THE
WIRELESS ENGINEER
AND
EXPERIMENTAL WIRELESS

VOL. XII. JULY, 1935 No. 142

Editorial

Electric Lines of Force and Faraday Tubes

IN describing the transmission of wireless waves over the surface of the earth, it is usual to picture a more or less vertical electric field sweeping radially outwards from the transmitting aerial, associated with a horizontal magnetic field expanding with the electric field. Each field can be expressed in terms of, and explained by, the movement of the other. In both cases the field is represented graphically and generally referred to as if it consisted of a number of lines. A question which has been discussed from time to time is the degree of reality which one is justified in ascribing to the lines of magnetic induction, but the same question does not seem to have arisen in connection with the electric field.

Although people have exercised their minds over the problem as to whether the magnetic field of a bar magnet rotates with it when the magnet spins about its axis, the equally meaningless question as to the rotation of the electric field of a rotating charged sphere appears to have been neglected. This is surprising because is offers an excellent field to those who delight in the experimental chasing of this type of chimera.

If a charged metal sphere is suspended in a vacuum, certain phenomena can be observed in its neighbourhood, *e.g.*, small similarly charged bodies are radially repelled. Although the region in which these phenomena are observable is said to be an electric field, it is doubtful if anyone has the faintest conception of what constitutes such a field. One may, perhaps, derive some satisfaction by saying that the space—or ether, they are both words of five letters—is in a peculiar condition of electric strain. One may draw, or imagine, lines radially from the sphere, that is, in the direction of the force experienced by a small charged body, and may adopt a convention as to the number of these lines of force, so that the number per square centimetre is equal to the strength of the field, or a million times the strength of the field if one prefer it. Instead of lines we may draw radial tubes, or imagine them drawn, such that each tube encloses, where it meets the sphere, unit charge. These are called Faraday tubes or tubes of displacement. For the sake of simplicity we are assuming that the charged sphere is far removed from any other body.

Eminent physicists, notably Sir J. J. Thomson, have shown that the magnetic field can be calculated from the movements of the Faraday tubes, and that the electric current in a conductor may be regarded as the movement of the ends of the Faraday tubes. Electromagnetic waves are sometimes regarded as the movement of Faraday tubes, and one text-book in explaining an ordinary direct current circuit says: "The function of the battery is to furnish a continuous supply of Faraday tubes." Surely, if this be so, these tubes must be something more than mere mathematical abstractions or the product of the imagination. Let us, therefore, consider in some detail the simple case of the charged sphere. If it be moved from one position to another the electric field everywhere will undergo a change, but it will be correctly represented by assuming the lines of force to move as if they were radial bristles rigidly attached to the sphere. The moving charge acts like a current and the magnetic field produced at any point by the movement can be calculated from the assumed movement of the Faraday tubes.

If now the centre of the sphere remains at rest, relatively to the observer and surroundings, whilst the sphere spins rapidly about a vertical axis, there is at no point any change in the strength or direction of the electric field. Unless the Faraday tubes have an individuality and can be marked or distinguished in some way, how can one decide whether they are being carried round with the rotating sphere or not? A test which suggests itself at once is the production or non-production of a magnetic field. Now the rotating charged sphere undoubtedly sets up a magnetic field which could presumably be calculated on the assumption that the Faraday tubes rotate with the sphere, but the fallacy of this as a proof of their rotation is evident from the fact that the same magnetic field can be produced without any electric field. If, for example, the charged sphere be replaced by a spherical coil carrying currents of the correct magnitude, or if it be replaced by a sphere made up of insulated zones charged alternately positively and negatively, arranged to rotate in opposite directions, there will be no electric field and no Faraday tubes, but the same magnetic field as before. This can, however, be readily explained away, and the explanation shows at once what degree of reality the Faraday tubes possess. If it be assumed that the space around the coil or neutral sphere is the seat of two equal and opposite radial electric fields and that the two sets of tubes rotate in opposite directions, or that one set rotates whilst the other remains stationary, the magnetic field can still be attributed to their movement.

This may satisfy a mathematician, but few electrical engineers will be favourably impressed by the expedient of seeking to explain something—if we dare so refer to a magnetic field—by assuming nothing to consist of two equal and opposite sets of tubes rotating in opposite directions.

In case anyone may have doubts about the charge on a sphere rotating with the sphere itself, it may be pointed out that the sphere could be made of two hemispherical shells separated by a thin vertical layer of insulation, or it could be made of insulating material covered with metallic patches or particles, all uniformly charged. No one can doubt that in these cases the charge would rotate with the sphere.

The external magnetic effect of the rotation of such a sphere would be unaffected by placing within it a similar but smaller sphere, equally but oppositely charged, and at rest; the external electric field would then vanish. In the space between the two charged spheres the Faraday tubes, if endowed with any reality, must find it difficult to decide whether to follow the dictates of their head or their feet, for at one end the charges are stationary and at the other rotating.

If regarded merely as mathematical abstractions these difficulties do not arise, and one is really forced to adopt this point of view. If, however, the Faraday tubes are mathematical abstractions, the question whether or not they rotate with the sphere is not a question of experimental fact, but of definition. If one decides to regard the production of a magnetic field as due to the movement of Faraday tubes in one case, it is only reasonable to picture the same cause wherever a magnetic field exists. From this point of view the external magnetic field of a permanent magnet is due to the combined movements of all the Faraday tubes proceeding from all the atomic charges in the magnet, but it is doubtful if anyone will derive any help from looking at it in this way.

The production of the magnetic field by the rotating charged sphere may be a mystery, but nothing is done towards clearing it up by postulating movement of an electric field which is undergoing no change whatever either in magnitude or direction.

Until one defines what he means by the rotation of such a field, it is impossible to say whether it rotates or not.

G. W. O. H.

For important errata see page 374.

Further Notes on Precision Heterodyne Oscillators*

By W. H. F. Griffiths, F.Inst.P., A.M.I.E.E., M.I.R.E.

In an article in the May, 1934 issue of this journal the author stressed the importance of making at least one of the radio frequency heterodyning oscillators of a beat tone oscillator extremely stable. In order to emphasise the necessity for this, reasoning was introduced to show that, for a given increment $\triangle C_2$ in the capacity of the beat frequency calibrated variable condenser, the beat frequency F is proportional to the cube of the basic high frequency f_1 of the fixed frequency oscillator when the zero beat method of scale setting is employed. Many readers appear to have misinterpreted this reasoning and to disagree with the conclusion to which it leads.

Although correct, the reasoning is, perhaps, unnecessarily confused instead of simplified—as the author had intended—by the assumption of equality of the inductances L_1 and L_2 of the oscillatory circuits of the fixed and variable frequency oscillators respectively. The reasoning does not depend upon that condition of equality—it does not, in fact, depend upon f_1 being produced by an *oscillatory circuit*, although it has been shown in the previous article that exactly similar resonant circuits L_1, C_1, L_2, C_2 are desirable.

The problem can, perhaps, be approached better by first proving the general law :—

" The change in frequency of any resonant circuit *of fixed inductance* due to a given small change of capacity is proportional to the cube of the frequency."

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

$$f - \triangle f = \frac{1}{2\pi\sqrt{LC\left(1 + \frac{\triangle C}{C}\right)}}$$

$$= \frac{f}{\sqrt{1 + \frac{\triangle C}{C}}}$$

$$= f\left(1 - \frac{\triangle C}{2C}\right) \text{ approximately}$$

$$\frac{\triangle f}{\triangle C} = \frac{f}{2C} \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

If L is fixed

$$\frac{1}{C} = 4\pi^2 L f^2$$

and

$$\frac{\triangle f}{\triangle C} = 2\pi^2 L f^3 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

The heterodyne problem may now be solved by applying this general law to the resonant circuit of the variable frequency oscillator.

Let f_1 = fixed frequency.
F or $\triangle f_1$ = heterodyne beat frequency.
L_2 = inductance (fixed) of the variable frequency oscillator.
C_2 = capacity of the variable frequency oscillator when F is adjusted to be zero.

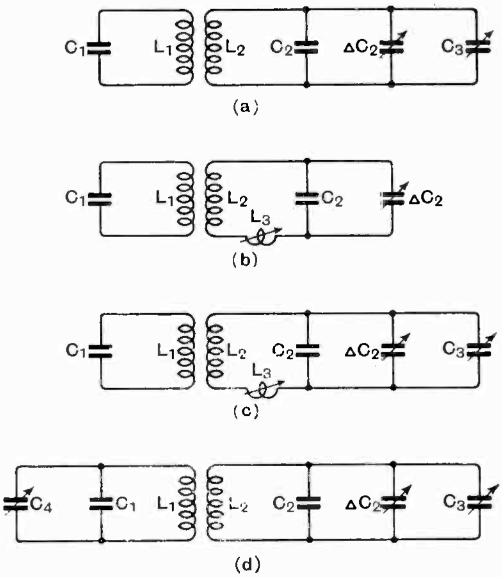


Fig. 1.—*Various methods of adjusting the beat frequency scale of a heterodyne oscillator.*

* MS. received by the Editor October, 1934.

$\triangle C_2$ = the increase of C_2 which produces the beat frequency F.

f_2 = variable frequency $= f_1 - \triangle f_1$.

From (2) $\dfrac{\triangle f_1}{\triangle C_2} = 2\pi^2 L_2 f_1^3$

or $F \propto f_1^3 \triangle C_2$

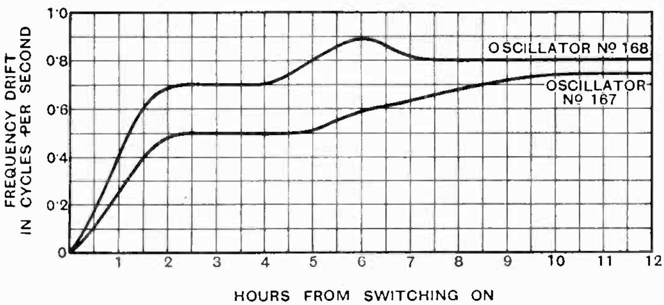


Fig. 2.—*Frequency stability curves of Ryall-Sullivan Heterodyne Oscillators.*

Fig. 3.—*Frequency curves of heterodyne oscillators.*

That is to say, for a given increment $\triangle C_2$ in the capacity of the beat frequency calibrated variable condenser, the beat frequency is proportional to the cube of the basic high frequency.

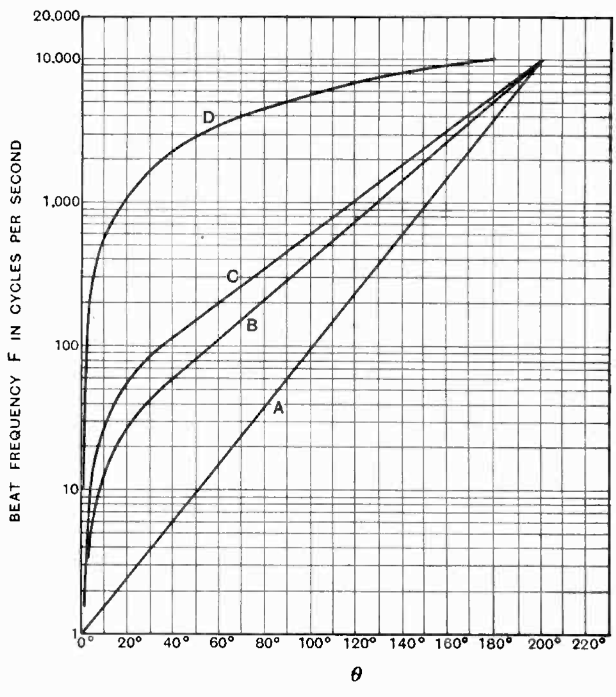
It is seen, therefore, that if, from any cause of instability whatever, a small percentage change occurs in the frequency f_1 of the fixed frequency oscillator, it will produce three times that percentage change of beat frequency F for a given value of $\triangle C_2$. This possibility of large error in the beat frequency calibration of a heterodyne oscillator occurs only if the method of scale setting is that in which, with the beat frequency scale set to zero, the frequency f_2 of the variable frequency oscillator is adjusted to equality with f_1 by means of a "scale setting condenser" in parallel with C_2 as indicated by C_3 in Fig. 1a. For the purposes of the reasoning set out above C_3 is supposed to be included quantitatively in C_2.

This means of scale setting is invariably employed but it is of interest to note that, instead, any inconstancy or drift of f_1 may be imitated in f_2 by a slight adjustment of L_2 by means of a very small variometer L_3 in series with it as indicated in Fig. 1b. Under these conditions C_2 is kept constant and, therefore, since f_1 is the only variable in

$$F = f_1 \frac{\triangle C_2}{2C_2} \quad \ldots \quad \ldots \text{ from (1)}$$

it is seen that the percentage beat frequency scale error for any given value of $\triangle C_2$ is equal to the percentage drift which occurs in f_1.

At first glance it would appear, therefore, that an inductance adjustment of scale would be an improvement in that it would better preserve the beat frequency calibration. This is not so, however, because C_2 cannot



be made as constant as L_2 owing to the change of inter-electrode capacity which occurs with valve replacement. Any change of C_2 due to this or any of the other quite numerous causes which occur in practice must be corrected by a capacity adjustment in order to preserve C_2 constant. Obviously it is not possible to have an uncalibrated capacity adjustment C_3 to correct for changes in C_2 *and* an uncalibrated inductance adjustment L_3 to compensate for changes in f_1 as indicated in Fig. 1c since these two variables are inter-dependent. As the uncertainty of C_2 is, in the author's opinion, more serious than the variation of f_1 in a really good dynatron circuit, the conventional capacity adjustment of scale zero is probably the better method.

The above reasoning applies more particularly to those heterodyne oscillators in which the beat frequency scale is "set" by the zero beat method by bringing the variable frequency oscillator into synchronism with the fixed frequency oscillator when the scale is set at zero frequency. If, however, means are *also* provided for checking the scale at a beat frequency well removed from zero, small variable capacities C_4 and C_3 may be included in the fixed and variable frequency oscillators respectively as indicated in Fig. 1d. Although these two auxiliary scale setting condensers are inter-dependent in adjusting f_2 to equality with f_1 with the calibrated scale set to zero, C_4 may now be used to correct for a drift or inconstancy of f_1. For, since $F = f_1 \dfrac{\triangle C_2}{2C_2}$, a given (calibrated) value of $\triangle C_2$ cannot produce a given beat frequency F if changes occur in f_1. An adjustment of C_3 will not compensate for a drift in f_1 but will make matters worse as has already been shown. Various adjustments are therefore made on C_4 and after each adjustment C_3 is used to produce zero beat with the scale set at zero frequency. For all of these adjustments the scale error is noted at the known standard audio frequency until, by this trial and error procedure, a value of C_4 is found for which the calibrated value of $\triangle C_2$ produces the correct beat frequency.

The standard audio-frequency for checking and setting the scale by this method may be provided by using the beat frequency output to operate a tuned reed or other resonant device or to supply a frequency bridge network which has been set to a definite fixed frequency at which a null balance must be obtained with the oscillator set to the same frequency. In order to obtain a high degree of accuracy of checking, the discrimination of resonance or of the balance of these devices must be sharp. For this reason their frequencies are usually fixed in the neighbourhood of 1,000 cycles per second and so the *whole* of the calibration of the beat frequency variable condenser cannot be checked also by this method, for at a beat frequency of a 1,000 per second only about one-tenth or one-twentieth of the total variable capacity is in circuit.

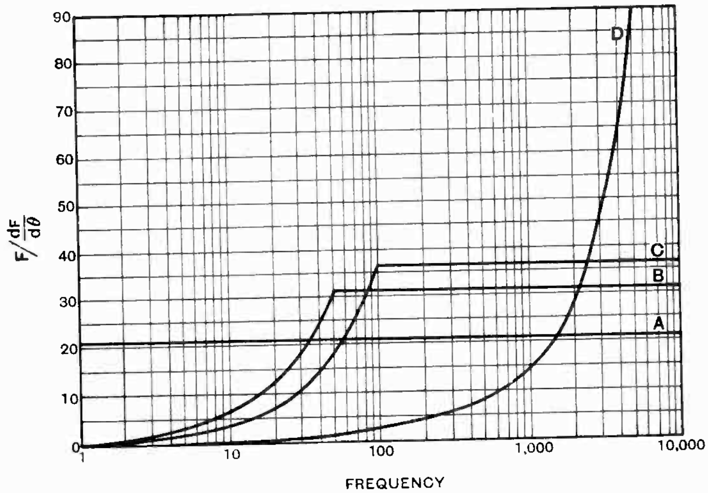


Fig. 4.—*Scale accuracy curves for heterodyne oscillators corresponding to the similarly lettered curves of* Fig. 3.

This scheme of providing scale adjusting condensers on both oscillators must, the author feels, be much more troublesome and, therefore, should not be employed if satisfactory results can be obtained by the more simple zero beat method. Moreover, if the former method is resorted to there is a strong temptation to employ resonant circuits of poor quality in the heterodyning oscillators of such poor quality, in fact, that a large frequency "drift" occurs throughout a test period. Really good stable oscillators will, on the other hand, both ensure the success of the zero beat method of scale setting *and* reduce the frequency "drift" to less than 0.1 cycle per second per hour.[1]

As has been stated previously, the fixed frequency oscillator need not in any way be similar to the variable frequency oscillator from considerations of calibration permanence over a long period. In order to eliminate the frequency drift throughout a period of hours, however, it is necessary to make the oscillatory circuits of the two heterodyning oscillators as nearly as possible alike. As examples of the best frequency stability that can be achieved in this manner the curves of Fig. 2 are given. These show the frequency stability of two Ryall-Sullivan oscillators immediately from switching on. These tests were carried out in a laboratory in which the temperature was constant to within ± 1 degree Fahrenheit. Further tests show the temperature coefficient of frequency to be less than ± 0.1 cycle per second per degree Fahrenheit.

Another controversial design point appears to be the type of scale for heterodyne oscillators. The most suitable scale "law" depends to some extent upon the purpose for which the oscillator is to be used. Except for the purpose of audio-interpolation by interference with the heterodyne beat notes in the measurement of radio frequencies, the most useful scale is logarithmic. The telephone engineer and acoustic engineer most certainly need a logarithmic scale. Such a scale gives a uniform reading accuracy at all frequencies and, in consequence, equal scale distances for octaves throughout the whole range.

If the scale is made logarithmic throughout the whole range from, say, 1 cycle per second to 10,000 as curve A of Fig. 3, the scale reading accuracy is unnecessarily limited, as shown by the correspondingly lettered curve of $F\Big/\frac{dF}{d\theta}$ given in Fig. 4, at the more useful portion of the scale. If the logarithmic nature of the scale is limited to the useful frequencies above 50 per second or so, an appreciable increase of scale accuracy is obtained as shown by the curves lettered B in Figs. 3 and 4. This scale is that of the heterodyne oscillator condenser plate system drawn in Fig. 4 of the previous article. The curves of Figs. 3 and 4 lettered D show the frequency scale and reading accuracy obtained when employing a variable air condenser having a linear capacity law throughout its range. An excellent scale is obtained with this condenser for frequencies above 2,000 per second but only at the expense of scale accuracy over the extremely useful 200–1,000 cycles per second band. The linear capacity scale is of no use whatever except for oscillators of very limited frequency range.

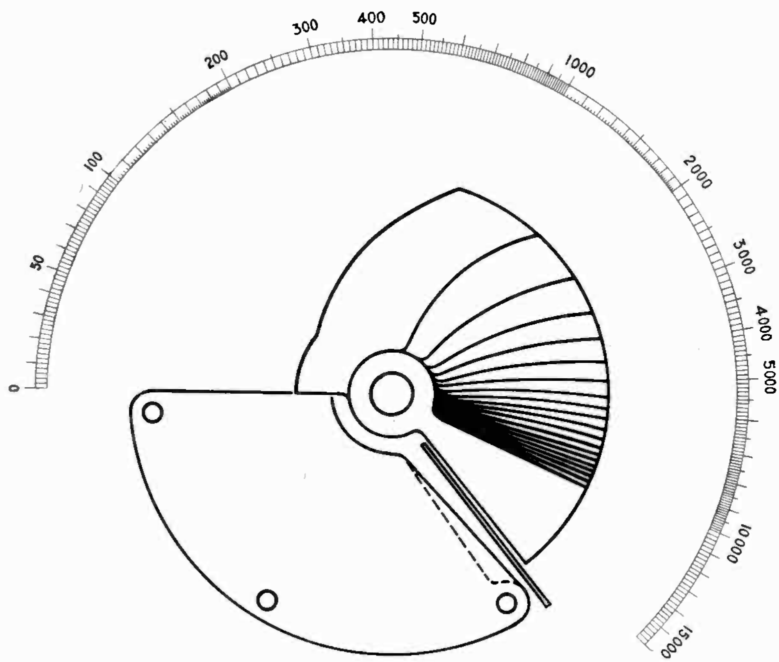


Fig. 5.
The plate system and scale of beat frequency of the heterodyne oscillator condenser designed to the curves "C" of Figs. 3 and 4.

Since the original "B" condenser was

[1] A test figure obtained on the latest design of Ryall-Sullivan Heterodyne Oscillator.

designed the author has decided to adopt as standard, the scale recommended by the Comité Consultative Internationale for telephone transmission testing. This scale, which is represented in Figs. 3 and 4 by the curves lettered C, is linear for frequencies up to 100 per second and logarithmic from 100–10,000 per second. It gives a considerably better reading accuracy over the logarithmic portion of the scale, somewhat at the expense of that over the lower frequencies for which the scale is linear. Besides being standardised Internationally for the telephone engineer this scale is the best compromise for practically all purposes. It should be noted that the linear portion of the scale must have the same (constant) value of $dF/d\theta$ as that of the logarithmic portion at 100 cycles per second—the point at which the law changes. This is necessary in order to eliminate errors of interpolation which would otherwise occur in the vicinity of the change of law.

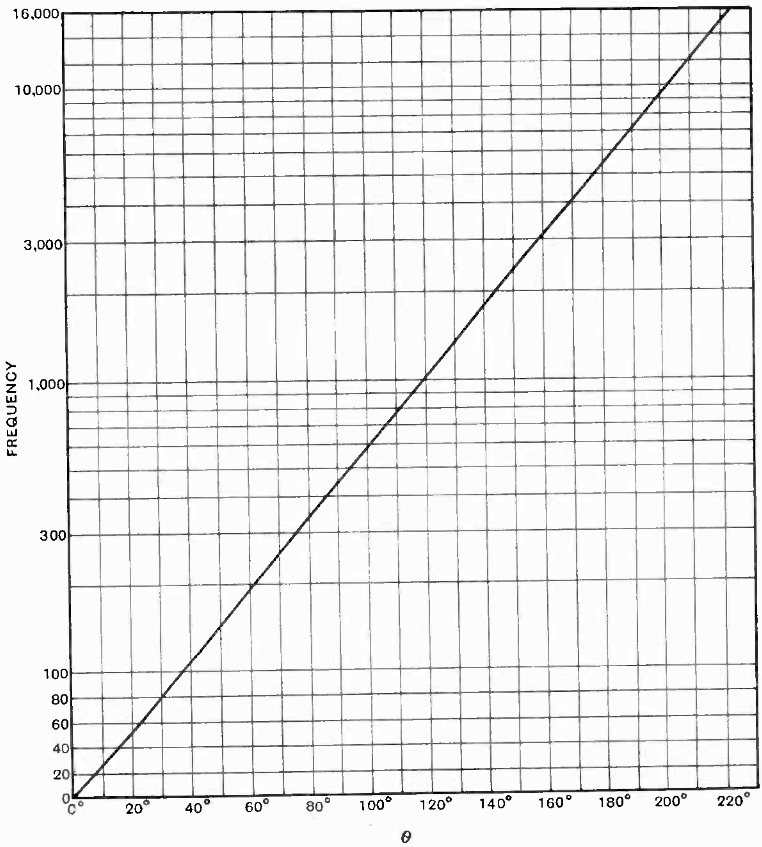


Fig. 6.
The calibration curve of beat frequency of the condenser shown in Fig. 5. *The trueness to "law" is so good that the departures cannot be seen, the* law *inaccuracies having to be shown in* Fig. 7.

In order to determine, for any particular purpose, the frequency range which can be covered by the *logarithmic* law, the total angular movement, $\theta_{max.}$, of the scale and the total frequency, $F_{max.}$, to be covered must be decided upon. Then, using the curves of Fig. 4 as a guide, decide upon the scale accuracy, $F\Big/\frac{dF}{d\theta}$, required of the logarithmic portion of the scale. The low limit of $F\Big/\frac{dF}{d\theta}$ is $\frac{\theta_{max.}\log_{10}\epsilon}{\log F_{max.}}$.

The law of the logarithmic portion of the scale is

$$F = a\epsilon^{b\theta}$$

$$\frac{dF}{d\theta} = ab\epsilon^{b\theta} = bF$$

$\therefore b = \frac{dF}{d\theta}\Big/F$ the reciprocal of the scale accuracy already decided upon

and $a = \frac{F_{max.}}{\epsilon^{b\theta_{max.}}}$.

The linear portion of the scale must obey the law $F = a_1\theta$ and its value of $\frac{dF}{d\theta}$ must be equal to $\frac{dF}{d\theta}$ of the logarithmic portion where the change of law occurs. At this point therefore,

$$a_1 = bF$$
$$F = bF\theta$$
$$\theta = 1/b$$

from which the frequency at which the logarithmic law must cease is given, for, where $\theta = 1/b$,

$$F = a\epsilon$$

If this frequency is too high it is obvious that the scale accuracy must be lowered in order to obtain the logarithmic range required.

It will no doubt be of interest to see how closely true to the C.C.I. "law" a condenser can be constructed. The author's plate system of Fig. 5 has been constructed to the laws

$$F = 2.79\,\theta \text{ from 0–100 cycles per second}$$

and $F = 36.31\epsilon^{0.0279\theta}$ from 100–10,000 cycles per second and the scale of the same figure is that actually obtained by calibration. The frequency curve, Fig. 6, of this scale is so good that the deviations from law cannot be observed although the errors were plotted as carefully as possible on the large original curve from which this figure is reproduced.

These departures from law produce the actual percentage frequency departures from "law-calculated" frequencies shown in Fig. 7. The departures are not, of course, present as scale errors if the oscillator is individually calibrated but are present if the variable condenser is rotated synchronously with a recording drum for the automatic recording of frequency characteristics of a telephone cable or other electrical system.

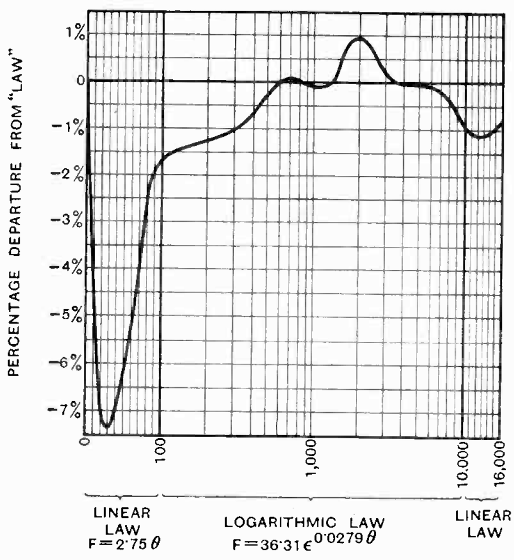


Fig. 7.—*The* law *inaccuracies of the Ryall-Sullivan precision heterodyne oscillator condenser. The inaccuracies shown must not be confused with calibration inaccuracies which are of a much lower order—less than* 0.2 *per cent. at all cardinal frequencies. See also corresponding* Figs. 5 *and* 6.

Book Reviews

Electro-acoustique

By Ph. le Corbeiller: pp. 87. Étienne Chiron. Paris. 15fr.

The author is not only an Engineer in the French Post and Telegraph Service but also a lecturer at the École Supérieure and the book under review is based on the series of lectures which he has given there. The six chapters deal respectively with (1) oscillations, resonance and wave propagation; (2) electro-mechanical transformers such as pick-ups and loud-speaker mechanisms; (3) mechanical-acoustic transformers, such as diaphragms and horns; (4) the production of oscillations by means of drums, violins, organ pipes, etc.; (5) acoustic physiology; and (6) acoustic measurements.

We note that the author calls $\sqrt{\omega_0^2 - a^2}$ the *resonant* pulsation of a damped system; we should prefer to call this its *natural* or free pulsation; the damping does not affect the resonant frequency.

The treatment is necessarily limited but the book covers as much ground as is possible in six lectures and can be recommended as giving a good general foundation on a subject of ever-increasing importance. A list of books and periodicals which the author recommends consists mainly of works in English and German, only two being in French, a fact which the author laments in the preface.

Radio-électricité générale Vol. I.

By R. Mesny: pp. 375 + xi. Étienne Chiron. Paris. 50fr.

The sub-title of this first of three volumes is "Etude des Circuits et de la propagation." The subsequent volumes will deal with II, transmitters and receivers; III, Emissions et réceptions diverses. The author is a Professor at the École Supérieure d'Électricité and is a well-known writer on the application of mathematics to electrical problems. The present volume opens with a chapter on differential equations, complex quantities and hyperbolic functions, which is followed by chapters on oscillations in a closed circuit, oscillations in coupled circuits, resonance curves, the generation of oscillations, synchronisation, open circuits, lines, aerials, high-frequency resistance, energy losses in dielectrics and in iron, propagation of waves through space, the upper atmosphere and finally propagation along the surface of the earth. Nearly every chapter concludes with a bibliography of the more important papers dealing with the subject.

The work is characterised throughout by the thoroughness which one associates with Professor Mesny's treatment of circuit and radio problems, and it can be unreservedly recommended as a text-book on the theory of circuits and propagation.

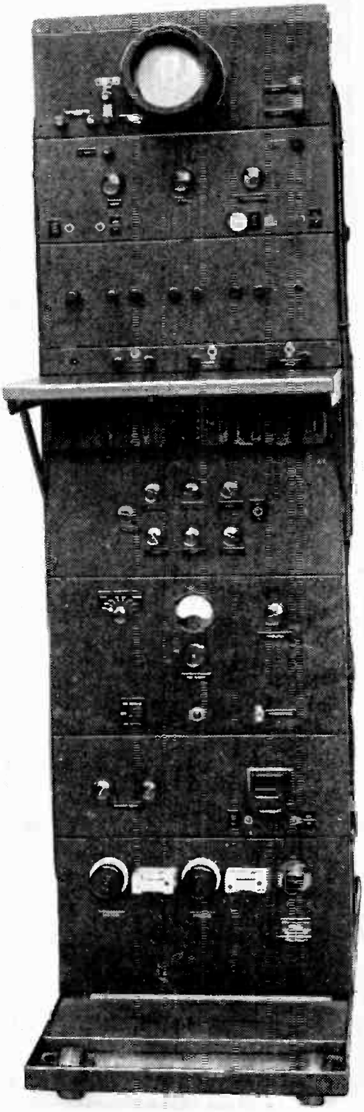
G. W. O. H.

Oscillographic Response-Curve Examination*

An Equipment for the Visual Delineation of the Response Curves of R.F. Filters

By R. F. Proctor, B.Sc., A.M.I.E.E., and M. O'C. Horgan, M.Sc.

(Communication from the Staff of the Research Laboratories of The General Electric Company, Limited, Wembley, England)



The paper deals with the sources of error that occur in the construction of an equipment for the visual demonstration of response curves of filters on a cathode ray oscillograph. The various stages are dealt with one by one and a paragraph is devoted to certain important time-constants which affect the result. Finally a description of a complete equipment embodying all the precautions is given.

1. Introduction

THE generally accepted method of obtaining the response curves of radio-frequency tuned circuits or filters is by the use of a variable frequency signal generator and a valve voltmeter, taking a number of gain readings at intervals through the necessary frequency band; and such a method probably cannot be improved upon for the accurate delineation of a curve once the filter is adjusted.

But when the method is applied to filters in the course of adjustment or to experimental filters where the effect of altering the variables one by one is required, the method is slow and tedious.

In a filter consisting of, say, four tuned circuits, the quantities whose variation affects the response curve comprise four inductances, four capacities, three coupling coefficients and two terminating impedances; not to mention stray coupling fields and leakages whose presence may not even be suspected.

Even though such large filters are not commonly used, there is a demand for an apparatus which, by producing a continuous visual picture of the response curve, enables the effect of the variation of any quantity to be instantly apparent.

As will be shown in the course of this paper, it is comparatively simple to produce such a visual picture, but unless a large number of points are watched carefully, the result will not be the true response curve of the filter, for large distortion may be introduced by incorrect circuits.

* MS. received by the Editor December, 1934.

The method briefly is as follows. The input to the filter under test is taken from an oscillator whose frequency is constantly varied over a suitable band by some mechanical or electrical means. The output from the filter is rectified and applied to the Y-plates of a cathode ray oscillograph, producing a deflection at any instant, proportional to the response of the filter to the instantaneous frequency. The X-plates are connected to a linear time base device which can be so synchronised with the oscillator that any point in its traverse occurs at the same instantaneous value of frequency from the variable frequency oscillator.

In the following paper it is proposed to deal first with the separate units which go to make up the apparatus, setting out in each case the precautions necessary to ensure that no distortion of the response picture occurs.

A complete equipment embodying all these units will then be described. It is designed for laboratory and research use, and its field of application is therefore made as wide as possible.

2. The Variable Frequency Generator

The requirements of the generator are as follows :—

(*a*) Output voltage sufficient.

(*b*) Frequency sweep of suitable width.

(*c*) Frequency change linear with time over required range.

(*d*) Output constant with frequency changing.

(*e*) Frequency independent of output load.

(*f*) No stray pick up.

Requirements (*a*), (*e*) and (*f*) show that the generator should comprise an oscillator stage, a separator-amplifier stage, and some form of variable attenuator output which need not be calibrated, the whole being suitably enclosed in an earthed screen. Such a circuit is shown in the left-hand end of Fig. 1, and consists of a Hartley circuit oscillator followed by a power pentode

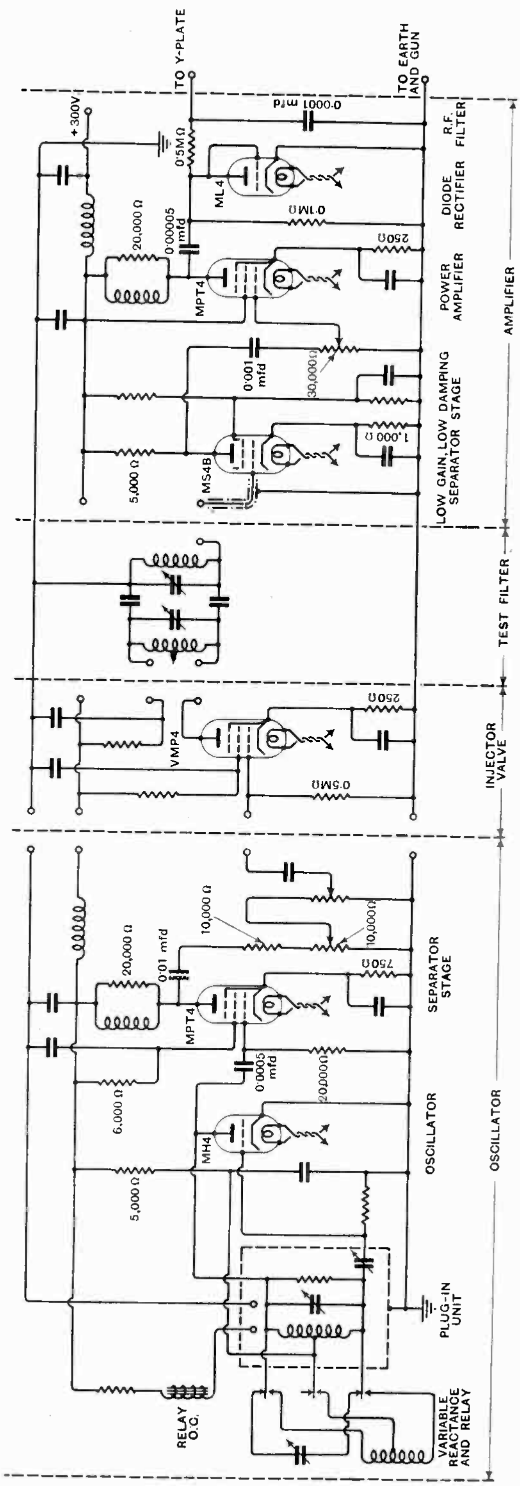


Fig. 1.—*The complete circuit diagram of the units used to obtain visual reproduction of filter response-curves on a Cathode Ray Oscillograph. Only a few of the component values are shown where these are important or critical.*

separator-output valve. The output from this to the filter will be ample for almost all purposes, and further amplification can easily be added when required.

Regarding the variable frequency circuit of the oscillator valve, it was decided that mechanical means of variation were more easily applied than any electrical means, and were perfectly satisfactory so long as the speed of rotation remained constant. The effect of changes in the motor speed is discussed more fully in section 3, but it has been found that both synchronous and induction motors with fairly large armature inertia are satisfactory. Any form of commutator machine is not recommended, as appreciable interference is caused by pick up from the brush contacts.

The actual frequency variation may be accomplished by altering either the inductance or the capacity of the oscillatory circuit and the choice should be governed by the frequency sweep required and the "mid-band" frequency. It has been found that, for general use sweeps varying from about ± 12 kc/s at 100 kc/s to ± 35 kc/s at 1,500 kc/s are needed to give pictures of complete response curves of suitable size.

At frequencies below about 500 kc/s the inductance should be varied, since a condenser to give the necessary sweep would be unduly large. At frequencies above this limit a variable condenser becomes the easier proposition.

The design of variometer is important as it must cause in the frequency calibration curve of the oscillator *a linear change of frequency with time or variometer rotation* throughout the frequency band already decided on.

It has been found that a suitable design is that shown in Fig. 2. The inductance is wound in two halves and to avoid rubbing contacts, which usually cause transients on the oscillograph picture, the rotor is a closed copper ring, sweated to the shaft and thereby earthed. The important feature is that the clearance between the coil and the ring shall be as small as possible, and this is brought about by precise mechanical construction and shaping the coil formers to the circle of rotation of the ring. The greater the clearance the smaller the change of inductance and this inevitably causes the frequency characteristic to be non-linear at the ends of the working range, since this latter has to be extended in order to obtain the necessary frequency sweep.

With a variometer of the type shown in Fig. 2, a working range of 41° was found to be sufficient and this was easily obtained on the linear part of the frequency characteristic. The frequency calibration curve is shown for the whole cycle in Fig. 3 where the

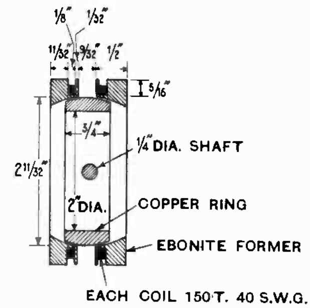


Fig. 2.—*The variometer comprises a copper ring rotated inside two coils which are joined in series. The constructional details are shown in this sketch. It should be noted that in order to get a reasonably large linear frequency change, the clearance between the copper ring and the coil winding should be as small as possible.*

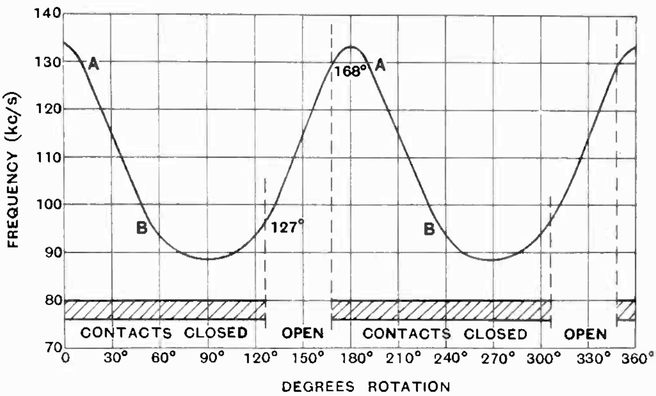


Fig. 3.—*A typical calibration curve for an oscillator unit using the variometer shown in Fig. 2 for frequency variation. A sufficiently wide, and at the same time linear, frequency sweep is obtained by opening the contacts in the time base circuit for 41°. The particular section of the curve is chosen by relative adjustment of contact and variometer ring on the motor shaft.*

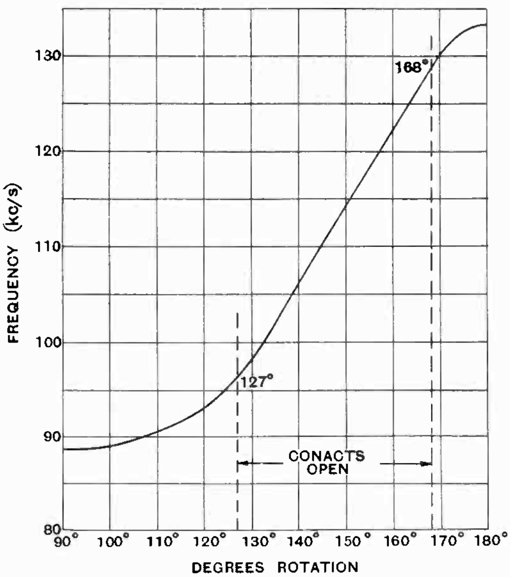


Fig. 4.—*The linearity of the portion of the oscillator calibration curve that is selected by the correct positioning of the time-base contact, can be seen from this figure, which represents an enlarged view of part of Fig. 3.*

remarks "Contacts open" and "Contacts closed" refer to the synchronous time base, as will be explained in section 3. The working range is shown by "contacts open," and an enlarged view of this portion of the curve is shown in Fig. 4.

The variometer is designed to constitute by itself the inductance for an oscillatory circuit at 110 kc/s, but it is naturally not necessary to employ separate variometers for other frequencies up to 500 kc/s. Other ranges are readily obtained by shunting the variometer with suitable inductances and this method is recommended in preference to merely reducing the circuit capacity, since it produces more suitable frequency sweeps, and prevents the circuit capacities becoming unduly low. In Fig. 5 is given a typical set of inductances showing the frequency sweeps obtained. These are the actual figures calculated for the equipment described in paragraph 7, and in each case the frequency calibration is very nearly linear, certainly within the limits required in this apparatus.

For frequencies above 500 kc/s a variable condenser is employed. This should be of series-gap pattern to avoid any rubbing contacts, and the rotating plates should be designed to give linear frequency variation with rotation. It is found in practice that it is unnecessary to produce plates having complicated shapes, a sensibly linear frequency change being produced by a straight cut plate of the form shown in Fig. 6, larger capacity changes occurring progressively at the lower frequencies.

In the actual design employed the condenser and variometer are both mounted on the same shaft, so that a limiting working

No.	Mean f (kc/s).	Inductance in Screen Box (μH.)	Variable Component.			Change of Cap.	Max. Frequency Sweep.	
			Total $C_{max.}$ $\mu\mu$F.	Total $C_{mean.}$ $\mu\mu$F.	Total $C_{min.}$ $\mu\mu$F.		+ kc/s.	− kc/s.
1	1,400	96.5	140.5	133	125.5	15	37	37
2	1,000	200	134	126.5	119	15	29	29
3	600	704	104.5	97	89.5	15	22	22
		C $\mu\mu$F.	$L_{max.}$ mH.	$L_{mean.}$ mH.	$L_{min.}$ mH.	Change of L.		
4	475	70	7+ 2.6	5+ 2.6	3.75+ 2.6	0.34	24	24
5	300	93	7+ 7.5	5+ 7.5	3.75+ 7.5	1.12	27	27
6	225	143	7+11.62	5+11.62	3.75+11.62	1.53	25	25
7	150	126	7	5	3.75	3.25	23	23
8	125	325	7	5	3.75	3.25	19	19
9	110	460	7	5	3.75	3.25	17	17

Fig. 5.—*This table shows a list of the capacities and inductances used for the oscillator circuit at different frequencies, and the frequency sweep that was obtained with each. The inductance figures in Nos. 4, 5 and 6 represent inductances in parallel with the variometer.*

range of 41° is set by the variometer. (*See* section 3.)

In order to produce suitable frequency sweeps the condenser was designed to give a total capacity change of 15 $\mu\mu$F. over the above angle, and a typical oscillator frequency calibration curve when using this condenser is shown in Fig. 7.

For practical purposes this is linear, and further linear ranges can be produced at other frequencies by changing the value of parallel capacity.

The constants for such ranges are set out in the upper half of Fig. 5.

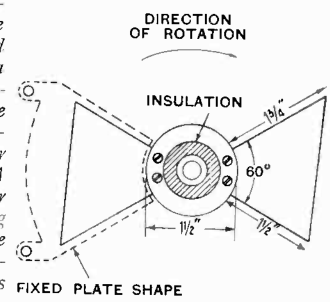
The other important problem in the design of the oscillator is that the output shall remain constant over the whole of the frequency band swept out.

In the case of mid-band frequencies greater than 500 kc/s it is found that the problem does not arise, firstly because the damping of the oscillatory circuit is not materially altered by the change in position of the variable condenser, and secondly, because the percentage change of frequency is low, being at most about $\pm$ 4 per cent.

When using the variometer, however, the case is different. To obtain the required frequency sweep it is necessary to vary the frequency by about 30 per cent. This necessitates a reduction of about two to one in the inductance of the coil, thereby producing a large decrease in the dynamic resistance, which more than compensates for the increase due to the change in the frequency term. The dynamic resistance is still further lowered by the presence of eddy current losses in the rotor, although these may be small. These effects cause the output of the oscillator to fall off with rising frequency.

There are two methods of overcoming this defect, that have been used successfully. The first, which is applicable to one frequency band only, consists of a compensation in the coupling between the oscillator and amplifier valves. If the coupling condenser is made small (say 50 $\mu\mu$F) and the grid resistance small (say 5,000 ohms), we have a coupling favouring the higher frequencies, and by a suitable choice of the ratio of these impedances sufficiently close compensation is possible.

Fig. 6.—*For capacity changes of the magnitudes required in this oscillator a simple shape of variable condenser plate gives a very near approximation to linear output frequency. A series-gap condenser having two moving plates of the shape shown gives a frequency response as shown in Fig. 7.*



However, for every frequency band the impedance ratio will be different. The method has the further disadvantage that it accentuates the harmonic percentage in the generator wave-form, due to its high frequency "favouritism."

The second method consists of merely shunting the oscillatory circuit with a resistance (say 10,000 ohms) of such a value that any change in dynamic resistance of the oscillator tuned circuit, due to the above-mentioned causes, is negligible. The circuit has now a constant dynamic resistance (of 10,000 ohms in the case assumed).

The reaction feed-back is increased accordingly to give a stable condition of oscillation, and the output remains constant.

This method has the additional advantage that it tends to reduce the magnitude of the

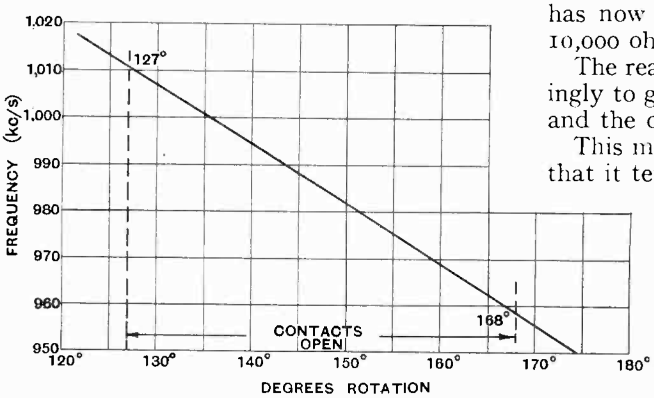


Fig. 7.—*The curve shows a typical calibration for an oscillator unit using the variable condenser for changing the frequency. It will be seen that the contacts are open over the same range as in the case of the variometer-controlled frequency.*

harmonics in the oscillator output rather than accentuate them.

For, taking the case of the variometer alone, if the reaction is adjusted to give a stable oscillation at the high frequencies when the circuit dynamic resistance is lowest, the feed-back at the low frequencies is far too great, and bad distortion occurs.

With the damped variometer, the feed-back required is constant, so that an almost constant wave form is obtained.

It is of interest to state that the frequency calibration of the variometer and variable condenser can be done statically, i.e., point by point. The calibration has been proved to hold accurately for the condition when the speed of rotation is increased from zero up to 1,000 r.p.m.

The remainder of the generator is straightforward, but it should be mentioned that the decoupling of the various valve circuits should be complete.

3. The Synchronous Time-Base

In order to obtain a true picture of a resonance curve on the oscillograph screen, we require the "Y" axis to represent the output voltage of the filter, and the "X" axis to represent frequency to some scale. The usual frequency scale employed for resonance curves is a linear one, so that the time base must move across the screen in such a way that the distance moved is proportional to frequency change.

The variable frequency from the oscillator has been made to follow a linear law with respect to angular rotation, and at constant speed of revolution it will be linear with time. We therefore require an "X sweep" which shall have a linear law of displacement from zero with time and which shall be triggered off at the start of the selected working range in every revolution.

This was accomplished by the use of the fact, that for a considerable part of its working range a pentode valve behaves as a constant current device.

The circuit (Fig. 8) shows the H.F. pentode with its various voltages applied. When the anode voltage is on, the potential across the valve and condenser is fixed. Suppose we now arrange that at the instant the varying frequency enters the working range, the lead from the H.T. supply to the anode is broken.

The valve continues to take current at a constant rate, drawing on the charge in the condenser for its supply.

But $Q = CV$ where the letters have their usual significance,

$$\text{i.e.}\quad \int i\,dt = CV$$

$$\text{i.e.}\quad i = C\frac{dV}{dt}$$

But as both C and i are constants over the range considered, the voltage will change linearly with time. This voltage is applied to the "X-sweep" terminals of the tube.

The synchronisation of the trigger point is brought about by means of a commutator on the shaft carrying the variometer and variable condenser, which short circuits two

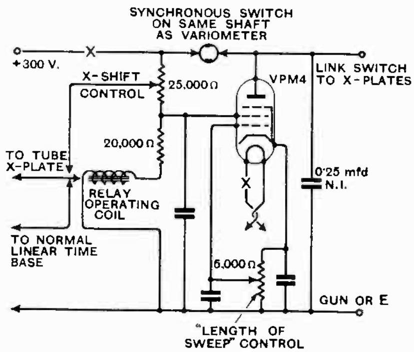


Fig. 8.—*The circuit diagram of the synchronised time-base. For a predetermined portion of each revolution the valve draws current from a reservoir condenser causing the voltage applied to the X-plates of the cathode ray tube to fall. The rate of fall is controlled by the grid bias on the valve. The object of the relay is to introduce a steady voltage on one X-plate, to balance the large mean H.T. voltage applied to the other, thus keeping the picture on the screen. Such a bias is unwanted when a normal linear time-base is used.*

brushes and closes the anode lead except during the 41° arc comprising the working period.

The relay circuit shown in Fig. 8 serves the following purpose. For normal use the "PX-plate" is joined to earth through an "X-shift" device.

On switching on the synchronous time-base one of the PX-plates is raised to a potential above earth equal to the H.T. to the pentode. In consequence, the picture is deflected off the screen beyond the control of the normal "shifting" device, provided with the linear time-base circuit employed for the examination of wave forms, etc. The relay, connected in the screen grid potentiometer, applies an opposite voltage to the other plate, automatically returning the picture on to the screen. By making this cancelling voltage variable (i.e., by using a potentiometer as shown) a separate X-shift device is provided enabling the normal one to be dispensed with.

The actual length of sweep may be varied by varying the current taken by the valve, i.e., by altering the grid bias. This is most conveniently done by a variable cathode resistance, as shown in Fig. 8.

By means of this variable bias resistance the length of the X-path on the screen may be adjusted to represent the known frequency change of the oscillator to some convenient scale, allowing rapid measurements to be made direct on the cathode-ray picture.

Such a sweep circuit has been tested and found completely satisfactory. As a rapid test for linearity, a known linear sweep can be joined across the "Y"-plates giving two sweeps at right angles. Any error in the linearity of the sweep under test is then shown by a deviation of the resultant picture on the tube screen from a diagonal straight line.

In the commutator constructed, two diametrically opposite "breaks" were made corresponding to the two "working ranges" of the variometer and variable condenser. By this means the picture is scanned twice per revolution instead of once, and this is an advantage when the shaft is driven at slow speeds (see Section 6), in that it reduces the "flicker." Alternatively by use of a second commutator to short the oscillator output during one "break," a base line can be added to the picture which is of use for convenient measurement on the screen picture of relative voltage outputs at different frequencies off tune. These can be then expressed in decibels, as is usual in measuring response curves.

In practice, a celluloid gridded scale has been made so that both frequency changes and voltage ratios can be measured with the utmost ease.

It can now be seen why the constancy of speed of revolution is an important factor.

The length of the "X-sweep" depends on a condenser discharging at a constant current. If the motor speed suddenly drops it means that the time during which the commutator is in the "break" position is lengthened. The discharge of the condenser is carried further, giving a longer X-sweep, and, in the extreme case, probably lowering the voltages on the pentode below the "constant current" range.

At the same time, the rate of frequency change of the oscillator is lowered in the same proportion, so that the oscillograph picture, whilst maintaining its correct relative dimensions, expands along the X axis.

Since the load on the motor is constant, such speed changes will be brought about entirely by changes in the supply mains voltage, and the necessity for speed compensation devices must depend on the mains steadiness in any particular case.

The simplest remedy is the use of a synchronous A.C. motor, but it is found that in most cases any motor having a fairly level voltage characteristic and an appreciable inertia against transient voltage changes, such as are caused by switching on apparatus at other points on the supply system, may be used without any trouble from speed variation.

4. Input to Filter under Test

The output from the oscillator is not designed to work into a low impedance load, so that the method of injection into the filter under test which employs a small series resistance in the first tuned circuit cannot be employed.

For general use the best method is to inject through a small condenser of a few micromicrofarads straight across the first tuned circuit. In order to prevent any alteration in the filter characteristic, due to any added damping, the coupling condenser should be as small as possible, or the high potential injection point tapped down on the tuned circuit inductance, if this can be conveniently done.

For intervalve filters, or any filter that is to work normally in a position following an amplifier valve, the working conditions can be imitated on test by injecting the oscillator voltage across the grid circuit of an amplifier valve, in whose anode circuit the test filter is connected. Such a circuit is shown in Fig. 1, and it will be realised that an amplifier such as this may also be used to inject into filters where the added input damping is to be low, by increasing the grid bias to give a very small gain across the stage, and at the same time a lower damping.

5. Post-Filter Amplifier and Diode Rectifier

If it is desired to obtain the response curve in the form of a line diagram rather than a high frequency envelope, giving a much brighter image on the screen, the output from the filter must be rectified and the remaining high frequency components suppressed.

The rectification has to be linear and a diode rectifier is suitable for the purpose. If, however, the diode is placed immediately after the filter under test, the damping it introduces may alter completely the response of the filter and lead to erroneous results.

It is, therefore, necessary to introduce a low damping separator valve in between the two; further experiments have shown that a single valve cannot satisfactorily give both low damping and sufficient output to the diode without distortion, so that a two-stage amplifier becomes necessary. The first valve acts as separator and low damping input valve, while the second gives the requisite amplification and output to the diode.

The scheme employed is shown to the right of the complete circuit diagram of Fig. 1.

The amplifier unit as a whole must therefore fulfil the following conditions :—

(*a*) Low input damping, to avoid modification of filter performance.

(*b*) Linear amplification of all frequencies.

(*c*) Rectified output of about 50 volts.

(*d*) Linear amplification of all input voltages up to that required for 50 volt output.

(*e*) Linear rectification.

(*f*) Output free from radio frequency voltages.

The important point of design is that the input resistance must be high, because it is found that the design of the whole amplifier is modified by this feature.

The damping is made up of two parts, first the actual resistance to earth of the components used on the input to the first valve, and secondly the reflected damping from the anode circuit of this valve on to the filter circuit, across the grid-anode capacity.

Even when the usual precautions have been taken to keep the damping low, it is found on measurement that the resistance is sufficiently low to be of the same order as the dynamic impedance of the filter.

The effect is worst at the higher frequencies, and above 1,000 kc/s it is only by taking the most elaborate precautions that a sufficiently high input resistance can be obtained. This will perhaps be realised more readily if some details of the actual amplifier built up are given.

First the valve that is to be used. This should be chosen with as low a value of grid-anode capacity as possible—preferably below 0.002 $\mu\mu$F—as a prevention against excessive Miller effect. The valve used had a value of 0.0015 $\mu\mu$F. It was selected from a number tested as having a high input impedance cold.

After decapping, it was found to have an input impedance cold of 24 megohms at 1.2 megacycles. It had a grid working voltage between cut-off and incidence of grid current of 3.2 volts and no trace of backlash.

The input wire to the grid is self-supporting, being held only by the pinch of the valve and the amplifier input terminal fixed in a large quartz bush on the panel. The input resistance when in position with all voltages applied, but no anode load, was 18 megohms at 1.2 megacycles.

This does not allow for Miller effect, which depends on the nature of the anode load, the stage gain and the interelectrode capacity. The last point has been taken into account in our choice of valve type, but it is essential to have the grid circuits and anode circuits completely screened from each other to prevent stray capacities exaggerating the Miller effect through the valve.

Considerable trouble was experienced, due to a stray capacity which defied detection, until it was realised that a variable potentiometer spindle protruding through the panel was connected to the grid circuit of the second valve (and therefore to the anode of the input stage) and was feeding back to the input wire from the filter five or six inches away.

A further factor in determining the Miller feedback is the stage gain, and this must be reduced to about 5 for the first stage, by suitably raising the bias and lowering the anode load resistance.

After taking all these precautions, a resultant input damping of 8.5 megohms at 1.2 megacycles was obtained in the working condition.

Requirement (*b*), demanding linear amplification of all frequencies, is dealt with in deciding the nature of anode loads of valves and inter-coupling systems.

In order to obtain a sufficient output voltage from the second stage without distortion, an output pentode has to be used. An input to the amplifier of about 0.5 volt R.M.S. is sufficient to load this second stage sufficiently and provides linear amplification through the whole amplifier.

The R.F. envelope from the second stage is then rectified by the diode rectifier and the remaining R.F. voltage filtered out by the resistance capacity filter, shown in the circuit diagram of Fig. 1. The output voltage, a D.C. voltage proportional to the output from the test filter, is applied across the Y-plates of the oscillograph.

Further references to the diode and its filter are to be found in the next section.

(*To be concluded.*)

A Noteworthy Letter

In looking through an old letter file we came upon the following :—

Dorhurst, Dormans Park,
3rd June, 1911.

DEAR PROFESSOR HOWE,

Is it known whether the Zeeman effect is greater for red rays than for blue; if so might not this account for the bending round of the much longer wireless waves north and south?

Yours very truly,
C. C. F. MONCKTON.

So far as we know this was the first suggestion that the magnetic field of the earth might play a part in the refraction of wireless waves in the upper atmosphere by affecting the electronic oscillations.

Mr. Monckton will be remembered by pre-war radio engineers as the author of a text-book on the subject published in 1907. He superintended the erection of the first Colonial Wireless Stations in the West Indies in 1904. G. W. O. H.

Correspondence

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

Time Flight of Electrons

To the Editor, The Wireless Engineer

SIR,—Having spent some time lately on the problem of the transit time in a cylindrical diode, I have read Prof. C. L. Fortescue's article, in the June issue, with much interest. There is an alternative method of approach, which indeed is implicit in Prof. Fortescue's analysis, which I have found convenient to use. The method is very obvious, but since I have not seen it pointed out explicitly, I venture to hope it is not inappropriate to write this note calling attention to it. I shall use the notation adopted by Prof. Fortescue and hence need not define my symbols.

One necessary condition for a diode in a steady state is that the same current shall cross any cylindrical surface: expressed in symbols this is:

$$2\pi r u \rho = I$$

$$\therefore \int_{r_c}^{r} 2\pi\rho r\,dr = \int_{r_c}^{r} \frac{I}{u}\,dr$$

$$= I\int_{r_c}^{r} \frac{dr}{\frac{dr}{dt}}$$

$$= It.$$

Hence, the time taken for an electron to travel a distance r from the cathode is equal to the total space charge between it and the cathode divided by the current.

In the condition of space-charge limitation the total space charge in transit is equal to the charge on the anode, since the field at the cathode is zero. Hence then,

$$T = \frac{\text{charge on the anode}}{I}.$$

If the diode has planar electrodes separated by a distance d, it is well known that the charge per unit length of anode is expressed by the equation

$$\sigma = \frac{1}{3\pi}\frac{V}{d}$$

$$\therefore T = \frac{V}{3\pi d I} = 3d\left(\frac{2eV}{m}\right)^{-\frac{1}{2}},$$

which is the well-known expression. Since

$$\frac{dV}{dI} \equiv R_0 = \frac{2}{3}\frac{V}{I},$$

the transit time can also be written

$$T = \frac{2R_0}{4\pi d} = 2R_0C.$$

This relationship was pointed out by Mr. W. E. Benham in equation 17, p. 471, of his paper in the *Philosophical Magazine*, Feb. 1931, but was derived less directly.

Returning now to the cylindrical diode,

$$v = V\left(\frac{\beta}{\beta_a}\right)^{4/3}\left(\frac{r}{r_a}\right)^{2/3},$$

where β_a is the value of β at the anode of radius r_a.

$$\therefore \frac{dv}{dr} = \frac{4}{3}\frac{V}{r_a^{2/3}\beta_a^{4/3}}\left(\frac{\beta}{r}\right)^{1/3}\left(r\frac{d\beta}{dr} + \tfrac{1}{2}\beta\right)$$

$$\equiv \frac{4}{3}\frac{V}{r_a^{2/3}\beta_a^{4/3}}\left(\frac{\beta}{r}\right)^{1/3}\alpha,$$

where it can be shown that

$$\alpha = \left\{1 - \frac{3}{10}\gamma + \frac{9}{120}\gamma^2 - \frac{49}{4400}\gamma^3 + \ldots\right\}$$

Hence at the anode

$$\frac{dv}{dr} = \frac{4}{3}\frac{V\alpha_a}{r_a\beta_a},$$

$$\therefore 2\pi\sigma r_a = \frac{2}{3}\frac{V\alpha_a}{\beta_a}$$

$$\therefore \quad T_a = \frac{2}{3}\frac{V\alpha_a}{\beta_a I}$$

$$= 3r_a\left(\frac{2e}{mV}\right)^{-\frac{1}{2}}\alpha_a\beta_a.$$

Comparing this with Prof. Fortescue's equation (1.5) it follows that

$$\left(\frac{d\phi}{dr}\right)_a = 2\alpha_a\beta_a$$

$$\therefore \frac{d\phi}{dr} = 2\beta_a\left(r\frac{d\beta}{dr} + \tfrac{1}{2}\beta\right),$$

and this is the value it should have. Thus the two slightly different methods of approach are shown to yield the same result.

I have been in the habit of defining a factor S, such that

$$S \equiv \frac{r_a}{r_a - r_c}\beta_a\alpha_a,$$

and then

$$T = 3(r_a - r_c)\, S\sqrt{\frac{m}{2eV}}.$$

Thus S is seen to be a factor which expresses the transit time in a cylindrical diode as a fraction of the transit time in a planar diode having the same separation between anode and cathode. The values I have evaluated for S are shown in the table below :—

r_a/r_c	1	2	3	4	5	10	20	30	40
S	1	0.876	0.826	0.794	0.775	0.67	0.63	0.6	0.57

For large values of r_a/r_c, S appears to tend to $\frac{1}{2}$. I believe it is well known that the transit time for a cylindrical diode tends to be half that for a planar diode, and this was stated by Mr. Benham on p. 653 of the *Philosophical Magazine* March, 1928, Vol. 5.

The relation between my factor S and Prof. Fortescue's $f_1(r_a, r_c)$ is seen to be

$$S = \frac{r_a}{3(r_a - r_c)}\sqrt{\frac{2e}{m}}f_1(r_a, r_c)$$

$$\therefore f_1(r_a, r_c) = \frac{2.9S}{10^9}\left(1 - \frac{r_c}{r_a}\right)$$

when V is expressed in absolute E.S. units of potential. My values of S result in values of $f_1(r_a, r_c)$ which are from about 0.5 to 2 per cent. higher than the values calculated by Prof. Fortescue. Since I did not have access to Dr. Langmuir's tabulated values, I have no doubt that Prof. Fortescue's values are more correct than my own. Using his value for $f_1(r_a, r_c)$ when $r_a/r_c = 1000$, it may be found that then $S = 0.5155$.

I hope that the relationship that the transit time is equal to the anode charge divided by the anode current is of sufficient interest to justify this letter.

Engineering Laboratory, Oxford. E. B. MOULLIN.

5th June, 1935.

The Transient Aspect of Wide-band Amplifiers.

To the Editor, The Wireless Engineer

SIR,—In his article under the above heading in the May number, Mr. Puckle makes a plea for the use of time-constants for describing the properties of television amplifiers.

I believe that Mr. Puckle is the first to give expression to the need for an adequate method of specifying the characteristics of networks in which phase-shift as well as attenuation is of importance, and I strongly endorse his views on the subject. There can be little doubt that functions of time rather than of frequency offer the most promising possibilities. In order that this conception may be of general application, however, may I suggest that consideration should not be confined to elementary time-constants.

After allowing for aperture and fluorescence distortion, the excellent method of measurement used by Mr. Puckle yields the indicial- or time-admittance type of function (response to suddenly-applied unit force) which, in both theory and practice, lends itself admirably to the treatment of transient effects. In my opinion, the investigation into methods of specifying television networks might well be continued with a study of the principal features of time-admittance curves, such as the build-up time of the " head," the die-away time of the " tail," and the relations between the peak and the maximum positive and negative slopes.

London. N. W. LEWIS.

Colloidal Graphite

Its Properties and Some Applications

By H. Higinbotham, B.Eng.

GRAPHITE is an allotrope of carbon and diamond. The atoms in the material are situated at the corners of hexagons which in their turn are arranged in horizontal planes so that alternate, but not adjacent, planes are vertically under one another. This arrangement gives rise to a weak fourth linkage perpendicular to the hexagons, which accounts for the "metallic" properties of graphite and its ability to cleave basally. It is this cleavage or lamination which gives the mineral its unctuous feeling.

Acheson Colloidal Graphite in water, familiar to the electrical industry, is a colloidalised form of highly pure graphite. The graphite is manufactured in the electric furnace and deflocculated to a very small particle size. It is interesting to note that Finch and Wilman in recent analyses of thin films, carried out with an electron diffraction apparatus, have observed the thickness of these particles to be of the order of 10 millimicrons. Such particles exhibit the true characteristics of a colloid and will pass through a suitable filter paper and permeate fibrous material by capillary action. Their extreme fineness, coupled with their purity, gives colloidal graphite a wide range of applications, chief among which are those demanding homogeneous coats or films. Fibrous materials, such as porous papers, can also be rendered electrically conductive by impregnation.

Graphite made in the electric furnace has a density of about 2.3, so that coats formed by a colloidal solution will have a density less than this value. Such coats are homogeneous in texture, opaque, and usually present a grey-black matte appearance. They can be formed on glass of all types, metal, porcelain, ebonite and soft and hard rubber, to which they adhere by means of a superficial penetration or, in certain circumstances, by a mechanism akin to adsorption, depending on the nature of the substrate.

Various thicknesses of film can be obtained, ranging from an invisible surface, which has been formed on ebonite, to an appreciably thick deposit. The thickness is largely controlled by the concentration of the solution used.

The physical characteristics of these films or coats have a bearing on their employment in electrical work. Such films will not seriously interfere with heat transmission, where that factor has to be taken into consideration. On the other hand, they have an important advantage in a good black body factor. This advantage has been shown in practice by the maximum output of thermionic valves of the larger capacity being greatly increased when the elements have been coated with colloidal graphite. In the case of a graphite coat the black body factor can be varied by polishing. A grey-black mirror-like polish can be imparted by rubbing, but will dissipate heat less efficiently than the normal matte surface.

Pure graphite, such as Acheson Graphite, is chemically inert, so that films of the material will be unaffected by acid atmospheres. "Varnodag"[1] colloidal graphite (in varnish) can also be used, instead of the colloidal solution in water, to give films which are unaffected by atmospheric moisture. This alternative solution is used widely for the manufacture of high resistances.

The electrical characteristics of the material are essentially a curiosity. As has been mentioned above, it is due to the weak fourth linkage of its atoms that the mineral differs so widely from carbon and diamond, in being "metallic." Aharden gives the specific resistance of Acheson Graphite as 12 ohms at 20° C. The surface resistivity of

[1] Registered Trade Mark of E. G. Acheson, Ltd.

films formed by "Aquadag"[1] on ebonite has been given by Church and Daynes[2] as 3,000 ohms per centimetre square. When rubbed the surface value was observed to fall to 2,000 ohms, this being due to the greater homogeneity given to the crystals composing the film by the pressure of rubbing.

Experiments[3] carried out with an electron diffraction camera have shown that rubbing of graphite coats results in a reduction of the crystal size and its orientation with the basal plane parallel to the surface on which it lies. This ability of the graphite crystals to orientate themselves explains why the colloidal product is superior to a suspension for electrical work. In the latter case the suspended particles tend to deposit on a surface heterogeneously. In circuits employing high amplification, such as audio-frequency types, the continuity of structure in a coat can play an important part. It has been observed, for instance, that arcing and the resulting microphone noises have been eliminated by the use of coats formed by colloidal graphite in place of those of powdered graphite.

Church and Daynes have also measured the surface resistivity of an invisible surface formed by "Aquadag" on ebonite; this was found to be 10^{12} ohms per centimetre square. Resistances with values over a considerable range can be formed by varying thicknesses of films. Moreover, such electrodes do not creep when once formed on material and therefore preserve a sharp edge of demarcation.

The extreme division of the graphite particles in the colloidal solution enables them to make intimate contact with a substrate. In this respect a film formed by "Aquadag" is superior to mercury, as is shown by the tabulated figures extracted from a curve by Church and Daynes.

Time after Application of Potential.	Resistance across Ebonite Panel.	
	With Mercury Contact.	With Aquadag Contact.
5 mins.	0.7×10^{15} ohms	0.6×10^{15} ohms
8 mins.	1.2×10^{15} ohms	0.9×10^{15} ohms
10 mins.	1.5×10^{15} ohms	1.1×10^{15} ohms

Graphite coats, formed from the colloidal solutions, have been used for some years now as a coating for the grids of thermionic valves, and in exhibiting a good black body value they show themselves to be useful in combating the vitiating factors in valve operation. The inert surface provided by the material discourages the emission of secondary electrons and keeps the temperature of the elements relatively low by radiation. The photoelectric effect in a valve is also reduced by the dark coat, as is the secondary emission set up by X-rays.

A short résumé as this would be incomplete without reference to the use which is being made of colloidal graphite in coating the inside walls of the envelope of the cathode ray tube. It forms an opaque surface extending from the "gun" up to the fluorescent screen, and as such constitutes an anode with good focusing qualities.

No attempt has been made to describe more fully the various applications of pure graphite coats. Colloidal graphite is particularly useful in the laboratory where it can be adapted to the mobile requirements of research. The coats formed by it dry quickly, while occluded moisture may be expelled by heat without damaging their structure. "Aquadag" is an 18 per cent. (by weight) solution of colloidal graphite in water. Dilution can be effected with distilled water, and while it is an irreversible colloid, it can be stored for long periods under normal conditions, and as such is always available.

[2] "A Method of Making Electrical Contact with Ebonite and Soft Rubber for Insulation Tests," by H. F. Church, B.Sc., and H. A. Daynes, D.Sc., F.Inst.P., F.I.R.I., Institution of Rubber Industry Transactions, Vol. 6, No. 1 (1930).

[3] *Phil. Mag. Ser.* 7, Vol. 17 (1934).

Errata

On page 294 of the June number the frequency scales of Figs. 6 and 7 contain a number of intermediate points; these are incorrectly numbered 2×10^5, 2×10^6, etc., they should be 5×10^5, 5×10^6, etc., as in Table III. It should also be noticed that in the latter part of the article, subsequent to Fig. 4, l is used to designate the length of the equivalent line, which is only half that of the resistance rod; this applies to $flCR$ in Fig. 8.

Frequency and Phase Distortion*

Note on Compensation by a So-called "Negative Impedance" Method

By M. Marinesco

(Assistant Director, "Electro-communication Laboratories," Polytechnic School, Bucharest)

IT is known that in alternating current circuits, the power absorbed by an impedance Z is $P = UI \cos \phi$, where "$\cos \phi$" is the ratio of the resistance R to the total impedance Z of the circuit. The efficiency of such a circuit in changing electric energy into mechanical power decreases therefore with increasing reactance of the windings on the iron cores which enter into the construction of the apparatus in the circuit.

In electrical communication, where we have to change electric energy into acoustic energy, at *different frequencies*, "$\cos \phi$" will vary with the frequency, producing thus a so-called "frequency distortion." Beside this we will have also phase distortion due to the "time constant" $\frac{L}{R}$ of the circuit.

Methods for compensating these distortions have already been devised, using "correcting networks" or filters. Another method applied specially to loud speakers, is given by an additional compensating coil in series with the moving one, but fixed into the pole pieces (*see Wireless Engineer*, July, 1929, p. 380). All these methods are expensive and give satisfactory results only on a limited frequency band; they also produce supplementary losses which lower the efficiency of the circuits.

We have found theoretically and experimentally that a perfect compensation of these distortions can be realised by coupling the plate circuit to the grid of the output valve, in the manner described below.

The method compensates not only for the reactances but also for their losses (iron or dielectric) for which compensation by networks is very complicated if not impossible.

* MS. accepted by the Editor, November, 1934.

From the theory of the new method, it will be seen that it compensates by the creation in the utilisation circuits of negative impedances equal in magnitude to the one we wish to cancel. It may be remarked, that reaction between stages at low frequencies is usually considered as increasing frequency distortions by resonance in the transformer couplings.

Let us consider, as in Fig. 1, a source of alternating e.m.f. applied to the grid circuit of a triode valve. We may consider the load as consisting of a resistance R_e and a reactance X which we want to cancel. Let the alternating voltage across this reactance be u and let us couple the plate circuit to the grid as is shown in the figure, by a network N, the voltage applied between grid and filament by this network being v. In

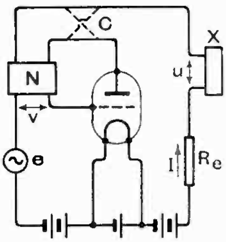


Fig. 1.

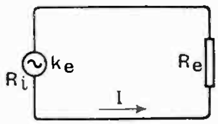


Fig. 2.

general, we will have $u = f(\omega_1 I)$; $v = \psi(\omega_1 I)$; let us also assume that $v = k_1 u$; (k_1 being a constant).

In the steady state, the current in the plate circuit will be given by the equation:

$$-ke \pm kv = (R_1 + R_e)I + XI \quad .. \quad (1)$$

where k is the amplification factor and R_i the resistance of the valve.

The sign $\pm$ preceding the term kv depends on the reversing switch C.

If we take the sign + equation (1) becomes:

$$-ke = E = (R_i + R_e)I + u - kv = RI + (1 - kk_1)u \; ; \quad \text{as } v = k_1 u \quad \ldots \quad (2)$$

We see that if $k = \frac{1}{k_1}$ we will have:

$$E = RI, \text{ where } R = R_i + R_e$$

and the appearances are as if in place of the circuit of Fig. 1, we have the circuit of Fig. 2, in which an e.m.f. E equal to ke and of internal resistance R_i is applied to a load R_e. The useless reactance X being cancelled by an equal but negative one:

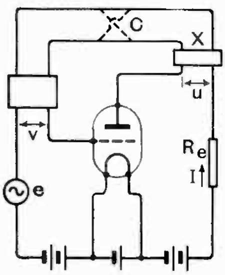


Fig. 3.

$$X' = -X = kk_1 \frac{u}{I}.$$

Another type of "negative impedance" distortion compensation is shown in Fig. 3; in which the coupling from plate to grid is realised by a shunt instead of a series connection as in Fig. 1. In this case, $v = f(\omega_1 u)$ and considering the current in the plate circuit as before, we arrive at the same conclusions.

The choice of one of the both methods of couplings, the "series" or the "shunt" one, is dictated in practice by the kind of apparatus, its impedance, etc., to which the compensation is to be applied.

As regards the transient state, it will be considered separately in each particular case treated below.

The experimental proof of the above theoretical views was obtained with two practical "negative impedance" devices. The first, as seen in Fig. 4, is an application of the "series" principle. L is the inductance to be cancelled, it was 0.27 H. in value; $R_e = 1{,}000\,\Omega$ is a non-inductive load; the valve was an RE604 (Telefunken) having following constants: $k = 3.5$, $R_i = 1{,}000\Omega$; T is a transformer of mutual inductance $M = 0.052$ H, the primary of which has a negligible inductance compared to L (to be cancelled).

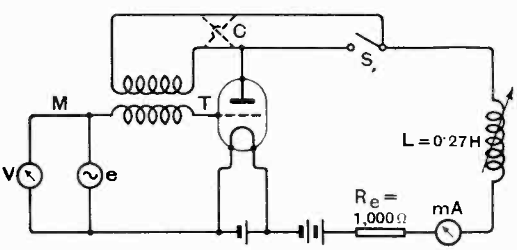


Fig. 4.

The experiment was carried out as follows: a constant e.m.f. of 3 volts, measured by a valve voltmeter V, was applied to the grid of the valve. As the frequency was varied, the alternating current in the plate circuit was read on an ammeter first with S closed (therefore without compensation) and then with S open (with compensation).

The results are plotted in Fig. 5; curve II uncompensated and curve I compensated.

We see that the compensation is almost perfect, giving thus an experimental confirmation of the above theory.

If the inductance L is smaller than 0.27 H., self-sustained oscillations will occur. This result was to be expected theoretically. As we will see, the current in the plate circuit is given by

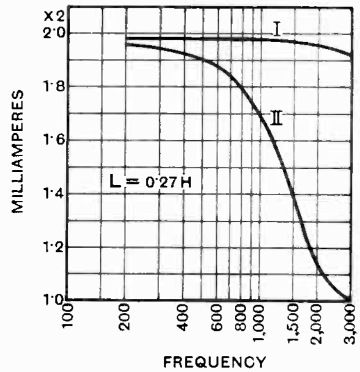


Fig. 5.

$$I = \left[1 - e^{-\frac{R}{L - kM}t}\right] \frac{kE}{R + j(L - kM)\omega} \sin \omega t \quad (3)$$

and when $kM > L$, we see that the current grows beyond any limits, and sustained oscillations may occur.

When $kM = L$ perfect compensation takes place, and the building up process (transient state) disappears, an important result when distortionless transient transmission is required.

In our case with $M = 0.052$ H. and $k = 3.5$ we see that the inductance that could theoretically be cancelled is

$$L' = 3.5 \times 0.052 = 0.182 \text{ H.}$$

In practice it seems that we can compensate more (0.27 in the above test) a rather surprising result due to auxiliary phenomena as

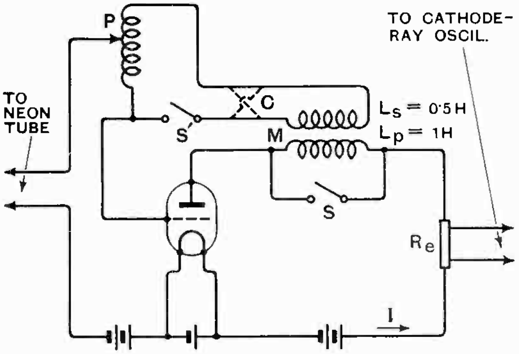


Fig. 6.

will be explained later. (Capacity couplings and capacity of windings.) To test also phase distortion compensation by the "negative impedance" compensation method, the practical device with which experiments were made is shown in Fig. 6.

An e.m.f. given by a "neon" discharge tube, having a very sudden discharge, *i.e.*, a very sudden fall of p.d., was applied to the grid.

The form of the current in the plate circuit was observed on a Cathode Ray oscillograph: (*a*) without self-induction; (*b*) with self-induction not compensated; (*c*) with self-induction and compensation. Photographs were taken of the current curves, appearing on the fluorescent screen. They are reproduced on Fig. 7.

We see how alike curves (*a*) and (*c*) are, and how flattened by transient and phase distortion is curve (*b*), which proves that phase and transient distortions are cancelled by the new method.

The self-induction was of 1 H.; leads were taken to C from a second coil wound on the first and having an inductance of 0.5 H.; the potentiometer P for the regulation of the magnitude of the negative inductance to be produced, was a 1 MΩ potentiometer, and was adjusted to half its value. Therefore $v = \frac{1}{4}\mu$, and the theoretical value of self-induction to be cancelled was $L' = \frac{3.5}{4}$ H.; in this case also, the practical value compensated is a little greater, on account of the same auxiliary phenomena.

As I mentioned at the beginning of this article the method cancels also the distortions due to losses in iron (hysteresis and eddy currents).

Let us consider the device of Fig. 4; as the transformer T_1 has iron losses, the flux ϕ through the windings lags behind the current I in the primary, by an angle θ. We may therefore resolve the flux ϕ into two components: ϕ_1, in phase with I and ϕ_2 at right angles, and write:

$$\phi = \phi_1 - j\phi_2 = aI - jbI$$

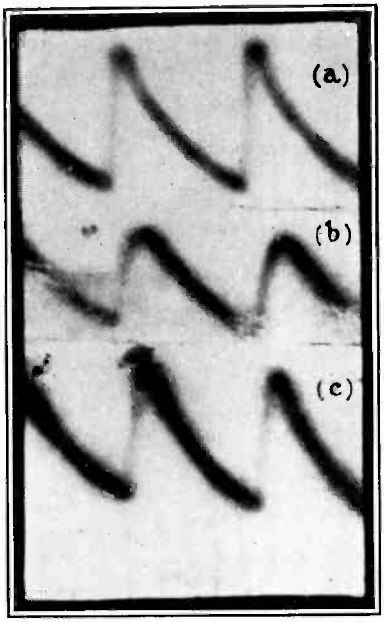


Fig. 7.

Now if we consider the primary of T, we may write:

$$u = RI + n_1\frac{d\phi}{dt} = RI + n_1\frac{d\phi_1}{dt} - jn_1\frac{d\phi_2}{dt} \quad (4)$$

$$= RI + jn_1\omega aI + n_1\omega bI$$

(u is the p.d. across the primary of T, R the ohmic resistance of the same).

We also have :

$$u = RI + jL_p\omega I + \rho I \quad .. \quad (5)$$

where ρ is the iron loss equivalent resistance of primary and L_p its effective inductance.

On identifying (4) and (5) we get :

$$\rho I = -jn_1\frac{d\phi_2}{dt};\ jL_p\omega I = n_1\frac{d\phi_1}{dt} \quad .. \quad (6)$$

In the secondary of T we will have :

$$e_s = -n_2\frac{d\phi}{dt} = -n_2\frac{d\phi_1}{dt} + jn_2\frac{d\phi_2}{dt}$$

referring to (6) :

$$e_s = j\frac{n_2}{n_1}L_p\omega I - \frac{n_2}{n_1}\rho I = -(j\mu L_p\omega + \mu\rho)I$$
$$= -(jM\omega + \mu\rho)I;$$

as $M = \mu L_p$ where $\mu = \frac{n_2}{n_1}$

this e.m.f. by a suitable position of the reversing switch C will give rise in the plate circuit to a negative impedance :

$$Z = -(jkM\omega + \mu k\rho)$$

From which we see that beside the negative inductance jkM we get also a negative resistance $\mu k\rho$ compensating for the losses in iron. (ρ is a function of ω.)

Let us consider the transient state in the device of Fig. 6. Applying a sudden alternating e.m.f. at the grid (the system being without compensation, with S open) the plate current will rise slowly to the steady value on account of L. The equation giving i is :

$$-ke = L_p\frac{di}{dt} + Ri;\quad R = R_i + R_e;$$

the solution of which is :

$$i = \frac{kE}{R + jL_p\omega}\left[1 - e^{-\frac{R}{L_p}t}\right]\sin\omega t.$$

Applying compensation (S closed) we get :

$$-ke = (L_p - kM)\frac{di}{dt} + Ri$$

on the supposition that the valve does not produce any lag between e.m.f. and current. Therefore :

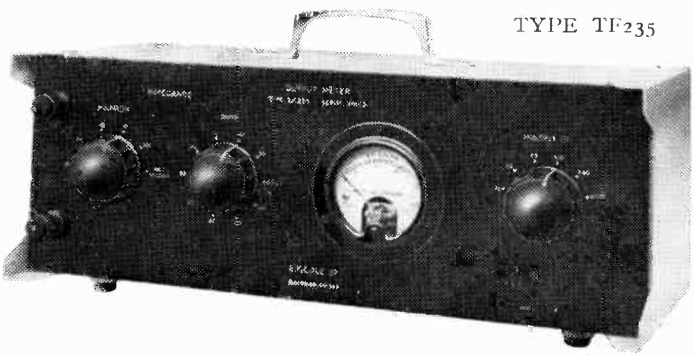
$$i = \frac{kE}{R + j[L_p - kM]\omega}\left[1 - e^{-\frac{R}{L_p - kM}t}\right]\sin\omega t$$

We see that the transient period is reduced and for $L_p = kM$ it is zero.

Further research is being carried out to reduce the parasitic effect of capacity coupling and for practical application.

Ekco Output Meter

TYPE TF235



DESIGNED for power output measurements in wireless receivers and other communications apparatus, this latest addition to the list of test apparatus made by E. K. Cole, Ltd., of Southend-on-Sea, combines a rectifier type voltmeter with a resistance network giving a range of impedances from 2 to 20,000 ohms in 40 discrete logarithmic steps. The voltage range is from 0.3 to 200 volts, equivalent to a power range of 5 micro-watts to 2 watts. For short periods 5 watts may be dissipated in the resistance network. Frequency errors do not exceed 2½ per cent. up to 12 kc/s.

The instrument is housed in a metal case measuring 15½in. × 8in. × 7in. and the price is £20.

Considerations in the Design of a High Fidelity Radio-Gramophone

Paper by W. J. Brown, B.Sc., A.M.I.E.E., read before the Wireless Section, I.E.E., on May 13th, 1935

Abstract

THIS paper, which concluded the Wireless Section Session, was somewhat unusual for the I.E.E. being a detailed description of The Gramophone Coy's 15-Valve superheterodyne radio gramophone. Since a very large part of the paper is devoted to details, not well adapted for abstract presentation, the scope of the paper and of the instrument which it describes is best conveyed by the specification of the performance to be provided. This is as follows—

SPECIFICATION.

Fidelity.

(1) The overall characteristic from radio input to acoustic output to be level to within ± 7 db over the following alternative frequency ranges :—

Extra-high fidelity, 50 to 8 000 cycles per sec.
High fidelity, 50 to 7 000 cycles per sec.
Normal, 50 to 5 000 cycles per sec.
High selectivity, 50 to 3 000 cycles per sec.

The gramophone characteristic to be similar, except that the reduction in bass amplitude during recording must also be completely compensated.

(2) The balance of top and bass to be correct for normal listening-room conditions and to remain substantially unchanged when the frequency range is altered.

Output Power.

Eight watts for 5 per cent. harmonic distortion (a conservative figure being necessary owing to the extended frequency range).

Radio Sensitivity.

One microvolt or less for 0.5 watt output over whole of medium- and long-wave ranges. The sensitivity to be greatest in the 3- and 5-kc/s positions and reduced automatically in the 7- and 8-kc/s positions (to prevent attempts at receiving weak and static-ridden stations in the high-fidelity position).

Radio Selectivity.

To vary with frequent range as follows :—

A 3-kc/s range to have the highest commercially attainable selectivity with an attenuation of not less than 60 db when 9 kc/s off tune.

A 5-kc/s range to have normal commercial selectivity, with attenuation of about 40 db when 9 kc/s off tune.

The 7- and 8-kc/s ranges to have sufficient selectivity to avoid direct heterodyne interference from stations which are adjacent to a desired station at 100 miles range. The attenuation required for this to be determined by experiment.

Automatic Volume Control.

(*a*) To have a threshold of not more than 5 microvolts.

(*b*) To deal with signal inputs up to 2 volts without overloading or distortion.

(*c*) To maintain such constancy of output over this range as not to require readjustment of the manual control under any conditions of carrier strength.

Quiet Tuning.

The radio output to be automatically muted at all times except when accurately tuned to a carrier.

Visual Indicator.

A quick-acting visual indicator was also called for in order that the extreme sharpness of tuning engendered by the above should not make it possible to tune through a station without noticing it.

Contrast Amplifier.

A contrast amplifier stage to be introduced for the purpose of increasing the range of volume levels, the optimum degree of expansion of volume range to be determined by aural tests ; a means to be also provided for reducing this expansion in volume range to half its maximum value or to zero at will.

" Anti-Static " Aerial.

In order to reduce the effects of " man-made static " when the receiver is used in congested area a special aerial system embodying a step-down radio-frequency transformer and screened low-impedance down-lead to be arranged for fitting when necessary.

Short Waves.

In order that every type of broadcast transmission could be received, including transoceanic, but to ensure that the medium- and long-wave performance was not impaired in any way, a separate radio-frequency circuit with its associated valve and tuning elements was called for, three short-wave ranges being specified extending from 13.5 to 85 metres, in addition to normal ranges of 200 to 550 and 1 000 to 2 000 metres, the tuning condenser to be ganged to the main gang condenser for ease of control.

The following special adjustments on the short-wave bands were considered necessary to render the set entirely suitable for short-wave reception :—

(*a*) Reduced output volume	To avoid damage by telegraph stations to the loud speakers and irritation to the listener.
(*b*) Reduced bass amplitude	

(*c*) Reduced top response	To increase signal/noise ratio.
(*d*) Increased audio gain	To obtain improved sensitivity.
(*e*) Increased A.V.C. feed-back	To make (*a*) and (*c*) simultaneously possible.
(*f*) Removal of muting between stations	To facilitate searching for short-wave stations by reducing the sharpness of tuning, at the same time providing maximum sensitivity.

Record-playing Facilities.

It was specified that 8 records, either 10- or 12-inch, should be played consecutively, with arrangements for repeating a single record indefinitely if desired, and, furthermore, that the playing of records or part of a record by hand should in no way be complicated by the existence of the automatic mechanism. (This was achieved by a simple adaptation of an existing standard type of mechanism.)

It was furthermore specified that the record-reproducing equipment, i.e., motor, turntable, pick-up, and needle, should meet the following conditions :—

(*a*) Frequency range of 50 to 8 000 cycles per sec.

(*b*) Response from the pick-up to vary in linear fashion with the record-groove amplitude over the entire frequency range.

(*c*) Wear on records to be appreciably less than with conventional pick-up arrangements.

(*d*) Motor speed constancy to be perfect as judged by a critical listener.

(*e*) Motor and mechanism to be inaudible under the conditions obtaining in a private house in a quiet country location.

(*f*) In addition, accurate compensation to be provided in the amplifier for reduction in bass amplitudes during recording.

Hum.

To be quite inaudible in a private house under quiet country conditions.

Electrical Operating Controls.

Wave-change Switch.—A single switch to give the alternatives of :—

Gramophone.
Long wave.—2 000–1 000 metres.
Medium wave.—550–200 metres.
Short wave 3.—85–48 metres.
Short wave 2.—48–27 metres.
Short wave 1.—27–13.5 metres.

The switch to be so arranged that on all the short-wave ranges the various functions outlined under "Short Waves" are automatically put into operation, and when in the gramophone position the radio oscillators are completely muted.

The Tuning Control.—Tuning drive of high reduction ratio to be fitted with large knob and handle to facilitate quick tuning through long and medium wave-bands or slow and careful adjustment on short waves, at will.

Tuning Scales.—Single tuning dial with alternative apertures operated by the wave-change switch uncovering the various wave ranges to be provided.

Tone-Compensated Volume Control.—A single control for radio and gramophone to cover, substantially logarithmically, the whole range from inaudibility to full output.

Tone compensation to be arranged to prevent the well-known effect of apparent loss of bass, due to the variations in ear sensitivity with frequency when the volume is turned down to a low level.

Balance Control.—A "balance control" was called for, to be used when occasion arises. It was specified that this should tilt the characteristic either way so as to favour either the higher frequencies or the bass at will, without restricting the frequency range and without substantially altering the average output volume level.

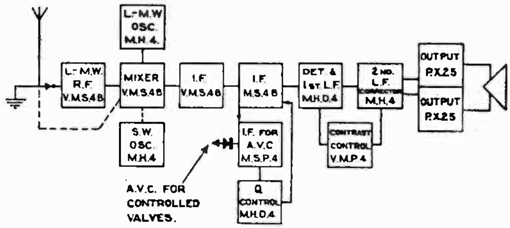


Fig. 3.—*Schematic lay-out of complete circuit.*

Master Control Switch.—A control switch is required to carry out the following operations :—

(1) *Radio Selectivity-Fidelity Action* :—

(*a*) Alternative condensers coupling radio-frequency band-pass circuits.

(*b*) Mechanical displacement of intermediate-frequency coils.

(*c*) Switching of damping resistances across intermediate-frequency coils.

(*d*) Switching of top-boosting circuit for high fidelity.

(*e*) Switching of bass-cutting circuit for high selectivity.

(*f*) Increased audio gain as band width is decreased.

(2) *Gramophone Fidelity.*—Switching of various top- and bass-cutting filters for alteration of frequency range.

(3) *Radio Sensitivity* :—

(*a*) Variation in sensitivity of muting or noise-suppression device to suit local conditions.

(*b*) Variation in sensitivity with selectivity, in order to prevent attempts at receiving very weak stations in the "high fidelity" positions.

(4) *Contrast Amplifier.*—Provision of full, half, or zero "contrast expansion" according to programme received.

The schematic lay-out of the complete circuit is shown in Fig. 3. Fig. 4 shows the arrangement of the signal-frequency amplifier for the medium and long-wave ranges, while Fig. 6 shows the short-wave connections, omitting the h.f. stages of Fig. 4. The anti-static aerial effect is secured by providing that the medium and long-wave aerial coupling coils are of moderately low impedance, so that it is possible to match a screened line of a step-down anti-static device with satisfactory accuracy, thus dispensing with one of the two matching transformers usually necessary.

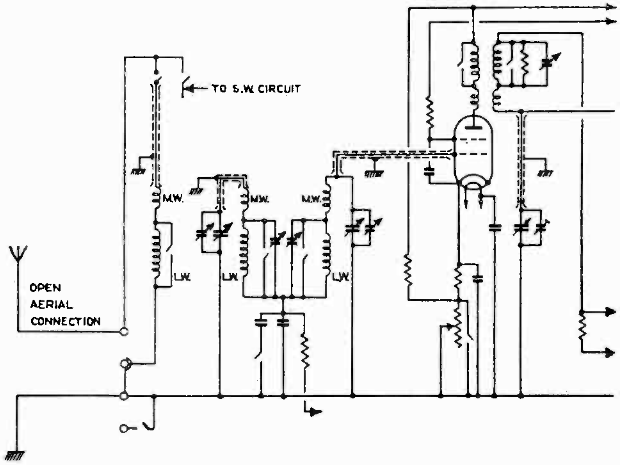


Fig. 4.—*Signal-frequency amplifier.*

Variable selectivity in the i.f. amplifier is obtained by the physical variation of magnetic coupling in the three transformers, the mounting of the movable coils on a common spindle being found the most practical way of obtaining the required range of band-width. The characteristics are shown in Fig. 7. The i.f. curves of 7 and 8 kc/sec. are identical but "top boost" is introduced into the l.f. amplifier for the wider-band response.

The automatic volume control is of the amplified delayed type, amplification being obtained from a high-frequency pentode. For medium and long waves a delay of 30 volts is obtained by taking the earth terminal of the rectifier back to a point on the main potentiometer supply. On short waves, however, this delay is reduced to 2 volts chiefly to protect the loud speakers when tuning through powerful telegraph stations. A separate a.v.c. rectifier channel is employed.

The audio-frequency amplifier consists of two amplifying stages, a contrast-expansion stage, and a class-A push-pull output. Points of particular interest are :

(1) *Compensated volume control* :—When the volume control is turned down the relative gain at 50 cycles is progressively increased to a maximum of 8 db in order to compensate for the loss of ear sensitivity at low frequencies and low levels. This effect is obtained by shunting the bottom quarter of the volume control potentiometer with a paralleled resonant circuit, as in Fig. 13.

(2) *The Balance Control.*—This consists of a variable condenser and resistor ganged to one knob. When the knob is rotated in one direction the condenser comes into operation and when it is rotated in the other the resistor functions. The condenser is connected across the secondary of the intervalve transformer and gives a gradual loss from 1 000

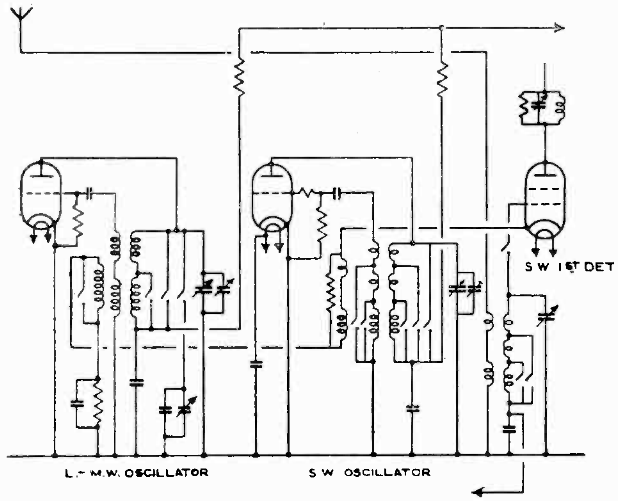
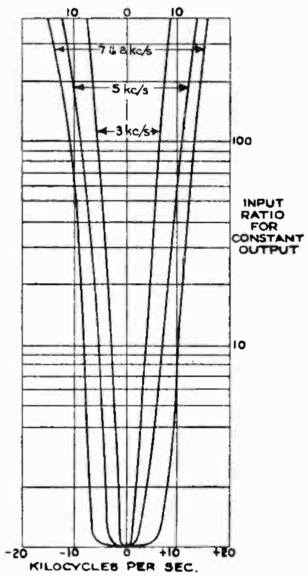


Fig. 6.—*Oscillators and short-wave input circuit.*



(*Right*) Fig. 7.—*Intermediate-frequency selectivity curves.*

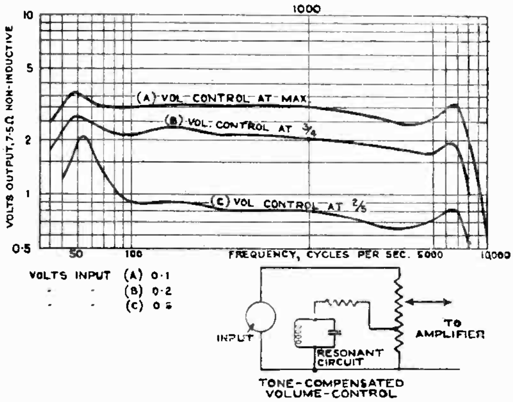


Fig. 13.—*Low-frequency amplifier characteristics, showing tone compensation at low levels.*

cycles per sec. upwards. In the maximum top cutting position the loss at 7 000 cycles per sec. is about 14 db, with 3 db loss at 1 000 cycles per sec. The variable resistance is connected across one half of the primary of the inter-valve transformer and gives a gradual loss of bass, as shown in Fig. 14.

(3) *Contract Expansion.*—This is an optional characteristic which is available in the 7- and 8-kc/s fidelity positions. It was found desirable to avoid volume expansion when the set is being played at very low levels, and this accounts for the lower limit to the operating range, the characteristic of which is show in Fig. 16(*a*).

The method used is indicated schematically in Fig. 16(*b*), which shows the primary of the inter-valve transformer connected to a potentiometer. The variable part of this potentiometer consists of a valve the bias of which is varied in proportion to the signal level, the bias being derived from a diode rectifier tapped off the amplifier at a point previous to the control stage. The rectified signal is filtered before being applied to the valve and consequently there is a time-lag between changes in signal level and changes in bias. This time-lag is governed by the condensers and resistances used in the filter.

The valve used as the variable impedance is a variable-μ pentode. Such valves normally have a very high anode resistance, but this is reduced to about 15 000 ohms (at 1 volt bias) by the use of negative feed-back. In this method the grid is connected to a tapping on a potentiometer taken between anode and cathode, shown in Fig. 16(*c*).

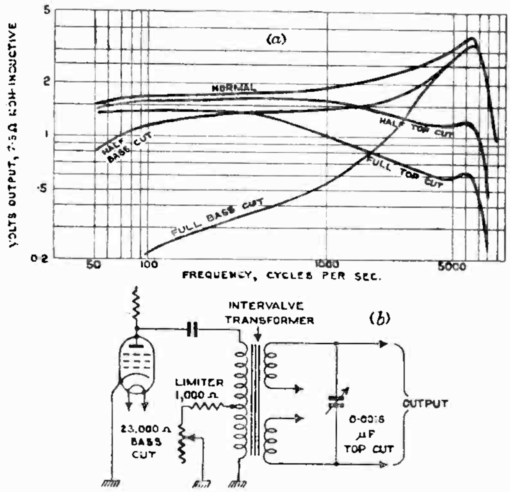


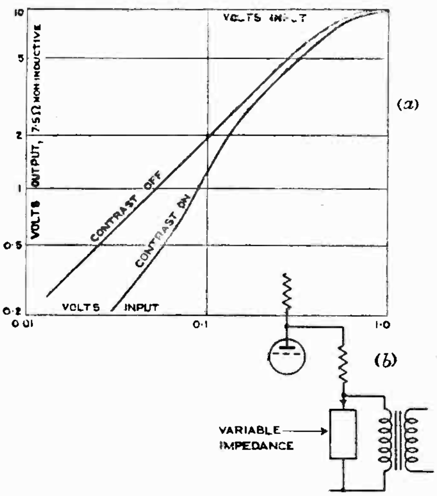
Fig. 14.—*Balance control;* (a) *Frequency characteristics;* (b) *Circuit.*

The resistance than becomes almost inversely proportional to the mutual conductance and is controllable by changing the bias or varying the potentiometer.

Discussion

During the reading of the paper demonstrations were given, both of radio and of gramophone reproduction, illustrating the various controls of frequency response obtainable.

The discussion which followed the reading of the paper was concerned largely with details either of the paper or of the manner in which other designers had tackled similar problems. The discussion was opened by Mr. P. W. Willans, other speakers being Messrs. P. K. Turner, G. Bailey, H. L. Oura, H. L. Kirke, L. E. C. Hughes, H. A. Moxon, M. G. Scroggie, D. H. Williams and P. Voigt.



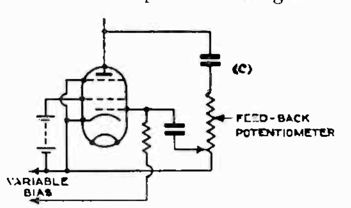


Fig. 16.—*Contrast expansion amplifier.* (a) *Characteristic;* (b) *Schematic arrangement of contrast amplifier potentiometer;* (c) *Connection of pentode as variable impedance.*

Abstracts and References

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

PROPAGATION OF WAVES

2151. THE SELECTIVE DISPERSION AND ABSORPTION OF HERTZIAN WAVES DUE TO A SYSTEM OF RESONATORS [Experimental Confirmation of Dispersion Formulae].—K. F. Lindman. (*Ann. der Physik*, Series 5, No. 6, Vol. 22, 1935, pp. 591–608.)

The object of the experimental work described in this paper was to test the Ketteler-Helmholtz dispersion formulae (1) and (2) for a group of resonators, and to determine the constants involved. Damped waves of length from 16 to 35.4 cm were used and the resonators were circular arcs, almost closed, of natural wavelength 27.4 cm and arranged in the form of a triangular prism with acute refracting angle. The experimental scheme is shown in Fig. 1. The intensity of the refracted ray was measured by a small resonator, detector and sensitive galvanometer It was found that the formulae were confirmed as closely as the accuracy of the apparatus allowed. Fig. 2 shows the intensity curves for five different wavelengths and Fig. 5 gives the measured and calculated dispersion curves: the expected anomalous dispersion is well shown. The results are also tabulated. The prism was found to separate the incident damped radiation into its component frequencies. A paraffin lens was also used; its refractive index was found to be constant for the wavelength range employed.

2152. INDEX OF REFRACTION OF WATER AND PARAFFIN AT HIGH FREQUENCIES [3×10^9 c/s: Results accord with Classical Theory].—L. S. Skaggs and R. T. Dufford. (*Phys. Review*, 15th Jan. 1935, Series 2, Vol. 47, No. 2, pp. 201–202: abstract only.)

2153. ULTRA-SHORT-WAVE PROPAGATION: MOBILE URBAN TRANSMISSION CHARACTERISTICS.—Burrows, Hunt and Decino. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 253–272.) *See* 930 of April.

2154. ULTRA-SHORT-WAVE PROPAGATION: BLUE HILL [Harvard] RANGES: THE EFFECTS OF TEMPERATURE INVERSIONS.—C. F. Brooks. (*Science*, 1st March, 1935, Vol. 81, No. 2096, Supp. p. 10.)

2155. INTERNATIONAL 28-MC COMMUNICATION AGAIN! [Four-Hour R9 Contact over 5 000 Miles: Communication between America and Australia and New Zealand: America and Japan, etc.: All on Waves around 10 Metres].—G. Grammer. (*QST*, May, 1935, Vol. 19, No. 5, pp. 9–12.)

2156. PROPAGATION OF ELECTRIC WAVES IN THE EARTH'S MAGNETIC FIELD [and the Complete Explanation of Observed Effects without Recourse to Hypothesis of Several Layers].—Th. Jonescu and C. Mihul. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1301–1303.) Extension of the work dealt with in 649 and 650 of March, where the effect of the magnetic field was neglected.

2157. INTERPRETATION OF FERMAT'S PRINCIPLE [Discussion].—O. Darbyshire: T. Smith. (*Nature*, 13th April, 1935, Vol. 135, pp. 586–587.) *See* Smith, 1934 Abstracts, p. 432.

2158. A METHOD OF MEASURING THE COLLISIONAL FREQUENCY OF ELECTRONS IN THE IONOSPHERE [Formula deduced from (P', f) Diagram: Discussion of Eckersley's Measurements: Optical Path not Negligible].—E. V. Appleton: Eckersley. (*Nature*, 20th April, 1935, Vol. 135, pp. 618–619.) *See* 1729 of June; also 2159, below.

2159. FREQUENCY OF COLLISIONS OF ELECTRONS IN THE IONOSPHERE [Discussion of Eckersley's Measurements: Effect of E Region Absorption: F_2 Region Collisional Frequency has value 1.6×10^3].—F. T. Farmer and J. A. Ratcliffe. (*Nature*, 13th April, 1935, Vol. 135, p. 585.) *See* also 2158, above, and 1934 Abstracts, p. 85 (Eckersley).

2160. MULTI-FREQUENCY IONOSPHERE RECORDING AND ITS SIGNIFICANCE [based on 1933/1934 Results].—T. R. Gilliland. (*Journ. of Res. of Nat. Bur. of Stds.*, March, 1935, Vol. 14, No. 3, pp. 283–303.)

For the recorder used *see* 1934 Abstracts, p. 199, and *ibid.*, p. 607, for some results. A "solid diagram" is given representing the year's critical-frequency measurements. "The day E- and F_1-layer critical frequencies are seen to follow in phase with the sun, both diurnally and seasonally. During the winter night the F-layer c.f. drops until an hour or two before midnight, then increases until about 0400, after which it decreases again before sunrise. The maximum density of ionisation frequently more than doubles after the first minimum." During the day, "fine structure" is often in evidence, indicating other strata between the usual E and F_1 layers. The night F-layer critical frequency minimum for September, 1934, is about 180 kc/s higher than for September, 1933; it is too soon to say whether this increase in ionisation density is connected with the new sunspot cycle. Some of the results were applied to a practical communication problem—the skipping of signals in short-distance transmission along one of the air-ways.

2161. IONOSPHERE STUDIES DURING PARTIAL SOLAR ECLIPSE [Ionisations of E, F_1 and F_2 Regions primarily controlled by Solar Ultra-Violet Radiation].—S. S. Kirby, T. R. Gilliland and E. B. Judson. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 632–633.)

Graphs are given of the average critical frequencies of the various regions for several days before and after the eclipse day (3rd Feb. 1935) for comparison with those of the eclipse day. The minimum of ionisation of F_2 region occurred within 9 minutes after the eclipse maximum. Comparison with the results of the August 1932 eclipse indicates that F_2 region is ionised in a different way in summer and winter.

2162. IONOSPHERE MEASUREMENTS DURING SOLAR ECLIPSE OF FEBRUARY, 1935.—Schafer and Goodall. (*Bell Lab. Record*, March, 1935, Vol. 13, No. 7, p. 208: paragraph only.)

2163. RADIO FIELD INTENSITY MEASUREMENTS AT BANGALORE DURING THE POLAR YEAR [Low and Medium Frequencies, from Near and Distant Stations: 1933 Eclipse Effects].—P. L. Narayanan. (*Journ. Indian Inst. of Sci.*, Part III, Vol. 17 B, pp. 47–67.)

Among the results are the following:—On the 75 kc/s signals from Madras, Fig. 5a is a record with the axis of receiving frame parallel to direction of transmission: as sunset approaches the sky wave undergoes a rotation of polarisation giving rise to a component of the electric vector perpendicular to plane of propagation: this component fades almost as severely as the component in the plane of propagation. During the partial solar eclipse of August, 1933, there is a small but definite *decrease* of intensity during the first half of the eclipse, followed by a gradual increase during the second half: "observations made on medium wavelengths in England during the eclipse of 29th Jan. 1927 and in America on 24th Jan. 1925 show a rise instead of a fall . . . during the first half." A feature of the Rugby 16 kc/s curve is the hump appearing between 0600 and 0700 I.S.T.

2164. RESEARCHES ON THE CONDITION OF THE IONOSPHERE IN THE NEIGHBOURHOOD OF THE EQUATOR.—I. Ranzi. (*La Ricerca Scient.*, May, 1934, 5th Year, Vol. 1, Supp. to No. 9/10, pp. 598–605.) The full paper on the work dealt with in 1934 Abstracts, p. 142.

2165. AN APPARATUS FOR RECORDING AVERAGE AMPLITUDES OF WIRELESS ECHOES.—F. T. Farmer. (*Proc. Camb. Phil. Soc.*, April, 1935, Vol. 31, Part 2, pp. 295–302.)

The advance in this work is in the recording arrangement, which consists essentially of "two units, (1) an 'echo selecting circuit' for isolating the echo to be measured from the ground ray and any other echoes, and (2) an 'integrating circuit' for averaging the amplitude of the echo so isolated, and recording at intervals its resultant value." Fig. 1 shows the "echo selecting circuit," which uses a thyratron to render the receiving amplifier inactive except for the brief periods during which the echo is arriving. The sensitivity of the receiver is constant during these periods. The scheme of the "integrating circuit" is shown in Fig. 2. A valve is fed from the diode detector of the receiver: in its anode circuit are a battery, condenser and high resistance so arranged that the potential difference across the condenser is proportional to the integrated signal e.m.f., for an unmodulated signal. During the inactive periods the high resistance is made infinite. The complete arrangement is shown in Fig. 3; the tests employed are described and some specimen records given.

2166. THE HALS [Long-Delay] ECHO AS A PHENOMENON OF THE IONOSPHERE [and the "World-Radio Research League" Observations].—J. Fuchs. (*Hochf:tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, pp. 111–117.)

In his previous paper (356 of February: *see* also 942 of April) the writer showed that these echoes probably originate in the F layer, and deduced that no light gases (hydrogen, helium) are present there. He now deals with the organised observations on the special transmissions from GSB between 20th May and 8th July, 1934 (*see*, for example, 2167, below), finding that an analysis of these results fits in well with this theory. It also leads to the emergence of certain "preferred" path times, namely 9 and 25–27 secs. and perhaps 2 and 50 secs. (Fig. 1). He compares this result with the Poulo Condore eclipse observations (Galle, Abstracts, 1930, p. 500) where the most numerous path times were at or above 20 and below 10 secs., very few between 10 and 20 secs. being found.

The present material shows also that only echoes with times around 9 secs. cover great distances, those with longer times being limited to ranges of 100 to 200 km. But even the 9-sec. echoes are more than twice as frequent at distances below 200 km, so that it is concluded the long ranges are only exceptional occurrences due to a disturbance of the horizontal distribution of ionisation, or perhaps to a splitting of the main signal: in the latter connection Cutts's observations of 3-sec. echoes (wavelengths between 30 and 50 m), over distances up to about 10 000 km, are mentioned (Stranger, *World-Radio*, 1934, p. 539). But taken all in all the majority of echoes of various delay times occur at a distance of about 120 km from GSB (whose skip distance is about 700 km—*see* Fig. 3) as shown in Fig. 2; so that their skip distance may be taken as about 100 km. Such a short skip distance indicates a practically vertical incidence in the ionosphere and (for the 31.55 m wave) leads by the writer's theory to an ionisation density, at the peak of the path, of $N = 1.12 \times 10^6/\text{cm}^3$, which agrees well with the value $1.3 \times 10^6/\text{cm}^3$ given by Försterling and Lassen for the maximum density in the F layer (Abstracts, 1932, p. 217).

The preferred path times of 9 and 25–27 secs. are traced to correspond to the right- and left-handed components of the doubly-refracted wave (*see* equations 6 and 13a and 7 and 13b), and the writer sums up: "Long-delay echoes can occur when at the peak point of the echo wave the ionisation density, with a low gradient, is large enough to make $n \simeq 0$ for the component entering, and when in addition the peak point lies at a level where the collision frequency is equal to or less than 1 per sec. (atmospheric pressure equal to or less than 3×10^{-9} mm mercury)."

2167. Organisation of Echo Tests [1934/1935 Results: Few, if Any, Long-Delay Echoes, in Agreement with Störmer's Theory].—R. Stranger. (*World-Radio*, 19th and 26th April, 1935, pp. 13 : 11.)

2168. Interaction of Radio Waves [Observations agree with Theoretical Prediction of Distortion of Impressed Modulation in favour of Lower Frequencies].—V. A. Bailey and D. F. Martyn. (*Nature*, 13th April, 1935, Vol. 135, p. 585.) For previous papers *see* 1934 Abstracts, pp. 199 and 606: *also* 1318 of May.

2169. Interaction of Radio Waves: a Summing-Up of Listeners' Experiments, *and* Interaction of Radio Waves.—Appleton: Stranger. (*See* 2251 and 2252, under "Reception.")

2170. The Tellegen Effect [Non-Linearity in Medium necessary for "Luxembourg Effect": Relation to Side-Band Controversies: Possibility with Light ?].—R. R. Ramsey. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, pp. 257–258.) For Hazel's paper referred to *see* 970 of April.

2171. Wireless and the Weather [Atmospheric Pressure as a Vital Factor in Reception outside Service Area: Reception deduced from Isobars].—F. A. C. Todd. (*World-Radio*, 22nd Feb. 1935, p. 8.)

2172. Apparatus for the Taking of Samples and the Study of the Composition of the Air of the Stratosphere [by Exploring Balloons].—A. Lepape and G. Colange. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1340–1342.)

2173. The Götz Inversion of Intensity-Ratio in Zenith-Scattered Sunlight [for Study of Ozone Distribution and perhaps of Ionosphere Problems].—S. Chapman. (*Philos. Trans. Roy. Soc. London*, Series A, No. 737, Vol. 234, 1935, pp. 205–230.)

2174. The Absorption of Sunlight by the Earth's Atmosphere in the Remote Infra-Red Region of the Spectrum [Spectroheliometric Observations to 21 μ: Long Wave Limit 13.5 μ].—A. Adel, V. M. Slipher and E. F. Barker. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 580–584.)

2175. Photometric Study of the Solar Corona for Radiations situated in the Red and Near Infra-Red.—A. Lallemand. (*Ann. de Physique*, February, 1935, Series 11, Vol. 3, pp. 181–197.)

2176. Rotating Electromagnetic Waves.—N. S. Japolsky. (*Phil. Mag.*, May, 1935, Series 7, Vol. 19, No. 129, pp. 934–958.)

This paper gives the theory of rotating "superfast" cylindrical waves propagated in a homogeneous, isotropic non-conducting medium. They are "super-fast" when their phase velocity is greater than that of plane waves in the medium, and "cylindrical" when they are axially symmetric and propagate along their axis of symmetry without spreading. They are obtained as solutions of Maxwell's equations in cylindrical co-ordinates r, θ, x by assuming expressions of the form $Ee^{i(\Omega t + \kappa x + n\theta)}$ for the force components, where E is the amplitude and depends only on r. Ω is the "angular time frequency" and κ is the "angular distance frequency." For the functions to be single-valued, n must be an integer. On this assumption the theory is developed on the lines of that usual for ordinary plane electromagnetic waves. Particular attention is paid to polarisation, which for rotating cylindrical waves must be considered in three dimensions and represented by an ellipsoid; a distinction is made between (1) polarisation of the field as a whole and (2) polarisation of the electric (and magnetic) vector at a given point. Compound rotating cylindrical waves are also considered; these may be analysed into their components (which have the same wavelength and frequency but different n) by Fourier's theorem. "Planar waves" have their energy concentrated in one axial plane ("principal plane"). Expressions for the energy flux and energy density and their average values are found. The wave front is undulating, but, on the average, a helical surface, so that the propagation of energy is screw-like. The average speed of energy propagation is found and leads to a comparison between the rotating cylindrical waves and de Broglie's material waves. These rotating cylindrical waves may be a more suitable representation of optical wave trains than the plane waves usually assumed. In an appendix, certain contour integrals used in the text are discussed.

2177. Multiple Scattering [of Electromagnetic Waves] at Small Spheres [Mathematical Expressions for Potentials].—W. Trinks. (*Ann. der Physik*, Series 5, No. 6, Vol. 22, 1935, pp. 561–590.)

2178. Experimental Researches on the Optical Dissymmetry of Space.—E. Esclangon. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1165–1168.)

2179. Energy and Angular Momentum in Certain Optical Problems [Circularly Polarised Light possesses Angular Momentum: Reflection from Conducting Surfaces].—R. d'E. Atkinson. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 623–627: abstract p. 639.)

2180. The Constancy of the Velocity of Light [Experimental and Astronomical Data for]. —R. J. Kennedy. (*Phys. Review*, 1st April, 1935, Series 2, Vol. 47, No. 7, pp. 533–535.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2181. Atmospheric Radioelectricity [Editorial]. —R. Bureau. (*L'Onde Élec.*, April, 1935, Vol. 14, No. 160, pp. 193–202.)

The ionosphere: troposphere, ionosphere, and propagation of waves: the importance of the diurnal variation and its anomalies: influence of latitude: the 27-day period: the meteorological origin of certain anomalies of the E region.

2182. Investigations on Lightning Discharges and Broadcast Interference in Sweden, with the Cathode-Ray Oscillograph. —H. Norinder. (*E.T.Z.*, 4th April, 1935, Vol. 56, No. 14, pp. 393–398: Discussion, *ibid.*, 18th April, No. 16, pp. 468–469.)

For a previous paper *see* 666 of March. A total of 450 oscillograms of lightning flashes, within a radius of 29 km from the station, are available for the study of the general discharge form of lightning and the structure of the partial impulses: 130 records taken on frame aerials allow determination of the current-strength relations in the strokes. Up to February, 1935, about 13000 atmospherics giving interference with broadcast reception were oscillographed; the material is examined with regard to the amplitude, duration and form of the interferences.

2183. Return Strokes as Cause of Large Proportion of Lightning Breakdowns on a 100 kV Line, and Their Reduction, *and* New Results of Lightning Current Measurements on H.T. Lines.—Zwanziger: Zaduk. (*E.T.Z.*, 25th April, 1935, Vol. 56, No. 17, pp. 474–475: 475–479.)

2184. Induced Lightning Surges and Their Relation to Return Strokes.—V. Aigner. (*E.T.Z.*, 2nd May, 1935, Vol. 56, No. 18, pp. 497–500.)

2185. Proposals for the Observation of Lightning Disturbances.—H. Müller. (*E.T.Z.*, 23rd May, 1935, Vol. 56, No. 21, pp. 577–579.)

2186. Lightning Research from Foreign Publications in 1934.—D. Müller-Hillebrand. (*E.T.Z.*, 11th April, 1935, Vol. 56, No. 15, pp. 417–420.)

2187. The Electrical Strength of Air under Various Conditions of Strain [Survey of Recent Work].—W. Weicker. (*E.T.Z.*, 11th April, 1935, Vol. 56, No. 15, pp. 423–425.)

2188. On the Relation between the Electrical Conductivities of the Air and the Danger of Lightning Strokes [Susceptibility caused by Predominance of *Negative* Ions, Not always by Strong Ionisation].—R. Gibrat and G. Viel. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1233–1235.)

2189. Ion Distribution during the Initial Stages of Spark Discharge in Non-Uniform Fields [Cloud-Chamber Photographs of Distribution between Point (Negative and Positive) and Plane].—C. D. Bradley and L. B. Snoddy. (*Phys. Review*, 1st April, 1935, Series 2, Vol. 47, No. 7, pp. 541–545.)

2190. Atmospheric Condensation Nuclei [Measurement of Mobility and Radius of Large Atmospheric Ions].—J. J. Nolan and V. H. Guerrini. (*Nature*, 27th April, 1935, Vol. 135, p. 654.)

2191.—The Rôle of Surface Instability in Electrical Discharges from Drops of Alcohol and Water in Air at Atmospheric Pressure.—J. Zeleny. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 638: abstract only.)

2192.—The Amplitude of the Semi-Diurnal Component of the Gradient of Terrestrial Electric Potential, and Solar Activity [Remarkable Agreement between Curves].—R. Guizonnier. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1235–1236.)

2193. The Annual Variation of the Earth's Magnetic Field [and Its Connection with the 11-Year Solar Period].—L. Éblé. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1342–1343.)

2194. Statistical Error in Counting Experiments [particularly Cosmic Rays: Methods of Calculation for Minimum Error].—R. Peierls. (*Proc. Roy. Soc.*, Series A, 10th April, 1935, Vol. 149, No. 868, pp. 467–486.)

2195. A Note on the Production of Cosmic-Ray Showers [Variation with Depth below Top of Atmosphere].—W. H. Pickering. (*Phys. Review*, 1st March, 1935, Series 2, Vol. 47, No. 5, p. 423.)

2196. Frequency and Magnitude of Cosmic-Ray Bursts as a Function of Altitude.—R. D. Bennett, G. S. Brown and H. A. Rahmel. (*Phys. Review*, 15th March, 1935, Series 2, Vol. 47, No. 6, pp. 437–443.)

2197. The Variation with Altitude of the Production of Bursts of Cosmic-Ray Ionisation.—C. G. Montgomery and D. D. Montgomery. (*Phys. Review*, 15th March, 1935, Series 2, Vol. 47, No. 6, pp. 429–434.)

2198. The Enhancement of Cosmic-Ray Nuclear Bursts by the Presence of Subsidiary Material.—C. G. Montgomery, D. D. Montgomery and W. F. G. Swann. (*Phys. Review*, 15th March, 1935, Series 2, Vol. 47, No. 6, pp. 512–513.)

2199. On the North-South Asymmetry of Cosmic Radiation [Theory and Discussion]. —G. Lemaitre, M. S. Vallarta and L. Bouckaert. (*Phys. Review*, 15th March, 1935, Series 2, Vol. 47, No. 6, pp. 434–436.)

2200. North-South Asymmetry of the Cosmic Radiation.—T. H. Johnson. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 326: abstract only.)

2201. Absorption of Cosmic Rays [Inapplicability of Klein-Nishina Formula: Nuclear Absorption Neglected].—H. J. Walke. (*Nature*, 23rd March, 1935, Vol. 135, p. 472.)

2202. Ionisation by Cosmic and Radioactive Radiation at Different Gas Pressures. The Influence of the Wall of the Vessel. Disintegration of Heavy Atoms by Cosmic Rays.—J. Clay. (*Physica*, February, 1935, Vol. 2, No. 2, pp. 111–124: in English.)

2203. Comparative Measurements of Cosmic and Gamma Rays with Ionisation Chamber and Counter [Influence of Secondary Radiation].—R. Hilgert. (*Zeitschr. f. Physik*, No. 9/10, Vol. 93, 1935, pp. 589–610.)

2204. Dependence on Pressure of the Residual Ionisation Current [in Cosmic Ray Electrometers] in Different Gases.—J. A. Priebsch. (*Zeitschr. f. Physik*, No. 1/2, Vol. 93, 1934, pp. 22–34.) Continuation of work referred to in 1934 Abstracts, p. 147.

2205. On the Secondary Effects of the Cosmic Rays.—P. Auger and A. Rosenberg. (*Comptes Rendus*, 4th Feb. 1935, Vol. 200, No. 6, pp. 447–449.)

2206. Concerning the Recovery Time of Geiger-Müller Counters [of Cosmic Rays].—W. E. Danforth. (*Journ. Franklin Inst.*, January, 1935, Vol. 219, No. 1, pp. 108–110: *Phys. Review*, 1st Dec. 1934, Series 2, Vol. 46, No. 11, pp. 1026–1027.)

2207. The Resolving Power of Counter Arrangements [for Cosmic Rays: Determination of Time between Separable Impulses and Necessary Corrections].—H. Volz. (*Zeitschr. f. Physik*, No. 7/8, Vol. 93, 1935, pp. 539–542.)

2208. The Study of the Electrical Characteristics of Geiger-Müller Tubes using a Cathode-Ray Oscillograph [Analysis of Counting Cycle: Recommendations for Increased Resolution].—J. F. Sears and G. E. Read. (*Phys. Review*, 15th Jan. 1935, Series 2, Vol. 47, No. 2, pp. 197–198: abstract only.)

2209. On the Falling Cloud-Chamber and on a Radial-Expansion Chamber.—C. T. R. Wilson and J. G. Wilson. (*Proc. Roy. Soc.*, Series A, 15th Feb. 1935, Vol. 148, No. 865, pp. 523–533.)

PROPERTIES OF CIRCUITS

2210. Some Simple Transformations of the Impedance Functions of Electric Networks and Applications to Wave Filters.—S. Ekelöf. (*E.N.T.*, March, 1935, Vol. 12, No. 3, pp. 100–106.)

The writer begins (§ 2) by defining the "image frequency" $\overline{\omega}$ (eqn. 1) and the "band width" Δ and "image band width" $\overline{\Delta}$ (eqn. 2) of one angular frequency ω with reference to another, ω_0. The relations are shown graphically in Fig. 1. The complex impedances of the circuits in Fig. 2 are given in terms of these quantities (eqns. 3). A circuit with known constant elements is then considered; one of its properties, *e.g.*, the impedance measured between two points, is assumed to be known as a function of ω, $f(\omega)$, and the circuit is transformed so that $f(\omega)$ becomes $f(-\overline{\omega})$ for the transformed network. Using resonance circuits, two other transformations are obtained and all are tabulated (p. 101). The results of the transformations are specially investigated for a low-pass filter (Fig. 3a); they give Figs. 3b, c, d respectively.

In § 3 transient phenomena are discussed for transformations 2 and 3, as van der Pol has already discussed them for transformation 1 (1934 Abstracts, p. 556—two). The transformation of an operator function in an impedance transformation is investigated (eqns. 4–23) with special reference to the writer's three transformations, and further application to the determination of a time function corresponding to an operator is described (§ 5) with applications.

2211. "A General Theory of Electric Wave Filters."—H. W. Bode: Bell Tel. Lab. (At Patent Office Library, London: Catalogue No. 74 908.) *See* also next two abstracts.

2212. A General Theory of Electric Wave Filters [Based on Image Parameters and Normal Co-ordinates].—H. W. Bode. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 211–214: summary only.)

2213. Ideal Wave Filters [Method of Design for Arbitrarily Close Approximation to Required Properties].—H. W. Bode and R. L. Dietzold. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 215–252.)

This paper develops the general theory referred to in the above abstract. The expressions for the constants of a symmetrical lattice can be approximated in practice by using the known development of a tangent function as the quotient of two infinite products, which themselves can be expressed as products of Gamma functions, so that asymptotic series can be derived for the constants; these enable curves to be computed for the network characteristics, and many illustrative charts are given. A numerical example of the practical design of a band-pass filter is included. Finally, the design of filters with linear phase shift through the cut-off is discussed.

2214. "Les Filtres Électriques: Théorie, Construction, Applications": with a Supplement "Sur les Systèmes sélectifs complexes" [including Wagner-Campbell and Cauer Filters: Book Review].—P. David. (*Rev. Gén. de l'Élec.*, 4th May, 1935, Vol. 37, No. 18, p. 563.)

2215. The Algebraic Structure of the Admittances of a Filter as a Function of the Frequency.—J. Haag. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1169–1172.)

The fundamental principles of electric filters are derived from the canonical algebraic form of the impedance of a circuit, using former work by the writer (1798 of June). The pass region is defined and the principles of choosing the cut-off frequencies are given. Necessary conditions (4) for realising the most general filter circuit are found: the writer has not proved them to be sufficient but proceeds to find the conditions that the admittances of several circuits in parallel should add algebraically, and discusses the special case of a tripole.

2216. ON NON-PERIODIC FORCES, ACTING ON OSCILLATORY SYSTEMS [*e.g.* Radio Interference].—J. W. Alexander. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 273–285: in English.)

The conclusions reached by this analysis include the following:—(i) "In a selective circuit an interference causes a damped oscillation with a frequency and a damping coefficient equal to the natural frequency and the damping coefficient of the circuit, and an amplitude equal to that of the Fourier component with said frequency of the interference." (ii) It is not the exact *form* of the interference that defines the Fourier component, *but rather the duration or the time necessary for it to reach a maximum*; "there are different classes of interferences which have approximately the same Fourier component and which cause therefore the same tension in a circuit . . . For different forms of interferences, given by $f(t) \neq 0$ when $0 < t < \tau$, and having one maximum, the amplitude of the Fourier component with the frequency ω [$=2\pi/T$] is approximately (with a maximum deviation of 10%) given by the surface of the interference, when T is greater than $(2.5 \text{ to } 4)\tau$. The well-known impulse function (of the first order), for which the said rule is already known, belongs to this class."

(iii) "Thus far, interferences have been studied which last a definite time τ, but we shall now proceed to study interferences with a quite different character"—namely impulses of the oth order, $f(t) = A$ = constant when $t>0$. It is found that if the time τ necessary for reaching the maximum amplitude a is smaller than 0.25 to 0.4 of the time of oscillation T, then the amplitude of the Fourier component with frequency $\omega = 2\pi/T$ is equal to a/ω, with a maximum deviation of 10%. (iv) Two fundamental types of interference have thus been considered, namely 1st order ($I_1 = a\tau$) and oth order ($I_0 = a/\omega$). For both types, it is shown that when the amplitude of the tension caused by the interference is equal to that caused by a sinusoidal tension, then the amplitude of the interference is much greater than that of the sinusoidal tension. Other fundamental types must exist, such as $I_2 = a\tau . \omega\tau$, but these are not examined. (v) "In this section the incomplete Fourier spectrum of some interferences will be studied. In practice this occurs in amplifiers with a limited frequency range, and also applies to statics, between the place of origin and the receiver." This section illustrates the importance of the time of interference τ.

2217. DISTORTIONS [of Transient Phenomena] IN NON-LINEAR SYSTEMS.—H. Tischner. (*E.N.T.*, March, 1935, Vol. 12, No. 3, pp. 91–99.)

A general idea of the distortion produced by a non-linear characteristic (*e.g.* of an amplifying valve) is given by Fig. 1. The phenomena may be investigated theoretically with the aid of Fourier integrals. (1) is that of the original transient, while (2) is the form after passing through the non-linearity, which is introduced under the integral sign; this must be re-integrated. This process is generally very complicated and a simpler method of solving the problem is given, illustrated by the stages in the passage of a rectangular impulse (on a film) across a slit (Fig. 2). It is found that "the non-linear distortion of a [rectangular] switch-on pulse is equivalent to the linear scanning of a given pulse (of different form, in general) by two slits of given distribution of brightness." Fig. 3 shows the distortion produced by a curved characteristic, the general mathematics being given in eqns. 7–12. A simple harmonic distribution of intensity on the film is next considered (eqns. 13–19). The method used is explained in greater detail in eqns. 20–25, using the actual curves of Fig. 3. Fig. 4 illustrates the point that the effect of a non-linear characteristic is to eliminate the zeros in the frequency spectrum of a pulse, though the general character may be similar to that of the original pulse.

Fig. 5 gives the circuit for an aural test of the spectrum of a pulse before and after passage through a non-linear element; the difference is clearly perceived by ear and the calculated spectra are shown in Fig. 7. In §2 periodic phenomena are considered, starting from a function for the pulse which contains even as well as odd harmonics (a rectangular pulse contains only the latter). A procedure similar to that of §1 is adopted. Fig. 8 illustrates distortion of a zig-zag curve, for which calculations are given in eqns. 35–37.

2218. THE NON-LINEAR THEORY OF THE MAINTENANCE OF OSCILLATIONS.—Ph. le Corbeiller. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, p. 256: summary of I.E.E. lecture.)

2219. A THEORY OF IDEAL DETECTOR.—A. K. Balihin. (*Izvestia Elektroprom. Slab. Toka*, February, 1935, No. 2, pp. 18–28.)

Author's summary:—Full treatment of action of ideal detector; frequency and non-linear distortions; relation between input resistances and load selected for diode; non-linear distortions are analysed as dependent on degree of modulation; charts are given for load selection, for determination of frequency and non-linear distortions, and for determination of input resistance.

2220. CLASS AB AMPLIFIER DESIGN [Importance of Design of Components: Class AB to be regarded as Under-Biased Class B rather than Over-Biased Class A: etc.].—M. Apstein. (*Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 10–11 and 15.)

2221. THEORETICAL CONSIDERATIONS ON THE EFFECTS OF RETROACTION IN AMPLIFIERS [and the Confusion, in the Classic Theory, between Self-Sustained and Forced Oscillations].—M. Rousseau. (*L'Onde Élec.*, April, 1935, Vol. 14, No. 160, pp. 228–242.)

2222. The Theory of Operation of an Over-Driven Valve.—A. I. Berg. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1934, pp. 1–7.)

A theoretical investigation into the operation of a valve when it is over-driven, *i.e.*, when instantaneous grid potentials exceed the corresponding values of anode potential. This condition is characterised by the appearance of a trough in the crest of the anode current curve. Starting from the assumption that under normal operating conditions the anode current curve is flat at the top, a formula (7) is derived determining the internal resistance R_i'' of an over-driven valve, and the following fundamental relationship is established :—$V_g = DI_{a1}(R_i''+R_e)$, where V_g is the grid voltage, D the reciprocal of mu, I_{a1} the amplitude of the 1st harmonic of the anode current (fundamental a.c. component), and R_e the equivalent anode-circuit resistance.

It is shown that as the valve is over-driven its internal resistance increases and the ratio of the amplitude of the 1st harmonic to the d.c. component of the anode current decreases. Since the output of a valve working into a circuit tuned to unity power factor is $\frac{1}{2}I_{a1}V$, where V is the oscillating anode voltage, it appears that the highest efficiency is obtained with the flat-topped anode current curve. It is pointed out, however, that when this curve takes a more complicated form, V increases, which in turn increases the efficiency of operation. A detailed numerical example is added.

2223. New Basis for the Theory and Design of the Grid Circuits of Triodes.—R. V. Lvovich. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1934, pp. 7–14.)

In view of the extensive use of valves operating in the over-driven condition it is important to be able to calculate accurately the grid currents and to determine their effect on the anode current. In this paper the author gives a preliminary report on his investigation, as a result of which the following equation for the grid-current dynamic characteristic has been obtained :—$i_g = n_1(v_g - V_{g0}) - n_3(v_g - V_{g0})^3 + n_5(v_g - V_{g0})^5 \ldots$ (1), where i_g is the grid current, v_g the grid swing, V_{g0} the grid voltage at which the grid current begins to flow, and n_1, n_2 and n_3 are constants depending on the type of valve and the operating conditions.

Methods are indicated for the determination of n_1, n_2 and n_3, and grid-current curves for a certain type of valve are given showing a very close approximation between the theoretical and experimental results. With regard to the effect of the grid current on the anode current, reference is made to another work of the author which is being prepared for publication. In the present paper an outline only is given of a method for expressing equation (1) and the equation of the anode-current dynamic characteristic in the same co-ordinates, so as to make possible a direct comparison between the two curves.

2224. Remarks on the Paper "Skin Effect in Layered Cylindrical Conductors."—S. Ekelöf: Kruse and Zinke. (*Hochf: tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, p. 140.) Comments by Ekelöf on the paper dealt with in 698 of March.

TRANSMISSION

2225. Barkhausen-Kurz Oscillator Operation with Positive Plate Potentials [Two Discrete Oscillation Zones below Critical (Breaking-Off) Potential, with Wave Ranges differing by (*e.g.*) 11–19%: Separated by Zone of Instability].—L. F. Dytrt. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 241–243.)

2226. Micro-Wave Equipment and Tests of the R.I.E.C. [Leghorn].—(*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 241–251.)

2227. On the Design of Ultra-Short Wave Transmitters.—I. M. Vekslin. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1934, pp. 24–30.)

A report on an investigation carried out at a Leningrad factory with a view to increasing the efficiency of the final stage of an ultra-short wave transmitter. This stage utilised two 5 kw water-cooled valves in parallel, and in addition to power amplification served as a frequency doubler. It was driven by a crystal-controlled oscillator. The operating wavelength was of the order of 6 m. A description is given of the neutralising circuit used, in which the self-inductance of the grid and filament leads was taken into account, and the question of the reduction of losses in the anode circuit is discussed in detail. Attention is drawn to the importance of correct tuning of coils in the filament, grid, and anode leads. It is shown, for instance, that if $\lambda_{max.}/\lambda_{min.} = 1.5$ and all the coils are tuned for $\lambda_{max.}$, there will be a loss in efficiency of about 20% when operating at $\lambda_{min.}$. A number of curves obtained experimentally are shown, and formulae for accurate and approximate calculation of the natural wavelengths of coils are given.

2228. Progress in Ultra-High-Frequency Gear: Some Details of the New Equipment at W1HBD [Hartford/Boston Tests, including "Organ-Pipe" (Resonant Line) Transmitters].—R. A. Hull. (*QST*, May, 1935, Vol. 19, No. 5, pp. 30–32 and 106.) For Terman's paper on resonant lines *see* 1934 Abstracts, p. 556; *cf.* Whitmer, same Abstracts, p. 33.

2229. Trials of New Wide-Band Programme Circuits.—Hamilton. (*See* 2306.)

2230 Discussion on "High Quality Radio Broadcasting" [Discrepancy between Measured and Calculated Vertical Field Pattern of Guyed Cantilever Aerials explained by Non-Sinusoidal Current Distribution: etc.].—H. Roder: Ballantine. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 256–260.) For Ballantine's paper *see* 1934 Abstracts, p. 379. *Cf.* also Gihring and Brown, 2274.

2231. The Design of a H.F. Transformer for Coupling a Radio Transmitter to an Aerial Circuit.—Lvovich. (*See* 2283.)

2232. AUTOMATIC SYNTRACTION OF TWO BROADCAST CARRIERS [in Common-Wave Broadcasting: D.C. Ammeter, acting as Phase Meter in Beat-Note Circuit, automatically corrects Station Frequency by Vane carried on Pointer].—V. V. Gunsolley. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 244–248.)

2233. PHASE RELATIONSHIP IN AN OSCILLATOR USING A PARALLEL RESONANCE CIRCUIT. [Voltage and Current Relationships in an Oscillator with Auto-Parametric Excitation].—S. I. Tetelbaum. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1934, pp. 15–23.)

Supplementing a previous article by the same author (100 of January), a study is made of the conditions arising in an auto-parametric excitation oscillator system when the controlling frequency is varied within a certain range, known as the synchronisation interval, over which the system is capable of oscillating. The variation of this frequency alters the amplitudes and phases of the voltages and currents in the oscillating circuit, which is assumed to be of the parallel resonance type. Limiting conditions are established for the operation of the oscillator system and a grapho-analytical method is expounded by means of which voltage and current resonance curves, and curves showing the variation of phases, can be calculated. A numerical example is included.

2234. PUSH-PULL-PUSH OSCILLATOR CIRCUITS FOR 15-WATT SECOND-HARMONIC OUTPUT [with Great Possibilities as Exciter or Low-Powered Transmitter: for Tri-Tet or Electron-Coupled Connection].—J. S. Brown. (*QST*, May, 1935, Vol. 19, No. 5, pp. 53–56.)

2235. THE CHARACTERISTICS OF THE DYNATRON [and Their Mathematical Expression].—J. Groszkowski. (*W.P.P.I.T.* [*see* 2313], No. 3, Vol. 6, 1935, pp. 3–11.)

With French summary. The equation of the dynatron characteristic is established in three sections—formulae I, II and III—corresponding to the three regions where the anode voltage is below the value for provoking secondary emission at the anode; where secondary emission occurs but is completely taken up by the grid; and where the difference of potentials between anode and grid is not great enough for the secondary emission to be taken up completely by the grid. These three sections are shown in Fig. 5. In §6 the writer analyses the reasons for the deviations of the actual characteristic from the theoretical formula. In §7 he gives a formula (34) for the negative resistance of the dynatron in section II. In §8 some information is given on the determination of the characteristic coefficients. In Part II, experimental, the results of measurements on some triodes functioning as dynatrons are described. Fig. 11 gives a comparison between the experimental and calculated curves.

2236. A NEW TYPE OF TWO-TERMINAL OSCILLATOR CIRCUIT: THE USE OF THE 57 OR 6C6 TO OBTAIN NEGATIVE TRANSCONDUCTANCE AND NEGATIVE RESISTANCE [for Frequencies up to 15 Mc/s: Advantages over Dynatron Oscillator].—(*QST*, April, 1935, Vol. 19, No. 4, pp. 45–47 and 58.)

RECEPTION

2237. A MAINS-DRIVEN 7-METRE WAVE RECEIVER [Insensitive to Hand-Capacity: Large Output].—C. F. A. Pailler: Möller. (*Funktech. Monatshefte*, April, 1935, No. 4, pp. 151–153.) Improved version of a receiver described by Möller.

2238. RECEIVER CONSTRUCTION FOR ULTRA-SHORT-WAVE BROADCASTING ON 7 METRES.—E. Schwandt. (*Funktech. Monatshefte*, February, 1935, No. 2, pp. 55–61.)

2239. MICRO-WAVE EQUIPMENT AND TESTS OF THE R.I.E.C. [Leghorn].—(*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 241–251.)

2240. OSCILLATIONS IN THE MAGNETO-IGNITION SYSTEM AND THEIR ELIMINATION.—W. B. Smith. (*Canadian Journ. of Res.*, April, 1935, Vol. 12, No. 4, pp. 508–518 and Plates.)

Author's summary:—A theoretical analysis of the magneto-ignition system operated in air shows that there are 10 possible oscillations, but an oscillographic analysis shows that in the range tested there are only two actually present, one of frequency about 3 500 c/s and the other about 180×10^3 c/s; the latter is responsible for most of the radio interference. Series resistances, "suppressors," were found to reduce the interference and, when combined with good shielding, very nearly eliminated it, but when large values of series resistance were used the brilliancy of the spark was greatly reduced. This was overcome by increasing the electrostatic capacity of the spark plug by a special design, so that, when the plug was used with a 50 000-ohm suppressor and adequate shielding, there was negligible interference with only a slight reduction in the brilliancy of the spark in air.

2241. TUNED ANTENNA CIRCUITS FOR AUTO RADIO [to increase Signal/Noise Ratio].—(*Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 20–21.)

2242. ON NON-PERIODIC FORCES, ACTING ON OSCILLATORY SYSTEMS [*e.g.* Radio Interference].—Alexander. (*See* 2216.)

2243. A DETECTOR CIRCUIT FOR REDUCING NOISE INTERFERENCE IN C.W. RECEPTION: A NEW EXPERIMENTAL ANGLE IN THE ATTACK ON MAN-MADE STATIC [New One-Valve Limiting Device as Second Detector in Superheterodyne Receiver].—L. E. Thompson. (*QST*, April, 1935, Vol. 19, No. 4, pp. 38–40.)

The signal voltage on the device must be at least equal to the c.w. oscillator voltage, so that the circuit is limited practically to use as the second detector of a superheterodyne receiver. The signal produces a peak a.f. voltage proportional to the peak voltage of the oscillator, the wave form of the a.f. signal being *approximately sinusoidal*, at a frequency, say, of 1 000 c/s. The interference produces a peak audio voltage of approximately the same amplitude, the latter being limited by the magnitude of the c.w. oscillator voltage. The audio wave form of the interference is somewhat flat-topped, occurs (say) 120 times per second, and each impulse lasts (say) 1/5000th sec. Thus the signal voltage has a much higher *effective* value than that of the interference, and a signal/noise ratio of 4/1 has been measured when with the ordinary circuit it was impossible to tell whether the signal was present. A similar arrangement for telephony reception is being tested.

2244. Radio Interference [particularly Industrial: Methods of Suppression: Measurement].—T. H. Kinman. (*B.T-H Activities*, March/April, 1935, Vol. 11, No. 2, pp. 45–53.)

2245. Meeting of the Measuring Sub-Committee of the Broadcast Interference Section (CISPR) of the International Electrotechnical Commission (IEC) in December, 1934 (Berlin).—(*E.T.Z.*, 4th April, 1935, Vol. 56, No. 14, pp. 409–410.)

2246. Interference Suppression in Switzerland [Table of Data].—(*E.T.Z.*, 18th April, 1935, Vol. 56, No. 16, p. 464.)

2247. Apparatus for Measuring the Severity of Radioelectric Interference [used by French Administration in connection with the 1934 Decree regarding Interference].—H. Subra. (*Ann. des P.T.T.*, April, 1935, Vol. 24, No. 4, pp. 368–384.)

2248. Mains Interference with Directly Heated Output Valves [Oscillographic Investigation of Hum].—J. F. Tönnies. (*Funktech. Monatshefte*, April, 1935, No. 4, pp. 138–139.)

The advantage of the use of a potential divider, instead of the mid-point of the transformer, for push-pull connection: the comparative unimportance of the fundamental mains frequency: the advantage of a special heating transformer: interference produced by a magnetron action of the mains transformer, in addition to the usual inductive action.

2249. The Influence of High-Tension Insulators on Broadcast Reception [Interference Investigation].—W. Furkert. (*E.T.Z.*, 18th April, 1935, Vol. 56, No. 16, pp. 449–452.)

Results on the insulator losses, measured by a Schering bridge method, are compared with results on the interference produced in a broadcast receiver. The curves of Figs. 9–11, taken with different types of insulator, show that the sudden rise of interference occurs at the same potential where the loss curve rises suddenly. The directness of the loss method, thus confirmed as to its applicability, makes it preferable for the investigation of new insulator types. Various important types are considered critically, and methods indicated for improving them. Oscillograms of receiver noise are also used to supplement the interference measurements (Figs. 14 and 15). The writer refers to recent work of Vieweg, Dennhardt, and Schuepet and Sollima.

2250. Improved Interference-Quenching Circuits [and the Avoidance of Danger from Electrical Machines provided with Large Condensers].—W. Koch and H. Maas. (*E.T.Z.*, 4th April, 1935, Vol. 56, No. 14, p. 410: summary only.)

2251. Interaction of Radio Waves: a Summing-Up of Listeners' Experiments [Field Strengths of 5 mV/m sufficient to produce Interaction: Conflicting Evidence on Effect of Fading: etc.].—E. V. Appleton. (*World-Radio*, 1st and 8th March, 1935, pp. 17 and 21: 16.) For a report on the results obtained by the World-Radio Research League see *ibid.*, 3rd and 10th May, 1935, pp. 19 and 15: also 2252, below.

2252. Interaction of Radio Waves [Do Medium Waves impose on Long Waves? Apparent Case of a Morse Station imposing on Beromunster—Is Morse Interference largely an Interaction Effect? etc.].—R. Stranger. (*World-Radio*, 8th Feb. 1935, p. 22.) For other work on the "Luxembourg Effect" *see* 2168 and 2170, under "Propagation of Waves."

2253. Receiver Selectivity Characteristics: What They Mean and How to Use Them.—J. J. Lamb. (*QST*, May, 1935, Vol. 19, No. 5, pp. 37–41.)

2254. Dual A.F. Amplifiers [as in Howard "Grand" Receiver].—(*Rad. Engineering*, April, 1935, Vol. 15, No. 4, p. 20.)

2255. Dual I.F. Amplifiers [One for High-Fidelity Broadcasting, the Other for Distant Broadcasting and Short-Wave Reception].—(*Rad. Engineering*, April, 1935, Vol. 15, No. 4, p. 21.)

2256. The Application of Superheterodyne Frequency Conversion Systems to Multi-Range Receivers [Unwanted Space-Charge Coupling in Converter: 1600 kc/s I.F. advantageous but requires Several Circuits for Adequate Selectivity: L/C Ratio: etc.].—W. A. Harris. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 279–294.)

2257. A Single-Span "People's" Superhet [Three-Valve, with Rectifier for A.C. Model: Constructional Details].—W. J. Wilhelmy. (*Funktech. Monatshefte*, April, 1935, No. 4, pp. 143–150.) For previous German papers on single-span receivers *see* 1424 of May and 1849 of June.

2258. The German "People's Receiver."—P. Besson. (*L'Onde Élec.*, April, 1935, Vol. 14, No. 160, pp. 256–263.)

2259. A 1935 Version of the Original Single-Signal Superhet.—E. A. Hubbell. (*QST*, May, 1935, Vol. 19, No. 5, pp. 44–47 and 120, 122.)

2260. The Saba 330 WL, a Three-Circuit Three-Valve Band-Filter Receiver for A.C.—(*Funktech. Monatshefte*, April, 1935, No. 4, pp. 161–164.)

2261. The Design Calculation of Ganged Condensers giving a Constant Frequency Difference [for Superheterodyne Receivers: Single-Knob Tuning by Suitable Profile-Shapes of Rotor Plates].—Schad. (*Funktech. Monatshefte*, April, 1935, No. 4, pp. 155–156.)

2262. ADJUSTABLE COUPLING FOR I.F. TRANSFORMERS [in Superheterodyne Receivers: leading to Economies in Manufacture].—(*Rad. Engineering*, April, 1935, Vol. 15, No. 4, p. 21.)

2263. EFFECTS OF AVC VOLTAGE DISTRIBUTION [Investigation of Different Percentages applied to Various Stages, and the Effects on Noise Level].—E. E. Overmier. (*Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 12 and 19.)

2264. RECENT PROBLEMS FROM THE TECHNIQUE OF AUTOMATIC VOLUME CONTROL.—Th. Sturm. (*Funktech. Monatshefte*, February, 1935, No. 2, pp. 49–53.)

AVC by (a) valves of special characteristic (variable-mu, hexodes); (b) cathode-circuit resistance; (c) biased diode: section (d) discusses the effect on "dynamic" in music, and section (e) shows how this effect can be avoided by the use of a second diode or copper-oxide rectifier. (f) Complete independence of input signal strength by simultaneous r.f. and a.f. control; (g) crack-killer with diode; (h) controlled mixing valves; and (i) the limits of control.

2265. THE OVERWORKED MULTIGRID TUBE [6B7 arranged to give I.F. Amplification, Detection, A.F. Amplification, Noise Suppression and AVC].—(*Rad. Engineering*, April, 1935, Vol. 15, No. 4, p. 21.)

2266. ON THE "DIFFUSION" COUPLING [or "Depolarisation" Coupling: Only a Capacity Effect? Criticism and Reply].—S. Krauthamer: Cordebas. (*Rev. Gén. de l'Élec.*, 11th May, 1935, Vol. 37, No. 19, pp. 595–598.) For Cordebas' original announcement *see* 1933 Abstracts, p. 622.

2267. PRICING RADIOS BY FORMULA: AN EMPIRICAL METHOD OF DETERMINING MINIMUM LIST PRICES.—(*Electronics*, April, 1935, p. 120.)

2268. "PRÜFEN UND MESSEN VON RÖHREN UND EINZELTEILEN" [for Broadcast Receivers: Book Review].—R. Wigand. (*E.T.Z.*, 25th April, 1935, Vol. 56, No. 17, p. 495.)

AERIALS AND AERIAL SYSTEMS

2269. REFLECTORS FOR ULTRA-SHORT WAVES.—W. Majewski. (*W.P.P.I.T.* [*see* 2313], No. 2, Vol. 6, 1935, pp. 15–27.)

With French summary. After stressing that these reflectors by no means behave like optical reflectors, the writer gives, in Part I, general considerations on "grid" and "solid" reflectors: the theoretical study is so complicated that design is best based on experimental data, and in Part II the results by Gresky, Köhler and Darbord are discussed (Abstracts, 1929, p. 106; 1932, p. 525; and 1932, pp. 346 and 525). "From the comparison of the behaviour of the various reflectors (table III) it appears that the action of untuned grid reflectors, of opening not greater than 5λ, is stronger than that of the others. Since the action of solid reflectors, with openings up to 5λ, is weaker than that of untuned grid reflectors, it would be interesting to study the change in effectiveness of the directive systems in question as we pass from the untuned grid to the solid types by a gradual decrease of the spacing. Another interesting question, little studied, is the action of the resonators (non-energised aerials) forming the reflector elements, as a function of their reflecting aptitude (wave reflectors) or of their energy-concentrating aptitude (wave directors), which is connected with their length being greater or less than λ/2." The writer ends with the remark that the study of the application of reflectors to ultra-short waves, for the transmission of signals or energy, is only in its infancy.

2270. PAPER AND DISCUSSION ON MICRO-WAVES [including Aerials, Reflectors, etc.].—R. W. Corkling. (*Journ. Television Soc.*, March, 1935, Series 2, Vol. 2, Part 1, pp. 1–11.)

2271. THE CONTROL OF RADIATED FIELD PATTERNS [and a New Aerial for Short and Ultra-Short Waves].—J. L. Reinartz. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 272–273: summary only.) *See* also 1434 of May.

2272. EXPERIMENTS WITH DIRECTIVITY STEERING FOR FADING REDUCTION.—E. Bruce and A. C. Beck. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 195–210: *Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 357–371.)

Experiments are described in which changes in short-wave fading are correlated with changes in the directive pattern of a rhombic antenna made by mechanically changing its shape (1932 Abstracts, p. 96). The "steerable" antenna directivity enables one only of the several rays present in the received signal to be accepted, thus reducing the fading. "The results demonstrate that sharp angular discrimination is a basically sound method of combating fading which is due to phase interference."

2273. CONTROLLED RADIATION FOR BROADCASTING [Details of the WOR Aerial: Nitrogen-Filled Concentric Feeder: Coupling and Phase-Shift Units].—J. F. Morrison. (*Bell Lab. Record*, April, 1935, Vol. 13, No. 8, pp. 232–237.)

2274. GENERAL CONSIDERATIONS OF TOWER ANTENNAS FOR BROADCAST USE [Means for Improving Current Distribution and Performance: Sky-Wave Reduction more important than Ground-Wave Increase: Effect of Base Capacity: Ground System and Earth Currents: etc.].—Gihring and Brown. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 311–356.) The full paper, a summary of which was dealt with in 1866 of June.

2275. NON-SINUSOIDAL CURRENT DISTRIBUTION IN GUYED CANTILEVER AERIALS AND ITS EFFECT ON THE VERTICAL FIELD PATTERN.—Roder. (*See* 2230.)

2276. MEASUREMENTS OF THE VERTICAL RADIATION CHARACTERISTICS OF [Anti-Fading] BROADCASTING AERIALS.—von Handel, Krüger and Pfister. (*Hochf:tech. u. Elek: akus.*, April, 1935, Vol. 45, No. 4, pp. 109–111.)

"Up to now the effectiveness of the new broadcasting aerials for increasing the fading-free reception zone has only been backed—apart from statistical material of field-strength measurements on the ground—by theoretically calculated vertical radiation characteristics. The attempt at a measured determination of the radiation, in America [Ballantine, 1934 Abstracts, p. 379], led to a negative result. The present paper gives the results of aircraft measurements in Germany, which are in good agreement with the theoretically expected results." The measurements were taken in an all-metal aeroplane with a 1 m vertical aerial, flying horizontally at various heights at about 4 km from the transmitter: for very steep angles the flights at a height of 3 000 m were brought gradually nearer to the transmitter. The angle of elevation of the aeroplane was measured by an observer (in short-wave communication with the aeroplane) at the foot of the aerial at the moment when the direction of flight was at right angles to the direction of the transmitter: which was also the moment when the receiver output voltage and the flying height were taken in the aeroplane. In working out the results the receiving aerial characteristic was taken as a cosine function of the angle of elevation, and the field strength was assumed to be inversely proportional to the distance.

The aerials tested were the Munich "high antenna" (Lorenz), consisting of an 80 m vertical dipole fed at 120 m above earth and loaded at the ends; the Tegel (Berlin) Telefunken vertical aerial on a 160 m mast, with loaded end and current antinode 26 m above earth (similar to the Breslau aerial); and, for comparison, the T-aerial of the Deutschland-Sender. In the Munich case a direct comparison (Fig. 1) was made with an ordinary straight-wire $\lambda/4$ aerial. Both the anti-fading aerials showed a marked minimum at 70°; this is rather higher than the angle calculated on the assumption of a perfectly reflecting earth (62° for the Munich dipole: on the assumption of $\sigma = 10^{-13}$ and $\epsilon = 20$ this would approach 70°).

2277. A SHORT-WAVE DIRECTIONAL ANTENNA OPERATING ON TWO WAVELENGTHS HAVING AN INTEGRAL RATIO AND IN A DEFINITE WAVELENGTH RANGE.—G. I. Michelson. (*Izvestia Elektroprom. Slab. Toka*, February, 1935, No. 2, pp. 1–10.)

The possibility of such operation is discussed "and some new types of such antennae are proposed (Figs. 3–8 and 11). A method for calculating the parameters of such antennae is given, and the following are determined for each type of antenna: (1) the optimum phase-shift between the antenna and reflector currents, as well as the ratio of these currents; (2) the radiation resistance; (3) the directivity factor; (4) the input impedance; and (5) the travelling wave ratio at the feeding point. Formulae 1 and 2, for calculating the radiation characteristics of antennae operating on wavelengths having an integral ratio, and diagrams showing their radiation distribution in the horizontal and vertical planes, are also given."

2278. PASSIVE VIBRATORS OF ARBITRARY LENGTH [Reflectors, Directors, Ropes, Masts, etc., as Components of Modern Transmitting Aerial Systems: Theoretical Treatment].—M. S. Neumann. (*Izvestia Elektroprom. Slab. Toka*, February, 1935, No. 2, pp. 10–18.)

2279. ON A THEORY OF THE ACTION OF RECTANGULAR SHORT-WAVE FRAME AERIALS [Development of "Formatising" Theory: Critical Dimensions for Rectangular Frames].—L. S. Palmer and D. Taylor. (*Proc. Phys. Soc.*, 1st May, 1935, Vol. 47, Part 3, No. 260, pp. 377–387.)

This paper develops the approximate theory already given by the writers (1934 Abstracts, p. 153—three) and considers the magnitude of the errors arising therein. Critical dimensions for rectangular transmitting and receiving frames are exactly determined; the maximum errors arising from the use of the approximate formulae are not greater than the experimental errors arising with short waves of length comparable to the frame dimensions. *See* also 2280.

2280. THE CURRENT VARIATIONS IN A SHORT-WAVE SQUARE FRAME AERIAL REVOLVING IN ITS OWN PLANE [Experimental Confirmation of Theory].—L. S. Palmer and R. Witty. (*Proc. Phys. Soc.*, 1st May, 1935, Vol. 47, Part 3, No. 260, pp. 388–399.)

See also 2279. Current measurements were made with the frame fixed amd the measuring instrument moving round it, and the frame revolving while the measuring instrument was fixed. Current variations agreed with those already predicted theoretically. "When a square frame aerial is used with short waves and revolves in its own plane, then, in addition to spatial current-variations round the perimeter of the frame due to the formation of fixed current nodes and antinodes, there may also be temporal current variations at any fixed point due to the fact that the frame may become alternately formatised and deformatised as it revolves."

2281. THE V-DOUBLET NOISE-REDUCING RECEIVING ANTENNA.—H. A. Crossland. (*QST*, May, 1935, Vol. 19, No. 5, pp. 29 and 110.)

2282. MORE ON THE PRACTICAL OPERATION OF TRANSMITTING ANTENNAS: IMPEDANCE MATCHING AND DIRECTIONAL FEATURES OF HARMONICALLY-OPERATED LONG-WIRE TYPES.—W. S. Potter and H. C. Goodman. (*QST*, April, 1935, Vol. 19, No. 4, pp. 21–26.)

2283. THE DESIGN OF A HIGH-FREQUENCY TRANSFORMER FOR COUPLING A RADIO TRANSMITTER TO AN AERIAL CIRCUIT.—R. V. Lvovich. (*Izvestia Elektroprom. Slab. Toka*, No. 2, 1935, pp. 29–39.)

A simple coupling circuit is examined consisting of an inductance L_1 in the anode circuit of the final stage coupled to an inductance L_2 in the aerial circuit. A method is presented for calculating L_1, L_2, and mutual inductance M, for given transmitter output voltage and aerial power. The method is similar to that generally used in designing two inductively coupled oscillating circuits, but the practical requirements of the case are taken into consideration and certain simplifications allowed. The case of a tuned anode circuit is also examined. The amplitude of the second harmonic is determined for each case. It is shown that the use of a tuned anode circuit does not present appreciable advantages, at any rate within the limits of the assumptions on which this discussion is based, *viz.*, that capacities and inductances are lumped, and voltages and currents are quasi-stationary. Numerical examples are given and some suggestions added with regard to constructional details of the h.f. transformer.

VALVES AND THERMIONICS

2284. ACORN-TYPE PENTODE [Type RCA 954, R.F. Amplifier, Companion of 955 Triode: for Ultra-High Frequencies: Gains of 3 or more at 1 Metre].—(*Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 13–15: *QST*, May, 1935, Vol. 19, No. 5, pp. 42 and 88, 90, 92.) Including its application as exploring valve-voltmeter.

2285. THE USE OF TYPE 57 OR 6C6 VALVES TO GIVE NEGATIVE TRANSCONDUCTANCE AND RESISTANCE. (*See* 2236.)

2286. ALL-METAL RECEIVING TUBES.—General Electric Company. (*Electronics*, April, 1935, pp. 116–117: *Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 18–19.) *See* also 1887 of June.

2287. MIXING VALVES.—M. Strutt: Wey. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, p. 258.) Querying some of Wey's values (1890 of June).

2288. THE ELECTROMETER TRIODE AND ITS APPLICATIONS [with Literature References].—G. W. Warren. (*G.E.C. Journ.*, May, 1935, Vol. 6, No. 2, pp. 118–123.)

2289. THE PERFECTION OF THE THERMIONIC VALVE [during 1910–1935].—B. S. Gossling. (*Nature*, 4th May, 1935, Vol. 135, pp. 748–750.)

2290. "ELECTRON TUBES AND THEIR APPLICATION" [including Rectifiers, Photocells, Cathode-Ray Tubes, etc.: Book Review].—J. H. Morecroft. (*E.T.Z.*, 4th April, 1935, Vol. 56, No. 14, p. 415.)

2291. MAINTENANCE OF ELECTRON EMISSION FROM THE FILAMENT OF A TRIODE AFTER ITS LOW-TENSION SUPPLY IS DISCONNECTED.—R. L. Narasimhaiya. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 249–255.)

With certain types of dull-emitter valves only. The emission is maintained at abnormally high anode or grid voltages, but also at normal or subnormal electrode potentials provided the valve is made to oscillate under high-efficiency (non-sinusoidal) conditions: it is due to heating by the anode or grid current (or both) passing through the filament. A high negative grid current is shown to flow during a small fraction of each cycle, due to secondary emission from the grid. Under static conditions it is found that with the Cossor 215P the minimum anode maintenance current, to ensure steady operation of the valve without l.t. supply, was 20 mA, less than one-seventh of the normal filament current. "If tubes having filaments of still higher emission efficiency could be manufactured, so that a current of say 10 mA flowing through the filament would cause copious emission, the phenomenon might find useful fields of application."

2292. THE SECONDARY EMISSION OF ELECTRONS FROM METALS FROM THE VIEWPOINT OF CONTEMPORARY PHYSICS [and the Electronic Theory of Metals].—W. Majewski. (*W.P.P.I.T.* [*see* 2313], No. 3, Vol. 6, 1935, pp. 12–28: with French summary.)

2293. SHOT EFFECT OF SECONDARY EMISSION.—M. Ziegler. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 415–416: in English.)

Preliminary notice of experimental results on secondary emission, using shot effect as a tool, and leading to the theory that the passage of a primary electron from cathode to collecting electron, and the passage of the secondaries released by that electron, *must be considered as one impulse*: the escapes of the secondaries are correlated with the primary impact. This contradicts previous beliefs.

2294. SPACE CHARGE DEPRESSION OF SHOT EFFECT [" Internal " Smoothing Influence on Emission Fluctuations in addition to Shunting Effect].—M. Ziegler. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 413–414: in English.)

2295. THE THERMIONIC [and Photoelectric] PROPERTIES OF TANTALUM.—A. B. Cardwell. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 628–630.)

Outgassed tantalum, when heated 1 000 hours at temperatures up to 2 200° K, gave an *apparent stable condition* of the surface; further heating up to 2 500° K gave a *final stable condition*. The values of the thermionic constants in the two conditions are given. The thermionic and photoelectric work functions of the *same* surface agree whether the surface is thoroughly outgassed or not.

2296. THE THERMIONIC EFFECT OF Pd/Ag ALLOYS WITH ADSORBED HYDROGEN [Increase of Thermionic Emission, due to Increased Number of Free Electrons and Lowering of Work Function: Alloy 60% Pd/40% Ag gives Minimum on Emission Curve].—J. Schniedermann. (*Ann. der Physik*, Series 5, No. 5, Vol. 22, 1935, pp. 425–442.)

DIRECTIONAL WIRELESS

2297. THE SYSTEM FOR REMOVAL OF AMBIGUITY IN RADIOGONIOMETRY [and the Bellini-Tosi Patents for Cardioid Production in Reception and Transmission].—E. Bellini. (*L'Onde Élec.*, April, 1935, Vol. 14, No. 160, pp. 214–215.)

2298. AURAL RADIO-RANGE BEACON OF THE GONIOMETRIC TYPE.—A. N. Plemiannikov. (*Izvestia Elektroprom. Slab. Toka*, November, 1934, No. 9, pp. 30–42.)

Author's summary:—Fundamental data on

designing aural radio beacons of the goniometric type; analysis of tuning up the circuits in the case of a goniometer with an untuned stator; description of a goniometric aural radio-range beacon operating as a four-course-indications beacon or as a beacon giving 10° bearings.

2299. DIRECTIONAL RADIO AS AN AID TO MARINE NAVIGATION [Short Survey, including Warble-Note "Warning" Beacon].—(*Tech. News Bull. of Nat. Bur. of Stds.*, February, 1935, No. 214, pp. 11–12.)

2300. PLAN OF ORGANISATION OF THE MARINE RADIO-BEACONS IN ITALY [and Data of the First Installations].—S. Rosani. (*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 138–153.)

ACOUSTICS AND AUDIO-FREQUENCIES

2301. TETRODE COUPLING IN LOW-FREQUENCY AND DIRECT-CURRENT AMPLIFICATION.—H. C. Huizing. (*Tijdschrift Nederlandsch Radiogenoot.*, December, 1934, Vol. 6, No. 6, pp. 109–114.)

In Dutch. From the author's summary:—"A space-charge tetrode in a saturated condition is used as a coupling device in such a way that the internal differential anode resistance is very large compared with the d.c. resistance. With a Philips s.g. valve E446 as amplifier, and a space-charge-grid valve A441 as coupling element, it is possible to obtain a gain of 2 500 per stage for l.f. or d.c. voltages, using normal battery voltages. A uniform amplification of some hundred times in the audible range may be obtained after suitable adjustment if special care is taken as regards parasitic capacities."

2302. CABLE CROSSTALK—EFFECT OF NON-UNIFORM CURRENT DISTRIBUTION IN THE WIRES [Proximity Effect].—R. N. Hunter and R. P. Booth. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 179–194.)

A description of tests "made to determine the influence of the proximity effect on the mutual inductance between circuits; data are given both for the case of two isolated non-twisted pairs and for the case of pairs in a quadded 19-gauge cable." Figures are given of the current distribution and phase shift at frequencies of 56 and 112 kc/s, and for the complex mutual inductance between pairs of parallel wires as a function of frequency.

2303. DISTORTIONS IN NON-LINEAR SYSTEMS.—Tischner. (*See* 2217.)

2304. FERROMAGNETIC DISTORTION OF A TWO-FREQUENCY WAVE.—R. M. Kalb and W. R. Bennett. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 322–359.)

A small magnetising force of two incommensurable frequencies was used to produce ferromagnetic induction. Two-frequency wave-shapes of two given classes, distinguished by the ratios of amplitudes and frequency, were chiefly studied and the types of hysteresis loops produced are shown in Fig. 1. From these loops, sinusoidal components of the flux wave are determined, using Fourier's series. The theory of the multi-branched hysteresis loop is given and the induction calculated. Intermodulation products are worked out. The voltages calculated by the theory are then compared with measured values for several coils, using two common core materials. Good agreement is found. A correlation with single-frequency results is given. Hysteretic impedances are calculated and measured.

2305. THE VARIATION WITH FREQUENCY OF THE POWER CAPACITY OF IRON-CORED TRANSFORMERS [for Transmitter Modulation or Big Loud-speaker Equipments, etc.].—G. Eckart. (*Hochf:tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, pp. 137–140.)

"For the anode modulation of large transmitters and for high-power loudspeaker installations, the problem presents itself of transmitting large powers at high frequencies. The question therefore arises as to what powers an iron-cored transformer can transmit at various frequencies without its copper or iron becoming too warm through overloading; we will call the power thus defined the 'power capacity.' Further, since variation with frequency is usually only dealt with from the communication-engineering standpoint, where the maximum power capacity plays no part, it is of theoretical interest to investigate the dependence on frequency from the power-engineering standpoint." Permeability is assumed to be constant: this assumption is the more justified the higher the frequency (a 1909 paper by Schames is here quoted). Skin effect and winding capacity are neglected, the load is taken as purely active, and other assumptions regarding copper and iron losses, generally fulfilled by designers, are made.

The behaviour of the tuned transformer, in which the effect of leakage inductances is compensated by capacities, is first examined (§ 2): here of course only a small frequency band around the resonance frequency can be dealt with. In § 3 the untuned transformer, in which the effects of leakage have to be taken into account, is dealt with. Equation 11 is derived for the load resistance R_a under the conditions of maximum permissible secondary output at different frequencies: R_a is a measure of the required power capacity, and Fig. 3 gives its characteristic curve (full line) as derived from equation 11. But this curve must be corrected at the low and high frequencies, as shown in Fig. 4, for reasons given. In the final section the frequency giving the maximum power capacity is sought, for conditions of small and large leakage respectively (Figs. 5 and 6). *See* also *Arch. f. Elektrot.*, No. 3, Vol. 29, 1935, p. 215.

2306. TRIALS OF NEW WIDE-BAND PROGRAMME CIRCUITS [40–8 000 c/s: between Chicago and San Francisco].—H. S. Hamilton. (*Bell Lab. Record.*, February, 1935, Vol. 13, No. 6, pp. 177–183.)

2307. ON THE STUDY OF MECHANICALLY COUPLED ACOUSTIC SYSTEMS.—F. N. Trotsevitch. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 4, 1934, pp. 1746–1755.)

A theoretical study exemplifying the use of the method of electro-mechanical analogies. The system studied consisted of two diaphragms actuated by the same coil and mounted on opposite sides of the same framework. An experimental verification of the results obtained is given.

2308. OPTIMUM REVERBERATION OF MUSIC ROOMS.—S. Liwschitz. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 4, 1934, pp. 1740–1745.)

After a critical review of the work of Knudsen (1932 Abstracts, p. 40) an equation is derived (4) which enables the optimum reverberation of a room of volume V to be calculated from the optimum reverberation already determined experimentally for a similar type of room of volume V_1. Experiments are described which were carried out with a view to determining the constants of equation (4) for a concert hall, radio studio, and cinema auditorium, and curves are given from which the optimum reverberation can be found for various sizes of each of the above types of room. It is pointed out that in the case of the cinema auditorium the reverberation of the recording studio must be taken into account, and that the combined reverberation is normally 0.1 sec. higher than that of the auditorium alone. A curve is also added showing the variation of the optimum reverberation with frequency.

2309. NOVEL ACOUSTICS OF KÖNIGSBERG STUDIOS.—(*Electronics*, April, 1935, p. 121.)

2310. THE CONTRIBUTIONS OF SCIENCE TO THE DEVELOPMENT OF THE MODERN GRAND PIANOFORTE [General Historical Account].—G. Marriner. (*Journ. Franklin Inst.*, January, 1935, Vol. 219, No. 1, pp. 1–15.)

2311. PRECISION STUDY OF PIANO TOUCH AND TONE.—Hart, Fuller and Lusby. (*Journ. Acoust. Soc. Am.*, October, 1934, Vol. 6, No. 2, pp. 80–94.)

2312. SELF-OSCILLATING SYSTEMS SIMILAR TO THE REED HARMONIUM AND THE CLARINET.—W. I. Juswinski. (*Tech. Phys. of U.S.S.R.*, No. 2, Vol. 1, 1934, pp. 194–204: in German.)

2313. THE RECTIFYING PROPERTIES OF VARIABLE RESISTANCE [*e.g.* Carbon] MICROPHONES.—J. Groszkowski. (*Wiadomósci i Prace Państwowego Inst. Telekomunikacynego*, Warsaw ["*W.P.P.I.T.*"], No. 2, Vol. 6, 1935, pp. 13–14.)

It is shown theoretically, and confirmed experimentally, that such a microphone, excited by a loudspeaker, functions as a synchronised rectifier if connected in a circuit (Fig. 1) containing the source of e.m.f. exciting the loudspeaker. Different rectifying conditions are obtained as the phase of the excitation is varied with respect to that of the circuit.

2314. A SINGLE-POLE TELEPHONE RECEIVER.—C. Bähr. (*E.T.Z.*, 16th May, 1935, Vol. 56, No. 20, p. 570.)

2315. METHOD OF FREQUENCY MULTIPLICATION FOR "SLOW MOTION" REPRODUCTION OF SOUND-ON-FILM RECORDS.—Silka. (*See* 2328.)

2316. AN ACOUSTIC BOLOMETER [and Its Use in Carbon Microphone Investigations].—B. G. Shpakovsky. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 4, 1934, pp. 1768–1773.)

A theoretical and experimental investigation of the rise in resistance of a carbon microphone when the sound impinging on the diaphragm increases in intensity. The sound intensity in these experiments was indicated by the angle of twist of a thin aluminium disc suspended on a thread between the source of sound and the microphone. This instrument is called a bolometer, since it is similar in action to the ordinary bolometer used for measurement of radiant heat.

2317. ON THE INCREASE OF LOUDNESS PRODUCED BY MORE THAN ONE SOURCE OF SOUND.—E. Lübcke: Aigner and Strutt. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 16, 1935, pp. 77–80.)

Küchenmeister, in 1926, and Aigner and Strutt (1501 of May) by a different method, found that when equally strong sounds from two sources, with a timbre difference, reached an observer with a time difference of 1/5 to 1/30 sec., they produced an increased loudness greater than the theoretical value of 3 phon ($L_2 = L_1 + 10 \log 2 = L_1 + 3$ phon). Since this point is of importance in comparing subjective and objective methods of measuring sound, the writer has carried out tests with two loudspeakers, taken separately and together and using subjective and objective measuring methods. Subjectively, an increased loudness of 5 to 6 phon is found, while objectively the increase is only 3 phon—which is the value given subjectively when there is no path-length difference. The writer attributes this subjective exaggeration to an apparent bringing-closer and magnification of the sound image, produced more by time effects than by timbre differences; quoting in this connection the results of Steudel and of von Békésy (Abstracts, 1933, p. 510; 1929, p. 638; *also* 1931, pp. 45 and 101.)

2318. AURAL RECTIFICATION.—Stowell and Deming. (*Journ. Acoust. Soc. Am.*, October, 1934, Vol. 6, No. 2, pp. 70–79.)

2319. A MAGNETOSTRICTION ECHO DEPTH-RECORDER.—Wood, Smith and McGeachy. (*Journ. I.E.E.*, May, 1935, Vol. 76, No. 461, pp. 550–566.) The full paper and discussion, a summary of which was referred to in 1118 of April.

2320. VELOCITY OF SOUND IN LIQUID OXYGEN [Measured by Scattering of Light by Supersonic Waves].—R. Bär. (*Nature*, 26th Jan. 1935, Vol. 135, p. 153.)

2321. OPTICAL OBSERVATIONS OF SOUND WAVES IN ARCS [Sound Velocity in Arc gives Temperature].—C. G. Suits. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 335: abstract only.)

2322. A NEW METHOD AND APPARATUS FOR THE PRODUCTION OF HIGHLY DISPERSED CONDITIONS [Emulsions and Colloidal Solutions by use of Piezoelectric Quartz].—Claus. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 16, 1935, pp. 80–82.)

2323. "HANDBUCH DER EXPERIMENTALPHYSIK VON W. WIEN AND H. HARMS" [Review of Vol. 17, Part I].—(*Hochf: tech. u. Elek: akus.*, January, 1935, Vol. 45, No. 1, p. 36.)

PHOTOTELEGRAPHY AND TELEVISION

2324. A Study of Television Image Characteristics. Part 2: Determination of Frame Frequency in Terms of Flicker Characteristics [for Progressive and Interlaced Scanning].—E. W. Engstrom. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 295–310.) For Part 1 *see* 1934 Abstracts, p. 157.

2325. Investigations on High-Vacuum Cathode-Ray Tubes [Studies of Electrostatic Deflection, Wehnelt-Cylinder Brightness Control, and Immersion-Lens Concentration].—W. Heimann. (*Funktech. Monatshefte*, February, 1935, No. 2, Supp. pp. 1–5.)

2326. Recent Improvements in Cathode-Ray Tubes, with Particular Reference to Television.—G. Parr and W. T. Price. (*Journ. Television Soc.*, March, 1935, Series 2, Vol. 2, Part 1, pp. 15–18.)

2327. Cathode-Ray Television with Automatic Synchronisation.—R. Barthélémy. (*Comptes Rendus*, 24th April, 1935, Vol. 200, No. 17, pp. 1470–1472.)

The picture signals and the synchronising signals arrive mixed at the receiver. They are separated by the simultaneous action of (a) a valve with automatic bias which passes the oscillations of large amplitude and suppresses those of small amplitude, and (b) a low-impedance transformer between this valve and the control grid of the " line " thyratron: this transformer does not transmit impulses " below a certain frequency, or—more correctly—below a certain steepness of front." In this way two eliminating effects are added, one based on the amplitude and the other on the shortness of the " top " compared with the picture modulation. " The separation obtained is complete and does not depend, within wide limits, on the absolute strength of the signals."

In addition to the "line" thyratron there is an " image " (framing) thyratron, and this is controlled as follows:—at the transmitting end, the synchronising signal normally sent at the end of each line is omitted at the end of the *last line but one* of the frame: at the receiving end, a suitable coupling is provided between the discharge circuit of the " line " thyratron and the grid of the " framing " thyratron. The effect of the omission of this signal is that the " line " thyratron is not actuated and that, as a result, the voltage on the condenser continues to grow: the bias being so arranged that this thyratron can stand (say) twice its usual anode voltage without discharging. Then, at the end of the *last* line, the ordinary " line " signal causes the discharge of the quadrupled energy, at the moment of completion of the image. It is this extra-large discharge, acting through the coupling to the " framing " thyratron, which actuates the latter. The last line is, of course, lost; this is of little importance and has compensating advantages, among these being the fact that as a result of the doubled " line " voltage the spot is thrown further than usual, so that its vertical path at frame-change is almost entirely outside the useful part of the screen.

2328. Frequency Multiplication by Amplitude Distortion [Silka's Sound-Film Work on Optical Distorting Devices with Special Forms of Characteristic giving a Transposing Action: Possible Applications to Television].—P. Hatschek: Silka. (*Funktech. Monatshefte*, February, 1935, No. 2, Supp. pp. 5–7.)

By Silka's arrangement a five-fold (say) frequency multiplication takes place at the recording of the sound film, during which the film is moving with five times the normal speed. Reproduction occurs at normal speed, without change in pitch or character, but in " slow motion." Hatschek considers that the principle involved, of frequency multiplication by static distortion, is of immediate interest as regards intermediate-film television, and that other possibilities will appear as the subject is further studied.

2329. The Report of the Television Committee. —E. V. Appleton. (*World-Radio*, 8th Feb. 1935, pp. 4 and 5.)

2330. Television in England: the Report of the English Television Committee [without Comment].—(*Funktech. Monatshefte*, April, 1935, No. 4, Supp. pp. 21–24.)

2331. Addresses at the Opening of the Berlin Television Service.—(*Funktech. Monatshefte*, April, 1935, No. 4, Supp. pp. 13–16.)

2332. Film-Scanner and Scanning-Beam Scanner of the Berlin-Witzleben Ultra-Short-Wave Transmitter.—R. Möller. (*Funktech. Monatshefte*, April, 1935, No. 4, Supp. pp. 16–19.)

2333. The Broadcasting of Sound and Vision on Ultra-Short Waves [German Scheme and Propagation Tests].—G.W.O.H. (*Wireless Engineer*, April, 1935, Vol. 12, No. 139, pp. 177–178.) Editorial on Scholz' paper (1526 of May). For an omission see *ibid.*, May, p. 237.

2334. Wide-Band Transmission over Coaxial Lines.—Espenschied and Strieby. (*Funktech. Monatshefte*, April, 1935, No. 4, Supp. pp. 24–27.) *See* 810 of March.

2335. The Problem of Long-Distance Television [and Its Transmission Lines].—G. Valensi. (*Ann. des P.T.T.*, April, 1935, Vol. 24, No. 4, pp. 301–346: to be continued.)

I. Conditions to impose on installations and lines for high-quality television (including a discussion of the proportion of the theoretical band-width actually occupied, various types of distortion, etc.). II. Types of installation and line which could be used for long-distance television: photoelectric amplifiers, inter-urban line amplifiers and lines (inductive couplings between two pairs of same cable even when capacitive couplings are eliminated —a paper by Dohmen and Mayer is here quoted: etc.). The writer then deals at length with those types of line which he considers suitable, in which crosstalk can be reduced sufficiently even when television is passing in both direction in the same " artery ": namely suitably transposed two-wire overhead circuits, screened parallel pairs, and concentric pairs. These three types are dealt with in turn, Russel's 1912 analysis being given in the case of the concentric circuit, Schelkunoff's work (435 of February—*see* also 811 of March) being referred to. Fig. 12 shows the calculated variation of the attenuation of such a circuit as a function of the ratio of diameters.

2336. PHASE DISPLACEMENTS IN RESISTANCE-COUPLED AMPLIFIERS, AND THEIR COMPENSATION.—R. G. Shiffenbauer. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1934, pp. 11–15).

When resistance-coupled amplifiers are used in television apparatus the quality of reproduction is seriously affected by the phase displacements of the amplified currents. In this paper the following two cases are examined separately: (a) when the amplifier is operated at low frequencies (image frequency and its harmonics) and (b) when it is operated at the upper limit of the frequency range. A formula (1) is derived for (a) determining the magnitude of the phase displacement for given circuit constants and frequency. The only two variable factors in this formula are R_ϕ and C_ϕ (decoupling resistance and capacity), the other constants being determined by the required bandwidth, the gain of the amplifier, and stability of operation. A number of curves are given for various frequencies showing the relationship between the relative phase displacement (θ/ω) and R_ϕ. It can be seen from these curves that the lower the frequency the greater is the value of R_ϕ required for complete compensation of the displacement. It is pointed out, however, that a displacement of 1 000 μsecs. is quite permissible in practice. In the case of a multistage amplifier the maximum permissible displacement per stage is found from the relationship $(1\,000 - t)/N$, where t is the displacement in μsecs. introduced by other sections of the television apparatus, and N is the number of stages.

It is also shown that by increasing the value of the grid leak or decreasing the value of the anode resistance complete compensation at a given frequency can be achieved with much lower values of R_ϕ. The over-compensation at the higher frequencies which will take place under these conditions can be easily counteracted by an increase of C_ϕ. A numerical example is given showing that when $C_\phi = 6\,\mu$F and the displacement at a frequency of 12.5 c/s is completely compensated, the over-compensation at the harmonics of the fundamental frequency does not exceed 25 μsecs. The increase in the amplitude of the lower frequencies due to the increase of R_ϕ and C_ϕ is next examined, and a formula is derived determining the ratio output E to input E for given circuit constants and frequency.

The practical procedure suggested by the author in designing an amplifier is as follows:—Having fixed the values of the anode resistance, grid leak and coupling capacity in accordance with the operating requirements of the amplifier, curves $\theta/\omega = f(R_\phi)$ and $E_{out}/E_{in} = \phi(f)$ are drawn for the image frequency and its second harmonic and for various values of C_ϕ. Then, taking into account the number of stages of the amplifier and the conditions necessary for its stable operation, R_ϕ and C_ϕ are so chosen that the phase displacement and the amplitude distortion do not exceed the permissible limits. With regard to the operation of the amplifier at the upper limit of the frequency range it is shown that phase displacement is not important in comparison with the amplitude distortion which takes place at these frequencies.

2337. ON THE CORRECTION OF AMPLITUDE AND PHASE CHARACTERISTICS OF AMPLIFIERS.—G. V. Braude. (*Journ. of Tech. Phys.* [in Russian], Nos. 9 and 10, Vol. 4, 1934, pp. 1714–1739 and 1818–1828.)

A theoretical and experimental investigation with a view to reducing the amplitude and phase distortion in resistance-coupled amplifiers used in television. The amplification factor of the amplifier is expressed as a function of frequency $f(\omega)$, which is then expanded into a Taylor's series as follows:—$f(\omega) = f(\omega_0) + f'(\omega_0)(\omega - \omega_0)/1! + f''(\omega_0)(\omega-\omega_0)^2/2! + \ldots + f^n(\omega_0)(\omega-\omega_0)^n/n! + R_n$, where ω_0 is the image frequency at which the amplitude and phase distortion should be kept as low as possible. It can be seen from the above expression that, in order to maintain the amplification factor constant at all frequencies, the derivatives of $f(\omega)$ with respect to ω_0, and the residual term R_n, should be equal to zero. It is shown that in practice the number of derivatives satisfying this condition cannot exceed the number of parameters of the amplifier circuit. A similar method is applied to phase shift, which (it is pointed out) can be corrected much more easily than amplitude distortion. Thus if one derivative only is made equal to zero the phase shift is reduced to a value within the permissible limit, while the amplitude distortion still remains excessive.

Using the above method, a number of circuits are examined in detail, and the two following are found to be the most suitable:—(a) Input stage: two inductances are added in the output circuit of a triode, one being connected in series with the anode resistance and the other between the anode of the triode and the grid of the subsequent stage; and (b) Intermediate stages: screen-grid valve with an inductance in series with the anode resistance. A method is given for the complete calculation of the components of (b), while in the case of (a) until further research is made only approximate calculation is possible.

As an illustration, Zworykin's system is examined having an amplification factor of the order of 50 000. It appears than even if 22 stages are employed, using ordinary resistance coupling, the maximum loss in amplitude would be of the order of 36%. If circuit (b) is employed the loss is reduced to 5% when only 7 or 8 stages are used. The phase shift in this circuit is reduced to the permissible value (18° on the higher frequencies) by using 5 or 6 stages, which once more indicates that amplitude distortion is the more difficult to correct.

2338. DISTORTIONS IN NON-LINEAR SYSTEMS.—Tischner. (*See* 2217.)

2339. THE TRANSIENT ASPECT OF WIDE-BAND [Television] AMPLIFIERS: EXAMINATION WITH THE CATHODE-RAY OSCILLOGRAPH.—O. S. Puckle. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, pp. 251–256.)

Using a second oscillograph (deflected by the saw-tooth time base common to both) to provide the light pulse which acts on the photocell and furnishes the transient. The writer urges that the behaviour of such amplifiers should be measured in terms of time constants (at the two ends of the gamut) rather than in terms of a gain/frequency characteristic. The method permits of these measurements.

2340. AN APPROACHING REVOLUTION IN LIGHT TECHNIQUE [the Development of the Gaseous Discharge Lamp, particularly the Very High Pressure Small Quartz Type].—P. Hatschek: Boll. (*Funktech. Monatshefte*, April, 1935, No. 4, Supp. pp. 19–21.)

2341. LAWS OF EMISSION OF RADIATION FROM THE POSITIVE COLUMN OF THE NEON DISCHARGE [Energy Distribution in Red Line Spectrum].—H. Krefft and E. O. Seitz. (*Physik. Zeitschr.*, 1st Dec. 1934, Vol. 35, No. 23, pp. 980–983)

2342. ELECTRODES OF [Special New] ALLOYS FOR LUMINOUS DISCHARGE TUBES, AND THEIR APPLICATION [including Television].—J. B. Abadie. (*Rev. Gén. de l'Elec.*, 18th May, 1935, Vol. 37, No. 20, pp. 627–633.)

2343. ON THE TIME LAG OF GAS-FILLED PHOTOCELLS.—I. F. Kvartshava and P. V. Timofeev. (*Tech. Phys. of U.S.S.R.*, No. 4, Vol. 1, 1935, pp. 469–478: in English.)

A brief review of the literature on the subject is given in which it is pointed out that so far no satisfactory explanation of the phenomena has been put forward. An account is then presented of experiments with caesium photocells filled with neon and argon under various pressures. The results obtained are given in the form of curves showing the fall in the output voltage of the cell with increase in the modulating frequency. On the basis of these results it is suggested that contrary to the opinion expressed by Campbell and Stoodley (1932 Abstracts, p. 648) the time lag is mainly determined by the time τ taken by an ion in travelling from the anode to the cathode. It is also mentioned that the time lag is affected by the presence of space charges in the photocells. Finally, it is pointed out that the photocurrent corresponding to a certain intensity of illumination of the cathode reaches its steady value only after a time interval $n\tau$, where n is the number of increasingly large groups of electrons which are liberated from the cathode. It is shown that a mathematical interpretation of the conclusions reached closely conforms to the experimental results obtained.

2344. THE CORRECTION OF THE FREQUENCY CHARACTERISTIC OF COPPER-OXIDE PHOTOCELLS FOR USE IN TELEVISION AND SOUND CINEMA.—A. D. Weissbrut and V. L. Kreutzer. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 4, 1934, pp. 1707–1713.)

A copper-oxide cell can be regarded as an a.c. generator working into a capacity C, a shunting resistance R, and a series resistance which can be neglected. The change in the impedance of this circuit and the fall in the output voltage of the cell at frequency ω as compared to the values at zero frequency are found from the expression $Z_0/Z_\omega = \sqrt{1+\omega^2R^2C^2}$ . . . . (5). It is suggested that in order to compensate this loss an inductance L and a resistance R_a should be connected in series with the anode of the valve which amplifies the output of the cell. The output impedance neglecting capacity C_e shunting the anode load will then be equal to $\sqrt{R_a^2 + \omega^2L^2}$ and the gain at frequency ω will be found from the expression $Z_{a\omega}/Z_{a0} = \sqrt{R_a^2 + \omega^2L^2}/R_a$ . . . . . (6).

It follows from the above that the loss in the photocell will be completely compensated when (5) and (6) are equal. Methods are indicated for determining the constants of the photocell and compensating circuit. Experimental curves are given showing that without the compensating circuit the loss at 12 000 c/s is 80% of the amplitude at 1 000 c/s, but when the compensating circuit is employed the overall characteristic is practically straight up to 24 000 c/s.

2345. CONCERNING THE SCHOTTKY EFFECT IN BARRIER-LAYER PHOTOELEMENTS [and the Decrease of Work Function at the Semi-Conductor/Barrier-Layer Limit as the Cause of Increasing Photocurrent with Increasing Accelerating Potential].—G. Liandrat. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1311–1312.) Discussion of a result mentioned at the end of a previous Note (Abstracts, 1934, p. 568).

2346. A NEW SELENIUM-SULPHUR RECTIFIER [Barrier-Layer] PHOTOELECTRIC CELL.—G. P. Barnard. (*Proc. Phys. Soc.*, 1st May, 1935, Vol. 47, Part 3, No. 260, pp. 477–500: Discussion pp. 500–501.)

A full description is given of the new cell already briefly described by the writer (*Illum. Engr.*, 1933, Vol. 26, p. 163). The construction of the cell is related to the results obtained, showing how far they support the theories of A. H. Wilson (1932 Abstracts, pp. 108 and 597) and of Frenkel and Joffé (*Physik. Zeitschr. der Sowietunion*, 1932, Vol. 1, p. 60: *see* also 1932 Abstracts, p. 290). Simple equations are deduced to express the performance of the cell.

2347. TEMPERATURE EFFECTS ON PHOTOVOLTAIC CURRENT AND E.M.F. OF A SELENIUM MONO-CRYSTAL PLATINUM FILM COMBINATION.—R. M. Holmes and L. C. Whitman. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 337: abstract only.)

2348. PHOTOVOLTAIC CELLS IN COMPOUND CIRCUITS: PRACTICAL DATA FOR APPLYING SERIES AND MULTIPLE COMBINATIONS.—E. D. Wilson. (*Electronics*, April, 1935, pp. 118–119.)

2349. CONTRIBUTION TO THE PHYSICO-CHEMICAL STUDY OF PHOTOSENSITIVE ELECTRODES OF COLOURING MATTER.—Cécile Stora. (*Comptes Rendus*, 18th March, 1935, Vol. 200, No. 12, pp. 1034–1037.)

2350. THE THERMIONIC [and Photoelectric] PROPERTIES OF TANTALUM.—Cardwell. (*See* 2295.)

MEASUREMENTS AND STANDARDS

2351. [Ultra-] HIGH-FREQUENCY MEASUREMENTS AT 1-METRE WAVELENGTH [avoiding Use of Instrument in Circuit under Test, by Möller's Audion-Wavemeter Method].—W. A. Krause. (*Hochf:tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, pp. 128–137.)

At wavelengths around 1 m ordinary measuring methods have serious defects: the small energy available makes necessary a tight coupling between test circuit and generator circuit, leading to strong retroaction between the two: the introduction of a meter into the test circuit produces a serious change in the latter's tuning and damping: beat methods of measuring frequency-change are impracticable, for they would require a frequency constancy of about $10^{-5}\%$: and the conditions in the oscillatory circuit can no longer be regarded as quasi-stationary. "The only calculable system is the Lecher system," and the writer shows that the audion-wavemeter method developed by H. G. Möller, which avoids the introduction of a measuring instrument into the test circuit, is just as applicable at these ultra-high frequencies as at ordinary frequencies.

The theory of the use of this retroactively-coupled blocked-grid audion wavemeter circuit, for the investigation of (*e.g.*) the damping of quasi-stationary circuits, is first briefly set out, and is followed by an analysis of its application to a Lecher system for waves of and below 1 m. It is shown that there is a complete analogy between the two cases. Preliminary tests gave a form of resonance curve (Fig. 3) quite unlike a normal resonance curve: to understand this it is necessary to consider the mechanism of the B.-K. oscillator employed in the test, and particularly the frequency and amplitude changes evoked by an alteration in the attached Lecher system (p. 131 onwards). The first attempt to compare the values of the damping of a Lecher system, calculated from the d.c. resistance by Sommerfeld's formula, with the values actually measured by the method in question, gave not even an approximate agreement. The discrepancy was thought to be due to the radiation from the parallel-wire Lecher system employed, and a screened (tube and concentric wire) Lecher system was then adopted: this at once gave a damping resistance of about 1 ohm instead of the 13 ohms measured on the parallel wires, and subsequent tests showed that the results obtained by the measuring method now agreed almost to 1% with the theoretical values. Constructional details of the tube-and-wire Lecher-system test circuit, and of the coupling between this and the parallel-wire generating ("primary") circuit, are shown in Figs. 13a and b. The final section shows how the method can be used for measuring quantities other than the damping.

2352. MEASUREMENT OF THE ABSORPTION OF [Ultra-] SHORT ELECTRIC WAVES IN DIPOLE LIQUIDS.—J. Malsch and E. Keutner. (*Physik. Zeitschr.*, 15th April, 1935, Vol. 36, No. 8, pp. 288–292.)

Waves from 0.5 to 10 m were used, and the method employed was that of Haase (Abstracts, 1934, p. 221). The work confirms former work by Malsch (1934, p. 393: *see* also 283 of January), by another method, which disagreed with the results of Haase and Krause (*loc. cit.*; also 284 of January). No maxima in the absorption curves are found, and the dipole theory is confirmed.

2353. AN EXPLORING VALVE-VOLTMETER FOR ULTRA-HIGH-FREQUENCY WORK, USING AN ACORN-TYPE PENTODE, TYPE 954.—(*See* 2284.)

2354. HIGH-FREQUENCY MEASURING CURRENT CONVERTERS [Transformer-Thermocouple Combination].—R. E. Albrandt. (*Izvestia Elektroprom. Slab. Toka*, November, 1934, No. 9, pp. 62–64.)

Described as "a logical development of measuring transformers for very high frequencies; description of measuring transformers of the author's system designed for currents from 15 to 50 A and a wavelength range from 20 to 150 m, working with an error not above 4%; frequency errors of the instruments are exceedingly small compared with those of the best hot-wire ammeters."

2355. CURRENT MEASUREMENT AT RADIO FREQUENCIES [Valve Ammeter for Small Currents].—H. E. M. Barlow. (*Nature*, 27th April, 1935, Vol. 135, p. 662.) Note on an I.E.E. paper.

2356. MULTI-RANGE RECTIFIER INSTRUMENTS HAVING THE SAME SCALE GRADUATION FOR ALL RANGES.—F. E. Terman. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 234–240.)

The character of the scale of a rectifier meter is shown to depend only on the impedance of the network across the rectifier input: this can be kept constant by suitable combinations of single series and shunt elements while at the same time the voltage and current sensitivities are varied, so that the various ranges can accurately follow the same scale.

2357. ALTERNATING-CURRENT POWER MEASUREMENT BY MEANS OF RECTIFIERS.—K. B. Karandeer and L. V. Voroshilov. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 4, 1934, pp. 1756–1762.)

The theory of operation of a wattmeter developed at the Electro-Physical Institute of Leningrad. The wattmeter employs two copper-oxide rectifiers and use is made of the fact that their characteristics are expressed by equations of the second order. The instrument is very sensitive and is capable of measuring powers of the order of a few watts.

2358. ANODE POTENTIAL MEASUREMENTS [under Undisturbed Working Conditions] WITH A VOLTMETER.—L. Bainbridge-Bell: Cosens. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, p. 257.) *See* 1594 of May for Cosen's paper. A different proof is here given, together with a simpler method of measurement.

2359. NEW RESONANCE GALVANOMETER [Adjustable Restoring Force produced by Second, Rigidly Connected Coil in Electro-Magnet Gap].—H. A. Vuylsteke. (*Rev. Gén. de l'Élec.*, 27th April, 1935, Vol. 37, No. 17, pp. 537–539.)

2360. THE DESIGN CALCULATION OF THE WINDING OF SENSITIVE MEASURING INSTRUMENTS [Optimum Ratio of Winding Weight to Dead Weight of Moving System, etc.].—H. Dallmann. (*E.T.Z.*, 4th April, 1935, Vol. 56, No. 14, pp. 400–401.)

2361. AN IMPROVED ELECTROTHERMIC INSTRUMENT [for measuring Watts, etc: by Thermal Expansion of Liquid in Closed System including Bourdon Gauge].—P. M. Lincoln. (*Elec. Engineering*, May, 1935, Vol. 54, No. 5, pp. 474–481.)

2362. THE RESISTANCE OF AN EARTH ELECTRODE AND THE METHODS OF MEASURING IT.—J. Wójcikiewicz. (*W.P.P.I.T.* [*see* 2313], No. 3, Vol. 6, 1935, pp. 29–36: in Polish.)

2363. MEASUREMENTS OF DIELECTRIC CONSTANTS [with High Precision and requiring only Small Samples: Industrial Applications].—P. C. Henriquez. (*Physica*, May, 1935, Vol. 2, No. 5, pp. 434–437: in English.)

A precision variable condenser of tubular form is described, by which a capacity difference of 5 cms can be determined: the tangential stress for the rotating movement (giving the capacity adjustment through a hollow screw) is transmitted by a special mechanism. The liquid condenser is immersed in oil, water, or mercury in a Dewar flask. Special precautions are taken in the procedure. For the capacity-measuring method *see* 2364.

2364. ACCURATE CAPACITY MEASUREMENTS [particularly for Dielectric Constant Measurements].—P. C. Henriquez and A. W. Renaud. (*Physica*, May, 1935, Vol. 2, No. 5, pp. 429–433.)

See 2363, above. Three variations of the usual beat-note method of measuring capacity and capacity changes are described. In the first, the primary circuit of a transformer, shunted by a condenser C, was connected in the anode circuit of the amplifier valve following the detector: its secondary circuit contained a rectifier and milliammeter. By a proper choice of C and of the transformation ratio, a very sharp peak in the readings could be obtained by varying the precision condenser (compensating condenser) in the test circuit. With a total capacity of 200 cms and a 1 Mc/s frequency, the adjustment was accurate within less than 10^{-4} cm. In the second method the second r.f. generator was abolished, the resonance of a quartz crystal being worked with (Figs. 5 and 6): with the same milliammeter and other conditions as before, the same accuracy was obtained. The third method also used a quartz crystal in a different connection. During prolonged measurements, any inconstancy of generator frequency was detected by having a check condenser which could be switched in to replace the dielectric-test condenser and its parallel compensating condenser, and which was made equal to these at the beginning of the measurements. On switching (by a switch of special design) this check condenser into circuit, any change in the rest of the circuit could be detected and compensated. For the constant frequency generators employed *see* 2365.

2365. CONSTANT GENERATORS [Constant-Frequency, A.C. Mains-Driven R.F. Oscillators for Precision Capacity Measurements].—P. C. Henriquez and A. W. Renaud. (*Physica*, May, 1935, Vol. 2, No. 5, pp. 425–428.)

See 2363 and 2364, above. As in Franklin's "master oscillator" (*Short Wave Wireless Communication*, Ladner and Stoner) the circuit elements of this two-pentode oscillator were so chosen and arranged as to restrict as much as possible the influence of the filament/grid capacity, and the threshold of oscillation was worked on. No mains stabilisation was found necessary: great rigidity of design was provided, and the apparatus was mounted on four tennis balls to insulate it from vibration.

2366. THE NATIONAL PRIMARY STANDARD OF RADIO FREQUENCY [Description, Procedure and Performance].—E. L. Hall, V. E. Heaton and E. G. Lapham. (*Journ. of Res. of Nat. Bur. of Stds.*, February, 1935, Vol. 14, No. 2, pp. 85–98.)

2367. MONITORING THE STANDARD RADIO-FREQUENCY EMISSIONS [Method, Equipment and Results].—E. G. Lapham. (*Journ. of Res. of Nat. Bur. of Stds.*, March, 1935, Vol. 14, No. 3, pp. 227–238.) "The records show that the emissions have been in agreement with the primary frequency standard within 2 parts in 100 million at practically all times, and the absolute value of the frequency transmitted is rarely in error by as much as 1 part in 10 million."

2368. A PRECISION FREQUENCY METER [for Monitoring Wireless Stations, etc: Resonance indicated by Constancy of Anode Current on Reversing R.F. Potential to Second Grid].—(*Rev. Gén. de l'Élec.*, 4th May, 1935, Vol. 37, No. 18, pp. 581–582.)

The pick-up loop voltages are applied directly to one grid of a two-grid valve, and indirectly, by induction in the tuning circuit, to the other grid. When the tuning circuit is exactly in resonance the two voltages are $\pi/2$ out of phase, and when this is so one voltage can be reversed by a commutator without the anode milliammeter showing any change.

2369. VERY ACCURATE MEASUREMENTS OF TIME AND FREQUENCY (SUMMARISING REPORT [with Literature References]).—U. Adelsberger. (*E.N.T.*, March, 1935, Vol. 12, No. 3, pp. 83–91.)

2370. SPECIAL RADIO TEST TRANSMISSIONS ON 12TH AND 13TH MARCH, 1935 [U.R.S.I. Tests: Bangalore Results]. — (*Current Science*, Bangalore, April, 1935, Vol. 3, No. 10, pp. 479–483.) *See* also 2015 of June.

2371. ON WAVEMETER ERRORS.—I. B. Selutin. (*Izvestia Elektroprom. Slab. Toka*, No. 10, 1934, pp. 22–28.)

This investigation is confined to the calibration and reading errors and the resultant total error of wavemeters using the following three types of tuning condenser:—(a) straight line capacity condenser, for which $\lambda^2 = M\alpha + N$, where α is the scale reading and M and N are constants; (b) straight line frequency condenser, for which $f = A - B\alpha$; and (c) mid-line condenser, for which $d\lambda/\lambda\,d\alpha$ = const.

It is pointed out that the accuracy of a wavemeter does not remain constant throughout its range, and that there is therefore no direct method for comparison of wavemeters using different types of condenser. In order to obviate this difficulty use is made of the so-called "mean integral error," which is determined by the following expression:—

$$(\Delta\lambda/\lambda)_{\text{mean}} = \{1/(\alpha_2 - \alpha_1)\} \cdot \int_{\alpha_1}^{\alpha_2} (\Delta\lambda/\lambda)d\alpha$$

where α_1 and α_2 are the first and the last divisions on the scale. It is shown that when the error of reading is interpreted in terms of the mean integral error its value is found from the same formula in all three cases, namely $\Delta\lambda/\lambda = (\log\gamma)/2m$, where m is the ratio of the total number of the divisions on the scale to that fraction of a division which can be read with accuracy, and γ is the ratio between the longest and shortest wavelengths covered by the wavemeter.

Using the conception of the mean integral error, formulae are deduced, for each of the three cases, determining the calibration and the total error. It is pointed out that the latter is not an arithmetical sum of its components. On the assumption that $d\alpha_1 = d\alpha_2 = d\alpha$, the following conclusions are reached for all three cases:—(1) the calibration error $\Delta\lambda/\lambda = 0.64(\log\gamma)/m$, and (2) the calibration error is 63% of the total error.

2372. An Adjustable Oscillator of High Precision [Accuracy of 3 c/s in Band from 10 to 1 000 kc/s: including Synchronous-Motor Control of Oscillator Air Condenser: for Filter Measurements in Carrier-on-Cable Work, etc.].—L. Armitage. (*Bell Lab. Record*, March, 1935, Vol. 13, No. 7, pp. 203–208.)

2373. A Determination of Some of the Properties of the Piezoelectric Quartz Resonator [Resonance Curve and Oscillographic Decay Methods agree: Factors affecting Decrement: Element Values of Equivalent Network: etc.].—K. S. Van Dyke. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 386–392.)

2374. Frequency/Temperature Characteristics of Oscillating Quartz Plates with Zero Temperature Coefficient.—I. Koga and M. Shoyama. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1224–1227.)

"We have shown [in previous Japanese works of 1932] that for a thin plate of quartz whose principal faces are parallel to the electrical axis x the so-called 'thickness' vibrations, used for the stabilisation of oscillators, are pure 'shear' vibrations. The experimental study of the relation between the co-latitude θ of the principal surfaces and the coefficient of variation of frequency with temperature has shown that, for $\theta = 55°$ and $138°$ approximately, the temperature coefficient is zero [1021 of April]. Recent experiments have shown us that, contrary to a previous statement (*loc. cit.*) the frequency does not vary linearly as a function of the temperature, but follows a much more complicated law, as shown in Fig. 2 and table I. The plates tested were all rectangular and their principal surfaces were made parallel to the electrical axis within about a half-minute, by means of an X-ray spectrometer."

2375. On the Laws of the Disengagement of Electricity by Torsion in Piezoelectric Substances.—P. Langevin and J. Solomon. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1257–1260.) The phenomena of "strephoelectricity" (*see*, for example, 2027 and 2028 of June) are all covered, qualitatively and quantitatively, by Voigt's general theory of piezoelectricity. But *see* 2376.

2376. Considerations on the Disengagement of Electricity by the Torsion of Quartz, and on the Reciprocal Phenomenon [Torsion does *not* cause Compressions of Electrical Axes, or *vice versa*].—E. P. Tawil. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1306–1308.) "Thus it is not in mechanical constraints, but in their effects on the equilibrium of the atomic edifice, that one should seek the bond connecting these two phenomena" [strepho- and piezo-electricity]. *See* 2375.

2377. Adjustment of Quartz Crystal Frequency by Coating with Waterproof Drawing Ink.—(*QST*, April, 1935, Vol. 19, No. 4, p. 15.)

2378. Röntgen-Laue Diagrams with Crystals Oscillating Piezoelectrically [Discussion and Experiments].—F. Klauer. (*Physik. Zeitschr.*, 15th March, 1935, Vol. 36, No. 6, pp. 208–211.) *See* also Schaeffer and Bergmann, 194 of January, and Fox and Carr, 1931 Abstracts, p. 570: also 2379, below.

2379. Explanation of the Schaefer-Bergmann Interference Figures with Oscillating Crystals.—E. Fues and H. Ludloff. (*Physik. Zeitschr.*, 15th March, 1935, Vol. 36, No. 6, p. 214: abstract only.) *See* 2378 and back references.

2380. A High-Precision Speed Regulator [for Voice-Frequency Carrier Generators: Resonant Bridge Circuit controlling Motor Field: Constancy within 0.05%].—Trucksess. (*Bell Lab. Record*, February, 1935, Vol. 13, No. 6, pp. 187–190.)

2381. The Control of the Average Frequency of Power Networks, and the Use of Their Current in Chronometry.—J. Thomas. (*Génie Civil*, 27th April, 1935, Vol. 106, No. 17, pp. 406–408.)

SUBSIDIARY APPARATUS AND MATERIALS

2382. Theory of the Electron Microscope with Application to Pure Magnetic Fields.—Wallauschek and Bergmann. (*Zeitschr. f. Physik*, No. 5/6, Vol. 94, 1935, pp. 329–347.)

The differential equations for electron beams in axially symmetrical fields are given and specialised to the case of pure magnetic fields. The images thus produced are discussed from examples and a general method is given for determining the optical constants of the system for any distribution of field strength.

2383. RECOIL IONIC BEAMS AND CATHODE-RAY OSCILLOGRAPH.—E. W. Freisewinkel. (*Arch. f. Elektrot.*, 5th April, 1935, Vol. 29, No. 4, pp. 272–280.)

The paper describes observations made in the investigation of the fluorescent spot which causes pre-blackening of the film in internal recording and which is due to beams of recoil ions (*see* also Burch and Whelpton, Abstracts, 1933, p. 339). The oscillograph already described by the writer (528 of February) was used; Fig. 1 shows the screen (zns, mica) with pre-concentration but incomplete magnetic locking. The effect of various combinations of voltages on the electrodes on the behaviour of the spot is described and illustrated in Figs. 2–6. The ions were seen to react to the magnetic field in a different way from the electrons. From the different amounts of deflection, the mass of the ions could be estimated; they were found to be principally hydrogen atoms with a single negative charge. The ionic current could be estimated by the charging and discharging of a condenser (curves Figs. 7–10); Fig. 11 gives the ionic current as a function of the anode current, and Fig. 12 as a function of the exciting voltage. This ionic current may be very much weakened by electrostatic locking in the discharge part of the tube. Finally, the dark patches in the quadrants of the fluorescent screen (Figs. 13, 14) are considered.

2384. "THEORY OF ELECTRON GUN": CORRECTIONS.—Maloff and Epstein. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, p. 263.) *See* 1178 of April.

2385. THE ELECTRON MICROSCOPE AND ITS APPLICATIONS [and Future Development].—von Borries and Ruska. (*Zeitschr. V.D.I.*, 27th April, 1935, Vol. 79, No. 17, pp. 519–524.)

2386. ON A METHOD OF VIEWING AND RECORDING INDUCTION COIL TRANSIENTS WITH THE CATHODE-RAY OSCILLOGRAPH.—Woonton. (*Canadian Journ. of Res.*, February, 1935, Vol. 12, No. 2, pp. 272–275.) Based on Turner's "transient visualizer" (1931 Abstracts, p. 281).

2387. THE IMPORTANCE OF THE AFTER-GLOW OF THE VIEWING SCREEN ON THE QUALITY OF THE X-RAY IMAGE [and Methods of Investigation using a Revolving Screen].—Wolf and Riehl. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 16, 1935, pp. 142–148.)

It is not the duration of the after-glow, but its intensity immediately after the cessation of excitation, which determines the quality: this depends on the nature of the transition from fluorescence to phosphorescence (*cf.* Figs. 8 and 9).

2388. THE QUADRATURE OSCILLOGRAPH: AN ELECTRO-MECHANICAL DEVICE HAVING TWO DEGREES OF FREEDOM [L.F. Substitute for Cathode-Ray Oscillograph]. — Sherman. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 380–385.)

2389. A LIQUID JET GALVANOMETER [prompted by Cathode-Ray Oscillograph: Results with Experimental Model].—Bull. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1184–1185.)

2390. HIGH SPEED MOTION PICTURES [Improved Stroboscopic Camera Equipment].—Edgerton. (*Elec. Engineering*, February, 1935, Vol. 54, No. 2, pp. 149–153.) *See* also *Electronics*, March, 1935, p. 94, for application to microscopic photography.

2391. ON THE PRODUCTION OF VERY FINE GRAIN EMULSION.—Burmistrov and Shatihina. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 4, 1934, pp. 1572–1574.)

A special emulsion has been developed by the State Optical Institute of Leningrad, for use in the production by photographic methods of microscopic scales and gratings: it allows recording up to 800 lines/mm to be accomplished.

2392. PROBLEMS AND PROGRESS IN PHOTOGRAPHY [Summary of Recent Work].—O. Bloch. (*Nature*, 19th Jan. 1935, Vol. 135, pp. 89–92.)

2393. IMPROVING THE FINAL VACUUM OF OIL-DIFFUSION PUMPS BY ABSORBING THE OIL VAPOUR BY SUBSTANCES OF LARGE SURFACE [Silica Gel].—Kerris. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 16, 1935, pp. 120–122.)

2394. OIL DIFFUSION PUMP [giving Vacua of order of 10^{-5} mm without Traps].—Stojarov. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 4, 1934, p. 1763.)

2395. A SIMPLE HIGH-SPEED OIL DIFFUSION PUMP.—Zabel. (*Review Scient. Instr.*, February, 1935, Vol. 6, No. 2, pp. 54–55.)

2396. A TWO-STAGE OIL DIFFUSION PUMP.—Henderson. (*Review Scient. Instr.*, March, 1935, Vol. 6, No. 3, pp. 66–67.)

2397. THE MERCURY-VAPOUR INVERTER WITH COMBINED MAGNETIC AND "CURRENT IMPULSE" CONTROL.—Savagnone. (*L'Elettrotec.*, 10th May, 1935, Vol. 22, No. 9, pp. 318–328.)

2398. STEEL-CYLINDER GRID-CONTROLLED MERCURY-ARC RECTIFIERS IN RADIO SERVICE.—Durand. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 372–379.)

2399. MULTISTAGE CIRCUITS FOR GRID-CONTROLLED RECTIFIERS [Mathematical Analysis of a Series Combination] *and* MULTIPHASE CIRCUITS FOR GRID-CONTROLLED RECTIFIERS WITH ZERO ANODES AND INTERPHASE TRANSFORMERS. — Babat. (*Izvestia Elektroprom. Slab. Toka*, November, 1934, No. 9, pp. 67–76: February, 1935, No. 2, pp. 42–49.) For previous work *see* 544 of February.

2400. CONTROL BY MEANS OF [Single-Anode] CURRENT RECTIFIERS ON THE PRIMARY SIDE OF SINGLE-PHASE LOW-POWER TRANSFORMERS.—Schilling. (*Arch. f. Elektrot.*, 11th Jan. 1935, Vol. 29, No. 1, pp. 33–39.)

2401. Calculation of the Parallel Alternating Rectifier under Ohmic Load [Working Characteristics].—Schilling. (*Arch. f. Elektrot.*, 11th Feb. 1935, Vol. 29, No. 2, pp. 119–130.)

2402. The Copper-Oxide Rectifier [and the Superposed Current, Saturating as Voltage Rises, due to Conductivity of Barrier Layer Itself].—van Geel. (*Physica*, December, 1934, Vol. 1, No. 12, pp. 1143–1152.)

In German. Further development of the work dealt with in 1931 Abstracts, p. 513. It is concluded that the barrier layer is practically pure Cu_2O, with hardly any surplus oxygen. ΔW (W being Sommerfeld's "internal work function") is 0.6 volt. The small, saturating superposed current is given by $i = V/R\{1 + f(V)\}$, while the emission current (Cu_2O negative) is $i = CV^{2/3}T^n e^{-BT}$, where $n = \frac{1}{2} \rightarrow 2$.

2403. The Copper/Cuprous-Oxide Rectifier Elements [Manufacturing Details, Quality Control, Sorting, etc.: Factors leading to High Quality].—Gvosdov and Toorkooletz. (*Izvestia Elektroprom. Slab. Toka*, February, 1935, No. 2, pp. 49–55.)

2404. Remark on the [Positive] Hall Effect in Copper Oxide.—von Auwers: Gudden. (*Zeitschr. f. Physik*, No. 1/2, Vol. 93, 1934, pp. 90–91.) Confirmation of work of Gudden, *Ergebnisse der exakten Naturwissenschaften*, 1934, Vol. 13, p. 237.

2405. The Influence of Oxygen Loading on the Electrical Behaviour of Valve-Like Films of W, Ta, Nb.—O. Mohr. (*Zeitschr. f. Physik*, No. 5/6, Vol. 93, 1935, pp. 298–314.)

This paper refers to the capacity changes, dependent on voltage, observed by Güntherschulze and Betz in valve-like films of W and Ta (Abstracts, 1931, p. 515, and 1932, p. 51). The writer uses a two-frequency method and investigates the magnitude and lag of the changes as regards the effect of age, film thickness, temperature and frequency. They are explained as being due to changes in the conductivity of parts of the films, caused by the varying amount of oxygen present at any instant. A theory of the film construction is given.

2406. Asymmetric Conductivity of a Metal/Salt Layer/Adsorbed Alkali Metal Electrode System [*Not* due to Difference in Work Functions but to High Field produced by Point Action of Adsorbed Alkali Metal, yielding Greater Cold Emission].—de Boer and van Geel. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 309–320: in German.)

Followed, on pp. 321–327, by an account of further developments in which the formation of conducting bridges in the salt layer (CaF_2, NaCl or KCl), which was inclined to interfere with the first tests, was prevented by the presence of a protecting layer (shellac, sulphur, etc.) between the metal plate and the salt layer.

2407. The Effect of Heat, Ultra-Violet Light, and X-Rays on Crystal Rectification.—Khastgir and Gupta. (*Phil. Mag.*, March, 1935, Series 7, Vol. 19, No. 127, pp. 557–564.) Experimental results are given in diagrammatic and tabular form. The discussion is left to a future paper.

2408. Internal Unipolar Conductivity of Certain Crystals ["Volume" Conductivity of Carborundum, quite independent of Contact Effects].—R. Deaglio. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1303–1306.)

2409. Contact Phenomena in Carborundum Resistances.—Kurtschatow, Kostina and Rusinow. (*Physik. Zeitschr. der Sowietunion*, No. 2, Vol. 7, 1935, pp. 129–154: in German.)

"It is shown that the physical processes in carborundum resistances are connected with electron transfers under the influence of the electrical contact field and that these transfers, for small potentials, are in agreement with the 'tunnel' theory. In the course of the investigations the idea is developed that two zones of conductivity are present in semi-conductors."

2410. An Investigation into the Structure of Pressed Carborundum.—A. Shakirov. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 4, 1934, pp. 328–331.)

Measurements are made of the high-frequency resistance of pressed carborundum, and on the basis of the results obtained suggestions are put forward regarding the spacing between adjacent particles and their effective common surface.

2411. A Wire-Wound Grid Resistance [up to 500 000 Ohms: Divided Winding of Nickel-Chromium Wire dissipating 2 Watts].—Ogg. (*Bell Lab. Record*, February, 1935, Vol. 13, No. 6, pp. 184–186.)

2412. Designing Resistive Attenuating Networks [Collection of Old and New Material: Tables and Curves].—McElroy. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 213–233.)

2413. A Universal Network Chart.—Ebel. (*Electronics*, March, 1935, pp. 84–85.)

2414. Experiments on Stabilised Rectifiers [for Anode Supply: using Combination of Iron Barretter and Glow-Discharge Stabilisator: Oscillographic Investigation of Instantaneous Changes].—Ferrario. (*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 154–160.)

2415. The Glow-Discharge Potential Divider [including the Reflex Connection].—G.W.O.H. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, pp. 235–237.) For the reflex connection *see* also 1597 of May.

2416. A Many-Sided Charging Apparatus [embodying the Budich Multi-Tap Auto-Transformer and Selenium Rectifier].—Nentwig. (*Radio, B., F. für Alle*, January, 1935, No. 1, pp. 14–15.)

2417. The Employment of a Buffer Accumulator for Stabilising the Feed to an Incandescent Filament. — Capdecomme. (*Comptes Rendus*, 7th Jan. 1935, Vol. 200, No. 2, pp. 115–117.)

The feed circuit includes the source of supply, a regulating rheostat, the whole winding of a potentiometer, and the filament. The buffer accumulator is connected across the slider of the potentiometer and the far side of the filament.

2418. Recent Progress in the Application of Electronic Tubes to the Precision Regulators of Electrical Machinery.—Berthold and von Engel. (*Rev. Gén. de l'Élec.*, 9th Feb. 1935, Vol. 37, No. 6, pp. 197–198 : long summary only.)

2419. Primary Battery utilising the Energy of the Oxidation of Alcohol.—Karpen. (*Comptes Rendus*, 15th Oct. 1934, Vol. 199, No. 16, pp. 708–710.)

2420. High-Wattage Vibrator-Type Converters [and the Need for Commutation rather than Interruption : for Heat Removal : for Tuning : etc.].—Garstang. (*Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 16–17.)

2421. Application of a Thyratron to Induction Coils [replacing Hammer Make-and-Break and Mercury Interrupter].—Verman. (*Journ. Scient. Instr.*, May, 1935, Vol. 12, No. 5, pp. 167–168.)

2422. A High-Voltage Relay [Remote-Control Vacuum Switch for 1 250 Volts for Aircraft Transmitters].—Ronci. (*Bell Lab. Record*, April, 1935, Vol. 13, No. 8, pp. 241–244.)

2423. Micro-Switch [operating with a Movement of 1/1 oooth Inch].—(*Journ. Scient. Instr.*, May, 1935, Vol. 12, No. 5, pp. 170–171.)

2424. Differential Dilatometer.—Deysenrot and Smirnov. (*Izvestia Elektroprom. Slab. Toka*, No. 9, 1934, pp. 64–67.)

Description of a dilatometer for very accurate measurement of changes with temperature in the volumes of various materials. The instrument may find wide application in the manufacture of radio apparatus, the correct operation of which, especially on short waves, is very much affected by variation in the size of components.

2425. A Precision Cathetometer [for Measuring the Length of Single-Layer Inductance Coils].—Moon. (*Journ. of Res. of Nat. Bur. of Stds.*, March, 1935, Vol. 14, No. 3, pp. 363–365.)

2426. The Axial Pressures in Single-Layer Cylindrical Coils, without Iron, with a Contribution to the Calculation of the Inductance of Such Coils [Theoretical Investigation].—H. Buchholz. (*Arch. f. Elektrot.*, 5th April, 1935, Vol. 29, No. 4, pp. 281–296.)

The coil is assumed to be of finite height, with a very close winding of metallic bands of negligible thickness. The current density is assumed uniform. Suitable integrals are found for the field-strength from the magnetic vector-potential (§§2.1, 2.2) ; §2.3 gives a calculation for the axial pressure on the outermost winding, §2.4 the self-inductance of the coil, which is transformed mathematically in §3. §4.1 considers a coil of infinite length on one side and §4.2 the additional force for a coil of finite height. In §4.3 the formulae for the maximum axial force on the outermost winding are collected.

2427. A Negative-Resistance Device [" Kallirotron " Type] and Its Application to Harmonic Analysis.—C. W. Oatley. (*Proc. Phys. Soc.*, 1st May, 1935, Vol. 47, Part 3, No. 260, pp. 471–476 : Discussion p. 476.)

The circuit given is similar to the " kallirotron amplifier " of L. B. Turner (*Radio Review*, 1920, Vol. 1, p. 317 : a negative-resistance circuit without secondary emission, consisting of two triodes " connected by batteries and resistances disposed in a kind of vicious circle.") When the device is used to decrease the effective resistance of a tuned circuit, there is no appreciable distortion of the resonance curve of the circuit. The application to the electrical harmonic analyser is described, with experimental results. A rapid method for determining the effective resistance of the circuit is given.

2428. A New Harmonic Analyser on the Principle of the Polar Planimeter.—J. Harvey. (*Génie Civil*, 15th Dec. 1934, Vol. 105, No. 24, pp. 552–555.)

2429. Mechanical Analysis of Waves [Simple Planimeter Equipment for Speech Sounds Analysis].—Koenig. (*Bell Lab. Record*, May, 1935, Vol. 13, No. 9, pp. 258–263.)

2430. The Preparation of Highly Sensitive Thermo-Couples by Electrical Welding [by Condenser Discharge].—Renatus. (*Funktech. Monatshefte*, September, 1934, No. 9, pp. 379–380.)

2431. Sealing Electrode Leads into Experimental Apparatus [using " Dumet " Leads from Scrapped Lamps, etc.].—Maddock. (*Journ. Scient. Instr.*, December, 1934, Vol. 11, No. 12, p. 405.)

2432. A Device for Binding Flex-Ends [" Hellerman System "].—Siegrist. (*Journ. Scient. Instr.*, November, 1934, Vol. 11, No. 11, p. 369.)

2433. The Melting Time of Fuses [Formula for Thick Fuses holds also for Thin Ones : Determination of Inertia Constant].—van Liempt and de Vriend. (*Zeitschr. f. Physik*, No. 1/2, Vol. 93, 1934, pp. 100–110.)

2434. Iron-Cored Coils in High-Frequency Technique [Survey, with Latest Developments].—Boucke. (*Funktech. Monatshefte*, April, 1935, No. 4, pp. 133–138.)

Among points of interest are the following :—Wolman's formula relating the iron thickness with permeability, " limiting frequency," etc. (Abstracts, 1930, p. 228) : compression and casting processes: Ferrocart : influence of effective core permeability on the merit of a coil (Clausing and Jaumann's work for Siemens) : the writer's use of the core in two planes (2076 of June) : independence of permeability on load (Faulhaber, 1934, pp. 628–629): the advantages of "trimming," and actual tuning, by means of the iron core or adjustable discs (mention is made of the Steatite-Magnesia Company's new experimental tuner and of a paper by Riepka appearing soon): tuning by variation of biasing current, including a distant-control tuning arrangement developed by Leithäuser and the writer; the work on this has shown that the modern iron core should be useful in short- and particularly in ultra-short-wave work.

2435. A SIMPLE APPARATUS FOR THE CONTINUOUS VARIATION OF CURRENT, SUITABLE FOR EXPERIMENTS ON MAGNETIC HYSTERESIS.—Stephens. (*Journ. Scient. Instr.*, October, 1934, Vol. 11, No. 10, pp. 334–336.)

2436. MAGNETIC MATERIALS—TESTING AND PRACTICE.—(*Electronics*, March, 1935, p. 100: summaries only.)

2437. A NEW TESTING INSTRUMENT FOR PERMANENT-MAGNET STEELS AND COMPLETE MAGNETS.—Neumann. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 473–477.)

2438. THE INTERPRETATION OF THE MECHANICAL DAMPING OF FERROMAGNETIC MATERIALS BY MAGNETISATION [Eddy-Current Damping].—Kersten. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 463–467.)

2439. FERROMAGNETIC DISTORTION OF A TWO-FREQUENCY WAVE.—Kalb and Bennett. (*See* 2304.)

2440. THE MAGNETIC BEHAVIOUR OF FERROMAGNETIC MATERIALS IN SWITCH-OFF PHENOMENA [Quicker Breakdown of Induction Flow: Measurements of Relaxation Time of Demagnetising Process and Effective Permeability].—G. Kiessling. (*Ann. der Physik*, March, 1935, Series 5, Vol. 22, No. 4, pp. 402–420.)

2441. THE EFFECT OF SUPERIMPOSED MAGNETIC FIELDS ON THE BREAKDOWN VOLTAGE OF DIELECTRICS.—Narayanaswami and Mowdawalla. (*Journ. Indian Inst. of Sci.*, Part II, Vol. 17 B, pp. 19–46.)

2442. BEHAVIOUR OF DIELECTRICS UNDER ALTERNATING STRESS [up to Radio Frequencies: Study of Power Factor of Non-Polar Material with and without Polar Materials in Dilute Solution].—Sommerman. (*Journ. Franklin Inst.*, April, 1935, Vol. 219, No. 4, pp. 433–458.)

2443. THE [Electrostatic] INSULATING PROPERTIES OF AMBER, QUARTZ, GLASS AND SULPHUR IN DRY AND MOIST AIR.—Gnann. (*Physik. Zeitschr.*, 1st April, 1935, Vol. 36, No. 7, pp. 222–230.)

2444. THE PHYSICAL STRUCTURE OF [Paper Dielectric] CONDENSERS.—Nauk. (*E.T.Z.*, 28th March, 1935, Vol. 56, No. 13, pp. 371–374.)

2445. DIRECT-CURRENT AMPLIFIER CIRCUITS FOR USE WITH THE ELECTROMETER TUBE [and a Circuit combining Their Main Advantages].—Penick. (*Review Scient. Instr.*, April, 1935, Vol. 6, No. 4, pp. 115–120.) For Barth's similar circuit *see* 1934 Abstracts, p. 217.

2446. TETRODE COUPLING IN LOW-FREQUENCY AND DIRECT-CURRENT AMPLIFICATION.—Huizing. (*See* 2301.)

2447. AMPLIFIER SYSTEMS FOR THE MEASUREMENT OF IONISATION BY SINGLE PARTICLES.—Dunning. (*Review Scient. Instr.*, November, 1934, Vol. 5, No. 11, pp. 387–394.)

2448. A PORTABLE GEIGER-MÜLLER TUBE [for detecting Lost Radium Tubes: with Medicus Corona-Tube Stabiliser for H.T. from Intermittent or Variable Source].—Kerr Grant and Iliffe. (*Journ. Scient. Instr.*, January, 1935, Vol. 12, No. 1, pp. 6–8.) For the Medicus stabiliser *see* 1933 Abstracts, p. 638.

2449. A FURTHER HYDROELECTRIC COUNTER FOR ELEMENTARY RAYS AND PHOTOELECTRONS [Hydrostatic Type instead of Hydraulic].—Greinacher. (*Helvet. Phys. Acta*, Fasc. 1, Vol. 8, 1935, pp. 89–96.) For the hydraulic type *see* 2450.

2450. NOTE ON A GREINACHER HYDRAULIC COUNTER FOR QUANTA AND IONISING PARTICLES.—Summers: Greinacher. (*Review Scient. Instr.*, February, 1935, Vol. 6, No. 2, pp. 39–40.) A modified form of the instrument (1934 Abstracts, p. 570) to increase the frequency range. See 2449 for a hydrostatic type.

2451. CONSTRUCTION AND TEST OF AN ALTERNATING-CURRENT BOLOMETER [Sensitivity 0.068 Volt per Watt/cm², probably 5 to 10 Times Greater with Smaller Wires].—Moon and Mills. (*Review Scient. Instr.*, January, 1935, Vol. 6, No. 1, pp. 8–15.)

2452. UNIVERSAL ALIGNMENT CHART [Alignment Chart with Movable Scales on Slide-Rule Principle].—Peek. (*Bell Lab. Record*, April, 1935, Vol. 13, No. 8, pp. 250–254.)

2453. TESTING ENAMELLED COPPER WIRE.—Savage. (*Distribution of Electricity*, January, 1935, Vol. 7. No. 80, pp. 1702–1703.)

2454. A MORE EFFICIENT IMPELLER FOR WIND-DRIVEN GENERATORS.—Lynch. (*QST*, April, 1935, Vol. 19, No. 4, pp. 48–49.)

STATIONS, DESIGN AND OPERATION

2455. THE MICRO-WAVE IN THE ROYAL ITALIAN NAVY.—(*La Ricerca Scient.*, 15/30th April, 1935, 6th Year, Vol. 1, No. 7/8, pp. 405–413.

2456. 7-METER [Ultra-Short-Wave] BROADCASTING: ONE YEAR'S EXPERIENCE AT WBEN-W8XH [on Hotel Statler, Buffalo].—(*Electronics*, April, 1935, pp. 114–115.)

2457. A DESCRIPTION OF THE BOSTON/PROVINCETOWN RADIO [Ultra-Short-Wave] AND WIRE CIRCUIT.—Fletcher. (*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, p. 269: summary only.)

2458. NATION-WIDE BROADCAST DEVELOPMENT IN INDIA [Survey of the Problem: Table of Data on Other Countries: a Suggested Organisation].—Sreenivasan. (*Current Science*, Bangalore, March, 1935, Vol. 3, No. 9, pp. 396–406.) For an Editorial *see* pp. 393–395.

2459. AUTOMATIC SYNTRACTION IN COMMON-WAVE BROADCASTING.—Gunsolley. (*See* 2232.)

2460. THE RADIOELECTRIC INSTALLATION OF THE S.S. "NORMANDIE."—Adam. (*Génie Civil*, 16th March, 1935, Vol. 106, No. 11, pp. 257–259.)

2461. TWO-WAY POLICE AUTO RADIO SYSTEMS.—Prescott. (*Gen. Elec. Review*, April, 1935, Vol. 38, No. 4, pp. 178–180.)

2462. THE SIEMENS-HELL RADIO TELESCRIPTOR [Printing Telegraph using Phototelegraphy Technique].—Guyot. (*L'Onde Elec.*, April, 1935, Vol. 14, No. 160, pp. 203–213.)

GENERAL PHYSICAL ARTICLES

2463. RESEARCHES WITH POSITRONS [including a Laboratory Source, e/m Measurements, Separation from Electrons, etc.]—Rupp. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 575–579.)

2464. A SPECTROSCOPIC DETERMINATION OF e/m [Value $(1.7579 \pm 0.0003) \times 10^7$]. — Shane and Spedding. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, pp. 33–37.)

2465. THE VALUE OF THE ELECTRONIC CHARGE [from Measurements on Alpha-Particles: 4.780×10^{-10} e.s.u.].—Birge and McMillan. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 320.)

2466. ARRANGEMENT FOR THE PRODUCTION OF IONS IN A HIGH VACUUM [at Crossing of Electron Beam and Molecular Jet].—Planiol. (*Comptes Rendus*, 11th Feb. 1935, Vol. 200, No. 7, pp. 539–540.) *See* further *ibid.*, 25th Feb. 1935, pp. 730–731.)

2467. ELECTRICAL PHENOMENA AT EXTREMELY LOW TEMPERATURES [Kelvin Lecture].—McLennan. (*Journ. I.E.E.*, December, 1934, Vol. 75, No. 456, pp. 693–709.)

2468. THE THERMODYNAMICS OF MAGNETISATION [including Magnetostriction Relations].—Stoner. (*Phil. Mag.*, March, 1935, Series 7, Vol. 19, No. 127, pp. 565–588.)

2469. THE SUPERPOSITION OF ELECTRIC AND MAGNETIC DOUBLE REFRACTION [Absence of Reciprocal Influence].—Scherer and Piekara. (*Journ. de Phys. et le Rad.*, November, 1934, Series 7, Vol. 5, No. 11, pp. 568–570.)

2470. A THEORY OF THE ROTATIONS OF MOLECULES IN SOLIDS AND OF THE DIELECTRIC CONSTANT OF SOLIDS AND LIQUIDS.—Fowler. (*Proc. Roy. Soc.*, Series A, 1st March, 1935, Vol. 149, No. 866, pp. 1–28.)

2471. THE CHANGE IN RESISTANCE OF METALS IN A MAGNETIC FIELD [Quantum-Theoretical Investigation].—Titeica. (*Ann. der Physik*, Series 5, No. 2, Vol. 22, 1935, pp. 129–161.)

2472. MAGNETO-RESISTANCE OF LIQUID SODIUM-POTASSIUM ALLOY.—Armstrong. (*Phys. Review*, 1st March, 1935, Series 2, Vol. 47, No. 5, pp. 391–392.) *See* also 1933 Abstracts, p. 579 (Fakidow and Kikoin).

2473. ON THE MAGNETO-RESISTANCE OF BISMUTH, ETC., BY THE LONGITUDINAL MAGNETIC FIELD AT LOW AND HIGH TEMPERATURES.—Matuyama. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 26.)

2474. THE FAILURE OF OHM'S LAW AT HIGH CURRENT DENSITIES [Concept of Compressibility introduced into Equation of Metallic Conduction].—Weber. (*Phys. Review*, 15th Feb. 1935. Series 2, Vol. 47, No. 4, p. 327: abstract only.]

MISCELLANEOUS

2475. "NUMERICAL STUDIES IN DIFFERENTIAL EQUATIONS" [Book Review].—Levy and Baggott. (*Journ. Scient. Instr.*, May, 1935, Vol. 12, No. 5, p. 174.)

2476. THE APPLICATION OF TENSORS TO THE ANALYSIS OF ROTATING ELECTRICAL MACHINERY. PART I: THE ALGEBRA OF HYPERCOMPLEX NUMBERS.—Kron. (*Gen. Elec. Review*, April, 1935, Vol. 38, No. 4, pp. 181–191.)

2477. BESSEL FUNCTIONS FOR ENGINEERS [and the Mathematician's and Engineer's Different Degrees of "Rigour"].—McLachlan. (*Wireless Engineer*, May, 1935, Vol. 12, No. 140, pp. 258–259.) Letter prompted by the review referred to in 1711 of May.

2478. COMPLEX HYPERBOLIC FUNCTION CHARTS.—Woodruff. (*Elec. Engineering*, May, 1935, Vol. 54, No. 5, pp. 550–554.)

2479. NOTE ON A SELF-CHECKING NOTATION FOR VECTOR EQUATIONS AND VECTOR DIAGRAMS [Suffixes and Signs sum up to balance on Each Side of Equations].—A. C. Walshaw. (*Phil. Mag.*, May, 1935. Series 7, Vol. 19, No. 129, pp. 1027–1032.)

2480. SOME TESTS OF SIGNIFICANCE [of Difference between Two Sets of Observational Data], TREATED BY THE THEORY OF PROBABILITY. —Jeffreys. (*Proc. Camb. Phil. Soc.*, April, 1935, Vol. 31, Part 2, pp. 203–222.)

2481. ON THE LAWS OF PROBABILITY AT EXHAUSTIVE ["Sufficient"] ESTIMATION.—Darmois: Fisher. (*Comptes Rendus*, 8th April, 1935, Vol. 200, No. 15, pp. 1265–1266.)

2482. The Application of Statistical Methods to the Quality Control of Manufactured Products.—Dudding and Baker. (*Trans. Soc. Glass Technology*, Vol. 17, pp. 239–259.)

2483. Sampling Analysis and Sample Size [Functional Relationship with Tolerance Limits, Degree of Assurance and Homogeneity].—Holmes. (*Journ. Franklin Inst.*, April, 1935, Vol. 219, No. 4, pp. 483–486.)

2484. Problems and Work of the Polish National Institute of Telecommunications.—Groszkowski and Dobrski. (*Wiadomości i Prace Państwowego Inst. Telekomunikacynego*, Warsaw, ["*W.P.P.I.T.*"] No. 1, Vol. 6, 1935, 15 pp: in Polish, with French summary.)

2485. Radio Technique and Radio Industry in Italy.—Vallauri. (*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 161–164.)

2486. Report on the Activity of the P.-T. Reichsanstalt in 1934 [including Notice of New H.F. and Acoustic Laboratories].—Stark. (*Physik. Zeitschr.*, 1st April, 1935, Vol. 36, No. 7, pp. 233–266.)

2487. Works and Researches of the French National Laboratory of Radioelectricity in 1934 [with List of Publications].—Gutton. (*Ann. des P.T.T.*, March, 1935, Vol. 24, No. 3, pp. 205–221.)

2488. Reviews of the Leipzig Fair, 1935.—(*E.T.Z.*, 16th May, 1935, Vol. 56, No. 20, pp. 553–566.) For Radio, etc., *see* pp. 560 and 565.

2489. Tenth Plenary Meeting of the International Consultative Committee of Telephony [C.C.I.F., Budapest, 1934].—(*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 165–179.)

2490. Joint [April] Meeting of the Institute of Radio Engineers and American Section, U.R.S.I. [Notice of Programme].—(*Proc. Inst. Rad. Eng.*, April, 1935, Vol. 23, No. 4, pp. 265–267: *Journ. Franklin Inst.*, April, 1935, Vol. 219, No. 4, pp. 492–494.)

2491. Wireless and Jubilees [since 1879].—Watson Watt. (*World-Radio*, 3rd May, 1935, pp. 3–6.)

2492. Review of 1934 [Telegraphy, Telephony, Phototelegraphy, Television, Broadcasting, etc.].—(*Ann. des P.T.T.*, March and April, 1935, Vol. 24, Nos. 3 and 4, pp. 222–250 and 347–367.)

2493. Progress in Radio Communication [during 1910–1935].—Appleton. (*Nature*, 4th May, 1935, Vol. 135, pp. 745–747.)

2494. On the Origin and Applications of the Method of Double Syntony [Radio-Frequency and Audio-Frequency Tuning] in Radio-Electricity [especially for Distant Control, etc.].—Blondel. (*L'Onde Élec.*, January, 1935, Vol. 14, No. 157, pp. 5–9.)

2495. A System for Sporadic Telemetering [Installation for 24 Pairs of Telemeters].—Garkusha. (*Izvestia Elektroprom. Slab. Toka*, December, 1934, No. 10, pp. 56–60.)

2496. A Super-Audio Telegraph System.—Jacobsen and Montgomery. (*Elec. Communication*, January, 1935, Vol. 13, No. 3, pp. 246–251.)

2497. Theoretical Foundations for the Design of Carrier-Current Telegraph Systems [including Particular Attention to the Phase Characteristic and the Coupling Coefficient].—Listov. (*Izvestia Elektroprom. Slab. Toka*, November, 1934, No. 9, pp. 42–61.)

2498. Magnetic and Magneto-Acoustic Methods of Testing Workshop Materials, etc.—Berthold. (*Zeitschr. V.D.I.*, 20th April, 1935, Vol. 79, No. 16, pp. 479–483: in a Survey.)

2499. An Electro-Magnetic Vibrometer.—Sacerdote and Semenza. (*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 231–240.)

2500. New Method of Measuring the Time and Efficiency of Photographic [Between-Lens] Shutters.—Eyles and Selwyn. (*Proc. Phys. Soc.*, 1st May, 1935, Vol. 47, Part 3, No. 260, pp. 446–454.)

2501. An Improved Dowling Ultramicrometer [Measurement of Length from Variable Capacity of Movable Plate Condenser in Valve Circuit].—Gustafsson. (*Ann. der Physik*, Series 5, No. 5, Vol. 22, 1935, pp. 507–512.)

2502. The Welding of Wires by means of Condenser Discharges.—Zdralek and Wrana. (*E.T.Z.*, 23rd May, 1935, Vol. 56, No. 21, pp. 579–580.) *See* also 2430.

2503. Electrical Aids in Geophysical Prospecting.—Ambronn. (*E.T.Z.*, 23rd May, 1935, Vol. 56, No. 21, pp. 581–585.)

2504. Applications of Electron Tubes [List of Non-Communication Uses of Rectifiers, Amplifiers, Photocells, Grid-Glow Tubes and Thyratrons, Cathode-Ray Tubes, etc.].—(*Electronics*, January, 1935, pp. 2–5.)

2505. Photocell Static Discharger at WLW [Power Supply automatically Shut Off during Flashover].—(*Electronics*, October, 1934, p. 316.)

2506. Photocell Guard against Suicides and Sleep-Walking.—(*Electronics*, November, 1934, p. 355.)

2507. A Questionnaire for Proposed Photo-electric Installation. — (*Electronics*, January, 1935, p. 20.)

2508. Records of an Amplified Galvanometer Deflection [using Photocell Amplification].—Downing and Hill. (*Journ. Scient. Instr.*, March, 1935, Vol. 12, No. 3, pp. 91–92.) For previous work *see* 618 of February and 1934 Abstracts, p. 633.

2509. THE AMPLIFICATION OF GALVANOMETER DEFLECTIONS [Survey of Thermal and Photocell Methods].—Moss. (*Journ. Scient. Instr.*, May, 1935, Vol. 12, No. 5, pp. 141–148.)

2510. AMPLIFICATION OF A GALVANOMETER DEFLECTION BY RETROACTION WITH A PHOTOCELL.—Watton. (*Journ. Scient. Instr.*, April, 1935, Vol. 12, No. 4, pp. 115–118.)

2511. THE USE OF PHOTOCELLS FOR DETERMINING THE DEGREE OF DISSOCIATION IN THE GAS EQUILIBRIUM $N_2O_4 \rightleftarrows 2NO_2$ FROM THE MEASURED VALUES OF LIGHT ABSORPTION.—Bergwitz and Schweckendiek. (*Physik. Zeitschr.*, 2nd Jan. 1935, Vol. 36, No. 1, p. 35.)

2512. RECENT DEVELOPMENTS IN PHOTOELECTRIC CELLS AND THEIR APPLICATIONS.—H. R. Ruff. (*Journ. Television Soc.*, September, 1934, Series 2, Vol. 1, Part 11, pp. 352–366.)

2513. PHOTOELECTRIC DENSITY COMPARATOR FOR ANALYSING SPECTROGRAMS.—(*Electronics*, November, 1934, p. 358.)

2514. A NULL METHOD PHOTOELECTRIC PHOTOMETER.—Edwards. (*Phys. Review*, 1st Feb. 1935, Series 2, Vol. 47, No. 3, p. 258: abstract only.)

2515. PHOTOELECTRICITY AND THE CHEMICAL INDUSTRY.—Walters. (*Chemistry and Industry*, 22nd March, 1935, Vol. 54, pp. 258–261.)

2516. THE APPLICATIONS OF THE PHOTOELECTRIC CELL IN THE PAINT AND VARNISH INDUSTRY.—Fritz. (*Chimie et Industrie*, March, 1935, Vol. 33, No. 3, pp. 541–545.)

2517. AUTOMATIC SIGNALLING AT CROSS ROADS BY A PHOTOCELL EQUIPMENT.—(*Génie Civil*, 30th March, 1935, Vol. 106, No. 13, pp. 317–318.)

2518. THE "PHOTOELECTRIC PILOT" [Combination of Magnetic Compass, Photoelectric Equipment and Motor-Operated Steering Gear].—Hill. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, p. 197: summary only.) "It serves primarily to maintain a vessel on a predetermined course and has been used extensively on private and commercial craft with a high degree of success."

2519. AUTOMATIC MEASURING APPARATUS FOR MECHANICAL WORK [and a Photoelectric Work Counter].—Döring. (*Zeitschr. V.D.I.*, 6th April, 1935, Vol. 79, No. 14, pp. 441–443.)

2520. THE POSSIBILITIES OF PHOTOELECTRIC MEASURING AND CONTROL METHODS.—Keller. (*Bull. Assoc. suisse des Élec.*, No. 10, Vol. 26, 1935, pp. 263–267: in German.)

2521. A LINEAR PHOTOELECTRIC DENSITOMETER [and Its Use for measuring Blackness of Opaque Objects].—Miller. (*Review Scient. Instr.*, April, 1935, Vol. 6, No. 4, pp. 125–127.)

2522. A NEW [Photoelectric] REFLECTION METER.—Michaelson. (*Gen. Elec. Review*, April, 1935, Vol. 38, No. 4, pp. 194–196.)

2523. "OBJEKTIVE PHOTOMETRIE" [Book Review].—Sewig. (*Hochf:tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, p. 144.)

2524. BRAIN WAVES [Researches in Recording the Berger Rhythm].—Elmslie. (*World-Radio*, 8th March, 1935, pp. 17 and 20.) On the Cambridge work of Adrian and Matthews.

2525. REMARKS ON HEHLGANS' PAPER "A NEW AMPLIFIER-OSCILLOGRAPH FOR THE RECORDING OF ACTION CURRENTS, USING A CATHODE-RAY TUBE."—Schmitz: Hehlgans. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 16, 1935, pp. 151–152.) *See* 1253 of April.

2526. HEART TESTING BY CATHODE RAY [and the Cossor-Robertson Electro-Cardiograph].—(*Wireless World*, 19th April, 1935, Vol. 36, pp. 388–390.)

2527. CATHODE-RAY ELECTRO-CARDIOGRAPH.—Brookes-Smith. (*Elec. Communication*, January, 1935, Vol. 13, No. 3, pp. 235–239.)

2528. ULTRA-SHORT-WAVE DIATHERMY.—Mirk and Axten. (*Elec. Communication*, January, 1935, Vol. 13, No. 3, pp. 240–245.)

2529. DEEP DIATHERMIC EFFECT [of Short Radio Waves] AND LOCALISATION BY MEANS OF "AUXILIARY DIELECTRIC ELECTRODES" IN THE CONDENSER FIELD.—Nagelschmidt. (*Nature*, 23rd Feb. 1935, Vol. 135, p. 303.)

2530. ELECTRIC IMPEDANCE OF SUSPENSIONS OF LEUCOCYTES.—Fricke and Curtis. (*Nature*, 16th March, 1935, Vol. 135, p. 436.)

2531. ELECTRIC IMPEDANCE OF MUSCLE [at Radio Frequencies: Data for Fibre Membrane].—Cole and Bozler. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 644: abstract only.)

2532. ELECTRICAL ARTIFICIAL LARYNX.—(*Bell Lab. Record*, March, 1935, Vol. 13, No. 7, Supp. p.v.)

2533. ELECTRIC SHOCKS FROM EARTHED APPARATUS.—Taylor. (*World Power*, April, 1935, Vol. 23, No. 136, pp. 170–174.) Report F/T82 of the British Electrical and Allied Industries Research Association.

2534. ON THE POSSIBILITY OF EXPLODING OXY-HYDROGEN GAS BY HIGH-SPEED ELECTRONS.—Malinowski and Skrynnikow. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 7, 1935, pp. 43–48.)

2535. NATURE AND ORIGIN OF THE [Highly Absorbable] RADIATION FROM SEMI-CONDUCTING CELLS.—Déchène: Reboul. (*Journ. de Phys. et le Rad.*, November, 1934, Series 7, Vol. 5, No. 11, pp. 553–562.)

2536. ON THE ELECTROMOTIVE FORCE PRODUCED BY THE FLOW OF WATER VAPOUR.—Milhoud. (*Comptes Rendus*, 25th March, 1935, Vol. 200, No. 13, pp. 1091–1093).

2537. "CONTRIBUTION À LA BIBLIOGRAPHIE DE LA RADIOÉLECTRICITÉ, 1922–1932" [Book Review].—(*Wireless Engineer*, May, 1935, Vol. 12, No. 140, p. 259.)

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.

WIRED-WIRELESS SYSTEMS

Application date, 19*th April*, 1933. *No.* 418138

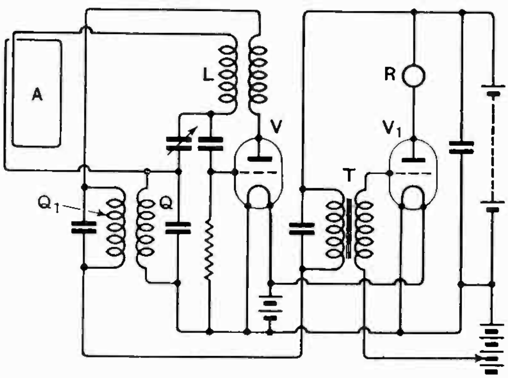
A load-indicator is inserted in each programme "line" to show how many loud-speakers are connected in circuit at any given time. The indicator consists of two coils mounted at right-angles and free to rotate in a magnetic field. One coil is fed through a rectifier with a direct voltage proportional to that across the transmission line, whilst the second coil is fed with a direct current proportional to that in the line. The resultant rotation of the coils then gives an indication of the line impedance or load, which enables the supervisor at the central station to judge of the popularity of each item and to adjust the operating voltages and power output accordingly.

Patent issued to Standard Telephones and Cables, Ltd.; K. E. Latimer; and A. R. A. Rendall.

CALLING-UP DEVICES

Application date, 20*th May*, 1933. *No.* 418525

A calling signal is given by interrupting the carrier wave from a wireless transmitter at a definite group-frequency. At the receiving end, a super-regenerative circuit is used since this gives a large change of anode current under the conditions stated. The super-regenerative valve *V* is back-coupled at *L* to the frame aerial *A*, and is periodically quenched by the interaction of the grid and anode circuits *Q*, *Q*1. The rectified impulses are transferred through a circuit *T*, tuned to the interruption frequency of the carrier wave, and there operate a calling relay *R* inserted in the anode circuit of the amplifier *V*1.



No. 418525.

Patent issued to N. H. Clough, and Wireless Telephone Co., Ltd.

GAS-FILLED VALVES

Convention date (*Germany*), 2*nd May*, 1932. *No.* 418991

The presence of gas in a valve leads to the production of ions which tend to reduce the normal space-charge, and so give the valve a higher amplification factor. On the other hand, with a gas-filling it is inadvisable to use a high anode-voltage, because the resulting high-speed ions bombard and damage the cathode.

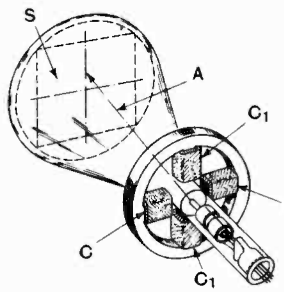
According to the invention ions are produced in a gas-filled valve by applying a relatively low voltage to an auxiliary electrode or screen-grid, which is placed so close to the anode that a high voltage can be applied to the latter without producing any substantial further ionisation—or acceleration of existing ions—in the space between the screen grid and the cathode.

Patent issued to Telefunken ges. für drahtlose Telegraphie m.b.h.

CATHODE-RAY TUBES

Convention date (*U.S.A.*), 30*th November*, 1932. *No.* 418940

It is desirable that the axis *A* of the electron stream from the "gun" should normally be directed on to the centre of the screen *S*, so that scanning takes place symmetrically about that spot. In practice, however, and particularly in the case of mass-produced tubes, the "lining-up" of the gun electrodes is sometimes not sufficiently accurate to ensure this.



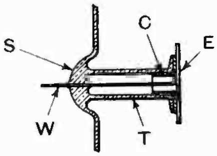
No. 418940.

To meet this difficulty the scanning-coils *C*, *C*1 are fed with an auxiliary direct current, in addition to the usual A.C. deflection currents, in order to allow the electron stream to be centred or adjusted as desired. The coils are fed with the D.C. current through chokes which prevent the usual scanning currents from being by-passed through the D.C. supply. Adjustment is effected by means of a rheostat.

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

Application date, 12*th May*. 1933. *No.* 419379

With high control-voltages it is practically essential to mount the deflecting electrodes of a cathode-ray tube from the sides instead of from the base of the glass bulb. The difficulties are :—



No. 419379.

(*a*) when a metal-to-glass point is used, the heat is liable to crack the glass and also to oxidise the surface of the electrodes; and (*b*) if the electrode is supported by a simple nickel wire, the strain set up during the sealing-in operation may cause subsequent displacement, and so throw the electrodes out of alignment.

As shown in the Figure each electrode *E* is welded to a short split-cylinder *C* of nickel which is " sprung " into the bore of a glass tube T. The latter is " flared " at one end to make contact with the nickel cylinder, and is fused at the other end to the sides of the cathode-ray bulb. A connecting wire *W* is sealed through the glass to convey the control voltages to the electrode.

Patent issued to Marconi's Wireless Telegraph Co., Ltd. and W. E. Benham.

TELEVISION TRANSMITTERS

Application date, 5*th May*, 1933. *No.* 419452

A cathode-ray tube is fitted with a light-sensitive electrode, which is formed of a " mosaic " of short aluminium rods, insulated from each other, and having one end coated with photo-electric material. The picture to be transmitted is focused on to the prepared surface of the electrode through a transparent window at the end of the tube. Simultaneously the unsensitised surface of the electrode is scanned by the normal electron stream from the anode of the tube. This produces a secondary emission from the uncoated surface of the electrode which fluctuates in value with the intensity of the light incident on the sensitive surface.

In other words, the focused picture produces an electrostatic image, which the primary electron stream " discharges " by secondary emission, the sensitised electrode, as a whole, being restored to a fixed or zero potential between each scanning operation. The secondary emission is collected by an auxiliary ring-shaped electrode and is used to modulate the carrier wave.

Patent issued to Electric and Musical Industries, Ltd., and J. D. McGee.

MIRROR DRUMS FOR TELEVISION

Application date, 10*th February*, 1933. *No.* 419523

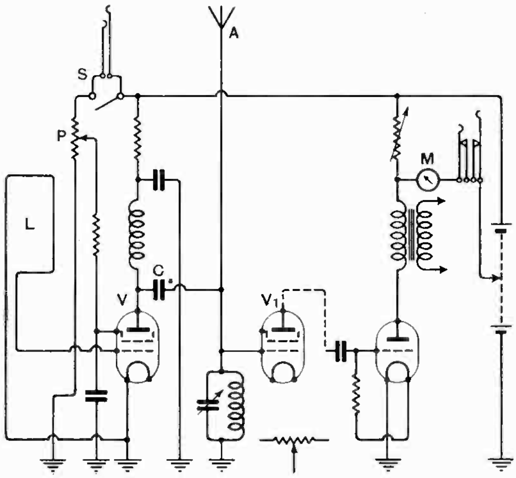
A series of mirror-strips, used for scanning, are supported around the periphery of a drum so that they can be independently adjusted in two directions relative to the axis of rotation of the drum. The mirror-strips are screw-mounted on tongues cut out from a flange at the top of the drum, so that they can be rotated or " set " at the correct angle. The second angular adjustment is obtained by utilising the natural elasticity of the cut-out tongues in the upper flange to ensure the correct bend or " tilt."

Patent issued to Electric and Musical Industries, Ltd., and C. O. Browne.

D.F. APPARATUS

Application date, 17*th May*, 1933. *No.* 419676

A direction-finding set, particularly suitable for aircraft, comprises a frame aerial *L* and a non-directional or trailing-wire aerial *A*. The former is connected between the grid and cathode of a " switching valve " *V*, the anode of which is connected to the trailing-wire aerial through a condenser *C*. The aerial *A* is also directly connected to the grid of the first H.F. amplifier *V*1. The screening grid of the valve *V* is connected through a switch *S* and a gain-control potentiometer *P* (which allows the input from the two aerials to be matched) to the H.T. supply.



No. 419676.

In operation, with the switch *S* open, the milliammeter *M* indicates the pick-up from the trailing-wire aerial, and is adjusted to a central zero. When the switch *S* is closed, if the needle remains steady, the loop-aerial *L* is in the " minimum " position or at right-angles to the line joining the aeroplane to the transmitting station. If, however, the needle moves to right or left, the amount of deflection gives a direct indication of the " off bearing " setting of the loop aerial. The loop may be permanently wired in the wings of the machine. The arrangement is particularly suitable for " homing " since the ammeter deflection is independent of the increase in field strength as the machine approaches the transmitting beacon.

Patent issued to C. F. Sutton.

MOTOR-CAR SETS

Application date, 13*th April*, 1934. *No.* 419710

In a motor-car radio-set it is usual to obtain the plate voltage from the vehicle battery through a

" trembler " contact (which converts the D.C. into A.C.) and a step-up transformer. In most cases such sets are specially designed for the converted voltage and are only suitable for use on the vehicle.

In order to allow a standard " house " set to be occasionally used in a motor-car, the output from the vehicle-battery " converter " is fed only to the heating-coil of the set, the primary winding of the normal mains-supply unit being left open-circuited. The anode voltage is then derived from the coupling between the heating-coil and the secondary winding of the mains-transformer.

Patent issued to R. Bosch. Akt.

CATHODE-RAY TUBES

Convention date (Germany), 22nd April, 1932.
No. 419727

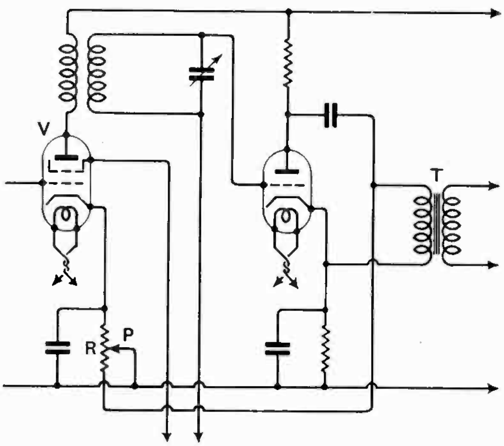
A cathode having a comparatively large emissive surface is associated with a curved focusing-electrode which is arranged within a distance of 1 mm. and carries a positive bias of from 10 to 15 volts. This serves to direct the emitted electrons through a small anode-aperture from 0.1 to 1 mm. in diameter, so that the electron-optical combination gives an intense and clear-cut beam. The concentrating electrode may also be used to apply the signal-control voltages.

Patent issued to Radio Akt. D. S. Loewe.

MANUAL VOLUME-CONTROL

Application date, 18th May, 1933. *No.* 419749

A wide range of control is secured by means of a single potentiometer which serves to vary the grid bias of one of the valves and also, but in a reverse sense, the effective impedance of an intervalve



No. 419749.

coupling on the L.F. side. As shown, the resistance *R* is in the cathode circuit of the valve *V*, and is also in shunt with the primary winding of the intervalve transformer *T*. The adjustable contact *P* of the potentiometer is connected to the earth-line of the set, so that as it is shifted to increase the resistance in the grid-cathode circuit of the valve *V*, it reduces the shunt resistance across the primary of the transformer *T*, and vice versa.

Patent issued to The Paragon Rubber Manufacturing Co., Ltd., and H. C. Atkins.

PUSH-PULL AMPLIFIERS

Convention date (U.S.A.), 10th March, 1933.
No. 419784

Instead of using a transformer input-coupling to a push-pull amplifier, the signals are applied to the third or outermost grid of a pentode valve. The potentials on the other electrodes of the pentode are so arranged that any change in signal voltage causes the current in the anode circuit to vary inversely with that of the current in the circuit of the second or middle grid.

The anode circuit of the pentode is then coupled to the input of one of the push-pull amplifiers, whilst the middle-grid circuit is coupled to the second push-pull amplifier. The total output-current from the pentode is maintained substantially constant, and secondary emission is prevented.

Patent issued to Hazeltine Corporation.

PICTURE TELEGRAPHY

Convention date (Holland), 3rd August, 1932.
No. 419836

For recording pictures received by wire, or through the ether, the incoming currents are applied to an arrow-shaped cutting-tool which, when moved axially, produces an " amplified " lateral cut. The cut or trace is recorded on a surface which consists of a paper or other support covered with a thin layer of wax or gelatine 0.012 mm. thick, overlaid with a surface of colouring matter. Or the cutter may be used to engrave directly on a surface of copper so as to produce a durable block.

Owing to the " amplification " effect due to the shape of the cutting-tool, it is possible to record currents of much higher frequency than usual, and this in turn allows both the scanning velocity and the recording speed to be increased. The cutter can be operated by 5–10 watts instead of the 300 watts normally used. At the same time the increased width of cut enhances the clearness of a picture scanned with a comparatively large " pitch."

Patent issued to N. V. Philips Gloeilampenfrabrieken.

MULTI-GRID VALVES

Convention date (Germany), 16th March, 1934.
No. 420047

A valve fitted with a control grid, a screen grid, and a suppressor grid, in addition to anode and cathode, is characterised by the fact that the screen grid is made considerably longer than the control grid and is provided with a solid-metal or wire-gauze cap, which shields the control grid electrostatically from the anode. A metal ring connected to the cathode serves the same purpose at the lower end of the grid. The construction enables the surface of the anode to be extended longitudinally, so as to favour cooling, without involving any falling-off in effective screening.

Patent issued to Vereinigte Gluhlampen und Electricitats Akt.