THE

WIRELESS ENGINEER

AND

EXPERIMENTAL WIRELESS

NUMBER 118 VOLUME X *JULY 1933*

A JOURNAL OF

RADIO RESEARCH

AND

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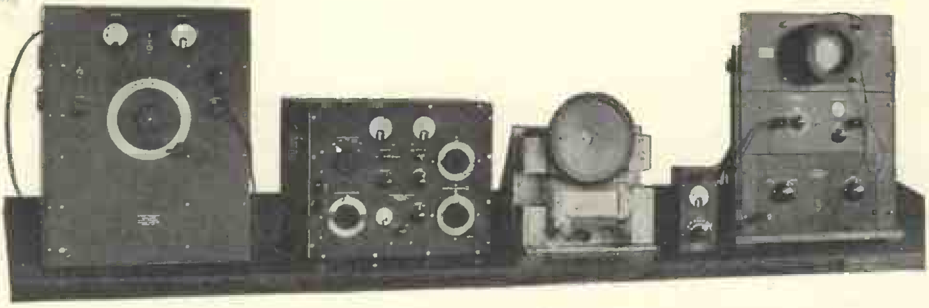

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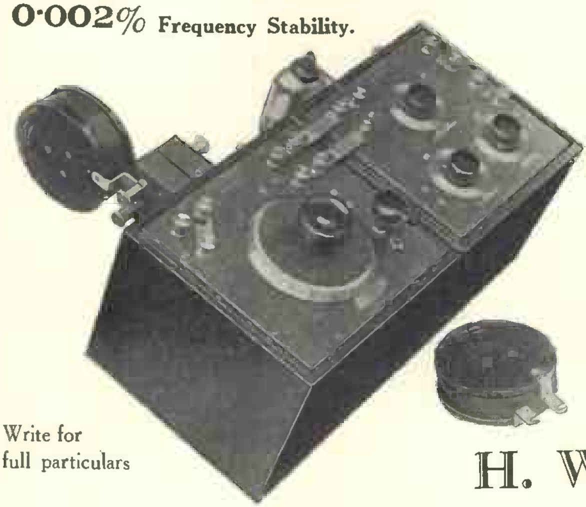

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The
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and EXPERIMENTAL WIRELESS

A Journal of Radio Research & Progress

Editor
HUGH S. POCOCK

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

VOL. X. No. 118

JULY 1933

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Published Monthly on the first of each month

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

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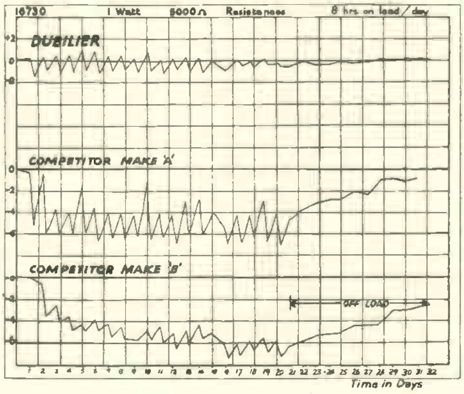

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VOL. X. JULY, 1933. No. 118

Editorial

The Cathode Ray Oscillograph in Radio Research

A BOOK with the above title has just been published.* It is a record of achievement in the application of a new tool to the investigation of a new problem. To a large extent it is a record of personal achievement by the authors, all of whom are associated—one as superintendent, and the others as scientific officers—with the Slough Research Station of the Radio Research Board, the chairman of which, Colonel A. G. Lee, has contributed a prefatory note to the book. By a coincidence another record of achievement in the application of the cathode ray oscillograph, but in a different direction, appeared almost simultaneously in *Electrotechnik und Maschinenbau* (Vienna), which celebrated the fiftieth year of its existence by publishing a special number to which Professor Rogowski of Aachen contributed an article on the Cathode Ray Oscillograph (*E. u. M.*, p. 249, 23rd April).

Although the cathode ray oscillograph was invented by Braun in 1897, it may rightly be described as a new tool, for it is only comparatively recently that it has been developed to the stage where it could be successfully employed to unravel the complexities of the problems propounded by modern radio research. In 1913 Zenneck succeeded in photographing an oscillation with a frequency of 4,000, but Rogowski reproduces a photograph of the oscillation occurring on the single breakdown of a spark-gap, the frequency being 10^8 and the velocity of the fluorescent spot over the screen 32,000 km./sec., *i.e.*, about a tenth of the velocity of light; he states that double this speed can be recorded by using a specially actinic screen material. Such an instrument offers obvious advantages over mechanical oscillographs, such as those of Duddell and Einthoven, which have resonant frequencies within the audible range and are quite useless for the resolution of oscillations of radio frequency. Such speeds as the above are only possible with voltages of about 100,000. The authors of the book have confined their attention to tubes working up to about 2,000 volts, with which the maximum writing speed is about 20 km./sec. and the upper limit of frequency for a single trace about 100,000 cycles per second. Many of the applications described

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* *The Cathode Ray Oscillograph in Radio Research*, by R. A. Watson Watt, J. F. Herd, and L. H. Bainbridge Bell. Pp. 290 + xvi, with 113 Figs. and 17 plates. H.M. Stationery Office; 10/-.

in the book under review depend, however, on the use of the cathode ray tube in a manner which, quite apart from frequency limitations, is entirely outside the scope of any other type of oscillograph. We refer to the comparison of two electric or magnetic forces at right angles by observing the resultant direction of motion of the spot. When used in this way the authors refer to the oscillograph as a voltage comparator. The authors speak very highly of the contribution of von Ardenne to the development of the low-voltage oscillograph, but it is pleasing to note that they also state that Messrs. A. C. Cossor now make the best oscillograph of the kind commercially available.

Should References be to Chapter or Page?

The book is divided into six parts and each part is divided into chapters which are further subdivided into sections; the second section in the third chapter of the fourth part is referred to as Chapter 4.3.2. Unfortunately these symbols do not appear at the top of the page, but only the page number, whereas the references are always to the chapter and never to the page. This makes the references, of which there are many, very annoying for one cannot find them by merely looking at the top of the page, but must necessarily hunt through the text to find a section heading and then try again. It has also misled the authors themselves, for on page 56 one is told that "this method will be discussed in Chapter 2.3." If the chapter numbers had been printed at the top of every page the author reading the proof would have spotted that something was wrong as he would have seen at once that this statement occurs in Chapter 2.3 itself.

Part 1 is introductory and deals with the history, properties and operation of the oscillograph. Part 2 discusses the study of the variation of electromotive forces with time. This part is of great interest to all users of cathode ray oscillographs as it deals with the most general form of its application in electrical engineering and discusses many very ingenious devices which will undoubtedly be used in researches on phenomena of a transient character in other branches of engineering. We find described here the various types of time-base, linear, zig-zag, circular, elliptical and spiral, the methods of locking the time-base frequency to the frequency of the recurrent phenomenon and, most ingenious of all, the recording of a single transient which is made to trigger-off the time-base device automatically and thus give a record of a discharge which may happen rarely and erratically.

In Part 3, the special applications of these various methods to two radio problems are considered. The first, which the authors call a purely oscillographic application, is the study of the wave-forms of atmospherics; this was one of the earliest problems to which the Radio Research Station applied the oscillograph. The other application is one which nobody who was fortunate enough to attend the lecture recently given at the Institution of Electrical Engineers by Sir Frank Smith is likely to forget; we refer to the continuous recording of the echo-pulses received from the ionised regions of the upper atmosphere. This the authors call the "cyclographic" method of using the instrument. On page 105 there is a reference to the "well-known 'Loftin-White' circuit"; no doubt this is well known to the select few to whom it is well known.

Part 4 deals with an entirely different method of using the oscillograph, in which one signal produces a vertical movement and another signal a horizontal movement of the spot, so that the simultaneous reception of the two signals causes the spot to trace a line at an angle which is a measure of the relative strengths of the two signals, assuming them to be in phase. If the two signals are the two components of a single signal as received on the two coils of a direction finder, the direction of the line on the screen will depend on the relative strengths of these two components and thus on the direction of the received signal. The highly successful development of this method has been one of the achievements of the Radio Research Station and a photograph is given of a complete direction-finding equipment made in this country for the United States Navy Department.

This visual indication of the direction from which a signal is coming has obvious possibilities in its application to navigation which are discussed in the book.

The simple direction finder is only reliable in the absence of abnormal polarisation in the received wave, but this defect has opened up a new field of usefulness for the oscillograph in its application as a radio-polarimeter. This is discussed and some photographic reproductions given in a chapter of entrancing interest.

Part 5 deals with the use of the oscillograph as a relay by fitting it with electron collecting cups into which the beam can be deflected ; this opens up possibilities some of which are discussed in the book.

The final part discusses photographic problems and will prove of great utility to anyone setting out on the design of cameras, etc., for use with cathode ray oscillographs.

In their historical introduction the authors say that, although their work has been confined to the use of low voltage tubes, there are important problems awaiting solution by the use of high voltage apparatus. The article by Rogowski, although occupying only six pages, gives a very good review of the present stage of development of the high voltage oscillograph and is very suggestive of the lines and possibilities of future development.

A 100 Candle-power Cathode Ray Screen

Those who think of the luminous spot on the fluorescent screen as a somewhat feeble phenomenon will be surprised to learn that in the 100,000-volt oscillograph to which we referred above, with the spot unconcentrated, the screen has a candle-power of considerably above 100 ; it is the concentration of this beam that enables a photographic trace to be recorded at a speed of over 30,000 km. per second.

In their preface the authors say that " the charge of doing violence to the King's English is so frequently levelled at writers on scientific and technical subjects that we feel ourselves bound to offer some explanation of systematic departures from strict orthodoxy which will be found, in addition to the casual departures which may have escaped correction, in this book." As might be expected from the authors of such a delightfully disarming apologia, the English throughout the book is carefully chosen ; in fact we often found ourselves having to read a sentence twice, being far too impressed with the resounding succession of words to grasp their meaning at once. The authors give Fowler's " Modern English Usage " as their authority for the application of " whose " to inanimate objects, but, although we dislike the usage, we would point out that the translators of the Authorised Version had no Fowler's " Modern Usage " to fall back upon when they wrote of " a city which hath foundations, whose builder and maker is God."

We have rarely come across a book so free from typographical errors. In one place (p. 280) Kc is written instead of kc, which is adopted elsewhere throughout the book, but great care has evidently been taken to use standard symbols, thus saving the reader much annoyance.

It is a pity that the plates are not inserted either at the end of the book or facing the pages on which reference is made to them ; instead of this they are sometimes inserted in another section of the book, Plate VIII, for example, which shows a record of ionospheric height being inserted—presumably for some book-binding reason—in the section on direction finding. Fortunately, a list is given at the beginning of the book showing where the various plates are to be found.

The book is one of which the authors may be justly proud ; it will be read and studied by all who are interested in the cathode ray oscillograph and especially by those who are interested in the wonderful results recently achieved in the application of radio waves to the exploration of the upper atmosphere.

G. W. O. H.

The Magneto-Ionic Theory*

By *J. A. Ratcliffe, M.A.*

(1) Introduction

THE Magneto-Ionic Theory is the name which has been given to the theory of the propagation of electro-magnetic waves through an ionised medium in the presence of a steady imposed magnetic field. The ionised regions of the upper atmosphere (the "ionosphere") in the presence of the earth's steady magnetic field constitute such a medium, and the theory of the phenomena occurring when wireless waves pass through these regions is very important in the study of wireless propagation.

The magneto-ionic theory has been studied by Appleton,[1] [2] Goldstein[3] and Hartree[4]. The final result shows that when any electromagnetic wave is propagated through an ionised medium in the presence of a steady magnetic field, it is split up into two component waves of different polarisations and each travelling with its own characteristic velocity. The characteristic polarisations and velocities depend on the frequency of the wave, on the density of ionisation, and on the angle between the direction of propagation and the magnetic field. The medium may be said to be doubly refracting, but the state of affairs is more complicated than in the ordinary doubly refracting crystal. Appleton[2] has shown, in a recent lecture to the I.E.E., how to take account of the collisions between the ions and neutral molecules, and how to deduce the amount of attenuation suffered by the wave in consequence of these collisions. This collisional friction further complicates the problem, for we find that the polarisation and the velocity depend also on the frequency of collision. The final result is expressed by Appleton by means of the following formulae, in which the refractive index, μ, the absorption coefficient, κ, and the polarisation, R, are expressed in terms of certain quantities, which are explained below.

$$\left(\mu - \frac{ic\kappa}{p}\right)^2 = c^2q^2 = 1 + \frac{2}{2(\alpha+i\beta) - \dfrac{\gamma_T^2}{1+\alpha+i\beta} \pm \sqrt{\dfrac{\gamma_T^4}{(1+\alpha+i\beta)^2} + 4\gamma_L^2}} \quad \ldots \quad (1)$$

$$R = \frac{\mathfrak{H}_z}{\mathfrak{H}_y} = + \frac{i}{\gamma_L}\left\{\frac{1}{c^2q^2 - 1} - (\alpha + i\beta)\right\} \quad \ldots \quad (2)$$

Here $\alpha = -\dfrac{mp^2}{4\pi Ne^2} - l$

$\beta = \dfrac{mp\nu}{4\pi Ne^2}$

$\gamma_{L,T} = \dfrac{mp\left(\dfrac{H_{L,T}\,e}{mc}\right)}{4\pi Ne^2}$

where m, e = mass, charge of ion.†

N = number of ions per c.c. (ionic density)

p = angular frequency of the wave

ν = frequency of collision between the ions and neutral molecules. It is this "collisional friction" which is responsible for the absorption of the wave.

H_L = imposed magnetic field resolved along the wave normal

H_T = imposed magnetic field resolved perpendicular to the wave normal.

l = "Lorentz term" to be discussed below.

The wave is supposed to be propagated along the positive X axis, and the imposed magnetic field lies in the XZ plane, H_L being along OX and H_T along OZ as shown in Fig. 1. R is the ratio of the axes of the ellipses which represent the state of the polarisation of the wave, as explained in Section 3*e*. $\mathfrak{H}_z$ and $\mathfrak{H}_y$ are the components of the magnetic field *of the wave* itself.

---

* MS. received by the Editor, October, 1932.

† We here depart a little from Appleton's notation and write our equations for positive ions. If, later, we wish to deal with electrons, we shall have to take e to be negative.

Since the expressions (1) and (2) contain so many variables, they appear at first sight to be very complicated, and it is difficult to see how the refractive index or the polarisation varies as any one of the parameters is varied. It is the purpose of this paper to show that, in spite of this apparent complication, the general behaviour of the medium can be expressed in terms of one or two fundamental curves, and the behaviour in any special case can be visualised, at any rate approximately, by a very simple substitution of numerical quantities.

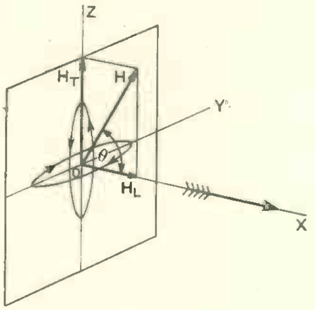

Fig. 1.

There is nothing in this paper which is not implicit in the equations (1) and (2), due to Appleton ; all that we shall do here is to attempt to give a simple account of the results which may be deduced from the theory, for the benefit of workers who have not time to delve deeply into the rather intricate mathematical expressions. We shall consider the equations in the abstract, and will content ourselves with indicating how the behaviour of a wave may be deduced from them under conditions which are likely to be of practical importance.* Although almost every point which we shall deduce abounds with significance for the interpretation of wireless propagation phenomena, we shall not here make any mention of the application of the results of theory to practical cases.

2. Method of Treatment

Before we proceed to discuss the expressions (1) and (2) we must discuss the significance of the " Lorentz term l." A term of this type and of numerical value $\frac{1}{3}$ was introduced into the theory of dispersion by Lorentz[5] who showed that it was due to the polarisation of the medium by the wave. (Polarisation is here used to mean the separation of charges in the medium, and is not to be confused with the polarisation of the wave.) The presence of this term in the case of the ionosphere has been discussed by Hartree,[4] who gives reasons for supposing that we should take $l = \frac{1}{3}$ for this case also, though perhaps it should no longer be thought of as a result of the polarisation of the medium.

In order to present a clear treatment of the magneto-ionic behaviour we shall first make the simplifying assumption that $l = 0$ and later we shall show how all our conclusions are modified by taking $l = \frac{1}{3}$. There are two advantages in this method of treatment ; first, it enables the results to be presented more simply, and, secondly, it cannot yet be taken as definitely established whether it is correct to take $l = 0$ or to take $l = \frac{1}{3}$.

In what follows we shall also assume throughout that there is no collisional friction, so that we may take $\nu = 0$. The conditions under which this assumption approximates to reality will be considered in Section 5.

In the wireless problems with which we are usually concerned we have to deal with a wave of given frequency travelling upwards into regions of gradually increasing ionisation. We are therefore most interested in the way in which the refractive index and polarisation vary with ionic density for a given frequency. For this reason we shall plot curves to show how μ^2 varies with N.

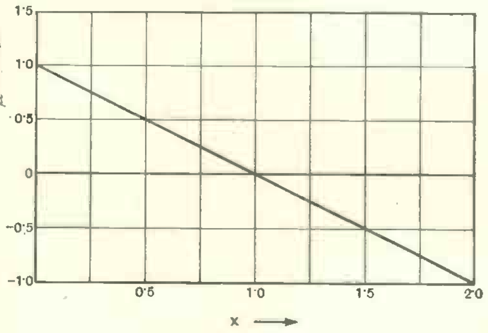

Fig. 2.

A wave sent up into the ionosphere will be returned when it reaches a point where $\mu = 0$ (or even earlier for oblique incidence). We may therefore simplify our problem by not considering, in any detail, the behaviour

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* While this article was in the Editor's hands a paper along somewhat similar lines was read (Dec. 16th, 1932), to the Physical Society by Dr. Mary Taylor.

of a μ^2-N curve beyond the point where $\mu^2 = 0$.

Goldstein[3] has considered in some detail the type of curves which result from equations (1) and (2). From his work it is not, however, easy to visualise the curves for all conditions, because he does not make it clear how the curves change progressively as the angle between the wave normal and the imposed magnetic field (θ in Fig. 1) is varied. By investigating this progressive change in detail we shall show how the curves may be visualised for all conditions.

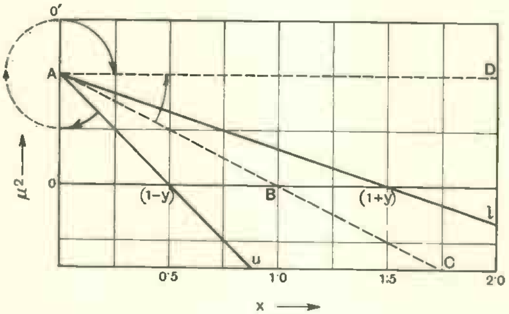


Fig. 3.

3. Treatment Neglecting the Lorentz Term ($l = 0$).

Appleton has shown that equation (1) may be written more conveniently as follows, for the case where $\beta = 0$ and where $l = 0$.

$$c^2q^2 = \left(\mu - \frac{i\kappa c}{p}\right)^2 = 1 - \frac{2x(1-x)}{2(1-x) - y_T^2 \mp \sqrt{y_T^4 + 4y_L^2(1-x)^2}} \quad (3)$$

Here $x = p_0^2/p^2$ where $p_0^2 = \dfrac{4\pi Ne^2}{m}$

$$y_L = p_L/p \quad \text{where } p_L = \frac{H_Le}{mc}$$

$$y_T = p_T/p \quad \text{where } p_T = \frac{H_Te}{mc}$$

We shall also use

$$y = p_1/p \text{ where } p_1 = \frac{He}{mc};$$

$$H = \sqrt{H_L^2 + H_T^2}.$$

It will often be useful to write

$$y = \frac{\lambda}{\lambda_1} \text{ where } \lambda_1 = \frac{2\pi c}{p_1}.$$

We shall now investigate the results to be obtained from equation (3).

(*a*) *No magnetic field.*

We first take the case with no magnetic field present by writing $H = 0$, and hence $y_L = y_T = 0$. We then have $\mu^2 = 1 - x$ and the graph showing μ^2 against x is shown in Fig. 2. In connection with this and the following graphs it is important to remember that x is proportional to N.

(*b*) *Magnetic field present. Longitudinal case.*

Next we suppose that a magnetic field is present and that the wave travels along the field direction. This we call the longitudinal case and we have $y_T = 0$, $y_L = y$, so that equation 3 reduces to

$$\mu^2 = 1 - \frac{x(1-x)}{(1-x) \mp y(1-x)}$$

$$= 1 - \frac{x}{1 \mp y}.$$

An expression equivalent to this was deduced more simply for this special case of propagation along the field by Lorentz, before the general theory was developed. The curve showing μ^2 as a function of x now splits into two, one corresponding to the upper sign in the equation and the other to the lower. Both are straight lines, cutting the x axis at $x = 1 - y$, and $x = 1 + y$ for the upper and lower signs respectively. As y increases from zero to infinity the line corresponding to the lower sign (marked l in figure (3)) swings round from ABC to AD. The line corresponding to the upper sign (u in the figure) swings from ABC to AO as y increases from 0 to 1, and then from AO' to AD as y increases from 1 to infinity. The behaviour in any special case is clear if we remember that $y = \dfrac{\lambda}{\lambda_1}$. For $H = 0.5$ e.m.u. and e and m of electronic magnitude it is found that λ_1 is approximately 200 ms. Thus for a 100 m

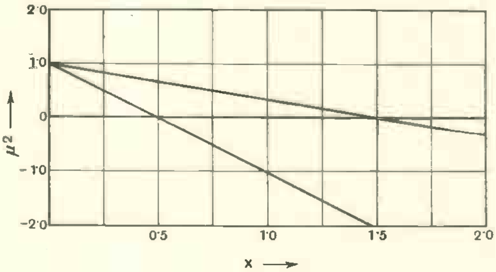


Fig. 4*a*.

wave $y = \frac{1}{2}$ and the curves are as shown in Fig. 4*a* and for a 400 ms. wave $y = 2$ and the curves are as in Fig. 4*b*. It is noticeable that for values of y greater than 1 (λ greater than 200 ms.) the curve u gives only values of μ^2 greater than unity.

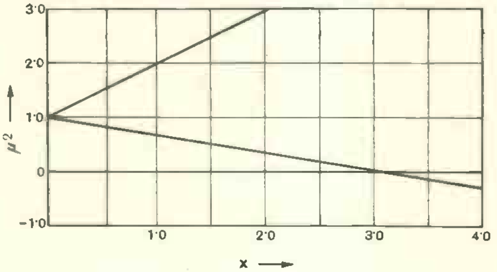


Fig. 4*b*.

(*c*) *Transverse case.*

When the wave normal is perpendicular to the magnetic field (transverse case), so that $y_L = 0$, $y_T = y$, equation (3) becomes the two equations

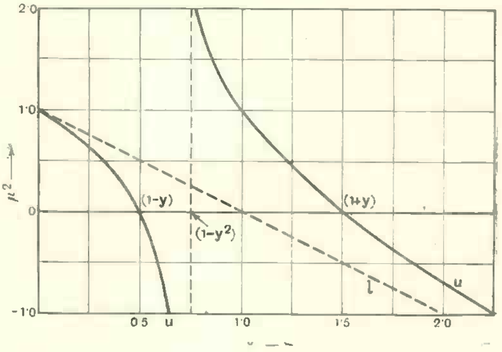
$$\mu^2 = 1 - x \quad \ldots \quad \ldots \quad \ldots \quad (4a)$$

$$\mu^2 = 1 - \frac{x(1 - x)}{1 - x - y_T{}^2} \quad \ldots \quad (4b)$$

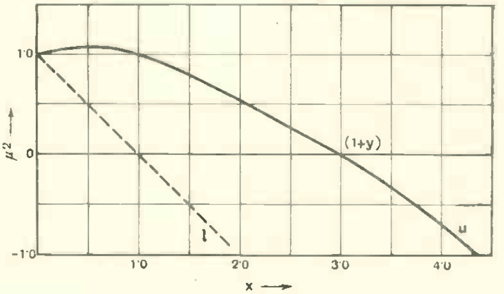
for the lower and upper signs respectively.

The curves of μ^2 against x then take the form shown in Fig. 5. Equation 4*a*, corresponding to the lower sign in equation 3, gives rise to the straight line (l). This is the same as the straight line obtained when there is no field present. It therefore represents a wave which is uninfluenced by the field, and, by analogy with the optical case of double refraction it is called the " ordinary " wave. Equation 4*b* corresponding to the upper sign in equation (3) gives rise to different curves according as y is greater or less than unity. In the case of y less than unity we have the curve (u) in Fig. 5*a*. This crosses the x axis at the two points $x = 1 \pm y$ and is asymptotic to infinity at $x = 1 - y^2$. It also passes through $\mu^2 = 1$ at $x = 1$. If we also notice that the slope at $x = 0$ is the same as that of the line $\mu^2 - 1 = -\dfrac{x}{1 - y^2}$ (i.e., it sets off as if it were going to cut the x axis at $1 - y^2$) ; and for large values of x, $\mu^2 - 1$ is equal to $-x$, then it is a simple matter to sketch the curves for any value of y less than unity. It is clear that the wave represented by this curve is influenced to a large extent by the steady magnetic field and it is, therefore, called the " extraordinary " wave by analogy with the case of double refraction.

For values of y greater than unity the behaviour is shown in Fig. 5b. The ordinary wave behaves as before, but the extraordinary wave behaves as shown at (u). The infinity has disappeared and for values of x between 0 and 1 we find values of μ^2 greater than 1. At $x = 1$ we have $\mu^2 = 1$ and the curve crosses the x axis at $x = 1 + y$. The initial slope is as if the curve had gone through $x = 0$ at $x = 1 - y^2$ as before, but this is now a negative point. For large x, $\mu^2 - 1$ is proportional to $-x$ as before. It is now a simple matter to sketch the behaviour in the transverse case for any value of y.



(*a*) ($y = \frac{1}{2}$, *approx.* 100 *m.*)



(*b*) ($y = 2$, *approx.* 400 *m.*)

Fig. 5.

(*d*) *General case* (*y less than unity*).

Figs. 4a and 5a represent the curves for the longitudinal and the transverse cases respectively. The question now arises "What is the form of the curves for some intermediate direction of the magnetic field ?" As the direction of the field is gradually altered from the longitudinal to the transverse position there must be a gradual change from the curves of Fig. 4a to those of Fig. 5a and at first sight the nature of this gradual change-over is far from obvious. We shall now show that a clear understanding of the nature of this change-over leads at once to a simple method of visualising the approximate behaviour for any general direction of the field.

Consider first the chief points in the behaviour of the general case as represented by the equation

$$\mu^2 = 1 - \frac{2x(1-x)}{2(1-x) - y_T^2 \mp \sqrt{y_T^4 + 4y_L^2(1-x)^2}} \quad (3)$$

From this equation it may be shown that, for the upper sign $\mu^2 = 0$ at $x = 1 \pm y$, there is an infinity at $\frac{1 - y^2}{1 - y^2\cos^2\theta}$, and $\mu^2 = 1$ at $x = 1$. For the lower sign, $\mu^2 = 0$ at $x = 1$. In the case of the lower sign the "critical ionisation" where $\mu^2 = 0$ is independent of the value of the magnetic field, just as it was in the corresponding transverse case, so we still call the wave corresponding to this sign the "ordinary wave." It is to be noted, however, that in the general case the *shape* of the curve for this ordinary wave is *not* independent of the field, it is only the point where the curve cuts the axis which shows this independence.

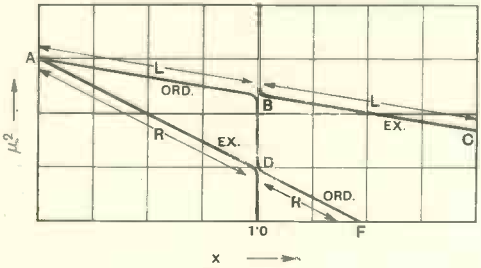


Fig. 6.

The degeneration of the general case into the transverse case is accomplished by putting $\theta = \frac{1}{2}\pi$ so that the infinity moves to $x = 1 - y^2$, and the zeros being at $x = 1 \pm y$ and $x = 1$ for the extraordinary and ordinary waves respectively, the agreement with Fig. 5a is clear. To investigate the degeneration into the longitudinal case of Fig. 4a we put $\theta = 0$ and we find that the extraordinary wave has zeros at $x = 1 \pm y$ and an infinity at $x = 1$, whereas the ordinary wave has a zero at $x = 1$. It is then clear that the curves for the longitudinal case take the form shown in Fig. 6; for if, at the point $x = 1$ we change over from the extraordinary curve (Ex) to the ordinary curve (Ord) and *vice versa*, we have the straight lines of the simple Lorentz case (Fig. 4a). It is to be noted that in deriving Fig. 6 from Eq. 3 as in Section 3b we cancelled a factor $(1 - x)$ which is responsible for hiding the singularity at $x = 1$. In the simple Lorentz derivation of the longitudinal case there is no singularity at $x = 1$ and it is quite clear that each of the curves (Fig. 4a) represents the behaviour of one of the two circularly polarised waves which can travel in the medium. There is no question of a change over from one of these curves to the other at $x = 1$. It is therefore important to consider what is the physical meaning of the change-over in Fig. 6. This entails a study of the state of polarisation of the wave, to which we will now proceed.

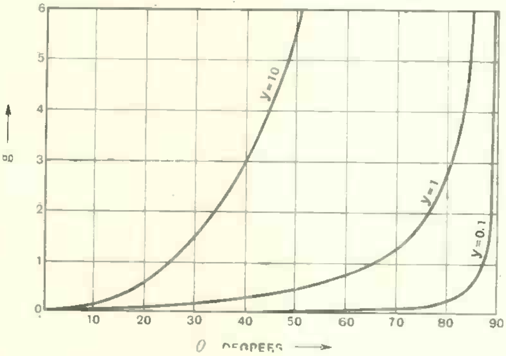


Fig. 7.

(*e*) *Polarisation.*

The two waves which can travel in the medium have their magnetic vectors in the wave-front and are, in general, elliptically polarised (cf. Fig. 1). The axes of the ellipses are in, and at right angles to, the plane containing the wave normal and the direction of the imposed magnetic field. (We will call this plane the "magnetic plane," it is the plane *ZOX* in Fig. 1.) The ellipses in the two cases are similar but situated with their major axes perpendicular to each other, and they have opposite senses of rotation. If we denote by R the ratio of the axis which lies in the magnetic plane to the axis at right angles to this plane, then we may show from equation 2, that, for the ordinary wave

$$R_o = \left(\frac{\mathfrak{H}_z}{\mathfrak{H}_y}\right)_o = f\left\{1+\sqrt{1+1/f^2}\right\} = -\left(\frac{\mathfrak{H}_y}{\mathfrak{H}_z}\right)_{ex} = -\frac{1}{R_{ex}}$$

where $f = \frac{1}{2} y \frac{\sin^2\theta}{\cos\theta} \frac{1}{1-x} \equiv g \frac{1}{1-x}$

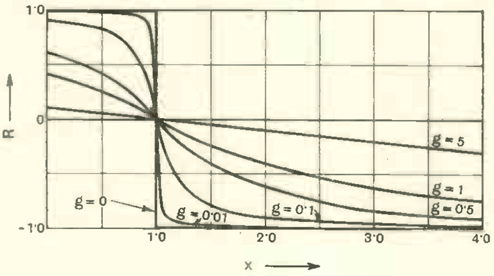


Fig. 8.

The suffixes o and ex mean that the quantity refers to the ordinary or the extraordinary wave respectively. If R is positive then the sense of rotation is right-handed as viewed by an observer looking along the direction of propagation. We shall call this type of polarisation right-handed in what follows. If we take negative electrons (such as are supposed to be active in the ionosphere) and a field which has a component along the direction of propagation (as with downcoming waves in the Northern hemisphere) then for vanishingly small ionisation density and for the ordinary wave R_o is negative and corresponds to a left-handed polarisation.

R is a function of the quantity $\frac{1}{2} y \frac{\sin^2\theta}{\cos\theta}$ which is itself a function of the wavelength and the angle θ. We shall denote this quantity by g. It is exhibited as a function of y and θ in Fig. 7, and Fig. 8 shows how R_o varies with x (proportional to N) for a given value of g. Thus suppose we wish to investigate the polarisation of a 135 ms. wave ($y = 0.67$) travelling at 60° to the magnetic field. We first find from Fig. 7 that for $\theta = 60°$ and for $y = 1$, $g = 0.75$; for $y = 0.67$ we therefore have $g = 0.5$. Then the curve corresponding to $g = 0.5$ in Fig. 8 shows how the polarisation changes with x. It is especially to be noted that R varies with x, and hence, that the type of polarisation changes as the wave penetrates into the ionosphere. As we pass the point at which $x = 1$ the sign of R changes, so that what was previously a left-handed wave becomes right-handed and *vice versa*. At the point $x = 1$, R is zero under all conditions, which means that here the wave is always plane polarised. Thus it will not be correct to speak of the ordinary wave as (say) left-handed, it is only left-handed for sufficiently small ionisation densities and becomes right-handed for larger densities.*

Let us now consider the polarisation in the two special cases of propagation along, and at right angles to, the field. In the transverse case $\theta = 90°$ and hence $g = \infty$ (see Fig. 7), therefore from Fig. 8 $R_o = 0$ everywhere. This means that the ordinary

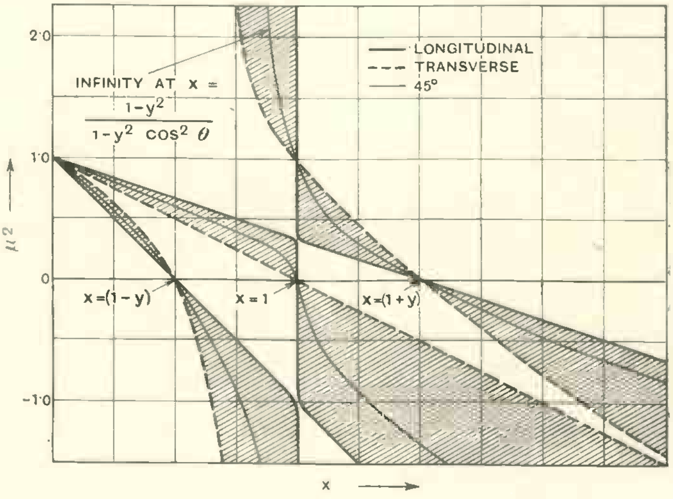


Fig. 9. ($l = o$; $y = \frac{1}{2}$, *approx.* 100 *m.*)

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* Of course, other reasons may prevent the wave ever reaching a place where the ionisation density is greater than that given by $x = 1$.

wave is everywhere plane polarised with its magnetic vector perpendicular to the "magnetic plane" and its electric vector in this plane; and the extraordinary wave is plane polarised at right angles to this. In the longitudinal case ($\theta = 0$) we find $g = 0$ and the corresponding curve of Fig. 8 shows that $R_o = +1$ up to $x = 1$ and $R_o = -1$ beyond this point. Thus the change in the sign of R which always takes place at $x = 1$ takes place discontinuously in this case. Up to $x = 1$ the ordinary wave is circularly polarised with one sense of rotation; beyond $x = 1$ it is circularly polarised in the opposite sense. The extraordinary wave behaves in a complementary manner. This discontinuous change of polarisation in the longitudinal case gives us the clue to the interpretation of Fig. 6. If we follow one sign in the equation (3) we must follow one of the lines (Ex) or (Ord) in Fig. 6 with its discontinuity at $x = 1$. But we must also remember that up to $x = 1$ this line refers to circular polarisation with one sense of rotation, whereas beyond that it refers to the other sense of rotation. The senses of rotation are as marked in the figure (L) and (R), and if we decide to follow one type of polarisation, rather than one sign in the equation, we get the lines *ABC* and *ADF* without any discontinuity. This, of course, agrees with the simple theory of Lorentz.

Now if we plot on the same diagram the curves for the transverse and for the longitudinal cases, considering the latter as a limiting example of the general case, we have the diagram of Fig. 9. This is to be read in conjunction with Fig. 8 showing how the polarisation changes with x. It is now clear how the gradual change-over from the transverse to the longitudinal case comes about. An intermediate case for $\theta = 45°$ is sketched in the figure. The ordinary wave has a zero at $x = 1$ and finishes parallel to $\mu^2 - 1 = -\dfrac{x}{1 - y\cos\theta}$, i.e., as though it had passed through $\mu^2 = 0$ at $x = 1 - y\cos\theta$. The extraordinary wave has zeros at $x = 1 + y$ and $x = 1 - y$ and an infinity at $x = \dfrac{1 - y^2}{1 - y^2\cos^2\theta}$ and finishes parallel to $\mu^2 - 1 = -\dfrac{x}{1 + y\cos\theta}$.

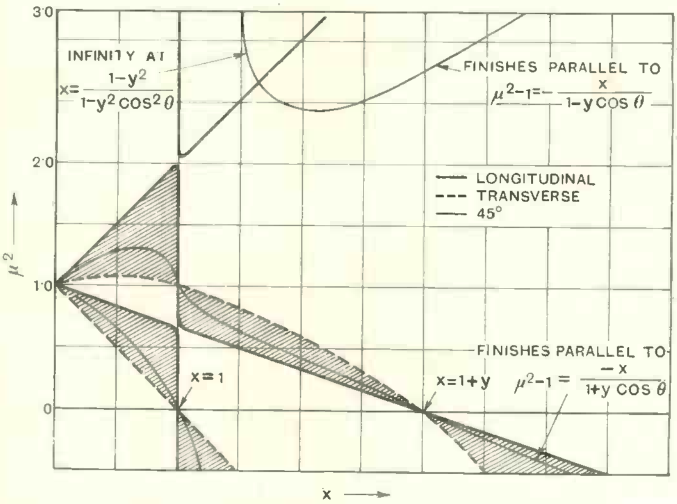

Fig. 10. ($l = 0$; $y = 2$, *approx.* 400 *m.*)

For all angles θ the curve lies inside the shaded areas and it is possible to estimate its course with a fair degree of accuracy without any further calculation.

(*f*) *y greater than unity.*

Exactly similar considerations enable us to visualise the case where y is greater than unity: The equation for the general case shows that there is an infinity at $x = \dfrac{1 - y^2}{1 - y^2\cos^2\theta}$, and, since y is greater than unity, this infinity only occurs if θ is sufficiently small, that is, in cases approaching the longitudinal. For the longitudinal case itself the infinity occurs at $x = 1$. This longitudinal case, considered as a limit of the general case, together with the transverse case, is shown in Fig. 10, and an intermediate case ($\theta = 30°$) is sketched.

4. Inclusion of the Lorentz Term

In the foregoing we have dealt, entirely, with the case where $l = 0$. We will now investigate the changes which are introduced by making the assumption that $l = \frac{1}{3}$. It may be shown that all the above expressions with $l = 0$ may be transformed into expressions in which $l = \frac{1}{3}$ by writing x/η and y/η in place of x and y respectively, where $\eta = \left(1 + \frac{x}{3}\right)$, and is itself a function of x. This gives more complicated expressions, but the various quantities are easily exhibited graphically by noting the following points :—

(1) For x very small η approximates to unity, and hence the behaviour for x small is the same as that previously considered. Even at $x = 0.25$ the departure is less than 10 per cent.

(2) For all values of y and θ, μ^2 approximates to -3 for very large values of x.

(a) y less than unity.

Limiting ourselves now to the cases where y is less than unity we have also

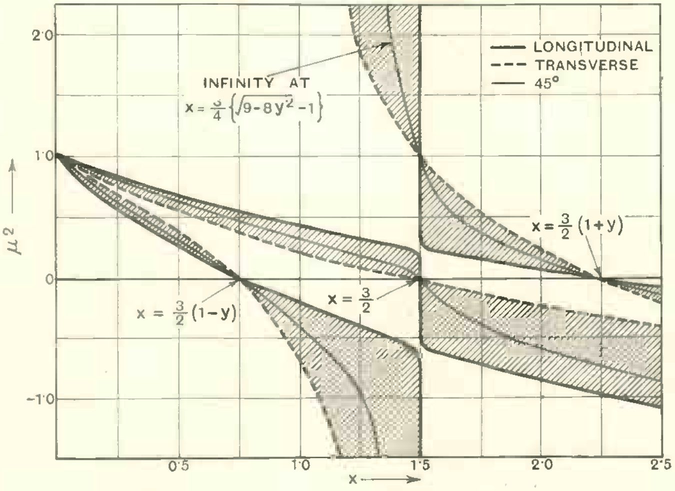

Fig. 11. ($l = \frac{1}{3}$; $y = \frac{1}{2}$, *approx.* 100 *m.*)

(3) The zeros become $x = 3/2$ for the ordinary wave and $x = \frac{3}{2}(1 \pm y)$ for the extraordinary wave

(4) The infinity falls at

$$x = \tfrac{3}{4}[\sqrt{9 - 8y^2} - 1]$$

for the transverse case. The curves for the transverse case and for the longitudinal case considered as a limit of the general case are shown in Fig. 11 for $y = \frac{1}{2}$. An intermediate case is sketched for $\theta = 45°$. By substituting x/η and y/η for x and y respectively in equations (4) it may be shown that the curves showing R as a function of x are derived from those in the case where $l = 0$ simply by extending the x scale by a factor 3/2. The new curves obtained are shown in Fig. 14. These are still to be read in conjunction with the curves of Fig. 7 giving the values of g. It is clear that the type of behaviour is very similar to that obtained in the case in which $l = 0$, but that the critical points occur at values of x which are 3/2 times as great as those previously obtained.

(b) y greater than Unity.

Here the transverse case gives curves very similar to those of Fig. 10. The ordinary wave has a zero at $x = 3/2$ and the extraordinary passes through $\mu^2 = 1$ at $x = 3/2$ and has a zero at $x = \frac{3}{2}(1 + y)$. The longitudinal case derived as a limit of the general case differs from that obtained with $l = 0$ in that it shows *two* infinities, one at $x = 3(y - 1)$ and one at $x = 3/2$. For values of y which lie between 1 and 1.5 the first of these two infinities occurs for a value of x less than 3/2 and it can be shown that both the infinities occur in the curve for the extraordinary wave, as in Fig. 12 for $y = 1.25$ [$\lambda = 250$ ms]. For values of y greater than 1.5 the second infinity occurs for values of x greater than 3/2 and both the infinities occur in the curve for the ordinary wave as shown in Fig. 13 for $y = 2$ (400 ms.). As before, the curve for an intermediate direction of propagation lies between the curves for the longitudinal and the transverse cases, *i.e.* somewhere in the shaded areas of Figs. 12 and 13. If we begin with the longitudinal case and slowly increase θ it is found that the two infinities run together in either of the cases of Fig. 12 or Fig. 13, and for values of θ greater than a certain critical value there are no infinities in the curves. Intermediate cases are sketched in Figs. 12 and 13.

5. The Assumption of No Collisional Friction

Throughout this treatment we have deduced values for the refractive index and the polarisation on the assumption that there is no collisional friction so that $\beta = 0$. It is now necessary to determine the actual conditions under which this assumption approximates to reality. It may be shown that the exact equation (1) is equivalent to the approximate equation (3) provided that

$$\beta << |(1 + a)|$$

i.e., provided that

$$\frac{\nu}{p} << |(1 - l)x - 1|.$$

Now at the height of the Heaviside layer (100 kms.) ν is probably of the order of 10^5, so that ν/p is a small quantity provided p is greater than 10^6. Thus, except very near the point $x = \frac{1}{1 - l}$ ($x = 1$ or 3/2 according as the Lorentz term is, or is not, neglected) we are justified in neglecting β in the calculation of the refractive index in the neighbourhood of 100 kms. for waves of frequency greater than $\frac{10^6}{2\pi}$, *i.e.*, of wavelength less than 1,800 ms. For waves longer than this more detailed investigation is needed, and for waves much longer the frictional term will profoundly modify the refractive index, so much so indeed that for very long waves the height of reflection is probably determined by the magnitude of the collisional friction rather than by the ionisation density.

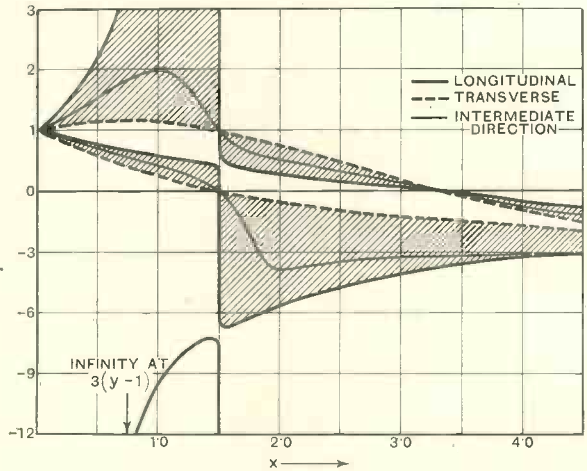

Fig. 12. ($l = \frac{1}{3}$; $y = 1{\cdot}25$, *approx.* 250 *m.*)

Near the point $x = \frac{1}{1 - l}$, where the ordinary wave is returned, it appears probable that the effect of the collisional friction will be to prevent the value of μ becoming absolutely zero. In spite of this, however, it is probable that *true reflection* will take place at this height for vertical incidence, instead of *refraction* or "total reflection" which would occur if there were no friction. The final result is therefore the same in both cases. Lower down in the atmosphere the value of ν/p becomes comparable with $|(1 - l)x - 1|$ and, near the ground $\frac{\nu}{p} >> |(1 - l)x - 1|$. It may be shown, however, that if this occurs where μ calculated from the approximate formula does not depart appreciably from unity, then the introduction of the frictional term does not cause any such departure. We may therefore summarise the conclusions by

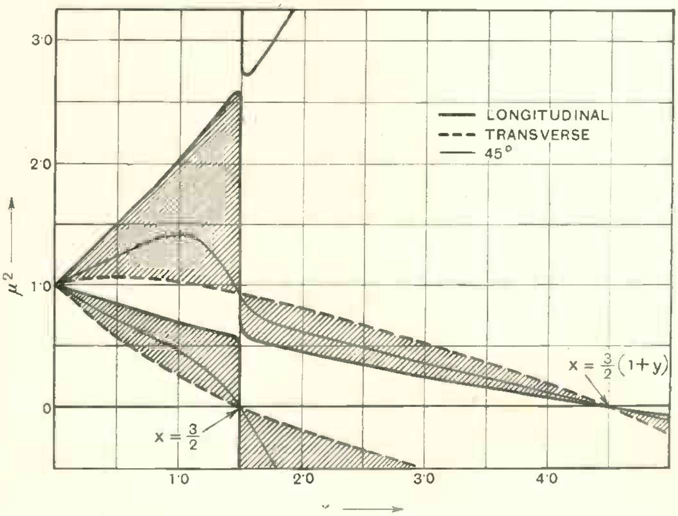

Fig. 13. ($l = \frac{1}{3}$; $y = 2$, *approx.* 400 *m.*)

saying that, in all probability (depending on the assumed values for the collisional friction), the approximate equations for μ, with β neglected, will hold in the case of the ionosphere for wavelengths less than about 1,800 ms.

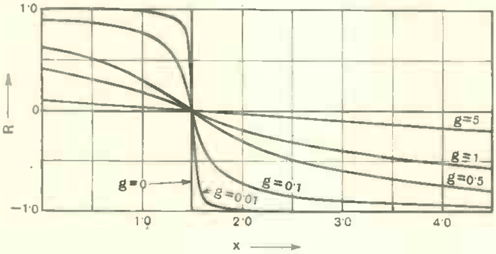

Fig. 14.

The effect of the collisional friction on the polarisation of the waves is much more important. It may be shown that the polarisation will undergo a continual change as the wave travels to regions where ν is greater, and, at ground level, all waves, whatever the frequency, are circularly polarised for all directions of travel except those which are extremely nearly perpendicular to the imposed field.

Besides influencing the values already deduced for the refractive index and the polarisation, the introduction of a frictional term will, of course, introduce absorption of the waves. The study of the equations with a frictional term is of great interest and importance, but we cannot pursue it here.

6. Conclusion

The final results of the magneto-ionic theory with frictional collision neglected are summarised in Figs. 8 to 14. The results will be valid for the ionosphere in the following practical cases. The curves for μ (Figs. 9, 10, 11, 12, 13) will probably hold for wavelengths less than 1,800 ms. The curves for R, the polarisation, will hold approximately where $\nu < p$, that is, they will hold, for waves of length less than 1,800 m., in the deviating portions of the ionosphere (*i.e.*, where μ departs appreciably from unity; in not very exact language, we may say " in the layer itself "). Near the ground they will not hold at all, in fact, both waves received at the ground will be circularly polarised.

References

(1) Appleton, *U.R.S.I.*, Report, 1928.

(2) Appleton, *Journ. Inst. Elec. Engs.*, Vol. 71, p. 642, 1932.

(3) Goldstein, *Proc. Roy. Soc. A.*, Vol. 121, p. 260, 1928.

(4) Hartree, *Proc. Camb. Phil. Soc.*, Vol. 27, p. 143, 1931.

(5) Lorentz, " Theory of Electrons," p. 137 and Notes 54 and 55.

Standard Audio-Frequency Oscillator

A MAINS-OPERATED audio-frequency, oscillator has been developed by Standard Telephones and Cables, Ltd. especially for laboratory use. It covers a range of from 20 to 10,000 c/s. in a series of graduated steps, the power output being of the order of 20 milliwatts. The wave-form is good, the sum of all the harmonics not exceeding 3 per cent. of the output voltage, and the frequency stability is within ± 0.2 per cent. throughout.

Standard Telephones A.C. mains-operated oscillator for audio-frequency tests

Provision is made for checking the frequency where controlled 50 c/s. mains are available, and the price is £42. A thermo-ammeter set for use with the oscillator costs £12 10s. complete, and an attenuator is available at £15.

The Pentagrid Converter*

By C. L. Lyons, B.Sc.

IN view of the ever-increasing popularity of the Superheterodyne Receiver, great interest attaches to the newly produced American "Pentagrid Converter" valves, which have been especially developed for combined oscillator-detector service in all superhets. These new valves are being made in two types, designated 2A7 and 6A7. The 2A7 is for employment in 2.5 volt receivers, whilst the 6A7 has been designed for the "Car Radio" market, or normal A.C. receivers, and also for service in the new "Cigar-box" A.C./D.C. Compact Receivers, some popular types of which were described in *The Wireless World*, issue dated March 24th, 1933.

Either type can supply the local oscillator frequency, and, at the same time, mix it with the radio-frequency input to produce the requisite intermediate-frequency. These new valves possess manifold advantages in their design, which will now be discussed in detail.

These two new valves are designated "Pentagrid Converters": they are 5-grid *electron coupled* detector-oscillators especially designed for service in superheterodyne circuits. Each one offers the possibility of securing greater radio-frequency to intermediate-frequency translation gain than hitherto obtainable in any form of combined detector-oscillator system. Furthermore, there is the very real advantage of complete isolation between the radio-frequency, oscillator, and intermediate-frequency circuits.

Except for their heater-ratings and a small difference in "cut-off," these new valves are identical in operational characteristics. Type 6A7 has a 6.3 volt, 0.3-ampere heater, and the 2A7 is for receivers having a 2.5 volt heater supply: the 2A7 draws 0.8 ampere.

Briefly, the structural arrangement of these tubes is as follows (proceeding outward from the cathode):

(*a*) Indirectly heated cathode.

(*b*) Grid No. 1, oscillator grid.

(*c*) Grid No. 2, anode-grid.

(*d*) Grid No. 3, screen-grid (connected to grid No. 5).

(*e*) Grid No. 4, control- or modulator-grid (for R.F. signal).

(*f*) Grid No. 5, screen-grid (connected to grid No. 3).

(*g*) Anode.

Elements (*a*), (*b*) and (*c*) form the oscillator

Makers' Tentative Rating and Characteristics

Heater voltage (2A7)	2.5 volts, A.C. or D.C.
Heater current (2A7)	0.8 Ampere.
Heater voltage (6A7)	6.3 volts, A.C. or D.C.
Heater current (6A7)	0.3 Ampere.
Anode voltage	250 Volts maximum.
Screen voltages (*d* and *f*)	100 Volts maximum.
Anode-grid (*c*)	*250 Volts maximum.
Control-grid (*e*)	−3 Volts minimum.
Total cathode current	14 milliamperes maximum.

Direct inter-electrode capacities (approximate values with valve shield).

Control- or modulator-grid to anode (*e–g*)	0.5 μμF
Ditto to anode-grid (*e–c*)	0.25 μμF
Ditto to oscillator-grid (*e–b*) ..	0.15 μμF
Oscillator-grid to anode-grid (*b–c*) ..	1.40 μμF
†Control-grid to *all other* electrodes (R.F.I)	9.40 μμF
§Anode-grid to *all other* electrodes (oo) ..	6.10 μμF
§Oscillator-grid to *all other* electrodes (oi)	7.20 μμF
§Anode (*g*) to all other electrodes (Do) ..	12.00 μμF

(" R.F.I." = R.F. input: "OO" = oscillator output: "OI" = oscillator input: "DO" = detector output).

† *i.e.*, $Cg_4(k + g_1 + g_2 + g_3 + g_5 + p)$ = R.F. Input

§ Capacity also cumulative.

Typical Operation in the Laboratory

Heater voltages and currents	As per makers ratings.
Anode voltage	250 Volts.
Screen voltage (*d* and *f*)	100 Volts.
Anode-grid voltage (*c*)	*250 Volts.
Control-grid voltage (*e*)	−3 volts
Oscillator grid resistor (grid *b*) ..	50,000 ohms
Anode current	4.0 mA
Screen current	2.0 mA
Anode-grid current	3.5 mA
Oscillator-grid current	0.5 mA
Anode resistance	0.3 megohm
Conversion conductance††	475 micromhos
Conversion conductance (2A7) at −50 volts on (*e*)	2 micromhos
Conversion conductance (6A7) at −42.5 volts on (*e*)	2 micromhos

* See precaution given under Installation and Precautions below.

†† The ratio of I.F. Component of Output Current to R.F. Signal Voltage applied to Grid (*e*).

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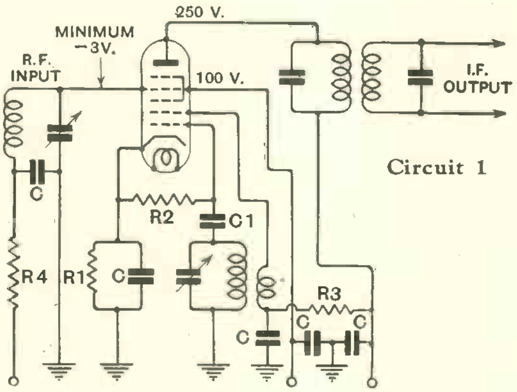
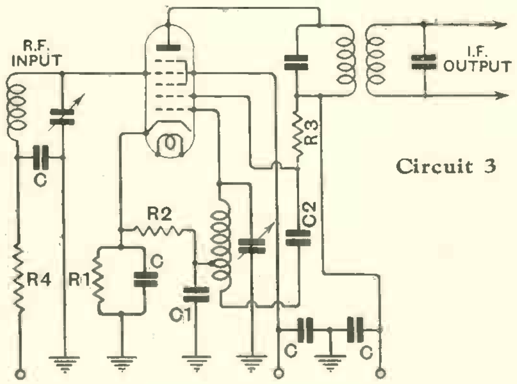
* MS. received by the Editor, April, 1933.

section of the valve. They also constitute a virtual cathode for the modulator unit. It is apparent that the control-grid (grid No. 4) is electrostatically shielded from the other valve elements by the screen-grids located on both sides of it. The modulator section includes the virtual cathode, the modulator control-grid, the screen and the anode. Thus the oscillator portion functions as a triode whilst the modulator portion functions as a variable-mu tetrode.



Circuit 1



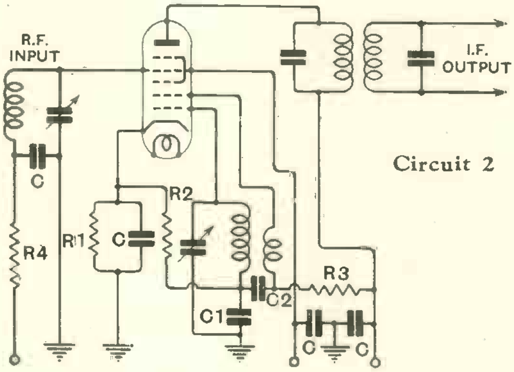
Circuit 3

Fig. 1 gives three typical schematic circuits clearly showing how these new valves are being employed. Figs. 2 and 3 give typical characteristics in graphic form, showing mutual conductance and translation-gain. Fig. 4 gives (*a*) a diagram of the standard U.S.A. base which has been adopted for these new valves, which is of the new 7-pin pattern (the eighth connection, grid No. 4 being taken to the cap of the valve); (*b*) schematic of the inter-electrode assembly, and (*c*) dimensions and shape of the envelope.

Installation and Precautions

The small 7-pin base has the following connections (looking at the bottom of the base and proceeding clockwise from the left heater pin): heater, anode, screen grids (*d* and *f*), anode-grid (*c*), oscillator-grid (*b*), cathode, heater. The cap at the top of the valve is the modulator-grid (*e*) connection. (See base, Fig. 4).

Heater.—The customary precautions to operate the heater at its rated voltage should be taken in order to insure proper performance. When operated on A.C. the transformer winding which supplies the heater circuit should be designed to operate the heater at 2.5 volts for the 2A7 and 6.3 volts for the 6A7, for full load operating conditions at the average line voltage expected. (Note.—In the U.S.A., for automobile receiver service the socket heater terminals are connected directly across the 6-volt battery. The normal battery voltage fluctuation, whilst charging and discharging, is stated not to alter the performance of these valves).



Circuit 2

Fig. 1.—Circuits for the Pentagrid valve. Circuit 1, R1, 250 ohms approx.; R2, 10,000–100,000 ohms (see text); R3, 20,000–40,000 ohms (see text); R4, A.V.C. filter resistor; C, 0.1 F; C1, F. Circuits 2 and 3, R1, R2, R3, R4, same as in Circuit 1; C, 0.1 F; C1, oscillator tracking condenser; C2, 0.005–0.01 F.

When employed in sets designed for series operation of the heaters, the current should be adjusted to 0.3 ampere for the normal line voltage supply.

Cathode.—The conventional methods applying to cathode circuits are applicable to these valves. When the cathode is not directly connected to the heater, the potential difference between them should be maintained at a minimum.

Anode-grid.—For the 250-volt rating on this electrode, a series resistance of approximately 20,000 ohms should be inserted in order to prevent excessive heating. If the resistor is omitted these rods will get red hot whenever the oscillations are feeble, due to the small bias voltage developed across the grid-leak and to the high anode-grid potential.

Screen-grids.—A detailed discussion of considerations involving the oscillator-grid resistor is given under circuit applications.

Shielding.—The use of valve shields is generally necessary to insure against undesired intercoupling between the pentagrid circuits and other stages.

Bulb.—The new American type ST12 bulb is standard for both the 2A7 and 6A7. Provision for cooling the bulb by radiation and very free air circulation is essential in order to avoid excessive temperatures. The appearance and measurements of this new style of envelope is shown in Fig. 4.

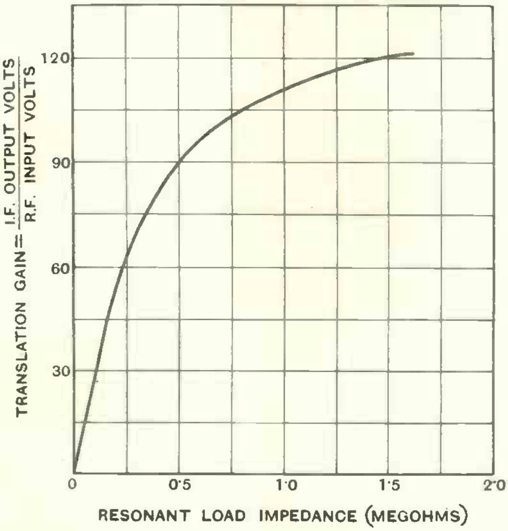


Fig. 2.—Typical characteristics of Sylvania 6A7; E_p, 250 volts; E_{g3} and E_{g5}, 100 volts; E_{g4}, -3 volts; E_{g2}, 100 volts; E_{g1}, Peak Volts 60; Oscillator grid resistance (E_{g1}) 50,000 ohms.

Circuit Applications

The superheterodyne is primarily a frequency translation device in which the desired radio signals are received at their proper—*i.e.*, transmitted—frequency and, by beat methods, converted to a new frequency. The underlying principles of the superhet are nowadays so well known that there is no need for them to be dealt with in a brief article, which has as its object only the description of improved oscillator modulator systems.

Once the translation has been effected, the main selectivity and amplification are obtained at the beat, or intermediate, frequency. The value of the I.F. is a precise constant, dependent entirely on the circuit design.

In all previous designs, the general method provided for the application of the incoming signal, and also the locally generated (oscillator) frequency to the grid of the first detector valve. The local frequency was furnished either by a separate valve or within the detector valve itself, there being reactive couplings between the detector and oscillator circuits. Hitherto no combined detector-oscillator system has been developed which may be regarded as really satisfactory, and the separate oscillator system has been distinctly preferable.

The design of the 2A7 and 6A7 offers an oscillator modulator system that involves only one physical valve structure (single cathode structure), yet which possesses all of the advantages of the two valve system and provides, in addition, several most important improvements in performance. These improvements include:

(1) A considerably higher "translation gain."

(2) An oscillator system which is entirely independent of the radio-frequency system.

(3) The application of a bias voltage that can be used to control volume, resulting in volume control which certainly approaches the ideal.

(4) The possibility of A.V.C. with a minimum number of valves.

Instead of employing capacity or inductive means to provide for coupling the oscillator and detector circuits, the new types 2A7 and 6A7 valves permit "electron coupling." This method eliminates undesirable intercoupling effects, simplifies circuits greatly, and establishes much greater oscillator stability.

The electrons from the cathode (*a*) are accelerated through the oscillator grid (*b*) by the positive anode-grid (*c*) and screen-grid (*d*). The anode-grid in reality consists of a pair of side-rods, no grid wires being strung on them. Most of the electrons approaching the anode-grid possess high velocities so that they shoot past (*c*) and for the most part through the screen-grid (*d*) and approach the modulator grid (*e*). This grid *has a negative potential*, which therefore retards the oncoming electron stream.

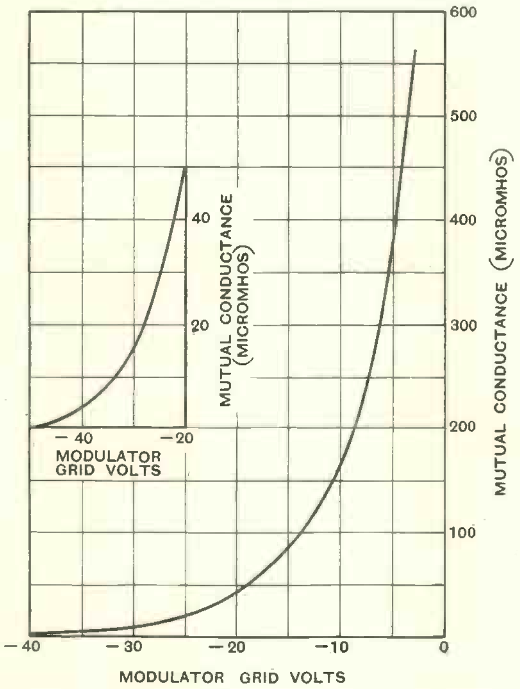
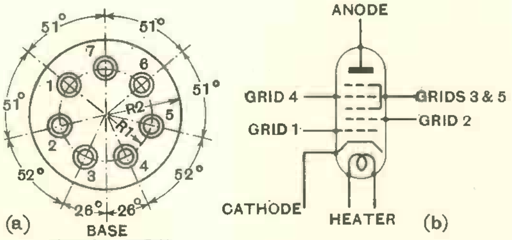


Fig. 3.—Typical characteristics of Sylvania 6A7; E_f, 6.3 volts; E_p, 250 volts, E_{g_2}, 250 volts—(2,000 ohms × IC_2); E_{g_3} and E_{g_5}, 100 volts (grid No. 1 oscillating); E_{g_1}, 25 volts (0.5 mA. through 50,000 ohm grid leak).

The cloud of retarded electrons between grids (*d*) and (*e*) therefore constitutes the virtual cathode for the modulator section of the valve. Electrons may be drawn away from this source in a manner analogous to that by which they were originally accelerated away from the cathode element (*a*). Elements (*e*), (*f*) and (*g*) together with the virtual cathode provide a tetrode modulator valve. The R.F. signal is applied to grid (*e*) and the intermediate frequency output circuit is connected to the plate (*g*).

If the oscillator grid (*b*) is only slightly negative, or even somewhat positive, then the virtual cathode has an ample electron stream for the modulator unit. Whenever the oscillator grid swings to more negative values, the number of electrons arriving at the modulator plate is temporarily reduced, or possibly even cut off. Thus, the oscillator can modulate the signal in the modulator section and produce the I.F. beat-note in the anode circuit.

The current necessary to produce sustained oscillations is controlled by the oscillator grid and not by the modulator grid, the latter being incapable of producing "cut-off" in the oscillator section. Thus, the gain of the modulator can be controlled to a nicety over a considerable range by a variable negative bias on the grid (*e*) without substantially affecting the oscillator unit. The modulator grid (*e*) shows a gradual and extended "cut-off" action, somewhat similar to the action of a variable-mu R.F. pentode, but the conversion gain is considerably higher. The screen grids increase the output impedance of the valve, thereby improving the gain; and the one nearest the cathode serves to reduce the local-



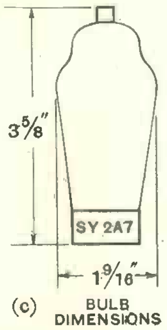


Fig. 4.—Sylvania 2A7 valve, dimensions of base :—

R1, .375in.
2R2, 1 5/32 in. maximum.
Pins 3 and 4 .156in. ± .003in. dia., other pins .125in. ± .003in. dia.

Pin No. 1 .. Grids 3 and 5.
,, No. 2 .. Anode.
,, No. 3 .. Heater.
,, No. 4 .. Heater.
,, No. 5 .. Cathode.
,, No. 6 .. Grid 1.
,, No. 7 .. Grid 2.
Cap. .. .. Grid 4.

frequency radiation. This reduction in the oscillator-frequency radiation is of considerable importance to the receiver manufacturer.

As has been stated above, these new valves do not call for special follow-on design. Coils for the oscillator circuit may be of absolutely conventional design, as employed in present-day advanced superheterodynes. Anode-grid (*c*) voltages less than the 250-volt maximum rating, will prove adequate for the best translation gain. The value of the oscillator grid resistor has not been found to be critical, but will be determined primarily by the voltages applied to the anode-grid and the screen. The following table can be given, following investigations on a number of specimens of the new valves :

Anode (*g*) Volts.	Anode-Grid (*c*) Volts.	Screen (*d and f*) Volts.	Approximate Values of Oscillator Grid (*b*) Resistor Ohms. (R_2 in Circuits).
250	250	100	75,000
250	100	75	40,000
250	100	50	17,500
100	100	50	16,000

With some circuit set-ups an audio-frequency oscillation was experienced. This seemed to be due to the fact that there was too much feed-back for the value of grid-leak and condenser employed. In these cases it was necessary to reduce the coupling between the oscillator-grid and anode coils, or to lower the value of the grid-leak resistance, this in some cases having been set at too high a value.

The average cathode current for proper operation was about 11 milliamperes. It was found definitely inadvisable to exceed the 14 mA maximum rating.

The translation gain of the valve is best controlled by a variable negative voltage on the modulator grid (*e*). This may be obtained either from a separate supply or from a variable resistance in the cathode circuit. If the latter method is used, the oscillator-grid return *must* be made directly to the cathode. Otherwise the oscillator performance will be affected by variations in the modulator-grid bias.

The range of control-grid bias voltage required to control the gain will be governed by the screen voltage. With 100 volts on the screen grids (*d and f*) and -3 volts on the signal grid, the range of bias voltage will be from -3 to a value near anode current cut-off. The cut-off will be less remote for lower screen voltages. In conjunction with automatic volume control, the 2A7 or 6A7 provides all of the advantages previously obtained with a separate oscillator and a variable-mu first detector. Because of this, their use permits a reduction in the minimum number of valves required.

It was found important to employ an anode load capacity of sufficient size (at least 0.00005 μF) in order to limit the R.F. voltage built up across this load. Otherwise an R.F. voltage feed-back will occur between the anode and oscillator-grid, producing degeneration.

Conventional circuits for a triode oscillator are applicable for the oscillator sections of the 2A7 and 6A7, provided proper consideration is given to the constants involved. Likewise, the detector section may, in general, be considered as functioning in a similar manner to a separate variable-mu detector. However, due to the series modulation which results from the oscillator control of the electron stream, it is not necessary to feed the oscillator voltage into the detector grid circuit ; nor is there any cause for anxiety that the signal-grid will be driven positive.

Circuit 1 of Fig. 1, shows a straight series feed oscillator circuit for the oscillator section, and may be employed to advantage where a formed anode oscillator tuning condenser is employed. Somewhat stronger oscillations will be obtained at the high *frequency* end. If sufficient coupling is used to give reasonably strong oscillations at the low frequency end, the translation gain will not vary appreciably over the entire range.

The other circuits provide for compensation at the low frequency end, due to the added coupling from the oscillator tracking condenser. With the proper amount of inductive coupling it is easily possible to obtain practically constant oscillation strength over the entire frequency band covered. Circuit 3 shows a simple coil with one tapping used as the oscillator coil.

In circuits 2 and 3 a value of $C2 = 0.005$ to 0.01 μF is indicated. It should be mentioned that in certain instances this value can be made as low as 0.0001 μF with advantage.

Summary

Present-day design seems definitely to call for a reduction in the number of valves to be employed in receivers, primarily because this reflects lowered production costs and, as a corollary, an increased consumption by the purchasing public. The 2A7 and 6A7 valves mark a definite step forward in the simplification of the most popular type of receiver which, to-day, seems to be the superheterodyne. The necessity for valves such as the new American 2A7 and 6A7 has long been felt. The set manufacturer is more or less entirely dependent upon the valve manufacturer for improvements in circuits, performance, stability and to a certain extent sensitivity and selectivity as well. If, therefore, this account will bring nearer the Home production of valves of the 2A7 and 6A7 pattern, and help those interested to employ such devices, it will have performed some real service.

Correspondence

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

The Simplification of Accurate Measurement of Radio-frequency

To the Editor, The Wireless Engineer.

Sir,—In his interesting account of developments in wavemeter design in your May number, Mr. W. H. F. Griffiths makes a statement which may give an incorrect impression. He says "The Lucas-Sullivan crystal-controlled multivibrator . . . has an accuracy, stability, and degree of permanence, decidedly better that that of the fork." The primary standard wavemeter at the National Physical Laboratory at the present time is a tuning-fork controlled multivibrator, designed by the late Dr. Dye, and the performance of this instrument has been so good that no existing instrument could be said to have decidedly better accuracy, stability and permanence.

Mr. Griffiths probably meant that, when a number of crystal-controlled and fork-controlled multivibrators are constructed in the same workshops, it is his experience that in general the crystal gives the better results. It is undoubtedly mechanically simpler, smaller, and therefore more easily controlled, and there is no doubt that the tuning fork makes considerable demands on workmanship in its construction, and that it must be used under very carefully controlled conditions, but how its performance under such conditions compares with that of a crystal under comparable conditions is not yet known. It is known that either of them will provide all the accuracy that is required in practice over short periods, but no general statement such as that made by Mr. Griffiths, taken in its widest sense, can be made.

Teddington. L. Hartshorn.

To the Editor, The Wireless Engineer.

Sir,—I have to thank Dr. Hartshorn for pointing out that the primary standard wavemeter of the National Physical Laboratory at the present time is a tuning-fork controlled multivibrator, and that the performance of this instrument is so good that no existing instrument could be said to have decidedly better accuracy, stability and permanence.

I must, however, explain that my statement was made after careful consideration of the results obtained on a quartz controlled multivibrator made by my Company which was under observation for a period of eighteen months using the standard frequency transmissions carried out under the direction of the Radio Scientifique Internationale, Committee 1, Standards. These transmissions are effected by modulating the carrier wave of the British Broadcasting Corporation's Daventry station at 1,000 cycles per second, by means of a standard fork for a period of 90 minutes. This modulation frequency is measured throughout the test by the N.P.L. and other collaborating laboratories, and the observations and records are forwarded to the N.P.L. who act as co-ordinating authority.

Spread over eighteen months three such observations were made. One of these, made during the night of June 29/30, 1932, gave a value within 0.7 parts in 10^7 of the N.P.L. measured value, while the other two observations produced values within 3 parts in 10^7. There is every possibility that the crystal was more constant over the entire period than the above figures indicate, since there was *no temperature control of the crystal* and the larger discrepancy quoted above is of the order which one would anticipate, from a knowledge of its temperature coefficient, due to the known order of temperature uncertainty during the test period. It appears, therefore, that this crystal standard, *even with temperature uncertainty* remained for eighteen months as constant as the fork standard *without* such uncertainty.

While this does not, of course, prove conclusively that the crystal is better than the N.P.L. fork standard, I believe that no instrument of commercial manufacture has shown as good a performance as this Lucas-Sullivan crystal controlled standard frequency equipment, a performance which has now been improved upon by the exact temperature control of the crystal.

Mottingham, S.E.9. W. H. F. Griffiths.

A Method of Tone Control

To the Editor, The Wireless Engineer.

SIR,—In the January number of the *Wireless Engineer* there is an article by Colebrook on tone control. In it he gives, *inter alia*, the method which depends upon reducing the damping on a transformer and thereby enhancing the peak due to leakage flux resonance. He does not mention another, in some respects analogous which depends for its effect upon a series resonant circuit consisting of a choke in the grid lead to a valve, its input capacity (augmented if necessary) and the A.C. resistance of the preceding valve.

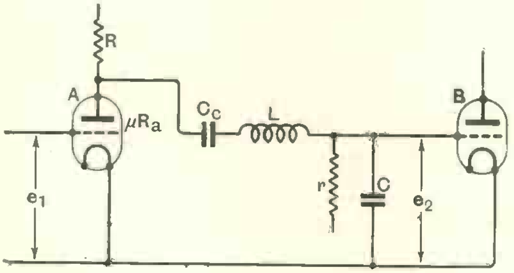


Fig. 1.

The method which is most readily adapted to resistance coupled amplifiers or to follow a diode is not new; it is believed to be due to Captain Round and was employed to compensate for the loss of sidebands due to several cascaded tuning circuits in a well-known long range receiver some years ago.

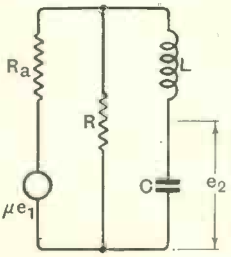


Fig. 2.

Fig. 1 gives the arrangement following a resistance coupled valve and Fig. 2 gives the equivalent circuit. In deriving it we can neglect the influence of the coupling condenser and grid leak of Fig. 1, as they will presumably have been designed "for good quality." We may also neglect the resistance of *L*, as its effect will only be to increase the apparent value of *Ra*.

From Fig. 2 we get

$$\frac{e_2}{e_1} = \frac{\mu R}{R + R_a} K$$

where $K \equiv$ tone correction factor

$$= \left[(1 - LC\omega^2)^2 + \left(\frac{R}{R + R_a} \right)^2 R_a^2 C^2 \omega^2 \right]^{-\frac{1}{2}}$$

and is greater than one until after the resonant frequency at which it is a maximum $\left(\text{given by } f_r = \frac{1}{2\pi\sqrt{LC}}\right)$ is passed. The values of $K_{\text{max.}}$ for a few likely values of the quantities involved are given in the table. If the $K - f$ curve be plotted as in Fig. 3 for a given set of values of the other quantities, it will be found that the shape of the curve is very like that of a transformer following a low impedance valve. The curve is flat until (say) 2*KC* after which it rises more or less sharply to resonance beyond which it falls again rapidly to zero. The cause of the rise is in fact the same: *L* in the case of a transformer represents the leakage flux and *C* is the input capacity of the following valve plus the self capacity of the windings.

fr *KC*	*Ra* *KΩ*	*L* *H*	*C* *μμF*	$K_{\text{max.}}$
8	20	5	80	15·
		1	400	3·
	4	5	80	75·
		1	400	15.
4	20	5	320	7·5
		1	1,600	1.5
	4	5	320	37·5
		1	1,600	7·5

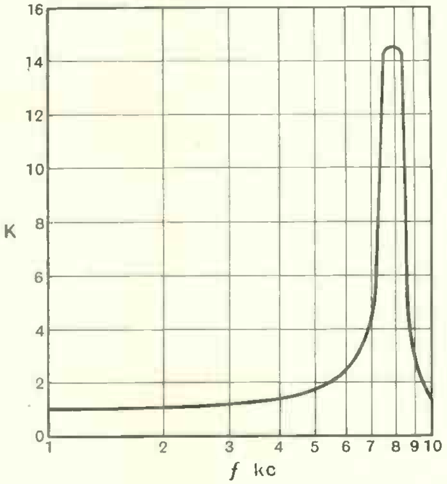


Fig. 3.

It is exceptionally easy with this method to control the resonant frequency by using as part of C a variable condenser, the moving plates of which, since they are connected to the filament of valve *B*, will be at earth potential. It is less easy to control the value of $K_{\text{max.}}$ by inserting a variable resistance in the circuit *Ra*, *L*, *C*; as both of its poles will be at an audio frequency potential above earth. In practice however it is usually possible to select valve *A* so that it will give the required value, whilst fulfilling its other necessary requirements. The other great advantage of the method is that it is a genuine "treble raiser," whereas most of the usual methods, *e.g.* that which uses a choke (tuned or untuned) in the anode circuit are "bass cutters" and necessitate an extra stage. From the point of view of the purist who dislikes iron in his circuits the arrangement suffers from the disadvantage that unless considerable space is available *L* will have to be iron-cored. A 5*H* air cored inductance is an imposing object!

W. F. COPE.

The Optimum Decrement of Tuned Circuits for the Reception of Telephony*

By D. A. Bell

It has been suggested in certain quarters that the sensitivity and selectivity of a wireless receiver can be greatly improved by reducing the decrement of the tuned circuits to a very low value, tone-correction being applied in the audio-frequency amplifier to compensate for the cutting of side-bands. The question naturally arises whether there is any limit to the improvement which can be obtained by this process, other than the difficulty of producing circuits of sufficiently low, and at the same time constant, decrement. Tone-correction suffers from certain limitations in practice, *e.g.*, the necessity for a high degree of audio-frequency amplification, and the risk of exaggeration of spurious harmonics which was recently pointed out by Dr. McLachlan. But for the present we shall assume that tone-correction can be provided to an unlimited extent, and with any desired frequency characteristic.

When selectivity was normally only required to separate stations some 40 kc/s apart, it was natural to think of the desired transmission as occupying the peak of the resonance curve, which was more or less flat topped, and interfering signals away on the skirt of the curve. With this picture in one's mind it seemed obvious that selectivity could always be improved by pushing up the peak of the curve. Under present-day conditions, with powerful stations only 9 kc/s apart, the side-bands of the desired transmission and interfering signals merge into one another, so that selectivity is largely governed by the slope of a particular portion of the curve. With this new point of view we must reconsider the whole question from first principles.

The standard formula for the current induced in a tuned circuit by an E.M.F. e is

$$i = \frac{e}{\sqrt{\{(Lp' - 1/Cp')^2 + R^2\}}} \quad \ldots \quad (1)$$

where p' is the "pulsatance" of the applied E.M.F., *i.e.*, 2π times the frequency. If p is the pulsatance corresponding to the resonance frequency of the tuned circuit, we have also $LC = 1/p^2$. The voltage developed across the tuned circuit is found by multiplying the current by the impedance of the inductance; making use of the expression for the pulsatance at resonance we can eliminate C, and after some rearrangement the voltage is found to be

$$V = \frac{e}{\sqrt{\{(p'/p - p/p')^2 + R^2/L^2p^2\}}} \quad \ldots \quad (2)$$

The physical importance of this form of the expression lies in the fact that $(p'/p - p/p')$ depends only on the percentage detuning, while R/Lp differs from the logarithmic decrement, which is universally employed to indicate the damping of a resonant system, only by a factor π. It should be noted that even if the resistance of the circuit were constant, the damping, as measured by the decrement, would still vary with the frequency to which the circuit is tuned.

The voltage at resonance depends solely on the damping, which in turn is governed by the ratio R/L. But in the reception of telephony we are concerned more with the side-bands than with the carrier itself; so that if the modulation is of frequency n and corresponding pulsatance $\omega = 2\pi n$ we must consider the response of the tuned circuit to pulsatances $p' = p \pm \omega$. If the modulation frequency is small compared with the carrier frequency, as is true in all broadcast reception, we can write with sufficient accuracy $p'/p - p/p' = 2\omega/p$. From (2) the expression for the modulated voltage produced in the tuned circuit is therefore

$$\frac{e}{\sqrt{\{4\omega^2/p^2 + R^2/L^2p^2\}}}$$

The only quantities here which are under our control are R and L; consequently, our only means of increasing signal strength is by a reduction in the ratio R/L, and even this ceases to be effective beyond the point

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* MS. received by the Editor, July, 1932.

where R^2/L^2 becomes negligible in comparison with $4\omega^2$. The correct procedure in designing a tuned circuit to give the highest sensitivity is to decide upon the highest modulation frequency to be received, multiply by 2π to give the corresponding value of ω_m, and then make R^2/L^2 small compared with $4\omega_m^2$. If R^2/L^2 is reduced to one-twentieth of $4\omega_m^2$ the sensitivity will be 95 per cent. of that which might theoretically be obtained with a circuit of zero resistance. The same conditions apply to the selectivity, as is clear from Fig. 1, where the full line curve shows the response of our actual circuit and the dotted line the theoretical response for zero resistance. We arranged that the two curves should differ by only 5 per cent. at the points $p \pm \omega_m$ corresponding to the highest modulation frequencies, and as ω increases beyond this value they gradually coincide, so that the response to interfering signals would be very little affected by a further reduction in resistance.

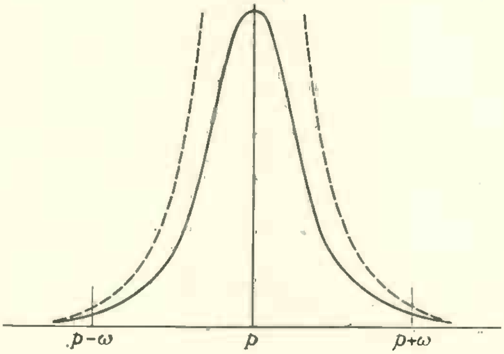

Fig. 1.

It is not advisable to attempt to approach too near the theoretical maximum sensitivity; for very large increases in the response to the carrier and neighbouring frequencies will result, with serious risk of overloading valves and causing instability, while the gain in signal strength is almost entirely in the lower modulation frequencies which will have to be cut down again in the tone-correcting stage.

We have shown that there is an optimum degree of damping for a tuned circuit where the applied E.M.F. is independent of the characteristics of the circuit, as is practically true of an aerial circuit; but we have yet to consider whether this is true of the tuned anode circuit in a high-frequency amplifier, where the efficiency of the valve feeding the circuit depends upon the impedance or "dynamic resistance" of the circuit. The dynamic resistance of a tuned circuit at resonance is familiar to us in the form L/RC; but, as before, we must consider the side-band frequencies rather than the carrier. Suppose a difference of potential V exists between the ends of a tuned circuit as in Fig. 2; if the resistance is zero, the total current produced by V, which is the difference between the currents through the inductance and the capacity since these two currents are in opposite phase, is

$$I_0 = i_1 - i_2 = V(Cp' - 1/Lp')$$

This current will be 90° out of phase with the potential difference, so that it involves no energy. If now the circuit has resistance R in series with the inductance, we can imagine another current I_1 in phase with the potential difference V supplying the energy Ri_2^2 which is dissipated in the resistance R. If R is small compared with Lp', and p' not very different from p, we simplify matters by writing $i_2 = V/Lp$. Then, equating the energy supplied by I_1 to that expended in R, we have

$$VI_1 = Ri_2^2 = RV^2/L^2p^2$$

Since I_0 and I_1 differ in phase by 90°, we must add their squares to find the square of the total current, and after expressing I_0 in terms of ω and p instead of L, C, and p', the total current is

$$I = (V/Lp)\sqrt{\{4\omega^2/p^2 + R^2/L^2p^2\}}$$

As before, we find that the response is independent of the resistance when R^2/L^2 becomes negligible compared with $4\omega^2$. For a circuit of zero resistance the impedance of the circuit would be

$$V/I_0 = Lp^2/2\omega$$

In a tuned anode circuit it is especially desirable that the decrement of the circuit should not be unnecessarily reduced, since the stability of the amplifier depends upon the maximum amplification obtained, *i.e.*, that of the carrier, and is independent of the

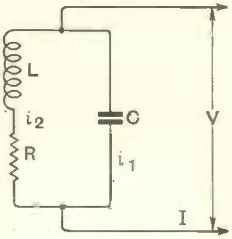

Fig. 2.

amplification of the modulated signals. Table I gives values of R which give approximately 95 per cent. of the theoretically attainable sensitivity for various upper limits of modulation frequency, and for two values of inductance which correspond roughly to the two broadcast wave-bands. It must be remembered that R represents all the losses involved in the tuned circuit, such as valve input damping, as well as the high frequency resistance of the inductance, so that the values for the medium wave inductance are really lower than can be approached without reaction.

TABLE I.

Inductance Micro-henries.	R $n = 5{,}000$.	R $n = 7{,}500$.	R $n = 12{,}000$.
200	2.8	4.2	6.75
3,000	45	67	108

The expression for the maximum dynamic resistance, $Lp^2/2\omega$, shows that even when the damping is negligible a further improvement can be effected by increasing the inductance. In a straight set the value of the inductance is practically fixed by the requirements of the tuning range, but in a superheterodyne receiver this point might be worth considering, since this increase in L produces the same improvement for all modulation frequencies. Table II gives the approximate values of the effective dynamic impedance of a circuit of negligible damping for various modulation frequencies. An inductance of 200 microhenries is assumed for medium waves, and 3,000 microhenries for long waves :

TABLE II.

Wave-length.	Impedance $n = 5{,}000$.	Impedance $n = 7{,}500$.	Impedance $n = 12{,}000$.
200	280,000	189,000	118,000
600	31,000	21,000	13,000
1,000	170,000	113,000	70,500
2,000	42,500	28,250	17,600

The dynamic impedance of an actual tuned circuit will naturally be slightly less than the values given for the ideal case. If the resistance of the circuit were independent of frequency, the dynamic impedance to the carrier (*i.e.*, at resonance), which is usually written as L/RC could be expressed as L^2p^2/R. Since this also varies as the square of the carrier frequency, the amount of side-band cutting would then be independent of the carrier frequency. In practice, however, the resistance increases with rising frequency ; a good commercial coil might therefore result in the dynamic impedance of the tuned circuit at resonance remaining nearly constant at 80,000 ohms from 200 to 600 metres. The amplification given by a S.G. valve the internal resistance of which is large compared with the impedance of the anode circuit is practically equal to the product of the mutual conductance of the valve times the impedance of the anode circuit, so that the dynamic impedance of the anode circuit is a direct measure of the stage gain. From Table II we see that at 600 m. with the coil mentioned above the ratio of amplification of carrier to amplification of 5,000 cycles per sec. modulation is 80,000/31,000, which represents a loss of approximately 4 decibels at 5,000 c/s. At 200 m., on the other hand, the loss will be quite negligible. This represents the conditions in a single H.F. stage of high efficiency. The results in a receiver employing two H.F. stages will not be very different, since the presence of two tuned circuits is partly compensated for by the use of lower impedance circuits.

Since the loss of the higher modulation frequencies varies so much with different carrier frequencies, it would be very difficult to compensate it by tone-correction, but it is interesting to calculate the efficiency which would be obtained under such conditions. If we postulate that the receiver must give a uniform response to all modulation frequencies within a certain range, the effective amplification of any stage is the smallest value received by any modulation frequency in the stage in question, since any frequencies which receive greater amplification must receive correspondingly less in some other stage. If we assume that the response must be uniform up to 5,000 c/s, and that the screened grid valve has a mutual conductance of 1.5×10^{-3} amps./volt, Table II shows that the effective amplification is 46.5

at 600 m. and 120 at 200 m. This is not altogether a fair measure of the utility of the H.F. stage, since the larger amplification of the carrier may be advantageous from the point of view of rectification, and, of course, in present-day receivers a certain amount of quality is sacrificed to sensitivity.

There are two theoretical methods of increasing the effective amplification: by increasing the inductance, or by using a band-pass filter.

With variometer tuning the impedance to high modulation frequencies would be independent of carrier frequency; for the expression obtained above, $Lp^2/2\omega$, can be put in the form $1/2\omega C$ by eliminating L in terms of C which is now the constant factor. But the dynamic impedance at resonance would be very much greater at low carrier frequencies than at high frequencies (it is $1/Rp^2C^2$), so that the degree of tone-correction required still depends upon carrier frequency. If, however, provision could be made for adjusting the resistance of the circuit so as to be always inversely proportional to the square of the carrier frequency, the conditions would be the same for all frequencies as are shown in Table II for a carrier wavelength of 200 m. With a uniform response up to 5,000 c/s one could then obtain an effective amplification of 120 per stage, with a loss of only one decibel per stage at 12,000 c/s.

The other alternative is to use a band-pass filter, which gives a smaller response at resonance than a single circuit of low resistance, but owing to its double peaked resonance curve the conditions throughout the range of frequencies covered by the side-bands correspond to the conditions near the carrier with a single circuit. It is at present customary to employ a band-pass filter in the aerial circuit of a receiver when good selectivity is required, and owing to the difficulties of accurate ganging it is scarcely practicable to use two filters with the single dial control which is universally demanded. If cross-modulation interference can be completely eliminated by the use of variable mu valves, however, it might be worth while using a single aerial circuit and a filter in the anode circuit of the H.F. valve. The problem is complicated by the difficulty of maintaining constant band width in a filter, so that the band-pass filter seems scarcely practicable for H.F. amplifiers with variable tuning, though ideal for the intermediate frequency stages of superheterodynes, where they are now becoming standard practice.

Books Received

Applications of the Cathode Ray Oscillograph in Radio Research

By R. A. Watson Watt, J. F. Herd and L. H. Bainbridge-Bell, of the Radio Research Station, Slough.

Including the study of Variation of E.M.F. with Time; Time Variation in Radio Problems; Voltage Comparators, the Oscillograph as a Relay; Photographic Methods and Auxiliary Apparatus. Pp. 290 + xvi with 111 diagrams and 17 plates. Published by H.M. Stationery Office. Price 10s.

A Textbook of Wireless Telegraphy and Telephony (2nd edition).

By W. Greenwood, B.Sc., A.M.I.E.E., A.C.G.I.

Intended for those having a general knowledge of Electrical Engineering apart from Wireless and giving an outline of the general principles of Oscillating Circuits, Electromagnetic Waves, Thermionic Valves, Receivers, Transmitters, etc. Pp. 307 + viii with 210 diagrams. Published by the University Tutorial Press, Ltd., London. Price 5s. 6d.

National Physical Laboratory. Report for the Year 1932

The Wireless Section, which forms only a small part of this general report, outlines the work which has been carried out during the past year by the Radio Research Board and includes a description of the new Transmitter, Research and Ultra-short waves, Interference and Selectivity, Constant frequency oscillator, the Electrical properties of the earth's surface and other subjects. Pp. 277 + vi (in the complete report) with 52 illustrations and diagrams. Published by H.M. Stationery Office. Price 14s.

Principles of Radio Communication (3rd edition, revised)

By J. H. Morecroft, B.Sc., A. Pinto and W. A. Curry.

A standard Text-book comprising chapters on Fundamental Ideas and Laws, Resistance, Inductance, Capacity, Shielding, Oscillating Circuits, Spark Transmission, Valves and their Applications, Radio telephony, etc. Pp. 1084 with numerous illustrations and diagrams. Published by John Wiley and Sons, Inc., New York, and Chapman and Hall, Ltd., London. Price 46s. 6d.

On the Amplitude of Loud Speaker Diaphragms at Low Frequencies[*]

By N. W. McLachlan, D.Sc.

1. Introduction

FOR constant output at low frequencies the amplitude of a rigid diaphragm[†] operating in an infinite baffle increases inversely as the square of the frequency, *e.g.*, at 50 ~ it is 25 times its value at 250 ~. When the intensity level and the power output are high (acoustically) alien tones are created due to two salient causes: (1) violation of Hooke's law in the surround and centring device [‡]: (2) motion of the coil in the non-uniform magnetic field of the magnet. Owing to (1) the acoustic wave form is flattened and partially rectified (Fig. 1), whilst (2) is associated with electro-mechanical rectification.[§] The radial magnetic field is uniform for about 70 per cent. of the gap width, but falls away on either side due to leakage which is usually different at each end of the gap (Fig. 2). To avoid alien frequencies the flux interlinkage with the coil must be constant at all amplitudes. Thus the field must either be uniform throughout the travel of the coil or the coil must be wider than the field so that the latter is wholly embraced even at large amplitudes. If the field is symmetrical about the centre of the gap but non-uniform and the flux interlinkage varies during motion, the case is akin to that of a valve characteristic which is symmetrical but curved on either side of the bias point. Operation is accompanied in each instance by alien frequencies. The question arises as to the maximum amplitude permissible before alien frequencies become aurally disconcerting. This can only be settled properly by experiment. In the meantime, therefore, we shall approach the problem by computing the amplitudes likely to occur in the operation of loud speakers.

2. Amplitude to Radiate 1 Watt of Acoustic Power

To calculate the amplitude required we shall assume the diaphragm to be a rigid disc 10 cm. radius operating in an infinite baffle in free space. The maximum of the mean acoustic pressure per unit area on *one* side of the disc is given by[‖]

$$p_{\text{max.}} = \rho c \omega X \left[1 - \frac{J_1(2ka)}{ka} \right] \quad .. \ (1)$$

where ρ = density of air gm. per cc.

c = vel. of sound cm. per sec.

$k = \omega/c = 2\pi/\text{wavelength}$.

X = maximum amplitude cm. (ωX = axial velocity)

a = radius of disc cm.

J_1 = Bessel's function of unit order.

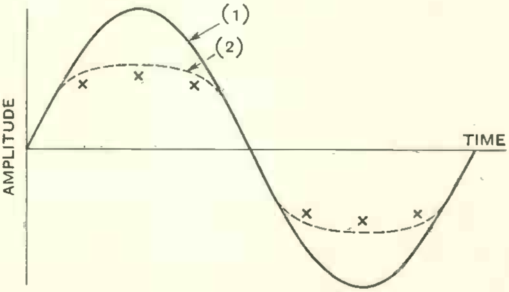

Fig. 1.—*Diagram showing influence of imperfectly elastic surround which limits excursion of diaphragm. Curve* (1) *is a sine wave being the form of the displacement for an elastic surround. Curve* (2) *is the displacement curve for the actual surround. If a vibration several times the frequency of curve* (1) *is superposed there will be appreciable mechanical rectification over the regions X X X.*

At low frequencies where $ka \leqslant 0.5$, the function $\left[1 - \frac{J_1(2ka)}{ka} \right] \doteqdot \frac{k^2a^2}{2}$ and formula (1) can be written

$$p_{\text{max.}} = \frac{\rho a^2 \omega^3 X}{2c} \quad .. \quad .. \ (2)$$

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[*] MS. received by the Editor July, 1932.

[†] Below 200 ~ L.S. diaphragms move substantially as a whole.

[‡] When the diaphragm is passing through a position where the restoring force/amplitude curve is curvilinear, rectification of the complete output occurs in varying degree.

[§] *The Wireless Engineer*, June, 1932. The mathematical analysis is given in a letter published in *The Wireless Engineer*, October, 1932.

[‖] Rayleigh, Sound, **2**, 164 (1894). *Phil. Mag.* 14, Novr. Suppl. p. 1012, 1932. All formulae herein are deduced in terms of absolute units.

Since the area of *one* side of the disc is πa^2 the total acoustic pressure is

$$\pi a^2 p_{\text{max.}} = \frac{\pi \rho a^4 \omega^3 X}{2c} \quad .. \quad (3)$$

The power radiated is the *mean* value per cycle of the product of the total pressure and the axial velocity. Since this mean value for sine wave motion is half the maximum, we get

$$W = \frac{\pi \rho a^4 \omega^4 X^2}{4c} \quad .. \quad .. \quad (4)$$

When $W = 10^7$ ergs per second (1 watt) we have from (4) the maximum amplitude

$$X = \frac{2}{a^2\omega^2}\sqrt{\frac{10^7 c}{\pi\rho}} \quad .. \quad .. \quad (5)$$

Inserting $a = 10$ cm., $c = 3.41 \times 10^4$ cm. per sec., $\rho = 1.21 \times 10^{-3}$ gm. per cc. ($t = 18°C$, 76 cm. Hg.), $\omega = 2\pi f$, $f =$ frequency, we obtain

$$X_{\text{cm.}} \doteq \frac{4.7 \times 10^3}{f^2} \quad .. \quad .. \quad (6)$$

Some idea of the requisite low frequency amplitudes will be gained from the data in Table 1.

TABLE 1

Amplitude of rigid disc 10 cm. radius vibrating in infinite baffle in free space the radiation from one side being 10^7 ergs per sec.

Frequency. (~)	Amplitude. (cm.)
32	4.6
64	1.15
128	0.29
256	0.07

At 64 ~ the amplitude is very large, *viz.*, 1.15 cm. Since the gap width of the magnet seldom exceeds 1 cm., alien frequencies of appreciable magnitude will be created if the travel of the coil is as large as this. In general the surround does not permit an excursion of this extent, so that both types of distortion cited in section (1) will occur. By doubling the radius of the diaphragm the amplitude is reduced to $\frac{1}{4}$ the above amount. It is then unsuited for proper reproduction of the upper frequencies. This emphasises the fact that when the low frequency radiation is large, two or more units of different diameters should be used to cover the desired frequency range to be reproduced.

3. Amplitude in Average Case

The amplitude obtainable in receivers having moving-coil loud speakers can be calculated from data pertaining to the speaker and the power valve, *provided there is no resonance due to the diaphragm on its surround.* Under this latter condition the resistive component of the driving force is negligible compared with the component due to mass reactance. Thus we can write,

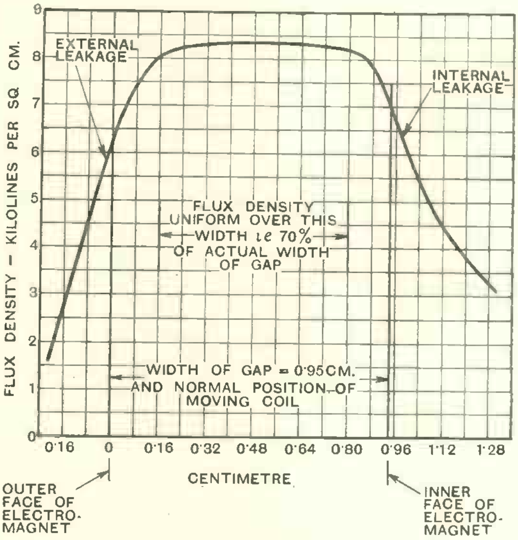

Fig 2.—*Diagram showing axial distribution of flux in a moving-coil loud speaker magnet. The approximate linear decay outside the magnet should be noted.*

Driving force = effective mass × acceleration,

or

$$F = M_e \omega^2 X \quad .. \quad .. \quad (7)$$

where X is the maximum sine wave amplitude. If the effective mass, including diaphragm, coil and accession to inertia, is 20 gm., we obtain from (7)

$$X = \frac{F}{20\omega^2} \quad .. \quad .. \quad (8)$$

If W_1 is the maximum distortionless output from the valve and r_1 the corresponding load resistance in its anode circuit, the maximum current

$$I_1 = \sqrt{\frac{2W_1}{r_1}} \quad .. \quad .. \quad (9)$$

The electrical motional reactance of the coil is negligible above 60 ~ unless the magnetic field is very strong. Thus the transformer ratio is $\sqrt{\frac{r_1}{r_2}}$, where r_2 is the total resistance of the secondary circuit. The coil current is, therefore

$$I_1\sqrt{\frac{r_1}{r_2}} = \sqrt{\frac{2W_1}{r_2}}$$

and the force driving the diaphragm can be written

$$F = C\sqrt{\frac{2W_1}{r_2}} \quad \ldots \quad \ldots \quad (10)$$

where C = force on the coil per unit current,
= length of wire × field strength,
= $\pi\, dnH$ dynes per unit current.

From (8) the amplitude at any given frequency is proportional to F and can readily be ascertained from the preceding analysis.

According to H. Fletcher* we can expect the greatest low frequency power from pipe organs to occur in the vicinity of 64 ~. From (8) and (10) the maximum amplitude at this frequency is

$$X = 4.3 \times 10^{-7} C\sqrt{\frac{W_1}{r_2}} \quad \ldots \quad (11)$$

provided *all* the available power is used at 64 ~.

Taking $C = 6 \times 10^6$, $W_1 = 5 \times 10^6$, $r_2 = 6 \times 10^9$, each being in absolute units, we find that $X = 0.73$ mm. If only one-half the power were allotted to the 64 ~ note $X = 0.51$ mm.

4. Resonance of Diaphragm on Surround

In moving-coil speakers I have shown elsewhere † that the lower register is feeble unless resonance occurs. When the diaphragm vibrates as a whole on the surround—this being quasi-elastic—resonance generally occurs between 40 and 100 cycles per second. The amplitude is then appreciably in excess of the value we calculated in the preceding section. The stretching capability of the surround is usually quite small and the axial amplitude is less than it would be with a perfectly elastic control. Thus the wave form is flattened as indicated in curve 2, Fig. 1. In this way powerful alien tones may be created if the resonance is intense and the driving force large. As stated in section (1) the permissible degree of distortion should be settled empirically.

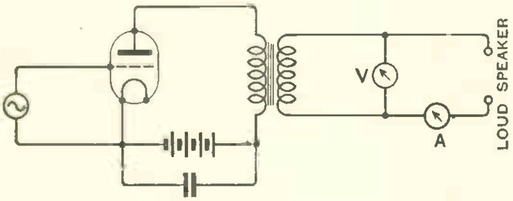

Fig. 3.—*Arrangement of apparatus for measuring coil current. The radiation resistance at resonance increases considerably and reduces the reading of A connected preferably on the other side of V. The measurements can also be made on other circuits, e.g., push-pull, choke-condenser output.*

The resonance can be examined by aid of the apparatus shown schematically in Fig. 3. A constant sine wave voltage of varying frequency is applied to the grid and filament of the power valve. Owing to the large increase in radiation resistance at resonance, the secondary current is a minimum. The current/frequency curve has a crevasse at the resonance point as shown in Fig. 4. If the current is also measured at the resonant frequency with the speaker coil fixed, the radiation resistance can be found approximately. This includes mechanical losses in the diaphragm and surround and is an apparent value.

Let V_2 = Secondary voltage at resonance with coil free,

V_2' = Secondary voltage at resonance with coil fixed,

$I_2 I_2'$ = Corresponding currents, then the apparent radiation resistance at resonance is

$$R_m = \left(\frac{V_2}{I_2} - \frac{V_2'}{I_2'}\right) \quad \ldots \quad (12)$$

the voltages being measured with a valve voltmeter. Formula (12) is based on the fact that the secondary impedance is mainly resistive. This holds at low frequencies where the inductive reactance of the speaker coil is relatively small.

In the case illustrated in Fig. 4, $R_m \doteqdot 50$ ohms. The transformer used for the experiments had a ratio of 10/1 so that the load in the anode circuit due to R_m was 5000 ohms. The combined valve resistance was about 600 ohms and the load resistance due

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* Speech and Hearing, Fig. 55.

† *The Wireless World*, May 6th, 13th (1931). *Phil. Mag.*, 11,771 (1931).

to the coil apart from radiation, etc., 1500 ohms. Thus the influence of resonance was to increase the total anode circuit resistance from 2100 to 7100 ohms, causing a reduction of primary current in the ratio 2100/7100 $\doteq$ 0.3.

With only one LS5A valve this ratio becomes approximately 0.5, giving about 1.7 times the previous amplitude. With a pentode there is little variation in current and the amplitude is 3.3 times its value with the 5LS5A's in parallel.

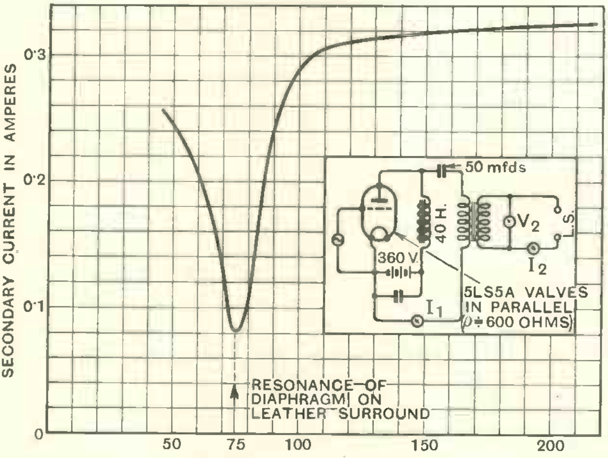

Fig. 4.—*Current/frequency curve of M.C. loud speaker having resonance at 75 ∼. The crevasse is due to the enormous increase in apparent radiation resistance owing to enhanced amplitude, the motional back e.m.f. being in anti-phase with the impressed e.m.f. Radiation resistance at resonance referred to coil circuit $\doteq$ 50 ohms.*

5. Amplitude at Resonance

It has been shown that the radiation resistance of a moving-coil system, mounted on a perfectly elastic surround of negligible area, is given by the formula*

$$R_m = \frac{C^2\omega^2 B}{\omega^2 B^2 + (k_1 - \omega^2 M_e)^2} \quad \ldots (13)$$

where C = force on coil per unit current as above.

B = Mechanical resistance due to motion (radiation + frictional losses).

$k_1 \begin{cases} = \text{coefficient of restitution of surround} \\ = \text{force per unit deflection.} \end{cases}$

M_e = effective mass of diaphragm including accession to inertia.

At resonance $(k_1 - \omega^2 M_e) = 0$, and the radiation resistance in (13) reduces to

$$R_m = \frac{C^2}{B} \quad \ldots \quad \ldots (14)$$

When the surround control is negligible $k_1 \doteq 0$, the resistive component B is usually small compared with the reactive component ωM_e and (13) becomes,

$$R_m' = \frac{C^2 B}{\omega^2 M_e^2} \quad \ldots \quad \ldots (15)$$

this being the non-resonant value.

Thus $\dfrac{R_m}{R_m'} = \dfrac{\omega^2 M_e^2}{B^2}$. This is the power ratio of a resonant to a non-resonant system when the driving force and, therefore, the coil current is constant. The square root of this quantity is the amplitude ratio or magnification, namely, $\omega M_e/B$, and is analagous to the electrical case $\omega L/R$ for a tuning coil. Using the value of B from (14) we obtain the

Amplitude magnification μ

$$= \frac{\omega M_e R_m}{C^2} \quad \ldots (16)$$

Where a triode is concerned we have to incorporate the reduced value of the current at resonance in evaluating the magnification. Thus (16) becomes

$$\mu_1 = \frac{\omega M_e R_m}{C^2} \cdot \frac{I_2}{I_2'} \quad \ldots \quad \ldots (17)$$

The values of I_2, I_2' and R_m are found experimentally as shown in section 4. R_m can also be measured by aid of a bridge, and I_2/I_2' calculated as shown in section 6. Hence the increase in amplitude at resonance can be determined. Using the data $C = 6 \times 10^6$, $R_m = 5 \times 10^{10}$, $M_e = 20$ gm., $I_2/I_2' = 0.3$, and $f = 75$ ∼ we find that at resonance the amplitude increases nearly *four* fold. From section (3) we compute that in a non-resonant system a valve† loss of 0.25 watt (2.5×10^6 ergs per sec.) at 75 ∼ corresponds to an amplitude of 0.27 mm. Thus at resonance the amplitude is $4 \times 0.27 =$

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* *Phil. Mag.*, 11, 3, (1931) or *Proc. Phys. Soc.*, 44, 90 (1932).

† $\rho = 600$ ohms to be in keeping with Fig. 4.

1.08 mm. With a pentode the current at resonance does not decrease appreciably, the amplitude is 3.6 mm. and the power output some twelve times that with the paralleled triodes. From this viewpoint the pentode is not to be recommended.

6. Calculation of I_2/I_2'

Referring to the anode circuit of the power valve the primary current under non-resonant conditions is (Fig. 5a)

$$I_1' = \frac{E}{3{\cdot}5\rho} \qquad \ldots \quad \ldots \quad (18)$$

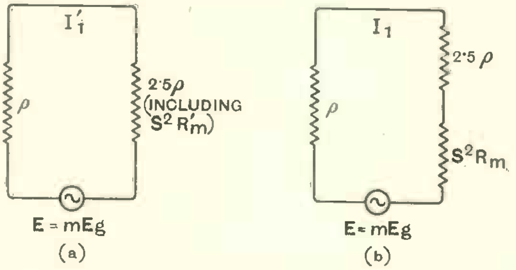
where E = voltage change in anode circuit.

ρ = valve resistance.

$2.5\ \rho$ = optimum load resistance, including radiation resistance.

At resonance (Fig. 5b) since $R_m >> R'_m$, the increase in resistance is substantially S^2R_m.

Thus
$$I_1 = \frac{E}{3{\cdot}5\rho + S^2R_m} \qquad \ldots \quad (19)$$



(a) (b)

Fig. 5.—*Equivalent diagrams of primary or anode circuit of M.C. speaker under (a) non-resonant and (b) resonant conditions. In (a) $S^2R'm$ the radiation resistance referred to the anode circuit is small compared with 2.5ρ and can be neglected.*

where S is the transformer ratio; and we get with a good transformer (constant ratio)

$$\frac{I_2}{I_2'} = \frac{I_1}{I_1'} = \frac{3{\cdot}5\rho}{3{\cdot}5\rho + S^2R_m} \qquad \ldots \quad (20)$$

7. Optimum Power and Amplitude at Resonance

The power (radiation + losses) at resonance is given by

$$I_2^{\,2}R_m = \frac{E^2S^2R_m}{(3{\cdot}5\rho + S^2R_m)^2} \qquad \ldots \quad (21)$$

If ρ, S and E are constant there is a certain value of R_m for which the power and, therefore, the vibrational amplitude is a maximum. By differentiating (21) with regard to R_m we find that for maximum power[*]

$$R_m = \frac{3{\cdot}5\rho}{S^2} \qquad \ldots \quad \ldots \quad (22)$$

this being the total non-resonant valve circuit resistance divided by the square of the transformer ratio. The power is then $E^2/14\rho$. Taking the data given in section 5, the optimum value of R_m is 21 ohms, whereas its actual value is 50 ohms. Consequently the power at resonance is not a maximum by any means. This undesirable optimum may occur in commercial designs owing to the magnetic field being too weak. The advantages to be gained by employing an intense magnetic field are as follows:—

(1) With any given triode the stronger the field the greater the reduction in current at resonance. A corresponding reduction in amplitude and output ensues.

(2) The electromagnetic damping is enhanced thereby reducing the growth and decay periods. This provides a better "attack" whilst natural oscillations of the diaphragm are more heavily damped.

(3) The general output is augmented and the relative increase in power due to resonances reduced.

If in addition the portion of the field over which the radial flux is uniform exceeds the length of the coil, or vice versa, the possibility of electromechanical rectification is reduced. On the whole it seems reasonable to believe that more powerful magnetic fields would effect a definite improvement. This can only be realised economically by employing electromagnets.

8. Relationship between Amplitude and Loudness

It would be useful and interesting to find this relationship for an average room. Owing, however, to the complex influence of (1) the shape and size of cabinets and flat baffles on the sound distribution and output in an ordinary room where reflection occurs; (2) the position of the loud speaker, etc., we shall restrict our analytical activities to something simpler.

The case chosen is that of a loud speaker diaphragm 10 cm. radius operating in an infinite baffle in free space. The results obtained will apply to pure tones only. In

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[*] Differentiation respecting S^2 also yields the result in (22).

practice sounds are complex and masking effects play an important role.

The sound distribution at distances exceeding, say, 200 cm. is uniform in all directions provided the diameter of the diaphragm is small compared with the wavelength. If the power radiated is W ergs per sec., the fraction associated with one square centimetre, on the surface of a hemisphere of radius r at whose centre the diaphragm vibrates, is $W/2\pi r^2 = W_2$. At distances from the diaphragm exceeding two wavelengths the acoustic pressure and the particle velocity are substantially in phase. The r.m.s. pressure* $p = \rho cv$, so that the r.m.s. particle velocity $v = p/\rho c$. The power $W_2 = pv = p^2/\rho c$ per unit area. Equating the above values of W_2 we obtain $p^2 = \rho c W/2\pi r^2$. Using the value of W from (4) the r.m.s. pressure is given by

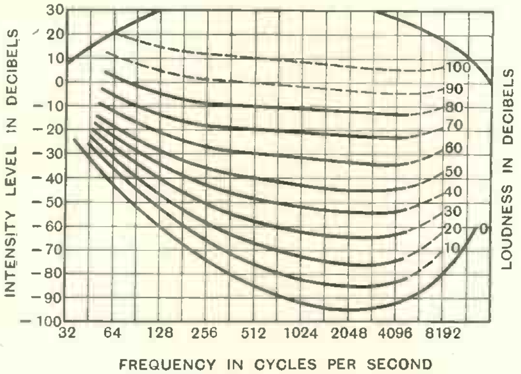

Fig. 6.—*Curves showing the relation between intensity level, loudness and frequency. "Isobels" or contour lines of equal loudness for pure tones.*

$$p = \rho a^2\omega^2 X/2\sqrt{2}\,r \quad .. \quad (23)$$

The datum level of sound intensity is taken as 10 ergs per sec. per sq. cm.† and this corresponds closely to a root mean square pressure of 20 dynes per sq. cm. under normal atmospheric conditions at 18° C. Using (23) the deviation in decibels from this level for a diaphragm 10 cm. radius is given by

$$D = 20 \log_{10} \frac{f^2 X}{11.8 r} \quad .. \quad .. \quad (24)$$

Taking $f = 64 \sim$, $X = 0.1$ cm., $r = 500$ cm., we find $D = -23$ decibels. Using the curves‡ in Fig. 6, we can ascertain the loudness level corresponding to 23 decibels below the datum. At 64 ~ the loudness is 44 db., which is on the low side, although many listeners will not tolerate a greater level at home. If the diaphragm were set in the centre of a wall in an average room the intensity would probably be about 10 db. higher, *i.e.*, 13 db. below the datum. This yields a loudness of 66 db. at 64 ~ which is ample for domestic purposes.

Book Review

A New Book on Valve Theory

IT is unusual to find a technical or scientific text book with a page dedication of such a character as "To Alice," but such is the dedication of a new book on valve theory.* Professor Chaffee is well known to readers of American technical literature. The new book is based on lectures on valves delivered by him at Harvard. The present book deals essentially with fundamentals, for example, of the valve itself and of its essential performance and applications, while the argument is confined to valves of the receiving type. The theory of power amplifiers and oscillators, soft valves, rectifiers, etc., will appear, it is stated, in a further volume.

The present book is entirely theoretical and mathematical in character—four pages are devoted to lists of symbols—but it provides a very full account of the essentials of valve operation from the fundamentals of electron emission, electronic conduction and the general physical aspects of the hard valve. Thereafter the various applications of the valve are discussed in very considerable detail, and the valve as an amplifier and as detector for large or small signal-voltages is analysed in what is possibly the fullest mathematical treatment available in any text book.

While the book is of American origin the treatment is so fundamental and general as to be equally applicable to British practice. The mathematics are at times rather difficult, but are presented with a thoroughness such as to be highly valuable to the more advanced reader. Useful lists of references are included at the end of each chapter, and the text is well broken up into suitable chapters dealing very specifically with the titular scope of their respective headings.

Although the lectures on which the book is based were started in 1922, the text is thoroughly modern in character, bringing screened-grid valves and pentodes within the scope of its concluding chapter.

J. F. H.

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* Rayleigh, Sound, 2, p. 16 (1894).

† Fletcher, *loc cit.*, p. 154.

‡ Fletcher, *loc. cit.*, Fig. 109.

* *Theory of Thermionic Vacuum Tubes*, by E. Leon Chaffee; London: McGraw Hill Book Coy. Inc. Price 36/- net.

Abstracts and References

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PROPAGATION OF WAVES

AUSBREITUNGSVERSUCHE MIT DER 1.3-M-WELLE (Propagation Tests with the 1.3-Metre [Ultra-Short] Wave).—A. Esau and W. Köhler. (*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, pp. 153–156.)

Tests over various types of land, with horizontal and vertical polarisation. Authors' summary :—" The propagation tests with a 1.3 m wave showed that even in conditions where an optical path was not present a 1.5 watt r.f. power enabled distances up to 10 km to be covered [a super-regenerative receiver being employed]. The field strength, however, decreased very quickly through absorption, reflection and scattering. The ranges obtained in the tests for equal field strengths over (*a*) optical paths, (*b*) flat land partly covered with trees, and (*c*) dense woods, were in the ratio 25 : 4.1 : 1.

" Received signal strength increases with height of transmitter and is maximal for optical paths. Vertical polarisation is in general superior to horizontal when the transmitter is near the ground. Up to $d/\lambda = 1$ (where d is the transmitter height) the received amplitude for vertical polarisation is on the average 100% greater than for horizontal polarisation. Only for propagation in dense woods is the horizontal polarisation superior, by reason of the screening action of the tree trunks and their vertical branches. As the transmitter height is increased the ratio of the field strengths for the two types of polarisation gets nearer to unity and reaches it when an optical path is obtained. Reception of the 1.3 m wave is completely independent of the time of day. No fading was found in any instance." The deflections of the receiver instrument were constant within 5% during daytime, twilight and night, and the weather had no effect whatever. A hill whose summit was from about 100 to 200 m above the stations allowed a range of 2.8 km to be obtained, but marked rotation of polarisation, up to 90°, was observed. Here again vertical polarisation was the better. Tests with a mound of about 50 metres' height between the stations, and with the receiver taken 10 metres down a pit, indicated that the waves circumnavigate rather than penetrate such an obstacle : signals vanished when a grid reflector at the pit mouth had its wires parallel to the transmitting aerial, and reappeared when the reflector was turned through 90°. Direction finding on the transmitting station was generally possible with horizontal polarisation : only when the transmitter was completely screened by large obstacles (blocks of houses, high hills) did serious errors occur, due to rotation of polarisation produced by diffraction and reflection.

SOME RESULTS OF A STUDY OF ULTRA-SHORT-WAVE TRANSMISSION PHENOMENA.—C. R. Englund, A. B. Crawford and W. W. Mumford. (*Bell S. Tech. Journ.*, April, 1933, Vol. 12, No. 2, pp. 197–227.)

See June Abstracts, p. 318, where the first writer's name is spelled wrongly.

ULTRA-SHORT WAVE PROPAGATION.—J. C. Schelleng, C. R. Burrows and E. B. Ferrell. (*Bell S. Tech. Journ.*, April, 1933, Vol. 12, No. 2, pp. 125–161.) *See* June Abstracts, p. 318.

BEMERKUNGEN ÜBER DAS AUSBREITUNGSGESETZ FÜR LANGE ELEKTRISCHE WELLEN UND DIE WIRKUNG DER HEAVISIDESCHICHT (Remarks on the Propagation Law for Long Electric Waves and the Action of the Heaviside Layer [with a New Interpretation of the Austin Formula]).—F. Noether. (*E.N.T.*, April, 1933, Vol. 10, No. 4, pp. 160–172.)

There is no reason to doubt the possible occurrence of Zenneck's " surface waves," with their energy concentrated, as in waves in wires, near the surface and spreading without appreciable loss due to surface curvature. The doubtful point, however, has been whether such waves could be produced (at any rate in sufficient strength) by an aerial close to the earth's surface ; although Sommerfeld answered this in the affirmative, Weyl, and later the writer, have contradicted this.

The above considerations were based on the assumption of a homogeneous atmosphere : the writer now investigates the possibility that the co-operation of the Heaviside layer may make the " Zenneck wave " theory hold good. Here again he finds a negative answer, except on the assumption of a far greater conductivity for the layer than is reasonable (a conductivity greater than, or at least equal to, that of the earth itself). He then examines Watson's theory of the transmission of waves round the earth, and its relation to the Austin formula: here again he finds that the theory does not represent the facts, requiring as it does a layer conductivity of the order of 10^{-14} to 10^{-15} in contrast to the value given by Elias of 10^{-19} for the lower part of the layer, rising to 10^{-15} at the top.

Finally he develops his own interpretation of the processes leading to the fulfilment of the Austin formula: this involves the reflection of only low-radiated waves, at the lowest parts of the Heaviside layer. His new version of the damping factor resolves itself into the Austin factor in its original form, $e^{-9.5\theta/\sqrt{\lambda}}$, when a layer conductivity of 10^{-17} to 10^{-16} is assumed. This comparatively narrow range of conductivity values for which the formula retains its validity may explain the variations of received signal strength with atmospheric conditions; these affect not merely the numerical value given by the formula but also the form of dependence on the wavelength. Moreover the assumed conductivities fit in with theory, agreeing for instance with the values given by Elias.

The Electrical Properties of Soil for Alternating Currents at Radio Frequencies.—R. L. Smith-Rose. (*Proc. Roy. Soc.*, May, 1933, Vol. 140, No. A 841, pp. 359–377.)

Author's summary:—The application of a laboratory method for measuring the conductivity and dielectric constant of samples of soil taken from selected sites at the National Physical Laboratory, Teddington, is described. These measurements were made over a range of frequencies of from 1 000 c/s to 10^7 c/s, and for various moisture contents ranging from practically zero up to a value exceeding that normally experienced for surface soil taken direct from the ground. The results of these measurements show that the conductivity varies from less than 10^5 e.s.u. for dry soil, up to a value of approximately 10^8 e.s.u. for normal moisture content. Corresponding values for the dielectric constant range from 2 or 3 for dry soil up to about 20 for moist soil at high radio frequencies. The results of measurements made on a number of samples of soil taken at random from several other sites are included in the paper, and show that both the normal moisture content and the conductivity can have values which are appreciably higher than those experienced at Teddington.

The paper concludes with a brief discussion of the penetration of r.f. currents in the earth, and the effective depth of penetration has been calculated in some instances with the aid of the experimental values of conductivity and dielectric constant determined above.

Voortplanting van Golven van 150–2 000 kc/s (2 000–150 Metres) over Afstanden van 50–2 000 km (Propagation of Waves of 150–2 000 kc/s over Distances of 50–2 000 km).—B. van der Pol. (*Tijdschr. Nederl. Radiogenoot.*, April, 1933, Vol. 6, No. 2, pp. 26–38.)

The first of the three reports, summaries of which were referred to in June Abstracts, p. 319, r-h column.

Bemerkung zu einer Arbeit von Murray und einer Arbeit von van der Pol und Niessen über die Ausbreitung elektromagnetischer Wellen (Remark on a Paper by Murray and One by van der Pol and Niessen on the Propagation of Electromagnetic Waves).—K. F. Niessen. (*Ann. der Physik*, 1933, Series 5, Vol. 16, No. 7, pp. 810–820.)

For abstracts of the papers referred to *see* Abstracts, January, p. 40, l-h col., and 1931, p. 30, r-h col. The writer of this note finds an error in Murray's mathematical treatment of the complex integrals occurring in his analysis, but shows that Murray's method, with appropriate correction, may also be used to obtain the formula derived by himself and van der Pol using operational methods.

Travel of Wireless Waves. Sir Frank Smith's Kelvin Lecture—How Radio Research Has Enlarged Our Knowledge of the Upper Atmosphere.—(*Electrician*, 5th May, 1933, Vol. 110, No. 2 866, pp. 580 and 581–582.)

The Contribution of Radiotelegraphy to Geophysics.—(*Nature*, 6th May, 1933, Vol. 131, pp. 642–643.)

A short account of the Kelvin lecture for 1933, giving a survey of our present knowledge of the properties of the ionosphere.

Le nuove Vedute sulla Composizione dell' Atmosfera (The New Views on the Composition of the Atmosphere).—F. Vercelli. (*La Ricerca Scient.*, 15th Feb., 1933, 4th year, Vol. 1, No. 3, pp. 133–139.)

Der Stand der Wellenforschung in der oberen Atmosphäre (The Present Position of the Investigation of the Upper Atmosphere by the Study of the Propagation of Waves).—H. Rukop. (*E.N.T.*, Feb., 1933, Vol. 10, No. 2, pp. 41–58.)

Discussion on Papers by Bartels and Rukop on the Upper Atmosphere.—Bartels: Rukop: Lassen: Franck. (*E.N.T.*, Feb., 1933, Vol. 10, No. 2, pp. 59–60.)

Discussion on the survey by Rukop referred to above and that by Bartels referred to in May Abstracts, pp. 262–263. Franck raises the point that it is incorrect to calculate the partial pressure of hydrogen in the higher layers by applying the barometric height formula to measurements at the ground—which, moreover, are very inexact. In the layers where ozone and oxygen atoms are produced by ultra-violet radiation, hydrogen may be oxidised to water; on the other hand, water may again be decomposed photochemically. Moreover, chemical reactions and collisions of the second type will produce many atoms with velocities largely exceeding those of gas kinetics. More light atoms, therefore, must be able to leave the earth than are calculated according to the Boltzmann distribution. Later, he raises the point whether the ionisation is considered to occur in one step or by a step-by-step process.

Lassen deals at some length with the question of the presence of light gases in the upper atmosphere; in spite of the absence of helium and hydrogen lines in spectroscopic observations, he considers that the great thickness of the Appleton layer (of the order of 100 km) can at present be explained only by the presence of at least one of these two gases; while the thickness of the Kennelly-Heaviside layer agrees with the presence of nitrogen and oxygen. Chapman's idea that the Appleton layer is composed chiefly of atomic oxygen would lead to the conclusion that this layer was about twice as thick as the K-H layer; but the records shown by Rukop indicate that the latter layer does not vary in height according to the time of day: it is either at a more or less fixed height or not present at all, whereas the Appleton layer varies by several hundred km during the 24 hours. This suggests that the ratio of thicknesses is more like 10 : 1 than the 2 : 1 of Chapman's hypothesis. Moreover, Chapman deduces a maximum electron density in the Appleton layer at about 220 km, whereas various records (including some shown by Rukop) indicate that this height represents about the lower limit of the layer, the maximum lying between 300–400 km.

ECHOMESSUNGEN AN DEN IONISIERTEN SCHICHTEN DER ATMOSPHÄRE (Echo Measurements on the Ionised Layers of the Atmosphere [on Six Rapidly Changed Wavelengths between 40 and 1 000 Metres]).—G. Goubau. (*E.N.T.*, Feb., 1933, Vol. 10, No. 2, pp. 72–74: Discussion p. 75.)

Using cathode-ray tube recording with circular time base and radial deflection (1932 Abstracts, p. 596, l-h column). Successive records were photographed on a film, on which the times and wavelengths were automatically registered; 8 000 records were taken.

At those times when several waves were reflected from the lower layer (*e.g.* between $15^h\,40^m$ and 21^h) they all gave about the same reflection height, whereas in the case of the upper layer the different wavelengths gave very different heights (*cf.* Lassen, above). It may therefore be deduced that the gradient of ionic and electronic density is much greater in the lower than in the upper layer.

At mid-day the shorter waves of 40, 80 and 150 m were reflected at the lower layer while the longer waves were absorbed. About sunset these shorter waves (and after sunset also the 250 m wave) penetrated the lower layer and were reflected by the upper layer. Simultaneously, reflections of the 250 and 1 000 m waves occurred at the lower layer at about the same height as the earlier short-wave reflections. Thus the electron density in the lower layer decreases about sunset and during the night, but the maximum ionisation remains at about the same height. After sunset the ionisation in the upper layer also decreases, as is seen from the disappearance of the 40 and 80 m wave reflections.

Sunrise observations (Fig. 4) showed similar processes reversed in point of time, except that the transition from one layer to the other took place gradually instead of suddenly.

In the subsequent Discussion, the writer replies to Möller (who suggests that the differences in the apparent heights of the upper layer, measured with different wavelengths, are due to differing delays in the lower layer) by pointing out that the shorter waves give a greater height than the longer waves. Wagner remarks that two factors, opposed to each other, are involved in the height differences—the greater delay of the longer waves in the lower layer and the stronger ionisation needed for the reflection of the shorter waves.

To Lassen, who asks about the daytime absorption of waves above about 100 m, the writer replies that by day, when ionisation is noticeable in still lower layers, a fairly strong damping may occur on account of the higher gas pressure. He mentions that under certain conditions reflection can take place at a height of about 50 km. He has one record of this, and Appleton has also found it; von Handel remarks that his and Plendl's observations (*see* below) include many reflections at apparent heights of 50 km and less.

SELEKTIVE SCHWUNDERSCHEINUNGEN UND HÖHENMESSUNGEN DER IONOSPHÄRE (Selective Fading Phenomena and Height Measurements of the Ionosphere [Fictitious Heights liable to be obtained by the "Pulse" and Other Systems]).—P. von Handel and H. Plendl. (*E.N.T.*, Feb., 1933, Vol. 10, No. 2, pp. 76–92: Discussion pp. 93–94.)

See also 1932 Abstracts, p. 575, r-h column. In the "pulse" procedure a periodic succession of very short r.f. wavetrains is sent out: if they arrive at the receiver after travelling by two paths of different length, each radiated impulse gives two received impulses whose spacing is a measure of the path difference. If, as sometimes happens, more than two impulses are received, they are taken as representing the effects of more than two paths, each of the multiple echoes being allotted its own particular path. But this way of regarding things leads to difficulties when multiple echo impulses are received in great numbers and with continually varying spacing. "Such occurrences make it necessary to subject the processes of the 'pulse' method to a closer examination, in which the selective fading phenomena play an important rôle."

The writers therefore begin by describing their experiments on selective fading, in which a frequency-variation procedure similar to that of Appleton was followed at the transmitter (with a single horizontal dipole aerial), the signals being received on two crossed horizontal dipoles. Records indicating the selective rotation of an approximately linear polarisation ($\lambda = 51.4$ m) are shown: these were further elucidated by the use of a cathode-ray oscillograph with its two pairs of plates connected to the crossed dipoles through their receivers, giving the polarisation rotation illustrated in a sketch (Fig. 4). In a later set of experiments four separate frequencies in quick succession were used instead of the continuous variation employed in the first set.

The writers' method of regarding the typical "multi-path" record is then developed. It is based on the treatment of the transmitted pulse not as a simple r.f. train but as a modulated waveband; a complex echo record with several peaks is interpreted as representing a complex condition of selective polarisation. Thus with what the writers call the "impulse modulation" interpretation there is no need to postulate the existence of cyclones, etc., in the ionosphere, to explain the records. They support their interpretation by describing tests on the comparative behaviour of impulses when received with and without beat-note production in the i.f. circuits of the receivers: according to the old notions the two methods would yield the same oscillogram under all conditions, while by the new interpretation they might give very different results, not only in the amplitude but also in the *number* of received impulses (Fig. 11).

Another set of experiments show that very different results are obtained if the transmitter sends out circularly polarised, instead of linearly polarised, waves. Thus in Fig. 13, film *b* (for circularly polarised signals) shows only a single echo impulse corresponding to a height of 180 km, whereas film *c* (linearly polarised signals) shows two echoes separated by 0.5 millisec., equivalent to a path difference of about 140 km. These records are discussed in connection with the magnetic double refraction effect of the ionosphere.

The writers then describe a further set of experiments, in which the difference in pulse reception with and without the suppression of the ground wave was examined; these were prompted by the discovery that while the ground-wave signals remained constant in amplitude so long as no indirect wave was present, the amplitude varied directly strong echo impulses arrived. This suggested that the resolving power of the equipment was not sufficiently great to prevent an echo with very short path-time from being superposed on the direct signal. The ground wave in the horizontal dipole was therefore compensated by means of a vertical aerial. It was in these experiments that the apparent reflection heights of 85 m down to 50 m were obtained, to which von Handel refers in the Discussion of Goubau's paper (*see* preceding abstract).

The last part of the paper discusses the "impulse modulation" theory as it affects the question of "selective penetration" into the reflecting layers. Taking as an example a 50 m wave reaching, at vertical incidence by day, an equivalent height of 150 m, the writers point out that an increase of penetration with frequency, amounting to only 2 cm per cycle, would cause the selective penetration effect to indicate an effective height of 210 km. The amount of selective penetration may be assumed to be the greater, the nearer the point of reflection lies to the height of maximum electron concentration; its effect therefore is most marked on the highest frequencies returnable from the ionosphere. It is not unreasonable to expect that for a 50 m wave at certain times the selective penetration might reach 10–30 cm per cycle: this would yield apparent heights of 450 to 1 050 km. Finally the writers apply their conclusions to methods of height measurement other than the pulse method: both Appleton's frequency-change procedure and the Mirick and Hentschel method (aeroplane: *see* 1929 Abstracts, pp. 500–501) are stated to be subject to the same trouble. The only method said to be free from it is the angle-measuring procedure of Appleton and Barnett. Results from the other methods can, it is stated, only be relied on when it is certain that no polarisation changes and no selective penetration are present. But Plendl, in the subsequent Discussion, mentions the Mirick and Hentschel method, in addition to the angle-measuring method, as free from the selective effect owing to its use of a single undamped frequency. Plendl also mentions that while the use of a circularly polarised transmission overcomes the difficulties of selective rotation of polarisation, the use of a rotating-field aerial at the receiving end would have the same effect: tests have already been made on this.

RICERCHE SULLA DISTRIBUZIONE DELLA DENSITÀ IONICA NELLA IONOSFERA E SULLE SUE VARIAZIONI (Researches on the Distribution of Ionic Density in the Ionosphere and on Its Variations).—I. Ranzi. (*Nuovo Cim.*, Jan., 1933, Vol. 10, No. 1, pp. 21–36.)

Author's summary:—"The author, as a result of a numerous series of measurements of the apparent height of reflection of electromagnetic waves of length 40–100 metres, has succeeded in establishing an approximate relation between the true and apparent heights of reflection, and thus an approximate law of distribution of electronic density with height. This also throws light on the often observed fact of the increase which the maximum ionic density in the two regions E and F may undergo during the night. On the basis of all the correlations of meteorological, lunar and magnetic observations regarding such variations of ionic density, the writer deduces the arrival, even at the part of the earth which is in darkness, of solar electronic radiation deflected by the earth's magnetic field." *See* also January Abstracts, p. 28.

A STUDY OF THE INTENSITY VARIATIONS OF DOWNCOMING WIRELESS WAVES [Lateral Deviation and Fading].—J. A. Ratcliffe and J. L. Pawsey. (*Proc. Camb. Phil. Soc.*, May, 1933, Vol. 29, Part 2, pp. 301–318.)

Authors' summary:—Experiments are made on wavelengths between 200 and 500 m for distances of transmission less than 200 km. It is found that the variations of downcoming wave intensity are uncorrelated on two receivers separated by about one wavelength, and it is shown that this implies a considerable amount of lateral deviation of the waves [*cf.* Australian results, below]. A special receiver is used to confirm the occurrence of lateral deviation, and an estimate of the angle of deviation is made. The possible causes of intensity variation are considered in the light of these experimental results, and it is suggested that a major cause of "fading" is the interference, at the ground, of waves "scattered" from a series of diffracting centres distributed over an area of radius at least 20 km in the present experiments. The possible results of such a mechanism are discussed.

1. A PRELIMINARY INVESTIGATION OF FADING IN NEW SOUTH WALES. 2. STUDIES OF FADING IN VICTORIA: A PRELIMINARY STUDY OF FADING ON MEDIUM WAVELENGTHS AT SHORT DISTANCES. 3. STUDIES OF FADING IN VICTORIA: OBSERVATIONS ON DISTANT STATIONS IN WHICH NO GROUND WAVE IS RECEIVED.—A. L. Green and W. G. Baker: R. O. Cherry and D. F. Martyn: R. O. Cherry. (*Radio Research Board, Australia*, Report No. 4, 1932, 59 pp.)

All the observations were on broadcast wavelengths and in directions at various angles to the magnetic meridian. In summarising the results discussed in the three papers, it is convenient to divide the work into two sections: (*a*) results at 65–200 km, where slow, quick, and "periodic" types of fading were observed, all appearing at any time after ½ hr before sunset and disappearing about the same length of time after sunrise (the periodic type being most frequent from 1–2 hrs after sunset), and (*b*) results at 590–870 km, where slow and quick fadings were observed.

In (*a*) the slow fading is shown to be due to interference between the ground wave and a downcoming wave reflected from a height of about 100 km. The quick fading is probably due to a downcoming wave reflected from the upper layer at a height of more than 200 km. "Periodic fading is believed to be caused by a ray reflected from the lower layer, though the mechanism of its production must remain unspecified at present. The lack of phase correspondence of the fading observed simultaneously on the two different aerial systems [loop and vertical straight wire], the fact that phase correspondence improves with distance from the transmitter, and the fact that the value of the height of the ionised layer deduced from such simultaneous observations tends always to be lower than that deduced by other methods, all suggest strongly that there is considerable lateral deviation of the sky wave at these distances" [*see* May Abstracts, p. 265, l-h col.; *also* Ratcliffe and Pawsey, above].

In (*b*) it is considered that slow fading is due to intensity variations in a single ray reflected from the Heaviside layer, while quick fading is produced by interference between this ray and a second ray reflected from the Appleton layer.

THE STATE OF POLARISATION OF SKY WAVES: HEIGHT MEASUREMENTS OF THE HEAVISIDE LAYER IN THE EARLY MORNING [Waves of Broadcast Frequencies].—A. L. Green. (*Radio Research Board, Australia*, Report No. 2, 1932, pp. 11–36: 37–80.)

The first paper describes the Australian experiments whose results, confirming the predictions of the magneto-ionic theory, were quoted by Appleton (1932 Abstracts, pp. 154–155). The writer, in mentioning experiments in progress to control the fading of broadcast signals, points out that previous attempts to solve this problem have encountered the difficulty of inconstancies in the Heaviside layer: "the polarisation experiments have shown that there is at least one property of a downcoming wave, namely the phase difference between its normally and its abnormally polarised components, which shows a certain measure of constancy whether the height of the deviating layer is normal at about 100 km or abnormally high at about 250 km." At the same time he remarks that these polarisation experiments were made only on transmissions along the earth's magnetic field, and that there is every reason to suppose that the results would be different for any other direction of propagation.

In his summary of the second paper the writer says: "Reflection coefficients of the Layers were calculated in most cases, and it was found that a mean value for the lower Layer was about 15% for the period preceding sunrise, and about 30% for the upper Layer in the early morning, when the lower Layer has ceased to reflect. Reasons are given for supposing that the reflection coefficient for the Heaviside Layer would be about 50%, so that the average values of about 15% indicate imperfect reflection as well as extra attenuation of the sky wave at points along its path where it passes through the '*D*' region of absorbing ionisation. Speculations in an appendix to the paper lead to the supposition that a doubly-reflected wave suffers the usual loss of 50% at the first reflection, but enjoys nearly perfect reflection at the second deviation.

"Times in minutes after the time of sunrise at ground level, called 'cut-off times,' at which the intensities of sky waves fall below easily measurable values, seem to depend on the time of year and on the type of Layer movement observed earlier in the same morning." These types of movement, and their effects on the cut-off times, are discussed in detail in the paper, which ends with a section on the comparison between English and Australian results.

THE INFLUENCE OF THE EARTH'S MAGNETIC FIELD ON THE POLARISATION OF SKY WAVES.—W. G. Baker and A. L. Green. (*Radio Research Board, Australia*, Report No. 3, 1932, 33 pp. with inset Addendum.)

The authors "have developed an analysis capable of specifying the polarisation of waves travelling at any given angle to the lines of force of the earth's magnetic field. They have shown that it is possible to calculate the polarisation of downcoming waves as received at any point on the ground, and have constructed, as an example, maps of New South Wales having contours corresponding to (*a*) the ratio of components, or the ratio of the abnormally polarised to the normally polarised components of a downcoming wave, and (*b*) the phase difference between these two components. These two maps are sufficient to determine completely the polarisation as measured at the ground in all directions from station 2BL, but it should be noted that the same maps would not hold for stations operating on different wavelengths. However, the mathematical analysis is capable of further interpretation in order to include other transmitting stations, and the corresponding maps can be drawn when the necessity arises." An appendix deals with "The Effect of Collisions between Electrons and Gas Molecules on the Calculations of Polarisation," and it is shown that the polarisation maps will represent the true state of affairs fairly accurately, so long as the collision frequency is low compared with the frequency of the wave transmission, so that the extraordinary ray is not returned to earth with an intensity comparable to that of the ordinary ray.

See also abstract under "Directional Wireless."

Polarisation of Echoes from the Kennelly-Heaviside Layer.—T. L. Eckersley. (*Nature*, 8th April, 1933, Vol. 131, pp. 512–513.)

This letter corrects an error contained in a previous letter by the writer (January Abstracts, pp. 29–30). According to the magneto-ionic theory the left-handed circularly polarised ray should really be less attenuated than the right-hand one, and not *vice versa*. Recent experiments have substantially confirmed previous observations as to the opposite polarisations of split echo components, but indicate "that it is impossible to generalise with regard to the strength of the various types of rays."

Recording Wireless Echoes at the Transmitting Station.—S. K. Mitra and H. Rakshit: R. A. Watson Watt and L. Bainbridge-Bell. (*Nature*, 6th May, 1933, Vol. 131, pp. 657–658.)

The first-named writers have succeeded in receiving echoes from the ionosphere on the aerial used to emit the pulses. The last-named writers suggest that the reduction of echo amplitude near the receiving aerial, mentioned by the first writers, may be due to the receiver as a whole being rendered relatively insensitive, for periods of many milliseconds, by the incidence of the strong ground pulse.

Results of the Third [Polish] Investigations on the Propagation of Intermediate [200–50 m] and Short [50–10 m] Waves.—D. M. Sokolcow and J. Bylewski. (*Wiadomości i Prace Inst. Radjotech., Warsaw*, No. 3–4, Vol. 4, 1932, pp. 35–73: in Polish and French.)

For the previous series of investigations *see* 1931 Abstracts, p. 261. Among the conclusions reached are the following:—(1) Contrary to the view widely held, the fields produced by the reflected wave are proportional to the currents in the transmitting aerial: (2) the variations of received field strengths from day to day, with intermediate and short waves, indicate that the propagation of these waves depends greatly on geographical conditions; the behaviour of the waves around 50 m, largely and successfully used in the U.S.A. for aircraft services, is especially interesting, suggesting that the compact mass of the American continent renders the layers stable compared with the conditions above Europe. (3) On the whole, propagation during this 3rd series was better than during the 2nd: signals were stronger, but underwent stronger variations. Communication could be established by using waves from 20–100 m during the whole 24 hours over distances up to 2 000 km, with a morning and evening change of wave; sometimes without any change at all, which was never possible in the former tests.

Experimental Contribution to the Study of the Propagation of Short Waves [based on Paris–Buenos Ayres and Paris–New York Services].—Maire. (*See* under "Stations, Design and Operation.")

Continuous Kennelly-Heaviside Layer Records of a Solar Eclipse [with Suggestions of a Corpuscular Effect on Appleton Layer].—H. R. Mimno and P. H. Wang. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol. 21, No. 4, pp. 529–545.)

Preliminary work leading to the new recorders used in these tests was referred to in 1932 Abstracts, p. 632, r-h column. The drum-type recorder, for laboratory use, has its drum mounted in an engine lathe and rotated by a 60-cycle motor synchronised with the pulse transmitter. The usual peripheral speed is about 400 cm/sec. The recording lamp (sound camera, gaseous discharge type) is mounted with its optical system on the tool carrier, which is drawn slowly along the lathe bed by the lead screw. The pitch of the resulting helix is determined by the lathe change gears, which are special. The incoming signals cause an increase in the intensity of the light spot (*cf.* Rukop and Wolf, 1932 Abstracts, pp. 275–276.) The portable recorder, for field use, uses the same recording lamp and electrical circuit, but has the lamp stationary, while a mirror and lens rotate at high speed and record by sweeping the spot across a slowly moving tape. This tape is bent to form a section of a cylinder where it passes the rotating spot: the latter, therefore, remains in exact focus as it crosses the tape.

In their discussion of the results of the solar eclipse observations, on about 86 metres (3 492.5 kc/s), the writers say; "Preliminary reports from other groups of American and European physicists indicate that the older methods of observation were unable to detect significant changes in layer height before the approximate time of optical total eclipse, and this has led to the impression that the corpuscular eclipse (if present at all) did not produce any measurable effect. Under these circumstances the double peak obtained by our continuous recorder is of especial interest. The first peak occurred about 40 minutes before totality [an abrupt rise from the 'normal' value round 220 km to a maximum round 330 km, separated by a broad minimum, slightly above the 'normal' value, from a second maximum round 350 km, at 4^h10^m: totality being at 3^h30^m]. This strongly suggests a corpuscular effect on the high layer, although we are not yet willing to rule out other possibilities. The corresponding records obtained by Kenrick and Pickard at a different geographical location [*see* next abstract] are in excellent agreement with our own curves, and show a similar double peak."

Observations of the Effective Height of the Kennelly-Heaviside Layer and Field Intensity during the Solar Eclipse of August 31, 1932.—G. W. Kenrick and G. W. Pickard. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol. 21, No. 4, pp. 546–566.)

Authors' summary:—"The result of observations of the effective height of the Kennelly-Heaviside layer on frequencies of 1 640, 3 492.5, and 4 550 kilocycles are described. On the higher frequencies two height maxima, one before and one after totality, are observed. These maxima occur at approximately 50% totality" [and "it is not necessary to invoke 'corpuscular' or other non-optical eclipses to account for the times of the layer changes shown by the records"—*cf.* Mimno and Wang, above].

"Field intensity observations on 6 095, 940, and 16.1 kilocycles taken at Tufts College are also described, and a marked eclipse effect is found on the two higher frequencies [none on the 16.1 kc/s Rugby signals, but the conditions were less favourable for noticing small changes than in the case of Austin's 1925 positive results on 57 kc/s, where moreover the transmitter was within the path of totality]. The nature of the field intensity variations observed is in good agreement with those anticipated as a result of observations during the eclipse of 1925." The various height-recording equipments were on the modulated neon lamp principle used by Mimno and Wang (above) but were of different mechanical design; in one type (the most convenient) the lamp and lens were kept stationary and the light beam rotated by a totally reflecting prism driven by a synchronous motor.

Observations in Transmission during the Solar Eclipse of August 31, 1932.—J. R. Martin and S. W. McCuskey. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol. 21, No. 4, pp. 567–573.)

"Signals in the 7 500-kilocycle band were transmitted from a point in the path of totality and were recorded in Cleveland, Ohio [about 600 miles from the path]. The records show a slow rise in [signal strength] level until a few minutes before totality, when a sharp increase was observed. At totality the signals suddenly dropped to a very low level, then increased slowly until the end of the eclipse, when a second rise in intensity [to "about the same value" as the first—if anything, higher] took place. This peak continued for several minutes and then fell to the normal level."

Cyclones, Anticyclones, and the Kennelly-Heaviside Layer.—R. C. Colwell. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 721–725.)

See January and June Abstracts, pp. 28 and 321, l-h columns. Author's summary :—"Fading curves taken in Morgantown upon the signal of KDKA in Pittsburgh show an increase of intensity after nightfall provided a cyclonic area covers both cities or lies to the north of Morgantown. If a high-pressure area covers both cities the night intensity does not increase above the day intensity and may even fall below it. These observations are explained by the theory that the Kennelly-Heaviside (E) layer is found at night in cyclonic regions but is not present in anticyclones. This theory is strongly supported by recent experiments of Ranzi on 100-metre waves."

Direct Measurement of the Gravitational Effect of the Moon [24.8 Hours Period: Unexplained Small Time Lag compared with Theoretical Curve, larger than Computed Effect of Sun].—K. Hartley. (*Physics*, April, 1933, Vol. 4, No. 4, pp. 162–163.)

The Magnetic Properties of Liquid Ozone.—P. Lainé. (*Comptes Rendus*, 27th March, 1933, Vol. 196, No. 13, pp. 910–912.)

Experiments on Electromagnetic Shielding at Frequencies between One and Thirty Kilocycles.—Lyons: King. (*See* under "Subsidiary Apparatus and Materials.")

Sheath Grounds Affect Travelling Waves in Cables.—E. Beck. (*Elec. Engineering*, April, 1933, Vol. 52, No. 4, pp. 238–239.)

Die Umgestaltung von Wanderwellen durch Koronaverluste (The Change of Form undergone by Surges as a result of Corona Loss).—F. Voerste. (*E.T.Z.*, 11th May, 1933, Vol. 54, No. 19, p. 452.)

Light Intensity at Different Depths in Lake Water [down to 70 Feet: Exponential Intensity Variation for Some Wavelengths only: Calculation of Absorption Constants].—H. A. Erikson. (*Journ. Opt. Soc. Am.*, May, 1933, Vol. 23, No. 5, pp. 170–177.)

Zur Lichtstreuung in stark getrübten Medien (The Scattering of Light in Very Clouded Media).—W. A. Fabrikant, W. L. Ginsburg and W. L. Pulver. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 11/12, pp. 795–798.)

Über die Eigenschaften der Interferenz von weit geöffneten Lichtbündeln (The Properties of the Interference of Widely Divergent Pencils of Light Rays [and the Polarisation in the Interference Field of Two Pencils]).—S. I. Wawilow and E. M. Brumberg. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 3, 1933, pp. 103–114.)

The Depolarisation of Light diffused by a Uniaxial Crystal when the Optical Axis is parallel to the Diffused Ray. Experimental Study and Theoretical Considerations.—J. Cabannes. (*Comptes Rendus*, 3rd April, 1933, Vol. 196, No. 14, pp. 977–979.)

Progressive Periodic Waves at the Surface of Water in a Shallow Container [Verification of Kelvin's Formula].—J. Baurand. (*Comptes Rendus*, 3rd April 1933, Vol. 196, No. 14, pp. 1 002–1 003.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

Nature of Cosmic Rays.—A. H. Compton. (*Nature*, 20th May, 1933, Vol. 131, pp. 713–715.)

The substance of an address, on our present knowledge of the nature of cosmic rays, an abstract of which was dealt with in June Abstracts, p. 322, l-h column.

NEW TECHNIQUES IN THE COSMIC-RAY FIELD AND SOME OF THE RESULTS OBTAINED WITH THEM.—R. A. Millikan. (*Phys. Review*, 15th April, 1933, Series 2, Vol. 43, No. 8, pp. 661–669.)

The full paper, an abstract of which was referred to in June Abstracts, p. 322, l-h column.

COSMIC RAYS MEASURED IN STRATOSPHERE [100 Times more intense at 18 Kilometres than at Sea Level].—R. A. Millikan, I. S. Bowen and H. V. Neher. (*Sci. News Letter*, 29th April, 1933, Vol. 23, No. 629, p. 264.)

Measurements at heights of 18 km with pilot balloons indicate that cosmic ray intensities there are approximately 100 times greater than at sea level. Penetrating power decreases rapidly with altitude. The phenomena are best interpreted "in terms of cosmic ray photon bands of widely differing penetrating power, the less penetrating bands coming into play at higher altitudes."

ORIGIN OF COSMIC RADIATION.—H. Alfvén. (*Nature*, 29th April, 1933, Vol. 131, pp. 619–620.)

The writer of this letter seeks to explain the origin of the cosmic rays by applying the kinetic theory of gases to the conditions of world space.

ON THE ABSORPTION OF COSMIC RADIATION BY THE ATMOSPHERE [Support of the Writer's View of Radioactivity of Free Protons as Ionising Agency and Extra-Nuclear Electrons as Agency for Absorption].—E. Sevin. (*Comptes Rendus*, 3rd April, 1933, Vol. 196, No. 14, pp. 1005–1007.). *See* January Abstracts, p. 33, r-h column.

COSMIC RAYS [Exclusively Corpuscular at Sea-Level: Primary Radiation from Outer Space also probably Corpuscular: "Transition Effects" in Absorption Curves Explained].—B. Rossi. (*Science*, 7th April, 1933, Vol. 77, No. 1997, Supp. pp. 8–9.)

SPECTRUM AND LATITUDE VARIATION OF PENETRATING [Cosmic] RADIATION.—E. J. Williams. (*Nature*, 8th April, 1933, Vol. 131, pp. 511–512.)

The writer gives the results of "some calculations on the spectrum and latitude variation of penetrating radiation on the assumption that it consists of electrons coming to the earth from outside."

FIRST RESULTS OBTAINED IN A NEW COSMIC RAY OBSERVATORY.—L. Tuwim. (*Comptes Rendus*, 27th March, 1933, Vol. 196, No. 13, pp. 950–952.)

Leading to the conclusion that with a low-pressure counter tube the number of cosmic ray impulses is equal to the number of ion pairs in an ionisation chamber of the same dimensions and at the same pressure: this may be explained either by the counter tube being set in action by a single ion pair, or by the cosmic rays producing, in the majority of cases, only one pair in a low-pressure counter.

COMPARISON OF THE ANGULAR DISTRIBUTIONS OF THE COSMIC RADIATION AT ELEVATIONS 6 280 FT. AND 620 FT.—T. H. Johnson. (*Phys. Review*, 1st March, 1933, Series 2, Vol. 43, No. 5, pp. 307–310.)

The results of the experiments here described "show a distribution less concentrated about the vertical at the higher elevation." The average ray at the higher elevation is found to produce 1.31 as many ions per unit path as the ray at the lower elevation. It is supposed that the softer rays, more predominant at the upper level, "produce more secondary rays from the walls of the ionisation vessel."

ANGULAR DISTRIBUTION OF LOW ENERGY COSMIC RADIATION AND INTERPRETATION OF ANGULAR DISTRIBUTION CURVES.—T. H. Johnson and E. C. Stevenson. (*Phys. Review*, April 1st, 1933, Series 2, Vol. 43, No. 7, pp. 583–584.)

The writers conclude from their measurements that the angular distribution of the total radiation may be interpreted on the basis of straight line paths through the atmosphere. They obtain good agreement between observed and calculated distributions at sea level.

THE COSMIC-RAY HODOSCOPE AND A CIRCUIT FOR RECORDING MUPTIPLY COINCIDENT DISCHARGES OF GEIGER-MÜLLER COUNTERS.—T. H. Johnson. (*Phys. Review*, 1st March, 1933, Series 2, Vol. 43, No. 5, pp. 379–380.)

Short abstract of paper describing "a continuously sensitive method for tracing the paths of the cosmic rays throughout an extended volume."

A CIRCUIT FOR RECORDING MULTIPLY-COINCIDENT DISCHARGES OF GEIGER-MÜLLER COUNTERS [of Cosmic Radiation].—T. H. Johnson and J. C. Street. (*Journ. Franklin Inst.*, March, 1933, Vol. 215, No. 3, pp. 239–246.)

THE VARIATION OF COSMIC-RAY INTENSITIES WITH AZIMUTH ON MT. WASHINGTON, N.H.—T. H. Johnson. (*Phys. Review*, 1st March, 1933, Series 2, Vol. 43, No. 5, p. 381: abstract only.)

A NEW METHOD OF DETERMINING THE EMANATION CONTENT OF THE ATMOSPHERE AND ITS APPLICATION TO THE INVESTIGATION OF THE CONNECTIONS WITH METEOROLOGICAL FACTORS AND OF THE INFLUENCE OF THE EMANATION CONTENT OF THE ATMOSPHERE ON MEASUREMENTS OF COSMIC RADIATION.—W. Messerschmidt. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 1/2, pp. 84–100.)

The method described depends on a direct measurement of the conductivity of air compressed in an ionisation chamber.

ZUR ATOMZERTRÜMMERUNG DURCH ULTRASTRAHLUNG (Disintegration of Atoms by Cosmic Rays).—W. Messerschmidt. (*Naturwiss.*, 14th April, 1933, Vol. 21, No. 15, pp. 285–286.)

High-Speed Ions of Stellar Origin [Bearing on Cosmic Radiation].—R. Gunn. (*Phys. Review*, 1st March, 1933, Series 2, Vol. 43, No. 5, p. 380: abstract only.) *See* also April Abstracts, p. 209.

A Mechanism of Acquirement of Cosmic-Ray Energies by Electrons.—W. F. G. Swann. (*Journ. Franklin Inst.*, March, 1933, Vol. 215, No. 3, pp. 273–279.) *See* May Abstracts, p. 268, r-h column.

Cosmic Rays—What Physicists Have Learned About Them.—K. K. Darrow. (*Elec. Engineering*, April, 1933, Vol. 52, No. 4, pp. 221–228.)

Progressive Lightning; a New Stereoscope.—C. V. Boys. (*Nature*, 8th April, 1933, Vol. 131, pp. 492–494.)

The writer describes his stereoscope for examination of photographs of progressive lightning; he compares and contrasts it with the instrument devised by Halliday for the same purpose (April Abstracts, pp. 208–209).

Effect of Lightning on Transmission Lines [Steepness of Wave Front can reach 15 to 20 Thousand kv/Microsec.: Highest Potential 5 Million Volts: etc.].—C. L. Fortescue. (*Sci. Abstracts, Sec. B*, Jan., 1933, Vol. 36, No. 421, p. 44.) *See* also January Abstracts, p. 32, r-h column.

Lightning [Height of Cloud and Extent of Charge deduced from Form of Wave Front: Duration and Nature of Discharge from Rear Slope: etc.].—P. W. Peek, Jr. (*Ibid.*, p. 44.).

Formation of Local Thunderstorms. Part II. Processes in the Free Atmosphere above Lindenberg on 2nd and 3rd July, 1932.—H. von Ficker. (*Sci. Abstracts, Sec.A*, Feb., 1933, Vol. 36, No. 422, p. 132.)

Ionic Over-Voltage Protectors.—AEG. (*E.T.Z.*, 27th April, 1933, Vol. 54, No. 17, Advt. p. 13.)

Lichtenberg Figures in Gases and Liquids.—Y. Toriyama. (*Sci. Abstracts, Sec.A*, Feb., 1933, Vol. 36, No. 422, p. 117.) *See* also 1932 Abstracts, p. 635, l-h column.

Practical Application of Periodogram Analysis.—J. W. Sandström: Lindquist. (*Sci. Abstracts, Sec.A*, March, 1933, Vol. 36, No. 423, p. 217.)

Summation Methods in Smoothing Curves.—F. Vercelli. (*Ibid.*, p. 217.)

Investigations of the Auroral Spectrum during 1921–26 [and Conclusions regarding Upper Atmosphere].—L. Vegard. (*Sci. Abstracts, Sec.A*, March, 1933, Vol. 36, No. 423, pp. 240–241.)

Ergebnisse kinematographischer Höhenmessungen und Nachweis einer Ultrarot-Strahlung des Nordlichtes (Results in Cinematographic Height Measurements and Proof of an Infra-Red Radiation in the Aurora Borealis [due to Nitrogen rather than to Oxygen]).—W. Bauer. (*E.N.T.*, Feb., 1933, Vol. 10, No. 2, pp. 68–72.) *See* also 1932 Abstracts, p. 578, l-h column.

Die wichtigsten Ergebnisse der Nordlichtforschung (The Most Important Results of Aurora Borealis Research).—C. Störmer. (*E.N.T.*, Feb., 1933, Vol. 10, No. 2, pp. 60–68.)

Including two diagrams from the writer's recent paper "How the horseshoe-formed auroral curtains can be explained by the corpuscular theory."

Auroral Curtains and the Corpuscular Theory.—C. Störmer. (*Sci. Abstracts, Sec.A*, Jan., 1933, Vol. 36, No. 421, p. 43.)

Electronic Bombardment as a Factor in Atmospheric Phenomena.—W. M. Cohn. (*Sci. Abstracts, Sec.A*, March, 1933, Vol. 36, No. 423, p. 245.)

Le Ricerche sulle Relazioni fra Fenomeni solari e terrestri (The Researches on the Relations between Solar and Terrestrial Phenomena).—G. Abetti. (*La Ricerca Scient.*, 15th Jan., 1933, 4th Year, Vol. 1, No. 1, pp. 3–12.)

Some Problems of Modern Meteorology, No. 10. Terrestrial Magnetism—the Magnetic Variations of Short Duration.—A. H. R. Goldie. (*Quart. Journ. Roy. Meteorolog. Soc.*, Jan., 1933, Vol. 59, No. 248, 15 pp.)

Field Energy of Magnetic Storms.—S. Chapman. (*Sci. Abstracts, Sec.A*, Jan., 1933, Vol. 36, No. 421, pp. 42–43.)

Sudden Changes in the Earth's Magnetic Field.—L. Rodés. (*Ibid.*, p. 43.)

PROPERTIES OF CIRCUITS

New Results in the Calculation of Modulation Products [applicable to Linear, Square Law and Other Rectifiers, Peak Choppers, etc.].—W. R. Bennett. (*Bell S. Tech. Journ.*, April, 1933, Vol. 12, No. 2, pp. 228–243.)

Author's summary:—A new method of computing modulation products by means of multiple Fourier series is described. The method is used to obtain, for the problem of modulation of a two-frequency wave by a rectifier, a solution which is considerably simpler than any hitherto known.

Theory of the Detection of Two Modulated Waves by a Linear Rectifier.—Aiken. (*See* under "Reception.")

Discussion on "Some Notes on Grid Circuit and Diode Rectification."—Kelly: Nelson: Terman. (*See* under "Reception.")

Note on Tuned-Anode and Transformer-Coupled R.F. Amplifiers.—Marique. (*See* under "Reception.")

Circuits with a Capacity in Parallel with a Saturated Diode.—C. Dei. (*Lincei, Atti d. R. Accad.*, Oct., 1932, Vol. 16, pp. 334–342.)

Experimental confirmation of the writer's theoretical work (1929 Abstracts, p. 331, l-h column).

Mathematical Expression of a Saturation Curve: Useful in Calculating Non-Linear Circuits.—C. M. Summers. (*Gen. Elec. Review*, April, 1933, Vol. 36, No. 4, pp. 182–185.)

Non-Linear Circuits Applied to Relays.—Suits. (*See* under "Subsidiary Apparatus and Materials," p. 403.)

Sustained Oscillations [from a Photoelectric Cell Circuit].—Hochard. (*See* under "Transmission.")

Mechanical Models for the Investigation of Electrical Stability Problems.—M. Darricus. (*E.T.Z.*, 11th May, 1933, Vol. 54, No. 19, pp. 456–457.)

TRANSMISSION

Experimentelle Prüfung der Theorie der Barkhausen-Schwingungen (Experimental Examination of the Theory of the Barkhausen Oscillations [Möller's "Sorting-Out" Theory of the Electrons]).—E. W. Helmholz: Möller. (*E.N.T.*, April, 1933, Vol. 10, No. 4, pp. 181–193.)

For Möller's papers *see* 1931 Abstracts, pp. 381–382, and back references. The experiments confirm the correctness of the "sorting-out" theory. The writers find that increased agreement between theory and experiment is obtained by assuming that the density of the to-and-fro space-charge cloud decreases at each passage through the grid to a fraction of its value, giving a factor $1/\{2(1-\beta)\}$ instead of Möller's $1/(1-\beta^2)$. The tests were made on valves with cylindrical electrodes, whereas Möller's work was based on plane electrodes: his results are applied to the former type of valve by taking the area of the grid in place of the plane surface area. In general, the calculated and observed values of the "excitation factor" agree within about 2%.

Production of Electronic Oscillations with a Two-Electrode Valve.—J. S. McPetrie. (*Nature*, 13th May, 1933, Vol. 131, p. 691.)

The writer has obtained strong electronic oscillations with a valve consisting of "a central metal rod anode of 1 mm diameter around which are arranged four filaments in parallel spaced equally on a ring 12.5 mm in diameter . . . By means of a tuned external circuit, the frequency of the oscillations appears to be adjustable within fairly wide limits while all other operating conditions are kept constant." A similar valve was recently described by J. Sahànek (January Abstracts, p. 36, r-h column.)

Système de Liaison S.F.R. à Magnétrons par Ondes extra courtes (S.F.R. Ultra-Short Wave System using Magnetrons [for Wavelengths 70–120 cm]).—Soc. Française Radio-Électrique. (*Bull. S.F.R.*, Jan.–Feb., 1933, Vol. 7, No. 1, pp. 1–10.)

In the magnetron circuits used for transmission, the wavelength is a function only of the external circuit. With anodes of 5 mm diam. and fields of 600–800 gauss, the applied voltage is around 500 v, and the useful power is several watts: the efficiency of the magnetrons at 85 cm is about 50%. The ample power allows long feeders (10–20 metres) to be used without these being rigorously tuned. "A special device (patented) avoiding energy absorption by the feeder is used for this purpose. The feeder is just an ordinary copper tube, about 2 cm in diameter, made with pieces fitting into each other." Various types of aerials and reflectors were used, and the calculated curves were found to be correct. Thus with a 12-rod (2 rows of 6) Chireix-Mesny aerial on 80 cm the zeros were at 26°, as calculated. Ranges of 50–100 km or more were obtained, for good "visibility" between the points linked, using a Barkhausen receiving circuit.

100 Metres and Below [Survey of Methods of Generation of Ultra-Short Waves].—C. C. Whitehead. (*Wireless World*, 28th April, 1933, Vol. 32, pp. 304–307.)

The Interdependence of the Frequency Variation and the Harmonic Content in an Oscillating System. Constant-Frequency Oscillators.—J. Groszkowski. (*Wiadomości i Prace Inst. Radjotech.*, *Warsaw*, No. 5–6, Vol. 4, 1932, pp. 77–89: in Polish.)

Investigations of the frequency variations of systems with negative non-linear resistance, based on the fundamental differential equation of the simple oscillatory circuit, are exact but often very intricate and sometimes impossible; symbolic calculus, if applied to non-linear circuits, gives only approximate results. The writer here employs the symbolic calculus in such a way as to obtain complete and exact results, by applying it to the fundamental frequency as well as to all the harmonics appearing in the system. This is made possible by the investigation of the functioning of the negative resistance from the energy viewpoint.

He takes into consideration the fact that in the negative resistance characteristic $i = f(v)$, i must be the univocal function of v, and therefore that the area described by the instantaneous point of work during one cycle of the fundamental oscillation must be zero, or $\oint i\,dv = 0$. On the other hand, i and v can be considered, with regard to the external circuit connected to the negative resistance, as the sum of the harmonic currents and potentials. In this way he obtains formulae which allow the interdependence of frequency variation and harmonic content to be determined. It is shown that it is just these harmonics, whose amount varies with changes in operating conditions (supply voltages, etc.), which are responsible for the frequency variations.

As a result of the above, methods of frequency stabilisation can be devised. The theoretical conclusions have been verified experimentally.

RESEARCHES ON THE ESTABLISHMENT OF A LIMIT OF INTENSITY FOR THE HARMONICS OF TRANSMITTING STATIONS.—K. Krulisz and S. Wolski. (*Wiadomości i Prace Inst. Radjotech., Warsaw*, No. 2, Vol. 4, 1932, pp. 19–22: in Polish.)

A survey of the problem discussed at two meetings of the C.C.I.R., followed by a description of some tests on a few actual stations.

DISCUSSION ON "A FOURIER ANALYSIS OF RADIO-FREQUENCY POWER AMPLIFIER WAVE FORMS."—F. E. Terman: Hallman. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 726–731.)

A long argument on the correctness of the plate efficiency calculation (for the class C amplifier) given by Hallman in the paper dealt with in January Abstracts, p. 37, r-h column.

SERIES MODULATION [and Its Advantages over Other Systems].—W. T. Ditcham. (*Marconi Review*, March–April, 1933, No. 41, pp. 1–8.)

On the modulation system, also known as the "constant potential" method, dealt with in May Abstracts, p. 271, l-h col. The Marconi Company has so far developed it up to an output of some 30 kw, a power sufficient to drive a final amplifier rated at 300 kw carrier energy. It has not been found difficult to secure a frequency characteristic which is level within 0.5 db from 50 to 10 000 c/s, with a distortion factor well below the 4% limit; this feature makes the system very suitable for television purposes.

THE SINGLE SIDE-BAND SYSTEM APPLIED TO SHORT-WAVE TELEPHONE LINKS.—A. H. Reeves. (*Electrician*, 12th May, 1933, Vol. 110, No. 2 867, p. 623.)

Summary of an I.E.E. paper. For previous papers on the subject *see* Abstracts, 1931, p. 613, l-h column; 1932, p. 94, r-h column; and back references.

ZUR FRAGE DER WAHL DES GLEICHWELLENSYSTEMS (The Question of the Choice of Common-Wave Systems [Synchronised or Unsynchronised]).—F. Gerth. (*E.N.T.*, April, 1933, Vol. 10, No. 4, p. 193.)

Practical experience of German stations on both systems has shown that the disturbed zone is considerably broader with the unsynchronised than with the synchronised system. The greater simplicity of the former system, however, makes it suitable in certain cases, particularly where the use of directive aerials can be brought in to help matters.

SHORT-WAVE CIRCUIT EMITTING TRAINS OF WAVES AT EQUAL INTERVALS OF TIME [and Possible Applications].—G. Petrucci. (*Nuovo Cim.*, Jan., 1933, Vol. 10, No. 1, Review p.v: summary only.)

Continuation of the work dealt with in 1932 Abstracts, p. 637. Apart from the application of the circuit to the transmission of time signals, it may also be used for the comparison of condensers.

SUR LES OSCILLATIONS ENTRETENUES (Sustained Oscillations [from a Photoelectric Cell Circuit]).—E. Hochard. (*Comptes Rendus*, 27th March, 1933, Vol. 196, No. 13, pp. 905–906.)

If a photoelectric cell is connected in series with a voltage source and a high resistance R, and has across it a condenser C, then on illumination the establishment of a stable régime is not instantaneous; the condenser C discharges itself partly through the cell, the discharge current rising suddenly from zero to i_0 and then gradually decreasing. On the other hand the current in the main circuit is established progressively, rising from zero to the value I_0 equal to the photoelectric current in the absence of C. A corresponding phenomenon takes place on the cessation of the illumination. The duration of the variable régime depends on C and R.

Under these conditions if the luminous flux falling on the cell is suitably controlled by the variations of I or of i, a series of charges and discharges of C can be produced and oscillation set up. A simple method is to include in the circuit a galvanometer whose spot of light acts on the cell in such a way that the incident flux diminishes when the galvanometer current increases. When the galvanometer is in series with the condenser the period can be adjusted over a wide range, from 1/10th sec. to several minutes: it is a function of C, R, the brightness of the spot, and the shape of the latter and of the window covering the cell. A record of the deflections of the galvanometer yields curves of very varied shape: in particular, the various types of curve described by van der Pol (1930 Abstracts, p. 566) can be obtained: on increasing the spot brightness one passes from the quasi-sinusoidal form to the form characteristic of relaxation oscillations. If, on the other hand, the galvanometer is connected in the main circuit, the oscillations may be of very large amplitude, but their period is always close to the natural period of the galvanometer, even for large variations of CR. Their form, except for strong illumination, is nearly sinusoidal.

Finally, if anywhere in the circuit a resistance is introduced which lies in the grid circuit of a triode, the various currents can be amplified and oscillations of several milliamperes obtained; while if the galvanometer is transferred to the plate circuit of the valve, oscillations can be maintained even with a galvanometer or oscillograph too insensitive to be used directly in the cell circuit. *Cf.* Abstracts, 1932, p. 342, Sewig, and 1931, p. 102, Ruedy (on Rosing's work).

RECEPTION

BEEINFLUSSUNG DES RUNDFUNKEMPFANGS DURCH QUECKSILBERDAMPF-GLEICHRICHTER (Interference with Broadcast Reception due to Mercury-Vapour Rectifiers).—A. Dennhardt. (*E.T.Z.*, 4th May, 1933, Vol. 54, No. 18, pp. 419–422.)

Such interference is almost exclusively of l.f. type; r.f. interference is only experienced in exceptionally unfavourable circumstances (it has been noticed particularly in the case of the smaller glass rectifiers). The possibility of r.f. interference with a l.f. note character has recently been pointed out: "as a result of the [receiving ?] antenna effect of the overland supply circuit and of the overhead network on which the rectifiers function, a modulation of the transmitted energy taken up by the conductors may be brought about by the rectification process and give the effect of l.f. interference." Such secondarily modulated r.f. interference, which would be spread by the network, would have to be dealt with by action at the receiver, such as the use of filters between mains and receiver and the screening of the aerial where it passes near the power wires.

The main part of the paper deals with the l.f. interference. Thus sections II, A and B, discuss theoretically the way in which the interference is generated and in which it acts; IIc deals with the measurement of the interference potential; IId defines "telephone form factor" and "broadcast form factor"; IIe includes a table of practical values of interference voltage: the increase, with increasing load, of the generated interference is discussed, and it is mentioned that in certain cases with 6-phase rectifiers the contrary effect has been found by Schulze.

Section IIf deals with measures which can be taken at the rectifiers to avoid the production of l.f. interference. But the writer considers that with our present knowledge of receiver design such measures are not necessary, and in section IIg he discusses the various ways (galvanic, for d.c. mains sets, capacitive, and inductive coupling) in which the interference may be introduced, and the methods of counteracting each.

Over de Grondslagen voor de Bestrijding van Radiostoringen (Fundamental Points in the Suppression of Radio Interference [Man-Made]).—J. W. Alexander. (*Tijdschr. Nederl. Radiogenoot.*, April, 1933, Vol. 6, No. 2, pp. 45–51.)

Author's summary:—"Attention is given to the two principal questions which are to be considered when fighting disturbances: (1) The importance of the frequency to which the receiving set is tuned. This leads to the investigation of power (l.f.) apparatus and conductors as to their behaviour with respect to high-frequency (r.f.) currents [*cf.* Wild, May Abstracts, p. 272]. It is mentioned by way of example how to render a motor free from causing disturbances. (2) The question as to the extent to which a decrease in disturbances should be continued so that a reception free from disturbances may be obtained [*see* 1932 Abstracts, p. 639, r-h column]. Mention is made of various still unknown factors which are important in connection with the anti-disturbance problem" [as regards calculating the size necessary for a condenser to deal with a given motor, etc.]. Elias and van der Pol take part in the subsequent Discussion.

Various Methods of Detecting Faulty Insulators on H.T. Lines under Tension.—G. A. Robertson. (*Sci. Abstracts, Sec.B*, Jan., 1933, Vol. 36, No. 421, p. 16.)

The Radio-Noise Meter and Its Application to the Measurement of Radio Interference.—C. R. Barhydt. (*Gen. Elec. Review*, April, 1933, Vol. 36, No. 4, pp. 201–205.)

"The radio-noise meter, a device which detects radio noise, measures its intensity [by the substitution method, using a multivibrator circuit generating a saw-tooth wave], and locates its source, has brought this interference phenomenon into the ranks of measurable quantities."

Theory of the Detection of Two Modulated Waves by a Linear Rectifier.—C. B. Aiken. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol 21, No. 4, pp. 601–629.)

Author's summary:—"In this paper there is developed a mathematical analysis of the detection, by a linear rectifier, of two modulated waves. Solutions are obtained which are manageable over wide ranges of values of carrier ratio and degrees of modulation. These solutions are of greater applicability and are more convenient than those previously obtained, and give a full treatment of the action of an ideal linear rectifier under the action of two modulated waves.

"The development is first made in terms of the derivatives of zonal harmonics of an angle which is directly related to the phase difference between the carriers. As these derivatives are tabulated functions the solution is convenient.

"The solutions are limited by the condition that $K < (1 - M)/(1 + m)$, K being the carrier ratio, M the degree of modulation of the stronger carrier, and m that of the weaker. Two methods of attack are developed, one of which is applicable when K is small and M and m large, and the other when M and m are small and K large.

"The cases of identical and of different programmes are both considered and a number of curves are given showing the magnitudes of various output frequency components under typical operating conditions.

"In the latter part of the paper the phase angle between the carriers is set equal to μt so that a beat note exists. There is then considered the effect of a noise background on the reception of signals on shared channels, and it is shown that much less 'flutter' effect and much less distortion of the desired signal will result from the use of a linear rectifier than from the use of a square-law rectifier under the same conditions.

"Finally, brief consideration is given to heterodyne detection and to 'masking' effects." With regard to the latter phenomenon the writer states that none of the earlier analyses are valid for a wide range of values of K and M except that of Moullin (1932 Abstracts, pp. 522–523) "who has developed expressions which cover the ground quite thoroughly." Regarding Moullin's treatment of the linear detection of heterodyne signals, his method is different from the writer's, "and leads him to the conclusion that the modulating and carrier beat frequencies must be small compared with the frequency of either carrier. From the discussion . . . in the present paper it is evident that this restriction is unnecessary."

Discussion on "Some Notes on Grid Circuit and Diode Rectification" [Distortion avoided even for 100 % Modulation by connecting Grid Leak to Positive Point instead of to Earth].—F. G. Kelly: Nelson: Terman. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol. 21, No. 4, p. 630.)

Referring to the Discussion (April Abstracts, p.

213) on Nelson's paper, Kelly points out that it is agreed that at around 100 % modulation distortion is inevitable with the usual circuit; he himself uses a circuit differing slightly from Terman's and giving no distortion, theoretically or practically, up to and including 100 % modulation. The difference lies in disconnecting the ordinary leak from the rectifier cathode and reconnecting it to a point on the d.c. supply positive with respect to the cathode by several times the peak of the rectified envelope: this renders the leak current very nearly constant (as the bias fluctuations are then only a small part of the total voltage across the leak) and gives an approach to the ideal leak which is a constant-current device from zero applied voltage to the highest. The resistance of the leak would then be increased to bring its average d.c. back to what it was before.

Note sur les Amplificateurs pour haute Fréquence à Circuit d'Anode accordé et à Transformateur (Note on Tuned-Anode and Transformer-Coupled R.F. Amplifiers).—J. Marique. (*L'Onde Élec.*, Jan., 1933 [delayed in publication], Vol. 12, No. 133, pp. 29–40.)

The writer examines various curves, derived from the classical formulae, which allow a comparison to be made of the tuned-anode and transformer-coupled types of r.f. amplifier, from the points of view of amplification and selectivity.

Only linear amplification is dealt with, without retroaction and without serious interference. He concludes that the equations and curves show that in the majority of cases, especially with modern valves, the two types have very similar properties. Thus as regards amplification, the slight advantage of the transformer coupling may be completely nullified by a change in the type of valve. As regards selectivity, the tuned-anode type is always inferior to the transformer-coupled type where $K\sqrt{L_1/L_2} < 1$ and superior where $K\sqrt{L_1/L_2} > 1$, K being the coupling coefficient between the two inductances L_1 and L_2.

Ferro-Inductors and Permeability Tuning.—W. J. Polydoroff. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 690–709.)

" Brief analysis indicates that tuning by variation of inductance in such a manner that L/R of the circuit is kept constant results in constant selectance and amplification throughout the tuning range [the writer defines " selectance " as the band width between the maximum of the resonance curve and that point where the amplitude is reduced to $1/n$th of the maximum: $S_n = n/2\pi \cdot R/2L = 0.08n \cdot R/L$]. Very finely divided and compressed magnetic-core material has been developed for this purpose [1932 Abstracts, pp. 345 and 584, r-h columns]. . . . This material exhibits extremely low losses at broadcast frequencies and possesses exceptional magnetic stability, from which other than radio applications follow [*e.g.*, telephone circuits, loading coils]. Constructional details of variable ferro-inductors are given, together with their behaviour and application in radio circuits. Because of inherent uniformity of the circuits, they are most applicable in tuned r.f. receivers, several forms of which are shown in their performance and construction."

Iron-Content Cores for High-Frequency Coils.—Schneider. (*See* under " Subsidiary Apparatus and Materials," p. 403.)

Tatsfield Relaying Receivers.—(*World-Radio*, 5th and 12th May, 1933, Vol. 16, Nos. 406 and 407, pp. 597–598 and 631–632.)

Practical Short-Wave Reception.—C. C. Whitehead. (*Wireless World*, 5th May, 1933, Vol. 32, pp. 316–319.)

Details of practical short-wave circuits are given for use on the 2 to 15 metre waveband.

Universal A.C. Short-Wave Converter.—W. T. Cocking. (*Wireless World*, 28th April, 1933, Vol. 32, pp. 300–303.)

Full details are given for the construction of a two-valve frequency changer which can be used in front of any existing broadcasting receiver. The waveband covered is 12.5 to 100 metres.

A Super-Regenerative Short-Wave Attachment [for Telephony Reception].—(*World-Radio*, 5th May, 1933, Vol. 16, No. 406, p. 605.)

The Pentagrid Converter [Single-Valve Frequency Changer for Superheterodynes].—Lyons. (*See* under " Valves and Thermionics.")

Tone Control Output Unit.—A. Vaughan. (*Wireless World*, 5th May, 1933, Vol. 32, pp. 321–322.)

An article for the amateur constructor. This unit is mainly intended for attachment to receivers not already incorporating some form of tone correction.

Automatic Gain Control of Radio Receivers [on Commercial Channels].—I. J. Cohen. (*P.O. Elec. Eng. Journ.*, April, 1933, Vol. 26, Part 1, pp. 58–59.)

Set Analysers [for Testing Broadcast Receivers].—E. J. G. Lewis. (*World-Radio*, 12th May, 1933, Vol. 16, No. 407, pp. 633–634.)

Broadcasting Progress in 1932, *and* European Broadcasting *versus* Economic Depression [U.I.R. Statistics of Listeners].—A. R. Burrows. (*World-Radio*, 21st April, 1933, Vol. 16, No. 404, pp. 516–517: 5th May, 1933, No. 406, pp. 584–586.)

Rundfunk und Stromlieferung (Broadcasting and Current Supply [Statistics regarding Increased Power Consumption due to Broadcasting]).—A. Civita. (*E.T.Z.*, 23rd March, 1933, Vol. 54, No. 12, pp. 286–287: summary only.)

AERIALS AND AERIAL SYSTEMS

ÜBER DIE SCHWUNDVERMINDERNDE ANTENNE, DES RUNDFUNKSENDERS BRESLAU (The Fading-Diminishing [" One-Wire "] Aerial of the Breslau Broadcasting Station).—F. Eppen and A. Gothe. (*E.N.T.*, April, 1933, Vol. 10, No. 4, pp. 173–181.)

See February Abstracts, p. 101, r-h column. Authors' summary :—" Measurements on the Breslau aerial have resulted in a far-reaching confirmation of the theory of the production of fading. The Breslau aerial suppresses space radiation at angles of about 65° and upwards and thus about doubles the zone of fading-free reception given by a quarter-wave aerial. The decrease of space radiation brings with it an increased ground-wave radiation, giving a 26% increase of horizontal field strength."

LATTICE MASTS OF TUBULAR CONSTRUCTION, WITH WELDED JOINTS.—H. Rixe. (*E.T.Z.*, 6th April, 1933, Vol. 54, No. 14, p. 333.)

CONDUCTOR VIBRATION FROM WIND AND SLEET.—J. P. den Hartog. (*Elec. Engineering*, April, 1933, Vol. 52, No. 4, pp. 240–242.)

VALVES AND THERMIONICS

THE " CATKIN " RADIO VALVE.—(*Nature*, 20th May, 1933, Vol. 131, p. 735.)

A new receiving valve in which the amount of glass-work has been reduced to a minimum. The electrode dimensions are of greater precision and the performance is uniform for valves of the same type. Susceptibility to microphonic effects is low. Complete screening can be obtained by a metal cover fitting over the entire valve. A diagram of the various parts is given. *See* also below.

THE CATKIN VALVE.—(*Wireless World*, 12th May, 1933, Vol. 32, pp. 340–341.)

By adopting an entirely new method of construction it is claimed that for the first time real consistency in the characteristics of mass-produced valves is obtained, and that the valves are not likely to be affected by rough handling. These improvements have been brought about by locating the electrodes rigidly inside a metal envelope by mica spacing pieces. The metal envelope forms the anode ; owing to the large cooling surface thus provided, improved electrical efficiency is obtained, especially in the case of output valves. Compactness is another feature of the design. *See* also below.

NEW RECEIVER VALVES : THE " CATKIN " TYPES.—G. E. C. and Marconiphone Company. (*Electrician*, 12th May, 1933, Vol. 110, No. 2 867, pp. 610 and 611–612.)

" The new Marconi and Osram Catkin valve has a copper container . . . forming the anode. This construction has been used for their high-power transmitting valves in which the metal anode itself is the envelope, mainly to permit of cooling by water circulation. Transmitting valves of this type are designated 'C.A.T.' (cooled-anode transmitters) " : hence the name applied to the new and smaller air-cooled receiving valves. The advantages discussed include, besides those mentioned in the preceding abstracts, the elimination of electrostatic charges, a new low-loss electrode support and seal, and the retention of high vacuum.

THE SPRAY SHIELD TUBE [Negative Potential on Shield prevents Accumulation of Charges on Inner Wall, suppressing Valve Noise and Localised Heating : Electrostatic Screening : Very Low Feed-Back Capacitance].—H. W. Parker and F. J. Fox. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 710–720.)

THE DOUBLE DIODE TRIODE.—C. N. Smyth and J. Stewart. (*Wireless World*, 19th May, 1933, Vol. 32, pp. 355–356.)

The double diode triode valve has just made its appearance in this country (*cf.* 1932 Abstracts, pp. 459–460). The advantage of the use of an ordinary diode rectifier followed by a triode amplifier are well known, and in this new valve the diode and triode electrodes are built into one envelope, giving greater convenience and decreased cost with no loss in efficiency. Two anodes are provided for the diode, the second of which can be usefully employed in an automatic volume control circuit provided that a variable-mu valve is used for r.f. amplification.

THE PENTAGRID CONVERTER [Single-Valve Frequency Changer for Superheterodynes].—C. L. Lyons. (*Wireless World*, 12th May, 1933, Vol. 32, pp. 347–348.)

Recently developed in the U.S.A., this consists of a special valve incorporating in one envelope the electrodes necessary for a triode oscillator and a variable-mu first detector. Simplification of receiver design, coupled with freedom from aerial radiation and interaction between tuning circuits, are the main advantages claimed.

A CORONA-DISCHARGE " VALVE " AT ATMOSPHERIC PRESSURE.—Gemant. (*See* abstract under " Subsidiary Apparatus and Materials.")

THE FILAMENTLESS TUBE.—(*Radio Craft*, March, 1933, Vol. 4, pp. 528–529.)

GRAPHICAL DETERMINATION OF PERFORMANCE OF PUSH-PULL AUDIO AMPLIFIERS.—B. J. Thompson. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol. 21, No. 4, pp. 591–600.)

Author's summary :—" Previous methods used for determining graphically the performance of push-pull audio amplifiers are inaccurate because they neglect the coupling between the tubes through the output transformer. A relatively simple method is presented which takes this effect into account. It consists in combining the plate-current–plate-voltage characteristics of the tubes to form a family of composite characteristics. This may be used to determine the performance for any load resistance in the same manner as is done for single tubes. This method is equally applicable to class A or class B conditions.

" It is found that each tube operates into a variable load resistance, which, under optimum conditions, is equal to its internal resistance at every point throughout the cycle. An experimental verification under a number of operating conditions is presented, showing close agreement between computed and measured values of power output, distortion, and average plate current." *Cf.* Kilgour, June Abstracts, p. 328, r-h column.

THE OUTPUT POWER OF THE FINAL VALVE IN AN AMPLIFIER, AND ITS PRACTICAL SIGNIFICANCE.—Kammerloher : Leithäuser. (*See* under "Acoustics and Audio-frequencies.")

ELECTRONICS AND ELECTRON TUBES: PART I. ELECTRON AND ATOMIC THEORIES. PART II. ELEMENTS OF ELECTRON TUBES.—E. D. McArthur. (*Gen. Elec. Review*, March and April, 1933, Vol. 36, Nos. 3 and 4, pp. 136–138 and 177–181.)

SUL CALORE DI EVAPORAZIONE DEGLI ELETTRONI NELL' EFFETTO TERMOJONICO (The Heat of Evaporation of Electrons in the Thermionic Effect).—T. Franzini. (*Nuovo Cim.*, Feb., 1933, Vol. 10, No. 2, pp. 57–77.)

Tests on a tungsten filament. For temperatures up to 2 150°K the variation of the extracted energy E as a function of the thermionic current j agrees well with the hypothesis of a Maxwellian distribution of the initial velocity of the emitted electrons. At higher temperatures this function $E = f(j)$ increases rapidly, indicating that the current from the filament is not all of thermionic origin but is in part due to electrons of higher velocity drawn out by the external field.

ÜBER DIE AUSTRITTSARBEIT DER ELEKTRONEN AUS METALLEN (The Work Functions of Electrons Emitted from Metals).—Ig. Tamm and D. Blochinzev. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 3, 1933, pp. 170–205.)

A preliminary report of this theoretical investigation was referred to in January Abstracts, p. 47, r-h column. The conclusion arrived at is that by considering the work function to depend on the image force rather than a potential threshold at the surface of the metal, values can be calculated which show a satisfactory agreement with experimental results.

THE VARIATION OF SECONDARY EMISSION WITH HEAT TREATMENT.—P. L. Copeland. (*Journ. Franklin Inst.*, April, 1933, Vol. 215, No. 4, pp. 435–443.)

LIBERATION OF ELECTRONS FROM A METAL UNDER BOMBARDMENT BY SLOW POSITIVE IONS [and Calculation of Minimum Potential Drop (of the order of 1 Volt) for which an Ion will extract Electrons].—G. Valle. (*Sci. Abstracts, Sec.A*, Feb., 1933, Vol. 36, No. 422, p. 172.)

EFFECT OF AMMONIA ON POSITIVE ION EMISSIVITY OF IRON, NICKEL, AND PLATINUM.—A. K. Brewer. (*Sci. Abstracts, Sec.A*, Feb., 1933, Vol. 36, No. 422, p. 200.)

Among other results, "the surprising fact appears that at low temperatures a pure iron filament in NH_3 emits positive ions more copiously than even the best of potassium-impregnated positive ion sources."

DIRECTIONAL WIRELESS

RADIO AIDS TO AIR NAVIGATION [New Target-Flight Radio Compass, and Its Combination with Magnetic Compass for Automatic Steering Control with Drift Correction: Landing Aids].—C. F. Green and H. I. Becker : G.E.C. (*Elec. Engineering*, May, 1933, Vol. 52, No. 5, pp. 307–313.)

For an outline of the automatic steering system *see* June Abstracts, p. 331. The present paper describes the principles of the new radio compass employed, one great advantage of which is that when the aircraft is on its correct course the signals remain unspoiled and can be used for communication. A loop and a vertical aerial are used in such a way that the combined r.f. energy is transformed into d.c. which reverses when the loop is turned from the "adding" position to the "subtracting" position. This is accomplished by modulating the output of the loop with an a.f. having a special asymmetrical wave form. When the aircraft is on its course the loop (being normal to the direction of propagation) gives a minimum output, so that the vertical-aerial signals are not spoiled.

The sensitivity around the zero point depends on the type of signal received. On unmodulated c.w. it is a maximum, and on badly over-modulated waves a minimum, averaging about 10 degrees for full-scale deflection on daylight reception from broadcasting stations 150 miles away. By using headphones, directions can be obtained down to a fraction of a degree.

The combination of this radio compass with a magneto compass is described. "Using test equipment a plane has been automatically steered to destination with correction for drift by the described method, but work remains to be done to reduce the equipment to service form."

A RADIO COMPASS DEVELOPED IN H.M. SIGNAL SCHOOL.—C. E. Horton and C. Crampton. (*Electrician*, 7th April, 1933, Vol. 110, No. 2862, p. 458.)

Summary of an I.E.E. paper describing a direction-finder by which direction and sense can be determined in a single operation. "The principle involved is a combination of a figure-of-eight reception characteristic with a cardioid under conditions which ensure :—(1) That the minimum of the cardioid is coincident in direction with one zero of the figure of eight. (2) That the cardioid e.m.f. is in quadrature with that of the figure of eight." Special precautions are necessary when the instrument is installed in a metal ship, but it is shown that it gives a satisfactory performance in all cases where direction-finding with simpler apparatus is possible.

ERRORS IN DIRECTION-FINDING CALIBRATIONS OF STEEL SHIPS DUE TO THE SHAPE AND ORIENTATION OF THE AERIAL OF THE TRANSMITTING STATION.—J. F. Coales. (*Electrician*, 7th April, 1933, Vol. 110, No. 2862, p. 458.)

Short summary of an I.E.E. paper. Owing to the effect of the ship on the incoming wave, a vertical magnetic field may, through re-radiation, cause errors in the observed bearing. "Experiments show that in the case of calibrations carried out with a roof aerial, errors of 1° or 2° may arise if the roof is not symmetrical. The error, however, decreases rapidly with increasing distance from the transmitter, and also with increasing frequency."

Mathematical expressions for the errors are derived and " it is shown that they are closely allied to the ordinary deviation due to ' ship effect.' The error should be most marked in the direction of the electric axis of the ship (that in which the deviation is zero, usually the fore-and-aft line) and non-existent at right angles to this."

THE INFLUENCES OF THE EARTH'S MAGNETIC FIELD ON THE POLARISATION OF SKY WAVES [and Its Bearing on Errors in Direction-Finding].—Baker and Green. (*See* under " Propagation of Waves," pp. 385–386.)

" One point which might later have some practical importance in its bearing on radio direction-finding appears from an examination of the maps of polarisation. It is seen that the ratio of components of a downcoming wave becomes very small at distances of about 200 miles or more in a direction north of the transmitting station. In other words, the relative intensity of the abnormal component of the sky wave is about one-tenth or less that of the normal component. For a large area south of the transmitting station the polarisation is approximately circular, so that the normal and abnormal components would be about equal here. It follows that errors in apparent bearing of a station should be large at night when the direction finder is south of the transmitter, and comparatively small when the finder is north of the sender and at a distance of about 200 miles or more from it. The authors do not know of any experiments in which simultaneous bearings of a transmitter have been taken at two receiving points, the one north and the other south of the sender, so that this point still requires confirmation practically."

SUR LA PRÉCISION ATTEINTE AU CADRE GONIOMÉTRIQUE ET SUR LA COMMODITÉ DE LA " DROITE-RADIO " (The Precision attained by a Goniometric Frame, and the Convenience of the " Radio Line ").—Ch. Bertin. (*Comptes Rendus*, 27th March, 1933, Vol. 196, No. 31, p. 913.)

" I recommend, as the geometrical locus of a craft, which takes a bearing on a coast station of known co-ordinates, the ' radio line ' which passes at a distance (from the calculated position of the craft) given by the vector $\Delta Z \tan M$, where M is the distance of the craft from the station and ΔZ the discrepancy between the bearing taken on board and the bearing calculated by dead reckoning. The ' radio line ' is itself inclined to the meridian at the angle $Z \pm g \sin \phi_m$, g being the displacement in longitude and ϕ_m the mean latitude. This angle is also the angle at which the station would place the craft.

" Of a total of 58 observations made in mid-Atlantic . . . eight gave vectors less than 3 or 5 miles, while the distances ranged up to 800 and 1 200 miles (Sayville, Marion, Marseilles, Land's End . . .). This procedure, therefore, should provide a very fine rapid accuracy for aircraft."

A NEW BEACON FOR IRISH WATERS [Lightship Automatic Wireless Beacon combined with Submarine Sound Transmitter, giving Distance as well as Bearing]. (*Marconi Review*, March–April, 1933, No. 41, pp. 31–32.)

RADIO DIRECTION FINDING [including the Cathode-Ray Cyclograph].—R. Mesny. (*Sci. Abstracts, Sec.B*, Jan., 1933, Vol. 36, No. 421, p. 67 : Internat. Elec. Congress Paper.)

ACOUSTICS AND AUDIO-FREQUENCIES

THE REPRODUCTION OF MUSIC BY NEW METHODS.—Stokowski. (*Science*, 21st April, 1933, Vol. 77, No. 1999, Supp. p. 6.)

" Three loud-speakers on an empty stage, three telephone lines running to three microphones in a sound-proof room containing the Philadelphia Symphony Orchestra, Leopold Stokowski turning electrical control knobs instead of wielding a baton, telephone engineers operating the electrical circuits, was the most advanced development of musical reproduction that will be introduced to the public in a Philadelphia–Washington concert for the National Academy of Sciences on April 27th." At a demonstration for scientists and music critics " Wagnerian music was played with whispering pianissimos and thunderous crescendos hitherto unheard by human ears."

This merging of music and telephone science has introduced three factors in the electrical reproduction of orchestral music :—(1) Auditory perspective : this was obtained by three loud speakers at left, right and centre of stage connected to three microphones similarly placed on the orchestra's stage. (2) Tone and overtone control : a range of frequencies from about 35 to 16 000 c/s was used, whereas " radio by federal regulation is limited to a band of 5 000 c/s. . . . Each of the three telephone wires carried the full range of frequencies, and the frequency channels utilised were therefore roughly nine times those of the most perfect radio transmission." (3) Volume control : the sound could be varied from an output equivalent to 10^{-6} watt to a sustained 100 watts and even a kilowatt at momentary peaks without distortion. *See* also next abstract.

PERFECT QUALITY AND AUDITORY PERSPECTIVE IN THE TRANSMISSION AND REPRODUCTION OF MUSIC.—F. B. Jewett. (*Science*, 12th May, 1933, Vol. 77, No. 2002, pp. 435–440.)

See also preceding abstract. Moving-coil microphones are used (1932 Abstracts, p. 101, l-h col., and 589, r-h col. (Wente and Thuras : Thuras). Each of the three loud speaker assemblies consists of one large unit for frequencies below 300 c/s and two small units for all frequencies above 300 c/s. A diagram is given showing the frequency range for speech and for various noises and musical sounds which the system is capable of reproducing without noticeable distortion. These extend from the low notes of the bass viol and tuba up to the frequencies of cymbals, violin, oboe, hand-clapping and key-jingling.

The transmission and reception circuits are shown diagrammatically. " The carrier system employed is single sideband with the carrier frequency at 40 kc and lower sideband transmission. In order, however, to obtain satisfactory transmission of the very low musical frequencies, what is known as 'vestigial' sideband transmission is employed. This means that the unwanted (*i.e.* upper) sideband is not entirely suppressed in the neighbourhood of the carrier but is allowed to pass through the circuit to some extent so as to help out in the preservation of the low notes." A special 20 kc/s control current is transmitted over each line and, after doubling, supplies the accurately phased carrier necessary for demodulation.

Die Nachhallverhältnisse bei Rundfunk-, Tonfilm- und Grammophon-Wiedergabe (Reverberation Relations in Broadcast, Sound Film and Gramophone Reproduction [where the Sounds are Produced and Reproduced in Different Rooms]).—L. Citron. (*E.N.T.*, April, 1933, Vol. 10, No. 4, pp. 147–153.)

Among the conclusions arrived at is the following: if the reverberation times of the studio and the room in which reproduction takes place are t_1 and t_2 respectively, the reproduction is heard as if the whole process took place in a room with reverberation time $t = t_1 + 0.6t_2$ (where $t_1 \geqq t_2$). If it is assumed that the reverberation of the studio is not completely effective, so that an appreciable fraction ($1/n$) of the sound energy is due to direct sound, the mathematical calculation is simple: the fraction $1/n$ follows the exponential law and the remainder ($1 - 1/n$) follows the formula arrived at by the writer. The paper ends with a table of calculated data for various values of t_1 and t_2, the resultant reverberation times being given together with indications as to the suitability for speech, chamber music, orchestra, and lightly modulated music.

On the Collection of Sound in Reverberant Rooms, with Special Reference to the Application of the Ribbon Microphone [on account of its Directional Characteristics being Independent of Frequency.]—H. F. Olson. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 655–672.)

Music Transmission over Short-Wave Commercial Radio-Telephone Circuits.—Gracie. (*See* under "Stations, Design and Operation.")

Permissible Amplitude Distortion of Speech in an Audio Reproducing System.—F. Massa. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 682–689.)

Experimental results on a system with a fairly flat characteristic from 80 to 14 000 c/s. The effect of distortion (introduced in the form of various proportions of harmonics), in modifying the character of reproduction, was judged by a number of observers when the transmission band was cut off at 5 000, 8 000, and 14 000 c/s in turn.

Messungen der Ankerkräfte bei Lautsprechern (Measurements of Armature Forces in Loud Speakers).—O. Amsel. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 14, 1933, pp. 202–211.)

The loud speaker is fixed so that the motion of its armature (or its moving coil in the case of an electrodynamic speaker) is horizontal: this motion is transferred to a rigid horizontal rod of V-shaped cross section, the angle of the V resting on the grooved edge of a friction disc which can rotate in the vertical plane containing the horizontal rod. At a point A on the rod, on the far side of the disc, is fixed a string which passes over the disc (lying in the groove on one side of the V-shaped rod) and ends in a scale-pan 1. At a point B on the rod, between the disc and the loud speaker, a second string is fixed which passes over the disc, lying on the other side of the rod, and ending in a second scale-pan 2. Thus a load in scale-pan 1 tends to force the rod, and with it the armature, in one direction, while loading the scale-pan 2 tends to force it in the other direction. The motion of the armature, and its restitution to the position of rest, is observed by watching through a measuring microscope a mark near the free end of the rod. A d.c. of known value i is passed through the loud speaker and either 1 or 2 is loaded with g grammes until the position of rest is restored. Then if R is the resistance of the speech coil, the constant of the loud speaker is given by $a = 981g/i\sqrt{R}$ · dynes/ampere . ohm$^{-\frac{1}{2}}$.

A table is given of results (including values of the constant a and of the restoring force c) obtained by this method with twelve commercial loud speakers of various types. The table reveals that in four m.c. types the forward and backward motions of the diaphragm are by no means equal for the same driving current: this is due partly to the moving coils not being placed centrally in the air gap, and partly to the restoring force being unsymmetrical. The acoustic effect of this difference between forward and backward motion was investigated in a special test on these four speakers and another m.c. type in which this inequality was very small, the loudness of note produced by motion in one direction being compared with that produced by motion in the other. It is pointed out that the difference in loudness must result in the formation of combination tones.

The paper then deals with a new magnetic drive system evolved by Nernst and Driescher in order to overcome the difficulty that the restoring force cannot be made as small as is desirable without rendering the instrument too sensitive to outside vibrations. By their new design the armature system is practically rigid so long as the field magnet system is not excited, whereas directly the field is switched on the resultant restoring force, partly mechanical and partly magnetic, is much smaller than the purely mechanical restoring force of the un-excited condition. The usefulness of the testing method is illustrated by measurements on various models on this new design.

A New Electro-Magnetic Loud Speaker Movement with Small Restoring Force when Field is Excited.—Nernst and Driescher. (*See* end of preceding abstract.)

A High-Quality Ribbon Receiver [Head Telephones].—H. F. Olson and F. Massa. (*Proc. Inst. Rad. Eng.*, May, 1933, Vol. 21, No. 5, pp. 673–681.)

Authors' summary:—"The ribbon receiver consists of a ribbon diaphragm in a magnetic field. In order that the ratio of pressure in the ear cavity to the applied voltage shall be independent of the frequency, the ratio of the amplitude of the ribbon to the applied voltage must be independent of the frequency. This is accomplished by employing an acoustic system consisting of two resonant circuits. The amplitude response of this receiver has a maximum variation of ± 2½ db in the range 30 to 10 000 c/s." It was found very important to prevent all leakage of air from the front to the back of the ribbon, in order to preserve the low-frequency sensitivity: this was accomplished by a seal in the form of a strip of empire silk cemented to the ribbon and clamped between the split pole-shoes, a window being cut in the silk behind the ribbon to decrease the effective mass. This ribbon also provides enough damping to prevent diaphragm resonances at the higher frequencies.

THE OUTPUT POWER OF THE FINAL VALVE IN AN AMPLIFIER, AND ITS PRACTICAL SIGNIFICANCE: CORRESPONDENCE.—J. Kammerloher: Leithäuser. (*E.T.Z.*, 13th April, 1933, Vol. 54, No. 15, p. 366.)

Referring to Leithäuser's paper (Jan. Abstracts, p. 45) the writer points out that, owing to the curvature of the characteristic, the formulae $N = U^2/32R_i$ and $N = U^2/16R_i$ give values about twice as great as those actually obtained (Kammerloher, 1932 Abstracts, pp. 43–44). He recommends amending these formulae by writing $(U - X/D)^2$ for the numerator, D as usual representing the "durchgriff" (penetration coefficient, reciprocal of μ) and X being derived from the grid/anode current characteristic. Leithäuser replies that the original formulae are perfectly correct if the right value of R_i is used: this should be taken *not* at the steep part of the curve but near the working point, where it is about twice as large.

GRAPHICAL DETERMINATION OF PERFORMANCE OF PUSH-PULL AUDIO AMPLIFIERS.—Thompson. (*See* under "Valves and Thermionics.")

EIN VERBESSERTER ÜBERLAGERUNGSSUMMER (An Improved Heterodyne Note Generator [giving Constant Frequency, Straight-Line Frequency Characteristic, and Freedom from Overtones]).—R. von Radinger. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 14, 1933, pp. 197–202.)

A description of the considerations leading to the design of a note generator with two ranges, 0–750 and 0–11 000 c/s; after a one-minute's run the frequency in the latter range remains constant within about 0.3 c/s; in the former range no change can be noted. The coefficient of non-linear distortion, for an output power of 1 watt, is about 0.5% for frequencies above 100 c/s. The frequency curve, for no load in the range 10–11 000 c/s, is constant within ± 2.5%. These good results are obtained without the complications of quartz oscillators, thermostats, etc.

The measures taken to ensure constancy of frequency include the following:—the leakage inductance of the reaction coil (the effect of which in producing a lagging anode-current component has a bad influence on the constancy of frequency) is kept very low by making the L/C ratio in the oscillating circuit as small as possible; thus the reaction winding can consist of very few turns, the coupling coefficient being made very large (over 0.7). The unavoidable leakage inductance is compensated by a condenser in front of the grid. The grid circuit leak is of 50 000 ohms, thus making the effective grid/cathode resistance very high and decreasing its influence. The low L/C ratio has also the advantage that by reducing the damping of the oscillating circuit it decreases the effect of the residual wattless component of the anode current, and that it diminishes the effect of changes in the valve capacities due to heating. The number of frequency-determining circuits is kept to a minimum, and variable couplings and reaction couplings are avoided. Mechanically rigid and screened coils are used, and specially temperature-independent mica condensers are employed: this last point is of particular importance. The valves are carefully ventilated, and the hot air prevented from warming the rest of the apparatus. For high constancy at the lower frequencies the second range c–750 c/s is provided, in which the r.f. oscillators work at only 20 000 c/s instead of at 200 000 c/s as in the longer range.

The various precautions to secure freedom from harmonics are described in section 3. Thus in order to obtain a good sinusoidal heterodyne curve with the linear rectifier employed, it is necessary to make the ratio of amplitudes of the two r.f. oscillations large (1:20 to 1:30). Section 4 deals with the obtaining of a uniform frequency curve throughout the two ranges (Fig. 7): since the l.f. voltages are chiefly dependent on the smaller r.f. voltage, and hardly at all on the larger, it is the frequency of the *stronger* oscillator which is made variable. Section 5 deals with the supply of the equipment from d.c. mains.

MEASUREMENTS AND TESTS SPECIAL TO TELEPHONY.—B. S. Cohen. (*Sci. Abstracts, Sec. B*, Jan., 1933, Vol. 36, No. 421, p. 61: Internat. Elec. Congress Paper.)

NEUBILDUNG VON UNTERDRÜCKTEN SPRACHFREQUENZEN DURCH EIN NICHTLINEAR VERZERRENDES GLIED (The Restoration of Suppressed Speech Frequencies by means of a Non-Linearly Distorting Section [Dry-Plate Rectifier or Valve Circuit]).—K. O. Schmidt. (*T.F.T.*, Jan., 1933, Vol. 22, No. 1, pp. 13–22.)

THE SUPPRESSION OF NOISE [British Association Paper].—G. W. C. Kaye. (*Engineering*, 9th September and 7th October, 1932, Vol. 134, pp. 314–316 and 432–434.)

THE RADIO-NOISE METER AND ITS APPLICATION TO THE MEASUREMENT OF RADIO INTERFERENCE.—Barhydt. (*See* under "Reception.")

ÜBER DIE HÖRSAMKEIT DER EIN- UND AUSSCHWINGVORGÄNGE MIT BERÜCKSICHTIGUNG DER RAUMAKUSTIK (On the Audibility of Transient Phenomena, with Consideration of Space Acoustics.)—G. von Békésy. (*Ann. der Physik*, 1933, Series 5, Vol. 16, No. 7, pp. 844–860.)

PHOTOTELEGRAPHY AND TELEVISION

Sur la Détermination des Fréquences les plus Élevées à Transmettre et l'Influence de la Distorsion de Phase en Television (The Determination of the Highest Frequencies to be Transmitted [for a given Image Quality], and the Influence of Phase Distortion in Television).—M. G. Fayard. (*L'Onde Élec.*, Jan., 1933 [delayed in publication], Vol. 12, No. 133, pp. 53–60.)

The scanning of a line of a black and white chequered surface by an infinitely small spot yields a current whose general expression is of the form

$$I = A\{\sin (2\pi/T)t + \tfrac{1}{3} \sin (2\pi/T/3)t + \tfrac{1}{5} \sin (2\pi/T/5)t + \ldots,$$

where I represents the scanning time for two consecutive squares. At the receiving end the suppression of the band of frequencies whose period is inferior to a certain period T/p will not appreciably affect the physiological result. The value $p = 5$ appears to be practically satisfactory. If the image is divided into n elements and is explored r times a second, we have $5/T = r \,.\, n/2 \,.\, 5 = f_5$. Thus if $n = 5\,000$ and $r = 12$, $f_5 = 150\,000$ c/s.

The dimensions of the spot are linked up with the transmission of the highest frequency and the value of the linear distortion. If T' represents the period of the highest frequency and a_1 the inverse of the fraction of this period, corresponding to the displacement of the spot by a distance equal to its width, the coefficient of linear distortion, obtained by resolving the integral of the mean photoelectric current, is given by $(2a_1/4\pi) \sin 2\pi/a_1$. If a_1 is chosen as 4, the coefficient is of the order of 0.65, which is admissible in practice and can easily be corrected by the suitable choice of amplifier characteristics.

Examination of the above equation for I shows that the component amplitudes should be in phase at the origin of time in order to give faithful reproduction. The writer, in the final section of the paper, considers the effect produced by the relative variations of phase such as occur in every radiotelephone transmitter or receiver. It is found that this phase distortion may easily be so large as to be inadmissible, and the writer urges that all causes likely to produce it should be eliminated from both transmitter and receiver if correct television is to be obtained.

Mirror Drum Scanning: the Optical Efficiency.—J. C. Wilson. (*Television*, May, 1933, Vol. 6, No. 63, pp. 184–186.)

The Balancing of Mirror Drums.—E. E. Wright. (*Journ. Scient. Instr.*, May, 1933, Vol. 10, No. 5, pp. 150–152.)

From the Baird Laboratories. "A method of dynamically balancing Weiller mirror drums is described and a formula giving the magnitude of the correcting masses in terms of the dimensions of the drum is developed."

Sixty-Line Scanning: Demonstration at University College.—(*Television*, April, 1933, Vol. 6, No. 62, pp. 143–144.)

Scanning System allowing the use of Ordinary Talking Films for both Picture and Voice Transmission.—W. H. Peck. (*Television*, May, 1933, Vol. 6, No. 63, p. 183.)

Sight and Sound on One Wave.—F. Wood. (*Television*, April and May, 1933, Vol. 6, Nos. 62 and 63, pp. 157 and 191–192.)

Correspondence on the outline of Wood's patent referred to in May Abstracts, p. 279, l-h column.

Colour Television.—J. Gouck : Williams. (*Television*, April, 1933, Vol. 6, No. 62, pp. 156–157.)

A letter on William's suggestion (March Abstracts, p. 168, l-h col.). The writer tried a similar method for colour cinematography, and it gave "the most realistic and natural colours I have seen screened." Certain difficulties are discussed.

Synchronisation in Television [including Description of the Marconi Method].—L. E. Q. Walker. (*Marconi Review*, March–April, 1933, No. 41, pp. 9–19.)

The Suitability of "Series Modulation" ["Constant Potential" Modulation] for Television Transmission.—Ditcham. (*See* abstract under "Transmission.")

The Television Exhibition.—(*Television*, May, 1933, Vol. 6, No. 63, pp. 179–182.)

Television Exhibition.—(*Electrician*, 7th April, 1933, Vol. 110, No. 2862, p. 472.)

Including a paragraph on an apparatus the vital part of which is a sound film taken from a broadcast television programme. This film, when suitably mounted on a gramophone turntable and used in conjunction with a photoelectric cell and amplifier, will give television signals (repeating themselves every 1.75 seconds) and thus enable experimenters to make tests independently of broadcast programmes.

Zur geometrischen Elektronenoptik des axialsymmetroschen elektromagnetischen Feldes (The Geometrical Electron Optics of the Electromagnetic Field with Axial Symmetry).—W. Glaser. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 9/10, pp. 647–686.)

This theoretical paper discusses the differential equations of electron optics with an axially symmetrical electromagnetic field, works out the analogies between electron and geometrical optics, including aberration, coma, astigmatism, etc., and finds theoretical conditions for combinations of the focusing electric and magnetic fields, so that the system may be free from aberration and distortion. No numerical calculations are given. *See* also May Abstracts, p. 283, r-h column.

Cathode-Ray Tubes costing 75 and 150 Marks.—Pressler Company. (*Television*, April, 1933, Vol. 6, No. 62, p. 147.)

Cf. 1932 Abstracts, p. 475, r-h col. "The tubes work on voltages from 250 to 2 000, and judging from the demonstration which was given to me [at the Leipzig Fair] they certainly mark a big stride forward. The light spot is very sharp indeed."

Über die Temperaturabhängigkeit des Kristallphotoeffektes (The Temperature Dependence of the Crystal Photoelectric Effect).—G. Barth and H. Dember. (*Physik. Zeitschr.*, 1st April, 1933, Vol. 34, No. 7, pp. 284–286.)

The investigations of which this is a preliminary account deal with the variation with temperature of the crystal photoelectric voltage of single crystals of cuprous oxide, using light which has been separated into its spectral components. The experiments follow on those of Dember, referred to in Abstracts, January, p. 47, r-h col. *See* also 1932, pp. 232 and 291, l-h cols. Many experimental curves showing variation of photoelectric current and voltage with frequency and temperature are given.

Ein Beitrag zur Theorie des Kristallphotoeffektes (Contribution to the Theory of the Crystal Photoelectric Effect).—H. Teichmann. (*Physik. Zeitschr.*, 1st April, 1933, Vol. 34, No. 7, pp. 283–284.)

A note on work of the writer's which has already been referred to in Jan. and March Abstracts, pp. 48 and 170, l-h columns.

A.C. Rectification by Photosensitive Aggregates [Objections to Eccles's Thermoelectric Theory of Crystal Detector: New Theory].—G. P. Barnard: Eccles. (*Sci. Abstracts, Sec.A*, Jan., 1933, Vol. 36, No. 421, p. 87.)

Untersuchung der Sperrschichtphotozellen. III. (Investigation of Barrier-Layer Photocells [Effects of Electrode Thickness and of Nature of Gas used in Sputtering Process: Photoelectric Properties not due to Unipolar Conductivity: etc.]).—M. Borissow, C. Sinelnikow and A. Walther. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 3, 1933, pp. 146–169.)

A method is described by which copper-oxide photocells with reproducible properties can be obtained. No appreciable unipolar conductivity was found, in spite of the excellent photoelectric properties of the cells thus constructed. This is completely contrary to the theory of Joffé and Frenkel, as also are the facts that the photo-e.m.f. showed a marked saturation and that it varied very little, if at all, with the temperature.

Zur Frage nach dem inneren Photoeffekt im Kupferoxydul (The Question of the Internal Photoelectric Effect in Cuprous Oxide).—D. Nasledow and L. Nemenow. (*Zeitschr. f. Physik.*, 1933, Vol. 81, No. 9/10, pp. 584–604.)

The writers have investigated the electrical conductivity of polycrystalline cuprous oxide, (*a*) unilluminated and (*b*) illuminated, at the temperature of liquid air. Other phenomena connected with the internal photoelectric effect in cuprous oxide were also studied and the conclusion was reached that the probability of the real existence of an internal photoelectric effect in cuprous oxide was small [but *cf.* Kikoin and Noskow, June Abstracts, p. 336]. The writers find, however, a large internal photoelectric effect when the cuprous oxide was in a badly conducting state. For their work on the photoelectric effect on irradiation by ultra-violet light, *see* abstract below Kikoin and Noskow, *loc. cit.*

Über den Nachweis einer Grenzschicht in Kupferoxydul-Sperrschichtzellen (On the Proof of a Boundary Layer in Cuprous Oxide Barrier-Layer Photocells).—F. Rother and H. Bomke. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 11/12, pp. 771–775.)

The writers show that a diffusion process takes place in the thermal formation of copper oxide from copper; they discuss the presence of various zones of different conductivity and conclude that "the hypothetical barrier layer is represented by a layer of purest oxide without electrical conductivity." A similar explanation is given for the "front wall effect."

The Conductivity of Electronic Semi-Conductors in a Magnetic Field [Derivation of Theoretical Formula].—M. Bronstein. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 3, 1933, pp. 140–145: in English.)

Oxide-Film [Barrier-Layer] Photoelectric Cells.—L. Bloch. (*Sci. Abstracts, Sec.B*, Jan., 1933, Vol. 36, No. 421, p. 57: Internat. Elec. Congress Paper.)

Photoelectric Cells for Ultra-Violet Light [Uranium, Cerium, etc., Cells in Corex-D Glass and Quartz].—H. C. Rentschler, D. E. Henry and K. O. Smith. (*Ibid.*, pp. 57–58: Internat. Elec. Congress Paper.) *See* also March Abstracts, p. 169.

Der Einfluss von Sauerstoff und Schwefel auf den photoelektrischen Effekt von Alkalien—K und Na (The Influence of Oxygen and Sulphur on the Photoelectric Effect in Alkali Metals—K and Na).—P. W. Timofeew and W. W. Nalimow. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 9/10, pp. 687–696.)

Recent Developments in the Study of the External Photoelectric Effect.—L. B. Linford. (*Reviews of Mod. Phys.*, Jan., 1933, Vol. 5, No. 1, pp. 34–61.)

Sustained Oscillations [from a Photoelectric Cell Circuit].—Hochard. (*See* under "Transmission.")

MEASUREMENTS AND STANDARDS

On the Beat Method of Calibrating Wavemeters [Liability to 0.5% Error].—G. Kahan. (*Wiadomości i Prace Inst. Radjotech., Warsaw*, No. 2, Vol. 4, 1932, pp. 23–24: in Polish.)

Author's summary:—The beat method of calibrating wavemeters, considered to be the most exact, was recommended in all cases where a high precision was required. It is shown, however, that this method may lead to an error of as much as 0.5%. This is due to the following fact: when the heterodyne oscillator is tuned to the natural frequency of the wavemeter, and the latter is then thrown considerably out of tune, the frequency of the oscillator changes, contrary to the opinion generally held. This variation is caused by the decrease of the wavemeter load as it affects the heterodyne oscillator; this decrease provokes a change in amplitude of the oscillator oscillations, that is to say a change in its working conditions and consequently in its harmonic content. This last, as is well known, has a marked effect on the emitted frequency.

A Differential Frequency Indicator [suitable for Monitoring Purposes].—J. Groszkowski. (*Ibid.*, pp. 25–31: in Polish.)

Author's summary:—An oscillatory circuit has its capacity periodically varied around the resonance point, by means of a rotating commutator, in such a way that the working point lies on the slope of two resonance curves. A second commutator synchronously reverses the direction of the rectified current in the galvanometer circuit of the indicator. If the frequency under observation corresponds exactly to the point of symmetry between the two resonance curves, the two currents in opposite directions are identical and the galvanometer remains at zero. For a given coupling the deflection is proportional to the variation of frequency. The whole scale corresponds to about ± 150 cycles, the nominal frequency being 94.4 kc/s. The indicator is provided with a warning device which functions when the frequency variation exceeds a certain amount, *e.g.* ± 50 c/s.

The Stabilisation of Frequencies and Their Exact Measurement: Erratum.—Decaux. (*L'Onde Élec.*, Jan., 1933 [delayed in publication], Vol. 12, No. 133, p. 60.) *See* June Abstracts, p. 338, r-h column.

Precise Frequency Measurement.—E. Giebe. (*Sci. Abstracts, Sec.B*, Jan., 1933, Vol. 36, No. 421, pp. 68–69: Internat. Elec. Congress Paper.)

Frequency Measurements at Radio Frequencies: Bulletin 10.—General Radio Company. (Book Review in *Review Scient. Instr.*, April, 1933, Vol. 4, No. 4, p. 245.)

Change in Schedule of Radio Transmissions of Standard Frequency.—Bureau of Standards. (*Journ. Franklin Inst.*, April, 1933, Vol. 215, No. 4, pp. 481–482.)

This note gives details of the changed schedule of standard frequency transmissions from the Bureau's station WWV every Tuesday.

Short Wave Circuit emitting Trains of Waves at Equal Intervals of Time [Applicable to Time Signals and to the Comparison of Condensers].—Petrucci. (*See* under "Transmission.")

Eine neue Methode zur Bestimmung der statischen Dielektrizitätskonstanten von Halbleitern und DK-Messungen an Seignettesalz (A New Method of Determining the Statical Dielectric Constant of Semiconductors, and Measurements of the Dielectric Constant of Rochelle Salt).—G. Oplatka. (*Physik. Zeitschr.*, 1st April, 1933, Vol. 34, No. 7, pp. 296–300.)

A circuit is given which reduces to 10^{-7} sec. the switching time in the usual method of determination of dielectric constant with a ballastic galvanometer and charged condenser. This is applied to the investigation of Rochelle salt.

Mechanical Factor of Merit with respect to Electrical Instruments.—J. H. Goss. (*Gen. Elec. Review*, April, 1933, Vol. 36, No. 4, pp. 188–191.)

Set Analysers [for Testing Broadcast Receivers].—E. J. G. Lewis. (*World-Radio*, 12th May, 1933, Vol. 16, No. 407, pp. 633–634.)

A Valve-Voltmeter for Measurements of Hydrogen-Ion Concentration [with Unusually Wide Range of Battery-Voltage Compensation].—A. S. McFarlane. (*Journ. Scient. Instr.*, May, 1933, Vol. 10, No. 5, pp. 142–147.)

A Survey of the Vacuum-Tube Voltmeter Field.—C. H. W. Nason. (*Radio Craft*, March, 1933, Vol. 4, pp. 543–545.)

Galvanometer with Moving Magnets rendered Astatic by a New Method.—L. Meylan. (*Sci. Abstracts, Sec. A*, Jan., 1933, Vol. 36, No. 421, p. 89.)

Suggested Unit of Vibration Amplitude [the "Pal," corresponding to the Phon in Acoustics].—W. Zeller. (*Zeitschr. V.D.I.*, 25th March, 1933, Vol. 77, No. 12, p. 323.)

SUBSIDIARY APPARATUS AND MATERIALS

Gesteuerte dunkle Entladung in freier Luft (Controlled Silent [Corona] Discharge at Atmospheric Pressure).—A. Gemant. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 14, 1933, pp. 187–191.)

Description of the development of an arrangement for current control using ions, produced by ionisation by collision, in place of electrons produced by thermionic methods. An oblong ebonite plate carries four metal strips near its four edges. Between the two longer strips are stretched a number (30) of steel wires, forming the positive electrode: between the two shorter strips a number (8) of brass bars (5 mm diam., spaced 10 mm), forming the negative electrode. The third, control electrode is in the form of a plate lying on the ebonite base underneath the stretched wires and separated from these by an air gap of 0.5 mm: or if a smaller penetration coefficient ("durchgriff") is desired the plate can be coated with an insulating layer and the wires can lie directly on this. The distance between the control plate and the nearest plane of the negative bars is about 5 mm.

With an applied d.c. voltage of 6–7 kv this arrangement works well. The penetration coefficient ($1/\mu$) is about 0.2, the internal resistance 1.5 megohms (control electrode area 360 cm^2). These values also hold good for note-frequency a.c., so that the device lends itself directly to a.c. amplification. By suitably matching the circuit to the high internal resistance, self-excited oscillations can be produced: with the experimental model frequencies of 100–500 c/s were obtained, of about 50 v amplitude. *See* also Gemant, Abstracts, May, p. 275, l-h col.; *also* Güntherschulze and Keller, 1932, p. 227, r-h column.

THE PARALLEL TYPE OF INVERTER [3-Electrode Hot-Cathode Gas-Filled Tube: including Use for Supplying Power from D.C. Systems to A.C. Radio Sets].—F. N. Tompkins. (*Elec. Engineering*, April, 1933, Vol. 52, No. 4, pp. 253–256.)

X-RAY STUDY OF THE DENSITY DISTRIBUTION IN A [Mercury Vapour] DISCHARGE TUBE.—Y. Ishida and T. Suetsugu. (*Sci. Abstracts, Sec.A*, February, 1933, Vol. 36, No. 422, p. 174.)

"It was found that in all cases the X-ray photographs remained almost the same for several minutes after stopping the discharge, showing that the distribution of electrons and gas atoms persists for some time after the discharge stops."

INVESTIGATION OF THE COPPER OXIDE RECTIFIER AT HIGH VOLTAGES [Contradiction of Cold Emission Theory and Agreement with Joffé-Frenkel Gas Theory].—N. Nasledow and L. Nemenow. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 2, 1932, pp. 128–145.)

ELECTRICAL CONDUCTIVITY OF CUPROUS OXIDE [and Its Variation with Temperature: Energy of Electron Dissociation].—W. P. Jusé and B. W. Kurtschatow. (*Ibid.*, No. 6, Vol. 2, 1932, pp. 453–467.)

THE CONDUCTIVITY OF ELECTRONIC SEMI-CONDUCTORS IN A MAGNETIC FIELD [Derivation of Theoretical Formula].—M. Bronstein. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 3, 1933, pp. 140–145: in English.)

A.C. RECTIFICATION BY PHOTOSENSITIVE AGGREGATES [Objections to Eccles's Thermo-electric Theory of Crystal Detector: New Theory].—G. P. Barnard: Eccles. (*Sci. Abstracts, Sec.A*, Jan., 1933, Vol. 36, No. 421, p. 87.)

A.C. CAPACITIES OF ELECTROLYTIC CONDENSERS, *and* POTENTIAL GRADIENTS IN ANODIC FILMS.—F. W. Godsey, Jr. (*Sci. Abstracts, Sec.A*, March, 1933, Vol. 36, No. 423, p. 298.)

MEASUREMENTS ON CONTACT POTENTIAL DIFFERENCE BETWEEN DIFFERENT FACES OF COPPER SINGLE CRYSTALS.—H. E. Farnsworth and B. A. Rose. (*Phys. Review*, 1st March, 1933, Series 2, Vol. 43, No. 5, p. 375: abstract only.)

CALAN, A NEW INSULATING MATERIAL FOR HIGH-FREQUENCY ENGINEERING [Non-Porous Ceramic Silicate with High Magnesium Content].—(*E.T.Z.*, 4th May, 1933, Vol. 54, No. 18, p. 422.)

In the wave-range 25–150 m the loss factor tan δ in percentages is 0.021 for Special Calan and 0.036 for ordinary Calan, compared with about 0.016 for mica, 0.027 for quartz glass and 0.67–0.148 for opaque quartz glass. A notable advantage is that Calan can be turned, cast, etc., before it is fired, and then can be accurately ground and polished. Insulators of the most difficult shapes can thus be made commercially, even in comparatively small quantities. Both Calan and Special Calan are unaffected by heat and moisture, and are free from ageing and fatigue effects; moreover, they can be fire-silvered and the coating can then be thickened, either galvanically or by spraying, until suitable for soldering purposes.

SINTERKORUND [a New Insulating Material from Aluminium Oxide].—Siemens & Halske. (*E.T.Z.*, 23rd March, 1933, Vol. 54, No. 12, p. 287.)

CONDUCTING PROPERTIES OF RUBBER STRONGLY IMPREGNATED WITH LAMP BLACK [and Their Variation with Tension and Compression: Applications to Radio Technique].—J. Granier. (*Comptes Rendus*, 3rd April, 1933, Vol. 196, No. 14, pp. 1009–1011.)

The conductivity is small when the rubber is at rest and increases considerably under tension or pressure. The writer has used this property for variable resistances in a resistance-coupled amplifier, for a vibrometer or microphone, for a pick-up, and for maintaining a tuning fork in vibration for several days on end.

EFFECT OF TEMPERATURE CHANGE ON THE RESISTIVITY OF DIELECTRICS [Absence of the Lag stated by Maxwell to occur between Temperature Change and Resistivity Change].—D. K. McCleery. (*Sci. Abstracts, Sec.B*, Feb., 1933, Vol. 36, No. 422, pp. 93–94.)

EMPFINDLICHER KALTKATHODENOSZILLOGRAPH (Sensitive Cold Cathode Ray Oscillograph).—W. Rogowski. (*Naturwiss.*, 21st April, 1933, Vol. 21, No. 16, p. 300.)

The writer has devised a cold cathode ray oscillograph in which the electrons are produced by a high voltage (*e.g.* 8 000 v) and then retarded by an opposing voltage (*e.g.* 7 000 v) to a low final voltage. The retarding field has a focusing effect on the electrons. Thus it is likely that in a short time cold cathode ray oscillographs will be available which need no special focusing device.

CATHODE-RAY TUBES COSTING 75 AND 150 MARKS.—Pressler Company. (*See* under "Phototelegraphy and Television.")

APPLICATIONS OF THE CATHODE RAY OSCILLOGRAPH IN RADIO RESEARCH.—Watson Watt, Herd and Bainbridge-Bell. (Book Review in *World-Radio*, 12th May, 1933, Vol. 16, No. 407, p. 636.)

Cathode Ray Photography of Random Electrical Transients.—F. W. Chapman. (*Nature*, 29th April, 1933, Vol. 131, pp. 620–621.)

The writer photographs random electrical transients by using a Cossor oscillograph giving a long red afterglow and tripping the camera shutter by a thyratron arrangement actuated by a small fraction of the initial voltage. A second relay is used to move the film on to its next position. Photographs are reproduced of a condenser discharge through two different damping resistances.

The Geometrical Electron Optics of the Electromagnetic Field with Axial Symmetry [and the Avoidance of Aberration and Distortion].—Glaser. (*See* under "Phototelegraphy and Television.")

Experiments on Electromagnetic Shielding at Frequencies between One and Thirty Kilocycles.—W. Lyons: King. (*Proc. Inst. Rad. Eng.*, April, 1933, Vol. 21, No. 4, pp. 574–590.)

Author's summary:—"This paper describes a method used in measuring the ratio of magnetic field intensities within conducting cylindrical [aluminium] and spherical [copper] shells to that outside, values being given for various frequencies between 1 000 and 30 000 c/s of the exciting field and for various lengths and radii. A theoretical derivation of a shielding formula [based on the work of L. V. King, April Abstracts, p. 206] is given for a thin spherical shell and a cylindrical one of infinite length. Satisfactory agreement between theory and observation is found in the case of the sphere and in cylinders of lengths greater than their diameters." The theoretical values were calculated by using both l.f. and h.f. approximations of King's formula, the l.f. approximations being employed in the curves given because they were found to fit the experimental results more accurately. Tests on higher frequencies (1 mc/s) gave such a high shielding (99.9% and higher) that owing to limitations of the apparatus they had to be adandoned.

Iron-Content Cores for High-Frequency Coils [Vogt Iron (Ferrocart)].—A. Schneider. (*Wireless Engineer*, April, 1933, Vol. 10, No. 115, pp. 183–185.)

Prompted by the Editorial referred to in March Abstracts, p. 173, the writer discusses the theoretical considerations leading to the practical process of manufacture. "The question may be raised why, if each particle is insulated individually and aligned, the additional sub-division by paper and grooves is necessary." The two reasons are explained: the occurrence of ordinary (galvanic) eddy currents and of "capacitive eddy currents." The additional sub-division is so dimensioned as to form not only an interruption for the former but also a high capacitive resistance between the groups of particles. "This phenomenon is the principal reason for the low losses of the Vogt iron, and this also will explain why other inventors, although using very finely divided and well insulated iron particles, could not attain a definite success, especially in the short-wave range 200–600 m, but had to make the core movable, withdrawing it from the coil at these shorter waves." As a result of the construction, the share of magnetic material is rather low; the permeability cannot be increased much beyond 18 without increasing the losses to an extent far outweighing the advantages of the higher permeability. With the weak fields encountered in receivers the permeability is constant over a wide range of loading.

A Mercury Jig for Testing [Permeability of] Toroidal Cores [of Permalloy-Dust].—C. H. Young. (*Bell Lab. Record*, April, 1933, Vol. 11, No. 8, pp. 227–231.)

Ferro-Inductors and Permeability Tuning.—Polydoroff. (*See* under "Reception.")

Non-Linear Circuits [Saturating Reactors in Resonance Circuits] Applied to Relays.—C. G. Suits. (*Elec. Engineering*, April, 1933, Vol. 52, No. 4, pp. 244–246.)

Further development of the work referred to in 1932 Abstracts, p. 236, r-h column. Such relays are characterised by great sensitivity "which does not depend upon the calibration of a spring or the accurate construction of the mechanical parts, but is fundamentally due to the electrical properties of a circuit which may reasonably be expected to remain constant over long periods of time. Data available from life tests and service in the field bear out this conclusion." The special properties of the resonant-current relay make it particularly suitable for use as an under-current or under-voltage relay.

A High-Speed Reactance Relay [using Induction Dynamometer Principle for Torque Production].—A. R. van C. Warrington. (*Ibid.*, pp. 248–252.)

The Suppression of Disturbing Noises [in Telephone Installations] by Gaseous Discharge Cut-Outs.—H. Werrmann. (*E.N.T.*, April, 1933, Vol. 10, No. 4, pp. 153–159.)

Electrometer Triode in the X-Ray Ionisation Spectrometer.—W. A. Wooster: B. W. Robinson. (*Nature*, 15th April, 1933, Vol. 131, pp. 545–546.)

The Application of the Electrometer Triode to the Measurement of Ionisation Current [a Simple Circuit for Currents of the order of 10^{-15} Ampere].—J. A. C. Teegan and A. M. Hayes. (*Journ. Scient. Instr.*, April, 1933, Vol. 10, No. 4, pp. 110–114.)

Measurements of the Dielectric Constant of Rochelle Salt by a New Method.—Oplatka. (*See* abstract under "Measurements and Standards.")

Untersuchung der dielektrischen Eigenschaften des Seignettesalzes mittels Röntgenstrahlen (Investigation of the Dielectric Properties of Rochelle Salt by means of X-Rays).—H. Staub. (*Physik. Zeitschr.*, 1st April, 1933, Vol. 34, No. 7, pp. 292–296.)

Progressive Lighting ; a New Stereoscope.—Boys. (*See* under "Atmospherics and Atmospheric Electricity.")

Mechanical Models for the Investigation of Electrical Stability Problems.—M. Darricus. (*E.T.Z.*, 11th May, 1933, Vol. 54, No. 19, pp. 456–457.)

STATIONS, DESIGN AND OPERATION

Common Wavelength Relay Broadcasting [Nature and Possibilities].—N. Wells. (*Marconi Review*, March–April, 1933, No. 41, pp. 20–27.)

"Experience has shown that the maximum frequency discrepancy should not cause more than 2 beats every second, and on a wavelength of 300 m this implies a stability of ± 1 in 1 million cycles at each station. . . . While present technique cannot be expected to produce apparatus of a routine stability beyond 1 in 1 million cycles, it may be stated that higher limits are desirable and can be anticipated, but cannot be guaranteed. Perhaps the limit it is possible to anticipate at present is a stability corresponding to 1 beat every 2 seconds. . . . The [Marconi] Company is at this moment engaged in developing [crystal control] apparatus for which the guaranteed performance is a stability of 1 in 1 million cycles, over 24 hours. . . . To sum up, for countries where the demand is likely to be localised into areas around various centres, in other words where the demand is unlikely to spread to any appreciable extent over the intervening districts, the Relay scheme has been a proved success. It is perhaps correct to state that the B.B.C. still bear in mind a return to some form of small power relay working as a possible future eventuality."

The Question of the Choice of Common-Wave Systems [Synchronised or Unsynchronised].—Gerth. (*See* under "Transmission.")

Development of Broadcast Transmissions [International Organisation, Administration, etc.].—R. Braillard. (*Sci. Abstracts, Sec.B*, Jan., 1933, Vol. 36, No. 421, p. 69 : Internat. Elec. Congress Paper.)

Contribution expérimentale à l'Étude de la Propagation des Ondes courtes (Experimental Contribution to the Study of the Propagation of Short Waves [based on Paris–Buenos Ayres and Paris–New York Services]).—M. Maire. (*L'Onde Élec.*, Jan., 1933 [delayed in publication], Vol. 12, No. 133, pp. 41–52.)

Dealing with the various difficulties encountered in short-wave communication, the writer discusses atmospherics, "insignificant in the 14–20 m region, appearing at 20–35 m, becoming troublesome from 35–45 m and considerable above 45 m," so that between two short waves giving the same signal intensity it is always advisable to choose the shorter. Regarding echoes he quotes, as an example of this trouble not being confined to short waves, the case of reception from JND (Japan) on 17 200 m, in which the two sets of signals in opposite directions round the earth produce echo effects on a simple frame receiver. As regards short waves the difficulty has been practically abolished by the use of reversible aerial and reflector systems.

Dealing with the choice of waves for transcontinental services, the writer concludes that when the great circle path is all in daylight the best waves are between 14.50 m and 20 m ; when it is all in darkness, above 35 m up to 70 m, according to distance ; when it is partly in daylight and partly dark, intermediate waves of 20–35 m are best. Sudden variations of the optimum wave take place at sunrise and sunset at either end, particularly at the transmitter ; during periods of slow variation the best average wave is practically the same for both stations, whatever their positions. In each wave band the wavelength to employ varies inversely with the distance.

Music Transmission over Short-Wave Commercial Radio-Telephone Circuits.—A. J. A. Gracie. (*P.O. Elec. Eng. Journ.*, April, 1933, Vol. 26, Part I, pp. 60–62.)

The paper concludes : "Tests carried out with the modified circuits have shown that when the received field strength is high and fading is slight, the transmission of music of sufficiently good quality to permit re-broadcasting in the distant country is feasible. It is doubtful, however, whether circuit conditions will frequently permit the extension of the band width above the present upper limit of about 5 000 cycles, in view of the small energy carried in frequencies above this value and the considerable decrease in the received signal/noise ratio which will result from the still greater increase in the receiver band width."

Experimental Broadcasting on a Wave of 7.85 Metres in Amsterdam.—P. J. H. A. Nordlohne. (*L'Onde Élec.*, Jan., 1933 [delayed in publication], Vol. 12, No. 133, pp. 5–27.)

French version of the paper dealt with in June Abstracts, p. 342, l-h column.

Ultra-Short-Wave Developments in Aircraft : a Description of Equipment for Duplex Telephony on One Aerial.—W. C. Gee. (*World-Radio*, 28th April, 1933, Vol. 16, No. 405, pp. 566–567.)

Wireless Equipment in British Warships. Part I.—R. H. Garner. (*World-Radio*, 12th May, 1933, Vol. 16, No. 407, pp. 629 and 632.)

Transoceanic Radio Communication [RCA Network].—H. H. Beverage, H. O. Peterson and C. W. Hansell. (*Elec. Engineering*, May, 1933, Vol. 52, No. 5, pp. 331–336.)

West Regional Broadcasting Station in Great Britain.—(*Nature*, 6th May, 1933, Vol. 131, pp. 664–665.)

RADIO LUXEMBOURG: JUNGLINSTER HIGH-POWER BROADCASTING STATION.—Soc. Française Radio-Électrique. (*Bull. S.F.R.*, Jan.–Feb., 1933, Vol. 7, No. 1, pp. 11–27.)

THE FADING-DIMINISHING [" One-Wire "] AERIAL OF THE BRESLAU BROADCASTING STATION.—Eppen and Gothe. (*See* under " Aerials and Aerial Systems.")

GENERAL PHYSICAL ARTICLES

THE NEUTRON.—F. N. D. Kurie. (*Science*, 3rd March, 1933, Vol. 77, No. 1992, Supplement pp. 8–9; *Sci. News Letter*, 4th March, 1933, Vol. 23, No. 621, p. 138.)

By measuring the angles at which protons are ejected from nitrogen atoms by neutrons, the author has concluded that " the neutron is not a mere close combination of electron and proton acting like a fundamental particle . . . , but it actually is an elementary particle itself."

NEW EVIDENCE FOR THE POSITIVE ELECTRON.—J. Chadwick, P. M. S. Blackett and G. Occhialini. (*Nature*, 1st April, 1933, Vol. 131, p. 473.)

The evidence is obtained from the interaction of neutrons and matter observed by Wilson cloud chamber photography.

THE POSITIVE ELECTRON.—C. D. Anderson. (*Phys. Review*, 15th March, 1933, Series 2, Vol. 43, No. 6, pp. 491–494.)

Photographs of cosmic ray tracks in a vertical Wilson chamber gave a small proportion of tracks of positive particles of mass smaller than that of the proton. " If these particles carry unit positive charge the curvatures and ionisations produced require the mass to be less than twenty times the electron mass. These particles will be called positrons. Because they occur in groups associated with other tracks, it is concluded that they must be secondary particles ejected from atomic nuclei."

FREE POSITIVE ELECTRONS [" Positron " suggested as Name: Lose energy more rapidly than " Negatrons " in passing through Matter].—W. Davis: Anderson. (*Science*, 24th Feb., 1933, Vol. 77, No. 1991, Supplement p. 5.)

POSITRON FORMALLY INTRODUCED; NEGATIVE PROTON PREDICTED.—C. D. Anderson. (*Sci. News Letter*, 25th March, 1933, Vol. 23, No. 624, p. 179.)

CONTRIBUTION TO THE STUDY OF THE POSITIVE ELECTRONS.—I. Curie and F. Joliot. (*Comptes Rendus*, 10th April, 1933, Vol. 196, No. 15, pp. 1105–1107.)

ENERGY TURNED INTO MASS FOR FIRST TIME IN HISTORY: ATOM DISINTEGRATION EXPERIMENTS CONFIRM EINSTEIN'S THEORY OF MASS-ENERGY EQUIVALENCE.—K. T. Bainbridge. (*Sci. News Letter*, 8th April, 1933, Vol. 23, No. 626, p. 213.)

THE LINEAR MOMENTA OF ELECTRONS IN ATOMS AND IN SOLID BODIES, AS REVEALED BY X-RAY SCATTERING.—J. W. M. Du Mond. (*Reviews of Mod. Phys.*, Jan., 1933, Vol. 5, No. 1, pp. 1–33.)

EXTENSION OF WOO'S FORMULA. INTENSITY OF THE LIGHT DIFFUSED BY AN ELECTRON IN MOTION.—C. Cannata. (*Sci. Abstracts, Sec. A*, Feb., 1933, Vol. 36, No. 422, pp. 141–142.)

SCATTERING OF ELECTRONS BY IONS AND THE MOBILITY OF ELECTRONS IN A CAESIUM DISCHARGE.—C. Boeckner and F. L. Mohler. (*Bur. of Stds. Journ. of Res.*, March, 1933, Vol. 10, No. 3, pp. 357–363.)

MISCELLANEOUS

LE ROY'S GENERALISATION OF BOREL'S METHOD OF SUMMATION OF DIVERGENT SERIES: THE THEORY OF THE PRODUCT OF TWO SERIES.—J. C. Vignaux. (*Comptes Rendus*, 10th April, 1933, Vol. 196, No. 15, pp. 1076–1078.)

PRACTICAL APPLICATION OF PERIODOGRAM ANALYSIS.—J. W. Sandström: Lindquist. (*Sci. Abstracts, Sec. A*, March, 1933, Vol. 36, No. 423, p. 217.)

SUMMATION METHODS IN SMOOTHING CURVES.—F. Vercelli. (*Ibid.*, p. 217.)

THE CONTRIBUTION OF RADIOTELEGRAPHY TO GEOPHYSICS.—(*See* under " Propagation of Waves.")

RESEARCH DEVELOPMENTS IN 1931 AND 1932.—E. Koenemann. (*Zeitschr. V.D.I.*, 1st April, 1933, Vol. 77, No. 13, pp. 329–335.)

PROGRESS IN 1932 IN THE WORK OF THE GERMAN STATE POST OFFICE.—(*T.F.T.*, Feb., 1933, Vol. 22, No. 2, pp. 29–36.)

THE RADIO INDUSTRY IN 1932 [Some Statistics].—(*Electrician*, 31st March, 1933, Vol. 110, No. 2861, p. 437: paragraph only.)

APPLIED SCIENCE NOT SO EFFICIENT AS SUPPOSED: OVERALL EFFICIENCY OF AUTOMOBILE TRANSPORTATION OF PASSENGERS ONLY 3%.—J. Winston. (*Sci. News Letter*, 15th April, 1933, Vol. 23, No. 627, p. 234.)

VARIATION OF CONDUCTIVITY OF RUBBER IMPREGNATED WITH LAMP BLACK: APPLICATIONS TO VARIABLE RESISTANCE, VIBROMETER, PICK-UP, TUNING FORK, ETC.—Granier. (*See* abstract under " Subsidiary Apparatus and Materials," p. 402.)

X-RAYS IONISE AT 100 FEET [and the Possibility of using such Distant Ionising Action for " Short-Circuiting Aeroplane Engines "].—Du Mond. (*Electronics*, Feb., 1933, p. 53: short paragraph only.)

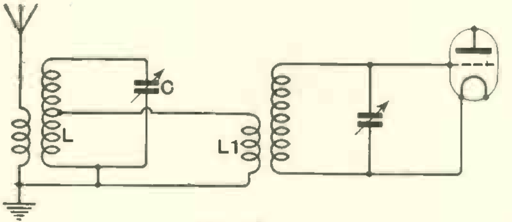
Some Recent Patents

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.

SUPERHETERODYNE RECEIVERS

Convention date (U.S.A.), 7th July, 1931.
No. 384544

" Image " frequencies are eliminated by tapping-off a part of the secondary coil *L* and coupling it, through a link circuit formed by a parallel coil *L*1, to the signal-tuned input of the first amplifier. The part of the coil *L* above the tapping point together with the condenser *C* forms a series-tuned rejector circuit for the undesired frequency, which is thereby short-circuited to earth. The coil *L*1 is preferably combined with a high-voltage secondary winding in order to compensate for the reduced coupling between the aerial and the first signal-tuned circuit.



No. 384544

Patent issued to Hazeltine Corporation.

Convention date (Belgium), 25th June, 1931.
No. 384583

In order to maintain the amplitude of the local oscillations on the grid of the first detector valve constant over the whole frequency-range of the set, the inherent tendency of the local oscillator to generate oscillations of increasing amplitude at the higher frequencies (owing to the inductive back-coupling) is offset by the provision of a capacity coupling between that valve and the H.F. amplifier, whereby the energy-transfer is varied in the opposite sense to keep the desired balance.

Patent issued to N. V. Philips Gloeilampenfabrieken.

LOUD SPEAKERS

Convention date (Germany), 11th August, 1931.
No. 384610

A piston-like movement is given to the diaphragm by making the driving-rod in two parts, coupled together by a small ring which is arranged to lie in a plane parallel to the pole-pieces. As the armature swings to and fro past the pole-pieces, any rocking movement is taken up by the action of the ring-coupling, so that only a straight-line or " piston " drive is communicated by the rod to the diaphragm.

Patent issued to Ideal Werke Akt für drahtlose Telephonie.

DRY-CONTACT RECTIFIERS

Application date, 18th May, 1932. *No.* 385515

Plates or discs of an electro-positive metal, such as aluminium, are alternated with discs of the sulphide of an electro-negative metal such as copper, and the whole is then assembled under pressure by means of a central bolt and end plates. The surface of the copper-sulphide disc is moistened with a solution of iodine in alcohol, which reacts with the copper sulphide to form a coating of copper iodine. Preferably magnesium oxide is added to the iodine solution, and results in the formation of some magnesium iodide, which facilitates the rectifying action.

Patent issued to C. Hambuechen.

TUNING DEVICES

Application date, 9th December, 1931. *No.* 384796

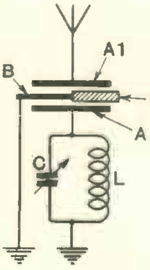
To avoid an unnecessary drain on the accumulator of a wireless set, a lamp used for illuminating the tuning-scale is arranged so that it is lit only during the actual tuning operation. The knob of the tuning control is capable of an independent axial movement to close the lamp circuit, a spring automatically restoring it to its normal position so as to extinguish the lamp as soon as the knob is released.

Patent issued to D. P. Wheeldon.

VOLUME CONTROL

Convention date (Germany), 12th June, 1931.
No. 384917

The fixed plates *A*, *A*1 of a differential condenser are connected respectively to the high-potential end of the tuned circuit *L*, *C* and to the aerial down-lead. The movable plate *B* is directly earthed and is fitted with an insulating piece *P*, designed to maintain a constant capacity between the fixed plates *A*, *A*1 as well as between the plates *A* and *B*. As the movable plate slides out, the capacity of the plate *A* relatively to the plate *B* decreases, whereas the capacity of the plate *A* relatively to the plate *A*1 increases. The distance between *A* and *A*1 is larger than that between *A* and *B*, but the desired balance is maintained by a suitable choice of the dielectric value and the size of the insulating piece *P*. An earthed screen may surround the upper of the two fixed plates to counteract any leakage field.



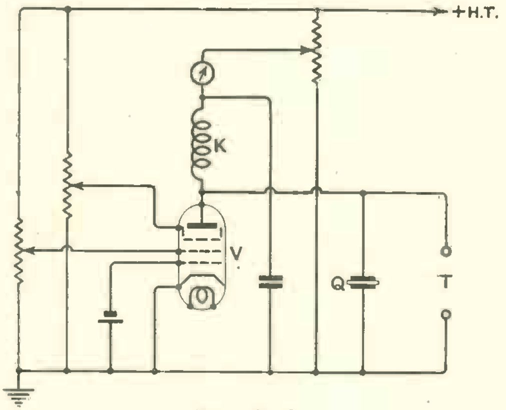
No. 384917

Patent issued to N. V. Philips Gloeilampenfabrieken.

HIGH-FREQUENCY OSCILLATORS

Convention date (*U.S.A.*), *8th June*, 1931.
No. 385187

H.F. oscillations are generated by the dynatron action of a triode, S.G. valve, or pentode valve, the frequency being determined solely by a piezo-electric crystal or a magneto-strictive device shunted across the anode and cathode. The arrangement is distinguished from the known arrangement in which a tuned circuit in a back-coupled valve-oscillator is shunted by a piezo-electric crystal. The figure shows a pentode controlled by a crystal *Q* connected between the anode and earth. A choke *K* is inserted in parallel, its inductance being such that in combination with the interelectrode capacities of the crystal *Q* and valve *V* it is resonant to a frequency approximately half that of the generated frequency. The electrode potentials are adjusted to give the valve a negative-resistance characteristic. The load is taken from the terminals *T*.



No. 385187

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

VARIABLE CONDENSERS

Convention date (*Germany*), *2nd December*, 1931.
No. 385508

In order to avoid the difficulty of accurately milling or cutting the bolts which support the vanes of a variable condenser, the bolts are made of soft metal and of angular cross-section. The vanes are pierced with holes of similar cross-section, and after they have been assembled and spaced in a jig, the bolts are inserted and are turned through an angle sufficient for the edges of the apertures in the plates to bite firmly into the soft metal, thus fixing the vanes in position.

Patent issued to Ritscher G.m.b.H.

PERMANENT MAGNETS

Application date, *13th November*, 1931. *No.* 385400

Relates to permanent magnets for moving-coil loud-speakers of the type in which the central and outer pole-pieces are separated by an annular air-gap in which the speaker coil is fitted. In order to provide a construction of relatively small axial length and of high magnetic efficiency, the pole-pieces extend radially from the axis of the air-gap, and their outer ends are joined by magnetic connectors extending in a plane substantially at right-angles to the axis of the gap.

Patent issued to Darwins, Ltd., and A. C. Catherall.

BEAM SYSTEMS

Convention date (*Germany*), *5th October*, 1931.
No. 385255

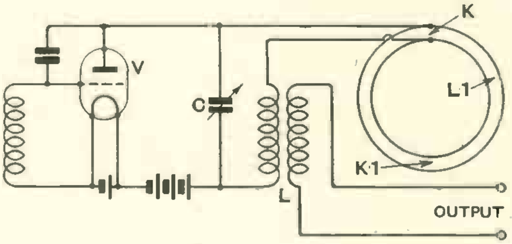
In short-wave systems where a parabolic reflector is used to concentrate the radiation into a clear-cut beam, a second screening-element is sometimes placed in front of the parabolic reflector in order to cut-off the direct waves from the oscillator. According to the invention this second screen is so shaped and located that the direct waves impinging on it are first reflected back on to the main reflector, and then augment the principal outgoing stream of radiation.

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

HIGH-FREQUENCY SYSTEMS

Convention date (*U.S.A.*), *30th December*, 1930.
No. 385350

The object of the invention is to generate H.F. oscillations having a frequency of the order of a megacycle a second and to superpose on them a cylical variation of a lower order. This object is achieved by inserting in the main tuned circuit a spark-discharge gap which varies its position at a rate corresponding to the lower order of frequency, and in so doing periodically increases and decreases the effective value of inductance in the main oscillatory circuit. As shown in the figure the frequency-determining circuit *L*, *C* of the oscillating valve *V* is completed through a gap *K* across a circular pair of electrode-rails *L*1. The spark is created by an auxiliary circuit (not shown), and is made to travel at a constant rate around the rail-track *L*1 by a superposed magnetic field. When the spark is at the top of the rails, in the position shown, the valve *V* oscillates at its maximum frequency, but when the gap reaches the bottom of the track, *e.g.*, at *K*1, the inductance represented by the half-circle of wire *L*1 is then in circuit and reduces the H.F. oscillation to its minimum frequency, the variation being repeated cyclically.



No. 385350

Patent issued to Communication Patents Inc.

THERMIONIC VALVES

Convention date (Germany), 9th April, 1931.
No. 386484

An insulating screen of refractory material, substantially opaque to heat-rays, is mounted just above the " pinch " inside the bulb on the rods supporting the anode. The supporting rods for the other electrodes pass through clearing-holes formed in the screen, the entire radiating portion of the cathode being located on the side of the screen remote from the pinch. The arrangement protects the pinch (*a*) from metallic deposits formed during the " gettering " operation, and the consequent liability to leakage paths, or a direct short-circuit between the electrodes, and (*b*) from heat radiated by the cathode which may cause the " pinch " to crack.

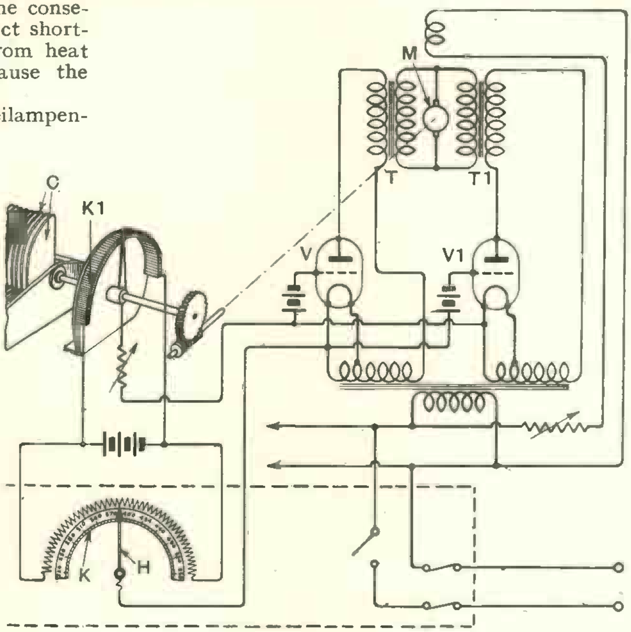
Patent issued to N. V. Philips Gloeilampenfabrieken.

REMOTE TUNING-CONTROL

Convention date (U.S.A.), 7th April, 1931. *No.* 385498

The setting of the tuning-condenser *C* of a wireless receiver is synchronised with the position of the hand *H* of a control unit *K* (located at a distance from the wireless set) by the action of two thyratron valves *V*, *V*1, and a motor *M* driven from the same source of supply. The remote-control unit *K*, which is in the form of a potentiometer, is in circuit with the cathode of the thyratron *V* and with the grid of the thyratron *V*1. A similar potentiometer *K*1 connected to the spindle of the tuning-condenser *C* is in circuit with the grid of the thyratron *V* and the cathode of the thyratron *V*1. If the contacts on the two potentiometers are not in identical positions, one of the valves *V*, *V*1 feeds current through one or other of the transformers *T*, *T*1 to the armature of the motor *M* until exact coincidence is ensured.

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



No. 385498

RIBBON MICROPHONES

Convention date (U.S.A.), 31st March, 1931.
No. 386478

A crimped ribbon of thin aluminium foil is supported in the magnetic field between two pole-pieces, so that its displacement under the impact of a sound-wave is substantially proportional to that of a particle acted on by the same wave in free air. The sound acts on opposite sides of the ribbon, and a symmetrical baffle keeps the wave-path between the two sides at least half a wavelength of the highest sound frequency. The ribbon is supported at both ends, without tension, its limpness being preferably such as to give it a natural period of about 10 cycles per second.

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

CONSTANT-COUPLING SYSTEMS

Convention date (Holland), 18th August, 1931.
No. 385560

To offset the natural falling-off in sensitivity towards the longer wavelengths, the input circuit and intervalve couplings of a multivalve receiver are made semi-aperiodic in character. Preferably they comprise two or more capacitatively-coupled circuits, which are designed to have a decreasing impedance between the upper limit of the short wave-band and the lower limit of the long wave-band and then an increasing impedance with wavelength. This ensures an approximately constant response throughout the whole tuning-range.

Patent issued to N. V. Philips Gloeilampenfabrieken.

REACTION CONTROL

Convention date (U.S.A.), 12th June, 1931.
No. 385863

In a short-wave receiver of the super-regenerative type, the radio-frequency stage is coupled to the tuned input of a screen-grid detector through a fixed coil, which also forms part of a feed-back path from the anode circuit of the detector. Reaction is controlled by adjusting the voltage on the screening grid, thus carrying the " gain " of the valve. By avoiding the use of a swinging coil it becomes possible to gang the tuning condensers. Even if this is not done, the present method of reaction facilitates the " logging " of stations.

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

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