Physik*, No. 7/8, Vol. 96, 1935, pp. 485–488.)

1273. A CABLE CODE TRANSLATOR SYSTEM [for Conversion of 3-Element to 2-Element Signals and *vice versa*].—Connery. (*Elec. Engineering*, November, 1935, Vol. 54, No. 11, pp. 1162–1166.)

1274. A SIMPLE [Bimetallic-Type] THERMO-REGULATOR.—Bloxam. (*Journ. Scient. Instr.*, November, 1935, Vol. 12, No. 11, pp. 361–363.)

1275. THE PRODUCTION OF VERY SHORT ELECTRIC SPARKS [for Projectile Photography].—Libessart. (*Ann. des Postes T. et T.*, November, 1935, Vol. 24, No. 11, pp. 1030–1035.)

1276. CONSTRUCTION AND BEHAVIOUR OF A HIGH-VOLTAGE CYLINDRICAL CONDENSER [of Lumite Glass, withstanding Steady Voltages over 100 kV].—Bundy and Pool. (*Review Scient. Instr.*, December, 1935, Vol. 6, No. 12, pp. 404–408.)

1277. PROBLEMS OF MODERN [Paper] CONDENSER CONSTRUCTION.—Nauk. (*Funktech. Monatshefte*, December, 1935, No. 12, pp. 476–477: summary of lecture.)

1278. TABLE OF GERMAN MANUFACTURERS OF RUBBERLESS INSULATING MOULDING MATERIALS AND THEIR PRODUCTS.—(*E.T.Z.*, 28th Nov. 1935, Vol. 56, No. 48, pp. 1312–1314.)

1279. XM-262: A NEW MINERAL-FILLED MOULDING MATERIAL DESIGNED PARTICULARLY FOR ELECTRICAL INSULATION REQUIRING LOW DIELECTRIC LOSSES [Power Factor 0.75% at 1 Mc/s].—Bakelite Laboratories. (*Rad. Engineering*, December, 1935, Vol. 15, No. 12, p. 17.)

1280. R.F. INSULATOR VOLTAGE LIMITS [Temperature-Rise Investigation: the Use of Corona Shields: etc.].—Lee. (*Electronics*, October, 1935, Vol. 8, pp. 11–12 and 42.)

1281. THE THERMAL CONDUCTIVITY OF GRANULAR MATERIALS.—Krischer. (*Zeitschr. V.D.I.*, 26th Oct. 1935, Vol. 79, No. 43, pp. 1315–1316.)

1282. INVESTIGATIONS OF SOME OPTICAL AND ELECTRICAL PROPERTIES OF DIDYMIUM GLASS [Photoelectric Conductivity: Fluoescence Bands].—Prosad, Bhattacharya and Chatterjee. (*Zeitschr. f. Physik*, No. 5/6, Vol. 98, 1935, pp. 324–335.)

1283. [Theory of] THE INFLUENCE OF ATTACHMENT [of Electricity Carriers in Dielectric] ON FIELD DISTRIBUTION AND CONDUCTIVITY.—Schumann. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 72–74.)

1284. CALCULATION OF VARIOUS PHYSICAL CONSTANTS OF HETEROGENEOUS SUBSTANCES. I. DIELECTRIC CONSTANTS AND CONDUCTIVITIES OF MIXTURES OF ISOTROPIC SUBSTANCES [with Experimental Verifications].—Bruggeman. (*Ann. der Physik*, Series 5, Nos. 7 and 8, Vol. 24, 1935, pp. 636–664: 665–679.)

1285. THE INFLUENCE OF THERMAL AND MECHANICAL TREATMENT ON THE OPPOSING VOLTAGE AND THE CURRENT/VOLTAGE VARIATION IN NaCl CRYSTALS [Deviation from Ohm's Law in Dielectrics connected with Polarisation Formation].—Wenderowitsch and Drisina. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 108–117.)

1286. ON THE CHANGE OF PHYSICAL PROPERTY OF THE ELECTRICAL INSULATOR BY HEAT [Thermo-Balance Tests].—Shimizu and Nishifuji. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 922–928: short English summary p. 117.)

1287. BREAKDOWN WITH INTERNAL PHOTOELECTRIC EFFECT [Tests on Rock Salt].—Goldman and Wul. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 8, 1935, pp. 369–377: in English.)

1288. EFFECT OF X-RAYS ON SOLID INSULATORS.—Shimizu. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 950–957: English summary p. 118.)

1289. DEMONSTRATION OF SPACE CHARGES AND IONISATION PROCESSES IN [Transformer] OIL WITH A STREAM ARRANGEMENT [of the Liquid Dielectric: Positive Charge at Metal/Liquid Dielectric Surface: Measurement of Ionic Mobility].—Christ. (*Zeitschr. f. Physik*, No. 1/2, Vol. 98, 1935, pp. 23–65.)

1290. SPACE CHARGE IN LIQUID DIELECTRICS [Potential Distribution between Parallel Plates measured in Insulating Oils: Space Charge involves Ions of High and Low Mobility].—Whitehead and Minor. (*Physics*, December, 1935, Vol. 6, No. 12, pp. 380–388.)

1291. THE DIELECTRIC PROPERTIES OF ALUMINIUM OXIDE FILMS PRODUCED ELECTROLYTICALLY.—Zauscher. (*Ann. der Physik*, Series 5, No. 7, Vol. 23, 1935, pp. 597–626.)

The aluminium oxide films were produced by anodic polarisation of aluminium electrodes in solutions of oxalic acid; they are used for insulation and protection from corrosion. The hygroscopic, dielectric and break-down properties of dry and oil-saturated films are here described, with experimental curves; samples of oil-saturated films gave smaller dielectric losses at higher alternating voltages.

1292. DIELECTRIC PROPERTIES OF ANODIC LAYERS IN ALUMINIUM ELECTROLYTIC CONDENSERS [Lagging and Non-Lagging Variations: Oscillographic Study of Harmonics].—Lilienfeld, Chandler and Goldman. (*Physics*, December, 1935, Vol. 6, No. 12, pp. 416–425.)

1293. ELECTROLYTIC CONDUCTION OF A SOLID INSULATOR AT HIGH FIELDS: THE FORMATION OF THE ANODIC OXIDE FILM ON ALUMINIUM.—Verwey. (*Physica*, December, 1935, Vol. 2, No. 10, pp. 1059–1063: in English.)

1294. DIELECTRIC LOSSES IN ELECTROLYTIC BARRIER LAYERS [on Al and Ta] AT EXTREME FIELD-STRENGTHS UP TO 10^7 Volt/cm.—Güntherschulze and Betz. (*Zeitschr. f. Physik*, No. 9/10, Vol. 96, 1935, pp. 686–690.)

For previous work see 338 of 1935. The electrolytic cell used to produce satisfactory oxide films on the metals Al and Ta is shown in Fig. 1 and the bridge circuit for measurement of dielectric loss in Fig. 2. Curves are given showing the variation of the tangent of the loss angle with duration of the measurement (Fig. 3), formation voltage (Fig. 4), alternating voltage (Fig. 5), direct voltage (Fig. 6), formation time (Fig. 7), temperature (Fig. 8), and frequency (Fig. 9).

1295. A New Method of Making Extremely Thin Films.—Lark-Horovitz, Howe and Purcell. (*Review Scient. Instr.*, December, 1935, Vol. 6, No. 12, pp. 401–403.)

1296. Variation in Electrical Resistance and Reflecting Power of Metallic Mirrors condensed at Low Temperatures.—Suhrmann and Barth. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 843–845: *Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 449–451.)

1297. Selective X-Ray Diffraction from Artificially Stratified Metal Films deposited by Evaporation [Method of Studying Atomic Diffusion in Solid State].—Du Mond and Youtz. (*Phys. Review*, 15th Oct. 1935, Series 2, Vol. 48, No. 8, p. 703.)

1298. Diffraction of Electrons by Metal Crystals and by Mica [Spot Patterns yielded by Oxide Films are due to Pure Metal Crystals caught up on the Films].—Darbyshire and Cooper. (*Proc. Roy. Soc.*, Series A, 15th Oct. 1935, Vol. 152, No. 875, pp. 104–123.)

1299. Method for Compensating Non-Linear Distortion [Use of Constant Auxiliary Voltage Whose Working Point is Displaced in Synchronism with the Input Frequency].—Siemens & Halske. (German Pat. 611 652, pub. 12.7.33: *Hochf:tech. u. Elek: akus.*, September, 1935, Vol. 46, No. 3, p. 107.)

1300. The Penetration of Transients into Electrical Machines and Protection of Machines connected directly to Cables in the Open [Protective Action of Condensers against Atmospheric Disturbances].—Neuhaus and Strigel. (*Arch. f. Elektrot.*, 5th Oct. 1935, Vol. 29, No. 10, pp. 702–721.)

1301. Carrier-Frequency Heterodyne Oscillator [1–100 kc/s].—Slonczewski. (*Bell Lab. Record*, October, 1935, Vol. 14, No. 2, pp. 60–64.)

1302. The Eddy Currents in a Plate with a Circular Hole in the Field of a Single Coaxial Conductor [General Mathematical Solution: Calculations of Energy Losses in Special Cases of Practical Importance].—Buchholz. (*Ann. der Physik*, Series 5, No. 3, Vol. 24, 1935, pp. 231–252.)

1303. Radio Manufacturers' Varied Uses of Nickel.—(*Electrician*, 10th Jan. 1936, Vol. 116, p. 45.)

1304. Soft Solders.—Falk. (*Bell Lab. Record*, November, 1935, Vol. 14, No. 3, pp. 89–93.)

1305. Electric Charges from Stretched Rubber Bands [produced by Friction, not Stretching ?].—Coop: Larson. (*Review Scient. Instr.*, December, 1935, Vol. 6, No. 12, p. 418.) *See* 4093 of 1935.

1306 A New Stroboscopic Speed Indicator [with "Whirling-Light Gun"].—Ashdown. (*Television*, December, 1935, Vol. 8, No. 94, p. 727.) Based on the tuning-fork and detent control dealt with in 1976 and of 1935.

STATIONS, DESIGN AND OPERATION

1307. Acceptance Tests for Broadcasting Stations [based on CCIR and American IRE Recommendations].—Gerber. (*Bull. Assoc. suisse des Élec.*, No. 1, Vol. 27, 1936, pp. 14–18.)

1308. Broadcast Maintenance Costs [Survey of 86 United States Stations].—(*Electronics*, November, 1935, Vol. 8, p. 25.)

1309. The Energy Consumption of the Swiss Broadcasting Stations in 1934.—(*Bull. Assoc. suisse des Élec.*, No. 26, Vol. 26, 1935, p. 750.)

1310. Important Broadcasting Developments in Brazil.—(*Marconi Review*, Sept./Oct. 1935, No. 56, pp. 30–32.)

1311. The New French Broadcasting Stations.—Adam. (*Génie Civil*, 28th Dec. 1935, Vol. 107, No. 26, pp. 603–609.)

1312. The Action of Automatic Regulating Apparatus [for Volume Control at Transmitter or Receiver].—Bartels and Ulbricht. (*See* 1054.)

GENERAL PHYSICAL ARTICLES

1313. [Direct] Proof of the Planck-de Broglie Relations [$E = h\nu$ and $p = h/\lambda$].—Glaser. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 481–484.)

1314. The Form of the Electromagnetic Equations [General Remarks: Presentation of a Symmetrical Form with Constants in Didactically Correct Position and Least Possible Sensitivity to Change of Units].—Fischer. (*Physik. Zeitschr.*, 15th Dec. 1935, Vol. 36, No. 24, pp. 914–916.)

1315. The Dimensions of Electromagnetic Quantities [Summary: Four Fundamental Quantities].—Sommerfeld. (*Physik. Zeitschr.*, 1st Dec. 1935, Vol. 36, No. 22/23, pp. 814–818: Discussion on practical units, pp. 818–820.)

1316. The Value of the Electronic Charge [Essential Correctness of Grating Value: Reliable Determination of h/e needed].—Birge. (*Phys. Review*, 1st Dec. 1935, Series 2, Vol. 48, No. 11, p. 918.)

1317. Angular Momentum of Circularly Polarised Light [Measured Value $h/2\pi$ per Quantum].—Holbourn. (*Nature*, 4th Jan. 1936, Vol. 137, p. 31.) *See* also 347 of January.

1318. The Temperature Dependence of Free Electron Specific Heat [in Metals: Application of Fermi-Dirac Statistics: Numerical Values].—Stoner. (*Phil. Mag.*, January, 1936, Series 7, Vol. 21, No. 138 pp. 145–160.)

1319. The Diffusion of Gases through Metals. II—Diffusion of Hydrogen through Aluminium [Rate depends on State of Surface: Oxygen Contamination reduces Rate].—Smithells and Ransley. (*Proc. Roy. Soc.*, Series A, Vol. 152, No. 877, pp. 706–713.)

1320. The Sorption of Hydrogen and Deuterium by Copper and Palladium. I. The Behaviour of Copper and Copper Oxides. II. The Sorption by Palladium and Diffusion through Copper.—Melville and Rideal. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1935, Vol. 153, No. 878, pp. 77–88: 89–103.)

1321. The Structure and Physical Properties of Thin Films of Metal on Solid Surfaces [Microscopic Examination of Structure of Sputtered Films of Ag and Au].—Andrade and Martindale. (*Phil. Trans. Roy. Soc.*, Series A, 21st Aug. 1935, Vol. 235, No. 747 III, pp. 69–100.)

1322. A Discussion on Supraconductivity and Other Low Temperature Phenomena [including the Propagation of Electromagnetic Waves in Metallic Conductors and Its Bearing upon the Problem of Supraconductivity].—McLennan, Kronig and others. (*Proc. Roy. Soc.*, Series A, 15th Oct. 1935, Vol. 152, No. 875, pp. 1–46.)

1323. The Electrical Resistance of Aluminium at Low Temperatures [Measurements down to 2.2° K: Relation to Theories of Metallic Conduction].—Boorse and Niewodniczański. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1936, Vol. 153, No. 879, pp. 463–475.)

1324. A Theory of Liquid Surface Rupture by a Uniform Electric Field [Field Emission from Liquid Surfaces at Lower Field Strengths than from Solids: Explanation of Lowered Sparking Potential to Liquid Mercury].—Tonks. (*Phys. Review*, 15th Sept. 1935, Series 2, Vol. 48, No. 6, pp. 562–568.)

1325. Ionic Mobility [in Electrolytic Solutions: Exact Calculation of Born's Effect of Movements of Dipoles with Ions].—Hermans. (*Zeitschr. f. Physik*, No. 11/12, Vol. 97, 1935, pp. 681–689.)

1326. The Wien Effect in Electrolytes, investigated with the Cathode-Ray Oscillograph [Current/Voltage Characteristics show Deviations from Ohm's Law].—Hüter. (*Ann. der Physik*, Series 5, No. 3, Vol. 24, 1935, pp. 253–272.)

1327. Statistical Theory of Strong Electrolytes [with Modified Expression for Dielectric Constant].—Levine. (*Proc. Roy. Soc.*, Series A, 15th Nov. 1935, Vol. 152, No. 877, pp. 529–559.)

MISCELLANEOUS

1328. Numerical and Mechanical Methods in Double Fourier Synthesis.—Robertson. (*Phil. Mag.*, January, 1936, Series 7, Vol. 21, No. 138, pp. 176–187.)

1329. On the Fundamentals of the Heaviside Operational Calculus.—Miyoshi. (*Journ. I.E.E. Japan*, July, 1935, Vol. 55 [No. 7], No. 564, pp. 599–606: English summary pp. 77–79.)

1330. The 11th Congress of German Physicists and Mathematicians in Stuttgart, 1935.—(*E.N.T.*, November, 1935, Vol. 12, No. 11, pp. 379–380: short note on lecture subjects only.)

1331. On a Method for the Calculation of Vector Potential Fields [and Application to the Vector Potential of a Current-Carrying Toroidal Coil].—Schlomka. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 479–481.)

1332. On the Effect of the Underlying Conductor on the Magnetic Field of a Thin, Circular Coil [as used in Geophysical Prospecting].—Ishibashi. (*Journ. I.E.E. Japan*, September, 1935, Vol. 55 [No. 9], No. 566, pp. 780–784: English summary pp. 98–99.)

1333. Measurement of the Conductivity of Blood in the Wavelength Range 6–25 m.—Graul. (*Ann. der Physik*, Series 5, No. 4, Vol. 24, 1935, pp. 326–348.)

1334. Experimental Methods of Electrodiagnostics.—(*Rev. Gén. de l'Élec.*, 16th Nov. 1935, Vol. 38, No. 20, pp. 659–660.)

1335. The Investigation of Mitogenetic Radiation with the Tube Counter.—Barth. (*Naturwiss.*, 4th Oct. 1935, Vol. 23, p. 688.)

1336. Nerve Messages [Lecture].—Hill. (*Electrician*, 13th Dec. 1935, pp. 743–744 and 745.)

1337. Radio-Like Waves guide Homing Pigeons [Electrical Disturbances, rather than Reduced Visibility, cause Failure of Flights: etc.].—Mayr. (*Sci. News Letter*, 9th Nov. 1935, p. 297.)

1338. "Foundations of Short-Wave Therapy" [Book Review].—Holzer and Weissenberg. (*Electrician*, 3rd Jan. 1935, Vol. 116, p. 15.) English translation of the book referred to in 372 of January.

1339. On the Question of the Power of Generators for Short-Wave Therapy [Method of Measurement: Maximum Tolerable Power: etc.].—Mittelmann. (*Elektrot. u. Masch:bau*, 1st Dec. 1935, Vol. 53, No. 48, pp. 568–571.)

1340. A Simple Apparatus for the Study of the Absorption of Electric Waves in Bodies [using 3–15 m Waves and a Very Small Dipole/Detector Receiver completely Out of Tune with Transmitter].—Petrucci. (*Nuovo Cimento*, June, 1935, Vol. 12, No. 6, pp. 361–367.)

Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

437 099.—Transmitting aerials with variable capacity top for controlling the space-wave component of radiation.

Compagnie Générale de T.S.F. Convention date (France) 9th June, 1934.

2 017 121.—Four half-wave aerials, arranged as a horizontal square, insulated from each other at the corners, and energized by diagonal feeders, to give a uniform field of radiation for broadcasting.

M. Gouriaud (assignor to Cie Generale de T.S.F.).

TRANSMISSION CIRCUITS AND APPARATUS

436 641.—High-frequency transmission circuit fitted with iron-cored intervalve couplings with the object of maintaining a constant amplitude over a wide frequency range.

C. Lorenz Akt. Convention date (Germany) 3rd May, 1934.

437 263.—Utilisation of telephone trunk lines as a multiplex high-frequency carrier for sound and picture signals.

J. J. Laub and F. Kirsch Stein. Convention date (Germany) 18th February, 1933.

1 995 164.—Generating oscillations partly by Dynatron action and partly by the capacity coupling between the grids of a valve of the pentode type.

J. N. Whitaker (assignor to Radio Corporation of America).

RECEPTION CIRCUITS AND APPARATUS

436 482.—Variable selectivity receiver in which the D.C. component of the rectified signals is used to vary, differentially, the tuning of two of the high-frequency circuits.

Marconi's W.T. Co. (assignees of R. A. Braden). Convention date (U.S.A.) 16th October, 1933.

436 856.—Noise-suppressor circuit in which an ohmic resistance is common to the anode-cathode of a control valve and of an L.F. amplifier, and also serves to bias the grid of the latter valve.

Ferranti and M. K. Taylor. Application date 15th February, 1934.

2 005 237.—The plates and filaments of a wireless set are supplied with current of a super-audible frequency, derived from A.C. mains. The set is of the super-regenerative type.

F. A. Parsons.

2 101 566.—Means for regulating the phase and amplitude of the feed-back in a regenerative amplifier-circuit so as to reduce distortion or to increase stability.

H. S. Black (assignor to Bell Telephone Laboratories).

DIRECTIONAL WIRELESS

436 839.—Radio navigation system in which the receiver on an aeroplane is provided with A.V.C. control regulated by the aerodrome boundary marking signals alone.

C. Lorenz Akt. Convention date (Germany) 14th August, 1934.

439 714.—Directional aerial of the Adcock type combined with a vertical aerial to remove the usual 180° ambiguity.

R. H. L. Bevan and C. Crampton. Application date 11th October, 1934.

2 014 732.—Rotating-beam beacon in which a number of crossed frame aerials are fed with a constant carrier but are separately modulated so as to transmit a characteristic " course " along any point of the compass.

C. W. Hansell (assignor to Radio Corporation of America).

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

438 090.—High-fidelity microphone in which a ribbon-conductor is mounted in a magnetic field and is backed by a labyrinth passage containing felt or other suitable damping material.

Marconi's W.T. Co. (assignees of H. F. Olsen). Convention date (U.S.A.) 21st November, 1933.

1 993 859.—Controlling the overall amplification of reproduced sound and varying simultaneously the relative intensities of the high and low notes.

W. van B. Roberts (assignor to Radio Corporation of America).

TELEVISION AND PHOTOTELEGRAPHY

435 637.—Means for reducing the air-pressure on a rotating scanning-disc as used for television.

J. D. Percy and Baird Television. Application date, 5th July, 1934.

436 543.—Means for preventing " halo " effects on the fluorescent screen of a cathode-ray tube.

A.C. Cossor (assignees of M. von Ardenne). Convention date (Germany) 13th April, 1933.

436 622.—Means for neutralising capacity coupling between the magnetic deflecting coils used in a cathode-ray tube.

Telefunken Co. Convention date (Germany) 30th January, 1934.

436 650.—Producing synchronising-impulses having a steep wave-front injected in correct phase-relation with the picture signals in television.

G. B. Banks and Baird Television. Application date 13th March, 1934.

436 734.—Television amplifier designed to amplify the higher frequencies more than the lower frequencies so that the latter can be kept at a favourable signal-to-noise ratio.

A. D. Blumlein and C. O. Browne. Application date 17th April, 1934.

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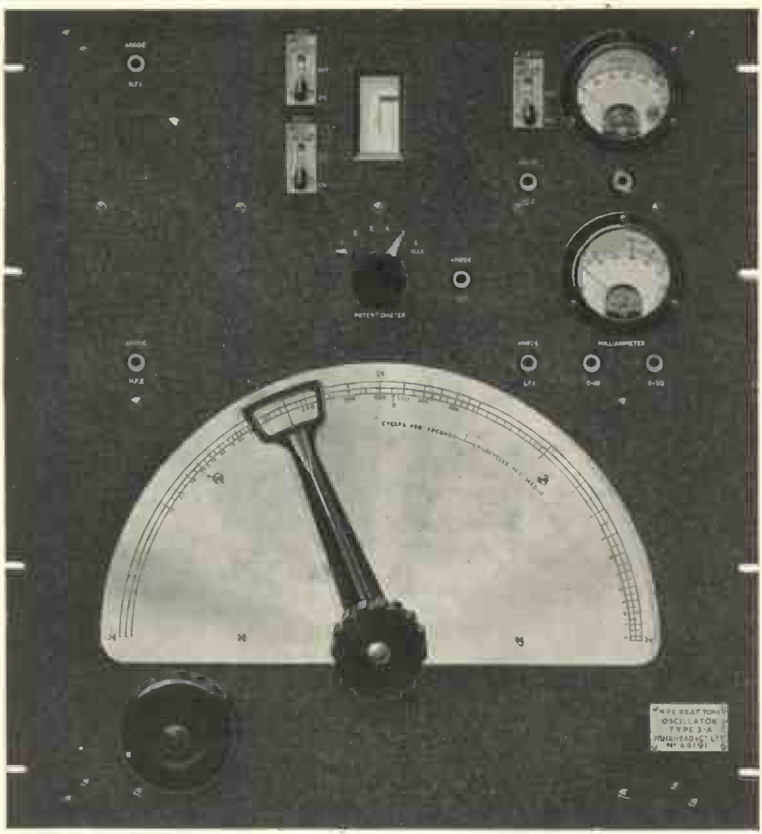

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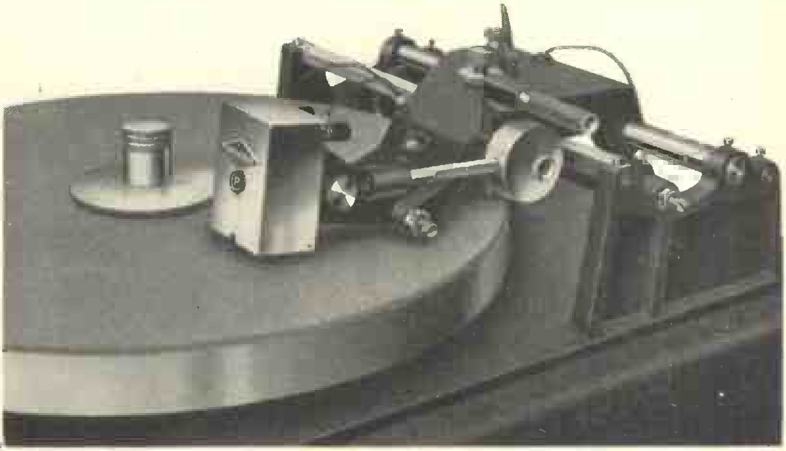

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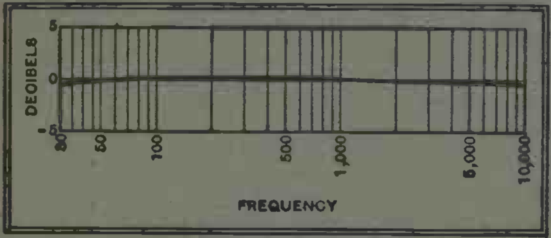

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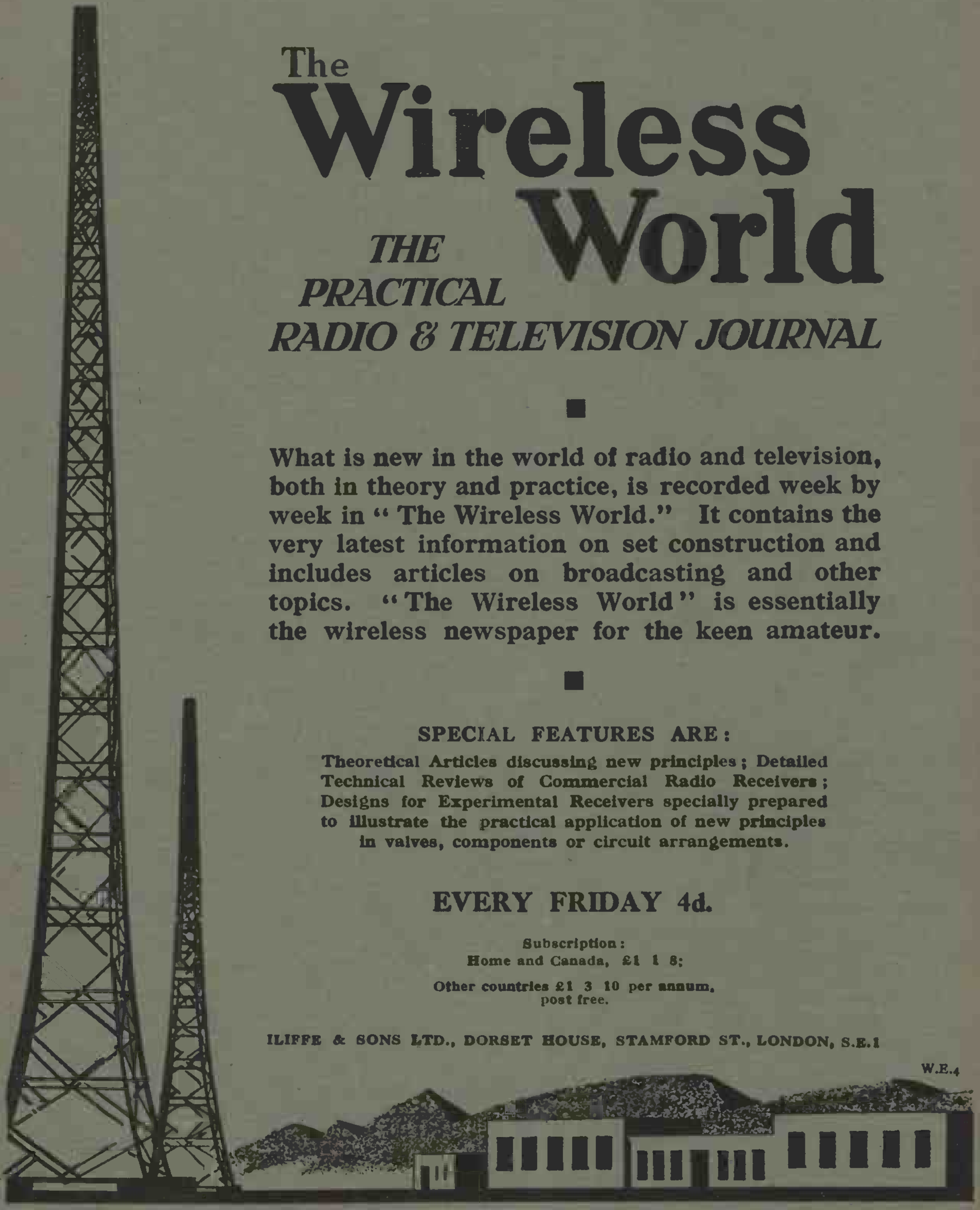

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